Stephen O'Connor

The Daily Grain Consumption of Classical Greek Sailors and Soldiers

aus / from

Chiron

Ausgabe / Issue **43 • 2013**
Seite / Page **327–356**
https://publications.dainst.org/journals/chiron/483/5091 • urn:nbn:de:0048-chiron-2013-43-p327-356-v5091.6

Verantwortliche Redaktion / Publishing editor
Redaktion Chiron | Kommission für Alte Geschichte und Epigraphik des Deutschen Archäologischen Instituts, Amalienstr. 73 b, 80799 München
Weitere Informationen unter / For further information see **https://publications.dainst.org/journals/chiron**
ISSN der Online-Ausgabe / ISSN of the online edition **2510-5396**
Verlag / Publisher **Walter de Gruyter GmbH, Berlin**

STEPHEN O'CONNOR

The Daily Grain Consumption of Classical Greek Sailors and Soldiers

I. Introduction

Establishing the daily food consumption of armies and navies is fundamental to understanding their logistics.[1] It is only when we have reliable figures for the food consumption of military forces that we can construct estimates of their provisioning needs. These estimates allow us, in turn, to develop a better understanding of the supply mechanisms used by military forces in the past, since the amounts of food armies and navies required determined the methods they used to supply themselves. And since military supply mechanisms and strategic choices are intrinsically linked,[2] ascertaining the daily food consumption of armed forces permits us to gain insights into the workings of entire military campaigns: so, for example, calculation of the daily consumption rates of Alexander's armies formed the basis of DONALD ENGELS' analysis of the strategy and marching routes of Alexander in Asia, and estimates of the daily grain requirements of the armies of the First Crusade underlie BERNARD BACHRACH's examination of the Crusaders' strategy at the Siege of Antioch in 1097–1098 C.E.[3]

If we turn to the Greek world, modern treatments of classical Greek military campaigns also use figures for the daily grain consumption of sailors and soldiers to elucidate the logistical, tactical, and strategic challenges facing these campaigns. JOHN LAZENBY, for example, uses an estimate of the daily grain requirements of classical Greek soldiers to calculate the transport needs and capabilities of Cyrus' march to Cunaxa[4] and of the 250 wagons supplying the Greek forces at Plataea in 479:[5] PETER KRENTZ does the same to calculate the number of ships it would take to supply Greek forces undertaking circumvallation sieges in the fifth century;[6] and JAMES THORNE also

[1] See, e.g., ROTH 1999, 7.

[2] JONES 1987, 54: «Military strategy combines tactics and logistics to shape the conduct of operations».

[3] ENGELS 1978, esp. 3–4, 123–126; BACHRACH 2002, esp. 85–89, 97–100. See, however, n. 83 below: ENGELS' calculations of the daily grain requirements of Alexander's armies were incorrect; BACHRACH's calculations are problematic, too.

[4] See also GABRIELLI 1995.

[5] LAZENBY 1994, 17. From this point on, all dates will be B.C.E. unless otherwise noted.

[6] KRENTZ 2007, 154.

uses estimates of the daily grain consumption of soldiers in his attempts to quantify the amount of grain foraged by the Spartans and their allies in their invasions of the Attic countryside in the first years of the Peloponnesian War.[7]

Yet, while modern investigations of the logistics and strategy of Hellenistic, Roman, and medieval military forces very often contain detailed discussions of the rations of the men making up these forces, devoting whole chapters or appendices to the subject,[8] there are no comprehensive treatments in modern works on classical Greek military history of how much food, and especially grain, Greek soldiers ate on average every day.[9] There are two reasons for this. Firstly, older studies of classical Greek provisioning used for their figures for the grain consumption of soldiers two passages from Herodotus and Thucydides that seemed to offer straightforward evidence that Greek sailors and soldiers consumed either 1 choinix of wheat (Hdt. 7.187.2) or 2 choinikes of ἄλφιτα, that is, barley-meal,[10] (Thuc. 4.16.1) per day.[11] It appears that the authors of these older works believed that the seemingly explicit and uncomplicated nature of the Herodotus and Thucydides passages on grain consumption (discussed in section ii below) saved them from the need for any extended treatment of this subject.

More recent studies of classical Greek military provisioning and warfare do not include detailed discussions of the daily grain consumption of Greek armies and navies for a quite different reason. On the basis of Hdt. 7.187.2 and Thuc. 4.16.1, taken together with IG XI 2, 158A ll. 37–50 (an inscription from Delos from the year 282, discussed in section ii below), it was taken by earlier scholars that two choinikes of ἄλφιτα were the nutritional equivalent of one choinix of wheat in classical and Hellenistic Greece.[12] Almost all discussions of the daily grain consumption of adult classical Greek males – and therefore sailors and soldiers – now reject this equivalence,

---

[7] Thorne 2001, 235–236. Thorne uses, however, the incorrect estimates calculated by Engels: see n. 83 on these.

[8] Hellenistic: Engels 1978, 123–126; Roman: Erdkamp 1998, 27–45, Roth 1999, 7–67; Medieval: Harari 2000, 301–305, Bachrach 2002, 97–100. See also Bachrach 2002, 97 for examples of modern treatments of early modern European logistics and strategy using calculations of daily food requirements as the basis of their analyses.

[9] With the partial exception of Tänzer 1912, 35–41, 67–70.

[10] See Dalby 2003, 46–47 (with ancient and modern references) for a list of the foods that could be made from ἄλφιτα: μᾶζα, a kneaded, uncooked, barley-cake was the form in which ἄλφιτα was most commonly consumed; barley-meal was also eaten in the form of gruel or porridge, or as flat, unleavened bread, though barley-bread was given to slaves only (see Athenaeus 7.34 with von Reden 2007, 390).

[11] See Tänzer 1912, 35–36 citing Hdt. 7.187.2 and Thuc. 4.16.1; Cruickshank 1954, 58–59 citing Hdt. 7.187.2 and Thuc. 4.16.1 at the beginning of his discussion of the provisioning of classical Greek armies; Anderson 1970, 49 citing Thuc. 4.16.1 for «the rations thought suitable for a Lacedaemonian hoplite».

[12] See Jardé 1925, 128–135 for the original argument for this position (though see Roebuck 1945, 159 for Jardé establishing daily grain consumption at too high a level on the basis of IG XI 2, 158A ll. 37–50).

however, on the basis of the results of some grinding and milling experiments carried out by Lin Foxhall, published in this journal in 1982.[13] In order to attempt to define the contribution made by grain to ancient Greek and Roman diets, and in the absence of any data from antiquity for the weight per volume of ἄλφιτα, Foxhall produced her own figure for the weight per litre of ἄλφιτα by some milling experiments with a small sample of (English two-rowed, hulled) barley.[14] Although Foxhall noted many reasons why any result from these experiments should be treated with caution,[15] the figure she produced – 0.643 kg of barley-meal per litre – was still used throughout her and Forbes' treatment of ancient grain consumption.[16] On the basis of this 0.643 kg/litre figure, a figure for weight per volume of wheat (from modern Messenia) of 0.772 kg per litre,[17] and the fact that the caloric value of wheat and barley is roughly the same, Foxhall and Forbes calculated that one litre of wheat would have provided (only) 440 more calories than one litre of ἄλφιτα.[18] They concluded from this that «[i]t is likely, then, that one *choenix* of wheat per man per day was the more or less standard Greek allowance, especially for army rations, though whether this is true of its possible corollary, two *choenikes* of *alphita* is more doubtful».[19]

---

[13] Jasny 1942, 752 n. 11 and Roebuck 1945, 159–160, had already rejected the 1:2 wheat: ἄλφιτα equivalence on the grounds that wheat has a nutritive value of roughly 35 percent more than barley by volume, and thus the ratio of 1:2 could not be valid as it did not accurately reflect the difference in nutritive value between wheat and barley – but the question here concerns barley-meal, and not barley, and therefore the 1:2 equivalence cannot be rejected on these grounds.

[14] Foxhall – Forbes 1982, 75–78.

[15] Foxhall – Forbes 1982, 77–78: «There are, however, some severe difficulties involved [in these experiments], and I am not fully convinced of the validity of th[e] figure produced [by them]. First, my sample of barley meal was made from English, not Greek, barley. Second, we do not know precisely which methods were used to remove the lemma and palea [from hulled barley grains] in antiquity. Third, we do not know the extraction rate of ancient *alphita*, i.e. what percentage of the original weight of grain is left after grinding and winnowing or sifting … It is likely that the extraction rate of ancient *alphita* fell within the 60–70 % range, but it is by no means certain, and again much further experimentation is needed».

[16] Foxhall – Forbes 1982, 44: «Unfortunately, we have carried out only one set of experiments with small samples, and the results are thus statistically dubious; but since these are the only weight/volume figures available for barley ground on a simple mill, they will have to suffice for the present». Foxhall and Forbes' article was ground-breaking both in its collection and treatment of the literary and epigraphical evidence for ancient Greek and Roman grain consumption, and in its attempts to compare this evidence with skeletal data (but see n. 98) and FAO/WHO information on human caloric requirements. Although new data have emerged since they published their article (see section iv below), it still remains the starting point for any research on the topic of the daily grain consumption of ancient Greek and Roman populations.

[17] See Foxhall – Forbes 1982, 43 for the source of this figure and their reasons for using it.

[18] Foxhall – Forbes 1982, 46, 53.

[19] Foxhall – Forbes 1982, 55. Although they carefully analyzed the ancient literary and epigraphical evidence for a standard daily grain allowance of two choinikes of ἄλφιτα per man per day (1982, 54–55), it was Foxhall's milling experiments that bore the weight of this conclusion (see 1982, 53, 55–56). See also n. 45.

After Foxhall and Forbes' article – or, more precisely, after Foxhall's calculation of the weight per volume of barley-meal – it has become standard in discussions of the grain requirements of ancient Greek and Roman populations to deny any equivalence between one choinix of wheat and two choinikes of ἄλφιτα.[20] It has also become standard in calculations of the daily grain consumption of classical Greek armed forces to simply refer to Foxhall and Forbes' article for the figure of one choinix of wheat *or* ἄλφιτα for the amount of grain eaten on a daily basis by sailors and soldiers.[21] It has also become standard, too, to use the figure Foxhall produced for the weight per volume of ἄλφιτα of 0.643 kg per litre to calculate the grain requirements of adult Greek males[22] – even for those few scholars still using two choinikes of

[20] Although Foxhall and Forbes nowhere in their article ever explicitly rejected the 1:2 equivalence between wheat and barley-meal. See, e.g., Gallo 1983, 453 (explicitly following Foxhall and Forbes, and consequently rejecting the 1:2 equivalence between wheat and barley [sic]); Garnsey 1989b, 38: «Until 1982, when Foxhall and Forbes published their article … it was generally accepted that the ‹standard ration›, at least in the Greek world, was 1 choenix of unmilled wheat per day, or double this volume of barley meal.» See also Markle 1985, 278–279, using Foxhall and Forbes' calculations to reject the 1:2 equivalence between wheat and barley-meal, and to compute a figure of 1.2 choinikes of barley-meal as a sufficient daily ration for an adult male. See, too, van Wees 2001, 48 (and n. 20) citing Foxhall and Forbes in using one choinix of «grain» (the context shows van Wees is thinking of barley-meal) to calculate the caloric requirements of the inhabitants of zeugite farms in classical Attica; cf. van Wees 2001, 47 and n. 11 for using Foxhall and Forbes' figures to calculate the grain-producing requirements for membership of Athenian property classes.

[21] Lee 2007, 8 and n. 33, 214 and nn. 46, 48 explicitly citing Foxhall and Forbes for the statement that a choinix of wheat or barley-meal was the standard daily ration for the Cyreans, and esp. Lee 2007, 38 and n. 142 citing Foxhall and Forbes in using a figure of one choinix of barley-meal to calculate how many days' rations the *xenia* given to the Cyreans by Sinope and Heraclea would have made for 8,000 men. See also Krentz 2007, 151 taking one choinix of «barley or (less often) wheat» to be a standard daily ration for classical Greek soldiers (although Krentz does not cite Foxhall and Forbes, the figure he cites for a weight of a choinix of grain, 0.84 kg, is obviously derived from Foxhall and Forbes' figure of 0.839 kg for one Attic choinix of wheat); Lazenby 1994, 16–17 and n. 143 citing Foxhall and Forbes on figures for rations for classical Greek military forces and their caloric equivalents. See also Lendle 1995, 373 taking one choinix of barley-meal to be the standard daily ration for the Cyreans on their march back from Cunaxa (though not citing Foxhall – Forbes).

