Col·lecció INSTRUMENTA 65

PAISAJES PRODUCTIVOS Y REDES COMERCIALES EN EL IMPERIO ROMANO

PRODUCTIVE LANDSCAPES AND TRADE NETWORKS IN THE ROMAN EMPIRE

José Remesal Rodríguez, Víctor Revilla Calvo, Daniel J. Martín-Arroyo Sánchez, Antoni Martín i Oliveras (eds.)

UNIVERSITAT DE BARCELONA

Edicions

PAISAJES PRODUCTIVOS Y REDES COMERCIALES EN EL IMPERIO ROMANO

PRODUCTIVE LANDSCAPES AND TRADE NETWORKS IN THE ROMAN EMPIRE

Col·lecció INSTRUMENTA 65

Barcelona 2019

PAISAJES PRODUCTIVOS Y REDES COMERCIALES EN EL IMPERIO ROMANO

PRODUCTIVE LANDSCAPES AND TRADE NETWORKS IN THE ROMAN EMPIRE

J. Remesal Rodríguez
Víctor Revilla Calvo
Daniel J. Martín-Arroyo Sánchez
Antoni Martín i Oliveras (eds.)

Universitat de Barcelona
Edicions

Universidad de Barcelona. Datos catalográficos

Paisajes productivos y redes comerciales en el Imperio Romano = Productive landscapes and trade networks in the Roman Empire. – (Col·lecció Instrumenta ; 65)

Inclou referències bibliogràfiques
ISBN 978-84-9168-263-9

I. Remesal Rodríguez, José, editor literari II. Revilla Calvo, Víctor, editor literari III. Martín-Arroyo Sánchez, Daniel J., editor literari. IV. Martín i Oliveras, Antoni, editor literari V. Títol paral·lel: Productive landscapes and trade networks in the Roman Empire VI. Col·lecció: Instrumenta (Universitat de Barcelona) ; 65
1. Imperi Romà, 30 aC-476 dC 2. Medi rural 3. Productes agrícoles 4. Comerç d'aliments 5. Distribució comercial 6. Ceràmica romana 7. Història econòmica 8. Història antiga

Adolf Florensa, s/n
08028 Barcelona
Tel.: 934 035 430
Fax: 934 035 531
comercial.edicions@ub.edu
www.publicacions.ub.edu

1.ª edición: Barcelona, 2019

Director de la colección: José Remesal
Secretario de la colección: Antonio Aguilera

CEIPAC
http://ceipac.ub.edu

Sello de Calidad en Edición Académica. Promovido por la Unión de Editoriales Universitarias Españolas (UNE) y avalado por la Agencia Nacional de Evaluación de la Calidad y Acreditación (ANECA) y la Fundación Española para la Ciencia y la Tecnología (FECYT).

Unión Europea: *ERC grant agreement nº ERC-ADG340828*. ARIADNE plus is funded by the European Commission under the H2020 Programme, contract no. H2020-INFRAIA-2018-1-823914.

Gobierno de España: DGICYT: PB89-244; PB96-218; APC 1998-119; APC 1999-0033; APC 1999-034; BHA 2000-0731; PGC 2000-2409-E; BHA 2001-5046E; BHA2002-11006E; HUM2004-01662/HIST; HUM200421129E; HUM2005-23853E; HUM2006-27988E; HP2005-0016; HUM2007-30842-E/HIST; HAR2008-00210; HAR2011-24593; HAR2015-66771-P (MINECO/FEDER, UE); HAR2017-85635-P (MINECO/FEDER, UE).
MAEX: AECI29/04/P/E; AECI.A/2589/05; AECI.A/4772/06; AECI.A/01437/07; AECI.A/017285/08.

Generalitat de Catalunya: *Grup de Recerca de Qualitat*: SGR 95/200; SGR 99/00426; 2001 SGR 00010; 2005 SGR 01010; 2009 SGR 480; 2014 SGR 218; 2017 SGR 512; ACES 98-22/3; ACES 99/00006; 2002ACES 00092; 2006-EXCAV0006; 2006ACD 00069.

The research leading to these results has received funding from the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013). ERC grant agreement nº ERC-2013-ADG340828.

Montaje: Ariane Capdevila Sanz y Mateo González Vázquez.

Imagen de la cubierta: Mosaico de los trabajos del campo (detalle). Museo de Cherchell, Argelia.

Impresión: Gráficas Rey

Depósito legal: B-14.915-2019

ISBN: 978-84-9168-263-9

Índice general

Prólogo

José Remesal Rodríguez
Universidad de Barcelona, CEIPAC

Este volumen recoge las contribuciones y discusiones tenidas durante la celebración de la sección: *The production and distribution of food in the Roman Empire: modelling political, economic and social dynamics,* (27ª reunión del *TRAC* en Durham, 28-31 marzo 2017).

Pretendíamos, desde la perspectiva del proyecto EPNet (*Production and Distribution of Food during the Roman Empire: Economic and Political Dynamics*) discutir algunos aspectos de la economía romana, partiendo no sólo de los métodos analíticos tradicionales, sino desde la aplicación de métodos formales, que nos permitan discutir, desde nuevas perspectivas, las visiones económicas sobre el Imperio Romano.

Hemos partido, más que de una discusión general y teórica sobre la economía romana, de un análisis de casos concretos, que permiten entrever la complejidad de la economía imperial romana. De lo particular podremos ir abstrayendo precisiones de carácter más general que nos ayuden a comprender el sistema en su globalidad.

El Imperio Romano abarcó un amplísimo espacio con culturas y sistemas económicos diversos, pero que, como cualquier imperio, instituyó mecanismos, que le permitieran beneficiarse de los recursos del territorio conquistado. Podemos pensar en la producción de productos destinados al autoconsumo o a satisfacer las necesidades de un área reducida. Podemos analizar productos creados en una región concreta, como las diversos tipos de vajilla de mesa, destinados, sin embargo, a un amplio mercado, que exigen una amplia red de transporte y comercialización. Podemos analizar los recursos mineros, que no sólo exigen una amplia red de transporte y comercialización sino también de elaboración en las cuencas mineras y de transformación en los lugares donde llegasen dichos productos en forma de lingotes.

En nuestro caso, hemos prestado más atención a la producción y comercio de productos alimentarios. Asegurar su propio mantenimiento es el primer intento de cualquier sociedad. Bien lo recuerda Aristóteles, quien afirma que la primera cuestión que se discutía en las reuniones de las pritanías atenienses era si había grano o no en la ciudad. Si había grano, se podían discutir otras cuestiones.

Cuando estudiamos este problema, si hablamos de una sociedad compleja, como la de cualquier imperio, se nos abre la necesidad de abordar el tema desde muy diversas perspectivas: en primer lugar, los estudios dedicados a comprender los problemas relacionados con la organización de la propiedad de la tierra, que a su vez puede ser abordado desde el punto de vista del conquistador y de las relaciones que cada territorio conquistado establece con el poder central y de qué modo cada uno de los territorios responden a esa nueva situación. Sobre el problema de la propiedad de la tierra, se impone la cuestión de los modos de explotación, que son los que determinan el mayor o menor desarrollo de una región. Las formas de explotación en el mundo romano pasan por la discusión sobre una explotación de carácter esclavista, por formas más mitigadas, como el colonato, o la existencia de pequeños y medianos propietarios o de un gran grupo de trabajadores por cuenta ajena.

La dieta mediterránea, como bien sabemos, tiene tres productos básicos, trigo, vino y aceite. El primero se comercializaba en sacos, razón por la que se conservan pocos testimonios materiales de su comercio. En cambio, del vino y del aceite, que son productor elaborados a partir de la uva y la aceituna y se transportaron en ánforas, se han conservado muchos más testimonios arqueológicos. Otros muchos productos, entre los que destacan las conservas de pescado también se transportaron en ánforas. Pero en la comercialización de estos productos no sólo interviene la capacidad de producir, sino de transportar, en función de los limitados medios de transporte en la antigüedad, sólo las regiones que tuvieron a su alcance la posibilidad de un transporte marítimo-fluvial pudieron exportar los excedentes de sus productos y en consecuencia tener interés por producirlos. Sin duda, la gran distribución de productos vinculados a las conservas de pescado es una buena muestra de cuanto decimos.

La visión tradicional sobre la economía romana, siguiendo la frase del fisiócrata francés del siglo XVIII, Vincent de Gournay, era la de *Laissez faire et laissez passer, le monde va de lui même*. El estado romano no intervino en el desarrollo de la política económica del imperio. Se defendía que el Emperador sólo había intervenido en el acaparamiento del trigo de Egipto, para satisfacer las necesidades de las *frumentationes* en Roma.

La investigación desarrollada desde el grupo CEIPAC ha puesto de manifiesto, que el emperador debía asegurar no sólo la llegada de grano a Roma, sino conseguir la paz social asegurando el abastecimiento general de cualquier producto, para ahuyentar el fantasma del hambre en la capital del Imperio, Roma. Por otra parte, hemos puesto de manifiesto cómo el emperador estaba también obligado a asegurar el abastecimiento del Ejército. Todo ello obligó al estado romano a intervenir directamente en multitud de aspectos económicos.

El estado romano no monopolizo los medios de transporte, que dejó en manos de privados. La necesidad del Estado de acarrear productos, fuese a Roma o a los campamentos militares o a los teatros de operaciones militares, favoreció el desarrollo de un comercio a larga distancia que, sin el estímulo de las necesidades estatales, se hubiese visto muy limitado.

La investigación actual exige estudiar las características de la producción de cada uno de los productos y sus sistemas de comercialización. Al mismo tiempo estudiar qué papel jugó cada una de las provincias del Imperio Romano, como se relacionaron estas entre sí y con el poder central y de qué modo pudieron influir, a través de sus agentes, en el desarrollo general de la política económica de Roma.

Monte Testaccio. Un archivo único[1]

José Remesal Rodríguez

El monte Testaccio se encuentra situado en la zona logística de la antigua Roma, cerca de los *horrea Galbana* y *Seiana*[2]. (Fig. 1). En la actualidad tiene un perímetro próximo a un kilómetro y una altura próxima a 50 mts. (Fig. 2). Tiene la peculiaridad de que está compuesto, exclusivamente, por los restos de millones de ánforas, con la particularidad de que más del 80% corresponden a un solo tipo anfórico, conocido como tipo Dressel 20 (Fig. 3), que, como ya señaló Dressel, proceden de la provincia romana de la Bética y que, como sabemos, contuvieron aceite de oliva[3]. El resto de las ánforas allí conservadas proceden, en su mayoría de las provincias romanas de Tripolitania y el África proconsular. En muy escasa proporción proceden de las regiones orientales del Mediterráneo (+- 1%). También estas ánforas contuvieron aceite de oliva.

Las ánforas romanas fueron selladas, con mayor o menor frecuencia, antes de la cocción del vaso. Estos "sellos", tan duraderos como la misma cerámica, son muy frecuentes en las ánforas Dressel 20, gracias a los cuales hemos podido constatar su amplia distribución por todo el occidente romano y, en menor medida, también en la parte oriental del imperio. Si no todas las ánforas se sellaron[4], si necesitaron de una "etiqueta" (*titulus pictus*) que informase del producto contenido, del nombre del comerciante que las transportaba y de algunas anotaciones de control aduanero y fiscal. Los *tituli picti*, escritos con tinta negra o roja, han desaparecido en la mayoría de los casos. En el Testaccio se han conservado abundantemente.

---

[1] Esta investigación se integra en el proyecto: *Production and Distribution of Food during the Roman Empire: Economic and political Dynamics.* Financiado por la UE (FP7/2007-2013) ERC grant agreement mº ERC-2013-ADG340828 y en el proyecto HAR2017-85635-P.

[2] RODRÍGUEZ ALMEIDA, E. 1984. AGUILERA MARTÍN, A. 2002.

[3] DRESSEL, H. 1878.

[4] REMESAL RODRIGUEZ, J. 2016. Con el estado actual de la discusión y la bibliografía.

Figura 1. La llanura subaventina. Imagen extraída de: Aguilera, A. El monte Testaccio y la llanura subaventina. Topografía extra portam Trigeminam. Roma 2002, fig.7.

Figura 2. Vista aérea del Monte Testaccio hoy día. Imagen extraída de: Ramieri, A.M. “Roma e il Testaccio tra storia, costume e tutela” en Blázquez Martínez, J.M., Remesal Rodríguez, J. (Eds.) Estudios sobre el Monte Testaccio (Roma) IV. Instrumenta 24. Barcelona 2007, p.382, Fig. 1.

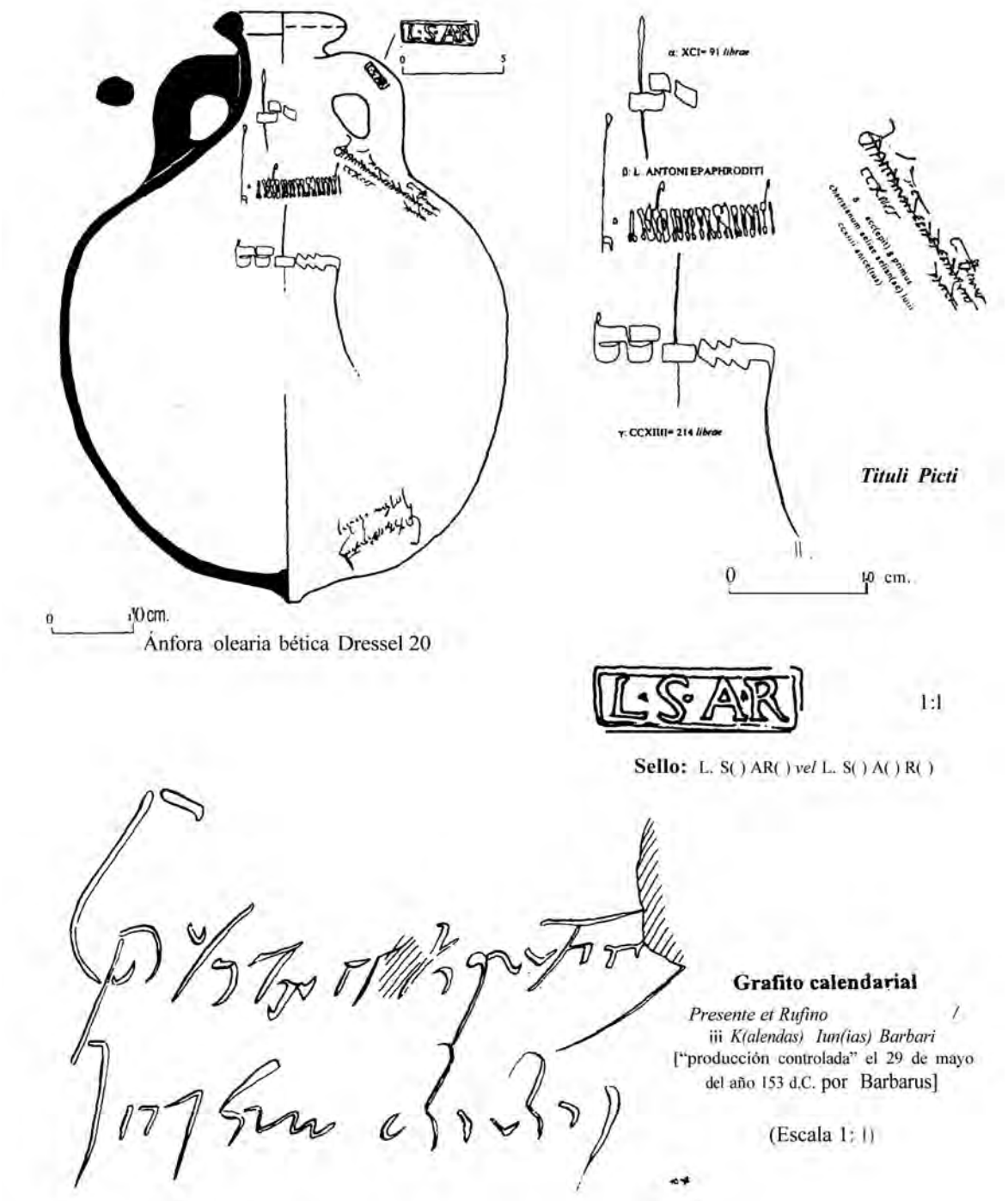


Figura 3. Ánfora olearia bética, tipo Dressel 20, con sus elementos epigráficos (s. II d.C.). Imagen extraída de: Aguilera Martín, A., Berni Millet, P. 'Las cifras hispánicas', en Mateu Ibars, J. (coords.) *Calligraphia et tipographia. Arithmetica et numerica. Chronologia.* Barcelona 1998. Fig. 2

Ya Dressel, el primer investigador del Testaccio, supo descifrar estos *tituli picti*, que dividió en cinco categorías: *alfa*: tara del vaso; *beta*: él creyó que se refería al nombre del propietario del ánfora, más tarde se demostró que correspondía a los nombres de comerciantes[5]; *gamma*: peso del contenido neto en aceite; *delta*: un complejo control fiscal-aduanero, en el que se hace constar el distrito del que procedía el ánfora (*Astigi, Corduba, Hispalis*), a veces un topónimo, nombres al genitivo y nominativo, cuyo significado seguimos discutiendo y la datación consular, es decir, la indicación del año en que se expidió el ánfora; *epsilon*: un número que parece hacer referencia o a lotes de almacenamiento o transporte[6] (Fig.4).

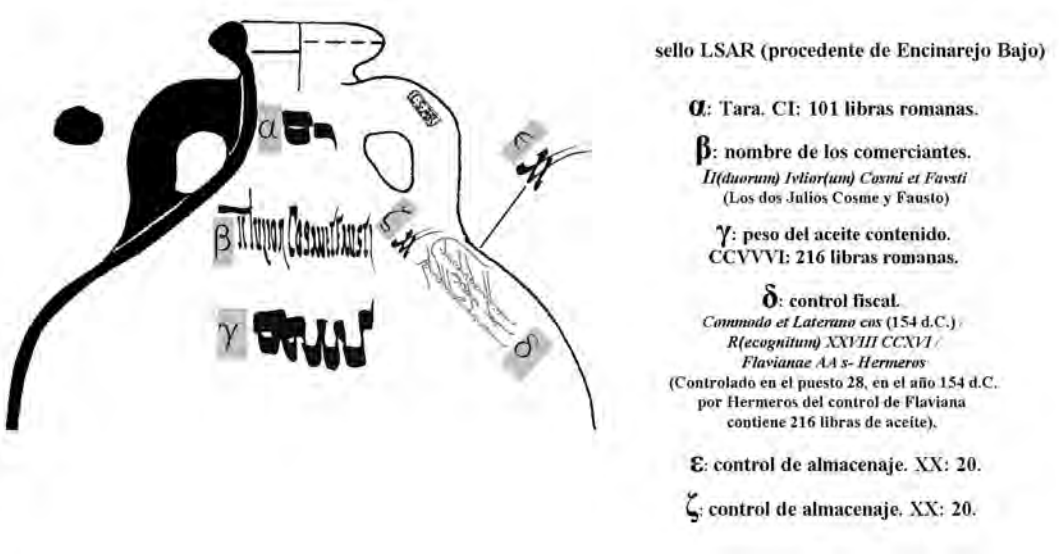


Figura 4. Titulatura de un ánfora Dressel 20 (mediados del siglo II). Imagen extraída de: Remesal Rodríguez, J. 'El valor estadístico de la epigrafía sobre ánforas Dressel 20', en Remesal Rodríguez, J., Revilla Calvo, V., Bermúdez Lorenzo, J.M. (eds.) Cuantificar las economías antiguas. Problemas y métodos. / Quantifying Ancient Economies. Problems and Methodologies. Instrumenta 60. Barcelona 2018, Fig. 1.

En definitiva, el Testaccio, que para los romanos no fue más que un vertedero, para nosotros se ha convertido en el mejor archivo para el estudio de la economía romana, porque tenemos grandes series de datos, cosa poco frecuente en el estudio del mundo antiguo, que, además, están datados con precisión absoluta. Aún más, la información del Testaccio se refiere a un solo producto, el aceite de oliva, y, fundamentalmente, a una sola provincia, la Bética.

Desde hace 30 años, el grupo de investigación CEIPAC (*Centro para el Estudio para la Interdependencia Provincial en la Antigüedad Clásica*) ha investigado sobre el área de producción de estas ánforas, sobre su distribución a lo largo y ancho del Imperio Romano, creando una base de datos con más de 43.000 registros, que contienen casi un millón de datos y realizando excavaciones en el Monte Testaccio (web: ceipac.ub.edu). Este estudio micro analítico – un producto, una región – permite analizar en su conjunto la política económica del Imperio Romano; su evolución administrativa y las relaciones entre poder político y poder económico a lo largo del Imperio Romano[7].

---

[5] HERON DE VILLEFOSSE 1914.
[6] DRESSEL, H. 1878; CIL. XV/2.
[7] Una síntesis de conjunto en REMESAL RODRIGUEZ, J. 2011.

Presentamos aquí una comparación entre los resultados de Dressel y los de nuestras recientes excavaciones, referido a los sellos.

Dressel realizó una prospección que hoy día podemos considerar como modélica: dividió el monte en sectores y cada uno de ellos en alturas, además señaló si en su opinión los sellos y *tituli picti* que hallaba se encontraban *in situ* o si estaban fuera de su contexto original[8]. (Fig. 5), llegando a la conclusión de que el monte se había formado en un dilatado espacio de tiempo y que los materiales habían sido depositados con un cierto orden. Más tarde, en 1881, realizó una serie de sondeos junto con el padre Luigi Bruzza, que le permitieron confirmar su hipótesis[9] (Fig. 6). Dado que en sus prospecciones y sondeos encontró dataciones entre los años 145 y 257 d.C. y que esto sólo le permitió conocer la "piel" del monte llegó a la conclusión de que debía tener un origen más antiguo, que el consideró desde época augustea[10].

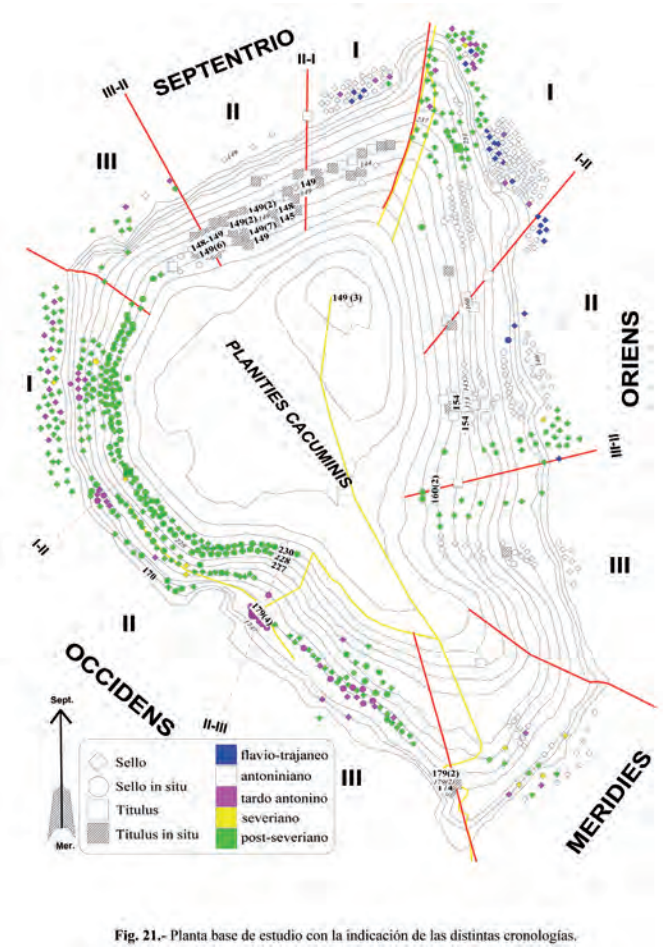


Fig. 21.- Planta base de estudio con la indicación de las distintas cronologías.

Figura 5. La epigrafía datada con criterios absolutos o relativos de la prospección de Dressel y Bruzza a partir de los datos publicados en el CIL XV según Berni Millet, P. "La piel del Testaccio. Un estudio sobre la primera prospección sistemática de Dressel, en Blázquez Martínez, J.M., Remesal Rodríguez, J. (Eds.) Estudios sobre el Monte Testaccio (Roma) I. Barcelona 1999, pp.205-273, Fig. 108.

---

[8] DRESSEL, H. 1878

[9] El estudio de conjunto fue publicado en el volumen CIL XV/2 en 1898.

[10] DRESSEL, H. 1878; BERNI MILLET, P. 1999.

E. Rodríguez Almeida, reanalizando los materiales de Dressel y los hallados por él en sus prospecciones, llegó a proponer que el Testaccio estaba formado por dos plataformas principales, la primera formada entre los tiempos de Augusto y mediados del s. II d.C., la segunda, al oeste de la primera, datada desde mediados del s. II d.C. hasta época severiana y por un pequeño depósito, al este de la primera plataforma, compuesto por materiales del s. III d.C. [11] (Fig. 7).

Figura 6. Las 12 catas de excavación de Dressel en el Testaccio; también los 2 cavi y el tasto 1 en los Orti Torlonia, junto al Monte y el sepulcrum Rusticelli. También, el Cavone y el Piccolo Testaccio. Imagen extraída de Aguilera, A. El monte Testaccio y la llanura subaventina. Topografía extra portam Trigeminam. Roma 2002, fig.47.

Nuestras excavaciones[12], iniciadas en 1989, tenían la finalidad de:

> Primero: recoger nuevos materiales y compararlos con los hallados por Dressel.
> Segundo: intentar comprender mejor la formación y evolución del monte y mejorar los datos cronológicos conocidos.
> Tercero: poner en relación estos materiales con sus lugares de origen.

Por lo que respecta al punto primero hemos obtenido materiales y dataciones concomitantes con lo hallado por Dressel y muchos otros documentos nuevos con dataciones no conocidas por Dressel.

---

[11] RODRÍGUEZ ALMEIDA, E. 1984. fig. 56.
[12] BLÁZQUEZ MARTÍNEZ, J.Mª. , REMESAL RODRIGUEZ, J., RODRÍGUEZ ALMEIDA, E. 1994. BLÁZQUEZ MARTÍNEZ, J.Mª. , REMESAL RODRIGUEZ, J. (Eds.) 1999, 2001, 2003, 2007, 2010, 2014.

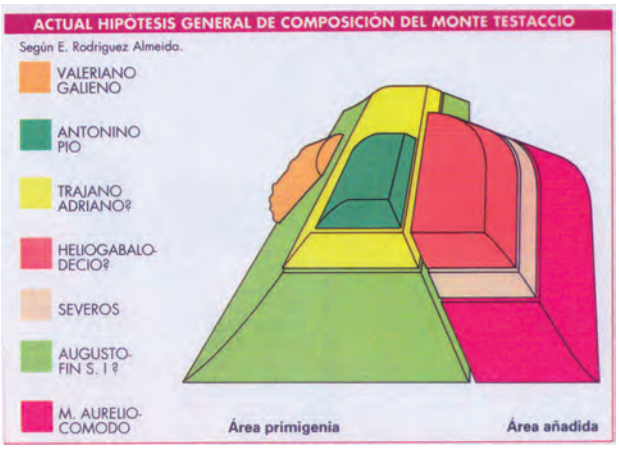


Figura 7. Hipótesis general de la distribución de los depósitos sobre el Monte Testaccio según E. Rodríguez Almeida. Imagen en: Rodríguez Almeida, E. 'Excavaciones españolas en el monte Testaccio', en Blázquez Martínez, J.M., Remesal Rodríguez, J., Rodríguez Almeida, E. Excavaciones arqueológicas en el monte Testaccio (Roma). Memoria Campaña 1989. Madrid 1994, Fig. 15.

Figura 8. Muro construido con ánforas Dressel 20. Campaña de excavación 2002. Foto: CEIPAC.

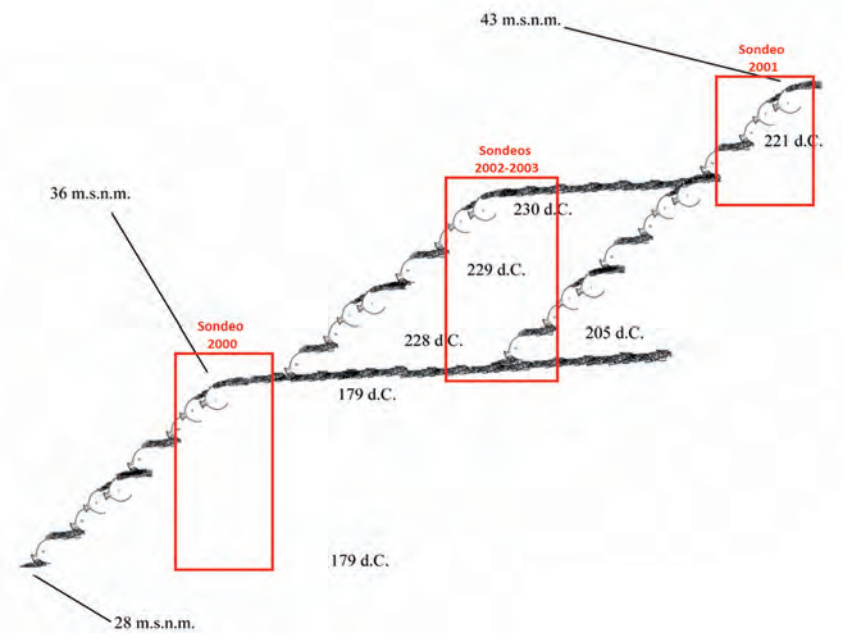


Figura 9. El presente diagrama presenta como el monte fue construido. En el sondeo del año 2000 se hallaron materiales de una primera plataforma del año 179 d.C. En las descargas sucesivas se realizaron en otro lugar hasta 205 d.C., cuando se creó otra plataforma (sondeos 2002-2003), más pequeña que la primera, que se usó hasta el año 221 d.C. (sondeo 2001). Más tarde se llenó el paso que había existido entre el borde de la plataforma de 179 d.C. y la de 205 d.C con materiales de los años 228-230 d.C. (sondeos 2002-2003).

Por lo que respecta al punto segundo hemos hallado elementos que permiten explicar la mecánica de formación del monte. El monte está formado por plataformas sucesivas y escalonadas, para ello se construían muros con ánforas del tipo Dressel 20 a las que se le rompía la base y se rellenaban con fragmentos de otras ánforas para hacerlas más pesadas. Con ellas se construía una línea y se descargaba detrás de ellas, una vez colmatado el espacio se volvía a construir otra fila de ánforas y así sucesivamente hasta formar una pirámide escalonada[13] (Fig. 8). En un momento determinado, en función de las necesidades, se rellenaban los escalones que se habían ido formando con materiales más recientes (Fig. 9). Hemos hallado varios de estos muros, que permiten definir mejor la evolución de las descargas de material en el monte. Además, hemos podido determinar que, lo que Rodríguez Almeida consideró una pequeña descarga a mediados del s. III d.C. constituía, en realidad, una tercera plataforma que cubría todo el costado oriental del Testaccio[14]. (Fig. 10).

Dedicaremos este trabajo a exponer los resultados relativos al punto tercero.

Las ánforas Dressel 20 fueron fabricadas a las orillas de los ríos Guadalquivir y Genil. Conocemos hoy día un centenar de estas *figlinae* (Fig. 11)[15]. Los sellos suelen ser producidos en un solo lugar, o en lugares próximos. Conocemos el lugar de producción de muchos de ellos. Al estudiar la distribución de las *figlinae* las hemos subdividido en relación a la división administrativa de la

[13] REMESAL RODRIGUEZ, J. 1994-1999.
[14] REMESAL RODRIGUEZ, J. 1994.
[15] PONSICH 1974, 1979, 1991. REMESAL RODRIGUEZ, J. 1977-1978. BERNI MILLET, P. 2008.

provincia de la Bética, tres de cuyos *conventus iuridici*: *Astigi* (Écija) *Corduba* (Córdoba) e *Hispalis* (Sevilla) incluían algún tramo de Guadalquivir (*Baetis*) y del Genil (*Singilis*).

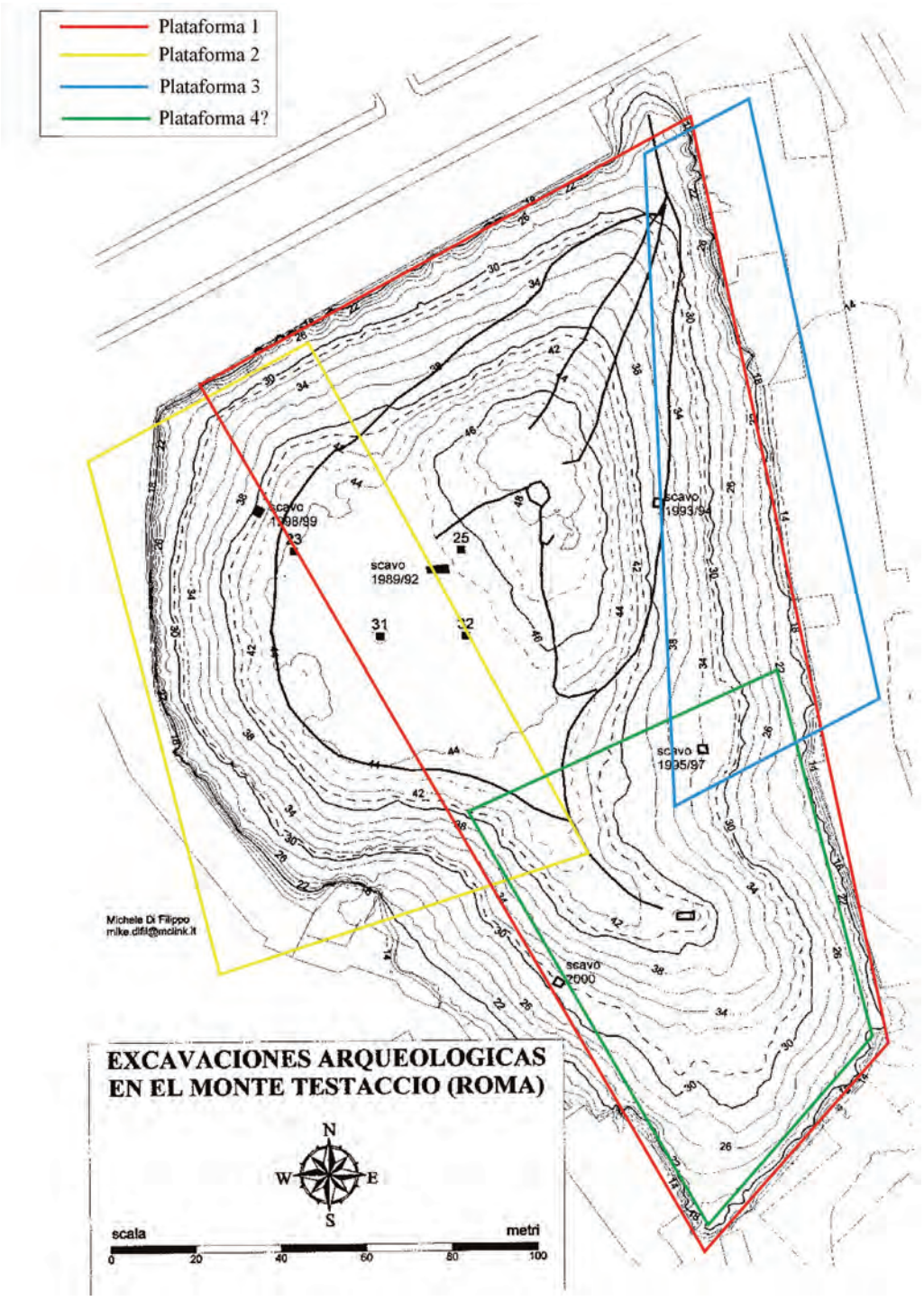


Figura 10. Posición teórica de las diversas plataformas, según J. Remesal. Imagen extraída de: Blázquez Martínez, J.M., Remesal Rodríguez, J. 'Las campañas de 1991 y 1992', en Blázquez Martínez, J.M., Remesal Rodríguez, J. (Eds.) Estudios sobre el Monte Testaccio (Roma) II. Instrumenta 10. Barcelona 2001, Fig. 3.

Si comparamos el volumen de material hallado en el Testaccio por Dressel, cuyo lugar de producción conocemos y el hallado por nosotros, podemos aseverar que la proporción es la misma (Fig. 12). Si ordenamos el material por periodos cronológicos y por *conventus*, podemos ver, de un modo más particular, la correlación entre ellos (Fig. 13). La escasa presencia de materiales de determinados periodos se explica porque, dado que el monte fue hecho de una manera muy organizada no se han realizado sondeos en los sectores en los que se depositó el material de esos periodos.

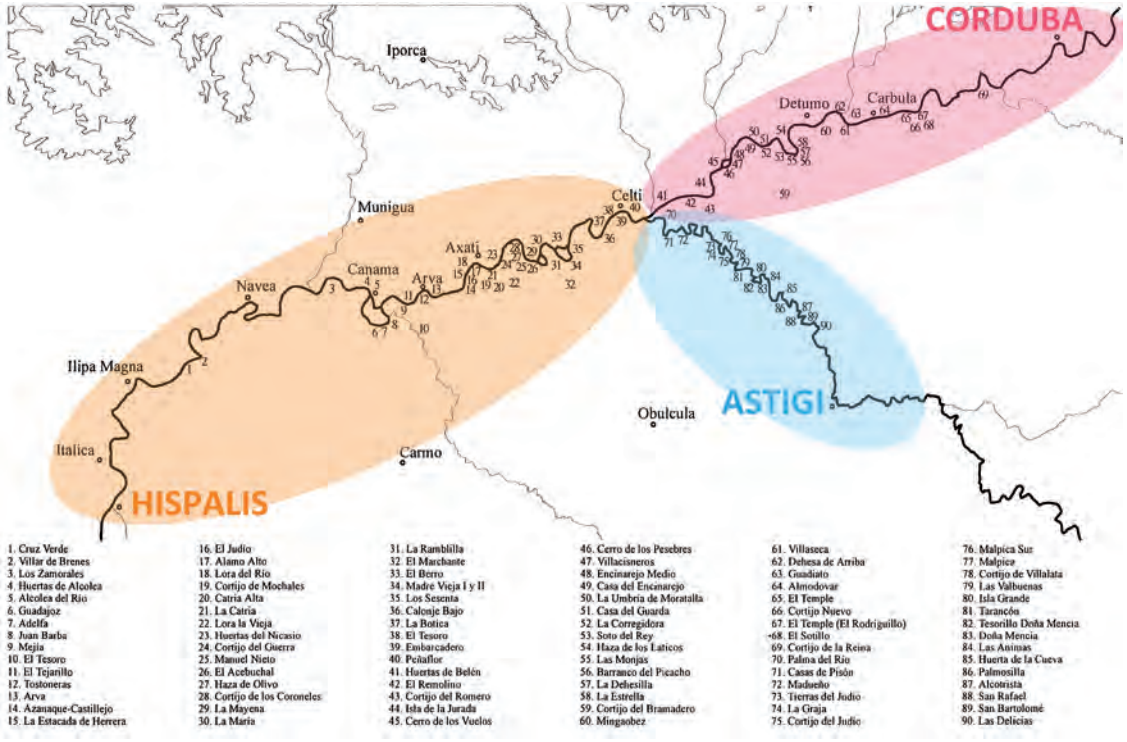


Figura 11. Alfares del Guadalquivir. Imagen extraída de: Remesal Rodríguez, J. 'El valor estadístico de la epigrafía sobre ánforas Dressel 20', en Remesal Rodríguez, J., Revilla Calvo, V., Bermúdez Lorenzo, J.M. (eds.) Cuantificar las economías antiguas. Problemas y métodos. / Quantifying Ancient Economies. Problems and Methodologies. Instrumenta 60. Barcelona 2018, Fig. 2.

Dado que Dressel realizó tanto una prospección como una serie de sondeos disponemos, por una parte, gracias a las prospecciones, de una visión general de la distribución del material y su cronología (Figs. 5 y 14). En el sector "oriente I", Dressel encontró sobre el tejado de las bodegas que circundan el monte mucho material del s. III d.C. su estudio fue el primer indicio que tuvimos para afirmar que en el lado oriental del Testaccio había existido una verdadera plataforma y no, como señaló Rodríguez Almeida, un pequeño acumulamiento[16]. Los sondeos realizados por Dressel fueron de muy diverso tamaño, el más grande, su sondeo C, alcanzó los tres metros de profundidad, seguido en tamaño por el sondeo H, de ahí la mayor proporción de materiales de las épocas correspondientes (Fig. 15). Algunos investigadores han creado un falso al considerar que el año 149 d.C. fue un año de gran abundancia, pues Dressel encontró mucho material de ese año[17]. No es así, se trata simplemente de que su sondeo "pinchó" materiales de ese año. Nuestros estudios han modificado estas cantidades

[16] REMESAL RODRÍGUEZ, J. 1994.
[17] ETIENNE, R. 1949. Opinión que se ha mantenido por largos años.

cuando hemos hallado periodos cronológicos que no investigó Dressel, como son los resultados de las campañas 1993/94 y 1995/97. En la primera de ellas se hallaron materiales seguramente anteriores a 145 d.C. mientras que en la segunda se hallaron materiales de época post-severiana (Fig. 16).

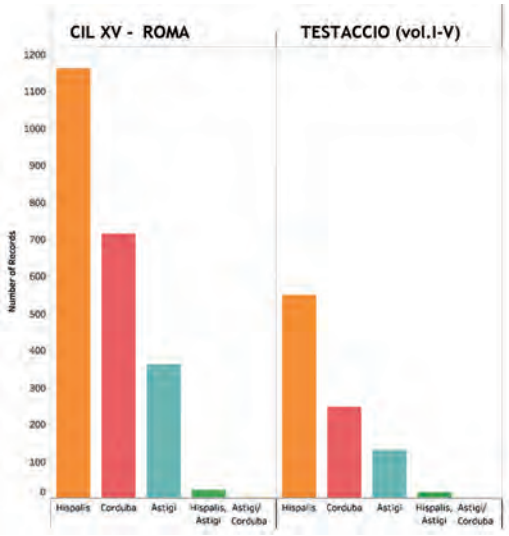


Figura 12. Comparación de los datos publicados por H. Dressel en el CIL XV sobre el monte Testaccio y nuestros sondeos.

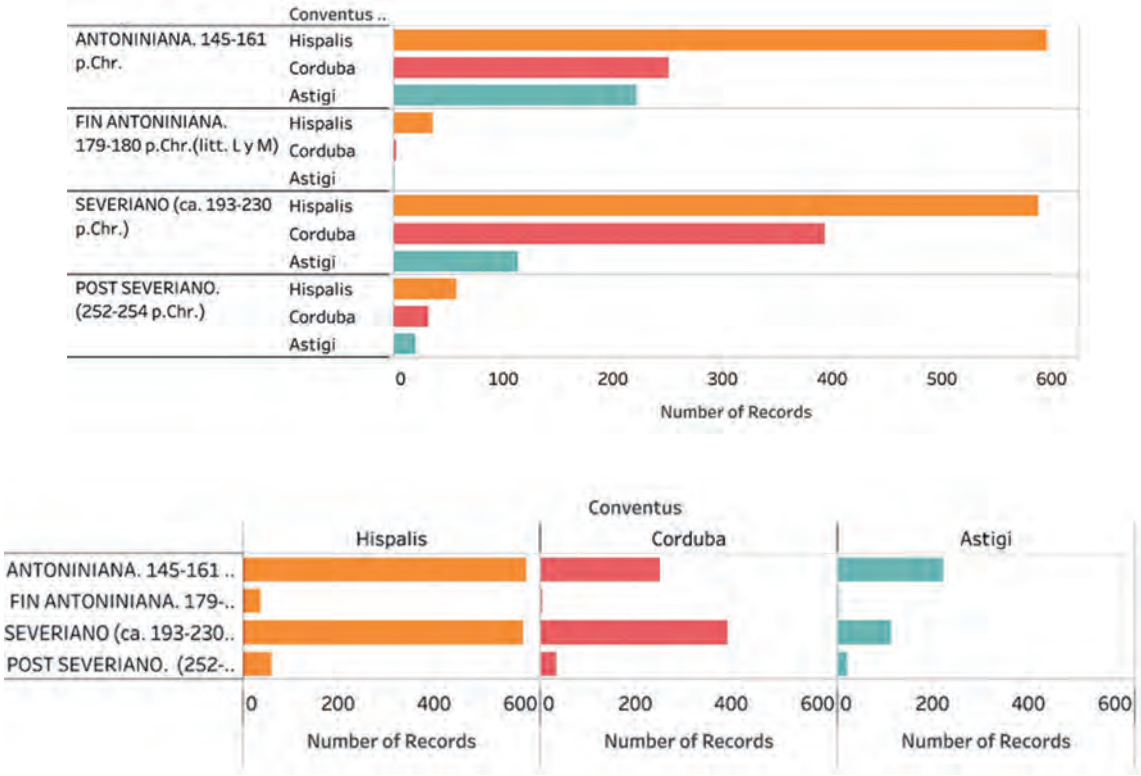


Figura 13. Distribución de los materiales publicados por H. Dressel en el CIL XV sobre el monte Testaccio de acuerdo por lo *conventus* de procedencia en la *Baetica* de los sellos y de los periodos cronológicos relacionados.

Si analizamos el material llegado desde cada conventus podremos conocer la importancia de cada uno de los centros productores de dicho *conventus*. Si observamos los materiales llegados desde el *conventus hispalensis*, podremos observar cuales fueron los lugares desde los que se envió más aceite a Roma (Fig. 17). Dentro de este territorio es el lugar conocido como "La Catria"[18] el lugar desde el que más aceite se envió a Roma. Un análisis de los materiales de "La Catria" permite ver cuales fueron los sellos que llegaron en mayor cantidad (Fig. 18). Sigue en importancia el territorio del municipio Flavio arvense (Fig. 19)[19], comparando ambas figuras podemos ver también la diferencia cronológica de la importancia de cada uno de ellos.

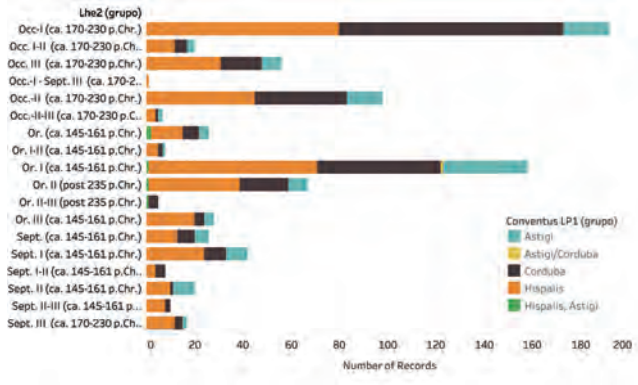


Figura 14. Materiales hallados por H. Dressel sobre la superficie del monte Testaccio según su *conventus* de procedencia en la Baetica.

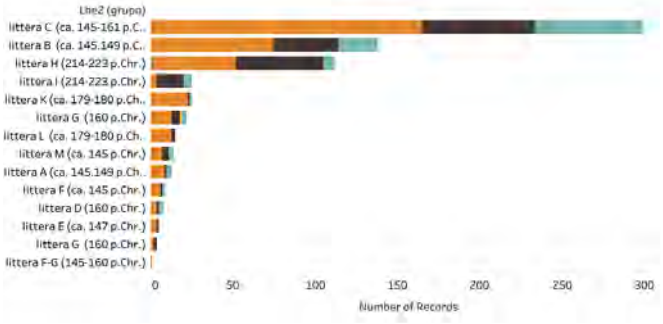


Figura 15. Materiales hallados por H. Dressel en sus sondeos en el monte Testaccio según su *conventus* de procedencia en la *Baetica*. Gráfico ordenado por número de registros.

Pero partiendo de nuestra base de datos CEIPAC podemos preguntarnos como se reflejan la presencia de determinados sellos, muy frecuentes en el Testaccio, en otras regiones del mundo romano. He elegido el caso de los sellos del grupo LFCCV + nombre de *figlinae*, producido en varios lugares de los *conventus astigitanus* y *cordubensis* [20], el sellos PNN de la región del *municipium flavium arvense*[21], ambos de época severiana y el sello SNR de La Catria[22], datado a mediados del s. II d.C. (Fig. 20).

---

[18] REMESAL RODRÍGUEZ, J. 1977/78. PONSICH 1979, 40 nº 75. BERNI MILLET, P. 2008, 318-334.
[19] PONSICH, M. 1974, 155 nº 64. BERNI MILLET, P. 2008, 279-304.
[20] REMESAL RODRÍGUEZ, J. (1989). BAREA BAUTISTA, J.S., BAREA BAUTISTA, J.L., SOLIS SILES, J., MOROS DÍAZ, J. (2008). BERNI MILLET 2008, 414-420, 451-462.
[21] PONSICH, M. (1974), 155 Nº 64.
[22] REMESAL RODRÍGUEZ, J. (1977/78).

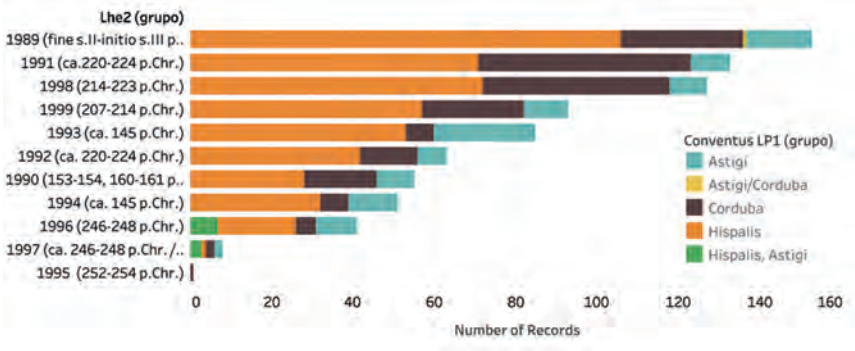


Figura 16. Procedencia de los sellos por *conventus* en la *Baetica* en nuestros sondeos. Gráfico ordenado por número de registros.

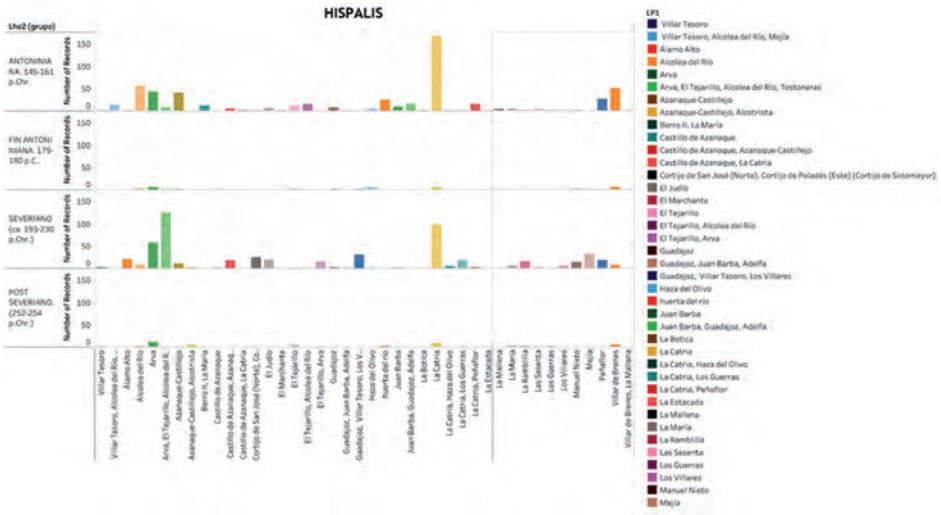


Figura 17. Materiales del monte Testaccio procedentes del *conventus hispalensis* desde la dinastía antonina al periodo post-severiano.

Gracias al proyecto EPnet hemos podido empezar a analizar nuestros datos mediante métodos formales. Un análisis de tipo bayesiano parece demostrar que, debido al gran número de agentes que suponen nuestros sellos (la mayoría de ellos representan a personajes de condición libre mediante la indicación de unos *tria nomina*) podemos hablar de una economía libre de mercado durante el imperio romano[23].

He defendido que el Testaccio es un vertedero especial, exclusivo de ánforas olearias particularmente béticas, porque estaba bajo el control del Estado y que allí llegaban la parte que los ciudadanos del valle del Guadalquivir debían pagar como impuesto en natura, en este caso, de un producto alimentario fundamental en la dieta mediterránea. Producto que, como el grano, fue intervenido por parte del estado romano para abastecer a la plebe de Roma y al ejército[24]. Esto no quiere decir que el estado romano distribuyera gratuitamente este aceite, sino que disponía de lo que hoy llamaríamos una reserva estratégica, que le permitía intervenir en el precio de mercado de este

[23] RUBIO CAMPILLO, X., COTO-SARMIENTO, M. PÉREZ-GONZÁLEZ, J. REMESAL RODRÍGUEZ, J. 2017.

[24] REMESAL RODRÍGUEZ, J. 1986; 1997; 1999; 2002. La idea sobre la *annona urbis* y su función y sobre la *annona militaris* y su organización constituyen hoy día uno de los temas más discutidos a partir de las ideas expuestas en estos y otros trabajos. Noticias sobre esta discusión en REMESAL RODRÍGUEZ, J. 2011, 41-42.

producto en Roma. A los soldados que lo recibían les era descontado el precio de aceite de su salario dentro del concepto "*in victum*"[25] .

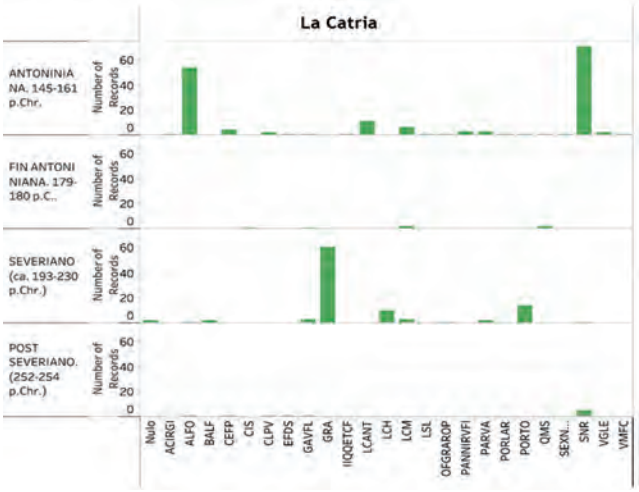


Figura 18. Materiales del monte Testaccio procedentes de La Catria desde la dinastía antonina al periodo post-severiano.

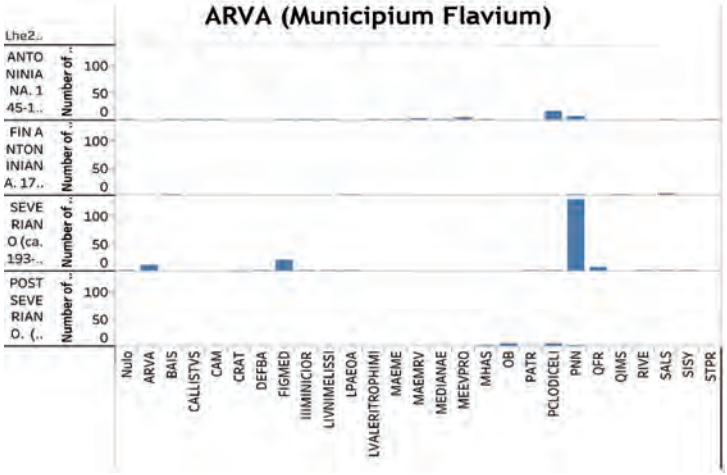


Figura 19. Materiales de Arva (*Municipium Flavium*) en el monte Testaccio desde la dinastía antonina al periodo post-severiano.

Si observamos el número de municipios romanos asentados a las orillas del Guadalquivir en el territorio del *conventus hispalensis* (Fig. 11) podemos observar que hay muchos más municipios que en el territorio de *Corduba* o *Astigi*. Para constituir un municipio hacía falta una cantidad de individuos, en teoría cien, para formar el *ordo decurionum*, que debían tener una fortuna de, al menos, cien mil sestercios. Tal vez esta sea la razón para entender la preponderancia de los materiales del *conventus hispalensis* en el Testaccio.

[25] REMESAL RODRÍGUEZ, J. 1990.

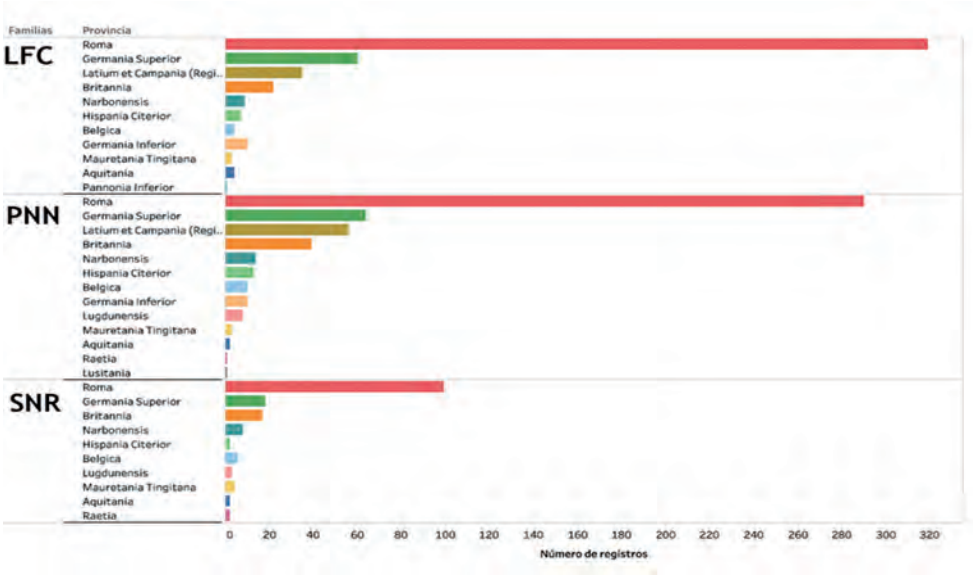


Figura 20. Familia de sellos LFC, PNN y SNR representadas en Roma, así como en las regiones itálicas y el restante de provincias romanas. Fuentes de datos: CEIPAC.

De todos modos, a la base de nuestra discusión está el significado que atribuyamos a los sellos en ánforas Dressel 20. Para muchos, empezando por Dressel, los sellos tria nominales de nuestras ánforas representan el nombre del dueño o gestor de las alfarerías[26]. En mi opinión los sellos tria nominales representan al dueño del aceite envasado en las ánforas, naturalmente, en el momento del envasado, sea el productor del aceite o el acaparador del aceite[27], no hay que olvidar que el aceite es un producto elaborado a partir de un fruto, la aceituna, no todos los propietarios de aceituna, necesariamente, son productores de aceite.

Si se acepta mi propuesta, los sellos pueden ayudarnos a conocer a personajes, sobre todo de ámbito municipal, y algunos casos tenemos identificados con seguridad, como los *Fulvii* del *municipum flavium arvense*[28], o el caso de *Iuventius Albinus* del municipio de Axati y alguno del *ordo senatorio*, si se acepta mi interpretación de los sellos de LFCCV+ nombre de figlina, como el nombre de L(*ucius*) F(*abius*) C(*ilo*) C(*larisimus*) V(*ir*)[29] o del sello IIMVSETPR[30], como miembros de la familia de los Mu(*mmii*) S(*ecundini*), cuyos bienes habrían sido confiscados por Septimio Severo[31].

Si se acepta que los sellos tria nominales indican el productor del ánfora, nada pueden ayudarnos para entender el comercio del aceite, más allá de afirmar que si un sello se ha difundido abundantemente a lo largo del imperio romano, lo único que nos indica es que las ánforas producidas en un determinado lugar se produjeron más abundantemente, lo que significaría una mayor producción

---

[26] LIOU, B., TCHERNIA, A. 1994. Un estado de la cuestión en BERNI MILLET, P. 2008, 23-38.
[27] REMESAL RODRÍGUEZ, J. 1977-78.
[28] REMESAL RODRIGUEZ, J. 1983.
[29] REMESAL RODRÍGUEZ, J. 1989. JACQUES, F. 1990. CHIC GARCÍA, G. 1994. Propuesta discutida por: van der WERFF 1995.
[30] PONSICH, M. 1979, 114 nº 120.
[31] REMESAL RODRÍGUEZ, J. 1996; 2013. REMESAL RODRÍGUEZ, MOROS DÍAZ, J. (en prensa); MOROS DÍAZ, J. 2014. Una interpretación diversa en CHIC GARCÍA, G. 1994a, 107-108.

de aceite en ese lugar, pero no nos dirían nada del propietario del aceite contenido en ellas, Aunque si sobre la organización productiva de la *figlina*.

Si compleja es la definición e interpretación de los sellos de las ánforas del Testaccio, aún más compleja es la interpretación de los *tituli picti* que, casi en exclusividad, se encuentran en el Testaccio. Hay acuerdo en aceptar que los *tituli picti* beta reflejan los nombres de las personas dedicadas al comercio del aceite, de algunos de estos personajes han aparecido inscripciones monumentales que así lo demuestran[32]. Nuestras excavaciones en el Testaccio han ampliado notablemente la lista de estos personajes. Por lo que respecta a los *tituli picti delta* no hay acuerdo en su interpretación, hay acuerdo en la interpretación de algunos elementos: la indicación del distrito fiscal del que procede el ánfora, la certificación del contenido neto del ánfora y en la aparición de la datación consular, lo que permite datar nuestros documentos de forma absoluta y segura y, en consecuencia los sellos que aparecen en el mismo estrato, que se pueden convertir en un útil fósil director para datar estratos en infinidad de excavaciones en todo el espacio europeo ocupado por los romanos. No hay acuerdo en la interpretación de otros elementos como son los nombres de lugar, los nombres al genitivo o nominativo que aparecen en estos *títuli*, para unos se refieren a la finca de donde procede el aceite y el nombre del propietario de dicha finca[33]. En mi opinión hacen referencia a los personajes que intervienen en el control del ánfora y certifican el origen y la cantidad de aceite contenido[34].

En conclusión, gracias al Testaccio y a la documentación recogida en la base de datos CEIPAC, tenemos a nuestra disposición una gran cantidad de documentos seriales, algunos de los cuales podemos fechar con absoluta precisión, circunstancia rara en los estudios del mundo antiguo. La aplicación de nuevas técnicas de análisis formales y la migración de nuestra base de datos a un sistema ontológico, trabajos iniciados gracias al proyecto EPnet[35] nos ayudará a entender mejor el sistema y las relaciones que podemos establecer entre la economía, la política y la administración del imperio romano, por ejemplo, una larga controversia sobre el camino de acceso del material bético a Germania y Britannia, si por la ruta del Ródano o por la vía atlántica, ha quedado zanjada gracias a la aplicación de estos métodos formales[36].

Bibliografía

AGUILERA MARTÍN, A. (2000), Los *tituli picti delta* del convento astigitano en el primer tercio del s. III d.C. *Congreso Internacional Ex Baetica Amphorae. Conservas, aceite y vino de la Bética en el Imperio Romano (Écija y Sevilla, 17al 20 de Diciembre de 1998)*. Écija, 1231-1240.

AGUILERA MARTÍN, A. (2002), *El monte Testaccio y la llanura subaventina. Topografía* extra portam Trigerminam. Roma.

AGUILERA MARTÍN, A. (2004), Sistematización de los *tituli picti* anfóricos para la base de datos CEIPAC. En: J. REMESAL RODRÍGUEZ (Ed.), *Epigrafía anfórica*. (Instrumenta 17) Barcelona, 105-126.

---

[32] Una visión de conjunto de estos materiales, con la bibliografía en REMESAL RODRÍGUEZ, J. 2004.

[33] LIOU, B. , TCHERNIA, A. 1994.

[34] REMESAL RODRÍGUEZ, J. 1983; 2000. AGUILERA MARTÍN, A. 2000; 2002; 2004; 2007; 2012. REMESAL RODRÍGUEZ, J., BERNI MILLET, P., AGUILERA MARTÍN, A.2008. Y los capítulos dedicados al estudio de los *tituli picti* realizados por J. Remesal Rodríguez y A. Aguilera Martín en los volúmenes de nuestras excavaciones en el Testaccio: BLÁZQUEZ MARTÍNEZ, J.Mª. , REMESAL RODRIGUEZ, J. (Eds.) 1999, 2001, 2003, 2007, 2010, 2014.

[35] REMESAL RODRÍGUEZ, J., DÍAZ-GILERA, A., RONDELLI, B. RUBIO-CAMPILLO, X. AGUILERA MARTÍN, A., MARTÍN-ARROYO, d. MOSCA, A. RULL, G. 2015.

[36] REMESAL RODRÍGUEZ, J. (Ed.) 2018. RUBIO-CAMPILLO, X., MONTANIER, J-M., RULL, G., BERMUDEZ LORENZO, J-M. , MOROS DÍAZ. J. , PÉREZ GONZÁLEZ, J. , REMESAL RODRÍGUEZ, J. 2018.

AGUILERA MARTÍN, A. (2007), Evolución de los *tituli picti delta* de las ánforas Dressel 20 entre mediados del siglo I y mediados del s. III. *Acta XII Congressus Internationalis Epigraphiae Graecae et latinae (Barcelona 3-8 Septembris 2002)*. Barcelona, 15-22.

AGUILERA MARTÍN, A. (2012), La normalisation de l'epigraphie amphorique: les *tituli picti* des amphores Dressel 20. En : M.E. FUCHS, R. SYLVESTRE, C.S. HEIDENREICH (dir.) *Inscriptions mineures: nouveautes et reflexions. Actes du premier colloque Ductus (19-20 juin 2008)* Bern, 135-143.

BERNI MILLET, P. (1999), " La piel" del Monte Testaccio. Un estudio sobre la primera prospección sistemática de Dressel. En: BLÁZQUEZ MARTÍNEZ, J.Mª, REMESAL RODRÍGUEZ, J. (Eds.) (1999), *Estudios sobre el monte Testaccio (Roma)* I. Barcelona, 205-273.

BERNI MILLET, P. (2008), *Epigrafía anfórica de la Bética. Nuevas formas de análisis*. Barcelona.

BAREA BAUTISTA, J.S., BAREA BAUTISTA, J.L., SOLIS SILES, J., MOROS DÍAZ, J. (2008), *Figlina Scalensia. Un centro productor de ánforas Dressel 20 de la Bética* (Instrumenta 27). Barcelona.

BLÁZQUEZ MARTÍNEZ, J.Mª. , REMESAL RODRIGUEZ, J., RODRÍGUEZ ALMEIDA, E. (1994), *Excavaciones arqueológicas en el monte Testaccio (Roma)*. Madrid.

BLÁZQUEZ MARTÍNEZ, J.Mª, REMESAL RODRÍGUEZ, J. (Eds.) (1999, 2001, 2003, 2007, 2010, 2014), *Estudios sobre el monte Testaccio (Roma)* I-VI. Barcelona.

CHIC GARCÍA, G. (1994), Los centros productores de las ánforas con marcas de L.F.C. *Hispania Antiqva* 28, 171-233.

CHIC GARCÍA, G. (1994a), Economía y sociedad en la Bética alto imperial. El Testimonio de la epigrafía anfórica. Algunas notas. En: GONZÁLEZ ROMÁN, C., *La sociedad de la Bética. Contribuciones para su estudio.* Granada. 75-122.

DRESSEL, H. (1878), Ricerche sul Monte Testaccio. *Annali dell'Instituto di corrispondenza Archeologica,* 118-192.

ETIENNE R. (1949). Les amphores du Testaccio au III siècle. *MEFRA* 41, 152-181.

HERON DE VILLEFOSSE, A. (1914), Deux armateurs narbonnais. *Sextus Fadius Secundus Musa et P. Olitus Apolonius. Mémoires de la Société des Antiquaires de France*, 153-180.

JACQUES, F. (1990), Un exemple de concentration foncière en Bétique d'après le témoignage des timbres amphoriques d'une famille clarissime. *MEFRA* 102, 865-899.

LIOU, B., TCHERNIA, A. (1994), L'interprétation des inscriptions sur les amphores Dressel 20. En: *Epigrafia della produzione e della distribuzione. Actes de la VIIe Rencontre franco-italienne sur l'epigraphie du monde romain. Rome 5-6 juin 1992*. Rome, 133-156.

MOROS DÍAZ, J. (2014), La intervención severiana en la producción de aceite bético. En: BLÁZQUEZ MARTÍNEZ, J.Mª. , REMESAL RODRIGUEZ, J. (Eds.), *Estudios sobre el monte Testaccio* (Roma) VI (Instrumenta 47) Barcelona, 773-860.

PONSICH, M. (1974), *Implantation rurale antique sur le Bas-Guadalquivir* I. Madrid.

PONSICH, M. (1979), *Implantation rurale antique sur le Bas-Guadalquivir* II. Paris.

PONSICH, M. (1991), *Implantation rurale antique sur le Bas-Guadalquivir* IV. Madrid.

REMESAL RODRIGUEZ, J. (1977/78), La economía oleícola bética. Nuevas formas de análisis. *AEspA* 50/51, 87-142.

REMESAL RODRIGUEZ, J. (1983), Ölproduktion und Ölhandel in der Baetica: Ein Beispiel für die Verbindung archäologischer und historicher Forschung. *MBAH* 2/2, 91-111.

REMESAL RODRIGUEZ, J. (1986), *La annona militaris y la exportación del aceite bético a Germania*. Madrid.

REMESAL RODRIGUEZ, J. (1989), Tres nuevos centros productores de ánforas Dressel 20 y 23. los sellos de *L. Fabius Cilo*. *Ariadna* 6, 119-153.

REMESAL RODRIGUEZ, J. (1990), Die procuratores Augusti und die Versorgung des römischen

Heeres. *Akten des 14. Internationalen Limeskongresses 1986 in Carnuntum*. Wien, 55-65.
REMESAL RODRIGUEZ, J. (1994), Los sellos en ánforas Dr. 20. Nuevas aportaciones del Testaccio. En: *Epigrafia della produzione e della distribuzione. Actes de la VIIe rencontre franco-italienne sur l'épigraphie du monde romain*. Rome, 93-110.
REMESAL RODRIGUEZ, J. (1996), *Mummius Secundinus. El Kalendarium vegetianum* y las confiscaciones de Severo en la Bética (HA. Severus 12-13). Gerión 14, 195-221.
REMESAL RODRIGUEZ, J. (1997), *Heeresversorgung und die wirtschaftlichen Beziehungen zwischen der Baetica und Germanien. Materialen zu einem Corpus der in Deutschland veröffentlichten Stempel auf Amphoren der Form Dressel* 20. Stuttgart.
REMESAL RODRIGUEZ, J. (1999), Politica e regimi alimentari nel principato di Augusto. En Vera, D. (a cura di), *Demografia, sistemi agrari, regimi alimentari nel Mondo Antico. Atti del Convegno Internazionale di Studi (Parma 17-19 ottobre 1997)*, 247-271.
REMESAL RODRIGUEZ, J. (2000), *L. Marius Phoebus mercator olei ex provincia Baetica*. Consideraciones en torno a los términos *mercator, negotiator y diffusor olearius ex Baetica*. En: Paci, G. (Ed.) *Epigraphai. Miscellanea Epigrafica in onore di Lidio Gasperini*. Roma, 781-797.
REMESAL RODRÍGUEZ, J. (2002), Military supply during Wartime. En: DE BLOIS, L. , RICH, J. (Eds.), *The Transformation of economic Life under the Roman Empire*. Amsterdam, 77-92.
REMESAL RODRIGUEZ, J. (2004), Promoción social en el mundo romano a través del comercio. En: F. Marco Simón, F. Pina Polo, J. Remesal Rodríguez (Eds.), *Vivir en tierra extraña: emigración e integración cultural en el mundo antiguo*. Barcelona, 125-136.
REMESAL RODRIGUEZ, J. (2011), *La Bética en el concierto del Imperio Romano*. Madrid.
REMESAL RODRIGUEZ, J. (2012-2013), El monte Testaccio de vertedero a archivo. *Atti della Pontificia Accademia romana di Archeologia (Serie III). Rendiconti, volume LXXXV. Anno Accademico 2012-2013*. Roma, 111-128.
REMESAL RODRIGUEZ, J. (2013), Nuevos datos sobre las confiscaciones de Septimio Severo en la Bética. En: J. LÓPEZ VILLAR (Ed.), *Tarraco bienal. 1er Congrés Internacional d'Arqueologia i Món Antic. Homenatge a Géza Alföldy. Tarragona 29-30 de Novembre i 1 de Desembre. Tarragona*. Tarragona, 233-245.
REMESAL RODRIGUEZ, J. (2016), Sellar para qué. En: BUORA, M., MAGNANI, S. (a cura di), *Le iscrizioni con funzione didascalico-esplicativa. Commitente, destinatario, contenuto e descrizione dell'oggetto nell'Instrumentum Inscriptum. Atti del VI incontro instrumenta inscripta. Aquileia (26-28 marzo 2015)*. Trieste, 73-90.
REMESAL RODRIGUEZ, J., BERNI MILLET, P., AGUILERA MARTÍN, A. (2008), Amphoreninschriften und ihre elektronische Bearbeitung. En: HAINZMANN, M. WEDENIG, R. (Hrsg.) *Instrumenta inscripta Latina II. Akten des 2. Internationalen Kolloquiums Klagenfurt, 5-8 Mai 2005*. Klagenfurt, 247-264.
REMESAL RODRÍGUEZ, J., DÍAZ-GILERA, A., RONDELLI, B. RUBIO-CAMPILLO, X. AGUILERA MARTÍN, A., MARTÍN-ARROYO, d. MOSCA, A. RULL, G. (2015), *The EPNet Project. Production and distribution of food during the Roman Empire: economics and political dynamics. Information Technologies for Epigraphy and Cultural Heritage*. Proceedings of the First EAGLE International Conference. Europeana Eagle project. Convegni, Studi umanistici-Antichistica. Roma, 455-464.
RODRÍGUEZ ALMEIDA, E.(1984), *Il Monte Testaccio: ambiente, storia, materiali*. Roma.
RUBIO CAMPILLO, x., COTO-SARMIENTO, M. PÉREZ-GONZÁLEZ, J. REMESAL RODRÍGUEZ, J. (2017), Bayesian analysis and free market trade within the Roman Empire. *Antiquity*, 91(359),1241-1252.
RUBIO-CAMPILLO, X., MONTANIER, J-M., RULL, G., BERMUDEZ LORENZO, J-M. , MOROS DÍAZ. J. , PÉREZ GONZÁLEZ, J. , REMESAL RODRÍGUEZ, J. (2018), The ecology of Roman trade. Reconstructing provincial connectivity with similarity measures. *Journal of Archaeological Science*. 92, 37-47.

Moving food supplies to the Roman garrison of the Dobrogea

Stephen R Matthews
Royal Holloway University of London

This paper aims to illustrate a method of modelling the transport requirements necessary to move grain to feed the Roman army. The study region is the Dobrogea, that part of the Roman province of Lower Moesia where the Danube turns north and then east to complete its journey to the sea. This is a compact area where settlement activity is thought to have been encouraged in antiquity to provide food to feed the army.[1] The size of the garrison is reasonably well understood and quantifiable, and so therefore are their food requirements – the grain element of which can be represented as a quantity of arable land. For Romania there is a national database of archaeological sites – cIMeC – which is openly available, so that a survey of Roman period sites can be made starting from a single resource. This allows one to suggest an agricultural potential for the region in antiquity. With a quantifiable need and a quantifiable suggested solution it is possible to calculate how many vehicles of different types would have been required to move this arable produce. The road network of the region is also well understood and known to be extensive. As a result the routes by which a particular quantity of arable produce may have travelled to the garrison were many and various, and the possible permutations of transport solutions countless. However, by the use of the Service Area function within ArcGIS it is possible to arrive at suggestions of the most effective routes by which a particular fort was supplied. When moving any commodity by wagon or pack animal, some part of the cargo space must be given over to feed-barley for the animals. This reduces the effective cargo capacity of the vehicle by an increasing amount for every day travelled. If dealing with a finite local arable potential, the need for feed-barley also denudes the quantity of arable available to provide food for the garrison. By calculating the additional arable penalties that different transport methods brought with

[1] POULTER 1980: 729-744

them it is possible to measure the relative merits of slower oxen-drawn vehicles requiring less feed-barley, against faster mule-drawn vehicles requiring more feed-barley. The models proposed ought to show efficient methods which, although calculated with a computer tool, ought to reflect those used in antiquity, assuming that the Roman garrison and their suppliers strove for some level of efficiency.

The Roman garrison for the Dobrogea was derived from *diplomata*, to comprise nominally 12,827 men and 1738 horse.[2] The military ration was derived from Polybius who gives a daily bread-wheat ration for troops of two-thirds of an attic *medimnus*, a month. It is thought that Polybius was using a Greek equivalence to a Roman measure of two *sextarii* a day, which depending on the specific density of the grain is equivalent to 0.809kg of bread-wheat.[3] Polybius' figures for cavalry barley are not so straightforward; he reports a monthly ration of seven Attic *medimni* for a legionary cavalryman and five Attic *medimni* for an auxiliary cavalryman. These are quite significant quantities 235-168kg a month and it is thought that they were sufficient for remounts and/or, a pack animal. Dividing the legionary figure by three and the auxiliary figure by two, a single animal more probably consumed 2.5kg of feed-barley a day; a figure which is broadly corroborated by both an Egyptian papyrus and a writing tablet from Carlisle.[4] Mules employed as draft or pack animals needed less feed-barley than horses, a figure of 2kg a day was used. Green fodder, hay or other fodder crops, or simple pasture would have also been required. For simplicity of argument it is assumed that animals grazed pasture daily from the fields and these needs are not included in my calculations.[5] Oxen require far less feed-barley than green fodder, indeed if not working hard they can survive by just grazing, but I assumed they consumed 2.25kg of feed-barley a day. The military would have had civilian service providers attendant on them. Their number is difficult to be gauge: if they made up 20% of the general population for the region, which is in itself derived from a very broad brush estimate of 8 persons per km^2, then that would equal 13,920 service providers. I further assume they ate 70% as much bread-wheat as the soldiers. All of these numbers can be questioned; but what they do is allow me to suggest an annual arable need associated with the army of nominally 21,326ha. The farm workers that produced this food would have also needed to feed themselves, but because they would have eaten at source, for the purpose of the transport calculations their needs are excluded.

Against this need I have previously considered the study area to arrive at a quantified arable product in the region.[6] This was done with reference to the Romanian national database of sites – cIMeC – which aims to record every known archaeological site in the region. This has to be treated with caution, the criteria by which a site is added, and in particular the scale or status of that site is not always apparent, additionally the dating, whether a site was Roman or later Roman is often open to interpretation. Nevertheless it was used as a baseline against published works, especially Bărbulescu's archaeological survey of the region and Suceveanu's work.[7] One can quibble about the classification of particular sites, the scale of arable associated with these sites, the agricultural regimes employed, whether land was fallowed or crop-rotation practised and the potential crop yields; but, ultimately some arable potential is evident in the landscape. In large part this appears to have been provided by 46 *vici* in the region that were established with the arrival of the garrison.[8] I have

---

[2] RMD 399 (= RMD 165) AD 145, ROXAN 1994: 286-7; HOLDER 2006: 813 , RMD 50 AD 157, ROXAN 1978: 72-3

[3] Polybius 6.39; Pliny *NH* 18.66 for a specific density of Chersonesus bread wheat of 75kg/hl; FOXHALL & FORBES 1982: 62; ROTH 1999: 18-19

[4] *P Amh*. 2.107; *Tab. Luguval.* 1; TOMLIN 1998: 45, 48-49; ADAMS 1999: 120-121; ROTH 1999: 63-6 4; *cf* ENGELS 1980: 18, 126 who suggests 5.5kg a day

[5] GOLDSWORTHY 1996: 295; ROTH 1999: 61-67

[6] MATTHEWS 2015: 839-844

[7] SUCEVEANU 1991; BĂRBULESCU 2001

[8] POULTER 1980: 729-744

calculated that 16,283ha of arable potential is visible in the archaeological record and available to the garrison: 76.35% of the garrison's and their service providers' needs with a deficit initially of 23.65% which would have been required to be supplied from elsewhere.

The capacity of individual wagons and carts was of course various. The pictorial record from Trajan's and Marcus Aurelius' columns and the *Tropaeum Traiani* monument, all offer images of vehicles at work pulled by both mules and oxen but cargo capacities are not discernable.[9] A Vindolanda text does record wagons carrying 53-63 *modii*, 343-407kg of grain each; other texts show that resupply by wagons of unspecified capacity to Vindolanda was commonplace.[10] The Theodosian Code set maximum loads of 200 Roman lbs, 65kg for a two-wheeled vehicle, a *plaustrum*, 600 Roman lbs, 194kg for a cart, a *carrus*, 1000 Roman lbs, 323kg for a wagon, a *rheda*, and 1500 Roman, lbs, 485kg for heavy wagon, an *angaria*.[11] So within official parlance considerable variation was acknowledged and this must have been even more so in real life. More recently in colonial British India oxen-drawn wagons frequently carried 800 Imperial lbs, 363kg.[12] Because the Vindolanda text, the Theodosian Code and the colonial record all have figures in the region of 350kg cargo capacity this is the figure I used initially for modelling, accepting that one size does not, in reality, fit all. Trajan's Column also shows several instances of pack animals at work.[13] Diocletian's price edict gives a price for a 300 Roman lb, 97kg load for a mule.[14] Another later Roman reference from Cassiodorus suggests only 100 Roman lbs, 32.6kg, for a pack-horse.[15] The last seems very low, even though mules are more sure footed than horses and sturdier. Modern commentators suggest a range of figures for mules; I adopted a mid-range figure of 70kg load per animal.[16] With regard to speeds the ancient literary evidence is not forthcoming. Early 20th Century military manuals suggest that oxen should work for 7-8 hours a day at 3.2-4kph equating to 23-32km a day, this allowed them 6-7 hours to graze before and after working.[17] Mules were faster 50km a day is conceivable.[18] The Theodosian Code also reports that eight mules were required to pull a wagon of 1000 Roman lbs, 323kg, a large number in comparison to the two oxen required to move the same sort of load, but that was the number that I initially modelled on.[19] From all of this I pursued four modes of transport: oxen-drawn wagons moving at 23km a day, oxen-drawn wagons moving at 32km a day, mule-drawn wagons moving at

---

[9] Trajan's column: LEPPER & FRERE 1998 Scenes: xxxviii, xlix , lxi-lxii, cvi-cvii; Marcus Aurelius' column: COARELLI 2008, Scenes xxv, xxvi, xxviii, xxxviii, xxxix, lxxxv, xcii, cxi; Tropaeum Traiani monument: TOCILESCU 1895: 48, 61-62; FLORESCU 1962: 469, 476-477

[10] *TV* 3.649, 3.583-584

[11] *CTh* 8.5.8, 8.5.17, 8.5.28, 8.5.30, 8.5.47; TILBURG 2007: 54, 60

[12] GOLDSWORTHY 1998: 293

[13] LEPPER & FRERE 1988, Scenes xv, cvi, cx, cxxxviii

[14] Diocletian's Price Edict 14.11; ROTH 1999: 206

[15] Cassiodorus *Variae* 4.47; TILBURG 2007 60

[16] WOLSELEY 1871: 36-37; WHITE 1970: 300; ENGELS 1980: 14; *Animal Management* HMSO 1908 cited by GOLDSWORTHY 1998: 293; ROTH 1999 78; RAEPSAET 2002: 69; TILBURG 2007: 72

[17] *Animal Management* HMSO 1908 cited by GOLDSWORTHY 1998; 293; ENGELS 1980: 15

[18] *Animal Management* HMSO 1908 cited by GOLDSWORTHY 1998: 293; US Army *Manual of Pack Transportation* 1917cited by ROTH 1999: 206

[19] *CTh* 8.5.8

50km a day – in all these cases the load was assumed as 350kg and finally mule-trains of eight animals carrying 70kg each, so 560kg load, again travelling at 50km a day.

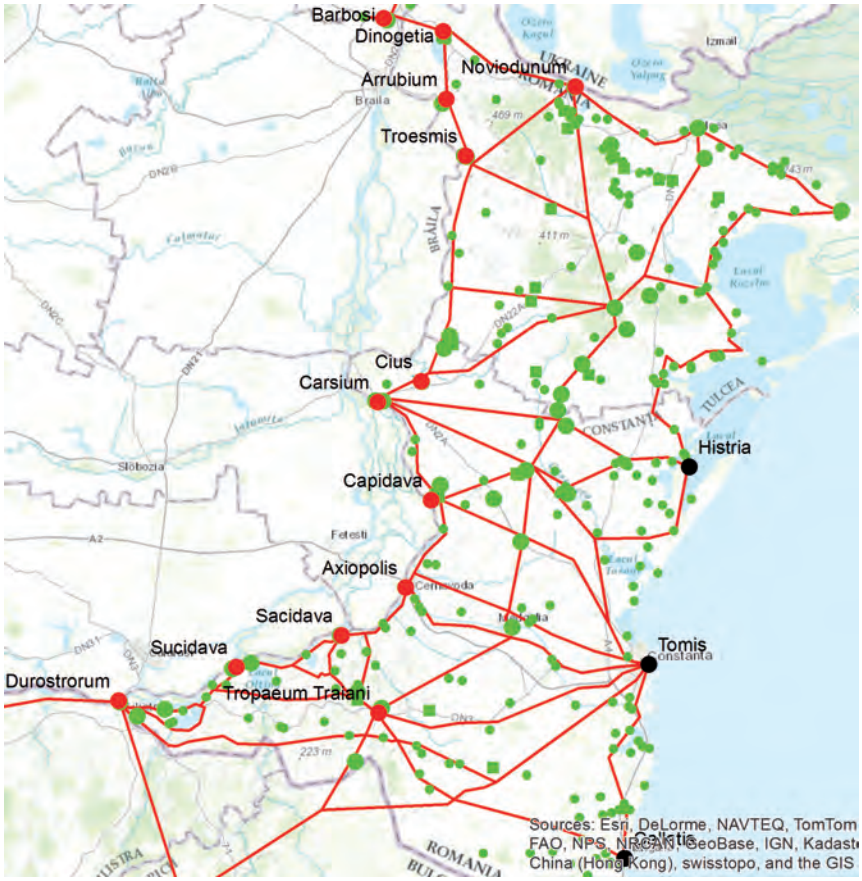


Figure 1. The Roman road network in the Dobrogea.

The road network of the Dobrogea is well understood. Dr Adriana Panaite is the leading figure in this field today.[20] Her work has been augmented by a collection of aerial images of the south of the region collected by Dr Ioana Oltean.[21] The road layout is displayed on Fig 1 alongside the military forts and producer sites. Because the road network was so well-developed, there were countless permutations by which a particular parcel of arable product could have moved to a particular consumer fort. It is because of this that the Service Area function of ArcGIS was employed. This is used by modern delivery companies to work out the most efficient routes for their drivers. The program produces irregular polygons according to the lie of the road network, which give a pictorial representation of the area best placed to serve a particular site within a selected timespan. These represent in effect the catchment areas of a particular consumer. The system was interrogated to produce service areas at 23km and 32km to represent a day's travelling by oxen at different speeds and at 50km for mule-drawn wagons and mule-trains. ArcGIS allows one to choose any distance

[20] PANAITE 2010, 2011, 2012, 2015

[21] OLTEAN 2013; Dr Oltean kindly provided shapefiles of these roads for use within ArcGIS

for a service area, so that the daily speeds used here can be easily adjusted if one wishes to examine different transport possibilities.

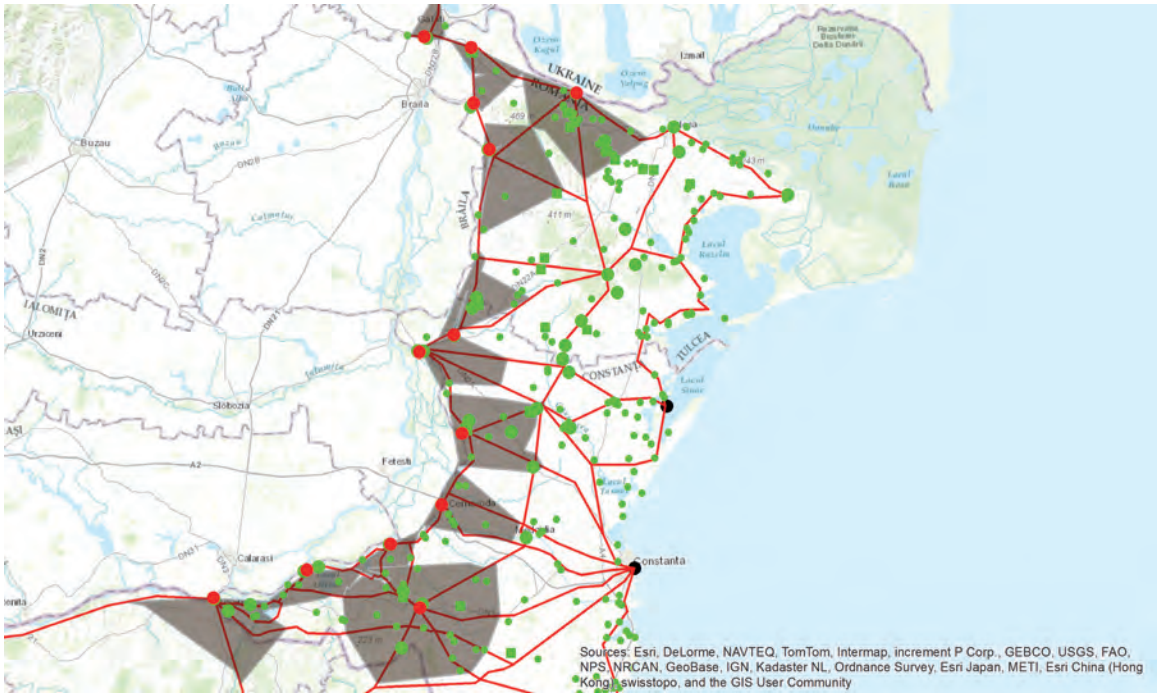


Figure 2. 23km Service Areas One day

The polygons in Fig 2 thus represent the area that could have been travelled by an oxen-drawn wagon travelling at 23km a day. Having produced an image such as this it was possible to count the number and type of sites within each polygon and apportion the arable visible to the fort from which the polygon was produced. If the needs of a particular fort were met then surpluses were directed to the next nearest fort. This was repeated at two to five days' travel; polygons were only produced for those forts where a deficit remained after each day's travel. Fig 3 shows 23km Service areas produced for one to five days travel. The process was continued for each of the four modes of transport.

Although I can make no claim to certainty that arable produce from a particular farm site went to a particular fort, and although these decisions were made by a computer program, what I can say is that the Service Areas represent the most efficient catchment areas to provide for the garrison. With practice and experience the suppliers to the military would have attempted to provide food using the fewest number of vehicles and so incur the lowest transport cost. As an aside, in the south and centre of the region at least, the distribution of sites was not unreasonably seen to be denser close to the consumer garrison, so that the *limes* ought to be thought of as a sort of linear central place, adhering to von-Thünen's central place theory.

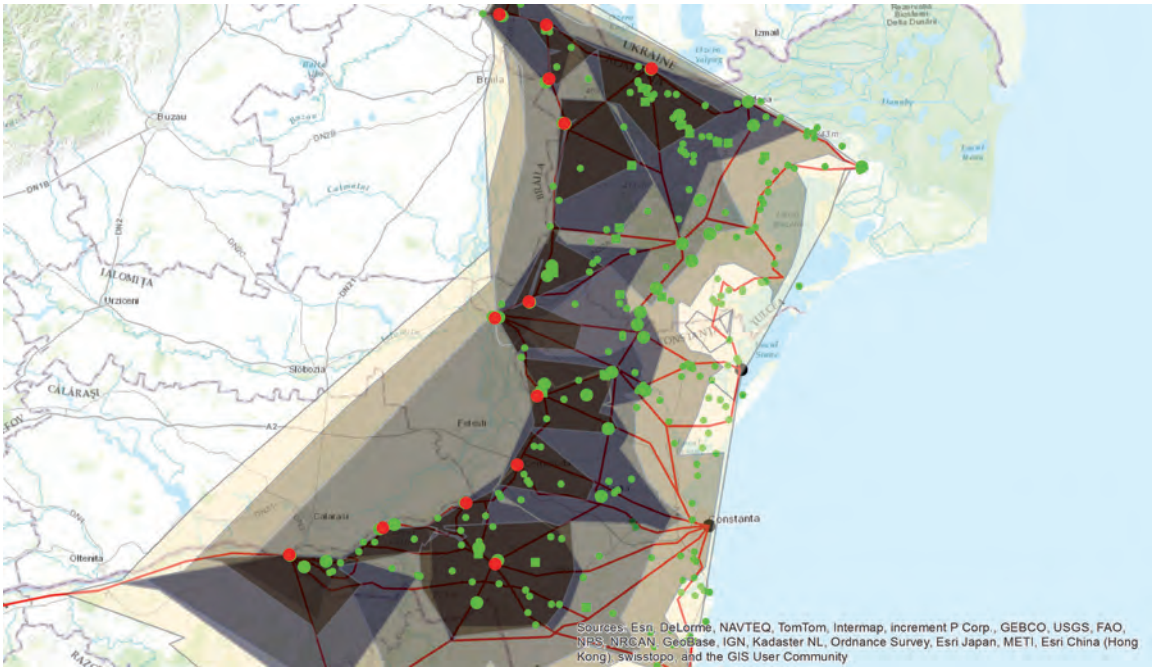


Figure. 3 23km Service areas One-Five days

When it came to calculating the transport needs, the quantity of arable visible in a particular service area could be multiplied by a yield to arrive at a load in kg. This in turn could be divided by a cargo capacity of a vehicle, in my case 350kg for a wagon and 560kg for a mule-train of eight animals, to arrive at a number of wagon or mule-train loads. Even assuming that they grazed their green fodder directly from the fields, the animals pulling these loads would have required feed-barley, which would have also had to be carried by the vehicle itself. The number of vehicle loads initially calculated had to be multiplied by the quantity of feed-barley required per travelling day, in my calculations accounting for a return journey: 9kg for two oxen and 32kg for eight mules. This was then divided by a suggested yield to arrive at a quantity of land that would have been required to be turned to feed-barley. This was deducted from the arable available within a particular Service Area, so that I arrived at two quantities of arable: one to provide bread-wheat to the garrison and another to provide feed-barley for the animals moving that food. Unfortunately, because of different suggested yields for wheat and barley, when the necessary arable to produce feed-barley was deducted from the total arable potential seen, then because less land was required for a given weight of barley than wheat, so a greater weight of arable produce could have been produced from the land than had been first estimated. This produced a higher overall cargo which required more wagons which in turn would require more feed-barley than initially estimated. These positive errors were resolved by repetitive calculations, where revised estimates of wagon numbers with increased feed requirements were carried out that slightly reduced the available wheat to the garrison with each iteration. The errors diminished so that after two or three such calculations, they became negligible. The calculations were carried out using formulae within Excel. Each calculation had to be repeated for each Service Area and every travelling day, the whole acting in effect like a simple algorithm. With each travelling day the amount of cargo space given over to feed-barley increased and so the effective cargo capacity of a vehicle was reduced.

The end result was that it was possible to build tabular models of which arable was moving to which fort over several travelling days, for each different mode of transport: oxen-drawn wagons moving at 23km and 32km a day, mule-drawn wagons moving at 50km a day and mule-trains moving at 50km a day. The total number of loads was multiplied by the total number of travelling days to arrive at a number of wagon or mule-train days which was then divided by a 300 day working year to arrive at a suggested number of vehicles required *per annum*. There had according to my assessment of the arable available in the region originally been a 23.65% deficit – the part of the garrison's needs not available locally. The size of this deficit now changed according to the transport method used, because of the differing quantity of the local arable required to be used as feed-barley for the transport animals. It was therefore possible to see the effect of each transport method on both the deficit and the quantity of vehicles required. Table 1 below shows that the faster moving 32km a day oxen-drawn wagons would have incurred the smallest increase in arable needs, and so the smallest increase in the size of the deficit. Mule-trains because they could carry more cargo required the lowest number of vehicles. Although the models assume mule-trains of eight animals, eight single mules owned and operated by eight individual farmers would have been equally effective, and this may have been cheaper and easier for the farmers than keeping oxen. However, oxen are better plough animals than mules so that without a fuller understanding of farming practices it is difficult to say which of these two would have been preferred. The slower oxen moving at 23km a day did not require much more arable or many more vehicles than the faster oxen, and were so considered still viable. Yet mule-drawn wagons, if using eight mules as the Theodosian Code recommended, would have required more than twice as much arable for feed-barley, for only a 23-34% reduction in vehicle numbers and were therefore least effective. The use of mule-drawn wagons on Trajan's column can be explained as a tactical imperative, they should have been the least preferred transport method in a garrison context. In all cases the total number of vehicles required *per annum* is thought to be very low for a garrison of nearly 13,000 men.

Table 1. Comparison of transport methods

Model	**% increase in overall needs for feed**	**% deficit of original needs**	**Vehicles *pa***
23km oxen-drawn wagons	+ 3.58%	- 27.23%	223
32km oxen-drawn wagons	+ 3.07%	- 26.71%	191
50km mule-drawn wagons	+ 8.44%	- 32.09%	148
50km mule-trains	+ 5.33%	- 28.98%	94

Up to this point I have only considered the local component, beyond which there was also the movement of the deficit to consider, which must have come from overseas. For the Dobrogea, Tauric Chersonesus and the Bosporan Kingdom which were famed as grain producing lands in antiquity, seem the most likely providers. The region supplied Athens in the 5th Century BC and continued

to pay tribute in grain to Mithridates in the 1st Century BC.[22] Anatolia has also been suggested as a supplier.[23] Irrespective of the source, there would have been a cost to moving grain across water, which is not the purpose of this discussion. Once the deficit arrived in the Dobrogea, there would have also been an additional transport cost. Ports are known at the Black Sea *poleis* of Histria, Tomis and Callatis, together with the naval station of *Noviodunum*, some 80km up river from the mouth of the Danube. Here a granary is known connected with the legionary garrison at Troesmis 30km distant.[24] The size of ship that could have travelled this far up river would have been limited by the depth of the channel.[25] Modelling was carried out to move the deficit from the nearest port to each particular fort where it was felt. The deficit was expressed as a weight and this weight was divided by wagon or mule-train capacity, less the quantity of feed required which would increase according to travelling day, to arrive at a number of wagon days. Again these wagon days were divided by 300 to arrive at a number of vehicles required at work *per annum*. At the same time the overall needs were increased further by the quantity of arable required for feed-barley to move the overseas component. This feed-barley for the overseas component was in the first instance assumed to have come from overseas also and not to have denuded the local arable further. An alternative assessment was carried out whereby the feed-barley to move the overseas component was provided from within the Dobrogea. This required several iterations of the calculations again, because if local arable were used to feed the animals moving the overseas component, this would have depleted the quantity of arable available to feed the garrison. As a result the deficit would have increased and more arable produce would have been needed from overseas. It was seen that in absolute terms the increase in the total quantity of grain required was only slightly higher if the feed-barley were supplied locally. However, if local arable were feeding the transport animals then more grain for the soldiers would have had to come from overseas which does not make military sense: soldiers ought to have been fed in preference to animals. Therefore in the tables below, it is the deficit, that part no longer available locally, that is critical, not the increase in needs *per se*. For comparison this deficit is measured in every case against the original needs. Table 2 shows that if local feed-barley was used to move the overseas component, the deficit of the garrison's original needs was higher in every case. This was most marked in the mule-drawn models because they required more feed than oxen. Therefore, if the garrison were supplied with grain from overseas, then the feed-barley to move that grain ought to have also come from overseas, so as not to denude the local arable available to the garrison.

Table 2. deficits and transport needs (via *Noviodunum* in the north)

Model	**% increase in overall needs for feed**	**% deficit of original needs**	**Vehicles *pa***
If feed-barley provided from overseas			
23km oxen-drawn wagons	+ 5.18%	-27.23%	323
32km oxen-drawn wagons	+ 4.17%	-26.71%	260

[22] Isoc 17.57; Syll[3] 206; Dem 20.31–33; App Mith 69; Strabo 7.4.4; GARNSEY 1988: 124; MORENO 2006: 189, 206-208

[23] MITCHELL 1993: 250

[24] LOCKYEAR *et al* 2011: 47

[25] It is 7mtr deep today, but that is the result of dredging

50km mule-drawn wagons	+ 12.59%	-32.09%	221
50km mule-trains	+7.55%	-28.98%	132
If feed-barley provided locally			
23km oxen-drawn wagons	+ 5.28%	-28.93%	330
32km oxen-drawn wagons	+ 4.21%	-27.86%	263
50km mule-drawn wagons	+ 12.97%	-36.62%	228
50km mule-trains	+7.64%	-31.29%	134

The tables above represent the best case situation where grain was shipped to the northern forts by the nearest port at *Noviodunum*. However, because the size of ship that could travel that far up river was limited, modelling was also carried out via the Black Sea port of Histria. Now the travelling distance from port to garrison was greater. If the feed-barley for the overseas component were also supplied from overseas, then although the overall needs increased, the deficit felt by the garrison remained as it had been if shipped via *Noviodunum*. Yet if the feed-barley were supplied from the Dobrogea itself then the size of the deficit felt by the garrison was even greater again, than if the overseas component were shipped via *Noviodunum*, further illustrating how the provision of feed-barley from within the Dobrogea should have been avoided. In this model the use of mule-drawn wagons was seen to be least economical again, when oxen-drawn wagons required a half to almost a third of the feed that mule-drawn wagons required, for comparatively not many more wagons.

Table 3. Deficits and transport needs (via Histria in the north)

Model	**% increase in overall needs for feed**	**% deficit of original needs**	**Vehicles *pa***
If feed-barley provided from overseas			
23km oxen-drawn wagons	+ 7.15%	-27.23%	446
32km oxen-drawn wagons	+ 5.68%	-26.71%	354
50km mule-drawn wagons	+ 15.95%	-32.09%	280
50km mule-trains	+ 9.19%	-28.98%	162
If feed-barley provided locally			
23km oxen-drawn wagons	+ 7.26%	-30.91%	453
32km oxen-drawn wagons	+ 5.73%	-29.38%	358
50km mule-drawn wagons	+ 16.55%	-40.2%	290

50km mule-trains	+ 9.34%	-32.99%	164

It is possible to contest every single planning assumption made so far: yields and fallow regimes, the size of the garrison, the numbers of service providers to the military, the quantity of food consumed by the garrison, the cargo capacity of the vehicles and the quantity of feed-barley required. Yet by doing these calculations in Excel it is possible to adjust any one of these questionable values and relatively quickly run a fresh calculation, to see the effect of changing that assumption. I have this far used a yield of 385kg/ha for bread wheat and 395kg/ha for barley, which are pessimistic estimates. If these were adjusted down even further to 200kg//ha for both crops, then the deficit of the garrison's needs was seen to be in the region of 72-75% depending on the transport method. This is far too great to have been sustained in the long run, but could reflect a drought situation and poor harvests. It was notable that the number of vehicles required was not significantly higher; indeed in the mule-drawn wagon and mule-train models the number of vehicles required was lower, than previously modelled. This was unexpected but can be explained by the travelling distance of the local component, against the overseas component. Because in the case of poor harvests more of the grain was potentially coming from overseas it was only travelling from the nearest port and if moved by mule-drawn wagons and mule-trains this would normally arrive within a single travelling day, maybe two of the garrison, whereas when the deficit was smaller and more arable was coming from the Dobrogea itself, then some of it would have travelled for three days and so the overall number of wagon days was higher. These calculations showed that the transport penalties associated with moving from the ports were not so significant that a year or two of poor harvest could not have been accommodated. At 600kg/ha yield then a surplus now existed in the Dobrogea of 17-27%. The number of vehicles required was similar to that seen when there was a deficit; in fact the number of mule-drawn vehicles required was now a little higher than originally calculated. Again this is because more arable was travelling a longer distance within the Dobrogea rather than a single day from the port. Previously I had also assumed alternate fallowing (although not necessarily bare fallowing). However, if I did not do so, then even more arable again would have been available, so that surpluses in the region of 62-72% were calculated. Such surpluses are thought unlikely and therefore alternate fallowing is thought to have been normally practised. Without a fallowing regime the number of vehicles required was not dissimilar, to those calculated with a fallowing regime. In short, the origin of the arable to feed the garrison had little significant effect on the number of vehicles required. Additionally it was possible to adjust the cargo capacity of the vehicles, which would of course change the number of vehicles at work. The eight mules used to pull a wagon reported in the Theodosian Code have already been questioned. There are several images on Trajan's column of two wheeled wagons pulled by two animals, which surely were also used by farmers maybe for lighter loads.[26] If two mules could have pulled 150kg then they would have been more efficient than the eight mules pulling a wagon of 350kg or indeed a team of eight pack animals. In this case the calculated deficit was 3.5% smaller than using mule-drawn wagons of 350kg capacity. Therefore the size and capacity of the vehicles used could have significantly impacted on the quantity of arable available to feed the army. Obviously many more vehicles would have been required, but here the comparison is unfair, if in antiquity it was cheaper and easier to own a two-wheeled wagon rather than a four wheeled one. Seasonality was also considered, so that rather than calculating with a 300 working days to a year, only 240 working days were used to account for the cold winters of the region. The deficit, the number of loads and wagon days would remain unaffected, but there would have been an increased

[26] Scenes: xlix, lxi-lxii, cvi-cvii; *CTh* 8.5.8 allows three mules to pull a two-wheeled vehicle

need for vehicles, although they would have been used for less of the year. If one assumes four idle months there would have been a 25% increase in the number of vehicles.

