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aus / from

Chiron

Ausgabe / Issue **12 • 1982**
Seite / Page **41–90**
https://publications.dainst.org/journals/chiron/1295/5644 • urn:nbn:de:0048-chiron-1982-12-p41-90-v5644.8

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 **Verlag C. H. Beck, München**

L. FOXHALL – H. A. FORBES

Σιτομετρεία: The Role of Grain as a Staple Food in Classical Antiquity

I. Introduction[1]

For over a century, ever since the beginning of the study of the social and economic history of the classical world, scholars have recognised the special position of cereals in the ancient Mediterranean, and it has been generally accepted that grain was at least as important a staple in antiquity as it is today.[2] Frequently, ancient historians have used estimates of grain consumption as the bases for discussions of ancient population, slavery, commerce, and agriculture.[3]

Although grain consumption is better documented than most aspects of ancient diet, the data that can be culled from the literary and epigraphic record are far from straightforward. There are relatively few instances of grain handouts – the main source of information on grain consumption – where we can be sure of the exact quantities involved. Even where available, these figures are not in a directly usable form, and such examples as we do possess occur under exceedingly varied circumstances, widely scattered in time and space.

Furthermore, in attempting to define the relationship between amounts of grain distributed and normal rates of consumption, certain questions need to be asked. Was the recipient of a grain handout the sole consumer? Can we determine the level of nourishment intended by the dispensers, i. e., was the handout supposed to form the total cereal component of the diet, or was it merely a supplement?

In spite of the problems that must be confronted in the interpretation of these data, most scholars have taken the ancient figures at face value. The result is that none

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[1] First and foremost we wish to thank G. E. Rickman, R. P. Duncan-Jones, P. D. A. Garnsey, J. K. Davies, S. Hodkinson, A. J. Graham, J. D. Muhly, K. D. White and A. R. Millard for all the help we received from them.

[2] Cf., for an extreme version of this view, Duncan-Jones, The Price of Wheat in Roman Egypt, Chiron 6 (1976), pp. 241–242.

[3] See, for example, Beloch, Die Bevölkerung der griechisch-römischen Welt, Leipzig (1886) pp. 393–412; Boeckh, Die Staathaushaltung der Athener I, pp. 50–51, 97 ff.; Roebuck, A Note on Messenian Economy and Population, CPh 40 (1945), pp. 149–165; Jardé, Céréales, pp. 128 ff.; Brunt, Italian Manpower, p. 382; Jameson, Agriculture and Slavery in Classical Athens, CJ 74 (1978), pp. 131 ff.; Engels, Alexander, pp. 123 ff.; Van Wersch MME, p. 185.

of the modern estimates of grain consumption in classical antiquity has been entirely satisfactory. In addition, even some very recent discussions of this topic have depended heavily upon works such as those of JARDÉ and JASNY, which were written before post-War developments in the study of human nutritional requirements. Under these circumstances it is necessary for more up to date nutritional information to be taken into consideration in studies of ancient diet.

This paper investigates both the amount and importance of grain in the ‹classical diet› under three headings: 1) the problems encountered in putting ancient figures into usable modern form, and the way in which these figures can be used to calculate the possible contribution of grain to the diet; 2) a detailed examination of the ancient literary and epigraphical evidence; 3) a comparison of the ancient data with information on dietary patterns among modern Greek peasants, with the aim of filling in some gaps in our knowledge concerning the contribution of non-cereal foods to the ancient diet. It is hoped that the results of this study will shed light on the character of the ancient Greek and Roman diet in general, and the role of grain in particular.

II. General Considerations: The Bases of the Calculations

The ancient figures available for grain distributions are not directly comparable either to each other or to modern statistics. In this section we shall outline the variables involved in computing grain consumption and the conversion of the ancient data into comprehensible and usable modern forms. However, in spite of the precise looking charts and profusion of numbers, the figures given here are only estimates – as accurate as possible – but estimates nonetheless. They should in no way be considered definitive or unalterable.

The most outstanding problem to be confronted when working with ancient grain figures is that in antiquity amounts of grain were normally expressed in units of volume, whereas today grain is handled in units of weight. (See Table 1 for ancient to modern measurement conversions.) This is important because weights of grain per unit of volume may vary considerably, for example, a litre of wheat weighs more than a litre of barley, a litre of naked barley weighs more than a litre of hulled barley, and a litre of spring-sown durum wheat weighs more than a litre of winter-sown bread wheat. These examples also give some indication of the kinds of factors that cause weight variations: both species and variety of grain, time of year sown, soil conditions, amount and type of fertiliser used, whether the grain is hulled or naked, and the amount of foreign bodies, weed seeds, etc. present in a sample.[4] Obviously, a litre of heavier grain (e.g., wheat) is more nutritious than a litre of lighter grain.

[4] FAO, Wheat in Human Nutrition, pp. 18–20; PETERSON, Wheat, p. 297.

Clearly it is impossible to account for all possible weight variations in attempting to calculate the weights of grain recorded in ancient volume measurements. In fact, it would be foolish to attempt it, since the ancient measures themselves were not as precise or consistent as modern ones.[5] On the whole, modern Mediterranean wheats and barleys are a bit lighter than those grown in Britain and the U. S. A., partly because of environmental conditions[6] which would have affected ancient cereal cultivation as well. Under these circumstances it seemed most practical for this study to use a median weight per unit of volume, derived from both modern grain samples and the weight/volume ratios for wheat given by Pliny (NH XVIII. 66). These are summarised in the chart below.

Wheat

Source	Roman measure	modern measure
Pliny,		(kg per L)
from Gaul and Chersonnesos	20 lb. per 1 modius	0.750[7]
from Sardinia	20½ lb. per 1 modius	0.768
from Alexandria and Sicily	20⅚ lb. per 1 modius	0.781
from Baetica	21 lb. per 1 modius	0.787
from Africa	21¾ lb. per 1 modius	0.815
Van Wersch (MME, p. 185)	–	0.772
our own sample (see Appendix)	–	0.782

Barley

Van Wersch (MME, p. 185)	–	0.618
our own samples (see Appendix)		
whole, hulled barley	–	0.587[8]
coarse barley flour, hulls removed, 60% extraction	–	0.643

Pliny's wheat figures are extremely interesting in that they give some idea of the possible variation in the weights of wheats alone. They are very close to the measurements for modern samples. In fact, Van Wersch's measurement from modern Messenia falls somewhere in the middle of Pliny's range, which is primarily why we have used it for our calculations in this study.

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[5] Cf., Lang and Crosby, The Athenian Agora X, Weights, Measures and Tokens, p. 1 and Duncan-Jones' valuable works on metrology in Graeco-Roman Egypt, The Size of the Modius Castrensis, ZPE 21 (1976), pp. 53 ff.; The Choenix, the Artaba and the Modius, ZPE 21 (1976), pp. 43 ff.; Variations in Egyptian Grain Measure, Chiron 9 (1979), pp. 347–375.

[6] Peterson, Wheat, pp. 69, 297.

For barley the situation is more complicated. The ancient sources never mention distributions of whole barley for human consumption; instead only handouts of *alphita* are known, that is, coarse barley flour with the inedible hulls removed. Therefore, for this study, we have used the figure for our own sample of coarse barley flour (0.643 kg per L). This is not as reliable as the median weight/volume figure for wheat for two reasons: 1) the difficulty of ascertaining ancient extraction rates for barley/*alphita*, and 2) the problem that a given weight of grain of a given volume will change in volume, even if the weight remains the same, when it is ground into flour (see Appendix, p. 78 for detailed explanations of these problems). 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.

To summarise, then, for wheat we have used a figure of 0.772 kilogrammes per litre as a basic weight to volume measurement, while for coarse barley flour (≈ *alphita*) we have used a figure of 0.643 kg per L.

Once the ancient grain distribution figures have been converted to a modern format, what do they tell us? The next logical step in the analysis is to determine the nutritive value (for these purposes, energy content) of grain distributed and compare it with human nutritional requirements. A number of different components go into a well balanced human diet: sufficient protein, minerals, vitamins, carbohydrates, lipids, etc. But, the most basic requirement for staying alive is energy, measured in calories.[9] Since grain is a staple food eaten in large amounts, its most essential contribution to the human diet is the large number of calories it provides. However, it should be kept in mind that grain does not consist merely of carbohydrates; it also supplies considerable amounts of protein, B vitamins, and other nutrients. This is particularly important in circumstances where cereals constitute a large proportion of the diet and where relatively little animal protein is consumed, as is (and always has been) the case in the Mediterranean region.[10] For example, in Crete in the

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[7] Jameson, Agriculture and Slavery, p. 131, n. 51, used Pliny's lowest figure for his discussion of grain consumption in calculating farm size in classical Attica.