[22] Scholars using Foxhall and Forbes' figure for weight per volume of barley-meal: Erdkamp 1998, 45 and n. 1, in an attempt to explicate the rations recorded at Thuc. 4.16.1 for the Spartiate soldiers at Sphacteria; Hodkinson 2000, 194, to argue that Hdt. 6.57.3 does not offer evidence for a daily ration in the Spartiate syssitia of two Attic choinikes of ἄλφιτα on the grounds that this would provide an unrealistically high number of calories; Hodkinson 2000, 195–196, to postulate daily mess rations for Spartiates of 1 Laconian choinix (1.5 litres) of ἄλφιτα; Scott 2005, 240–241, 553 nn. 2, 5 to reconstruct Spartiate daily rations. See also Figueira 1984, 93 n. 15 using Foxhall and Forbes' figure to calculate the wheat equivalent of ἄλφιτα (and see also nn. 53, 65 below); and Reger 1993, 325 n. 80 using the figure to calculate the monthly demand for grain of the population of Hellenistic Delos (and 307 n. 25 in a dis-

ἄλφιτα as their figure for the daily grain consumption of classical Greek populations and military forces.[23]

This change in thinking on the weight per volume and – especially – the daily consumption of ἄλφιτα has hugely important consequences for the way we think about the waging of classical Greek wars since, although wheat was the preferred and higher-status grain in the Greek world in the fifth and fourth centuries,[24] ἄλφιτα was the form of grain most commonly consumed by Greek military forces on campaign in this period. On those few occasions that contemporary authors specified the form of grain that classical Greek sailors and soldiers were eating, buying, or being given (when engaged in operations in the Greek world), it was always ἄλφιτα.[25] The only explicit mentions of wheat being bought by or distributed to classical Greek soldiers occur in exceptional circumstances: when Nicias attempted to discourage the Athenians from embarking on the Sicilian expedition by requesting an extraordinarily large logistical apparatus, he requested stores of wheat (together with roasted barley) to be prepared for the journey to Sicily (Thuc. 6.22); and when the Ten Thousand were operating in Mesopotamia, they sometimes bought or had wheat (products) distributed to them.[26]

---

cussion of the relative prices of wheat and ἄλφιτα); cf. Pryor 2006, 17, using it in an attempt to calculate the rations of early medieval military forces.

23 See Whitby 1998, 15; Gabrielli 1995, 119; Lazenby 1994, 17.

24 See, e.g., von Reden 2007, 390 (with earlier references there).

25 Thuc. 3.49.3 [427]: Mytilenian envoys prepare ἄλφιτα for the trireme sailing from Athens to Mytilene to inform Paches that the decision by the Athenian assembly to kill all the Mytilenians had been reversed (the sailors on board the trireme eat the ἄλφιτα kneaded with wine and oil as they row); Thuc. 4.16.1 [425]: the Spartiates blockaded on Sphacteria were each to receive two choinikes of ἄλφιτα per day, already kneaded; Thuc. 8.100.2 [411]: Thrasyllus orders stores of ἄλφιτα to be prepared at Methymna for the Athenian fleet (Hornblower 2008, 1041, incorrectly translates ἄλφιτα in this passage as «barley»). Xen., Hell. 1.7.11 [406]: an Athenian saves himself from drowning in the aftermath of the battle of Arginusae by clinging on to a barrel of ἄλφιτα. The *xenia* provided to the Ten Thousand by Trapezus (Xen., Anab. 4.8.23), Sinope (Xen., Anab. 6.1.15), and Heraclea (Xen., Anab. 6.2.3) in 400 all included ἄλφιτα as their grain component. A merchant ship arriving at Calpe from Heraclea carried, among other things to sell to the Cyreans, ἄλφιτα but no other form of grain (Xen., Anab. 6.5.1). Coeratadas' miserable attempt at Byzantium to feed the Cyreans included twenty men accompanying him carrying ἄλφιτα (Xen., Anab. 7.1.37). At Aristoph., Peace 368 (performed in 421), Trygaios pretends to take Hermes' threats about his imminent destruction to mean that he has been called up for military service, at which news he feigns concern that he has not bought barley-meal or cheese in order to meet his death: ἀλλ᾽ οὐδὲν ἠμπόληκά πω, / οὔτε ἄλφιτα οὔτε τυρόν, ὡς ἀπολούμενος. At Peace 475–477, the Argives are said to be happy with the Peloponnesian War since, by hiring themselves out to the warring parties, they can gain pay to buy ἄλφιτα (see esp. 477: καὶ ταῦτα διχόθεν μισθοφοροῦντες ἄλφιτα). The magistrates at Lampsacus, at some unknown point in the fifth or fourth century, ordered the price of ἄλφιτα in the city to be raised by fifty per cent when they heard that a fleet of triremes was approaching their city (ps.-Aristotle, Oec. 2.2.7, 1347a3–1347b2).

26 See Xen., Anab. 1.5.6: when the grain of the Greek mercenaries in Cyrus' army gave out as they were marching through the desert between Corsote and Pylae, their only recourse was to the Lydian market, in the non-Greek part of the army, where the prices charged for ἄλευρα (wheat-

Since Greek sailors and soldiers bought their food in friendly or neutral territory, and foraged for it in hostile territory,[27] it is clear that they would have sometimes had the opportunity to either purchase or forage for wheat – it is also clear, however, that the grain product they most frequently bought, foraged, and consumed was ἄλφιτα.[28] If we accept the current scholarly consensus, then, that the usual daily grain consumption of Greek sailors and soldiers was only one choinix of ἄλφιτα, rather than two choinikes, we effectively cut in half the provisioning needs of Greek military forces – an act that will (or should) radically change the way we think about the tactical and strategic choices of Greek military commanders.

This article aims to demonstrate, however, that there is, in fact, no reason to reject the weight of the literary and epigraphical evidence from the classical and Hellenistic periods that one choinix of wheat or two choinikes of ἄλφιτα was considered sufficient for the daily grain consumption of Greek sailors and soldiers (and, by extension, all Greek adult males). It will do so by demonstrating that there was an error in Foxhall's calculations of the weight per volume of ἄλφιτα which fatally undermines all attempts to use those calculations to estimate the grain consumption of ancient populations. It will then employ evidence that has come to light since the publication of Foxhall and Forbes' article in 1982 to provide a figure for use in calculating the amounts of ἄλφιτα consumed by Greek armies and navies, and demonstrate that this figure coheres with the data we currently possess on the caloric value of grains, classical Greek adult male skeletal heights, and the caloric requirements of human populations. Before all of that, however, a brief review of the most pertinent literary and epigraphical evidence for the daily grain consumption of Greek adult males will serve as the necessary basis for the rest of the discussion.[29]

---

flour) and ἄλφιτα were astronomically high; Xen., Anab. 1.10.18: the wheat-flour and wine which were loaded on four hundred wagons assembled by Cyrus before the battle of Cunaxa, and which were to be distributed to the Greeks in the case of famine in the army, were instead pillaged by the Persians in the aftermath of the battle; Xen., Anab. 2.4.27: the Cyreans bought (wheat) bread (ἄρτους) from the city of Caenae on the Tigris. At those points on their march when the Ten Thousand subsisted through foraging and plundering indigenous settlements in non-Greek lands, they often subsisted on grain (products) other than barley-meal: see Xen., Anab. 3.4.31 (wheat-flour, whole barley), 4.5.5 (wheat), 4.5.26 (wheat, whole barley), 5.4.27 (spelt), 7.1.13 (whole wheat and barley).

[27] See, e.g., van Wees 2004, 105–106.

[28] In contrast, wheat was the predominant grain for populations in the Hellenistic Greek world: see Gallo 1983, 462 n. 15 (with earlier references there). With this in mind, this article will focus on the grain consumption of classical military forces, since there is no controversy over the question of whether one choinix of wheat constituted a sufficient amount of grain for the daily grain consumption of an adult Greek male. All references in this article from this point onwards, then, to Greek sailors or soldiers or military forces should be taken (unless explicitly stated otherwise) as referring to the classical period.

[29] The focus here will be on daily grain consumption, and not on the consumption of any other food. This is so for two important reasons. Firstly, there is not sufficient information to calculate the daily consumption of wine or olive oil (or any other food) by Greek sailors and sol-

II. Classical and Hellenistic ideas of the daily grain consumption and requirements of adult males

I present here the four passages that offer the strongest contemporary evidence that both one choinix of wheat and two choinikes of ἄλφιτα were considered in the classical and Hellenistic periods as sufficient (but not excessive) for the daily grain requirements of adult males. I will be brief since Foxhall and Forbe's careful discussion of the evidence for ancient Greek grain consumption prevents the need for a lengthy discussion.[30]

To begin, Herodotus used one Attic choinix[31] of wheat to calculate the total grain requirements of the men in Xerxes' army and navy invading Greece in 481: εὑρίσκω γὰρ συμβαλλόμενος, εἰ χοίνικα πυρῶν ἕκαστος τῆς ἡμέρης ἐλαμβάνε, καὶ μηδὲν πλέον, «for I find reckoning that each man received a choinix of wheat each day, and nothing more …» (7.187.2); the fact that Herodotus used this figure to make his calculation of Persian military requirements in grain strongly implies that such an amount was considered usual (and sufficient) for the daily subsistence of sailors and soldiers in the classical period.[32]

The same implication can be drawn for the Hellenistic period from an inscription from Crete.[33] In a treaty between Attalus I of Pergamum and Malla, made ca. 200,[34] it was stipulated that, on the arrival at Malla of auxiliary soldiers sent by Attalus, the Mallians would provide for the maintenance of the men, giving one Aeginetan drachma to each man (and two to their officers) and one Attic choinix (of wheat) to all

---

diers: see Foxhall – Forbes 1982, 69–70 (not possible to estimate oil consumption in antiquity); see also Harris 2005, 22 (the contribution of olive oil and wine to the caloric needs of ancient Mediterranean populations still unclear). Secondly, demand for oil and wine, unlike grain, was elastic: see Erdkamp 2005, 167–170. Greek sailors and soldiers could live without their oil and wine, but not without their grain.

[30] 1982, 51–62, esp. 51–55. It should be noted, however, that Foxhall and Forbes' discussion of the caloric values of Spartiates' syssitia contributions (1982, 58–59) is invalid because of their failure to realize that Plutarch's account of the common mess dues used Laconian (and not Attic) measures (see Figueira 1984, 92 n. 11, Hodkinson 2000, 206 n. 9, 206–207 n. 12).

[31] Herodotus was almost certainly thinking here of one Attic choinix, since Attic(-Euboic) measures are assumed as the ‹default› measures throughout the rest of his work: when he converts the Persian artaba into Greek measures for his audience, he uses the Attic medimnos and choinix (1.192.1); similarly, when he converts Babylonian talents into Greek talents, he twice uses the (Attic)-Euboic standard (3.89.2, 3.95.1). One Attic choinix = 1.094 litres (Moreno 2007, 325).

[32] See Foxhall – Forbes 1982, 52, 55. See also Tänzer 1912, 36: one should accept this figure of one choinix as «ein Durchschnittsmaß» for the grain consumption of classical Greek soldiers. There is nothing in this passage to suggest that the choinix of wheat mentioned here constituted a «low daily ration» (contra Cruickshank 1954, 58–59).

[33] Foxhall – Forbes 1982, 52.

[34] See Ducrey 1970, 637, 639–642 for the date and inscribed text of the treaty.

(Face A, ll. 20–24): Ὅταν δὲ παραγένωνται πρὸς Μαλλαίους, τ[ρ]ε[φ]έτωσαν τὴν συνμαχίαν αὐτοί, παρέχ[ο]ντες τῆς ἡμερᾶς ἑκάστωι ἀνδρι δραχμὰν αἰγιναῖαν, τῶν δ' ἡγεμόνων ἑκάστωι δραχμὰς δύο καὶ κατὰ σῶμα χοίνικα ἀττ[ικ]ὴν ...[35] This passage, then, gives us additional reliable evidence for Greek thinking that one Attic choinix of wheat was considered a proper and sufficient continuous allowance for the daily grain consumption of sailors and soldiers.[36]

There is also sound evidence for an equivalence between one volumetric unit of wheat and two of ἄλφιτα in the accounts of the temple of Apollo on Delos for the year 282 (IG XI 2, 158A ll. 37–50). For the first seven months of their service in this year, two τεχνῖται employed by the temple received 1.5 choinikes of wheat per day, in addition to two obols per day εἰς ὀψώνιον.[37] In the last three months of the year, however, when wheat prices on Delos had risen significantly,[38] cheaper ἄλφιτα was substituted for the wheat at the rate of 3 choinikes per day.[39] Although these rations do not provide evidence for Greek thinking on the usual daily grain consumption of adult males – since they were meant to provide for the two craftsmen's households, too[40] – they do demonstrate that it was thought on Delos in 282 that two volumetric units of ἄλφιτα were the equivalent of one volumetric unit of wheat.