In conclusion, the Service Area function within ArcGIS allows one to assess the most effective catchment areas around a consumer site according to the lie of the known road network. The computer programme rapidly produces polygons which provide a visual representation of a particular consumer site's catchment area. This can be adjusted according to the believed speeds of different transport methods. Therefore it was possible to model a situation where arable potential seen in the archaeological record was moved to each fort until its needs were met, while any surplus was directed to the next most convenient fort. Such calculations showed the relative merits of different modes of transport. Mule-drawn wagons required the greatest quantity of arable to be turned to feed-barley and were seen in every model to be the least efficient means of transport – they should have been avoided at least in a garrison context. Mule-trains required the lowest number of vehicles to be at work, for a greater quantity of feed-barley than oxen. Clearly the faster a yoke of oxen moved, the more effective it would have been. It is difficult to say which of the faster moving oxen-drawn wagons, or the mule-trains would have been preferred, without a greater understanding of animal ownership and the additional advantages of both oxen and mules to a farmer. When the effect of moving an overseas component to meet a deficit was considered, if the transport feed was provided from within the Dobrogea this increased the size of the deficit felt by the garrison as more land was used to feed the transport animals. This is militarily foolhardy, so that if a part of the needs of the garrison came from overseas then the feed-barley to move that grain should have also come from overseas. Finally the advantages of carrying out these sort of calculations within Excel as simple algorithms is that any of the figures used, yields, fallow regime, vehicle capacities or speeds can be adjusted and alternative models can be produced relatively quickly.

Bibliography

ADAMS, C.E.P. (1999) 'Supplying the Roman army: bureaucracy in Roman Egypt' In *The Roman Army as a Community*, eds. A. Goldsworthy & I. Haynes, Portsmouth, 119-126.

BĂRBULESCU, M. (2001) *Viața Rurală* în *Dobrogea Romană (Sec I-III P.Chr)*, Constanța.

COARELLI, F. (2008) *La Colonna di Marco Aurelio*, Roma.

ENGELS, D.W. (1980) *Alexander the Great and the Logistics of the Macedonian Army*, Berkeley.

FLORESCU, F.B. (1962) *Monumentul de la Adamklissi Tropauem Traiani*, Bucuresti.

FOXHALL, L. & FORBES, H. A. (1982) 'Sitometria: The Role of Grain as a Staple Food in Classical Antiquity', *Chiron* 12, 41-89.

GARNSEY, P. (1988) *Famine and Food Supply in the Graeco-Roman World: Responses to Risk and Crisis*, Cambridge.

GOLDSWORTHY, A.K. (1998) *The Roman Army at War 100BC-AD200*, Oxford.

HOLDER, P.A. (2006) *Roman Military Diplomas V*, London.Lepper, F. & Frere, S. (1988) *Trajan's Column, A new edition of the Cichorius plates*, Gloucester.

LOCKYEAR, K. POPESCU, A. SLY, T. (2011) 'Rome and Byzantium on the Danube: the Noviodunum Archaeological project 2005-2008', *Archaeology International* 11, 45-48.

MATTHEWS, S.R. (2015) 'Supplying the *limes* Garrison in the Dobrogea', In *Limes XXII, Proceedings of the XXII Limes Roman Frontier Studies Congress Ruse Bulgaria September 2012*, eds. L. Vagalinski & N. Sharankov, Sofia 839-844.

MORENO, A. (2007) *Feeding the Democracy: The Athenian Grain Supply in the Fifth and Fourth*

Centuries BC, Oxford.
MITCHELL, S. (1993) *Anatolia Land of Men and Gods*, Oxford.
OLTEAN, I.A. (2013) 'Burial mounds and settlement patterns: a quantitative approach to their identification from the air and their interpretation', *Antiquity* 87, 202-219.
PANAITE, A. (2010) 'Roman Roads in the territory of Histria (1st-3rd Centuries AD)', In *Antiquitas Istro-Pontica Melangers D'Archeologie et D'Historie Ancienne offerts à Alexandru Suceveanu*, ed. M.V. Angelescu, Cluj-Napoca, 373-379.
PANAITE, A. (2011) 'Drumurile Romane în Moesia Inferior,' *SCIVA* 62, 145-151.
PANAITE, A. (2012) 'Roman Roads in Lower Moesia. Epigraphical Evidence', *Novensia* 23, 131-143.
PANAITE, A. (2015) 'Roman Roads in Moesia Inferior, Archaeological and Epigraphical Evidence', In *Limes XXII*, *Proceedings of the 22nd International Congress of Roman Frontier Studies Ruse Bulgaria September 2012*, eds. L. Vagalinski & N. Sharankov, Sofia, 593-600.
POULTER, A.G. (1980) 'Rural Communities (*vici* and *komai*) and their role in the organization of the *limes* of Moesia Inferior', *In Proceedings of the 1979 limes Congress*, eds. W.S. Hanson &L.J.F. Keppie, Oxford, 729-744.
RAEPSAET, G. (2002) *Attelages et techniques de transport dans le monde gréco-romain*,Bruxelles.
ROTH, J.P. (1999) *The Logistics of the Roman Army at War*, Leiden-Boston.
ROXAN, M. (1978) *Roman Military Diplomas I*, London.
ROXAN, M. (1994) *Roman Military Diplomas III*, London.Suceveanu, A. (1991) 'La Dobroudja aux Ier – IIIer Siècles n.è.', In eds. A. Suceveanu & A. Barnea, *La Dobroudja Romaine*, Bucharest, 22-153.
TILBURG, C. VAN. (2007) *Traffic and Congestion in the Roman Empire*, London.
TOCILESCO, GR. G. (1895) *das Monument von Adamklissi Tropaeum Traiani*, Wien.
TOMLIN, R.S.O. (1998) 'Roman Manuscripts from Carlisle: The Ink Written Tablets', *Britannia* 29, 31-84.
WHITE, K. D. (1970) *Roman Farming*, London.
WOLSELEY, G.J. (1871) *Soldier's Pocket Book for Field Service*, London.

The Economy of Roman wine: A proposal for analyse an intensive wine production system and trade. Case Study Research: *Regio Laeetana (Hispania Citerior Tarraconensis)* from 1st century BC to 3rd century AD

Antoni Martín i Oliveras[1]
Víctor Revilla Calvo
José Remesal Rodríguez

CEIPAC- EPNet Project
Universitat de Barcelona

"Hispaniarum Laeetana copia nobilitantur,
elegantia vero Tarraconensia atque
Lauronensia et Baliarica ex insulis
conferuntur Italiae primis".
Caius Plinius Secundus, *Naturalis Historia* XIV, 71[2]

Introduction

Ancient Roman viticulture has multiple fields of knowledge and expertise with enormous possibilities for research. Most studies dedicated to the development of viticulture in antiquity, have

[1] amartinioliveras@ub.edu

[2] "Among the Hispanian (wines), the Laietanian (wine) is famous for its large productivity; beside the Tarraconensian (wine), the Lauronensian (wine) and the Balearian (wine) from the islands, (these ones) gather a certain elegance comparable to the best Italian (wines)" (Author's translation).

in common the use of the archaeological information and the written sources as a complementary support to confirm the absolute chronology of a settlement, a socio-economic phenomenon or an exact location of a winegrowing production or a pottery activity in a specific territory[3].

The intensive viticulture practised during the Roman period in the ancient Laetanian region situated in the centre of Catalan Coastal Depression was a widespread phenomenon with huge economic implications which represented a cultural revolution for this territory in all areas and at all orders. This research project builds on a previous work where was established the theoretical and epistemological framework of study of the different variables, factors and endogenous and exogenous agents involved in every stage of the production, distribution, trade and consumption of wine in the Roman period between the 1st century BC and 3rd century AD[4].

A further study must be focused on a geospatial and geoeconomic analysis, which supposes the identification of the settlement patterns, the organization of the rural habitat, the forms of production and management related to the crops capacities to obtain optimal yields for generating surpluses in a context of a growing population. The utilization of quantitative methods such as mathematics, statistics and linear programming models allows us to interpret and make predictions, regressions, and reconstructions about the evolution of the wine economy, understood as a situation that includes all the aspects needed to produce wines of various qualities, along with a group of complementary activities related to the production, elaboration, distribution, trade and consumption.

Epistemological & methodological issues

This research is developed from the application of the assumptions defended by the *scientific realism* or *ratio-empiricism* theoretical current and also by the application of the experimental and hypothetical-deductive method.

From a *conceptual* point of view we distinguish three levels of knowledge:

- *Study in-depth of written sources -primaries and secondary's- and also the ancient iconography*. Latin agronomist like Cato, Varro, Columella, Palladio and Pliny the Elder described issues related to the production systems and trade as agrarian techniques, vine-growing procedures, and winemaking processes. Other authors like Martial, Ovid, Horace, Juvenal and Virgil, inform us about symbolic aspects, tastes and preferences in wine consumption during the Roman period. Iconographic representations in different supports like sculpture, painting, gravure and so on, shows technological elements fixtures and tools, some of the perishable nature.
- *Study of the archaeological evidence and ethnographic parallels analysis*. It supposes the seeking of parallels in other similarly archaeological sites, near or far, with the same issues and chronologies. Ethnographic data from modern and contemporary periods can provide different models and techno functional solutions that could be applied in our interpretations.
- *Experimental Archaeology*. It consists in the rigorous reproduction of winegrowing and winemaking ancient production procedures and trade processes applying the ancient techniques and technological resources to check or refute our working hypotheses.

---

[3] REVILLA (1998), p. 185.
[4] MARTÍN i OLIVERAS (2015b).

From a *territorial* point of view we distinguish six types of studies:

- *Paleoenvironmental analysis*: Provide important information that enables us to make inferences related to the landscape transformation, whether natural or anthropic and its evolution over time. It includes different "data proxy" markers from inter alia: Sedimentological, palynological, carpological, anthracological analysis, etc.
- *Geospatial analysis*: Serves for modelling the settlement patterns related to the landowners, the *fundus* extension and the characterization of different typologies of production centres and workshops related to winemaking or pottery production: *villae* system, big or little specialized farms with *torcularia* and/or *cellae vinariae*, *figlinae*, etc., and its evolution over time[5]. A combination of tools will be used to implement them: Geographic Information Systems (GIS), relational databases and statistical analysis programs.
- *Archaeomorphological analysis*: For modelling agricultural uses of territory from a diachronic point of view as regards the geomorphological structure of the fields and land distribution evolution: *ager divisus et asignatus* (*cadastro et centuriato*), *ager per extremitatem mensura comprehensus* and *ager arcifinalis*, the types of terrain and soils and the configuration of the vineyards by different cultivation techniques and propagation systems, driving and pruning the grapevines, etc.
- *Technofunctional analysis:* Both for the installations (building organization), for the production structures (kilns, collecting and storage tanks, tools and enamelware, etc.) and also for the technological innovation in machinery, processes, and procedures: kiln types, wine presses, winemaking techniques, etc., in each settlement "type".
- *Geoeconomic analysis:* To calculate efficiency, profitability and scales of productivity in absolute terms of the maximum productive capacity of the properties as a whole, both for the vineyards (*Crop Simulation Models*-CRM) and for the processing and storage installations (productivity *yields*). These geoeconomic studies can be also analysed at different levels and territorial scales: macroeconomics (*regio*), mesoeconomics (*territorium*) and microeconomics (*torcularium atque figlina*).
- *Demographic analysis*: To calculate the fluctuations of population and to analyse its role as labour force in the agrarian economic system over time, either due to a good economic performance or either due to an economic and social crisis that could be motivated by multiple factors as migrations, plagues, diseases, war etc., that means population increases or decreases.

Written sources quotations

Hispanian wines are occasionally mentioned in the literature between the mid-1st century BC and the mid-2nd century AD, despite including Greeks and Romans writers from a wide range of social and cultural backgrounds, members of the elite or individuals of more humble origins, both from Italy and from the provinces and some in direct connection with the emperors themselves as in the case of

---

[5] Frontinus in *De agrorum qualitate, Praef.*1.2.3.; divides lands into three heads or *qualitates*: *Ager divisus et assignatus*; *ager mensura comprehensus* and *ager arcifinius*. *Ager divisus et assignatus* was public land that was assigned or granted to private persons by *centuriato et catastro*. The *ager mensura comprehensus* appears to signify a tract, of which the limits were defined by measurement, which was given in the mass to some community: '*cujus modus universus civitati est assignatus*'. The *ager arcifinius* appears to express the whole of a territory, which had only some natural or arbitrary boundary, and was not defined by measurement: '*qui nulla mensura continetur*'. See: http://www.thelatinlibrary.com/frontinus.html. Also see: SMITH (1875): *AGER*, in *Lacus Curtius*: http:// penelope.uchicago.edu/Thayer/E/Roman/Texts/secondary/SMIGRA*/Ager.html; CASTILLO (2011), p. 83-110.

Martial. The same can be found in the genres used. It is interesting to see how the information provided by the literature is organized in different ways and presents different features in each period.

The few quotations documented during the late Roman Republic and Julio-Claudian period are similar in their geographical vagueness and the frequently negative comments made about the wine. Thus, Ovid only mentions Hispanian wine in order to criticize it[6]. Only Strabo relates a Hispanian wine production to a geographic location, namely Turdetania, but it is a generic mention referring to its abundance[7]. This lack of precision paradoxically coincides with the regular presence of Hispanian wines in the Western Empire provinces and Rome during the Augustan period and the first half of the 1st century AD, which has been well established through archaeology[8].

The situation at the end of the 1st century AD and the beginning of the 2nd is different. A number of writers from the Flavian and Trajan periods mention specific qualities and geographic areas of origin. Pliny the Elder, in particular, establishes a clear distinction between vineyards and grape varieties with limited production, which gives us great wines of the first and second rank, and other vineyards and grape varieties that give us common wines of the third and fourth rank. Other authors, such as Martial, Juvenal, Silius Italicus and Fronto, give both positive and negative subjective assessments[9].

This considerable number of quotations, apparently, stands in contrast to the archaeological record, since wine amphorae from *Provincia Citerior Tarraconensis* appear in very small quantities in the stratigraphies of Ostia and Rome[10]. This highlights a contradiction between literature and archaeology, being that the mentions coincide with the social and political presence of Hispanian elites in Rome in the second half of the 1st century AD.

In this historical context a geography of production could be compiled, placing certain wines into a specific "designation of origin" as *Tarraco*, *Lauro*, etc; linked to generic territories as Laetanian wine or a geographic provenance as the Balearic Island's wine[11]. In any event, no writer mentions technological, productive, legal or financial aspects relating to the production and commercialization of Hispanian wine. Neither do they provide data on the making of different quality wines. The closest we get is the distinction among great and common wines, but always from the subjective point of view of the consumer. Quotations also present problems of accuracy and context. In some cases, the data collected may be contemporary with the text, but in others, they could be anachronisms[12].

Archaeological dataset

The progress on archaeological field research has shown itself to be an essential resource for defining the geography of vineyards, since the technological evidence relating to the production and storage of wine or the manufacture of amphorae containers can, in many cases, be located and dated

---

[6] Ovid. Ars. III, 645.
[7] Str. Geog. III, 2, 6.
[8] MIRÓ (1988), p. 295ff.
[9] Mart. Epig. 1.26.9-10; 7.53.6; 13.118; Juv. Sat. 5.29-30; Sil. Ital. Pun. 3.369-370; 15.176-177; Front. Ep. *De eloquentia*, 1.1;
[10] Dressel 2-4 *Tarraconensis* is residual in 2nd century AD stratigraphies from Ostia and Rome. Others such as Pascual 1 and Oberaden 74 are no longer trade by mid-1st century AD or even before: MIRÓ (1988); RIZZO (2014), p. 198-199 & 205-206.
[11] *Vide* note (1).
[12] REVILLA (2008), p. 217-220.

with quite an accuracy. Archaeology's contribution has been also essential as regards increasing our knowledge of the rural habitat and of how the territory was occupied and exploited[13].

The establishment of viticulture in the Laetanian region is related to the thorough transformations brought about by the Roman conquest. Especially interesting in this sense is the existence of early wine production in the territory close to the indigenous *oppida* of the central Catalan coast, which survived until the mid-1st century BC. This phenomenon is already confirmed in the final third of the 2nd century BC, in connection with the global transformation of the settlement and production structures[14]. This development brought with it a need to manufacture specific containers for transport, in the form of imitations of the Dressel 1 and Lamboglia 2 Italic amphorae[15]. However, the spread of vineyards geared commercialization towards in overseas markets did not come about until the second half of the 1st century BC, specifically in the final third of that century. This is confirmed by the foundation chronologies of many pottery workshops and numerous villa-type settlements and other rural centres, equipped with facilities for pressing and storing wine production. This incipient viticulture can be found also in certain territories of the central Catalan coastline (see map 1)[16].

Roman viticulture spread rapidly after the change of era and throughout the first half of the 1st century AD, covering new territories or exploiting more intensively those spaces that were already occupied. The first evidence are placing in the north coastal area situated between the Baetulo (Besós River) and the *Arnum* (Tordera River), where the villa system had been strongly established since the Augustan period, organized around two *municipia* founded in the late Republican period, *Baetulo* and *Iluro*, and the small *oppidum* of *Blanda* or *Blandae*. These rivers and other minor streams connected the coast settlements with inland territory, ensuring access to other agricultural spaces and their resources. It also affected the plain area situated between the *Rubricatum* (Llobregat River) and *Baetulo* (Besós River), reorganized with the founding of the colony of *Barcino*. From a time well into the 1st century AD, the economic interests of important families from the colony would become a consolidated presence in whole this area. This makes it possible to understand the economic development of *Barcino* in the 1st and 2nd centuries AD[17].

This specific distribution responds to different ways of exploiting the territory, characterized by a particular architecture based on the Roman *villa* concept, defined by spatial planning, differentiating between, one sector called *pars urbana* with all the services necessary for domestic life set aside to the private spaces for the owner, and another sector used for agricultural production, either for processing, *pars rustica*, or for storing, *pars fructuaria*. In general, the technology for winemaking, including several presses along with one or more tanks for collecting the must, is found in neighbouring buildings around the residential sector. But they could also be a little further away. Some *villae* had the agricultural and artisan sectors set apart from the residential area. In some places, however, there is evidence of the simultaneous storage of a cereal production, either for personal use or for trade[18]. Some of these establishments had also a pottery workshop where amphorae were made. So far over ninety pottery workshops have been identified in the present-day Catalonia (see map

---

[13] Bibliography on rural settlement is difficult to summarise: REVILLA/GONZÁLEZ/PREVOSTI (2008-2011), conference proceedings.

[14] MIRET/SANMARTÍ/SANTACANA (1991) p. 47-53; REVILLA (2004b), p.175-202; REVILLA (2010b), p. 139-159.

[15] LÓPEZ/MARTÍN MENÉNDEZ (2008b) p. 689-724.

[16] REVILLA (1995), p. 122-125; REVILLA (2008), p. 198 & 202.

[17] RODÀ/MARTÍN i OLIVERAS *et al.* (2005), p.47-57. OLESTI (2006), p. 175-200; OLESTI (2009), p. 141-158; OLESTI/CARRERAS (2012), p. 309-333; OLESTI/CARRERAS (2013), p. 147-189.

[18] REVILLA (2011-2012), p. 87.

2). All this suggests that these were places given over to intensive and specialized work processes forming part of a production structure organized elsewhere, possibly a nearby villa. Indeed, some buildings were occupied only seasonally, during certain phases of the agricultural cycle[19].

Over a hundred agrarian establishments have so far been identified as having traces of pressing facilities or spaces for storing liquids, mainly wine[20] (see map 1). These facilities vary greatly in importance, from modestly-built settlements with a single press to large buildings with four or more presses, distinguish three different sizes[21]:

- *Big establishments 1500/2000 m²* with a complex spatial organization and a basically productive function. These places would contain all infrastructure needed for making and storing wine on a certain scale. There are several *calcatoria* for crushing the grapes, some pressing rooms or *torcularia* with from 4 to 6 presses, various tanks or *lacus* for collecting the must and different storing spaces set aside of between 100 and 200 *dolia* an aggregate, called *cellae vinariae*. Artisan activities as pottery, forge and so on, have also been identified in most of these settlements.
- *Medium establishments 1000/1200 m²* with an wide range of buildings. Most were used for producing wine and had one or two presses, a collecting *lacus* and a *cella vinaria* of between 30 and 50 *dolia*.
- *Small establishments 400/500 m²* with a simpler spatial organization formed by one or two spaces compartmented also dedicated to winemaking production with a single press and a *cella vinaria* of 5-10 *dolia*. These facilities often are integrated in into small or medium size *villae* or urban *domus* and are aimed at self-consumption or for local trade.

This type of viticulture geared towards exporting to overseas markets would continue, depending on the area, until the mid or late 2nd or even the early 3rd century AD, when agricultural establishments would see the abandonment or gradually reduction of pressing facilities between the second half of the 2nd and the beginning of the 3rd century AD. In the case of the pottery workshops, some would disappear between the last third of the 1st and the start of the 2nd century AD, while others would convert and diversify their production. This ensured their continuity during the 2nd and 3rd centuries AD[22].

---

[19] Some examples: BURCH *et al.* (2005); REVILLA (2010a), p. 36-37.

[20] In the absence of a synthesis study for presses in the whole province, see PEÑA (2010).

[21] Settlement typology: REVILLA (2010a), p. 35-42. In the absence of an overall study on the rural settlement in *Hispania Citerior* see: PREVOSTI (2005) p. 345-445 and REVILLA/GONZÁLEZ/PREVOSTI (eds.), (2008-2011), p. 19-80. Installations equipped with 5-6 presses must be highlighted in the Roman *villa* of Pont del Treball Digne-La Sagrera-Barcelona, ALCUBIERRE/HINOJO/RIGO (2015), p.372-398; ALCUBIERRE/ARDIACA/ARTIGUES/LLOBET (2016). Installations equipped with 4 presses must be highlighted in Veral de Vallmora, (Teià, Barcelona), MARTÍN i OLIVERAS (2009), p. 193-213; and the Roman *villa* of Els Ametllers (Tossa de Mar, Girona), PALAHÍ/NOLLA (2010). See also: SÁNCHEZ *et al*. (1997), MARTÍN i OLIVERAS (2009), p. 19-38; MARTÍN I OLIVERAS (2012), p.59-98; MARTÍN i OLIVERAS (2015b), (with the previous bibliography); PEÑA (2011-2012), p. 37-57.

[22] Production and activity management: REVILLA (1995), p.104-113; REVILLA (2004a), p. 185-188; TREMOLEDA (2008), p. 113-150.

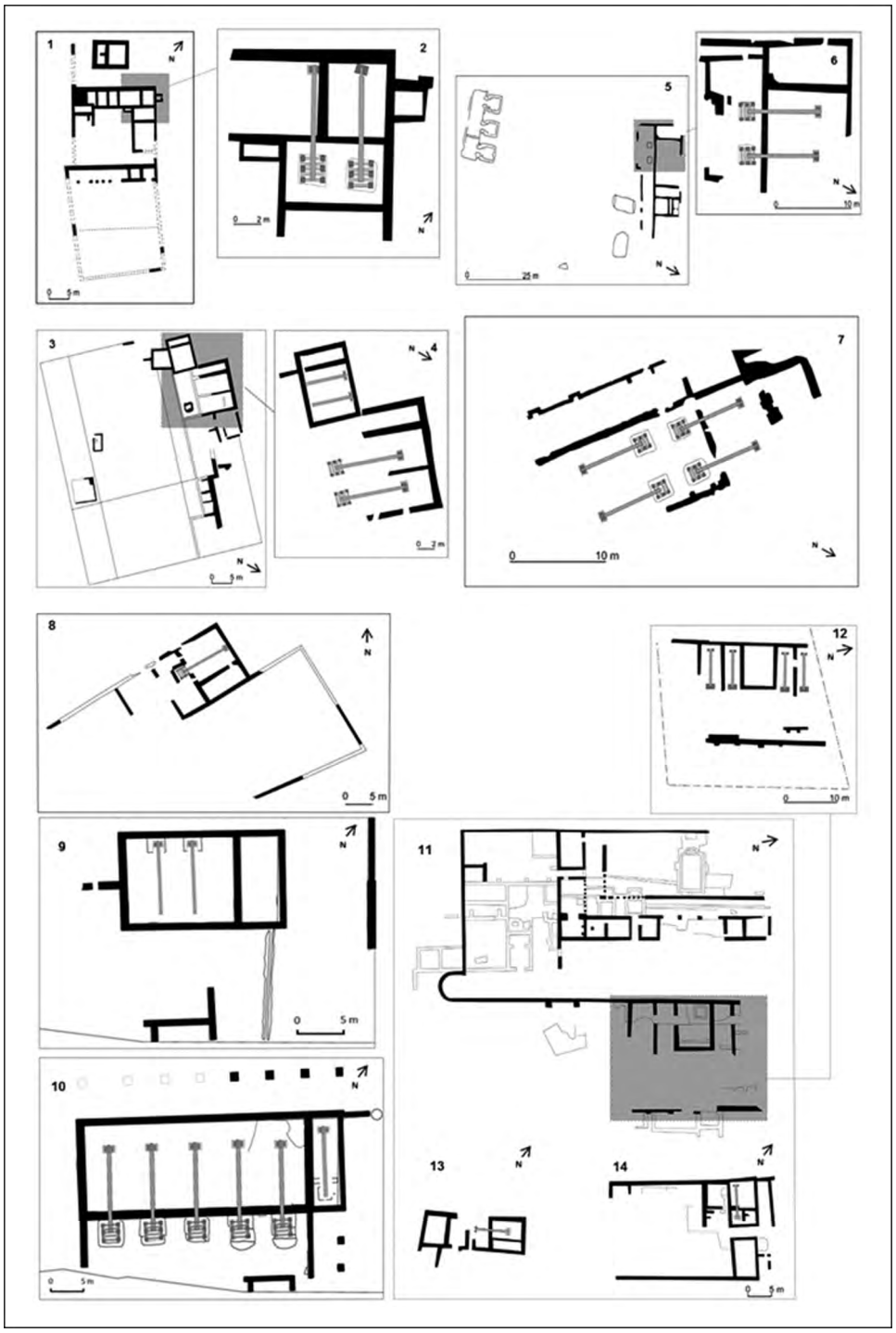


Figure 1. *Torcularia* from Laetanian region: 1 & 2. El Moré (Sant Pol de Mar, Maresme, Barcelona). 3 & 4. Veral de Vallmora (Teià, Maresme, Barcelona). 5 & 6. Can Feu (Sant Quirze del Vallès, Vallès Occidental, Barcelona). 7. Can Pedrerol de Baix (Castellbisbal, Vallès Occidental, Barcelona). 8. Torrebonica (Terrassa, Vallès Occidental, Barcelona). 9 & 10 Pont del Treball Digne Roman Villa (La Sagrera, Barcelona, Barcelonès) 1st century AD & 2on century AD. 11& 12 Felix Turissa - Els Ametllers Roman Villa (Tossa de Mar, la Selva, Girona). 13 & 14. Ses Alzines and Mas Carbotí (Tossa de Mar, la Selva, Girona). Image editors: M. Cubero & A. Martín i Oliveras.

The Roman economy has been the subject of numerous studies over time, being addressed from different epistemological and methodological currents which, through the application of different theoretical models, have focused on the analysis of the factors of production: Production strength, division of labour, etc.; as well as other indicators related to the growth from a diachronic and macroeconomic perspective: *Per Capita* income, demographic increase and urban development, application of technological advances, currency emission, price analysis and fluctuation, etc[23].

The study of the production, distribution, and trade of wine during the Roman period has been developed from two types of approaches. On one side we have the so-called *primitivist* or *substantivist* school, which argues that the study of models derived from sociology and anthropology work best for the analysis of the economic behaviour in ancient times, because the cultural constraints and the ideological issues plays a very important role in their development, so the application of the modern economic theory has a little explanatory value. On the other side, we have the so-called *modernist* or *formalist* school, which argues that the models derived from the modern economy (*New Institutional Economics*), constitute a very useful methodological tool due to the main objectives pursued were and are exactly the same: Productive efficiency, low costs and maximum benefit; and are the markets and consumption trends those that determine the characteristics of the production modes and trade patterns, from the fluctuation of supply and demand[24]. Not wishing to enter into this theoretical-methodological debate, we must consider that both positions are perfectly useful.

Macroeconomics versus microeconomics

The first references to Roman wine as an economic activity must be placed in the 19th century. Mommsen establishes the existing relationship between winegrowing and economic growth during the Roman Republic in the Italic peninsula due to the legislative changes referred to the land tenure and its high level of profitability, placing it in approximately a 6% net profit on capital and labour inverted[25]. Marx, in *Das Kapital,* when analyse the productive systems during antiquity, defines Roman viticulture as a capitalist system of production[26]. Weber refers it implicitly when describes the use of slave labour force as reporting of enormous profits[27]. Others authors such as Rostovtzeff attribute this voracious pseudo-capitalist productive system the origin of the Roman imperialist behaviour that causes its expansionism and the conflicts with other Mediterranean economic and commercial powers such us Carthage[28].

In Italy, De Martino and Carandini also raise a materialistic scenario, with an intensive farming model based on the concept of *villa*, initially with an autarkic character and later as surplus producer, binder of capital, the forms of production and workforce, from the increase of the *latifundia* and the slave labour[29]. Other scholars such Finley and Jones consider that although agriculture constitutes the activity par excellence of the Roman Economy, the role attributed to it has been oversized, because most of the products were produced for self-consumption and not for export, except in the case of the

---

[23] GREENE (1990), p. 16; SCHEIDEL *et al.* (2008); p. 5, BOWMAN & WILSON (2009), p. 3-8.

[24] The *New Institutional Economics* (NIE) is a theoretical current that defends a perspective of knowledge based on the analysis of social and legal relations and the study and application of the underlying economic rules that regulates a productive and commercial activity. See also: CONISON (2012), p. 39-40; JONES (2014).

[25] MOMMSEN (1862), p. 375.

[26] MARX *et al.* (1906), p. 654.

[27] WEBER (1891), p. 133.

[28] ROSTOVTZEFF (1926), p. 18.

[29] DE MARTINO (1985), p. 95-116; CARANDINI (1989), p. 101-192.

large cities, which constituted the habitual residence of the large owners and acted as administrative centres supplier*s* and distributors of goods[30]. This point of view will be further increased by Hopkins, who owe a wider vision with the incorporation of new concepts and quantitative variables for macroeconomic analysis such as: The production of surplus and the rising of *per capita* income, the urban phenomenon versus population growth, the productive increase by the application of technological advances and the division of labour, the process of monetization, the large increase in long-distance trade and the regulation of the different economic activities by the Roman state who implies the imposition of taxes and rents, etc.; in addition to the incorporation of archaeological evidence and other datasets from the experimental sciences that allow us the implementation of a diachronic macroeconomic evolution over time[31].

These quantitative studies are carried out with the objective to obtain new data to corroborate or refute work hypotheses derived from the written sources and other specific scholar studies, standing out the works of Duncan-Jones, Greene and, more recently, those of Bowman and Wilson[32]. The incorporation of the archaeological data gives us a wider view of the winegrowing productive function, allowing us to make inferences about certain processes and activities. In this sense, it should be noted the work done by A. Tchernia and J.-P. Brun as regards the study of the different productive stages, techniques and winemaking procedures during the Roman period, incorporating data provided by the detailed analysis of the written sources, the ancient iconography, the current archaeological evidence and, especially, new data provided from the experimental archaeology with the construction and set up working in the year 1996, of a Catonian beam press in the *Mas de Tourelles* (Beaucaire, Gard, France). By these experiments they reproduced the different elaboration processes and winemaking treatments documented by the Latin agronomists -Cato, Varro, Pliny the Elder, Columella and Palladium– in relationship with others operational aspects such as productivity indices and yields[33]. It is precisely these types of microeconomic studies that we consider it must be strengthened in the future to improve the knowledge of the winegrowing productive function, in addition to other activities related to the packing, transport, distribution and consumption of wine during the Roman period.

Theory of the Production

Well-being and wealth of any society are created by a productive process, that includes all actions that aim to satisfy directly or indirectly human needs through the development of economic activities that generates consumer goods, whether products or services. But regardless of the organization and the model adopted, there are certain economic principles that drive all production and commercial processes:

- *The Principle of Scarcity*: Promotes the management of economic, technical, material and human resources with rationality, since the number of available assets are limited, while material needs of society are increasing and unlimited. It refers to the relationship between *supply* and *demand* of a good. It is one of the determinants of the price of goods and services in a *market economy* with a situation of *perfect competition*, where no agent influences the sale of the product and only the interaction of supply and demand determines its price. In opposite to the *imperfect competition* that is a situation of *market failure* in which a single agent or a few manipulates the sale conditions

[30] FINLEY (1973), p. 180; JONES (1974).
[31] HOPKINS (1978), p.35-79.
[32] DUNCAN-JONES (1974), p. 33-59; GREENE (1990), p. 67-97; BOWMAN & WILSON (2009), p.3-84; BOWMAN & WILSON (2013).
[33] TCHERNIA & BRUN (1999), p. 91- 147; BRUN (2004a); BRUN (2004b).

affecting the final prices of the good or service. Many times they are not the producers those who alter prices, but the commercial intermediaries which distribute and trade it, or the Roman state itself through the imposition of abusive taxes, rates, and rents or by promulgating excessive regulatory measures (see figure 2A).

- *The Law of Diminishing Returns*: Defends that by increasing the physical quantities of a determined production factor leaving the rest in equal number, the resulting physical product increase to a certain maximum point, then stagnate or fall from a certain value, so that in the long run a greater production supposes a lower performance, which implies decreasing marginal yields. Thus, when the units of labour increases from L1 to L2, total product increases by the amount indicated (see figure 2C). But if the units of labour increased again in the same quantity, production increases less, and so on. The marginal product decreases to the right of point A or *optimum yield point*. Point B indicates the limit turning from which marginal returns are negative. In this way, the prices of agricultural products will tend to grow, and with it, the land rent (see figure 2D).
- *The Production Function*: Determining systemic factor in producing a good or service in a situation of perfect or imperfect competition. In most agricultural production processes, all the factors of production are used, although the proportion involved may vary depending on the possibilities offered by the available technology ([34]). The production function shows the maximum quantity of product that can be obtained with a certain quantity of inputs ([35]). The point where the change of slope is found implies the optimal level of productive equilibrium between factors of production and quantity of goods produced (see figure 2B). There are thousands of productive functions, one for each activity or product and represent the different combinations of productive factors: Land or raw materials, capital invested, labour force, work organization, know-how, etc. The indicative values of employed factors and products obtained reflect the available technology and define the production function. Initiatives that opt for the best combinations will get the best results. The productive function makes those responsible for an agricultural operation try to achieve maximum productivity with a certain number of factors. If you improve the technology you will get a greater quantity of product with the same amount of factors, so that the production function will change.
- *The Principle of Economic Efficiency*: It pursues the maximum productivity with the minimum possible economic cost. It supposes that the optimal production level has been reached when the *Average Total Cost* (ATC) for producing one unit of the product turns out to be the lowest possible. Thus, if the number of units of one of the factors of production is varied while maintaining the number of units of the other factors fixed, the optimum equilibrium will be reached at that point where the cost of producing a unit of product is the lower. Another possibility is that the producer is obliged to obtain a fixed quantity of goods and must restructure all the factors to achieve that certain productive level. The most effective variant of the factors of production is known as the *least-cost combination.*

The productive efficiency, or optimal level of production, is represented by the intersection:

P1 / Q1 & MC / ATC

The *Marginal Cost* (MC) is the cost for producing one more unit of a good. It is the change in total cost that arises when the quantity produced has an increment per unit at each production level and includes the additional expenses required to produce the next unit. The *optimal level of production*

---

[34] Technology means the state of the technical knowledge of the society under study at a given time.

[35] It is called input everything necessary to produce, such as the land or raw material and other factors, which combined in a production chain, define the process of making a good or product.

is represented by the point where the *sales price* (P1) and the *quantity of product produced* (Q1) are found (see figure 2E):

$$MC = A\ (T)\ C$$

The *Marginal Revenue* (MR) is the additional value that will be generated by increasing sales of products in a unit and can be described as the unit revenue of the last item sold. In a situation of perfect competition, the additional income, generated by the sale of an additional unit, is equal to the price that the producer/seller is able to charge to the buyer of the good. This is because a producer/seller in a competitive market will always obtain the same price increase for each unit sold, regardless of the number of units sold, since the amount of sales cannot affect prices, unless produces a situation of *market failure*, either by *imperfect competition* or by a *monopoly* (see figure 2F).

In case of *imperfect competition*, the price of all units sold must be lowered to increase sales by one unit. Therefore, the *Marginal Revenue* (MR) generated will always be lower than the price that the producer or seller is able to charge for each unit sold since each reduction makes the *Average Revenues* (AR) were lower. Thus, the *Marginal Revenue* (MR), relative to the increase in the *Average Revenues* (AR), is the price obtained from the additional unit sold, less the loss of revenue due to the reduction in the price of the remaining units sold before the decrease (see figure 2G).

Monopoly is a similar situation than the *imperfect competition*, but with the variant that the production and sales are controlled by a single agent, whether the producer or seller, the commercial intermediary or the buyer, and price is not determined by *the supply and demand law* but by the agent who controls the market. If this control is executed by more than one agent, this situation is called an *oligopoly*. An example in the Roman world are the supply of agricultural products for the *annona* (grain, oil, meat, etc.), since the own consumption of the Roman State determines the demand, reason why this determines the sales and even sets the prices of the whole system by law ([36]).

- *The Supply and Demand Law*: Determines the *pricing policy* and implies that the production and commercial system is adapted to the needs of the market. In a *free market* and in a situation of *perfect competition,* the price of the product is determined by the interaction between the quantity of products offered and the quantity of products demanded. The *Law of Supply* indicates that it is directly proportional to the price: If demand is higher, more units will be offered for sale. On the contrary, the *Law of Demand* indicates that it is inversely proportional to the price: If the price is higher, fewer consumers will demand it. The markets determine the adaptation of the productive, logistic and commercial system to the needs of the demand. Any variation implies an adaptation of the productive, distributive and commercial function. This is so and never the reverse. The graph shows the effect of an increase in the demand curves from D1 to D2, where we see that the *Price* (P) and the total *Quantity* (Q) sold increases. Thus, the price of a good is determined by the equilibrium between the two curves *Demand* (D) and *Supply* (S) (see figure 2H).

Roman Wine Production Process

The production process is the global system that characterizes a productive activity. The factors of production constitute the *inputs* of the economic system. A specific technology specifically

[36] REMESAL (1990), p. 355-367.

combines these *inputs* -raw materials, energy, labour, machinery, tools, facilities, etc.-. The *outputs* are the finished products, the goods or services resulting from the productive activity.

In any type of socio-economic organization, the production of goods and services may be in the hands of the state or in the hands of private producers. The Roman wine production process is not alien to all these factors, conditions and microeconomic variables and has also its particular production function with its own inputs intervening in the different stages of the productive chain.

Yields quantification

Its calculation is fundamental for the study of agricultural production processes, so we will try to adapt it both to the crop and to the processes of transformation, production and exploitation, in the different stages of the productive chain[37]. The analysis of viticultural and wine production can be approached in several ways according to different parameters of study:

- *Vineyards yields*: It calculates both the yield of the crop itself and the yield from the harvest. To estimate the global vineyards yields we must have to take into account the following data set:
  - *Yield per strain*: It refers to the productive capacity of the plant, in order to obtain data on absolute yields and means of productivity of grapes that include a hairpin from maximum to minimum. Factors related to both the configuration of the vineyard and the cultivated grape variety, the planting frame and the number of vines/hectare (*vitis/iugera*), the pruning and loading of buds, the number of hectares/*iugera* cultivated, etc. Once the productive capacity of the plant and the variety of grapes chosen are fixed according to the geomorphological characteristics of the territory under study and the soil pedological characteristics of the land to be cultivated, we will be able to analyze the different parameters and intervening factors, in order to obtain a whole series of values that we can compare with productivity data from the written sources themselves and statistical data of yields from modern and contemporary periods, basically from 19th and 20th centuries.
  - *Harvesting yield*: Refers to the grapes collection prior to pressing. The data set and factors to be analyzed are of different nature and origin. The most important are the aerial configuration of the vineyards, which can facilitate or hinder the manual grapes collecting of the clusters. This process is conditioned by the harvest time available, which can last between 15-30 days depending on the staff's picking expertise and the maturation time necessary of the cultivated grape variety.
  - *Winery's yields*: It calculates the yields from the processes of treading and pressing the grapes, its transformation into must and then into wine, as the maximum productive capacity of the facilities as regards to the processing machinery and the capacity needs of the collecting, ageing, and storing structures.
  - *Productivity of the processing machinery*: Once knew it the technical, mechanical and operational constraints of the Roman beam presses, we can analyze the different parameters and intervening factors that allow us to make an assessment of the productive performance of a winery installation in terms of productive capacity[38]. The productive capacity measures the proportion between the volume of grapes processed and the volume of must obtained, depending on the time used, counted in hours or days, taking into account the *vindemian* period related to the characteristics of the grape varieties to be processed. All these factors are connected to each

[37] AMOURETTI & BRUN (1993), p. 551- 562.
[38] MARTÍN i OLIVERAS & BAYÉS, (2009), p. 215-248.

other and influence in the final result, so we will have to calculate the yields in absolute values of maximum productivity in order to get an idea of the real and total capacity, both for the processing and pressing machinery as for the necessary collection and storage structures (*lacus*, *dolia*, *cupae*, etc.). We can also compare the results with the absolute data of productivity and capacity of the installations coming from the written sources, especially from Cato and Pliny the Elder, previously studied by modern scholars, with historical data from modern vintages and with data from experimental archeology -currently we only have those from the *Mas de Tourelles* experience-[39]. Subsequently, we can extrapolate them to vineyard field's extension values to give us an idea of the amount of must and wine that a "type" installation, with certain characteristics established according to the different typologies of Roman wineries documented in the area, can process, establishing models and systems of production. Their analysis can also inform us about the settlement patterns, the size of properties or *fundus* and the organization and tax control of the vine-growing and winemaking production in the former territory object of study.

Costs quantification

The production of a particular good or service involves the use of a number of factors that have a quantifiable economic value: The *costs*. The cost structure of an economic activity is considered as a diagram of consecutive allocation of *direct costs* -raw materials, labour power and energy- and *indirect costs* -maintenance costs of tools, infrastructure and facilities and administrative, commercial and financial expenses-[40]. The calculation of production costs of a good or service is complex since it is necessary to take into account all the costs structure and the proportional part of the capital investment.

In order to calculate the productive and commercial costs of a wine amphora, the first thing we have to do is to try to obtain a scale of ancient real prices situated in the chronological context that we want to study. That allow us to make a calculation, as close as possible, to the real productive costs in a fixed-value Roman monetary unit, such as *sestertius* (HS),[41]. However, in order to understand the general theoretical framework of costs, we will randomly develop an example of production or service provision X, which can show us the behavior of the variable costs and total costs of each one good or service produced in units, tens, hundreds or thousands values[42].

---

[39] Plin. *N.H.XVIII*, 317; Cat.*Agri.*11; BRUN (2004a), p. 20.

[40] MAZA & GONZÁLEZ (1992).

[41] See DUNCAN-JONES (1974), quantitative studies related to the calculation of costs and yields of productive activities and price scales of goods and services in different places of the Roman Empire and chronological periods. See also data sets from the written sources and other preserved documentation: *Mensa Ponderaria* and prices lists of Pompeii (1st century AD), Edict of Maximum Prices of Diocletian (Ca.301 AD), etc.

[42] The units of value employed in this theoretical example are imaginary and have only a quantitative numeral value expressed in units, tens, hundreds or thousands of units to facilitate economic calculation.

QUANTITIES PRODUCED	TOTAL FIXED COST (TFC)	TOTAL VARIABLE COST (TVC)	TOTAL COST (TC)
0	2000	0	2000
1	2000	800	2800
2	2000	1360	3360
3	2000	1680	3680
4	2000	1910	3910
5	2000	2150	4150
6	2000	2550	4550
7	2000	3210	5210
22	2000	9610	11610

Table 1. Behaviour of the Total Fixed Cost (TFC), Total Variable Cost (TVC) and Total Cost (TC) of each of the units produced in estimate economic calculation values.

- *The Average Costs per Unit*: The *Average Cost* (AC) is the Total Cost (TC) divided by the *Quantity* (Q) of units produced. Although the total costs are very important, the average costs per unit are even more for the short-term analysis of the production centre (exploitation), since when comparing them with the price of the product or with the average income, is making a profit. The average costs per unit are essential for the evaluation of inventories in matters related to the "design" of the product. These concepts also play an important role in the introduction of a new product on the market. In modern microeconomics, the decisions to buy or not to buy a product and the decision of reject or accept a new production line depend on the available information on the *Average Cost per Unit*. Other short-term unit costs are usually calculated to complement the decisions, such as:
  Average Fixed Cost (AFC) = *Fixed Cost* (FC) / *Quantity* (Q) of units produced
  Average Variable Cost (AVC) = Variable Cost (VC) / *Quantity* (Q) of units produced
  Marginal Cost (MC) = cost of each additional unit

- *The Marginal costs*: The *Marginal Cost* (MC) is defined as the change that affects the *Total Cost* (TC), when one more unit of product is produced:

$$MC = \frac{\text{Change in } \textit{Total Cost} \text{ (TC)}}{\text{Change in } \textit{Quantity} \text{ (Q)}}$$

Change in TC = TC2-TC1
Change in Q = Q2 - Q1

It is calculated by subtracting each total cost from the column 4 (in table 1)and the lower row unit n, the cost of the n-1 unit; can also be obtained from each variable cost of column 3 and the lower row cost of the previous unit, because variable costs grows up exactly the same.

The *Average Cost* (AC) and the *Marginal Cost* (MC) are known as short-term costs, because those acts during the period of decision-making, in which some costs are fixed and others variables. In the example above, if the cost of producing 5 units is 20,750 u. (where the 48.2% are fixed costs and the remaining 51.8% are variable costs), the *Average Cost* (AC) of production is 4,150. If the centre produces one additional unit (6 units), the *Average Costs* (AC) are reduced to 3,790, and by

producing 7 units the *Average Cost* (AC) continues to decline, but when there are 8 again begins to increase due to the *Law of Decreasing Returns* and due to the increasing number of units for a fixed capital investment. These results are shown in the *Marginal Cost* (MC) column 5, in which it is observed as this one decreases to the fourth unit and from here again begins to increase.

The marginal cost must always be lower than average cost, but the more units are produced, this will be closer to the average cost, and to justify the production of more units when the marginal cost is above the medium cost, the selling price should be equal to the marginal cost of the last unit produced, so that the activity does not incur in losses when producing this last unit. Table 2 shows how the progression of unitary costs is not constant; this is initially decreasing, and then goes to constant progression, to then grow back generating three moments:

QUANTITIES PRODUCED (Q)	AVERAGE FIXED COSTS (TFC/Q)	AVERAGE VARIABLE COSTS (TVC/Q)	AVERAGE TOTAL COSTS (TC/Q)	MARGINAL COST (MC)
0	-	-	-	-
1	10.00	4.00	14.00	4.00
2	5.00	3.40	8.40	2.80
3	3.33	2.80	6.13	1.60
4	2.50	2.39	4.89	1.15
5	2.00	2.15	4.15	1.20
6	1.67	2.12	3.79	2.00
7	1.43	2.29	3.72	3.30
8	1.25	2.57	3.82	4.50
9	1.11	2.92	4.03	5.75
10	1.00	3.40	4.40	7.75

AVERAGE FIXED COSTS-AFC
AVERAGE VARIABLE COSTS-AVC
AVERAGE TOTAL COSTS-ATC
MARGINAL COST-CM

AFC = TFC/ Q
AVC = TVC/ Q
ATC = TC/ Q
MC = COST OF EVERY ADDITIONAL UNIT

Table 2. Behaviour of Average Fixed Costs (AFC), Average Variable Costs (AVC), Average Total Costs (ACT) and Marginal Cost (MC) of each of the units produced in estimate economic calculation values (in thousands).

The combination of available fixed resources with small amounts of variable resources will not achieve arise the full potential efficiency of the exploitation, which supposes high unitary costs for the first products.

As the scale of units produced increasing, the proportions of the combination of fixed resources with variable resources allows better overall returns, reducing these costs in proportion to the units produced. Production continues to rise until the fixed resources do not support to produce additional units in equal conditions so that they will be processed at higher proportions cost.
See the following graphs, which represent, on the one hand, the behaviour of the *Total Fixed Costs* (TFC), the *Total Variable Costs* (TVC) and the *Total Costs* (TC) (see figure 2 I); and, on the other hand, the behaviour of the *Average Variable Costs* (AVC=TVC/Q) and the *Marginal Cost* (MC) (see figure 2L).
Due to the *Total Fixed Costs* (TFC) are by definition equal and independent of the level of production, the *Average Fixed Cost* (AFC=TFC/Q) decreases as production increases, and is

represented by a continuously lowering curve. When the production increases by adding variable resources, because the *Total Variable Cost* (TVC/Q) reflects the *Law of Diminishing Returns*, one we can first obtain increasing returns, but in the end it would yield diminishing returns; then the *Average Variable Cost* (TVC /Q) decreases at the beginning, it reaches a minimum and returns to increase, so the graph is U-shaped. The *Marginal Cost* curve (MC) reaches its level lower in four units, below cost mean variable (TVC/Q), or the *Average Total Cost* (TC/Q), and cuts the mean the *Total Variable Cost* curves (TVC/ Q) and the *Average Total Cost* (TC/Q), respectively low points, because while the cost (MC) is below the *Average Total Cost* (TC/Q), the average presses down, and when is above, the average presses upwards (see figure 2K).

- *The Long-term production costs*: As a result of a successful operation, a centre can modify its installed production capacity to expand its, or in case of different results expected, in the long run it could also reduce their size. Either decision seeks to obtain the lowest *Average Total Cost* (ATC) of possible production. The reduction in the price of resources and technological progress displace cost curves down. Similarly, the increase in the price of resources shifts it towards above (see figure 2J)[43].

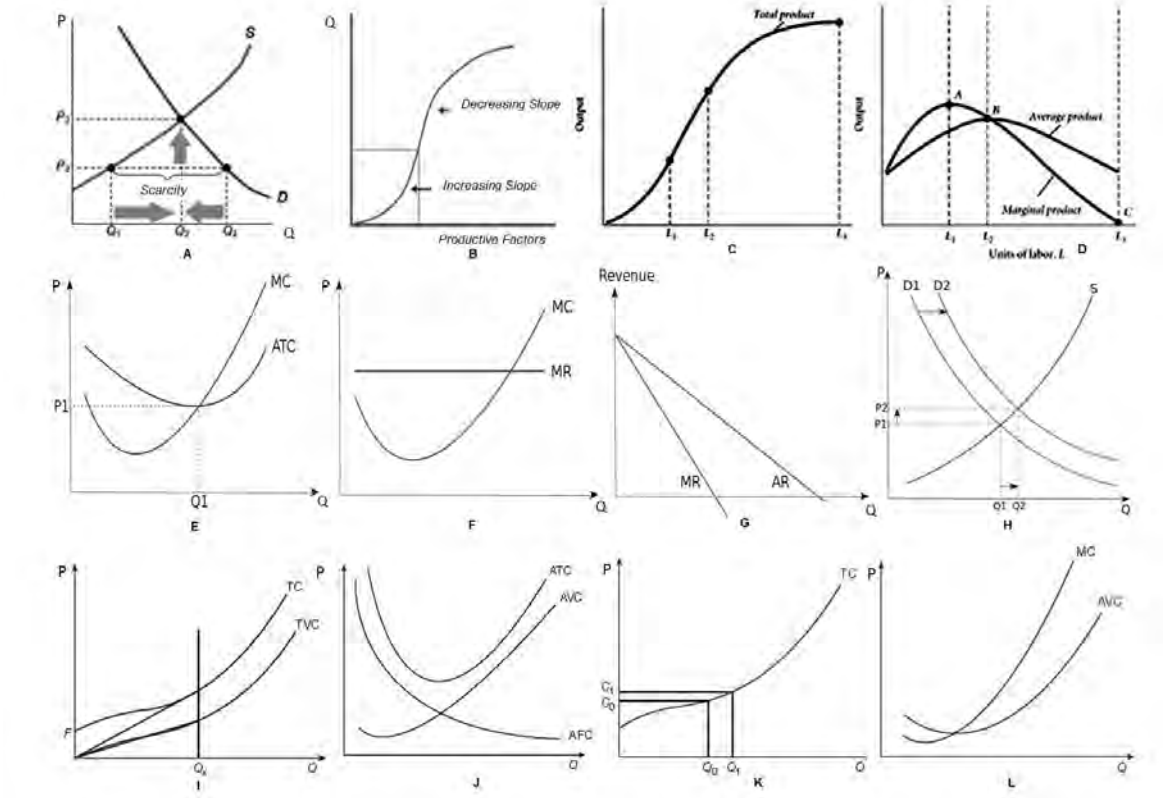


Figure 2. A: Principle of Economic Scarcity. B: Production Function curve. C/D: Comparative charts of Decreasing Returns Law, (from Maza & González, 1992); E: Economic Efficiency graph. F: Curves of Marginal Cost (MC), in relation to Marginal Revenue (MR) in situation of perfect competition. G: Marginal Revenue (MR) curve with respect to Average Revenue (AR). H. Supply (S) and Demand (D) curves. I. Cost curves: Total Cost (TC) and Total Variable Cost (TVC). J. Average Total Cost (ATC), Average Variable Cost (AVC) and Average Fixed Cost (AFC) curves. K: The Marginal Cost concept. L: Marginal Cost (MC) and Average Variable Cost curves (from Jones, 2014, p. 8-54).

[43] VILCALPOMA (1995), p.1-45, JONES (2014), p. 8-54.

The decision to expand the production centre seeks to achieve economies of scale or serial production. When the size of the centre increases, factors such as -specialization of labour, better utilization of staff, efficient use of capital and technical resources, the allocation of indirect costs and other costs arising from the expansion of the producing centre in a number of units- contributes to reduce the unit costs for the producer, who can expand its scale of operations. It is, therefore, the set of circumstances that allow reducing the average cost of production as the total product increases. They are also defined as gains in production and the costs resulting from the increase in the size of the producing centre, which implies an improvement in the buying prices of the inputs or factors of production and a most efficient use of them. The improvements in economies of scale can be internal, due to the indivisibility of the factors of production, or external, due to the expansion of the producing centre as a whole. Economies of scale stimulate mass production and are achieved rapidly when the size of the producing centre increases, which means that the decreasing returns only appear when the scale of production is very high, the total average cost decreases over a wide interval of production. This can lead to the development of monopolies and oligopolies of producers and investors, due to the large initial investments required and the difficulty of obtaining minimum short-term yields and costs, in order to protect themselves against new competitors. For example, when an amphora of noble wine is produced, high fixed costs must be faced to buy the land, plant the vines, build the *torcularium*, the *cella vinaria* and other facilities, but when this entire infrastructure is already operating at full capacity, the cost of filling an amphora of wine is more or less the same. Thus, if these infrastructure costs hypothetically 20,000 units of investment and the production of each wine amphora costs hypothetically 500 units, the "real" unitary cost is 5 units producing 100 wine amphoras, 2.5 units for 200 wine amphoras, and 1 unit for 500 wine amphoras.

Demographic studies

Demographic studies of ancient societies have been increased during the last years, trying to recognize the internal organization of population's evolution and to identify possible settlement patterns related to the resources management, urban development and agrarian exploitation of the territory. These studies allow us to revise basic concepts such as the relationship between the urban and rural world, as regards the urbanism development related to the implementation of an intensive agrarian production system and the different administrative status, sizes and ranges of ancient Roman cities.

Range	Name example	Extension	Inhabitants
1st	Rome	+200 Ha.	1-1,5 M
2on	Ostia	+ 100 Ha.	30.000
3rd	Mediolanum	133-83 Ha.	25-5000
4th	25 cities	83-16 Ha.	25-5000
5th	400 cities	16-3 Ha.	5-1000

Table 3. Sizes and ranges of ancient Roman cities according to Carreras (2014) after Morley (1996).

Quantitative and qualitative analyses of territories have been favoured by a better knowledge of the urban perimeters and the settlement patterns of rural distribution; either from the contribution of urban archaeology, field-surveys, and cadastral studies.

Therefore, the most important interrelations that can be to take into account for make our analysis is the total number of population, its distribution -urban or rural- and its internal configuration trends, such us -gender, age, social status, etc- for every chronological period in the area object of study. This serves to calculate, on one hand, the needs of food stuff in terms of maintenance and self-consumption and, on the other hand, the labour availability necessary to make the different activities that allows the wine intensive system of production, distribution and trade works.

In this same sense, some scholars attempted to convert the results obtained from archaeological excavations and field-surveys into demographic data. Thus, some analyses achieve to develop ranges of estimated inhabitants by settlement typologies, despite there are important methodological problems, such as the samples and the data obtained are partials, due to the fact that not the entire territory can be excavated or prospected and not all domestic or habitational spaces have been preserved[44].

Types	Extension	Population
Big *Vicus*	800 m2	80 persons
Big *Villa*	500 m2	50 persons
Little *Vicus*	400 m2	40 persons
Little *Villa*	300 m2	30 persons
Big farm	100 m2	10 persons
Little Farm	60 m2	5 persons

Table 4. Typology of rural Roman settlements and estimation of inhabitants according to Carreras (2014) after Perkins (1999).

Others studies try to quantify the food supplies necessary for cover the basic diet of resident population in urban and rural settlements as regards the main crops and other derivate products -wheat, vegetables, wine and olive oil, as well as animal husbandry; to transform them in estimate units of land necessaries for produce it. The Roman agronomists such as Cato, Varro and Columella also inform us, about some environmental aspects, labour and facilities to consider for manage an agricultural holding. Issues, all of them, that can help us about the calculation of this minimal unit of land necessary for its self-sufficient maintenance[45]:

1 worker = 7 *iugera* (*iug*) vineyard
1 worker = 51 *modii* (m) wheat / 1 year
1 iug x 4 m seed x 3 m wheat = 12 m / 1 *iug*
51: 12 = 4.25 *iug*
6.138 *iug* for wheat and reposition of seed
6.138 x 3 (triennial rotation system) = 18.414 *iug*
18.414 + 7 = 25.414 *iug* / 1 worker[46]

---

[44] CARRERAS, (1996), p. 59-82, CARRERAS (2014), p. 53-82.
[45] Cato *Agr.*1-11; Varro *R.R* 1.4-1.11; Col. *R.R.* 3.3.8-9.
[46] MARTÍN-ARROYO (2016) p. 105-124. The *iugerum* or *iugera* is an ancient Roman unit area for land measures. It corresponds to 71 meters long and 35.5 wide, equivalent to 0.623 acre or 0.2518 hectares. The *modius* is an ancient Roman unit of Dry measures, equivalent to 8.73 litres.

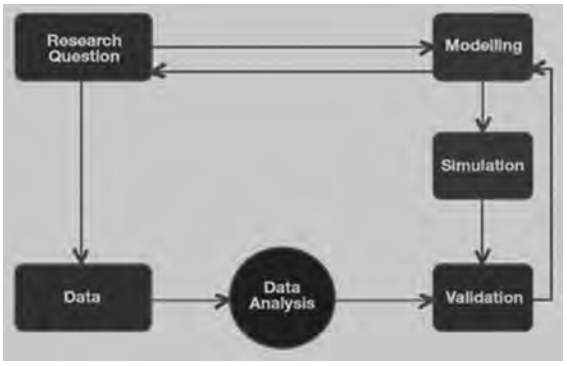
The internal quote of wine consumption has been also an important parameter to take into account, so that the balance between intra-regional and extra-regional consumption can determine the performance of the intensive productive wine economy in our study area and the possibility to obtain surpluses for trade and benefits for increasing social position of some intervenient agents such us: *vilici*, *conductores*, *mercatores*, *negotiatores*, *argentari*, *naviculari*, *institores*, etc.

Endogenous and exogenous factors as economic success and wealth increment can stimulate population's rates increases, otherwise poor harvests, wars, diseases, plagues, etc; can provoke social conflicts and economic crisis that supposes population's rates decreases. In this sense, as regards the Laetanian region, historical events such as the Antonine Plague (165-180 AD), the Plague of Cyprian (250-266 AD) and the Franks and Allemandes incursions (276 AD), could have caused widespread manpower shortages in agriculture and important casualties in the Roman army that could make conditions change and the system falls.

Modelling processes

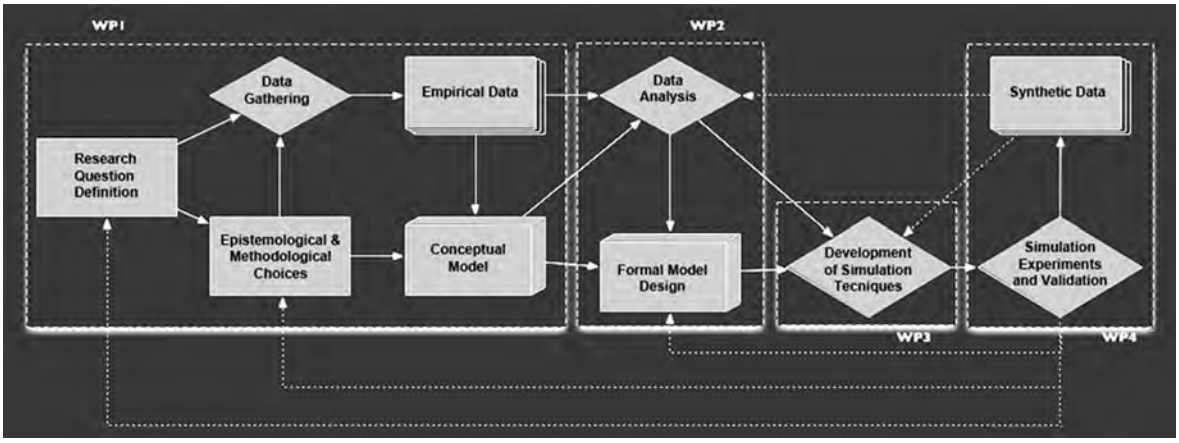
A model is any concept, relationship or object used to study and represent some part of the empirical reality simply and comprehensibly[47]. Therefore, in order to obtain an objective, empirical understanding of a past or present reality, study models need to be established to enable us to explain it and simulate it. On the basis of this definition and through the extensive use of mathematical and statistical models and online linear programming, we can analyse, interpret and make predictions, regressions or reconstructions about the evolution of ancient economic systems as regards the potential production of a region or territory, the production surplus that could be commercialized in foreign markets, and variables such as the selling price, market reactions, production and transport costs, business trends and the consequences of economic policy.

The following diagrams show the different stages and processes that define the cognitive process through the application of models:



[47] RUBIO (2009). http://diposit.ub.edu/dspace/handle/2445/41457

They also show the different phases or stages of the research through the way these are developed and applied:



Any investigation that aims to obtain a more detailed knowledge must follow a methodology that includes developing its studies at different scales of analysis:

- *Geospatial*: At macro-spatial (*regio*), meso-spatial (*ager* or *territorium*) and micro-spatial (*torcularium atque figlina*) levels.
- *Geoeconomic*: At macroeconomic (*regio*), mesoeconomic (*ager* or *territorium*) and microeconomic (*torcularium atque figlina*) levels.

As far as the origin, development and spread of vitiviniculture in the *regio Laeetana* between the 1st century BC and 3rd century AD is concerned, an important catalyst seems to have been the territorial and demographic configurations themselves and the specific interaction between these two variables and the intra-regional and extra-regional economic networks. This interaction comes about due to a series of behaviours and decision-making processes that can be studied and modelled. There are three modelling categories:

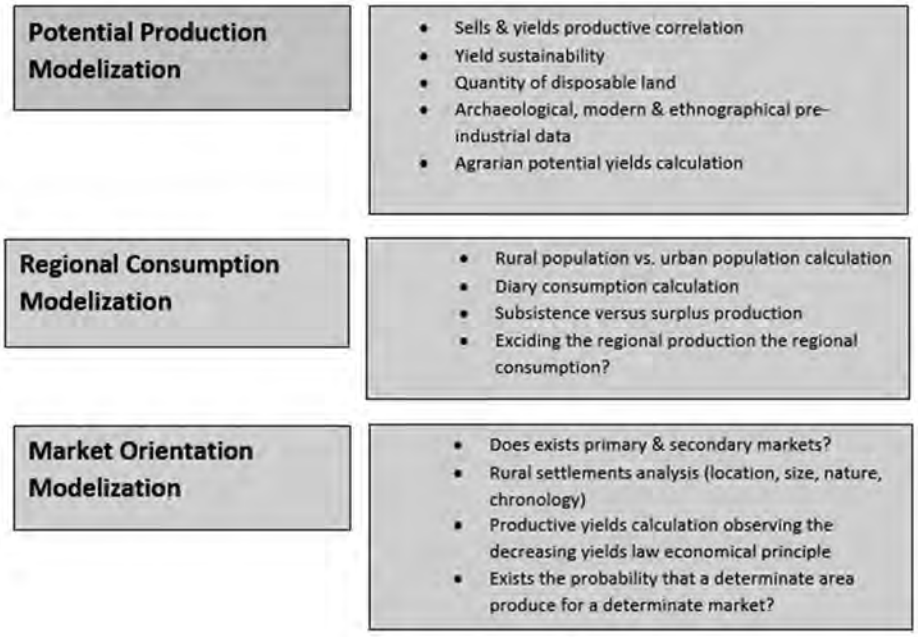
- *Descriptive models*: These quantify the interrelations of the data in order to group them and classify them in sets, e.g. economic and econometric models developed through the adoption of geospatial and geoeconomic quantification processes, adapted to a past reality ([48]).
- *Decision-making models*: These describe decisions in connection with all the elements, variables, and agents that play a part in the process. They serve to predict possible results depending on the decisions made, e.g. multi-agent models.
- *Predictive/regressive/reconstructive models*: These analyse situations and events in the past in order to make predictions. They can simulate human behaviour and the evolution of a socioeconomic system (production or market) when faced with different stimuli or specific situations ([49]). The predictive model is also an excellent tool for calculating, analysing and interpreting the balance between the intra-regional consumption and the extra-regional export of wine.

---

[48] MADDALA (1985); PULIDO (1987); WOOLDRIGE, (2006); PEDACE, (2013), p. 307-314.

[49] VERHAGEN (2007).

The following diagram shows three groups of variables that we consider essential for the development of our study, along with the different parameters that can be studied:



Case study proposal

Object

Our object of study is focused on the knowledge of the origin, development and evolution of intensive vitivinicultural production in the ancient *regio Laeetana* through the identification of different microeconomic, mesoeconomic and macroeconomic models. Using these as a starting point, our aim is to develop econometric models and specific predictive/regressive/reconstructive models to enable us to analyse the evolution of this historical phenomenon in the period from the mid-1st century BC to the mid-3rd century AD.

Territorial scope

The Laetanian region is an ill-defined area in historical terms that includes, among other things, the *oppidum* of *Blanda* or *Blandae*, the *municipia* of *Iluro* and *Baetulo* and the *colonia* of *Barcino*. The extension and limits of these cities' territories have not been precisely defined with the exception of the *ager Barcinonensis*, the constitution and legal status of which must have had an effect on the urban centres that were there before[50].

[50] PALET (1997); PALET/FIZ/ORENGO (2009), p. 106-123; PALET /ORENGO/RIERA (2011), p. 113-129; PALET/JULIÀ/RIERA/ORENGO/PICORNELL/LLERGO (2012), p.341-352.

Figure 3. Laetanian region with its Latin toponymical items and main roads (1st. century BC to 3rd. century AD).

Laetanian territory also comprised the extensive plain situated between *Baetulo* River (Besós) and the mouth of *Rubricatum* River (Llobregat), located on the other side of Montjuïc promontory. The first foothills of the Garraf Massif would have risen from this point. Away from the coast, the colony's *ager* would have included the lower course of the Llobregat River as far as *Ad fines* (Martorell) and the lower course of Besós River to where it joined Ripoll River and the Congost-Mogent basin, spreading across the great Vallès plain as far as the Catalan Pre-Coastal Range. Attending the special features of the *Laeetana regio*, as regards its particular geospatial configuration, geoeconomic characteristics and historical evolution over time, we distinguish four specific areas of study:

- Study area 1: Barcelona Hinterland Plain-*Ager Barcinonensis*
- Study area 2: Central Coast-*Territoria* of *Baetulo*, *Iluro* and *Blandae*
- Study area 3: Lower Llobregat-*Rubricatum* estuary
- Study area 4: Vallesian Plain-*Territoria* of *Arraona, Egara* and *Aquae Calidae*

In the interest of the efficiency and therefore not duplicate unnecessary work, these analyses will be developed profiting all the quantitative and qualitative data provided by the scholar's, whether from doctoral theses or from further synthesis works related to landscape evolution and wine-growing economy in this territory during the Roman period or between 18th-20th centuries[51].

[51] PREVOSTI (1981a), (1981b); RIERA (1994); OLESTI (1995); PALET (1997); RUESTES (2002); FLÓREZ (2011); OLLER (2015); TELLO/BADÍA-MIRÓ/CUSSÓ/GARRABOU/VALLS (2008) p.1-42; TELLO & BADÍA-MIRÓ (2011), p.1-30; BADÍA-MIRÓ &TELLO (2013), p.1-31; BADÍA-MIRÓ &TELLO (2014), p.203-226.

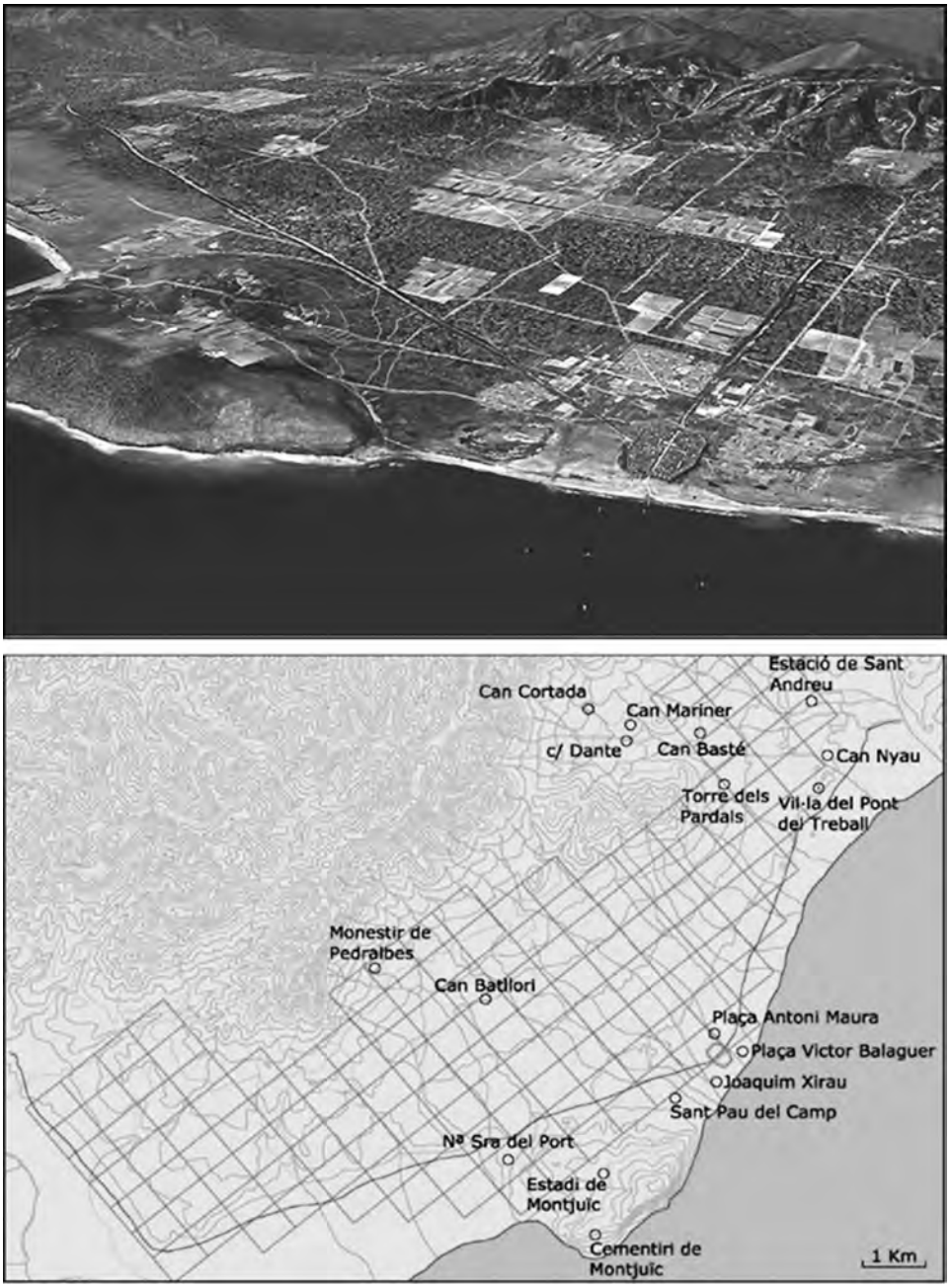


Figure 4. General view of *Barcino* Roman colony hinterland plain in the 3rd century AD- Image from *Barcino* 3D http://ajuntament.barcelona.cat/arqueologiabarcelona/pla-barcino/barcino3d. *Ager Barcinonensis centuriato* proposal from Palet, Julià, Riera, Orengo et al. (2012), p.341-352.

Work hypothesis

The amphoric studies carried out in recent decades and the suggestions put forward regarding how to interpret them make it possible to propose a chronocultural-evolutionary sequence of vitiviniculture in this territory during the Roman period from both perspectives, production and trade. We start with the premise that there are five main chronocultural phases of development, which we

consider correspond to the configuration of different agricultural and artisan production systems[52]:

- *Phase 1. Origins (½ 2nd C-½ 1st C BC):* First productions of *Citerior* amphoric containers imitating forms as Greco-Italic, Dressel 1A, 1B and 1C.
- *Phase 2. Expansion (½ 1st C BC-middle decades of 1st C AD*): The appearance of the first widely manufactured amphorae forms: *Tarraconense 1/Layetana 1* and *Pascual 1*, the latter being the first *Tarraconense* amphora intended for large scale trade. Appearance of first imitations of the Dressel 2-3 italic form.
- *Phase 3. Reorientation (middle decades of 1st C AD-end of 1st C AD):* Characterized by large-scale production of Dressel 2-3 *Tarraconense* amphorae form and *dolia* (big pottery jars) for the massive export of wine, both individually packaged and in bulk, mainly destined for the Italic Peninsula and the city of Rome itself.
- *Phase 4. Peak (early 2nd C AD-mid 3rd C AD):* Period when the production structures were transformed, probably connected to the export of wine in bulk in other types of containers such as *cupae* (barrels) and *culleii* (wineskins), and possibly as a consequence of having to reduce costs when supplying heavily-used, strongly competitive markets.
- *Phase 5. Decline (½ 3rd C AD-early 5th V AD):* Crisis and the end of viticulture for export? The phenomenon could be due to the appearance of new producers with much lower costs, which would imply a change in market orientation. The vitivinicultural centres are restructured to carry out other agrarian activities or were gradually abandoned.

Operational goals

- Inventory and catalogue all archaeological sites knew it in the different areas of study with presence of wine production structures between the 1st century BC and the 3rd century AD.
- Identify possible models or patterns that allow us to do a diachronic lecture of settlement tenancy and agricultural uses of land in the chronological period studied.
- Characterize a typology of paradigmatic settlements or "types" studying its productive structure and its evolution over the time for identifying possible economic models.
- Develop microeconomic studies of costs, benefit margins, and productive pricings to establish econometrical models (implies quantification).
- Calculate the population level and its fluctuations over the time, trying to identify the causes of its increases or decreases as regards the quantification of self-consumption needs and labour available.
- Establish possible geospatial and geoeconomic generic models that allow us to develop predictive /regressive/reconstructive models capable of being applied diachronically to any agrarian or artisan activity in ancient times.

Discussion and conclusions

The regional variability is one of the main points for understanding the changes in the rural settlement patterns of any historic ancient period.

---

[52] MARTIN i OLIVERAS (2015b), p. 199-207; cf. MIRÓ (1988), p. 210-226.

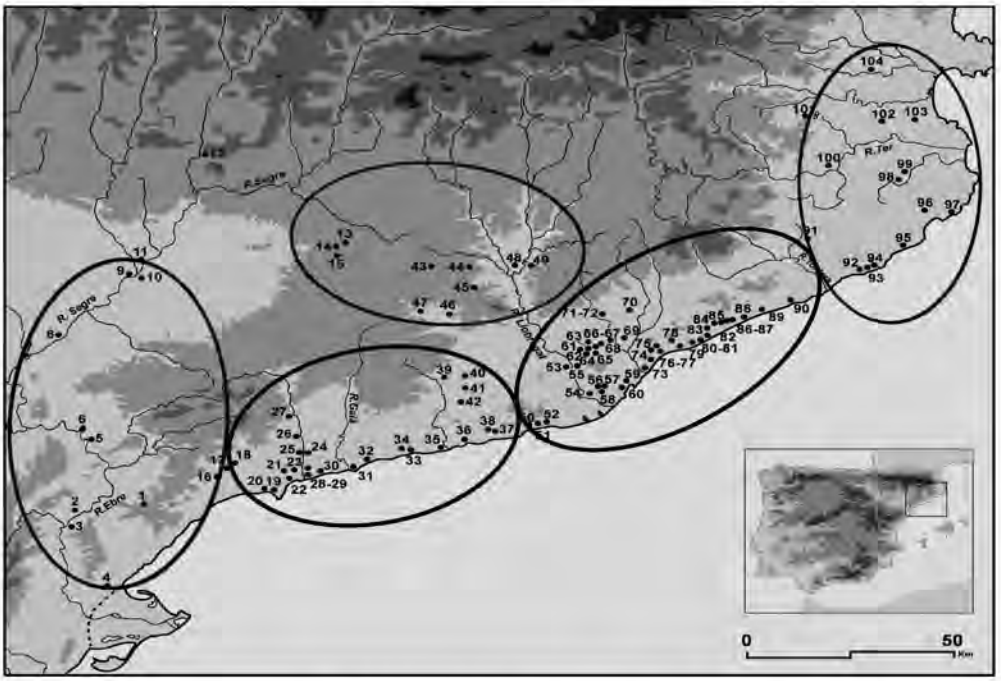
The specific interactions between the intra-regional and extra-regional economic networks were an important catalyst for the inception, development, and expansion of Roman viticulture phenomenon in the *regio Laeetana* between the 1st century BC and the 3rd century AD.

The application of economic theory could be an important tool to calculate production costs on the study of different systems of production, packing, shipment and distribution of wine. The evolution of supply and demand is determined by changes in consumption and in markets. Thus, a change of commercial orientation necessarily implies changes in the production system as well as in the system of transport and distribution of the product.

Demographic studies can also help us to calculate the amount of population, its distribution and its fluctuations over the time, trying to identify the causes of increases or decreases as regards the quantification of self-consumption needs and labour available.

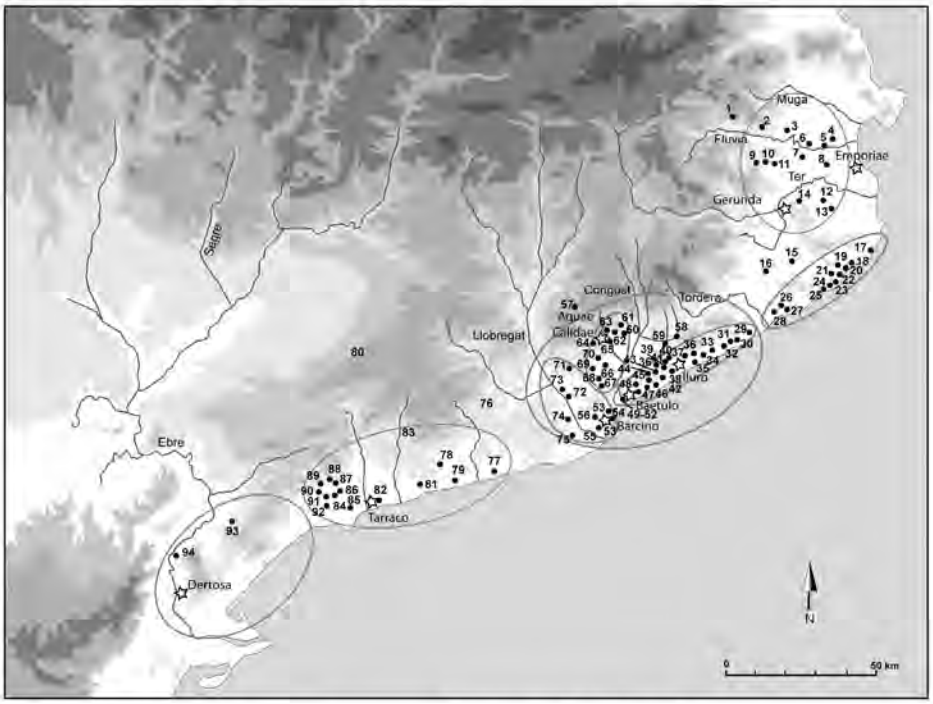
The level of dependency of rural population from a given area to the regional markets and the urban centres and its later expansion to external markets, in our case of study western Europe, Italic peninsula and the city of Rome itself, are responding to a series of patterns and socioeconomic behaviour that could be analysed by economic and econometric models.

The wide utilization of mathematics, statistics and linear programming models allows us to analyse, interpret and make predictions, regressions and reconstructions about the evolution of an ancient economic system, in relation with potential calculation of crop yields, the consumption level, the productive surplus susceptible of being traded in external markets and the study of several variables as the sales prices, the market reactions, the production trade and transportation costs, the business tendency and the consequences of economic policies in the sociopolitical affairs.



1. L'Aumedina (Tivissa)
2. Emportells (Benissanet)
3. Mas del Catxorro (Benifallet)
4. Camarles (Camarles)
5. La Fontjoana (Vinebre)
6. Pradell (Flix)
7. El Bovalar (Serós)
8. Gebut (Soses)
9. Secà del Colo-Tossal del Moro (Corbins)
10. Cantaperdius (Bellvis)
11. Hostal Nou (Balaguer
12. La Colomina (Talarn)
13. *Iesso* / Guissona
14. Vinya del Crispí (Guissona)
15. Els Vilassos (Tarroja de Segarra)
16. Velòdrom (Mont-Roig del Camp)
17. Hort del Pelat (Riudoms)
18. Molins Nous (Riudoms)
19. La Burguera (Salou)
20. Urbanització El Mirador (Salou)
21. La Canaleta (Vila-Seca)
22. La Pineda/Cal·lipolis (Vila-Seca)
23. Els Aragalls (Vila-Seca)
24. Centcelles (Constantí)
25. Mas de Bosch (Constantí)
26. Vil·la *Dow Chemical* (La Pobla de Mafumet)
27. La Malacuca (Els Garidells)
28. *Tarraco* / Tarragona
29. Vil·la del Parc Central (Tarragona)
30. Vil·la Ceratònia (Tarragona)
31. Els Munts (Altafulla)
32. La Clota (Creixell)
33. El Vilarenc (Calafell)
34. Creu de Coma-ruga (El Vendrell)
35. La Solana (Cubelles
36. Darró (Vilanova i la Geltrú)
37. El Bosquet (Sant Pere de Ribes)
38. Garrofer de la Cisterna (St Pere Ribes)
39. Cal Posastre (Sant Martí Sarroca)
40. Can Cotoliu (Vilobí del Penedès)
41. La Rectoria (Pacs)
42. Mas Castellar (Els Monjos)
43. Coromines (Aguilar de Segarra)
44. Sant Amanç (Rajadell)
45. Vilaclara (Castellfollit del Boix)
46. L'Espelt (Òdena)
47. La Fogonussa (Sant Martí de Maldà)
48. La Feliua (Sant Fruitós del Bàges)
49. Sant Bartomeu (Navarcles)
50. Castell (Castelldefels)
51. Ermita de Sales (Viladecans)
52. La Roca (Gavà)
53. Ca l'Espluga (Pallejà)
54. Cornellà
55. Can Pedrerol (Castellbisbal)
56. Carretera Reial (St.J.Desvern-St.J.Despí)
57. Urb. Torreblanca (St.Just Desvern)
58. Ermita del Bon Viatge (St.Joan Despí)
59. Carrer Salses-Can Cortada (Barcelona)
60. *Barcino* / Barcelona
61. Can Bosch (Terrassa)
62. Torrebonica (Terrassa)
63. Can Solà del Racó (Matadepera)
64. Can Feu (Sant Quirze del Vallés)
65. Poble Sec (Sant Quirze del Vallés)
66. La Salut (Sabadell)
67. Can Roqueta (Sabadell)
68. Can Marata (Polinyà)
69. Camí Serra Can Valls (P-Solità i Plegamans)
70. Can Terrés (La Garriga)
71. Can Valls (Caldes de Montbui)
72. Mas Manolo (Caldes de Montbui)
73. *Baetulo* / Badalona
74. Can Riviere (Badalona)
75. Sentromà (Tiana)
76. Hort del Magre (Alella)
77. Hort d'en Parera (Alella)
78. Veral de Vallmora (Teià)
79. Cal Ros de les Cabres (El Masnou)
80. Partida Fosses Clotes (Teià-Premià de Mar)
81. Horta Farrerons (Premià de Mar)
81bis. Can Nolla-Sta.Anna (Premià de Dalt)
82. La Muralla (Vilassar de Mar)
83. La Peirota (Cabrera de Mar)
84. Can Bartrina (Argentona)
85. Parc Central (Mataró)
86. Can Rafart (Mataró)
87. Cirera (Mataró)
88. Torrent Forcat (Mataró)
89. Can Sans (St.Andreu Llavaneres)
90. El Moré (Sant Pol de Mar)
91. Hort d'en Bach (Maçanet Selva)
92. Mas Carboti (Tossa de Mar)
93. Ses Alzines (Tossa de Mar)
94. Els Ametllers (Tossa de Mar)
95. Pla de Palol (Platja d'Aro)
96. Vilarenys (Vall-llobrega)
97. Llafranc (Palafrugell)
98. Santa Cristina (Corçà)
99. Puig Rodon (Corçà)
100. Pla d'Horta (Sarrià de Ter)
101. Vilauba (Camós)
102. Camp del Bosquet (Camallera)
103. Els Tolegassos (Viladamat)
104. Font del Vilar (Avinyonet de Puigventós).

Map 1. Wine production centres or *torcularia* in the Catalonian area according to V. Revilla (2004a), only includes those archaeological sites where the presence of winemaking production or storage structures was confirmed.



1-Sant Aniol de Finestres (Garrotxa)
2- El Forn de l'Home Dret (Maià de Montcal, Garrotxa)
3- Camí de Can Miró (Navata, Alt Empordà)
4- La Bomba (Vilamacolum, Torroella de Fluvià, Alt Empordà)
5- Clos Miquel (Sant Miquel de Fluvià, Alt Empordà)
6- Mas Castellar (Pontós, Alt Empordà)
7- Camp dels Recs (Orriols, Bàscara, Alt Empordà)
8- Camí a la Creu d'Albons (Viladamat, Alt Empordà)
9- Vilauba (Camós, Pla de l'Estany)
10- Ermedàs (Cornellà del Terri, Pla de l'Estany)
11- Palol de Revardit (Pla de l'Estany)
12- El Viaró (Rupià, Baix Empordà)
13- Puig Rodon (Corçà, Baix Empordà)
14- Can Cornellà (Celrà, Gironès)
15- Massanet de la Selva (Gironès)
16- Llagostera (Gironès)
17- Llafranc (Palafrugell, Baix Empordà)
18- Vilarenys (Vall-llobrega, Baix Empordà)
19- Palamós (Baix Empordà)
20- El Collet de Sant Antoni (Calonge, Baix Empordà)
21- Cap Roig (Calonge, Baix Empordà)
22- Solius (Castell-Platja d'Aro, Baix Empordà)
23- Can Llovarons (Castell-Platja d'Aro, Baix Empordà)
24- S'Agaró (Castell-Platja d'Aro, Baix Empordà)
25- La Caleta (Sant Feliu de Guixols, Baix Empordà)
26- Vinya Badosa (Tossa de Mar, La Selva)
27- Els Ametllers (Tossa de Mar, La Selva)
28- Fenals (Lloret de Mar, La Selva)
29- Can Viader (Malgrat de Mar, Maresme)
30- El Roser o El Mujal (Calella, Maresme)
31- El Moré (Sant Pol, Maresme)
32- Torre Martina o el Farrel (Sant Pol, Maresme)
33- El Sot del Camp (Sant Vicenç de Montalt, Maresme)
34- Horta Nova (Arenys de Mar, Maresme)
35- El Morrel (Llavaneres, Maresme)
36- Les Casetes (Mataró, Maresme)
37- Santa Cecília (Mataró, Maresme)
38- Torre Llauder (Mataró, Maresme)
39- Can Portell (Argentona, Maresme)
40- Sant Sebastià (Argentona, Maresme)
41- Ca l'Arnau (Cabrera de Mar, Maresme)
42- Veïnat del Sant Crist (Cabrils, Maresme)
43- La Fornaca (Vilassar de Dal, Maresme)
44- Veral de Vallmora (Teià, Maresme)
45- Club Tennis Barcelona (Teià, Maresme)
46- Riera de Teià (El Masnou, Maresme)
47- Cal Ros de les Cabres (El Masnou, Maresme)
48- Alella-Autopista (Alella, Maresme)
49- Can Riviére (Badalona, Barcelonès)
50- Can Cabanyes (Badalona, Barcelonès)
51- Can Valls (Badalona, Barcelonès)
52- Badalona (Barcelonès)
53- Avinguda Francesc Cambó (Barcelona, Barcelonès)
54- Carrer Princesa (Barcelona, Barcelonès)
55- Estadi de Montjuïc (Barcelona, Barcelonès)
56- Nostra Senyora del Port (Barcelona, Barcelonès)
57- Cal Roc (Boades, Bages)
58- Forn d'en Serra (Llinars del Vallès, Vallès Oriental)
59- Can Collet (Llinars del Vallès, Vallès Oriental)
60- Can Cabot (Santa Eulàlia de Ronçana, Vallès Oriental)
61- Can Vendrell (Santa Eulàlia de Ronçana, Vallès Oriental)
62- Sant Miquel dels Martres (Caldes de Montbui, Vallès Oriental)
63- Can Carerac (Caldes de Montbui, Vallès Oriental)
64- Carrer Balmes/carrer Espartero (Caldes de Montbui, Vallès Occidental)
65- Mas Manolo (Caldes de Montbui, Vallès Oriental)
66- Camp d'en Ventura de l'Oller (Santa Perpètua de Mogoda, Vallès Occidental)
67- Santa Maria de les Feixes (Cerdanyola del Vallès, Vallès Occidental)
68- Poble Sec (Sant Quirze del Vallès, Vallès Occidental)
69- Can Feu (Sant Quirze del Vallès, Vallès Occidental)
70- La Salut (Sabadell, Vallès Occidental)
71- Can Jofresa (Terrassa, Vallès Occidental)
72- Can Tintorer (El Papiol, Baix Llobregat)
73- Can Pedrerol (Castellbisbal, Vallès Oriental)
74- Can Reverter o can Perals (Sant Vicenç dels Horts, Baix Llobregat)
75- Vila Vella (Sant Boi del Llobregat, Baix Llobregat)
76- Sant Martí Sarroca (Alt Penedès)
77- Darró (Vilanova i la Geltrú, Garraf)
78- Tomoví (Albinyana, Baix Penedès)
79- El Vilarenc (Calafell, Baix Penedès)
80- Plans d'en Jori (Montblanc, Conca de Barberà)
81- La Clota o el Rincón del César (Creixell, Tarragonès)
82- Tarraco (Tarragonès)
83- El Burguet (Alcover, Alt Camp)
84- Les Planes del Roquis (Reus, Baix Camp)
85- Els Antigons (Reus, Baix Camp)
86- El Vilar (Reus, Baix Camp)
87- La Buada o l'Espluga Pobra (Reus, Baix Camp)
88- El Brugar (Reus, Baix Camp)
89- Mas del Coll (Riudoms, Baix Camp)
90- Mas de l'Antoni Corts (Riudoms, Baix Camp)
91- Tímba del Castellot (Riudoms, Baix Camp)
92- Molins Nous (Riudoms, Baix Camp)
93- L'Aumedina (Tivissa, Ribera d'Ebre)
94- Mas del Catxorro (Benifallet, Baix Ebre)

Map 2. Pottery workshops or *figlinae* in the Catalonian area according to J. Tremoleda (2008) only includes those archaeological sites with evidences of wine pottery containers production: *amphorae et dolia*.

ALCUBIERRE, D., HINOJO, E. & RIGO, A. (2015): Primers resultats de la intervenció a la vil·la romana del Pont del Treball a Barcelona, in Tribuna d'Arqueologia 2012-2013, Departament de Cultura, Generalitat de Catalunya, Barcelona, 372-398.

ALCUBIERRE, D., ARDIACA, J., ARTIGUES, P. Ll. & LLOBET, S. (2016): Resultats preliminars de la nova intervenció arqueològica a la vil·la romana del Pont del Treball a Barcelona, in Tribuna d'Arqueologia 2013-2014, Departament de Cultura, Generalitat de Catalunya, Barcelona (in press).

AMOURETTI, M.C. & BRUN, J-P. (1993): Les Rendements, in M. C. Amouretti y J.-P. Brun (eds.), La production du vin et de l'huile en Méditerranée, Bulletin de Correspondance Hellénique. Supplément 26, Ed. École Française d'Athènes, Atenas-Paris, 551-562.

BADÍA-MIRÓ, M., TELLO, E. (2013): An agency-oriented model to explain vine-growing specialization in the province of Barcelona (Catalonia, Spain) in the mid-nineteenth century in Documents de Treball de la Facultat d'Economia i Empresa. Col·lecció d'Economia E13/290, Universitat de Barcelona, Barcelona, 1-31.

BOWMAN, A. & WILSON, A. (eds.) (2009): Quantifying The Roman Economy. Methods and Problems. Oxford Studies on the Roman Economy. Oxford University Press, Oxford.

BOWMAN, A. & WILSON, A. (eds.) (2013): The Roman Agricultural Economy: Organization, Investment and Production, Oxford Studies on the Roman Economy. Oxford University Press, Oxford.

BRUN, J-P. (2004a): Archéologie du vin et de l'huile. De la préhistoire à l'époque hellénistique, Ed. Errance, Paris.

BRUN, J-P. (2004b): Archéologie du vin et de l'huile dans l'Empire romain, Ed. Errance, Paris.

BURCH, J. et al. (2005): El fundus de Turissa entre el segle I aC i l'I dC. Arqueología de dos establiments rurals. Mas Carbotí i Ses Alzines, Girona.

CASTILLO, M. J. (1996): Espacio en orden: el modelo gromático-romano de ordenación del territorio. Universidad de La Rioja, Logroño.

CARANDINI, A. (1989): La villa romana e la piantagione schiavistica, in Storia di Roma 4, Caratteri e morfologie, Turín, 101-192.

CARRERAS, C. (1996): A new perspective for the demographic study of Roman Spain in Revista da Historia da Arte e Arqueologia 2, 1995-1996, Campinas, 59-82.

CARRERAS, C. (2014): Nuevas tendencias y datos sobre la demografía romana en la Península Ibérica, in Boletín del Seminario de Estudios de Arqueología, LXXX, Universidad de Valladolid, Valladolid, 53-82.

CONISON, A. (2012): The Organization of Rome's Wine Trade, University of Michigan, Ann Arbor, Ph-D Thesis.

DUNCAN-JONES, R. (1974): The Economy of the Roman Empire, Cambridge University Press, Cambridge, 33-59.

FINLEY, M. I. (1973): The Ancient Economy, University of California Press, Berkeley.

FLÓREZ, M. (2011): Dinàmica del poblament i estructuració del territori a la Laietània interior. Estudi del Vallès Oriental de l'Època Ibèrica fins a l'alta Edat Mitjana, Universitat Autònoma de Barcelona, Ph-D Thesis, Bellaterra.

GREENE, K. (1990): The archaeology of the Roman economy. University of California Press. Berkeley-Los Angeles.

HOPKINS, K. (1978): Economic growth and towns in classical Antiquity, in P. Abrams y E. A. Wrigley (eds.) (1978), in Towns in Societies, Cambridge, 35-79.

JONES, A. H. M. (1974): The Roman economy: Studies in ancient economic and administrative

history, P.A. Brunt (ed.), Oxford University, Oxford.
JONES, D. W. (2014): Economic Theory and the Ancient Mediterranean, Wiley-Blackwell, Hoboken-New Jersey.
LÓPEZ MULLOR, A. & MARTÍN MENÉNDEZ, A. (2008b): Las ánforas de la Tarraconense, in D. Bernal & A. Ribera (eds.), Cerámicas hipanorromanas. Un estado de la cuestión, Cádiz, 689-724.
MARTÍN i OLIVERAS, A. (2009): Parc Arqueològic Cella Vinaria (Teià-Maresme-Barcelona) Descobrint el celler romà de Vallmora, in M. Prevosti & A. Martín Oliveras (eds). El Vi Tarraconense i Laietà. Ahir i Avui. Actes del Simposi, Institut Català d'Arqueologia Clàssica, Documenta 7, Tarragona, 193-213.
MARTÍN i OLIVERAS, A. (2011-2012): Arqueología del vino en época romana: el proyecto cella vinaria y el complejo vitivinícola de Vallmora (Teià - Maresme – Barcelona). Nuevas aportaciones a la investigación, in J. M. Noguera & J. A. Antolinos (eds.), De vino et oleo Hispaniae. Áreas de producción y procesos tecnológicos del vino y el aceite en la Hispania romana. Coloquio Internacional, Anales de Prehistória y Arqueologia, 27-28, Murcia, 101-127.
MARTÍN i OLIVERAS, A. (2012): Anàlisi tecnofuncional d'estructures productives i vitivinícoles d'època romana. Identificació i localització a Catalunya de fosses de maniobra de premses de biga amb contrapès tipus arca lapidum, in Pyrenae, 43/2, Universitat de Barcelona, Barcelona, 59-98.
MARTÍN i OLIVERAS, A., (2015a): Arqueología del Vino en Época Romana: Teoría económica, lógica productiva y comercial aplicada al envasado, la expedición, el transporte y la distribución de ánforas vinarias del nordeste peninsular (s. I a.C.-I d.C.), in V. Martínez Ferreras (ed.) La difusión Comercial de las Ánforas Vinarias de Hispania Citerior Tarraconensis (s.I aC-I dC), Roman Archaeology, 4, Oxford, 19-38.
MARTÍN i OLIVERAS, A. (2015b): Arqueologia del vi a l'època romana. Del cultiu al consum. Marc teòric i epistemològic, Premi d'Arqueologia Memorial Josep Barberà i Farràs (12a edició), Ed. Societat Catalana d'Arqueologia, Barcelona.
MARTÍN i OLIVERAS, A. (2015c): Arqueologia del vi a l'època romana. Del cultiu al consum. Aspectes ideològics i qualitatius, in Revista Auriga, 79, Barcelona, 22-25.
MARTÍN i OLIVERAS, A. & BAYÉS, F. (2009): Cella Vinaria de Vallmora (Teià-Maresme-Barcelona). Estudi per la reconstrucció de dues premses romanes, in M. Prevosti y A. Martín i Oliveras (eds.), El vi tarraconense i laietà. Ahir i avui. Actes del Simposi, Tarragona-Teià, Ed. Institut Català d'Arqueologia Clàssica-ICAC, Documenta 7, Tarragona, 215-248.
MARTÍN-ARROYO, D. J. (2016): Modelización de la ratio riparia/vinea: El emparrado romano entre Hasta Regia y Gades, in L. G. Lagóstena (ed.), Lacus autem idem et stagnus, ubi inmensa aqua convenit. Estudios Históricos sobre Humedales en la Bética (II), Cádiz, 105-124.
MARX, K., MOORE, S., AVELING, E. B., ENGELS, F. & UNTERMANN, E. (1906): Capital, a critique of political economy, The Modern Library, Nueva York.
MIRET, M., SANMARTÍ, J. & SANTACANA, J. (1991): From indigenous structures to the Roman world: Models for the occupation of central coastal Catalonia, in G. Barker & J. Lloyd (eds.), Roman Landscapes. Archaeological survey in the Mediterranean region, London, 47-53.
MIRÓ, J. (1988): La producción de ánforas romanas en Catalunya. Un estudio sobre el comercio del vino de la Tarraconense (siglos I a.C.-I d.C.), BAR International Series 488, Oxford.
MOMMSEN, T. (1862): The history of Rome, Londres.
MADDALA, G. S. (1985): Econometría, McGraw-Hill (Ed.), México.
MAZA, D. F. & GONZÁLEZ, A. J. (1992): Tratado de Economía Moderna, Ed. Panapo, Caracas.
MORLEY, N. (1996): Metropolis and hinterland: the city of Rome and the Italian economy 200 B.C. – A.D.200. Cambridge: Cambridge UP.
OLESTI, O. (1995): El territori del Maresme en època republicana (s. III-I aC): Estudi d'arqueomorfologia i història, Caixa d'Estalvis Laietana, Premi Iluro 1994, Mataró.

