

10. Food for thought: what's next on the menu?

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Introduction

Classical studies of the Roman economy have tended to concentrate on the core area of the Empire and the supply of commodities to civilians (Garnsey 1988; Morley 1996; Rickman 1980) even though the professional armed forces probably consumed a major part of the Empire's economy (Garnsey and Saller 1987: 88–90; Whittaker 2004:88) with their food supply the main constituent cost (Groenman-van Waateringe 1997: 263). Since the military were usually deployed towards the peripheries of the Empire, in areas with fewer classical sources, archaeological data provide a major contribution to studies of the Roman military economy. This monograph has presented several case studies, which mainly concentrate on basic food supplies from plants and animals from a relatively small area of the Roman Empire: the north-western provinces. Foodstuffs, like many commodities, range from the essential (basic nutritional requirements) to the frivolous ('luxuries' or 'treats': see Van der Veen 2003).

Essential supplies required sustainable production and supply networks with a large capacity, whilst less fundamental supplies could tap into the established transport system and also exploit more opportunistic mechanisms. It may have taken some time to establish secure and reliable production and supply systems to active military zones, and geographical sources and modes of production may have changed with the economic, social and political fluctuations of the Empire. Can archaeological data detect these systems and their variations through time and space, and can we relate tangible remains with economic theories?

This paper has three main sections. Firstly, it considers why the supply of basic foodstuffs provided various challenges to the Romans in the past and why the study of these provisions challenges archaeologists in the present. It then reviews the contributions of the case studies in this monograph, highlighting areas that have been elucidated and areas that remain problematic or under-studied. Finally, it makes suggestions for improved working methods in studies of Roman military provisioning, and calls for *iterated* research that is more *interactive* and genuinely *interdisciplinary*.

Why are studies of foodstuffs and other natural resources a particular challenge? The case of the Roman army

The maxim '*An army marches on its stomach*' reflects the simple truth that soldiers need to be fed in order to survive. Troops can be garrisoned in camp and even go on campaign when ill-equipped with weaponry, but they cannot exist without food. Organising and ensuring a constant and adequate supply of foodstuffs, therefore, must have been a prime and constant concern of

military leaders and administrators (Bishop 1999: 111–112; Whittaker 2004: 12). Failure would have jeopardised military success and hence colonial and political power. Indeed, some authors (Fulford 1992: 302; Hanson 2002; Whittaker 1994) have suggested that ecological and logistical constraints of constantly supplying the army contributed to the geographical limitations of the Empire.

Unlike many inorganic resources and their manufactured products, the availability of foodstuffs is particularly time-dependent. All organisms (whether edible or not) take time to grow. Some, such as cereals, can grow in a few months and provide annual crops, although these are usually only available on a seasonal basis rather than all year round. Once obtained, some resources require processing (*e.g.* threshing of cereals) before they can actually be consumed. Others, such as livestock, may take several years before they attain their most desirable qualities, or may be required for diverse other products before their eventual slaughter and consumption. Timber, an important but non-edible natural resource, may take several decades if not centuries to reach optimal condition. Resources, therefore, had to be managed or conserved in the long term, or qualities and sustainability risked being compromised. Since the yields of agricultural resources (both plant and animal-based) can vary considerably from year to year due to many factors beyond people's direct control such as rainfall, warfare, disease and pests, it was important that a range of buffering mechanisms could be employed to maintain supplies in adversity (Halstead and O'Shea 1989). The geographical scale and diversity of the Roman empire made several mechanisms possible, including shipment from distant areas, although sometimes this must have incurred considerable costs. In contrast, whilst climate, geographical location and local ground conditions may have placed logistical constraints on the exploitation of some inorganic resources such as clay and mineral ores, these are permanently available in stable quantities and locations, are unlikely to deteriorate in quality and do not need to mature before they can be 'harvested'.

Another special aspect of foodstuffs that the army had to contend with is their shelf-life. Biological materials such as meat and vegetables are biodegradable; thus, prevention of their deterioration before consumption must have been a key consideration for military supply. Issues of concern would have included the speed of transport, storage qualities, and the suitability of different foodstuffs for preservation by smoking, drying, pickling or salting to prolong their edibility. An abundant harvest or fecund herds in one part of the Empire would have been no help for troops several hundred miles away if the cereals could not be kept dry and free from grain pests (Buckland 1978) or if the meat spoiled before it could reach the soldiers. Again, this temporal aspect, which is critical for food supplies, is far less relevant to inorganic materials such as ceramics and metalwork. All resources are also affected by the costs of transport (von Thünen: see Morley 1996) which might have outweighed the value of the commodity, and speedy transport would have been particularly expensive.

A third factor that would have affected the availability of food supplies, as well as many other organic and inorganic resources, is that sources were not evenly distributed. Environmental factors both facilitate and constrain what can be grown in different locations. Environmental determinism should be avoided, but it is true that different organisms thrive better in different combinations of soils, slope aspect, altitude, temperature, precipitation and daylight regimes. Mørch (1994) has calculated risks of crop failures in a specific part of Tunisia, for instance, and shown that some crops could not have been grown in this location to provide a reliable surplus for the army. Others (*e.g.* Hanson 2002: 29) have argued that the empire needed to maximise the productive quality of the land within its borders whilst benefiting from a suitable infrastructure

for its exploitation (Groenman-van Waateringe 1980; Whittaker 1994: 85–97). Several people (e.g. Fulford 1992: 300–302) have suggested that the large numbers of troops stationed in the northern European provinces were supplied with basic commodities including cereals from the Mediterranean (especially at times of conquest) although there is considerable uncertainty about just how much could have been (or was) produced locally. This topic is specifically addressed by some of the papers in this volume. Documentary sources certainly indicate that cereals were sometimes transported considerable distances (e.g. 300km) in north Africa, from producer to military consumer (Adams 1999:122).

Whilst food was an absolutely fundamental resource, military administrators had to contend with these three main restrictions on its availability: foodstuffs were not ubiquitously available in adequate and reliable quantities in the areas in which they were required; the provision of most resources necessitated forward planning to allow for considerable growing time and seasonal availability; and all resources had limitations on how long they were usable, although some shelf-lives could be extended by preservation techniques.

Why are studies of foodstuffs and other natural resources a particular challenge? The case of the archaeologists

Taphonomy

The biodegradation of organic remains provides a challenge for modern archaeologists in terms of the nature of the evidence that survives. Taphonomic studies emphasise the partially serendipitous preservation of plant remains through waterlogging, charring, mineral replacement, desiccation and freezing, and the human activities that crucially influenced site formation processes (see e.g. Evans and O'Connor 1999: chapters 6 and 7). Meat and dairy produce are more likely to survive as biomolecular residues than as tangible items, but egg shells and animal bones do have a good chance of surviving in most archaeological deposits (provided that the ground conditions are not too acidic; Lyman 1994). The low visibility of many organic resources (enhanced by the fact that the most successful food items are those that are completely consumed) has led some people to suggest that other, more durable materials such as ceramics could be used as markers of where food might have been in the past. Fulford (1984 but see also 1992) noted the long distance trade of Black Burnished pottery from the southern coast of England up to the military zone of Hadrian's Wall, and suggested that other, more perishable, items such as foodstuffs might have been contained within the pottery or have accompanied it on its trade routes (see Gerrard, this volume). Now that archaeologists are developing increasingly subtle ways of detecting and provenancing 'invisible' resources, we can begin to investigate their production and supply independently, permitting a more rigorous investigation of how different commodities related to each other.

