

Agricultural production and social change in the Bronze Age of southeast Spain: the Gatas Project

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This paper presents new data on agricultural production, the palaeoenvironment and social change during the Bronze Age of southeast Spain. The authors argue against the inference of irrigation as the basis for agriculture and relate the emergence of cereal monoculture to the extraction of surplus and the exploitation of human labour.

Key-words: southeast Spain, Bronze Age, agricultural production, irrigation, social change, Gatas

The site of Gatas is located in the foothills of the sierra Cabrera, on the southern edge of the basin of Vera, in the east of Almería province, southeast Spain (FIGURES 1–2). The hill on which the settlement is located occupies an area of about 1 hectare, and is naturally defended by vertical slopes on all but one side. It was discovered in 1886 by Louis and Henri Siret, who excavated Bronze Age structures and deposits, including burials, on the top of the hill (Siret & Siret 1887: 165–77). No further fieldwork has taken place at Gatas until almost exactly a century later. The settlement and funerary records of sites such as Gatas, El Argar and Fuente Alamo within the Vera basin testify to the existence of stratified society in the late 3rd and early 2nd millennia BC (for details of sites, cultures and dating, see Chapman 1990; Castro *et al.* 1996). It is this record of social change which makes the Vera basin sites and sequence of wider importance in the study of the European Bronze Age.

Debate on the local origins of stratification has centred on the nature and role of Copper and Bronze Age production and on the degree to which the palaeoenvironment was different to the degraded, semi-arid one visible today in the Vera basin and other parts of lowland south-

east Spain. The link between production and environment is seen clearly in the debate over the existence, or not, of capital investment in irrigation and polyculture, and their role in enabling (by whatever means) agricultural settlement and social stratification. Central to this debate has been

- a an evaluation of the actual evidence for these practices (e.g. Chapman 1978; 1990),
- b different interpretations of the local climate in later prehistory (given existing palaeoenvironmental data) and the extent to which it determined particular productive practices (e.g. semi-arid climate — see Chapman 1978; 1990; Gilman 1976; Gilman & Thornes 1985; humid climate — see Lull 1980; 1983; Ramos 1981), and
- c contrasting ideas as to the role of agricultural production in social change (e.g. the adaptationist position of Chapman 1978, as opposed to the capital investment model of Gilman 1976, the complementary production model of Lull 1980; 1983, and the social storage model of Mathers 1984a; 1984b).

The main objective of the Gatas project is the evaluation of these models. This is to be achieved by the analysis of the successive oc-

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Received 15 March 1999, accepted 4 May 1999, revised 31 August 1999.

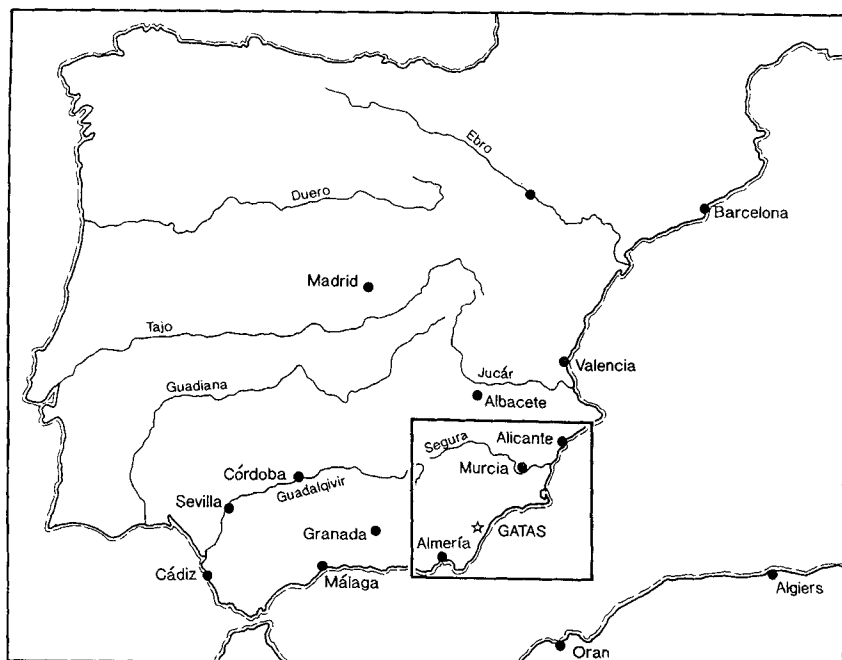


FIGURE 1. Location of Gatas in southeast Spain.