Finally, the terms of the armistice between the Athenians and the Spartans in 425 after the Spartiate force on Sphacteria had been cut off from the mainland provides strong evidence that two Attic choinikes of ἄλφιτα per day were considered in the classical period as sufficient to cover the daily grain requirements of soldiers over a continuous period of time: the Athenians permitted the Spartans on the mainland to send the Spartiates blockaded on Sphacteria a fixed amount of two Attic choinikes of (already kneaded) ἄλφιτα, as well as two kotylai (around half a litre) of wine and a

---

[35] The treaty also stipulated (at ll. 24–26) that the Mallians were to continue to distribute the ration of one Attic choinix a day during operations in enemy territory if there were no opportunity to forage there. Although the type of grain is not specified in the treaty, since wheat was by far the most commonly consumed grain in the Greek world ca. 200 (see n. 28), we should take it that wheat is the grain referred to here.

[36] For the limited evidential value of other passages mentioning the distribution of one choinix of wheat to adult Greek males, see Foxhall – Forbes 1982, 51–53.

[37] Actually 45 choinikes of wheat and 10 drachmas εἰς ὀψώνιον per month. ὀψώνιον here is used in the sense of ὄψον (see LSJ 7) – the companion to the grain component of the Greek diet.

[38] I do not enter here into the controversy surrounding the reason for this price rise: see Oliver 2007, 241–247 for a good recent summary and treatment of the controversy.

[39] Actually 90 choinikes of ἄλφιτα. Reger's discussion of the relative prices of wheat and barley-flour on Hellenistic Delos (1993, 304–317) is not helpful in ascertaining the relative cheapness of ἄλφιτα on the island in 282 since it is based on an incorrect conversion of whole barley (κριθαί) prices into barley-meal (ἄλφιτα) prices: see Sosin 2002, 138.

[40] This can be stated for two reasons: firstly, both 1.5 choinikes of wheat and 3 choinikes of barley-meal would provide an overabundance of calories for one adult male (see the discussion of caloric values of wheat at pp. 341–343); secondly, «the 2 obols per day εἰς ὀψώνιον is too much for other food, such as oil, wine, fruit and vegetables, for one person» (Markle 1985, 295).

piece of meat, per day;[41] the Helots accompanying the Spartiates on Sphacteria were to receive half their rations (Thuc. 4.16.1).[42] This passage demonstrates that Athenians and Spartans in the late fifth century believed that two choinikes of ἄλφιτα were enough to sustain a hoplite over a continuous period. If the Helots were only to receive half this ration, this does not mean that one choinix of ἄλφιτα was considered sufficient to cover the daily energy requirements of an adult male Helot; rather, this reflects Helots' lower status as compared to Spartiates[43] – Helots could not be expected to receive the same allowances as Spartiates in a public agreement.[44]

---

41 Roebuck (1945, 160) suggested that the rations of two choinikes of ἄλφιτα and two kotylai of wine received by the Spartiates on Sphacteria could have been a ration deliberately designed to humiliate them (and thus might not offer evidence for usual daily food consumption rates). This view is based on inferences about daily consumption rates drawn from evidence for Spartiate contributions to their syssitia; these contributions, however, cannot be used to reconstruct Spartiates' daily (or monthly) food consumption since there is no indication in any ancient source that the Spartiates' consumption in the messes matched their contributions and also because it is probable that some of the food they contributed went to feed non-Spartiates: see Garnsey 1989b, 91 n. 8 for these points.

42 Not barley, as Moreno 2007, 32 n. 184 has it.

43 Thuc. 4.16.1 has been cited along with Athenaeus 6.272B by Figueira 1984, 91, and Moreno 2007, 32 n. 184, as evidence that slaves normally received one choinix (of barley-meal) per day. But the statement at Athenaeus 6.272B that the Corinthians had so many slaves that the Pythian priestess called them «pint-measurers», χοινικομέτρας, «merely informs us that the *choenix* was the unit normally used for measuring out grain for slaves; it is not specifically stated how many *choenikes* or with what product slaves were fed» (Foxhall – Forbes 1982, 51); for the measuring out of grain for distribution as particularly associated with slaves, see Theophr., Characters 9.4. Note also here that Hornblower 1996, 169–170, states ad Thuc. 4.16.1 that «a single choinix – here, the helot ration – is the … daily ration of corn assumed by Hdt. at vii.187.2.» But it is not the same ration assumed by Herodotus at 7.187.2, since the helots were receiving ἄλφιτα, and not wheat.

44 For the limited evidential value of other passages mentioning the distribution of two choinikes of ἄλφιτα to adult males in the classical and Hellenistic periods, see Foxhall – Forbes 1982, 54. I add here some notes on Hdt. 6.57.3. Herodotus states in this passage that if the Spartan kings «do not come to the messes, two choinikes of barley-meal and a kotyle of wine are sent to each of them at their houses, but when they come they shall receive a double share of everything (διπλήσια πάντα); and the same honor shall be theirs when they are bidden by private citizens to dinner …» (This is an adaptation of the Loeb translation.) Hodkinson 2000, 194–195, has taken this passage as evidence that Spartiate kings received two Laconian choinikes (= 3 Attic choinikes) of ἄλφιτα and Spartiates one Laconian choinix (= 1.5 Attic choinikes) of ἄλφιτα as their daily mess rations (see, e.g., Figueira 1984, 89 for one Laconian choinix equalling 1.5 Attic choinikes). There are three major problems with this view. Firstly, Hodkinson 2000, 194, states that «the word διπλήσια [at 6.57.3] describes the relationship between the kings' rations and those of other citizens, not that between the kings' rations at the mess and at home», and therefore that other Spartiates' daily rations were one choinix of ἄλφιτα. But Hodkinson, 2000, 194, is forced to note that «Herodotus' text, however, clearly intends some contrast between home and mess»; it is hard to see what that contrast could be if it were not between the portion of two choinikes of barley-meal and a kotyle of wine received at home, and the double portion of these foods received at the mess. Secondly, Hodkinson's interpretation of διπλήσια

III. Foxhall's calculations of the weight per volume of ἄλφιτα

There is, then, reliable evidence from the classical and Hellenistic periods to support the idea that one choinix of wheat was considered a usual and sufficient amount of grain for the daily subsistence requirements of sailors and soldiers, from the early Hellenistic period that one choinix of wheat was considered the equivalent of two choinikes of ἄλφιτα, and from the late fifth century that two choinikes of ἄλφιτα were considered sufficient for the daily subsistence of soldiers. There is no good reason, on the internal evidence of the texts presented in section ii, to reject any or all of the information that they provide to us on grain consumption.[45] But, as discussed in section i, most recent discussions of Greek military provisioning do just this on the basis of the results of grinding and milling experiments carried out by Lin Foxhall. The figure for weight per volume of barley-meal Foxhall's experiments produced, 0.643 kg/litre (now the standard figure used by Greek military historians), meant that two choinikes of barley-meal would have produced (on the figures available to Foxhall and Forbes in 1982) 4641 kcal: an amount of calories far in excess of what an adult male would have required on a daily basis – and 1838 kcal more than one choinix of wheat would have produced in their calculations.[46] It is because of these calculations that it is now the consensus to reject the ancient evidence that two choinikes of ἄλφιτα were a normal rate of daily consumption (or the equivalent of one choinix of wheat).

πάντα means that he has to postulate a daily mess ration of half a kotyle of wine (since this is half of the king's ration of wine). This figure is most problematic since it implies a very small – almost certainly too small – portion of wine for daily consumption: see Lipka 2002, 151 n. 27. Thirdly, Hodkinson 2000, 194, thought that Herodotus was using Laconian rather than Attic measures here, but there is good reason to think that Herodotus was, in fact, using Attic measures in this passage. Herodotus uses Attic measures elsewhere (see n. 31), and slightly earlier in his description of the perquisites of the Spartan kings, Herodotus notes that they receive at each new moon and each seventh day of the first part of the month, a full-grown victim for Apollo's temple, a medimnos of barley-meal and a ‹Laconian quart› of wine (καὶ οἴνου τετάρτην Λακωνικήν) (6.57.2). The fact that Herodotus specifies a Laconian measure only here in his account of the kings' perquisites implies strongly that he is using other (i.e. Attic) measures in the rest of his description; in fact, Herodotus probably singles out the Laconian quart for mention in his description since it was an unusual measure (Scott 2005, 556). Finally, it should be noted here that Moreno 2007, 32 n. 184, cites Hdt. 7.187 with Hdt. 6.57 and Thuc. 4.16 for the statement that «[t]wo *choinikes* of barley were perceived as the nutritional equivalent of one *choinix* of wheat». But both Hdt. 6.57.3 and Thuc. 4.16.1 refer to barley-meal, not barley.

[45] I should note here that Foxhall and Forbes do not dispute the usefulness of Hdt. 7.187.2 and the Malla treaty as evidence for one choinix of wheat being a «standard ration» (see esp. 1982, 55), do not employ an analysis of its internal evidence to dispute the implications of IG XI 2, 158A ll. 37–50 (1982, 53–54), and only dispute the usefulness of the internal evidence of Thuc. 4.16.1 because of the one choinix of ἄλφιτα ration for Helots found there (1982, 54, 55) – but see p. 335 for explanation of this ration.

[46] See the summary at Foxhall – Forbes 1982, 86–87 Table 3; cf. Foxhall – Forbes 1982, 56 n. 49.

There is, however, in addition to the problems cited by FOXHALL and FORBES in using the figure for ἄλφιτα produced by FOXHALL's milling experiments,[47] a major problem in their calculations that renders invalid their figure for the weight per volume of barley-meal. For her experiments, FOXHALL states that she started with a sample of one litre of «very clean» English autumn-sown wheat (*triticum vulgare*) with a net weight of 782.2 g per litre, and with a sample of English two rowed, hulled barley, «fodder quality, reaped by combine harvester, not cleaned, numerous hull and rachis fragments included», with a net weight of 587.0 g per litre.[48] But in the presentation of her milling results, FOXHALL lists a figure for her («whole, hulled grain») barley sample («before grinding») of 750 g per litre: it was the grinding, winnowing, and sifting of this sample that produced her figure for the weight per volume of barley-meal of 0.643 kg/litre.[49] This figure – 750 g per litre – for weight per volume of hulled barley grains is not possible, however. The normal weight per volume ratio between wheat and barley (made ready for sale or distribution, i.e. «cleaned»), as found in all other times and places, is roughly 6:5[50] or 5:4.[51] But the barley sample used by FOXHALL weighing 750 g per litre does not fit this ratio either with her own sample of wheat – which only weighed 32.2 g more per litre – or with the weight per volume of any sample of wheat known from antiquity (or modernity).[52]

Secondly, as FIGUEIRA has pointed out, a weight of 750 g/litre for barley is heavier than USDA #1 barley (c. 606 g/litre) and heavier than the upper range for weight per volume of barley allowed in modern grain storage handbooks.[53] At some point in her

---

47 See n. 15.

48 See FOXHALL – FORBES 1982, 76.

49 FOXHALL – FORBES 1982, 76. FOXHALL gives no indication as to why she uses this different figure of 750 g/litre for her weight per volume of barley, instead of the original 587 g/litre figure.

50 This ratio between wheat and barley is attested for classical Attica (STROUD 1998, 54), Roman Egypt (RATHBONE 1983, 270 [and see here also for this ratio being found in other times and places in pre-modern and modern Europe]), and the modern United States of America (see again STROUD 1998, 54). See also TÄNZER 1912, 36 n. 3: securing figures, through word of mouth, of 750 g/litre for wheat and 650 g/litre for barley, resulting in a 75:65 ratio.

51 The latter ratio is attested for modern Messenia (see VAN WERSCH 1972, 185: a figure of 772 g/litre for wheat compared to a figure of 618 g/litre for barley) and the modern United States (PRITCHETT 1956, 193).

52 Since for a sample of wheat to cohere with FOXHALL's figures for barley, it would have to have a weight per volume of 900 g/litre or 937.5 g/litre. These weights per volume would be above any known for antiquity (see, e.g., FOXHALL – FORBES 1982, 43 on the figures from Pliny, Natural History 18.66; RATHBONE 1983, 270 on weights per volume for wheat from Roman Egypt) or known to me from modern agriculture: the National Association of British and Irish Millers (the U.K. trade association for flour millers), for example, quotes a figure for weight per volume of wheat of 750 g/litre (I am grateful to SAM MILLAR, Head of Cereals & Milling Department, Campden & Chorleywood Food Research Association, for this information).