[8] The considerable differences between Van Wersch's weight measurements and our own can probably be accounted for by the fact that his sample was a different cultivar from ours. Van Wersch's was most likely (modern) six-rowed, hulled barley (the type grown elsewhere in the Peloponnese – e. g., Methana and the southern Argolid – at present), whilst our sample was a two-rowed, hulled variety grown in England.

[9] At present, the joule is preferred to the traditional calorie by many scholars for measuring energy output and input, see FAO, Energy and Protein Requirements, pp. 12–13. We have retained the older calorie for this study because it is more familiar.

[10] On the whole, the ‹classical diet› was probably quite reasonable as far as the supply of vitamins and minerals is concerned. Diets containing a high proportion of wheat and barley are less deficient in protein, vitamins and minerals than diets based on polished rice or root crops: «a community at the lowest level of agricultural productivity, living predominently on cereals, even on coarse cereals such as barley, maize, sorghum or millet, if they have enough calories,

late 1940's, at a time when less grain than normal may have been eaten because of wartime disruptions, cereals supplied, on average, 39% of the total calories and 47% of the protein consumed.[11]

For this study we calculated the *per diem* calorific value of each of the grain distribution figures that were available. We then compared them with the known human calorie requirements[12] to see: 1) if the amounts of grain represented by the ancient figures would have furnished a reasonable supply of energy and under what circumstances; 2) what proportion (percentage of calories) of the diet might have been grain; and 3) how the absolute amounts of grain eaten and the position of cereals in relation to other foods compare with modern rural Greek dietary practices, since the more complete modern data seem to bear some similarities to the ancient situation.

Analogous to the variations in weights, there are slight variations in the nutrient content and calorific value of different cultivars of wheat and barley, as well as among samples of the same cultivar grown under different conditions.[13] Again, it is not practical to account for the numerous small variations that occur, thus we have

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will also receive enough protein, though this is not the case with peoples living predominently on root crops such as cassava, sweet potatoes, yams or taro», CLARK and HASWELL, Econ. Subst. Agr., p. 7. The Greeks and Romans seem to have consumed a large variety of vegetables, wild greens and fruit (though not necessarily a large quantity of any one item), cf., JAMESON, Agriculture and Slavery, pp. 130–131. In particular, many wild greens are high in vitamins and minerals and relatively high in protein. For example, Amaranthus spp., eaten by both modern Greeks (βλίτο) and ancient Greeks and Romans (βλίτον, *blitum*), contain more protein than almost any vegetable except fresh beans (3.7–5 g per 100 g), and are also high in calcium, iron, vitamin A, thiamine, riboflavin, nicotinamide (B vitamins) and ascorbic acid (vitamin C), FAO, Table of Representative Values of Foods Commonly Used in E. Africa, s. v., amaranth leaves; PELLETT and SHADAREVIAN, Food Composition Tables for Use in the Middle East, sec. I, no. 75. Legumes and some other vegetables such as grape leaves and mallow also provide proteins complementary to those in cereals, i. e., high in essential amino acids such as lysine that cereal protein lacks, PELLETT and SHADAREVIAN, Food Composition Tables for Use in the Middle East, sec. I, nos. 81-2, 92, 106, 108, 111, 117, 135–42; sec. III, nos. 21–34, 48–9. For the consumption of Amaranthus spp. (and other wild greens) in classical antiquity see, FRAYN, Subsistence Agriculture in Roman Italy, pp. 59 ff.

[11] ALLBAUGH, Crete, p. 107.

[12] There is, not surprisingly, a considerable amount of debate over what level of calorie intake is necessary or desirable. For some of the problems of using calorie requirements in studies of ancient nutrition, especially in their application to archaeological data (without documentary evidence) see, DENNELL, Prehistoric Diet and Nutrition. The FAO figures for calorie requirements we have used here have been considered by some researchers to be on the high side, cf., DENNELL, Prehistoric Diet and Nutrition, p. 125; and by others to be rather low, cf., CLARK and HASWELL, Econ. Subst. Agr., pp. 11–13, although their criticisms are of the FAO 1950 and 1957 statistics, in fact, the 1973 calorie requirements are more in line with the figures they propose, FAO, Energy and Protein Requirements (1973).

[13] FAO, Wheat in Human Nutrition, pp. 18–20, PETERSON, Wheat, p. 297.

used the FAO standards of 3340 calories per kg for ‹average› wheat, and 3320 calories per kg for 60–70% extraction barley meal made from hulled barley.[14]

It is interesting to note that the nutritive compositions (by weight) of the *edible portions* of wheat and barley are, on average, very close (see Table 2).[15] The phrase ‹edible portion› is stressed here, since a considerable proportion of the weight of hulled barley is in the hulls; the FAO calorific value given is for barley groats of a 65% extraction rate. Thus, the actual calorific value of 1 kg of whole, hulled barley would be only 2158 calories.

As mentioned above, the handouts of barley that are documented for classical antiquity are all in the form of coarse barley flour. For this study we have applied the FAO figure of 3320 calories per kg directly to the 60% extraction,[16] hand-ground, coarse barley flour that is used here as a basis for estimating the weight per volumetric unit that ancient *alphita* might have had. However, there is some potential difficulty with this methodology. When barley is ground on a primitive mill, at least some of the hulls are pulverised and included with the final product, whilst a small but significant proportion of the endosperm sticks to large hull fragments and is winnowed out with the chaff.[17] It is not clear how the FAO sample of barley groats was produced, but it was most likely fairly efficiently machine milled, i. e., with little

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[14] FAO, Food Composition Tables, Table 2, Items 1, 16. Coefficients of digestibility (i. e., the fact that not all calories contained in a food can be utilised by the human body) have been taken into account in the FAO tables, see pp. 3, 41. Cf., FAO Energy and Protein Requirements, Annex 2, pp. 102 ff. CLARK and HASWELL, Econ Subst. Agr., use a lower figure of 3150 calories per kg for wheat, assuming, we think unjustifiably, a minimum 10% loss in milling.

[15] FAO, Wheat in Human Nutrition, pp. 18–19. Cf., JARDÉ, Céréales, p. 130, ROEBUCK, Messenian Economy and Population, p. 160, MORITZ, Grain Mills, p. xxi, and others who have maintained that wheat is more nutritious than barley, largely on the testimony of the ancient medical writers. Wheat was, of course, the higher status grain in antiquity, which probably accounts to some extent for it being considered more nourishing. More importantly, since wheat ‹weighs heavier› than barley, and a considerable portion of whole barley is not edible, in a culture where corn is measured almost entirely in units of volume, a unit of whole wheat provides significantly lot more food than a unit of whole barley. A litre of barley flour contains about 479 (ca. 18%) fewer calories than a litre of whole wheat: not as great a difference in nutritional value as proposed in the past, cf. JASNY, Competetion among Grains in Classical Antiquity, AHR 47 (1941–2), p. 752. This difference is much too small to have been actually discerned by the Greeks and Romans.

In this paper we have purposely avoided using JASNY's botanical and nutritional information as presented in «Competition among Grains in Classical Antiquity» and «The Wheats of Classical Antiquity». Although the work of this exceedingly practical scholar has been of inestimable value for the study of economic and social history, at this point many of his botanical and nutritional ‹facts› are no longer accurate. We do not wish to disparage JASNY's important studies. Indeed, many of his ideas are still very useful, but it is simply the case that scientific findings go out of date much more rapidly than classical or archaeological ones.

[16] FAO, Food Composition Tables for International Use, item 16, p. 18, claims this calorific value is applicable to extraction rates of 60–70%.

[17] See Appendix, p. 77.

or no loss of endosperm or incorporation of hulls. Thus, ancient *alphita* (and our coarse barley flour sample), processed with simple mortars and mills, may have had a considerably lower calorific value per unit of weight than the FAO sample of ground barley, because less of the edible portion of the barley found its way into the final product.