OLESTI, O. (2006): Propiedad de la tierra y élites locales. El ejemplo del ager Barcinonensis, in A. Gonzalès et al. (eds.), Histoire, Espaces et Marges de l'Antiquité: Hommages à Monique Clavel-Lévêque, vol. 4, Besançon, 175-200.
OLESTI, O. (2009): Propietat i riquesa a l'ager Barcinonensis, in C. Carreras & J. Guitart (eds.), Barcino I. Marques i terrisseries d'àmfores al Pla de Barcelona, Barcelona, 141-158.
OLESTI, O. & CARRERAS, C. (2012): Esclavos y libertos en la producción vinícola y alfarera en el Ager Barcinonensis: De la marginalidad al éxito económico, in F. Reduzzi Merola (ed.), Dependenza ed emarginazione nel mondo antico e moderno. Atti del 33 Convegno G.I.R.E.A., Nápoles, 309-333.
OLESTI, O. & CARRERAS, C. (2013) : Le paysage social de la production vitivinicole dans l'ager Barcinonensis, in Dialogues d'Historie Ancienne, 39/2, Presses universitaires de Franche-Comté, Besançon, 147-189.
OLLER, J. (2015): El territorio y poblamiento de la Layetania interior en época antigua (ss. IV a.C-I d.C). Col·lecció Instrumenta, 51, Universitat de Barcelona, Barcelona.
PALAHÍ, Ll. & NOLLA, J.Mª. (2010): Felix Turissa. La vil·la romana dels Ametllers i el seu fundus (Tossa de Mar, la Selva). Documenta 12, Institut Català d'Arqueologia Clàssica, Tarragona.
PALET, J.M. (1997): Estudi territorial del Pla de Barcelona. Estructuració i evolució del territori entre l'època ibero-romana i l'altmedieval. Segles II/I aC-IX/X dC, Universitat de Barcelona, Ph-D Thesis, Barcelona.
PALET, J.M., FIZ, J.L. & ORENGO, H.A. (2009): Centuriació i estructuració de l'ager de la Colònia de Barcino: Anàlisi arqueomorfològica i modelació del paisatge, in Quaderns d'Història i Arqueologia de la Ciutat de Barcelona 5, Barcelona, 106-123.
PALET, J.M., JULIÀ, R., RIERA, S., ORENGO, H.A., PICORNELL, L. & LLERGO, Y. (2012): The role of the Montjuïc promontory (Barcelona) in landscape change: Human impact during Roman times, in Bertoncello, F.; Braemer, F. (eds.). Variabilites environnementales, mutations sociales: Nature, intensités, échelles et temporalités des changements, Éditions APDCA, CNRS, Antibes, 341-352.
PALET, J.M., ORENGO, H.A. & RIERA, S. (2011): Centuriación del territorio y modelación del paisaje en los llanos litorales de Barcino y Tarraco. Una investigación Interdisciplinar a través de la integración de datos arqueomorfológicos y paleoambientales, in Dall'aglio, P.L.; Rosada, G. (eds.). Agri Centuriati-International Journal of Landscape Archaeology, Sistemi Centuriali e Opere di Assetto Agrario tra Età Romana e primo Medioevo. Atti del convegno borgoricco (Padova)-Lugo (Ravenna), 113-129.
PEÑA, Y. (2010): Torcularia. La producción de vino y aceite en Hispania, Institut Català d'Arqueologia Clàssica, Documenta 14, Tarragona.
PEÑA, Y. (2011-2012): Variantes tecnológicas hispanas en los procesos de elaboración de vino y aceite en época romana, in J. M. Noguera & J. A. Antolinos (eds.), De vino et oleo Hispaniae, Áreas de producción y procesos tecnológicos del vino y el aceite en la Hispania romana. Coloquio Internacional, Anales de Prehistoria y Arqueologia, Murcia, 37-57
PERKINS, P. (1999): Etruscan settlement, society and material cultura in central coastal Etruria. Oxford: BAR International Series, 788.
PREVOSTI, M. (1981a): Cronologia i poblament de l'àrea rural de Baetulo, in Monografies Badalonines 3, Badalona.
PREVOSTI, M. (1981b): Cronologia i poblament de l'àrea rural d'Iluro. Caixa d'Estalvis Laietana, Premi Iluro 1980, Vol. I-II, Mataró.
PREVOSTI, M. (2005): L'època romana, in E. Giralt (dir.), Història agrària dels Països Catalans, vol. I, L'antiguitat, J. Guitart (coord.), Universitat de Barcelona, Barcelona, 345-445.
PULIDO, A. (1987): Modelos econométricos Ed. Pirámide. Madrid.

PEDACE, R. (2014): 10 Components of a Good Econometrics Research Project, in Econometrics for Dummies. Wiley (ed), New Jersey, 307-314.
REMESAL, J. (1990): El sistema annonario como base de la evolución económica del Imperio romano, in Le commerce maritime romain en Méditerranée occidentale, PACT 27, Ed. T. Hackens & M. Miró, Barcelona, 355-367.
REVILLA, V. (1995): Producción cerámica, viticultura y propiedad rural en Hispania Tarraconensis (siglos I a.C.-III d.C.), Barcelona.
REVILLA, V. (1998): Modelos económicos y modelos culturales en una sociedad provincial romana: El vino en Hispania, Boletim do CPA 5/6, Campinas, 181-202.
REVILLA, V. (2004a): Ánforas y epigrafía anfórica en Hispania Tarraconensis, in J. Remesal (ed.), Epigrafía anfórica, Publicacions de la Universitat de Barcelona, Barcelona, 159-196.
REVILLA V. (2004b): El poblamiento rural en el noreste de Hispania entre los siglos II a.C. y I d.C.: organización y dinámicas culturales y socioeconómicas, in P. Moret & T. Chapa (eds.), Torres, atalayas y casas fortificadas. Explotación y control del Territorio en Hispania (S. III a. de C. – S. I d. de C.), Jaén, 175-202.
REVILLA, V. (2008): La producción anfórica en el sector meridional de Cataluña: prácticas artesanales, viticultura y representaciones culturales, in La producció i el comerç de les àmfores de la provincia Hispania Tarraconensis. Homenatge a Ricard Pascual i Guasch (Barcelona, 17 i 18 de novembre de 2005), Museu d'Arqueologia de Catalunya, Monografies 8, MAC-Barcelona, Barcelona, 189-226.
REVILLA, V. (2010a): Hábitat rural y territorio en el litoral oriental de Hispania Citerior: perspectivas de análisis, in J. M. Noguera (dir), El poblamiento rural romano en el sureste de Hispania. 15 años después, Ediciones de la Universidad de Murcia, Murcia, 20-75.
REVILLA V. (2010b): Rural Settlement in the central littoral area and the interior regions of Catalonia in the 1st and 2nd centuries BC, in Time of Changes. The beginning of the Romanization, Studies on the rural world in the Roman period 5, Girona, 139-159.
REVILLA, V. (2011-2012): Viticultura, territorio y hábitat en el litoral nororiental de Hispania Citerior durante el Alto Imperio, in J. M. Noguera & J. A. Antolinos (eds.), De vino et oleo Hispaniae, Áreas de producción y procesos tecnológicos del vino y el aceite en la Hispania romana. Coloquio Internacional, Anales de Prehistoria y Arqueologia 27-28, Murcia, 67-83.
REVILLA, V., GONZÁLEZ, J. R. & PREVOSTI, M: (eds.), (2008-2011): Actes del Simposi Les vil·les romanes a la Tarraconense. Implantació, evolució i transformació. Estat actual de la investigació del món rural en època romana (Lleida, 28-30 novembre 2007), 2 vols, Barcelona.
RIERA, S. (1994): Evolució del paisatge vegetal Holocè al pla de Barcelona a partir de les dades pol·liníques, Universitat de Barcelona, Ph-D Thesis, Barcelona.
RIZZO, G. (2014): Ostia VI. Le Terme del Nuotatore. Le anfore, Ostia e i commerci mediterranei, en C. Panella & G. Rizzo, Ostia VI. Le Terme del Nuotatore, Studi Miscellanei 38, Roma, 65-481.
RODÀ, I., MARTÍN i OLIVERAS, A., et al. (2005): Personatges de Barcino i el vi laietà. Localització d'un fundus dels Pedanii Clementes a Teià (El Maresme) a partir de la troballa d'un signaculum de plom amb inscripció (segle II dC), in Quarhis. Quaderns d'Arqueologia i Història de la ciutat de Barcelona, època II, núm. 1, Barcelona, 47-57.
ROSTOVTZEFF, M. I. (1926): The social and economic history of the Roman Empire, Oxford Clarendon Press, Oxford.
RUBIO, X. (2009): Modelització i simulació aplicades a la recerca i interpretació de camps de batalla, Universitat de Barcelona, Ph-D Thesis, Barcelona.
RUESTES, C. (2002): El poblament antic a la Laietània Litoral (del Besòs a la riera de Caldes): l'aplicació de un GIS (Sistema d'Informació Geogràfica), a l'estudi de la seva evolució i les seves relacions espacials. Universitat Autònoma de Barcelona, Ph-D Thesis, Bellaterra.

SÁNCHEZ, E. et al. (1997): El jaciment romà del Morè. Sant Pol de Mar, Maresme, Departament de Cultura, Generalitat de Catalunya, Barcelona.
SCHEIDEL, W., MORRIS, I. & SALLER, R. P. (ed.) (2008): The Cambridge Economic History of The Greco-Roman World, Cambridge University Press, Cambridge.
SMITH, W. (1875): Dictionary of Greek and Roman Antiquities: AGER in Lacus Curtius: http://penelope.uchicago.edu/Thayer/E/Roman/Texts/secondary/SMIGRA*/Ager.html, London.
TCHERNIA, A. & BRUN, J-P. (1999): Le vin romaine antique, Ed. Glénat, Grenoble.
TELLO, E., BADÍA-MIRÓ, M., CUSSÓ, X., GARRABOU, R. & VALLS, F. (2008): Explaining vineyard specialization in the province of Barcelona (Spain) in the mid-19 century in Documents de Treball de la Facultat de Ciències Econòmiques i Empresarials. Col·lecció d'Economia E08/201, Universitat de Barcelona, Barcelona, 1-42.
TELLO, E., BADÍA-MIRÓ, M. (2011): Land-use profiles of agrarian income and land ownership inequality in the province of Barcelona in mid-nineteenth century, in Sociedad Española de Historia Agraria-Documentos de Trabajo, 11-01, Girona, 1-30.
TREMOLEDA, J. (2008): Les instal·lacions productives d'àmfores tarraconenses, in La producció i el comerç de les àmfores de la provincia Hispania Tarraconensis. Homenatge a Ricard Pascual i Guasch (Barcelona, 17 i 18 de novembre de 2005), Monografies del Museu Arqueològic de Catalunya 8, Barcelona, 113-150.
VERHAGEN, Ph. (2007): Case Studies in Archaelogical Predictive Modelling, in Archaeological Studies, Leiden University, Leiden.
VILCALPOMA, L. (1995): Teoría de la producción y costos. Una exposición didáctica, Documento de Trabajo 123, Universidad Católica del Perú, Lima, 1-45.
WEBER, M. (1891), (1982): Historia Agraria Romana, Ed. Akal, Madrid.

GIS-based Modelling for the *Riparia*/*Vinea* Ratio: from *Portus Gaditanus* to *Nabrissa Veneria*[1]

D. J. Martín-Arroyo Sánchez
EPNet Project-CEIPAC[2]-Universidad de Barcelona
M. del M. Castro García
Riparia Project[3]-Seminario Agustín de Horozco-Universidad de Cádiz

1. Introduction

Models are idealized representations of our assumptions. Here we deal with a Roman agrarian context in a specific delineated geographical area. However, the re-creation of rural settlement is secondary to the analysis of an agrarian formula, which is our principal goal. Focus on this modelling enables us to study the possibilities of the implantation of a Roman vine training system (the *uinea iugata*), dealing with the ideal self-sufficiency and the limitations in a simulated historical context. The starting point is a ratio given by *Columella* in order to supply osier-willow and reeds for the *iuga* in the vineyards, as bindings and cross-rails (Col. 4, 30, 2.). Other training systems could be adopted as well as other species, but advantages in productivity and the suitability of raw materials were related to this ratio. The main motivation would come from the viticulture itself as a lucrative activity.

---

[1] We are grateful to Nick Bennett-Britton for the English revision.
[2] EPNet (Production and Distribution of Food during the Roman Empire: Economics and Political Dynamics) (FP7/2007-2013)/ERC *grant agreement* nº 340828. http://www.roman-ep.net. The CEIPAC's research lines are supported too by the Project HAR2015-66771-P (MINECO/FEDER. UE).
[3] RIPARIA 2 La interacción histórica sociedad-medio ambiente: humedales y espacios lacustres de la Bética romana. MINECO. Programa Estatal de Fomento de la Investigación Científica y Técnica de Excelencia (HAR2016-77724-P).

The Punic tradition of vineyard without supports would be opposite to the Italian influence in the training of vines, a cultural difference attested by *Varro* and *Columella* (Varr. *R.* 1, 8, 1; Col. *Arb.* 4, 1.). Actually, *Columella*'s *De Re Rustica* and our study area are related. *Columella* was from *Gades*, a city with a remarkable Punic background but well integrated into the Roman world, as evidenced by its municipality. On the other hand, Italian migration is possibly linked to the promotion of the neighbouring city of *Hasta Regia* as a Roman colony. *Columella*'s work compiles data from several previous agronomists, from different periods and provenances. For example, the ratio *riparia*/*uinea* was taken from *Iulius Aticus*' work. In that sense, it is convenient to research which parts of his general schemes could have been effectively performed in a specific Roman region or other.

On this occasion, we have expanded the geographical framework from preceding issues (MARTÍN-ARROYO & TRAPERO 2015; MARTÍN-ARROYO 2016; MARTÍN, MARTÍN-ARROYO & REVILLA 2017, 216-218; MARTÍN-ARROYO & REMESAL 2018, from the original 73 archaeological sites to the current 225 sites. The goal is to improve the comparative analysis of Roman sites and zones with new different geographical and civic contexts.

2. Methodology

The geographical framework is divided into two zones: one of them from *Portus Gaditanus* to the *castellum* of *Ebora*, the other zone in the hinterland of *Nabrissa Veneria* (Fig. 1). The main factor in the selection of the former case study was the described relationship of Columela, *Gades* and its agrarian surrounding area. The choice of *Nabrissa* was given by some related evidence of ancient viticulture in its territory and the shores of the *lacus Ligustinus* (today the Doñana Marshlands, in the low Guadalquivir valley). *C. Silius Italicus* related the city name with the cult of Bacchus (Sil. 393.). The amphora type Dressel 7-11 is recorded for the archaeological site of Las Playas (Lebrija) (CARRERAS 2001: 424). This amphora type could have been used to transport grape-based products. The bunches of grapes in the coinage of the nearby city of *Orippo* (Torre de los Herberos, Dos Hermanas)(GARCÍA-BELLIDO 2001, 304-305) could be interpreted as evidence of a meaningful crop in the *lacus Ligustinus*' shore.

2.1. Space distribution

The first criterion of the delimitation for the study zones has been the spatial continuity of surveys[4]. We have avoided the empty spaces on the rural settlement record. Then we have created a Thiessen Polygons network that allows us to associate every site with a certain quantity of surrounding land (Fig. 2). Resulting Polygons on the border of the network were anomaly large because of the emptiness of sites beyond, so they were excluded. In order to determine which Polygons were affected by the "border of map effect", a simple criterion was established. All perimetric sites were linked by a line. All the Polygons cut by this line were considered affected by the exterior emptiness, so they were excluded. Coastal or marsh shores were established as a factor of delimitation for associated areas to sites. They avoided the border effect for an important number of sites (Fig. 2a).

[4] The related bibliography is quoted after each municipality involved in this work. Las Cabezas de San Juan: GARRIDO 2005. Chipiona: RIESCO 1987. El Cuervo, Sanlúcar de Barrameda and Jerez de la Frontera: PONSICH 1991. Lebrija: LINARES 2014. El Puerto de Santa María: LÓPEZ & PÉREZ 2013, 167, fig. 75. Rota: SÁNCHEZ 2010. Trebujena: GÓMEZ, RUÍZ, PÉREZ-AGUILAR & GUILLÉN 2014.

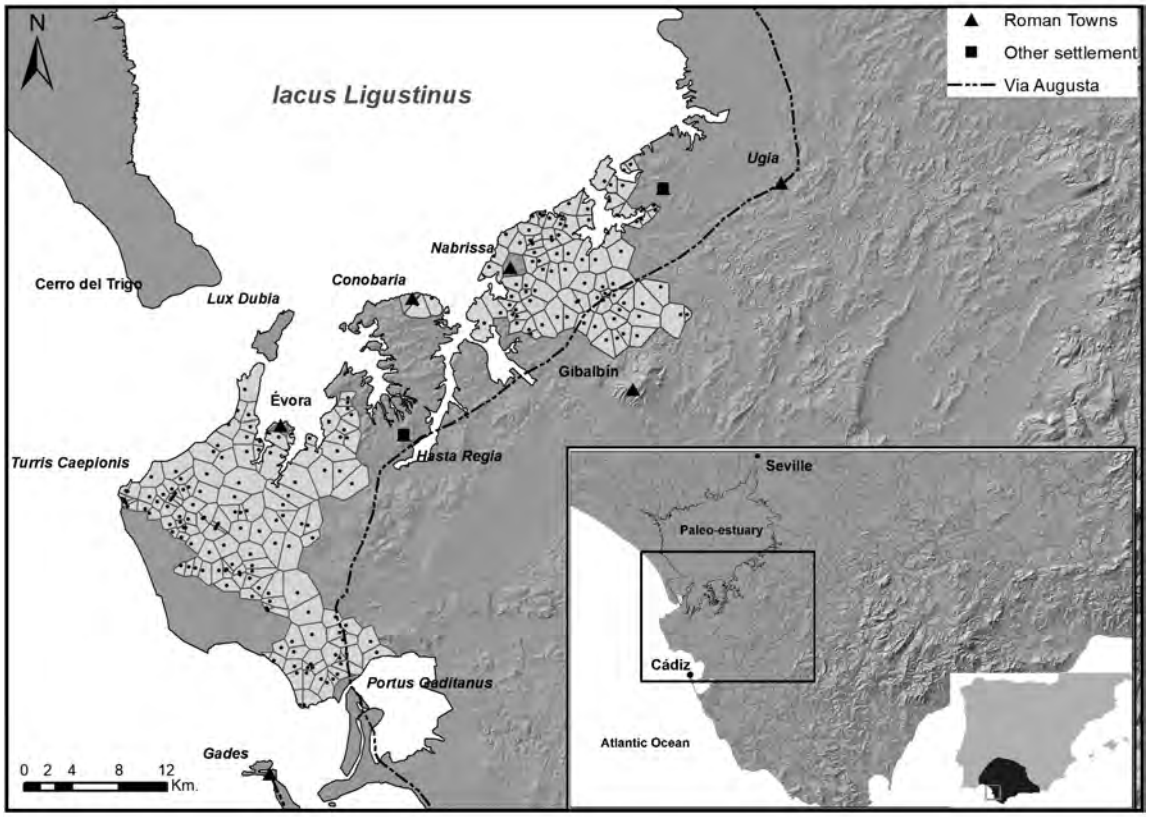


Figure 1. Geographical framework of the study zones.

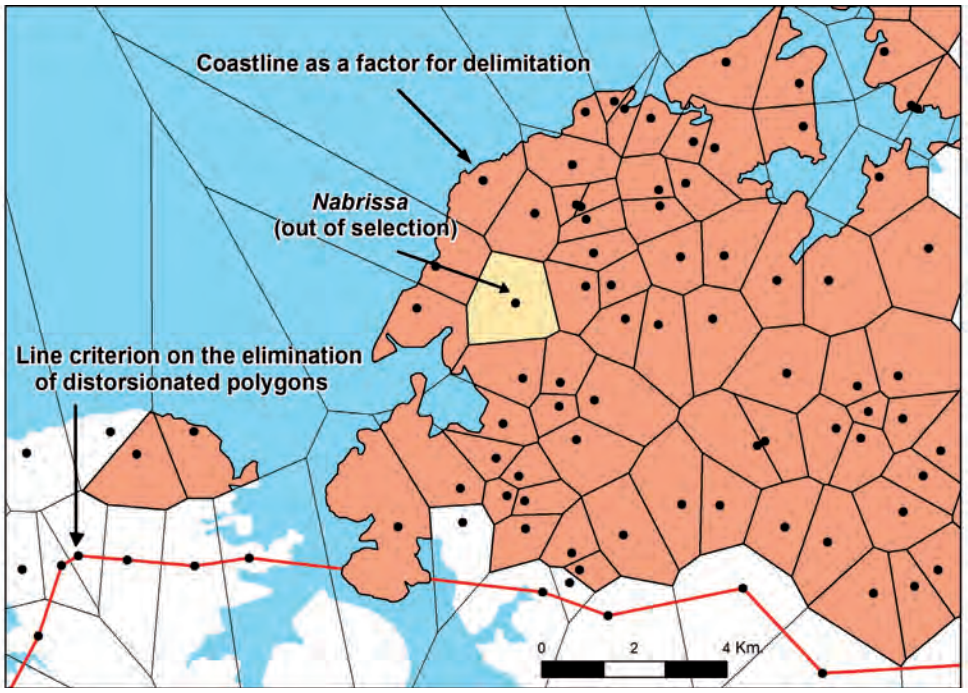


Figure 2a. Criteria of delimitation for the study zones. Selection of Thiessen Polygons.

The inland prolongation of marshes in the study area posed a problem because of the resulting spatial discontinuities inside the Polygons. In order to solve this, these pieces of land, separated from the original nucleus of their Polygons by marshes, were reintegrated into the neighbouring Polygons, on the other side of the marshes (Fig. 2b).

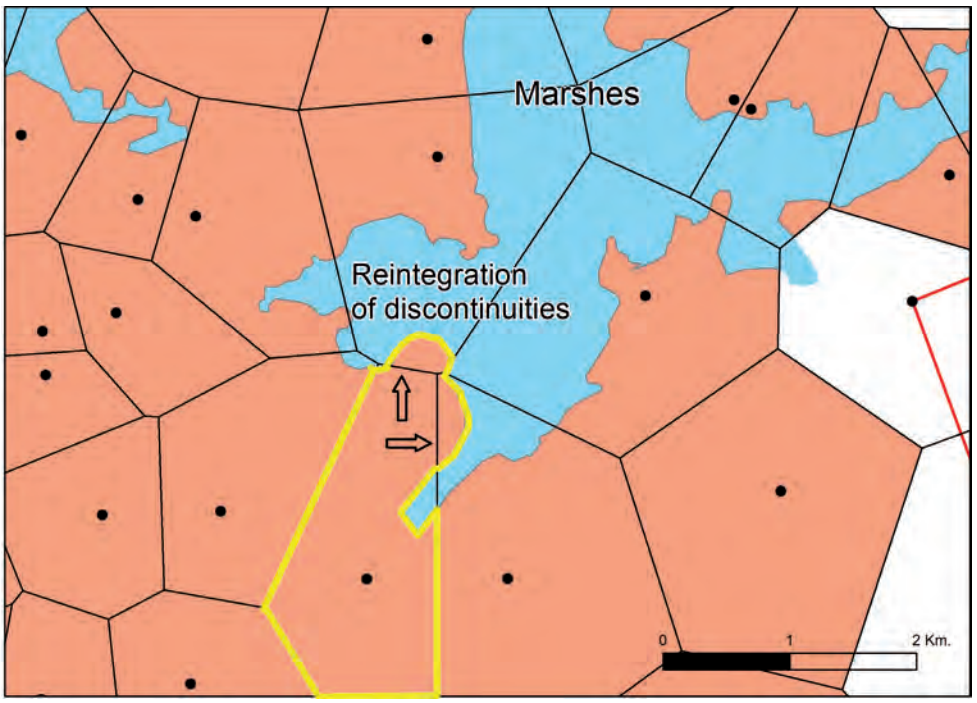


Figure 2b. Criteria of delimitation for the study zones. Marshes effect and the reintegration of discontinuities.

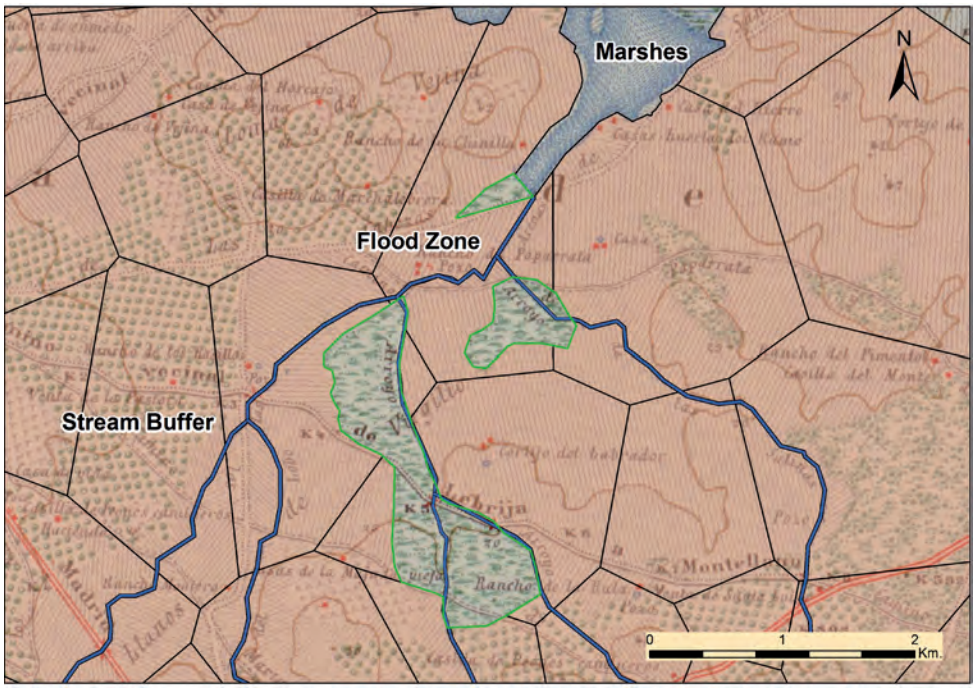


Figure 2c. *Riparia* land and borders of marshes.

2.2. Selection of sites

Some sites beyond the proposed coast-line have been removed[5]. They were probably piers or wrecks. Non-rural sites and their related Polygons have been removed too: *Portus Gaditanus*, *castellum Ebora* and *Nabrissa* (Fig. 1). The Polygon of *Ebora* was created by merging other Polygons related to the nearby sites of Évora, Cortijo de Évora and Évora Oeste. The remains of the ancient city of *Conobaria* are probably located in Cerro de las Vacas or under the current town of Las Cabezas de San Juan, respectively, to the Southwest and Northeast of *Nabrissa*. Both sites have been excluded. Other notable entities for the understanding of the historical context in the study area were the *colonia* of *Hasta Regia*, the *oppidum civium Latinorum* of *Ugia* and the *municipium* of *Gades*. Actually, *Portus Gaditanus* would be established in the territory of *Gades* beyond the Bay of Cádiz. Cerro del Trigo and Gibalbín were probably ancient cities too. Another notable feature was *Turris Caepionis*, an important lighthouse for navigation from the Atlantic coast to the *lacus Ligustinus*. The main axis of the terrestrial communication was the *via Augusta*.

Obviously, not all the selected sites were identical in chronology and size. Nevertheless, we may assume that most of the sites that provide evidence of late Roman settlement were established in an earlier period. Actually, the late Roman evidence of the survey of the land surface probably masks former remains. The floruit of this settlement would start in late republican times with the civic promotion of *Gades* and *Hasta Regia*. It would continue through the high imperial period with the establishment of the *via Augusta* and the *villae* system. For now, we will not deal with the problem of the size of the underground archaeological structures. Our study is focused on the relationship between resources and manpower with the surrounding land. We have considered the sites and their Polygons as units of farm activity. Other interpretations of the archaeological evidence, such as the status of owners or dwellers, remain for future research.

2.3. Modelization

The next step in this modelization was the delimitation of the *riparia* land (Fig. 2c). Paleoenvironmental studies are not available for our area in order to provide the required information. We have therefore used the German Map of 1940-1944[6] for drawing the hydrologic items. It depicts the territory before more recent transformations, caused by agricultural and urban development. This source is the older evidence on the identification of required flood zones, streams and lakes. The complete surface of flood zones has been taken as *riparia* land. For streams and lakes, buffers have been used along every shore. These buffers are 5,92 metres wide, based in a ratio given by *Columella* on the cultivation of these sorts of spaces (Col., 8, 15, 5. MARTÍN-ARROYO 2016, 118). The German Map has been used to delimit the shores of marshes in the Bay of Cádiz and the flood plain of the Guadalquivir (ancient *lacus Ligustinus*)[7].

Every site and its polygon were linked to a delineated surface of *riparia* and non-*riparia* land (Fig. 3)[8]. *Riparia* would be required for osier-willow and reed cultivation, as regards to *Columella*'s ratio. Reeds could be also cultivated on non-*riparia* land. Land required for the cultivation of woods is located in non-*riparia*, as a third crop for poles production, main supports within the training

[5] Las Playas and El Hornillo (Lebrija).

[6] Cartografía del Estado Mayor del Ejército Alemán, 1:50.000, 1940-1944 (MTA504_1944). Instituto de Estadística y Cartografía de Andalucía. http://www.ideandalucia.es/wms/mta50r_aleman_1944?

[7] On the *lacus Ligustinus*: MARTÍN-ARROYO 2012.

[8] We are very grateful to Jordi Pérez González for the TreeMaps in Figure 3.

system. Other statements from Latin agronomy allow us to define a self-sufficient system with some surplus provided for viticulture (MARTÍN-ARROYO & REMESAL 2018, 216-217). From these statements, the *iugerum* is the common unit of measurement, that is approximately a quarter of hectare (2523,3408 m^2). Seven *iugera* of vineyard required one worker for maintenance. To this non-*riparia* land must be added the space needed to supply the wheat annually consumed by the worker, and one extra piece of land for the reposition of seeds[9]. This arable area of land would be increased in order to set a triennial rotation system. This system would provide complementary food for the worker's diet or raw materials for the general maintenance of the farm (Fig. 3a).

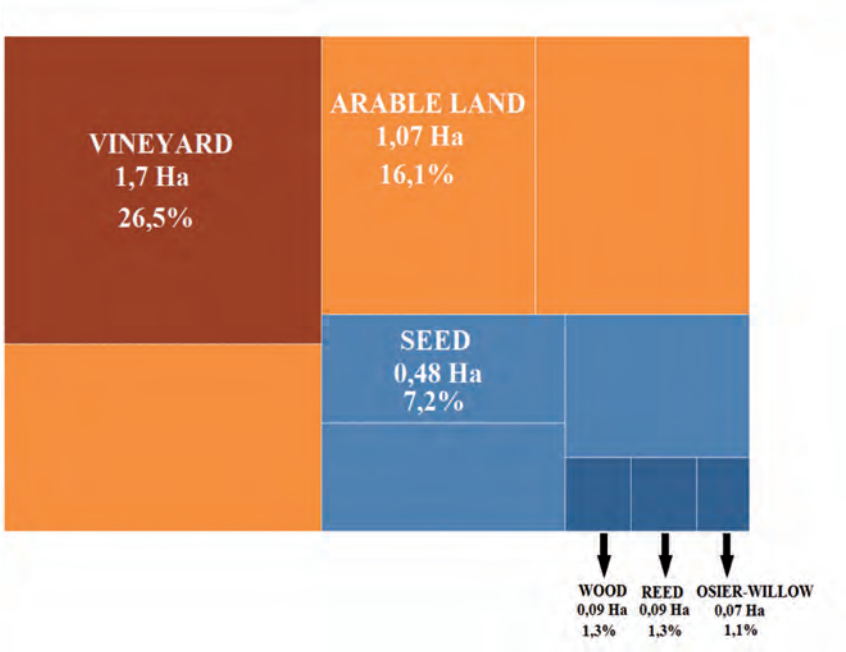


Figure 3a. Modelling units. Land distribution for each unit.

The total of non-*riparia* surfaces is the largest part of land in every unit of modelization. Osier-willows and reeds reach slightly more than the two per cent of the total unit in the Model 1 (Fig. 2b). This percentage is lower in Model 2 because the reeds are moved to the non-*riparia* (Fig. 2c). One polygon gets one unit in the modelization for every completed amount of *riparia* surface and its related non-*riparia* land.

[9] BANG 2008, 89: "Therefore it makes good sense initially to express an agrarian economy in terms of wheat equivalents". See estimations in BANG 2008, 87-89 and 91.

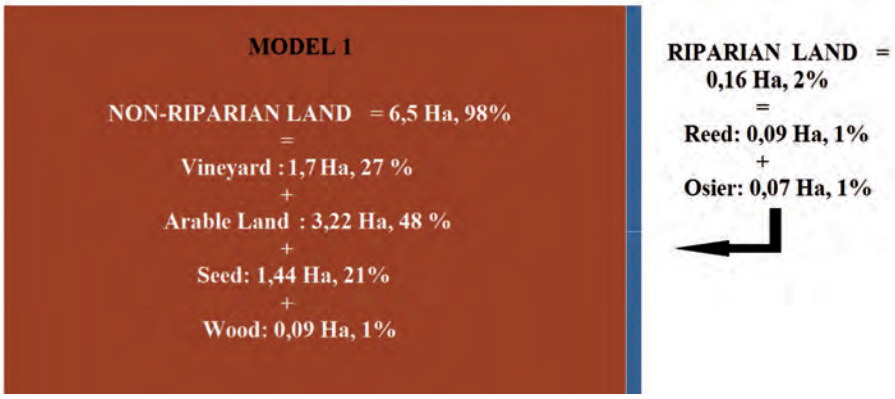


Figure 3b. Modelling units. Riparian and non-riparian land in Model 1.

3. Quantitative and comparative analysis

3.1. Land distribution

The data for both zones in the study area must be examined. We have provided a synthesis of results by using km^2 and *iugera* as units of measure (Fig. 4a). 138 sites are recorded in the zone from *Portus Gaditanus* to the *castellum* of *Ebora* and 87 sites in the surrounding area of *Nabrissa*. That is 61 and 39% respectively. Non-*riparia* distribution (62 and 38%) approximately fits these percentages (Figs. 4a, 5, and 6). Regarding the total extent of both areas, the density of settlement is very similar, from 1,8 to 1,7 sites per km^2.

General distribution of the *riparia* slightly favours the zone of *Portus*, where 77% of the total *riparia* is given for the 61% of the total of sites in the study area (Fig. 4a, 7, and 8). The distribution of the *riparia* affects 58 (42%) of the sites in the zone of *Portus* and 44 (49%) of the sites in the zone of *Nabrissa*.

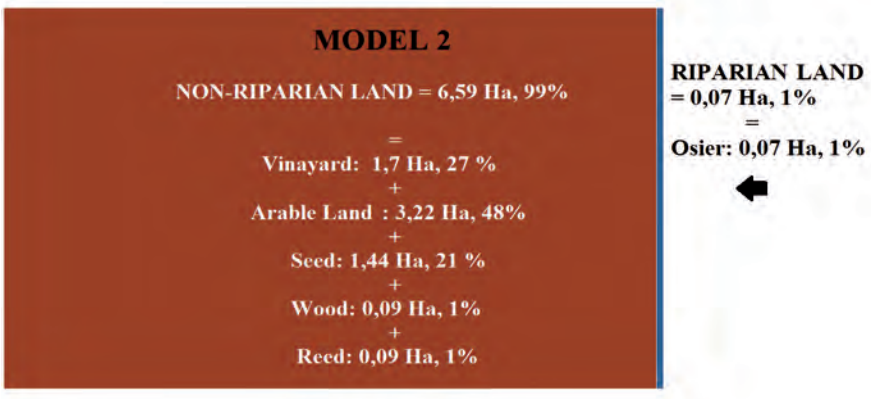


Figure 3c. Modelling units. Riparian and non-riparian land in Model 2.

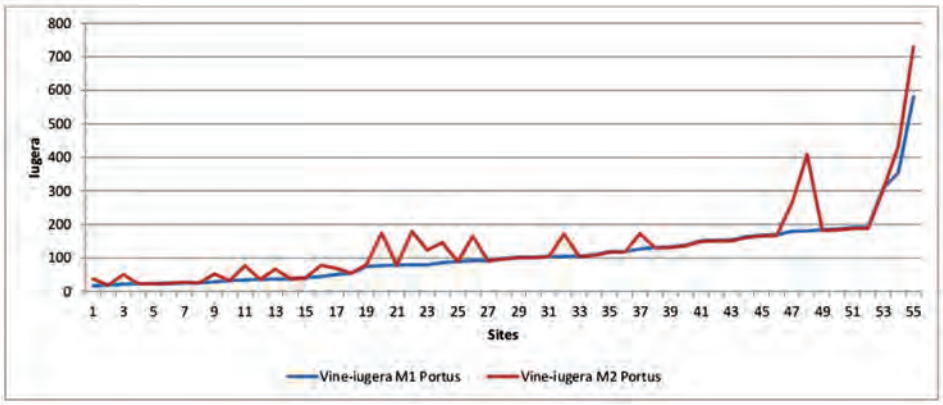
Fig. 4.a	Sites		Km2		Density	*Riparia*		No-*riparia*	
Portus	138	61%	257	63%	1,86	11,8	77%	245	62%
Nabrissa	87	39%	153	37%	1,76	3,5	23%	150	38%
TOTAL	225	100%	410	100%	1,82	15,3	100%	395	100%

	Sites		*Iugera*		Density	*Riparia*		No-*riparia*	
Portus	138	61%	101866	63%	738,2	4672	77%	97194	62%
Nabrissa	87	39%	60696	37%	16,1	1402	23%	59294	38%
TOTAL	225	100%	162562	100%	754,3	6074	100%	156488	100%

Fig. 4.b	Sites with NºU ≥ 1		NºU M1		Average M1	NºU M2		Average M2
Portus	55	57%	878	51%	16	1047	49%	19
Nabrissa	41-42	43%	841	49%	21	1096	51%	26
TOTAL	96-97	100%	1719	100%	18	2142	100%	22

Fig. 4.c	Sites with NºU ≥ 1		Vine-*iugera* M1		Average M1	Vine-*iugera* M2		Average M2
Portus	55	57%	6148	51%	112	7327	49%	133
Nabrissa	41-42	43%	5887	49%	144	7670	51%	183
TOTAL	96-97	100%	12035	100%	125	14997	100%	155

Fig. 4d



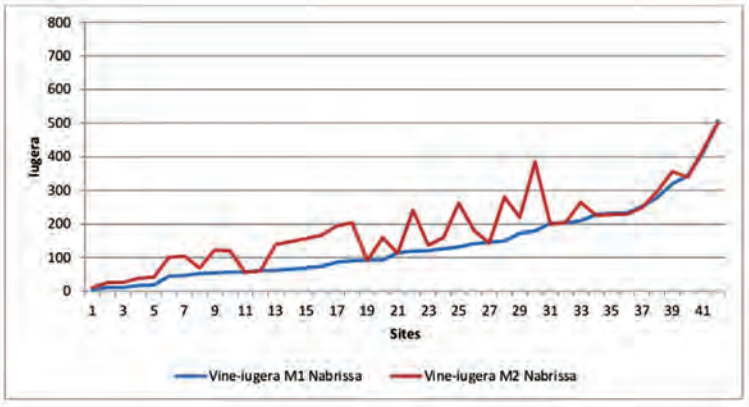


Figure 4. Synthesis of modelling results. a) Sites and land distribution. b) Sites with one or more model units (NºU≥1) incoming from Model 1 (M1) or 2 (M2). c) Extension in *iugera* of the modelled vineyards. d) Charts of extension in *iugera* of the modelled vineyards.

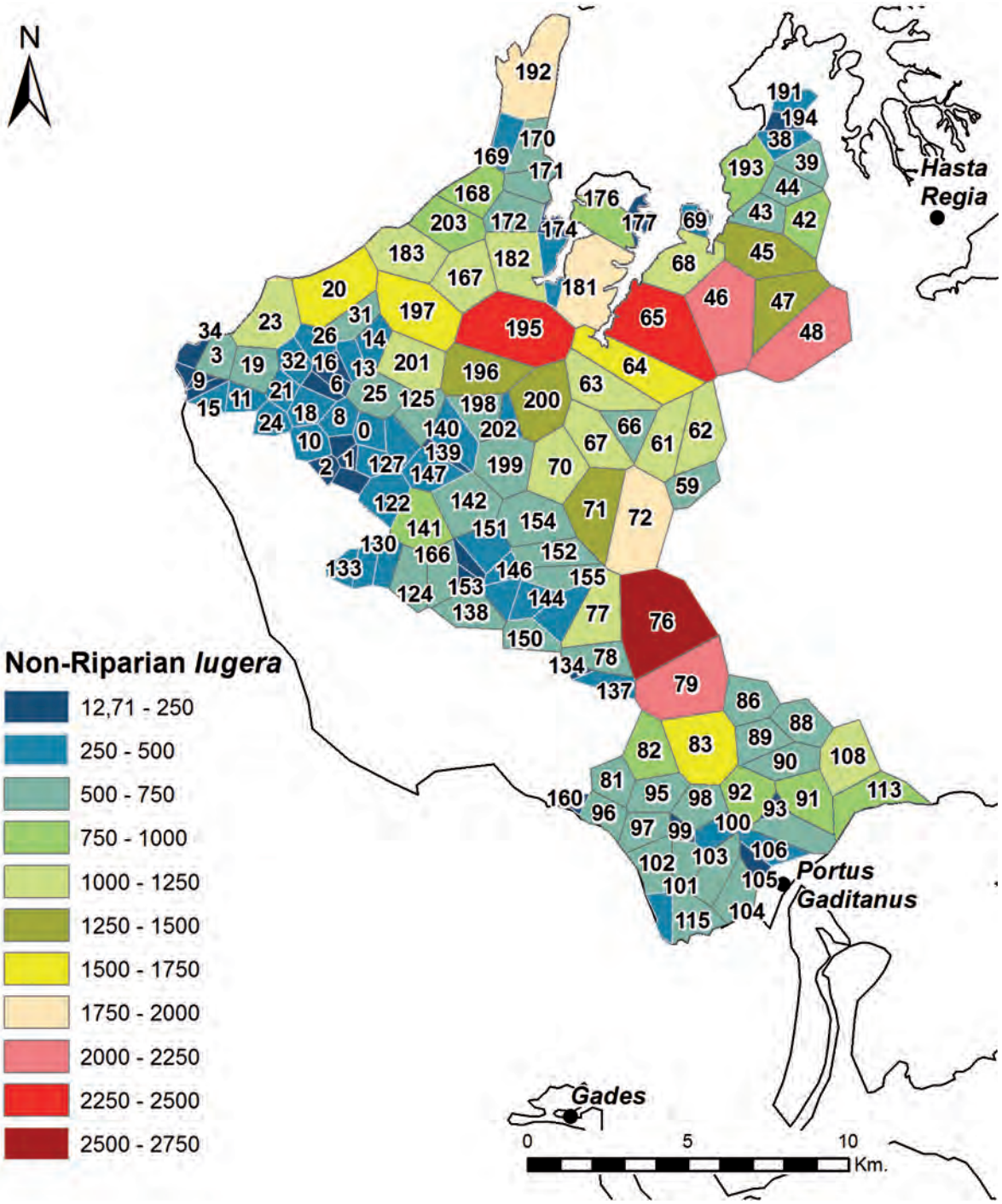


Figure 5. *Portus* zone: non-*riparia* land distribution.

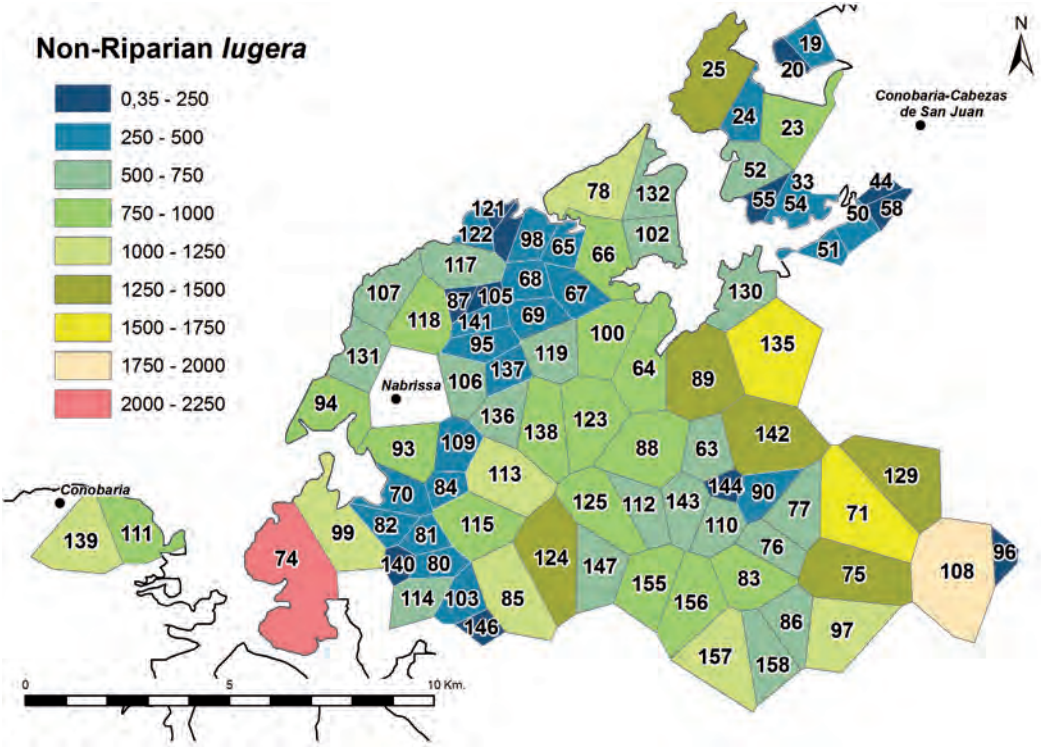


Figure 6. ***Nabrissa*** **zone: non-*riparia* land distribution.**

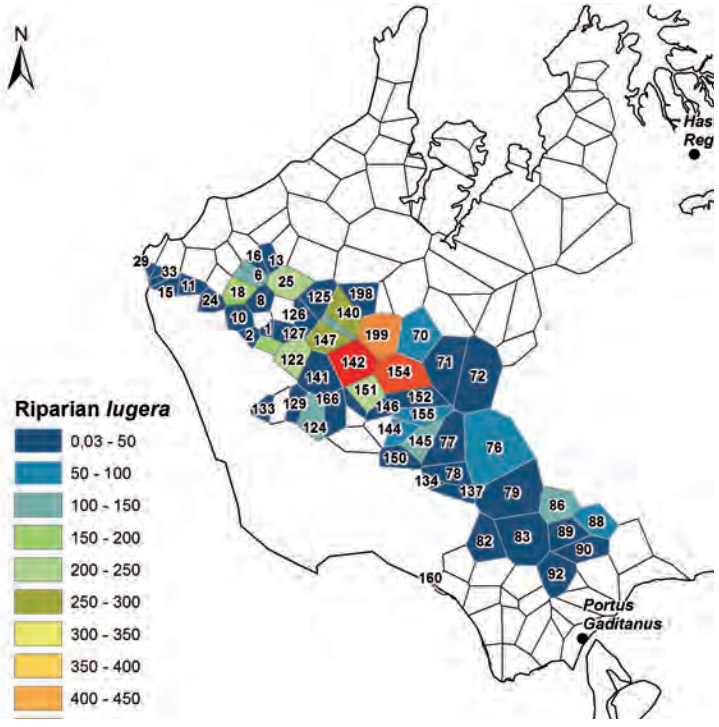


Figure 7. ***Portus*** **zone: *riparia* land distribution.**

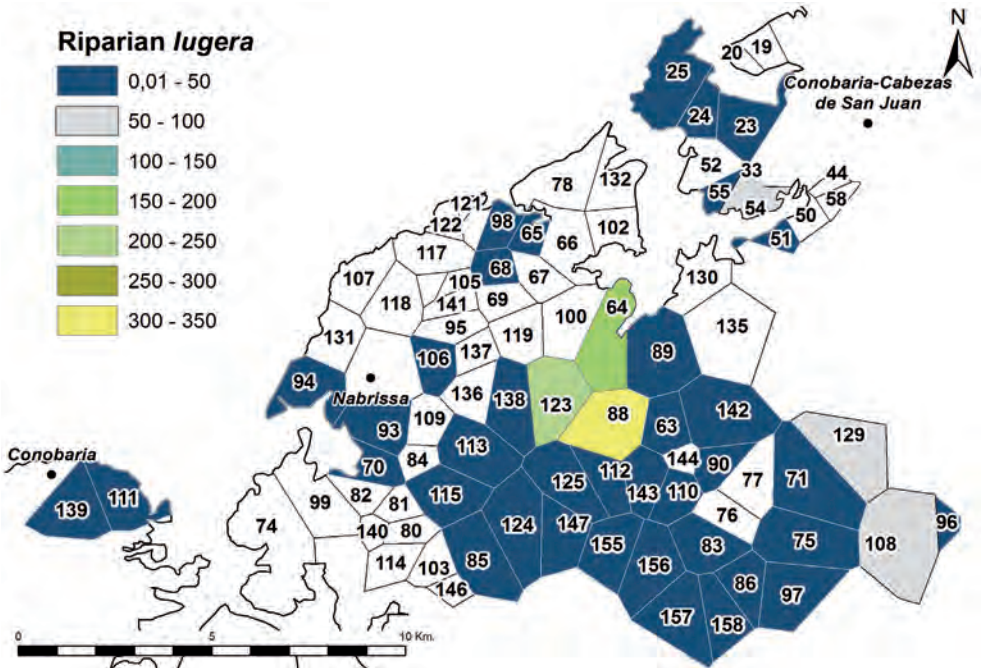


Figure 8. ***Nabrissa*** **zone: riparia land distribution.**

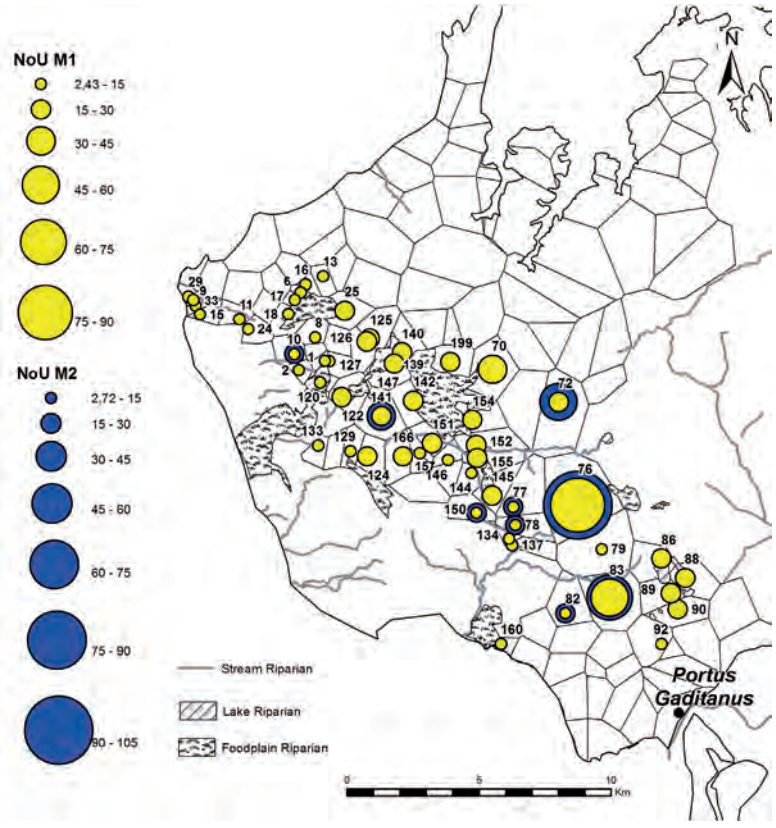


Figure 9. ***Portus*** **zone: outcomes from modelization.**

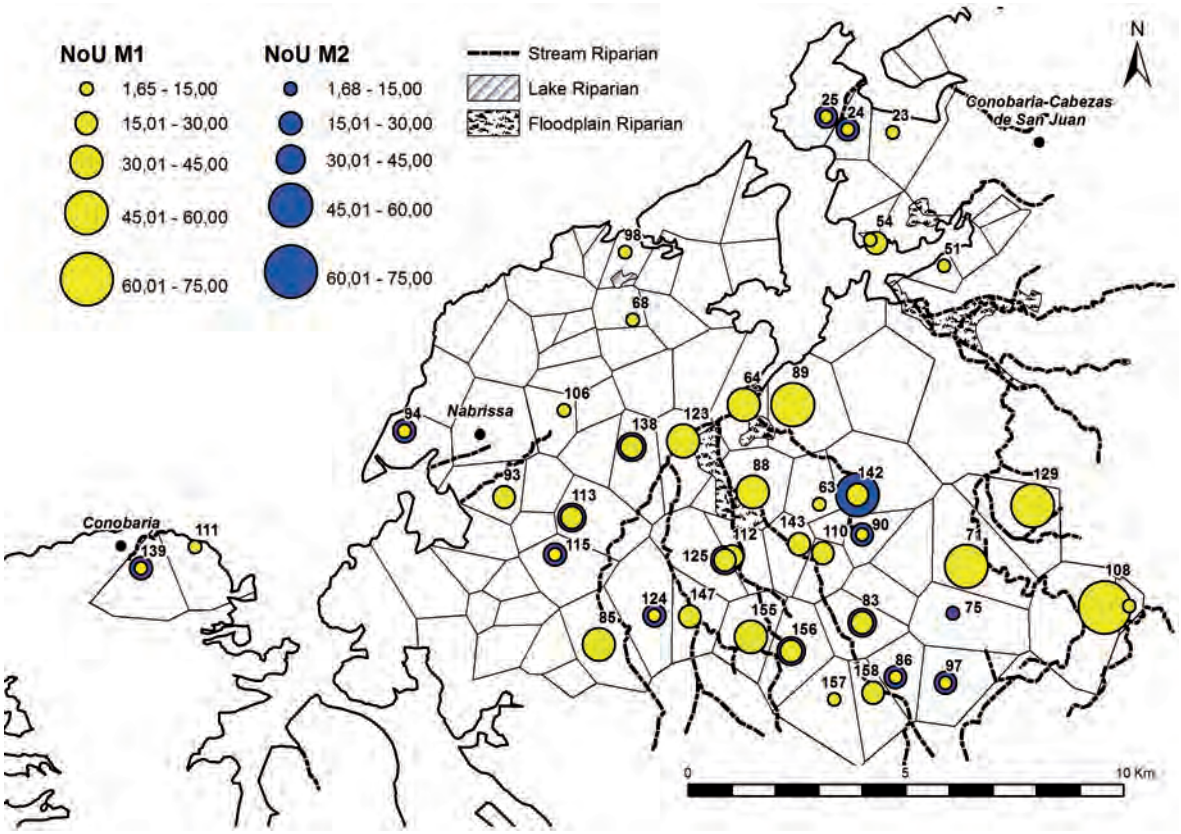


Figure 10. *Nabrissa* zone: outcomes from modelization.

3.2. Outcomes from modelization

The distribution of the *riparia* limited the number of modelled sites to 55 for *Portus* and 41-42 for *Nabrissa* (Fig. 4b). That is 57 and 43% of the total of sites for each zone respectively. One site is recognised in this modelization when it has enough *riparia* and non-*riparia* land in order to provide at least a single unit of modelization. Each unit requires one worker, so outcomes with less than one unit are not useful in a self-sufficient *fundus* approach. The workforce is not measurable as a fractional number lower than 1 (for instance, 0,5 workers). So 0,5 units are considered as 0 units in this modelization. In the zone of *Nabrissa*, we have one site (number 75 (Fig. 10), Arriba I (Cortijo de)) where the *riparia* land does not provide a single unit to Model 1, but does provide a unit to Model 2. Therefore, we have recorded two different quantities of sites (41-42) with one or more units of modelization for *Nabrissa*.

The graphic display visually favours the zone of *Portus*, with more dots, but the number of the resulting units is nearly 50% for each zone (Figs. 4b, 9, and 10). On the one hand, Model 1 requires a higher extent of *riparia*. It slightly favours *Portus*, which reaches 51% beside the 49% of *Nabrissa*. On the other hand, Model 2 requires a lower extent of *riparia*, so it favours *Nabrissa*, changing the percentages to 49 and 51 respectively.

By comparing Figures 5 to 10, the results can be explained as follows:

- At *Portus*, 77% of the total *riparia* (Fig. 7) is divided by 57% of the total of modelled sites (Fig. 9). The extent of non-*riparia* ranges between 12 and 750 *iugera* in most of these sites (Fig. 5). There are notable exceptions, including one which reaches 2750 *iugera*.
- At *Nabrissa*, 33% of the total *riparia* (Fig. 8) is divided by 43% of the total of sites (Fig. 10). The extent of non-*riparia* ranges between 500 and 1000 *iugera* in most of these sites (Fig. 6). There are some exceptions. These are less remarkable than in the case of *Portus*; where they reach 2250 *iugera*.

In conclusion, *Portus* has more sites and *riparia* but the concentration of sites surrounding flood zones is disadvantageous. Here non-*riparia* becomes rare. *Nabrissa* has fewer sites and *riparia*, but streams generate a better distribution of the *riparia* over bigger sized plots of non-*riparia*, increasing the outcomes from models. So two zones with different distributions of the *riparia* and density of settlement can offer the same productivity in the established model for the *uinea iugata* cultivation.

3.3. Resulting vineyards

The sizes of the resulting vineyards are proportional to the outcomes from the modelization (Figs. 9 and 10). In Figure 4d, results in blue are given by Model 1 and the red ones by Model 2. The outcomes from Model 2 show the unequal increase of *iugera* depending upon the characteristics of each site.

The average sizes for these vineyards in both models are 112 and 144 for *Portus* and 133 and 183 for *Nabrissa* (Fig. 4c). There is hardly any data on the extent of Roman vineyards to compare these sizes. There are some calculations based on classical and archaeological evidence of wine storage in some *villae*. Resulting sizes of Roman vineyards reach from 6 (*P. Oxy.* 3354) to 654 (MAUNE 2003, 328) *iugera*. Sizes reach from 44 to 119 *iugera* in 8 out of 13 case studies. An Italian vineyard cited for *Columella* and *Plinius* could have reached from 250 to 300 *iugera (*TCHERNIA 1995, 390).

Martin estimated the ideal size of catonian (50-100 ha) and columellian (500-1500 ha) plots[10]. The former ones range between 198 and 396 *iugera*. In the other case, the plots range between 1986 and 5945 *iugera*. In the proposed unit of modelization, the vineyard reaches the 26,5% (Fig. 3a). If we use this percentage in these ideal plots, the resulting vineyards approximately reach 50 to 100 and 500 to 1500 *iugera* respectively. Each Martin's catonian plot would require 15-20 slaves (MARTIN 1971, 352). These figures fit with the average amounts of units in Model 1 (18) and 2 (22) (Fig. 4b), which mean a similar number of workers. We can propose a hypothetical framework in which Roman imperial columellian properties were divided into smaller exploitation units, equal or similar in size to the catonian ones. In summary, general average sizes of 125 or 155 *iugera* for our study area becomes reasonable. The difference between Models 1 and 2 increases the resulting average size by 24%.

[10] MARTIN 1971, 350-356. On Martin's and Duncan-Jones' approaches to the Columella's figures, see MARTIN-ARROYO & REMESAL 2018, 214-215.

4. Challenges and conclusions

Are our outcomes resulting from some pattern of settlement? New zones could be modelled to get some feedback. For example, beyond our modelled study area, north-west of *Nabrissa*, a high density of sites is related to flood zones, as we have observed in the case of *Portus*.

Different distributions in size of plots and *riparia* items (flood zones and streams) make similar quantitative outcomes (51 and 49% of units) for both displayed models (M1 and M2 in Fig. 4b). Therefore, in such a hypothetical framework, the proposed system of self-sufficient plots with some surplus coming from the *uinea iugata* get some slight advantage in the *Nabrissa* zone. In both zones, the resulting vineyards reach expected average sizes. Without archaeological evidence, we cannot suppose that this landscape became real. But we can improve our analytical approach of the Roman agronomy by testing different ranges over the parameters than we consider fundamental for some phenomena. In that sense, we attest that a modification of just 1% in the spatial configuration of modelling units (reeds location in Fig. 3b) can generate differences than reach 24% in the average size of the resulting vineyards (Fig. 4c).

New challenges include testing the effects of drainage or biennial rotation systems on the outcomes from modelization. In this way, we can test the utility of GIS modelling to deepen the explanation of settlement patterns and to substantiate the credibility of our assumptions about the Roman agronomy.

Bibliography

BANG, P. F. (2008) The roman bazaar: a comparative study of trade and markets in a tributary empire, Cambridge.

CARRERAS MONFORT, C. (2001), Producción de Haltern 70 y Dressel 7-11 en la inmediaciones del lacus Ligustinus (Las Marismas, Bajo Guadalquivir). Congreso Internacional Ex Baetica Amphorae. Conservas, aceite y vino de la Bética en el Imperio Romano. Écija y Sevilla, 17 al 20 de diciembre de 1998. Écija, 419-426.

GARCÍA-BELLIDO, M. P. and BLÁZQUEZ CERRATO, C. (2001), Diccionario de cecas y pueblos hispánicos, vol. II, Catálogo de cecas y pueblos. Madrid.

GARRIDO IBÁÑEZ, E. (2005), Nuevo Plan de Ordenación Urbanística, Las Cabezas de San Juan, Inventario de Yacimientos Arqueológicos. Servicio de Urbanismo de la Diputación de Sevilla., Mayo 2005. Sevilla.

GÓMEZ PEÑA, A., RUÍZ NIETO, E., PÉREZ-AGUILAR, L.-G., GUILLÉN RODRÍGUEZ, L. (2014), Revisión historiográfica sobre las prospecciones arqueológicas en el Término Municipal de Trebujena (Cádiz), In: PARODI ÁLVAREZ, M. (Coord.), Ex illo tempore. Actas de las I Jornadas de Arqueología del Bajo Guadalquivir. Sanlúcar de Barrameda, 251-265.

LINARES AGÜERA, A. (2014), PGOU Lebrija, Documento III-A: Memoria de Protección y Catálogo, Redacción Alfredo Linares Agüera, Aprobación Provisional Abril 2014, Junta de Andalucía, Consejería de Medio Ambiente y Ordenación del Territorio, Parte III-A1: Estudio del Patrimonio Arqueológico, http://www.lebrija.es/opencms/opencms/lebrija/galeriaFicheros/pgou/PGOU/ [consulted 17/03/17].

LÓPEZ AMADOR, J. J. and PÉREZ FERNÁNDEZ, E. (2013), El Puerto Gaditano de Balbo. El Puerto de Santa María. Cádiz. El Puerto de Santa María.

MARTÍN, A., MARTÍN-ARROYO, D. J. and REVILLA, V. (2017), The wine economy in Roman Hispania. Archaeological data and modellization. In: J. REMESAL (Ed.), Economía romana.

Nuevas perspectivas. The Roman Economy. New Perspectives. Instrumenta 55. Barcelona, 189-236.
MARTIN, R. (1971), Recherches sur les agronomes latins et leurs conceptions économiques et sociales. Paris.
MARTÍN-ARROYO SÁNCHEZ, D. J. (2012), La intervención romana sobre los medios ribereños. Aproximación al estero de *Hasta Regia* (Jerez de la Frontera, Cádiz), In: LÓPEZ-GETA, J.A., RAMOS GONZÁLEZ, G., FERNÁNDEZ RUBIO, R. and LORCA FERNÁNDEZ, D. (Eds), El Agua en Andalucía. Retos y avances en el inicio del milenio, T. I, Serie Hidrogeología y aguas subterráneas 30. Madrid, 761-771.
MARTÍN-ARROYO SÁNCHEZ, D. J. (2016), Modelización de la ratio *riparia/uinea*: el emparrado romano entre *Hasta Regia* y *Gades*. In: LAGÓSTENA BARRIOS, L. (Ed.), Lacus autem idem et stagnus, ubi inmensa aqua convenit. Estudios históricos sobre humedales en la Bética (II). Cádiz, 105-124.
MARTÍN-ARROYO SÁNCHEZ, D. J. and TRAPERO FERNÁNDEZ, P. (2015), La explotación romana de la vegetación *riparia* y el análisis espacial de la ocupación rural, In: LAGÓSTENA BARRIOS, L. Qui lacus aquae stagna paludes sunt… Estudios históricos sobre humedales en la Bética. Cádiz, 243-260.
MARTÍN-ARROYO SÁNCHEZ, D. J., and REMESAL RODRÍGUEZ, J. (2018), Modelado SIG de la agricultura romana en un marco colonial teórico. Vegetación de ribera y viticultura en *Hasta Regia*. *Spal* 27.1, 211-235.
MAUNE, S. (2003), La villa gallo-romaine de "Vareilles" à Paulhan (Hérault; fouille de l'autoroute A75). Un centre domainal du Haut-Empire spécialisé dans la viticulture?, RAPic 1.2, Cultivateurs, éleveurs et artisans dans les campagnes de Gaule romaine, 309-337.
PONSICH, M. (1991), Implantation rurale antique sur le Bas-Guadalquivir. T. IV. Écija, Dos Hermanas, Los Palacios y Villafranca, Lebrija. Sanlúcar de Barrameda.
RIESCO GARCÍA, F. J. (1987), Carta arqueológica de la desembocadura del Guadalquivir: zona sur. Sevilla.
SÁNCHEZ ALONSO, G. (2010), Análisis de la documentación arqueológica de la Villa y el Término Municipal de Rota, Rota.
TCHERNIA, A. (1995), Les dimensions de quelques vignobles romains. In: Du latifundium au latifondo. Un héritage de Rome, une création médiévale ou moderne? Actes de la Table ronde internationale du CNRS organisée à l'Université Michel de Montaigne-Bordeaux III les 17-19 décembre 1992. París, 383-394.

La localización de los viñedos de Marco Columela: literatura agronómica y análisis GIS en el interfluvio Guadalquivir-Guadalete[1]

Lázaro Lagóstena Barrios
Pedro Trapero Fernández
IVAGRO - Universidad de Cádiz

Sobre la producción vinaria en el espacio de estudio y el conocimiento de la estructura del poblamiento rural. Indicadores de la producción vitivinícola

La historiografía asume la importancia de la vitivinicultura romana en las campiñas del interfluvio Guadalquivir-Guadalete aunque no se ha realizado aún una investigación territorial profunda sobre esta actividad agraria en la región. Los indicadores de la existencia de estos aprovechamientos se hallan tanto en las fuentes literarias como en las arqueológicas. Por ejemplo, en los espacios artesanales de tradición púnica del entorno gaditano se atestigua la producción, en los inicios del período romano republicano en *Hispania*, de ánforas que imitan las series vinarias greco-itálicas y las más antiguas variantes de la Dr. 1[2]. Ya en época tardo-republicana continúa la producción de estas imitaciones anfóricas en las series más tardías de la misma familia Dr. 1C y Dr. 1D, asociadas al envasado de productos vinificados, producidas tanto en las campiñas gaditanas como en las hastenses, y en el marco del modelo artesanal

[1] Esta contribución se ha desarrollado en el marco del proyecto *RIPARIA 2 La interacción histórica sociedad-medio ambiente: humedales y espacios lacustres de la Bética romana*. MINECO. Programa Estatal de Fomento de la Investigación Científica y Técnica de Excelencia (HAR2016-77724-P). lazaro.lagostena@uca.es .
[2] BUSTAMANTE, MARTÍN-ARROYO, 2004.

romano implantado con la municipalización cívica y la colonización territorial[3]. Al mismo tiempo se reconoce la producción local, especialmente asociada al *ager Hastensis,* de otros envases vinícolas, relacionados con la familia de las denominadas Haltern 70[4]. Hasta que no se caractericen mejor estas últimas producciones no estaremos en condiciones de incorporar con precisión a nuestras fuentes la información proporcionada por la epigrafía anfórica pintada, sellada o grafitada que se le asocia.

Respecto a los sistemas de plantación y a las estructuras edilicias relacionadas con la transformación vinícola en el agro hastense, carecemos por ahora de suficiente información sobre la *pars rustica* y la *pars fructuaria* de las potenciales *villae* del territorio dedicadas a estas actividades. Es una consecuencia de la escasez de intervenciones arqueológicas practicadas en los espacios productivos del ámbito rural en la provincia gaditana[5] y constituye actualmente una línea de estudio de gran interés para su desarrollo.

Entre la información transmitida por las fuentes literaria cabe destacar la alusión de Estrabón a las exportaciones vinarias turdetanas, dato que nos ubica en un escenario productivo relacionado con los derivados vinícolas de la región ya consolidado en tiempos augusteos, aunque la cita se refiere a un amplio territorio[6]. Sin embargo sigue siendo la obra de Columela y sus alusiones a las prácticas agrícolas de su tío Marco, como veremos luego, el mejor refrendo de la existencia y de la incidencia económica de la viticultura romana en este territorio.

Sobre el territorio de estudio

El espacio sobre el que centramos el estudio, actualmente el de mayor potencialidad vitícola de la provincia gaditana y parte del Marco Productivo del Jerez/Sherry, se ubica geográficamente entre las desembocaduras de los ríos Guadalquivir y Guadalete, y está limitado por la costa atlántica al Oeste (Figura 1). Constituye una fértil campiña que conoce una ocupación y explotación agraria sin solución de continuidad desde la Prehistoria Reciente[7]. Esta vinculación del espacio productivo con los grandes ríos de la región y la costa marítima constituyó en la Antigüedad un importante incentivo para el desarrollo de una agricultura orientada a la transformación de productos alimenticios, de gran interés en el comercio marítimo, como los derivados del fruto de la vid.

Desde el punto de vista del ordenamiento cívico, el territorio estuvo bajo la influencia jurisdiccional del municipio de *Gades* y de la colonia *Hasta Regia*, sin que hasta la fecha se haya propuesto una hipótesis de delimitación entre los *territoria* de ambas entidades.

Es un espacio bien comunicado tanto por la red de puertos marítimos y fluviales establecida entre *Gades* y *Hasta* como por el paso de la *via Augusta* que, desde la desembocadura del Guadalete y *portus Gaditanus*, se dirige hacia *Hasta Regia, iter* viario que hubo de constituir el principal eje de articulación del *ager* en cuestión[8]. También destacada es la posición de ambas entidades en relación

---

[3] LAGÓSTENA, 1996,

[4] CARRERAS, 2001; CARRERAS 2004.

[5] Sobre las estructuras edilicias excavadas *vide*: RAMOS, RIESCO, 1990; MATA, LAGOSTENA, 1997; MATA, 2001. Sobre los indicios de los sistemas de plantación, *vide*: LÓPEZ AMADOR, RUIZ GIL, 2007a; LÓPEZ AMADOR, RUIZ GIL, 2007b.

[6] Str. III.2.6.

[7] LÓPEZ AMADOR , RUIZ MATA, RUIZ GIL, 2008.

[8] Para la articulación marítima, LAGÓSTENA, 2014; sobre este *iter* de la *via Augusta*: SILLIÈRES, 1990; RUIZ GIL, LÓPEZ AMADOR, 2004; MARTÍN-ARROYO, 2013.

con la navegación fluvial por el Guadalete y Guadalquivir respectivamente como vías de penetración al *hinterland* productivo.

La intensa ocupación rural documentada para época romana resulta sin embargo poco caracterizada: desde el punto de vista de su precisa ubicación espacial; de las cronologías individuales de cada asentamiento; de la adscripción funcional y tipológica de los establecimientos[9]. Las causas principales son debidas a la falta de un proyecto de investigación específico e integrado para este estudio, y a la actual parcelación del espacio en los términos de diversos municipios. No obstante se vienen realizando prospecciones y cartas arqueológicas desde la década de los ochenta del pasado siglo que proporcionan una valiosa información[10].

Presentación de la hipótesis y los objetivos

La hipótesis general de nuestra investigación plantea una creciente importancia de la vitivinicultura en el territorio de estudio, actividad que alcanzaría su auge productivo hacia el siglo I d.C. Esta agricultura con vocación mercantil se asociaría a los procesos de colonización y la municipalización de las campiñas de *Hasta* y *Gades*. Se producirían distintos derivados procesados de la uva que serían exportados en envases de factura local, pertenecientes morfológicamente a las familias de las Dr. 1 y las Haltern 70, distribuyéndose hacia los mercados urbanos del imperio y otros destinos oficiales del *limes*.

Los principales objetivos de esta contribución consideran la localización y la caracterización de las potenciales áreas productoras vitivinícolas en la región hacia época augústea. También la identificación de los espacios y asentamientos del territorio más relacionados con este sector productivo, y el avance en la cuantificación del peso de la viticultura en la economía regional. Iniciar los trabajos para una modelización del territorio productivo como parte de la metodología de la investigación se suma a los objetivos anteriores.

Sobre las fuentes del estudio

Ya hemos comentado la importancia de Columela como fuente literaria principal para el estudio de la vitivinicultura gaditana. Su *origo* y el peso de la experiencia personal vivida con su tío paterno Marco Columela en sus *fundi* béticos, parte importante de su formación agronómica, permiten deducir que ciertos conocimientos como viticultor los adquiriría en estas tierras[11]. Nuestra aproximación a la *res rustica* columeliana pretende identificar en el texto prácticas y saberes tradicionales de su cultura vinícola, propios de las tierras gaditanas; también caracterizar los viñedos que su pariente aquí poseía y explotaba, para alcanzar una propuesta de posible localización de los mismos, contrastándola con los datos que otras fuentes nos aportan[12].

La caracterización física del territorio es otra de las fuentes informativas esenciales. A partir de la modelización del terreno, de la tipificación de los suelos, la red hidrológica, el relieve, la incidencia solar y otras variables, como las tradiciones agrícolas del Marco del Jerez, se propone la

---

[9] LAGÓSTENA, e.p.

[10] LAVADO, 1987; RIESCO, 1987; PONSICH, 1991; RAMOS, GONZÁLEZ, 1990; GONZÁLEZ, RUIZ, AGUILAR, 1991; RIESCO, 2010; SÁNCHEZ, 2010.

[11] Cabe destacar en este sentido los trabajos de Pedro Sáez Fernández: SÁEZ 1983; SÁEZ 1987; SÁEZ, 1988; SÁEZ 1994; véase también HOLGADO, 1988; LAGÓSTENA 2010.

[12] Sobre este particular, véase TRAPERO 2016a; TRAPERO 2016b.

ubicación de las mejores tierras potencialmente dedicadas al viñedo. Otro tipo de análisis espacial (distancias medias, costes, visibilidad, orografía, etc.) nos permite proponer hipotéticamente el alcance de los *territoria* jurisdiccionalmente adscritos a *Gades* y *Hasta*.

Es sobre este territorio modelizado sobre el cual georreferenciamos la información de carácter arqueológico que conocemos, especialmente la ubicación de las posibles *villae* y de las *figlinae* productoras de envases vinarios. Para la creación de ambas capas informativas se ha realizado una revisión crítica de las cartas y catálogos arqueológicos actualmente disponibles[13].

La epigrafía constituye otra fuente de interés para el estudio. Ya se ha indicado la necesidad de caracterizar las producciones anfóricas locales con objeto de poder vincular a los estudios económicos del territorio la información epigráfica registrada sobre estos envases. Pero la aproximación al análisis social y a la identificación de los *possessores* se nutre de la epigrafía cívica y funeraria, tanto la hallada en las urbes como las del agro. Así, por ejemplo, se ha analizado la dispersión de los *Iunii* en este espacio como un indicador más de la posible adscripción ciudadana de Marco Columela a través de su *gens* y de la posible localización de sus propiedades fundiarias.

El interfluvio Guadalquivir-Guadalete

Resulta esencial para la comprensión de la actividad agraria romana en este espacio la investigación de dos aspectos relevantes: el alcance y la caracterización de la jurisdicción cívica sobre el territorio productivo; y la estructura de la ordenación y articulación del parcelario antiguo (Figura 2[14]). Para elaborar una hipótesis de trabajo sobre la primera cuestión hemos considerado la ubicación de las urbes con entidad jurídica del territorio y el cálculo de las distancias medias entre ellas. Y hemos considerado también la configuración orográfica del espacio, particularmente atendiendo al borde fluvio-marítimo, a las cuencas vertientes y a las divisorias de aguas como factores destacados en la ordenación espacial[15].

Las ciudades preeminentes de este territorio, que comprende 843 km^2, son el municipio de *Gades* y la colonia de *Hasta.* Hacia el oeste de sus localizaciones no parecen haber existido entidades cívicas en el período, aunque las fuentes en alguna ocasión insinúan esa condición para el asentamiento de *Ebora*[16].

Poco se ha indagado sobre el *territorium* de *Gades* pues su insularidad fue un hecho destacado. Sin embargo el control territorial gaditano trascendía el paleo-archipiélago y, por ejemplo, las primeras mansiones que jalonan la *via Augusta* se denominan con elementos propios de la ciudad: *ad Herculem, ad Pontem, ad Portum*[17]. El establecimiento del nuevo *portus Gaditanus*, sobre cuya

---

[13] Para la localización de las *figlinae*, véase particularmente: LAGÓSTENA 1996; LAGÓSTENA, BERNAL, 2004. Sobre los criterios de revisión, LAGÓSTENA, e.p. Véase la contribución de RUIZ GIL, LAGÓSTENA, PÉREZ MARRERO, MARTÍN MOCHALES, TRAPERO, CATALÁN en este volumen.

[14] Insertamos en las figuras correspondientes nuestra propuesta de trazado de la *via Augusta* desde *Gades*. En este recorrido la vía superó tramos intertidales, empleando tómbolos arenosos relacionados con la desembocadura de cursos como el Zurraque o el Guadalete. Sobre estos ambientes, al igual que para la superación de varios esteros en el entorno de *Hasta Regia*, hubieron de ejecutarse obras viarias de las cuales se conservan vestigios arqueológicos.

[15] ALONSO, MÉNANTEAU, 2010; LAGÓSTENA, 2016; HERMON 2017.

[16] πόλις en Str. 3.1.9; *castellum* en Mela, 3.4 y Ptol. 2.4.9.

[17] La primera alusiva al acceso al templo de Melkart-Hércules gaditano; la segunda relacionada con un puente que daría acceso desde el continente a las primeras islas gaditanas; la tercera indicando la dirección hacia el nuevo *portus* que Balbo hizo construir para la ciudad. Véase para las fuentes epigráficas y literarias oportunas LAGÓSTENA, ZULETA, 2009, 119 ss.

ubicación bajo la actual ciudad de El Puerto de Santa María caben pocas dudas, es un indicador del control territorial ejercido por la ciudad allende la Bahía. Hacia el Este de *Gades* su *ager* sería limítrofe con el de *Asido Caesarina*, localizada a unos 34 kilómetros. El contorno de la actual bahía de Cádiz parece haber integrado buena parte del *territorium* de la ciudad antigua gaditana.

Hasta Regia, la ciudad de los esteros, limitaría al noreste con el municipio de *Nabrissa* y hacia el Este con la entidad cívica localizada en Gibalbín, que se ha propuesto identificar con *Ceret*, con *Cappa*, o bien con *Vgia Castrum Iulium*[18]. También el territorio de *Asido* tendría alcance aquí por el Sureste, hasta las riberas del Guadalete[19].

En las campiñas interfluviales hemos considerado como probable límite territorial entre *Gades* y *Hasta* la divisoria de aguas que separa la cuenca del Guadalquivir con la cuenca del Guadalete. En este espacio se identifican tres subcuencas hidrográficas: una para el tramo final del Guadalquivir, en el espacio de *Hasta*, que comprende unos 276 km^2; otra tributaria del Guadalete y en la que su ubicaría el *portus Gaditanus,* con 416 km^2; y una tercera, Guadalquivir-costa, que se extiende por 151 km^2, en la que se localizaba el enclave portuario de *Turris Caepionis*. Nuestra propuesta inicial es vincular el primer espacio al territorio hastense, y el segundo como parte del gaditano. Sobre el tercer sector sólo el avance de las investigaciones podrá sugerir su hipotética adscripción territorial.

Si circunnavegáramos desde la desembocadura del Guadalete la península conformada por este interfluvio hallaríamos, en época altoimperial, una interesante red portuaria, constituida por *portus* principales y secundarios: *portus Gaditanus*, entorno portuario de Las Mezquitas, en el arroyo Salado de Rota, la propia Rota, *Turris Caepionis*, *Lux Dubia*, *Ebora*, el cortijo de Alventus, y el Muelle de Mesas. Particularmente interesante es el establecimiento de *Turris Caepionis* en el 139 a.C. por Q. Servilio Cepión, sin que sepamos sobre qué espacio jurisdiccional se edifica el *monumentum* o faro que se convierte en una pieza importante en la expansión atlántica de Roma[20] y que sin duda juega un rol destacado en la configuración del paisaje simbólico de la región.

Prácticamente inexistentes son los estudios sobre la ordenación fundiaria de estos espacios. A pesar del carácter colonial de *Hasta Regia* no se han publicado aún propuestas sobre su organización catastral, sobre la *pertica*, ni sobre posibles centuriaciones de su territorio[21]. Mejor conocido es el recorrido de la *via Augusta* entre *portus Gaditanus* y *Hasta Regia,* y consideramos *a priori* que debía ser éste un eje fundamental para comprender la articulación de este parcelario[22]. También la doble condición de las propiedades fundiarias de este espacio bajo el control del municipio y la colonia – privadas y públicas respectivamente- podrían reflejarse en la disposición del poblamiento rural, reflejando así dos modelos diferentes que podrían orientar sobre la ubicación de sus *confines* territoriales.

Hemos centrado nuestra atención sobre dos elementos poblacionales destacados del espacio, los asentamientos con posible carácter villático y los alfares productores de envases vinarios (Figura 3). Los primeros nos parecen piezas esenciales para desentramar la organización romana del territorio,

---

[18] GONZÁLEZ, 2014; una revisión historiográfica sobre Gibalbín y la actualización de su corpus epigráfico en RUIZ, VEGA, GARCÍA, 2016. Opinamos que la proyección territorial de *Hasta* hacia las campiñas asidoneses y en concreto hacia la *Turris Lascutana*, documentada en *CIL* II, 5041, obedece a una coyuntura puntual, propia de las circunstancias dadas la finalización de la Segunda Guerra Púnica, y no puede considerarse representativa del alcance del posterior *ager Hastensis*.

[19] LAGÓSTENA, 2010.

[20] Str.3.1.9; Mela 3.4; CHIC 1994.

[21] Cfr. al respecto la revisión historiográfica realizada en MARTÍN-ARROYO, 2013.

[22] SILLIÈRES, 1990; RUIZ GIL, LÓPEZ AMADOR, 2004; ALONSO, MÉNANTEAU, 2010; MARTÍN-ARROYO, 2013.

considerando su rol en la ordenación del mismo; los segundos juegan un papel importante en la comprensión de las actividades económicas orientadas a la exportación de productos alimenticios, y concretamente las relativas al viñedo y la vinificación.

Dado que las fuentes de información arqueológica son dispáres hemos aplicado algunos criterios básicos para discriminar de entre los asentamientos rurales aquellos que pudieron corresponderse con la *pars urbana* de las *villae* del territorio. Para ello hemos considerado como indicadores culturales la presencia de vestigios edilicios de cierta entidad y calidad (sillares, columnas, muros, mosáicos, estucos, elementos marmóreos, etc.) y la documentación *in situ* de series cerámicas que atestigüen una continuidad secular del asentamiento. La imagen del poblamiento resultante tras la aplicación de estos criterios parece más coherente con la lógica de ocupación territorial romana que la arrojada por las diversas cartas arqueológicas elaboradas para los municipios de la comarca (Figura 4).

Más precisa es la información disponible sobre las *figlinae* del territorio[23]. Conocemos ciento dieciocho de ellas dispuestas tanto en torno a la actual Bahía de Cádiz como en el ámbito interfluvial que aquí estudiamos (Figura 5). Sobre este conjunto hemos identificado aquellos alfares donde se documentan envases potencialmente destinados a contenidos vinarios, resultando un total de sesenta y uno los que muestran indicios de producción de las series Haltern 70, Dressel 1 y otras formas tardorrepublicanas y altoimperiales que pudieron contener derivados vinícolas (Figura 6. Tabla 2).

En definitiva, los elementos que combinamos en la modelización territorial y de su vinculación productiva con el viñedo en el intefluvio Guadalquivir-Guadalete son: las potenciales *villae*, las *figlinae* relacionadas con la producción de envases vinarios; las proyecciones hipotéticas de los límites territoriales de *Hasta* y *Gades*; la red portuaria potencialmente vinculada con las exportaciones vinícola; la *vía Augusta* como factor clave en la articulación del parcelario agrícola; y, como veremos más adelante, la identificación de los mejores espacios agrícolas para la plantación del viñedo, aplicando a esta geografía los criterios proporcionados por las agrónomos latinos en general y por Columela en particular, considerando la caracterización geográfica, geológica y edafológica de estos suelos[24].

Marco Columela como arquetipo viticultor

Una de las claves para avanzar en el conocimiento de la viticultura de los territorios hastenses y gaditanos reside en la información transmitida por Lucio Jnio Moderato Columela, pues se basa parcialmente en su aprendizaje en tierras béticas gaditanas y en la experiencia que le transmitió su tío Marco Columela[25]. Es precisamente este pariente del agrónomo, perteneciente a la *gens Iunia* gaditana el que focaliza en esta ocasión nuestra atención[26].

Aunque Columela declara su vinculación con el municipio gaditano[27], no tenemos seguridad sobre la *origo* de Marco Columela, planteándonos la hipótesis inicial de su posible integración en la *civitas* hastense o en la gaditana. Probablemente Marco Columela o sus ascendientes directos participaron de la migración oficial tardorrepublicana que nutrió las colonias y municipios del sur de la Bética, por tanto pertenecería a la primera o la segunda generación relacionada con estos contingentes poblacionales. Sería esta circunstancia la que le convertiría en *possessor* de diversos

[23] Véase el catálogo en LAGÓSTENA, BERNAL, 2004.
[24] TRAPERO 2016a; TRAPERO 2016b.
[25] SÁEZ, 1987.
[26] Véanse los comentarios sobre el personaje en HOLGADO, 1988 y LAGÓSTENA 2010.
[27] Col. *r.r.* 8.16.9-10.

fundi que deberían localizarse en las campiñas de la actual provincia de Cádiz, en algunos de los cuales tendríamos literariamente atestiguada la actividad vitivinícola. De sus propiedades fundiarias y de sus prácticas productivas deben conservarse vestigios arqueológicos, aunque de los asentamientos que tenemos documentados no se ha identificado aún ninguno como suyo ni se han podido relacionar directamente con el personaje. Si parte de sus propiedades hubieran sido heredadas por su sobrino Lucio, quizá se aludiría a ellas en la *Res rustica.* En cualquier caso no cabe duda de que quedan atestiguadas en su obra agronómica sus prácticas agrarias en tierras béticas.

Agrícola y viticultor, parte de las labores y los saberes tradicionales de Marco Columela nos han sido transmitidas por su sobrino. De estos testimonios, varios se refieren al cultivo del viñedo y a los procesos de vinificación. Esta información nos permite además una aproximación a la ubicación, la tipología y la funcionalidad de sus viñedos, y a las variedades de viñas que en ellos cultivaba.

La fuente sugiere que la propiedad rural de Marco Columela en estas tierras estaría compuesta por varios *fundi*. Geográficamente algunas de estas fincas debieron estar cerca del mar o bien comunicadas con la costa[28]. Otras sufrían el azote del *Volturno*, el viento de levante, que en la región afecta más al litoral y la bahía gaditanas que al territorio hastense, y que además sugiere que parte de estas propiedades y sus cultivos estaban expuestos y orientados al Este[29]. También hallamos menciones a sus viñas palustres, por lo que la *pars rustica* de algunas de sus fincas podrían localizarse en zonas ribereñas, terrenos bajos o humedales. Y en contraposición poseía viñedos en colina[30]. En otra ocasión, las prácticas de mejoras de suelos nos indican que entre sus propiedades se hallaban terrenos arenosos y gredosos, siendo los primeros en la región más propios de las inmediaciones costeras[31]. Marco Columela cultivaba variedades de vides destinadas a la producción de frutos de mesa, y otras más apropiadas para la vinificación[32]. Su sobrino asocia el cultivo de las primeras con *fundi* periubanos o en cualquier caso cercanos a los lugares de consumo, dada el carácter perecedero de los frutos y la necesidad para los productores de colocarlos pronto en el mercado[33]. Y aquí podríamos deducir que estos viñedos frutícolas deberían hallarse en las cercanías de los núcleos urbanos o aglomeraciones habitacionales de importancia de este espacio.

Otro aspecto del que nos informa Columela es sobre los encargos que realizaba en las *figlinae* del territorio, bandejas cerámicas adecuadas a sus necesidades para la conservación de la uva[34]. En esta ocasión nos interesará la distribución espacial de las alfares tardorrepublicanos como un elemento del paisaje productivo alfarero en conexión con los *fundi* cercanos.

Como indicábamos anteriormente, la dispersión geográfica de los *Iunii* gaditanos podría proporcionarnos un elemento adicional para intentar identificar y localizar las propiedades de

---

[28] Col. *r.r.* 12.21.4. *Infra.*

[29] Col. *r.r.* 5.5.15. *M. Quidem Columella patruus meus, vir illustribus disciplinis eruditus ac diligentissimus agricola Baeticae provinciae, sub ortu caniculae palmeis tegetibus vineas adumbrabat, quoniam plerumque dicti sideris tempore quaedam partes eius regionis sic infestantur Euro, quem incolae Vulturnum appellant, ut nisi teguminibus vites opacentur, velut halitu flammeo fructus uratur.*

[30] Col. *r.r.* 12.21.4. *Hac conditura Columella patruus meus, inlustris agricola, uti solitus est in his fundis, in quibus palustres vineas habebat. Sed idem, cum collina vina condiebat, aquam salsam decoctam ad tertias pro sale adiciebat. Ea porro facit sine dubio maiorem mensuram et odoris melioris, sed periculum habet, ne vitietur vinum, si male cocta sit aqua; sumitur autem haec, ut iam dixeram, quam longissime ab litore; nam liquidior et purior est, quantum altiore mari hausta est.*

[31] Col. *r.r.* 2.15.4.

[32] Col. *r.r.* 3.2.1.2. Cfr. Cato, *Agr.* 7. *De fundo suburbano*; Var. *r.r.* 1.2.10.

[33] Col. *r.r.* 1.1.19-20; LAGÓSTENA, 2010.

[34] Col. *r.r.* 12.44. 5-6; LAGÓSTENA, 2010.

Columela. Aunque el *nomen* está bien representado, hasta el momento no lo tenemos epigráficamente documentados ni en *Hasta* ni en *Asido*. En cambio conocemos diecisiete *Iuniae*[35] y cinco *Iunii* en la necrópolis gaditana[36]. Entre los restantes municipios del entorno documentamos *Iunii* en *Carissa Aurelia* (Espera), *Iptuci* (Prado del Rey) y *Ugia* (Torres de Alocaz)[37]. Ya en un contexto rural conocemos a *Iunia Polytima,* en la localidad de Torrecera, en el cortijo de El Boyal[38], un testimonio de interés pues procedería de un *fundus* ubicado, por el sureste, en los confines entre *Hasta* y *Asido*.

Finalmente, tanto los elementos que hemos trabajado para modelizar el territorio y su comportamiento productivo como la información literaria sobre Marco Columela se retroalimentan en nuestro análisis histórico, y nos permiten proponer localizaciones con posibilidades de haber formado parte de los *fundi* columelianos en las tierras gaditanas y hastenses (figura 7).

Condiciones geográficas de los viñedos según los agrónomos latinos

No resulta sencillo asignar de manera fehaciente un tipo de suelo actual a la denominación que hacían los agrónomos del mismo, aunque existen algunas propuestas al respecto[39]. La edafología de la zona a estudiar es muy variada, contando con suelos particulares que no aparecen apenas en otros espacios fuera de la provincia de Cádiz, como es el caso de los regosoles calcáreos, comúnmente denominados albarizas. Estos suelos actualmente son considerados los mejores para el cultivo del viñedo y fueron ya mencionados por Columela[40].

La caracterización de suelos dentro de los agrónomos latinos es algo genérica, ya que no nos describen las propiedades físico-químicas de los mismos. Además, para el caso del resto de agrónomos, salvo Columela, apenas encontramos referencias a esta problemática[41]. Columela sin embargo sí tiene un mayor cuidado en la descripción de suelos, definiendo sus características físicas, tales como la humedad, compactación y tamaño del granulado de la tierra[42]. De esta manera es posible hacer la comparativa entre los tipos de suelos que son recomendados por el agrónomo para la viña y especialmente los que para este fin cultivaba su tío. El principal tipo tiene unas características contrapuestas, pues se trata de una adición de material, para hacer un suelo duro más suelto y viceversa. Uno de estos tipos de suelos lo relacionamos con los regosoles calcáreos, albarizas, mientras que el segundo tipo, se puede corresponder con arenas, tierras de arenosoles y luvisoles. Además habría que considerar aquí la referencia a las tierras *palustres*[43], que podrían ser tierras de vertisoles o cambisoles, por sus características húmedas. La implantación de viñas en zonas muy húmedas está desaconsejada por los agrónomos en general y solo está aconsejado en casos de suelos muy secos[44].

---

[35] Presentando onomásticas de carácter libre, servil y liberto, como *Iunia Faustilla, Iunia Galla, Iunia Hedia, Iunia Hedone, Iunia Modesta, Iunia Prima Domnina, Iunia Sinmodin, Iunia Duenta, Iunia Deutera, Iunia Hilara, Iunia Clitara, [Iun]ia --- Rest[ituta]. CIL* II, 1831-1837; *IRPCadiz* 389; *IRPCadiz* 391; *IRPCadiz* 427; *IRPCadiz* 442; *IRPCadiz* 495.

[36] *Iunius Gennialis; Q. Iunius Martialis; Q. Iunius Licinius Ingenuus; Q. Iunius Sodalis; Sextus Iunius* (*CIL* II, 1838-1839; *AE* 1995, 78; *AE* 1995, 808; *HEp* 11, 2001, 195). En la epigrafía de *Gades* se documenta también el *cognomen Moderatus: L. Annius Moderato* (*CIL* II 1851).

[37] *Iunius Cornelianus* en *Carissa*; *Q. Iunius Saturninus* en *Iptuci; Iunius Sisenna* en *Ugia* (*AE* 1982, 558; *AE* 1982, 562; *HEp* 7, 1997, 908).

[38] *IRPCadiz* 116

[39] SÁEZ 1987.

[40] Col. *r.r.* 2.15.4.

[41] Cato *Agr.* 1.1. Varro. *R.R.* 1.6.

[42] Col. *r.r.* 2.2.

[43] Col. *r.r.* 12.21.4

[44] Col. *r.r.* 5.4.4.

Dado que el adjetivo no puede estar referido a suelos con aguas permanentes, debe emplearse para tierras cercanas a las riberas de ríos y arroyos, o a terrenos endorréicos estacionalmente inundables[45].

Esta terna de tipología edafológica coincide con los considerados hoy mejores suelos, actualmente dedicados al viñedo en el Marco del Jerez, zona de renombre vitivinícola insertada en nuestro ámbito de estudio. Esta información geográfica, puede ser cuantificada con metodología GIS, con lo que podemos clasificar las tipologías de tierras. Además de las mencionadas, existen otras de escaso valor agrícola, como los planosoles (zonas inundadas), gleysoles (ocupadas con agua permanentemente) o litosoles (afloramientos rocosos y pedregosos).

La segunda característica orográfica relacionada con los viñedos en general en el mundo romano, se refiere a las condiciones de altura y de pendiente requerida para su cultivo. En nuestro ámbito de estudios la altura no resulta un condicionante, dada su configuración orográfica. La vid puede ser cultivada en tierras llanas, sin embargo se preferían suaves laderas de colinas para su plantación[46].

La fuente agronómica informa que Marco Columela poseía plantaciones de viñedos en ambos tipos de terrenos, por un lado las ya comentadas *palustres* que, en cualquier caso, debían estar en zonas llanas y bajas, y otras en colina y ladera[47]. Este criterio es fácilmente mensurable si se aplica una herramienta de pendiente a un modelo digital del terreno, donde las idóneas son las que tienen una pequeña inclinación, siendo además las que actualmente se usan preferentemente para los viñedos en el Marco del Jerez. Para el caso de grandes pendientes, hablaríamos de zonas de dehesa y montaña, pero prácticamente no existen grandes elevaciones en el territorio a estudiar, sino que está jalonado por pequeñas colinas y por ello este último factor de suelos poco óptimos es poco relevante en la modelización.

La tercera condición que habría que considerar tiene un gran impacto en el cultivo, nos referimos a la insolación que recibe el terreno, y por tanto a su orientación cardinal. Esta condición del suelo agrícola constituye una preocupación generalizada en los agrónomos en relación con la mayoría de los cultivos, y especialmente para las viñas cultivadas en ladera[48].

Para el caso concreto de la zona de estudio hay un cuarto factor relevante, como se relata para los viñedos de Marco Columela, que es la exposición del plantío a los vientos dominantes. El testimonio de Columela acredita que la región gaditana estaba en la Antigüedad afectada especialmente por los vientos de Levante, cuya acción puede llegar a dañar seriamente la fructificación de las viñas. Columela nos refiere las prácticas empleadas por su tío para proteger de esta amenaza a sus viñedos[49].

Con carácter general cabría considerar la preferencia en este territorio por las propiedades menos expuestas a la acción del viento del Este, pero para nuestro territorio, dada la información de Columela, puede ser un indicador del alcance de la extensión del viñedo en la comarca, incluso ocupando *fundi* no especialmente idóneos para su cultivo, aunque sin duda interesante para el *possessor* por la rentabilidad de su cultivo. Por otra parte la orientación de las plantaciones al Este eran consideradas beneficiosas por los agrónomos, pues proporcionaba una mayor exposición al

---

[45] SÁEZ, 1988.
[46] Var. *R.R.* 1.6.5.; Col. *r.r.* 3.1.6.; *r.r.* 3.1.8.; *r.r.* 2.8.3.
[47] Col. *r.r.* 12.21.4.
[48] Cato *Agri.* 6.3.; Varro *R.R.* 1.24.3; Col. *r.r.* 4.22.8.
[49] Col. *r.r.* 3.12.6.

recorrido solar y a la insolación[50], pero en el caso de estas tierras béticas coincidían con la orientación de la entrada de los vientos dominantes y hubo de ser un elemento a sopesar por el agricultor.

Basados en estos condicionantes orográficos y climatológicos, según la estimación vertida en las fuentes agronómicas antiguas, realizamos una modelización del territorio para identificar las áreas que mejor cumplen las propiedades y condiciones para el cultivo del viñedo en los *territoria* hastense y gaditano[51]. Estas capas de información son creadas mediante herramientas de ArcGIS, incluidas en Spatial Analyst/surface, como son pendiente, sombreado u orientación. Estas se aplican a un modelo digital de elevaciones de 5x5 metros de resolución. La tipología de suelos, la obtenemos de la Infraestructura de Datos de Andalucía. Cada criterio es medido de manera acumulativa y con el mismo grado de importancia entre ellos, destacando y reclasificando el análisis para valorar dos grandes grupos de datos: los mejores suelos (regosoles calcáreos) junto con media elevación y buena insolación; y cualquier otro tipo de suelo bueno, junto con media elevación y buena insolación (Figura 8).

La cartografía obtenida nos permite identificar y cuantificar los suelos óptimos para el cultivo del viñedo en el *territorium Gaditanum* y en el *territorium Hastensis*, así como en la región no adscrita preliminarmente a estas comunidades (Figura 9). De la misma manera procedemos con los suelos de calidad media. Este mapa base resultante es de gran interés para estimar la superficie productiva del viñedo en este territorio bético, así como para su interrelación con los restantes indicadores históricos-arqueológicos disponibles, todo ello con el fin de establecer hipótesis productivas de la vitivinicultura en la región en torno al cambio de era.

Conclusión: el *fundus Columellianus* y la modelización de los viñedos hastenses y gaditanos

La modelización de las tierras del interfluvio Guadalquivir-Guadalete y la identificación hipotética de los terrenos óptimos para el cultivo del viñedo, conforme a los criterios especificados, proporcionan un instrumento interesante para el avance en el estudio económico cuantitativo del marco productivo de las entidades cívicas de la región (Tabla 1).

Las áreas identificadas en el contexto de los *territoria* propuestos para *Hasta Regia* y *Gades* indican que sólo un porcentaje muy reducido reúne las mejoras condiciones para el viñedo y deben constituir estas superficies el espacio nuclear de esta actividad productiva en la región. Mayor es el porcentaje que puede atribuirse a las consideradas tierras buenas, con el 6’66% y el 5’84% de la superficie total respectivamente. Sobre un total de 84.365 ha para todo el territorio, el 3’83% se consideran tierras óptimas, y el 16’31 % tierras buenas, es decir 1161 ha de tierras óptimas y 4850 ha de tierras buenas.

La suma del territorio hastense y no adscrito (42757 ha) arroja una superficie similar a la del territorio gaditano (41.608 ha), sin embargo en el primer caso el 2’51% estaría constituido por tierras óptimas y el 10’47% por tierras buenas, frente al 1’32% y 5’84% de tierras óptimas y buenas en el caso gaditano, duplicándose el potencial vitivinícola del primer espacio sobre el segundo.

---

[50] Varro. *R.R.* 2.2.6. y 2.3.7. 26.; Verg. *G.* 2.185 y 2.295.

[51] DE CARA 2010; GOODCHILD 2013; GOODCHILD, WITCHER 2010; TRAPERO 2016a; TRAPERO 2016b.

Estas superficies pueden ser relacionadas espacialmente con el mapa de dispersión de las *villae* conocidas en el territorio, ofreciendo una selección de ámbitos productivos preferentes para la investigación de la vitivinicultura en los espacios tanto hastenses como gaditanos. La misma lógica puede ser aplicada en la relación de tierras óptimas y buenas para el viñedo con la ubicación de las *figlinae* productoras de envases de morfologias vinarias.

El tercer factor que interesa relacionar con los anteriores –viñedos, *villae* y *figlinae*- es el relativo a las comunicaciones y las vías de exportación. Al mapa de espacios portuarios conocidos, principales o secundarios, podemos ahora añadir los ámbitos de producción, procesado y envasado vitivinícola, estableciendo puertos preferentes en el embarque y exportación de los productos del viñedo hastense y gaditano (Figura 10)

Otro elemento de análisis lo constituye la relación de los suelos adecuados con los núcleos poblacionales de importancia demográfica, que permitiría observar la potencial plantación de viñedos para el consumo, y por tanto, dedicado a viñas adecuadas a la producción de uva de mesa, o, en caso de mayor lejanía de los espacios más habitados, su dedicación para viñas adecuadas para la vinificación. En este mismo análisis convendría incluir tanto los establecimientos villáticos como las *figlinae*, y observar si existe incidencia sobre la tipología y los porcentajes de las formas anfóricas producidas en cada caso, especialmente dada la presencia de diversos subtipos de Dr. 1 y Haltern 70 en el marco productivo.

Como se ha indicado anteriormente no se tienen datos significativos sobre la *pertica* de la ciudad. Por ello tampoco sabemos por el momento si el proceso de colonización implicó una reordenación efectiva del *ager*, hipótesis verosímil, ni cómo afectaría la presunta reordenación espacial a las posesiones más productivas en relación con una *mercatura* tan interesante como era la derivada de la explotación del viñedo.

Todos los elementos anteriormente citados permitirán avanzar en el conocimiento de la actividad agrícola en la región, también de las estrategias de ocupación del espacio, al menos en tiempos tardorrepublicanos y altoimperiales. Los cálculos relativos a la potencial producción vitivinícola y a la capacidad exportadora de *Hasta Regia*, cuando dispongamos de un mayor conocimiento de sus producciones anfóricas, podrán relacionarse con las rutas y los destinos documentados arqueológicamente a lo largo del imperio y de sus confines limitáneos.

Aunque no se dé respuesta a la exacta localización de los *fundi Columelliani* no cabe duda de que la imagen modelizada en esta contribución es esencial para avanzar en el conocimiento de la vitivinicultura romana en *Hasta Regia* y *Gades*. Marco Columela no es más que un arquetipo de *agricola* de esta época y este espacio, de *possessor* de tierras entre cuyas especializaciones productivas se hallaban las relacionadas con la viticultura. Los intereses de Marco, las circunstancias históricas de sus actividades económicas dejaron vestigios, al igual que las de sus pares, en la región, y podemos mediante nuevos enfoques avanzar en su conocimiento.

C. ALONSO, L. MÉNANTEAU, 2010: Les ports antiques de la côte atlantique de l'Andalousie, du bas Guadalquivir au détroit de Gibraltar. Problématique et étude de cas (Baelo, Tarifa), L. HUGOT, L. TRANOY (Ed.), *Les structures portuaires de l'Arc atlantique dans l'Antiquité : bilan et perspective de recherche*, *Aquitania Supplément* 18, 13-38.

M. BUSTAMANTE, D. MARTÍN-ARROYO, 2004: La producción de ánforas greco-itálicas de imitación y su evolución en la bahía gaditana durante el siglo II a.C.: los contextos de la avenida Pery Junquera en San Fernando (Cádiz), D. BERNAL, L. LAGÓSTENA (eds.), *Figlinae Baeticae. Talleres alfareros y producciones cerámicas en la Bética romana (ss. II a.C.-VII d.C.*), BAR I.S. 1266, Vol. 2, Oxford, 441-446.

C. CARRERAS MONFORT, 2001: Producción de Haltern 70 y Dressel 7-11 en las inmediaciones del *Lacus Ligustinus* (Las Marismas, Bajo Guadalquivir), *Actas del Congreso Internacional Ex Baetica Amphorae. Conservas, aceite y vino de la Bética en el Imperio Romano*, Écija, 419-426.