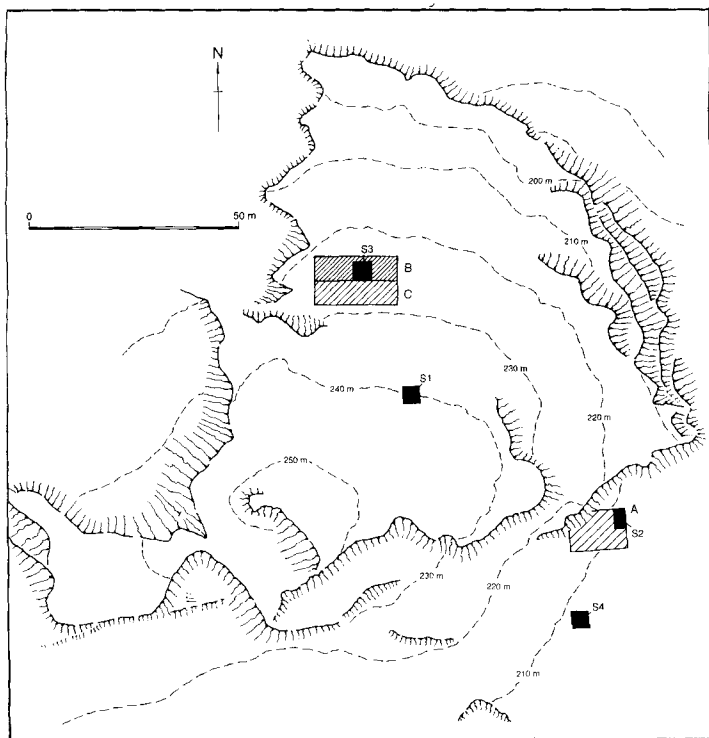


FIGURE 2. The location of modern towns, villages and prehistoric sites in the Vera basin mentioned in the text.

- 1 El Oficio.
- 2 Fuente Alamo.
- 3 Almizaraque.
- 4 Campos.
- 5 El Argar.
- 6 Gatas.
- 7 Las Pilas.

cupations at Gatas, within a context of critical evaluation of contemporary prehistoric settlements in the same region. Three phases of fieldwork began with archaeological and palaeoecological

survey in 1985 (Chapman *et al.* 1987), followed by sondage excavations in 1986–7 (Castro *et al.* in press a) and more extensive, area excavations in 1987, 1989, 1991 and 1995 (Castro

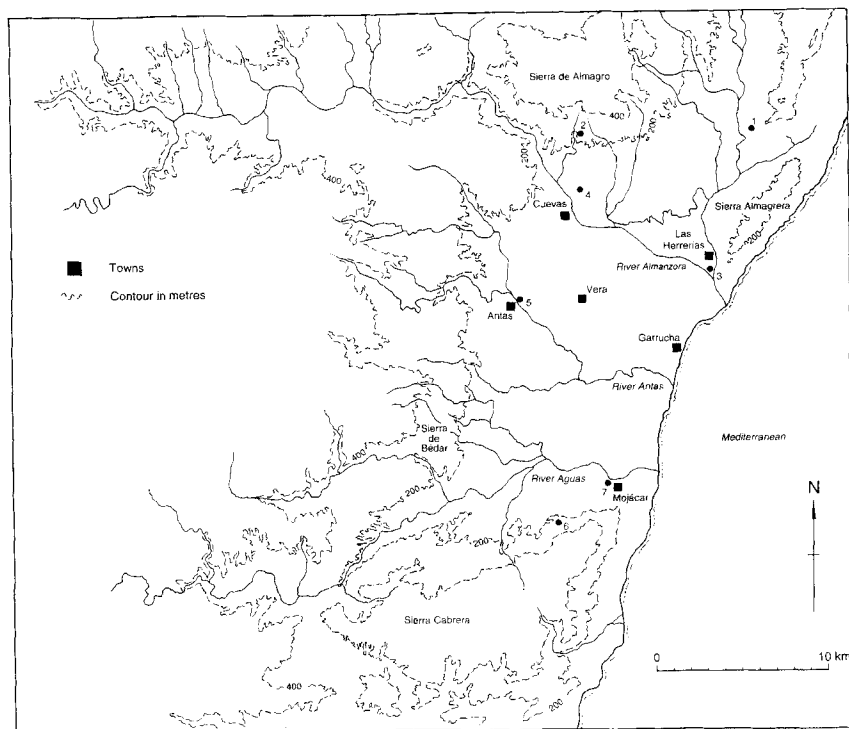


FIGURE 3. Plan of Gatas, showing Sondeos 1–4 and Zones A–C. Contours at 10-m intervals.

et al. 1991; 1993 in press b; Buikstra *et al.* 1995).

In the rest of this paper, we present data from Gatas principally on changing production during the Copper and Bronze Ages, developing the arguments proposed in an earlier paper (Ruíz *et al.* 1992). Most of this data comes from phase 2 of the project (Castro *et al.* in press a), although none of the data so far available to us from phase 3 in any way contradict our broad interpretation. Wherever possible, the Gatas data will be placed in a more regional context (for site locations, see FIGURE 2). The data are presented by radiocarbon-dated occupation phases at Gatas (see Castro *et al.* in press a).