Challenges common to all types of archaeological data

Most (if not all) types of archaeological evidence provide biased and incomplete data sets, although the organic nature of most foodstuffs means that they are particularly vulnerable to decay and destruction.

Just like the original food resources, the historical and archaeological evidence is not evenly distributed. Classical texts tend to refer to ideal practices in the geographical area around

Rome whilst papyri and ostraca are largely concerned with circumstances in North Africa and the Near East (*e.g.* Adams 2001; Bingen *et al.* 1992; Welles *et al.* 1959). Although wooden writing tablets such as those found at Vindolanda and Carlisle (both in northern England) and Vindonissa (Switzerland) describe many aspects of immense interest for north-west Europe, very few of these documents relate to normal food production and supply. Only about 20 out of 1500 Vindolanda tablets deciphered by 1993 refer directly to supplies (Whittaker 2004: 88) and many of these are for 'special' commodities rather than basic requirements (Pearce 2002), although the latest group of translations does include some more basic supplies (Bowman and Thomas 2003) as do some of the tablets from Carlisle (Tomlin 1998: 42–51). Similarly, archaeological evidence survives very patchily. Sometimes this is due to human influences such as: (i) the lack of excavation of relevant sites: for example, the native sites that might have produced food for the local troops garrisoned along the frontier of Hadrian's Wall in northern England have received little attention compared to the military installations themselves (Hall and Huntley 2007; Stallibrass 1995: 133–157); and (ii) poor recovery of relevant material (many of the early excavations of the military sites were undertaken before bulk sediment sampling for botanical remains became routine: Stallibrass and Huntley 1995: 202–204).

Challenges of our own making

In addition to the intrinsic problems of biodegradation, taphonomy and site formation processes, and the tendency for ancient writers to document and discuss what was important to them rather than what might be most important to archaeologists, archaeologists have created their own obstacles to comprehensive studies of existing data and the application of environmental evidence to economic theories. There are three main areas of malfunction and, although they are not restricted to environmental archaeology, these lines of enquiry are particularly susceptible.

Firstly, most post-excavation specialists are primarily concerned with one particular type of material (*e.g.* ceramics, chipped stone tools, plant macrofossils, animal bones). This need not create a problem but, unlike some specialists who may be able to concentrate their studies on a particular culture or time period (*e.g.* Romano-British ceramics), specialists trained in the identification and analysis of environmental remains are often obliged to work with material from any period or type of site that their funding organisations excavate. Although the specialists may be extremely experienced in terms of scientific techniques and site formation processes, they are unlikely to be equally familiar with the current hypotheses and existing information concerning all time periods and cultures. This relative ignorance can be mutual; for example, period- or theory-based archaeologists may be equally unaware of new developments and discoveries in environmental studies. Specialists are usually well aware of the limitations and biases of 'their' data and methodologies, but they cannot hope to be as well informed of these facets in other sub-disciplines. Suggestions often become entrenched as received wisdom and may be regarded as fact by people who do not have the means to test them. An example is the supposed tannery at Catterick, North Yorkshire: first suggested by Wachter in the 1960s and considered (*e.g.* Whittaker 2004:90) to have been confirmed by a reference (in Vindolanda Tablet II. 343: Bowman and Thomas 1994) to a wagonload of hides awaiting collection from Catterick. Re-evaluation of all of the available evidence, including industrial/environmental data, demonstrated that there was, in fact, no supporting evidence for a tannery at the site (Stallibrass 2002: 403–404; Wilson 2002: 53–54). Similar mistakes are made by environmentalists and other specialists attempting to relate their data to theoretical issues when they fail to appreciate the controversies, biases and

precise requirements relating to particular economic models (Saller 2001). More fundamentally, many environmentalists fail to engage at all with economic theories such as those of Finley (1999), Hopkins (1983) and Rostovtzeff (1957) despite the greatly increased value of data when theoretical stances are applied in synthetic reviews (Morley 1996).

Secondly, this situation is perpetuated when specialist reports are published as discrete sections or chapters in excavation reports: a practice that has been deplored for years but which continues to prevail (Cool 2006: 1–2). This is a particular waste of data and ideas if the main text fails to integrate the specialist findings, since non-specialists seldom read all (if any) of the detailed reports concatenated at the rear of publications.

The third malfunction concerns the lack of publication of environmental data. Many detailed reports are left as archive documents whilst the publicly available versions, for financial reasons, tend to summarise specialist findings. These archive and client reports are often termed ‘grey literature’ and the problem in Britain has reached a level where most of the recent regional archaeological research frameworks cite the practice as a major hindrance to progress (e.g. Brennand 2007:189–191). The problem is not restricted to any particular period, but English Heritage is currently funding the Roman Grey Literature project (Holbrook in prep.) to assess the scale of the problem and the potential of unpublished ‘grey’ material.

In summary, environmental specialists may be inadequately aware of theoretical considerations and comparable material; non-environmental archaeologists may be unaware of the potential value of environmental data to studies of past economies, and there is a large body of non-published data that needs to be synthesised and applied to theoretical considerations. These self-made problems are additional to the intrinsic biases in preservation and discovery of evidence noted above.

The contributions of these case studies: advances and persistent gaps

Introduction

The question: *How did the Roman army feed itself?* is deceptively simple, and subsumes many different, albeit inter-connected, lines of enquiry, three of which are considered here: production, logistics and economics.

Firstly, what was produced for military supplies? The ‘army’ included soldiers, their livestock such as horses and traction animals, their families, and personnel such as slaves, grooms and servants who may not have been official military employees (Haynes 1999). What products did this army eat? Did they eat the same rations wherever they were in the Roman Empire, or was there geographical and cultural variation: did they ‘go native’, or did troops who were drawn from different areas and cultures eat different foods or prepare food in different ways, reflecting the culinary traditions of their home countries? Did the army eat different foodstuffs depending on whether they were on campaign, on manoeuvres, at outposts or based in camp? Who produced the raw resources for food and where were they produced? Was food processed and/or preserved and/or stored in any way – and, if so, how and where and by whom? What were the timescales involved in producing, preserving and storing foodstuffs? Many of these questions can be investigated using environmental remains but many other lines of evidence are also relevant, both historical and archaeological.

Secondly, there is a set of economic issues that include how the Roman army ‘paid’ for its food. Did they take it, take it and give a nominal sum in return, pay a full market price for it, or

control its production on state farming estates and basically grow it for themselves? All these aspects require an integration of evidence for trade, monetary systems, taxation methods *etc.* which should involve numismatists, epigraphers and economists as well as specialists investigating a range of resources and commodities that might be constituents of any economic system.