The number of calories per day needed by a human are also subject to numerous variables such as sex, age, size, rate of activity and individual rate of metabolism.[18] Since World War II a considerable amount of research has been conducted in order to establish human calorie requirements by the FAO, WHO and other organisations and individuals. The most recent recommendations published by the FAO, which have been used in this study, are based upon a ‹reference man› who is: «... between 20 and 39 years of age and weighs 65 kg. He is healthy, that is, free from disease and physically fit for active work. On each working day he is employed for 8 hours in an occupation that usually involves moderate activity. When not at work, he spends 8 hours in bed, 4–6 hours sitting or moving around in only very light activity and two hours in walking, in active recreation, or in household duties.»[19] Adjustments for the variables of body weight, activity level and age differing from the 'reference man' (or 'reference woman') can then be made.

It is extremely difficult to determine, even very approximately, the average body weight of the ancient Greek or Roman male[20] population since archaeological skeletal material has been largely ignored. A study by Angel (published 35 years ago) suggests an average (mean) height for the ancient Attic male of 162.2 cm, but unfortunately the results are not statistically significant because of the small number of skeletons examined (61 male, 43 female).[21]

The examination of modern height/weight statistics can help to add flesh to these very bare bones. The average height of Allbaugh's male subjects in Crete was quite close to that of Angel's skeletal sample; and comparison of these measurements suggests, as we might expect, that ancient Athenians were, on average, somewhat smaller and thus slighter than their Cretan counterparts of A. D. 1948[22] – though this

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[18] FAO, Energy and Protein Requirements, p. 22, and see note 19.

[19] FAO, Energy and Protein Requirements, p. 28.

[20] We have concentrated on calorie requirements for adult males, aged 20–39, since: 1) this group constitutes a major single category in the FAO tables and, 2) most of the ancient grain distributions we possess are to men probably within this age range-soldiers and labourers. The calorific requirements of women and of households are discussed below, see note 26.

[21] Angel, Skeletal Material from Attica, Hesperia 14 (1945), pp. 284–5. This sample may be biased in favour of higher socio-economic groups since it is the graves of the comparatively wealthy that are most likely to receive attention from archaeologists.

[22] Allbaugh, Crete, Tables A 17 and A 18, pp. 481–3. Allbaugh found that the average height for rural males over 18 (i. e., born before 1930) was 65.4 inches (ca. 163.5 cm). The average weight of rural males over age 21 was 142.6 lb (ca. 64.8 kg); of males aged 20–40 the average weight was 141 lb (ca. 64.1 kg). This evidence is supported by the valuable height/weight studies on modern Greek soldiers and university students by Valaoras: τὸ ἀνάστημα

conclusion is derived as much from impression as from sound evidence. For this study we have adopted an estimated average body weight of 62 kg (136.4 lb; 9 stone, 10.4 lb) for the smaller, slighter ancient Greek (or Roman) male.

Clearly, the more active a person is, the greater his energy intake will have to be. It is extremely difficult to estimate generalised activity levels for modern peoples – especially for groups such as peasant farmers who work at different levels of activity at different times.[23] For the ancient world, levels of energy expenditure are not directly measurable, and are thus even less accessible. Fortunately, we do at least know the occupations of many of the men for whom we have records of grain handouts, even if we do not know precisely of what activities these occupations consisted. For this study the FAO general categories for levels of energy output[24] have been used. Of these categories, those most applicable to classical antiquity (and especially to the soldiers and labourers for whom we have records of grain handouts) are the ‹very active› and ‹exceptionally active› levels. According to the FAO standards, a man

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'Ελλήνων στρατιωτῶν, Πρακτικὰ τῆς 'Ακαδημίας 'Αθηνῶν 43 (1968), p. 424, fig. 2; and βιοκοινωνικὴ ὑφὴ 'Ελλήνων Φοιτητῶν, Δέλτιον πρακτικῶν τῆς 'Ιατρικῆς 'Εταιρείας 'Αθηνῶν (1970), p. 23, fig. 15; p. 24, table 9, fig. 16; p. 25, fig. 17. The subjects of the latter study may have had heights and weights higher than those of the Greek populace as a whole since university students in Greece often belong to higher than average income groups.

[23] Clark and Haswell, Econ. Subst. Agr., pp. 11 ff.; FAO, Energy and Protein Requirements, p. 25; FAO, Nutrition and Working Efficiency, p. 9.

[24] FAO, Energy and Protein Requirements, p. 25. These categories of energy output are roughly defined for modern occupations as follows:

«*LIGHT ACTIVITY*

men: office workers, most professional men (such as lawyers, doctors, accountants, teachers, architects, etc.), shop workers, unemployed men.

women: office workers, housewives in households with mechanical household appliances, teachers, and most other professional women.

MODERATELY ACTIVE

men: most men in light industry, students, building workers (excluding heavy labourers), many farm workers, soldiers not on active service, fishermen.

women: light industry, housewives without mechanical household appliances, students, department store workers.

VERY ACTIVE

men: some agricultural workers, unskilled labourers, forestry workers, army recruits and soldiers on active service, mine workers, steel workers.

women: some farm workers (especially peasant agriculture), dancers, athletes.

EXCEPTIONALLY ACTIVE

men: lumberjacks, blacksmiths, rickshaw-pullers.

women: construction workers.»

These categories are calculated by the FAO on the basis of an 8 hour workday. This is reasonably applicable to modern Greek farmers (see Allbaugh, Crete, p. 245; Forbes, unpublished field notes), although, of course, we have no idea of the length of the ‹average› working day in antiquity. Certainly an 8 hour work day is much longer than that of peasants in many parts of the world; Clark and Haswell prefer to use a 4 hour work day in their calculations, Econ. Subst. Agr., pp. 13–16.

aged 20–39, weighing 62 kg, would require 3337 calories per day if he were ‹very active› and 3822 calories per day if he were ‹exceptionally active›, but only 2852 calories per day if he were ‹moderately active›.[25] These are the three calorific requirement levels for adult males that we have used in this study.

In a few instances we have also used an estimated calorific requirement of 15,495 calories per day for a hypothetical household of six members (see note 26) – the composition of which is, inevitably, highly arbitrary since we have so little idea of ancient demography. This figure has been used merely for comparative purposes, in circumstances where grain handouts seem to have been intended to feed (at least to some extent) both the recipients and their families. The FAO tables allow the computation of the calorie requirements of both children (on a very generous scale) and older adults.[26]

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[25] FAO, Energy and Protein Requirements, pp. 79–84.

[26] Older FAO calorie requirements (1957 and 1950) for children have been considered much too high by some researchers, cf., Clark and Haswell, Econ. Subst. Agr., p. 16. Even the more recent FAO requirements (1973), although lower than those criticised by Clark and Haswell (cf., FAO, Energy and Protein Requirements, p. 33), are high compared to some estimates of the calorific requirements of children. The FAO calorie requirement levels are based primarily on European studies, Energy and Protein Requirements, p. 33. The criticism of Clark and Haswell (and others) is that European based data may not be applicable to areas such as Africa and Asia. Findings based on European data do seem to be generally applicable to modern Greece, and with small modifications, probably to ancient Greece as well. But, it should be noted that the estimate of household requirements used here is most likely *extremely* generous.

The hypothetical household used for this study was constructed as follows:

household member	*daily calorie requirement* (FAO, 1973)
adult female, 52 kg, 60–69 years, ‹very active›	1947
adult male, 62 kg, 20–39 years, ‹very active›	3337
adult female, 52 kg, 20–39 years, ‹very active›	2434
male child, 13–15 years, ‹very active›	3237
female child, 10–12 years	2350
child, 7–9 years	2190
TOTAL	15495

Body weights and calorie requirements for females were computed similarly to those for males using the FAO standards. The average height of ancient Attic females in Angel's skeletal study was 153.35 cm (see note 21). In Allbaugh's sample (Crete, 1948, see note 29), average height for women over 18 (born before 1930) was 62.4 inches (ca. 156 cm), average weight for rural women over 21 was 124.3 lb (ca. 56.5 kg), for rural women aged 20–40, 124.09 lb (56.4 kg). As was the case for males, Valaoras' university student subjects were larger than

One minor difficulty with using calorie requirements for this kind of investigation is that the number of calories *required* to meet energy needs can be quite different from the number of calories *actually consumed.*[27] Vivid testimony of this is provided by the comparison of, for example, obese Americans with emaciated Third World malnutrition victims. In many societies there are significant differences in the number of calories consumed by the highest and lowest income groups.[28] Yet again, in this kind of study we are forced to work with the ‹average›. It must be assumed that normally not too many people were starving to death; those who were were probably not usually employed as soldiers or labourers. It is also unlikely in classical antiquity that a significant number of people were able to exceed their calorie requirement by much because of limits on the availability of food. The exceptions would have belonged to the higher income groups, who would also not normally have been employed as soldiers (in the ranks) or labourers in any case.[29] We have deemed it most sensible for this study to ignore any discrepancies that may have existed between calorie requirements and actual calorie intake until better evidence of the extent of variation is available. 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?›.