Agricultural production at Gatas

Phase 1. Copper Age: c. 2850–2650 BC

The earliest occupation at Gatas consists of Copper Age lithics and pottery found in two areas of the hill, in S1 and Zone C (FIGURE 3). In neither case is there any trace of structures *in situ*, which, along with small sample size, restricts the weight that can be placed on this data. Nearly 90% of the plant remains consisted of one ce-

real, *Hordeum vulgare*, while the remainder consisted of legumes. Such a dominance of cereals over legumes, while based on a small sample at Gatas, is repeated at other Copper Age sites with larger samples, as for example at Almizaraque in the north of the Vera basin (Rivera & Obón unpublished). Animal bones are also present in small numbers (only 12.4% could be identified to species and body part, Castro *et al.* in press a) and include domesticated ovicaprids and pigs; the absence of bovids is attributed to the nature of the sample, given that they are present in other faunal assemblages in southeast Spain. Such evidence for agricultural production is not accompanied in this phase by the presence of grinding stones.

The location of Gatas, some 5 km inland from the coast, and at an altitude of 253 m, contrasts with sites such as Almizaraque, which have cultivable soils closer to hand. Along with other sites of both types, they were occupied in the Copper Age in a landscape with greater vegetation cover than at the present day: as shown by pollen from Gatas and Almizaraque, the denser

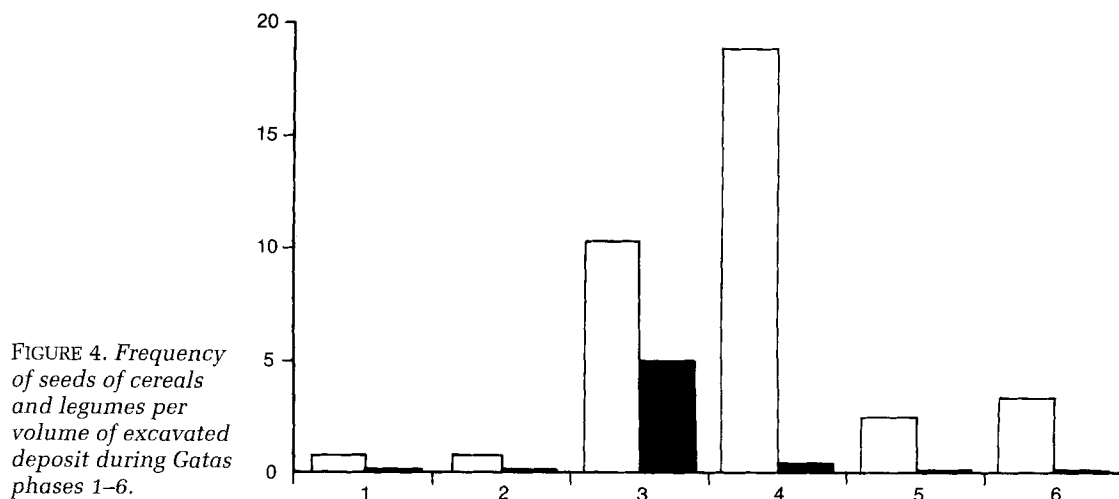


FIGURE 4. Frequency of seeds of cereals and legumes per volume of excavated deposit during Gatas phases 1-6.

river-side cover included deciduous species, indicative of greater local humidity related to higher water-tables and more running water.

Phase 2. Argaric Bronze Age: c. 2250-1950 BC

This is the first of 3 phases of the early Bronze Age group known after the type-site of El Argar, located c. 13 km to the north of Gatas in the middle of the Vera basin. This phase sees the abandonment of many low-lying Copper Age sites, with the emphasis now on more elevated settlements like Gatas, terraced into the foothills and using ovoid to rectilinear, rather than circular, structures. Other changes included individual intra-mural, rather than collective megalithic, burial, and a marked increase in metal production. Domestic and funerary evidence supports the inference of increasing social stratification during the phases of the Argaric (Lull 1983; Lull & Estévez 1986; Lull & Risch 1995).

As in the Copper Age, the plant and animal remains comprise small samples. The plant remains are dominated by cereals: whether identified to species or not, cereals add up to 97.6% of the assemblage from the sondages, with legumes comprising the remaining 2.4%. Identified wheat and barley occur in roughly equal percentages. The faunal assemblage is dominated by bovids and ovicaprids, together amounting to 90% of the total by weight. As in phase 1, grinding stones were absent.

Much the same vegetation cover is indicated as for the Copper Age, with species such as *Ulmus* and *Salix/Populus* growing in woods along riversides and more open, *maquia* veg-

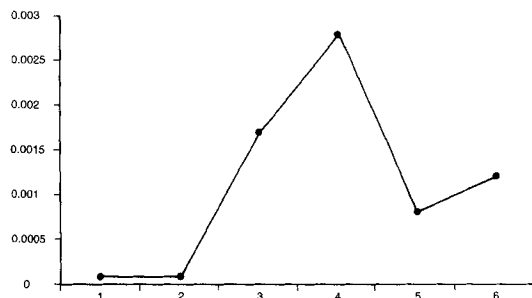


FIGURE 5. Frequency of grinding stones per volume of excavated deposit during Gatas phases 1-6.

etation, with areas of open evergreen woodland (*Pistacia*, *Olea*, *Pinus*, *Quercus*) away from rivers and streams.