53 FIGUEIRA 1984, 93 n. 15. Curiously, however, having pointed this out, FIGUEIRA then proceeds to use FOXHALL's figures in his own calculations of a wheat equivalent for ἄλφιτα: see n. 65 below. TÄNZER's word of mouth figure of 650 g/litre for the weight per volume of barley (see n. 50) is the heaviest I know of.

experiments or calculations, then, Foxhall made an error that led her to use a figure for weight per volume for her barley sample that was invalid – and since her figure for the weight per volume of ἄλφιτα was derived from this invalid figure, her figure for the weight per volume of barley-meal must be considered invalid, too.

Foxhall's calculations, then, offer no grounds to reject the implications of the literary and epigraphical evidence presented in section ii. There is now no reason, on internal or external grounds, to doubt the ancient evidence that one choinix of wheat and/or two choinikes of ἄλφιτα was considered proper and sufficient for an adult Greek male's daily consumption of grain. In addition, all the calculations of Foxhall and Forbes (and subsequent scholars) of the grain requirements of adult male populations – including armies and navies – made on the basis of Foxhall's figure of 0.643 kg/litre for the weight per volume of ἄλφιτα must now be rejected.

IV. The wheat equivalent of ἄλφιτα; was one choinix of wheat per day sufficient to cover the energy requirements of classical Greek sailors and soldiers?

Since the publication of Foxhall and Forbes' article in 1982, new data on the weight per volume of wheat and barley in classical Greece have emerged from a recently discovered inscription recording an Athenian law from the year 374/3 establishing a tax on grain from the islands of Lemnos, Imbros, and Skyros.[54] The law prescribed that the contractors of the tax, once they had transported the tax grain to a building in the Athenian agora (the Aiakeion),[55] weigh out the wheat at the weight of one talent for 5/6 of a medimnos and the barley at the weight of one talent per medimnos.[56] An initial objective of this article was to use this equivalence to come up with a figure for weight per volume for barley-meal, but there are no data (from any geographical region or historical period) presently available on the weight ratio between a given volume of barley-meal and the given volume of barley it was produced from.[57]

This is a serious problem since, as discussed in section i, Greek sailors and soldiers most commonly consumed ἄλφιτα on campaign. I propose here, then, the following solution to this problem: if there is no explicit equivalence made in any classical or Hellenistic literary or epigraphical source between one choinix of wheat and two choinikes of ἄλφιτα,[58] one choinix of wheat or two choinikes of ἄλφιτα was considered a standard amount of grain for the daily consumption of an adult Greek male and the accounts of the temple of Apollo on Delos show that two volumetric units of ἄλφιτα

[54] Stroud 1998; Rhodes – Osborne 2003, no 26; SEG 48, 96.

[55] Stroud 1998, 54.

[56] Rhodes – Osborne 2003, no 26 ll. 21–25.

[57] I have searched through ancient literary and epigraphical texts, secondary literature on ancient grain production and consumption, secondary literature on the metrology of pre-modern Europe, work and research on the modern production and milling of barley, and have consulted archaeobotanists about this question, but all to no avail.

[58] Foxhall – Forbes 1982, 54.

were considered the equivalent of one volumetric unit of wheat. And if we do not have any figures for the weight per volume of barley-meal, we can establish a weight per volume for wheat from the Athenian grain-tax law of 374/3. Although ancient measures cannot be expected to have been as precise or consistent as modern measures are,[59] and although there is some doubt on the precise weight of an Attic talent,[60] one can use, following MORENO,[61] the Attic market weight of 27.47 kg for a talent[62] to use the weight/volume ratios provided by the grain-tax law to obtain a figure of 0.687 kg per Attic choinix of wheat. We can use this normative[63] figure to construct a figure for the consumption of ἄλφιτα of Greek military forces in kilogrammes of wheat equivalent (reflecting the fact that, in the classical Greek world just as in other pre-industrial European societies, grain was the single greatest component of both output and consumption).[64] Since two choinikes of ἄλφιτα were considered the equivalent of one choinix of wheat, the wheat equivalent of two choinikes of ἄλφιτα will be 0.687 kg (= the weight of one choinix of wheat) of wheat equivalent; and one medimnos (= 48 choinikes) of ἄλφιτα will equal 16.482 kg of wheat equivalent.[65]

---

59 See FOXHALL – FORBES 1982, 43.

60 See the discussion at STROUD 1998, 55.

61 MORENO 2007, 325.

62 ROSIVACH 2000, 32 n. 6, and VON REDEN 2007, 403 n. 96, mistakenly use Attic coin weights in converting the weight/volume ratio found in RHODES – OSBORNE 2003, no. 26 into metric weight equivalents of volumetric units of wheat.

63 STROUD 1998, 55, evinces caution in taking the weight/volume ratios recorded in the grain-tax law as standard figures either for Athens or for Greece in general. The point is well taken, but I would emphasize here that this is a weight per volume ratio for wheat prescribed by the polis of Athens for an indefinite period of time and not a ratio derived from one random and therefore possibly unrepresentative transaction.

64 For the use of wheat equivalent to generate cross-cultural and cross-temporal comparisons, see CLARK – HASWELL 1970, 55ff.; FIGUEIRA 1984, 91–92; HOPKINS 2002, 198. See FIGUEIRA's definition of a kilogramme of wheat equivalent (1984, 92): this «is equivalent to either the amount of nutrition derived from a kilogramme of wheat or to the value of other foodstuffs expressed in terms of wheat by price».

65 FIGUEIRA 1984, 92–93 and nn. 14–15, calculated an equivalence for ἄλφιτα and wheat of 1 medimnos of ἄλφιτα = 0.72 medimnos of wheat. To arrive at this figure, FIGUEIRA first noted that barley was valued in the modern Mediterranean at 65 per cent of the value of wheat, and that this figure was approximated in the few surviving ancient data available to us. To get from this figure to the relationship between the value of barley-meal and wheat, he used FOXHALL's figure for weight per volume of barley-meal, even after noting that the figure for the barley from which she produced her barley-meal was implausibly high (see pp. 337–338 above). FIGUEIRA then substituted (arbitrarily) for FOXHALL's figure of c. 750 g/litre a weight per volume for barley of 583 g/litre and then, using the relationship between this figure and FOXHALL's figure for barley-meal of 643 g/litre (the latter is 1.103 times greater than the former), multiplied 65 (the value of barley as compared to wheat in percentage terms he had already noted) by 1.103 to reach a figure of 72 per cent for the price relationship between barley-meal and wheat. Since FOXHALL's figure for weight per volume of barley-meal is invalid, the second and third steps of FIGUEIRA's calculations are also invalid, and therefore his figure for the wheat equivalent of ἄλφιτα is, too.

While such a figure will not give us an absolute weight for the amounts of ἄλφιτα consumed by individual Greek sailors and soldiers, or by Greek armies and navies, it will, at least, allow us to make cross-cultural comparisons across time with the consumption of military forces in other periods.

These calculations beg the question, though: would one Attic choinix of wheat (the basis for the foregoing calculations) have been sufficient to meet the energy needs of Greek sailors and soldiers?[66] To answer the question, I will use the figure for weight per volume of wheat the Athenian grain-tax law of 374/3 gives us in order to calculate whether one choinix of wheat would have provided a sufficient amount of calories to provide for the energy requirements of an average Greek sailor or soldier.[67] Before proceeding, I should state that I am aware of the limitations of the results produced by the calculations I undertake in the rest of this section. All of the key variables underlying the following calculations (the weight/volume conversion for wheat, the caloric value of ancient wheat,[68] the height, weight, age, and physical activity levels of the average Greek sailor or soldier) allow of greater or lesser amounts of imprecision. But the range of uncertainty will not be so large that «the parameters of the possible»[69] on this question will not be able to be established; that is, despite the imprecision of the calculations, I aim to demonstrate that they will still show that it is possible to establish whether one choinix of wheat (and thus two choinikes of barley-meal, its equivalent)

---

[66] Although there is no current controversy over this question (see n. 28), it is worth asking because, as I will demonstrate, since the publication of Foxhall and Forbes' article in 1982, in addition to the new evidence of the Athenian grain-tax law, new data have also appeared on the caloric value of wheat, Greek adult male skeletal heights, and the caloric requirements of adult males, all of which provide the opportunity to improve upon Foxhall and Forbes' calculations of the contribution one choinix of wheat made to the diet of an adult Greek male. Note, for example, that the figure for weight per volume of wheat from the Athenian grain-tax law (0.687 kg/litre) is much lighter than the figure for weight per volume of wheat Foxhall and Forbes were using (0.772 kg/litre); this means that their calculations of the caloric value of one choinix of wheat exaggerate its caloric contribution to ancient diets.

[67] Note that von Reden 2007, 403 and n. 96 has already made use of Rhodes – Osborne 2003, no 26 to calculate the daily and annual grain consumption of average classical Greek soldiers, and that Rosivach 2000, 32 and n. 6 and Moreno 2007, 32 have already used it to calculate the annual grain consumption of classical Athenian adult males. None of these scholars, however, have attempted to calculate whether the amount of wheat contained in a choinix as implied by Rhodes – Osborne 2003, no 26 ll. 21–25 would have provided a sufficient amount of calories for a classical Greek adult male, and, furthermore, there is an error in Rosivach's and von Reden's calculations (see n. 62).

[68] Cf. the remarks of Devroey 1987, 88 on attempting to ascertain the caloric value of rations in the Carolingian period: «Quantitative research creates problems for the study of history of the early middle ages. By calculating cereal yields and calorific values of rations on the basis of uncertain metric data there is a danger of substituting tenuous knowledge for ignorance. The resulting illusion of reality may be no more than the reflection of our own hopes, anxieties and prejudices».

[69] See Starr 1977, 152 for this phrase.

provided a (roughly) sufficient amount of calories to meet the energy requirements of Greek sailors and soldiers.

I have already established a weight per volume of wheat: 0.687 kg per Attic choinix of wheat. Estimating the caloric content of this weight of wheat is fraught with difficulties. Firstly, it is not possible to ascertain the cultivar of wheat grown on the islands of Lemnos, Imbros, or Skyros.[70] Secondly, «[f]ood composition depends on a large number of factors: climate, soil, variety, transport, storage, and preparation.»[71] Because of these factors, modern food composition databases will only have a limited predictive accuracy for any single sample of wheat,[72] although it should be noted that uncooked grains have a low water content and therefore are less variable in composition than other foods.[73] Thirdly, we do not know the typical extraction rates for wheat in classical Greece, i.e. how much of the original grain was left after milling, winnowing, and sifting.[74] Extraction rates would have differed according to whether the wheat was foraged or bought, and, if the grain was bought in bread or flour form, whether it was a more or less refined flour. We may assume, however, for Greek sailors and soldiers foraging for wheat and using simple hand-held mills,[75] that the usual extraction rate was (very) high. With all of these problems in mind, I will use the figures of 343 kcal per 100 g dry measure edible portion of whole grain or meal soft wheat (*triticum aestivum*) (for foraged wheat), and 356 kcal per 100 g dry measure edible portion of soft wheat flour of an extraction rate of 80–89 per cent, and 367 kcal per 100 g dry measure edible portion of soft wheat flour at an extraction rate of 72 per cent (these three figures are drawn from FAO/USDA food composition data for the Near East)[76]

[70] See Dalby 2003, 348–349 for a brief summary of the different cultivars of wheat grown in the Greek world. Sallares 1991, 324, 326, states that bread wheat was unknown in classical Greece, but it has been found in archaeological excavations of Protogeometric and Geometric Greek sites, and the scant archaeobotanical data from archaic and classical Greek sites suggests that it was cultivated in these periods, too: Megaloudi 2006, 77–79, 81 with Tables 5.12, 13, 14.

[71] Sika et al. 1995, 62; and see the differences noted in that article in caloric and nutrient content for grains by national region, country, and continent (1995, 64–67). Cf. Greenfield – Southgate 2003, 19: «Foods, being biological materials, exhibit variations in composition; therefore a database cannot accurately predict the composition of any given single sample of food.» The problem was noted by Foxhall – Forbes 1982, 45. For the classical Greek period, see Theophr., Enquiry into Plants 8.4.5: differences in densities between Pontic, Sicilian, Boeotian, and Attic wheat.

[72] Southgate 1993, 268–269. The problem is exacerbated by the fact that the producers of food composition databases have not always indicated precisely the sources of their data and variations therein, or included descriptions of their samples: see Sevenhuysen 1994; Greenfield – Southgate 2003, 19–20.

[73] Southgate 1993, 269.

[74] Cf. Foxhall – Forbes 1982, 78; Clark – Haswell 1970, 53–54.

[75] See Xen., Cyr. 6.2.31 for an example; cf. Frontinus, Strat. 3.10.10 (Philip II allowing only one attendant per ten men in order to carry the millstones and ropes).