ALLBAUGH's subjects. For women, aged 20–29, average height was 159.1 cm, average weight was 58.7 kg. A woman of 153 cm height weighed, on average, 54,9 kg (see note 22). Again, postulating a smaller, slighter person in antiquity, I have used 52 kg as the basic female body weight.

The energy requirement of the hypothetical adult female, aged 60–69, is lower than that of the adult female, aged 20–39, because older people require a lower energy intake, FAO, Energy and Protein Requirements, pp. 31–32. At a ‹moderate› level of activity her requirement would be 1664 calories per day.

[27] Although, in fact, the FAO standards used here are based on studies of *actual* calorific consumption, FAO, Energy and Protein Requirements, p. 24.

[28] Cf., ALLBAUGH, Crete, pp. 127–129; CLARK and HASWELL, Econ. Subst. Agr., pp. 8–9.

[29] Even more recently the Greek diet has provided little in the way of excess calories, cf., ALLBAUGH, Crete, pp. 118–120, 131, where the average per capita calorie intake was 2554 calories per day. The generally ‹Spartan› character of the modern rural Greek diet is confirmed by FORBES, unpublished field notes.

[30] There is a great deal of information on Ptolemaic Egyptian grain consumption recorded on papyri which we have not considered in this study. Egypt has a unique ecosystem with its own special cultivars. It is quite different from the Mediterranean littoral region and not comparable to it. For recent work on Ptolemaic Egyptian diet see, CRAWFORD, D. J., Food: Tradition and Change in Hellenistic Egypt, World Archaeology 11.2 (Oct. 1979), pp. 136–146, and

III. The Ancient Evidence

At this point it is finally possible to examine the ancient evidence. In Table 3 the ancient grain distribution figures which are both relevant and accessible[30] are presented along with their conversions to modern units of measure (litres and kilogrammes), projected annual weight of corn consumed, calories per day provided, percentages of total calorie requirements provided by each ancient figure for the adult male requirements of 3382 (‹exceptionally active›), 3337 (‹very active›), and 2852 (‹moderately active›) calories per day, and if applicable, the percentage of the total calorie requirement of the estimated household requirement of 15,495 calories per day. Also presented are the comparable cereal consumption data from the three modern Greek studies used; those of ALLBAUGH, VAN WERSCH, and FORBES. Most of the following discussion is directly related to this chart.

IIIa. The Greek Sources

One *choenix* of wheat per man per day (ca. 0.839 kg) – labelled ‹Greek standard rations› on Table 3 – is the figure that has been generally accepted and used by modern scholars as the regular ancient Greek consumption rate.[31] The evidence for the Greek ‹standard› consists of a series of literary and epigraphical references over a long period, most of which are given by JARDÉ.[32]

Under close scrutiny almost all of the literary references prove to be less helpful than one might wish. The earliest mention of the *choenix* as a grain measure is in the Odyssey XIX. 27–28 where it refers to the *choenix* as exactly that – a measure of stored grain.[33] The later references (and many are very late) are not always explicit about how the *choenix* measure relates to daily rations. For example, Athenaeus' statement (VI. 272 B) that the Corinthians had so many slaves that τὴν Πυθίαν κεκληκέναι 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. This is important since a *choenix* of wheat is not equal (in weight or calorific value) to a choenix of e.g., *alphita.*[34]

REEKMANS, T., La sitométrie dans les archives de Zenon, (Pap. Brux. 3), Brussels (1966). For recent work on grain HSPh 79 (1975), pp. 16–24 and J. REA, POxy. XL.

[31] JARDÉ, Céréales, p. 129 (with references to earlier scholars using this figure); ROEBUCK, Messenian Economy and Population, pp. 158 ff.; JAMESON, Agriculture and Slavery, p. 131, n. 51; STARR, Econ. and Soc. Growth of Early Greece, pp. 152–153, 155, 244 n. 28.

[32] JARDÉ, Céréales, p. 129.

[33] Odyssey, XIX. 27–28: ξεῖνος ὅδ'· οὐ γὰρ ἀεργὸν ἀνέξομαι ὅς κεν ἐμῆς γε χοίνικος ἅπτηται.

[34] In this category of unilluminating references can be included the late interpretations of the Pythagorean saying μὴ καθῆσθαι ἐπὶ χοίνικα. Plutarch (Moralia 12 e) thought that it

The most helpful literary reference is Herodotus' estimate of the amount of grain that would have been needed to feed Xerxes' army (Htd. VII. 187.2): εὑρίσκω γὰρ συμβαλλόμενος, εἰ χοίνικα πυρῶν ἕκαστος τῆς ἡμέρης ἐλάμβανε, καὶ μηδὲν πλέον. He then goes on to compute (erroneously) the number of *medimnoi* and concludes by stating: γυναιξὶ δὲ καὶ εὐνούχοισι καὶ ὑποζυγίοισι καὶ κυσὶ οὐ λογίζομαι. In spite of the fact that the calculations are only hypothetical, Herodotus specifically states that he is using one *choenix* of wheat per man per day as the basis of his reckoning. We can infer then, that this rate of rationing would seem a normal and reasonable ‹rule of thumb› to use for calculating military grain supplies to a 5th century Greek – more will be said on the implications of this below.

The examples of grain distribution in the Greek epigraphical record do not unequivocally support the general use of the one *choenix* per day standard implied in the literary record. Out of a total of eight inscriptions of very assorted character mentioning handouts of grain which also include the per capita quantities distributed, only two actually specify an amount of one *choenix*. The first is a treaty between Attalos I of Pergamon and the Cretan city of Malla, dating to the end of the 3rd century B. C.[35] Here, one Attic *choenix* of grain per man per day and a cash wage are to be supplied by the Malleans to any troops that might be sent to their aid during the time that the troops are in the vicinity of Malla. It is interesting that a status distinction between troops and officers is maintained only in the cash wage, which is higher for officers; both groups receive the same ration. The type of grain is not specified, but by this period it is almost certainly wheat. This inscription provides a very interesting complement to Herodotus' hypothetical calculation of supplies needed by the Persian army – an example of the actual use of the same ‹rule of thumb› in relation to armies. Unfortunately, it is unique. As will be shown below, none of the other epigraphical examples are easily interpreted as providing for regular distributions of grain at this rate.

The second inscription specifying a ration of one *choenix* per man is from Aegiale, Amorgos (2nd century B. C.), and describes the arrangements for a splendid public festival (privately financed), including games and a banquet, extending over two

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meant προνοεῖν ὅπως τὴν ἀναγκαίαν παρασκευαζῶμεν τροφὴν and the interpretations of Athenaeus (X. 452 e) and Diogenes Laertius (VIII. 18) are similar. Although they may imply that a *choenix* of wheat (?: see Roebuck, Messenian Economy and Population, p. 161) is generally considered to be a day's food, they do not present an actual example of the use of this ration. Also these interpretations may well have had nothing whatsoever to do with the intended meaning of the precept, cf., Kirk and Raven, Presocratic Philosophers, Cambridge (1957), p. 226.