Phase 3. Argaric Bronze Age: c. 1950-1700 BC

It is in phase 3 that sample size increases, with marked increases in the frequency of evidence for agricultural production, both on the hill of Gatas and in the deposits located at its southern foot. This phase is also marked by the first buildings with dry-stone foundations, replacing those built of upright posts in phase 2.

In addition to sample size, the range of plant food species also increases in phase 3. Although cereals still dominate the assemblage, their overall frequency is down to 69.5%, while leguminous species (especially *Pisum* and *Vicia*)

increase markedly. Among the identified cereals, *Hordeum vulgare* now dominated *Triticum* by a ratio of 11.4:1, and the barley was introduced 'clean' into the settlement. Other species identified in minimal numbers included *Ficus carica*, *Linum usitatissimum* (both in the fill of tomb 26), and *Vitis vinifera* (one seed).

Historical data from the Almanzora valley, in the north of the basin of Vera, show that dry farming (*secano*) of cereals, with a normal alternation of 3–4 years fallow for every year of cultivation, was practised successfully in the 18th century AD. Within the Aguas valley, close to Gatas, at the present day 91% of the cultivated area is for dry farming of cereals, predominantly barley (Capel & Pascual 1984). Indeed barley is not only the main crop cultivated today: it was also so in historic periods (Kleinpenning 1967; Martín Galindo 1975). It is known for its greater adaptability to arid and semi-arid conditions, its earlier maturity and its greater resistance to parasites. In contrast the water requirements of the legumes, and especially the beans (the quality of which declines significantly when cultivated in regions with less than 400–500 mm of rainfall, see Fornés 1983: 51–2), and the flax, suggest that these species were cultivated in conditions of water enhancement, near river courses and in areas with higher water tables or seasonal inundation. Peas and vetch are sensitive to lack of water during growth (García Romero 1941; Langer & Hill 1987), while flax requires annual precipitation of 400–750 mm and moderate to cool temperatures during growth. According to Martin & Leonard (1976: 798–9), high temperatures and drought lead to reduced yields, smaller sizes and poorer oil quality. The short root system of flax means that it is dependent on moisture within 60 cm of the surface. The habitats of some of the weeds of cultivation found in phase 3 (e.g. *Galium aparine*, *Euphorbia peplus*) also suggest some form of *huerta* cultivation.

This reconstruction of extensive barley cultivation and locally intensive *huertas* for legumes, flax and species such as *Brassica* is preferred to one of crop rotation. In addition to the data on known habitats and yields, the dominance of cereals over legumes at Gatas (as well as at Almizaraque and Fuente Alamo) argues against simple crop rotation, as do our calculations of the areas of land required for cultivation of these species in this (and later) periods of the Bronze Age (Castro *et al.* 1998;

in press a). Given the cultivation of the basin of Vera during the last 5000 years, we prefer a reconstruction of one year's cereal cultivation alternating with 1–2 years fallow, rather than the longer fallow practised in recent times.

The cultivation of pulses would have provided an important source of protein, and, in combination with cereals, would have given the inhabitants of Gatas most of the amino acids required for a healthy diet. At the same time it is worth stressing that not all of the pulses need have been consumed by humans: the case for the cultivation of vetch for animal feed, based on modern observations, has been made in Castro *et al.* (in press a) and by Halstead & Jones (1989). The benefits of pulse cultivation came at a cost, given their increased labour costs (e.g. weeding, hoeing etc., see White 1970: 191; Halstead & Jones 1989: 49), although these would also have been beneficial to flax, which is best grown away from weeds and after row crops or legumes (Martin & Leonard 1976: 803).

Although domesticated species dominated the faunal assemblage (ovicaprids, followed by bovids and pigs), the presence of species such as *Cervus* and *Felis sylvestris* indicates areas of Mediterranean woodland (dominated by olive, mastic, pine, kermes oak, etc.) surrounding the cultivated plots, while mountain goats would have lived higher in the sierra Cabrera.

The case for an increase in agricultural production in phase 3 is also supported by the increase in the frequency of seeds per volume of excavated deposit (FIGURE 4), and of grinding stones and other macrolithic tools (FIGURE 5). Charcoal and pollen evidence also testifies to increased clearance and increased exploitation of woody species.

Phase 4. Argaric Bronze Age: c. 1700–1500 BC

The last phase of the Argaric sees a further increase in agricultural production. Now the frequency of leguminous species declines to less than 2% of the plant foods, and barley dominates this cereal monoculture by a ratio of 114:1 over wheat. The absence of data from the excavated areas at the southern foot of the hill makes it difficult to decide whether primary processing/threshing of cereals took place here, or elsewhere, before being introduced to the settlement.