[76] FAO/USDA 1982 (this study would have been unavailable to Foxhall and Forbes): I chose the figure for *triticum aestivum* on the basis of the works cited at n. 70; see also Mega-

(for purchased wheat) to calculate the (possible) caloric value of one Attic choinix of wheat. Assuming an extraction rate of 90 per cent for one Attic choinix of wheat,[77] it would have been milled down to 0.618 kg and have had a caloric content of 2120 kcal; assuming an extraction rate of 80 per cent, it would have been milled down to 0.545 kg and contained 1940 kcal; assuming an extraction rate of 72 per cent, it would have been milled down to 0.495 kg and contained 1817 kcal.[78]

Comparative evidence suggests that cereals will have made up between 60 and 75 per cent of an average Greek adult male's caloric needs: this is a guess, but an informed guess.[79] The scarce stable isotopic evidence we have for the classical period gives credence to this guess.[80] It has sometimes been suggested that the diet of Greek soldiers may have included more cereals than the normal ‹civilian› diet.[81] There is no reason to think this, however: in friendly or neutral territory, military forces acquired their provisions from markets similar in scale and structure to those used by civilian populations and therefore had access to a ‹normal› range of foodstuffs; in enemy territory, foraging might, in fact, have provided opportunities for a more variable diet than that usually consumed.[82] Extrapolating from the 60 to 75 per cent estimates, then, one choinix of wheat at an extraction rate of 90 per cent would have been part of a diet providing between 2826 and 3533 kcal, one choinix of wheat at an extraction rate of

---

loudi 2006, 35. Foxhall and Forbes used the figure of 334 kcal per 100 g for «medium» wheat of 100 per cent extraction (noted, however, as applicable to extraction rates of 94 to 100 per cent) from FAO/Chatfield 1949, Table 2, Item 1. But, firstly, see next note on extraction rates for wheat and other grains; secondly, Chatfield's study is now out of date, because of changes and improvements in analytical methodologies and documentation procedures since its publication (see FAO n.d.); thirdly, and related to the second point, the values found in her study for the caloric value of wheat are consistently lower than those found in more recent publications (cf., e.g., Sika et al. 1995, 67 Table 5; USDA, Agricultural Research Service 2005). Of more recent FAO food composition data, I chose the data from the Near East since it clearly indicated caloric values for different extraction rates of indigenous wheat (from a region more closely comparable to the Mediterranean and Black Sea region than other sources of FAO research data [Africa, Asia, Latin America] on food composition more recent than FAO/Chatfield 1949).

[77] See Clark – Haswell 1970, 53–54: consumption of grain at extraction rates above 90 per cent were (in 1970) unknown in contemporary third-world countries; they therefore assumed a roughly 10 per cent loss in weight in milling «in the hands of a cultivator who has to exercise strict economy» (1970, 54). Foxhall – Forbes 1982, 46 n. 14 reject Clark – Haswell's assumption, but without providing a reason.

[78] Note that wheat flour does not lose any calories in the process of being made into bread (Foxhall – Forbes 1982, 80; Garnsey 1989a, 90 n. 18).

[79] See esp. Garnsey 1989a, 31; cf. von Reden 2007, 390.

[80] See Vika et al. 2009, 1077 (stable isotopic analysis of 30 skeletons from Thebes in the classical period indicating a diet consisting of animal and C^3 [i.e. wheat and barley] protein). See also Keenleyside – Panayotova 2005, 33: «a recent stable isotopic analysis of the remains of 54 individuals from Apollonia … revealed that the [classical] population relied heavily on a terrestrial diet of C^3 plants, principally wheat and barley».

[81] Garnsey 1989b, 39, von Reden 2007, 403.

[82] See, e.g., van Wees 2004, 105–106.

80 per cent part of a diet providing between 2587 and 3233 kcal, and one choinix of wheat at an extraction rate of 72 per cent part of a diet providing between 2423 and 3028 kcal.

How do these figures compare to the energy requirements of Greek sailors and soldiers?[83] Energy requirement is defined as «the amount of food energy needed to balance energy expenditure in order to maintain body size, body composition and a level of necessary and desirable physical activity consistent with long-term good health.»[84] Human energy requirements are determined by a number of variables: gender, weight, age, and level of physical activity.[85] We can state with certainty that Greek sailors and soldiers were male (!). What of the other variables?

---

[83] Military historians of other periods in pre-industrial European history have attempted to calculate both the energy requirements of sailors and soldiers and the caloric content of known figures for military diets. Engels 1978, 123–126 used a figure of 3600 kcal per man per day for the caloric requirements of Alexander the Great's army and a daily ration of 3.9 lbs. of grain (to make 3.5 lbs. of bread). But Engels' figure of 3600 kcal per day was the U.S. Army RDA for a 19-year-old soldier of 175.2 cm height – Alexander's (and classical Greek) soldiers will almost certainly have been both shorter and older, and therefore would have needed fewer calories (Roth 1999, 7, 12). Secondly, Engels overestimated the amount of grain required per man per day because he misunderstood the bread-making process (Foxhall – Forbes 1982, 80) and because he mistakenly counted only grain consumption in his calculations of the food needed to meet daily energy requirements (Roth 1999, 47–48). All estimates that have been made by scholars of the caloric requirements of Roman, medieval, and early modern European sailors and soldiers and the energy values of their diets are more or less loose and based on uncertain calculations, and so offer no useful concrete comparative evidence (see the survey in Bachrach 2002, 97–100; Bachrach 2002, 86 uses a figure for grain consumption for the forces of the First Crusade besieging Antioch of «approximately one kilogram of milled wheat for each person per day» but this would produce a contribution for wheat alone of upwards of 3600 calories to the diets of the besieging forces and thus an implausibly high total caloric content for their diet of somewhere between 4800 and 6000 calories). There are, at first sight, promising data in four medieval figures for the daily diets of galley crews and crusading forces (see Pryor 2006, 10–12); but since the grain component of each of these diets consisted of ship's biscuit, and we do not know either the volume or weight of grain needed to make a given weight of biscuit (Pryor 2006, 14–15), we cannot estimate the caloric content of these diets (Lane 1966, 264 n. 2, in a ground-breaking article on the diets of early modern Italian sailors, used modern unshortened water crackers to estimate the caloric content of biscuit, but this amounts to no more than a guess). On the whole subject, see already Garnsey 1989b, 36, and esp. 38: «In short, it is difficult to be enthusiastic about medieval and early modern sources on food consumption.» But comparative evidence does offer two insights. Firstly, a survey of the scholarly literature on the rations of pre-industrial European military forces demonstrates «the dominance of grain as the staple of the soldier's diet in the pre-modern West» (Bachrach 2002, 100). Secondly, the wheat ration of the Roman Republican army was approximately the same as one choinix of wheat: see Polyb. 6.39.13 with Foxhall – Forbes 1982, 62.

[84] FAO/WHO/UNU 2004, 5. Cf. Morley 2007, 598: «In its simplest form subsistence may be equated with the calories necessary for the survival of an average person».

[85] FAO/WHO/UNU 2004, 8, 35–36.

An adult male's BMR (basal metabolic rate: «[t]he minimal rate of energy expenditure compatible with life»),[86] and therefore the bulk of his energy requirements, is determined by his body weight.[87] We have no data for the weights of Greek adult males, but there are skeletal data providing an indication of the average stature of classical Greek adult males, which I summarize here:[88]

Classical Greece[89]	170.5 cm (number = 52)
Metapontum[90]	166.6 cm (n = 20)
Spartiates[91]	170.0 cm (n = 13)
Messenians[92]	171.3 cm (n = 4)
Apollonians[93] (Black Sea)	163.25 cm (n = 4)
Thebans[94]	179 cm (n = 2)
Argives[95]	166.95 cm (n = 2)

[86] FAO/WHO/UNU 2004, 9.

[87] FAO/WHO/UNU 2004, 7: Adult males need energy for basal metabolism which «is determined mainly by the individual's age … body size, and body composition». Basal metabolism represents 45 to 70 per cent of daily total energy expenditure. Adult males also need energy for metabolic response to food which «increases total energy expenditure by about 10 percent of the BMR [basal metabolic rate] over a 24-hour period in individuals eating a mixed diet»; and for physical activity which «is the most variable and, after BMR, the second largest component of daily energy expenditure».

[88] A number of notes regarding these figures. The figures given for ‹Classical Greece›, Metapontum, and Spartiates are averages reported by the respective authors. Also, none of these figures, with the exception of those in Breitinger 1937, would have been available to Foxhall and Forbes. Finally, von Reden 2007, 388 Table 14.1 has also summarized average classical Greek adult male statures, but there are several problems with her table. Firstly, she missed Bisel – Angel 1985, a publication that supersedes the Angel articles from 1971 and 1972 which she cites (see next note). Secondly, she reports a figure for classical Akanthos of an average of 169.2 cm for male skeletons without providing a reference for this figure (this comes from Bisel's dissertation, which is superseded by Bisel – Angel 1985; see next note). Thirdly, she states that «sample size is given in cases in which n < 50» but does not note sample size for the figures from Metapontum and for the skeletons from the grave of the Messenians where the sample sizes are < 50. Her table does not include the figures for the Spartiates, Argives, and Apollonians (the last published after her chapter) included here.

[89] Bisel – Angel 1985, 203 Table 4: The classical period is periodized there as 650–300 B.C., and the skeletons are listed as coming from «various sites in Greece». (It should be noted here that none of the other skeletons in this table are included in Bisel and Angel's figures.) Although the article gives no indication of the sources of the classical skeletal heights it provides, it can be taken both from the authors' comments at 1985, 197 on the Mycenaean skeletons they report in this article and on the numbers of classical Greek skeletal heights they report (greater than in their previous publications; see Angel 1975 and Bisel 1980 for their previous publications of classical Greek statures) that this work supersedes their previous publications of skeletal data from the classical period. Kron 2005, 72 n. 22 notes regarding this article that Angel

The mean of these figures is 169.46 cm.[96] A total of 97 heights for classical Greek males is clearly a very small sample set to be working from; that said, the sample is not skewed by any subjective bias (representing simply the classical Greek skeletal heights that have been published) and is drawn from all over the Greek world. From the figure established here for average stature, one can reconstruct an average body weight for classical Greek adult males by using an exponential equation developed by Henneberg, Hugg, and Townsend precisely for this purpose. The equation is:

---

employed the (commonly used) Trotter and Gleser method (for extrapolating stature from long bones) which «arguably gives very slightly exaggerated results compared to the more conservative Olivier method». But note that Kron 2005, 79–80 himself uses results gained by using the Trotter and Gleser method since it is generally «considered accurate».

[90] Henneberg – Henneberg 1998, 520. These skeletons were found in cemeteries dating from the 6th to the 3rd centuries (ibid. 519). Henneberg – Henneberg 1998, 505 used the Trotter and Gleser method to reconstruct stature from the skeletal remains they examined. Two more notes on their figure for average stature in the table above: the standard deviation for this figure is 6.1; and the average height corrected for age is given ibid. 520 as 165.6 cm (std. 6.0).

[91] Breitinger 1937, 203. Breitinger reports an average of 170 cm, with the three tallest individuals being 178, 181, 185 cm, respectively, and the smallest being 160 cm. These skeletons are the remains of the Spartiate dead from King Pausanias' Athenian expedition of 403: see Xen., Hell. 2.4.33. Breitinger did not indicate the method he used to reconstruct the statures of the Spartiates, but it is almost certainly the method he developed and published in 1938 (Breitinger 1937a) which is generally considered reliable (Formicella 1993). It should be noted here that these heights may have been skewed upwards by attempts to accommodate them to the National Socialist ideological position that classical Spartiates were part of the same ‹Northern race› as Germans (see 1937, 203). Finally, see Stroszeck 2006, 104–105: there were, in fact, 23 skeletons found in this grave, which is awaiting full publication.

[92] Bisel 1990, 159 Table 7. The four skeletons in question were Messenian, not Athenian (as von Reden 2007, 388 Table 14.1 has it). The skeletons date from, respectively, 360/50, shortly before 350, the beginning of the second half of the fourth century, and the early second half of the fourth century (Kovacsovics 1990, 35, 57, 58, 60). Although Bisel does not state the method she used to reconstruct the heights of these skeletons, I take it on the basis of her previous work (see n. 89 and also Bisel 1980, 6) that she used the Trotter and Gleser method to reconstruct the heights found here.

[93] Hermary et al. 2010, 96, 105, 106, 113. The four skeletal statures were reported as 155–157 cm, 163 cm, 166 cm, 166–170 cm: for calculating the average stature of the skeletons, I took 156 cm and 168 cm as the middle range of the skeletal heights reported as 155–157 cm and 166–170 cm. The four skeletons dated from around 420, 400–390, the middle of the fourth century, and the beginning of the third quarter of the fourth century; Hermary et al. did not indicate the method they used to reconstruct the statures of these skeletons.