A third strand concerns the logistics of supply, and this needs to be linked in closely to the first two strands: the costs of storage, transport *etc.* affect the economic efficiency of supply and demand, as do the nature and extent of the road, river and sea-borne transport routes. Economists, archaeologists and epigraphers amongst others need to pool their knowledge.

No specialist can cope with all of these interlinked strands of investigation, hence the need to be *interactive* and *interdisciplinary*.

Production

The first strand of enquiry – production – forms the major focus of most of the papers, particularly with regard to whether resources found on military sites could have been supplied by local sites. Several authors (Derremaux *et al.*, Groot, Thomas) highlight the essential requirement of data establishing the ‘status quo’ prior to the invasion and occupation by the Roman army. This would appear to be stating the obvious, but all too often we have little or no evidence of the situation immediately preceding military invasion (*e.g.* Huntley *et al.* forthcoming), and thus we cannot assess the degree of change observed when the Roman military invade or occupy a region. Cavallo *et al.*, for instance, demonstrate that the proportion of pig bones at the auxiliary fort of Meinerswijk (17% of the total number of cattle, sheep/goat and pig bones) is significantly higher than at the local rural settlements (where pig bones never reach more than 1%). It is the relative proportion (the prevalence) that matters, not the actual proportion *per se*. In other locations, a proportion of 17% would not be regarded as high, and it is significantly lower than the 55–60% seen at the earlier legionary site at the Hunerburg in Nijmegen in the same district, emphasising that not all military sites had the same supplies and that there can be considerable differences over time and between garrisons.

Several of the papers make explicit statements about what they would expect to see if a settlement were producing a surplus to supply to consumers elsewhere, such as the army (*e.g.* Groot, Thomas). This is not a simple procedure since any group producing agricultural commodities will need to: (i) consume some of those commodities themselves in order to stay alive; and (ii) retain a considerable proportion of their products to ensure sustainable production (breeding stock and immature animals, seed corn *etc.*). There is, then, no simple dichotomy between ‘producers’ and ‘consumers’ but a continuum of consumers, some of whom can also be net producers. This contrasts with manufacturing industries such as tile and pottery kiln-sites, where the producers may not consume any of the products and where calculations of quantities produced may equate with quantities available as supplies. Carrington makes explicit the numbers that he is using in his models of producer/consumers and consumers for staple plant foods in the vicinity of the Roman military fortress at Chester in northern England. He concludes that the local hinterland could have produced adequate quantities for themselves plus non-agricultural civilian and military populations.

Cavallo *et al.* and Groot investigate whether or not local communities increased their productivity, or changed their agricultural regimes to prioritise particular commodities in order to supply the local army bases. Their results clearly demonstrate that production practices are complex and that changes in one resource may be distinct from others. Cavallo *et al.* highlight

differences between plant and animal resource production. They conclude that the farmsteads within the military frontier of the Rhine were able to increase their cereal production a little in the later first/early second centuries, by expanding in size and by emphasising arable cultivation within a mixed economy. The extra cereals, however, may have been required to feed the increase in rural population and some supplies of cereals, perhaps quite a large proportion, were still required to be imported from elsewhere to feed the military personnel. The area beyond the frontier to the north-west had rather brackish soils and the size, distribution and arable productivity of the farmsteads show no change in this period, possibly due to the natural constraints of the landscape and possibly combined with its location beyond the frontier (although this need not, necessarily, deter economic developments). The decline in relative numbers of 'expedient pigs' during this period of military consolidation leads Cavallo *et al.* to suggest that the military meat supply had become embedded in the local production of livestock, precluding the need to import animals or meat from elsewhere.

Groot demonstrates the subtleties of livestock husbandry reflecting shifts in emphasis on particular products from different species. In her study area in The Netherlands, there was a continuity in emphasis on sheep rearing at some sites but a change in the target resource: changes in sex ratios and age at death suggest that wool rather than meat became the preferred product. Cattle continued to be raised for various 'lifetime' products rather than meat (*e.g.* traction, dairy products, breeding stock) both before and after the establishment of the military forts in the lower Rhine. Although the soldiers would have required and consumed large quantities of meat, they were not in a position to demand the uniform slaughter of young prime beef cattle, which would have jeopardised the sustainable resources required from mature animals such as traction. Inhabitants of all settlement types (towns, rural settlements and military forts) consumed cattle of various ages, mostly mature, after they had provided a range of sustainable resources for several years prior to their eventual death and availability as meat, hide and bone *etc.* (a pattern also witnessed in central southern England; Thomas). The consumption of mature beef need not be an indication of 'failure' in meat production: current predilections for young beef are partly a fashion affected by desires for 'fast food' in preference to slow cooking methods and are at least partially an economic consequence of the decline in the use of cattle for sustainable resources, which has its origins in the later medieval period (Albarella 1997). The continued pattern of mixed ages at slaughter, though, masks changes in sex ratios (see below) that suggest changes in uses during life. A third domestic animal species shows yet another type of production. Several of Groot's settlements show an increase in the relative numbers of horse bones. These tend to be sites or areas that showed an emphasis on horse husbandry rather than sheep husbandry during the preceding Iron Age.

Both Cavallo *et al.* and Groot indicate that areas tended to change by developing or emphasising the production of resources that were already well established rather than by introducing new types of resource, and not all of these products were meat. Carrington similarly notes that one of the few rural settlements investigated in the Chester hinterlands appears to have developed a focus on cheese production: another basic commodity and one that can be preserved (using salt) for transport, storage and deferred consumption. All of the study areas reveal considerable continuity in agricultural practices, although the degree, nature and timing of observed developments varied. None of the case studies provides any evidence of destabilisation, even in the earliest phases of military occupation.

It is much more difficult to establish whether new commodities seen during the Roman occupation periods were imported from elsewhere or were new developments locally. A few

plants and animals seen at Roman-period sites in north-west Europe are well beyond their natural ranges of geographical distribution or habitat and can be considered with some confidence to have been imported; simple presence/absence data is all that is required. Examples include olives, which need a Mediterranean climate and do not thrive in north-western Europe, and tunny fish (*Orcynus thynnus*), which are also a Mediterranean species. Similarly, any marine resources including shellfish found at inland sites (e.g. Thomas) must have been imported from a coastal area. Johnstone's review suggests that donkeys were imported as domestic animals into several new areas within the Roman Empire far beyond the original geographical distribution of their wild ancestors, and evidence for this includes a donkey bone that was recovered from deposits dating to almost immediately after the arrival of the Roman military at Arras in northern France (Derremaux *et al.*).