As with phase 3, we argue that this emphasis on cereal cultivation would have been based on dry farming, as again supported by some of the weeds of cultivation. The increase in produc-

tion (FIGURES 4–5) would have required clearance of larger areas for cultivation and for fallow periods of at least 2 years. The practise of opportunistic, continuous dry cultivation has also been observed in recent times when there is sufficient rainfall (Kleinpenning 1967). An increase in such clearance of *maquia* and Mediterranean woodland around, and at an increasing distance from, Gatas is supported by the charcoal species recovered. Pollen analysis supports this interpretation, with more clearance along the water-courses where the legumes would have been cultivated, and the increase of herbaceous plants characteristic of dry, waste or saline areas is also telling, as is the evidence for more degraded *maquia*.

Given this evidence, we argue that the model of stubble grazing proposed by Halstead for Neolithic Greece (1981; 1987) is also relevant in the lower Aguas. As in phase 3, ovicaprids are the most frequent of the domesticated animals and could have grazed on the fallow areas, fertilizing them at the same time. The fact that pigs were next in frequency is perhaps in contradiction to the picture of increased clearance of the low-lying woody areas by the side of rivers and streams, and would have required some feeding supplement. Cattle and horse may have been used for both traction and carriage, as well as for threshing crops.

These changes in phase 4 can be put into a broader context, not only of the preceding phases of the Argaric, but also of the lower Aguas as a whole. As far as the latter is concerned, two trends are important. First, the population of the lower Aguas may have doubled or tripled from the Copper Age to the Argaric, according to our calculations based on surface areas and agricultural production (Castro *et al.* 1998; Castro *et al.* in press c), while aggregating in a smaller number of settlements. Secondly, these settlements differed in size (up to 3 ha) and location (low-lying vs foothills around the basin) right across the Vera basin, but the relationship between settlement size and amounts of accessible cultivable land was not as expected (FIGURE 6): the larger settlements had less cultivable land within 2 km, suggesting that smaller settlements were linked to primary, agricultural production, while the larger sites received tribute from, and exercised politico-economic control over, the smaller, low-lying sites.

This agricultural production was marked by a 'take-off' during phases 2–4 at Gatas, if we compare the indices for frequency per volume

of excavated deposit for plant remains (FIGURE 4) with those for grinding stones (FIGURE 5) and lithic tools in general (FIGURE 7). This increase in production was even more marked at the contemporary site of Fuente Alamo in the north of the Vera basin (Stika 1988). In both sites the emphasis was on the cultivation of barley, and the smaller seeds at Fuente Alamo and El Argar support the inference of dry cultivation (Hopf 1991; Stika 1988). But while barley could give good yields under a system of dry farming, fallow and stubble grazing, the leguminous species are more likely to have been wet farmed in *huertas*, as argued for phase 3. Flax was also present at Fuente Alamo (as in other contemporary sites such as El Argar, La Bastida de Totana, and Zapata), comprising 30% of the seeds during the first two phases of occupation. The dominance of cereals:legumes on both sites also argues against crop rotation and in favour of our interpretation of extensive dry farming for cereals and localized horticulture for legumes at both sites. The existence of such horticulture is also suggested by the soil micromorphology analyses on deposits at the southern foot of the hill of Gatas (Castro *et al.* in press a).

While labour could be organized in relation to the sowing and harvesting regimes of cereals and legumes, the extension of dry farming, especially in Gatas 3–4, would have increased labour costs in getting to and from fields, as well as the costs of cereal processing, animal traction and the ability to provide adequate animal manure for fallow areas (*cf.* Gamble 1982). Reducing the period of fallow to enable more continued cultivation of existing fields would have led to rapid exhaustion of the soils. As it is, the marked increase and climax in exploitation of wood species from the *maquia* vegetation in phase 4 supports the argument for wider clearance to expand dry farming of barley. Lastly, it is worth noting that the grinding stones used at Gatas increased in frequency during phases 3–4, they were smaller in size than those known from contemporary sites such as Fuente Alamo and would have been less productive of flour. Thus the expansion of agricultural production in these phases depended more on human labour than on improvement in the productive technology.