[35] Ducrey, Traités Attalides avec des cités crétoises, BCH 94 (1970), p. 639, no. 2, face A, II 20 ff.: Ὅταν δὲ παραγένωνται πρὸς Μαλλαίους, τ[ρ]ε[φ]έτωσαν τὴν συνμαχίαν αὐτοί, παρέχ[ο]ντες τῆς ἡμερᾶς ἑκάστωι ἀνδρὶ δραχμὰν αἰγιναῖαν, τῶν δ'ἡγεμόνων ἑκάστωι δραχμὰς δύο, καὶ κατὰ σῶμα χοίνικα ἀττ[ικ]ήν. Cf. M. Launey, Recherches sur les armées hellenistiques, II, Paris (1950), pp. 762–3.

days (IG XII. 7. 515). In addition to the banquet, various foodstuffs were to be distributed: wine, pork to the ephebes, and wheat to all residents (citizens, metics and foreigners), one half *choenix* to boys and one *choenix* to men.[36] It is, however, not appropriate under such special, ceremonial circumstances to consider the grain dispensed on this occasion to be a proper ration (as JARDÉ, Céréales, p. 132, does). This corn handout is more comfortably placed in the category of corn donations provided by private benefactors to their cities, given as a gift and perhaps distributed at the rate of what was reckoned to be approximately a day's grain, although under these circumstances the amount may have no significance.[36a] It certainly cannot be used as evidence of continuous consumption at this level.

It has been suggested by JARDÉ[37] that two volumetric units of *alphita* were the equivalent of one volumetric unit of wheat in ancient Greek rationing, and he argued that two *choenikes* of *alphita* was the nutritional equivalent of one *choenix* of wheat because (he thought) barley was considerably less nourishing and more difficult to digest than wheat. However, in the ration records under discussion, it was not wheat and barley that were distributed, but wheat and *alphita*, a ground product of barley. So, although a given weight of unmilled wheat has a higher calorific value than the same weight of unmilled hulled barley (and the difference is greater per unit of volume), we have seen (p. 46) that the edible portions of wheat and barley, per unit of weight, have about the same calorific value. One litre of wheat should contain only about 440 calories more than one litre of *alphita;* and the calorific value of one kg of each is virtually identical. Furthermore, there is almost no difference in digestibility between processed wheat and barley.[38] The apparent 2 : 1 relationship between *alphita* and wheat in the ration records has been discussed by others as well.[39]

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[36] IG XII. 7.515, lines 70 ff.: τὰ δ[ὲ] παρατιθέμενα ἅπαντα ἔστω ἀποφορητὰ [ἀ]πὸ τ[ο]ῦ τρικλίνου. σιτομετρείτωσαν δ[ὲ οἱ] ἐπιμεληταὶ ὠνησαμένοι σῖτον πύρινον ἀπὸ τοῦ ἀργυρίου διδόν[τ]ες τῃ προτεραίᾳ τοῖς τε πολίταις τοῖς ἐπιδημοῦσιν καὶ παροίκοις καὶ ξένοις τοῖς παρεπιδημοῦσι τῶν μὲν ἄνδρων ἑκάστῳ χοίνικα τῶν δὲ παίδων ἥμισυ χοίνικος. Cf. the translation by HANDS, Charities, pp. 177–178 (D 5).

[36a] A number of other inscriptions record gifts of public grain handouts by individuals to cities, see HANDS, Charities and p. 23, where those giving actual amounts are discussed. It is noteworthy that the amounts of the grain handouts in these texts are all different, and they are not distributed at short enough intervals to have any major dietary significance.

[37] JARDÉ, Céréales, pp. 128–135. JARDÉ based his argument on two pieces of evidence: 1) the ration allowed by the Athenians to the Spartans blockaded on Sphacteria (Thucydides IV. 16.1) of two choenikes of *alphita* per man per day which, he noted, was double the ‹standard› Athenian wheat ration, and 2) the monthly payments of grain to two stone masons on Delos in 282 B.C. (IG XI. 158.37 ff. = BCH 14 [1890], pp. 481–2), which consisted in some months of 1½ *choenikes* of wheat per man per day and in other months of 3 *choenikes* of *alphita.* These stone masons also received a cash wage of 2 obols per day. It was on the basis of this larger handout in the Delian inscription that JARDÉ considered that one *choenix* of wheat per man per day was a minimum ration, Céréales, pp. 129, 135.

[38] FAO, Energy and Protein Requirements, Table 31, pp. 103–104.

[39] ROEBUCK, Messenian Economy and Population, pp. 159–161. GLOTZ, Le prix des den-

When one attempts to pinpoint examples of the actual use of a ration of two *choenikes* of *alphita,* as was the case with the one *choenix* wheat ration, very few (only three) are to be found. The only epigraphical example is the grain payment to a cook on Mykonos around 200 B.C. in return for slaughtering and barbequeing two pigs for Demeter Chloe at a festival; his total payment consisted of: ὀσφὺν καὶ κωλῆν τῆς ὑὸς τῆς ἑτέρας, ἀλφίτω[ν] δύο χοίνικας, οἴνου τρεῖς κοτύλ[α]ς.[40] Since he was not given a wage in money this is likely to represent payment for services rendered in the form of approximately a day's food, similar to the grain handout in the Aegiale inscription. Because this would have been a ceremonial occasion and probably not the man's daily employment, it cannot be assumed that this represented his normal diet.

The second example, the Spartans blockaded on Sphacteria who were allowed two *choenikes* of *alphita* by their Athenian captors, has already been mentioned, but it is noteworthy that the Spartan slaves were only allowed one *choenix* of *alphita* (Thucydides IV. 16. 1).

Finally, Herodotus tells us that the Spartan kings were given two *choenikes* of *alphita* and a *kotyle* of wine on days when they did not go to the public banquet.[41] However, at public banquets, as dinner guests at a private house, or at religious festivals the kings were given portions double the size of those of ordinary citizens.[42] This may imply that two *choenikes* of *alphita* was a larger ration than an ordinary citizen might have expected.

It is very difficult, then, on the presently available evidence, to support the use of a 2 : 1 *alphita* : wheat ratio in Greek grain handouts. Aside from the fact that there are very few actual examples of rations of either one *choenix* of wheat or two *choenikes* of *alphita,* the only document in which the 2 : 1 relationship is explicit is the Delian account of 282 B.C., (see notes 37 and 39), and there the amounts are larger. Fur-

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rées à Delos, JS 11 (1913), p. 20, argued that the price of wheat was twice that of *alphita,* thus double rations of barley had to be given to equal wheat rations in cost. But, the Delian account for 282 B.C. (IG XI. 158.37 ff. = BCH 14 [1890], pp. 481–2) gives the price per *medimnos* of wheat and *alphita* over several months (see Table 4). The prices of both commodities varied considerably throughout the year, although the 2 : 1 ratio was still maintained in the rations. More importantly, in the preserved section of the inscription, wheat is almost never exactly double the price of *alphita.* It is difficult to draw conclusions from this document since the accounts for two months are missing, but it seems as though wheat was given to the masons until it became too expensive at 10 *drachmae* per *medimnos,* at which point *alphita,* being considerably cheaper at 4 *drachmae* per *medimnos,* was handed out instead.

Short-term fluctuations in grain prices were a major problem in antiquity, and many attempts were made to stabilise the market, see Duncan-Jones, Economy of the Roman Empire, p. 146. This is a problem even for modern governments, cf., the stringent regulations on the prices of bread and wheat in the U.K.

40 Dittenberger, SIG³ 1024, lines 14–16.

41 Herodotus VI. 57.3.

42 Herodotus VI. 57.1–3.

thermore, neither differential prices nor differential nutritional values explain it. If this 2 : 1 ratio in wheat and *alphita* rationing was actually in general use (and it may well not have been) it is perhaps attributable simply to the greater desirability of wheat over barley – which might not be directly reflected in price within a highly volatile grain market.

How standard, then, was the ‹Greek standard ration›? Again, on presently available evidence this is a difficult question to answer. Certainly the literary references imply that it was normal, especially Herodotus' hypothetical calculations for Xerxes' army, which must have been intended to sound credible (i. e., not unusual) to his audience. However, it is problematic that we possess only one record of a continuous ration (or at least what would have been such) of one *choenix* of wheat per man per day: the Malla treaty.[43] Even if we include two *choenikes* of *alphita* as the ‹Greek standard ration›, we can add only one more example of a continuous (though short term) ration, that of the Spartans on Sphacteria.[44] Even this example is not free from difficulties, since the Athenians thought that the Spartan slaves could survive perfectly well on half this amount, and indeed the energy value of one *choenix* of *alphita* seems quite sufficient for survival (see Table 3).[45] Nonetheless, distributions of one *choenix* of wheat per man per day (and even two *choenikes* of *alphita*) seem more standard than any other amounts. Of the other surviving Greek grain distribution records, no two are for the same amount (see Table 3). It 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. However, it must be remembered that many different figures were used as bases for grain distribution, perhaps at least as frequently as the ‹standard›, depending on the particular circumstances at hand. Given the paucity of data, it is not possible to determine how widespread the use of a one *choenix* (wheat) standard was.