C. CARRERAS MONFORT, 2004: Geografía de la producció de les Haltern 70, AA.VV. *Culip VIII i les àmfores Haltern 70*. Monografies del Casc 5. Museu d'Arqueologia de Catalunya. Centre d'Arqueologia Subaquàtica de Catalunya, Girona, 75-81.

G. CHIC GARCÍA, 1994: Roma y el mar: del Mediterráneo al Atlántico, *Guerra, exploraciones y navegación. Del mundo antiguo a la edad media*, Ferrol, 55-89.

J.A. DE CARA GARCÍA, 2010: Características agroclimáticas de la vid. Agencia Estatal de Meteorología*, Servicio de Aplicaciones Agrícolas e Hidrológicas.*

H. GOODCHILD, 2013: GIS Models of Roman Agricultural Production, *The Roman Agricultural Economy: Organisation, Investment and Production*, 55-84.

H. GOODCHILD, R.E. WITCHER, 2013: Modelling the agricultural landscapes of Republican Italy, *Agricoltura e scambi nell'Italia tardo repubblicana*, 187-220.

J. GONZÁLEZ FERNÁNDEZ, 2014: Inscripción romana del yacimiento de Gibalbín (Cádiz) con indicación de su condición de municipio, *SPAL*, 23, 2014, Sevilla, 191-196.

R. GONZÁLEZ, D. RUIZ MATA, L. AGUILAR, 1991: Prospección arqueológica superficial en la margen izquierda de la marisma de El Bujón (T.M. De Jerez de la Frontera), *AAA*'91 vol. 2, 83-92, Sevilla.

E. HERMON, 2017: Les *loca sacra* dans le *Corpus agrimensorum romanorum* (CAR), *CEA* 54, 69-93.

A. HOLGADO REDONDO, 1988: Introducción, A. HOLGADO (ed.), *De los trabajos del campo de Lucio Junio Moderato Columela*, Madrid.

L. LAGÓSTENA BARRIOS, 1996: *Alfarería romana en la Bahía de Cádiz*, Cádiz.

L. LAGÓSTENA BARRIOS, 2001: *La producción de salsas y conservas de pescado en la Hispania romana (II a.C. – VI d.C.)*, Col.leció Instrumenta 11, Barcelona.

L. LAGÓSTENA BARRIOS, 2010: Columela: una visión provincial de la *pastio villatica*, L. PONS (ed.), *Hispania et Gallia. Dos provincias del Occidente romano*, Col.leció Instrumenta 38, 93-108, Barcelona.

L. LAGÓSTENA BARRIOS, 2011: *Asido Caesarina*: la antigüedad romana de Medina Sidonia, *Historia de Medina Sidonia I. De los orígenes a la Época Medieval*, Cádiz, 119-193.

L. LAGÓSTENA BARRIOS, 2014: La percepción de la ribera en la costa atlántica de la *provincia Hispania Ulterior Baetica*. El *lacus Ligustinus*, E. HERMON, A. WATELET (Dir.), *Riparia, un patrimoine culturel*. *La gestion intégrée des bords de l'eau*, BAR I.S. 2587, Oxford, 187-197.

L. LAGÓSTENA BARRIOS, 2016: El *lacus Ligustinus* como agente de articulación urbana y conectividad territorial: de las riberas de *Hasta Regia* a *Carissa Aurelia* y el acceso a la serranía, *SHHA* 34, 63-86.

L. LAGÓSTENA BARRIOS, e.p.: Estructura de la ocupación rural romana en las campiñas Hastenses y Gaditanas, V. MAYORAL, I. GRAU, *Arqueología y sociedad de los espacios agrarios: en busca de la gente invisible en la materialidad del paisaje* (Mérida, junio 2017).
L. LAGÓSTENA, D. BERNAL, 2004: Alfares y producciones cerámicas en la provincia de Cádiz. Balance y perspectivas, D. BERNAL, L. LAGÓSTENA (eds.), *Figlinae Baeticae. Talleres alfareros y producciones cerámicas en la Bética romana (ss. II a.C.-VII d.C.*), BAR I.S. 1266, Vol. 1, 39-124.
L. LAGÓSTENA, F. ZULETA, Gades y su acueducto: una revisión, L. LAGÓSTENA, F. ZULETA (eds.), *La captación, los usos y la administración del agua en Baetica. Estudios sobre el abastecimiento hídrico en comunidades cívicas del conventus Gaditanus*, Cádiz 2009, 117-172.
M.L. LAVADO FLORIDO, 1987: Carta Arqueológica de la margen izquierda de la desembocadura del Guadalquivir: Sanlúcar (Norte) y Trebujena, *AAA*'87, vol. II, 126-133 Sevilla.
J.J. LÓPEZ AMADOR, J.A. RUIZ GIL, 2007a: Arqueología de la vid y del vino en El Puerto de Santa María, *Revista de Historia de El Puerto*, 38, 11-36.
J.J. LÓPEZ AMADOR, J.A. RUIZ GIL, 2007b: Arqueología de los vegetales y la agricultura en El Puerto de Santa María, *Revista de Historia de El Puerto*, 39, 11-39.
J.J. LÓPEZ AMADOR, D. RUIZMATA, J.A. RUIZ GIL, 2008: El entorno de la Bahía de Cádiz a fines de la Edad del Bronce e inicios de la Edad del Hierro, *RAMPAS* 10, 215-236.
D. MARTÍN-ARROYO SÁNCHEZ, 2013: *Proyección territorial y colonización romana. El caso de Hasta Regia*, Tesis doctoral, Cádiz.
A. MARTIN I OLIVERAS, 2015: *Arqueologia del vi a l'època romana. Del cultiu al consum. Marc teòric i epistemològic*, Societat Catalana D'Arqueologia, Barcelona.
E. MATA ALMONTE, 2001: El asentamiento romano de La Florida, *Revista de Historia de El Puerto* 26, 11-51.
E. MATA, L. LAGÓSTENA, 1997: Ocupación antigua en la Sierra de San Cristóbal (El Puerto de Santa María, Cádiz), *Revista de Historia de El Puerto* 18, 11-45.
M. PONSICH, 1991: *Implantation rurale antique sur le Bas-Guadalquivir*, vol. IV, Madrid.
A. RAMOS, J.C. RIESCO, La villa romana de Las Canteras (Chipiona, Cádiz). Procesos formativos y transformativos del registro arqueológico e inferencias preliminares del asentamiento,
J. RAMOS MUÑOZ, R. GONZÁLEZ RODRÍGUEZ, 1990: Prospección arqueológica superficial en el término municipal de Jerez de la Frontera, Cádiz. Campaña 1990". *AAA*'90, vol. 2, 64-75, Sevilla.
F. RIESCO GARCÍA, 1987: *Carta Arqueológica de la desembocadura del río Guadalquivir. Zona Sur*. Memoria de Licenciatura (inédita), Sevilla.
F. RIESCO GARCÍA, 2010: La presencia romana en el territorio de Rota. De la Prehistoria a la Rábita y la villa, *Arqueología de Rota y la Bahía de Cádiz*, Cádiz, 149-172.
A. RUIZ CASTELLANOS, E. VEGA GEÁN, F.A. GARCÍA ROMERO, 2016: *Inscripciones latinas de Jerez de la Frontera. Epigrafía y contexto*, Cádiz.
J.A. RUIZ GIL, J.A. LÓPEZ AMADOR, 2004: Itinerario de la vía Augusta a su paso por El Puerto de Santa María, D. BERNAL, L. LAGÓSTENA (eds.), *Figlinae Baeticae. Talleres alfareros y producciones cerámicas en la Bética romana (ss. II a.C.-VII d.C.*), BAR I.S. 1266, Vol. 2, 691-694, Oxford.
P. SÁEZ FERNÁNDEZ, 1983: Columela, De R.R. XII, 52,6: *canalis et solea*, *Habis* 14, 147-152, Sevilla.
P. SÁEZ FERNÁNDEZ, 1987: *Agricultura romana de la Bética I*, Sevilla.
P. SÁEZ FERNÁNDEZ, 1988: Sobre algunos tipos de tierra vitícolas de la Bética, *Actas del 1er Congreso Peninsular de Historia Antigua*, vol. 2, 521-529, Santiago de Compostela.
P. SÁEZ FERNÁNDEZ, 1994: Columela y la Betica, S.ORDOÑEZ, P. SÁEZ (coord..), Homenaje al profesor Presedo, 687-698, Sevilla.
G. SÁNCHEZ ALONSO, 2010: *Análisis de la documentación arqueológica de la villa y el término*

municipal de Rota, Cádiz.
P. SILLIÈRES, 1990: *Les voies de communication de l'Hispanie méridionale*, Toulouse.
P. TRAPERO FERNÁNDEZ, 2016a: Roman viticulture analysis based on Latin agronomists and the application of a Geographic Information System in lower Guadalquivir, *Virtual Archaeology Review*, 7 (14), 53-60.
P. TRAPERO FERNÁNDEZ, 2016b: Perspectives about the analysis of Roman viticulture in Guadalquivir estuary, *RIPARIA* 2, 55-74.

Tabla 1

	Territorio gaditano	**Territorio hastense**	**Territorio no adscrito**	Área Total
Superficie estimada	41.608 ha	27.623 ha	15.134 ha	84.365 ha
Tierras Óptimas	551 ha	505 ha	105 ha	1.161 ha
Tierras Buenas	2.431 ha	1.841 ha	578 ha	4.850 ha.
% Tierras Óptimas	1'32%	1'82%	0'69%	3'83%
% Tierras Buenas	5'84%	6'66%	3'81%	16,31%

Tabla 2

Figura 4: *Villae* identificadas en el marco de estudio		**Figura 5: *Figlinae* identificadas en el marco de estudio**				**Figura 6: *Figlinae* con potencial producción de envases vinarios en el marco de estudio**	
1	Mojón Blanco	1	Poco Aceite	61	Hijuela de Tio Prieto	1	PocoAceite
2	El Pastor	2	Cerro de los Villares	62	Jardines de Cano	2	Cerro de los Villares
3	Cerro Capita	3	Las Playas	63	Calle Javier Burgos	3	La Carrascona
4	El Morisco	4	La Carrascona	64	La China	4	Las Playas
5	El Olivar	5	Loma de Overo	65	Martelilla	5	Loma de Overo
6	El Peñon	6	Majada Vieja	66	La Zarza	6	Majada Vieja
7	Corchitos	7	El Redondón	67	Doña Benita	7	Alventu
8	Monteagudo Oeste	8	Adventus	68	La Cerería	8	El Redondón
9	Haza de la Torre	9	Rancho Centeno	69	Calle Doctor Marañón	9	Rancho Centeno
10	Molino de Monteagudo	10	Casa de Quincena	70	Las Canteras	10	Hacienda de los Micones
11	Cerro de las Monjas	11	Hacienda de los Micones	71	La Cabaña 1	11	Cortijo del Bufido
12	Cortijo del Bujón VD	12	Cortijo del Bufido	72	Olivar de los Valencianos	12	Casa de Quincena
13	Viña Cabeza Alcaide	13	Monasterejos	73	Cerro de Ceuta	13	Monasterejos
14	El Cementerio	14	Cerro de los Castillejos	74	La Cabaña 2	14	Cerro de los Castillejos
15	El Tesorillo	15	Mojón Blanco I-II-III	75	EL Almendral	15	Mojón Blanco I-II-III
16	Portugalejo	16	Cerro Capita	76	EL Gallinero	16	Cerro Capita
17	Loma de Espartinas	17	Cerro Blanco	77	Canteras de Lavalle I	17	Cerro Blanco
18	Moral	18	El Cementerio I-II-III	78	Casines	18	El Cementerio I-II-III
19	Cortijo de Painobo	19	El Tesorillo I	79	Cantera de Lavalle II	19	El Tesorillo I
20	Arroyo de la Compañía	20	Loma de Espartinas	80	Torrealta B	20	Loma de Espartinas
21	Evora Este	21	Arroyo de la Compañía I	81	Casa de las Tinajas	21	Arroyo de la Compañía
22	Alamedinilla	22	Montegil (Cortijo Antiguo)	82	El Carpio Chico	22	Montegil (Cortijo Antiguo)
23	Regajo	23	Prados de Montegil	83	Fábrica Lavalle	23	Alamedilla III
24	Pozos del Rosario	24	Alamedilla III	84	La Cachucha II	24	Haza del Camino
25	Evora Sur	25	Haza del Camino	85	La Cacucha I	25	Marisma de Rajaldaba
26	La Galguera	26	Marisma de Rajaldaba	86	Torrealta A	26	Loma de Ventosilla
27	Espartinas	27	Loma de Ventsilla	87	Avenida de Portugal	27	La Zangarriana
28	Casa de Carranza	28	La Zangarriana	88	Puente Melchor	28	Lopina
29	Cortijo de la Fuente	29	Lopina	89	El Carvajal	29	El Olivar
30	Norieta Grande	30	El Olivar	90	Santa Domingo	30	Rabatún

31	Casa de Hornillas	31	Torre Melgarejo	91	San José	31	Las Aguilillas
32	Casa de la Norieta	32	El Almendral	92	Villanueva	32	Vaina
33	Finca el Olivillo	33	Haza de las Piedras	93	Malas Noches	33	Cortijo del Conejo
34	Casa del Aguila	34	Rabatún	94	Fádricas	34	Casa de la Vicuña
35	Cortijo de Cestelo	35	La Peña	95	Cerro de los Caracoles	35	Las Manoteras
36	Montijo	36	Viña la Cantaras	96	Albardoneros	36	Buena vista
37	Las Carreñas	37	Las Aguilillas	97	Pery Junquera	37	El Torno
38	El Bonete	38	Venta Alta	98	La salineta	38	El Tesorillo
39	Rancho de Pérez Gil	39	Vaina	99	Canal I	39	Cantarranas. Los Cipreses
40	Las Canteras	40	Cortijo del Conejo	100	Picapollo	40	Los Sauces
41	Loma Baja	41	Casa de la Vicuña	101	Centro Altlántida	41	Jardín de Cano
42	Los Rizos	42	El Barranco	102	Cuartel de Camposoto	42	Hijuela de Tío Prieto
43	Cortijo de la Cañada	43	Pernita	103	Cerro de las Baterías	43	Calle Javier Burgos
44	El Poedo	44	Los Tercios	104	Calle Asteroides	44	La China
45	Cerro de la Cañada	45	Laguna Salada	105	Los Villares	45	Martelilla
46	Alcanora	46	Las Manoteras	106	Cerro de los Mártieres	46	Calle Doctor Marañon
47	Torre Melgarejo	47	Buena Vista	107	Gallineras	47	Olivar de los Valencianos
48	Campín	48	Rancho Perea	108	Pozo Alcudia	48	Casines
49	El Almendral	49	El Torno	109	La Almadraba	49	Cantera de Lavalle I
50	Monte Petri	50	Viña las Cantarranas	110	Huerta del Rosario	50	El Almendral
51	El Villar	51	Cruce de las Almenas	111	El fontanar	51	El Gallinero
52	Dehesa Nueva	52	Cerro de las Cabezas	112	Casa de Huertas	52	Torrealta A
53	El Saloral	53	San Ignacio	113	Calle Lafuente	53	Puente Melchor
54	Casa de la Pintada	54	La Florida	114	Antigua Bodega Delamar	54	El Carvajal
55	Cerro de las Cabezas	55	Puntilla de Fuentebrava	115	Cerro del Castillo	55	Pery Junquera
56	La Canaleja	56	El Palomar. Puerto Nuevo	116	Calle Convento	56	Gallineras
57	Meloneras	57	Cantarranas. Los Cipreses	117	La Esparragosa	57	Cerro de los Mártires
58	Regodón	58	El Tesorillo	118	Loma del Puerco	58	El Fontanar
59	Elice	59	Molino Platero			59	Calle Convento
60	Vaina	60	Los Sauces			60	Cerro del Castillo
61	Llagunetas					61	La Esparragosa
62	Campillo					62	Loma del Puerco
63	Casa de la Vicuña						
64	Los Tercios						
65	Hijuela de las Coles						
66	Cerro de los Olivares						
67	Villa Base de Rota						
68	Las Manoteras						
69	Buenavista						
70	Campsa						
71	Los Villares						
72	Los Almenas						
73	La Florida						
74	Cortijo el Tesorillo						
75	Barjas						
76	La Zarza						
77	Santo Domingo						
78	Malasnoches						

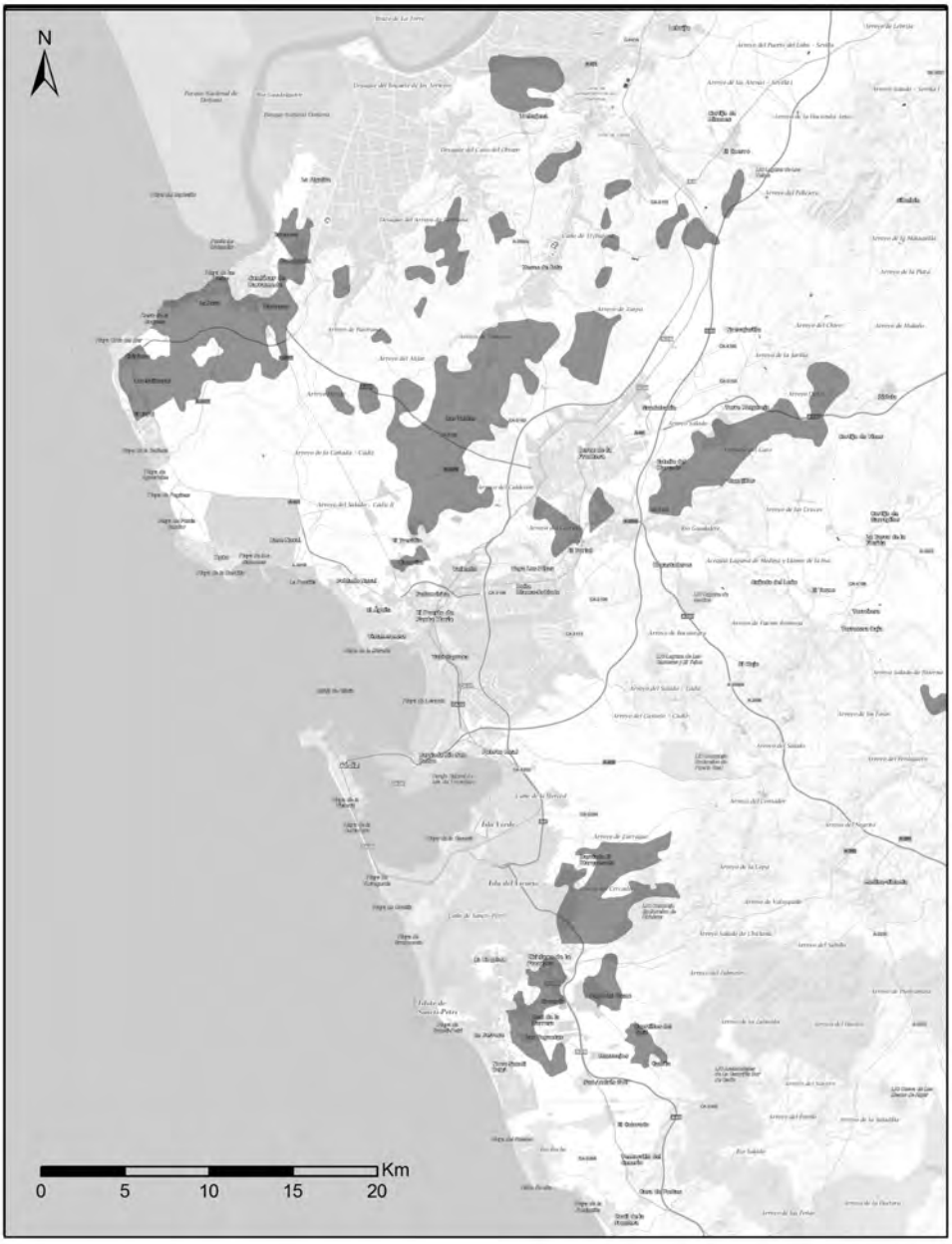


Figura 1: Marco general actual

Viñedos actuales Marco del Jerez

ETRS89-UTM H30

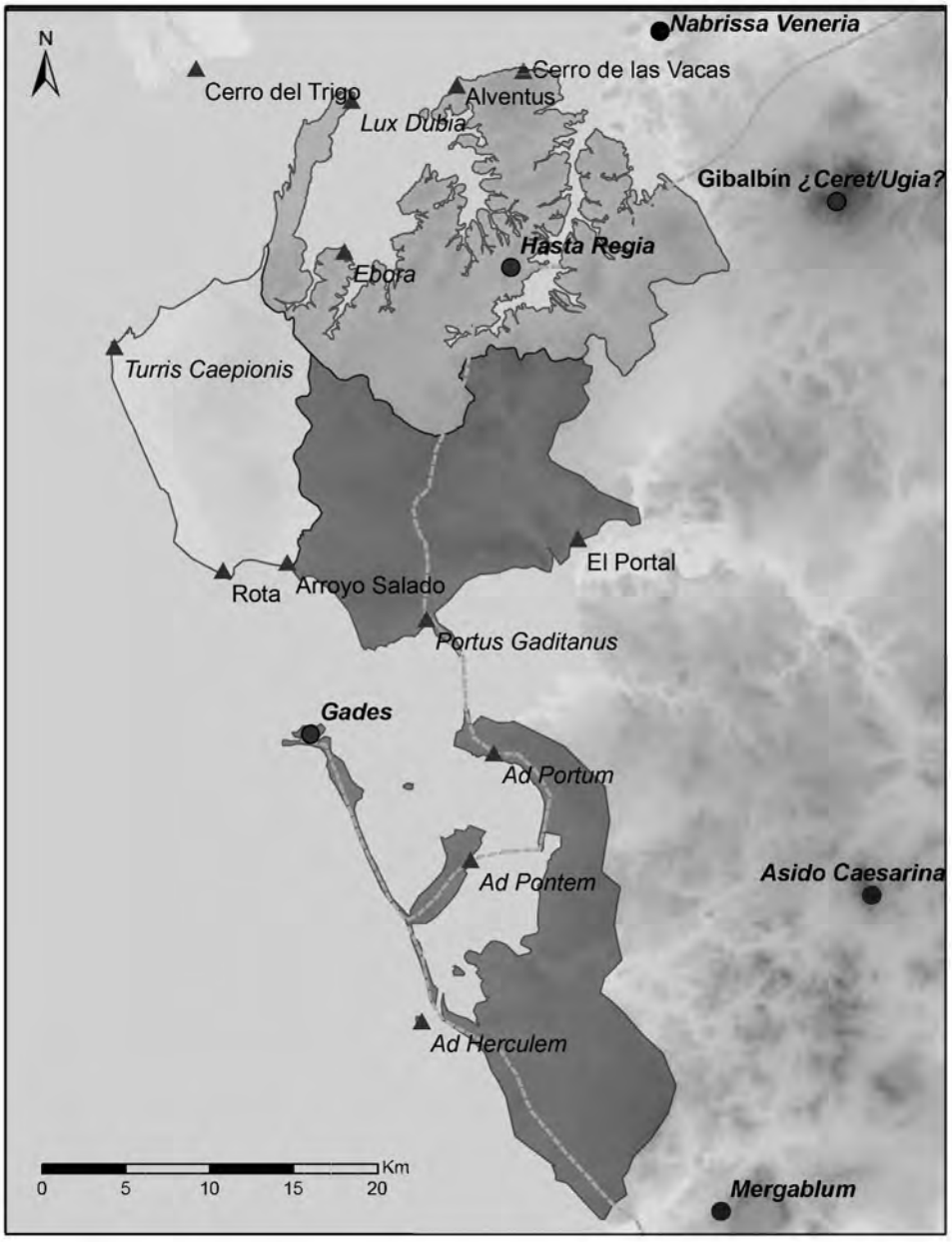


Figura 2: Hipótesis de proyección y articulación territorial

- Entidades cívicas
- Puertos y embarcaderos
- *Via Augusta*
- Hipotético *territorium* de *Hasta*
- Hipotético *territorium* de *Gades*
- *Ager* de adscripción indeterminada

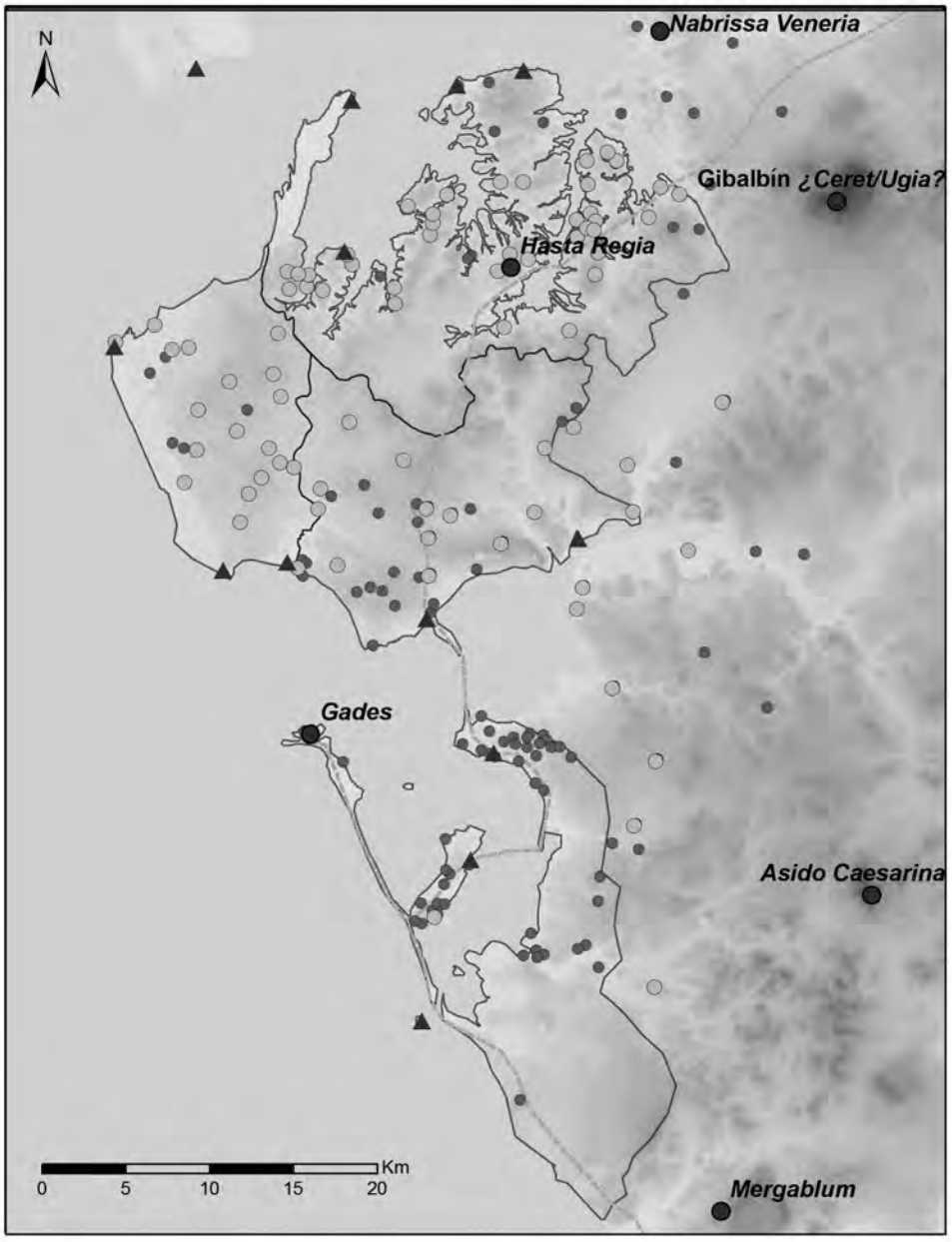


Figura 3: ***Figlinae*** **y** ***villae*** **en el marco de estudio**

Entidades cívicas
Puertos y embarcaderos
Villae
Figlinae
Via Augusta

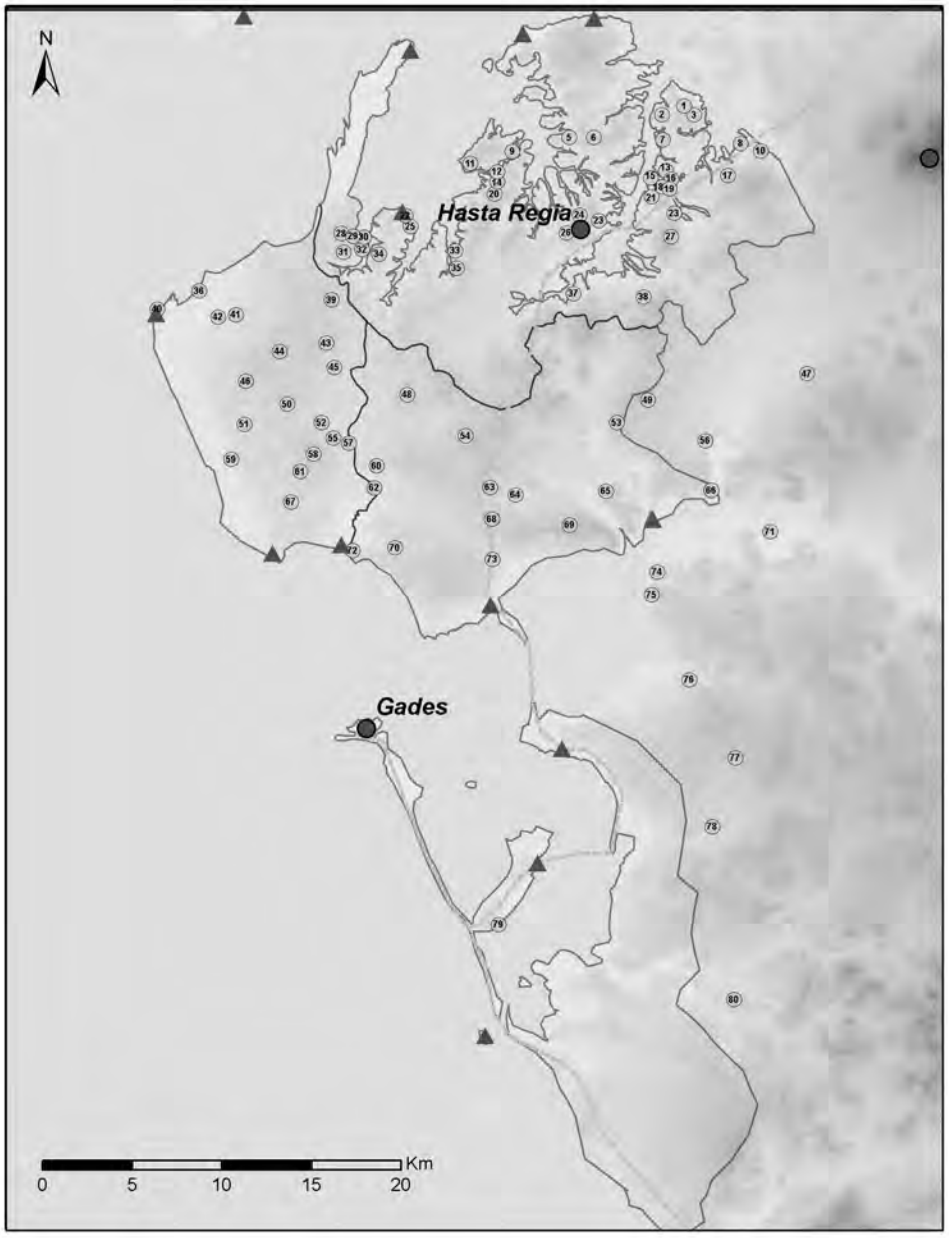


Figura 4: *Villae* identificadas en el marco de estudio

ETRS89-UTM H30

Entidades cívicas
Puertos y embarcaderos
Villae
Via Augusta

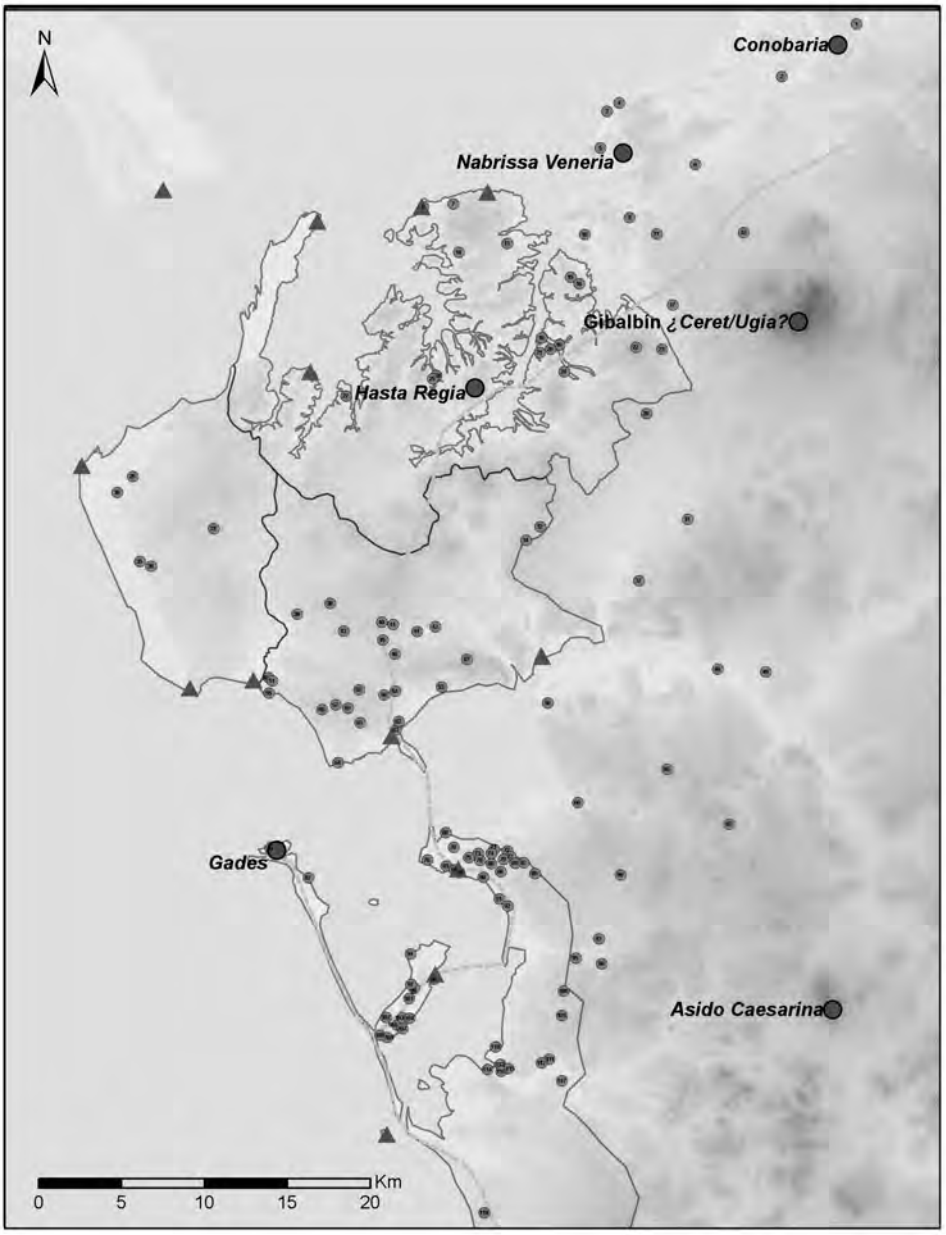


Figura 5: *Figlinae* **identificadas en el marco de estudio**

ETRS89-UTM H30

Entidades cívicas
Puertos y embarcaderos
Figlinae
Via Augusta

© Seminario Agustín de Horozco http://agustindehorozco.uca.es

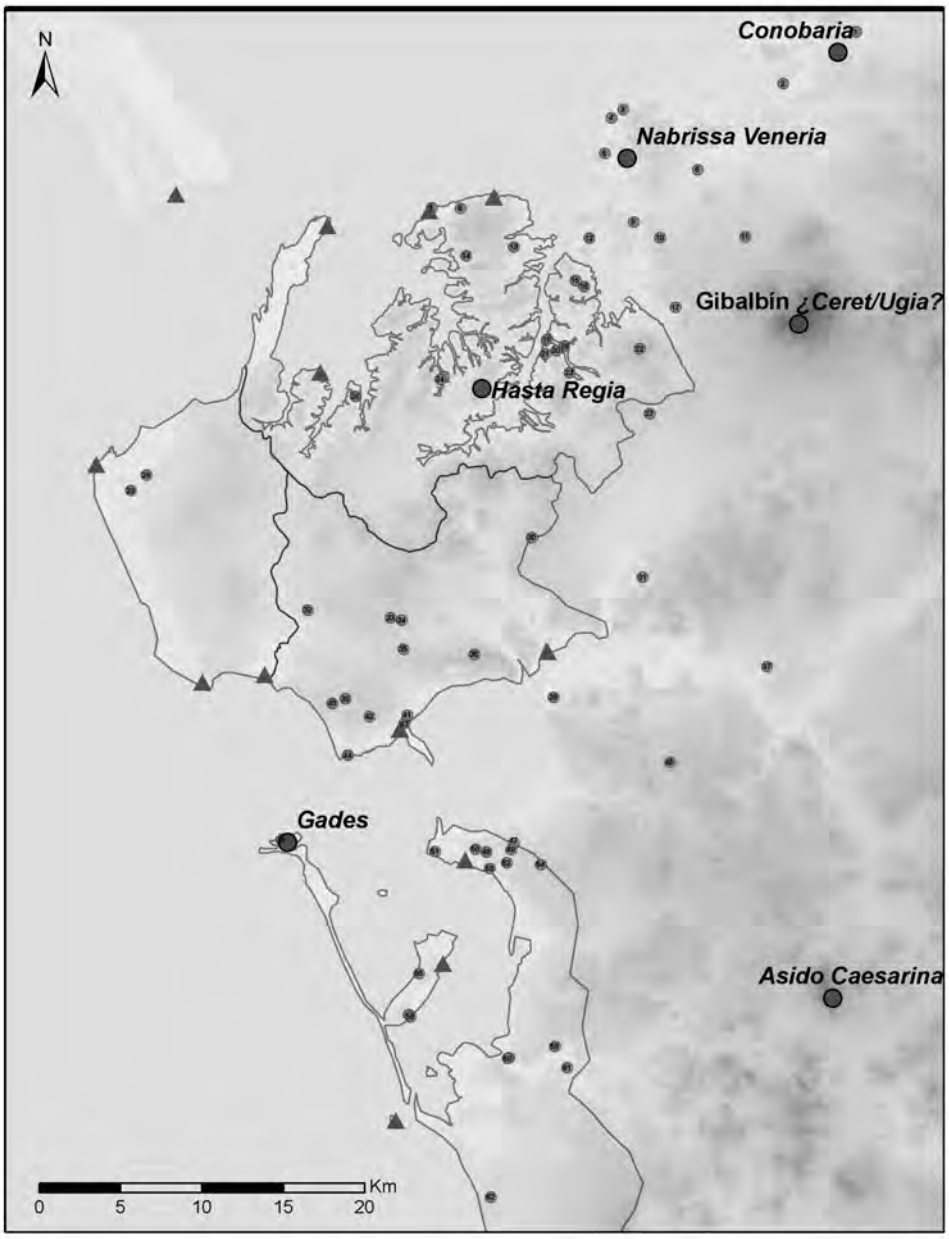


Figura 6: ***Figlinae*** **con potencial producción de envases vinarios en el marco de estudio**

ETRS89-UTM H30

Entidades cívicas

Puertos y embarcaderos

Figlinae con potencial producción de envases vinarios

© Seminario Agustín de Horozco http://agustindehorozco.uca.es

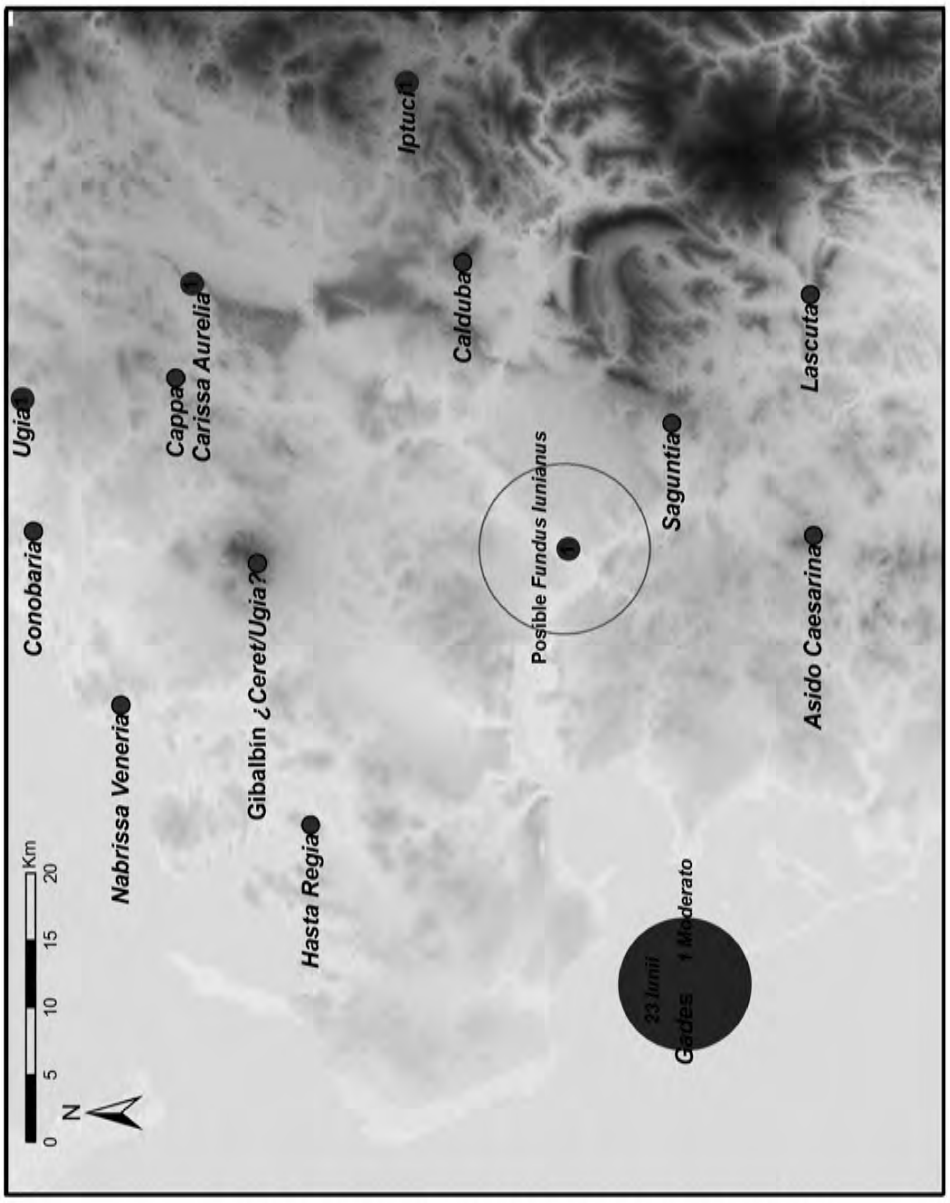


Fig. 7: Distribución territorial de la epigrafía de la *gens Iunia*

Iunii registrados epigráficamente

Entidades Cívicas

ETRS89-UTM H30

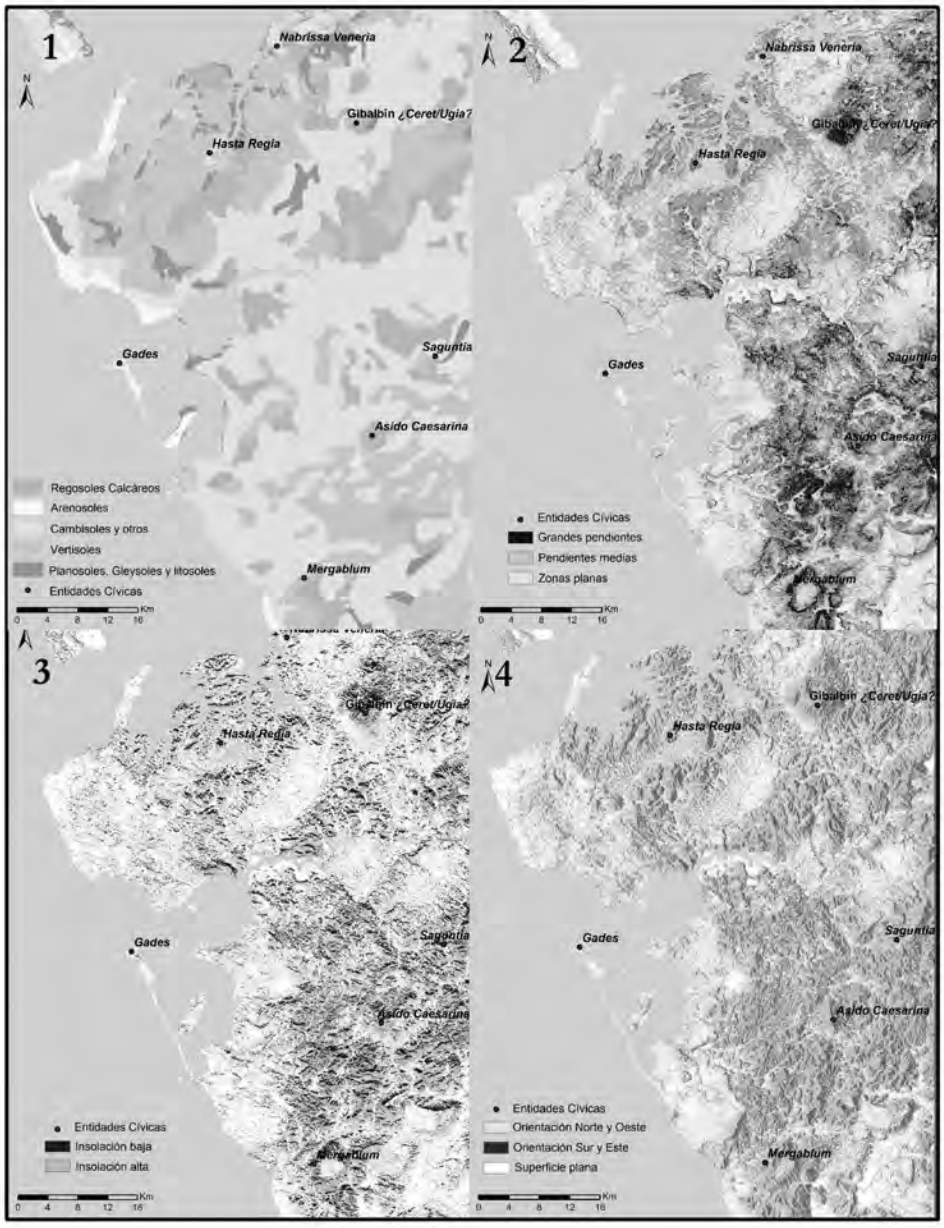


Figura 8: Criterios para la caracterización de los suelos óptimos para el viñedo

ETRS89-UTM H30

1- Mejores suelos según la geología y la edafología
2- Pendientes del terreno
3- Insolación del terreno
4- Orientación del terreno

© **Seminario Agustín de Horozco** http://agustindehorozco.uca.es

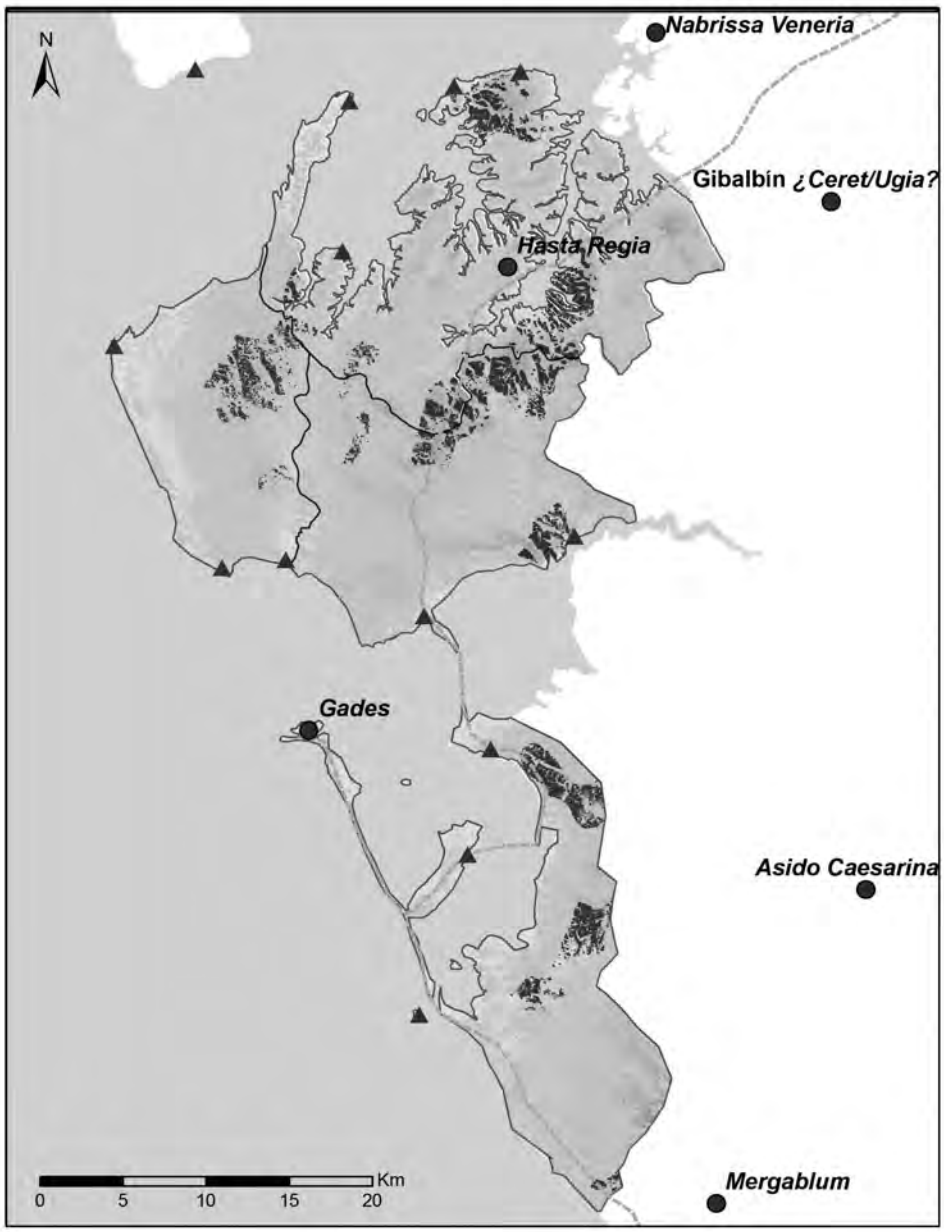


Figura 9: Modelización de suelos óptimos y buenos para el viñedo en el marco de estudio

Suelos óptimos para el viñedo según la agronomía romana

Suelos buenos para el viñedo según la agronomía romana

Entidades cívicas

Puertos y embarcaderos

ETRS89-UTM H30

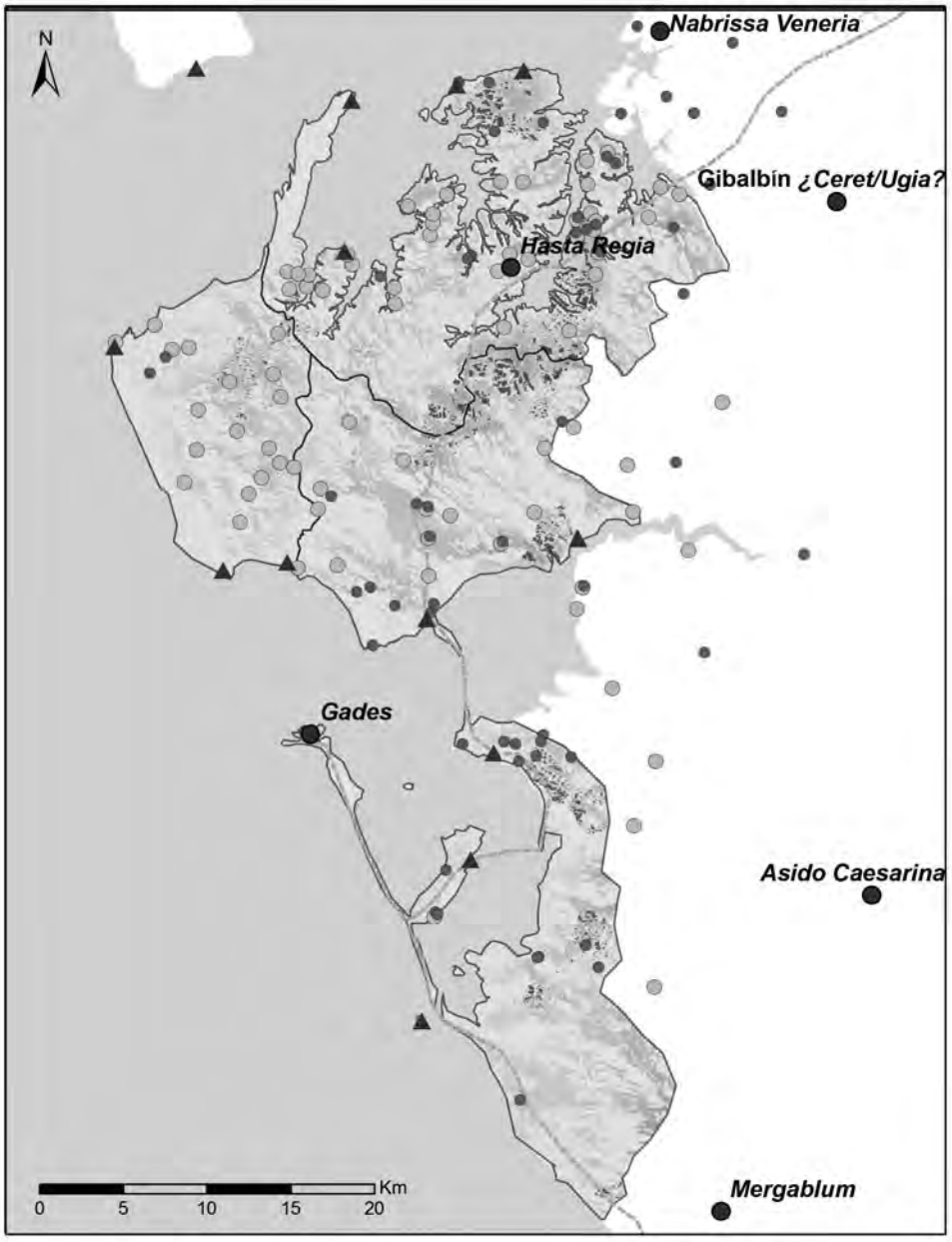


Figura 10: Modelización de las condiciones del viñedo Hastense y Gaditano

ETRS89-UTM H30

Suelos óptimos para el viñedo según la agronomía romana

Suelos buenos para el viñedo según la agronomía romana

Entidades cívicas

Puertos y embarcaderos

Figlinae

Villae

Villae y *Figlinae* a orillas del *Lacus Ligustinus*. Análisis GIS y prospección geofísica en el *territorium* ribereño de *Hasta Regia*

José Antonio Ruiz Gil[1]
Lázaro Lagóstena Barrios
Jenny Pérez Marrero
Domingo Martín Mochales
Pedro Trapero Fernández
Javier Catalán González

IVAGRO
University of Cádiz

El *territorium* de la colonia romana *Hasta Regia* se extiende entre la divisoria de aguas de la cuenca del Guadalquivir y las orillas del antiguo *Lacus Ligustinus* en la provincia de *Baetica*. Este territorio, caracterizado por su feraz campiña, su condición ribereña, y surcado por numerosos esteros, como describía Estrabón, conoció una intensa explotación agrícola, destacando la producción y la exportación de derivados vitivinícolas en ánforas de la familia Dressel 1 y Haltern 70. La aplicación de técnicas de análisis GIS combinadas con prospección geofísica con georradar nos permite proponer nuevas claves del ordenamiento de este espacio, conocido hasta la fecha mediante prospecciones superficiales tradicionales. Se analiza la distribución del sistema de *villae* en un espacio presuntamente centuriado. Igualmente, se identifican y analizan los alfares productores de ánforas destinadas a la distribución de los productos hastenses. La exploración de la *urbs* con georradar

[1] jantonio.ruiz@uca.es

Stream X permite reflexionar sobre la aplicación metodológica de nuevas técnicas al estudio no invasivo del territorio urbano y productivo de la ciudad romana.

1. El *ager Hastensis*: estado de su delimitación y conocimiento.

Hasta Regia fue una de las colonias establecidas en la *provincia Ulterior Baetica,* adscrita al *conventus Hispalensis* según informa Plinio[2]. A pesar de su estatus destacado no ha recibido especial atención por parte de la investigación reciente, y poco se conoce sobre el alcance de su proyección territorial, sobre la extensión de la *pertica* de la ciudad, sobre posibles parcelaciones relacionadas con su trayectoria cívica, sobre la organización, dimensión y articulación de su *ager* en definitiva.

El alcance del *territorium* bajo la jurisdicción de la *civitas* Hastense no ha sido objeto de publicaciones específicas[3]. La información transmitida por el conocido Bronce de Lascuta, según la cual el poder político territorial de la ciudad alcanzaría a la población de *turris Lascutana*, que se ubicaría en el actual término municipal de Alcalá de los Gazules, sugeriría que la ciudad de los esteros disponía de un amplísimo espacio sometido a su dominio[4]. Parece necesario matizar este dato proporcionado por el epígrafe dado que su contexto histórico - la conclusión de la segunda Guerra Púnica, la *deditio* que supuso el *foedus Gaditanus*, los inicios de la administración provincial romana en la *Ulterior,* el vacío momentáneo de poder regional que supusieron estos acontecimientos- justifica un intento de establecimiento en la región de un nuevo dominio político por parte de la ancestral comunidad de *Hasta,* y proporciona una explicación plausible y coyuntural del literal del decreto de L. Emilio Paulo[5].

Para ofrecer una hipótesis sobre el alcance de la jurisdicción territorial de la *colonia Hasta Regia* hemos recurrido a la combinación de algunos aspectos que parecen determinantes en la percepción y la ordenación del espacio compartido por muchas de las sociedades de la antigüedad mediterránea. Estas perspectivas están presentes también en la cosmovisión del paisaje cívico de la sociedad latina. Nos referimos al recurso a los límites geográficos y orográficos de un espacio como base de la articulación del mismo, al que se deben añadir otros factores de índole cultural, como los simbólicos y los religiosos[6]. El objetivo es establecer un marco territorial hipotético, verosímil y válido para un período concreto, que permita una modelización del funcionamiento económico de este espacio rural, extrapolable para su comparación con otras propuestas territoriales, otras comunidades y otras cronologías .

Los principales confines naturales que delimitarían el espacio de la ciudad son, por una parte las actuales marismas del río *Baetis*, hoy terrenos sedimentarios conformados sobre la isolínea de

---

[2] Plin. *N.H*. 3.11

[3] Véase la contribución de LAGÓSTENA y TRAPERO en este mismo volumen. Sobre ello se ha reflexionado y se ha dedicado interesantes aportaciones en MARTÍN-ARROYO, 2013, 284 ss.

[4] *C.I.L.* II, 5041. Amplísima es la bibliografía dedicada a diversos aspectos del epígrafe. Consideramos que *turris Lascutana* se debía corresponder con el *oppidum* localizado en la finca Las Correderas, mientras *Lascuta* se ubicaría bajo el actual pueblo de Alcalá de los Gazules, siendo por tanto entidades distintas aunque lógicamente emparentadas.

[5] CHIC GARCÍA, 1984; LAGÓSTENA, 2011, 161 ss.

[6] Cabe recurrir aquí al esclarecedor testimonio de Hygino, *De condicionibus agrorum*, 2: *Territorii [aeque] iuris controversia agitatur, quotiens propter exigenda tributa de possessione litigatur, cum dicat una pars in sui eam fine territorii constituta<m>, et altera e contrario similiter. Quae re<s> [haec autem controversia] territorialibus est finienda terminibus, nam invenimus saepe in publicis instrumentis significanter inscripta territoria ita ut EX COLL<ICVL>O QVI APPELLATVR ILLE, AD FLVMEN ILLVD, ET PER FLVMEN ILLVD AD RIVVM ILLVM aut VIAM ILLAM, ET PER VIAM ILLAM AD INFIMA MONTIS ILLIVS, QVI LOCVS APPELLATVR ILLE, ET INDE PER IVGVM MONTIS ILLIVS IN SVMM<VM> ET PER SVMMVM MONTIS PER DIVERGIA AQVAE AD LOCVM QVI APPELLATVR ILLE, ET INDE DEORSVM VERSVS AD LOCVM ILLVM, ET INDE AD COMP<I>TVM ILLIVS, ET INDE PER MONVMENTVM ILLIVS AD locum unde primum coepit scriptura esse* (CASTILLO PASCUAL, 2011).

contacto fluvio-continental de las paleoriberas del humedal conocido en la Antigüedad como *lacus Ligustinus*[7]. Por el Oeste esta ribera alcanzaba hasta la actual desembocadura del río, determinado en la Antigüedad por una barra arenosa litoral donde, no por casualidad, se localizaba el santuario de *Lux Dubia*[8]. Hacia el Este, el límite habría de confinar con el *territorium* del municipio latino de *Nabrissa Veneria*[9] y vendría establecido por un amplio estero – estero de El Cuervo- que conecta con uno de los cauces secundarios– arroyo de La Molineta- que drenan desde el Cerro de Gibalbín, monte donde por cierto se localiza una entidad urbana cuya adscripción es aún discutida. Esta combinación del estuario del río, de las paleoriberas del *Ligustinus*, y de los esteros que penetran hacia el interior conectando con la red hidrológica de la cuenca, establece un límite geográfico verosímil para la parte septentrional y *aestuaria* del *territorium* Hastense. Un segundo elemento geográfico, precisamente destacado por los agrimensores como idóneo para la delimitación territorial, está constituido por los *divergia* o *divortia aquarum*, es decir, la divisoria de aguas de las cuencas fluviales. En el caso que nos ocupa, *Hasta Regia* se localiza en un lugar claramente central de la subcuenca final de la margen izquierda del Guadalquivir. El territorio comprendido entre la paleoribera y la divisoria de aguas de esta subcuenca configura en nuestra opinión el territorio nuclear de la *civitas* hastense. Los espacios colindantes al Sur forman parte de la cuenca del río Guadalete y en nuestra hipótesis, por razones cuya explicación exceden el marco de esta contribución, debe vincularse preferentemente con el territorio jurisdiccional gaditano[10].

Al Oeste de este escenario y colindante con el mismo hallamos una cuenca fluvial –la del arroyo Salado – que se sitúa entre el último tramo de las cuencas finales del Guadalquivir y del Guadalete, cuya adscripción bien a *Gades* bien a *Hasta* es discutible pero cierta, pues no parece existir en fechas tardorrepublicanas y altoimperiales otra opción cívica en este espacio, salvo la dudosa *Ebora*.

Cabe implementar esta propuesta de restitución basada en la configuración orográfica del espacio con otro tipo de elementos de carácter cultural. En este sentido se ha destacado el papel desempeñado en la delimitación de los territorios políticos por elementos articuladores como la red viaria, elementos religiosos como los *loca sacra*, los espacios funerarios, y otros hitos propios del paisaje simbólico como los *monumenta*. Todo este conjunto de hitos se atestiguan también tanto por las fuentes literarias como arqueológicas para el espacio que analizamos[11].

Respecto a los elementos viarios, la *via Augusta* es el principal eje de comunicación en este territorio. Algunas consideraciones que añadir a la amplia bibliografía sobre la misma, y concernientes a esta contribución son: la doble orientación que su trazado adquiere en el *iter* que

---

[7] Recientemente hemos dedicado sendas contribuciones a diversos aspectos del humedal: a su percepción por las sociedades antiguas a tenor de la información literaria grecolatina (LAGÓSTENA, 2014); y a su papel fundamental en el ordenamiento urbano y en la articulación territorial del Bajo Guadalquivir (LAGÓSTENA, 2016).

[8] Sobre el santuario: PÉREZ LÓPEZ, 1999. Se ubicaba en un espacio muy dinámico geomorfológicamente hablando, no sólo por su condición de desembocadura fluvial atlántica, también por su exposición a los períodicos eventos catastróficos de alta energía, como los maremotos documentados en RODRÍGUEZ VIDAL et alii, 2011, que sin duda modificaron en varias ocasiones su configuración estuaria. Sobre el papel de los *loca sacra* en el marco del catastro colonial, HERMON, 2017.

[9] Str. 3.1.9; 3,2,5; Plin. *N.H*. 3.11; Sil. 3.393; Ptol. 2.4.10. Interesante para la cuestión el testimonio del Bronce de Bonanza (*C.I.L*. II, 5042) y su alusión al *ager Venerensis*. Un reciente estado de la cuestión en MARTÍN-ARROYO 2013, 292 ss.

[10] No obstante la zona de la cuenca media del Guadalete ubicada entre la Laguna de Medina, el cortijo de Los Villares y la Cartuja de Jerez resulta un espacio limítrofe si proyectamos los polígonos Thiessen entre *Gades*, *Hasta* y *Asido*, un ámbito donde un *trifinium* territorial no sería descartable. La misma situación persiste si añadiésemos a este cálculo las hipotéticas jurisdicciones territoriales del probable municipio ubicado en Gibalbín y de la *civitas* de *Saguntia* (Baños de Gigonza).

[11] Un magnífico ejemplo de este elenco territorial en este espacio los hallamos sintetizado en Mela, 3.4: *In proximo sinu portus est quem Gaditanum, et lucus quem Oleastrum adpellant, tum castellum Ebora in litore et procul a litore Hasta colonia. Extra Iunonis ara templumque est, in ipso mari monumentum Caepionis scopulo magis quam insulae impositum.*

discurre entre *portus Gaditanus* y *Vgia*; para este mismo trayecto, y a diferencia de lo documentado en las inmediaciones del territorio gaditano, la ausencia de *stationes* y *mansiones* secundarias; finalmente, la escasez de miliarios conocidos[12].

Si bien la orientación general de la vía en el tramo en cuestión puede estar condicionada por la base geográfica y, para el tramo *Hasta-Vgia* en particular, por la orientación de la cuenca del Guadalquivir, no deben desestimarse otras razones vinculadas con la ordenación espacial para esta elección cardinal. Así el hecho de discurrir por los *territoria* de dos comunidades con condición diversa –municipal y colonial- constituidos por *agri* con consideraciones jurídicas distintas –privado y público- podría ser un factor clave en el planteamiento de la vía. Un elemento a valorar en esta problemática es la orientación NO-SE que comenzamos a documentar mediante las prospecciones geofísicas para los cardos y las *insulae* de la *urbs* hastense, resultando *decumani* alineados con el tramo *Hasta-Vgia* de la calzada. Opinamos por tanto que se debe establecer una correlación entre la orientación de la vía, el alcance territorial de las comunidades limítrofes, y la probable ordenación coetánea de la urbanística colonial y de la *pertica* de la ciudad.

En el ámbito territorial gaditano, entre *Gades* y su nuevo puerto, y en relación con los confines de su bahía, se ubican según las fuentes itinerarias diversas *mansiones* que cabría poner en relación no solo con la vía, sino también con la proyección espacial de la *civitas* gaditana y con sus encrucijadas: *ad Herculem*, *ad Pontem*, *ad Portum* y el propio *portus Gaditanus*. Sin embargo este tipo de elementos no son habituales en el siguiente tramo de la vía. Sí conocemos, en cambio, un topónimo que pudiera responder tanto a la estructura etimológica como al valor limitáneo de las mansiones, denominadas con la expresión *ad* + acusativo. Se trata de *ad Ventus* que parece ser el origen del topónimo actual Alventus. Se trataría de un espacio portuario, hoy situado junto a las marismas de Trebujena, relacionado con la ruta fluvial del Guadalquivir, y precisamente ubicado en las inmediaciones del límite que proponemos para los *territoria* de *Hasta* y *Nabrissa*.

El territorio nuclear así definido para *Hasta* alcanza las 27.623 ha. Es este el espacio cuya ocupación rural analizamos preferentemente en esta contribución, siendo consciente de la potencial ampliación del mismo, especialmente hacia el Oeste (Figura 1).

2. Caracterización geomorfológica del *ager* hastense y su relación con el poblamiento productivo.

Un primer elemento de la modelización que proponemos para este ámbito de estudio se refiere a su caracterización geológica. Interesa por una parte identificar la diversidad de formaciones geológicas y por tanto de condiciones edafológicas que se generan en el hipotético territorio nuclear de *Hasta*, cuantificándolo tanto en sus valores absolutos como en su porcentual relativo al conjunto del agro por nosotros delimitado. Este acercamiento nos permite establecer una relación entre las condiciones geológicas del espacio y la ubicación de los establecimientos productivos conocidos hasta la fecha en el mismo, además de aproximarnos y valorar las condiciones que ofrecería la geología del *territorium Hastense*.

---

[12] *Vide*: MARTÍN-ARROYO 2013, 287-288.

Figura 1

Así las formaciones geológicas presentes en este espacio se corresponden con diversas caracterizaciones:

- ✓ Una formación de cordón dunar cuya génesis se relaciona con los procesos de la Transgresión Flandriense, cuando el lento descenso del nivel marino se conjuga con la acumulación de depósitos fluviales que, en el margen izquierdo de la desembocadura del Guadalquivir, son frenados por la corriente de deriva costera del Golfo de Cádiz.
- ✓ La formación de Margas blancas y azules, localmente limos, arenas, y sílex, que fue descrita en el siglo XIX por Cerón, llamadas popularmente albarizas o tierra de anafes, compuestas por un 60/70% de carbonato de cal, arcilla, algo de sílice y acaso magnesia. Morfológicamente muestra formaciones de cerros y colinas[13].

[13] CERON, 1877, 11.

- ✓ Otra formación característica son los vertisoles que presentan una composición con más de un 30% de arcilla, lo que los hace pesados para el laboreo, pues se endurecen en exceso en la estación seca y se reblandecen en la estación lluviosa. La abundancia en agua del medio provoca tanto hidromorfismos como salinas.
- ✓ En el Mioceno Superior, con posterioridad a la orogenia alpina, se inicia la sedimentación con materiales autóctonos, conformando las margas azules, con tonalidades desde el gris azulado al beige, según la humedad, que resultan propias de un ambiente marino pelágico[14].
- ✓ También en el Mioceno, areniscas, arenas y limos amarillos, junto a calizas toscas, se superponen a las margas blancas –albarizas- y caracterizan la formación geomorfológica que denominamos "tipo mesas".
- ✓ Como margas azules y blancas se expresan los materiales de transición entre las cordilleras béticas y la cuenca del Guadalquivir, de cronología Mesozoica y de inicio del Terciario[15].
- ✓ Otra formación de arenisca calcárea, arenas, limos amarillos y margas, se estratifican en karst continental relleno por arenas rojas, ricas en cuarzo, localizadas en la desembocadura de los cauces. El origen de estas arenas rojas está asociado a procesos de erosión y sedimentación de los fenómenos de karstificación[16].
- ✓ Las formaciones continentales del Pleistoceno son terrazas fluviales, tipo conglomerados de cantos de areniscas y calizas con matriz arenosa[17].
- ✓ Las marismas muestran canales de marea con arcillas arenosas de cantos dispersos y conchas, como en la marisma de Mesa de Asta. Bordeando las formaciones marismeñas del Guadalquivir aparecen pequeños conos aluviales con arenas y arcillas con cantos. En las zonas bajas de la marisma hay limos de inundación.
- ✓ También está presente la formación de Olistostroma, constituida por grandes masas de materiales movidas de su posición original por efecto de la gravedad, como consecuencia del hundimiento de la placa europea bajo la africana[18].
- ✓ Y finalmente las calcarenitas, calizas de algas y brechas, arenas y limos amarillos pliocenas, sedimentos de carácter litoral, conglomerados de arenas y limos con ostreidos y pectínidos, de coloración gris y amarillenta (Figura 2).

[14] GUTIERREZ *et alii*,1991,144.
[15] GUTIERREZ *et alii*,1991, 7.
[16] GUTIERREZ *et alii*,1991, 57.
[17] RODRÍGUEZ VIDAL,1989, 31.
[18] GUTIERREZ *et alii*,1991, 49.

Figura 2

En la tabla que incluimos a continuación reflejamos la superficie en hectáreas que en el territorio delimitado de *Hasta* se corresponde con las diversas formaciones geológicas anteriormente descritas. Se incluye además el porcentaje que supone cada formación en relación con el total de la superficie territorial propuesta. De la misma manera indicamos el número y porcentaje de asentamientos productivos – *villae* y *figlinae*- que conocemos en el territorio, asociados a cada una de las correspondientes formaciones geológicas.

La relación del poblamiento productivo con la morfología geológica del territorio de estudio ofrece algunos datos de interés. En primer lugar destaca la relación del poblamiento en villas con las formaciones dominadas por las margas, donde se localizan 35 de los 37 asentamientos identificados como potenciales villas. En conjunto las margas de distinto origen geológico constituyen el 74’63% de la superficie mientras que los asentamientos establecidos sobre ellas suponen el 94,59%. Otro dato de interés es la ausencia de establecimientos de esta naturaleza en terrenos de vertisoles, representando éstos el 10’92% del suelo. Estos vertisoles se relacionan con las formaciones de estuario marismeño y la ausencia de poblamiento sobre ellos pueden ser un indicativo de sus condiciones hidromórficas en época romana, y un elemento a integrar en las propuestas de restitución paleogeográfica.

Por su parte las *figlinae* se localizan iguamente sobre suelos de margas azules y blancas y solo en un caso se relacionan con terrenos marismeños. Esta relación de los alfares con los suelos margosos parece más lógica dada la naturaleza de la actividad a desarrollar y las materias primas necesarias para su funcionamiento.

Relación entre la superficie del territorio de *Hasta*, su constitución geológica y la localización de sus establecimientos productivos.			
Tipo de Formación Geológica	**Superficie**	***Villae***	***Figlinae***
Margas blancas y azules. Localmente limos, arenas, y sílex	14.073,13 ha. (50'94 %)	24 (64'86 %)	13 (86'66%)
Margas azules	5.043,27 ha. (18'25%)	5 (13'51 %)	
Vertisoles	3.019,38 ha. (10'92%)		
Margas azules y blancas	1.503,08 ha. (5'44%)	6 (16'21 %)	1 (6'66%)
Cordón dunar	1.393,25 ha. (5'04%)		
Areniscas, arenas y limos amarillos	1.058,99 ha. (3'83%)	1 (2'70%)	
Marismas	809,8 ha. (2'93%)	1 (2'70 %)	1 (6'66%)
Arenisca calcárea, arenas, limos amarillos y margas	402,26 ha. (1'45%)		
Gravas, arenas y limos	205,06 ha. (0'74%)		
Calcarenitas, calizas de algas y brechas, arenas y limos amarillos	74,31 ha. (0'26%)		
Olistostroma	57,16 ha. (0'20%)		
Total	**27.623,97 ha.**	**37**	**15**

Las restantes formaciones muestran una representación muy baja sobre el territorio y es lógica la ausencia de asentamientos relevantes sobre las mismas. En cambio el cordón dunar, especialmente localizado en la desembocadura del *Baetis*, representa el 5'04%, y aquí se conocen dos asentamientos que *a priori* no se identifican con establecimientos rurales productivos. El primero es el santuario de *Lux Dubia*, cuya ubicación se relaciona con los rituales y las prácticas arcaicas de navegación marítimo-fluvial; el segundo se ha querido relacionar con actividades de explotación de los recursos marinos.

3. Sobre el poblamiento de *Hasta Regia*. El centro urbano y los preliminares de la exploración geofísica.

La *urbs* de *Hasta Regia* se localiza en las actuales Mesas de Asta. Esta formación amesetada, de compleja estructura geológica y unas veinticinco hectáreas de extensión, parece haber sido el solar de la ciudad rodeada por el recinto amurallado. En su entorno se localizan otros vestigios constructivos y sobre todo una extensa necrópolis.

En realidad, dada la escasez de intervenciones arqueológicas, es muy poco lo que sabemos sobre el proceso de construcción de esta ciudad, cuyas raíces se remontan al Bronce Final. Ni siquiera sabemos si los elementos topográficos que conforman hoy la plataforma principal corresponden, originalmente, a distintas formaciones amesetadas conectadas gracias al proceso histórico conocido

por el urbanismo hastense y la acción antrópica sobre su solar. Entre los retos de la investigación de la urbe de *Hasta Regia* se encuentran los siguientes: delimitar la extensión de la ciudad sobre la propia mesa; localizar y caracterizar el núcleo primigenio; conocer las vicisitudes expansivas o contractivas de la ciudad a lo largo de su historia; en el mismo sentido, identificar las estructuras que constituyeron su recinto o recintos amurallados, así como las transformaciones que estos recintos conocieron en distintas épocas, particularmente en los momentos de tensión bélica que vive la ciudad y documentan las fuentes literarias.

Como se ha indicado, el territorio que hipotéticamente se adscribe a la ciudad comprende 27.623 ha. El estudio de la ocupación rural de este espacio nunca se ha abordado desde la problemática histórica de la ciudad de *Hasta Regia*. Se han realizado diversas prospecciones que nunca se enmarcaron en un proyecto centrado en la antigua colonia, ni entre sus objetivos principales estuvo la caracterización del poblamiento del *ager* hastense[19]. Así el poblamiento romano de este territorio arroja actualmente un total de 158 asentamientos conocidos que muestran vestigios de la cultura material del período. De entre ellos hemos identificado treinta y siete que muestran indicios propios de un asentamiento tipo *villa*, y quince que ofrecen vestigios de producción anfórica, de los cuales al menos seis se relacionan directamente con *villae* y nueve parecen responder a *figlinae* no conectadas espacialmente con *villae*, aunque lógicamente se puedan integrar en la *pars fructuaria* de los *fundi* correspondientes.

Para dar respuesta a la investigación preliminar sobre la estructura urbana de la ciudad y los elementos de la ocupación y explotación rural de su *ager*, hemos iniciado prospecciones sobre el agro y proyectado una extensa exploración geofísica en la *urbs*.

En nuestro análisis de *Hasta Regia* y su territorio consideramos que no es posible abordar el estudio del espacio agrario, de su poblamiento, articulación y conectividad sin considerar la propia ordenación de la *urbs* hastense, su planeamiento, la ubicación y orientación de sus ejes viarios, sus accesos y puertas sobre el recinto murado. Conocer la urbanística de *Hasta* puede contribuir en nuestra opinión a comprender algunas pautas del ordenamiento del espacio rústico allende la ciudad.

Sin embargo, como indicábamos anteriormente, muy poco sabemos del núcleo urbano, de su estratigrafía, de su evolución tanto horizontal como vertical. Siguen siendo las excavaciones de Manuel Esteve las que proporcionan los referentes estratigráficos y la secuencia cultural de la entidad urbana existente en las Mesas de Asta[20].

Por esta causa hemos comenzado el desarrollo de un plan de prospección geofísica intensiva, que cubra toda la superficie de lo formación geológica donde se ubica el núcleo urbano. Estas prospecciones se iniciaron en 2016 y se han desarrollado hasta la fecha en cuatro etapas: la primera en primavera de 2016; la segunda en otoño de 2016; la tercera y cuarta respectivamente en primavera y otoño de 2017[21].

---

[19] PONSICH, 1991; LAVADO 1987; RIESCO, 1987; RAMOS, GONZÁLEZ, 1990; GONZÁLEZ, RUIZ MATA, AGUILAR, 1995; RIESCO, 2010; SÁNCHEZ ALONSO, 2010.

[20] Las campañas arqueológicas de Esteve se desarrollaron durante los siguientes períodos: 1942-1943, 1945-1946, 1949-1950, 1955-56 y 1957-58.

[21] Las exploraciones han sido realizadas por la Unidad de Geodetección y Georreferenciación del Patrimonio Agrícola y Agroalimentario de la Universidad de Cádiz. Se ha empleado un georradar Stream X, parte de la dotación de la citada unidad, usando una antena de 200 MHZ. Se ha empleado por lo general la configuración *System Type GPS+PPS COM1, 115200*, con pasadas en muestras de 512 a 0.1100 m, y un rango de velocidad de 80ns.

La metodología de esta exploración nos ha llevado a sectorizar la plataforma amesetada, abordando su exploración paulatinamente, comenzando por el extremo sur y avanzando hacia el norte de la misma. Los sectores se han definido considerando la topografía de la mesa, su conformación perimetral y los distintos cauces y arroyadas estacionales que la fragmentan y dividen.

El análisis preliminar de los resultados de la exploración realizada hasta la fecha, que cubre ya unas 6 ha, ha permitido identificar un conjunto de vestigios edilicios localizados en las cotas superiores. Estos vestigios aportan los primeros datos sobre la configuración urbanística de la ciudad romana. Entre los primeros datos obtenidos destacamos la potencial identificación de algunos *cardines* delimitando una *insula*, la presencia de un gran edificio, de unos 600 metros cuadrados y sólida estructura, probablemente público, localizado en el lateral Este de la Mesa. También parece definida la orientación general de la edilicia en sentido NO-SE como se indicaba anteriormente, además de numerosos edificios cuyo estado fragmentario dificulta por el momento su interpretación e integración lógica en la planta de la ciudad (Figura 5). Algunos de los análisis de los que hablaremos a continuación pueden relacionarse con estos datos arquitectónicos preliminares.

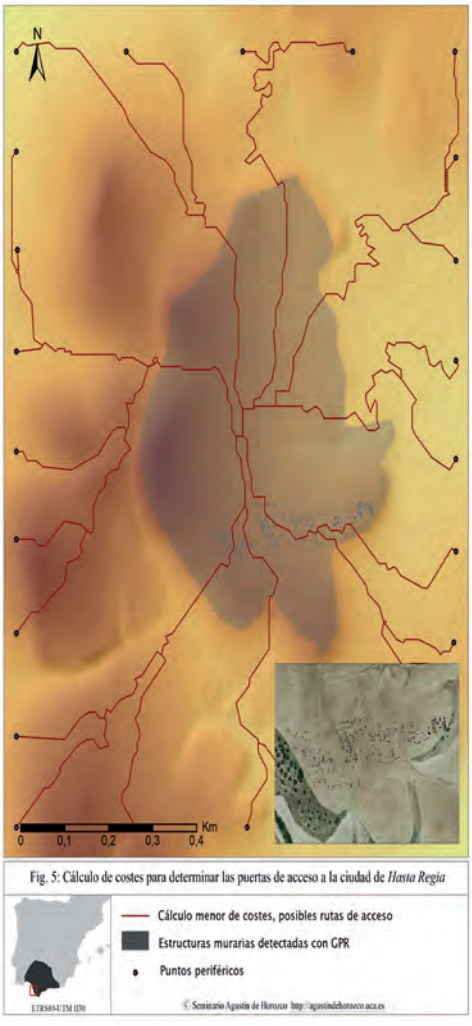


Figura 5

4. Análisis de la distribución de los establecimientos productivos.

A la hora de realizar un estudio de la distribución y la densidad ofrecida por el panorama productivo del territorio –*villae* y *figlinae*- se ha tenido en cuenta un total de treinta y seis asentamientos de época romana que se localizan en el espacio propuesto para la delimitación del territorio nuclear de *Hasta*. La caracterización de estos yacimientos se corresponde con explotaciones rurales establecidas preferentemente en época republicana. Aunque actualmente llevamos a cabo diversas tareas para revisar la información y documentación disponible para este conocimiento del poblamiento rural romano del *ager* Hastense, como nuevas prospecciones superficiales y estudio de materiales depositados en diversos museos de la provincia, hay que destacar que buena parte de los datos recabados proceden de campañas realizadas por diferentes equipos, en el marco de proyectos con objetivos distintos a los planteados en nuestra investigación, y con resultados muy heterogéneos[22].

Aún en estado preliminar, hemos establecido una relación de asentamientos que ofrecen una aceptable calidad de los datos espaciales, cronológicos y funcionales, prescindiendo temporalmente de aquellos que no ofreciesen la adecuada fiabilidad bibliográfica o descriptiva. De este modo trabajamos con una relación que, si bien será susceptible de ampliación a medida que avancen nuestras investigaciones, ofrece una imagen plausible de la realidad rural del territorio de *Hasta*.

Además de la caracterización de cada yacimiento, uno de los datos más valorado ha sido la geolocalización de los mismos, un factor fundamental a la hora de analizar su distribución y organización sobre el territorio. Una vez establecido el corpus de asentamientos en número y posicionamiento, se han realizado diversos análisis empleando herramientas de QGIS y partiendo de dos capas de puntos diferenciadas, una dedicada a los asentamientos que hemos considerado *villae*, y otra con los que corresponden con alfares productores de ánforas. Estas capas se han sometido a diferentes análisis con el objeto de visibilizar y calcular la densidad del poblamiento productivo y su distribución en el marco del agro de *Hasta Regia.*

En el caso de la densidad, se han generado varias capas raster en las que se ha proyectado un diferente cromatismo en función de la proximidad entre los yacimientos. Para ello se ha utilizado la herramienta HeatMap, usando la premisa de aumentar la temperatura de color en las zonas en las que la densidad de los yacimientos fuese mayor. Una vez generados los rasters han sido modificados en transparencia y dotados de una banda de pseudocolor para lograr la representación de densidad (Figura 3.a y 3.b).

En relación con la distribución hemos realizado al cálculo de los polígonos Thiessen generados usando la herramienta QGIS de Polígonos de Voronoi. Como criterio, se ha cuidado que la capa fuente no fuese multipunto, y se ha establecido el *shape* de la delimitación del territorio de *Hasta* como límite gráfico del cálculo para evitar el efecto borde (Figura 3.c y 3.d).

En las cartografías generadas se han incluido a efectos comparativos los territorios de *Gades* y de la cuenca del Salado[23], si bien los yacimientos aquí ubicados se encuentran también en fase de revisión. En todo caso resulta muy interesante y descriptivo para comenzar a entender los procesos de ocupación y explotación del entorno de la bahía gaditana y las riberas del *lacus Ligustinus* el análisis

---

[22] LAGÓSTENA, e.p.

[23] Véase la contribución de LAGÓSTENA y TRAPERO en este mismo volumen.

comparativo y cuantitativo entre las tres áreas delimitadas, razón por la cual han sido analizadas por los mismos procedimientos.

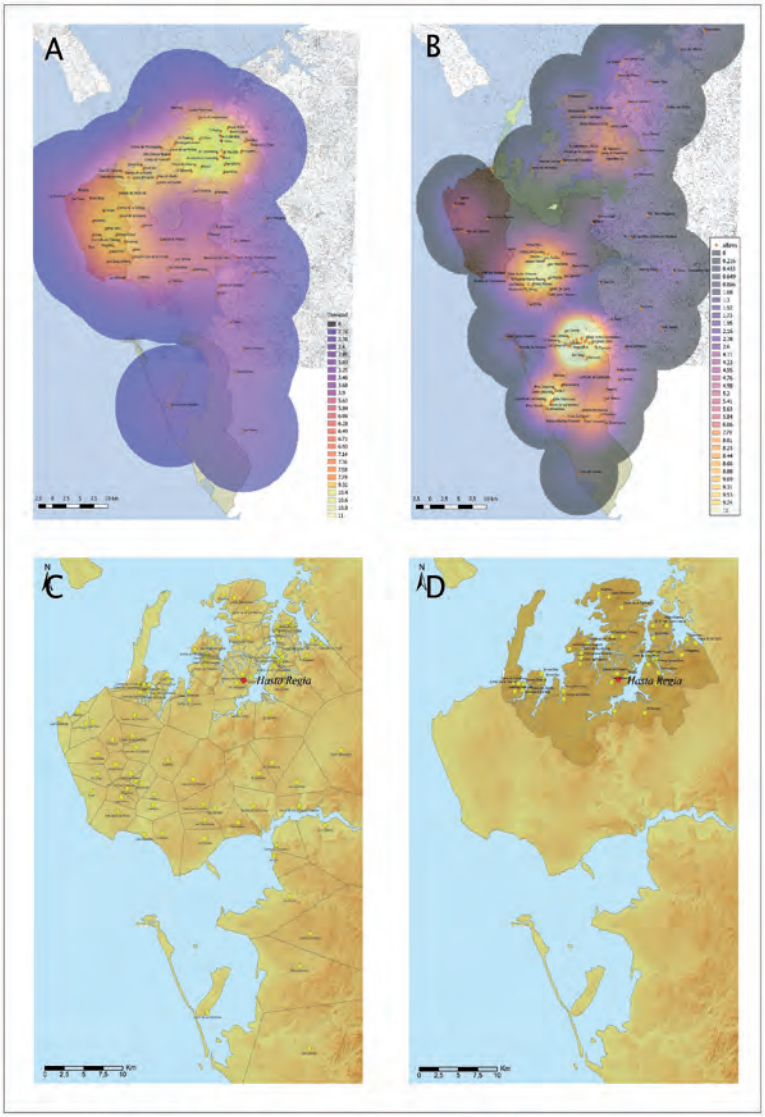


Figura 3

Respecto a los resultados que ofrece el análisis de densidad aplicado a los asentamientos que podrían identificarse potencialmente como *villae* cabe realizar varias observaciones. En primer lugar, destaca, respecto a la totalidad del ámbito analizado, la alta ocupación registrada en el territorio

hastense, especialmente en la zona más cercana a la ubicación de la *urbs*, en un área que se puede localizar en un círculo aproximado de 4'5 kilómetros de radio desde las Mesas de Asta. El resto del territorio nuclear de *Hasta* sigue mostrando una densidad alta. Le sigue en el rango el territorio adscrito a la cuenca del Salado y, a continuación, las campiñas al norte del Guadalete, en la cuenca de este río, adscrita hipotéticamente a *Gades*. Finalmente, la densidad al Este y al Sur del territorio gaditano es muy inferior (Figura 3a).

Esta diversidad en la densidad poblacional del ámbito analizado obedece, en parte, a causas orográficas, pues las condiciones de la campiña difieren de las de las riberas del Guadalquivir. Sin embargo entre la cuenca del Salado y la del Guadalete, siendo orográficamente similares se manifiesta una distribución espacial distinta, con mayor densidad en la primera que en la segunda. En este sentido hay que destacar dos cuestiones importantes que se visualizan en la figura. Por una parte, la posible existencia de procesos no coetáneos o no sujetos a las mismas condiciones jurídicas en el desarrollo de la ocupación rural romana de estos territorios gaditanos y hastenses. Por otra, el importante papel condicionante que juega en la configuración del poblamiento rural romano de la colonia *Hasta* la presencia de los esteros y escotaduras características de las riberas del *Ligustinus*, con cuyas pendientes y cabeceras se asocia preferentemente la localización de los yacimientos. Este rol no debe interpretarse en nuestra opinión como un determinismo ofrecido por la geografía. Más bien cabe relacionarlo con el potencial económico y comunicativo de esos espacios de contacto entre el estuario y el espacio continental. Además otorga un rasgo singular al *territorium* y el poblamiento de esta colonia en relación con las restantes conocidas en la *Baetica*, y constituye una de las causas por las cuales es difícil percibir en este territorio un ordenamiento clásico y centuriado del agro hastense.

Aunque es bien conocida la dispersión de los establecimientos alfareros en este territorio, vinculados a la artesanía desarrollada en el ámbito rural y a la producción anfórica, no se había realizado con anterioridad este cálculo de densidades. La imagen (Figura 3b) ilustra de forma precisa sobre los espacios de concentración alrededor de la Bahía de Cádiz: el principal, se localiza al Este de la bahía; otras concentraciones, algo menores, aunque relevantes, se sitúan al Norte y Sur. Ahora podemos apreciar la densidad no despreciable de las *figlinae* localizadas en el entorno lacustre de *Hasta Regia,* y comparar la entidad del fenómeno con el peso específico que muestra en la producción de ánforas la Bahía de Cádiz, si bien detrás de ello se encuentran especializaciones económicas diferentes, con el predominio de los aprovechamientos marítimos en el caso gaditano, y el de los productos agrarios en el caso hastense. También se observa un interesante foco de actividad alfarera en el entorno de *Turris Caepionis*, cuya adscripción jurídica, como hemos dicho, es aún objeto de discusión.

5. Modelización para una aproximación a la articulación del territorio.

Para obtener una imagen que nos permita avanzar en el conocimiento de la articulación del territorio hastense, más allá de la localización de la red de puertos litorales y fluviales, principales y secundarios, o de la recreación del trazado por este ámbito de la *via Augusta*, hemos planteado la modelización de varios elementos que pudieron condicionar las comunicaciones establecidas en este espacio. Estos modelos se aplican por una parte a las inmediaciones del núcleo urbano; por otra parte al territorio que adscribimos a la ciudad.

El primer análisis se basa en el cálculo hidrológico, herramienta que se ha venido utilizando en procesos de cálculo de movilidad[24]. Su aplicación al caso de *Hasta Regia* tiene por finalidad modelar unas posibles redes hidrográficas que puedan corresponder con las zonas de acceso a la ciudad, proponiendo la ubicación de sus puertas y ofreciendo datos sobre uno de los elementos claves para avanzar en al conocimiento de la urbanística de la ciudad (Figura 4).

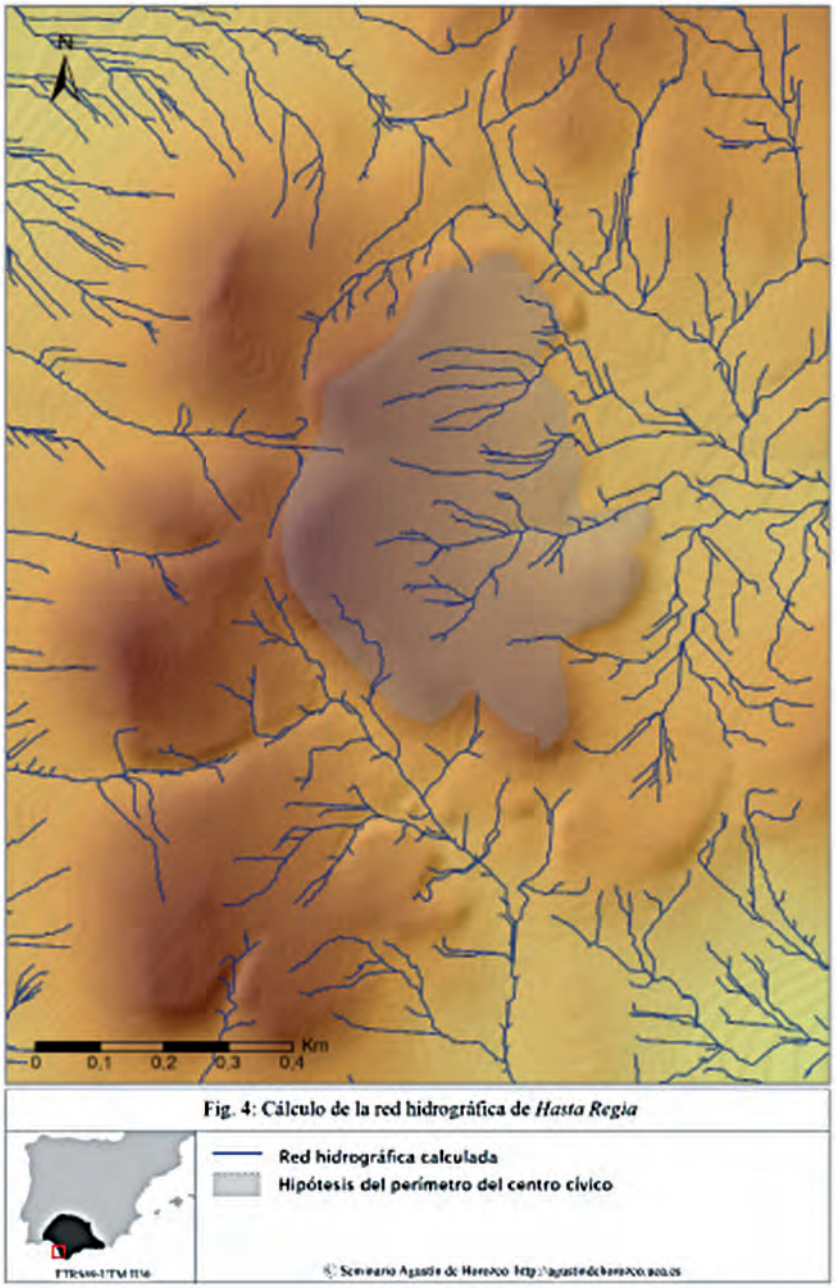


Fig. 4: Cálculo de la red hidrográfica de *Hasta Regia*

Figura 4

[24] FÁBREGA, 2016.

El cálculo lo realizamos utilizando un modelo digital de elevaciones, con la mayor precisión posible, que en este caso es de 0'5 m, y mediante las herramientas de dirección de flujo (Spatial Analyst Tools/Hydrology/Flow Direction) y acumulación de flujo (Spatial Analyst Tools/Hydrology/Flow Accumulation) de toolbox ArcGIS[25]. Por otra parte ha sido necesario utilizar la herramienta de relleno de hidrografía (Spatial Analyst Tools/Hydrology/Fill), ya que, por los propios condicionantes del terreno a estudiar, existen desniveles que dificultaban el paso.

Complementario con el anterior, se ha realizado un análisis de coste y ruta de distancia (Spatial Analyst Tools/Distance/Cost Path) considerando un conjunto de veinticuatro puntos perimétricos en un marco rectangular que abarca toda la Mesa (Figura 5). Desde estos puntos se calcula el coste con las herramientas de dirección de coste y tras ello planteando un punto central aproximado en el espacio que supuestamente ocupa la ciudad de *Hasta Regia*. Este cálculo da unas convergencias de líneas de coste que atraviesan el territorio, marcando los lugares de mejor accesibilidad y donde confluyen muchas de ellas. Este factor resulta interesante como indicador de las potenciales puertas de acceso a la ciudad[26].

La red generada en esta región es compleja al Este, fruto de la falta de pendientes acusadas. Sin embargo, en el centro destacan líneas que delimitan la mesa principal, en base a las cárcavas existentes, que en algunos casos, llegan a varios metros de profundidad. Estas líneas podrían relacionarse con los vestigios del sistema de cloacas de la *urbs* y por tanto con vestigios de la traza urbana. En este sentido destacan por el Oeste dos entradas claras a la ciudad, estando ambas en la misma orientación que otras alineaciones dentro de la mesa.

Respecto al análisis de coste para identificar entradas, destacamos los ejes Norte-Sur y Este-Oeste, donde hay una mayor concentración de rutas de coste. Especialmente en el área Oeste de la Mesa las confluencias se focalizan en un punto de acceso, siendo muy probable su identificación como una puerta de la ciudad. Hacia el Sur, no queda clara la vía de acceso, siendo múltiples las posibilidades, a pesar de que debiera existir un acceso importante por su relación espacial con la *via Augusta*.

La suma de estos dos cálculos supone una interpretación, *a priori*, de un eje Norte-Sur que ordena la Mesa. El coste hidrológico tiende a marcar los ejes cardinales, especialmente en el centro donde existen varias orientaciones Este-Oeste. Esto se complementa con los costes de acceso, que muestran una similitud respecto a estos, siendo plausible la coincidencia de caminos y cloacas en la misma orientación. Recordemos que las estructuras documentadas en la exploración geofísica muestran una tendencia general NO-SE.

El segundo análisis se centra en la modelización de las comunicaciones desde *Hasta Regia* hacia el territorio circundante (Figura 6). La modelización de la movilidad para época antigua debe considerar las transformaciones que ha podido sufrir el medio objeto de estudio. Para nuestro caso son los procesos sedimentarios que conoce el estuario del Guadalquivir, y la consecuente colmatación que afectó al denominado *lacus Ligustinus* alcanzando a su red de *aestuaria* o esteros, los causantes del principal condicionante que afectaría a la comunicabilidad terrestre.

[25] FUERTES, CARRASCO, JIMÉNEZ, ROMERO, 2011.
[26] FUERTES, CARRASCO, JIMÉNEZ, ROMERO, 2011.

Estas escotaduras o esteros, antaño espacios inundados o inundables, hoy muchos de ellos convertidos en suelos marismeños o continentales, supusieron un obstáculo para el desarrollo de las rutas, aunque tenemos constancia de la superación de algunos de ellos por la propia *via Augusta*[27].

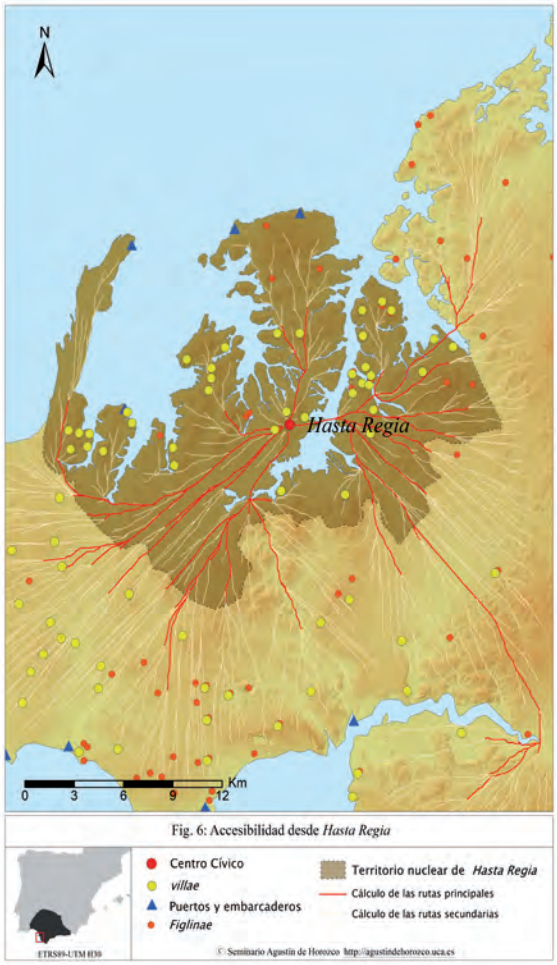


Figura 6

Para los modelados de movilidad terrestre se suele recurrir a herramientas SIG como coste de distancia de ArcGIS (Spatial Analyst Tools/Distance/Cost Distance)[28]. Por nuestra parte hemos preferido utilizar para esta modelización el sistema denominado MADO[29]. Consiste en crear un mapa de fricción sobre el que realizar un mapa de costes, utilizando el algoritmo de Tobbler. Tras ello se procede a utilizar este modelado, como base para crear un cálculo hidrológico, al igual que en el planteamiento anterior, mediante las herramientas de distancia y acumulación de flujo de ArcGIS[30].

[27] SILLIÈRES 1977.

[28] Existen multitud de trabajos al respecto, algunos descatados podrían ser para la Bética, JIMÉNEZ 2012; para la Tarraconense, LÓPEZ 2006

[29] Acrónimo de Modelo de Acumulación de Desplazamiento desde un Origen.

[30] Este modelo está basado en LLOBERA, FÁBREGA, PARCERO-OUBIÑA 2011; FÁBREGA 2016.

El cálculo planteado se basa en un modelo digital de elevaciones, una superficie raster cuyas celdas o pixeles representan la cota del mismo. El uso de algoritmos, como el ya mencionado de Tobbler, nos permite transformar estas elevaciones en factores de coste, respecto al ángulo de las pendientes. Estas herramientas de hidrología, dejan de serlo al aplicarlas a un modelo de costes que no muestra la altura del terreno, sino que sus valores son reemplazados, por la facilidad o dificultad de atravesar dichas celdas, por tanto el cálculo nos mostraría la facilidad o dificultad para ir desde un punto dado -*Hasta Regia*- al resto de celdas en el modelo propuesto. Es por ello que se genera una red tomando *Hasta* como punto de inicio. La penalización o efecto de borde producido en los límites del *raster* causan que las líneas de coste no lleguen hasta la paleocosta. El modelo de costes, por otro lado, se ha realizado con un MDT de 5 metros, recortando la línea de paleocosta, pero dejando los espacios por donde la *via Augusta* superaba los principales esteros sin modificación de valores.

El resultado es una red de comunicaciones cuyo centro es la ciudad de *Hasta Regia*. Hemos clasificado los itinerarios componentes de esta red como rutas principales y secundarias, en función de los valores conseguidos: los valores de la red principal son los que resultan significativos, interpretándose las rutas que seguían otros cursos de valores muy bajos como comunicaciones secundarias.