Many more species have ambiguous distributions, particularly when the slightly warmer climate of the Roman period is considered. Derremaux *et al.* highlight the difficulties incurred when trying to assess the significance of species that were rare or absent on earlier sites but which occurred with greater frequencies on Roman-period sites: they could have been chance, rare occurrences; they could have been imported from elsewhere; or they could have been produced locally after an initial importation. New species may have been imported either intentionally as products (e.g. cereal grains, herbs and spices in seed form) or unintentionally as by-products (e.g. arable weed seeds, grain beetles). They might have then become established as local populations of self-replicating plants and animals. Alternatively, although they may have failed to become established as 'breeding' stock, their persistent presence might have been attained through repeated importation. One potential method of distinguishing between locally established and continually imported plants is to consider the geological preferences and tolerances of the wild plants: these may indicate specific habitats (e.g. calcareous soils, acidic wetlands) that can then be compared with local availability (Derremaux *et al.*). It is not a definitive method of proof, but can be used to eliminate some possibilities. Another method is to compare potential 'producer/consumer' sites with those of the military. Cavallo *et al.* demonstrate that some specific types of cereals (species that were also present on Iron Age sites) are ubiquitous on rural and military sites in the lower Rhine area during the early Roman period. In addition, military sites also contain evidence of certain other cereals (species which were not previously common in the area) together with some exotic species of herbs *etc.* The implication is that the military sites used local supplies but also had access to extra resources that were not available to the rural sites, even though there are no environmental reasons why they might not have produced them themselves. In circumstances where civilian sites can tap into new trade networks, such 'exotic' items might also be found ubiquitously, and then it would be extremely difficult to tell if they were home produced or imported. Clearly, for all species where the differences rely on prevalence rather than on presence/absence data, much of our evidence is ambiguous or circumstantial. For instance, Cavallo *et al.*'s military sites produced evidence of 'luxury' items: bones of peacock, various wild game species and plenty of domestic fowl (chicken) together with fruit stones from peaches and olives. Although the peacock, peaches and olives are likely to have been imported from other parts of the Empire (based on their ecology and geographical distributions in the wild), it is not possible to suggest where the wild game birds and domestic fowl were raised. They may have been brought in as parts of a 'package' of imports, but equally they may have been caught and raised locally: if local people identified a sales niche for such produce, they may have targeted them specifically for the military market and refrained from eating them themselves in order to maximise their profit and sustain their resource.

Sometimes it is difficult to ascertain whether or not a 'new' resource is actually present: many authors have debated the presence and significance of larger types of domestic livestock within the Roman Empire, particularly cattle but also sheep. Filean questions whether the larger cattle noted in the lower Rhine area by Lauwerier (1988) actually were significantly larger than those present during the Iron Age, and concludes that the observed increases in average size and ranges of sizes can be explained by the presence of greater proportions of bones from males in the assemblages. His paper highlights the need to target questions with well-defined methodologies and techniques. The results of this study are also useful for demonstrating the change in sex ratios in adult cattle which in turn suggests a change in required product, similar to the emphasis on wool observed by Groot (perhaps a greater proportion of adult male cattle was required for traction to pull ploughs and carts). Thomas observes similar increases in the average sizes and diversities of sizes of cattle and sheep bones during the second to fourth centuries AD at sites in the Upper Thames Valley region. These changes post-date the early Roman (mid-first century) fortress at Alchester, whose animals were the same size as those in the local Iron Age sites. He, too, notes that these size changes need not (but could) indicate importation of new breeds. They might equally indicate diversification in source herds (*e.g.* a widened source area), secondary uses (*e.g.* ploughing), or management practices (*e.g.* different ages of castration). The original question – 'were new types of cattle imported?' – remains to be fully investigated and refined: if they were imported, were these new blood lines brought long distance from elsewhere in the Empire, or simply from a range of herds within the local hinterland? Long distance movements can be investigated using DNA and isotope analysis, local hinterland variability can be investigated using tooth wear patterns and isotopes, and all variability can be examined in terms of non-metric traits and metrical analyses of size and shape (conformation). The advantages of adopting the latter method are well exemplified by Johnstone. Through the biometrical analysis of equids (horses, donkeys and their hybrids, mostly mules), Johnstone has been able to suggest state involvement in the breeding of mules (see below). Johnstone also draws attention to regional variation in horse breeding. Although there appears to have been a general desire to breed larger horses, these were not standardised in terms of source livestock nor in the degree and timing of the observed changes in conformation. Larger horse bones are observed much earlier in Gaul, the Rhineland, the Balkans and the Danube area than in Britain, but each region seems to have developed their larger livestock from native breeds.

Several authors use plant and animal remains from early military sites to investigate whether or not incoming military garrisons brought supply systems with them, or whether they were initially dependent on supplies from the immediate hinterland. They also look for evidence of change in supply system from initial invasion to established occupation. Thomas compares the animal bones from the early legionary site of Alchester, in Britain, with those from several surrounding sites of both Iron Age and early Roman date and finds a 'mix and match' situation. In many ways, the food remains at the legionary fortress are extremely similar to those found at the other sites, but the legionary site does have higher proportions of pig bones. Cavallo *et al.* observe the same pattern at the early legionary site at the Hunerburg in Nijmegen, The Netherlands. Some early forts within the lower Rhine region also appear to have been characterised by high proportions of chicken (*e.g.* Velsen; Cavallo *et al.*). Whilst high proportions of 'invasion food' pig and chicken bones are found at some sites, several indicate that local sources of basic commodities were utilised right from the earliest military establishments: Derremaux *et al.*, for example, showed that the earliest fortress of "La Corette" used the same cereals as those found on local Iron Age sites. Pigs and chickens are similar in that both species breed rapidly, both are easy

to husband and can be fed on a range of foodstuffs including waste products, and both produce few resources other than food and manure. They are an easy, economic and rapid production source of good protein and both Cavallo *et al.* and Thomas suggest that the legions used them to ensure a basic level of meat provision for the invading army. However, the legions were predominantly drawn from Rome and the Mediterranean provinces, where pork meat formed a high proportion of the civilian diet, so perhaps the legions were simply importing 'comfort food' albeit one that was tactically convenient when local sources of meat might not be assured. Typically, the initial invasion by legionary forces was subsequently consolidated by auxiliary troops, drawn from a greater variety of regions within (and sometimes beyond) the Empire. The changes observed between the food remains associated with the initial legionary fortresses and those associated with slightly later auxiliary forts, therefore, may reflect changes in the troops' choices and preferences rather than changes in the system of food production and supply *per se*, although King (1999: 139) noted that later legionary sites in Britain and in Germany continued to show higher proportions of pig bones than auxiliary sites.

Most of these case studies concentrate on what was produced and where it was produced rather than on the mode of production. Some papers *e.g.* Carrington and Cavallo *et al.* note changes in rural settlement sizes or densities but since these local small farmsteads continued to produce similar crops and livestock as in previous periods the implication is that they were still occupied by indigenous people. Carrington and Derreumaux *et al.*, however, also note the development of large urban agglomerations: the implication here is that these are populated by a mixture of military, ex-military and civilian consumers, although Carrington suggests that some ex-military personnel may have settled in the rural hinterlands and become net producers. This is an area that would benefit from further research, using a range of evidence to ascertain identities (*e.g.* Allison 2006; Gardner 1999; Mattingley 1997).