[94] Ma 2008, 76: He states that both skeletons were «around 1.79 m», although no indication is given of the method used to reconstruct their statures. The two skeletons were among the Theban dead buried in the tomb underneath the Lion of Chaeronea commemorating the battle of Chaeronea in 338: see Ma 2008, esp. 82.

[95] Charles 1958, 289. I reconstructed these two skeletal heights (from the fifth and fourth centuries, Charles 1958, 286) from two left male femurs measuring approximately 443 mm and 448 mm, respectively, using Olivier et al. 1978, 517 Table 3.

[96] The standard deviation is 4.975.

W(eight) = 2.05 · exp[0.0208 · h(eight)].[97] Using the figure established for the mean stature of Greek males (169.46 cm), this equation produces a figure of 69.58 kg for the average body weight of classical Greek males.[98]

The third factor determining human energy requirements is age. Greek adult males of the requisite property class were liable to conscription for hoplite (and cavalry) service between the ages of 18 and 60,[99] although call-ups for active service on campaign for citizens at the upper end of this age range may have been limited in most poleis to extraordinary circumstances.[100] Citizens were conscripted for hoplite service by tribe and age-group so that the burden of military service could be distributed equitably

---

[97] Henneberg et al., 1989. See Henneberg – Henneberg 1998, 520 for a useful summary of the method: «Body weight can be reconstructed from numerous bone dimensions combined into multiple regression equations. Such an approach seems to be impractical in the case of our poorly preserved and often fragmentary material. Moreover, robustness of the skeleton only partially reflects body weight since the degree of fatness may fluctuate over short periods of time, as may the level of hydration of the body. Since the relationship between human body height and weight seems to be uniform over the wide range of individual ages and across populations, we have decided to reconstruct weight from body height. This approach obviously cannot provide for fluctuating levels of fatness or hydration. It can only indicate an average «normal» body weight. The relationship between body height and weight is exponential: weight = 2.05 exp[0.0208 height]».

[98] I am grateful to Maura Halpenny for her help with these calculations. I note here that Foxhall – Forbes 1982, 47–48 adopted an estimate of 62 kg for the average body weight of the «ancient Greek (or Roman) male». Remarking correctly that it was extremely difficult to determine even approximately average body weights for ancient Greek or Roman males (in 1982: see n. 88 above), because of the lack of attention paid to skeletal remains in classical archaeology, they arrived at this figure in two steps. Firstly, they cited Angel 1945, 284–285 for a mean height for the ancient Attic male of 162.2 cm (while noting that the results were not statistically significant because of the small sample size [61 males]). Secondly, in order «to add flesh to these very bare bones» (1982, 47), they supplemented Angel's figure with data for the average heights and weights of Cretan males in the 1940s and Greek soldiers and university students in the 1960s (1982, 47–48 and n. 22). But there is a serious methodological error underlying these calculations. Human height is determined by health and nutrition; as such, it is determined by environmental factors (see Larsen 1997, 8–9, 13–14 for environmental factors being the key determinant of stature and average statures of populations being highly sensitive indicators of the health of a population; see also Kron 2005, 69–71 for a brief survey of recent research in anthropometry): average heights will therefore vary by region and time period to reflect changes in, e.g., the economic, demographic, and epidemiological environments. Average heights (and weights) from modern Greece therefore cannot be used to reconstruct average heights and weights from classical (or ancient) Greece. Angel's figure of 162.2 cm cannot be used for the same reason, since it is an average calculated from skeletal material scattered chronologically over a time span of roughly 4500 years (from the Neolithic to the medieval periods) (1945, 330, 362–363 Table 8).

[99] See, generally, van Wees 2004, 46; and Bugh 1988, 52–55 for cavalry service (in Athens).

[100] See van Wees 2004, 242: Older age limit (in normal circumstances) for active service in Athens, which may have been caused exceptionally by the need for a substantial ‹home guard› to defend the extraordinarily long fortification walls and borders of Athens. But see also Thuc. 1.105.3–6, 4.44.4 for the «older men» at Corinth not taking part in land campaigns in normal circumstances. See, however, Hanson 2000, 89–95 and Couvenhes 2003 for examples of older hoplites, men in their forties and fifties, at Athens and elsewhere.

among those liable to conscription.[101] Although it was something of a topos that mercenary forces were fitter and more able for military service than citizen armies made up of hoplites of a range of ages,[102] there are numerous references in Xenophon's Anabasis, by far the fullest and most detailed account we possess of the ‹lived experience› of a classical Greek mercenary force on campaign,[103] to younger and older mercenaries marching and fighting in the army recruited by Cyrus.[104] There is no precise information on the recruitment to polis armies of light-armed troops, both because the presence of these forces on campaigns was generally ignored by contemporary historians and because there does not seem to have been any organized conscription of light-armed forces: that said, Thucydides' descriptions (for example) of general levies show that light-armed troops turned out in large numbers for campaigns and were therefore probably representative of the (property) classes from which they came.[105] Navies in this period were recruited through a mixture of citizen levies, the hiring of mercenaries, and the use of slaves of both of these groups:[106] there is no reason to think that the ages of the men rowing classical Greek triremes were skewed in any one direction. In sum, although the age profile of Greek armies and navies cannot be determined precisely, it can be said with a high level of probability that their composition was broadly representative of the adult male populations of their organizing poleis and the Greek world as a whole.

Finally, levels of physical activity. These would have varied according to type and stage of campaign. The total energy expenditure (TEE)[107] of, e.g., naval forces anchored at operating bases or on days during voyages spent in port or at anchorage, of amphibious and land forces engaged in the blockades of enemy poleis, or of land forces on rest days during marches, would obviously have been much lower than that of naval forces sailing from one base to another, or of infantry forces on marching days, or of either type of force engaged in battle. For the physical activity level (PAL)[108] of the first group of activities indicated here, I will adopt a PAL value consistent with a

---

101 The system is best attested, as usual, at Athens: see Hamel 1998, 24–28, Christ 2001 (at some point before 352, the method of conscription was changed from call-up by tribe to call-up by age-group). For evidence of organization (and presumably conscription) of other polis armies by tribal affiliation, see Hanson 2000, 122–123, Krentz 2007, 148.

102 See Xen., Hell. 6.1.5 with Hanson 2000, 89–90.

103 See Whitby 2004, 216, Lee 2007, 1–17.

104 See Lee 2007, 74–76 for references and discussion.

105 See van Wees 2004, 62–65.

106 See van Wees 2004, 209, 211–212, 218.

107 Defined at FAO/WHO/UNU 2004, 9 as «The energy spent, on average, in a 24-hour period by an individual or a group of individuals. By definition, it reflects the average amount of energy spent in a typical day, but it is not the exact amount of energy spent each and every day.»

108 Defined at FAO/WHO/UNU 2004, 9 as «TEE for 24 hours expressed as a multiple of BMR, and calculated as TEE/BMR for 24 hours. In adult men …, BMR times PAL is equal to TEE or the total energy requirement».

moderately active daily lifestyle: 1.75 × BMR;[109] for the second group of activities, I will adopt a PAL value consistent with a vigorously active daily lifestyle: 2.05 × BMR.[110] The typical rhythms of land, naval, and amphibious campaigns will have meant that the number of days spent by military forces engaged in the first type of activities described here would have been greater, normally considerably so, than the days spent engaged in ‹vigorous› activities.[111]

Combining these data, the daily average energy requirements of Greek sailors and soldiers can be estimated, using FAO research data,[112] to have been between approximately 3050 kcal for men aged 18 to 29.9 years with a moderately active lifestyle, and approximately 3600 kcal for men aged 18 to 29.9 years with a vigorously active lifestyle; approximately 2950 kcal for men aged 30 to 59.9 years with a moderately active lifestyle, and approximately 3450 kcal for men aged 30 to 59.9 years with a vigorously active lifestyle. Comparing these estimates of average daily energy requirements to the energy values calculated above for diets in which one choinix of wheat provided the

---

[109] See FAO/WHO/UNU 2004, 37–39 for a discussion and classification of physical activity levels.

[110] It should be noted here that these categories of physical activity levels «indicate the physical activity most often performed by most individuals in the population, over a period of time» and that «[e]nergy requirements of such populations will change with the energy demands of their cyclical lifestyles» (FAO/WHO/UNU 2004, 38). Obviously, on days of land and naval combat, the PAL and therefore TEE of armies and trireme crews would have been much higher, but such days were obviously rare.

[111] Typical (Athenian) amphibious campaigns in the fifth and fourth centuries were marked by some days or weeks of sail, followed by (at most) a few days' fighting, and then months or years of blockade (during which, fighting, if there was any, was intermittent); for classical navies, days spent at operating bases, or at ports and anchorages during voyages, far outweighed days rowing and fighting; finally, most land campaigns were marked by (at most) a few days' marching followed by the establishment of camps at frequent intervals so as to enable armies to ravage and forage their enemies' territory (Krentz 2007 is excellent on the usual rhythms of land campaigns).

[112] FAO/WHO/UNU 2004, 41 Table 5.4, 42 Table 5.5. Relying on my estimate of 69.58 kg for the average weight of classical Greek sailors and soldiers, I used the 70 kg mean population weight given in these tables to calculate energy requirements. This FAO/WHO/UNU research was obviously unavailable to Foxhall and Forbes: note that the 2004 FAO estimates of energy requirements are lower than the 1973 FAO estimates available to them; cf. Garnsey 1989b, 38 for the point that expert estimates of caloric requirements have gradually decreased over time. I should note here also that my reasons for presenting these data are the same as Foxhall – Forbes 1982, 50: «It must be stressed, however, that it is not possible to use calorific or other nutritional requirements to reconstruct ancient diets. Calorific requirements merely provide a set of independent parameters, useful for determining the limits of human food consumption, and thus useful as ‹yardsticks› against which modern hypotheses about ancient food consumption can be measured. That is to say, they can show whether our estimates of, e.g., ancient grain consumption are within the bounds of physiological possibility (or even likelihood), but they cannot by themselves provide an answer to the question ‹how much?›».

bulk of carbohydrates,[113] it can be seen that a diet (of 3533 kcal) in which one choinix of wheat milled at an extraction rate of 90 per cent provided 60 per cent of the calories – both assumptions with a high degree of probability – would have covered the TEE of both moderately and vigorously active Greek men aged 30 to 59.9 years, and the TEE of moderately active men aged 18 to 29.9 years. Such a diet would result in a deficiency of somewhere between 67 and 217 kcal for a vigorously active male aged 18 to 29.9 years – and therefore not so much as to result in serious physiological or behavioural penalties over time – especially considering that, for classical Greek sailors and soldiers, periods of vigorous activity would be interspersed among (many more) periods of moderate activity. Diets in which one choinix of wheat milled at an extraction rate of 80–89 % or 72 % would have provided 60 per cent of the calories (3233 kcal and 3028 kcal) would have (just about) covered the TEE of moderately active men both between 18 to 29.9 years of age and 30 to 59.9 years of age. Diets in which one choinix of grain provided 75 per cent of the calories of the diet would have struggled to cover the caloric requirements of both moderately and very active groups of men, since such diets would have provided, at extraction rates of 90 per cent, 80–89 per cent, and 72 per cent, respectively, 2826 kcal, 2587 kcal, 2423 kcal. It is probable, however, that grain (especially the more refined wheat of the lower extraction rates) never made up such a high percentage of classical Greek sailors and soldiers' diets.[114] In sum, one choinix of wheat could have formed – and probably did form – part of a diet providing a sufficient amount of calories to provide for the energy requirements of an average Greek sailor or soldier.

Finally, there is the question of the energy requirements of the slave attendants of hoplites and those slaves who rowed triremes. It was usual practice for citizen hoplites to be accompanied on campaign by slave attendants,[115] and slaves formed (sometimes

---

[113] It should be emphasized again that these calculations led to estimates of average consumption. When military forces received their monthly pay installments or bonuses and were operating in areas with markets where food was available in abundance, they may have consumed more food than required. In other cases, when sailors or soldiers were paid irregularly or not at all, or found themselves cut off from any means of acquiring provisions as a result of the movements of enemy forces, they may have consumed less food than required to meet their energy needs. But, in general, the consumption of classical Greek military forces would have been within the bands calculated here.

[114] See again the considerations at p. 342.