Phase 5. Postargaric: 1500–1300 BC

This phase marks the beginning of the Later Bronze Age in southeast Spain, with the end

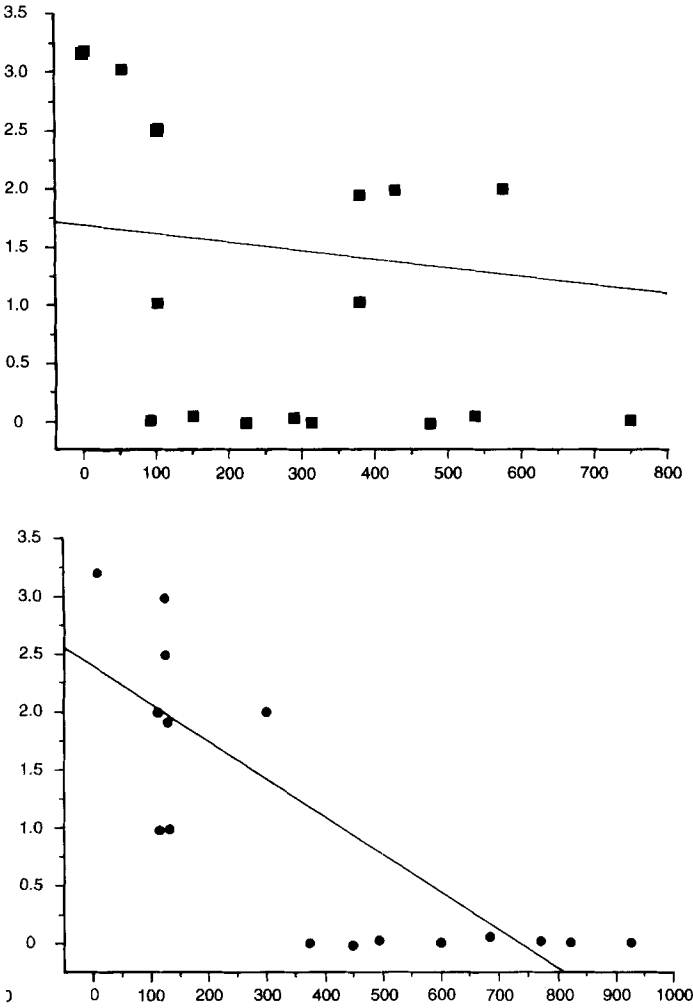


FIGURE 6. Relation of site size (vertical axis) to areas (horizontal axis) of dry (above) and wet (below) farming within 2 km of sites in the Vera basin.

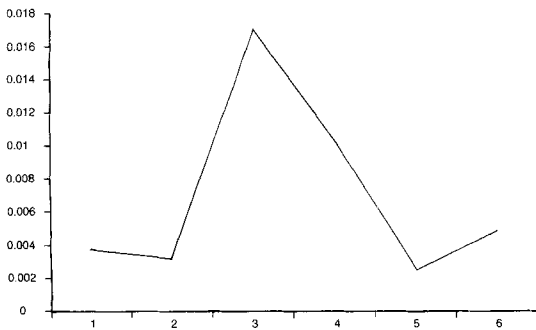


FIGURE 7. Frequency of lithics per volume of excavated deposit during Gatas phases 1-6.

of intramural burial among other changes. Cereals remain dominant among the plant remains, although the ratio of barley to wheat decreases to 8.6:1. While the remainder of the plant remains comprise only 1% of the total, the range of species is broader than in phase 4: they include species of legumes and flax, as well as *Vitis vinifera* and stones of *Olea Europea*, both in *sondeo* 2 at the southern foot of the hill. Once again we appear to be dealing with extensive dry farming of cereals and small patches of horticulture. The increased dietary range, along with the animal products, may indicate an improvement in diet and health over phase 4. A decrease in agricultural production is indicated (FIGURES 4-5). The presence of fragmented grinding stones with less maintained working surfaces suggests re-use from the Argaric occupation.

The charcoal assemblages from this phase are dominated by *Olea* and *Pistacea* (80% of the total), suggesting further clearance of the *maquia* vegetation at middle and low altitudes. The frequency of *Tamarix* charcoals also suggests the presence of saline soils in an increasingly steppe-like landscape. Overall the exploitation of timber resources is less than in the previous period (and more like that in phases 1–2), either as a result of decreasing demand or availability after the widespread clearance of phases 3–4.

Phase 6. Postargaric: c.1300–1000 BC

This is the last phase of occupation of Gatas for nearly two thousand years, and is part of a wider abandonment of settlements of Argaric origin in this area. Cereals dominate the plant remains with almost the same frequency as in phase 5, while the ratio of barley to wheat is also the same as in the previous phase. The range of species exploited decreased, and it appears that horticulture of leguminous and other species was abandoned. On the other hand, it is suggested that animal husbandry (mainly cattle) and hunting (deer) played an increasing role in subsistence.

Charcoals indicate the continued exploitation of the *maquia*, while pollen shows the final disappearance of the deciduous species which had been present along low-lying water courses since the beginning of the site's occupation. There are also indications of more arid conditions (see below).