Destaca en esta modelización la adecuación topográfica que ofrece el trazado de la *via Augusta*, pues aunque se ha permitido en el análisis el paso de la vía sobre los esteros no se le ha dado ningún privilegio de paso[31]. El resultado podría haber discurrido por otras opciones sobre el territorio, que coincida con los vestigios de la vía demuestra que, al menos en este tramo, aquella seguía la mejor ruta natural.

Dentro de las líneas principales de comunicación modeladas, destacan las que parten hacia el Norte desde *Hasta,* poniendo en comunicación esta región con asentamientos del estuario como Alventus y Cerro de las Vacas, para los cuales se propone una función portuaria. De igual forma existe hacia el Oeste dos ramales principales, uno que conecta con el asentamiento de *Ebora* y continúa hacia el Norte hacia la ubicación del santuario de *Lux Dubia;* y un segundo que se orienta hacia la costa donde se localiza *Turris Caepionis*. Hacia el Sur tenemos principalmente y más fiablemente el trazado de la *via Augusta*, si bien podemos ver que precisamente en este tramo, la hipótesis del trazado de la vía continúa recta, mientras que los costes se dividen. Es posible que sea un indicio que conduzca a revisar el trazado de la vía en este sector, uno de los peores conocidos en las hipótesis realizadas con anterioridad. Hacia el Este, la red se complica, generando varios ramales. Estos se corresponden en su mayoría con zonas hidrológicamente deprimidas donde se localizan arroyos. A pesar de ello es interesante observar la aparente ortogonalidad de su trazado.

En término de transportes la comunicación óptima entre todos los puntos del mapa con el centro de *Hasta* se realizaría preferentemente por estos ramales obtenidos. Existirán casos en el que rutas perpendiculares a aquellos atraviesen esta red radial, como en el caso de las comunicaciones con otras comunidades[32].

---

[31] Se podría otorgar este privilegio dado que como *cursus publicus* la via goza de mantenimiento preferente y constituye un eje principal de conexión de los nucleos primarios del territorio. Sobre estas cuestiones aplicadas al transporte en el imperio romano: MGROENHUIIZEN, VERHAGEN, 2015.

[32] DE SOTO, CARRERAS, 2009.

6. Modelación de la accesibilidad y de la visibilidad de *Hasta Regia*.

Como hemos visto para el caso de *Hasta Regia* el sistema de transporte terrestre debió estar constituido por una compleja red de calzadas, caminos y senderos que definieron en parte la morfología del ámbito rural y el desarrollo económico de la zona. Por tal motivo, resulta fundamental conocer la red viaria existente en el territorio en la época de estudio, determinando además su relación con los centros productivos y con la distribución de productos hacia otros centros cívicos del entorno.

En este apartado hacemos un estudio preliminar de la accesibilidad hacia la ciudad de *Hasta Regia* desde una posible red viaria de partida. El análisis se ha realizado desde un modelo desarrollado en GIS que ha tenido en cuenta factores de tipo geográfico y de las vías de comunicación posiblemente existentes. Para el cálculo de la accesibilidad el modelo diseñado convierte la facilidad con la que se puede ir de un lugar a otro en una variable cuantitativa equivalente al tiempo de viaje. Específicamente, se ha empleado la herramienta de análisis espacial, coste de distancia del programa ArcGIS (Spatial Analyst Tools/Distance/Cost Distance), partiendo de un modelo digital del terreno y de la red viaria que han permitido el cálculo de la superficie de fricción y de los tiempos de viaje a partir de los datos de partida. El resultado final ha sido una serie de mapas en los que se representan las isócronas, curvas que definen áreas del territorio con iguales rangos de tiempos de viaje hasta el centro cívico.

El análisis se ha desarrollado en dos partes. En la primera se consideró únicamente la topografía y la red viaria principal, la *via Augusta*. En un segundo análisis se ha ampliado la red viaria, incluyendo un entramado secundario hipotético correspondiente al trazado de la red pecuaria tradicional. A cada una de las tipologías de vías se le ha asignado una velocidad promedio de viaje: alta velocidad, vías principales, de 15 km / hora y baja velocidad, viario secundario, de 5 km / hora[33]. La velocidad de una persona caminando se ha estimado en 3 km / hora aproximadamente. El modelo también ha tenido en cuenta la hidrografía, como zonas de acceso restringido o barreras naturales para el transporte terrestre, en la que se incluye la ribera del *lacus Ligustinus* por su carácter ripario.

Del análisis realizado se puede concluir que era viable el acceso a la ciudad *de Hasta Regia* desde la *via Augusta*, localizada en su punto más cercano a 1 km al sureste de la ciudad. El discurrir transversal de la calzada con respecto a la urbe y la topografía hacían mas cortos los tiempos de viaje desde y hacia la zona suroeste del territorio con respecto a la zona noroeste, pudiendo alcanzar la línea de costa en pocas horas. Se puede asumir entonces un menor coste de viaje desde y hacia la zona sur de la bahía de Cádiz (Figura 7).

Para un análisis más completo (Figura 8) se tienen en cuenta las barreras naturales para el cálculo de la superficie de fricción. Se tiene además en consideración una hipótesis de viario secundario con una velocidad inferior. El mapa de isócronas se ha reclasificado en períodos de 8 horas, lo que se correspondería a un día de trayecto aproximadamente. Para las hipótesis asumidas se puede concluir que el desplazamiento terrestre dentro del territorio nuclear hacia el centro cívico se podría realizar casi en su totalidad en una jornada, en un radio de 20 km aproximadamente en dirección suroeste. La topografía y las barreras naturales imponen tiempos de viaje mayores para la zona Este del

---

[33] Algunos estudios recientes han establecido para las vías terrestres velocidades medias de un vehículo tipo romano, carro tirado por bueyes, de unas 25-30 millas diarias, lo cual suponía 1,14 milla/hora (1,83 Km /hora); Cfr. DE SOTO, 2011, 134-135. Valores superiores de velocidad se han registrado, velocidad media de 12,5 Km/hora viaje de Tiberio para visitar a Druso en Germania. En este recorrido, Moreno Gallo establece velocidad punta de 25 Km/hora. En coche ligeros se establece una ratio de 150 Km / día, 15 Km / hora suponiendo una jornada de viaje de 10 horas. Para los mensajeros se establece la media de 19 Km / hora, con cambio de caballo y una jornada de viaje de 16 horas; MORENO 2004, 25-26.

territorio y para las comunicaciones a través de la *via Augusta*. en su dirección noroeste, en donde los tiempos de viaje superan la jornada de 8 h. El río Guadalete y su estuario, representan una importante barrera natural para las comunicaciones hacia la zona suroeste de *Hasta* Regia, situación que se ve representada en el mapa de accesibilidad como el aumento del tiempo de viaje hacia el centro cívico.

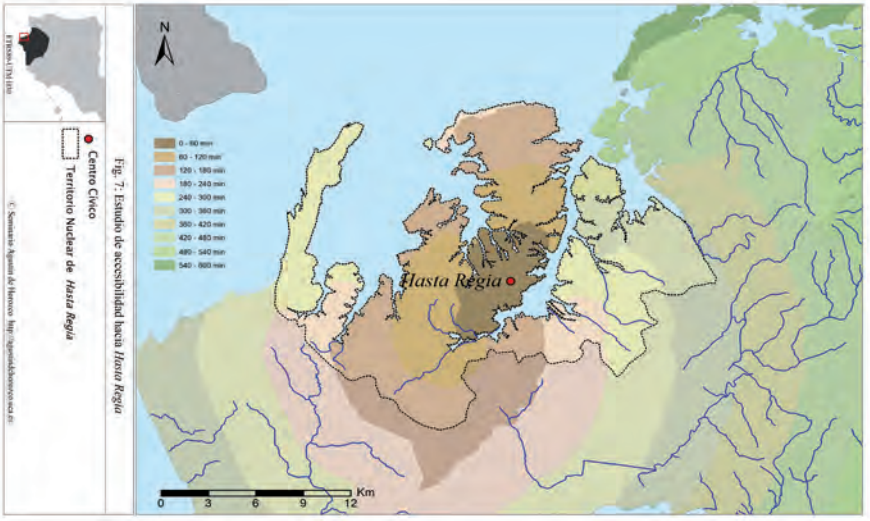


Figura 7

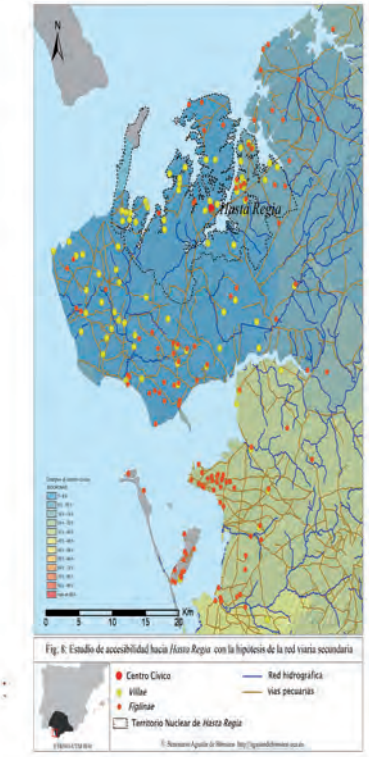


Figura 8

Es importante señalar que para esta fase del estudio no se ha tenido en cuenta la navegabilidad del *Ligustinus* y como afectaría a las comunicaciones terrestres. Se puede hacer un análisis complementario considerando la navegación en el lago a través una reclasificación de las superficies de fricción asignándole a cada píxel el tiempo de viaje asociado a una velocidad de embarcación tipo. Otro aspecto que se debe revisar son las velocidades promedio empleadas y su relación con el tipo de vía terrestre y las condiciones de la misma.

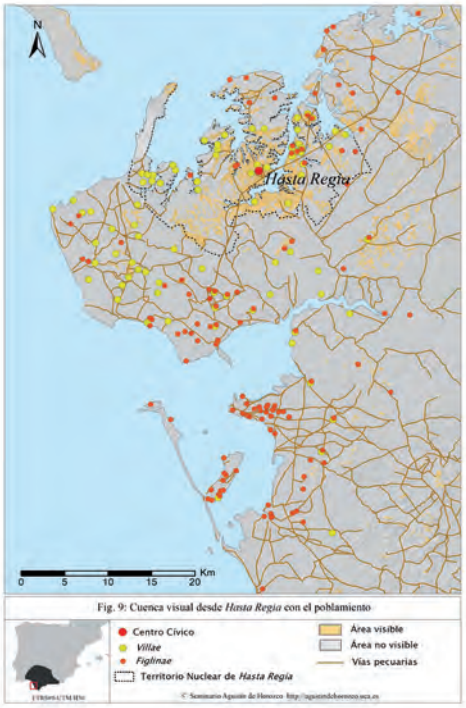


Figura 9

Otro análisis efectuado ha sido la determinación de la cuenca visual del núcleo cívico de *Hasta Regia*. En esta parte del trabajo se hizo uso del MDT del ámbito territorial y de la herramienta de ArcGIS para la determinación de la visibilidad desde un objetivo (Spatial Analyst Tools/Surface/ Viewshed). Los resultados muestran cómo desde el perímetro de la ciudad se obtiene un área de 7 Km de cuenca con casi total visibilidad, que se extiende hacia la zona suroeste hasta unos 11 km (Figura 9). Se aprecia además que la visibilidad alcanza zonas de ribera del *lacus Ligustinus* y lugares donde se localizan *villae* y *figlinae*.

7. Conclusiones: hacia una modelización histórica del territorio de *Hasta Regia*.

En esta contribución, complementaria con la presentada por otros integrantes de nuestro equipo en este mismo volumen, hemos ensayado diversos métodos de análisis y prospección espacial aplicados al hipotético territorio nuclear de la *colonia Hasta Regia*. Aunque los resultados de estos análisis pueden considerarse preliminares, especialmente debido al estado del conocimiento de los vestigios arqueológicos de la comunidad hastense, aportan perspectivas novedosas y ofrecen nuevos enfoques que ayudan a revitalizar los estudios histórico-territoriales en la región.

Las herramientas que nos ofrecen las nuevas tecnologías de la exploración geofísica y las TIG (Tecnologías de la Información Geográfica) van configurando un nuevo paradigma metodológico que avanza a buen ritmo hacia la investigación no invasiva y hacia la virtualización y modelización de los ámbitos objeto de estudio. Pero más importante aún es que finalmente disponemos de instrumentos que nos permiten progresar por el camino de la Historia Cuantitativa, obteniendo datos cuantificables y por tanto apropiados para su integración en los análisis propios de la Historia Económica, abordable hasta fechas recientes sólo de manera fragmentaria y mediante los vestigios de la cultura material.

Nuestras exploraciones geofísicas comienzan a arrojar luz sobre la urbanística de la colonia, siendo ésta una pieza clave en nuestra opinión para alcanzar una visión holística del espacio cívico, urbano y rural, de su ordenamiento y comprensión cultural.

La modelización territorial nos permite relacionar los establecimientos productivos que hemos seleccionados -los primarios rurales y los centros alfareros- con las condiciones geomofológicas del espacio; pero también nos permite, a partir de una hipótesis de proyección jurisdiccional de *Hasta Regia*, cuantificar superficialmente las condiciones edafológicas del *ager* hastense, y aproximarnos a su potencial aprovechamiento.

Los cálculos de densidades que hemos realizado ofrecen imágenes muy ilustrativas del comportamiento regional en la explotación del agro, nos permiten también analizar las diferencias entre las dos regiones influenciadas respectivamente por las *civitates* de la región, *Gades* y *Hasta.* Los polígonos de Thiessen, siendo solo un instrumento necesitado de correcciones topográficas en relación con las condiciones del territorio y con las propias estructuras del poder y del control del territorio en la Antigüedad, ofrecen una visión del ordenamiento hastense poco ortodoxa, muy condicionado, o quizá muy interesado, por los ambientes estuarinos, al menos en los espacios más cercanos al núcleo urbano.

Las modelizaciones realizadas para el análisis de la articulación del territorio y su accesibilidad, en relación a la comunicación y el control visual, muestran elementos importantes y novedosos. A los comentarios realizados en los apartados anteriores nos remitimos. Aportaciones importantes se aprecian en las propuestas de accesibilidad al territorio desde *Hasta Regia* y hacia *Hasta Regia*, en el avance del conocimiento del rol de la colonia en la organización y el control territorial. Estas aportaciones nos permiten avanzar en las claves para la comprensión del *iter* de la *via Augusta* en este espacio como elemento principal en su vertebración, y nos permiten, igualmente, establecer nuevas conexiones entre el poblamiento rural, los espacios portuarios, los espacios sacros y las entidades cívicas.

C. ALONSO, L. MÉNANTEAU, 2010: Les ports antiques de la côte atlantique de l'Andalousie, du bas Guadalquivir au détroit de Gibraltar. Problématique et étude de cas (Baelo, Tarifa), L. HUGOT, L. TRANOY (Ed.), *Les structures portuaires de l'Arc atlantique dans l'Antiquité : bilan et perspective de recherche*, *Aquitania Supplément* 18, 13-38.

C. CARRERAS, 2001: Producción de Haltern 70 y Dressel 7-11 en las inmediaciones del *Lacus Ligustinus* (Las Marismas, Bajo Guadalquivir), *Actas del Congreso Internacional Ex Baetica Amphorae. Conservas, aceite y vino de la Bética en el Imperio Romano*, Écija, 419-426.

C. CARRERAS, 2004: Geografía de la producció de les Haltern 70, AA.VV. *Culip VIII i les àmfores Haltern 70*. Monografies del Casc 5. Museu d'Arqueologia de Catalunya. Centre d'Arqueologia Subaquàtica de Catalunya, Girona, 75-81.

M.J. CASTILLO, 2011: (edición y traducción), *Hyginus et Siculus Flaccus. Opuscula Agrimensorum Veterum*, Universidad de La Rioja.

S. CERON, 1877: *Cultivo de las estepas y arenas de la provincia de Cádiz*, Madrid.

G. CHIC, 1984: *Cádiz. Historia Antigua*, Sevilla.

G. CHIC, 1994: Roma y el mar: del Mediterráneo al Atlántico, *Guerra, exploraciones y navegación. Del mundo antiguo a la edad media*, Ferrol, 55-89.

P. DE SOTO, 2011: La configuración territorial de NO: análisis desde una perspectiva de la accesibilidad y los costes de transporte, Ánforas Romanas de Lugo, 128-145.

P. DE SOTO, C. CARRERAS, 2009: La movilidad en época romana en Hispania: aplicaciones de análisis de redes (SIG) para el estudio diacrónico de las infraestructuras de transporte, *Habis* 40, 303-324.

M. ESTEVE, 1962: Excavaciones en Asta Regia, Mesas de Asta (Jerez), Campañas de 1949-1950 y de 1955-56, *Publicaciones del Centro de Estudio Jerezanos* 19.

P. FÁBREGA, 2016: Un alto en el camino: Notas acerca del uso del SIG en los análisis de movilidad en arqueología, M.C. MÍNGUEZ, E. CAPDEVILA (Coords) *Manual de tecnologías de la información geográfica aplicadas a la arqueología,* 161-180.

M. FERREIRO, 1982: Asta Regia según los geógrafos antiguos, *Gades* 9.

M.C. FUENTES, I. CARRASCO, A. JIMÉNEZ, C. ROMERO, 2011: Aproximación arqueológica al yacimiento de Ategua (Córdoba), *Romvla* 10, 135-198.

R. GONZÁLEZ, 1989: Prospección de superficie en la zona noroccidental del término municipal de Jerez de la Frontera (Cádiz), *AAA*'89 II, 85-88.

R. GÓNZALEZ, L. AGUILAR, F.J.. BARRIONUEVO, 1995: Mesas de Asta, un centro indígena tartésico en los esteros del Guadalquivir, *Tartessos: 25 años después, 1968-1993: Jerez de la Frontera,* 215-237.

R. GONZÁLEZ, D. RUIZ MATA, L. AGUILAR, 1991: Prospección arqueológica superficial en la margen izquierda de la marisma de El Bujón (T.M. De Jerez de la Frontera), *AAA*'91 vol. 2, 83-92, Sevilla.

M.R. GROENHUIIZEN, P. VERHAGEN, 2015: Exploring the dynamics of transport in the Dutch limes, *Etopoi Journal for Ancient Studies* 4, 25-46.

J.M GUTIÉRREZ, A, MARTIN, S. DOMINGUEZ BELLA, J. P. MORAL 1991: *Introducción a la Geología de la Provincia de Cádiz*, Cádiz.

E. HERMON, 2017: Les *loca sacra* dans le *Corpus agrimensorum romanorum* (CAR), *CEA* 54, 69-93.

A. JIMÉNEZ HERNÁNDEZ, 2012: Herramientas SIG para el estudio de la Carmona romana, *Romvla* 11, 7-26.

L. LAGÓSTENA, 1996: *Alfarería romana en la Bahía de Cádiz*, Cádiz.

L. LAGÓSTENA, 2001: *La producción de salsas y conservas de pescado en la Hispania romana (II a.C. – VI d.C.)*, Col.leció Instrumenta 11, Barcelona.
L. LAGÓSTENA, 2010: Columela: una visión provincial de la *pastio villatica*, L. PONS (ed.), *Hispania et Gallia. Dos provincias del Occidente romano*, Col.leció Instrumenta 38, 93-108, Barcelona.
L. LAGÓSTENA, 2011: *Asido Caesarina*: la antigüedad romana de Medina Sidonia, *Historia de Medina Sidonia I. De los orígenes a la Época Medieval*, Cádiz, 119-193.
L. LAGÓSTENA, 2014: La percepción de la ribera en la costa atlántica de la *provincia Hispania Ulterior Baetica*. El *lacus Ligustinus*, E. HERMON, A. WATELET (Dir.), *Riparia, un patrimoine culturel*. *La gestion intégrée des bords de l'eau*, BAR I.S. 2587, Oxford, 187-197.
L. LAGÓSTENA, 2016: El *lacus Ligustinus* como agente de articulación urbana y conectividad territorial: de las riberas de *Hasta Regia* a *Carissa Aurelia* y el acceso a la serranía, *SHHA* 34, 63-86.
L. LAGÓSTENA, e.p.: Estructura de la ocupación rural romana en las campiñas Hastenses y Gaditanas, V. MAYORAL, I. GRAU, *Arqueología y sociedad de los espacios agrarios: en busca de la gente invisible en la materialidad del paisaje* (Mérida, junio 2017).
L. LAGÓSTENA, D. BERNAL, 2004: Alfares y producciones cerámicas en la provincia de Cádiz. Balance y perspectivas, D. BERNAL, L. LAGÓSTENA (eds.), *Figlinae Baeticae. Talleres alfareros y producciones cerámicas en la Bética romana (ss. II a.C.-VII d.C.*), *BAR I.S.* 1266, Vol. 1, 39-124.
L. LAGÓSTENA, P. TRAPERO, e.p.: La localización de los viñedos de Marco Columela: literatura agronómica y análisis GIS en el interfluvio Guadalquivir-Guadalete, en este volumen.
M.L. LAVADO, 1986: *Aproximación a la Carta Arqueológica de la margen izquierda de la desembocadura del Guadalquivir: Sanlúcar de Barrameda (Norte)*. Tesis de Licenciatura. Universidad de Sevilla.
M.L. LAVADO, 1987: Carta Arqueológica de la margen izquierda de la desembocadura del Guadalquivir: Sanlúcar (Norte) y Trebujena, *AAA*'87, vol. II, 126-133 Sevilla.
M. LLOVERA, P FÁBREGA, C. PARCERO, 2011: Order in movement: a GIS approach to accessibility, *Journal of Archaeological Science*, 38, 843-851.
J.J. LÓPEZ AMADOR, J.A. RUIZ GIL, 2007a: Arqueología de la vid y del vino en El Puerto de Santa María, *Revista de Historia de El Puerto*, 38, 11-36.
J.J. LÓPEZ AMADOR, J.A. RUIZ GIL, 2007b: Arqueología de los vegetales y la agricultura en El Puerto de Santa María, *Revista de Historia de El Puerto*, 39, 11-39.
R. LÓPEZ ROMERO, 2006: Aplicación de los SIG al estudio del territorio de Segeda, *Stvdivm* 12, 57-84.
D. MARTÍN-ARROYO, 2013: *Proyección territorial y colonización romana. El caso de Hasta Regia*, Tesis doctoral inédita, Cádiz.
A. MARTIN I OLIVERAS, 2015: *Arqueologia del vi a l'època romana. Del cultiu al consum. Marc teòric i epistemològic*, Societat Catalana D'Arqueologia, Barcelona.
E. MATA, 2001: El asentamiento romano de La Florida, *Revista de Historia de El Puerto* 26, 11-51.
E. MATA, L. LAGÓSTENA, 1997: Ocupación antigua en la Sierra de San Cristóbal (El Puerto de Santa María, Cádiz), *Revista de Historia de El Puerto* 18, 11-45.
J. MONTERO, 2016: Los caminos de la vía Augusta en torno a Ceret, *Suplemento Digital de la Revista de Historia de Jerez*.
I MORENO, 2004: *Vías Romanas, Ingeniería y Técnica Constructiva.* CEDEX, Ministerio de Fomento.
I. PÉREZ LÓPEZ, 1999: *Los santuarios de la Baetica en la antigüedad: Los santuarios de la costa*. Recurso electrónico Universidad de Cádiz.

M. PONSICH, 1991: *Implantation rurale antique sur le Bas-Guadalquivir*, vol. IV, Madrid.
A. RAMOS, J.C. RIESCO, 1983: La villa romana de Las Canteras (Chipiona, Cádiz). Procesos formativos y transformativos del registro arqueológico e inferencias preliminares del asentamiento, *CPAG* 8, 375-416, Granada.
RAMOS, R. GONZÁLEZ, 1990: Prospección arqueológica superficial en el término municipal de Jerez de la Frontera, Cádiz. Campaña 1990". *AAA*'90, vol. 2, 64-75, Sevilla.
F. RIESCO, 1987: *Carta Arqueológica de la desembocadura del río Guadalquivir. Zona Sur*. Memoria de Licenciatura (inédita), Sevilla.
F. RIESCO, 2010: La presencia romana en el territorio de Rota. De la Prehistoria a la Rábita y la villa, *Arqueología de Rota y la Bahía de Cádiz*, Cádiz, 149-172.
J. RODRIGUEZ VIDAL, 1989: "El inicio de la red fluvial cuaternaria en el sector occidental de la depresión del Guadalquivir", *AEQUA*, 27-31.
J. RODRÍGUEZ VIDAL, F. RUIZ, L.M. CÁCERES, M. ABAD, M.L. GONZÁLEZ-REGALADO, M. POZO, M.I. CARRETERO, D. MONGE, y F. GÓMEZ TOSCAZO, 2011. Geomarkers of the 218-209 BC Atlantic tsunami in the Roman Lacus Ligustinus (SW Spain): A palaeogeographical approach. *Quaternary International* 242, 201-212.
A. RUIZ CASTELLANOS, E. VEGA, F.A. GARCÍA ROMERO, 2016: *Inscripciones latinas de Jerez de la Frontera. Epigrafía y contexto*, Cádiz.
J.A. RUIZ GIL, J.A. LÓPEZ AMADOR, 2004: Itinerario de la vía Augusta a su paso por El Puerto de Santa María, D. BERNAL, L. LAGÓSTENA (eds.), *Figlinae Baeticae. Talleres alfareros y producciones cerámicas en la Bética romana (ss. II a.C.-VII d.C.*), BAR I.S. 1266, Vol. 2, 691-694, Oxford.
P. SÁEZ, 1988: Sobre algunos tipos de tierra vitícolas de la Bética, *Actas del 1er Congreso Peninsular de Historia Antigua*, vol. 2, 521-529, Santiago de Compostela.
P. SÁEZ, 1994: Columela y la Betica, S.ORDOÑEZ, P. SÁEZ (coord..), Homenaje al profesor Presedo, 687-698, Sevilla.
G. SÁNCHEZ ALONSO, 2010: *Análisis de la documentación arqueológica de la villa y el término municipal de Rota*, Cádiz.
P. SILLIÈRES, 1977: Prospections le long de la Via Augusta", *Habis*, 8, 331–43.
P. SILLIÈRES, 1984: *Les voies de communication de l'Hispanie méridionale*, Toulouse.
G. TEJERA, 1977: Panorama Arqueológico de las Marismas del Guadalquivir, *Habis* 8, 207-215.
P. TRAPERO, 2016a: Roman viticulture analysis based on Latin agronomists and the application of a Geographic Information System in lower Guadalquivir, *Virtual Archaeology Review*, 7 (14), 53-60.
P. TRAPERO, 2016b: Perspectives about the analysis of Roman viticulture in Guadalquivir estuary, *RIPARIA* 2, 55-74.
P. VERHAGEN, 2018: Spatial Analysis in Archaeology: Moving into New Territories, C. SIART *et alii* (eds.), *Digital Geoarchaeology, Natural Science in Archaeology,* 11-25.
S. VOGEL, M. MARKER, D. ESPOSITO, F. SEILER, 2016: The ancient rural settlement structure in the hinterland of Pompeii inferred from spatial analysis and predictive modeling of *villae rusticae, Geoarchaeology* 31, 121-139.

Food and Power in the Post-Roman North: The Role of Food Supply in the Shaping of Power in Post-Roman Britannia

Paul Gorton

Introduction

Current theories regarding political change in Britain between AD 400 and 650 fail to fully explain the situation as it developed beyond the beginning of the fifth century[1]. Attempts have been made to develop a catch-all model that covers the decline of some Roman sites and the development of early medieval elite sites. Some have argued for a complete collapse of Roman authority, resulting in a bottom-up approach to societal rebuilding[2], others have argued that new power-groups appropriated Roman military defences and sites for their own legitimation and security. The latter model has seen several different iterations regarding northern Britain, including the re-defence of Hadrian's Wall in the sub-Roman period under the command of a still functioning *Dux Britanniarum*[3], and the development of political units around small Roman policing units, stationed beyond a retreating frontier, interacting with existing British political units[4].

This paper considers the development of the political situation in the frontier zone of Hadrian's Wall, where there seems to be a difficulty understanding how the occupational and political situations evolved between the fourth century and the seventh. I would argue that there is no catch-all

[1] I wish to thank my supervisors, Rick Jones and Alaric Hall, for their assistance on this piece. I am particularly grateful to Rick for his suggestions for the supply of the Roman garrison in Britain.
[2] FAULKNER, 2001.
[3] DARK, 1992.
[4] HALSALL, 2013.

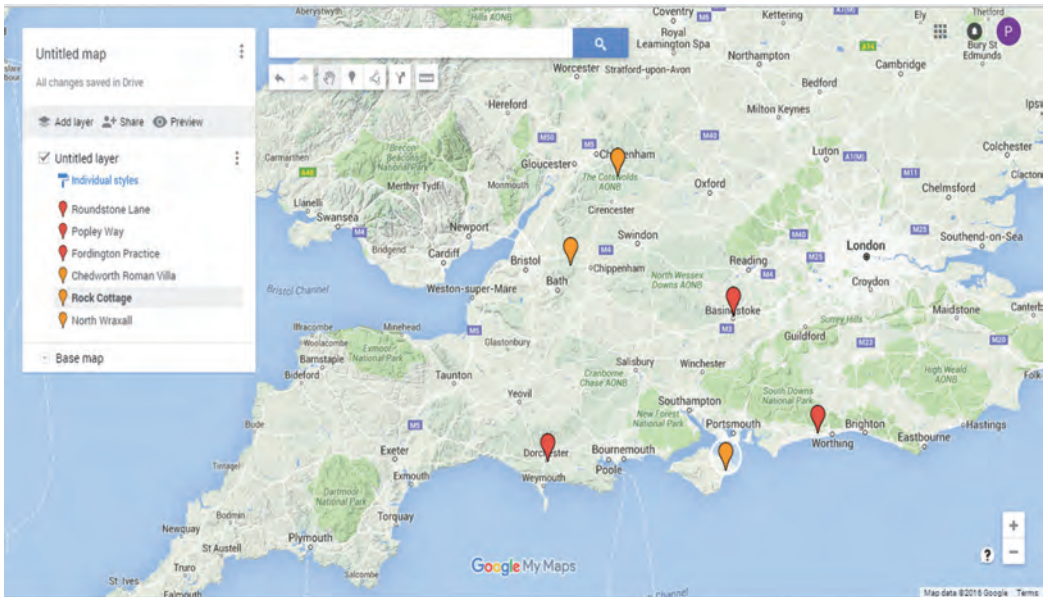
explanation and that what occurred were local developments aimed at resolving local issues with little resemblance to a grand political narrative. These local responses may have come from a playbook with which some broader models of political change are consistent, but no model explains the whole situation. This paper considers the utility of a different model (first applied to the villa region of southern Britannia) for the frontier region, to be applied alongside those others to explain some local developments. It also considers why those case studies that do not fit this model fail to do so.

Colm O'Brien has identified several attempts to explain why some Hadrian's Wall forts remained in use beyond AD 400, whilst others seem to have failed[5]. Tony Wilmott suggested that Birdoswald survived because the fort's garrison continued to extract taxes and developed into a self-sustaining unit by allying with local civilian groups under the command of a hereditary commander[6].Rob Collins has suggested that a reduction in the number of crossing points enabled some fort commanders to control movement through Hadrian's Wall, putting them in a position of power which developed into regional authority[7]. Both of these models include fort garrisons' eventual development into an elite warband which eventually became the nodes around which the early medieval kingdoms of the North formed. Furthermore, Collins has suggested that the shared experience of life as limitanei on the British frontier created a community amongst the frontier soldiers[8]. This principle, called Occupational Community Theory, is echoed by Ian Wood's suggestions for the origins of Bernicia. Wood asked: 'were the Bernicii (…) heirs to the Wall?'[9] This theory has been expanded to suggest a Germanic language as the spoken language of the frontier elites[10] and a consideration of whether the descendants of the frontier troops on Hadrian's Wall came to see themselves 'as part of the Anglian people of Northumbria.'[11] This poses interesting questions about how this development came about and how much of the frontier came to belong to these peoples and why certain parts of the frontier did not become part of the kingdom of Bernicia.

Seeking to explain continuity at villa sites in the lowland zone of Britannia, James Gerrard has proposed a model based on the control of food surpluses. He argues that at several Romano-British villa sites during the fifth century there was a move to centralise elements of crop storage and processing from their usual position at the periphery of the estates, putting them under the direct supervision of the landlord.[12] This, he argues, was a by-product of the unstable position that the Romano-British elite found themselves in after the diminishing of Roman authority in Britannia. He states that the relocation of these features could indicate 'a weakening of the obligations that assured the smooth rendering of the agricultural surplus to the elite'[13] and thus a need to bring them under direct elite control. This model maps the change from fourth-century villa sites such as Roundstone Lane, Angmering (Sussex), Popley near Basingstoke (Hampshire) and Fordington Bottom (Dorset), where corn driers are sited on the periphery of villa estates, to fifth-century sites such as Chedworth, Butleigh (Somerset), Brading and Rock (Isle of Wight) and North Wraxall (Wiltshire) where these driers were moved to areas that had previously been associated with elite functions.[14] Further to this is the association of these areas with industrial activities such as iron-making, as it was

[5] O'BRIEN, 2010, 110–20.
[6] WILMOTT, 1997, 228.
[7] COLLINS IN O'BRIEN, 2010, 113.
[8] COLLINS IN O'BRIEN, 2010, 111
[9] COLLINS IN O'BRIEN, 2010, 111
[10] SALWAY, 2001; ROBERTS, 2010, 120.
[11] WOOD, 2007; ROBERTS, 2010, 120.
[12] GERRARD, 2013, 225–28.
[13] GERRARD, 2013, 257.
[14] GERRARD, 2013, 257.

'necessary to equip and maintain not only the retinue but also the equipment needed for everyday use.'[15] Through this movement the elites were able to consolidate their power and create stable nodes from which they could govern their locality. Gerrard comments that 'from these locations the remnants of the Romano-British elite exercised control from what was a traditional seat of power.'[16] This association of lower-status activity with areas of elite function has the potential to be applied in the northern frontier zone, where changes in the use of buildings have been observed in a period beginning in around AD 350 and continuing after AD 400. This may suggest that some of the former forts of the frontier zone became seats of power for an elite which continued to identify with Roman culture, from which the fort commanders could have become regional powers in a similar way to those elites of the South.

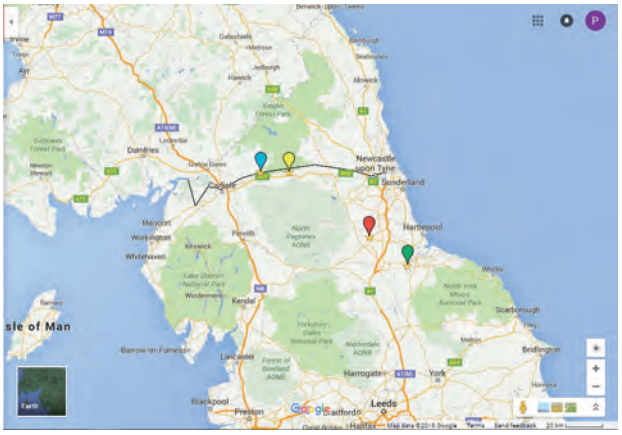


Gerrard's Villas:

- 4th C. villas inc. Roundstone Lane, Popley, Fordington Bottom
- 5th C. villas inc. Chedworth, Brading and Rock, North Wraxall

This paper considers the development and occupation at several sites across the frontier zone, including the wall forts of Birdoswald and Vindolanda, a frontier fort at Binchester, and the villa complex at Ingleby Barwick. It considers the potential of Gerrard's southern villa model at each of these sites, making efforts to consider the placement of industrially and agriculturally important apparatus.

[15] GERRARD, 2013, 255.
[16] GERRARD, 2013, 258.



Underlying this paper is a consideration of how these sites were supplied in the period leading up to and following the end of the fourth century. Supply to the frontier during the Roman period should not be considered monolithic, even during the Roman period. It is likely that it went through phases of development as the garrisons became more embedded in the landscape. A three-part system would seem to represent the most likely method of supply:[17] in the first phase, upon the initial Roman military occupation of an area and the foundation of a fort, we can expect almost all supplies to be moved in from outside of the region. In this phase, we would probably expect to see evidence of large storage facilities, as shipping smaller quantities more frequently would be more expensive. Examples of this kind of high-frequency supply can be seen at South Shields, which shows developments to support the third-century Severan campaign in Scotland. J. P. Gillam and John Dore noted that in the early third century the northern half of the fort was transformed into granaries to facilitate the storage of large quantities of grain.[18] This type of supply could not be expected to be sustained in perpetuity, especially given commitments to campaigns on other frontiers and the financial problems associated with the third-century crisis.[19] For a more settled frontier, it seems likely that phase 2 would have followed. In phase 2, we can suppose that a supply relationship with the local landscape developed. Milestones from Spain suggest that around each fort there was a territorium that it could exploit. On the northern frontier in Britain, the proximity of the forts to each other, and the landscape of the northern Pennines, may have made this phase more difficult to sustain.[20] The rugged character of this landscape may go some way to explaining the continued use of large supply deposits at certain sites, such as Building XV (a fourth-century double granary building) at Housesteads,[21] which we can assume was used to supply those forts of the central regions of the frontier that were not self-sufficient. It seems likely that if the supply relationship noted for phase 1 is unlikely to have been sustained, and phase 2 was unsuitable for some forts, there must have been a third phase, which saw the creation of supply depots for those forts that could not live off their immediate hinterland. In phase 3, there was presumably supply from further afield through purchasing mechanisms. In this market economy, forts would be expected to purchase their supplies (probably using pay from more central administration) either as individual units or as a bloc. This is a likely explanation for

[17] This model has been simplified for the purposes of this paper, the realities of the Roman economy were far more complicated and the nuances of Roman market economics are explored in far greater detail by other papers in this volume.
[18] DORE and GILLAM, 1979.
[19] DE BLOIS, 2002, 204–17; SOUTHERN, 2015, 1–50; DRINKWATER, 1987; DRINKWATER, 2005; KULIKOWSKI, 2007.
[20] Stephen Matthews (this volume) and Jamie Joyce (pers. comm.) have highlighted the need for external supply to continue to the Dobrogea and Dutch *limes* garrisons respectively to supplement that levied from local surpluses.
[21] COLLINS, 2015.

the widespread distribution of East Yorkshire pottery throughout the frontier region in the fourth century,[22] and could be used to help explain the distribution of coinage into the countryside.

If the frontier forts moved into phase 3 of this model, such a relationship would be expected to break down at the end of the fourth century, when coinage ceased to arrive from the Continent.[23] In this instance, the forts can probably be expected to have reverted back to phase 2, with those unable to establish, or sustain, a relationship with the local populace unable to sustain their position. This would chime with Wilmott's suggestion that the garrison of Birdoswald was able to levy taxes from the local area in the form of food supplies to continue to support the garrison after AD 400.[24]However, it is likely that such taxes would need to be collected in large quantities for a fort to be able to sustain itself over the period of a year, suggesting a need for mass storage facilities. If some forts were able to sustain themselves on a local surplus prior to AD 400, it may be that only certain goods were collected through a mechanism like that suggested for phase 3 but other goods were supplied through local tax regimes as in phase 2. If this is the case, then perhaps food supplies (at certain forts) would be one of those goods that continued to be supplied through direct taxation. This could be a predictor of later survival.

Jacqui Huntley argued that a typical fourth-century Wall garrison of c. 1000 men would require the produce of approximately 200 hectares of land per year in order to meet demand for the 1.4 kg of grain ration per soldier per day.[2526] If we assume that the garrisons of the Wall-forts were not the soldier-farmers that have been proposed as a solution to the problem of maintaining garrisons without central organisation,[27] and thus not able to grow these supplies themselves, then this supply must have come from the surplus created by the local population within the hinterland of each fort in addition to their own subsistence levels. This highlights the difficulty that low yield, subsistence areas faced. In such circumstances, supply of the fort is likely to have come from further afield, resulting in a larger territorium, and presumably would have been harder to maintain without state mechanisms. Such difficulties must have been exacerbated by the general reduction in cultivation west of the Pennines noted by Stallibrass and Huntley[28] after its fourth-century zenith. This change in cultivation levels did not mark a change in diet[29] and can therefore be assumed to mark a decline in land exploitation, perhaps resulting from more local tax regimes after the end of the fourth century.

The villa at Ingleby Barwick shows some signs of development typical of Gerrard's pattern. During phase 4 of development (mid-fourth century) the caldarium was modified to become a corn drier, bringing agricultural control closer to the central spaces of the site. If we apply Gerrard's model here, this could imply that the site's owners were attempting to consolidate control of the agricultural surplus, perhaps during a time of uncertainty. This corn drier was abandoned during the late-fourth-century phase 5 developments but another was built in phase 5C in area F, beyond the villa enclosure ditch.[30] Applying Gerrard's model, we could consider this to represent a period of greater confidence. A position of relative strength could further be inferred from the high levels of late Roman pottery

---

[22] WILSON, 1989; BIDWELL and CROOM, 2010.
[23] At many sites the latest coin deposited predates the beginning of the fifth century: BRICKSTOCK, 2000; BRICKSTOCK, 2010.
[24] WILMOTT, 1997, 228.
[25] HUNTLEY, 2000, 67–72.
[26] Such a calculation does not include the space needed to grow the additional nutrition needed, such as vegetables, by the garrison.
[27] LUTTWAK, 1984.
[28] STALLIBRASS and HUNTLEY, 2010, 92–95.
[29] STALLIBRASS and HUNTLEY, 2010.
[30] STEVEN WILLIS (ed.), 2013.

on the site from beyond the East Yorkshire potteries, which were prominent in the North during this period,[31] as well as the Swift type 6 gilded crossbow brooch found on the site.[32] Seemingly, there was a figure of some significance active at the site who seemed relatively confident of their position within the Roman world. On the other hand, it is also possible to argue that the development of a grain drier in area F, whilst indicating a greater confidence than phase 4, could not be considered peripheral to the site as it is only 50 metres from the villa, and so still represents a form of continued consolidation. However, we see from the later phases of the site (phases 5-6), from the late fourth to the seventh century, that there are no further moves towards consolidation at this site of the sort seen at sites further south, which the model would predict. (Though excavation of the central areas of the estate, in which the aisled building was placed, may change our understanding of this.)[33]

Binchester seems to fit the model described by Gerrard of a traditional seat of power from which a member of the Romano-British elite exercised control.[34] Phase 8 (mid-to-late fourth century) was marked by redevelopments of the praetorium building. This led to the creation of a courtyard building along the lines of those that were found at South Shields and Piercebridge.[35] This development included a bath complex, which was expanded several times. The similarity of the developments at Binchester to those at other fort sites in the north-east of Britannia, along with forts on other frontier systems, has led the excavators to suggest that the military elites of this part of the frontier system were displaying their status in a language that would be recognised in all parts of the Roman world and would mark them out as members of an Empire-wide elite.[36] Like phase 5 at Ingleby Barwick, the developments during Phase 8 at Binchester would seem to indicate an elite with confidence in their position. Whether the developments of this phase represent state economic input or the input of a wealthy hereditary commander is unknown, but in either case there was a change, or a growing significance, for the elite occupants of this fort during this period. This change would seem to reflect a move towards the site being indicative of the social status of its occupant,[37] perhaps in the same way a villa might be for a civilian.

The high-status building of Phase 8A was expanded in phase 8B by the development of a bath complex, dated around AD 350. At this time, it would seem that the praetorium was home to a person of high status who was functioning and displaying wealth within the context of a culture and style belonging to that of a fourth-century Roman elite. Phase 8C, which seems to have occurred at a similar time to 8B, includes the insertion of walls into larger rooms to sub-divide them into smaller spaces.[38] Overall this suggests the need for a change in the useable space within this complex, perhaps suggesting the development of a family unit, which could be indicative of the development of a hereditary command at the site, or a change in the administrative functioning of such a building, perhaps the need to share the trappings of higher status with a larger group. The same possible causes of change that were suggested for 8C could also be applied to the changes in 8D. The addition of two cold rooms and a new exercise hall could be indicators of either a new more lavish status, as Ferris and Jones suggest,[39] or further examples of a reorganisation born of a need to allow access to more of the trappings of elite life. Indeed, the development of the baths in phase 8 seems to correspond

[31] DAVID PETTS, 2013, 197.
[32] PETTS, 2013, 196.
[33] WILLIS, 2013, 29–57.
[34] GERRARD, 2013, 258.
[35] FERRIS and JONES, 2000; P. BIDWELL, SPEAK and BRICKSTOCK, 1994.
[36] FERRIS and JONES, 2000; FERRIS and ALBARELLA, 2010; FERRIS, 2011.
[37] FERRIS and JONES, 2000.
[38] FERRIS and JONES, 2000.
[39] FERRIS and JONES, 2000.

with the abandonment of the baths in the vicus which could perhaps suggest a use of the baths by a wider population.[40]

The change of usage for the house of phase 8 during phase 9 suggests a more utilitarian approach to life.[41] The change of high-status rooms in the main courtyard building into a slaughterhouse and a smithy highlight a need for these on the site and the loss of pretensions to grandeur that living in such a house had meant during the fourth century.[42] This suggests that the fort was becoming more of a self-sufficient community during this time. The movement of these important processes into elite spaces would potentially allow for the application of Gerrard's model. The centralisation of features of food processing such as the slaughterhouse would certainly imply the consolidation that Gerrard refers to. But without evidence of a centralisation of control of the grain supply, the application of Gerrard's model remains incomplete.

Vindolanda probably represents the site that most clearly fits Gerrard's villa model in our sample. It can be shown to represent the seat of someone with pretentions to elite status, if not actually belonging to the highest levels of the elite. The site also shows signs of attempts to diversify and consolidate the food supply to the fort, allowing it to continue to be occupied beyond the end of the fourth century.

Like Binchester phase 8, there seem to have been developments of the internal structures of Vindolanda during the fourth century. Whilst this seems to have been for the benefit of the fort praepositus, as it involved the development of the principia, which was upgraded to include a hypocaust heating system by AD 369,[43] it did not follow the same pattern of development as sites such as South Shields and Binchester, where renovations of the dwelling of the praepositus occurred at the praetorium.[44] The praetorium at Vindolanda, conversely, seems to have undergone a long-term, piecemeal demolition during the fourth century,[45] perhaps facilitating the movement of the praepositus to the principia. These developments included the addition of a bath house in the north part of the building, whilst the development of a potential church in the east wing[46] could indicate the importance of Christianity in the late Roman period and its association with authority, as well as situating this elite in a wider context. The adoption of Christianity may also go some way to explain the change of use in the chapel of the standards, which became a fire pit.[47] We should not, however, jump immediately to abandonment of the old religion(s) as an explanation for changes in religious spaces. These could also be explained by a comparison with Phase 9 at Binchester,[48] which suggest that new practicalities overrode previous compunctions. Andrew Birley suggests that the adjacent strong room may have been used as a larder and the cross hall used as a feasting chamber—a use he claims for the period 6A building at Birdoswald.[49] These changes suggest a desire for more efficient use of space. Further elements to consider in relation to these changes include what they may mean for the social organisation of Vindolanda. The movement of authority away from the praetorium marked by the demolition of this building and the construction of a church building in the east wing

[40] DAVID PETTS (pers. comm.)
[41] FERRIS, 2011, 554; FERRIS and JONES, 2000, 2.
[42] FERRIS and JONES, 2000, 2.
[43] A. BIRLEY, 2014.
[44] FERRIS and JONES, 2000.
[45] A. BIRLEY, 2014.
[46] A. BIRLEY, 2014.
[47] A. BIRLEY, 2014.
[48] A. BIRLEY, 2014. See also: FERRIS and JONES, 2000; FERRIS and ALBARELLA, 2010; FERRIS, 2011.
[49] A. BIRLEY, 2014, 201.

may suggest a slight difference in authority to Binchester. This, however, would seem to be countered by the enhancements made to the principia, and the suggestion that this became the residence of the praepositus. As such we could perhaps infer that there was simply a decline of the praetorium without the means or desire to restore it. This in turn could suggest a change in the command structure at the fort, with a move away from traditional Roman military mechanisms.

Andrew Birley has suggested that the continued occupation of the site is due to its position in the landscape securing lines of movement north-south and east-west as well as sitting on the confluence of two river basins – the Allen and the Tyne.[50] He highlights the pre-Roman agricultural cultivation of the site by a local population,[51] demonstrating the potential of the site to sustain a population in the post-Roman period,[52] as well as evidence of post-Roman mining in the vicinity for lead, iron, coal, sandstone and limestone.[53] All these factors suggest the importance of Vindolanda on a local or regional level in the Iron Age, the Roman period and after AD. 400.

The developments of the granaries at Vindolanda from the fourth century onwards highlight the continuing importance of food supply, and must have rendered the fort suitable for later occupation. The eastern granary ceased to be used for its original purpose in the mid-fourth century, suggesting an early change in either the mode or quantity of supply. The granary building remained in use in the fourth century, with extensive coin deposits suggesting that market activity occurred on the site, something that perhaps demonstrates a change into a commercial building.[54] We should perhaps ask, if commercial activity did take place in the building of the former granary, what kind of commercial activity took place and what this means for our understanding of Vindolanda's role in the local economy. We could suggest, based on the high levels of coin deposition and the end of occupation in the vicus, that the commercial activity of the building was a continuation of that which had taken place in the vicus in the second and third century. This is something that could suggest a breakdown in the distinction between soldier and civilian occurring in the fourth century, with civilian activities occurring within a military environment. Taken to a greater degree we could perhaps see the fort beginning to function as a local market place on this basis. This is likely to have solidified its position as an important local centre.

We could also ask if the use of the granary site for financial transactions could be symptomatic of a different shift. If the period in which the fort was directly supplied from South Shields[55] had come to an end by the time of this change of use, perhaps the high levels of coin deposition in the eastern granary is a sign of local purchasing taking place, of a new relationship with the local populace. If this were the case, however, we could expect occupation of the site to have been severely hampered at the beginning of the fifth century, when the end of an imperial coin supply to the fort would be expected to result in a need for a further change in methods of supply. As such, if we accept a commercial use for the building, we can probably infer that this change in use did not facilitate the

[50] A. BIRLEY, 2014.
[51] Although he notes the absence of a settlement
[52] A. BIRLEY, 2003, 1-5; A. BIRLEY, 2014, 197.
[53] R. BIRLEY, 2009, 32.; MCGUIRE in A. BIRLEY, 2014, 197.
[54] A. BIRLEY, 2014, 202.
[55] BIRLEY, see above

continued occupation of the site in a post-fourth century context, except perhaps as a stepping stone from imperial to local supply.

The platform of the eastern granary appears to have been reused as a domestic dwelling:[56] grain finds from the hearth in the north-east portion of the building indicate the continued supply of foodstuffs throughout the period.[57] This suggests that there was no break in continuity of supply, which presumably came from a local population. As such, this suggests that surplus extraction from the local area continued into the fifth century.

Both granaries at Vindolanda show use above the fourth-century levels, including the building of new structures over the existing granary floors. The southern half of the western granary had a new raised hypocaust type floor put in, although there are no signs of it being fired. Above this hypocaust flooring there are signs of storage of agricultural surplus.[58] As Birley notes, this shows a high level of sophistication and highlights the need to keep grain and foodstuffs dry.[59] The sophistication of this method of storage suggests a greater priority was being placed on the preservation of foodstuffs, and we can probably assume that they therefore held a greater value, as this level of care was certainly not evident in earlier phases of use of the granaries. This fits with Gerrard's model of surplus consolidation in the fifth century, with more importance being placed on the preservation of foodstuffs which were perhaps no longer as readily available. We can also see that there was a degree of low-level industrial activity occurring within the vicinity of the western granary, suggested by the discovery of iron slag in front of building.[60] Such developments fit with Gerrard's suggestion of consolidation, with important processes taking place in a small, easily protected environment, a single building. This may be due to a smaller population within the fort: it could be that the use and maintenance of a single building for both storage and industry was more cost-effective than maintaining multiple facilities.

Although the fourth-century occupation was not at the same social level as can be seen at Ingleby Barwick and Binchester, Vindolanda seems to have had pretensions towards a higher status with its fourth-century developments. The enhancements to the principia can be seen in the context of a claim to belonging to the same military elite that the developments to the praetoria at Binchester indicate. The continued use of western granary suggests less of a need for storage, but the fort was still in control of the local surplus. This would suggest that the fort represented a position of fifth-century and later strength and authority. As such, this site could be considered to represent the best candidate for the application of Gerrard's model.

Birdoswald follows Vindolanda and Binchester in possessing structural evidence for a potentially long period of continuity after the end of the fourth century. The traditional dating methods provide a terminus post quem of the later fourth century for the latest phases of Roman occupation. In two phases during period 6, the stone buildings within the fort were first adapted by the addition of timber structures and then ignored when the occupants erected entirely new timber buildings.[61]

The changes of period 6 suggest a change in the structure of the supply to Birdoswald as the conversion of the granaries to new uses hints at either a much smaller group within the fort,

---

[56] A. BIRLEY, 2014, 203
[57] A. BIRLEY, 2014, 203
[58] A. BIRLEY, 2014, 203
[59] A. BIRLEY, 2014, 203.
[60] A. BIRLEY, 2014, 203.
[61] WILMOTT, 1997, 226

therefore needing to be fed less, or a more direct method of gathering food and therefore the removal of the need to stockpile it. The developments highlighted by Birley at Vindolanda suggest that at least at some sites along the frontier there was still a need to store food; indeed, the care taken to ensure that the food supply was protected[62] suggests that a greater priority was being placed on food at Vindolanda. The absence of such features at Birdoswald suggest a different set of priorities and perhaps a different social structure there. One possible interpretation of the absence of food storage is that there were external groups involving themselves at Birdoswald. I consider this possibility below.

An important feature of the latest developments at Birdoswald is a general movement of activity from the central parts of the fort to more peripheral buildings. This contrasts with the trend seen at most forts, including the two others in our sample, where efforts in the fourth century seem to have gone into establishing a higher-status lifestyle for those occupying the central reaches at the forts, be it in developing the principia (as at Vindolanda) or the praetorium (as at Binchester). Whilst phase 9 at Binchester shows a more functional approach, with portions of the praetorium being used for more industrial and lower-status activities, the work of phase 8 highlights the status enjoyed by the fort commander, and perhaps his family. At Birdoswald, period 6 seems to indicate that there was less of a distinction being made between the commander and his troops. Unlike at Vindolanda, where we see evidence of bulk storage (to a lesser extent than in previous centuries) there is little evidence to support a conclusion that the inhabitants of Birdoswald could take control of a local surplus to the same degree. As such, we must ask what arrangements they had in place for the supply of the fort. In Britain, grain is harvested at one time of year, meaning that, somewhere in the landscape, bulk storage of the harvest must have been happening. With the absence of evidence for bulk storage, it seems likely that there was not the same kind of supply system in place at Birdoswald that is seen at Vindolanda. This suggests that the people of Birdoswald were not in control of their supply. A likely inference from this is that someone outside of Birdoswald was controlling the food supply to the fort and thus probably had control of the fort.

Conclusion

In summary, James Gerrard established that there were attempts by villa owners in the south of Britannia to consolidate control over industrial activities and the storage and processing of grain at their estates during the fifth century. This, he argued, helped to sustain these estates as local centres of authority and enabled the elites that owned such sites to exercise their authority in the new political situation that was developing during the fifth century. This paper has applied this model to various sites in the Hadrianic frontier region to test how far we can see evidence of consolidation and the possible creation of local centres of authority for the fifth century. The villa at Ingleby Barwick shows signs of making efforts to consolidate grain processing during the mid-fourth century (c. 360) and the later movement of grain driers further away from the centre of the estate shows signs of slightly greater confidence, although not enough to suggest a return to the pre-350 levels of confidence. It is important to note, however, that the grain driers remained firmly under the authority of the villa owner even after this movement away from the central buildings of the villa, such movement being limited to less than 50 metres. The discovery of a gold crossbow brooch at the site suggests that its owner held significance in the late Roman administration and we can predict that this site is likely to have represented a seat of at least some local authority in the period after AD 400. At Vindolanda and Binchester, we see evidence to suggest that consolidation of important industrial activities and resources occurred, enough to suggest a partial success in the application of Gerrard's model. Both sites exhibit behaviours that

[62] The building of a hypocaust system to ensure that there was less food spoilage.

seem to mark control over their hinterland and a degree of self-sufficiency, as well as evidence to mark their commanders out as important members of the local, late Roman elite.[63] Such conditions being met, I propose that these sites became local power centres during the fourth century, and early fifth century, and that this enabled their survival when there was no longer a military pay structure in place. Potentially, the later development of the granaries and apparent diversification of diet at Vindolanda are evidence of how a successful move to self-sufficiency could have occurred. Birdoswald shows no such signs of this kind of development in the fifth century. Rather than making efforts to consolidate control of supply and developing the architecture used to demonstrate the position of the commander of the fort as an important elite figure (as seen at Binchester and Vindolanda), the period after c. AD 400 shows a move in an entirely different direction. Phase six at Birdoswald is marked by an abandonment of existing Roman structures, with the demolition of the only known storage buildings and an abandonment of the central administrative buildings of the praetorium and the principia. As such, we can say conclusively that Gerrard's model does not apply at Birdoswald. We are forced to ask then, why is Birdoswald so different from our other sites, and given the absence of storage how could a population be sustained here in the period after AD. 400?

The evidence from Birdoswald would not support a conclusion of self-sufficiency for this fort in the fifth century or later. Whilst it remains a possibility that storage facilities for supplies for the fort may be found in other unexcavated parts of the fort and its hinterland, the evidence of the destruction of the granaries and the building of the great hall-like feature on their remains would seem to suggest a different sort of situation emerging from that experienced in the east. Furthermore, the development of storage buildings in other parts of the fort would suggest that there were new constructions when such buildings already existed, a remarkably inefficient choice for building, whilst the building of these storage facilities outside of the fort would suggest a different security experience to those seen throughout the British provinces and a complete absence of the expected consolidation of the fifth century, indeed an opposite response.

Rather than continuing the practice of a commander occupying a high status residence near the centre of the fort, whoever was in charge at Birdoswald seems to have adopted leadership practices more akin to those in evidence at Yeavering, suggesting a move in the social organisation towards a local warband.[64] Potentially this suggestion offers other avenues for consideration; if the fort at Birdoswald does represent an estate centre along the lines of that at Yeavering, we could perhaps ask how the fort fitted into a wider network and what other parts made up that network. Supply remains an issue, as Wilmott has noted, there no doubt continued to be a degree of local supply to the fort.[65] But how far this could have sustained the fort with its deficiencies regarding storage is a difficult to say. If supplies to the fort were extracted by force or threat of force, we might expect to find larger storage facilities to minimise opportunity for resistance. The absence of these could suggest that the supply was willingly given, perhaps as part of a symbiotic relationship.[66] However, the absence of storage facilities could also suggest that supply was used as a method of control. In this sense, either a local population (or perhaps elite) supplied the fort on a regular basis to ensure protection, or perhaps

---

[63] Sue Stallibrass (pers. comm.) has highlighted that what has been considered consolidation in this paper, in terms of bringing industrial activities from outside of the fort to its interior, could be simply the movement of the local civilian population to within the fort (something which seems to occur at several forts, including Binchester and South Shields, after c. AD. 350). This movement could however, be seen as evidence of the more unstable position experienced by the garrison commanders (elites) of these forts as Roman authority in the region was challenged, e.g. by the Barbarian Conspiracy, and as such represent another form of consolidation of their position.

[64] HOPE-TAYLOR, 1977.

[65] WILMOTT, 1997, 226–29; WILMOTT, 2001, 124–26.

[66] WILMOTT, 1997.

the fort was part of a wider network and was supplied by the elite in charge of that network to ensure loyalty. If there was such a network, Birdoswald may have been part of the network of elite sites that has become known as Rheged.

I propose that the changes witnessed at Birdoswald, particularly the creation of a hall, were part of a shift from the Roman military system to that of a peripatetic North-West regional elite.[67] If we assume that the basis of that regional power was the western part of the frontier system,[68] we could perhaps argue for a retention of a western frontier command. This is something that may be supported by the Harleian genealogies,[69] which seem to suggest that many of the local kings of the North and West in the period after AD 400 derived their authority from a single figure, who it has been proposed was the Dux Britanniarum,[70] and as such Birdoswald may owe its continuity to strategic concerns. If we assume that this intact command was not able to sustain occupation at all forts it may be that only key sites were left garrisoned and that the post-AD 400 developments at Birdoswald mark a hypothetical move to a position within a peripatetic network.

If food supply did offer an avenue for the consideration of power after the fourth century, it may be that the move towards self-sufficiency in the east of the frontier region created more localised interests than the larger network of the Roman period. Thus, independent power and identities may have developed. These identities and independent powers may have been much more mutable than that of the western half of the frontier, allowing the people of these sites to become part of the local populace and adopt the political practices of those they lived amongst, be they Anglo-Saxon, British or a mix of them. The continuing authority in the western part of the frontier may have ensured a continuing larger sense of identity and an ability to act in concert, something which lent itself to kingdom building.

Future Research

This paper has highlighted some of the advantages and pitfalls of attempting to apply a model to an area as large as the northern frontier in Britain. The case studies used have demonstrated certain significant differences in the fifth-century experiences of the garrisons of this frontier. As more modern excavations of sites in this region become available, continued application of Gerrard's villa model may be useful to further test the existence of an east-west divide. Such a divide could also be tested through consideration of material culture, an example being the use of East Yorkshire pottery (although any divide here may be the product of simple logistics). The suggestion that these sites came to represent estate centres could be further tested by direct comparisons with Anglo-Saxon elite sites from the seventh century, as well as British and Anglo-Saxon monastic sites, such comparisons would allow any trends in development to be traced. A comparison of Birdoswald with peripatetic elite sites in Ireland, Scotland, Wales and the South-West of England could help to develop an understanding of the possible direction development that this site was taking.

---

[67] For a discussion of a peripatetic regional elite in the North-west see: McCarthy, 2002; Toolis and Bowles, 2016. For consideration of peripatetic elites elsewhere see: Alcock, 1963; Alcock, Stevenson, and Musson, 1995; Morris,1999, 206–15.

[68] Perhaps including Carlisle (which had the dual distinction of representing a Roman administrative centre as well as a military one) as a primary estate centre.

[69] BARTRUM (ed.), 1966.

[70] MORRIS, 2001, 54.

BARTRUM, P. C. (ed.) 1966: *Early Welsh Genealogical Tracts / Edited with Notes and Indexes*, Cardiff, Univeristy of Wales.

BIDWELL, PAUL, STEPHEN SPEAK, AND R. BRICKSTOCK (eds.) 1994: *Excavations at South Shields Roman Fort. Vol. 1: [...]*, Monograph Series / Society of Antiquaries of Newcastle upon Tyne, 4, Newcastle upon Tyne: Society of Antiquaries of Newcastle upon Tyne with Tyne and Wear Museums.

BIDWELL, PAUL T., AND A. CROOM 2010: 'The Supply and Use of Pottery on Hadrian's Wall in the 4th Century AD', in *Finds from the Frontier: Material Culture in the 4th-5th Centuries*, ed. by Rob Collins and Lindsay Allason-Jones, CBA Research Report, 162, York, Council for British Archaeology.

BIRLEY, ANDREW 2003: *Vindolanda Research Report 2003: Volume 1. The Excavations of 2001 and 2002*, Bardon Mill.

BIRLEY, ANDREW, 2014: 'Brigomaglos and Riacus: The Balance of Power at Post-Roman Vindolanda', in *AD 410: The History and Archaeology of Late and Post-Roman Britain*, ed. by Fiona K. Haarer The Society for the Promotion of Roman Studies.

BIRLEY, ROBIN 2009: *Vindolanda: A Roman Frontier Fort on Hadrian's Wall*, Stroud: Amberley.

BRICKSTOCK, R.J. 2000: 'Coin Supply in the North in the Late Roman Period.', in *The Late Roman Transition in the North: Papers from the Roman Archaeology Conference, Durham 1999*, ed. by Tony Wilmott, Pete Wilson, and TRAC, BAR British Series, 299, Oxford: Archaeopress.
2010: 'Coins and Frontier Troops in the 4th Century', in *Finds from the Frontier: Material Culture in the 4th-5th Centuries*, ed. by Rob Collins and Lindsay Allason-Jones, CBA Research Report, 162, York: Council for British Archaeology.

COLLINS, ROB 2015: 'Economic Reduction or Military Reorganisation? Granary Demolition and Conversion in Later 4th Century Northern Brittania.', in *Roman Military Architecture on the Frontiers: Armies and Their Architecture in Late Antiquity*, ed. by Rob Collins, Matthew F. A. Symonds, and Meike Weber, Oxford ; Philadelphia: Oxbow Books.

COLLINS, ROB, AND LINDSAY ALLASON-JONES (eds.) 2010: *Finds from the Frontier: Material Culture in the 4th-5th Centuries*, CBA Research Report, 162, York: Council for British Archaeology.

COLLINS, ROB, AND JAMES GERRARD, (eds.) 2004: *Debating Late Antiquity in Britain AD 300 - 700*, BAR British Series, 365, Oxford: Archaeopress.

DARK, K. R. 1992: 'A Sub-Roman Re-Defence of Hadrian's Wall?', *Britannia* 23, 10 https://doi.org/10.2307/526105

DE BLOIS, LUKAS 2002: 'The Crisis of the Third Century A.D. in the Roman Empire: A Modern Myth?', in *The Transformation of Economic Life under the Roman Empire*, ed. by L. De Blois and J. Rich, Leiden: Brill, 204–17.

DORE, JOHN, AND J. P. GILLAM 1979: *The Roman Fort at South Shields: Excavations 1875-1975*, Monograph Series - Society of Antiquaries of Newcastle upon Tyne, no. 1, Newcastle [Eng.]: Society of Antiquaries.

DRINKWATER, JOHN 2005: 'Maximinus to Diocletian and the Crisis', in *The Crisis of Empire, AD 193-337*, ed. by Alan Bowman, Averil Cameron, and Peter Garnsey, The Cambridge Ancient History, 14 vols, Cambridge: Cambridge University Press, xii

FAULKNER, NEIL 2001: *The Decline and Fall of Roman Britain*, Stroud: Tempus.

FERRIS, IAIN 2011: *Vinovia: The Buried Roman City of Binchester in Northern England*, Gloucestershire ; [S.l.]: Amberley.

FERRIS, IAIN, AND R. F. J. JONES 2000: 'Transforming an Elite: Reinterpreting Late Roman

Binchester', in *The Late Roman Transition in the North: Papers from the Roman Archaeology Conference, Durham 1999*, ed. by Tony Wilmott, P. R Wilson, and TRAC, BAR British Series, 299, Oxford: Archaeoperess.

FERRIS, IAIN M, AND UMBERTO ALBARELLA 2010: *The Beautiful Rooms Are Empty: Excavations at Binchester Roman Fort, County Durham 1976-1981 and 1986-1991*, Durham: Durham County Council.

GERRARD, JAMES 2013: *The Ruin of Roman Britain: An Archaeological Perspective*, Cambridge ; New York: Cambridge University Press.

HALSALL, GUY 2013: *Worlds of Arthur: Facts & Fictions of the Dark Ages*, Oxford: Oxford University Press.

HOPE-TAYLOR, BRIAN 1977: *Yeavering: An Anglo-British Centre of Early Northumbria*, Department of the Environment Archaeological Reports, 07, London: Crown.

LESLIE ALCOCK 1963: *Dinas Powys, an Iron Age, Dark Age, and Early Medieval Settlement in Glamorgan*, Cardiff: Univeristy of Wales.

LUTTWAK, EDWARD N. 1984: *The Grand Strategy of the Roman Empire: From the First Century A.D. to the Third*, 3. Ed., Baltimore London: Johns Hopkins Univ. Press.

MCCARTHY, MICHAEL R., 1984: 'Roman Carlisle', in *Settlement and Society in the Roman North*, ed. by P. R WILSON, R. F. J JONES, AND D. M EVANS (Bradford, West Yorkshire; Leeds: School of Archaeological Sciences, University of Bradford ; Roman Antiquities Section, Yorkshire Archaeological Society.

MCCARTHY, MICHAEL R. 2002: *Roman Carlisle & the Lands of the Solway*, Stroud, Gloucestershire ; Charleston, SC: Tempus Pub.

MCCARTHY, MICHAEL R., AND M. M. ARCHIBALD 1990: *A Roman, Anglian and Medieval Site at Blackfriars Street, Carlisle: Excavations 1977-9*, Research Series / Cumberland and Westmorland Antiquarian and Archaeological Society, Kendal.

MORRIS, JOHN 2001: *The Age of Arthur: A History of the British Isles from 350 to 650*, Pbk. Ed, London: Phoenix Press.

MORRIS, C.D. 1999: 'Recent Work at Tintagel', *Medieval Archaeology* 43, 206–15.

O'BRIEN, COLM 2010: 'The Emergence of Northumbria: Artefacts, Archaeology and Models.', in *Finds from the Frontier: Material Culture in the Fourth and Fifth Centuries*, ed. by Rob Collins and Lindsay Allason-Jones, CBA Research Report, York: Council for British Archaeology, CLXII, 110–20.

PETTS, DAVID, 2013: 'The Late Roman to Early Medieval Settlement at Ingleby Barwick: A Discussion', in *A Roman Villa at the Edge of Empire: Excavations at Ingleby Barwick, Stockton-on-Tees, 2003-4*, ed. by Steven WILLIS AND PETER CARNE, CBA Research Report, 170, Council for British Archaeology.

ROBERTS, BRIAN K. 2010: 'Northumbrian Origins and Post-Roman Continuity: An Exploration', in *Finds From the Frontier: Material Culture in the Fourth and Fifth Centuries*, ed. by Rob Collins and Lindsay Allason-Jones, CBA Research Report, 162, York: Council for British Archaeology, 120–32.

SALWAY, PETER, 2001: *A History of Roman Britain*, Reissued, Oxford: Oxford University Press.

SOUTHERN, PAT, 2015: *The Roman Empire from Severus to Constantine*, Second edition, London: Routledge/Taylor & Francis Group.

STALLIBRASS, SUE, AND JAQUELINE P. HUNTLEY 2010: 'Can We See a 4th- or 5th- Century Diet from the Plant and Animal Remains?', in *Finds from the Frontier: Material Culture in the 4th-5th Centuries*, ed. by Rob Collins and Lindsay Allason-Jones, CBA Research Report, 162, York: Council for British Archaeology, 92–95

TOOLIS, RONAN, AND CHRISTOPHER R. BOWLES 2016: *The Lost Dark Age Kingdom of*

Rheged: The Discovery of a Royal Stronghold at Trusty's Hill, Galloway, Oxford ; Philadelphia: Oxbow Books.

WILLIS, STEVEN (ed.) 2013: *A Roman Villa at the Edge of Empire: Excavations at Ingleby Barwick, Stockton-on-Tees, 2003-04*, CBA Research Report, 170, Bootham, York: Council for British Archaeology.

WILMOTT, TONY 1997: *Birdoswald : Excavations of a Roman Fort on Hadrian's Wall and Its Successor Settlements: 1987-92*, London: English Heritage.

2001: *Birdoswald Roman Fort: 1800 Years on Hadrian's Wall*, Stroud, Gloucestershire ; Charleston, SC: Tempus Pub.

WILSON, PETE R., ed. 1989: *The Crambeck Roman Pottery Industry*, Claremont: Roman Antiquities Section, Yorkshire Archaeological Society.

WOOD, IAN, 2007: 'Fragments of Northumbria', in *Fragments of History: Rethinking the Ruthwell and Bewcastle Monuments*, ed. by F. Orton, I. Wood, and C. Lees, Manchester.

De Agri Cultura Experientia. From Modern Agronomy to Roman Economic Analysis

Helen Goodchild
University of York

1. Introduction

The modelling of modern agriculture is complex and wide-ranging. It is therefore not surprising that many techniques applied by geographers to measure or predict productive output from current datasets – such as ecological niche modelling, agro-ecological zoning, and habitat suitability modelling – have not been explored in more depth in terms of their applicability to the past. This paper presents some experiments applying a selection of agronomic modelling techniques to ancient datasets, and discusses the potentials and limitations of using these methods to investigate economic strategies in relation to agricultural and pastoral practices in the past.

Early Imperial Roman Italy is used here as a focus for trialling these agronomic methods, with a detailed case study from the Middle Tiber Valley. The aim is to investigate a range of crops and elements of animal husbandry. The case study corresponds to an area in which suitability maps were previously used to investigate potential agricultural production and its impact on settlement patterns in the Late Republic and Early Empire.[1] These models essentially look at land suitability, a method that has been used since the 1970s to study modern farming, and elements of which have been incorporated into some archaeological studies.[2] Though the models used herein follow a similar land

[1] GOODCHILD & WITCHER 2010.
[2] e.g. VAN JOOLEN 2003, WILSON 1994.

suitability assessment approach, they differ by the inclusion of climatic niches and more nuanced hydrological modelling.

2. Ancient Agricultural Modelling

The history of food production in the Mediterranean is diverse, with examples of economic specialisation, and of booms and busts. Given its central role in daily life, there are a multitude of approaches to its study, including economic history, [3]archaeobotanical and archaeozoological study,[4] and aspects of diet obtained from human remains or vessel residues.[5]

Until the last decade, however, few studies quantified production at a regional or local scale within real rather than abstract landscapes.[6] With this in mind, doctoral research was carried out to ascertain whether Geographic Information Systems (GIS) could be useful for such quantification, whether it could quantify production accurately and, if not, whether it could provide any insights into potential agricultural strategies.[7] Further models[8] developed this by looking in detail at the *Ager Veientanus*, north of Rome. These aimed to highlight whether assessing agricultural quality could help elucidate associated aspects of land exploitation (e.g., ownership; tenancy; access to good quality land) as well as the implications of surplus as a feeder for population growth.

Since then, interest in quantitative analyses of the Roman economy has increased dramatically, particularly regarding the use of Agent Based Models for simulating production and distribution.[9] More generally, archaeological use of environmental techniques is increasingly common, with studies making use of well-established methods of analysing modern landscapes (e.g. soil erosion models) and applying them to the past.[10]

The analyses of Goodchild (2007) and Goodchild & Witcher (2010) produced interesting results using a relatively simple approach. In order to explore the potential of modelling further, this paper looks beyond quantitative methods used in archaeology. It explores some aspects of how modern agriculture is studied globally, what methods are used for prediction and decision-making, what sorts of limitations are inherent in these analyses, and whether archaeologists might usefully repurpose some of their methods. Computational approaches to agronomy are wide-ranging, but the studies herein concentrate specifically on methods utilising GIS technology. This paper focuses on field and tree crops, and pastoralism, at regional and national scales. All datasets were compiled or derived from freely available sources, including climatic data, crop databases, soils, topography, and hydrology. Unless specified otherwise, all data were modelled within ESRI ArcGIS software.

2.1 Field and Tree Crops

Many modern agronomic analyses utilise GIS technology. These include measuring actual yields, predicting potential yields, and determining optimal crop strategies by assessing land suitability.

---

[3] ERDKAMP 2005, ROSENSTEIN 2004.
[4] MACKINNON 2004, SADORI & SUSANNA 2005, STEVENS 2003; VAN DER VEEN & JONES 2006.
[5] CRAMP & EVERSHED 2015, RICHARDS et al 1998.
[6] VAN JOOLEN 2003; VERHAGEN 2002.
[7] GOODCHILD 2007.
[8] GOODCHILD & WITCHER 2010.
[9] e.g. BRUGHMANS & POBLOME 2016, JOYCE & VERHAGEN 2016.
[10] see FRENCH 2010 for a discussion.

The latter is particularly important to understanding resilience and the impact of climate change on food security. At the most detailed end of the spectrum, Precision Agriculture is a discipline assessing local conditions (even on an intra-field basis). It integrates aerial or terrestrial remotely-sensed data (e.g. electrical conductivity to assess water content) with known environmental conditions such as soil type and drainage conditions, to assist in decision-making to maximise yields.[11] Precision farming techniques are particularly focussed on maximising output by micro-management of fertilizers and farming sustainably, and although not approaches easily applied to historical data, their detailed nature demonstrates the great variability in crop growth possible across even a single field.

With increasing concern over food sustainability, many national or continental models now exist. Often developed under the auspices of the FAO or the European Commission,[12] many are not openly available, though some crop simulation programmes can be used for academic research. Many of these are standalone proprietary softwares, complex simulation models, or a combination of the two (for a list of simulation models see http://ecobas.org/www-server/index.html).

At a global level, more generalised models are required, the current dominant model being GAEZ (Global Agro-Ecological Zoning) – a product of the Food and Agriculture Organization of the United Nations.[13] This is a highly complex simulation based on global datasets of diverse resolutions, and built on the principles of the FAO's Land Evaluation process,[14] and Agro-Ecological Zoning.[15] It provides a framework for characterizing climate, soil and terrain conditions relevant to agricultural production, and forms the basis of the modelling presented here.

GAEZ currently operates as an online portal (http://www.fao.org/nr/gaez/en/) where locations and their crop potential can be queried but, due to being a global model, this is at a relatively low resolution.

The main modelling processes are as follows:[16]

(i) Climate data analysis and compilation of general agro-climatic indicators;

(ii) Crop-specific agro-climatic assessment and water-limited biomass/yield calculation;

(iii) Yield-reduction due to agro-climatic constraints;

(iv) Edaphic assessment (characterisation of soil properties such as drainage, texture, chemistry) and yield reduction due to soil and terrain limitations;

(v) Integration of results into crop-specific grid-cell databases.

---

[11] e.g. CETIN et al., 2005.
[12] e.g. DONATELLI ET AL 2010.
[13] FISCHER et al., 2002.
[14] FAO 1976.
[15] FAO 1996.
[16] FISCHER et al. 2012, 2-3.

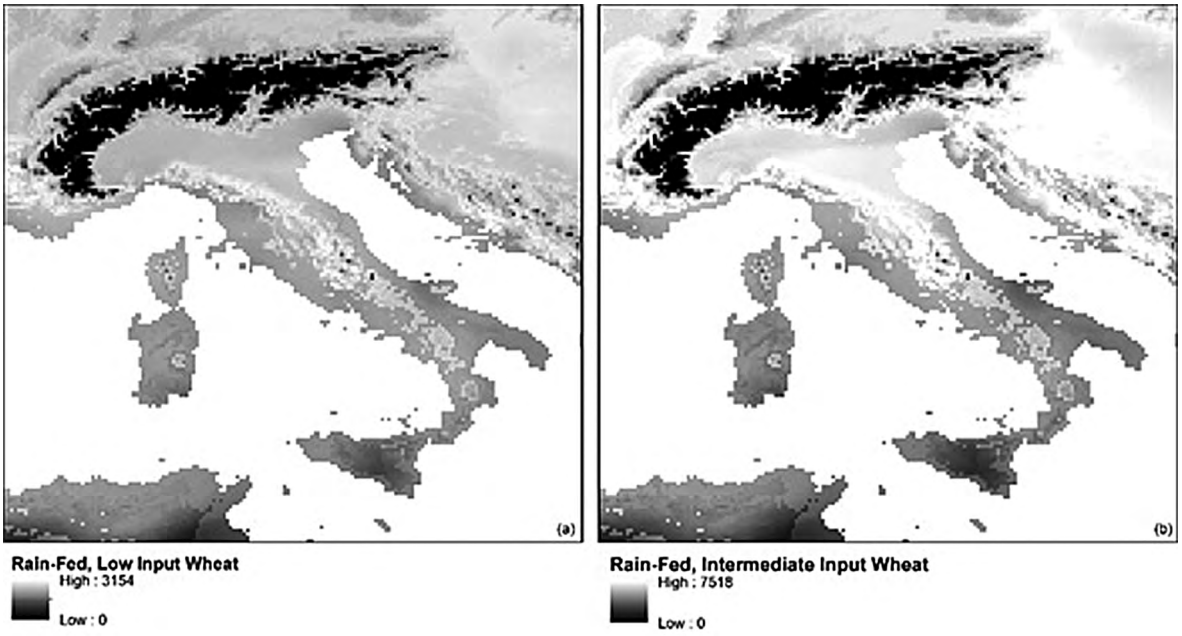


Figure 1. Detail from GAEZ output for a) low and b) intermediate input rain-fed agro-climatically attainable wheat yield in kg/ha (FAO/IIASA, 2011).

An example output from the GAEZ system assessing rain-fed wheat production in Italy is shown in Figure 1. The peninsula's most and least productive areas are clearly differentiated, showing the central Apennine and Po Valley regions as most agro-climatically suited to wheat production.

The strength of the GAEZ model is that it provides a variety of outputs that take different management strategies into account. Wheat models, for example, can be constructed using four labour input levels, five different levels of water input (i.e. rain-fed up to intensively irrigated), as well as incorporating fallow periods. This allows the user to see the impacts of different strategies on potential output for different kinds of crops.

Issues with applying this directly to the Roman period are threefold: firstly, the resolution is too low to allow local or regional settlement models to be explored in detail; secondly, many of the inputs are based on factors that are unstable over time (e.g., soil quality); and finally, all yields are based on data from 1961 onwards, which are less easily applicable to antiquity and its necessarily lower agricultural yields.

To highlight the difference in resolution between local and global models, all the fieldwalked sites from the *Ager Veientanus* study area of Goodchild and Witcher (2010) – an area of approximately 11 km^2 – sit within a single pixel of the GAEZ output. Under the lowest input conditions, the GAEZ model gives an estimated agro-climatically attainable yield for this cell of 2279 kg/ha (dry weight). In comparison, documented Roman yields for Etruria, with an absolute maximum of 15:1 (Varro *Rust*. 1.44.1), would have meant exceptional yields of 2025 kg/ha (at a sowing rate of 135kg/ha, or 5 *modii* per *iugerum*). Given subsequent technological improvements, this particular result is more comparable to the present-day low-input figure than we might expect.

Whilst useful as a general indicator of relative land quality, however, GAEZ model values cannot simply be applied to regional landscapes as representative of Roman production. In order to

utilise the GAEZ approach for Roman central Italy, a number of inputs are required that are unavailable from historic data. It is therefore necessary to disaggregate the model, and apply components as and where data are available. The applicability of using modern datasets to explore ancient questions is not without problems, though. Most modern agronomic models rely on empirical, or observation-based, models (i.e. those based on actual yields or field-based experiments). As historical datasets lack such observations, studies are reliant on mechanistic approaches, based on physical principles (e.g. killing temperatures for crops, or temperatures under which animals would suffer heat stress). It is then possible to generate the ideal conditions under which species can exist, and apply them to landscapes underrepresented by observational data.

To explore this, GAEZ sub-models were recreated within ArcGIS using inputs suitable for past landscapes, and augmented by models from a range of agronomic and archaeological sources. Climatic, edaphic, terrain, and water suitability were applied to the main Mediterranean crops known from the Roman period to see whether the results might elucidate why certain exploitation strategies took place in certain regions, and whether the models might also be scalable to the study of local settlement patterns.

2.1.1 Climatic Suitability

Climate is a critical variable in crop production, and 20th Century meteorological observations were used to create climatic suitability maps. Models of past climate (historic General Circulation Models, or GCMs) would be useful here, but the most recent available is from the mid-Holocene (6000 BP),[17] more distant in time from the study period than the present day. Climate during the Late Republican/Early Imperial Roman period is thought to have been relatively stable, with air temperatures similar to today, but more precipitation. These warm, wet conditions have been linked to the development of specialist agriculture such as viti- and oleoculture, population increases, and the rise of Rome as a power in Europe.[18] Based on the broad climatic comparability, the experimental analysis of agricultural systems in Roman central Italy was modelled using freely available, 20th Century climate data from WorldClim,[19] with the understanding that results would be largely comparable, but that differences in precipitation might have affected the viability of certain crops.

An assessment of crop-relevant climate data was carried out using specifications from the FAO Ecocrop Database (2007). The Ecocrop model outlines the optimal growing conditions for each crop, and feeds into multiple sub-models of the GAEZ simulation. It uses temperature and rainfall to determine climatically suitable niches for specific crops, and does not take into account soil quality or other factors. A simulation using this database has been implemented in the open source DIVA-GIS package[20] based on WorldClim data.[21] This simulation was run to produce a relative climate suitability map for a range of crops in Roman Italy.

The Ecocrop parameters for common Mediterranean crops, all known to have been cultivated in the Roman period, were used to create climatic suitability maps for three types of wheat (common wheat, emmer, spelt), barley, vines, and olives. However, the database is not exhaustive, and is

[17] HIJMANS et al., 2005.
[18] BÜNTGEN et al., 2011, LUTERBACHER et al., 2016, MCCORMICK et al., 2012, MENSING et al., 2015, SCHEIDEL 2012, 12.
[19] FICK & HIJMANS 2017.
[20] HIJMANS et al., 2001.
[21] FICK & HIJMANS 2017.

missing some modern cultivars as well as primitive crop types such as Einkorn. There is also no information on how much crop tolerances have changed over time.

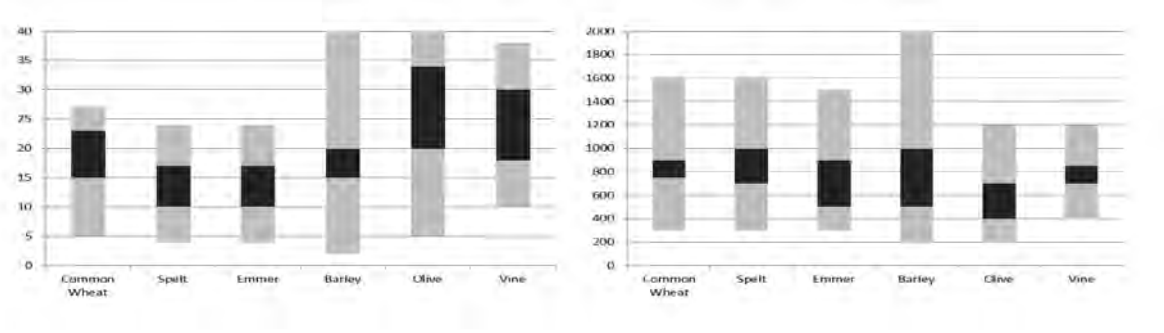


Figure 2. Optimal (black) and absolute (grey) limits for Mediterranean crops regarding a) temperature in degrees Celsius and b) rainfall in mm, based on Ecocrop parameters.

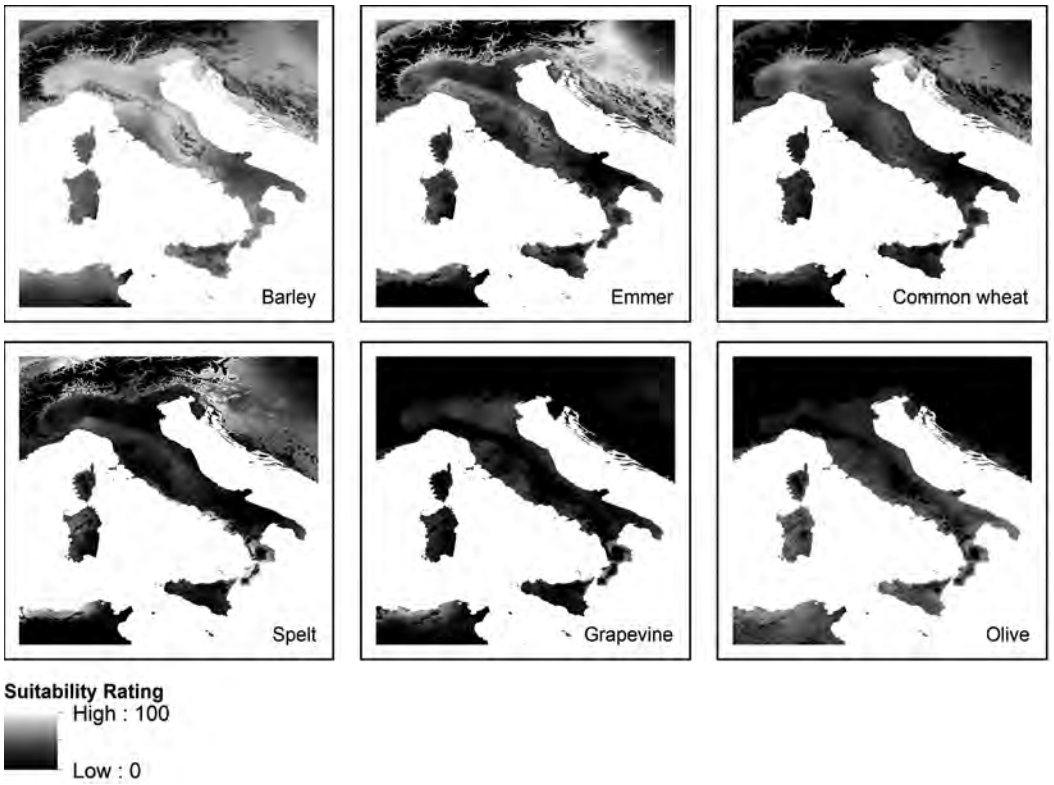


Figure 3. Climatic suitability for barley, emmer, common wheat, spelt, grapevines and olives.

According to the Ecocrop models (Figure 3), barley was by far the most climatically-suitable field crop in Roman Italy, followed by emmer, common wheat, then spelt. The differences in temperature and rainfall requirements for each crop (Figure 2) may help to explain further variations. There are only small differences in temperature tolerance between the three main wheat species, though common wheat is less tolerant of low temperatures in its early growth stages, and as a whole has a narrower envelope of temperatures and rainfall for optimal growth. Additionally, the photoperiod requirements (not shown) are a major factor, and spelt's requirement for over 14 hours of daily sunlight (compared with, for example, emmer's short day of less than 12 hours), seems to be the main reason for its relative unsuitability. How far this has changed through crop selection over time cannot

be established, but tolerance is likely to have improved. Crops in Roman Italy might have been less tolerant, but higher rainfall levels could have offset this somewhat.

Nationally, the Apennine and Po Valley areas appear to have been the most climatically suitable in Roman Italy. Given its reputation as a fertile region (e.g. Polybius 2.17.1, Strabo 5.4.3, Plutarch *Vit. Cam.* 16), the latter might be predicted, but the rugged terrain and more limited accessibility of the Apennines would likely make it less appealing for arable farming, despite its apparent suitability.

Remarkably, olives and grapevines appear to be relatively unsuited to the Italian climate, which seems at odds with knowledge of both present-day and Roman agriculture. However, the GAEZ model for the Mediterranean also indicates that only a few areas of North Africa, Spain and the Levant are considered climatically suitable for growing olives, under rain-fed conditions, and most of Italy is either moderate, marginal, or not suitable. Climatic suitability is, however, only one factor that impacts crop growth: success can also be dependent on local variations and microclimates, plus water management. Using these models could therefore help in interpreting required farming strategies at sites with marginal suitability. Should a site be shown to have been in a particularly low suitability area, it might indicate that methods such as irrigation, manuring or crop rotations were required to maintain soil quality, or that particular crop choices would have to have been made to maximise yield (e.g. more tolerant varieties). Incorporating increased irrigation into the GAEZ model raises potential suitability dramatically, and demonstrates the significant impact that increased water supply (either via irrigation strategies, or from higher levels of rainfall in the Roman period) could have had on viti- and oleoculture in the Mediterranean.

2.1.2 Water Limitations

Water availability is critical both for crop growth and animal rearing. The typical measure used in agronomy – Plant Available Water – is ordinarily determined via field tests and, as this was not possible, GIS models of wetness were carried out. There are several methods for estimating water availability, based on aspects such as hydrological flow across the landscape, or the storage capacity of the soils, including the Topographic Wetness Index,[22] Integrated Moisture Index,[23] and Depth-to-Water Index.[24]

The Topographic Wetness Index (TWI) was chosen as the most appropriate method for assessing the suitability of field and tree crops, because of its better performance in field tests in predicting deeper soil moisture levels than the Integrated Moisture Index.[25] The TWI (also called the Compound Topographic Index) was introduced by Beven and Kirkby (1979) and is based on the relationship between topography and water drainage. It takes no account of soil or geology, and assumes that topography is the driving force in controlling the movement of water, and consequently the ultimate pattern of soil moisture. As topography is relatively more stable than soil quality, this makes the method useful for historic study. In a modification of the TWI method, the relationship between wetness and plant available water was modelled by Bretzke et al (2012). The index was adapted to take account of rainfall to create a proxy Plant Available Water (PAW) map, which, although not providing percentage wetness values, does enable relatively wetter and drier areas to be identified.

---

[22] BEVEN & KIRKBY 1979.
[23] IVERSON et al., 1997.
[24] MURPHY et al., 2007.
[25] IVERSON et al., 2004, 516.

More recently, 'Wet Areas Mapping' or the 'Depth-to-Water Index' has been developed for forestry applications to establish potential areas of wetland. This method uses the known or predicted surface water locations (coastline, lakes, rivers, springs), calculates how far below the surface the water table should be, then deducts this from the original elevation to produce the likely water table elevation.[26] The water network – inland lakes and ponds, coastline, and rivers – was acquired from the Italian *Geoportale Nazionale* (http://www.pcn.minambiente.it/mattm/en/wfs-service/) and unified into a single layer, then the DTW model applied to create a nominal depth to water. The resulting index can be used as a proxy for soil drainage (Table 1).

Table 1. Depth to Water levels as a proxy for drainage (WHITE et al., 2012, 337).

<0.1m	Very poor
0.1-0.25m	Poor
0.25-0.5m	Imperfect
0.5-1m	Moderately well
1-20m	Well
>20m	Excessively well

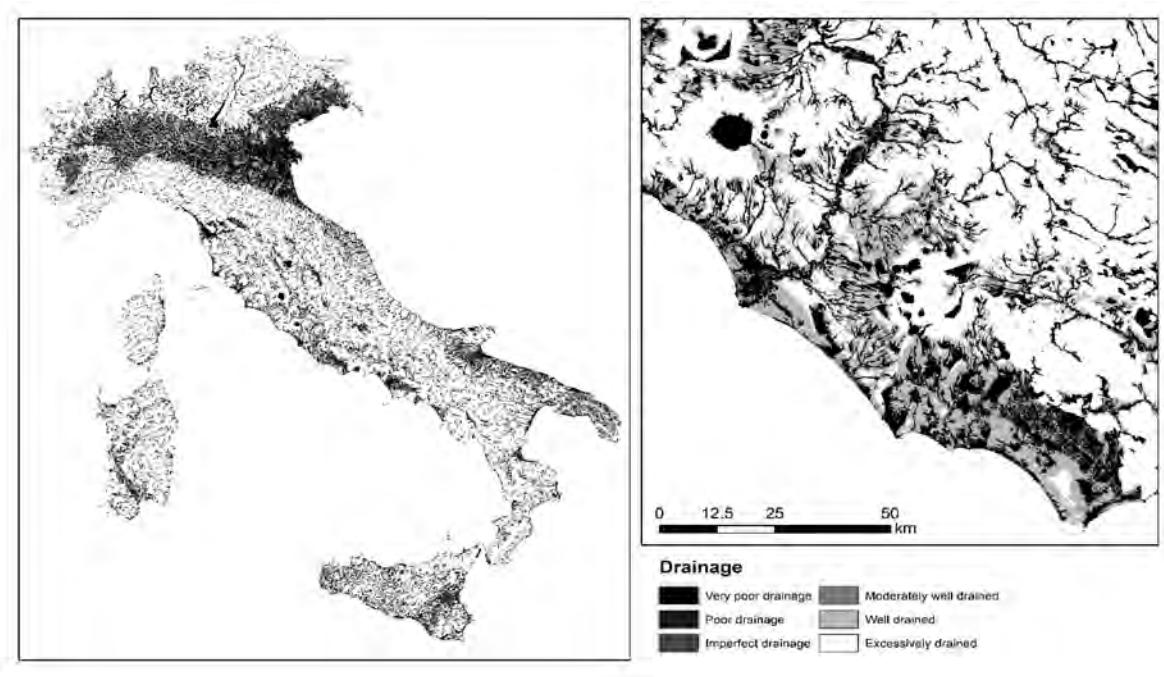


Figure 4. Depth-to-Water Index for Italy, and inset showing the area of the Pontine Marshes and Tiber Valley.

Finding wetlands is the main aim of this approach, and so has the potential to highlight areas that were likely to have required drainage works in the Roman and post-Roman periods. The Depth-to-Water Index in Figure 4 highlights lakes and river valleys effectively, as well as areas such as the Pontine Marshes, which was well-known as a marshy (and consequently malarial) area.[27] According to

[26] MURPHY et al., 2009.
[27] SALLARES 2002.

this model, northern Italy also has a significant amount of very poor potential drainage, corresponding to the Po Valley alluvial plains and the Venetian wetlands, as does the south-eastern region of Puglia.

To avoid redundancy by incorporating water twice, and to make its Depth-to-Water Index more applicable to agricultural modelling, the map was reclassified to show only those areas of 'very poor' and 'poor' drainage.

2.1.3 Terrain Assessment: Slope and Soils

Terrain assessment is primarily limited to assessment of slope, given its role in both workability of an area (i.e. the limits of draught animals or hand tillage), or the erosion risk of steeper slopes. The GAEZ model assigns slope suitability depending on the crop modelled (Table 2): perennials such as olives can be grown on slightly steeper slopes than annual field crops. As hand tillage, rather than animal-drawn ploughs, was likely to have occurred on many farms, data were scaled so that all N (Not Suitable) ratings were assigned a value of 0, enabling the remaining suitable values to be stretched between 0-100 using a logistic decay function.

Table 2. Slope restrictions (after FISCHER et al., 2012, Table 6-11, 79)

Crop	Suitability Rating*	Slope Range
Annuals (wheat, barley, etc.)	S1 S2 N	0-16% 16-30% 30%+
Perennials (olive, etc.)	S1 S1/2 N	0-16 16-30 30+
Perennials 4 (pasture, legumes, etc.)	S1 S1/2 S2/N N	0-16 16-30 30-45 45+

*S1 = Most Suitable, S2 = Suitable, N = Not Suitable

Soil data for Europe is available from several sources, the most comprehensive and highest resolution being the European Commission's European Soil Data Centre.[28] This dataset and associated products describe soils in terms of their structure and class, and derived datasets provide aspects such as drainage, texture, and water capacity. How far modern soils reflect those of antiquity is difficult to determine, though. Actions such as erosion and transport of material (via natural or anthropogenic means), or changes in nutrient quality mean that any assessment of soil suitability for field and tree crops using this data might only give a broad indicator of quality. There is evidence from agronomic literature to suggest that elite Roman farmers, at least, were aware of soil exhaustion and used legumes for replenishing nutrients, fallowing, and basic crop rotations (Pliny *HN* 18.91, Columella *Rust.* 2.17.4, Virgil *G.* 1.79). Whether they were aware of the erosion caused by activities such as ploughing steep slopes, and how much of this knowledge reached smaller farmers, however, is difficult to establish.

Consequently, only some elements of modern soil data are relevant to, or can be modelled for, the Roman period. Whilst erosion risk may be estimated via models such as the Revised Universal

[28] ESDAC: HIEDERER 2013, PANAGOS 2006.

Soil Loss Equation,[29] only slopes and drainage are appropriate factors to use in terms of relative stability over time. Both of these factors have already been addressed by the models above (Depth-to-Water and Slope suitability), and drainage via topographic simulation is arguably a safer dataset to use than the modern available water capacity.

2.1.5 Integration of crop suitability criteria

In the previous sections, factor maps have illustrated different aspects of the overall suitability of Italy for certain types of crops. The final stage is to standardize these on a 0-100 scale, integrate them into a single 'suitability' map, and compare them to the known locations of Roman sites (Figure 5). Initially, wheat was used as a case study for the whole of Italy, with factors weighted equally to test a scenario where all factors had an equal influence on productivity. This was considered to be the most conservative approach, given that it is not possible to know which factor had the most influence on crop production. Each layer was summed using map algebra and the total divided by the number of inputs. Before integration, the four layers (climatic suitability, PAW, DTW and slope) were assessed for collinearity to ensure that the factors were not strongly correlated; should any of the layers be correlated, the model would be taking account of the same factor twice. The results showed that Depth to Water and Slope were moderately correlated, and Depth to Water was therefore removed.

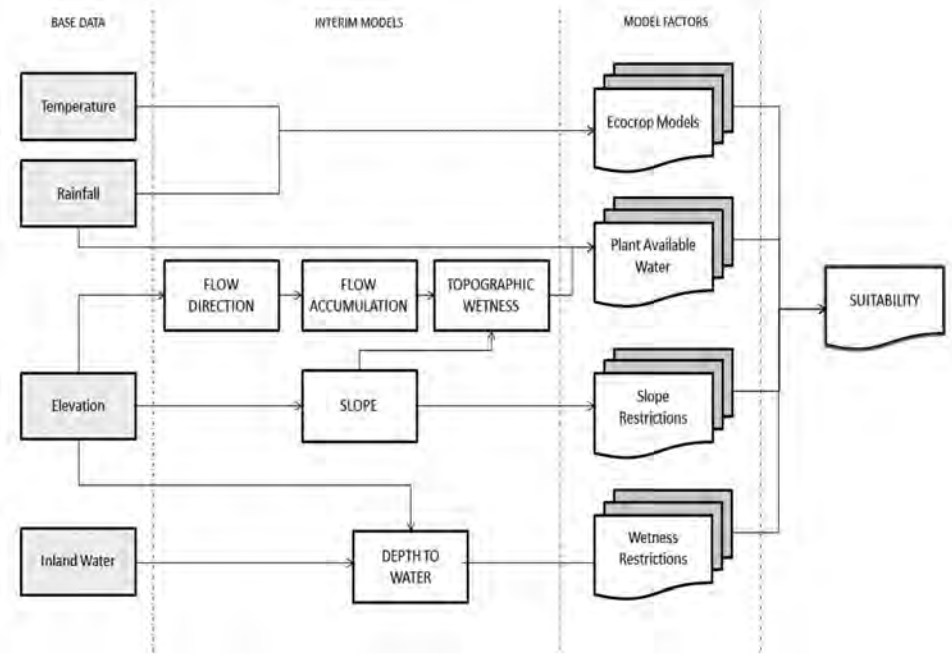


Figure 5. Flow chart showing model components

The model shown in Figure 6 is at a lower resolution than the previously published models of GOODCHILD & WITCHER (2010), and consequently their outputs cannot easily be compared. For case studies such as the Tiber Valley, at this smaller scale it is difficult to see the subtle changes in landscape that might affect local settlement patterns. However, looking at this bigger picture, it is interesting to note that regional and national patterns shown in the new models allow the exploration of why certain areas of the country were well-known for particular crops in the Roman period (e.g., the locations of famous vineyards, high-producing wheat areas, etc.).

[29] RUSLE: RENARD et al., 1991.

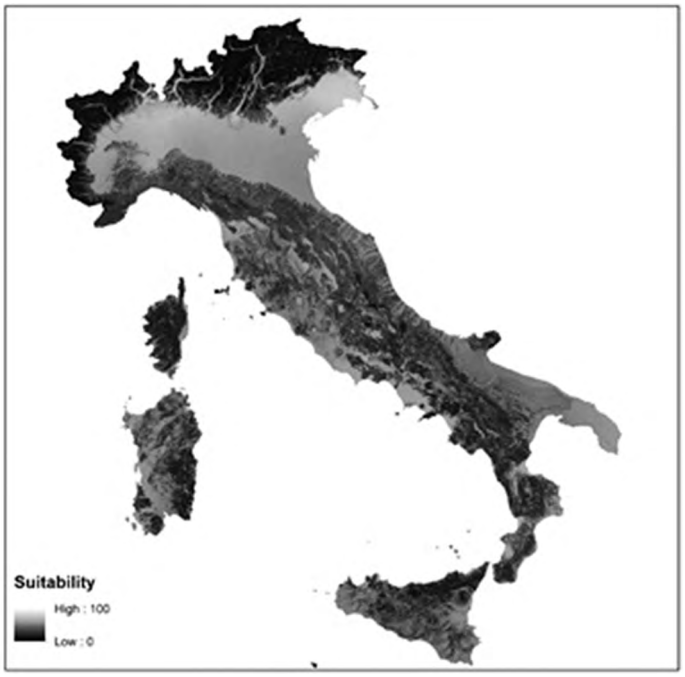


Figure 6. Common Wheat Suitability Model based on climatic suitability, Plant Available Water, and slope.