It is enlightening, however, to consider the energy value of one *choenix* of wheat, especially in view of the often quoted suggestion that it was a minimum ration.[46]

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[43] The Aegiale inscription represents a ‹one off› distribution.

[44] The cook in the Mykonos inscription has received a ‹one off› payment. The Spartan kings were rather atypical in that they supposedly received extra large portions of food, and in any case their ration of 2 *choenikes* of *alphita* only appeared when they did not attend the public banquet.

[45] Thucydides IV. 16.1. Because of the unusual circumstances involved in transporting food to the captives, it is possible that their diet was not typical. Though they had no legumes or other vegetables or fruit, the grain ration may have been larger than ‹normal›, and they had a regular ration of meat. Thucydides does not tell us the amount of meat issued per man, but that he mentions it at all is remarkable, particularly as part of a ration allowed to captive soldiers and their slaves.

[46] Jardé, Céréales, p. 129; Gernet, L'Approvisionnement d'Athènes en blé au V^e^ et au IV^e^ siècle, Mélanges d'histoire ancienne 25 (1909), p. 294, n. 7; Bolkestein, Wohltätigkeit,

One Attic *choenix* of wheat (0.839 kg) contains 2803 calories, which would provide 84% of the energy required by a ‹very active› adult male, 73% of the energy required by an ‹exceptionally active› adult male and 98% of the energy required by a ‹moderately active› adult male. That is to say, for a man working ‹flat out› this amount of grain would provide a reasonable, though rather large, proportion of his diet. For a man working very hard, but not to the limits of his physical capacity (e. g., a farmer, labourer or soldier) this amount would provide a very high proportion of his total calorific intake. For a man engaged in less arduous work the consumption of this amount of grain would most likely result in obesity.

Let us examine these figures in a broader context. At present, wheat rarely comprises much more than 60% of the total calories consumed,[47] and cereals and starches as a whole rarely comprise more than 75% of total calories, on average, even in poor, Third World countries where a great deal of grain and starchy foods are consumed.[48] As will be seen below, in modern Greece, grain contributes from just over 30% to just over 60% of total calories consumed in the average diet, depending on activity level (see below, p. 66 and Table 3). In view of this, a figure of 84% for the calorific contribution of cereals to the ancient diet (‹very active› adult male) sounds extremely high, if not quite incredible. Certainly we cannot possibly consider one *choenix* of wheat per man per day to be a minimum ration.[49]

What, then, does this seemingly high ration represent? We believe that Herodotus (VII. 187. 2) provides a clue to the answer. In his calculations of the amount of grain that Xerxes army would have needed, he used this figure as a convenient and credible ‹rule of thumb›.[50] One *choenix* of wheat per man per day is enough for a man doing the heaviest labour, and more than enough for a man in less pressing circumstances. This is the sort of rule according to which a farmer might have calculat-

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p. 264, n. 1; Boeckh, Staathaushaltung, pp. 97–98; Engels, Alexander, p. 125, considers this ration «inadequate to support human life».

[47] FAO Wheat in Human Nutrition p. 31.

[48] FAO, Wheat in Human Nutrition p. 75; FAO, Energy and Protein Requirements, pp. 20–1.

[49] Obviously, 2 *choenikes* of *alphita* would have an even higher calorific value than 1 *choenix* of wheat. Judging by the rather unreliable calorific values for coarse barley flour (p. 44), 2 Attic *choenikes* should provide 4641 calories, that is, 139% of the calories required by a ‹very active› adult male. Even reducing this figure by 15% to allow for the presence of indigestible hull fragments, etc., we arrive at a calorific value of 3945 calories = 118% of the calories required by a ‹very active› adult male.

[50] It has been suggested (eg., How and Wells, Commentary to Herodotus, s. v. VII. 187.2) that in Herodotus' calculations the phrase καὶ μηδὲν πλέον implies that one *choenix* of wheat per man per day was a minimum ration; i. e., that it means ‹and no other grain›. The phrase is more likely to mean ‹and no other kind of food› since the army would have needed a number of other provisions besides grain: oil, preserved meat or fish, dairy products, wine(?), etc. Herodotus' intention is to astound the reader with the enormous amount of grain, the main staple, that would have been required to feed such a large force – let alone anything else!

ed the amount of grain he needed for a year's food for his family. If he were able to put away a supply amounting to one *choenix* of wheat per family member per day, there would be enough to get through the year, with a bit over for emergencies and wastage.[51] This could also have been the rule (perhaps taken originally from an agricultural context?) according to which the state provisioned its army, its navy and its valuable hostages. One *choenix* of wheat per day would have been sufficient for a soldier at the worst times, and even if it were more than enough at the best times, it did not pay to let the army go hungry.

In a society where there is no readily available back-up corn supply in case supplies or estimates of supplies fall short of consumption needs, the *most* needed to get by is much more important than the *least* needed to get by. One *choenix* of wheat per man per day provides a supply of staple food sufficient to cover unforseen circumstances and unpredictable disasters. Similar ‹rule of thumb› formulae are applied to household storage and consumption calculations in modern Methana, especially for staples, e. g., oil, wine and wheat (see below p. 68). The amount counted on according to the formula may well be more than the amount that will be actually consumed.[52] In ALLBAUGH's detailed study of Cretan nutrition there was a significant discrepancy between the actual, carefully measured food consumption and householders' estimates of their own food consumption, the latter being considerably higher.[53] Here too, the Cretan families were probably calculating the most that would be enough, rather than the least. Thus, the seemingly standard ancient Greek allowance of one *choenix* of wheat per man per day can best be explained as the provision of a generous sufficiency.

It has already been noted that there are other Greek rations that bear no relation to a one *choenix* per day ‹standard›. Examination of the circumstances surrounding the four examples of continuous rations and the two examples of ‹one off› grain handouts provides interesting comparative information on the role of grain in ancient Greek diets (see Table 3).

The rations of 1½ *choenikes* of wheat per man per day (or 3 *choenikes alphita*) given to two Delian stonemasons and recorded in the Delian accounts of 282 B. C. have already been mentioned above (see notes 37 and 39). It is worth noting here, however, that this is a very large amount of grain for one man's consumption – 1½ *choenikes* of wheat would have provided considerably more energy than the total calories required by a ‹very active› adult male (126%). This ration must have been intended to cover the partial consumption needs of the masons' household or assist-

[51] Though farmers almost certainly stored more than enough to cover the current year's estimated consumption if they could, see n. 52.

[52] And, the amount stored is often more than they think they will need according to their consumption calculation formulae. Subsistence farmers in Methana store a full two years' supply of wheat, if they can manage it, in case the harvest fails the next year. Sometimes they store more than this, FORBES, unpublished field notes.

[53] ALLBAUGH, Crete, p. 107, and see p. 65–68.

ants: it would have provided 31% of the estimated household requirement, 73% of the total calories required by an adult man and an adult woman, or 64% of the total calories required by two adult men.

Of all the Greek data, the monthly contributions to the Spartan *syssitia* by its members are the most tantalising, for while they give a more complete picture of an ancient diet (albeit, perhaps, an unusual one) than any of our other sources, they are also beset with numerous interpretational difficulties. Plutarch (Lycurgus 12.2) gives the following list of the food requisitioned from each member:

commodity	ancient measure	modern measure	daily projected consumption rate	approximate daily[54] calories provided
alphita[55]	1 *medimnos*	30.9 kg	1.0288 kg	3416
wine[55]	8 *choae*	24 L	0.8 L	568
cheese	5 *minae*	3.013 L	0.1 kg (= ca. ¼ lb.)	106
figs	2½ *minae*	1.5065 L	0.05 kg (= ca. 2 oz.)	140
			TOTAL	4230

Although we have calculated the hypothetical per diem consumption and the energy values of each item in the table above, it is not known how much of the food given to the *syssitia* was actually eaten by the donor (or even by the *syssitia* as a whole), how much a Spartan ate outside the *syssitia*, or how much was purchased with the small cash contribution to cover *opsonia*, i. e., salt, olives, relishes, etc.[56] Certainly it seems that the messmates voluntarily contributed (and consumed) additional food for the part of the meal called the *epaiklon*, served after the staple main course.[57] A major part of the motivation for making these donations seems to have been the desire for personal prestige, for the name of the contributor was announced when his dish was served.[58] Meat and game were given by most people («making a show of their own

[54] For the calculation of calories in alcohol see, FAO, Energy and Protein Requirements, pp. 39–40; other energy values are from the FAO Food Composition Tables for International Use.