Agricultural production and palaeoenvironment

The results of the excavations at Gatas permit the construction of a more detailed, and rather different, sequence of agricultural production during the Copper and Bronze Ages of this region of southeast Spain. Throughout this sequence we propose that such production was based on dry farming of cereals, predominantly barley, with leguminous species and flax being grown in horticultural plots in low-lying areas of higher water-table, seasonal inundation or (less likely) small-scale irrigation systems. The dry-farming regime was based on short fallow periods and stubble grazing by domestic livestock. There was a marked increase in agricultural production during the Argaric Bronze Age, in Gatas phases 3–4, c. 1500–1000 BC, focussing increasingly on barley monoculture

and associated with more widespread vegetation clearance. This began with the deciduous species in riverside habitats (which disappeared by the end of the 2nd millennium BC) and extended to the woody species of the *maquia* vegetation at increasing distances from the settlement. During the Postargaric phases of occupation (Gatas 5–6), agricultural production declined and diversified as the effects of the over-expansion of the Argaric system took effect on the surrounding landscape.

This emphasis on dry farming for cereals and small horticultural plots for legumes and flax is supported by the data from the contemporary site of Fuente Alamo, in the north of the Vera basin. Further, independent support is given by analyses of plant seeds from later prehistoric sites in southeast Spain for their carbon isotope discrimination values, which relate to their water status during growth (Araus *et al.* 1997a; 1997b): higher values (above 18%) indicate growth under conditions of irrigation, or in naturally wetter soils. The values measured on wheat and barley seeds do not support the inference of irrigation practices, but the mean values for *Vicia faba* beans were c. 1% higher than those for cereals. Two hypotheses are proposed for this pattern. Either the differences in values were the result of differences in growth patterns between beans and cereals, or the beans were selectively watered in small plots at some sites (as we propose for Gatas). Unfortunately grain samples were analysed from only two sites in the Vera basin (Las Pilas and Campos, both of Copper Age date), but their results support the main pattern.

Climatic inferences are also made from the results of these analyses. For example, the mean carbon isotope discrimination values for seeds from archaeological sites in the Baza and Guadix basins (located to the northeast of Granada) were higher than those modern crops which are dry-farmed in the same region, indicating a wetter climate in the 3rd and 2nd millennia BC. Calculations of the water regime during grain filling (Araus *et al.* 1997a: 735–6), and hence of precipitation values, also support this inference. Comparison of samples from southeast and northeast Spain show a trend towards aridity from the Neolithic to the Iron Age, but a further 41% decrease in precipitation from then until the present day in the southeast (as compared with a 12% decrease in the northeast).

Araus *et al.* (1997b) cite other studies which show steady decrease in precipitation in southern Spain from the late 19th to the mid 20th centuries, with a decrease of 150 mm in the annual precipitation of the Murcia region, c. 90 km to the north of the Vera basin.

Data on changing temperatures are harder to come by, but the Gatas project has again made an important contribution. Oxygen isotope analyses on 12 sea shells (*Glycimeris*) from stratified and dated contexts in three *sondeos* (Castro *et al.* in press a) show that the average annual sea-surface temperature was the same, or even slightly higher, at the beginning of the 2nd millennium BC (in phases 3–4) as at the present day. This temperature fell by 1°C from 1500–1300 BC (phase 5, Postargaric) and by a further 1.5°C from 1300–1000 BC (phase 6, Postargaric).

Overall, then, there is a wide range of data to support the existence of environmental degradation in the Vera. In addition to the new data cited in this paper, cores in the lower valleys of the Almanzora and Aguas rivers as well as historical and contemporary data on falling water tables show the extent of soil erosion and coastal advancement, and the more regular water flow which characterized the basin's rivers in the past (Hoffman 1988).

These changes in our knowledge of palaeoenvironments are important not only in themselves, but also in terms of our inferences on agricultural production in the 3rd and 2nd millennia BC. Earlier in this paper we noted the debate which has taken place on the relationship between agricultural production and the palaeoenvironment in southeast Spain. This debate focussed on the relationship between the semi-arid climate of the southeast and the use of irrigation technology. On the premiss that 'dry farming is not a viable subsistence strategy in the arid lowlands', Gilman & Thornes (1985:183) argued that 'it is presumably the development of hydraulic technology that made agriculturally based occupation of the coastal lowlands possible' (1985: 183; see also Chapman 1978; 1990). They supported this hypothesis by analyses of site location strategies to demonstrate the potential for wet farming.

This hypothesis is not supported by the new data from Gatas. We argue that irrigation was not a necessity for successful agricultural production in the coastal lowlands of southeast Spain. Cultivation in small horticultural plots was important for the successful production

of pulses (and the sources of protein therein) and flax, but was not used for the farming of cereals, which provided most of the dietary input. The potential for such horticulture varied between site locations, as was argued by Gilman & Thornes, but the extent to which that potential was exploited depended on social and political factors. The location of Gatas 'maximises hydraulic potential' (Gilman & Thornes 1985: 110) and is classified as 'wet farming' according to its potential land use, while Fuente Alamo is in a potential 'dry farming' location (Gilman & Thornes 1985: 103–5). The archaeological evidence suggests the practice of a comparable, predominantly dry-farming, subsistence during the Bronze Age occupations at both sites. In the case of Fuente Alamo, the small area of potentially irrigable land close to the site may have been sufficient for the small-plot horticulture discussed in this paper. At Gatas the area at the southern foot of the hill by the rambla de Charco (Castro *et al.* in press a; Ruiz *et al.* 1992: 23) and the irrigated land to the north of the site (the most fertile in the basin of Vera at the present day) may have been more than sufficient to meet the horticultural needs of its inhabitants. The full 'potential' of Gatas' location for 'wet farming' was not exploited during the Bronze Age.