Furthermore, the lower resolution is relatively easily dealt with, given that many of the factors already discussed are derived from elevation data. Higher resolution data at 10m resolution is available on request from TinITALY[30] and was used to generate the derived layers (e.g. Plant Available Water) for a study area of *c*.11km^2 in the *Ager Veientanus*, approximately 17km north of Rome. To maintain resolution of the other factors, the precipitation data and Ecocrop outputs were resampled using bilinear interpolation, although it is recognised that this might not be the most robust method for increasing resolution, and methods such as regression analysis might improve on this.

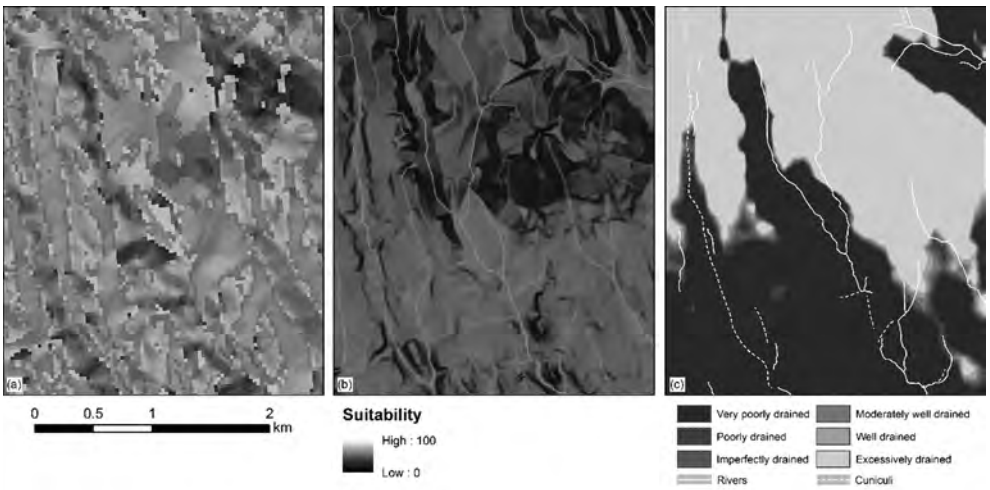


Figure 7. Comparison of a) Goodchild and Witcher 2010 model with b) higher resolution suitability map based on agro-climatic suitability, plus c) Depth-to-Water drainage surface of the same area (rivers and cuniculi layers copyright Tiber Valley Project).

[30] TARQUINI et al., 2007.

The output is a relative suitability map for wheat on a local scale, which can be used to determine whether farms and villas were situated in areas with the best land for production of this crop (Figure 7b). Comparing this output with prior models (Figure 7a), they show broadly similar patterns of suitability, though the new models generate less fragmented patches of land than those of Goodchild & Witcher (2010), and overall suitability is relatively lower. This is unsurprising as the previous models were based simply on slope, aspect and geology, and probably overestimated overall quality. As Depth-to-Water had been removed from the analysis, it was visually analysed separately. When compared with known water courses, the higher quality land from the suitability map appears to be in areas of potentially waterlogged ground. It is therefore interesting to note the correlation with the series of Etruscan *cuniculi* (underground channels for diverting water; Figure 7c), which would have most likely been used for drainage (AMPOLO 1980, 36–38).

Applying the model to other crops (Figure 8), barley outperforms all others in the study area, closely followed by olives, vines, then common wheat (due primarily to marginally higher climatic suitability). However, the extreme similarity of results implies that mixed strategies would have worked effectively in this area. That olives and vines are shown to be marginally more suitable than some types of wheat is also interesting, as it demonstrates that, here, the local conditions differ from the national averages shown in Figure 3.

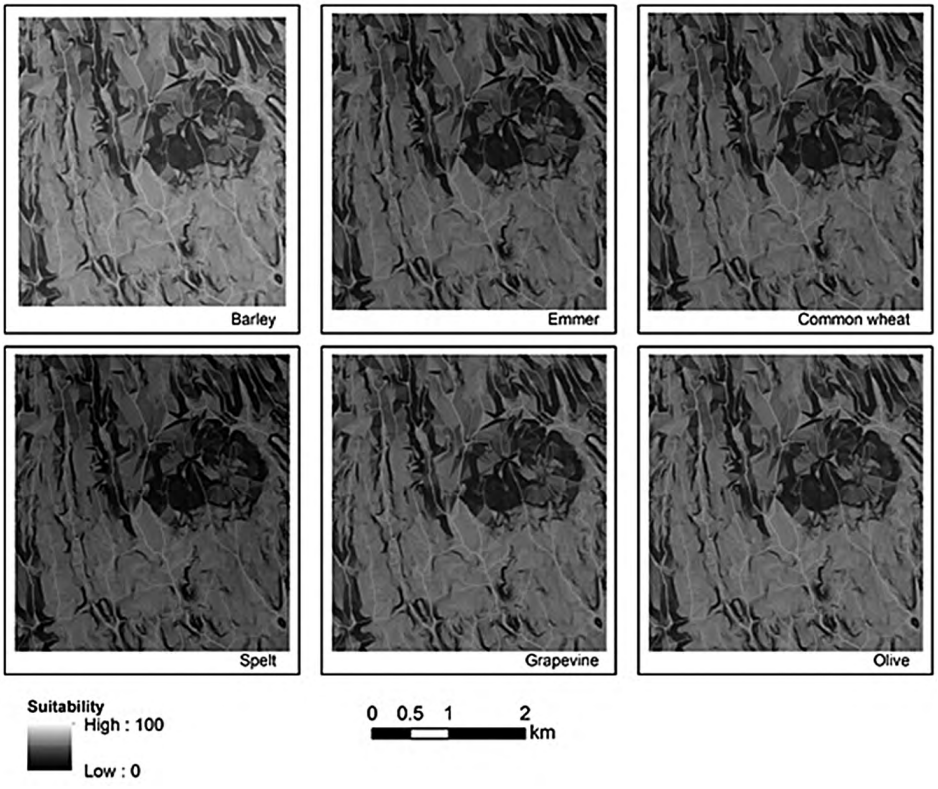


Figure 8. Suitability maps for a range of crops in the Ager Veientanus.

Each suitability map was reclassified into five equally-sized categories (from 0-20 [poor], up to 80-100 [excellent]). Circular buffers were then constructed around the known Roman farm sites, with an area of nine *iugera* (approximately 2.25 hectares) chosen as an appropriate test case (the size of the smallest farms used in the previous model).[31] Villas were given a buffer area of 100 *iugera*

[31] GOODCHILD & WITCHER 2010, based on work by ERDKAMP 2005.

(based on the size of Cato's *vinea*: Cato *Agr*. 11).[32] A pixel count of the different suitability ratings within each notional farm and villa estate was carried out, and the results tabulated in order to assess the spread of suitability classes for each crop type. These showed that, whilst both farms and villas contained a good spread of different quality land suitable for different crop types, villas tended to have proportionally less lower quality land within their buffers. Farms and villas which were new foundations in the Early Imperial period (rather than long-lived settlement throughout the Republic) were then tested independently: villas continued to cluster in the moderately-high suitability areas, but new farms also appeared at this level, i.e. on better land than previously occupied. This supports the results from the prior models, and it is interesting to see a similar pattern being derived from alternative modelling methods. Previously it was suggested that this pattern of land exploitation provides evidence for the emergence of tenancy, with higher quality land being made available to lower status sites.[33]

Why any of the sites did not exploit the best modelled land is unclear, but simulated circular territories are likely not very representative of actual estates. An alternative approach to local modelling is therefore to find those areas of the suitability map indicating ideal locations for agriculture. Using a tool called 'Locate Regions', it is possible to use set criteria (shape and size of units) to find those areas. This generates a map showing where farms or villa estates would be located if they were taking advantage of the best locations. Outputs may then be compared with actual locations to identify correlations. The tool is new within ArcGIS software (version 10.5 onwards), and can currently only process a maximum of 30 sites, whereas the study area contains over 70 sites in all. As a pilot, Early Imperial villas were modelled by setting the module to find the best 100 *iugera* for each of the 15 villas, and preferring square (rather than circular) territories (Figure 9).

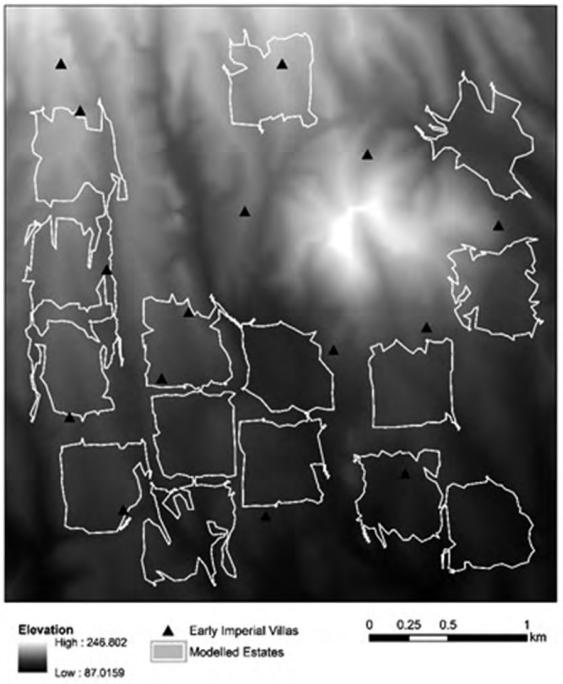


Figure 9. Modelled estates of 100 iugera occupying the most suitable contiguous parts of the Ager Veientanus. The black triangles indicate the location of the known villas.

[32] GOODCHILD 2007, 81-82, 117-119.
[33] GOODCHILD & WITCHER 2010, 214-216.

Villas in this area were mostly located on ridgetop locations towards the periphery of productive areas and, of the 15 known villa locations, only three were not located either within, or directly adjacent to the most suitable areas modelled. Monte Aguzzo (the high area of elevation to the north-east of the study area) appears relatively unattractive according to the model, most likely because of higher slope values or lower water availability.

The map shown in Figure 9 was created for wheat only, whereas estates would most likely have had mixed production. Nonetheless, the model highlights effectively that, even with relatively small villa estates of 100 *iugera*, not much space was available for much larger territories, particularly with a further 23 farms and many smaller scatters in the same region. This supports the argument of Potter (1979, 125) that, contrary to the idea of 300 *iugera*+ estates,[34] the fragmented topography of the *Ager Veientanus* was not suitable for the formation of large estates.

2.2 Pastoralism and Animal Habitats

Animal husbandry can take many forms, from locally-stalled animals to extensive long-distance transhumance. A common approach to studying animal management ecologically is to use GIS for Habitat Suitability Modelling. Habitat models allow for a species' habitat quality to be assessed in a specific area, and are used as inputs for least-cost path and corridor analyses (i.e. how animals move between habitats).[35] Such models are typically used to study the impact of human activity on wildlife behaviour but the approach is potentially useful for historic studies too. Many studies of modern animals, however, require abundance data, monitoring of animal movement, and field data collection methods that are not possible for a project using historical data, though methods exist that allow study via expert knowledge of behaviours and physical requirements.[36]

There is a lot of similarity in approach between Habitat Suitability Modelling and Ecological Niche Modelling for animals. The latter works by evaluating the fitness of a species to its environment, and the niche itself is an area where a species can subsist without need for immigration (i.e. it provides all resource requirements and allows a positive population growth rate).[37] For Roman Italy, however, it is not perfectly suitable niches that are being sought. Instead, it is the relative quality of an area for certain species, rather than whether it perfectly fulfils all criteria, that is of interest here, and so only certain aspects of the approach may be used.

In this paper, extensive grazing in Roman Italy is examined. The FAO has published guidelines for Land Evaluation for Extensive Grazing (FAO 1991), with similar approaches used to those of crop analysis, but with some methodological developments particular to animal husbandry. The use of GIS for the study of rangeland (i.e. open country used for grazing animals) has mostly been based on monitoring, estimating carrying capacity, and implementing management practices to avoid overgrazing and its associated erosion hazards,[38] some of which may be used within historical modelling.

Some elements of modern practices can be replicated in studies of past animal husbandry: animals have ideal climatological niches, and thermal comfort zones can be modelled with existing climatological data. Other essential factors, such as food and water, can be estimated using forage

[34] CELUZZA & REGOLI 1982.
[35] HIRZEL & LE LAY 2008.
[36] e.g. USFWS 1981.
[37] HIRZEL & LE LAY 2008.
[38] e.g. RYAVEC & VEREGIN 1998, TERFA & SURYABHAGAVAN 2015.

crop availability and distance to water or topographic wetness, and are of use in analysing husbandry strategies, or may feed into models of movement, such as transhumance routes.

Using information from the FAO and GAEZ databases, the model presented here is a form of Ecological Niche Modelling, which attempts to determine ideal habitats using temperature data, predicted forage, and water availability.

2.2.1 Thermal Comfort Zones

All animals have upper and lower heat limits that they can tolerate before health is affected by either hypo- or hyperthermia. Adverse temperatures can also affect growth, milk or egg production, and reproduction.[39] Animals should therefore be kept within their Thermoneutral Zone – the temperature range within which they do not need to expend excess energy to maintain a normal body temperature.

Critical temperatures vary between species, and between breeds, particularly with different coat thicknesses. Nonetheless, estimates of thermal comfort zones can still be useful in determining ideal environments.

Table 3. Thermal comfort zones of animals (KING 2006).

Animal	Min Temp in degrees C	Max Temp in degrees C
Goat	0	30
Sheep (fleeced)	-5	25
Sheep (shorn)	7	29
Cattle	-20	25
Pig	10	24

With these ranges, it is straightforward to create Boolean maps based on the air temperature within these zones. Applying them to monthly data allows permanently suitable, seasonally suitable, and unsuitable areas to be visualised (Figure 10a & b). The results show that very few areas in Italy get cold enough to be problematic for either sheep or cattle. In the summer months, however, some areas become too hot. Conversely, pigs are more sensitive to cold, so strategies such as stalling or woodland pannage would need to have been implemented to mitigate against this (Columella *Rust.* 7.9.6).[40]

Modelling monthly temperature changes indicates that, in some parts of Italy, management is required to keep livestock within their thermoneutral zone throughout the year. To avoid heat stress in summer, keeping animals in sheltered areas (e.g. woodland) is one possibility, whilst for the Apennine or Alpine regions, transhumance into cooler mountain areas is an alternative strategy. Recorded transhumance routes (*tratturi*) from the post-Roman period for central and southern Italy (Figure 10c) correspond very well with the temperature patterns observed for Italian summers. Most of the historic *tratturi* originate in the town of Foggia, located at the centre of the largest non-suitable temperature zone for cattle and sheep in the summer months (IGM 1959).

---

[39] HAHN et al., 2009.
[40] BARNISH 1987; MACKINNON 2001.

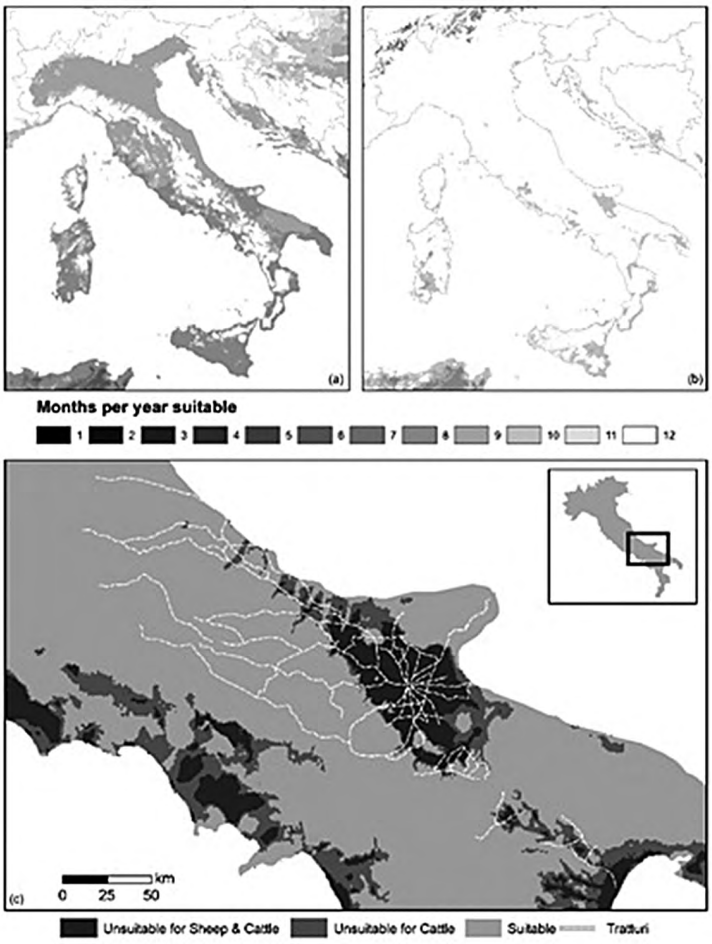


Figure 10. a) cattle and b) sheep suitability index based on number of months an area is within the Thermoneutral Zone. A value of 12 means an area is suitable throughout the year. c) shows the Thermoneutral Zones for cattle and sheep during the month of August with tratturi (IGM 1959) overlaid.

2.2.2 Forage

In modern terms, carrying capacity is primarily determined from quantities of forage, measured by Residual Dry Matter (RDM) per unit area. This is essentially the plant material present on the ground at the beginning of the growing season. Calculated by clipping, then drying and weighing, plant material from a fixed sample area,[41] RDM is therefore problematic to assess historically. New developments using remotely-sensed data to estimate RDM[42] also cannot be applied as they simply reflect modern vegetation conditions.

As such, for historical studies, modelling the ecological niches in which species ideally exist is again an appropriate proxy. Here, the Ecocrop simulation was used to determine the most suitable climatic niches for forage crops. Not all forage crops are available in the database, but some known

[41] BARTOLOME et al., 2006.
[42] e.g. TSALYUK et al., 2015.

Italian species can be mapped. These include grasses such as *Festuca ovina* (sheep's fescue), *Dactylis glomerata* (Cocksfoot), *Poa pratensis* (meadow grass), *Bromus inermis* (smooth brome), and *Phleum pratense* (Timothy), as well as forbs (broad leaved plants) such as *Trifolium repens* (white clover) and *Lotus corniculatus* (Bird's foot trefoil).[43] Grazing a variety of forage species provides a healthier diet for animals than a monoculture; combining these suitability maps into a single map shows areas likely to have greater biodiversity, and therefore more appealing pastures. This climatic niche may be adapted by using Plant Available Water as well as Solar Radiation, to highlight those areas where the pastures could be more lush and abundant (Figure 11).

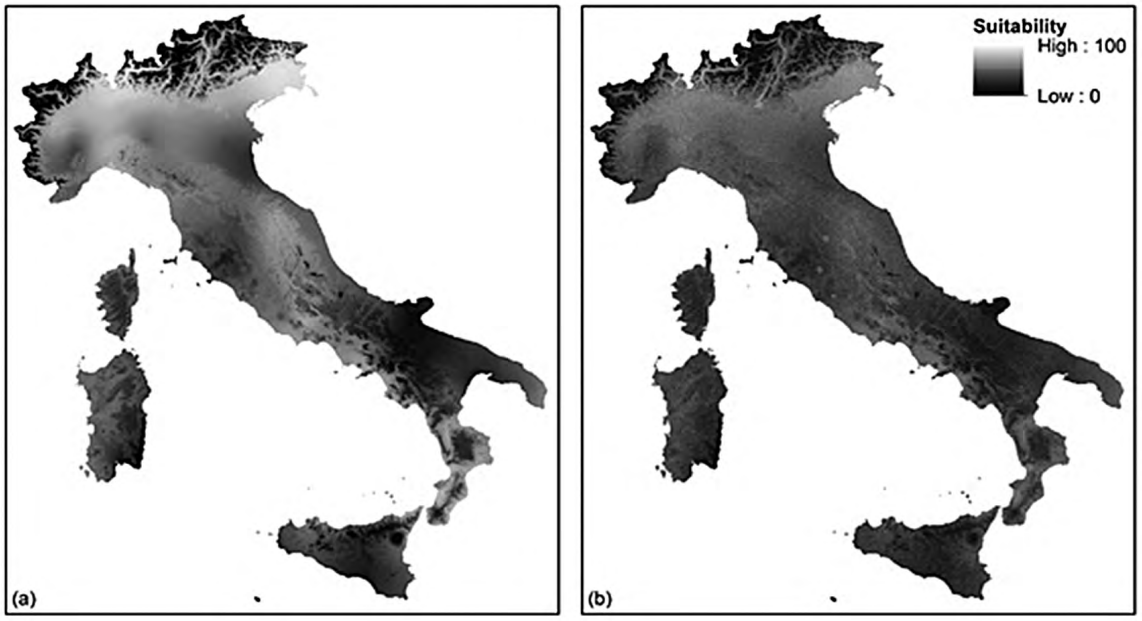


Figure 11. a) Combined forage crops climatic suitability, and b) adapted forage with Plant Available Water and Solar Radiation.

2.2.3 Water Restrictions

Rangeland studies have estimated the impact of water availability on carrying capacity for livestock: for example, recommendations for water proximity stipulate that cows should graze within two miles of a drinking water source.[44] In this study, using the Path Distance function allows terrain to be taken into consideration in terms of distance travelled across a slope, and therefore suitability can be constrained according to 'real' distance. Integrating distance to drinking water; thermal comfort; and forage abundance and biodiversity, then enables a rangeland suitability model to be produced (Figures 12 & 13).

[43] WHITE 1950, 27.
[44] HOLECHEK 1988, 10-14.

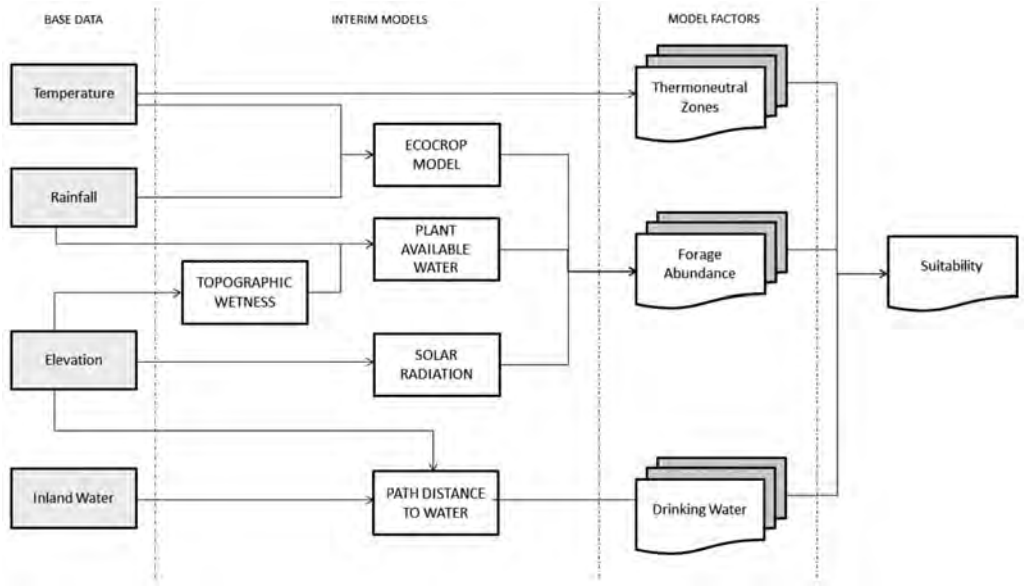


Figure 12. Model components for animal suitability model.

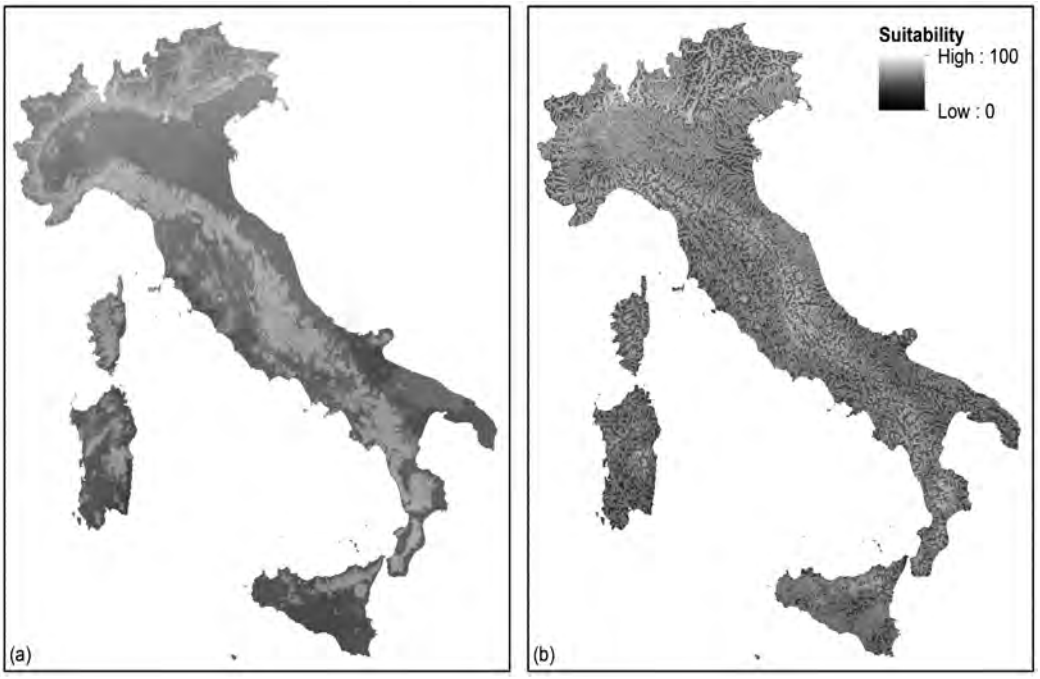


Figure 13. Rangeland suitability of a) Thermoneutral Zones and Forage Biodiversity, and b) with the addition of distance to drinking water.

3. Discussion

In the course of generating the models presented here, the process of model creation has allowed the most important aspects governing land use, and how they might be quantifiable in an historical context, to be explored. Looking at a range of crop types and animal species, for example,

has allowed variations in environmental tolerance to be mapped into physical space, thereby enabling abstract notions of the economy, such as patterns of landholding and tenancy, to be revealed. It can be tempting to model certain factors precisely because they *are* quantifiable, rather than because they are known to be important to agricultural strategies, and for historical studies where only some data are necessarily available, this can be a pitfall. Accepting that caveat within this study, there are nonetheless useful outcomes, and the models should not be thought of as stand-alone suitability models, only useful for one purpose. Rather, the approaches taken and the analyses produced might help inform larger simulations or alternative analyses.

One route is to consider such suitability models as 'desirability' surfaces, which might be input into analyses such as cost surfaces or Agent Based Models, and are immediately applicable to the study of transhumance. A recent study used cost surfaces to predict the likely transhumance paths through Umbria and Sabina in Central Italy.[45] Three factors were used in the cost analysis: modern land cover, natural obstacles (e.g. rivers), and altitude above sea level. It was then determined that the locations of *Castellieri* (pre-Roman fortified settlements on high ground) were likely to have been taking advantage of, or controlling, the most accessible routeways. Such analyses could be usefully augmented by the inclusion of the factors discussed above: climatic constraints, likely abundance of forage, and availability of drinking water, which may also have impacted the choice of transhumance routes.

The suitability models presented herein could also contribute to the interpretation of site-based assemblages. In studying local production and husbandry, plant or animal assemblages from archaeological excavations could be compared with modelled suitability levels. This could enable assessment of whether production was in marginal or good quality land, and whether strategies such as crop irrigation might have been required. If thermal indices suggest that an area was only seasonally suitable for animals, then alternative husbandry practices, such as short or long distance transhumance, stalling of animals or pannage, are likely to have been needed. With increasing palaeoenvironmental analyses from fossil data such as pollen,[46] this could be further refined by improved landscape reconstructions.

Though not attempted herein, an integration of multiple crop suitability maps might contribute to a better understanding of how complex, historic farming units functioned. If all crops were suitable, then it might be logical to follow a mixed strategy, whereas if one crop was excellent then a farmer might consider a monoculture for market-oriented surplus. Farmers are not always 'rational' in their choices, however, and there are inherent dangers in pursuing a monoculture. However, it is exactly these behaviours that might be simulated. By running multiple scenarios, the impacts of these choices may be modelled, and their results compared with the known archaeological and palaeoecological data.

4. Conclusion

Exploring the possible economic strategies of Roman Italy is challenging, but the modelling carried out here provides new and informative perspectives on the agriculture and landscapes of the period. By using models such as Ecocrop, which are reliant on physical crop properties rather than external factors, many potential biases have been removed. This has enabled a prediction of where ecological niches would have allowed particular crops to flourish. For a small study area in the Middle Tiber Valley, results from the new models corroborated the previous findings of GOODCHILD &

[45] CAMERIERI & MATTIOLI 2012.
[46] see e.g. FLANTUA et al., 2007, FYFE 2006, POSKA et al., 2008.

WITCHER (2010). Despite being based on different inputs, they produced similar results in terms of patterns of land suitability, and demonstrated comparable land selections for farmers and villa owners. The similarity in the predictions strengthens previous conclusions, and indicates that even basic modelling approaches are worthwhile.

Non-physically determined factors that would have had an impact on crop production, such as market proximity, land ownership, and economic strategy, should not be overlooked. However, by establishing the physical limits of crops and animals, this study has produced a series of analyses that can then be augmented with socio-economic factors in a more meaningful way.

The applicability of available climate data, which underpins all of these models, is a key issue. Existing data have proven useful in determining the limits of suitable areas for both crops and animals, which could be incorporated as criteria into larger models. In order to have the greatest utility, though, a publicly available Roman-period General Circulation Model is required on which the analyses could then be re-run. Existing Roman-period data indicate elevated rainfall compared with the present day, and it would be interesting to investigate the impact of increased rainfall on the suitability of crops such as olives and grapevines, particularly with regard to trade. Nonetheless, analytical methods such as those presented here have the potential to offer novel and revealing perspectives on the ancient economy.

Acknowledgements

My heartfelt thanks go to Rob Witcher and Francesco Carrer for their extremely useful comments at the eleventh hour. I am disappointed that I was not able to incorporate all of their sound advice within the scope of this paper. I would also like to thank the organisers of the TRAC session – José Remesal Rodríguez, Víctor Revilla Calvo, Daniel J. Martín-Arroyo Sánchez, and especially Antoni Martín i Oliveras – for inviting me to participate, and for their great patience in the production of this article. To Liam Herringshaw, I can only apologise, and thank profusely for his fine editing skills. My final thanks are reserved for Eliza Violet Goodchild Herringshaw, whose misadventures prevented me delivering this paper in the first place, and for derailing every spare opportunity I have had to work on it since, in the way that only toddlers can.

Bibliography

AMPOLO, C. (1980), Le condizione materiali della produzione. Agricoltura e paesaggio agrario. Seminario: La Formazione Della Città Nel Lazio. Roma, 24-26 Giugno 1977. Dialoghi Di Archeologia. n.s. 2, 15–46.

BARNISH, S.J.B. (1987) Pigs, Plebeians and Potentes: Rome's Economic Hinterland, C. 350-600A.D. Papers of the British School at Rome. 55.1987, 157-185.

BARTOLOME, J. W., FROST, W., & MCDOUGALD, N. K. (2006), Guidelines for residual dry matter on coastal and foothill rangelands in California. Rangeland Monitoring Series. Publication, 8092.

BEVEN, K. J., & KIRKBY, M. J. (1979), A physically based, variable contributing area model of basin hydrology. Hydrological Sciences Journal. 24.1, 43–69.

BRETZKE, K., DRECHSLER, P., & CONARD, N. J. (2012), Water availability and landuse during the Upper and Epipaleolithic in southwestern Syria. Journal of Archaeological Science. 39.7, 2272–2279.

BRUGHMANS, T., & POBLOME, J. (2016), Roman bazaar or market economy? Explaining

tableware distributions through computational modelling. Antiquity. 90.350, 393–408.
BÜNTGEN, U., TEGEL, W., NICOLUSSI, K., MCCORMICK, M., FRANK, D., TROUET, V., KAPLAN, J.O., HERZIG, F., HEUSSNER, K.-U., WANNER, H., LUTERBACHER, J., & ESPER, J. (2011), 2500 years of European climate variability and human susceptibility. Science. 331.6017, 578–582.
CAMERIERI, P., & MATTIOLI, T. (2012), Obscura itinera: a GIS-based approach to understand the pre-Roman and Roman transhumance pathways in Umbria and Sabina regions (Central Italy). In: EARL, G., SLY, T., CHRYSANTHI, A., MURRIETA-FLORES, P., PAPADOPOULOS,
C., ROMANOWSKA, I. & WHEATLEY, D., (Eds.), Archaeology in the Digital Era. Papers from the 40th Annual Conference of Computer Applications and Quantitative Methods in Archaeology (CAA), 26-29 March 2012. Amsterdam, 332-339.
CELUZZA, M. G., & REGOLI, E. (1982), La valle d'Oro nel territorio di Cosa. *Dialoghi Di Archeologia*. ns 4,1.1982.
CETIN, H., PAFFORD, J. T., & MUELLER, T. G. (2005), Precision agriculture using hyperspectral remote sensing and GIS. In: Proceedings of 2nd International Conference on Recent Advances in Space Technologies, 2005. RAST 2005. 70–77.
CRAMP, L. J. E., & EVERSHED, R. P. (2015), Reading the residues: the use of chromatographic and mass spectrometric techniques for reconstructing the role of kitchen and other domestic vessels in Roman Antiquity. In: SPATARO, M. & VILLING, A. (Eds.), Ceramics, Cuisine and Culture: The Archaeology and Science of Kitchen Pottery in the Ancient Mediterranean World. Oxford, 125–140.
DONATELLI, M., RUSSELL, G., RIZZOLI, A. E., AND 53 OTHER AUTHORS (2010), A Component-Based Framework for Simulating Agricultural Production and Externalities. In: BROUWER, F.M. & ITTERSUM, M.K. (Eds.) Environmental and Agricultural Modelling. Integrated Approaches for Policy Impact Assessment, 63-108.
ERDKAMP, P. (2005), The Grain Market in the Roman Empire: A Social, Political and Economic Study. Cambridge.
FAO (1976), A Framework for Land Evaluation. FAO Soils Bulletin 32. Rome.
FAO (1991), Guidelines: land evaluation for extensive grazing. FAO Soils Bulletin 58. Rome.
FAO (1996), Agro-Ecological Zoning Guidelines. FAO Soils Bulletin 73. Rome.
FAO (2007), ECOCROP: The crop environmental requirements database. Rome.
FAO/IIASA (2011), Global Agro-ecological Zones (GAEZ v3.0). Rome & Laxenburg.
FICK, S. E., & HIJMANS, R. J. (2017), WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology. 37.12, 4302–4315.
FISCHER, G., NACHTERGAELE, F. O., PRIELER, S., TEIXEIRA, E., TÓTH, G., VAN VELTHUIZEN, H., VERELST, L. WIBERG, D. (2012), Global Agro-ecological Zones (GAEZ v3. 0)-Model Documentation. Rome & Laxenburg.
FISCHER, G., VAN VELTHUIZEN, H. T., SHAH, M. M., & NACHTERGAELE, F. O. (2002), Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and Results, 140. IIASA Research Report. Laxenburg.
FLANTUA, S. G. A., VAN BOXEL, J. H., HOOGHIEMSTRA, H., & VAN SMAALEN, J. (2007), Application of GIS and logistic regression to fossil pollen data in modelling present and past spatial distribution of the Colombian savanna. Climate Dynamics. 29.7-8, 697–712.
FRENCH, C. (2010), Archaeology. People, societies, and landscapes. Science. 328.5977, 443–444.
FYFE, R. (2006), GIS and the application of a model of pollen deposition and dispersal: a new approach to testing landscape hypotheses using the POLLANDCAL models. Journal of Archaeological Science. 33.4, 483–493.
GOODCHILD, H. (2007), Modelling Roman agricultural production in the Middle Tiber Valley,

Central Italy (PhD), University of Birmingham.
GOODCHILD, H., & WITCHER, R. (2010), Modelling the agricultural landscapes of Republican Italy. In: LO CASCIO, E. & CARLSEN, J. (Eds.), Agricoltura e Scambi nell'Italia Tardo Repubblicana. Bari, 187–220.
HAHN, G. L., GAUGHAN, J. B., MADER, T. L., & EIGENBERG, R. A. (2009), Thermal indices and their applications for livestock environments. In: DESHAZER, J.A. (Ed.) Livestock Energetics and Thermal Environment Management. American Society of Agricultural and Biological Engineers. St Joseph, 113–130.
HIEDERER, R. (2013), Mapping Soil Properties for Europe - Spatial Representation of Soil Database Attributes. JRC Technical Report EUR 26082 EN, European Union.
HIJMANS, R. J., CAMERON, S. E., PARRA, J. L., JONES, P. G. AND JARVIS, A. (2005), Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology. 25, 1965–1978.
HIJMANS, R. J., GUARINO, L., CRUZ, M., & ROJAS, E. (2001), Computer tools for spatial analysis of plant genetic resources data: 1. DIVA-GIS. Plant Genetic Resources Newsletter. 127, 15–19.
HIRZEL & LE LAY (2008). Habitat suitability modelling and niche theory. Journal of Applied Ecology. 45, 1372–1381.
HOLECHEK, J. L. (1988), An Approach for Setting the Stocking Rate. Rangelands. 10.1, 10–14.
IGM (1959) Carta dei tratturi, tratturelli e bracci e riposi del 1959 redatta dal Commissariato per la reintegra dei tratturi di Foggia, Istituto Geografico Militare, Sezione Cartografia Storica.
IVERSON, L. R., DALE, M. E., SCOTT, C. T., & PRASAD, A. (1997), A GIS-derived integrated moisture index to predict forest composition and productivity of Ohio forests (U.S.A). Landscape Ecology. 12.5, 331–348.
IVERSON, L. R., PRASAD, A. M., & REBBECK, J. (2004), A comparison of the integrated moisture index and the topographic wetness index as related to two years of soil moisture monitoring in Zaleski State Forest. In: YAUSSY, D.A.; HIX, D.M., LONG, R.P. GOEBEL, P. C. (Eds.) Proceedings, 14th Central Hardwood Forest Conference, 2004 March 16-19. Newtown Square, PA, 515-517
JOYCE, J., & VERHAGEN, P. (2016), Simulating the Farm: Computational Modelling of Cattle and Sheep Herd Dynamics for the Analysis of Past Animal Husbandry Practices. In: LAC 2014 proceedings AC2014 Proceedings Amsterdam: Vrije Universiteit Amsterdam.
KING, G. (2006), Animals and Environments. http://www.aps.uoguelph.ca/~gking/Ag_2350/animenv.htm
LUTERBACHER, J., WERNER, J. P., SMERDON, J.E. & 42 OTHER AUTHORS. (2016), European summer temperatures since Roman times. Environmental Research Letters. 11.2, 024001.
MACKINNON, M. (2001). High on the Hog: Zooarchaeological, Literary, and Artistic Data for Pig breeds in Roman Italy. American Journal of Archaeology. 105.4, 649-674.
MACKINNON, M. (2004), Production and Consumption of Animals in Roman Italy: Integrating the Zooarchaeological and Textual Evidence. Portsmouth, RI.
MCCORMICK, M., BÜNTGEN, U., CANE, M. A., COOK, E. R., HARPER, K., HUYBERS, P.J., LITT, T., MANNING, S.W., MAYEWSKI, P.A., MORE, A.F.M., NICOLUSSI, K., & TEGEL, W. (2012), Climate Change During and After The Roman Empire: Reconstructing The Past From Scientific and Historical Evidence. The Journal of Interdisciplinary History. 43.2, 169–220.
MENSING, S. A., TUNNO, I., SAGNOTTI, L., FLORINDO, F., NOBLE, P., ARCHER, C., ZIMMERMAN, S., PAVÓN-CARRASCO, F.J., CIFANI, G., PASSIGNLI, S., & PIOVESAN, G. (2015), 2700 years of Mediterranean environmental change in central Italy: a synthesis of sedimentary and cultural records to interpret past impacts of climate on society. Quaternary

Science Reviews. 116, 72–94.
MURPHY, P. N. C., OGILVIE, J., & ARP, P. (2009), Topographic modelling of soil moisture conditions: a comparison and verification of two models. European Journal of Soil Science. 60.1, 94–109.
MURPHY, P. N. C., OGILVIE, J., CONNOR, K., & ARP, P. A. (2007), Mapping wetlands: A comparison of two different approaches for New Brunswick, Canada. Wetlands. 27.4, 846–854.
PANAGOS, P. (2006), The European soil database. GEO: Connexion. 5.7, 32–33.
POSKA, A., SEPP, E., VESKI, S., & KOPPEL, K. (2008), Using quantitative pollen-based land-cover estimations and a spatial CA_Markov model to reconstruct the development of cultural landscape at Rõuge, South Estonia. Vegetation History and Archaeobotany. 17.5, 527–541.
POTTER, T. W. (1979), The Changing Landscape of South Etruria. London.
RENARD, K. G., FOSTER, G. R., WEESIES, G. A., & PORTER, J. P. (1991), RUSLE: Revised universal soil loss equation. Journal of Soil and Water Conservation. 46.1, 30–33.
RICHARDS, M. P., HEDGES, R. E. M., MOLLESON, T. I., & VOGEL, J. C. (1998), Stable Isotope Analysis Reveals Variations in Human Diet at the Poundbury Camp Cemetery Site. Journal of Archaeological Science. 25.12, 1247–1252.
ROSENSTEIN, N. (2004), Rome at War. Farms, Families, and Death in the Middle Republic. London.
RYAVEC, K. E., & VEREGIN, H. (1998), Population and rangelands in Central Tibet: a GIS-Based Approach. GeoJournal. 44.1, 61–72.
SADORI, L., & SUSANNA, F. (2005), Hints of economic change during the late Roman Empire period in central Italy: a study of charred plant remains from “La Fontanaccia”, near Rome. Vegetation History and Archaeobotany. 14.4, 386–393.
SALLARES, R. (2002), Malaria and Rome: A History of Malaria in Ancient Italy. Oxford.
SCHEIDEL, W. (2012), Approaching the Roman economy. In SCHEIDEL, W. (Ed.), The Cambridge Companion to the Roman Economy. Cambridge Companions to the Ancient World, 1-22. Cambridge.
STEVENS, C. J. (2003), An Investigation of Agricultural Consumption and Production Models for Prehistoric and Roman Britain. Environmental Archaeology. 8.1, 61–76.
TARQUINI, S., ISOLA, I., FAVALLI, M., & MAZZARINI, F. (2007), TINITALY/01: a new triangular irregular network of Italy. Annals of Geophysics. 50.3, 407-425.
TERFA, B. K., & SURYABHAGAVAN, K. V. (2015), Rangeland Suitability Evaluation for Livestock Production using Remote Sensing and GIS Techniques in Dire District, Southern Ethiopia. Global Journal of Science Frontier Research. 15.1, 11-25.
TSALYUK, M., KELLY, M., KOY, K., GETZ, W. M., & BUTTERFIELD, H. S. (2015), Monitoring the Impact of Grazing on Rangeland Conservation Easements Using MODIS Vegetation Indices. Rangeland Ecology & Management. 68.2, 173–185.
USFWS (United States Fish and Wildlife Services) (1981) Standards for the Development of Habitat Suitability Index Models for use in the Habitat Evaluation Procedure. USDI Fish and Wildlife Service, Division of Ecological Services, ESM 103, Department of the Interior, Washington, DC, USA.
VAN DER VEEN, M., & JONES, G. (2006), A re-analysis of agricultural production and consumption: implications for understanding the British Iron Age. Vegetation History and Archaeobotany. 15.3, 217–228.
VAN JOOLEN, E. (2003), Archaeological Land Evaluation. A reconstruction of the suitability of ancient landscapes for various land uses in Italy focused on the first millennium BC. (PhD) University of Groningen.
VERHAGEN, P. (2002), Some Considerations on the Use of Archaeological Land Evaluation. In: ATTEMA, P., BURGERS, G.-J., VAN JOOLEN, E., VAN LEUSEN, M. & MATER B. (Eds.),

New Developments in Italian Landscape Archaeology: Theory and methodology of field survey, Land evaluation and landscape perception, Pottery production and distribution. Proceedings of a three-day conference held at the University of Groningen, April 13-15, 2000. Oxford, 200–204.
WHITE, B., OGILVIE, J., CAMPBELL D.M.H., HILTZ, D., GAUTHIER, B., CHISHOLM, H.K.H., WEN, H.K., MURPHY, P.N.C., & ARP. P.A.A. (2012) Using the Cartographic Depth-to-Water Index to Locate Small Streams and Associated Wet Areas across Landscapes. Canadian Water Resources Journal 37.4, 333-347.
WHITE, W. T. (1950), Pastures in the Italian Highlands. Rangeland Ecology & Management / Journal of Range Management Archives. 3.1, 22–28.
WILSON, A. (1994), Water supply for Roman farms in Latium and South Etruria. Papers of the British School at Rome. 62, 139–196.

Ancient rural settlement and land use in the Sarno River plain (Campania, Italy): Predictive models and quantitative analyses

Florian Seiler
German Archaeological Institute, Berlin (Germany)
Sebastian Vogel
Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Potsdam (Germany)
Domenico Esposito
Independent Researcher, Berlin (Germany)

The build-up of a comprehensive GIS database of archaeological evidence of the pre-Roman and Roman period in the hinterland of Pompeii has, so far, yielded a dataset of more than 650 entities. About 140 of them were assigned to Roman farms (*villae rusticae*) which are believed to have played an important role in ancient rural life and economy of the Sarno River plain. This involves agricultural production not only of food to supply the urban centres Pompeii, Stabiae and Nuceria but also of goods (e.g. wine) to be exported to Rome as well as to the western and eastern Mediterranean. To gain a more detailed understanding of the ancient rural settlement structure of the Sarno River plain, this fragmentary dataset on *villae rusticae* was used to carry out a series of quantitative GIS-based spatial analyses. At first, spatial statistics aimed at recognizing spatial patterns, trends and relationships of the distribution of *villae rusticae* to validate the first simply visual impression of a clustered organization around the urban centres Pompeii and Stabiae. Subsequently, a predictive modelling approach aimed at determining the potential area that may have been occupied by *villae rusticae* and agricultural production. This model incorporates paleo-environmental parameters and also tries to quantify some socio-economic parameters that may have controlled the spatial distribution of *villae rusticae*. For that, a recently generated, pre-AD 79 paleo-landscape model of the Sarno River plain was utilized characterizing the ancient topographical conditions before the eruption of Vesuvius in

AD 79. Finally, quantitative analyses and other GIS-assisted methods result in the reconstruction of the settlement structure in the hinterland of Pompeii, the *ager Pompeianus*.

1. Introduction

In recent decades, studies in the field of quantitative modelling of rural settlement have much increased and advanced the refining of attached methodologies[1]. In regions where archaeological rural structures are sparse and without context, a valuable approach to conceive a more complete concept of land use by settlement and cultivation is indeed the application of models. An instructive example represents the recent analysis of rural settlement in the Tiber valley which is based on sophisticated modelling[2]. The Sarno River plain affected most heavily by the eruption of Vesuvius in 79 CE provides an ideal playing field to practise analysis of rural settlement structures by applying predictive modelling (figure 1). In the Roman period, the territories of Pompeii and Stabiae were densely settled by farms (*villae, villae rusticae*) and the land was intensively cultivated. The exceptional state of preservation of both, archaeological findings and paleo-environmental features as well as paleo-botanical material, gives the unique opportunity to study structure and characteristics of the rural settlement in the context of the paleo-landscape. However, our knowledge about the actual ancient situation of the settlement density is fragmentary due to the randomness of archaeological discoveries. Therefore, in previous work, we developed advanced modelling tools in order to generate a predictive model which is able to indicate most favourable locations of Roman farms and agricultural land over a wide area of the Sarno River valley[3]. In this paper we take another big step forward and conduct an analysis and interpretation of the rural settlement on the northern part of the Sarno River, using the previously generated predictive model of suitability for the development of Roman farms and agricultural production. Beforehand, we shortly summarize the applied modelling methodology.

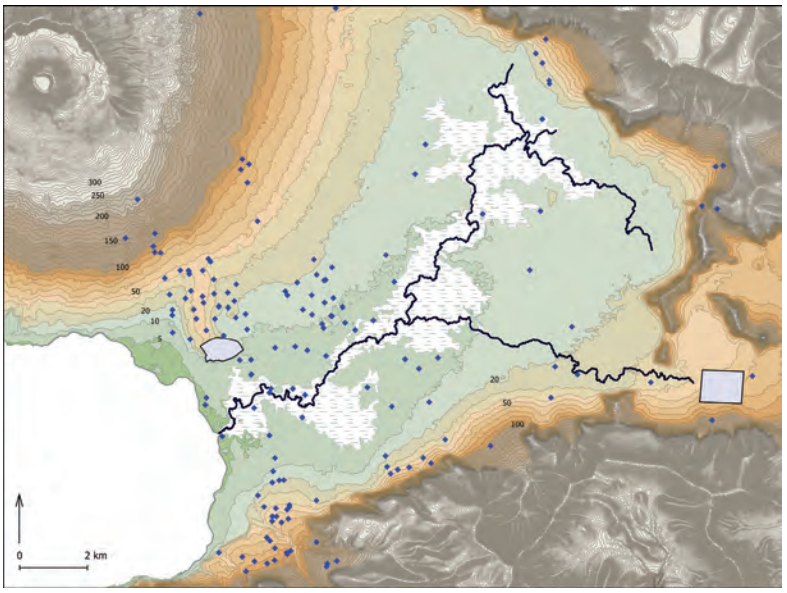


Figure 1. Sarno River plain. Digital elevation model (DEM) of the situation before the eruption of Vesuvius in 79 CE, mapped with the find spots of villas and the location of the ancient towns of Pompeii and Nuceria. (Vogel & Seiler)

[1] VERHAGEN 2007; GOODCHILD & WITCHER 2009; VERHAGEN & WHITLEY 2011.
[2] GOODCHILD 2007; GOODCHILD 2013.
[3] VOGEL, MÄRKER & SEILER 2016a.

2. Model generation

For an in-depth step-by-step description of the methodology to reconstruct the ancient rural settlement of the Sarno River plain we refer to VOGEL, MÄRKER & SEILER (2016a). It is based on an inductively derived predictive model which utilizes the empirically calculated spatial relationship between a dependent variable of an incomplete dataset and several independent variables that cover the entire study area. As dependent variable, the vector-based point dataset of a total of 140 *villae rusticae* was used which was combined with the previous developed raster-based pre-79 CE digital elevation model (DEM)[4], seven deduced pre-79 CE terrain characteristics and four socio-economic parameters as independent variables. The latter are based on distance calculations by means of nearest-neighbour analyses. For that, Euclidean distances as well as terrain-sensitive cost distances were calculated between the *villae rusticae* and the main branch of the paleo-Sarno River as well as the urban centres of Pompeii, Stabiae and Nuceria.

Figure 2 shows the general modelling work flow using GIS-based spatial analysis and descriptive statistics. It is separated into three main segments: (i) data pre-processing, (ii) statistics and (iii) raster processing.

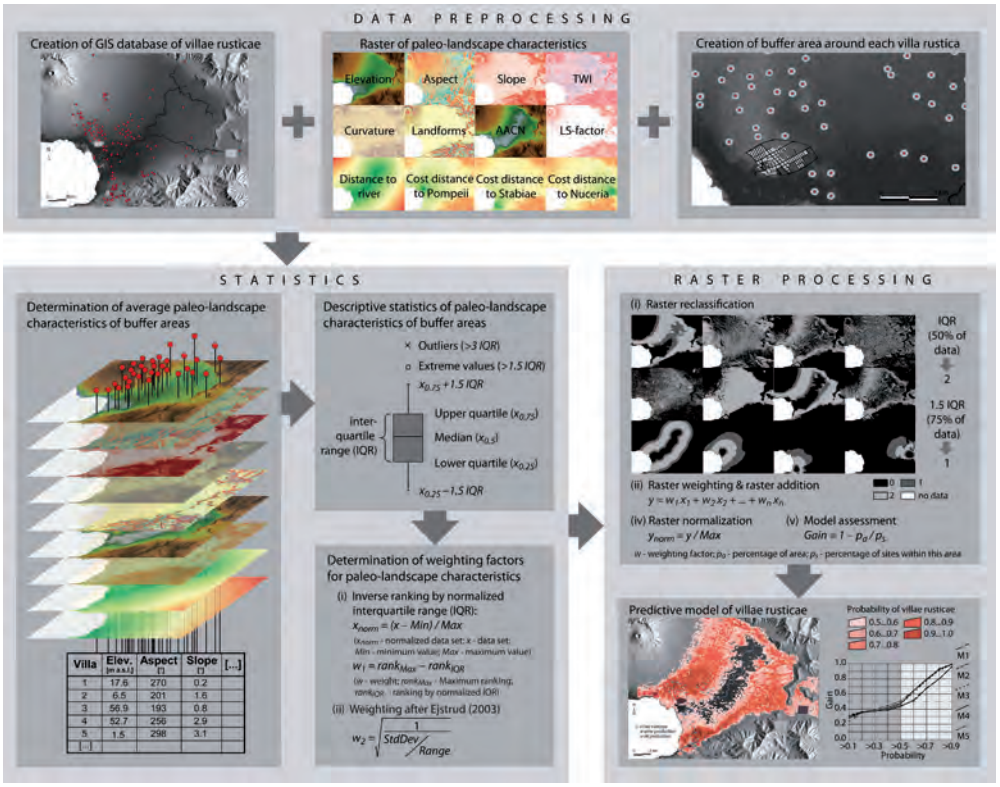


Figure 2. General modelling work flow using GIS-based spatial analysis and descriptive statistics. (Vogel)

[4] VOGEL, MÄRKER & SEILER 2011.

2.1 Data pre-processing

A GIS database is generated including the digitalized locations of 140 *villae rusticae* that are used as dependent variable for the model generation. To characterize the location of a *villa rustica* not only by the location of the main building but also by its surrounding agricultural land, the average location was determined of a buffer area of a radius of 50 m around each villa. Furthermore, the raster-based independent variables are deduced from the pre-79 CE DEM of VOGEL, MD RKER & SEILER (2011).

2.2 Statistics

A data table is generated including the data values of the 12 independent variables at the location of each *villa rustica*. This data table is then used as the training data set in the model generation. At first, for each independent variable, the range of values was determined that cover the average 50 and 75% of all *villae rusticae*. This was done by modified box-and-whisker plots giving insights into the statistical structure of the data as well as the statistical importance of the variables in explaining the locations of *villae rusticae*.

2.3 Raster processing

The ranges of values obtained from the descriptive statistics are then used to reclassify the raster-based independent variables. Afterwards, each variable is weighted in accordance to their statistical importance. Finally, the reclassified independent variables were added up by using a raster calculator in GIS to receive a model of the rural settlement structure. Kvamme's gain statistics was computed in order to assess the quality of that model.[5]

To optimize the predictive model, several model runs with different pre-settings were conducted and tested regarding their performances. The model that turned out to have the highest predictive power can be seen in figure 3 showing the entire Sarno River plain subdivided in different suitability zones for the development of rural settlements and agricultural production. The most suitable zones are represented in the model with the suitability values of 0.7–1.0.

4. The archaeological situation

For most archaeological regions, the task to analyse the ancient rural settlement structure is often confronted with the difficulty of a very unequal archaeological finding situation. This is especially the case in the Sarno River plain. For example, the area round Pompeii, including the districts of Boscoreale, Boscotrecase and Scafati show a rather dense distribution of villa sites, whereas other areas, such as the north-eastern and north-western parts of the Sarno River plain, show no or only sporadic find-spots (figure 1). However, such a discrepancy is the normal situation for wide ranging archaeological field analysis.

[5] KVAMME 1988.

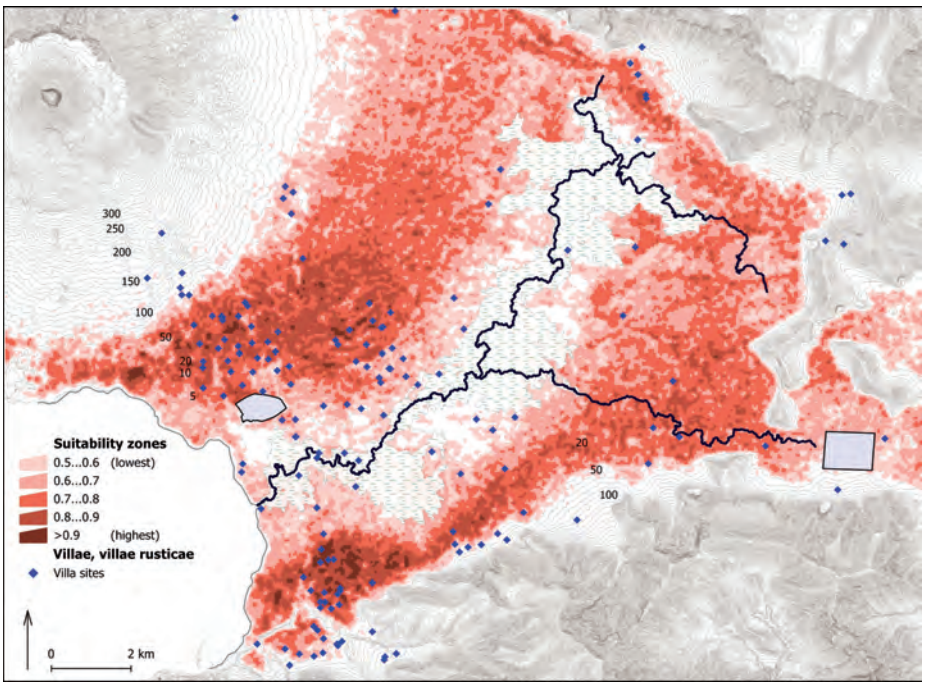


Figure 3. Sarno River plain. Predictive model of suitability of rural settlement development. (Vogel)

This phenomenon reflects, on the one hand, the unequal intensity of archaeological investigation and excavation activity in local communities. Excavations of scattered Roman villas in the surroundings of Pompeii began almost parallel to the archaeological work within the ancient town itself where the first discovery was made in 1748. The area around Pompeii was more intensely explored by excavations carried out especially by private landowners at the end of the 19th and the beginning of the 20th century[6]. The effect of the private digging rush which was legally authorized and surveyed by the Superintendence was that innumerable villa sites were uncovered around Pompeii and the valuable findings were removed before filling up the exploited huge cavities. From today's point of view, the published reports made by the surveying officials, containing only scarce archaeological notes, sketch plans and sometimes photographs, do not satisfy present archaeological standards. However, they are often the only evidence of the existence of a villa site and the only, and therefore extremely important, documentation about the relative finding[7]. A similar situation relates to the territory of Stabiae, where the Bourbon excavation of the ancient town in the 19th century yielded the uncovering of many villa sites around the nucleus of the well-known luxury villas. During the last three or four decades, rescue excavations undertaken by the Superintendence of Pompeii and Salerno aiming at recovering and conserving the archaeological heritage from destruction by the wildly growing urbanization has significantly increased. The function of steady archaeological control resulted in a great number of discoveries of new villa sites namely in the district of Scafati, Boscoreale, Boscotrecase and other cities in the more and more urbanized landscape[8]. In general, it can be said that– with very few exceptions such as Villa Regina in Boscoreale[9]– most of the villas

[6] OETTEL, 1996; GARCÍA Y GARCÍA, 2017.
[7] STEFANI 1994.
[8] e.g. STEFANI 2000; DE' SPAGNOLIS 2002.
[9] DE CARO 1994.

were not completely or only in small parts uncovered and almost all sites were filled up after the archaeological intervention. Thus, a systematic large-scale exploration of villas and their environment in most cases did not occur.

On the other hand, in reference to our predictive model, we suppose that the generated most suitable zones, where few or no archaeological findings are recorded, were likewise settled. These zones, represented in the model with suitability values of 0.7–1.0, are characterized by equivalent paleotopographic and paleoenvironmental conditions as the areas of Pompeii and Scafati which show accumulated villa findings. Hence, they form a continuous landscape with no physical break between them.

Therefore, we assume that (i) the lacking of villa sites in the as most suitable modelled zones is caused by the absence of archaeological findings, (ii) the blank zones were potentially colonized in the same density as the occupied zones of the same physiographic characterization. Consequently, we are able to reconstruct and quantify the 'unknown' villa areas utilizing the spatial patterns gained from the villa areas showing a high density of sites.

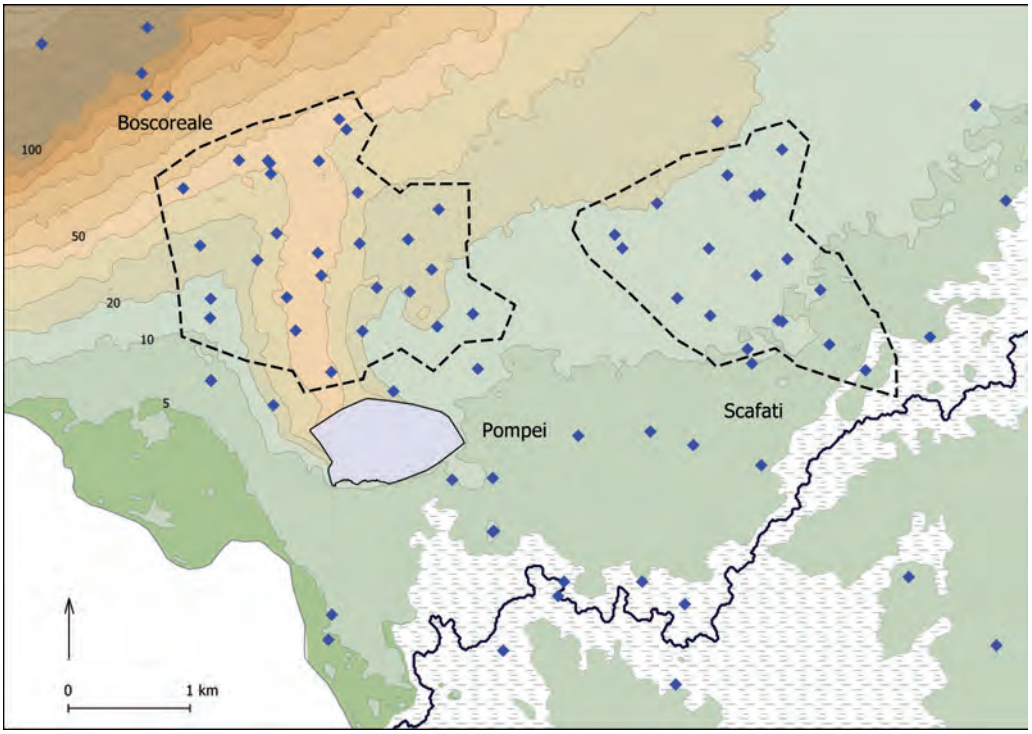


Figure 4. Selected study areas near Pompei and Scafati with a clustered distribution of villa locations, north of the Sarno River Pompeii. The blue dots are villa locations. (Seiler)

5. Quantitative studies

For the quantitative analysis, we selected two study areas, the above discussed area of Pompeii and that of Scafati where the dense site distribution and the collected data set provide a solid basis for investigations (figure 4). In this context we faced three main issues:

- to analyse the spatial distribution and to identify specific rural settlement patterns,
- to identify characteristic structural and functional features of *villae rusticae* in that region, and
- to discuss to what extent the discovered patterns can help in reconstructing the rural settlement structure in a wider regional area, such as the zone of modelled high suitability north of the Sarno River.

The selected area north of Pompeii which is situated on the gentle slope of Mount Vesuvius is characterized by a hillside situation. The moderate slope with a gradient up to 2% and the nutrient-rich loose volcanic soils favoured intensive agriculture. Especially viticulture finds best growing conditions and is well adapted to the dry ground. Since the gently sloped terrain is exposed to the southeast – the ideal aspect for wine-growing – it provides optimal insolation which supports grape ripening and enables the production of high quality wines. The Pompeii cluster consists of 28 villa sites, which form, at first appearance, a dense network with more or less equally distributed find spots. The delimited area has about 450 hectares which consist of 85% of the modelled zone of high suitability values (0.7–1.0).

The second selected area, Scafati, is situated entirely within the river plain. Topographically more precise, the area is located between the foot slope of Mount Vesuvius in the north, at the 20 m contour line, and the border of the floodplain of the Sarno River in the south. The terrain is generally flat without any noticeable elevation, in fact, characterized by alluvial sedimentation and deep soils rich in carbonate and nutrients. The favourable soil conditions and the availability of irrigation water enable intensive agriculture; primarily vine growing is common as it has been shown[10]. For the Scafati cluster, we determined 19 villa sites which form a relatively closed network similar to the Pompeii cluster. The area encloses about 320 hectare, more than half of it within the modelled zone of high suitability.

All in all, the present case study is based on 47 villa sites. This is one third of the collected villa sites in our data base and can be assessed as representative for the northern part of the plain on the right bank of the Sarno River. It is noteworthy that the study areas display topographically different landscape features, hillside as well as plain. On this basis, a series of analysis were carried out.

5.1 Network analysis

With the aim to identify spatial distribution patterns, at first, we measured the distances between villa sites, using a GIS-based Gabriel network analysis (figure 5). A Gabriel network is a network where the links are determined by making a pairwise comparison of points in the context of the points around them.[11] The resulting calculation shows that the villa sites are located not more than about 700 m away from each other. In the Pompeii cluster, the Euclidian distances range between a minimum of

[10] 2016b; SEILER et al. 2016.
[11] MANIFOLD 2007, Gabriel network.

85 m and a maximum of 711 m. Taking into account that the shortest distances of some tens of meters could connect two separately located parts of one and the same villa complex, the minimum distance increases to 157 m. The arithmetic mean of 43 measured distances (including the shortest) is 401 m.

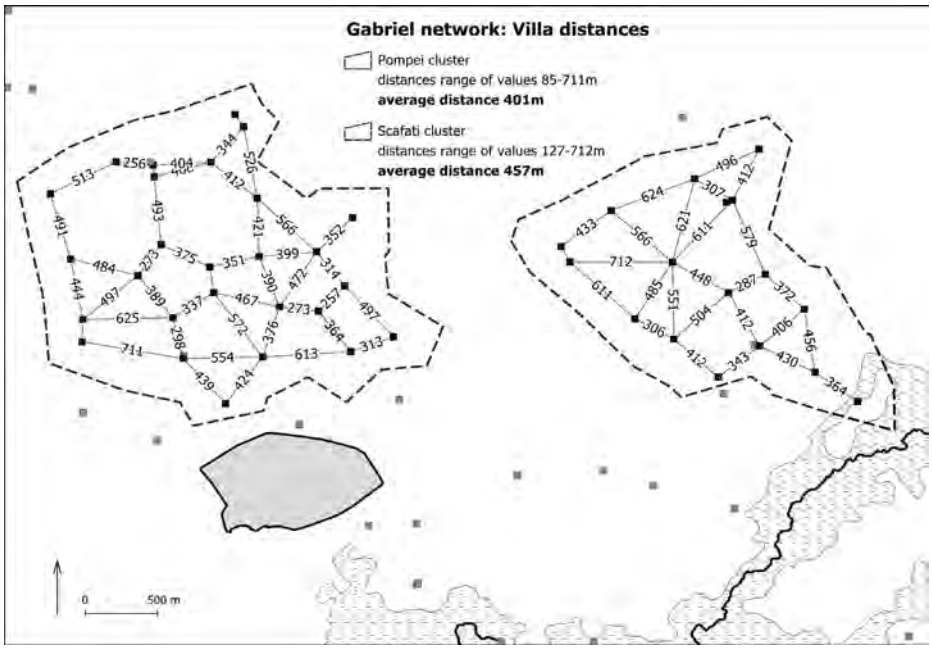


Figure 5. Study areas of Pompeii and Scafati. Distance measures between villas analysed by Gabriel networks. (Seiler)

The range of values is almost equal for the Scafati cluster. The minimum and maximum values of 26 measured distances are 127 m and 712 m. The arithmetic mean is 457 m. This is 50 m more compared to the Pompeii cluster. However, that difference is not significant. In general, it can be said that the villas are located approximately 400 to 450 m away from each other.

Villa distance network	number of measurings	minimum distance	maximum distance	arithmetic mean
Pompeii cluster	43	85 m	711 m	401 m
Scafati cluster	26	127 m	712 m	457 m

5.2 Areal calculations

To quantify the spatial extent of the area around each villa in relation to the neighbouring villas around we used the technique of Voronoi polygons or diagrams (figure 6). A Voronoi diagram divides the drawing into regions around each point that are shaped so that the borders of the regions are equidistant from the two nearest points. Every location within a Voronoi cell is closer to the point about which that cell is drawn than it is to any other point.[12] One technical problem calculating Voronoi polygons occurs with the boundary of the marginal cells which tend to diverge because outside there is no point to generate the edge of the cell. To solve this problem we extrapolated a set of theoretical points based on the pattern of the neighbouring points inside the network. After having created the Voronoi polygons the extrapolated points were cancelled. Obviously, the resulted polygons do not correspond to the exact form and proportions of the real villa plots as their physical boundaries are unknown. However, the data provide a valid scale of

[12] MANIFOLD 2007, Voronoi polygons.

the theoretical size of the villa's surrounding land in respect to the neighbouring units. The result is likewise significant. In Pompeii, except of one cell of 9 hectares, the vast majority of villa units, in fact 75%, belongs to the medium-sized class ranging from 10 to 20 hectares. The maximum unit does not exceed 25 hectares whereas the average size in the Pompeii cluster is 17 hectares.

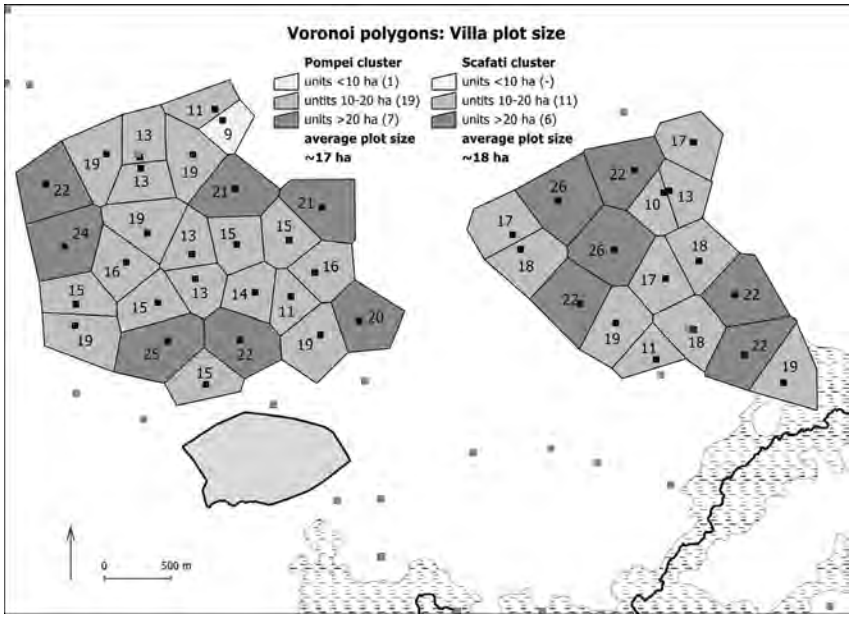


Figure 6. Study areas of Pompeii and Scafati. Quantification of villa plots by using Voronoi polygons. (Seiler)

In the Scafati cluster the results differ only marginally. The sizes range from the smallest cell of 8 hectares to the largest of 26 hectares. The majority, i.e. 63%, belongs to the medium-sized class of 10 to 20 hectares. The average size at Scafati is 18 hectares.

Villa plot size analysis	number of cells	minimum size	maximum size	percentage of class 10–20 ha	arithmetic mean
Pompeii cluster	27	9 ha	25 ha	75%	17 ha
Scafati cluster	19	8 ha	26 ha	63%	18 ha

From the previous calculations, it can be deduced that the theoretical plot sizes in both Pompeii and Scafati match perfectly in all categories, even though they are situated in different physiographic situations. This conformity is probably not by random chance. In contrast, we suppose that it results from an underlying settlement structure.

5.3 Villa size classification

In a next step, we will look more closely at the villas themselves, to examine the size and structure of their ground plans. For reasons given above, the state of documentation of the villas where ground plans exist, show a high variation. In the Pompei cluster, for only 15, i.e. somewhat more than half of the 28 villas, plan documentations exist. In Scafati, the rate is about 60% with 11 published plans of 18 villas. Obviously, the lack of plans concerning 40–50% of the villas to some extent, limits the significance of that analysis. However, even on the base of the existing plan documentations, valid results can be obtained. When a villa is only partly excavated, the probable outline of the plan was, as far as possible, roughly completed. In consequence of that procedure, we did not take into account exact measurements of the floor area but estimated size categories of the classifiable villa plans.

On the basis of 20 villas, the size classification shows significant results (figure 7). The majority of determinable structures in both villa clusters, i.e. 13 of 20 villas or 65%, can be classified as small *villae rusticae* ranging from 450 to 750 m². Only 7 villas belong to the class of 1000 to 1500 m², most of them located in the Pompeii cluster. Very large villas are not represented in the study area, but are not generally excluded. For example the Villa dei Misteri is a large villa having a size of 3000 m². However, this villa is located out of the study area and therefore not considered in the calculation. We suppose that the assumed share of small and medium-sized villas roughly reflects the authentic situation in the hinterland of Pompeii.

Villa size classification	number of villas with plan	number of classifiable villa plans	number of small villas 450–750 m²	number of medium-sized villas 1000–1500 m²
Pompeii & Scafati cluster	26	20	13	7

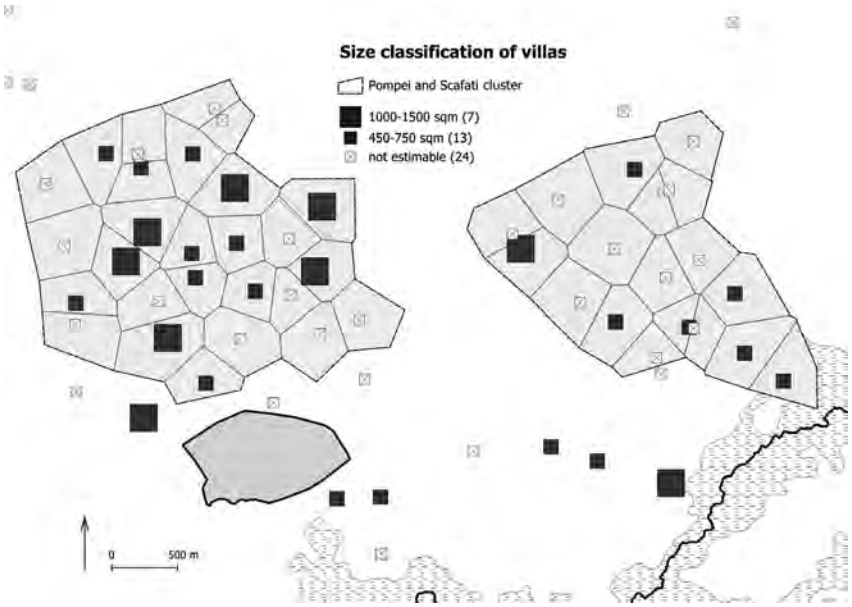


Figure 7. Study areas of Pompeii and Scafati. Mapping of villas according to their size classification. (Seiler)

5.4 Structural and functional features

Looking at the layout plan itself, we gain insight into the structure and function of the villas (figure 8a). At first sight, the great typological variety of the layout is a striking phenomenon. This mainly concerns the class of small *villae rusticae*. Apparently, the irregular layout is originated from the practise and functioning of the farms as well as external conditions, such as topographical and infrastructural constraints. Characteristic examples of such a layout plan are represented by the Villa Regina (no. 32) and the villa in location Civita Giuliana of the property of Antonio Prisco (no. 438). Without going into more detail, it is notable that, despite the great typological differences, specific functional features occur in similar patterns:

- the key position of the courtyard in the configuration of the villa (blue areas): used as space for communication, working and sometimes storage,
- the prevalence of spaces for agricultural use such as wine production, wine storage and drying floor (green areas): coherently organized with regard to working processes,
- the importance of areas for household and domestic use (yellow areas): focussed on needs for food, storage and domesticity,
- the low occurrence of luxury rooms (red areas): often consisting of only one dining room close to the wine production area; bathrooms are rare.

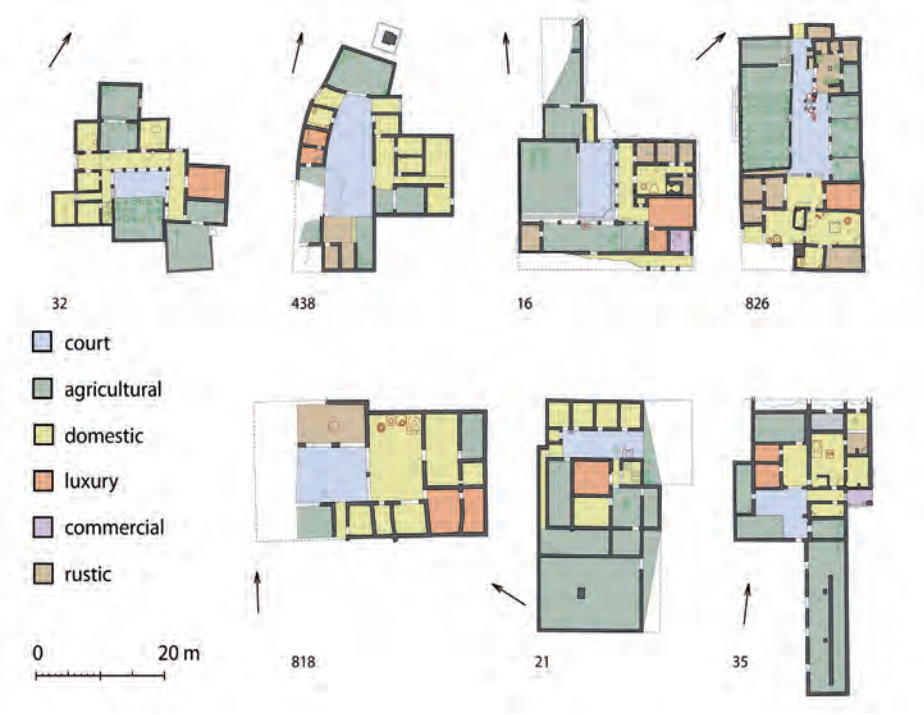


Figure 8a. Synopsis of villae rusticae of the small-sized class of 450–750 m². (Seiler)

In contrast to that, the plans of the medium-sized villas (1000 to 1500 m²) in general show a more regular and symmetric layout (figure 8b). The influence of urban and palatial architectural models on these typologies is apparent, as illustrates e.g. the Villa of P. Fannius Synistor (no. 81) . The dominating space of luxury use is distinctive and functionally much more differentiated. The courtyard, normally configured with porticoes and peristyles, has clearly representational purposes as it is shown by its decoration with wall paintings. That reflects the different 'public' demand and function in the social environment of the villa. However, also within this class, the villa structure provides space for wine production and storage, in some cases even of vast extent, as e.g. the Villa della Pisanella (no. 41) shows. One exceptional example is the Villa of Asellius (no. 15) having no agricultural equipment at all. It is the only exclusively luxury villa among a big number of wine producing small and medium-sized *villae rusticae* in the examined region.

Figure 8b. Synopsis of villa estates of the medium-sized class of 1000–1500 m². (Seiler)

5.5 Viticulture

The predominance of wine producing villas in the study area is striking. The statistics gained by analysis of our dataset attest that nearly 40% of the villas operated wine production. Moreover, the probability is high that among the only partially excavated villas portions of the *pars rustica* were yet uncovered. Hence, the percentage of wine producing villas can even be assumed to be 50% or more. Anyhow, on the base of the actual documentation it is hard to provide precise quantities of wine producing villas for both study areas. The available data, indeed, allow only a rough estimate. The evident expansion of vineyards into the plain, even adjacent to the floodplain of the Sarno River, shows that indeed intensive viticulture was practised everywhere (figure 9). The recent excavation and scientific investigation of a vineyard located in via della Resistenza in Safati[13], the wine producing *villae rusticae* of N. Popidius Narcissus Maioris in Scafati,[14] or that in Corso Trieste in Scafati,[15] 1000 m, 650 m and 400 m away from the riverside, are remarkable examples. Oil production in larger quantities is very rare and attested only in two villas in the Pompeii hillside area. As repeatedly shown, in the plain or anywhere in the region, there is no evidence for substantial cultivation of grain.[16] In this context we do not account for minor cultivation species and focus on viticulture which played obviously a dominant role in the agriculture of the region.

[13] SEILER et al. 2016.
[14] DE' SPAGNOLIS 2002.
[15] DE' SPAGNOLIS 1994.
[16] SCHEIDEL 1992; SENATORE 1998; DE SIMONE 2016, vs. JONGMAN 1988.

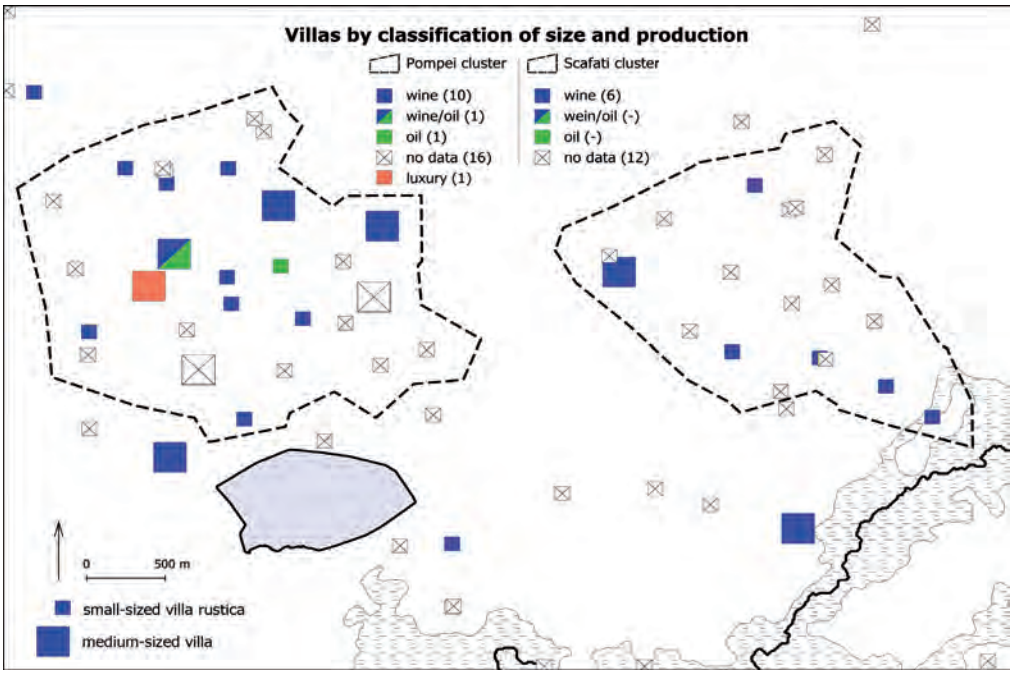


Figure. 9. Study areas of Pompeii and Scafati with villae rusticae and villas. Indicated are their size classification as well as wine and oil production and the only purely luxury villa. (Seiler)

5.6 Chronology

Finally, we deal with the chronological sequence of the villas. This results in differing outcomes between the Pompeii and the Scafati cluster (figure 10). In Pompeii, the majority of 18 villas can be dated to the 1st century BC, only 9 sites to the 1st century CE. This ratio is just the opposite in Scafati, where the number of early imperial villas is greater than the late republican units. Only one villa located in the Scafati cluster can be dated probably to the 2nd century BC. In this regard, it is relevant to know that during the archaeological excavations stratigraphical investigations below the Roman level of 79 CE as well as in-depth architectural studies were very scarce. Therefore, the Pre-Roman development of the rural settlement and the villa's building history remain rather vague.

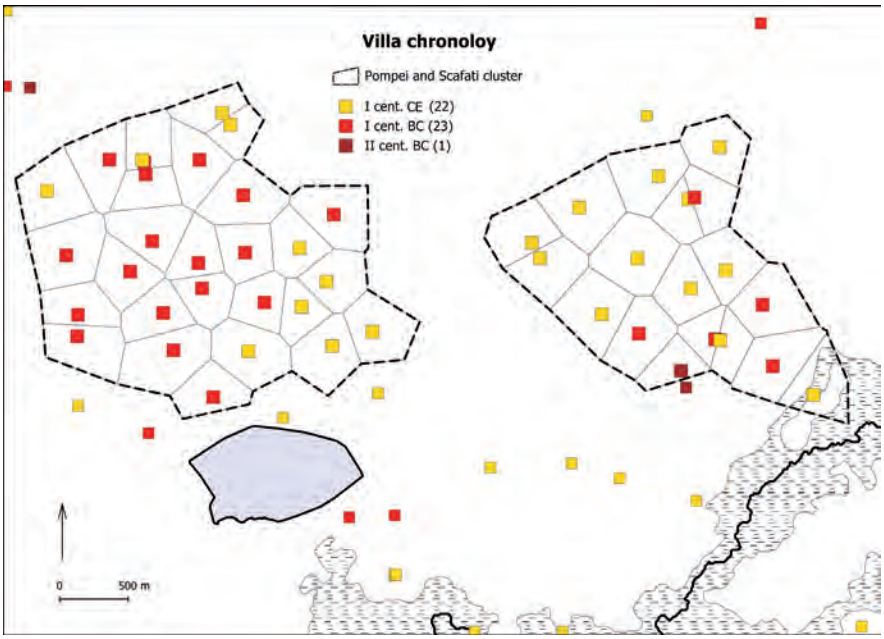


Figure 10. Study area of Pompeii and Scafati. Villa locations mapped in chronological order. (Seiler)

6. Reconstruction of the rural settlement structure

On the base of this multi-layered analysis, we obtain a differentiated characterization of the reconstructed settlement structure in the two study areas (figure 9).

The main features of the rural settlement can be described as follows:

- The distribution of villas and *villae rusticae* suggest a very homogeneous and regular settlement pattern. They are located 400–450 m away from each other whereas the area of cultivable land is approximately 17–18 hectares.
- Two-thirds of *villae rusticae* are not larger than 450 to 750 m², which can be classified as smallholders. In contrast, one third of the structures is twice as large ranging between 1000 and 1500 m² and can be classified as medium-sized villa estates.
- The functional structure of *villae rusticae* is perfectly adapted to agricultural production and dimensioned for the scope of smallholders, whereas the villa estates show a significantly higher proportion of luxury elements and a larger configuration for agricultural production.
- At least 40% of *villae rusticae* and villas, probably far more, operated wine production, most of them by smallholders.
- The settlement activity boomed in the 1st century BC and continued constantly in the 1st century CE until the eruption of Somma-Vesuvius in 79 CE.

On this solid base, we conducted various calculations for the region north of the Sarno River in order to reconstruct the settlement structure in detail. Using GIS techniques, such as grid-based procedures, we selected the areas of high suitability (0.7–1.0 values) from the predictive model of

VOGEL, MÄRKER & SEILER (2016a) and integrated the settlement patterns obtained from the analysis of the Pompeii and Scafati cluster.

The outcome of this reconstruction is shown in figure 11. The existing findings of villas are represented by blue dots. The black dots represent the projected hypothetical villas. To achieve that result, the following four steps were executed:

1) Construction of a grid with a cell size of 425 m which coincide with the average distance between villas in the study areas; the area of a cell of 18 hectares is equivalent to the average plot size.
2) Selection of the relevant parts of the grid which match the zones of high suitability from the predictive model and clipping the selected parts by excluding the two study areas of Pompeii and Scafati,
3) Classification of grid cells greater than 8 hectares which is the minimum size of the attested villa plots in the study areas; reclassification after patching the fragmented grid cells.
4) Generation of points within the identified cells by means of a centroids transformation which places a point at the approximate centre of balance of a cell.

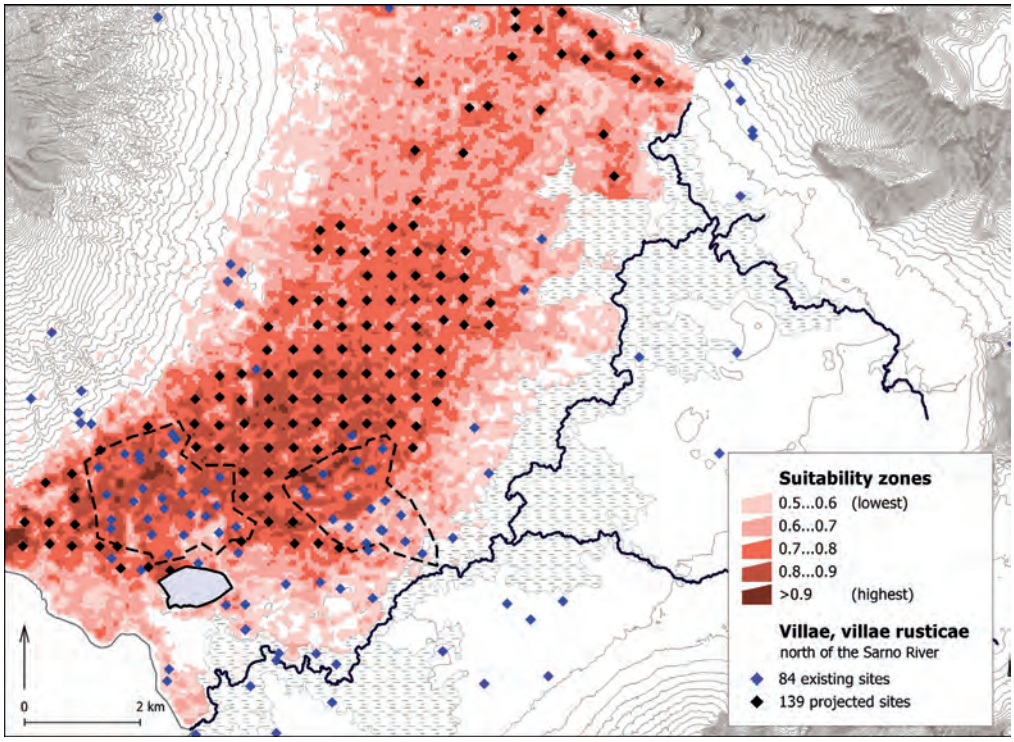


Figure 11. Northern part of the Sarno River plain. Predictive model with existing villa sites (blue dots) and reconstructed villa locations (black dots) in the zones of high suitability of 0.7-1.0. (Vogel & Seiler)

The points, i.e. the reconstructed location of villas show a rather regular distribution pattern due to the raster overlay which represents a simplified model. Obviously, the points do not correspond to the real position of the villas which is unknown. However, the pattern coincides arithmetically with the authentic villa distribution in the study areas of Pompeii and Scafati. The calculation yielded a total of 139 additional villa locations (excluding the study areas). Together with the 84 existing villa sites in the territory north of Sarno River (including the Pompei and Scafati study areas), this results in a total of 223 villas in the area of high suitability in Pompeii's hinterland, i.e. the *ager Pompeianus*.

7. Discussion of results

The above given analysis is an approach to reconstruct the settlement pattern in the hinterland of Pompeii. It is based on a previously calculated model that predicts the most suitable rural locations for the development of *villae rusticae* and agricultural production[17]. According to that, an area of high suitability extends in the shape of a belt from the Pompeiian hill along the slope of Vesuvius at 60 m a.s.l. and down to the fluvial plain of the Sarno River at 10 m a.s.l (figure 11). Another corridor of suitability runs along the coastline in the west. The area of high suitability thins out distinctly towards north-east and disappears about 7 km from the town wall of Pompeii. This belt-shaped corridor is, at its broadest position, about 3.5 km and covers an area of about 32.3 km². The conspicuous fact that outside of this zone of high suitability towards the hillside as well as in the river plain, some scattered villa sites are located does not disprove the reliability of the model. According to the parameters implemented in the model, these zones must indeed be considered less favourable, however they are far from being unsuitable for settlement. Further calculations considering the zones of lower suitability showing values of 0.5–0.7 would undoubtedly give analogous results, even though in a more scattered manner and probably not much higher than 150 m a.s.l.

It is noticeable that 85% of the villas situated north of the Sarno River are located up to 50 m a.s.l. at a slope gradient up to about 4% (figure 12). The most elevated villa location on the southern slopes of Somma-Vesuvius, referred to the reconstructed paleo-level of 79 CE, is situated at 215 m a.s.l. showing a slope gradient of 9–10%. Some others can be found at an elevation of more or less 100 m, one at 150 m and another one at 190 m a.s.l. The question is if these sparse find spots represent a denser but lost structure or if they are indeed evidence of a sparser settlement activity at that elevation level. We suppose the latter to be true because of special environmental conditions at higher elevations of Somme-Vesuvius. The more elevated and steeper the relief of a site the higher the costs of movement. At the elevation of 100 m to 300 m, the slope gradient is 9 to 10%. At this elevation, soil erosion is increased and considerably impacts the agricultural land[18]. Furthermore, steep slopes result in denudation processes which inhibit the establishment of an agriculturally usable soil cover. Finally, also the problematic access to water resources at that altitude is an important limiting factor to be considered. On Mount Vesuvius, there are no freshwater springs and the deep groundwater level is difficult to reach, hence, the domestic water supply can only be provided by cisterns. In terms of these environmental conditions, the negative impact on the agrarian development at higher elevations of Somme-Vesuvius must not be underestimated. The situation is comparable to the traditional agriculture at the slopes of Mount Vesuvius as it was still practised 50 years ago. At that time, the cultivated land extended up to an elevation of 250–300 m, however, the farms were situated at a lower level[19]. In terms of climatic and environmental conditions, the

[17] VOGEL, MÄRKER & SEILER 2016a.
[18] WAGNER 1967, 45–48.
[19] WAGNER 1967, 39–50.

situation may have been different at the northern slopes of Vesuvius where a "tight settlement pattern … between 100 and 400 m a.s.l." was recently assumed[20]. One reason could be the blockage effect of Somma-Vesuvius for the air-mass flow from the north and northwest. This results in higher amounts of precipitation at the northern flanks and a decrease along the southern slopes of the volcano. Hence, irrigation agriculture and thereby settlement may be possible up to higher altitudes in the north. Moreover, on the north side of the volcanic cone, agricultural terracing is more common because of steeper slope gradients.[21]

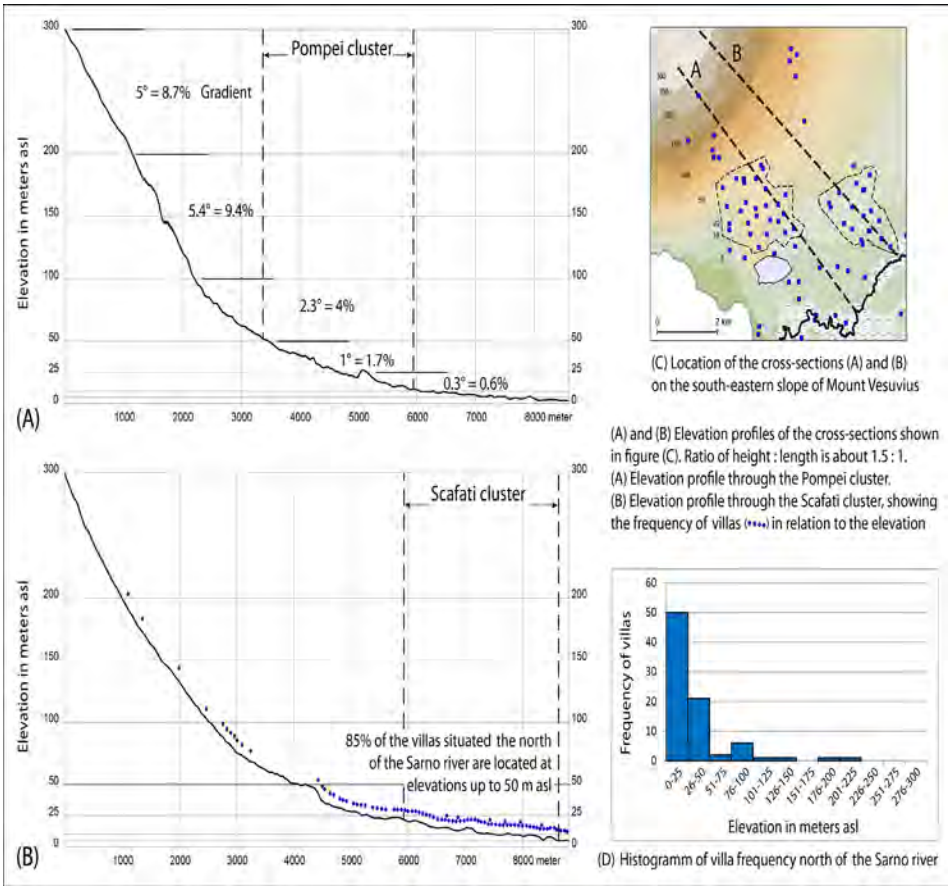


Figure 12. Elevation profiles of the cross-sections at the south-eastern slope of Mount Vesuvius, showing also the frequency and location of villas. The profiles represent the pre-79 CE ground level reconstructed on the basis of the DEM (Seiler)

For reasons of simplification, in our model we did not distinguish between the different levels of suitability but used a single class of high suitability ranging from 0.7 to 1.0. Apart from that, it is noteworthy to say that the area of highest suitability of 0.8–1.0 shows a clearly delimited zone to the north-east up to a maximum distance of 4.5 km from Pompeii (figure 11). That distance could be easily walked in one hour, even if the road was not straight as assumed by the Euclidian distance. We suppose that this zone arises from the proximity to the urban centre of Pompeii and the marketplace. This corresponds with the well-known references of Roman agronomists such as Varro (Res rusticae 1, 16)[22] and Columella (1, 2)[23] who stress a market-oriented selection for the location of a villa

[20] DE SIMONE 2016.
[21] WAGNER 1967, 49–50.
[22] TCHERNIA 2011, 21–23, 194–195.
[23] COLUMELLA 1960.

site. When the Pompeii-centred short distance of 4.5 km which coincide with the 0.8–1.0 zone of suitability can be considered as particular attractive for those people who conduct business in town and have their urban residence then it would perfectly apply to the proprietors of villa estates. By labels and stamps on amphorae, we know about the names and the status of the wine-growers and their relationships with each other.[24] They belong to the noble families of Pompeii who possessed villa estates in the countryside as well as residences in town. Eight of those luxury villas are located within that region, including the Villa dei Misteri at the gates of Pompeii and two others outside of the town. Another one is the luxury villa of Terzigno on the slopes of Vesuvius at 80 m a.s.l. and one is situated in the river plain next to the Roman road to Nuceria and to the riverbank. On the supposition that this clustering of luxury villas within that attractive 4.5 km radius is not random, we assume that a certain share of the 100 reconstructed villa sites in addition to the 43 existing villas within that zone are likewise luxury villas. When we compute that with the above given ratio of 35%, it would result in a total number of 50 luxury villas in the vicinity of Pompeii.

In the predictive model of VOGEL, MÄRKER & SEILER (2016a), the influence of ancient roads on the development of *villae rusticae* could not be considered since the archaeological record of roads is too sparse and heterogeneous. However, the Sarno River as a navigable waterway to transport goods from the hinterland to the harbour of Pompeii and vice versa, as reported by Strabo,[25] was included as a controlling factor. The agronomists Cato, Columella and Varro refer to the proximity of villa sites to transport ways on road and river for reasons of cost reduction.[26] As generally well known, the transport cost on waterways is by a multiple less than overland. The villa locations near the Sarno River were certainly also influenced by the fact of a short distance to the landing points at the riverbank in order to reduce transport costs. In a recent analysis of villa locations in the Vesuvian region of DE SIMONE (2016), that very important socio-economic location factor was disregarded. In general, studies from other regions such as the Tiber Valley and the Pontine region actually include transport networks as a driving factor.[27]

By quantitative analysis, we found out that the network of villas north of the Sarno River is generally determined by regular distances of 400–450 m and almost equal plot sizes of approximately 17–18 hectares. In other words, it can be said that the sites are distributed in close proximity, within sight and only a few walking minutes away from each other. This implies a close neighbourly relationship of the mostly smallholders and villa estates and a certain social control. This aspect is emphasized by Cato and other agricultural writers for the location of villas because of mutual practical assistance and reasons of security.[28] Similar interrelated structures and plot sizes are reported from other regions as for example the Tiber Valley.[29] In contrast, DE SIMONE (2017, 30), calculated a much smaller plot size for the Sarno River area, e.g. 8.3–14.8 ha for the Villa della Pisanella, compared to our results of 19.5 ha. That difference changes in large measure the assessment of agricultural yield and the regional economic output. It would go beyond the scope of this paper to

[24] PURCELL 1995, 8.
[25] geogr. 5, 4, 8; RADT 2003.
[26] CATO agr. 1, 3; COLUM. 1, 3, 3; VARRO rust. 1, 16, 1–2; 1, 16, 6.; COLUMELLA 1960; FLACH 2006.
[27] GOODCHILD 2007; ATTEMA & DE HAAS 2011; DE HAAS et al. 2014a; DE HAAS et al, 2014b.
[28] CATO agr. 1, 2; 4, 1; COLUMELLA 1, 3, 3; VARRO rust. 1, 16, 1; 1, 16, 6; cfr. VIITANEN 2010, 143–161.
[29] GOODCHILD 2007, 103–120.

discuss that comprehensive and much debated economic issue. Such an analysis will be carried out in another context utilizing our archaeological database and the obtained settlement patterns.

8. Outlook

The current research findings give detailed new insights into the ancient rural settlement structure and agriculture in the Sarno River plain. These data constitute a fundamental basis for a comprehensive investigation of the socio-economic conditions in pre-Roman and Roman times. The next steps of the SALVE research project to achieve this goal are the following:

- We complete the model of rural settlement for the region south of the Sarno River.
- We approach the reconstruction of the ancient road system and study the transport infrastructure including the waterways.
- We test new methods to analyse the underlying Roman land survey and centuriation systems.
- On the base of our archaeological database, the obtained settlement patterns and the results of our specific excavation of a Roman vineyard in Scafati, we analyse and re-quantify wine production and related economics in the Sarno River plain.
- We estimate the rural population on the base of the obtained settlement density.
- Finally, we intend to assess the economic potential of the whole region.

9. Acknowledgments

This study is part of the interdisciplinary SALVE research project undertaken by the German Archaeological Institute (DAI) in cooperation with the Heidelberg Academy of Sciences and Humanities (HAW) and the University of Tübingen (www.salve-research.org). The Project was funded by the German Research Foundation and the German Archaeological Institute. We would like to thank our local project partners and all their collaborators for their cooperation, the Soprintendenza Speciale per i Beni Archaeologici di Napoli e Pompei, the Soprintendenza per i Beni Archaeologici di Salerno e Avellino. A special thank goes to Giovanni Di Maio for various supports and scientific advices. Above all, we would like to thank Antoni Martín i Oliveras and his colleagues for inviting us to present this paper in their session of the TRAC 2017 in Durham and the opportunity of rapidly being publish in this volume. Finally, I would like to warmly thank my daughter S. Seiler and S. Posti, as well as the friends D. Guida, G. Di Maio, A. Drummer and T. Schulz for their generous hospitality in their lovely residences in Rome, Vico Equense and Orvieto where I could write down this paper with the utmost concentration and the pleasure of their friendship. (F. Seiler)

References

ATTEMA, P. & De HAAS, T. (2011), Rural settlement and population extrapolation. A Case study from the Ager of Antium, Central Italy (350 BC-AD 400). In: Bowman, A. & Wilson, A. Settlement, Urbanization, and Population. Oxford Studies on the Roman Economy, 97–140.

COLUMELLA (1960), Lucius Junis Moderatus Columella, Res rustica I. On Agriculture, translation by Ash, H. B. Loeb Classical Library.

DE CARO, S. (1994), La villa rustica in località Villa Regina a Boscoreale.

DE HAAS, T. et al. (2014a), Minor centres in the Pontine plain: The case of Forum Appii and Ad Medias, Papers of the British School at Rome 82, 109–134.

DE HAAS, T. et al. (2014b), The impact of infrastructural works on regional settlement systems: The Via Appia and the Pontine marshes. In: XVIII CIAC, Centre and periphery in the ancient world, Communication routes in Greece and Rome. Routes and infrastructures, Mérida, 697–701.