[55] Athenaeus (IV. 141 c), quoting the 4th century B.C. historian Dikaiarchos, mentions higher contributions of both *alphita* (1½ Attic *medimnoi* = 5603 calories per day, or allowing for a + 15% error = 4762 cal. p. d.) and wine (11–12 *choae* = ca. 730 calories per day); but does not specify amounts for contributions of cheese and figs. According to Dikaiarchos, the cash payment for *opsonia* was about 10 Aeginetan obols.

[56] See, Roebuck, Messenian Economy and Population, p. 186, especially note 86. Herodotus on the privileges (and eating habits) of the Spartan kings (VI. 57.1–3), exacerbates the already formidable problems of using Plutarch's and Athenaeus' information. But, since the kings seem to have been treated differently from the rest of the citizens (for example, being given double portions of food under many circumstances), we have eliminated them from the discussion here.

[57] Athenaeus, IV. 140 c–f; 141 c–e.

[58] Athenaeus, IV. 141 d.

ability at hunting»[59]), but wealthier members sometimes also gave wheaten bread and fresh fruits and vegetables in season.[60] It is interesting to note that the *ad hoc* donations consisted almost entirely of perishable foods, while the requisitioned items were storable staples. However, it seems rather odd on first glance that olive oil, normally considered an important Greek dietary staple, was not explicitly included in either category of food contributions. Athenaeus mentions it only as part of the *epaiklon* course, in a dish of *alphita* mixed with oil,[61] sometimes served on bay leaves; and this may indicate that olive oil in the Spartan diet was indeed a luxury, not a staple.

If we look at the per diem energy value of the food in the *syssitia* contribution, the Spartan diet does not seem very ‹Spartan› at a minimum of 4230 calories per day. This is at least 408–893 calories higher than the requirements of the most active adult men.[62] Given the number of food items for which we cannot quantify the amounts eaten, the large size of portions if we assume that the contribution was the equivalent of an individual's staple ration, and the accordingly high calorific value of the food, perhaps some of these staples were not consumed by the *syssitia,* but were used instead to purchase other food items. It is possible too that part of the requisitioned food went to feed servants (or helots?) working in the common mess. Unfortunately, it is also possible that Plutarch's and Athenaeus' information was either not correct or not complete.

From 2nd century B.C. Samos we have a decree recording the arrangements made by the city for buying up wheat and distributing it to the citizens, who were to receive two ‹measures› (μέτρα) of corn (σῖτος) per month as a gift for as long as the supply lasted.[63] Σῖτος, especially in this period certainly means wheat, particularly

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[59] Athenaeus, IV. 141 c–d: ἀλλὰ τῆς αὐτῶν ἀρετῆς ἀπόδειξιν τῆς κατὰ τὴν θήραν ποιούμενοι.

[60] Athenaeus, IV. 141 c: φέρουσι ... οἵ γε πλούσιοι καὶ ἄρτον καὶ ὧν ἂν ὥρα ἐκ τῶν ἀγρῶν.

[61] Athenaeus, IV. 140. c–d, f.

[62] Even if one subtracts 15% of the energy value of the barley meal because of potential calculation errors, assigning it an energy value of 2904 calories, this still gives a figure of 3718 calories for the per diem energy value of this diet, at the minimum. This figure falls between the requirements of a man in the ‹very active› category and one in the ‹exceptionally active› category, but as mentioned above, Plutarch's and Athenaeus' lists do not include some of the high calorie foods that were eaten, e.g., meat. Obviously, using the *alphita* and wine figures given by Athenaeus (see note 55) the number of calories per day provided is even higher.

The energy value used for cheese is conservative, 106 calories per 100 g, assuming a whey cheese like *mizithra;* the calorie content of a full fat, semisoft cheese like *feta* is about 200 calories per 100 g, FAO, Food Composition Tables for International Use.

[63] DITTENBERGER, SIG³ 976 lines 52 ff.: τὸν δὲ συναγορασθέντα πάντα διαμετρείτωσαν τοῖς πολίταις κατὰ χιλιαστὺν τοῖς ἐπιδημοῦσιν μετροῦντες ἑκάστωι τὸν μῆνα δωρεὰν μετρὰ δύο· ἀρχέσθωσαν δὲ τῆς διαμετρήσ[ε]ως μῆνος Πελυσιῶνος καὶ μετρείτωσαν ἑξῆς ἐφ' ὅσους ἂν ἐκποιῆι μῆνας ... Cf., the translation of this decree in HANDS, Charities pp. 178–180 (D 6) and the discussion of it, pp. 95–96.

since there is no specific mention of barley meal. The greatest interpretational difficulty here is the capacity of a *metron.* It has been identified by Bolkestein and Dittenberger as a *medimnos* on the grounds that this was the measure most regularly used for corn.[64] Furthermore, all the other monthly Greek grain distributions that we have are expressed in *medimnoi* (see Table 3).

The Samian citizens to whom the grain was given would, of course, have been men; and most of them would have been old enough to have been heads of households of their own. Assuming that *metron* = *medimnos,* they would have received the equivalent of 3.2 *choenikes* per day. As in the case of the Delian rations and the Roman *frumentationes* (discussed below) the wheat given out was obviously not meant for one man alone; its energy value is over twice as much as the total calorific requirement of the most active adult male. But, this amount would have easily covered the grain needs of a family, supplying 53% of the estimated total household calorific requirement.

Our last example of a continous ration, from an inscription commemorating the manumission of one Thrakidas from Delphi (2nd quarter of the 2nd century B. C.) is of particular interest since it includes the only record from Greece of a ‹ration› intended for a woman.[65] One of the conditions of Thrakidas' freedom was that, should something happen to his former master, he was to support his former master's wife, Dorkas, either by working their estate or by giving her four *hemihekteis* of wheat per month. This amount would have supplied about the same proportion of grain in the diet (i. e. % of total calories required) of a ‹moderately active› to ‹very active› elderly woman (71–83%) as the Greek ‹standard ration› of one *choenix* of wheat would have supplied for a ‹very active› or ‹exceptionally active› adult man (73–84%). The reasons for this relatively high allowance are probably much the same as in the case of the Greek ‹standard ration›, essentially providing a wheat supply for Dorkas large enough that she would be unlikely to run short.

The two examples of ‹one-off› grain distributions come from 1st century A. D. inscriptions which are similar in character both to each other and to the Aegiale inscription discussed above.[66] In the first, a decree listing the gifts and services to the

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[64] Bolkestein, Wohltätigkeit, p. 264; Dittenberger, SIG^3 976, commentary. Also in the Egyptian documents of the Roman period studied by Duncan-Jones, the term *metron* can refer to a ‹standard› 48 *choenix* capacity *medimnos,* see «Variations in Egyptian Grain Measure», p. 36: but cf., pp. 369–70, n. to no. 59, the term was not always used in this way.

[65] Collitz and Bechtel, Sammlung, no. 1884.

[66] Clearly, both could as easily be discussed with the Roman evidence; we have dealt with them here only because they are written in Greek.