[115] See Pritchett 1971, 49–51; van Wees 2004, 68–69. Other literary evidence, in addition to that collected by Pritchett and van Wees, for the presence of slave attendants assumed in classical Greek armies: Xen., Oec. 8.4; Polyaenus, Strateg. 2.3.10, 3.9.52. See also van Wees 2004, 271–272 n. 23 for iconographical evidence for slave attendants accompanying Athenian hoplites on campaign; and Hornblower 2008, 564 for inscriptional evidence for same. The presence of slave attendants on military campaigns was an extension of the fact that well-off classical Greek citizens, when travelling, were always accompanied by a slave attending to their needs: see Whitehead 1982, 120 for this point (and, in addition to the evidence collected there, see also, e.g., Thuc. 4.118.6; Xen., Mem. 3.13.6; Theophr., Characters 21.5, 30.7). Gomme 1956, 275, cit-

substantial parts) of trireme crews.[116] There is, however, no reliable ancient evidence for the normal daily grain consumption of slaves in the Greek world.[117] There is also no evidence for the heights (and therefore) weights of slaves. Any remarks on the typical age of slave-attendants will be no more than guesses. We can make the following probabilistic assumptions, however. The workloads of slave attendants on campaign will necessarily have been heavier than those of their hoplite owners. Slave rowers will have had the same caloric requirements as the free rowers of triremes. Slaves were valuable property and owners would have been usually concerned to make sure that they were not undernourished.[118] It is probable, too, that slaves' diets would have been determined by their owners, and that their owners would generally have wanted to meet their energy requirements in the cheapest way possible – i.e., by feeding them with grain. In light of these considerations, it is highly probable that the energy requirements of slave attendants and slave rowers were (in the first case) higher and (in the second) equal to their owners', that these requirements were met by their owners, and that they were met predominantly by grain. It seems best, then, to think that the daily grain consumption of slaves on land and naval campaigns was at least equal to that of their owners.[119]

V. Concluding remarks; suggestions for further research

The goal of this article has been to push as hard as possible against the limits of our knowledge, while indicating precisely the nature of those limits, and to establish a framework for further study.[120] Accordingly, the figures found here are not meant to

ing Thucydides' description of the battle of Delium and Athenian operations at Pylos, disagreed with the position that every hoplite had a slave-attendant: but, firstly, see already Pritchett 1971, 50 for Gomme's mistake in not realizing that Thucydides does mention slave-attendants at Delium; secondly, Thucydides does tell us, contra Gomme, why the Athenian hoplites at Pylos took up the «banausic work» of building a wall there (they were bored: 4.4.1); thirdly, Gomme did not take into account the rest of the abundant evidence for slave-attendants accompanying citizens of hoplite status during military campaigns and peacetime travels.

[116] See again n. 106.

[117] See again n. 43.

[118] See Garnsey 1989b, 39 for this assumption and the two following. See, though, Triantaphyllou – Bessios 2005: A classical period burial at Pydna of 115 skeletons who may have been slaves and who show «strikingly high prevalence of physiological stress markers … suggesting dietary and nutritional deficiencies or other severe stress factors». See, however, Little – Papadopoulos 1998, 393–395, on the difficulties of reconstructing identities or statuses, including that of slavery, from mortuary practices.

[119] This conclusion does not conflict with the evidence of Thuc. 4.16.1 since we are concerned here with the everyday lives of slaves on campaign and not with a document that wishes to present Helots as an inferior status group to Spartiates.

[120] Cf. the remarks of Foxhall – Forbes 1982, 75, which serve as a useful methodological guide in this respect: «Perhaps this study will best serve as a cautionary tale for researchers using grain consumption as one of the bases for constructing models of population size and/or structure, agricultural production, grain trade and other fundamental issues in classical social and

project a false sense of precision or certainty. That said, this study has nonetheless attained some significant and concrete results. There is now no reason to reject the evidence of our ancient sources that both one choinix of wheat and two choinikes of ἄλφιτα could, and did, serve to meet the daily grain consumption requirements of classical Greek sailors and soldiers. If we cannot yet calculate an absolute figure for the weight of ἄλφιτα contained in two choinikes, we can now construct an estimate of its wheat equivalent, which can allow us to compare the provisioning achievements and requirements of classical Greek military forces to other pre-industrial military forces. This figure for the wheat equivalent of ἄλφιτα is, in addition, consistent with, and confirmed by, currently available data on the caloric value of wheat, the average stature and weight of classical Greek males, and human energy requirements.

I end with some suggestions as to how the results of this article could be improved upon and how they could (should) become obsolete in the (near) future. While some of the variables in the calculations undertaken in this article will never be known precisely, such as, e.g., the age profile of Greek military forces, there are some areas of research where further precision is and will be possible:

1. The question of how much a given volume of barley-meal in the Greek world weighed in comparison to the weight of the given volume of barley it was made from could be determined within a range of probability by enlisting the services of a specialist miller stone milling barley with traditional techniques.[121] There are still in Greece today bakers using roughly milled, hulled barley to bake the traditional biscuit called dako on Crete and paximadi in Greece. The practical expertise of the millers producing the barley-meal for this biscuit could be used to ascertain the relationship between the volume/weight ratios of barley and barley-meal.

---

economic history. In order to estimate ancient grain consumption from the available ration figures and to use these data without merely repeating or enlarging upon past mistakes, one must continually re-evaluate and make explicit our underlying assumptions and understand the full range of variables involved. Only then can one incorporate estimates of grain consumption into wider-reaching hypotheses about life in antiquity».

[121] See already Foxhall, reporting the results of her milling experiments (1982, 77): «More experimentation with various methods of processing hulled barley is clearly very necessary». To my knowledge, no study focusing on classical antiquity has carried out any further experiments on the processing of hulled barley. Any such experiments would be fraught with difficulties: how to decide what cultivars of barley, type of grinding stone, or extraction rates to use? How does the processing of barley before and for milling differ today from antiquity? How much should the barley-flour be tamped down before measuring its volume? (See Foxhall – Forbes 1982, 78 for the last question.) But experiments of this type would still «get us further» in establishing possible parameters for this question. My thinking on this subject was greatly helped by the contributors to a thread of discussion on the subject of ‹barley and barley-flour weights/densities› on the Archaeobotany listserv (archaeobotany@jiscmail.co.uk) in March and April 2007 (I am again grateful to John (Mac) Marston for forwarding my question on the weight and density of barley as compared to barley-flour to the Archaeobotany listserv, and to Seth Pevnick for putting me in touch with John). In particular, I learned a lot from the comments in this thread of Sabine Beckmann, Nic Dolby, Delwen Samuel, and Anaya Sarpaki.

2. The greater attention now paid to botanical remains during the excavation of classical sites in the Greek world will aid in ascertaining the cultivars of barley (and wheat) grown in the classical period.[122] This, in turn, could aid in the attainment of greater precision in the choice of cultivars for the types of experiments just described and thus in greater precision in the results of such experiments.

3. It is only recently that skeletal remains have been recognized as bearers of important historical data for classical Greece.[123] Accordingly, until recently, skeletal remains found in classical period excavations were often ignored. Of those skeletal remains that were excavated, there are still many which remain unpublished.[124] In addition, new skeletal remains from the classical Greek world are being discovered constantly:[125] most exciting in this regard are the (at least) 136 skeletons of soldiers from the battles at Himera in 480 and 409, among thousands of other skeletons, recently found in Himera that have been reported in the popular press as having an average height of 175 cm.[126] The publication of some or all of these remains will obviously bring greater precision and more statistical significance to our calculations of the average statures of classical Greek sailors and soldiers.

4. Finally, stable isotope analysis has, as of now, hardly been applied to skeletal remains from the classical period: it can be expected that a much more precise idea of the role of cereals in the diet of classical Greek adult males will become possible in the coming years and decades as more stable isotope analysis of human remains from the classical period is performed.[127]

California State University, Fullerton
Department of History
800 N. State College Blvd.
Fullerton, CA 92834
U.S.A.
soconnor@fullerton.edu

[122] See now Megaloudi 2006.

[123] See Liston 2012, 126.

[124] See, e.g., Ma 2008, 76: Not only have the two hundred and fifty-four skeletons found during the excavations of the Lion of Chaeronea in 1879 never been fully published, but their current location is uncertain.

[125] See, e.g., Baziotopoulou-Valavani 2002, 190: 89 adult male and female skeletons discovered in a mass burial in the Kerameikos.

[126] Valsecchi 2008 (quoting the chief excavator at the site, Stefano Vassallo). I thank Graham Claytor for alerting me to this article. For preliminary publication of the remains of the soldiers from the battles of 480 and 409, see, e.g., Vassallo 2009, 2010. See also Valentino, in: Vassallo 2009, 256: as of 2009, there were ‹on file› at Himera the osteological remains of 3,000 individuals. For a recent summary of the excavations at Himera, see de Angelis 2012, 177–178.

[127] See, e.g., Buikstra – Lagia 2009, esp. 17–19 for discussion of the possibilities of this method of analysis.

Bibliography

Anderson 1970 = J. K. Anderson, Military Theory and Practice in the Age of Xenophon.
Angel 1945 = J. L. Angel, Skeletal material from Attica, Hesperia 14, 279–363.
Angel 1975 = J. L. Angel, Paleoecology, paleodemography and health, in: S. Polger (ed.), Population, Ecology and Social Evolution, 167–190.
Bachrach 2002 = B. S. Bachrach, Some Observations on the Role of the Byzantine Navy in the Success of the First Crusade, Journal of Medieval Military History 1, 83–100.
Baziotopoulou-Valavani 2002 = E. Baziotopoulou-Valavani, A mass burial from the cemetery of Kerameikos, in: M. Stamatopoulou – M. Yeroulanou (ed.), Excavating classical culture: recent archaeological discoveries in Greece, 187–202.
Bisel 1980 = S. C. Bisel, A Pilot Study in Aspects of Human Nutrition in the Ancient Eastern Mediterranean with Particular Attention to Trace Minerals in Several Populations from Different Time Periods (Ph.D. Diss., University of Minnesota).
Bisel 1990 = S. C. Bisel, Die Menschenknochen aus dem Grab der Messenier, in: W. K. Kovacsovics, Kerameikos xiv. Die Eckterrasse am der Gräberstrasse des Kerameikos, 151–159.
Bisel – Angel 1985 = S. C. Bisel – J. L. Angel, Health and Nutrition in Mycenaean Greece: A Study in Human Skeletal Remains, in: N. C. Wilkie – W. D. E. Coulson (ed.), Contributions to Aegean Archaeology: Studies in Honor of William A. McDonald, 197–209.
Breitinger 1937 = E. Breitinger, in: K. Gebauer – H. Johannes, Ausgrabungen im Keramaikos, AA 1937, 200–203.
Breitinger 1937a = E. Breitinger, Zur Berechnung der Körperhöhe aus den langen Gliedmassenknochen, Anthropologischer Anzeiger 14, 249–274.
Bugh 1988 = G. R. Bugh, The Horsemen of Athens.
Buikstra – Lagia 2009 = J. Buikstra – A. Lagia, Bioarchaeological Approaches to Aegean Archaeology, in: L. A. Schepartz – S. C. Fox – C. Bourbou (ed.), New Directions in the Skeletal Biology of Ancient Greece, 7–29.
Charles 1958 = R. Charles, Étude anthropologique des necropoles d'Argos. Contribution à l'étude des populations de la Grèce antique, BCH 82, 268–313.
Christ 2001 = M. R. Christ, Conscription of Hoplites in Classical Athens, CQ 51, 398–422.
Clark – Haswell [4]1970 = C. Clark – M. Haswell, The Economics of Subsistence Agriculture.
Couvenhes 2003 = J.-C. Couvenhes, La place des vieux citoyens dans l'armée civique athénienne à l'époque classique et hellénistique, in: B. Bakhouche (ed.), L'ancienneté chez les Anciens, Tome I: La vieillesse dans les sociétés antiques: la Grèce et Rome, 23–41.
Cruickshank 1954 = W. W. Cruickshank, Topography, movement and supply in the warfare of ancient Greece south of Thessaly and Epirus (Ph.D. Diss., London).
Dalby 2003 = A. Dalby, Food in the Ancient World from A to Z.
de Angelis 2012 = F. de Angelis, Archaeology in Sicily 2006–2010, AR 58, 123–195.
Devroey 1987 = J. P. Devroey, Units of Measurement in the Early Medieval Economy: The Example of Carolingian Fixed Rations, French History 1, 68–92.
Ducrey 1970 = P. Ducrey, Nouvelles remarques sur deux traités attalides avec des cités crétoises, BCH 94, 637–659.
Engels 1978 = D. W. Engels, Alexander the Great and the Logistics of the Macedonian Army.
Erdkamp 1998 = P. Erdkamp, Hunger and the Sword: Warfare and Food Supply in Roman Republican Wars (264–30 B.C.).
Erdkamp 2005 = P. Erdkamp, The Grain Market in the Roman Empire: A Social, Political and Economic Study.
FAO n.d. = FAO, www.fao.org/docrep/x5557e/x5557e00.htm (note on the use of FAO/Chatfield 1949), no date (accessed March 5, 2013).