DE SIMONE, G. (2016), The agricultural economy of Pompeii. Surplus and dependence. In: Flohr, M. & Wilson A. (Ed.), Economy of Pompeii, Oxford Studies on the Roman Economy, 23-51.

DE' SPAGNOLIS, M. (1994), Il Pons Sarni di Scafati e la via Nuceria-Pompeios, 86 with note 151, 109–110.

DE' SPAGNOLIS, M. (2002), La villa N. Popidi Narcissi Maioris in Scafati suburbio orientale di Pompei, Studia archaeologica 119.

FLACH, D. (2006), Varro. Über die Landwirtschaft. Texte zur Forschung 87.

GARCÍA Y GARCÍA, L. (2017), Scavi "privati" nel territorio di Pompeii. Disiecta membra di antiche strutture e villae rusticae. (Quaderni di Nova Bibliotheca Pompeiana, Series Maior, 1).

GOODCHILD, H. (2007), Modelling Roman agricultural production in the Middle Tiber Valley, Central Italy. Ph.D. thesis, University of Birmingham. http://etheses.bham.ac.uk/175/.

GOODCHILD, H. & WITCHER, R. (2009), Modelling the agricultural landscapes of republican Italy. In: Carlsen, J. & Lo Cascio, E. (Ed.), Agricoltura e scambi nell'Italia tardo-repubblicana , Pragmateiai 16, 187–220.

GOODCHILD, H. (2013), GIS models of Roman agricultural production. In: Bowman, A. & Wilson, A. (Ed.), The Roman agricultural economy, 55–83.

JONGMAN, W. (1988), The Economy and Society of Pompeii. (Dutch Monographs on Ancient History and Archaeology, 4).

MANIFOLD (2007), Manifold® System Release 8 (2007), User Manual, www.manifold.net , Index s.v. Gabriel network; Voronoi polygons.

OETTEL, A. (1996), Fundkontexte römischer Vesuvvillen im Gebiet um Pompeji. Die Grabungen von 1894 bis 1908.

PURCELL, N. (1985), Wine and wealth in ancient Italy. Journal of Roman Studies, 75, 1–19.

RADT, S. L. (2003), Strabons Geographika. Buch V–VIII. Text und Übersetzung.

SCHEIDEL, W. (1992), Neuen Wein in leere Schläuche: Jongman's Pompeii, Modelle und die kampanische Landwirtschaft. Athenaeum, Studi di letteratura e storia dell'antichità, 80, 207–213.

SEILER, F. et al. (2016), Sarno-Ebene, Italien, Landschafts- und siedlungsarchäologische Untersuchungen. Die Arbeiten der Jahre 2012 bis 2014. e -Forschungsberichte des D AI 2016, Faszikel 1, 54–66. urn:nbn:de:0048-DAI-EDAI-F.2016-1-13-3.

SENATORE, F. (1998), Ager Pompeianus: viticoltura e territorio nella piana del Sarno nel I sec. d. C. In: F. Senatore (Ed.), Pompei, il Sarno e la Penisola Sorrentina. Atti del primo ciclo di conferenze di geologia storia e archeologia Pompei Istituto "B. Longo" aprile-giugno 1997, 135–166.

STEFANI, G. (1994), Pompei. Vecchi scavi sconosciuti: la villa rinvenuta dal marchese Giovanni Imperiali in località Civita 1907–1908, Soprintendenza Archeologica di Pompei, Monografie 9.

STEFANI, G. (2000), Casali di ieri, casali di oggi. Architetture rurali e tecniche agricole nel territorio

di Pompei e Stabiae: Boscoreale Antiquarium Nazionale 16 aprile - 30 maggio 1999: Napoli Palazzo Reale Sala Dorica 28 marzo - 15 aprile.
TCHERNIA, A. (2011), Les Romains et le commerce, Naples, Centre Jean Bérard, Centre Camille Jullian.
VERHAGEN, P. (2007), A condensed history of predictive modelling in archaeology. In: P. Verhagen (Ed.), Case studies in archaeological predictive modelling (pp. 13–25).
VERHAGEN, P., & WHITLEY, T.G. (2011), Integrating archaeological theory and predictive modeling: A live report from the scene. Journal of Archaeological Method and Theory, 19 (1), 49–100.
VIITANEN, E.-M. (2010), Locus Bonus. The relationship of the Roman villa to its environment in the vicinity of Rome. Academic dissertation University of Helsinki. http://ethesis.helsinki.fi/
VOGEL, S., MÄRKER, M. & SEILER, F. (2011), Revised modeling of the post-AD 79 volcanic deposits of Somma-Vesuvius to reconstruct the pre-AD 79 topography of the Sarno River plain (Italy). Geologica Carpathica, 62(1), 5–16.
VOGEL, S., MÄRKER, M. & SEILER, F. (2016a), The ancient rural settlement structure in the hinterland of Pompeii inferred from spatial analysis and predictive modeling of villae rusticae. Geoarchaeology. An International Journal 31, 121–139.
VOGEL, S., MÄRKER, M. & SEILER, F., et al. (2016b), From a stratigraphic sequence to a landscape evolution model: Late Pleistocene and Holocene volcanism, soil formation and land use in the shade of Mount Vesuvius (Italy), Quaternary International, vol. 394, 155–179. http://dx.doi.org/10.1016/j.quaint.2015.02.033.
WAGNER, H.-G. (1967), Die Kulturlandschaft am Vesuv. Eine agrargeographische Strukturanalyse mit Berücksichtigung der jungen Wandlungen. Jahrbuch der Geographischen Gesellschaft zu Hannover.

Simulando el aprendizaje: modelización basada en agentes para comprender la producción anfórica en el Imperio Romano

Maria Coto-Sarmiento (Barcelona Supercomputing Center- Universitat de Barcelona)
Simon Carrignon (Barcelona Supercomputing Center)
Xavier Rubio-Campillo (University of Edinburgh)
José Remesal Rodríguez (CEIPAC -Universitat de Barcelona)

La producción de ánforas de aceite de oliva en el Imperio Romano

Uno de los items más característicos para conocer el desarrollo económico comercial del Imperio Romano ha sido el estudio cerámico. En gran medida por ser uno de los elementos materiales con mayor presencia en el contexto arqueológico y que mejor ha sobrevivido al paso del tiempo[1]. De la misma forma que nuestros contenedores actuales, su forma y volumen se encuentran estrechamente relacionados con el contenido, el lugar de fabricación, así como otras variables culturales, sociales y económicas que determinan la cantidad y calidad del producto[2]. Asimismo, la arraigada tendencia de utilizar la cerámica como indicador cronológico sigue siendo esencial para fechar los niveles de ocupación a partir de los cambios relacionados con su morfología. Como forma de detectar estos cambios, desde un principio se tendió a explicar este proceso a partir de clasificaciones basadas en variaciones morfométricas, aunque tan sólo una pequeña parte presentase pautas de evolución morfológica susceptibles de ser reconocidas a simple vista y reconstruidas en un sentido diacrónico. La eficacia de este tipo de clasificaciones permitió su perdurabilidad como

[1] REMESAL, 1977; REMESAL, 1998; TEMIN, 2013.
[2] BEVAN, 2014.

método a lo largo de los años a pesar de depender en cierta manera de la habilidad y percepción del ser humano[3]. El surgimiento de nuevas metodologías vinculadas con el avance tecnológico y el auge de proyectos multidisciplinares dieron lugar a la aparición de alternativas asociadas con otras disciplinas científicas. En cierta manera, estas *no tan* nuevas herramientas se fueron convirtiendo en un soporte esencial para detectar procesos de cambios entre diferentes tipos de producciones que serían inapreciables en los contextos arqueológicos.

Para solventar este problema, en los últimos años ha sido frecuente el diseño de modelos computacionales que permiten explorar diferentes fenómenos relacionados con esta casuística mediante el análisis de diversas formas de interacción entre individuos centrados en un entorno concreto[4]. En nuestro caso, dicha metodología nos ha permitido explorar estas cuestiones analizando las producciones de ánforas a gran escala durante el Imperio Romano. Durante este periodo surge progresivamente una amplia infraestructura con el objetivo de albergar una vasta producción, convirtiéndose a la larga en uno de los principales suministros de aceite para todas las provincias del Imperio Romano[5]. La gran cantidad de piezas anfóricas localizadas relacionadas con este comercio se encuentran estrechamente vinculadas con las dinámicas de cambio en la producción a través de la detección de diferentes patrones morfológicos en el registro arqueológico. De esta forma, resulta comprensible poder entender una parte de las dinámicas productivas del Imperio susceptibles de variar en el tiempo y en el espacio dependiendo de diferentes factores económicos, políticos o sociales[6]. En particular, nuestro interés versa en comprender qué mecanismos de transmisión, usados para enseñar a fabricar ánforas, permiten generar esta variabilidad para así poder detectar diferentes patrones de producción a través del uso de datos arqueológicos y simulación.

Con respecto a los modos de transmisión cultural, pueden distinguirse entre tres tipos: horizontal, vertical y oblicua. Si se aplica a la evolución cultural, transmisión horizontal sería cuando el aprendizaje es transmitido entre individuos de una misma generación de forma contemporánea. Este modelo se encuentra estrechamente relacionado con el aprendizaje vinculado a un sistema de intercambios y contactos con otras culturas[7]. En cuanto a la transmisión vertical, el modelo de aprendizaje es el resultado de una transmisión entre parentescos, es decir, de padres o madres a descendientes mientras que en la transmisión oblicua el aprendizaje es transmitido de una generación anterior a otra más reciente, sin ningún tipo de parentesco. Este último tipo de intercambio de mecanismos de conocimiento es conocido en otras sociedades a través de estudios etnológicos como una forma de perpetuar el oficio y el aprendizaje heredados[8].

Estas diferencias en la producción también podrían verse afectadas por diversos factores, entre ellos la distancia geográfica. En nuestro caso, planteamos como hipótesis la probabilidad de compartir rasgos morfométricos en la producción dependiendo de la distancia espacial: los talleres de producción más cercanos compartirían mayores rasgos morfométricos que los más lejanos. Se trataría de un hecho conocido por "aislamiento por distancia", donde se asocia la variación genética con la frecuencia geográfica[9]. Como veremos más adelante, este fenómeno explica que la probabilidad de

---

[3] EEKENS &BETTINGER, 2001
[4] DEL CASTILLO, 2011.
[5] CHIC GARCÍA, 2010-2011.
[6] REMESAL, 2011
[7] CAVALLI-SFORZA & FELDMAN, 1981
[8] EPSTEIN, 1998 ; BOWSER & PATTON, 2008
[9] SHENNAN ET AL., 2015

similitud entre dos comunidades dependerá de la proximidad geográfica, siendo mayor la similitud cuando la proximidad es menor.

Nuestro estudio pretende detectar el impacto en los modos de transmisión sobre la producción de ánforas en relación con la distancia geográfica. Es decir, si la transmisión vertical fuese la predominante en este proceso, las ánforas fabricadas en talleres más cercanos podrían compartir rasgos más similares que las ánforas fabricadas en talleres más lejanos. Si por el contrario la difusión de este conocimiento tecnológico fuese horizontal desde un principio, todos los talleres compartirían los mismos rasgos morfométricos independientemente de su distancia geográfica debido a una progresiva homogeneización en las formas, resultado de los continuos contactos entre individuos compartiendo las mismas técnicas de fabricación. Por lo tanto, en este artículo serán explorados los procesos de transmisión asociados a las producciones de ánforas a través de una combinación de análisis empírico y exploración teórica. Dentro de este contexto, el enfoque evolutivo propone una metodología alternativa para la interpretación de los procesos de cambio en la cultura material [10]. En particular, se ha usado un marco evolutivo para el estudio del impacto que este proceso de transmisión podría desencadenar en la producción de ánforas, siendo como principal objetivo mostrar la viabilidad de un enfoque evolutivo para explicar los acontecimientos históricos culturales del pasado.

No obstante, será necesario considerar previamente ciertos desafíos. Quizás uno de los mayores retos que tuvimos que hacer frente fue el alto nivel de ruido tanto espacial como temporal que existe entre los datos arqueológicos y la cronología de estos. En nuestro caso, la mayor parte de los talleres anfóricos que analizamos pertenecían a prospecciones arqueológicas, en su mayoría sin una cronología exhaustiva. Asimismo, la inmensa mayoría de estas prospecciones centraron su interés en la búsqueda de asas con sellos anfóricos por contener una información prioritaria. Esto obligó a que se descartara estudiar talleres donde la mayor parte de las muestras analizadas incluían en su mayoría sellos de ánforas.

Caso de estudio: la provincia *Baetica*

Nuestro ámbito de estudio se enfoca en la provincia romana de la Bética, una de las principales áreas de producción de ánforas de aceite de oliva durante prácticamente tres siglos[11]. Aunque no nos centraremos en el sistema de producción y comercio anfórico de aceite de oliva durante el Imperio debido a la extensa bibliografía que existe sobre este tema[12], será en este momento cuando se produzca un progresivo incremento de la exportación de aceite de oliva hispano en el Imperio como forma de satisfacer la alta demanda existente[13]. Este aumento en la producción, en parte debido a sus múltiples usos en el Imperio[14], tendió a desarrollar y concentrar un área específica dedicada mayoritariamente a la fabricación de ánforas para su trasporte como son las llamadas Dressel 20[15].

Dentro de esta provincia, diferentes investigadores han localizado alrededor de un centenar de talleres de ánforas Dressel 20 alrededor de los ríos Guadalquivir y su afluente Genil[16] . La mayoría

[10] MESOUDI, 2015
[11] REMESAL, 1977; GARCÍA VARGAS, 2010
[12] BELTRAN, 1970; REMESAL, 1977; BERNI, 1998
[13] REMESAL, 1986; REMESAL, 1998
[14] MATTINGLY, 1998; CHIC GARCÍA, 2005.
[15] DRESSEL, 1878; MARTIN- KITCHER, 1987; BERNI, 2008.
[16] BERNI, 1998: 18; MAUNÉ ET AL., 2014.

de estos alfares no fueron excavados en extensión pero sí prospectados permitiendo reconstruir una buena parte de la actividad artesanal de la producción de Dressel 20. Es interesante saber que una de las particularidades de esta producción ha sido su aparente homogeneidad, sin haber sufrido apenas cambios en casi tres siglos de fabricación[17]. Según algunos autores, esta estandarización estaría relacionada con el hecho de la existencia de una serie de cuadrillas de alfareros que se desplazaban de un sitio a otro de forma ambulante dependiendo del volumen de trabajo[18]. En relación con esta premisa, en nuestro trabajo quisimos testear dicha hipótesis a través del uso de una metodología estadística y de simulación como forma de explicar los procesos de transmisión del aprendizaje de la producción anfórica. En particular, el objetivo general será preguntarnos cómo estaba organizada la producción de ánforas y qué modelo de transmisión se usó para compartir el conocimiento tecnológico usado para la producción de ánforas.

3. Metodología

El principal propósito de este trabajo fue detectar diferencias morfométricas en la producción de ánforas entre diferentes talleres. Para ello, se analizaron un total de 473 muestras de ánforas repartidas entre cinco talleres diferentes: Malpica (Palma del Río, Córdoba), Villaseca (Almodóvar del Río, Córdoba)[19], Cerro de Belén (Palma del Río, Córdoba)[20], Parlamento (Sevilla)[21] y Las Delicias (Écija, Sevilla)[22] (Fig. 1). Como forma de homogeneizar la muestra, se seleccionaron las ánforas con más presencia en los talleres divididas entre Dressel C, Dressel D y Dressel E, basadas en la metodología de Martin-Kilcher y P. Berni anteriormente citadas y con una cronología entre la dinastía flavio-trajanea y la "tardoantoniniana" [23].

Figura 1. Mapa actual de la antigua provincia romana de la Bética. Detalle de los talleres ánforicos analizados repartidos entre los ríos Guadalquivir y Genil.

[17] BERNI, 1998: 25.
[18] REMESAL, 2011; REMESAL, 2016.
[19] GARCÍA VARGAS Y MORENA, EN PRENSA.
[20] DÍAZ TRUJILLO, 1992.
[21] GARCÍA VARGAS, 2000.
[22] FERNÁNDEZ ET AL. 2001; MAUNÉ ET AL., 2014.
[23] BERNI & GARCÍA VARGAS, 2016; BERNI, 2017

La selección de los talleres se hizo en base a dos criterios: a) la distancia geográfica entre ellos como forma de conocer si se encuentra correlacionada con la existencia de diferencias morfométricas en las piezas y b) los talleres que proporcionaron mayor cantidad de muestras con una cronología más extensa y exhaustiva, basada en previos estudios. Para llevar a cabo nuestro modelo, cada ánfora fue medida en ocho partes diferentes divididas entre a) diámetro exterior, b) diámetro inferior, c) altura del borde, d) anchura del borde, e) anchura general, f) altura del borde interior, g) anchura del borde y h) protuberancia (ver Fig. 2). Al no contar con una muestra suficiente de ánforas no fragmentadas, las medidas se enfocaron en el cuello del ánfora por tratarse de uno de los mayores indicadores de variabilidad en el caso de las Dressel 20[24].

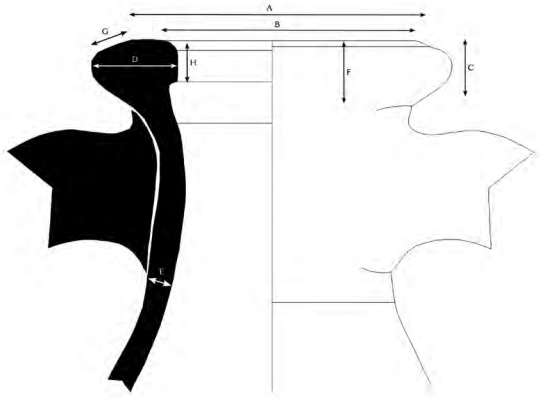


Figura 2. Ejemplo de las ocho medidas que se tomaron enfocadas en el cuello del ánfora.

3.1. Explorando la variabilidad cultural

Desde un principio, como forma de explorar los datos de las mediciones, se realizó un previo test de visualización con todas las muestras (medidas) divididas entre los cinco talleres estudiados para detectar estas diferencias. Para realizar este análisis, se seleccionaron las medidas que habían aportado mayor información y mayor variabilidad con respecto a toda la muestra: la anchura del borde (g) y la protuberancia de la pieza (h). La muestra dio como resultado una similitud en los rasgos morfométricos en el caso de Cerro de Belén, Malpica y Villaseca, mientras que Parlamento y Las Delicias parecieron mostrar un patrón diferente al resto con mayor variación en las medidas (Fig. 3).

[24] BERNI, 2017.

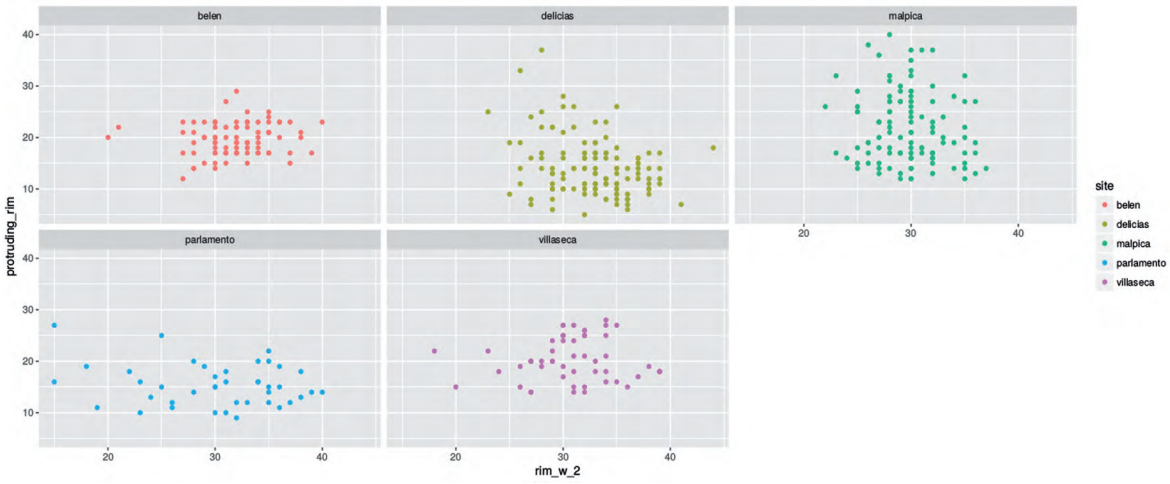


Figura 3. Método exploratorio de selección de dos medidas para calcular la variabilidad entre talleres. El eje Y corresponde a la medida H (protuberancia) y el eje X a la medida G (anchura del borde 2).

3.2. Análisis de Componentes Principales

Nuestra base de datos disponía de una extensa muestra de medidas difícilmente interpretables sin recurrir a la pérdida de información. Como forma de resolver este problema, se utilizó un análisis multivariante denominado Análisis de Componentes Principales. Este análisis permite reducir la dimensionalidad del número de variables creando un número menor de nuevas variables a partir de una serie de combinaciones de las originales[25]. Esto facilita la interpretación de los datos perdiendo el menor número de información posible y así, poder representar en un menor espacio dicha información. De esta manera se crean nuevas variables no correlacionadas entre sí, es decir, sin toda la información que es redundante o repetitiva. En arqueología, el amplio uso de métodos multivariantes se ha enfocado mayormente a la arqueometría[26]. En casos específicos, su utilización se ha relacionado en la detección de diferencias en los patrones de producción a partir de distinciones morfológicas del material arqueológico[27].

En nuestro caso, se hizo necesario reducir la dimensionalidad de la muestra para poder interpretar las diferencias entre los talleres a partir de las 8 mediciones realizadas. Así, se seleccionaron las ánforas Dressel 20 más frecuentes, estudiadas y clasificadas como Dressel 20C, Dressel 20D, Dressel 20E, con un total de 413 muestras. Cada muestra se dividió entre Malpica (55), Cerro de Belén (119), Parlamento (42), Villaseca (53) y Las Delicias (119). Finalmente, el análisis de componentes principales permitió agrupar esta varianza de las mediciones en dos principales componentes (Fig. 4), con un mayor porcentaje en la medida h (protuberancia), mostrada en la Tabla 1.

[25] SHENNAN, 2008: 265-266.
[26] ARNOLD, 2000; BAXTER, 2016.
[27] AGUILERA, 1998; AGUILERA, 1999 ; LI ET AL., 2014.

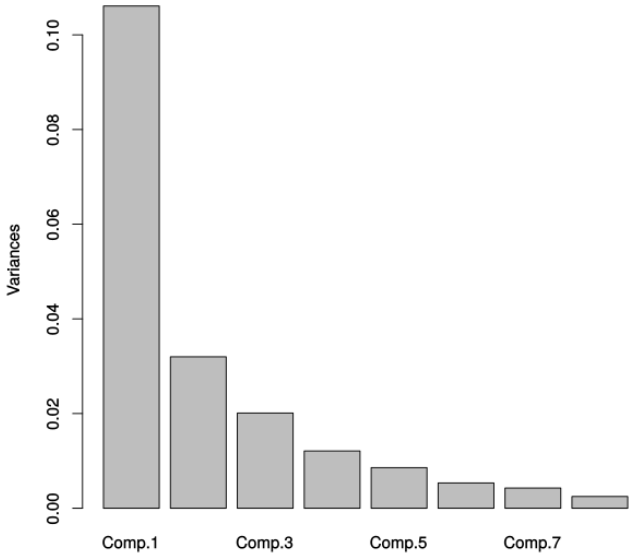


Figura 4. Resultado del Análisis de Componentes Principales donde se agrupó la mayor varianza en los dos primeros componentes.

VARIABLES	C1	C2	C3	C4	C5	C6	C7
Diámetro exterior		-0.194			0.337		-0.337
Diámetro interior				-0.155	0.899		0.309
Altura del borde			0.114	-0.480	-0.114	-0.779	0.355
Anchura del borde		-0.525	-0.104			-0.333	-0.626
Anchura general	-0.101		0.958	0.206	0.138		
Altura del borde interior		0.150	0.183	-0.825		0.405	-0.302
Anchura del borde		-0.805		-0.134	-0.192	0.321	0.422
Protuberancia	**-0.985**		-0.122				

Tabla 1. Resultado de los 8 componentes principales. La mayor variabilidad se concentró en la medida H (protuberancia).

Los resultados obtenidos a partir del análisis de los dos componentes principales fueron visualizados en una gráfica como forma de explorar las diferencias significativas entre talleres que habíamos obtenido previamente (ver Fig. 5). En consecuencia, los talleres anfóricos de Malpica, Cerro de Belén y Villaseca con una distancia espacial menor obtuvieron resultados más similares que el resto de talleres con una diferencia espacial más amplia, como en el caso de Las Delicias y Parlamento.

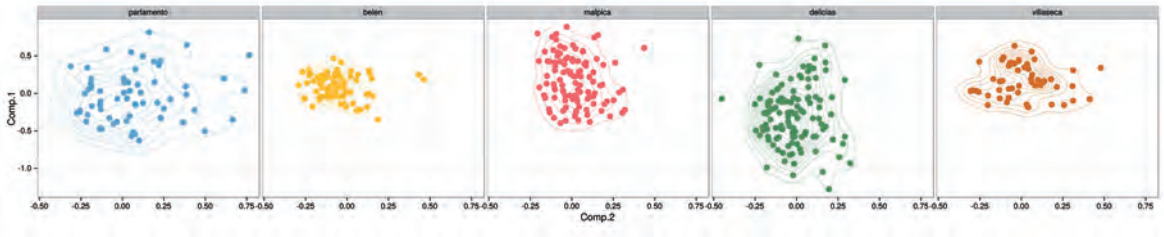


Figura 5. Resultados obtenidos a partir de los dos primeros componentes principales

3.3. Modelando el cambio cultural

A raíz de los resultados obtenidos en el Análisis de Componentes Principales, se propuso diseñar un Modelo basado en Agentes para la exploración del modo de transmisión entre alfareros. Generalmente, este modelo computacional permite simular tanto acciones e interacciones entre individuos (llamados agentes) como forma de observar fenómenos dentro de un entorno abstracto específico[28]. El modelo se basó en las dinámicas evolutivas y en el principio de la deriva aleatoria para testear la difusión de los modos de transmisión. En evolución cultural, la deriva aleatoria corresponde a un proceso de variación cultural que describe los cambios generados aleatoriamente a través del tiempo sin una particular selección[29]. Esta divergencia puede generarse en poblaciones por una serie de causas, siendo más frecuente cuando el número de habitantes se ve reducido por determinados factores. En nuestro caso, se pretende comparar diferentes procesos culturales de transmisión en la producción anfórica y el grado de difusión de este conocimiento sobre otros talleres que se producirían desde un principio de forma aleatoria, basadas en este modelo. En particular, se persigue comprender cómo la producción de ánforas evoluciona y los diferentes procesos de aprendizaje de técnicas de producción bajo circunstancias geográficas o constricciones culturales.

En este modelo todos los agentes (comprendidos como talleres) compartirían la misma producción técnica desde un principio. Cada taller produce una serie de ánforas y podrá intercambiar sus técnicas de producción en base a dos premisas:

- Modificando sus propias técnicas (propiamente transmisión vertical)
- Copiando las técnicas de otro taller (propiamente transmisión horizontal)

Para desarrollar el modelo se utilizaron las medidas que dieron los resultados más significativos en el Análisis de Componentes Principales y los cinco talleres anteriormente estudiados. Se crearon tres modelos de simulación para testear la influencia entre el tipo de transmisión y la distancia geográfica.

Modelo 1

Modelo en el que la transmisión vertical es predominante. La probabilidad de copia aleatoria entre talleres es 0. Esto significaría que no hay presencia de transmisión vertical, por lo que los cambios se producen sin compartir rasgos entre otros talleres resultado de una transmisión vertical.

---

[28] EPSTEIN, 1999.
[29] BENTLEY ET AL., 2004.

Por ejemplo, dos talleres producen ánforas pero no comparten rasgos entre sí porque no existe contacto entre cada uno (Ver Modelo 1 Fig. 6).

Modelo 2

El modelo 2 se define cuando la transmisión horizontal como vertical son predominantes pero con variables externas como la distancia geográfica. Por lo tanto, la probabilidad de copia en este caso es proporcional a la distancia espacial de los talleres. Es decir, los talleres más cercanos compartirían más rasgos en las formas de fabricar ánforas que los más lejanos. Por ejemplo, dos talleres que están próximos producirían ánforas más similares que otros talleres más lejanos. La distancia entre talleres es tomada en cuenta a la hora de diseñar el modelo (Ver Modelo 2 Fig. 6).

Modelo 3

En este modelo la distancia no es determinante. Por lo tanto, la probabilidad de copia es prácticamente igual entre talleres y la transmisión horizontal mayormente predominante. Por ende, todos los talleres de ánforas compartirían los mismos rasgos en la producción de ánforas porque la distancia no es relevante (Ver Modelo 3 Fig. 6).

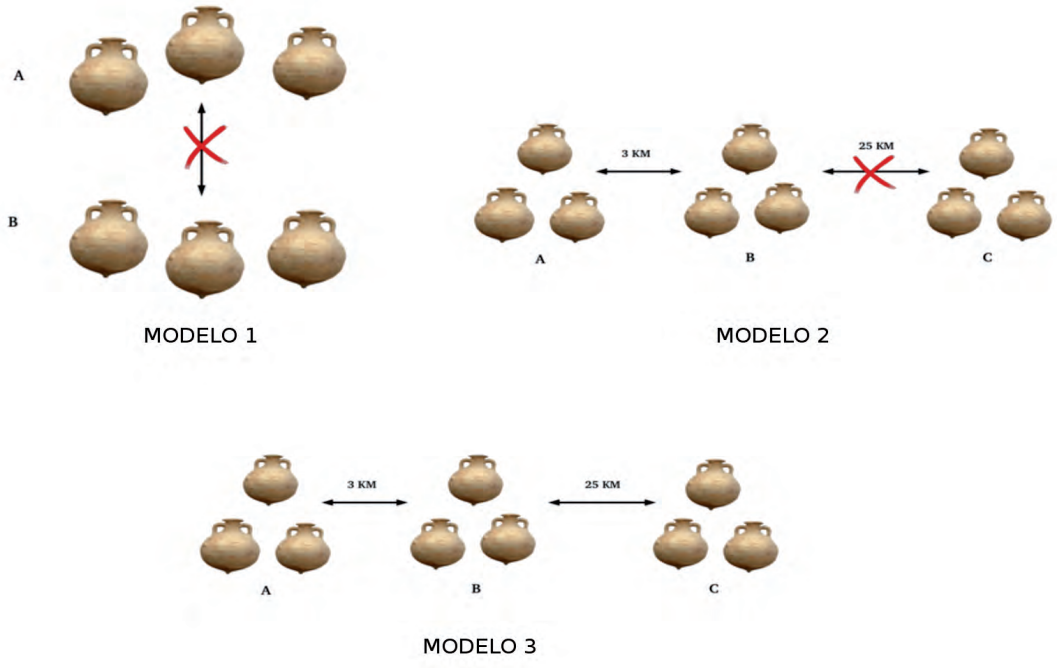


Figura 6. Modelo Basado en Agentes diseñado para testear los diferentes procesos de transmisión cultural. Se describen como Modelo 1 (la probabilidad de copia entre talleres es 0), Modelo 2 (la probabilidad de copia es proporcional a la distancia) y Modelo 3 (igual probabilidad de copia entre talleres)

3.4. Resultados

Para llevar a cabo la simulación, se utilizaron las medidas que habían dado los resultados más significativos en los análisis anteriormente citados: protuberancia interna de la pieza (H) y una de las anchuras de los bordes (D) de cada uno de los cinco talleres estudiados. Por cada medida de cada taller de ánforas fue obtenida la media, siendo el promedio que se halla al dividir la suma de un conjunto de números por la cantidad de números de ese conjunto. Posteriormente, se calculó la media de todas las medias obtenidas por cada taller. Este resultado fue usado para calcular la desviación estándar del total de todas las medias obtenidas por cada taller y cada medida. La desviación estándar permite explicar la variabilidad que existe en relación con cada taller puesto que se pretende conocer si esta variabilidad cambia dependiendo de cada modelo. Con este mismo sistema se hicieron un total de 200 simulaciones con 30.000 timesteps por cada modelo y por cada medida para explicar la relación entre los modos de transmisión y la distancia geográfica. La combinación de valores obtenidos por cada simulación dio como resultado la Figura 7.

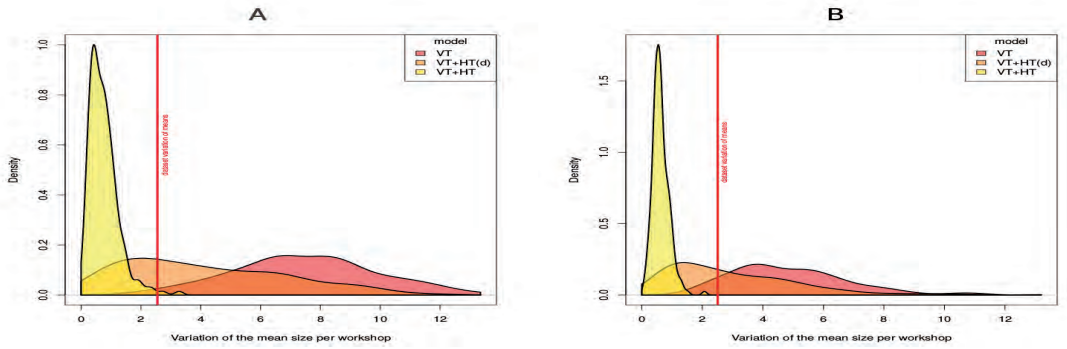


Figura 7. Resultados obtenidos a partir de la simulación correspondiente a los modelos VT (Modelo 1 donde la transmisión vertical predomina en el proceso), VT+HT (d) (Modelo 2 donde la distancia es predominante) y VT+HT (Modelo 3 donde la distancia no es determinante en el proceso y por lo tanto, la transmisión horizontal es predominante). La línea roja corresponde a los resultados de la variación de las medidas de los datos reales. La imagen A corresponde a la medida de la anchura del borde (medida D) mientras que la imagen B corresponde a la medida de la protuberancia de la pieza (medida H).

4. Discusión y conclusión

Tanto el análisis empírico como el modelo basado en agentes identificaron variaciones en los procesos tecnológicos entre talleres anfóricos. Se observó que esta variabilidad en las ánforas podría haber sido afectada por la distancia. El Análisis de Componentes Principales demostró que la similitud entre rasgos tecnológicos decrece cuando la distancia geográfica es mayor entre talleres de producción. Asimismo, la simulación del modelo para este análisis sugirió que cuando existe un predominio de transmisión vertical, es decir, el contacto entre talleres no es frecuente, la variación en los rasgos morfométricos tiende a ser más alta. Esto podría deberse a la falta de contacto entre talleres en los procesos de copia generando un aumento de la divergencia en las técnicas de fabricación. Por el contrario, cuando todos los talleres intercambian conocimientos sin existir ninguna variable que determine alguna diferencia como la distancia, la variabilidad en los rasgos técnicos tiende a ser más baja debido a que todos los talleres intercambian las mismas técnicas y mantienen la misma

producción sin el factor distancia. Por lo tanto, el modelo donde predomina la transmisión horizontal entre alfareros sin el factor distancia no hubiese podido ser el principal motor de transmisión de acuerdo con los resultados obtenidos por la simulación. En cualquier caso, la difusión de las técnicas de producción entre alfareros se ajusta más al modelo donde la distancia geográfica es tenida en cuenta coincidiendo con los resultados obtenidos por el Análisis de Componentes Principales. En general, a pesar de ser considerada una producción casi "estandarizada", los métodos usados en el estudio han observado diferencias entre talleres que podrían estar correlacionadas con la distancia geográfica.

Este proceso podría interpretarse como un predominio en un primer momento del modo de transmisión vertical/oblicuo donde el modelo de aprendizaje sería de maestro alfarero a aprendiz y, en consecuencia, estos conocimientos adquiridos serían transmitidos desde los talleres donde fueron educados. Por el contrario, la variabilidad que existe entre los talleres estudiados dificulta que pueda deducirse como un posible desplazamiento itinerante de alfareros. No obstante, los resultados obtenidos muestran un marco muy general, por lo que dentro de este contexto no se descarta que hubiese una influencia de transmisión horizontal en este proceso. Aún así, parece que el modelo de transmisión no horizontal predominó en un primer momento generando a la larga una progresiva red de alfareros que intercambiarían ideas y se trasladarían a los talleres más cercanos para aplicarlas, como parece demostrar nuestro modelo más plausible.

En cualquier caso, tanto el análisis empírico como la metodología cuantitativa y de simulación basada en agentes han permitido identificar particularidades en la morfología de las ánforas de aceite de oliva a pesar de ser una producción con diferencias poco visibles. En consecuencia, los análisis realizados podrían convertirse en un potente soporte a la arqueología para explorar los procesos de transmisión relacionados con la producción en la cultura material que son imperceptibles al ojo humano.

Bibliografía

AGUILERA, A. (1998), Análisis multivariable: una nueva vía para la caracterización cerámica. Pyrenae, 29:117–134.

AGUILERA, A. (1999), La cronología de las ánforas Dressel 20 a partir del análisis discrimintante. Estudios del Monte Testaccio (Roma): I, Universitat de Barcelona, 345-365.

ARNOLD, D.E. (2000), Does the standardization of ceramic pastes really mean specialization? Journal of archaeological method and theory, 7(4):333–375.

BAXTER, M. (2016), Multivariate analysis of archaeometric data. An introduction. Nottingham.

BENTLEY, R.; HAHN, M.; SHENNAN, S. (2004), Random drift and culture change. Proceedings of the Royal Society of London B: Biological Sciences, 271 (1547), 1443-1450.

BELTRÁN LLORIS, M. (1970), Las ánforas romanas en España. Anejos de Caesaraugusta. Monografías arqueológicas, vol. 8, Zaragoza.

BERNI, P. (1998), Las ánforas de aceite de la Bética y su presencia en la Cataluña romana. Col·lecció Instrumenta, vol. 4. Publicacions i Edicions UB, Barcelona.

BERNI, P. (2008), Epigrafía anfórica de la Bética. Nuevas formas de análisis. Barcelona: Colecciò Instrumenta, vol 29. Publicacions i Edicions UB, Barcelona.

BERNI, P. & GARCÍA VARGAS, E. (2016), «Dressel 20 (Guadalquivir Valley)», Amphorae ex Hispania. Landscapes of production and consumption
(http://amphorae.icac.cat/amphora/dressel-20-guadalquivir-valley)

BERNI, P. (2017), "Chapter 8. Amphorae-Epigraphy: Stamps, Graffiti and Tituli Picti from Roman

Nijmegen". Amphorae from the Kops Plateau (Nijmegen): trade and supply to the Lower-Rhineland from the Augustan period to AD 69/70. Archaeopress Roman Archaeology, 20. Oxford: 185-282, 289-343.
BEVAN, A. (2014), Mediterranean Containerization. Current Anthropology 55, 387–418.
BOWSER B. J. and PATTON, J. Q. (2008). Learning and Transmission of Pottery Style. Women's Life Histories and Communities of Practice in the Ecuadorian Amazon. In Cultural transmission and material culture: Breaking down boundaries, page 105–129. The University of Arizona Press.
CAVALLI-SFORZA, L. & L.; FELDMAN, M.W. (1981), Cultural transmission and evolution: a quantitative approach. Princeton University Press.
CHIC GARCÍA, G. (2005), El comercio de la Bética Altoimperial. Habis, 36. 313-332.
CHIC GARCÍA, G. (2010-2011), El aceite y el vino de la Bética entre el prestigio y mercado. AnMurcia, 25-26, 279-295.
DEL CASTILLO BERNAL, M. F. (2011). Modelización Basada en Agentes aplicada a sociedades cazadoras recolectoras patagónicas. Estrat crític: revista d'arqueologia, 5(1), 401-409.
DIAZ TRUJILLO, O. (1992), Excavación arqueológica de urgencia en el Cerro de Belén: Palma del Río, Córdoba, en Anuario Arqueológico de Andalucía. Junta de Andalucía, Consejería de Cultura, 121-129.
DRESSEL, H. (1878), Ricerche sul Monte Testaccio, Annali dell'Instituto di Corrispondenza Archeologica, vol. 50, 118-192.
EERKENS, J.W.; BETTINGER, R.L. (2001) Techniques for assessing standardization in artifact assemblages: Can we scale material variability?. American Antiquity, 66, n. 3, 493-504.
EPSTEIN, S. R. (1998), Craft guilds, apprenticeship, and technological change in preindustrial Europe. Journal of economic history, 58, 684-713.
EPSTEIN, J.M. (1999), Agent-Based Computational Models and Generative Social Science. Complexity 4, 41-60.
FERNÁNDEZ, P.S., MUÑOZ, J.T., GARCÍA VARGAS, E., GARCÍA DILS, S., (2001), Excavación arqueológica de urgencia en el alfar romano de las Delicias (Écija, Sevilla), en Anuario Arqueológico de Andalucía 1997. Junta de Andalucía, Consejería de Cultura, 562–575.
GARCÍA VARGAS, E., (2000), Ánforas romanas producidas en Hispalis: primeras evidencias arqueológicas. Habis 31, 235–260.
GARCÍA VARGAS, E. (2010), Formal Romanisation and the Atlantic Projection of Amphorae from the Guadalquivir Valley. In The Western Roman Atlantic Façade: A study of the economy and trade in the Mar Exterior from the Republic to the Principate, number 2162 in BAR International Series, page 55-66. Oxford, England, archaeopress edition.
GARCÍA VARGAS, E., MORENA, J.A. (en prensa), La excavación del alfar de ánforas Dr. 20 de Villaseca (Córdoba). Casa de Velázquez, Madrid.
LI, X.J., BEVAN, A., MARTINON-TORRES, M., REHREN, T., CAO, W., XIA, Y., and ZHAO, K. (2014). Crossbows and imperial craft organisation: the bronze triggers of China's Terracotta Army. Antiquity, 88(339): 126–140.
MARTIN-KILCHER, S (1987), Die römischen Amphoren aus Augst und Kaiseraugst. Ein Beitrag zur römischen Handels- und Kulturgeschichte, 1. Die südspanischen Ölamphoren (Gruppe 1). Forschungen in Augst , vol. 7/1, Augst.
MATTINGLY, D. J. (1988), Oil for export? A comparison of Libyan, Spanish and Tunisian olive oil production in the Roman empire. Journal of Roman Archaeology, 1, 33-56.
MAUNÉ, S., GARCIA VARGAS, E., BOURGEON, O., CORBEEL, S., CARRATO, C., GARCIA DILS, S., BIGOT, F., VAZQUEZ PAZ, J., 2014, L'atelier d'amphores à huile Dr. 20 de las Delicias à Écija (prov. de Séville, Espagne), pp. 419–444.
MESOUDI, A. (2015), Cultural Evolution: A review of Theory, Finding and Controversies,

Evolutionary biology, 1-17.
REMESAL, J. (1977), La economía oleícola bética: nuevas formas de análisis. *Archivo Español de Arqueología*, 50(135):87–144.
REMESAL, J. (1986), La *annona militaris* y el comercio de aceite bético a *Germania*. Madrid.
REMESAL, J. (1998), Baetica olive oil and the Roman Economy, The archaeology of Early Roman Baetica, 29, 183-200.
REMESAL, J. (2011), La bética en el concierto del Imperio Romano. Real Academia de la Historia. Madrid.
REMESAL, J. (2016), Sellar, ¿para qué? El sistema de comunicación en los sellos de las ánforas Dressel 20. Antichitá AltoAdriatiche, vol. 83, 73-90.
SHENNAN, S. (2008), Quantifying archaeology. Edinburgh University Press.
SHENNAN, S.J., CREMA, E.R., and KERIG, T. (2015). Isolation-by-distance, homophily, and "core" vs."package" cultural evolution models in Neolithic Europe. Evolution and Human Behavior, 36(2):103–109.
TEMIN, P. (2013), The economy of the Early Roman Empire, The Journal of Economic Perspectives, 20 (1), 133-151.

The *porticus* bears all the grain: an update of the area of the Porticus Minuciae (Rome), between archaeology and social history

Andrea Guaglianone
Università di Venezia "Ca' Foscari"

1. Introduction

The following work is a preliminary report about my PhD project concerning the topography of roman public wheat distributions. A project with the ambitious goal of bringing new light to the original aspect and function of the only certain *porticus Minucia* known until now, recognisable with the remains located around via delle Botteghe Oscure in Rome. Rivers of ink have been spilled about this topic and particularly about the identification of the name of the *porticus* after the discovery of its central temple in 1937, during the works for the widening of the old via delle Botteghe Oscure.[1] It was previously identified as the temple of Bellona *in Circo* and only after Guglielmo Gatti's correct identification of the Crypta Balbi and Lucos Cozza's work about the Marble Plan of Rome it was clear that it could be the temple of one of the *porticus Minuciae*.

2. The porticus Minuciae within the historical sources

Going in order, the names of both the builder and the building come from a passage of Velleius Paterculus (II, 8, 3) who talks about one or more *porticus Minucia* built by Marcus Minucius

[1] Cf. SANTANGELI VALENZANI 1995, pp. 89-92.

Rufus at the end of the II century BC.[2] It was probably the place where, interpreting a passage of Cicero, Antonius and probably other officials, set up their tribunals.[3]

For the imperial age, the earliest indication comes from an inscription of an imperial freedman, who lived under the rule of Claudius, who was registered to the 14th day and the 42nd *ostium* of the *Minucia.*[4] It shows that a distribution system divided per days and counters (*ostia*) already existed during the reign of Claudius and that it took place at the *porticus Minucia*.[5] A link between the *porticus Minucia* and the distributions of grain is confirmed by a later passage of Lucius Apuleius' *De mundo* (35): *... et alius ad Minuciam frumentatum venit…* In the III century AD, we find a *Minucia* in a passage of the *Historia Augusta,* talking about a bad auspice that occurred at the end of Commodus' reign and using, for the first time, the spelling *Minicia* instead of *Minucia*.[6]

In the calendars it occurs twice: the *Fasti praenestini* (6-10 AD), for December 22nd, report the celebration of the *Laribus Permarinis in porticu Minucia*[7]*,* and in the calendar of Philocalus (354 AD), under June 4th, where we find a *Ludi in Minicia.*[8] The indication, within the *Fasti Praenestini*, of the *Laribus Permarinis in portico Minucia* celebrations, indicates that the temple of these deities, vowed by M. Emilius Regillus in 190 BC and dedicated by M. Emilius Lepidus in 179, were perhaps later enclosed by the first *porticus Minucia*.[9]

In 354 AD the Chronograph mentions, for the first time, the *porticus Minucia vetus* making a list of buildings built or restored by Domitian after the blaze that hit the City in 80 AD.[10] Inside the same *corpus*, the Regionaries place two *porticus Minuciae* in the IX Region of the City: a *vetus* one and a *frumentaria* one, listed together between the *Porticus Philippi* and the *Crypta Balbi*.[11]

To recap, since the time of Claudius there is proof that the distribution of grain to the populace took place in a *porticus Minucia*, presumably a triumphal portico built by Marcus Minucius Rufus at the end of the II century BC or, perhaps, in a new portico built during the reign of Claudius and called *frumentaria*.[12] This latter, together with the circa 21 inscriptions of the *plebs frumentaria* still

---

[2] Vell. Pat. II, 8, 3: *Per eadem tempora clarus eius Minucii, qui porticus, quae hodieque celebres sunt, molitus est, ex Scordiscis triumphus fuit.* M. Minucius Rufus was consul in 110 BC and triumphed in 106 BC. F. Zevi (1993, p. 663) supposes that the triumph gave the opportunity to make the *porticus* as triumphal portico. Cf. also COARELLI 1997, pp. 296-297.

[3] Cic. *Phil*., II, 84: *Quidlibet, modo ne nauseet, faciat, quod in porticu Minucia fecit.* Cf. NICOLET 1976, pp. 48-50.

[4] *CIL* VI, 10223 = *ILS* 6071: *Ti. Claudius Aug. lib. |Ianuarius, curator | de Minucia die XIIII| ostio XLII, et| Avonia Tyche uxor eius| Pituaniani solaria de sua impensa… fecerunt.* Cf. VAN BERCHEM 1939, pp. 37-38; VIRLOUVET 1995, pp. 131, 236-241; 2009, pp. 61-64, 208-212; ZEVI 1993, p. 665. For an overview about the *frumentationes* and the problem of the *Minuciae* see CARDINALI 1906; VIRLOUVET 1987, 1995, 2009; NICOLET 1976.

[5] About the relationship between the *gens Minucia* and the *frumentationes* cf., among others, COARELLI 1997, pp. 300-302.

[6] *Commod.,* 16: *Herculis signum aeneum per plures dies sudavit in Minicia.*

[7] *CIL* I², p. 238: *[D XI C(omitialis) Laribus Perm]arinis in porti[cu Mi]nuci[a].* Cf. DEGRASSI 1963, p. 465.

[8] *CIL* I², p. 266: *III (nonas Iunias) senatus legitimus pridie (nonas Iunias) Ludi in Minicia.* Cf. DEGRASSI 1963, p. 543.

[9] Macrob. *Saturn.*, I, 10, 10: *Undecimo autem kalendas (Ianuarias) feriae sunt Laribus dedicatae, quibus aedem bello Antiochi Aemilius Regillus praetor in campo Martio curandam vovit.* Liv. XL, 52, 4-5: *Idem* (M. Aemilius Lepidus) *dedicavit aedem Larum Permarinum in Campo. Voverat eam annis undecim ante L. Aemilius Regillus navali proelio adversus praefectos regis Antiochi. Supra valvas templi tabula cum titulo hoc fixa est.* Cf. DEGRASSI 1963, p. 543; ZEVI 1993, p. 664; 2007, pp. 369-382; COARELLI 1997, pp. 258-268.

[10] Chron.: *Hoc imperante multae operae publicae fabricatae sunt:* (…) *Divorum, Iseum et Serapeum, Minervam Chalcidicam, Odium, Minuciam veterem, Stadium* (…). (VALENTINI-ZUCCHETTI 1940, pp. 121-132). In the Suetonius' passage about the same episode (*Dom.*, 5) the building is not mentioned.

[11] *Curiosum: ...Porticum Philippi, Minuciam Veterem et Frumentariam, Cryptam Balbi…; Notitia: ...Porticum Philippi, Minucias II (duas), veterem et frumentariam, cryptam Balbi...* (VALENTINI-ZUCCHETTI 1940, pp. 121-132).

[12] This thesis is accepted by F. Zevi (1993, p. 666).

surviving[13], the late ascription of *frumentatio* to Servius Tullius mentioned in the Chronograph[14] and a lead tessera with *Minucia* on the reverse side,[15] show that the *porticus Minucia* was divided into 45 *ostia* or sections, in which definite groups of people received their rations of grain in definite days in the month. In the first four centuries of the imperial age, the *porticus Minucia* seems to be mentioned always alone and in the singular and only in the IV century AD the sources distinguish between a *Minucia vetus* and a newer *Minucia frumentaria* mentioned only by the Regionaries. The relationship between the *vetus* and the *frumentaria* is very uncertain, whether they were separate buildings, or parts of one; and when the second building or part was erected.

3. Locating the porticus Minuciae, a debate 170 year long

3.1. Before 1960s

The most important (and famous) theses about the localization of these *porticus* before the Carettoni, Cozza and Gatti's works, had been summarized by Ferdinando Castagnoli in his brilliant article on the Campus Martius, edited in 1947:[16]

1) The porticoes nearby the Forum Olitorium (CANINA 1848, pp. 313-314);
2) In the area of piazza Montanara, between the Octavia's porticoes and the Capitol Hill (PELLEGRINI 1879, pp. 257-258; LANCIANI 1897, p. 511; 1917, p. 187; DELBRUECK 1903, p. 1; LUGLI 1930, p. 332); According to this theory the *porticus* lay between the foot of the Capitol Hill and the theatre of Marcellus, thus identifying the two buildings with ruins on the east side of the Piazza Montanara and in the Vicolo della Bufala.
3) The building in via di S. Maria dei Calderari (*M. vetus*: JORDAN–HÜLSEN 1907, I, pp. 547; *M. frumentaria:* HÜLSEN 1927, p. 94). Here, along the street, two travertine pilasters with engraved columns and the entablature are built into the front of the house, and there are traces of a second row of columns and a wall behind. Drawings of the sixteenth century show that this colonnade had an upper storey, with columns standing on the centre of the arches below, and there are also blocks of travertine pavement.[17] Hülsen is further inclined to derive the name of S. Maria de Publico (so called in a bull of 1186 and generally till the end of the fifteenth century), now known as S. Maria in Publicolis, from the *frumentum publicum* distributed here.[18]
4) In the ghetto area, between the building in via di S. Maria dei Calderari and the Tiber (JORDAN–HÜLSEN 1907, I, pp. 548);
5) In the area of via delle Botteghe Oscure, between via dei Ginnasi and the church of the Gesù (GILBERT 1883-90, III, p. 253);
6) Area of Largo Argentina (*M. vetus*: HÜLSEN-KIEPERT 1912, t. II; WIJKSTRÖM 1932, p. 30; both of them: WALL 1932, p. 52; VAN BERCHEM 1939, p. 82);

---

[13] The inscriptions, dating from the first to the third century AD, have been collected and studied by C. Virlouvet (2009).
[14] Chron., p. 144: *hic votum fecit ut quotquot annos regnasset tot ostia ad frumentum publicum constitueret.* It is an anachronism because it's impossible to refer the *ostia* of the *porticus Minucia* to the royal period, several centuries before its building (cf. CARDINALI 1906, p. 226).
[15] Rostowzew, Sylloge No. 336; Klio, Suppl. III.2122.
[16] CASTAGNOLI 1947, pp. 175-180.
[17] The drawings are made by B. Peruzzi (Uffizi, arch. 484r) and A. da Sangallo il Giovane (Uffizi, arch. 1138r and 1138v). Cf. TUCCI 1994-95, ff. 1-2.
[18] HÜLSEN 1927, pp. 94100.

It seems to be clear that there were many divergent opinions about the site of the porticoes. The prevailing view asserts that were two separate buildings, near the *porticus Philippi* and the theatre of Balbus, one of which, the *vetus*, enclosed the temple of Lares Permarini and perhaps that of Hercules Custos, and therefore was situated north of the Circus Flaminius and east of the *porticus Pompei*, on both sides of the Petronia stream.

3.2. After 1960s

A new chapter of the history of the studies about the topic of the *Minuciae* was opened in 1960, when the magnificient work on the Marble Plan of Rome was edited, by G. Carettoni, A.M. Colini, L. Cozza and G. Gatti.[19] This, with the correct localization of both the Crypta Balbi and the Circus Flaminius, has permitted to identify within the Plan two fragments (at least) representing the plan of the temple found in via delle Botteghe Oscure and the S.E. corner of its portico (fig. 1).[20]

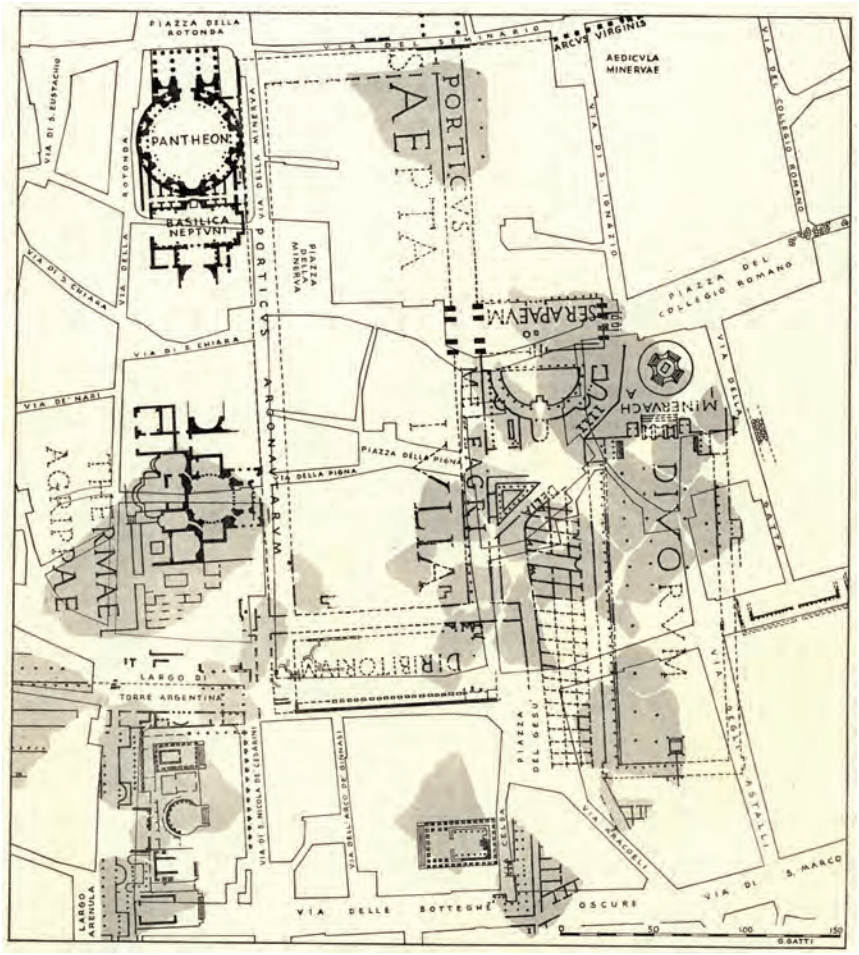


Figure 1. The fragments of the Marble Plan depicting the area arranged on the modern plan of the city (from CARETTONI ET ALII 1960, t. XXXI).

[19] CARETTONI *ET ALII* 1960.
[20] Cf. G. Gatti in CARETTONI *ET ALII* 1960, p. 101.

After that, in 1968, L. Cozza placed another fragment under the temple's plan with the inscription MINI[…] constituting, in the author's opinion, the word MINI[CIA].[21] In the same work Cozza produced an archaeological map of the area, the first one in the history of the study of this building, where he located all the information about the 1937-1941 excavations found by him with the help of G. Gatti. L. Cozza thought that the fragments depicted the *porticus Minucia vetus* with its temple of *Lares permarini*, a theory later followed also by F. Castagnoli, G. Rickman and L. Richardson.[22] In the same year, F. Coarelli presented another hypothesis: the *porticus Minucia vetus* should be identified with a triportico surrounding the Area Sacra of Largo Argentina and the portico in via delle Botteghe Oscure should be the *frumentaria*, a domitian widening of the former portico.[23] Consequently the author identified the temple of the *Lares permarini* with the temple D of the Area Sacra and C. Nicolet, in 1976, agreed to this hypothesis identifying the temple of via delle Botteghe Oscure with the temple of the Nymphs, that seems to had been the archive of the *recensiones* of the beneficiaries of *frumentationes*.[24]

Thanks to the archaeological investigations, conducted in 1983 by D. Manacorda and E. Zanini, in nine cellars of the buildings belonging to the Crypta Balbi Museum, on the south side of via delle Botteghe Oscure, it was finally clear the bimillennial stratification of this area of the Campus Martius.[25] The excavations unfortunately didn't reach the archaeological levels corresponding to the Republican period (where the Republican *porticus Minucia* should be) and the most ancient levels reached correspond, in a very limited area of the site, only with the final Republican and the early Augustan age. Underneath the pavement of the modern cellars, the excavators found a massive wall with a foundation in a conglomerate of travertine chips, a first course of travertine blocks and a second of peperino blocks. The wall delimited a pavement consisting of a layer of mortar mixed with marble and travertine chips and the whole structures can be dated to the Domitianic period or to the middle of the II centuy AD (fig. 7, 19).[26] According to the excavation data, the authors referred the structures as the *porticus Minucia frumentaria* built by Domitian, and then completed by Trajan, as a widening of the ancient *porticus Minucia*, identified with the Area Sacra of Largo Argentina, following the above-mentioned hypothesis of F. Coarelli and C. Nicolet.[27]

In 1993, in his first essay about the topic, F. Zevi identified the oriental portico of the Area Sacra with the fourth side of the *porticus* of via delle Botteghe Oscure that should be, according to his new interpretation of the archaeological data of the Manacorda-Zanini excavations, the *porticus Minucia vetus*.[28] The author, identified the *frumentaria* as the building in via S. Maria dei Calderari, in the area of the Circus Flaminius where, according to a passage of Ovid, perhaps there was a temple of *Hercules Custos*.[29] The identification could be validated by the link between a *Minucia* and the

---

[21] COZZA 1968, pp. 9-20.

[22] CASTAGNOLI 1984, pp. 520-526; RICKMAN 1983, pp. 105-108; RICHARDSON 1992, pp. 315-316. About the non-axial position of the temple compared to the portico cf. COARELLI 1997, p. 222.

[23] COARELLI 1968, pp. 365-375.

[24] NICOLET 1976, pp. 37-44. Cf. ZIOLKOWSKI 1992, pp. 120-122; Cf. *LTVR*, *s.v. Nymphae, aedes,* pp. 350-351; COARELLI 1997, pp. 223, 263-268.

[25] MANACORDA-ZANINI 1989, pp. 25-32. Unfortunately, most of these exacavations are still unpublished. Bibliography about some preliminary reports is available in MANACORDA 2017, p. 55, n. 2.

[26] MANACORDA-ZANINI 1989, Period IV, pp. 27-28. Part of this pavement is now published in MANACORDA 2017.

[27] MANACORDA-ZANINI 1989, p. 28.

[28] ZEVI 1993, pp. 672-676, 692.

[29] *Fasti*, VI, 209: *Altera pars Circi Custode sub Hercole tuta est*. The passage is under the day 4th June, the same day of the *Ludi in Minicia* within the above-mentioned *Fasti* of Philocalus. Cf. ZEVI 1993, pp. 681-683. See also ZEVI 1994, pp. 1073-1076; 2007, pp. 369-382. Cf. *contra* COARELLI 1997, p. 307.

god, remembered in the historical sources and a lead tessera depicting a standing Hercules holding a club and a *skyphos* and, on the reverse side, the word MINUCIAE.[30]

In 1997, an essay of D. Manacorda and E. Zanini, finally puts in order the data from all the excavations carried on in the area. The results are summarized in an archaeological map divided in two phases (Republican and Imperial age) that is basically an update of the Cozza's 1968 map.[31] In this work the authors have interpreted the remains of the *porticus* in via delle Botteghe Oscure with the *porticus Minucia frumentaria*, with its temple dedicated to the Nymphs, and put the *Minucia vetus* in the Area Sacra of Largo Argentina, following again the hypothesis of F. Coarelli and C. Nicolet.[32]

4. The *Porticus Minuciae* today, making a new and updated archaeological map

The archaeological map of the area has been left unaltered from the last systematic work of D. Manacorda and E. Zanini (1997). During my PhD research, a new examination of the all archive documentation has permitted to me to implement the information about the discoveries made in the area during the XX century. In particular, many important "new" pieces of information came from the unpublished excavation journals of Giuseppe Marchetti Longhi (non-edited notes, drawings, tracings and photos of the years 1928-1937), that allow for both the reconstruction and the dating of the phases of the building under via di S. Nicola de' Cesarini, discovered during the excavations of the Area Sacra at Largo Argentina.[33] A careful analysis of the archival material of the adjacent excavations of Guglielmo Gatti and Antonio Maria Colini (done on 1937-1941)[34] has also permitted to put on plan all the discoveries made by the archaeologists, relating them with the previous excavations done by Rodolfo Lanciani at the end of the XIX century[35] and the following – and above-mentioned – investigations conducted by Daniele Manacorda and Enrico Zanini above the temple of via delle Botteghe Oscure and at the Crypta Balbi. In the following pages I will divide the most interesting

---

[30] ZEVI 1993, n. 35, pp. 680-681.

[31] MANACORDA-ZANINI 1997, ff. 19-20, pp. 263, 265.

[32] MANACORDA-ZANINI 1997, pp. 249-293; MANACORDA 1996, pp. 350-351. For the connections between Nymphs, *Charites* and Graces with the distribution of free (*gratuitus*) grain in the ancient world see also MANACORDA-ZANINI 1997, pp. 270-272; MANACORDA 2012a, pp. 27-30; 2012b, pp. 463-476; 2013, pp. 9-14.

[33] For the history of the archaeology in Rome between the end of the XIX century and the half of the XX century see the essay of R. Santangeli Valenzani (2008, pp. 55-67). In particular, for the discover of Largo Argentina see MESSA 1995, pp. 77-83; MANCIOLI 1995, pp. 85-88 and GALLUPPI 2007, pp. 291-327, with a precious bibliography with all the publications of G. Marchetti Longhi. After his retirement, G. Marchetti Longhi organized all his own unpublished journals and papers in 21 folds which delivered to the archive of the Municipality of Rome, nowadays kept by the Sovrintendenza Capitolina. There I was able to consult them, thanks to the assistance of Monica Ceci, who is currently studying the Journals. The documentation consists of a collection of all his handwritten journals of the excavations, and of an undetermined number of photos taken during the excavations and often depicting remains that today do not exist anymore. These pages are often hardly legible, with a lot of messy or inaccurate indications, with missing pages and even wrong years. But, in spite of everything, even now they are a treasure trove of information.

[34] For the history of the discoveries made during the widening of the old via delle Botteghe Oscure see, in addition to the above-mentioned works of D. Manacorda and E. Zanini, SANTANGELI VALENZANI 1995, pp. 89-92. The unpublished papers of G. Gatti are kept by the Central State Archive in Rome ("Carte Gatti", *CG* doc. nn. 3449-3527; 3860-3881). The notes of A. Maria Colini about the excavation of the temple in via delle Botteghe Oscure are kept by the Sovrintendenza Capitolina and are partially published in COLINI 1937-38. Additional information come from the *Registri dei Trovamenti* (mentioned as *RT* in the following pages) and the *Registri di Zona* (*RZ*) that are registers of all the discoveries, excavations and restorations made from the end of the XIX century to the 1950s and kept by the Sovrintendenza Capitolina (*SBACAS*).

[35] I'm talking about the exacavations for the sewage pipe of Corso Vittorio Eamnuele II, on the north side of the *porticus* of via delle Botteghe Oscure. The discoveries are noted down on the Lanciani's Manuscripts kept by the Vatican Library (*Cod. Vat. Lat.* 13039 and 13040) and on the manuscript n. 22, kept by the Library of the Istituto di Storia dell'Arte e Archeologia in Rome. Lanciani placed the structures on its *Forma Urbis Romae* (t. XXI) and published them in some articles analysed, toghether with all the documentation, by M.P. Muzzioli (1995, pp. 139-168).

discoveries in two generic phases (republican and imperial phases) as done by D. Manacorda and E. Zanini in their work about the temple of via delle Botteghe Oscure (1997), trying to continue the debate using the same method.

4.1. Republican period (fig. 2)

This period, identified only in limited points of the area, consists of the archaeological evidence lying approximately beneath the altitude of 11,80 meters above sea level, coinciding with the imperial general ground level of the whole area that raised all the republican structures (excepted the temples, of course).[36]

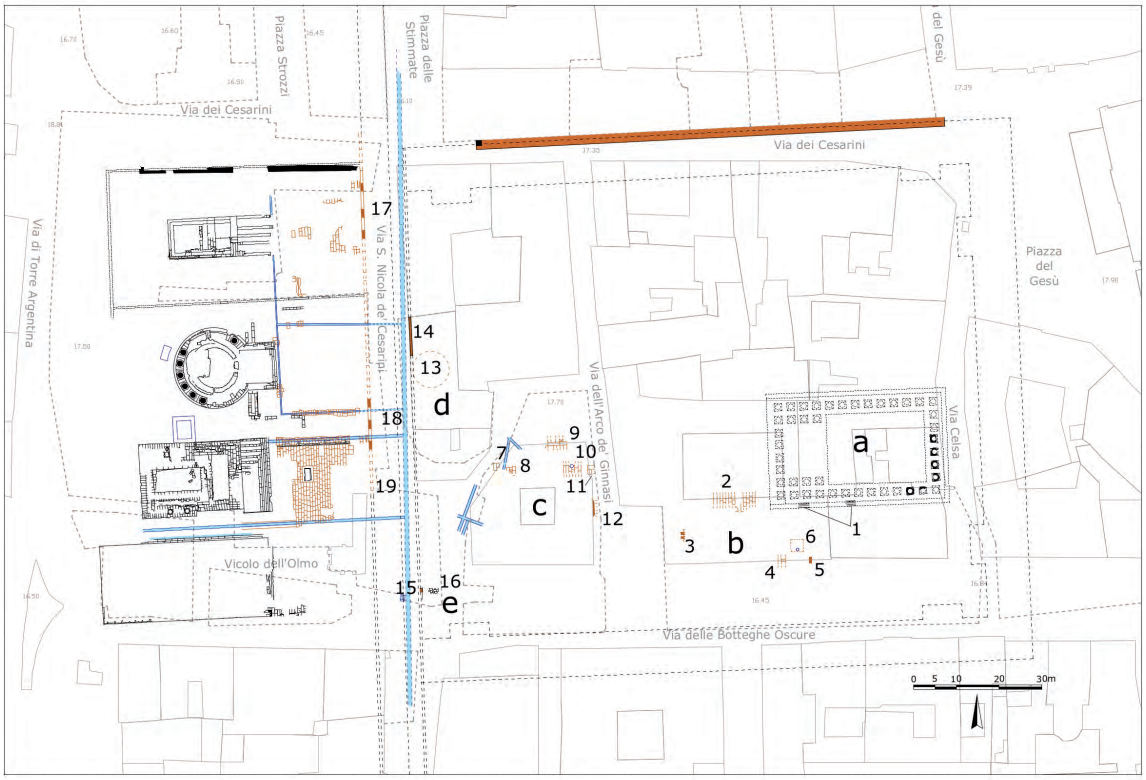


Figure 2. Archaeological map of the area: Republican phase (drawing by the author).

4.1.1 The temple of via delle Botteghe Oscure (fig. 2, a)

In this first phase, the temple of via delle Botteghe Oscure seems to have a crepidoma all over the podium, consisting in three travertine steps with a logline laying at its bottom and probably belonging to the end of the II century BC (fig., 2: 1).[37] The actual cladding of the podium belongs

[36] This period coincides with the "Period I" of MANACORDA-ZANINI 1989, pp. 25-26. Cf. the map in MANACORDA-ZANINI 1997, f. 20, p. 265.

[37] The bottom altitude of the steps is 10,70 meters a.s.l., the top altitude on the last one step is 11,55 m a.s.l. Altitudes from MANACORDA-ZANINI 1997, p. 251. For the dating cf. MANACORDA-ZANINI 1997, p. 281. The first phase of the podium cannot be dated before the second half of the II century BC because of the use of the *opus caementicium* seen by A.M. during the excavations (COLINI 1937-38, p. 261).

to the imperial age, so we are not able to know how the republican podium was. Only the columns, with their travertine Corinthian bases and tambours in peperino stone, are often interpreted as a rebuilding belonging to the second half of the II century BC.[38] The temple is an octastyle peripteral with 8 per 12 columns and it is oriented to the west, like that depicted on the 35ee fragment of the Marble Plan (fig. 1).

4.1.2 The porticus *of via delle Botteghe Oscure*

The republican sistemation of the open space surrounding the temple is actually known only through the archive documentation of the excavations done for the foundations of the new buildings built after the demolition of the former buildings in the north side of via delle Botteghe Oscure, between 1937 and 1941. Beginning by the nearest building site to the temple, in the site of the building for the "Maestre Pie Filippini" (fig. 2, b), between January and March 1938 G. Gatti found some tuff slabs 20-30 cm high, attributable to a first paving of a square (fig. 2: 2-4). Thanks to an unpublished plan depicting the site drawn by G. Gatti, that I've recently found at the Prints & Photographs Archive of the Museum of Rome, it's now possible to place in the right way all the remains seen by the archaeologist (fig. 3).[39]

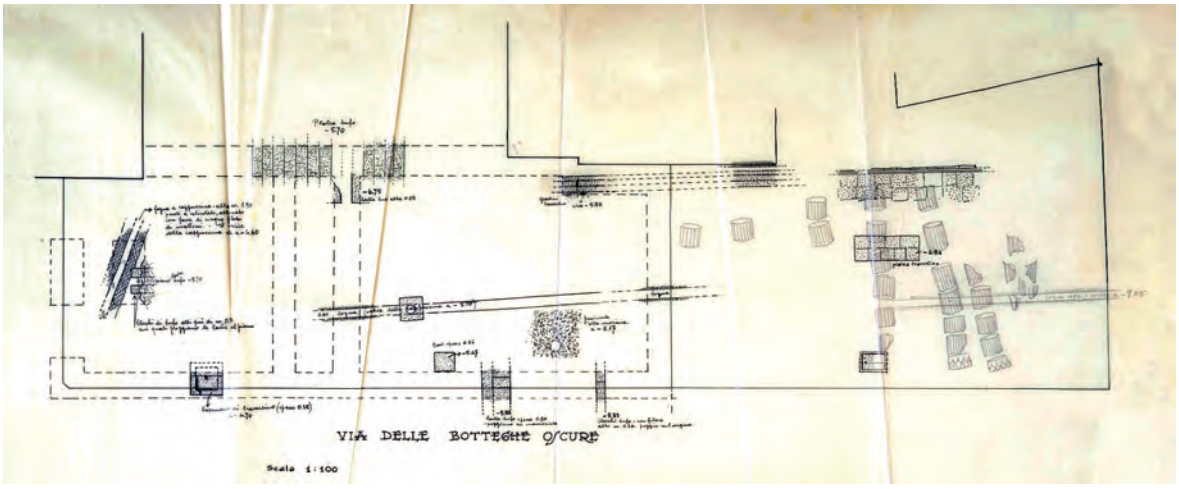


Figure 3. Plan of the "Maestre Pie Filippini" and "Lamaro Carbone" building sites. Unpublished drawing by G. Gatti. © Prints & Photographs Archive of the Museum of Rome (doc. MR 42345).

The plan depicts the building sites "Lamaro Carbone" on the right and "Maestre Pie Filippini" on the left, in a 1:100 scale, reporting remains that also G. Gatti himself omitted in his partial map of the area.[40] Thanks to the indication of the heights of the findings we can see that all the tuff slabs were found between 5,70 and 5,83 meters under the level of the street, corresponding to 10,75/10,62 meters above the sea level. The archaeologist also found a short section of a wall made by one row of tuff ashlars 50 cm high at the same altitude of the slabs (fig. 2: 5), probably the remains of a

[38] MANACORDA-ZANINI 1997, p. 281. The top altitude of the podium is 13,90 m a.s.l.

[39] 1): *CG* 3463, (5/01/1938). 2): *RT* XI, p. 78 (19-II-1938) = *RZ* 32, p. 12, 19/02/38; *RT* XI, p. 78 (21-II-1938) = *RZ* 32, p. 13, 21/02/38; *RZ* 32, p. 13, 23/02/38; *RZ* 32, p. 15, 26/02/38. 3): *CG* 3467: (4/03/1938); *RT* XI, p. 81 (4-III-1938) = *RZ* 32, p. 18, 4/03/38. 4): *CG* 3463: (5/01/1938); *RT* XI, p. 72 (3-I-1938) = *RZ* 32, p. 1, 3/01/38. 5): *CG* 3463: (5/01/1938). 6): *CG* 3466: (2/02/1938); *RT* XI, p. 75 (30-I-1938) = *RZ* 32, p. 7, 30/01/38; *RZ* 32, p. 7, 2/02/38. The plan of the building site is inventoried with the id. MR 42345 within the Antonio Muñoz Collection. I want to thank the curator of the collection, Donatella Germanò, for her courtesy.

[40] GATTI 1979, f. 10.

structure. Nearby we can see a cocciopesto pavement with a hole (fig. 2: 6). Its limits unfortunately hadn't been investigated and its altitude was 10,28 m a.s.l., circa 40 cm beneath the slabs. I think that the structure can be interpreted as a probable ritual basin and not with the ruins of a pre-existing residential building, considering that it was in proximity of the temple and that under the nearby row of ashlars Gatti found a level of "virgin" earth.[41]

The second building site where republican remains were found, is the site for the construction of the Ginnasi Palace (fig. 2: c). There G. Gatti found other slabs belonging to the republican level of the area (fig. 2, 7-11), 20/30 cm high and laying at an altitude of 10,20/10,50 meters a.s.l., of which two of them (fig. 2: 7) were found covered by cocciopesto.[42] On the east side of the site the archaeologist found another wall made by tuff ashlars (fig. 2: 12), 50/60 cm beneath the slabs, maybe the remains of a pre-existent structure in *opus quadratum*.[43]

The last tuff slabs of the area come from another two building sites in via di S. Nicola de' Cesarini. The first one, done for the realization of the Condominio Argentina Palace (fig. 2: d), revealed the presence of 8 square meters of the tuff paving, 6 meters under the street level (10,80 meters a.s.l. circa, fig. 2: 13). All the surveys depicting the structures found in this site, unfortunately, are currently lost so, at the moment, it's impossible to fix the right position of the slabs found.[44] In the same building site, precisely on its west side, a wall was found with a complicated vertical stratification (fig. 2: 14) with a section in tuff ashlars lying in a linear foundation made by tuff chips at 9,87 m a.sl.[45] A southern portion of this wall was probably seen by G. Gatti in 1941 during the works for the new sewage pipe of via delle Botteghe Oscure (fig. 2: e, 15). Together with the structure he found other slabs of the tuff pavement (fig. 2: 16) but, unfortunately, the space between the slabs and the building had been demolished by an imperial wall that was built against the republican wall.[46]

The presence of the tuff pavement here, against the tuff wall that should be the western limit of the republican square, shows that this fourth side of the *porticus*, in this phase, wasn't covered by a porch or a colonnade. So, we can imagine the republican *porticus Minucia* as a triportico with a double colonnade on the north, east and south sides and a simple wall with entrances on its west side.[47] It is a simple hypothesis because the other three sides of the *porticus* have been investigated only up to the imperial levels and never reached the republican evidence.

---

[41] Cf. *contra* MANACORDA-ZANINI 1997, p. 264.

[42] 7): *CG* 3453: (23/3/37). 8): *CG* 3456: (30/4/37); *RT* XI, p. 42 (26-30-IV-1937). 9): *RT* XI, p. 30 (23-III-1937); *CG* 3453: (23/3/37). 10): *CG* 3453: (19/4/37); *CG* 3455: (20/4/37). 11): *RT* XI, p. 27 (16-III-1937); *CG* 3452: (18/3/37).

[43] 12): *RT* XI, p. 27 (16-III-1937); *CG* 3452: (18/3/37).

[44] The only one grafic testimony is a plan depicting only the wall found in the west side of the site (fig. 2: 14), kept by the Sovrintendenza Capitolina (doc. 5281). The drawings were conducted by the company that made the building, allowed by A.M. Colini. The description of the ruins found is made by L. Cozza (1968, n. 19, p. 17) that probably saw the plans. See also: *CG* 3870: (24/11/38); *RT* XI, p. 127 (24-XI-1938) = *RZ* 32, p. 146, 24/11/38; *CG* 3870: (26/11/38); *RT* XI, p. 128 (26-XI-1938) = *RZ* 32, p. 147, 26/11/38.

[45] 14): *CG* 3870: (7/10/38); *RT* XI, p. 116 (7-X-1938) = *RZ* 32, p. 119, 7/10/38; *CG* 3873: (8/4/41).

[46] 15), 16): *CG* 3485; *CG* 3486: (24/03/1941).

[47] To determine the number of these entrances is a simple speculation. Nevertheless, I don't think that 45 entrances, like the number of *ostia* was, could find place on this wall. It was maximum circa 125 meters long so, supposing the entrances 1 m large at least we should have a wall 1,78 m long every *ostium*. This hypothesis doesn't find validation with the wall found in via di S. Nicola de' Cesarini where, on its circa 9 meters of length, none entrance was found. For the identification of the *porticus* of via di S. Nicola de' Cesarini as the *porticus Minucia vetus* (with 45 *ostia*) see DE STEFANO 2012, pp. 544-545 and D'ALESSIO 2012, p. 503.

4.1.3 The *porticus* under the modern via di S. Nicola de' Cesarini

Thanks to the archive documentation, kept by the Sovrintendenza Capitolina and the Prints & Photographs Archive of the Museum of Rome, related to the excavations of the Area Sacra of Largo Argentina, it's now possible to update the knowledge of the republican phases of the *porticus* as the eastern limit of the Area Sacra.[48]

First of all, it's important to fix the real extent of the row of pillars found by Giuseppe Marchetti Longhi under the modern via di S. Nicola de' Cesarini, regardless of its phases. All the scientific literature produced after the excavations talks about a row of 13 pillars trying, often, to recognize in it the *ostia* of the *porticus Minucia vetus* or *frumentaria,* depending on the case.[49] There are, in reality, 17 pillars, the first of them are actually visible on the side under Corso Vittorio Emanuele II, against the propylaea of the so-called Hecatostylon (fig. 4), the last one has been saw by G. Marchetti Longhi in 1913 (fig. 2: 19), under the cellars of the buildings' blocks at, the 42nd of via S. Nicola de' Cesarini, that will be demolished for the excavations.[50]

Figure 4. The first pillar of the oriental portico of the Area Sacra of Largo Argentina partially embedded in the modern masonry.

---

[48] I'm grateful to Monica Ceci and Angela Maria D'Amelio for having helped me in the research of the material.
[49] Cf. CARRE-VIRLOUVET 1985, p. 534; VIRLOUVET 1995, p. 153; omitted data in COARELLI 1981.
[50] MARCHETTI LONGHI 1918, t. IV. In the present paper the numeration of the pillars will follow the numeration adopded by G. Marchetti Longhi in all his publications.

Cross-checking the archive data with the structures still preserved nowadays, it has been possible to recognize the republican phase of the portico under the imperial reconstruction of 6 pillars: specifically, under the pillars number 3, 4, 5 (fig. 2: 17) and 13, 14, 15 (fig. 2: 18).[51] On the picture in Figure 5 the republican tuff ashlars are visible, constituting the first phase of the pillar number 3. The republican porch should have the same aspect of its imperial phase: pillars in *opus quadratum* built at the same time as the tuff pavement of the Area Sacra, having a travertine logline running at the bottom of the pillars (on its westside) that probably took the water draining from the roof of the portico (fig. 5). The only one difference is the absence of the semi-columns on its eastside that will be present in the imperial phase.[52]

Figure 5. Picture of the republican structures under the 3th pillar taken by G. Marchetti Longhi from north. (from MARCHETTI LONGHI 1960, t. XXIV, 1)

[51] In his work about the Campus Martius, F. Coarelli (1997, pp. 281-283) unfortunately doesn't keep in consideration the Republican phase of the pillars, ascribing the portico only to the domitianic phase.

[52] The presence of a Republican phase of these pillars demolishes the reconstruction of the *porticus Minucia* by F. Coarelli (1997, f. 66).

Thanks to an excavation conducted by G. Marchetti Longhi under the pillar number 4, it seems that the portico was built with a foundation of two ashlars in tuff 60 cm high, laying on a foundation in mortar and tuff chips at an altitude of circa 9,90 m a.s.l.[53] The same building technique and the height of this foundation allow us to put the portico in the same phase as the above-mentioned wall found in the building site of the "Condominio Argentina" (fig. 2, 14). Those are probably two sides of the same building: a covered passage that gave access to the Area Sacra of Largo Argentina, on its westside, and to the *porticus Minucia* of via delle Botteghe Oscure, on its eastside. The building was covered by a roof and it was perhaps circa 9,50 meters large, an uncommon width considering the period but, now, it's impossible to know if it was smaller or if a row of columns (or pillars) ran in its centre.

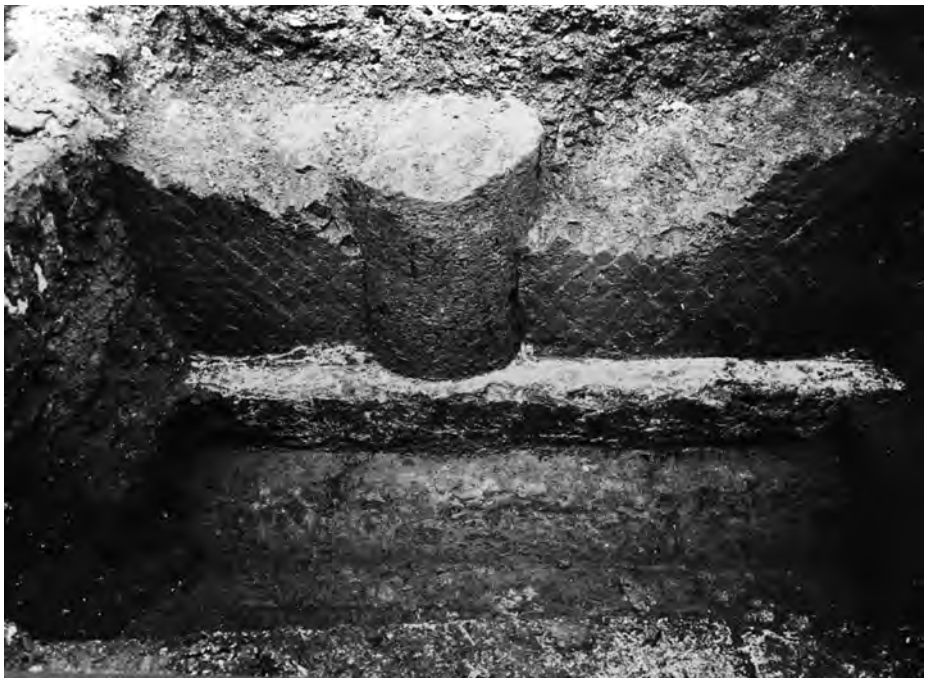


Figure 6. Facing East picture of the late republican closing wall between the 3th and the 4th pillars taken by G. Marchetti Longhi. (©SBACAF, inv. C/80)

In this first phase the portico had free arches between the pillars that permitted several accesses to the Area Sacra. Each access is circa 3,10 meters large except the access between the pillars 3 and 4, that is 4,50 meters long, a characteristic that will be kept by the imperial portico. It was probably because this was the first access to the Area Sacra for those who came from the North.

The connection between the pillars and the pavement in tuff slabs of the Area Sacra allows us to attribute this building to the interval between the end of the II century BC and the Sullan age.[54] Only after that, probably in a late-republican phase, several accesses were closed by walls in *opus incertum* or *reticulatum*. The above-mentioned large access between the pillars 3 and 4 is one of them, closed by a wall with a column in its centre (fig. 2, 17; 6).[55]

---

[53] MARCHETTI LONGHI 1932, pp. 335.

[54] For a summarize of the problems about an exact datation of the Republican pavements of the Area Sacra see COARELLI 1981, pp. 13-14.

[55] These walls closed the access between the pillars 3 and 4 (MARCHETTI LONGHI 1932, p. 336), 12 and 13 (visible *in situ*) and 14 and 15 (visible *in situ*). All these walls are cut by the travertine pavement at 11,80 m a.s.l. ca., so they stayed upright until the domitianic age.

4.2 Imperial period (fig. 7)

This phase consists in the archaeological evidence rising approximately from the altitude of 11,80 meters above sea level, coinciding with the above-mentioned late-domitianic general ground level of the whole area that raised the republican structures.[56]

4.2.1 The temple of via delle Botteghe Oscure (fig. 7, a)

After the creation of a new general level of the area, at 11,80 m a.s.l., during the reign of Domitian, the podium of temple was covered with new moulding slabs made in travertine, that are still visible. The republican columns remained untouched, only covered by a new layer of stucco.[57] Contemporary with these transformations the peristasis was covered by a new pavement in travertine slabs and the temple's cella was completely rebuilt using bricks.[58] In the imperial age the aspect of the temple should be the same as it was in the republican age, with few maintenance works that, also thanks to the application of "republican materials" like the travertine, were small enough not to be noticed. The only drastic work was the complete remake of the temple's cella, an interior operation made perhaps after a blaze that ruined part of the temple.

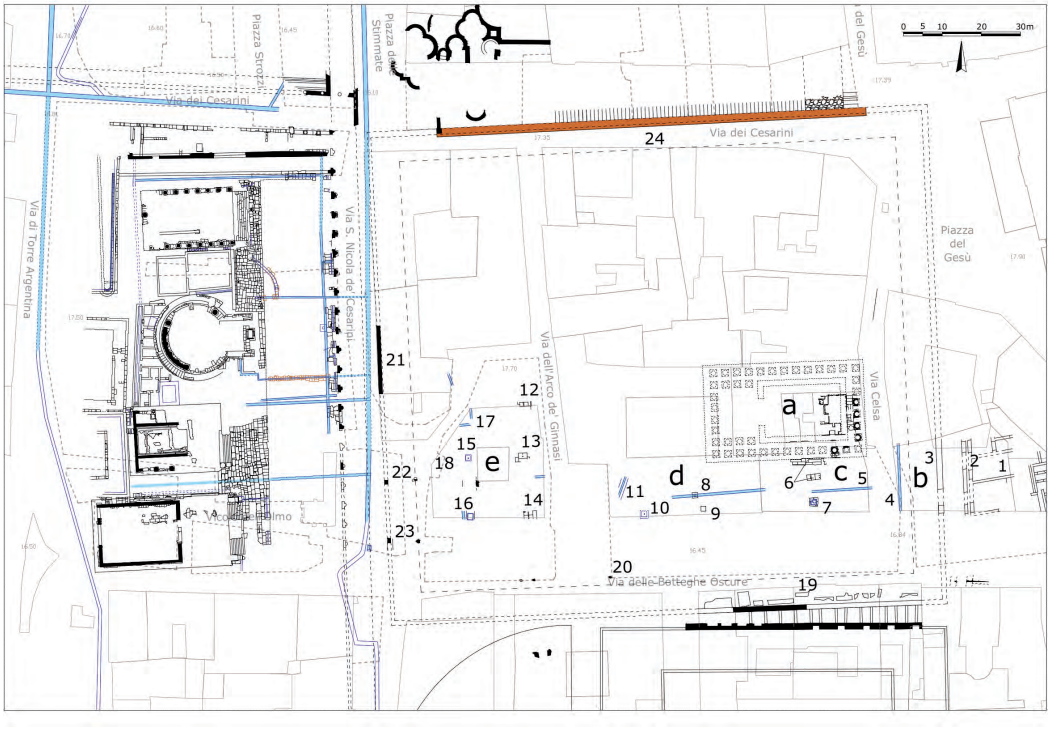


Figure 7. Archaeological map of the area: Imperial phase. (drawing by the author)

4.2.2 The porticus *of via delle Botteghe Oscure*

Outside the temple, this period is characterized by a complete urbanistic and architectural restoration that took place after the devastation caused to this area of the city by the fire of 80 AD.

---

[56] This period coincides with the "Period IV" in MANACORDA-ZANINI 1989, pp. 27-28.

[57] D. Manacorda (1997, pp. 258-259, 281) thinks that this second layer of stuccoes can be referred to a restoration that followed the blaze of Clodius (57-56 BC) according to the identification of the temple as the temple of the Nymphs.

[58] COZZA 1968, pp. 16-17; COARELLI 1968, p. 372; MANACORDA-ZANINI 1997, pp. 259-261.

The general ground level of the whole area was raised and its surface was paved here and there with travertine slabs. Remains of these slabs, circa 30 cm high, have been discovered within the building sites "Lamaro Carbone" (fig. 7: c, 6-7), "Maestre Pie Filippini" (fig. 7: d, 10) and "Palazzo Ginnasi" (fig. 7: e, 12-16).[59] Above some of them the archaeologists found four marble and travertine basins belonging to the same number of fountains that should decorate the area around the temple (fig. 7: 7, 10, 15, 16). One of them is still *in situ* (fig. 7: 7), within the actual archaeological area corresponding to the former "Lamaro Carbone" building site, that also preserves the ruins of the temple. It's interesting to note that, on its southern edge, the frame of this basin shows an inscription of four letters composing the word MINI (fig. 8). It probably indicates the destination of the plate: the fountain, after its creation, should be sent to the *Mini(cia)* or to the *Mini(ciae)*, where it has been found. This a very important discovery because it is an "archaeological proof" that, at least in the imperial age, here there was a *porticus Minucia* and that the creator of the fountain didn't need to distinguish the *porticus* between a *vetus* one and a *frumentaria* one.

Figure 8. Inscription Mini(cia) or Mini(ciae) on the plate of the fountain found in the "Lamaro Carbone" building site. (Picture taken during the 1996-1998 excavations of E. Zanini and D. Manacorda, ©SBACAF, MSd 26211)

The fountains seem to be at regular distances and perhaps other fountains should be on the non-excavated north sector of the area, surrounding the temple on its three sides.[60] Several sewers have been found relating to this level but, unfortunately, they are often badly described in the archive documentation, without indication of either their measurements or their aspect (fig. 7: 4, 5, 8, 11, 17, 18).

---

[59] 6): *RT* XI, p. 93 (19-V-1938) = *RZ* 32, p. 67, 18/05/38. 10): *CG* 3465: (14/01/1938) = *RZ* 32, p. 3, 15/01/38. 12): *CG* 3451: (11/3/37); *RT* XI, p. 25 (11-III-1937); *CG* 3453: (23/3/37). 13): *CG* 3457: (8/5/37); *RT* XI, p. 42 (8-V-1937). 14): *CG* 3453: (7/4/37); *RT* XI, p. 34 (5-IV-1937). 15): *CG* 3454: (14/4/37); *RT* XI, p. 38 (14-IV-1937). 16): *CG* 3454: (17/4/37); *RT* XI, p. 38 (15-IV-1937).

[60] Cf. the reconstruction of D. Manacorda and E. Zanini (1997, p. 250) that suppose the presence of 20 fountains all around the temple.

Up until now it has been thought that all the "square" around the temple was totally covered by a pavement with travertine slabs, many of which had been removed after the V century AD,[61] but the slabs found within the sites "Palazzo Ginnasi" and "Lamaro Carbone", seem to follow the disposition of the fountains around the temple (fig. 7: 12, 13, 14, 6). They are placed at regular distances between the basins and the temple, one for each fountain and shaped like platforms. The level could be not completely paved with travertine slabs, as happened for the domitianic travertine pavement of the Area Sacra of Largo Argentina, where a central sector was let uncovered and perhaps arranged like a garden.[62] It's possible to imagine an extended exposed area with a level of well-trod soil or gravel and travertine platforms, in connection with a fountain system, created to support statues or *ex voto* that couldn't lie directly on the soil.

Fortunately, three sides of a real portico surrounding the exposed area have been found by the archaeologists. The eastside has been discovered by G. Gatti within the building site "Impresa Costruzioni Urbane" (fig. 7, b, 3), consisting of a mortar foundation.[63] The southside is the most known side because it has been recently excavated by D. Manacorda and E. Zanini under the cellars of the Crypta Balbi Museum, where they found a massive wall, circa 57 meters long, with a foundation in a conglomerate of travertine chips, a first course of travertine blocks and perhaps a second of peperino blocks (fig. 7, 19). The wall delimited a pavement consisting of a layer of mortar mixed with marble and travertine chips and spread over a thick substratum of rubble.[64] On this side, approximately 4 meters from the Caetani Palace, along the via delle Botteghe Oscure, G. Gatti saw the top side of a column made of granite (fig. 7, 20).[65] It could be the only column of the colonnade known until now and allows us to reconstruct a double row of columns for a *porticus duplex* circa 9 meters large.[66]

The imperial phase of the west side of the portico is known thanks to the works made for the above-mentioned "Condominio Argentina" and for two trenches made by G. Gatti for the new sewage pipes of the Ginnasi Palace and for via delle Botteghe Oscure. Here there isn't the space to deal with the complexity of the phases of this side of the portico. Very briefly it is possible to say that the previous republican wall seems to be restored with a newer wall made by bricks. In front of the wall was erected a singular row of columns made of bricks, creating a colonnade of the portico that was absent during the former republican period. It's interesting to note that the imperial portico, on every side, doesn't seem to have the avant-corps neither the the double colonnade depicted by the fragment 35dd of the Marble Plan.[67]

Considering the wall found by Rodolfo Lanciani in 1884, within the trench dug for the sewage pipe of Corso Vittorio Emanuele II (figg., 2: 20; 7: 24), I think that it could belong the northside of the *porticus Minucia* of via delle Botteghe Oscure perhaps already from the republican phase.[68] It has the same orientation of the wall found near the Crypta Balbi, it is made by peperino or tuff blocks and it

---

[61] Cf. MANACORDA-ZANINI 1997, pp. 255-257.
[62] Cf. MARCHETTI LONGHI 1970-71, p. 11.
[63] 3): *RT* XI, p. 167 (3-V-1939); *RZ* 32, p. 238, 3/05/39.
[64] MANACORDA-ZANINI 1997, pp. 27-28.
[65] 20): *CG* 3484: (21/02/1940); *RT* XI, p. 228 (21-II-1940).
[66] Cf. the reconstruction done by G. Gatti (1979, f. 10).
[67] In his latest article D. Manacorda (2017, pp. 62-63) supposes that the central row of columns was eliminated during a restoration of the *porticus* that occured in the second half of the II century AD. But he also admits that the excavations didn't reach the colonnade for sure.
[68] Cf. MUZZIOLI 1995, p. 155.

has an outside pavement in travertine slabs at an altitude of circa 11,80 m a.s.l. that indicates that a roof could be on the southside of the wall.[69]

4.2.3 The porticus *under the modern via di S. Nicola de' Cesarini*

The 17 pillars under via di S. Nicola de' Cesarini were demolished and rebuilt together with the above-mentioned pavement of travertine slabs that was built in the Area Sacra, at circa the same altitude of the domitianic level of the *porticus Minucia* in via delle Botteghe Oscure.[70] The pillars were rebuilt in *opus quadratum*, with tuff blocks circa 60 cm high shaped like semi-columns on its eastside.[71] The presence, noticed by L. Cozza, of some walls perpendiculars to the wall of the *porticus Minucia*, found in via di S. Nicola de' Cesarini (fig., 2: 14)[72], together with the presence of a roman sewage under the same street,[73] could prove that the portico or *via tecta* didn't have a wall in common with the *porticus Minucia* of via delle Botteghe Oscure, and it is conceivable the presence of a service area between the two buildings, as the situation between the *porticus Minucia* and the *Crypta Balbi*.[74]

5. Conclusions

I think that the portico of pillars under via di S. Nicola de' Cesarini can be definitely identified as an independent covered passage (*via tecta*) that gave access to the sacred areas of the temples of Largo Argentina from the north to the south already from the Republican period. It is probably a covered segment of the *via triumphalis* destined to the pedestrian traffic. This identification together with the proved absence of any Republican portico embracing the temple D (at least), brings the *porticus Minucia vetus* outside the Area Sacra of Largo Argentina. The presence of several late-republican closures of its passages also contradicts the identification of them as the *ostia* of the republican *Minucia vetus* or of a Claudian *Minucia frumentaria,* that would have had its counters closed by walls from the I century BC to the end of the I century AD.

Regarding to the *porticus* of via delle Botteghe Oscure I think that it can be reasonably identified as the *porticus Minucia vetus*, considering the presence of an extended exposed and paved area already from the Republican age. According to this identification the temple of via delle Botteghe Oscure should be identified as the temple of *Lares Permarinis.* The aspect of the Republican phase of this portico continues to be indeterminable but, considering the proved absence of any colonnade on the westside of the area (via di S. Nicola de' Cesarini), it is reasonable to imagine it as a triporticus

---

[69] Putting here a side of the *porticus Minucia* could cause a problem with its identication as the ruins of the *Diribitorium* made by CARETTONI *ET ALII*, 1960, pp. 97-103. Alessandra Ten is currently studying this sector of the Campus Martius, trying to verify the real relationship between the fragments of the Marble Plan and the building that they depict. Cf. TEN 2016, pp. 41-76.

[70] Cf. CARRE-VIRLOUVET 1985, p. 534.

[71] The imperial aspect of the building can be compared to the sections of the portico of *via Triumphalis* existent in the area of the theater of Marcellus (cf. PENSABENE 2011). The pillars are still visible under the street of S. Nicola de' Cesarini and their highs were reduced to circa 3 meters by the works for the realization of the modern porch of the Area Sacra, during the 30s (cf. MARCHETTI LONGHI 1960, p. 69). The study of the travertine pavement in front of the pillars has revealed the presence of traces of a base for statue for each pillar (a preview of the complete results is in GUAGLIANONE 2017). The presence of these basis and the position of the semi-columns on the inner side of the building can be compared to the basilica of the Sanctuary of *Hercules Victor* at Tivoli (cf. TEN 1998-99, GIULIANI 2004, pp. 79-83).

[72] COZZA 1968, n. 17, p. 19.

[73] The sewage belongs to the modern sewage system called "Cloaca dell'Olmo", running under via di S. Nicola de' Cesarini. Cf., among other, the plate XXI of the Lanciani's *Forma Urbis* and, within the *Cabreo delle fognature della città di Roma*, the sections 736, 737, 739, 740, 767 partially reported in NARDUCCI 1889, pp. 34-39. For an updated overview about the sewage system of the area see CECI *ET ALII* 2018.

[74] See VENDITTELLI 2005, pp. 413-417.

instead of a quadriporticus, a shape, this last one, that it will have only with the end of the I century AD. Remains of this first *porticus* could still be under the domitianic structures considering that all the excavations haven't reached the republican levels until now. In my opinion, according to what happened with the fragments of the Marble Plan depicting the Area Sacra of Largo Argentina and the Crypta Balbi, the fragments 35dd and 35ee could represent the late-republican aspect of the *porticus* of via delle Botteghe Oscure, with some avant-corps that disappeared with the imperial age.[75] The identification as the *porticus Minucia vetus* finds a confirmation in all the historical sources and, in particular way, in the Fasti Praenestini that talk about an only one temple within the *porticus Minucia* and in the passage of the Chronograph that mentions a Domitianic re-building of the *porticus Minucia vetus* after the blaze that hit the City in 80 AD.

Finally, this present work doesn't add any new considerations for the location of the barely documented *porticus Minucia frumentaria* that, in my opinion, will be perhaps be sought, according to the hypothesis of Fausto Zevi, near the Circus Flaminius.

6. Bibliography[76]

CANINA, L. (1848), *Gli edifizj di Roma antica cogniti per alcune reliquie*, Roma.

CARDINALI, G. (1906), *Frumentatio*. In: E. DE RUGGERO (Ed.), *Dizionario epigrafico di antichità romane*, III, pp. 225-313.

CARETTONI, G. – COLINI, A.M. – COZZA, L. – GATTI, G. (Eds.) (1960), *La pianta marmorea di Roma antica*. Roma.

CARRE, M.B – VIRLOUVET, C. (1985), Rome, la limite orientale de l'Area Sacra du Largo Argentina. *MEFRA,* XCVII, pp. 532-542.

CASTAGNOLI, F. (1947), Il Campo Marzio nell'antichità. *MemAccLinc*, VIII, I, 4, Roma.

CASTAGNOLI, F. (1984), L'influenza alessandrina nell'urbanistica della Roma augustea. *Studi A. Adriani*, III, Roma.

CECI, M. – GUAGLIANONE, A. – MARCHELLO, A. (2018), Le acque sommerse: nuovi spunti per uno studio diacronico dell'area sacra di largo Argentina. In: M. BUORA – S. MAGNANI (Eds.), *I sistemi di smaltimento delle acque nel mondo antico. Atti dell'incontro di studio, Aquileia, 6-8 aprile 2017*. In: *Antichità Altoadriatiche*, (forthcoming).

COARELLI, F. (1968), L'identificazione dell'Area Sacra dell'Argentina. *Palatino*, XII, 4, pp. 365-373.

COARELLI, F. (1981), Topografia e Storia. In: *L'Area Sacra di Largo Argentina*. Roma, pp. 9-51.

COARELLI, F. (1997), *Il Campo Marzio. Dalle origini alla fine della Repubblica*. Roma.

COLINI, A.M. (1937-38), Appunti degli scavi di Roma II. Quaderni V-IXb. Edited by: C. BUZZETTI, G. IOPPOLO, G. PISANI SARTORIO, Roma, 2003.

COZZA, L. (1968), Pianta marmorea severiana: nuove ricomposizioni di frammenti. *QuadTopAnt*, V, pp. 9-22.

D'ALESSIO, M.T. (2012), Regione IX. *Circus Flaminius*. In: A. CARANDINI – P. CARAFA (Eds.), *Atlante di Roma antica. Biografia e ritratti della città*. Vol. I, pp. 493-541.