The case studies strongly emphasise the ways in which the incoming military troops tapped into local sources of basic foodstuffs as soon as they arrived, supplemented to various degrees with 'added extras' which were sometimes basic commodities (*e.g.* cereals) and sometimes 'luxury' or comfort foods. There is also comprehensive evidence, particularly in the lower Rhine region, for the development of local produce in terms of diversification and intensification, including many non-food commodities (*e.g.* textiles and transport facilities). The case studies do not directly address the possibility of extensification (Van der Veen and O'Connor 1998) although the observed increases in numbers of large male cattle may indicate greater intake of land for arable cultivation. Some changes through time can be observed but not yet explained and these relate in particular to changes in diet observed when garrisons of legionary troops were replaced by auxiliaries.

Logistics

The timescale problems associated with producing and supplying biodegradable commodities place a greater than usual emphasis on the need for efficient logistics. Besides the usual constraints of costs of production and transport, there is a need to preserve or store basic foodstuffs to ensure that they can be made available in the right place at the right time. Derreumaux *et al.* draw attention to the 'excessive' grain storage facilities at the small fort of "La Corette" in northern France during the late Republic and early Empire. The same cereal species are found at "La Corette" as on the surrounding Iron Age and Roman rural settlements, which suggests that the fort was supplied by local farms and stored the grain on site. Presumably, the grain was supplied

en masse when it became available and not kept at the production sites. This may be a similar system to that documented in Egypt where officials from the military notified village elders of what the village owed the administration. The village elders were responsible for coordinating and collecting the 'payments' of cereals after harvest and for delivering them to an agreed destination for the military administration to collect (Adams 1999) prior to shipment to Rome. Johnstone discusses the transport networks in north-western Europe pointing out that, although long distance transport was much cheaper by water than overland, terrestrial transport systems were required to take resources and products to the network nodes on the waterways and also to distribute them to where they were required once they had been landed and offloaded. The quantities of transport animals used were considerable and they were a commodity requiring production in their own right. There appear to have been various logistical sources of these animals in different parts of the Empire: state-run or contracted specialist farms in the core area (Johnstone), local farms in the north-western provinces (Groot) and farms just beyond the Empire's official frontier: Johnstone suggests that the area around Feddersen Wierde north of the Rhine raised horses which were exchanged for 'Roman' commodities.

Gerrard highlights the use of salt as a preservative that could permit the transport of perishable goods long distances. Maltby (2006a) used body part frequencies and butchery patterns on pig bones at various later Iron Age and early Roman sites in Britain to suggest that pigs were being processed, probably using salt, for preservation and transport. This level of detail could be applied to the case studies presented here, to investigate whether whole animals (probably locally produced) or processed carcass portions (probably imported) were present at the legionary sites with high prevalences of pig bones. Both Gerrard and Carrington suggest that some areas that had developed production systems to supply local military installations continued as 'hot spots' of production even when the main body of troops had moved elsewhere. This implies that good production systems were valued and maintained, and that investment in transport systems to facilitate long distance supply was economically viable, or at least sustainable. Hot spots may have related to particular commodities that had restricted sources but were particularly valued *e.g.* salt, specialist clays and shellfish. Areas may have been favoured if they had easy access to maritime or river transport networks. Maritime transport is relatively cheap for moving bulk commodities, but is not without risk from weather conditions and pirates. Gerrard raises the possibility that the long distance transport of a particular ceramic type (Black Burnished Ware I: BBI) and, perhaps, its contents, was linked to a particular legion, who had originally been stationed in the production area of the ceramics (a particular area on the south coast of Britain), and had continued to require it, or its contents, as a commodity even when they moved 550 km (350 miles) further north to the new frontier. It is less clear whether or not less geographically restricted resources such as livestock and cereals also retained supply networks when the military moved away. Good transport networks could be used by a variety of personnel for a variety of purposes and it is clear from the Vindolanda tablets (Birley 2002; Bowman 1994) that soldiers were able to request personal supplies of particular items or commodities as gifts or private purchases. No doubt entrepreneurs and merchants made use of the transport systems available and it is highly likely that small items of non-essential foodstuffs such as herbs and condiments were moved around the same networks as basic commodities. The presence of small 'luxury' items have been noted in all of the case studies but it is not possible to tell from their presence how they were brought to the sites, and their supply may have owed much to personal contacts and networking systems working in parallel to the formal requisitioning systems of the army administration.

Economics

The case studies within this volume highlight the need to consider logistics at different time scales ranging from the immediate (this year's cereal crops) to the long term (for sustained supplies), as well as the importance of considering the circumstances obtaining immediately prior to invasion and/or conquest by the Roman army. Gerrard notes that the BBI ceramics were supplied to the army almost as soon as the troops arrived in the production area and that this coastal area in southern Britain had already established strong trading links across the sea to northern France during the later Iron Age of Britain/late Republic period in northern France. Woolf (2001: 52) noted that Gaul had also established the capacity to produce tradable surpluses prior to the Roman conquest, and both raise the possibility that the Roman state or military administration systems may have been able to establish trading arrangements prior to any successful military conquest. Perhaps there are some parallels with the trading systems of the British East India Company prior to the formal establishment of the British Empire in India (Bowen 2006). State involvement with inland salt production has been suggested for central England (Nevell and Fielding 2005) and Jones and Mattingley (1990: 232) emphasise the large quantities of salt that might be required for bulk preservation of military meat supplies. Gerrard and Carrington note that their study areas both had 'special', *i.e.* highly localised and highly valued, resources of salt which gave them local wealth in the Iron Age. Although there is no evidence for Roman state involvement prior to the military invasion, they speculate that this wealth and preferential access to resources may have led to socio-economic developments within local Iron Age communities that might have quickly attracted the attention of the Roman administration. Johnstone also suggests state involvement in the production of mules and horses for the army. Her consideration of equids highlights the inter-relatedness of production systems, logistics and economics, since the animals were a commodity in their own right as well as a transport facility. She refers to classical sources indicating that mules were bred on large, dedicated estates in the core area of the Empire, suggesting contracts between formal administration and rich landowners. This 'mass production' of mules on specialist farms was suited to the Mediterranean area but not to northern Europe, where donkeys are ill-adapted to the temperate climate. Here, the continual importation of mules from further south may not have been economically (or logistically) sustainable, placing a much greater emphasis on the role of horses, some of which may have been raised beyond the frontier and traded in.