FAO/Chatfield 1949 = FAO/C. Chatfield, Food Composition Tables for International Use.
FAO/USDA 1982 = FAO/USDA, Food Composition Tables for the Near East (accessed March 10, 2013 at http://www.fao.org/docrep/003/X6879E/X6879E00.HTM).
FAO/WHO/UNU 2004 = FAO/WHO/UNU, Human energy requirements.
Figueira 1984 = T. J. Figueira, Mess contributions and Subsistence at Sparta, TAPhA 114, 87–109.
Formicella 1993 = V. Formicella, Stature Reconstruction for Long Bones in Ancient Population Samples: An Approach to the Problem of its Reliability, American Journal of Physical Anthropology 90, 351–358.
Foxhall – Forbes 1982 = L. Foxhall – H. A. Forbes, Σιτομετρεία: The Role of Grain as a Staple Food in Classical Antiquity, Chiron 12, 41–89.
Gabrielli 1995 = M. Gabrielli, Transports et logistique militaire dans l'Anabase, Pallas 43, 109–122.
Gallo 1983 = L. Gallo, Alimentazione e classi sociali: una nota su orzo e frumento in Grecia, Opus 2, 449–472.
Garnsey 1989a = P. Garnsey, Malnutrition in the Ancient World OR Was Classical Antiquity a Third World?, in: P. Garnsey (ed.), Food, Health and Culture in Classical Antiquity, 24–35.
Garnsey 1989b = P. Garnsey, Food Consumption in Antiquity: Towards a Quantitative Account, in: P. Garnsey (ed.), Food, Health and Culture in Classical Antiquity, 36–49.
Gomme 1956 = A. W. Gomme, A Historical Commentary on Thucydides: Volume II.
Greenfield – Southgate ²2003 = H. Greenfield – D. A. T. Southgate, Food Composition Data: Production, Management, and Use.
Hamel 1998 = D. Hamel, Athenian Generals. Military Authority in the Classical Period.
Hanson ²2000 = V. D. Hanson, The Western Way of War: Infantry Battle in Classical Greece.
Harari 2000 = Y. N. Harari, Strategy and Supply in Fourteenth-Century Western European Invasion Campaigns, Journal of Military History 64, 297–333.
Harris 2005 = W. V. Harris, The Mediterranean and Ancient History, in: W. V. Harris (ed.), Rethinking the Mediterranean, 1–42.
Henneberg – Henneberg 1998 = M. Henneberg – R. J. Henneberg, Biological Characteristics of the Population Based on Analysis of Skeletal Remains, in: J. C. Carter (ed.), The Chora of Metaponto: the Necropoleis II, 503–562.
Henneberg et al. 1989 = M. Henneberg – J. Hugg – E. J. Townsend, Body Weight/Height Relationship: Exponential Solution, American Journal of Human Biology 1, 483–491.
Hermary et al. 2010 = A. Hermary – K. Panayotova – A. Baralis – M. Damyanov – A. Riapov (ed.). Apollonia du Pont (Sozopol): la nécropole de Kalfata (Vᵉ–IIIᵉ s. av. J.-C.). Fouilles franco-bulgares (2002–2004).
Hodkinson 2000 = S. Hodkinson, Property and Wealth in Classical Sparta.
Hopkins 2002 = K. Hopkins, Rome, Taxes, Rents and Trade, in: W. Scheidel – S. von Reden (ed.), The Ancient Economy, 190–230.
Hornblower 1996 = S. Hornblower, A Commentary on Thucydides, Volume II: Books IV–V.24.
Hornblower 2008 = S. Hornblower, A Commentary on Thucydides, Volume III: Books 5.25–8.109.
Jardé 1925 = A. Jardé, Les Céréales dans l'Antiquité Grecque.
Jasny 1942 = N. Jasny, Competition Among Grains in Classical Antiquity, AHR 47, 747–764.
Jones 1987 = A. Jones, The Art of War in the Western World.
Keenleyside – Panayotova 2005 = A. Keenleyside – K. Panayotova, A Bioarchaeological Study of the Greek Colonial Population of Apollonia Pontica, Archaeologia Bulgarica 9, 21–38.

Kovacsovics 1990 = W. K. Kovacsovics, Kerameikos xiv. Die Eckterrasse am der Gräberstrasse des Kerameikos.

Krentz 2007 = P. Krentz, Part I: Archaic and Classical Greece: War, in: P. Sabin – H. van Wees – M. Whitby (ed.), The Cambridge History of Greek and Roman Warfare, Vol. I: Greece, the Hellenistic World and the rise of Rome, 147–185.

Kron 2005 = G. Kron, Anthropometry, Physical Anthropology, and the Reconstruction of Ancient Health, Nutrition, and Living Standards, Historia 54, 68–83.

Lane 1966 = F. C. Lane, Diet and Wages of Seamen in the Early Fourteenth Century, in: Venice and History: The Collected Papers of Frederic C. Lane, 263–268.

Larsen 1997 = C. S. Larsen, Bioarchaeology: Interpreting behavior from the human skeleton.

Lazenby 1994 = J. F. Lazenby, Logistics in classical Greek warfare, War in History 1, 3–18.

Lee 2007 = J. W. I. Lee, A Greek Army on the March: Soldiers and Survival in Xenophon's Anabasis.

Lendle 1995 = O. Lendle, Kommentar zu Xenophons Anabasis: Bücher 1–7.

Lipka 2002 = M. Lipka, Xenophon's Spartan Constitution.

Liston 2012 = M. A. Liston, Reading the Bones: Interpreting the Skeletal Evidence for Women's Lives in Ancient Greece, in: S. L. James – S. Dillon, A Companion to Women in the Ancient World, 125–140.

Little – Papadopoulos 1998 = L. M. Little – J. K. Papadopoulos, A Social Outcast in Early Iron Age Athens, Hesperia 67, 375–404

Ma 2008 = J. Ma, Chaironeia 2008: topographies of commemoration, JHS 128, 72–91.

Markle 1985 = M. M. Markle, Jury Pay and Assembly Pay at Athens, in: P. A. Cartledge – F. D. Harvey (ed.), Crux. Essays in Greek History presented to G. E. M. de Ste. Croix on his 75th birthday, 265–297.

Megaloudi 2006 = F. Megaloudi, Plants and Diet in Greece from Neolithic to Classic Periods: the archaeobotanical remains.

Moreno 2007 = A. Moreno, Feeding the Democracy: The Athenian Grain Supply in the Fifth and Fourth Centuries BC.

Morley 2007 = N. Morley, The Early Roman Empire: Distribution, in: W. Scheidel – I. M. Morris – R. P. Saller (ed.), The Cambridge Economic History of the Greco-Roman World, 570–591.

Oliver 2007 = G. J. Oliver, War, Food, and Politics in Early Hellenistic Athens.

Olivier et al. 1978 = G. Olivier – C. Aaron – G. Fully – G. Tissier, New estimations of Stature and Cranial Capacity in Modern Man, Journal of Human Evolution 7, 513–518.

Pritchett 1956 = W. K. Pritchett, The Attic Stelai: Part II, Hesperia 25, 178–317.

Pritchett 1971 = W. K. Pritchett, Ancient Greek military practices part 1.

Pryor 2006 = J. H. Pryor, Introduction: modelling Bohemond's march to Thessalonikē, in: J. H. Pryor (ed.), Logistics of Warfare in the Age of the Crusades, 1–24.

Rathbone 1983 = D. W. Rathbone, The Weight and Measurement of Egyptian Grains, ZPE 53, 265–275.

Reger 1993 = G. Reger, The Public Purchase of Grain on Independent Delos, ClAnt 12, 300–334.

Rhodes – Osborne 2003 = P. J. Rhodes – R. Osborne (ed.), Greek Historical Inscriptions: 404–323 BC.

Roebuck 1945 = C. Roebuck, A Note on Messenian Economy and Population, CPh 40, 149–165.

Rosivach 2000 = V. J. Rosivach, Some Economic Aspects of the Fourth-Century Athenian Market in Grain, Chiron 30, 31–64.

Roth 1999 = J. P. Roth, The Logistics of the Roman Army at War (264 B.C.–A.D. 235).

Sallares 1991 = R. Sallares, The Ecology of the Ancient Greek World.

Scott 2005 = L. Scott, Historical Commentary on Herodotus Book 6.

Sevenhuysen 1994 = G. P. Sevenhuysen, Food composition databases: Current problems and solutions, Food, Nutrition and Agriculture (FAO) 12, 21–26 (accessed October 1, 2010 at http://www.fao.org/docrep/V6000T/v6000t05.htm).

Sika et al. 1995 = M. Sika – A. Terrab – P. B. Swan – P. V. J. Hegarty, Composition of Selected Moroccan Cereals and Legumes: Comparison with the FAO Table for Use in Africa, Journal of Food Composition and Analysis 8, 62–70.

Sosin 2002 = J. D. Sosin, Grain for Andros, Hermes 130, 131–145.

Southgate [9]1993 = D. A. T. Southgate, Food composition tables, in: J. S. Garrow – W. D. T. James (ed.), Human Nutrition and Dietetics, 264–272.

Starr 1977 = C. G. Starr, The Economic and Social Growth of Early Greece 800–500 BC.

Stroszeck 2006 = J. Stroszeck, Lakonisch-rotfigurige Keramik aus den Lakedaemoniergräbern am Kerameikos von Athen (403 v. Chr.), AA, 101–120.

Stroud 1998 = R. Stroud, The Athenian Grain-Tax Law of 374/3 B.C.

Tänzer 1912 = K. Tänzer, Das Verpflegungswesen der griechischen Heere bis auf Alexander d. Gr.

Thorne 2001 = J. A. Thorne, Warfare and Agriculture: The Economic Impact of Devastation in Classical Greece, GRBS 42, 225–253.

Triantaphyllou – Bessios 2005 = S. Triantaphyllou – M. Bessios, A mass burial at fourth century BC Pydna, Macedonia, Greece: evidence for slavery?, Antiquity 79 (305), www.antiquity.ac.uk/projgall/triantaphyllou/index.html (accessed February 17, 2013).

USDA, Agricultural Research Service 2005 = USDA, Agricultural Research Service, USDA National Nutrient Database for Standard Reference, Release 18.

Valsecchi 2008 = M. C. Valsecchi, Ancient Mass Graves of Soldiers, Babies Found in Italy, National Geographic News, December 18 (pages not numbered, web publication accessed October 11, 2011 at http://news.nationalgeographic.com/news/2008/12/081217-himera-mass-grave.html).

van Wees 2001 = H. van Wees, The Myth of the Middle-Class Army: Military and Social Status in Ancient Athens, in: T. Bekker-Nielsen – L. Hannestad (ed.), War as a Cultural and Social Force: Essays on Warfare in Antiquity, 45–71.

van Wees 2004 = H. van Wees, Greek Warfare: Myths and Realities.

van Wersch 1972 = H. J. van Wersch, The Agricultural Economy, in: W. A. McDonald – G. R. Rapp (ed.), The Minnesota Messenia Expedition: Reconstructing a Bronze Age Regional Environment, 177–187.

Vassallo 2009 = S. Vassallo (with an appendix by M. Valentino), Himera. Indagini nelle necropoli, in: R. Bonaudo – L. Cerchiai – C. Pellegrino (ed.), Tra Etruria, Lazio e Magna Grecia: indagini sulle necropolis (Atti dell'Incontro di Studio, Fisciano, 5–6 marzo 2009), 233–260.

Vassallo 2010 = S. Vassallo, Le battaglie di Himera alla luce degli scavi nella necropolis occidentale e alle fortificazioni. I luoghi, I protagonisti, Sicilia Antiqua 7, 17–38.

Vika et al. 2009 = E. Vika – V. Aravantinos – M. P. Richards, Aristophanes and stable isotopes: a taste for freshwater fish in Classical Thebes (Greece)?, Antiquity 83, 1076–1083.

von Reden 2007 = S. von Reden, Classical Greece: Consumption, in: W. Scheidel – I. M. Morris – R. P. Saller (ed.), The Cambridge Economic History of the Greco-Roman World, 385–406.

Whitby 1998 = M. Whitby, The grain trade of Athens in the fourth century BC, in: H. Parkins – C. Smith (ed.), Trade, Traders and the Ancient City, 102–128.

Whitby 2004 = M. Whitby, Xenophon's Ten Thousand as a Fighting Force, in: R. Lane Fox (ed.), The Long March: Xenophon and the Ten Thousand, 215–242.

Whitehead 1982 = D. Whitehead, Two notes on the Old Oligarch, LCM 7, 119–120.