DE STEFANO, F. (2012), Appendice. L'area sacra di Largo Argentina. In: A. CARANDINI – P. CARAFA (Eds.), *Atlante di Roma antica. Biografia e ritratti della città*. Vol. I, pp. 542-548.

DELBRUECK, R. (1903), Die drei Tempel am Forum holitorium in Rom. Roma.

DEGRASSI, A. (1963), *Inscriptiones Italiae*, XIII, 2, *Fasti anni Numani et Iuliani*. Roma.

---

[75] Cf. MUZZIOLI 2014.

[76] The bibliographical abbreviations are the same in use by the Deutsches Archäologisches Institut.

GALLUPPI, R. (2007), La voragine insigne. Giuseppe Marchetti Longhi e la scoperta dell'area sacra del largo Argentina. *BCom*, CVIII, pp. 291-327.
GATTI, G. (1979), Il teatro e la Crypta Balbi in Roma. *MEFRA*, XCI, pp. 237-313.
GILBERT, O. (1883-90), *Geschichte und Topographie der Stadt Rom im Altertum*. I–III, Leipzig.
GIULIANI, C.F. (2004), *Tivoli. Il santuario di Ercole Vincitore*. Tivoli.
GUAGLIANONE, A. (2017), Sulle tracce degli dei. Una Minerva di Fidia nell'Area Sacra del Largo Argentina. In: A. POTRANDOLFO – M. SCAFURO (Eds.), *Atti del I Convegno Internazionale di Studi, Paestum 7-9 settembre 2016*. Vol. 5, pp. 1301-1306, Paestum.
HÜLSEN, CH. (1927), *Le chiese di Roma nel Medioevo*. Firenze.
HÜLSEN, CH. – KIEPERT, H. (1912), *Forma Urbis Romae antiquae*. Berlin.
JORDAN, H. – HÜLSEN, CH. (1907), *Topographie der Stadt Rom im Altertum*. I-II, Berlin.
LANCIANI, R. (1897), *The ruins and excavations of ancient Rome; a companion book for students and travelers*, Cambridge.
LANCIANI, R. (1917), I portici del Foro Olitorio e il tesseramento delle derrate nell'antica Roma. *BCom*, XLV, pp. 168-191.
LTVR: E.M. STEINBY (Ed.), *Lexicon Topographicum Urbis Romae*. Roma.
LUGLI, G. (1930), *I monumenti antichi di Roma e suburbio. I, La zona archeologica*. Roma.
MANACORDA, D. (1996), *s.v. Nymphae*, in *LTVR*, III, 1996, pp. 350-351.
MANACORDA, D. (2012A), A proposito delle Tre Grazie. In: R. DOLCE – A. FRONGIA (Eds.), Giornata della ricerca 2011. Roma, 7-8 giugno 2011. *Quinterni*, 5, pp. 27-29.
MANACORDA, D. (2012B), Per una lettura iconografica delle tre Grazie. In: I. COLPO – F. GHEDINI (Eds.), *Il gran poema delle passioni e delle meraviglie. Ovidio e il repertorio letterario e figurativo fra antico e riscoperta dell'antico. Atti del convegno, Padova, 15-17 settembre 2011*. *Antenor quaderni*, 28, pp. 463-476.
MANACORDA, D. (2013), Le Tre Grazie tra Roma e Afrodisia. In: N. BARBOLANI DI MONTAUTO – G. DE SIMONE – T. MONTANARI – C. SAVETTIERI – M. SPAGNOLO (Eds.), *Arte e politica. Studi per Antonio Pinelli*. Firenze, pp. 9-14.
MANACORDA, D. (2017), Il pavimento della *Porticus Minucia*. In: M. CUPITÒ – M. VIDALE – A. ANGELINI (Eds.), *Beyond limits. Studi in onore di Giovanni Leonardi*. *Antenor quaderni*, 39, pp. 55-65.
MANACORDA, D. – ZANINI, E. (1989), *The first millennium A.D. in Rome, from the Porticus Minucia to the via delle Botteghe Oscure. ARID*, Suppl. 16, pp. 25-32.
MANACORDA, D. – ZANINI, E. (1997), Il tempio di via delle Botteghe Oscure: indagini stratigrafiche. *Ostraka*, VI, pp. 249-293.
MANCIOLI, D. (1995), L'Area Sacra Argentina. In: L. CARDILLI (Ed.), *Gli anni del Governatorato (1926-1944). Interventi urbanistici, scoperte archeologiche, arredo urbano, restauri*. Roma, pp. 85-88.
MARCHETTI LONGHI, G. (1918), I tempii presso S. Nicola a' Cesarini e la sistemazione della zona Argentina. *BCom*, XLVI, pp. 115-160.
MARCHETTI LONGHI, G. (1932), Gli scavi del Largo Argentina. *BCom*, LX, pp. 253-346, tavv. I-IV.
MARCHETTI LONGHI, G. (1960), *L'Area Sacra del Largo Argentina. Itinerari dei musei, gallerie e monumenti d'Italia*, 102, Roma.
MARCHETTI LONGHI, G. (1970-71), Gli scavi dell'Area Sacra del Largo Argentina. Evoluzione e trasformazione dell'area e dei templi dall'età imperiale all'inizio del Medio Evo. *BCom*, LXXXII, pp. 7-62.
MESSA, L. (1995), La demolizione dell'isolato di S. Nicola ai Cesarini e la scoperta dell'Area Sacra Argentina. In: L. CARDILLI (Ed.), *Gli anni del Governatorato (1926-1944). Interventi*

urbanistici, scoperte archeologiche, arredo urbano, restauri. Roma, pp. 77-83, 198-204.
MUZZIOLI, M.P. (1995), I lavori per la Via Nazionale e il Diribitorio. *RIA*, s. III, XVIII, pp. 139-168.
MUZZIOLI, M.P. (2014), Sui mancati aggiornamenti della pianta marmorea severiana. In: R. COATES-STEPHENS – L. COZZA (Eds.), *Scritti in onore di Lucos Cozza. LTVR*, supplementum 7, pp. 107-122.
NARDUCCI, P. (1889), *Sulla fognatura della città di Roma*. Roma.
NICOLET, C. (1976), Le temple des Nymphes et les distributions frumentaires à Rome à l'époque républicaine d'après des découvertes récentes. *CRAI*, 1, pp. 29-51.
PELLEGRINI, A. (1879), Scavi. *Portici minucii. BdI*, pp. 257-258.
PENSABENE, P. (2011), Il 'Portichetto' tuscanico presso il tempio di Bellona e la 'Via Trionfale'. In: M. DE NUCCIO (Ed.), *Area del Teatro di Marcello. Ricerche e studi sui materiali dell'area sud-est del Circo Flaminio. Atti della giornata di studi (Roma, Istituto Archeologico Germanico, 10 giugno 2004*). *BCom*, CXII, pp. 251-291.
RICHARDSON, L. JR. (1992), *A New Topographical Dictionnary of Ancient Rome*. Baltimore-London.
RICKMAN, G. (1983), *Porticus Minucia*, In: K. DE FINE LICHT (Ed.), *Città e architettura nella Roma imperiale: atti del seminario del 27 ottobre 1981 nel 25° anniversario dell'Accademia di Danimarca. ARID, suppl*. X, pp. 105-108.
SANTANGELI VALENZANI, R. (1995), Rinvenimenti archeologici in via delle Botteghe Oscure. In: L. CARDILLI (Ed.), *Gli anni del Governatorato (1926-1944). Interventi urbanistici, scoperte archeologiche, arredo urbano, restauri*. Roma, pp. 89-92.
SANTANGELI VALENZANI, R. (2008), Archeologia e città. In: M.F. BOEMI – C.M. TRAVAGLINI (Eds.), *Roma dall'alto (catalogo della mostra, 25 ottobre – 30 novembre 2006).* Roma, pp. 55-67.
TEN, A. (1998-99), Santuario di Ercole Vincitore a Tivoli: nuove acquisizioni. *RendPontAcc*, pp. 327-345.
TEN, A. (2016), Sulla ricostruzione del contesto topografico antico nel Campo Marzio centrale: riflessioni e dati per un aggiornamento. In: F. FILIPPI (Ed.), *Campo Marzio: nuove ricerche. Atti del seminario di studi sul Campo Marzio: Roma, Museo Nazionale Romano a Palazzo Altemps, 18-19 marzo 2013*, Roma, pp. 41-76.
TUCCI, L. (1994-95), Considerazioni sull'edificio di via di Santa Maria de' Calderari. *BCom*, XCVI, pp. 95-124.
VALENTINI, R. – ZUCCHETTI, C. (1940), *Codice topografico della città di Roma*. Scrittori secoli I-VI. Roma.
VAN BERCHEM, D. (1939), *Les distributions de blé et d'argent à la plebe romaine sous l'Empire*. Genève.
VENDITTELLI, L. (2005), *Crypta Balbi-Porticus Minucia*: la conserva d'acqua. *BCom,* CVI, pp. 413-417.
VIRLOUVET, C. (1987), La topographie des distributions frumentaires avant la création de la Porticus Minucia frumentaria. In: *L'Urbs: espace urbain et histoire (Ier siècle av. J.-C. - IIIe siècle ap. J.-C.). Actes du colloque international de Rome (8-12 mai 1985)*. Rome: École Française de Rome, pp. 175-189.
VIRLOUVET, C. (1995), Tessera frumentaria. *Les procédures de distribution du blé public à Rome à la fin de la République et au début de l'Empire*. *BEFAR*, 286.
VIRLOUVET, C. (2009), La plèbe frumentaire dans les témoignages épigraphiques. Essai d'histoire sociale et administrative du peuple de Rome antique. *Revue des études latines*, 87.
WALL, B. (1932), *Porticus Minucia*. *ActaRom*, II, pp. 31-54.
WIJKSTRÖM, B. (1932), Welche sind die Tempel auf der Piazza Argentina? *ActaRom*, II, pp. 17-30.

ZEVI, F. (1993), Per l'identificazione della *Porticus Minucia frumentaria*. *MEFRA*, CV, pp. 661-708.
ZEVI, F. (1994), Ancora una nota sulla *porticus Minucia. MEFRA*, CVI, pp. 1073-1076.
ZEVI, F. (1995), Il tempio D del Largo Argentina: tempio delle Ninfe in Campo? *Archeologia Laziale*, 12, pp. 135-143.
ZEVI, F. (1997), Il tempio dei Lari Permarini, la Roma degli Emili e il mondo Greco. *RM*, CIV, pp. 1-115.
ZEVI, F. (2007), *Minucia frumentaria, Crypta Balbi, Circus Flaminius*: note in margine. In: D. PALOMBI – S. WALKER – A. LEONE (Eds.), Res Bene Gestae. *Ricerche di storia urbana su Roma antica in onore di Eva Margareta Steinby*. Roma, pp. 369-382.
ZIOLKOWSKI, A. (1992), *The temples of Mid-republican Rome and their Historical and Topographical Contex*t. Roma.

Dressel 6B and Dressel 6A's oil and wine production in North Italy and the Adriatic western coast (1st century BC - 2nd century AD)

Silvia Cipriano
Museo della Centuriazione Romana, Borgoricco (Padova)
Stefania Mazzocchin
Dipartimento dei Beni Culturali, Università degli Studi di Padova

1. Introduction

Since 1990 our research team is carrying on a study over a great number of amphorae (more than 5.000) in *Venetia*, used to improve the terrain and to drain the surface water.[1] This technique was used between the second half of 1st century BC and the first half of 2nd century AD[2] (fig. 1).

The frequent recovery of great quantities of amphorae in the river Po Valley towns allowed us to recover, for different range of time, the provenance of the containers and of the foodstuffs, in order to understand the amount of trade connections.

[1] MAZZOCCHIN 2013, 49-61.
[2] The pictures are published on concession of *Ministero dei beni e delle attività culturali e del turismo*; the copy is forbidden.

Figure 1. A reclamation depot with amphorae found in Padua.

In these contexts, Dressel 6B for oil and Dressel 6A for wine are the most numerous amphorae evidences; these are all Adriatic and north eastern Italy productions. Beyond them, there are mostly wine, oil and alum amphorae which come from Eastern areas and partially from the West, in particular the fish sauces's amphorae from *Baetica*.

Dressel 6A are wine amphorae, with gently rounded rim, distinct or ridge carination on the shoulder, where the shoulder meets the body, long and vertical handles, cylinder-shaped neck; pear-shaped body, the spike is long. Their production starts at the end of 1st century BC and goes on till the half of 1st century AD.[3]

Dressel 6B amphorae, as it is known,[4] are oil containers, with gently rounded rim, rounded shoulder, vertical handles with elliptical section, cone shaped neck, pear-shaped body, small knob at the base. Dressel 6B were produced for a long time, from the half of 1st century BC to the 4th century AD [5].

2. The Research status and the methods

Methodology developed to identify the provenience of Dressel 6A and Dressel 6B re-used in *Venetia* contexts of reclamation started out with the analysis of well-known workshops data.

Recent studies focused on wine and oil amphorae productive workshops along the Western Adriatic coast and in Northern river Po Valley[6]. In these years, the research teams of University of Pisa (South *Picenum* Survey Project) and University of Ghent (The Potenza Valley Survey) with Soprintendenza delle Marche carried out essential archaeological studies. Research methodology[7] is based on archaeological survey and detailed archaeological excavation; the discovery of clay quarries, kilns, productive buildings, as basins or drying buildings etc., ceramic overfired dumps are

[3] CIPRIANO & MAZZOCCHIN 2018.
[4] CIPRIANO 2009.
[5] For the chronology of Dressel 6B amphorae connected with their morphology see CARRE & PESAVENTO MATTIOLI 2003.
[6] CARRE, MONSIEUR & PESAVENTO MATTIOLI 2014; AURIEMMA & DEGRASSI 2015.
[7] About the relevance of scientific method of productive area identification: PANELLA 2010 and CARRE, MONSIEUR & PESAVENTO MATTIOLI 2014: 417-419.

essential markers of productive workshops. In some cases the archaeological investigation allowed to identify the amphora typology produced in a kiln, and the connected stamps. Specific archaeometrical research aims for amphorae clay characterization and for comparison with local clay, to define the origin area of the amphorae.

These research marked extraordinary results, particularly for the region defined by *Gallia Cispadana*, *Ager Gallicus* and *Picenum*, where some amphorae productive workshops have been located; moreover it is possible to define the typology of the amphorae produced in this area and in some cases the stamps related with them.

The well-known Dressel 6A kilns are located in the river Po Valley, in western middle Adriatic coast and in *Picenum* (fig. 2).

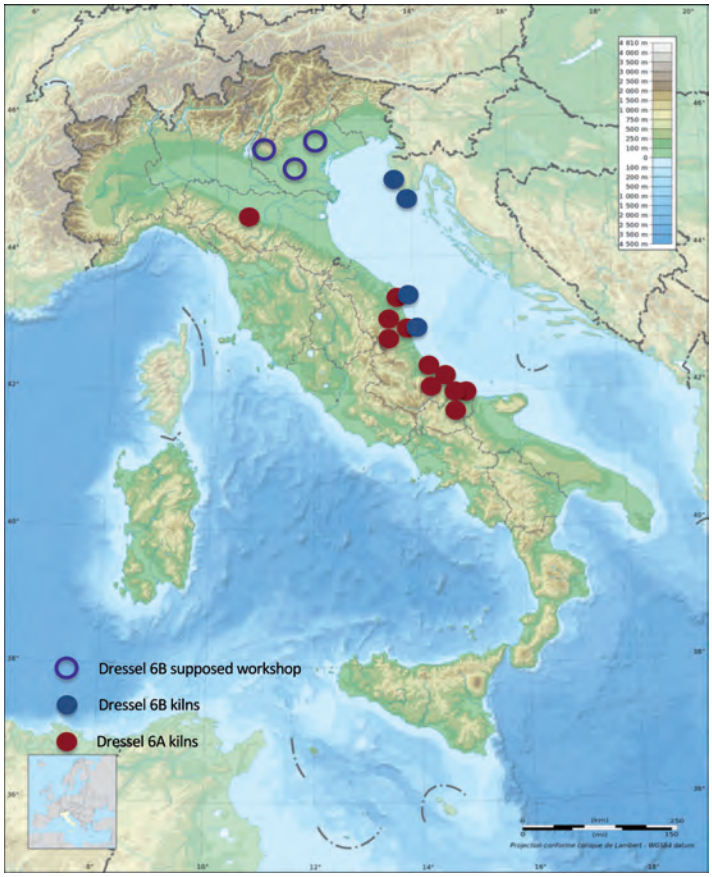


Figure 2. Map of Dressel 6A's and Dressel 6B's kilns.

Dressel 6A amphorae are produced at Sala Baganza (Parma), where ceramic kiln's dumping were funded.[8] At Portorecanati (Macerata), the ancient *Potentia*, remains of a farm building with walls composed of amphorae's necks were found: these kind of walls are usually part of production areas[9]. At Potenza Picena (Macerata), Casa Alvata site, several overfired sherds of Dressel 6A amphorae let us suppose a productive workshop in this area.[10] At Potenza Picena (Macerata),

[8] MARINI CALVANI 1981, 127-129.
[9] MERCANDO 1979, 281-282; DELPLACE 1993, 144-145; VAN LIMBERGEN 2011, 73.
[10] DELPLACE 1993, 146-147.

Casa Valentini site, archaeological research has identified a productive workshop of greco-italic amphorae/Lamboglia 2, Lamboglia 2, Dressel 6A and Dressel 6B.[11] At Valle del Potenza (Macerata) archaeological survey long the Potenza river revealed specifics ceramic clusters which correspond to settlements. The fabric of some of this pottery has local characteristics[12]; at *Ager Firmanus* (Fermo), where archaeometrical analysis on several sherds collected in the survey have confirmed some local production workshops of Lamboglia 2, Dressel 6A, ovoid amphorae, Dressel 2-4 and flat bottomed amphorae; at Fermo, Contrada Castagna di Capodarco, where archaeological research between the mouths of Tenna and Valloscura river and in Castagna di Capodarco site, has revealed important clusters of Lamboglia 2, Dressel 6A and with transitional shape, in addition to remains of basins and kilns. Some Lamboglia 2 and Dressel 6A amphorae found in Fermo, Contrada Castagna di Capodarco, have *L. Salvi* e *Barbul(a)//C. Iul(i) Poly(---)* stamps.[13] At Fermo, Torre di Palme, Fosso S. Biagio site, on the left bank of Fosso S. Biagio remains of buildings and of a kiln, several fragments of bricks and a lot of amphorae with transitional shape between Lamboglia 2 and Dressel 6A, in vertical position, were founded.[14] At Fermo, Torre di Palme, on the right bank of Fosso S. Biagio site was founded an amphorae's sherds dump: the recovery let us to presume a production workshop of Dressel 6A amphorae, with *Barbula/C. Iul(i) Poly(---)* stamp.[15] The production of Dressel 6A and flat bottomed amphorae with Q. Ninni Secundi stamp is located also at Montesilvano (Pescara), near the mouth of Saline river.[16] Finally at Città Sant'Angelo (Pescara), Silvi Marina site were founded overfired wastes of Lamboglia 2 and Dressel 2-4 amphorae, but deep archaeological research has revealed an extended productive workshop of Greco-italic amphorae, Lamboglia 2 and Dressel 6A. Several fragments of transitional Lamboglia 2 and Dressel 6A amphorae shape have *Publicius Malleolus* stamp in addition with the stamps of a number of *servi*; the stamps of *Malleolus* and his *servi Diphilus* and *Arthemius* are present on Dressel 6A amphorae, as proof of continuity of Lamboglia 2 and Dressel 6A production. Moreover, Dressel 6A amphorae have *Cadmus*, *Barbarus* and *Primus Bar(barus)* stamps.[17]

All these productions are dated between the Augustan period to the 1st century AD.

On the other hand, about the so called "classic" Dressel 6A (fig. 3) with *Safinia Pice(ns/na* or *Picentina*), *T. Helvius Basila*, *M. Herennius Picens* and the other members of *gens Herennia* stamps we haven't archaeological remains of kilns or productive workshops. But archaeometrical studies allow to connect characteristics of Dressel 6A with *Herenni* stamps samples to Adriatic regions[18].
The well-known Dressel 6B kilns were only the Fasana and Loron workshops, located in *Histria*, between the start of 1st century BC to 4th century AD (fig. 2).

---

[11] VERMEULEN *et alii* 2009, 93-95, table 2.

[12] VERMEULEN *et alii* 2002, 64, fig. 16, n. 20; 65, fig. 18; VERMEULEN 2003, p. 90.

[13] MENCHELLI & CIUCCARELLI 2009; BRANCHESI 2007.

[14] BRECCIAROLI TABORELLI 1984, 57-73.

[15] BRECCIAROLI TABORELLI 1984, 73-90.

[16] CARRE 1985, 235-239; STAFFA 2003, 131.

[17] STAFFA 2003, 119-129, figg. 4-8; 126.

[18] MAZZOLI, MARITAN & PESAVENTO MATTIOLI 2009; for the chronology of *Herenni*'s amphorae: CIPRIANO 2016, 148-150.

Figure 3. A "classic" Dressel 6A amphora.

In Fasana workshop, recently excavated,[19] were produced, from late Augustan to Flavian period, Dressel 6B with a peculiar double stamp. It consists of a first stamp with *C. Laekanius Bassus dominus* name and a second stamp with the name of *servus officinator*, the manager of the *figlina* and of the *fundus* connected (fig. 4). Between 78 and 80 AD the workshop and the possessions flow into the Imperial property; from this time the emperor name appears on the stamps at the place of *dominus* name.

In the late production phases, dated at the half of 2nd century AD, are produced smaller amphorae less frequently stamped[20].

In the *villa maritima* of Loron were brought to light[21] a workshop and some kilns, in activity from Augustan to Flavian period. This workshop produced Dressel 6B amphorae with the stamps of the different owners: *T. Statilius Taurus Sisenna*, *consul* of 16 AD, MES.CAE, CRISPIN, CRISPINILL, AELI.CRIS and CAL.CRISPINILLAE[22]. Starting from Domitian emperor, the whole productive workshop flows into the Imperial property; the stamps amphorae have the names of the Emperors until Hadrian. Finally, the late amphorae production, which reach the 4th century AD, isn't stamped. A production of these amphorae can be located also in the Middle-Adriatic area: workshops were found in Portorecanati and in Potenza Picena (Casa Valentini).

---

[19] BULIĆ & KONCANI UHAČ 2010.

[20] On Fasana workshops: BEZECZKY 1998, 3-43; BEZECZKY 2001; CIPRIANO 2009, 176-177 with bibliography; BEZECZKY 2014, 241-257.

[21] TASSAUX, MATIJAŠIĆ & KOVAČIĆ 2001; ROUSSE 2011; MARCHIORI & D'INCÀ 2011; MARCHIORI & D'INCÀ 2014.

[22] MARION & STARAC 2001, 99-107; CIPRIANO 2009, 177.

Figure 4. A Dressel 6B amphora with *Laekanius* stamp.

However, among the number of Dressel 6A and Dressel 6B amphorae recovered in North-Italic towns there are some amphorae which have different characteristics from the well-known productions. To identify the production area of these kind of amphorae our research team has carried out a project based on typological and epigraphycal studies and detailed archaeometrical studies.

In last ten years we have analyzed, beyond archaeometrical analysis, literary, archaeological and paleo-bothanical sources which concern olive tree plantation and oil production; moreover we have analyzed the current agricultural cultivation and the climatic environmental conditions of the actual agricultural land[23]. Then we start a systematic study of some stamps which are frequently discovered in *Cisalpina*; we collected all the published occurrences, we noted on the maps the topographical distribution showing peculiar clusters or lacks.

On Dressel 6A have been analyzed the *gentes Ebidia*, *Ebidiena*, *Gavia*, *Valeria*, *Hostilia* stamps[24]. They are on the rim, in rectangular cartouche with the letters in relief, and are referred to the *servi officinatores* of the workshop owner *gens*. These amphorae have small size (85/92 cm height), gently rounded rim, truncated cone-shaped neck, curved handles, groove on the shoulder, pear-shaped body and long spike. The fabric is pink (7.5 YR 7/4), with mica, calcite and chamotte.

The Dressel 6B amphorae have *Apic*, *Apici*, *Appulcri*, *Flav. Fontan*, *Fontani*, *L. Iuni Paetini*, *Pacci*, *P. Q. Scapulae*, *P. Sepulli P.F. Sepullium*, *L. Tre. Optati*, *Vari Pacci* stamps on the rim, in rectangular cartouche with the letters in relief.[25]

This approach allows to consider if the stuffs have used river or earth way and which town, as emporia, have collected merchandises and have redistributed them to specific areas.

Stefania Mazzocchin

---

[23] PESAVENTO MATTIOLI 2002-2003; CIPRIANO & MAZZOCCHIN 2004.

[24] PESAVENTO MATTIOLI 2002; PESAVENTO MATTIOLI 2002-2003; PESAVENTO MATTIOLI & BUONOPANE 2005; PESAVENTO MATTIOLI 2007.

[25] CIPRIANO & MAZZOCCHIN 2000; CIPRIANO & MAZZOCCHIN 2002.

3. Research results

Dressel 6A and Dressel 6B amphorae found out in North-Italic contexts and not referable to already known production areas, the Mid Adriatic one for Dressel 6A, the Istrian one for Dessel 6B, have been morphologically, epigraphically and archaeometricly studied, allowing to suggest some assumptions about their origin and to propose the North-Italic area as their production venue.

Firstly, a North-Italic Dressel 6A, characterized by small size and trademarks of *Gavia*, *Ebidiena*, *Valeria*, *Hostilia* and *Autronia gentes*, was hypothesized[26]. These amphorae, possibly, were supposed to carry the wines of the current Veneto and Friuli Venezia Giulia areas, such as the *Pucinum vinum* produced in the Aquileian coastal area[27], the wine obtained from the vitis raetica in Valpolicella, particularly welcome to *Augustus* (Svet., *Aug*. 77.1 and 3) and, probably, also the wine distillated in the East *Aemilia* region[28]. These small Dressel 6A are widespread all across the Northern Italy and Magdalensberg area, and are typical of the Augustan age (fig. 5).

About the Dressel 6B, the amphorae marked with the *Apic*, *Apici*, *Ap.Pulcri*, *Flav*. *Fontan*, *Fontani*, *L. Iuni Paetini*, *Pacci*, *P. Q. Scapulae*, *P. Sepulli P.F*, *Sepullium*, *L. Tre. Optati*, *Vari Pacci* stamps has been studied. These are morphologically combined by the ovoid-shaped body, however showing different joints of the rim and with more or less inflected handles (fig. 6). Additionally, the study has shown that their distribution is generally limited to the Padana plain area, particularly focused in the *Venetia*, *Aemilia* and to *Noricum* regions, especially to the Magdalensberg[29]. Most of the *gentes* appearing on these stamps are also known from *Cisalpina* area's lapidary epigraphy[30] and, in some cases, it is possible to link closely certain families to specific locations.

In particular, the *gens Sepullia* can be placed in *Patavium* and, through the prosopographic analysis, *Sepullius Macer*, *triumvir monetalis* in 44 BC, can be assumed as the *figlina*'s founder[31]. Instead, the *Apici gens* should likely be located in Este, where their nomen is largely attested and an atelier for bricks production rises[32]. For the numerous *Vari Pacci* branded amphorae, it has been possible to create an archeometric "reference group", allowing to identify the characteristic markers: some calcareous nanno-fossils inside the paste. Thus, the study has permitted to identify the clay's provenience in the Treviso's hilly area to whom it is possible to relate the probable production centre as well[33].

---

[26] About the *gens Gavia* stamps: PESAVENTO MATTIOLI 2002, 392-393, tab. 1; for the *gens Ebidiena* stamps: PESAVENTO MATTIOLI & BUONOPANE 2005, 177-178 and tab. I; for the *gens Valeria* stamps see PESAVENTO MATTIOLI 2002-2003, 111-113 and tab. 2; for the *gens Hostilia* stamps*:* MAZZOCCHIN 2013, 98; for the *gens Autronia* stamps: PESAVENTO MATTIOLI 2000, 109; see also PESAVENTO MATTIOLI & MONGARDI 2018.

[27] This is the wine which Livia attributed her longevity to (Plin, *N.H*., 14, 60).

[28] PESAVENTO MATTIOLI & BUONOPANE 2005, 179; PESAVENTO MATTIOLI 2007, 461.

[29] CIPRIANO & MAZZOCCHIN 2004, 107-108; CIPRIANO 2009,182, fig. 10.

[30] See especially the *gentes Quintia, Claudia, Flavia, Iunia* e *Trebia*: CIPRIANO & MAZZOCCHIN 2004, 108 and nt. 84.

[31] CIPRIANO 2009, 179-181.

[32] CIPRIANO 2009, 182.

[33] DE VECCHI, PESAVENTO MATTIOLI, FORNACIARI & MAZZOCCHIN 1999; CIPRIANO, MAZZOCCHIN, MARITAN & MAZZOLI in press. Petrographic features are also compatible with the Marne of Monte Piana area, from Tortona to Val Secchia.

Figure 5. A small North-Italic Dressel 6A amphora.

Therefore, several specimens of Dressel 6B are certified in the *Cisalpina* cities between the second half of the 1st century BC and the half of the 1st century AD. They reflect an equally different cultivation of the olive tree that should be detected in the Verona's hilly area, in the Atestino-Patavino territory and in the Treviso's landscape.

The analysis of the containers found in the remediation depots of the major cities of ancient Veneto has allowed to identify a "late" production of Dressel 6A, dated between 45-50 and 78-80 AD and characterized by the stamps COSSI, T^ICL.S, T.CAE.FVSCI, C. CAESI/NASICA^E, M.ARRI. ILI, P.C.P, OPTATI ET/MARCELLI and CLODC.F (fig. 7). These Dressel 6A are uncommon and they are characterized by a far smaller number of marks in the previous periods, sometimes totally unrelated and with no terms of comparison. These are marks essentially always imprinted on the neck or on the shoulder of the amphorae with carved open letters, consisting of often abbreviated *tria nomina*, *nomina* and *cognomina*, also linked with each other: moreover, in a particular case, also the patronymic is mentioned. Sometimes the same marks are recognisable on Dressel 2-4, as happens for the *Cossi*, *Caesi*/*Nasicae* marks or as for *M.Arri.Ili* stamp on flat bottomed amphora[34]. However, we are always talking about amphorae of different shape, which are still used for the transportation of wine and, therefore, may attest the passage to a new feature of amphora, before the complete dismiss of the previous shapes. The only exception is represented by the T^ICL.S stamp, found in a *collo ad imbuto* amphora, for which the oil container function has always been hypothesized and, therefore, could witness for *Ti. Cl(---) S(--)* the trade of both wine and oil.

[34] We know other stamps on Dressel 6A and flat bottomed amphorae (for example *Q. Ninnius Secundus* and *Sex. Iulius Aequanius Lautus*), on Dressel 6A and Dressel 2-4 (as *C. Iuli Poly* and TI.IVLP), on Dressel 6A and *collo ad imbuto* amphorae (as *Iulius Paulinus*).

Figure 6. A North-Italic Dressel 6B amphora.

These Dressel 6A are morphologically different from those discovered in the previous periods and are characterized by vertical or flattened rim, little marks in the neck attachment (and sometimes share similar features with the *collo ad imbuto* amphorae), truncated neck, long slanted, ovoid-elongated body and appears less waist than those of previous periods. The ceramic body is pink or hazel with inclusions of mica, calcite and *chamotte*. They are poorly widespread and distributed only in Northern Italy, Rome and sporadically in the East, following the *Picenum* area amphorae's distribution, although in a lower quantities if compared with the previous periods: this fact can be easily explained by the progressive marketing fortune of the flat bottomed container (which are possible to identify also in the same contexts of these Dressel 6A).

Figure 7. A "late" Dressel 6A amphora.

The hypothesis that the origin of these amphorae is the *Picenum* area, is also suggested by the continuity in the Dressel 6A "classical" production, which starts in the Late Republican-

Augustan age and lasts at least until the Claudia era, unlike the Dressel 6A North-Italic production, not exceeding the Augustan age. So, these data seems to be enough to assume that these containers continued to be produced in the *Picenum*'s workshops, in parallel with flat bottomed amphorae, which will completely replace them from the end of the 1st century AD, perhaps jointed with Dressel 2-4 for the wine and *collo ad imbuto* amphorae for the oil.

The morphological, epigraphic and prosopographic study of the containers present in Venetian remediation depots has finally led to the hypothesis of an Imperial Dressel 6A production characterized by several brands referring to *gens Iulia*, such as BA^RBV^L//C.IV^L.POLY, SEX. IVLI/AEQVANI/LAVTI, BAR//SEX IVL ORP, SEX.IV^LI.SEV^E^R, IVLI *palma*/PAVLINI, dating back to the end of the 1st century BC and the end of the 1st century AD.

What is common to these brands is their presence, in addition to Dressel 6A, on other wine containers, such as Lamboglia 2, Dressel 2-4 and flat bottomed amphorae, and / or olear containers, such as Dressel 6B and *collo ad imbuto* amphorae[35]. Some of these series are characterized by a double brand, and are all mainly spread in the *Cisalpina* area, as well as in Rome, the Mid-Adriatic area, Magdalensberg, Athens, Corinth and Carthage, resembling the same distribution of classic *Picenum*'s production of Dressel 6A.

In addition to the finding of workshops attributable to some of the characters present on the stamps[36], the morphology, the macroscopic and archeometric analysis of the paste of the amphorae, related with the study of the epigraphic and prosopographic apparatus of the brands, indicate the Mid-Adriatic and the Picenum as the original area for the production of these containers. In this area, an impressive organization of production and marketing of wine and, possibly, also of oil seems to be strictly connected with the *gens Iulia*. The presence of a patrimonial *Regio Picen(a)* and an owned imperial *procurator* in *Firmum* and Ricina territories, reinforce the hypothesis that these amphorae were strictly linked to the sale of products referring to the imperial property in the *Picenum* area[37].

4. Conclusions

The analysis of the relationship between the different occurrences of amphorae over the centuries and the chance of gathering a chronological scan of the different oil and wine inputs and their trading dynamics has been possible thanks to the numerous closed contexts found during excavations in the major cities of the *Venetia* area, unearthing re-utilized amphora in reclamation contexts to remedy the soil[38].

During the second half of the 1st century BC, in the Venetian area, wine and oil containers from the Middle Adriatic region, Lamboglia 2 and oval amphorae prevail, while are sporadically attested the oldest Dressel 6A for wine and Dressel 6B for oil, the production of which is to be located in the *Patavium* area. Over the Augustan period, the consumption of oil and wine is almost entirely satisfied by the regional production of the area, with small inputs from the outside, mainly

---

[35] An other stamp of *gens Iulia, C. Iuli Marcelli*, is testified on *collo ad imbuto* and flat bottomed amphorae.

[36] CIPRIANO & MAZZOCCHIN 2016 with bibliography.

[37] CIL VI, 8580; CIL IX, 5828; MAIURO 2012, 177-178; CIPRIANO & MAZZOCCHIN 2016, 234-236.

[38] About Padova: CIPRIANO & MAZZOCCHIN 2011 with bibliography; about Altino: TONIOLO 1991; CIPRIANO 2003; about Oderzo: CIPRIANO & FERRARINI 2001; about Vicenza: MAZZOCCHIN 2013; about Verona: BUCHI 1973; PESAVENTO MATTIOLI 1998.

from the Middle Adriatic region and *Histria*[39]. With several active manufacturers at the same time the presence of the North-Italic Dressel 6B is growing, spreading the oil trading throughout Cisalpina area and towards *Norico* and *Pannonia*, across the same commercial routes, without overwhelming the market; wine has also a predominantly regional production, alongside a small import from the Mid-Adriatic region.

In the Tiberian-Claudia era, oil is only partially produced in the Po valley. Thus, in Gallia Cisalpina, Magdalensberg and *Pannonia*, the amphorae of Istrian manufacture are prevalent and they are spread in the same areas of the regional North-Italic Dressel 6B, showing how different production and, perhaps, different quality of oil are enabled to meet the demands of this market. Now, the wine trade comes almost exclusively from the *Picenum* area.

In the Mid-Flavian age (45-50 – 78-80 AD), both oil and wine amphorae, characterized by the North-Italic stamps, are completely absent: wine still comes from the Middle Adriatic region, while oil arrives almost exclusively from *Histria*, particularly from Fasana and Loron.

Therefore, on the basis of this analysis, it seems possible to hypothesize that the North-Italic oil, after having replaced in the Augustan age the Mid-Adriatic oil production and having shared for a brief span of time their coexistence with the Istrian one, was totally replaced by the latter ones in the whole *Cisalpina*, from the second half of the 1st century AD. Similarly, the North-Italic wine production seems to have had a very short life span, coinciding with the Augustan age, when it juxtaposed the imports from the *Picenum* and the Mid-Adriatic area, which will be back as almost exclusive from the Tiberian-Claudia age.

Silvia Cipriano

Bibliography

AURIEMMA, R. & DEGRASSI, V. (2015), Flussi di circolazione e redistribuzione in Adriatico tra tarda Repubblica e Impero: anfore da contesti terrestri e subacquei. In: AdriAtlas et l'histoire de l'espace adriatique du VIe s. a.C. au VIIIe s. p.C. Actes du colloque international de Rome, Novembre 2013, Bordeaux, 453-478.

BEZECZKY, T. (1998), The *Laecanius* Amphora Stamps and the Villas of Brijuni, Wien.

BEZECZKY, T. (2001), The chronology of the end of the *Laecanius* workshop. In: Carinthia Romana und die Römische Welt. Klagenfurt, 421-424.

BEZECZKY, T. (2014), The *Laecanius* Amphorae. In: LIPOVAC VRKLIAN, G., ŠILJEG, B., OŽANIC ROGULJIŽČ, I. & KONESTRA, A. (Eds.), Officine per la produzione di ceramica e vetro in epoca romana. Produzione e commercio nella regione adriatica. Atti del II colloquio archeologico internazionale, Crikvenica, ottobre 2011, Crikvenica, 241-257.

BRANCHESI, F. (2007), Note sulla diffusione della serie anforica L. SALVI. Picus. Studi e ricerche sulle Marche nell'antichità. XXVII, 238-244.

BRECCIAROLI TABORELLI, L. (1984), Una produzione di anfore picene ed il vino palmense. Picus. Studi e ricerche sulle Marche nell'antichità. IV, 55-93.

BUCHI, E. (1973), Banchi di anfore a Verona. Note sui commerci cisalpini. In: Il territorio veronese in età romana, Atti del convegno, Verona, ottobre 1971,Verona, 531-637.

[39] There are also Dressel 6A coming from other areas, such as those with the stamps *Aneptes* and *Theodorus*, maybe from Central Italy (PESAVENTO MATTIOLI 2016).

BULIĆ, D. & KONCANI UHAČ, I. (2010), The pottery workshop at Fazana and its transformation the late roman period. Histria archaeologica. 41, 109-146.
CARRE, M.B. (1985), Les amphores de la Cisalpine et de l'Adriatique au début de l'Empire. Mélange de l'École Française de Rome. Antiquité. 97, 1, 207-245.
CARRE, M.B. & PESAVENTO MATTIOLI, S. (2003), Tentativo di classificazione delle anfore olearie adriatiche. Aquileia Nostra. LXXIV, 453-476.
CARRE, M.B., MONSIEUR, P. & PESAVENTO MATTIOLI, S. (2014), Transport amphorae Lamboglia 2 and Dressel 6A: Italy and/or Dalmatia? Some clarifications. Journal of Roman Archaeology. 27, 417-428.
CIPRIANO, S. (2003), Il consumo di derrate ad *Altinum* tra I secolo a.C. e II secolo d.C.: i dati dei contenitori da trasporto. In: Produzioni, merci e commerci in Altino preromana e romana, Atti del Convegno, Venezia dicembre 2001, Roma, Studi e ricerche sulla Gallia Cisalpina, 17, 235-259.
CIPRIANO, S. (2009), Le anfore olearie Dressel 6B. In CARRE, M.B. & PESAVENTO MATTIOLI, S. (Eds.), Olio e pesce in epoca romana. Produzione e commercio nelle regioni dell'alto adriatico. Antenor Quaderni 15. Roma, 173-189.
CIPRIANO, S. (2016), Anfore Lamboglia 2, Dressel 6A e Dressel 6B dal Piazzale della Cattedrale di Iulia Concordia: nuovi dati. In: BUORA, M. & MAGNANI, S. (Eds.), Le iscrizioni con funzione didascalico-esplicativa. Committente, destinatario, contenuto e descrizione dell'oggetto nell'instrumentum inscriptum. Atti del VI Incontro *Instrumenta inscripta*, Aquileia, marzo 2015. Trieste 2016, 145-158
CIPRIANO, S. & FERRARINI, F. (2001), Le anfore romane di *Opitergium*, Cornuda.
CIPRIANO, S. & MAZZOCCHIN, S. (2000), Considerazioni su alcune anfore Dressel 6B bollate. I casi di VARI PACCI e PACCI, APICI e APIC, P.Q.SCAPVLAE, P. SEPVLLI P.F. e SEPVLLIVM. Aquileia Nostra. LXXI, 149-192.
CIPRIANO, S. & MAZZOCCHIN, S. (2002), Analisi di alcune serie di anfore Dressel 6B bollate (AP.PVLCRI, FLAV.FONTAN e FONTANI, L.IVNI.PAETINI, L.TRE.OPTATI). Aquileia Nostra. LXXIII, 305-340.
CIPRIANO, S. & MAZZOCCHIN, S. (2004), La coltivazione dell'ulivo e la produzione olearia nella Decima Regio. Riflessioni su alcune serie bollate di anfore Dressel 6B alla luce delle analisi archeometriche. Aquileia Nostra. LXXV, 93-120.
CIPRIANO, S. & MAZZOCCHIN, S. (2011), Bonifiche con anfore a Padova: note di aggiornamento alla cronologia e alla distribuzione topografica. In: Tra protostoria e storia. Studi in onore di Loredana Capuis, Antenor Quaderni 20, Roma, 331-367.
CIPRIANO, S. & MAZZOCCHIN, S. (2016), Le produzioni di anfore adriatiche della *gens Iulia*. In MAINARDIS, F. (Ed.), 'Voce concordi'. Scritti per Claudio Zaccaria, Trieste, 217-246.
CIPRIANO, S. & MAZZOCCHIN, S. (2018), Sulla cronologia delle anfore Dressel 6A: novità dai contesti di bonifica della *Venetia*. Rei Cretariae Fautorum Acta 45, 261-271.
CIPRIANO, S., MAZZOCCHIN, S., MARITAN, L. & MAZZOLI, C. (in press), Le anfore Dressel 6B prodotte in area nord adriatica: studio archeologico e archeometrico di materiali da contesti datati. In: Recherches pluridisciplinaires récentes sur les amphores nord-adriatiques. Table Ronde Internationale, Bordeaux, avril 2016.
DELPLACE, C. (1993), La romanisation du *Picenum*: l'exemple d'*Urbs Salvia*. Collection de l'École Française de Rome, 177, Rome.
DE VECCHI, G.P., PESAVENTO MATTIOLI, S., FORNACIARI, E. & MAZZOCCHIN S. 1999, Analisi mineralogiche, chimiche e biostratigrafiche (nannofossili calcarei) per la determinazione di provenienza di un gruppo di anfore romane. In: D'AMICO, C. & TAMPELLINI P. (Eds.), Le scienze della terra e l'archeometria. Atti della V Giornata, Bari, febbraio 1998, Bologna, 46-50.
TASSAUX, F., MATIJAŠIĆ, R. & KOVAČIĆ, V. (Eds.) (2001), Loron (Croatie): un grand centre

de production d'amphores à huile istriennes (I^er-IV^e s. p.C.), Bordeaux.
MAIURO, M. (2012), *Res Caesaris*. Ricerche sulla proprietà imperiale nel Principato, Bari.
MARCHIORI, A., D'INCÀ, C. (2011), Le fornaci di Loron (Istria, Croazia). In: LIPOVAC VRKLIAN, G., RADIĆ ROSSI, I. & ŠILJEG, B. (Eds.), Officine per la produzione ceramica e vetro in epoca romana. Produzione e commercio nella regione adriatica. Atti del I colloquio archeologico internazionale, Crikvenica, ottobre 2008, Crikvenica, 83-90.
MARCHIORI, A., D'INCÀ, C. (2014), Le fornaci e il centro produttivo di Loron: nuovi dati, nuove riflessioni. In: LIPOVAC VRKLIAN, G., ŠILJEG, B., OŽANIC ROGULJIŽČ, I. & KONESTRA, A. (Eds.), Officine per la produzione di ceramica e vetro in epoca romana. Produzione e commercio nella regione adriatica. Atti del II colloquio archeologico internazionale, Crikvenica, ottobre 2011, Crikvenica, 127-139.
MARINI CALVANI, M. (1981), Un impianto produttivo romano a Sala Baganza. Per la Val Baganza, numero unico del Centro Studi della Val Baganza, 127-129.
MARION, Y., STARAC, A. (2001), Les amphores. In : TASSAUX, F., MATIJAŠIĆ, R. & KOVAČIĆ, V. (Eds.), Loron (Croatie): un grand centre de production d'amphores à huile istriennes (I^er-IV^e s. p.C.), Bordeaux, 97-125.
MAZZOCCHIN, S. (2013), Vicenza. Traffici commerciali in epoca romana: i dati delle anfore. Pulsar 1, Trieste.
MAZZOLI, C., MARITAN, L. & PESAVENTO MATTIOLI, S. (2009), Anfore da olio e anfore da pesce: le analisi archeometriche. In CARRE, M.B. & PESAVENTO MATTIOLI, S. (Eds.), Olio e pesce in epoca romana. Produzione e commercio nelle regioni dell'alto adriatico. Antenor Quaderni 15. Roma, 173-189.
MENCHELLI, S. & CIUCCARELLI, M.R. (2009), I depositi di anfore lungo il litorale fermano: nuovi dati per la produzione ed il commercio del vino piceno. The Journal of Fasti online (www.fastionline.org/docs/FOLDER-it-2009-132.pdf).
MERCANDO, L. (1979), Edificio rurale a Potenza Picena, a sud del Fosso Pilocco. Notizie degli Scavi di Antichità, 281-296.
PANELLA, C. (2010), Roma, il suburbio e l'Italia in età medio- e tardo-repubblicana: cultura materiale, territori, economie. Facta. A Journal of Roman Material Culture Studies 4, 11-123.
PESAVENTO MATTIOLI S. (1998), I commerci di Verona e il ruolo della via Postumia, un aggiornamento sui dati delle anfore. In: SENA CHIESA, G. & ARSLAN, E. (Eds.), *Optima Via*, Atti del Convegno internazionale di Studi Postumia. Storia e archeologia di una grande strada romana alle radici dell'Europa, Cremona, 311-327.
PESAVENTO MATTIOLI S. (2000), Anfore: problemi e prospettive di ricerca. In: BROGIOLO, G.P. & OLCESE, G. (Eds.), Produzione ceramica in area padana tra il II secolo a.C. e il VII secolo d.C.: nuovi dati e prospettive di ricerca, Mantova, 107-120.
PESAVENTO MATTIOLI, S. (2002), Una produzione norditalica di anfore bollate. In: Vivre, produire et échanger: reflets méditerranéens. Melanges offerts à Bernard Liou, Montagnac, 391-394.
PESAVENTO MATTIOLI, S. (2002-2003), Produzione e commercio del vino: un percorso di ricerca nella Valpolicella di età romana. Annuario Storico della Valpolicella, 103-116
PESAVENTO MATTIOLI, S. (2007), Aquileia e le anfore: lo stato della ricerca. In: CUSCITO, G. & ZACCARIA C. (Eds.), Aquileia dalle origini alla costituzione del ducato longobardo. Territorio - economia società. Antichità Altoadriatiche. LXV, 459-477.
PESAVENTO MATTIOLI, S. (2016), Anfore vinarie adriatiche bollate con data consolare. In: BUORA, M. & MAGNANI, S. (Eds.), Le iscrizioni con funzione didascalico-esplicativa. Committente, destinatario, contenuto e descrizione dell'oggetto nell'*instrumentum inscriptum*, Atti del VI Incontro *Instrumenta inscripta*, Aquileia 2015, Trieste, 91-99.
PESAVENTO MATTIOLI, S. & BUONOPANE, A. (2005), I rapporti commerciali tra Cisalpina

e Norico in età augustea. Il caso del vino norditalico. In: Die Geschichte der Antike aktuell: Methoden, Ergebnisse und Rezeption, Akten des 9. Gesamtosterreichischen Althistorikertages 2002 und der V. Internationalen Table Ronde zur Geschichte der Alpen-Adria-Region in der Antike, Klagenfurt, 175-185.

ROUSSE, C. (2011), Il sito di Loron (Istria, Croazia). L'organizzazione del complesso produttivo. In: LIPOVAC VRKLIAN, G., RADIĆ ROSSI, I. & ŠILJEG, B.(Eds.), Officine per la produzione ceramica e vetro in epoca romana. Produzione e commercio nella regione adriatica. Atti del I colloquio archeologico internazionale, Crikvenica, ottobre 2008, Crikvenica, 75-82.

STAFFA, A.R. (2003), Impianti produttivi d'età romana nel territorio della provincia di Pescara: le fornaci. Journal of Ancient Topography, Rivista di Topografia Antica XIII, 117-154

TONIOLO, A. (1991), Le anfore di Altino. Archeologia Veneta, XIV.

VAN LIMBERGEN, D. (2011), Wine and Oil Presses in Central Adriatic Italy between the Late Republic and the Early Empire. Evidence and Problems. Bulletin Antieke Beschaving 86, 71-94

VERMEULEN, F. (2003), The Potenza Valley Survey: Preliminary Report on Field Campaign 2002. Bulletin Antieke Beschaving 78, 71-106.

VERMEULEN, F., MONSIEUR, P. & BOULLART, C. (2002), The Potenza Valley Survey: Preliminary Report on Field Campaign 2001. Bulletin Antieke Beschaving 77, 49-71.

VERMEULEN, F., DE DAPPER, M., MUŠIČ, B., MONSIEUR, P., VERREYKE, H., CARBONI, F., DRALANS, S., VERHOEVEN, G., VERDONCK, L., HAY, S., STERRY, M., DE PAEPE, P. & DE SERANNO, S. (2009), Investigating the impact of Roman urbanisation on the landscape of the Potenza Valley: A report on Fieldwork in 2007. Bulletin Antieke Beschaving 84, 85-110.

Epilogue. Modelling Roman agricultural production: people, pots and power

Robert E. Witcher
Durham University

Throughout the late medieval and early modern periods, writers sought to explain the presence of a mountain of pottery sherds—a *mons manufactus*—on the bank of the River Tiber at Rome. One enduring interpretation can be traced back at least as far as Giovanni Cavallini's *Polistoria* of the mid fourteenth century: these ceramic sherds were the remains of vessels used to bring to the ancient city tribute from Rome's provinces and client kingdoms.[1] The hill therefore was a material manifestation of the city's imperial power, a monument to the emperors' ability to concentrate the wealth of the world at its centre. After almost 150 years of archaeological investigations, starting with Heinrich Dressel's excavations in the 1870s, we now know that Monte Testaccio is formed from millions of smashed amphorae filled originally, not with gold from Persia, but with green gold from Hispania: olive oil to feed and fuel the city's million-strong population. This 'unique archive', as José Remesal Rodríguez describes it, documenting the supply of a staple agricultural product to the city of Rome, is an appropriate place to begin this edited collection on the productive landscapes and trade networks of the Roman Empire. For more than simply waste packaging, these amphorae at the end of their life-histories have rich stories to tell about distant landscapes, about rural production and urban consumption, and about the complex technological, social and political organization needed to transport them thousands of kilometres across the Mediterranean. From Monte Testaccio, the other papers of this volume then spread out to consider case studies as far removed as coast of south-western Spain and the Dobrogea

[1] Donkin 2017.

in eastern Romania, and from Hadrian's Wall in Britain back to the heart of empire in the hinterlands of Rome and Pompeii. This epilogue draws out some of the key themes that emerge from these contributions and identifies some challenges and avenues for future research.

The volume, like the original conference session from which it derives, presents a diverse set of papers that demonstrate the richness and complexity of the evidence for agricultural production, trade and consumption in the Roman world. The authors make use of varied data sets, methods and theoretical models to interpret and evaluate the scale, organisation and significance of agrarian landscapes and the supply of urban and military markets. Central to many of the papers is the evidence of field survey: the collection of surface archaeological materials and the mapping of foci of activity across the landscape. In most cases, however, these data are supplemented with a variety of other sources including the study of stamps and *tituli picti* on amphorae and the texts of Roman authors, especially that of Columella who was probably born at Gades, the geographical focus of several of the contributions. Collectively, the papers also deploy a wide range of techniques from traditional urban topography through to GIS modelling and statistical analysis. This diversity of approaches is both a necessity and a strength of Roman archaeology and essential for dealing with the complexity and abundance of evidence. At the same time, the need to integrate these methods and their results is of growing importance due to the real challenges of dealing with the varied scales of analysis and levels of confidence involved.

Quantifying crops

At the heart of the volume are a set of six papers that make use of varied GIS applications to evaluate the productive potential and organisation of rural landscapes in Spain and Italy. Daniel Martín-Arroyo Sánchez and María del Mar Castro García evaluate the supply of willow and reeds sourced from wetlands (*riparia*) for viticultural use on estates in the territories of *Portus Gaditanus* and *Nabrissa Veneria*. Columella, like most agronomists, advocates self-sufficiency in such matters, but the authors' results demonstrate that, because *riparia* is unevenly distributed, sites had differential access to these resources. These results—like those of others reported here—highlight the discrepancy between ideal and reality but, more importantly, open up the potential for thinking about the economic relationships, and social dependencies, implicit in the uneven distribution of such resources.

Lázaro Lagóstena Barrios and Pedro Trapero Fernández also look to Columella in their examination of the territory between the Guadalquivir and Guadalete rivers, the hinterlands of the *municipium* of *Gades* and *colonia* of *Hasta Regia*. Using a set of topographical and environmental criteria, such as soils and solar insolation, the authors classify the landscape according to its agricultural potential, from best to worst. The results indicate that while only a small percentage of these urban territories falls into the category of the very best agricultural land, nevertheless, the distribution of known sites demonstrates that estates were able to produce for markets by locating in areas with access to a mix of resources, plus good communications and proximity to urban centres. Focusing down on the territory of *Hasta Regia*, José Antonio Ruiz, Lázaro Lagostena Barrios, Jenny Pérez Marrero, Domingo Martín Mochales, Pedro Trapero Fernández and Javier Catalán González also use GIS to examine the organisation of rural production, similarly identifying the uneven distribution of settlement in relation to natural resources. Their paper, however, moves on to wider questions, including the networks of movement between rural settlements, central places, ports and sacred spaces and even touches on the notion of the *cosmovisión*, or world view, of the inhabitants. Most important, however, is that the authors begin the process of integrating the rural evidence with

the urban, in the form of a georadar survey of part of the urban plateau, moving towards a holistic view of ancient civic space. Rural landscapes were linked to the wider world via local urban centres and their landowning families and market facilities. Whether or not these centres hosted production or processing activities, their administrative services and social infrastructure were essential for connecting local landscapes with the wider economy.

The paper by Helen Goodchild also makes use of GIS modelling of landscape suitability, drawing on ancient authors to calibrate variables such as sowing rates and yields. Here, she develops some of her earlier work on the productive potential of the hinterland of Rome by integrating data and methods used to evaluate modern-day farming. Drawing on a variety of resources developed for the planning and management of contemporary global agriculture, Goodchild works first at the scale of Italy, using criteria such as the availability of water to map the relative suitability of the peninsula for different crops and domestic animals. She then shifts focus to return to a small patch of the *ager Veientanus*, north of Rome, analysed in a previous study, to evaluate the performance of generalised models when applied at the local scale. This exercise produces the reassuring outcome that it is indeed possible to reproduce the original results, despite the shift in scale and the use of different variables. Significantly, however, this result also suggests that the original model, which used fewer and less complex variables, was just as effective as the new and more elaborate model. This raises the question of diminishing returns. It is tempting to add ever more parameters and variables into our models in the belief that this will make them better or more accurate, but this may not always be true. This result is a useful reminder of the need to evaluate our models and to focus attention on the most important aspects. Models, as Goodchild and a number of the other contributors emphasise, are not intended to be realistic, but rather to simplify reality so that real-world complexity can be understood.

Adopting a broadly similar approach to the previous contributors, Antoni Martín i Oliveras, Victor Revilla Calvo and José Remesal Rodríguez turn for their case study to the rich archaeological evidence of the Laetanian region on the Catalan coast. Their paper presents a particularly wide-ranging and comprehensive review of both the broader concepts and local data leading to the outline of an ambitious and all-encompassing model of Roman viticulture. This theoretical and methodological framework offers good potential for application to other wine-producing landscapes; it remains, nonetheless, a model of one specific sector of the Roman economy; from the Mediterranean coast, one only need travel a few kilometres inland to find a very different, and complementary, economic situation. Importantly, Antoni Martín i Oliveras, Victor Revilla Calvo and José Remesal Rodríguez introduce two fundamental issues: social and economic hierarchy—the diversity of sites and people represented by the 'dots' on our distribution maps—and, second, the explicit recognition of change through time—the temporal evolution of agricultural landscapes.

The final paper to adopt a modelling approach, by Florian Seiler, Sebastian Vogel and Domenico Esposito, deploys GIS methods to evaluate the agricultural exploitation of the Sarno river plain to the north and east of Pompeii. The quality of the evidence from the Vesuvian sites is enviable in many respects—but it also brings its own special challenges. In particular, the deep burial of ancient settlement, and the sprawl of modern development, means that the distribution of known sites is particularly patchy and additional work is needed to reconstruct the nature of the pre-AD79 landscape. Florian Seiler, Sebastian Vogel and Domenico Esposito characterise the locations and economic potential of settlements known through excavation, and then look to predict the locations of as-yet-undiscovered villas. Filling up the Sarno plain in this way demonstrates the economic potential of Pompeii's hinterland and contextualizes the evidence from the city for the processing and export of agricultural products. Of course, predictive models are only as good as the data used to

'train' them and this inevitably requires assumptions; for example, Florian Seiler, Sebastian Vogel and Domenico Esposito note a thin scattering of sites at higher elevations on the slopes of Vesuvius—are these traces of a more substantial occupation of these areas (underrepresented because archaeological work and accidental discoveries have focused closer to the city) or outliers of the main concentration on the plain? Not unreasonably, the authors assume the latter due to the limited availability of water on the volcano's slopes, but there is always the risk of circularity in such models. Nonetheless, a key result of the paper is the dense distribution of the modelled estates, mostly intervisible with their neighbours and only a few minutes' walk apart. As the authors rightly note, this has both economic and social implications including "a certain level of social control". Modelling agrarian landscapes is about much more than the quantification of crops.

Integration, connectivity and networks

All of these contributions, and the other papers in this volume, adopt case studies—specific urban hinterlands or individual monuments. Collectively, these raise issues of comparison, integration and scale. Firstly, how do we compare between these case studies to evaluate the similarities and differences? In some cases, the authors use generalisations of Roman agrarian organisation to interpret their specific contexts; does this risk homogenising the diversity of rural landscapes? Conversely, others concentrate on detailing the specifics of their case studies using bespoke methods, but how comparable are the results? Understanding the overall scale and organisation of the Roman economy requires the development of methods for rigorous comparison to draw out systematically the variability of rural landscapes. Above and beyond comparison, however, we also need theories and methods to advance the integration of these case studies. The individual urban hinterlands of Spain, for example, were connected to the demands of the city of Rome and the military frontiers. None of the papers here sets itself the impossibly ambitious task of addressing 'the' Roman economy, but all of their results are inevitably shaped by issues that extend far beyond the boundaries of any individual *territorium*. The decision to exploit certain soils or to plant particular crops was determined by a wider range of considerations than those experienced directly on the farm and amenable to modelling with environmental and climatological proxies.[2]

The paper by Silvia Cipriano and Stefania Mazzocchin, for example, points to the importance and potential of the integration of local case studies into wider models of the Roman economy. Like many of the other contributors, the authors concentrate on amphorae—this time, the Dressel 6A and 6B types from northern Adriatic Italy. Silvia Cipriano and Stefania Mazzocchin make use of an extraordinary assemblage of largely complete amphorae, preserved on account of their use as field drains (another reminder that amphorae could have useful lives after their original contents had been consumed). The authors are able to document relatively fine-grained shifts in the production and consumption of wine through the import and export of amphorae between the mid first century BC and the Flavian period. A brief window of local North Italic wine production during the Augustan age is particularly noticeable. During earlier and later phases, however, wine was imported from else, latterly from Picenum. The authors note the "impressive organization of production and marketing of wine" connected with the *gens Iulia* and imperial property in Picenum, but do not here investigate the mechanisms through which the economies of these two regions interacted and the consequent phases of expansion and contraction. It is these connections that allows this, and all the other case studies presented here, to contribute to wider debates about agricultural production and economy in the Roman world. These local cycles of growth and decline, opportunity and competition, animate

[2] E.g. Halstead 2014.

and articulate the wider Roman economy. The latter is often measured in terms of overall *per capita* growth, a single figure representing millions of lives and dozens of provinces, but it was in local rural landscapes that the variable effects of integration into the wider imperial economy—Roman globalization—were most visible and often most detrimental.[3]

The integration of the Roman economy also raises the theme of connectivity and the infrastructural and human networks that linked the producing and consuming regions of the Roman world. In terms of consumers, the two main groups that drove the long-distance supply of agricultural produce were the citizens of Rome and the soldiers of the imperial frontiers. In both cases, we can study the logistics of transporting oil from Baetica to Britannia or grain from the fields of Egypt to the Field of Mars—the ships, ports, routes, seasonality and journey times. It was, however, first and foremost social and political considerations that shaped such economic activities. Several papers directly address these issues. The central importance of Monte Testaccio has already been mentioned. The paper by José Remesal Rodríguez summarizes some of the results of 30 years' of excavation by researchers from CEIPAC and, in particular, the wealth of epigraphic evidence in the form of amphora stamps and *tituli picti*. Who and what, exactly, do these texts represent? Some scholars argue that the *tria nomina* stamps on Dressel 20 indicate the owners or managers of the *figlinae* that produced the amphorae; Remesal, however, argues that these individuals are, in fact, the oil producers. If correct, these stamps open up the interpretive possibilities as we connect not with the organization of pottery production, but rather with the agents and administration of the oil trade. This is the social network that created and directed the economic links between provincial producers and metropolitan consumers.

The other great consumer of the Roman world, the military, is the subject of the paper by Stephen Matthews. He uses the concept of 'service areas' around the Roman forts of the Dobrogea region, between the Danube and the Black Sea coast, to model the transport requirements for the supply of grain to the garrisons. Through quantification both of demand and of the costs of different transport methods (e.g. ox-wagon versus mule train), he is able to identify the cost-effectiveness of different supply arrangements. Matthews draws on a diverse range of sources to populate his model—from the Vindolanda Tablets to the Theodosian Code—illustrating the ingenuity required to patch together the evidence. The results indicate that mule-drawn wagons, as depicted on Trajan's Column, turn out to be the least efficient means of transporting bulky supplies. Matthews notes that this may reflect the different requirements of campaigning armies versus settled garrisons, but it may also indicate the role of display and propaganda—the conspicuous consumption of resources—and therefore the need for caution in combining very different sources of evidence. Matthews' models allow for the useful evaluation of different logistical solutions from least to most efficient; they cannot yet, however, demonstrate which of these options was used in reality. This does not invalidate the exercise for, as noted by Matthews and several of the other contributors, it is precisely the ability to make assumptions explicit and to evaluate the effects of changing variables that makes such modelling a valuable endeavour. The results, however, should not be confused with reality.[4]

Paul Gorton's paper also focuses on military sites but takes us to the post-Roman landscape of fifth-century Britain, by when not only Mediterranean imports of oil and wine had dried up, but even the use of wheel-thrown pottery and coinage. The communities based in the forts of the former Roman frontier, however, still needed to eat and Gorton examines the role of food supply to these

---

[3] Witcher 2017a.

[4] For another recent example of modelling of transport and supply on the frontiers, see Weaverdyck 2019.

sites in terms of the 'shaping of power'. By examining the archaeological evidence for continuity of activity and shifting attention to storage and prestige structures at each fort, Gorton identifies different strategies used by the communities of each site to sustain themselves as local centres of authority. Although a very different context from that of the other papers in this volume, the attention directed to the social and political aspects of food supply in this particular case study is a reminder of the importance of these considerations in relation to all ancient economic activity.

Big data and quantification

A key theme linking several of the papers is the use of quantification and modelling. This allows us, for example, to appreciate the scale of demand and its impact on rural landscapes or the organization of the distribution systems required to move foodstuffs. At the same time, however, it is noticeable that as we move into the context of post-Roman Britain, and the quantity of evidence declines, so too the use of quantification drops away. This raises an important question. Are quantification and modelling deployed in order to handle the 'big data' available from the Roman period or, specifically, because the organisation of the Roman economy is particularly suited to analysis with modern concepts and methods. As Goodchild notes in her chapter, just because something *can* be quantified does mean that it *should* be quantified. Formalist techniques of quantification and modelling present a veneer of objectivity but, like any method, may shape results and predispose us towards certain interpretations of them. Quantification, for example, tends to focus on abundant categories of evidence such as amphorae, which are readily translatable into proxies of 'commodities' such as oil and wine. But these goods formed only one sector of a much wider range of economic activity—including cereal cultivation and animal husbandry—and, moreover, wine, oil and ceramics were not exchanged and used solely under commercial conditions. We only need think of the diversity of social contexts in which objects such as Dressel 2-4 amphorae were used to appreciate that commercial exchange was only one form of economic activity.[5] Wine amphorae and terra sigillata tablewares may only have behaved as commodities—that is, goods interchangeable with other goods of the same type—for a brief part of their much longer life-histories—as drainage channels or burial containers, cheap crockery or markers of distant contacts and social status. In other words, the very abundance of some categories of material culture might lead us to use methods that emphasise scale, complexity and connectivity in ways that we would not for other periods. The use of modern economic models to discuss the Roman economy,[6] for example, contrasts with the ways in which we talk about the Etruscan, Phoenician or early medieval economies. Recently, Astrid Van Oyen has argued that formalist methods are predisposed towards modernist interpretations of the Roman economy;[7] the concepts and tools of the present-day economist make it difficult (though not impossible) to recognize primitivist tendencies because the methods assume autonomous profit-seeking individuals, looking to maximize returns through economically rational use of resources. As a result, such analyses of the Roman economy quickly turn to questions of growth, performance and prices, separating issues of economy from social power. The relative ease with which we can now quantify the Roman economy can make it easy to forget about the imperial authority, the colonial control, the military interventions and the political necessities, that shaped economic activity. In practice, theoretical and explanatory models of the Roman economy have advanced beyond the binary primitivist versus modernist, and substantivist versus formalist, dichotomies.[8] Our models

[5] Witcher 2017b.
[6] e.g. Jones 2014.
[7] Van Oyen 2017: 1357.
[8] e.g. Morris, Saller & Scheidel 2007.

therefore need to integrate people and power, information and institutions, as critical parameters in understanding the Roman economy. This involves developing more ambitious models that look beyond individual economic sectors characterized by the archaeologically prominent evidence for investment in specialist production, and the integration other economic sectors and the articulation of the structural links between them. How, for example, did viticulture in one region mesh with the agricultural production of neighbouring areas? Commercial wine estates worked by slaves required extra labour for the vintage; this could have been hired from local farms and villages with 'spare' labour or from nearby regions with capacity due to their different agricultural cycles. We have models to quantify wine production, but what component of a region's economic activity does this represent—in terms of land area, labour and wealth? How did this vary over time and how did the development of one region impact the development of another?

Finally, discussion of the role of labour is reminder that we should not to lose sight of the people—both collectively and as individual human agents—that underlie abstract concepts such as 'the economy'. Several of the papers emphasize the critical role of demography—or overall population size—in the organisation of agricultural production and the modelling of consumer demand. It is also important, however, to keep in mind the diversity of rural communities, looking beyond villa owners and their families to free, dependent and slave populations. The well-known difficulties of recognizing these groups archaeologically should not mean that they are neglected and the papers by Antoni Martín i Oliveras, Victor Revilla Calvo and José Remesal Rodríguez, and Florian Seiler, Sebastian Vogel and Domenico Esposito, and Helen Goodchild all hint at possible social dependencies in the rural landscape. Critical to developing this endeavour is the need to break the assumption that each rural site was at the centre of an independent estate operated along the lines of an idealized Catonian farm.[9] In turn, this opens the potential for more nuanced models of agricultural production that accommodate the variety of social and economic structural dependence.

The paper by Maria Coto Sarmiento, Simon Carrignon, Xavier Rubio-Campillo and José Remesal Rodríguez on the transmission of craft skills in the production of amphorae offers one example of how we can begin to think about the relationships between rural communities—in this instance, potters. Taking measurements of amphora rims from *figlinae* in Baetica, the authors use Principal Components Analysis to analyze slight variations in their forms and to relate these to models of skills transmission: vertical (i.e. without contact between *figlinae*) and horizontal (i.e. contact with other *figlinae*, declining with distance). Despite superficially appearing to be a highly standardized product, the authors identify systematic differences in the amphorae produced at individual workshops. They conclude that, initially, skills were transmitted vertically within individual *figlinae*, shifting to a horizontal model and the development of a wider network of potters that exchanged ideas and who moved to the nearby workshops to apply them. Approaches such as this permit insights into the human story of agricultural production and the communities of people that underpinned the Roman economy.

Coda

In contrast to the quantification and modelling techniques deployed by most of the other contributions to this volume, the paper by Andrea Guaglianone presents a more traditional topographical re-evaluation of the evidence for the location and form of the *porticus Minucia* at Rome. This detailed analysis of the rich but fragmentary archaeological, textual, epigraphic and antiquarian

[9] Witcher 2006.

sources is an example of the complex and specialist work that underpins so much of our knowledge of the ancient city and upon which synthetic accounts rely. More importantly, in the context of the present volume, this study of the *porticus Minucia* is a reminder that the supply of Rome involved not only the provision of efficient infrastructure for the transport and storage of foodstuffs—ports and granaries, roads and canals—but also the monumental display of the distribution of food to its citizens. We should not forget that Rome's population grew more or less to its greatest size well before the elaborate infrastructure of Portus was completed or the supply of Spanish oil began. As such, much of what we quantify—whether broken amphorae or the storage capacity of granaries—was not what was essential to supply the city with calories, but rather additional investment in the display of supply deemed necessary to the sustain the political regime.

And this brings us back to where we began, in Rome, with a mountain of sherds on the bank of the Tiber. A century and a half of archaeological research and 50 years of globalization have led us to an interpretation of Monte Testaccio, not as a monument to Rome's tributary empire, but rather as a monument to its complex and dynamic economy. Yet, whether understood as a statement of power or of economy, this 35m-high dump of broken amphorae remains a potent symbol of the city's ability to extract the wealth of distant landscapes to support its privileged citizens. The *mons manufactus* manifests both power and production, control and consumption. The Roman economy was a political economy.

Bibliography

DONKIN, L. (2017) ''Mons manufactus': Rome's man-made mountains between history and natural history (*c*. 1100–1700)', *Papers of the British School at Rome* 85, 171–204.

HALSTEAD, P. (2014) *Two oxen ahead: pre-mechanized farming in the Mediterranean*. Chichester.

JONES, D.W. (2014) *Economic theory and the ancient Mediterranean*. Malden (MA-USA).

MORRIS, I., SALLER, R.P. & SCHEIDEL, W. 2007. 'Introduction'. In *The Cambridge economic history of the Greco-Roman World*, eds. W. Scheidel, I. Morris & R.P. Saller. Cambridge, 1–12.

VAN OYEN, A. (2017) 'Agents and commodities: a response to Brughmans and Poblome (2016) on modelling the Roman economy'. *Antiquity* 91, 1356–1363.

WEAVERDYCK, E.J.S. (2019) 'The role of forts in the local market system in the Lower Rhine: towards a method of multiple hypothesis testing through comparative modelling'. In *Finding the limits of the limes: modelling demography, economy and transport on the edge of the Roman Empire*, eds. P. Verhagen, J. Joyce & M.R. Groenhuijzen, Cham, 165–190.

WITCHER, R.E. (2006) 'Agrarian spaces in Roman Italy: society, economy and Mediterranean agriculture', *Arqueología espacial (Paisajes agrarios)* 26, 341–359.

WITCHER, R.E. (2017a) 'The globalized Roman world'. In *The Routledge Handbook of globalization and archaeology*, ed. T. Hodos, Abingdon, 634–651.

WITCHER, R.E. (2017b) 'The global Roman countryside: connectivity and community'. In *The economic integration of Roman Italy: rural communities in a globalizing world*, eds. T.C.A. de Haas & G.W. Tol, Leiden, 28–50.

INSTRUMENTA

http://www.publicacions.ub.es/coleccion.asp?col=INSTRUMENTA

Colección de Historia Antigua.
Dpt. Història i Arqueologia
Facultat de Geografia i Història
Carrer de Montalegre, 6-8
08001 Barcelona, SPAIN
Tel. +34 93 403 75 57
Fax +34 93 403 75 41
http://ceipac.ub.edu
http://publicacions.ub.edu

Política editorial / *Editorial policy*

La colección *Instrumenta* publica obras sobre historia de la Antigüedad clásica que se signifiquen por el valor científico de sus aportaciones. El objetivo es promover la investigación y la divulgación de los resultados en ese campo del conocimiento, con una especial atención al mundo académico y profesional. Instrumenta sólo publica estudios inéditos y originales, tanto desde el punto de vista metodológico como teórico. Se dará preferencia a los estudios de síntesis frente a los analíticos. Los originales se publicarán en cualquiera de las lenguas científicas habituales en el ámbito de la historia antigua y la arqueología clásicas.

The Instrumenta collection publishes works about the history of classical Antiquity that are significant for the academic value of their contributions. The objective is to promote research and the dissemination of the results in this field of knowledge, paying special attention to the academic and professional world. Instrumenta publishes original unpublished studies only, from both the methodological and theoretical points of view. Preference will be given to synthesis studies as opposed to analytical ones. The originals will be published in any of the habitual academic languages in the sphere of ancient history and classical archaeology.

Presentación de originales / *Submission of originals*

Las propuestas editoriales pueden dirigirse al siguiente correo electrónico: **remesal@ub.edu**. En caso de que las propuestas editoriales se envíen a la dirección general de Edicions de la UB (**infopublicacions@ub.edu**), se remitirán a los responsables editoriales de la colección para que puedan valorarlas y comunicar su decisión. Los originales deben entregarse siguiendo los criterios especificados en las **normas de presentación de originales y las normas de estilo**, y han de ir acompañados de una descripción de la obra, así como de un breve currículum académico del autor o autores, donde deberá precisarse el nombre completo, el cargo institucional o la titulación, el lugar de residencia y el correo electrónico.

*Proposals for publication must be sent to the following email: **remesal@ub.edu**. If proposals for publication are sent to the Edicions de la UB general address (**infopublicacions@ub.edu**), they will be referred to the collection's heads of publishing so that they may evaluate them and inform authors of their decision. Originals must be submitted in accordance with the criteria listed in the **rules for the submission of originals and the style guide**, and they must be sent with an abstract describing the work, as well as a brief curriculum vitae of the author or authors, which must include his/her/their full name, institutional post or qualifications, place of residence and email address.*

Proceso de selección de los originales / *Selection process for originals*

Los originales son evaluados por expertos internos y externos a la Universidad de Barcelona, de acuerdo con la revisión por pares a doble ciego con el fin de asegurar el anonimato de autores y revisores. Una vez hecha la selección, el autor recibirá la respuesta de la dirección de la colección, tanto si la obra ha sido rechazada como si ha sido aceptada, y se le indicará, si procede, la posibilidad de reelaborar o replantear el original presentado para adecuarlo a los criterios editoriales de la colección, especificándose si los cambios son obligatorios u optativos. Si corresponde, el autor podrá volver a presentar el original, que será evaluado nuevamente. En el caso de aceptación de la obra, y si la dirección lo considera oportuno, la editorial contactará con el autor para comunicar la fecha prevista de publicación y facilitar los detalles pertinentes sobre el proceso editorial.

Originals are evaluated by in-house and external experts at the University of Barcelona in accordance with double-blind peer reviewing, in order to ensure the anonymity of authors and reviewers. Once the selection has been made, whether the work has been accepted or rejected, the author will receive a reply from the editor of the collection pointing out, if necessary, the possibility of rewriting or reworking the original submitted in order to adapt it to the collection's editorial criteria, and specifying whether the changes are obligatory or optional. Where appropriate, the author may re-submit the original, which will be assessed again. In the event of the work being accepted, and if the editor considers it appropriate, the publisher will contact the author to formalize the publishing contract and inform him/her/them of the planned publication date.

Normas de publicación
Rules for the submission of originals and style guide

Información general y de contacto / *General and contact information*

El texto deberá ser entregado tanto en papel como en soporte electrónico a:
The text must be submitted, in print and on a digital medium, to:
CEIPAC (Colección Instrumenta). Departamento de Historia i Arqueologia.
c/ Montalegre, 6-8
08001, Barcelona
tel. 0034 - 93.403.75.57
Universitat de Barcelona
remesal@ub.edu ó **antonioaguilera@ub.edu**

Caja de edición, márgenes y columnas / *Page box, margins and columns*

Los márgenes de la publicación son de 25 mm en el lado superior, 35 mm en el inferior, 25 mm en interior y 30 mm en el exterior. Las columnas tienen una separación de 12 mm.
No es imprescindible para el autor ajustar el texto a esa caja, si bien debe tener en cuenta que tablas e ilustraciones deberán quedar enmarcadas en estos márgenes (ya sea en formato vertical o apaisado), no siendo aceptadas las que los excedan.
The margins of the publication must be: top, 25 mm; bottom, 35 mm; inner, 25 mm, and outer, 30 mm. The columns must be 12 mm apart.
It is not essential for authors to fit the text into this box, although they must bear in mind that tables and illustrations have to be framed within these margins (in either vertical or oblong format) and those that stick outside them will not be accepted.

Uso de fuentes / *Use of fonts*

La fuente utilizada por defecto es la **Times New Roman** (11pt). Para los textos griegos el texto deberá ser entregado en Unicode, para mantener la uniformidad de la obra. Solamente en casos excepcionales, por extensión del texto, etc. estará contemplado el uso de otras fuentes. En estos casos deberá usarse las fuentes **Graeca** o **SGreek**, que pueden descargarse en esta misma página.
Está permitido el uso de otro tipo de fuentes (ibéricas, hebreas, etc.) siempre que no pueda usarse Unicode. En estos casos, éstas deberán ser entregadas también como archivo adjunto vía e-mail.
The default font used is Times New Roman (11-point). Greek texts must be sent in Unicode, to maintain the uniformity of the work. Only in special cases (due to the length of the text, for example), will the use of other fonts be considered. In these cases Graeca or SGreek fonts must be used.
The use of other font types is permitted (Iberian, Hebrew, etc.) whenever Unicode cannot be used. In these cases, they must also be sent as an attached file via email.

Divisiones internas / *Internal divisions*

Dentro de un capítulo están previstas divisiones internas de diferente orden, indicadas en cada caso por un cuerpo de letra diferente y, si es necesario, la numeración correspondiente.

1. **Capítulo**
1.1. Subcapítulo
1.1.1. Parte
1.1.1.1. Apartado
1.1.1.1.1. Subapartado

En el caso de que existan dichas divisiones, el autor deberá especificar el título de las mismas para una mejor organización i comprensión del índice general.
Within a chapter internal divisions of a different kind are envisaged, indicated in each case by a different letter style and, if necessary, the corresponding numbering. Example:

1. **Chapter**
1.1. Subchapter
1.1.1. Part
1.1.1.1. Section
1.1.1.1.1. Subsection

If these divisions exist, the author must specify their titles for a better organization and understanding of the general table of contents.

Nombre del autor/-es (sólo para obras colectivas) / *Name(s) of the author(s) (collective works only)*
Nombre de pila y apellidos, sin abreviatura – excepto nombres compuestos. A continuación, centro al que se adscribe y/o grupo de investigación (en el caso de que corresponda).
First name and surname(s), unabbreviated (except compound names). Then, the centre to which he/she/they is/are attached and/or the research group (where applicable)

Ejemplo/*example*: J. Remesal Rodríguez
CEIPAC - Universitat de Barcelona

Uso de la cursiva / *The use of italics, bold and underlining*
La letra cursiva queda reservada para las palabras y nombres propios latinos o griegos, así como para palabras en un idioma extranjero, diferente al del resto del texto. No está previsto el uso de la negrita y el subrayado en el texto, excepto en los apartados y subapartados, siguiendo los criterios detallados anteriormente. Para un uso de los mismos, el autor deberá coordinarse con el responsable de maquetación que se le adjudique.
Italic lettering is reserved for Latin or Greek words and proper names, and for words in a different language to that of the rest of the text. The use of bold lettering and underlining is not envisaged in the text, except in sections and subsections, according to the criteria previously outlined. For their use, the author must coordinate with the person responsible for page layout that he is assigned.

Normas para la inclusión de imágenes / *Rules for the inclusion of images*
Las imágenes que deban incluirse en el texto deben entregarse por separado del mismo (CD-rom, datos adjuntos a un mensaje de correo electrónico). Deben ser de una definición igual o superior a 300dpi y en formato .TIFF. Cuando las imágenes no sean en color deberán estar en formato Escala de Grises. Los mapas y similares, deben ser en Blanco y Negro. El texto correspondiente al pie de fotografía deberá ser conciso y escueto. Deberá entregársele al responsable de maquetación los pies de imagen en un archivo Word o equivalente (.doc; .odt; .txt) a modo de lista, para posteriormente ser incluidos en el texto junto con las imágenes.
The images that have to be included in the text must be sent separately from it (CD-ROM or attached files in an email message). Their definition must be equal to or greater than 300 dpi and in .tiff format. When images are not in colour they must be in greyscale format. Maps and the like must be in black and white. The text corresponding to the photo caption must be concise and succinct. Photo captions must be sent to the person responsible for page layout in a Word file or equivalent (.doc, .odt, .txt) in list form, to later be incorporated into the text along with the images.

Ejemplos/*examples*:
Figure 1. Carte minière de l'Hispania antique (C. Domergue *del.* 2008).
Figure 2. Carte minière de la Gaule antique (C. Domergue *del.* 2008).

Normas para índices temáticos / *Rules for thematic indexes*
Los índices temáticos se colocarán al final de la obra, e incluyen cuatro categorías: **Fuentes Antiguas** (diferenciando entre literarias, epigráficas y papirológicas), **Personajes Antiguos**, **Topografía** y de **Materias** o palabras clave, siempre que correspondan. Si fuera necesario incluir alguna categoría adicional, rogamos pónganse en contacto con el responsable de maquetación. El autor debe hacer llegar una lista con las palabras que desee indexar por cada uno de esos ítems. Para las **obras individuales**, el idioma principal será el idioma de referencia de la obra. En el caso de que se trate de una **obra colectiva** con participaciones en diferentes lenguas, se elegirá como idioma principal la lengua elegida por el editor. El indexado en estos casos se hará en base a los siguientes criterios:
a) En el caso de topónimos y palabras latinas, para facilitar el uso del índice por parte de lectores en el máximo número de idiomas posibles, se usará como idioma de referencia el latín.
b) En el caso de palabras en griego, se transliterarán al alfabeto latino.
c) En caso de palabras en varios idiomas, la referencia al número de página irá en la entrada correspondiente al idioma principal, mientras que en el resto de variantes, se hará llamada a la entrada en el idioma principal.
Thematic indexes will be placed at the end of the work, and they include four categories: Ancient Sources (differentiating between literary, epigraphic and papyrological), Ancient Personages, Topography and Subjects or Keywords, provided that they correspond. If it were necessary to include an additional category,

please contact the person responsible for page layout. The author must send a list of the words that he/she wishes to index for each of these items. For individual works, the main language will be the work's language of reference. In the event of a collective work with contributions in different languages, the language indicated by the editor will be chosen as main language. In these cases the indexing will be done based on the following criteria:
a) In the case of place-names and Latin words, to make it easier for readers to use the index in as many languages as possible, Latin will used as the language of reference.
b) In the case of Greek words, they will be transliterated using the Latin alphabet.
c) In the case of words in different languages, the reference to the page number will go in the entry corresponding to the main language, while in the remaining variants, readers will be directed to the entry in the main language.

Ejemplos/*examples*: *Barcino* 35
Barcelona *vide Barcino*
Barcelone *vide Barcino*
barco 26
bateau *vide* barco
ship *vide* barco

Normas para las citas bibliográficas / *Rules for bibliographical citations*

La bibliografía deberá ceñirse a las obras citadas a lo largo del texto. En las monografías publicadas por Instrumenta el autor deberá incluir una bibliografía general, que se colocará al final de texto, siguiendo los criterios a continuación expresados. En las obras de carácter colectivo publicadas por Instrumenta la bibliografía irá en notas a pie de página, sin preverse inicialmente un listado bibliográfico al final de cada contribución ni al final del volumen.
The bibliography must keep to the works cited throughout the text. In the monographic studies published by Instrumenta the author must include a general bibliography, which will be placed at the end of the text, according to the criteria given below. In the collective works published by Instrumenta the bibliography will go in footnotes. A bibliographical listing at the end of each contribution or at the end of the volume will not initially be considered.

Citas de libros / *Citations of books*

Inicial del nombre del autor, punto, y apellido del autor (en versales), coma, título de la obra (en cursiva), coma, lugar de edición (en la lengua en que aparezca en dicha obra) y fecha de edición (sin estar separados por coma). Cuando exista más de un autor se harán separaciones por punto y coma.
Initial of the author's first name, full stop, author's surname, comma, title of the work (in italics), comma, place of publication (in the language in which it appears in the said work) and date of publication (not separated by a comma). Where there is more than one author, they will be separated by a semi-colon.

Ejemplo/*example*: M. Ponsich; M. Tarradell, *Garum et industries de salaison dans la Mediterranée Occidental*, París 1965.

Si se hace referencia a algunas páginas en especial, seguido del año: coma, indicación de las páginas (inicial y final, separadas por guion, sin abreviación "pp." o similares). Aunque también se puede hacer referencia indicando el número de página y la abreviatura siguiente/s, s. o ss., sin espaciado (ejemplo 76ss.):
If any particular pages are referred to, followed by the year: comma, indication of the pages (first and last, separated by a hyphen, without abbreviation "pp." or similar). Although they can also be referred to by indicating the page number and the following abbreviation(s), s. or ss., without spacing).

Ejemplo/*example*: M.ª R. Cimma, *Richerche sulle società di publicani*, Roma 1981, 56-59 (or 56ss.).

Si la obra pertenece a una colección, su nombre será escrito tras el título, en redonda y entre paréntesis (el número de volumen de la colección se pondrá tras la misma sin coma).
If the work belongs to a collection, its name will be written after the title, in roman and in brackets (the volume's number in the collection will follow it without a comma).

Ejemplo/*example*: A. Chausa Sáez, *Veteranos en el África romana* (Instrumenta 3). Barcelona 1997.

Artículos de revista / *Journal articles*

Inicial del nombre del autor, punto, apellido del autor (en versales), coma, título del artículo (en redonda), coma, nombre de la revista (en cursiva, si se desea se podrá abreviar según los criterios de *L'Année Philologique* o de la *Archäologische Bibliographie*), número, coma, año de edición, coma, y páginas (inicial y final, separadas por un guión, sin abreviación "pp." o similares)

Initial of the author's first name, full stop, author's surname, comma, title of the article (in roman), comma, name of the journal (in italics, if you wish it can be abbreviated according to the criteria of L'Année Philologique *or the* Archäologische Bibliographie*), number, comma, year of publication, comma and pages (first and last, separated by a hyphen, without abbreviation "pp." or similar).*

Ejemplo/*example*: W. Den Boer, Die prosopographische Methode in der modernen Historiographie der hohen Kaiserzeit, *Mnemosyne* 22, 1980, 260-270.

Obras colectivas / *Collective works*

Inicial del nombre del autor, punto, apellido del autor (en versales), coma, título del artículo, de la contribución o del capítulo (en redonda), coma, en:, inicial del nombre del editor, punto, apellido del editor (versales), título de la obra colectiva (cursiva), coma, lugar de edición (en la lengua en que aparezca en dicha obra) y fecha de edición (sin estar separados por coma), coma, indicación de las páginas (inicial y final, separadas por un guion, sin abreviación "pp." o similares). Cuando exista más de un autor o editor se harán separaciones por punto y coma.

Initial of the author's first name, full stop, author's surname, comma, title of the article, of the contribution or of the chapter (in roman), comma, "in:", initial of the editor's first name, full stop, editor's surname, comma, title of the collective work (italics), comma, place of publication (in the language in which it appears in the said work) and date of publication (not separated by a comma), comma, indication of the pages (first and last, separated by a hyphen, without abbreviation "pp." or similar). Where there is more than one author or editor, they will be separated by a semi-colon.

Ejemplo/*example*: J. Alvar, Los misterios en la construcción de un marco ideológico para el Imperio, en: F. Marco Simón; F. Pina Polo; J. Remesal Rodríguez (eds.), *Religión y propaganda política en el mundo romano* (Instrumenta 12), 71-81.

Casos especiales / *Special cases*

En caso de querer especificar una/s pagina/s en especial, se puede indicar mediante la abreviatura "esp." (especialmente) y la pagina/s en cuestión.

If it is wished to specify one or more pages in particular, this can be indicated by using the abbreviation "esp." (especially) and the page/s in question.

Ejemplo/*example*: J. Rougé, Transports maritimes et fluviaux dans les provinces occidentales, *Ktèma* 13, 1988, 87-93, esp. 90.

Cuando se cite una obra más de una vez, se repetirá el nombre del autor (en versales), seguido de una coma, las dos primeras palabras del título del artículo o libro, seguido de puntos suspensivos (...).

When a work is cited more than once, the author's name will be repeated, followed by a comma, the first two words of the title of the article or book, followed by an ellipsis "...".

Ejemplos/*examples*: J. Rougé, Transports maritimes..., 91-93.
J. Alvar, Los misterios en la construcción..., esp. 74ss.

Cuando se repita una cita en dos notas consecutivas deberá utilizarse la fórmula ***Ibid***. o ***Idem***., cuando corresponda, en cursiva, seguido de la página.

When a citation is repeated in two consecutive notes the formula "Ibid." or "Idem" must be used, where appropriate, in italics, followed by the page.

Ejemplos/*examples*: *Idem*. 91-93
Ibid. 74ss.

Normas para las citas de autores clásicos / *Rules for citing classical authors*

Para la cita de autores griegos se utilizarán los criterios del diccionario ***Greek-English Lexicon*** de Liddel-Scott. Para los autores latinos, se utilizarán los criterios del ***Oxford Latin Dictionary***. Se señalarán los libros y capítulos como corresponda, ajustándose a las obras antes mencionadas. Cuando se sucedan dos citas o más de un mismo autor y libro se separarán por punto y coma.

To cite Greek authors the criteria of Liddell & Scott's Greek-English Lexicon will be used. For Latin authors, the criteria of the Oxford Latin Dictionary will be used. The books and chapters will be indicated appropriately in accordance with the aforementioned works. When two or more citations from the same author and book are stated, they will be separated by a semi-colon.

Ejemplos/*examples*: Hom. *Od.* 9.266-271.
Serv. *Aen*. 1.6.
Arr. 4.22.4; 5.3.2.

TÍTULOS PUBLICADOS

1. VÍCTOR REVILLA CALVO, *Producción cerámica y economía rural en el Bajo Ebro en época romana. El Alfar de l'Aumedina, Tivissa (Tarragona)*, 1993.

2. JOAN RAMON TORRES, *Las ánforas fenicio-púnicas del Mediterráneo central y occidental*, 1995 (AGOTADO).

3. ANTONIO CHAUSA SÁEZ, *Veteranos en el África romana*, 1997.

4. PIERO BERNI MILLET, *Las ánforas de aceite de la Bética y su presencia en la Cataluña romana*, 1998.

5. CÈSAR CARRERAS MONFORT y PEDRO PAULO A. FUNARI. *Britannia y el Mediterráneo. Estudios sobre el abastecimiento de aceite bético y africano en Britannia*, 1998.

6. JOSÉ M.ª BLÁZQUEZ MARTÍNEZ y JOSÉ REMESAL RODRÍGUEZ (eds.). *Estudios sobre el Monte Testaccio (Roma) I*, 1999.

7. JOSEP A. REMOLÀ VALLVERDÚ, *Las ánforas tardo-antiguas en Tarraco (Hispania Tarraconensis)*, 2000.

8. CÈSAR CARRERAS MONFORT, *Economía de la Britannia Romana: La importación de Alimentos*, 2000.

9. GIULIA BARATTA, *Il culto di Mercurio nella Penisola Iberica*, 2001.

10. JOSÉ M.ª BLÁZQUEZ MARTÍNEZ y JOSÉ REMESAL RODRÍGUEZ (eds.). *Estudios sobre el Monte Testaccio (Roma) II*, 2001.

11. LÁZARO LAGÓSTENA BARRIOS, *La producción de salsas y conservas de pescado en la Hispania Romana*, 2001.

12. FRANCISCO MARCO SIMÓN, FRANCISCO PINA POLO y JOSÉ REMESAL RODRÍGUEZ (eds.). *Religión y propaganda política en el mundo romano*, 2002.

13. LUÍS AMELA VALVERDE, *Las clientelas de Cneo Pompeyo Magno en Hispania*, 2002.

14. JOSÉ M.ª BLÁZQUEZ MARTÍNEZ y JOSÉ REMESAL RODRÍGUEZ (eds.), *Estudios sobre el Monte Testaccio (Roma) III*, 2003.

15. DESIDERIO VAQUERIZO GIL, *Immaturi et innupti. Terracotas figuradas en ambiente funerario de Corduba, colonia patricia*, 2004.

16. FRANCISCO MARCO SIMÓN, FRANCISCO PINA POLO y JOSÉ REMESAL RODRÍGUEZ (eds.), *Vivir en tierra extraña: emigración e integración cultural en el mundo antiguo*, 2004.

17. JOSÉ REMESAL RODRÍGUEZ (ed.), *Epigrafía anfórica*, 2004.

18. JUAN CARLOS MÁRQUEZ VILLORA, JAIME MOLINA VIDAL, *Del Hiberus a Carthagonova. Comercio de alimentos y epigrafía grecolatina*, 2005.

19. ISAÍAS ARRAYÁS MORALES, *Morfología Histórica del territorio de Tarraco*, 2005.

20. MARTA GARCÍA MORCILLO, *Las ventas por subasta en el mundo romano: la esfera privada*, 2005.

continuación…

TÍTULOS PUBLICADOS

…continuación

21. FRANCISCO MARCO SIMÓN, FRANCISCO PINA POLO y JOSÉ REMESAL RODRÍGUEZ (eds.), ***Repúblicas y ciudadanos: modelos de participación cívica en el mundo antiguo*****, 2006.**

22. SANTIAGO MONTERO HERRERO, ***Augusto y las aves. Las aves en la Roma del Principado: prodigio, exhibición y consumo*****, 2006.**

23. MONZEF BEN MOUSSA, ***La production de sigillées africaines. Recherches d'Histoire et d'Arqueologie en Tunisie septentrionale et centrale*****, 2007.**

24. JOSÉ M.ª BLÁZQUEZ MARTÍNEZ y JOSÉ REMESAL RODRÍGUEZ (eds.), ***Estudios sobre el Monte Testaccio (Roma) IV*****, 2007.**

25. ABDELLATIF MRABET, JOSÉ REMESAL RODRÍGUEZ (eds.). ***In Africa et in Hispania: Études sur l'huile africaine*****, 2007.**

26. BORJA DÍAZ ARIÑO, ***Epigrafía latina republicana de Hispania*****, 2008.**

27. JOSÉ SALVADOR BAREA BAUTISTA, JUAN LUÍS BAREA BAUTISTA, JUAN SOLÍS SILES, JUAN MOROS DÍAZ, ***Figlina Scalensia: Un centro productor de ánforas Dressel 20 de la Bética*****, 2008.**

28. RUI ALMEIDA, ***Las ánforas del Guadalquivir en*** **Scallabis** ***(Santarém, Portugal). Una aportación al conocimiento de los tipos minoritarios*****, 2008.**

29. PIERO BERNI MILLET, ***Epigrafía anfórica de la Bética. Nuevas formas de análisis*****, 2008.**

30. FRANCISCO MARCO SIMÓN, FRANCISCO PINA POLO y JOSÉ REMESAL RODRÍGUEZ (eds.), ***Formae Mortis: El Tránsito de la vida a la muerte en las sociedades antiguas*****, 2008.**

31. JORGE MARTÍNEZ-PINNA NIETO, ***La Monarquía romana arcaica*****, 2009.**

32. JAVIER ANDREU PINTADO (ed.), ***Los Vascones de las Fuentes Antiguas. En torno a una etnia de la Antigüedad Peninsular*****, 2009.**

33. MANEL GARCÍA SÁNCHEZ, ***El Gran Rey de Persia: formas de representación de la alteridad persa en el imaginario griego*****, 2009.**

34. LLUÍS PONS PUJOL, ***La economía de la*** **Mauretania Tingitana** ***(s. I-III d.C.). Aceite, vino y salazones*****, 2009.**

35. JOSÉ M.ª BLÁZQUEZ MARTÍNEZ y JOSÉ REMESAL RODRÍGUEZ (eds.). ***Estudios sobre el Monte Testaccio (Roma) V*****, 2010.**

36. FRANCISCO MARCO SIMÓN, FRANCISCO PINA POLO y JOSÉ REMESAL RODRÍGUEZ (eds.), ***Viajeros, Peregrinos y Aventureros en el Mundo Antiguo*****, 2010.**

37. FERNANDO LOZANO GÓMEZ, ***Un dios entre los hombres. La adoración a los emperadores romanos en Grecia*****, 2010.**

38. LLUÍS PONS PUJOL (ed.), Hispania et Gallia***: dos provincias del Occidente romano*****, 2010.**

continuación…

TÍTULOS PUBLICADOS

…continuación

39. JORGE MARTÍNEZ-PINNA NIETO, *Las leyendas de fundación de Roma. De Eneas a Rómulo*, 2011.

40. FRANCISCO MARCO SIMÓN, FRANCISCO PINA POLO y JOSÉ REMESAL RODRÍGUEZ (eds.), *Vae victis! Perdedores en el mundo antiguo*, 2012.

41. DANIEL GÓMEZ CASTRO, *Relaciones internacionales y mercenariado griego: del final de la Guerra del Peloponeso a la Paz del Rey (404-386 a. C.)*, 2012.

42. PAUL JOHNSON, *Economic Evidence and the Changing Nature of Urban Space in Late Antique Rome*, 2012.

43. JULIÁN ESPADA RODRÍGUEZ, *Los dos primeros tratados romano-cartagineses. Análisis historiográfico y contexto histórico*, 2013.

44. PABLO OZCÁRIZ GIL, *La administración de la provincia Hispania Citerior durante el Alto Imperio Romano. Organización territorial, cargos administrativos y fiscalidad*, 2013.

45. FRANCISCO MARCO SIMÓN, FRANCISCO PINA POLO y JOSÉ REMESAL RODRÍGUEZ (eds.), *Fraude, mentiras y engaños en el mundo antiguo*, 2014.

46. FRANCISCO JOSÉ GARCÍA FERNÁNDEZ, ENRIQUE GARCÍA VARGAS (eds.), *Comer a la moda. Imitaciones de vajilla de mesa en Turdetania y la Bética Occidental durante la antigüedad (s. VI a.C. – VI d.C.)*, 2014.

47. JOSÉ Mª BLÁZQUEZ MARTÍNEZ y JOSÉ REMESAL RODRÍGUEZ (eds.), *Estudios sobre el Monte Testaccio (Roma) VI*, 2014.

48. EDUARD SHEHI, *Céramiques sigillées importées et productions locales à engobe rouge en Illyrie Méridionale et en Chaonie*, 2015.

49. GONZALO FONTANA ELBOJ, *Los orígenes del cristianismo en Asia Menor (a. 70-135): Textos e historia*, 2015.

50. YANN LE BOHEC, *Inscriptions de la cité des Éduens. Inscriptions sur pierre*, 2015.

51. JOAN OLLER, *El territorio y poblamiento de la Layetania interior en época antigua (ss. IV a.C.-I d.C.)*, 2015.

52. DANIEL MATEO CORREDOR, *Comercio anfórico y relaciones mercantiles en Hispania Ulterior (ss. II a.C. – II d.C.)*, 2016.

53. FRANCISCO MARCO SIMÓN, FRANCISCO PINA POLO y JOSÉ REMESAL RODRÍGUEZ (eds.), *Autorretratos: La creación de la imagen personal en la Antigüedad*, 2016.

continúa en la contracubierta…

TÍTULOS PUBLICADOS

continuación

54. GUSTAVO GARCÍA VIVAS, *Ronald Syme. El camino hasta "La Revolución Romana" (1928-1939)*. Prólogo de Anthony R. Birley, 2016.

55. JOSÉ REMESAL RODRÍGUEZ (ed.), *Economía romana. Nuevas perspectivas / The Roman economy. New perspectives*, 2017.

56. JORDI PRINCIPAL, TONI ÑACO DEL HOYO, MONTSERRAT DURAN, IMMA MESTRES (eds.), *Roma en la Península Ibérica presertoriana. Escenarios de implantación militar provincial*, 2017.

57. HELENA JIMÉNEZ VIALÁS, Carteia *y* Traducta. *Ciudades y territorio en la orilla norte del estrecho de Gibraltar (siglos VII a.C. – III d.C.)*, 2017.

58. JOSÉ CARLOS BERMEJO BARRERA, MANEL GARCÍA SÁNCHEZ (eds.), Δεσμοὶ φιλίας / *Bonds of friendship. Studies in ancient history in honour of Francisco Javier Fernández Nieto*, 2017.

59. MANEL GARCÍA SÁNCHEZ, MARGARITA GLEBA (eds.), Vetus textrinum. *Textiles in the ancient world. Studies in honour of Carmen Alfaro Giner*, 2018.

60. JOSÉ REMESAL RODRÍGUEZ, VÍCTOR REVILLA CALVO, JUAN MANUEL BERMÚDEZ LORENZO (eds.), *Cuantificar las economías antiguas: Problemas y métodos / Quantifying ancient economies: Problems and methodologies*, 2018.

61. DANIEL J. MARTÍN-ARROYO SÁNCHEZ, *Colonización romana y territorio en Hispania. El caso de* Hasta Regia, 2018.

62. MANUELA MONGARDI, Firmissima et splendidissima populi Romani colonia. *L'epigrafia anforica di* Mutina e *del suo territorio*, 2018.

63. JOSÉ REMESAL RODRÍGUEZ (ed.), Colonia Ulpia Traiana *(Xanten) y el Mediterráneo. El comercio de alimentos*, 2018.

64. FRANCISCO MARCO SIMÓN, FRANCISCO PINA POLO, JOSÉ REMESAL RODRÍGUEZ (eds.), *Xenofobia y racismo en el mundo antiguo*, 2019.

65. JOSÉ REMESAL RODRÍGUEZ, VÍCTOR REVILLA CALVO, DANIEL J. MARTÍN-ARROYO SÁNCHEZ, ANTONI MARTÍN I OLIVERAS (eds.), *Paisajes productivos y redes comerciales en el Imperio Romano / Productive landscapes and trade networks in the Roman Empire*, 2019.

EN PREPARACIÓN

MANEL GARCÍA SÁNCHEZ, RENATA S. GARRAFFONI (eds.). *Mujeres, género y estudios clásicos: un diálogo entre España y Brasil / Mulheres, gênero e estudios clássicos: um diálogo entre Espanha e Brasil*.

JOSÉ M.ª BLÁZQUEZ MARTÍNEZ (†), JOSÉ REMESAL RODRÍGUEZ (eds.), *Estudios sobre el Monte Testaccio (Roma) VII*.

European Research Council

GOBIERNO DE ESPAÑA · MINISTERIO DE CIENCIA E INNOVACIÓN

UNIVERSITAT DE BARCELONA
Edicions

www.publicacions.ub.edu

9 788491 682639