Carrington specifically aims to explore the socio-economic relationships of the legionary fortress of Chester, its extra-mural settlement and the settlements in its hinterland in northern England. He contrasts the prevalences of coins and manufactured artefacts through time and looks at how these might reflect the varying numbers of military troops stationed in the fortress. He suggests that the rise in coin finds after the garrison was reduced may indicate a switch from tax in kind to tax in cash: a commodity that is easier to collect and redistribute. He points out that tax in kind is a rather static economic system whereby the contributor supplies commodities directly to the army. Although production may be stimulated to produce a surplus, this goes straight to the army and does not enter any larger network of exchange. In contrast, payment in coinage requires additional transactions between civilians in order to obtain the coinage to supply to the army in lieu of primary produce (Carrington's 'multiplier effect'). Ironically, although the army may originally have stimulated increased and diversified production whilst they were present in large numbers, this may have had little 'knock-on' effect other than in the seasonal farming routine. When they withdrew their main garrisons elsewhere they may have

had a much more profound effect on the regional economy by requiring local producers to enter a coinage-based market economy intimately linking the rural settlements with the town. Clearly the rural settlements did not collapse when the military withdrew, nor did the urban settlement, which seems to have taken on some of the military's economic role (and which, of course, may still have retained a military presence: Strickland 1999). Although the military demand for local primary resources was reduced, the economic market system that had developed permitted the urban settlement to thrive, supported by its hinterland. Several researchers have noted the intimate association of military bases and civilian towns in various parts of the empire (e.g. Sommer 1999). Derremaux *et al.* also demonstrate that towns became integrated into the same economic system as the military establishments in the Arras area of northern France. In the initial period, the early fortress imposed its presence locally but also required some cereals to be supplied through the Empire-wide *annona* system of redistribution of basic foodstuffs. In contrast, the later military establishments were integrated with the civilian *civitas* and shared local supplies of basic foodstuffs, with long distance transport being used not for staples but for 'new tastes' shared by civilian and military personnel alike. The 'enmeshment' of military and civilian economic systems was complex, and the case studies presented here have not addressed how the final withdrawal (as opposed to the redeployment) of Roman troops affected the civilian economies. Much further work is required using a variety of evidence for economic systems (such as coinage, documents, traded items, settlement types and distributions, storage structures, building styles *etc.* alongside the environmental evidence for agricultural production).

Carrington highlights the army's needs for a range of commodities, services and resources besides foodstuffs, preservatives and live animals, and notes the development of several industrial manufacturing sites in Chester's hinterland. Some of these developments occurred after the major redeployment of troops on the northern frontiers of Hadrian's Wall and the Antonine Wall. Interestingly, the distribution of these sites bears some resemblance to the manufacturing areas that developed during Britain's 'Industrial Revolution' during the nineteenth century, where sites were located close to sources of power (mainly water and coal) and river transport. Northern areas of Britain have very few villas: the whole county of Cheshire has only one known villa site and there are none known between it and Hadrian's Wall on the western side of the Pennine hills. Many of the manufacturing sites (producing salt, ceramic tiles, pottery and various unidentified products requiring heat and water (wooden barrels?)) have artefact assemblages and coinage that indicate connections with the military. Were these sites run by the military under state control, or linked by contracts to supply the state? Various authors e.g. Groenman-van Waateringe (1980) have suggested that the Empire relied on well-developed hierarchical social systems in the regions that they successfully conquered, but parts of the north-west provinces (e.g. northern Britain and the lower Rhine) are not known for their large Iron Age sites nor for Roman-period villas. In northern and western Britain, these large manufacturing sites contrast in scale with the disparate small farmsteads, each producing small quantities of agricultural produce to contribute to the army, and it is not clear who was actually working to produce the processed and manufactured commodities. Were local people expected to work here as well as farm their land or were non-locals brought in (or attracted to the sites) to provide a workforce?

Throughout all of the study areas, some commodities (such as herbs, Mediterranean fruits, shellfish and fish sauce) were definitely transported long distances: each military site appears to have been embedded within a network of different economic systems occurring at a variety of scales from the state-controlled to the individual black market transaction.

Summary

These papers have made substantial contributions concerning what was produced and supplied to the Roman army in three areas of the north-west provinces, with a particular emphasis on the early years of the Roman Empire. Each contributor has taken care to state explicit aims and methodologies: even a simple question such as 'Did this site produce surplus resources?' can be fraught with methodological problems, and these papers emphasise the need to further develop investigative approaches, supporting Smith's (2001) and Bakels's (2001) earlier calls for integration of different types of evidence in order to overcome, or compensate for, the biases and flaws associated with specific material-based methodologies. The papers have been particularly successful in demonstrating the complexity of modes of production: changes affecting one resource (*e.g.* a switch from mutton towards more wool production) need not affect another in the same way (*e.g.* cereal production), although they must have had some impact on the size of workforce required and the seasonal work pattern on a mixed farm within a rural community. Similarly, different regions and micro-regions changed in different ways (*e.g.* by intensifying livestock or cereal production) and even farms within the same small areas may have developed in different ways (*e.g.* by diversifying or by emphasising particular types of livestock husbandry). There are clear developments through time, as well, although it is still unclear whether certain traits (*e.g.* relatively high proportions of pigs and chickens) are linked to the status, ethnicity or community identity of the troops (legionaries or auxiliaries) or to the nature of the garrisons (initial invasion forces or army of occupation). Certainly, more fine-grained contextual analysis (*e.g.* Stokes 2000), rather than site-level aggregation (the approach taken by most of the contributors to this volume), would help in this regard.

Many of the aspects highlighted by these case studies of basic foodstuffs are applicable to other environmental resources such as textiles and timber, and all benefit from the creation of mathematical modelling: however imprecise, models serve to indicate orders of magnitude of requirements and supplies, and can provide indications of whether or not local production could have been at a suitable scale (Adams 2001: 183–188; Erdkamp 2005: 34–54; Goodchild 2006).

The contribution of the papers to considerations of logistics are mainly restricted to the papers on equids (Johnstone) and salt supply (Gerrard), but all highlight the need to combine a range of different lines of evidence such as storage structures, containers, transport mechanisms and route-networks. Again, there is a high potential for the application of mathematical models considering the bulk of items, their shelf-lives and the cost-effectiveness of long distance transport. Much work remains to be done on modes and scales of preservation and processing, and on the logistics of who undertook such work and where.

The third aspect – economic theory – has only been touched on tangentially or in small detail by most of the papers, with the exception of Carrington. Most authors considered the specific question: 'what resources were produced and supplied locally' without considering *how* supplies were procured (taxation by money, taxation in kind, tribute, requisitions *etc.*) although the former has to be ascertained before the latter can be asked. Interestingly, all of the case studies demonstrate that at least some of the basic foodstuffs required by the army appear to have (probably) been supplied locally even during early periods of military occupation. There is still an urgent need for foodstuffs to be considered alongside other commodities and for regional syntheses that look at wider issues than 'did this fort get its cereals from its immediate hinterland'. One of the greatest contributions of this monograph is its demonstration of variability, complexity and flexibility

of resource production and supply: even for basic essential foodstuffs. Clearly, environmental data are highly relevant to economic theories, and they can and should be investigated alongside other types of commodities in economic studies of production and supply.

What has this monograph been less successful in achieving? In addition to the shortcomings mentioned above (no single collection of papers can hope to cover all aspects!), the editors are both British faunal specialists and this has led to a bias in the views expressed in the introductory and final chapters. Both of us demonstrate the weaknesses outlined in 'Challenges of our own making' above and these flaws remain to be addressed. Although some of the papers have multiple authors, it was clear from early drafts that each specialist tended to write a section concerning his or her own individual specialism, and synthetic approaches took time to achieve through successive rewrites. In addition, by concentrating on detailed primary data (essential sources for synthetic papers such as Carrington's), the environmental case studies were limited in their scope which precluded consideration of a comprehensive range of other commodities and economic evidence (treatment of all types of evidence at the same level of detail would have produced a series of monographs rather than papers). Similarly, due to their pre-occupation with establishing what resources were produced and supplied locally, most of the papers fail to consider how these resources were paid for (if at all) by the army. This level of investigation is more suited to synthetic overviews, such as Carrington's and Johnstone's.