The evidence for water conservation in prehistoric southeast Spain (see Chapman 1978; 1990: 125–7) appears to relate to domestic consumption (most notably in hilltop, defended Argaric settlements such as Fuente Alamo and El Oficio). The famous 'galleries' found by the Sirets at the eastern foot of Gatas alongside the Rambla del Charco could have been used for water storage (gallery no. 1) and for irrigation (gallery no. 2), but they are not securely dated, and formal similarities currently favour construction and use during the Arab occupation of the area in the early 2nd millennium AD (Castro *et al.* in press a). Evidence for prehistoric water diversion comes from three sites. Ditches filled with water-deposited sediments have been excavated at the Copper Age settlements of Cerro de la Virgen (in the interior uplands of eastern Granada, Schüle 1967) and Ciavieja (on the southern coast to the west of Almería, Carrilero & Suárez 1989–90). In the case of the latter, the two ditches were only used in the earliest phase of occupation (Final Neolithic), which would hardly be expected if irrigation was the basis of successful agricul-

tural production. The excavators argue that these ditches were for drainage purposes, although they do not explain why they ceased to be used. The case for water transport via an aqueduct into the settlement at Los Millares has been questioned recently by Capel *et al.* (1998), who argue that it was used neither for transporting water from nearby hot springs, nor for protecting such water from evaporation processes. Clearly there is little evidence here to support the widespread practice of irrigation to enable successful agricultural production. Even if the ditch at Virgen were used for irrigating crops, the questions arise as to why, and for whose benefit?

Alongside irrigation, the case for the practise of polyculture in the Copper Age and Argaric Bronze Age in southeast Spain (e.g. Gilman 1976; 1981) has not received support from the excavations at Gatas (nor at Fuente Alamo). Although we gladly admit the small sample size at present, the evidence for the exploitation of vines and olives increases at the end of the Argaric (phase 4) and in the Postargaric (phase 5) (Castro *et al.* in press a), and *not* at the beginning of the occupation sequence. Even then we do not believe that this necessarily constitutes 'polyculture'. Elsewhere claims have been made for cultivation of olives (Rodríguez Ariza & Vernet (1991) on the Copper Age site of Los Millares). But given the problems in distinguishing wild and cultivated species of olives and grapes (e.g. Terral 1996) no reliable evidence exists for the production and consumption of either olive oil or wine (rather than grape juice) in later prehistoric southeast Spain.

Conclusions

One of the substantive results of the Gatas project to date has been the demonstration of changes in the content and context of agricultural production during the 3rd and 2nd millennia BC. Situating Gatas within its regional context in the basin of Vera, we argue that the social exploitation of nature included a balance of ex-

tensive dry farming of cereals and localized horticulture for legumes and flax. During the period of the Argaric Bronze Age c. 2250–1500 BC agricultural production intensified, as well as narrowing to barley monoculture, in the context of increasing social stratification. Primary production sites in areas where cultivable land was more accessible became subject to the extraction of surplus by hilltop, defended settlements in which cereals were processed into flour (e.g. see Risch & Ruiz 1994: 84 for evidence from such settlements as Cabezo Negro, Fuente Alamo and Ifre of flour production beyond the needs of self-sufficient, domestic units; see also Risch 1995; 1998). This productive system had increasingly negative consequences both for the local environment, as the *maquia* vegetation was degraded, and for the organization of human labour and the health of local populations, as monoculture developed and was practised on poorer soils and at increasing distances from Gatas (and other contemporary settlements). In particular we argue that Argaric agricultural production depended on human labour rather than development of productive technology. The political drive to produce ever increasing agricultural surpluses could not be sustained as labour became more stretched and the environment became more degraded. Major changes in this political system took place, not surprisingly, at the end of the Argaric c. 1500 BC, by which time it has made a major contribution to the long-term degradation and desertification of the Vera basin.

Acknowledgements. The work of the Gatas project reported in this paper was funded by the National Geographic Society, the British Academy, the Society of Antiquaries of London, the Prehistoric Society and the Consejería de Cultura of the Junta de Andalucía, which also granted permits for excavation. We have drawn upon the work of the following specialists in the course of this paper: Rowena Gale, Sandra Montón, Alan Clapham, Martin Jones, Montse Tenas, Marie Agnes Courty, Nicolas Fedoroff and Christel Hagedorn. The illustrations were prepared by Steve Allen. We thank them all for their collaboration.

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