Food for thought: later courses

Introduction

Earlier sections of this chapter discussed some of the challenges that face students of the production and supply of food to the Roman military. The biodegradation of organic resources posed logistical constraints on the Roman army administration and there are several lines of enquiry that can be pursued to elucidate preservation techniques (*e.g.* salted meat, cheese, parched grain) and the logistics of storage and supply. These need to be linked with studies of other organic resources that will also have left ephemeral physical remains, whether used as primary resources (*e.g.* turves, timbers, hay and leaf fodder, bedding) or as manufactured items (*e.g.* cordage, baskets, skins, textiles, wood and bone artefacts *etc.*). Containers made from plants and animals (*e.g.* baskets, sacks and barrels) were probably far more important as containers for transporting and storing foodstuffs than amphorae and pottery jars due to their capacity, resistance to breakage and cheapness of production.

The biodegradation of organic resources still poses problems for environmental archaeologists, but considerable progress continues to be made regarding the identification and quantification of taphonomic biases. Specialists tend to be well aware of the limitations of their data and methodologies, and are expanding the range of evidence that is being used to trace the former presence of organic remains, including biomolecular techniques (such as DNA and lipid analyses) and the study of trace elements and stable isotopes. What is very clear from the case studies presented here is that organic resources need to be investigated in their own right (as suggested by Gerrard).

In order to facilitate these new and continuing developments, designed to address the past and present problems of biodegradable resources, it is critical that we also address the problems of our own making, many of which relate to insular working methods and a lack of communication of ideas, experience and data.

This section considers ways to progress studies of how the Roman army were supplied with natural resources, particularly food, using the three-I principle: *iteration*, *interaction* and *interdisciplinary*.

Iteration

Environmental archaeology has good potential for addressing questions concerning the production of food and its supply to the army, but individual questions asked of individual data-sets can lead to a plethora of unlinked observations. These may lead to isolated narratives and fail to develop our understanding of more fundamental issues. The value of iterated studies is illustrated in this monograph in several ways: they can identify flaws in our methodologies, they can provide support for, or disprove, hypotheses, and they can identify new lines of enquiry. By being explicit about what might be expected from producers and consumers, several of the papers highlight the need for methodological improvements: exactly what evidence can differentiate between a self-sufficient producer/consumer, a surplus producer/consumer, and a consumer? This is an example of *iteration* in which existing models are repeatedly found to be incomplete or flawed, stimulating refinements so that new or developed models can be applied in future with greater confidence.

Thomas, Cavallo *et al.* and Derreumaux *et al.* all found that the initial military installations of the Roman army in 'new' frontier locations were notable for having a marked increase in the relative importance of pigs compared to indigenous sites, but the precise causes of this pattern remain unresolved. Four hypotheses have been suggested: (i) a practical, logistical interpretation that emphasises the expedient fecundity of pigs (Groenman-van Waateringe 1997: 263; Hodges 1984); (ii) a socio-cultural interpretation that links the observed frequencies to those in the troops' home region (Groenman-van Waateringe 1997: 263; King 1999: 139); (iii) a socio-cultural-environmental interpretation that notes that early Roman towns in northern France also had high proportions of pig bones (Derreumaux *et al.*); and (iv) a socio-economic interpretation that relates their prevalence to the status of the occupants (King 1984). Further iterations coupled with explicit methodologies designed to target underlying causal factors are required in order to establish whether all early sites have relatively high proportions of pig bones and whether we can predict what the main influences are that cause the high levels observed.

Pragmatically, for iteration to be most valuable, a balance is required between: (i) a basic standardisation of recording and analytical procedures that ensures that data from several sites can be synthesised; and (ii) a flexibility that facilitates methodological advances and the investigation of new intellectual questions. The papers here include syntheses of studies undertaken by a group of colleagues where some standardisation of recording practices might be expected (*e.g.* Cavallo *et al.*) and a comparison of studies undertaken by a range of independent specialists using disparate methodologies (Thomas). Other synthetic reviews in England include Dobney (2001), Dobney *et al.* (in prep), Hall and Huntley (2007), Huntley and Stallibrass (1995), Van der Veen (1992) and Van der Veen *et al.* (2007). All have had to cope to a greater or lesser degree with incompatible presentations of other people's data, and specialists need to continually debate their fundamental requirements for iterative research whilst avoiding restrictive practices that stultify improvements. Research frameworks can provide crucial shared objectives that can guide methodological practicalities.

The results presented here are important for demonstrating some emerging principles. Several papers show that the army sought to establish a procurement system whereby it could obtain

its food resources from the local area as soon as possible after it moved in on campaign (*i.e.* during its 'establishment' or 'consolidation' phase). At the same time, local circumstances may have placed constraints on this ideal: *e.g.* Cavallo *et al.* found that sufficient surplus livestock could be produced locally by developing previous expertise and agricultural practices, but that *part* of the local landscape was just not suitable for intensified or extensified arable production. Another principle relates to the army's long distance contacts: once an area had been 'groomed' or developed as a reliable area of production, then its resources might continue to be transported to the military zone, even if this zone moved geographically (*e.g.* Carrington on agricultural products and Gerrard on salt and Black Burnished ware pottery). However, two or three examples are not sufficient to establish a principle, and it is only by further iterations that these suggestions can be tested further and either substantiated, rejected, or refined: for instance, it might be only certain high value commodities that commanded sustained supply systems. There is a danger that a few, known, examples will become entrenched as 'standard knowledge' (*i.e.* 'myths').

All of the papers demonstrate that developments in the production and supply of one agricultural resource or commodity need not be mirrored by any or all of the others: developments were complex and flexible. The authors highlight the need to investigate each commodity (*e.g.* wheat, pulses, sheep, horses) in its own right, and then to consider how these changes related to each other (both at a single site and within a region or hinterland). This is particularly clear in the multi-authored papers.

Interaction

Some of the papers benefit from groups of specialists working together and it was clear from the discussions at the conference sessions that ideas and observations from one paper contributed insights to others. Some of the similarities have been pulled together subsequently during the writing of the introductory and concluding chapters of this volume, and we hope that this has highlighted their significance and helped to put them into perspective. The 'added value' of synthetic studies was clear in the papers that could call on material from a range of sites whose occupants must have interacted in the past, and in papers whose co-authors had benefited from collaborative discussions. But much more could be done, both with the case studies themselves and with future studies. This is an area where problems of our own creation as well as intrinsic limitations of our data need to be addressed. By approaching the same question using different lines of evidence we can support, test and complement each other's findings. But it is important that we discuss our findings interactively. Presenting data and interpretations alongside each other in a publication simply places the burden of synthesis and reconciliation onto each and every reader, who cannot benefit from questioning the authors. There are many ways in which specialists can interact. Sometimes they work in the same laboratory or organisation, and here there is no excuse for inadequate discussion of ideas, results and interpretations. Large projects normally include project seminars into their costed programmes of work, and these are usually extremely productive and can be invaluable for sorting out problems and unexpected results. Although face-to-face discussions and presentations may be logistically difficult or expensive to organise, these should always be considered as a possibility and encouraged, regardless of the source of funding for the project. Email discussions and joint authorship of reports (with drafts circulated for contributions and comments) should be normal practice, in order to maximise the value of the work. These are normal practices for scientific reports and published papers, and yet archaeologists still tend to work in isolation.

Calls for interactive collaborations are not new (*e.g.* Albarella 2001: 11; Evans 1995; Maltby 1979: 94, 2002) and despite Hughes and Hammon's (2001: 85 point 8) explicit recommendation for proper communication and feedback amongst all member of a post-excavation team such integration is still disappointingly rare. Were they cries in the wilderness or heralds of a new age? Is there any reason to believe that this paper will have any substantive influence?

Campaigns for change always take time to overcome initial inertia and logistical problems. Four factors may provide extra stimulus at the moment: Research Frameworks, developments in databases and Geographical Information Systems (GIS), sources of research funding, and government directives. In Britain, the current spate of Archaeological Research Frameworks, Agendas and Strategies for various periods, themes and geographical regions has definitely encouraged a wide range of people to meet to collaboratively consider common aims and how these might be achieved (*e.g.* Bayley 1998; Brennand 2006, 2007; Haselgrove *et al.* 2001; Petts with Gerrard 2007; James and Millett 2001; Manby *et al.* 2003; Wilson, forthcoming). Research Frameworks have involved very large numbers of people, working in the manner recommended here: pooling their expertise and knowledge in meetings and seminars, and contributing to multi-authored papers. They have been stimulating exchanges of skills, knowledge, experience and viewpoints and the networking of colleagues has empowered individuals by providing group support with shared aims. Databases and GIS have become far more powerful in the past five to ten years, facilitating the integration of spatial and point data with statistical, narrative and illustrative material: here is a tool that makes sharing and comparing different types of data feasible and practical. The benefits of collaborative work have been recognised by research funding bodies such as the Arts and Humanities Research Council (AHRC) who fund collaborative projects such as the Oxford Roman Economy Project (2005–2010; leaders Alan Bowman and Andrew Wilson) which is currently concentrating on classical sources, with much attention paid to quantifications and statistical modelling. Topics that can involve researchers from more than one country (as studies of the Roman army and the Roman Empire certainly do) are particularly in favour. In The Netherlands, archaeologists have been obliged to work to minimum standards provided in the Kwaliteitsnorm Nederlandse Archeologie (KNA the Dutch Archaeology Quality Standard) since August 2006. The published version current at January 2008 (Lauwerier, pers. comm.: see www.sikb.nl for a less up to date version) includes requirements for the integration of specialist reports into the final excavation report, and that this integration should be undertaken by both the specialists and the archaeologists.

Further evidence of increasingly positive action at various levels includes international conference sessions (*e.g.* Maltby 2006; this volume), individual excavation projects (*e.g.* Ribchester Roman fort, northern Britain: Buxton and Howard-Davies 2000; Stallibrass 2000) and landscape projects (*e.g.* Danebury environs, southern Britain: Campbell and Hammon, in prep.; Eastern Dutch River Area (The Netherlands): Groot *et al.*, in prep.). In addition, the academic value and importance of grey literature are being recognised (Bradley 2006) and put to good use in major syntheses (*e.g.* Bradley 2007).

Both The Netherlands and Britain have established online bibliographic databases that refer to specialist reports by environmental archaeologists, and these include fully published reports, archive reports and grey literature. In Britain, the Archaeology Data Service is funded as part of the Arts and Humanities Data Service by the AHRC at <http://ads.ahds.ac.uk>. It includes the Archaeobotanical Computer Database (ABCD) and the Environmental Archaeology Bibliography (EAB). In The Netherlands, BoneInfo is linked to the national archaeological database 'Archis' and is hosted by the Rijksdienst voor Archeologie, Cultuurlandschap en Monumenten (RACM)

at www.racm.nl. Lauwerier and de Vries (2004) provide a useful discussion of the metadata that need to be included in a searchable archive in order to facilitate information retrieval. There have also been some attempts to provide searchable databases that include primary data, but these have necessarily been more limited in scope *e.g.* the Animal Bone Metrical Archive Project (ABMAP 2003).

Interdisciplinary

The wide variety of types of evidence that are relevant to studies of the Roman army's supply systems is both a stimulus and a deterrent to integrated research. The archaeologists need to integrate work at a range of different scales (from lipid residues to landscapes) investigating organic and inorganic materials (both 'natural' and artefactual), structures, stratigraphy and the residues of industrial processes. No one person can hope to be well-informed about all of these various aspects, which is why *interactive* and *iterative* working practices are required. But studies of the Roman army also require other types of investigation such as epigraphy, classical history, economic history and statistical modelling, and so these discussions need to be *interdisciplinary* as well.

We all have our own perspectives. For instance, regarding the common presence of barley at military and non-military sites in frontier zones in Britain and The Netherlands, classical scholars may tend to trust the classical literature that states that wheat was food for soldiers whilst barley was food for horses, and thus interpret the barley as fodder for the mounts and transport horses (*e.g.* Tomlin 1998: 45) or, if feeling pessimistic, as second-rate fodder for the soldiers. Archaeologists may point out that barley was well established in these regions (and in the home regions of the auxiliary troops) and may have been acceptable food for non-legionary soldiers, suggesting that classical texts making recommendations in the core of the Empire might be less relevant to peripheral areas. Researchers who inhabit those peripheral regions, however, may prefer to interpret the ubiquitous presence of barley as an indication of the locals' predilection for beer (although as Cool 2006: 141–142 notes, wheat can also be used). Beer featured prominently in some of the Vindolanda tablets (Bowman and Thomas 1994; Whittaker 2004: 97) and appears to have been required in substantial quantities (Pearce 2002: 938–939) and to have been brewed in the forts or their adjacent *vici*. Each of these arguments chooses to select or emphasise different types and pieces of evidence, and each has flaws and biases. They need to be tested and refined rather than stated in isolation and retained as untested myths.

Conclusions

This paper has looked at some of the new evidence coming from archaeological studies of agricultural production and supply to military establishments in the north-western provinces of Britain, northern France and the lower Rhine. It highlights problems that are particularly pertinent to studies of this nature, and gaps in our knowledge base and in our methodological repertoire. It also identifies the complexity and flexibility of the situation in a relatively small part of the Empire, and provides several suggestions for further research. It ends by making recommendations for improved collaboration in working practices, knowledge exchange and knowledge transfer. These can be summed up by three 'I's': working practices should be *iterative*, *interactive* and *interdisciplinary*.

This volume is both an offering and a challenge. The authors are acutely aware that they

are familiar with a narrow range of research and urge readers to 'do as we say, not do as we do'. The challenge to others is to join in: to provide similar analyses to test ideas, to provide new lines of evidence, and to combine all results to provide an interpretation that is both more detailed and more robust. We hope we have whetted your appetite.

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