There are two epigraphical examples of annual bequests of grain handouts of specified amounts closely related in character and intent to the two discussed here and to the Aegiale inscription (p. 52). In one, unfortunately, W. H. Buckler, A Charitable Foundation of A. D. 237, JHS 57 (1937), p. 2, lines 16–20; p. 8, the relevant passage is so fragmentary (both the amount and the grain product distributed are restored) that sound conclusions cannot be drawn from it. The other inscription (dated to around 160–158 B. C.), Inschriften von Didycity undertaken by various wealthy Galatians in Ancyra (Asia Minor), it is recorded that Ἀμύντας Γαιξατοδιάστου ... σειτομετρίαν ἔδωκεν ἀνὰ πέντε μοδίους.[67] The second is one of several long decrees in honour of Epamonidas of Akraephia (Boeotia), who, in addition to numerous other benefactions to the city, on one occasion: [(ε)ἰς] τὴν μέλλουσαν ἑορτὴν ἔδωκεν πᾶσι τοῖς πολείταις καὶ παροίκοις καὶ ἐκτημένοις διδοὺς κατ' ἄνδρα ἕκαστον κόφινον σείτου καὶ οἴνου ἡμί[ναν].[68] Since these are (like the Aegiale decree) ‹one-off› grain handouts, not continuous rations, they do not inform us about normal rates of consumption. In all three cases the lavish gifts of grain provided more in the way of prestige for their donors than nourishment for the general populace. The amount of 5 *modii* given in the Ancyra inscription is interesting in this light. It is possible that Amyntas was attempting to enhance the status value of his gift by distributing the same amount as did the city of Rome in the famous *frumentationes*.[69] At any rate, the quantity of grain is larger than even a hypothetical daily ration (see Table 3).[70]

It is interesting, by way of comparison, to look briefly at two historical examples of rations that we know were very low, even starvation level: one from Thucydides and one from Diodorus. The first is the ration given to the Athenian prisoners of the Syracusans of two *kotylae* per day (Thucydides VII. 87.2). Here the captives suffered not only from hunger, but from hard labour and miserable living conditions as well (VII. 87.1). Even so, some men were apparently still alive after eight months of this treatment (VII. 87.3). It is interesting that the type of grain is not mentioned by Thucydides; it is merely called σῖτος. Later narrators of this episode specify barley in one form or another: Plutarch says κριθαί (Nicias XXIX. 1), Diodorus says ἄλφιτα (XIII. 20). But, neither one is entirely trustworthy, especially as far as this sort of detail is concerned; Diodorus, in fact, got the amount wrong (two *choenikes* instead of two *kotylae*). The Athenian captives would have been somewhat better off if

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ma, no. 488, lines 5–10; see also, P. Hermann, Neue Urkunden zur Geschichte von Milet im 2. Jahrhundert v. Chr., Istanbul. Mitteilung. (1965), pp. 105–110, provides for the distribution of 6 *hemihekteis* (= 15.4 kg) of wheat (*sitos*) to each of the citizens of Miletus on the anniversary of the day that Eumenes became king.

Although this is by far the most generous handout of any in this category, even this amount would not have fed the citizens for very long. For the ‹hypothetical household› of this paper (see p. 49) with a calorie requirement of ca. 15,495 calories per day, eating a diet consisting of 75% grain, this amount would have lasted about 4 days. And, like the inscriptions discussed above, it does not provide information about normal rates of grain consumption.

[67] Dittenberger, OGIS II, no. 533, lines 27–30, Augustan. Cf., Hands, Charities, p. 97.

[68] IG VII. 2712, lines 64–65. Cf., Hands, Charities, pp. 89–90.

[69] See Hands, Charities, pp. 109 ff. on the prestige value of such gifts. In Egypt at least, some cities seem to have imitated the Roman *frumentationes*, see Turner, Oxyrhynchus and Rome, HSPh 79 (1975), pp. 19–22.

[70] For the number of people 5 *modii* could feed, see p. 64 on the Roman *frumentationes*. In the Akraephia decree, 1 Boeotian κόφινον = ca. 7.55 kg wheat, an amount that is difficult to relate to normal consumption patterns.

they had been receiving wheat instead of barley or *alphita*, though we think that wheat rations for prisoners would be rather unlikely – so apparently did Diodorus and Plutarch.[71] In any case, the amount was certainly inadequate for proper nutrition; and the calorific computations do indeed confirm the starvation that Thucydides described.

The second example, from Diodorus (XIX. 49.2), occurred when Cassander had blockaded Olympias and her forces in Pydna in 316 B.C.: εἰς τοῦτο γὰρ ἦλθον ἀνάγκης ὥστε τῷ μὲν στρατιώτῃ σιτομετρεῖν χοίνικας πέντε τοῦ μηνός (= ca. 46 kg per year). This amount is less than half of what the Athenian prisoners at Syracusae got, so it is not surprising that disaster ensued: τῶν δ' ἱππέων οἱ ἅπαντες ἐτελεύτησαν, οὐκ ὀλίγοι δὲ καὶ τῶν στρατιωτῶν τῆς ὁμοίας καταστροφῆς ἔτυχον.

IIIb. The Roman Sources

The Roman grain consumption data uphold the Greek very well; indeed somewhat similar standards seem to be in operation.

Roebuck long ago noted that the rations of the Roman army, given by Polybius (VI. 39.13) as ⅔ of an Attic *medimnos* of wheat per man per month, were approximately equal to the Greek ‹standard ration› of one *choenix* of wheat per day.[72] It is clear from Table 3 that the Roman infantry ration provided only slightly more energy than the Greek ‹standard ration›. We think the same arguments must apply to the use of the former as apply to the latter – it supplied enough energy for the most active periods and more than enough at other times.

The provisions of the Roman and the allied cavalry, given in the same Polybius passage, are much higher than those of the infantry: 2 *medimnoi* of wheat per month to each of the Romans, 1⅓ *medimnoi* per month to each of the allies. The barley handed out (7 *medimnoi* per month to the Romans, 5 to to the allies) must have been for the horse. Walbank has suggested that such large amounts of grain must have included food for a groom.[73] It is noteworthy in light of Walbank's suggestion that

[71] There is a very slight possibility that σῖτος here means ‹bread›. Bread was at least sometimes measured in units of volume, e.g. *choenikes:* Xenophon, Anabasis VII. 3.23: λαβὼν δὲ εἰς τὴν χεῖραν ὅσον τριχοίνικον ἄρτον, perhaps meaning a loaf made with 3 *choenikes* of flour? And, the chained slaves on Cato's estate were given bread instead of grain (Cato, de Agr. 56), presumably because they lacked cooking facilities – as the Athenian prisoners at Syracuse may well have.

[72] Roebuck, Messenian Economy and Population, p. 159, note 74. It has been thought that this figure was meant to represent 3 *modii* per month, Walbank, Commentary Polyb., s.v. VI. 39.13, but we are grateful to R. P. Duncan-Jones for pointing out that ⅔ of an Attic *medimnos* actually equals 4 *modii.*

[73] Walbank, Commentary Polyb., p. 722. It is not clear from his statement here whether Walbank thinks that both the wheat and the barley were for human consumption, or, as we suggest, only the wheat.

if we take the infantry ration as the basic unit, then the allied cavalry ration is two times the basic unit (i. e., enough to feed two men) and that of the Roman cavalry is three times the basic unit (i. e., enough to feed three men). Is it possible that a Roman cavalry officer was ‹allowed› two attendants and an allied cavalry officer was allowed one?[74]

The slaves on Cato's estate (de Agr. 56) were provided with different amounts of grain depending on their position and the time of year (see Table 3). It is interesting that they received wheat (*triticum*) and not some cheaper grain. Cato does not actually specify the period these rations were intended to cover. On logical grounds we have assumed that the farm labourers' and the administrators' rations were monthly.

The farm labourers (*qui opus facient*) got more in the summer than in the winter, presumably because they were able to work more hours during the long summer days. Again the figures (4 *modii* in winter, 4½ in summer) are remarkably close to the Roman infantry ration and the Greek ‹standard ration›, providing sufficient food for even the days of hardest work (2964 and 3334 calories per day respectively).

It is interesting that the ‹administrators› on Cato's estate, the *vilicus, vilica, epistates* and *opilionus*[75] received less grain than the farm labourers, although their positions were of higher status (receiving 3 *modii* per month, which would supply 2223 calories per day). Was this because they were less active, or because their diet consisted of proportionally less grain and more of the more desirable foodstuffs such as oil, cheese or meat? It is not possible to answer this question from the information provided by Cato. It is worthy of mention, however, that the administrators' grain rations are not far from some of the modern Greek consumption figures, where grain does seem to form a smaller proportion of the diet than in antiquity (see below p. 69) because larger quantities of other high calorie staples, notably olive oil, seem to be eaten.

Cato's ‹chain gang› received bread, not grain, probably because there were no cooking facilities in the *ergastulum*. The amount given out was quite high, 4 Roman pounds (1.31 kg) except during the vine digging – the most arduous task of the agricultural year[76] – when it was 5 Roman pounds (1.637 kg).[77] On logical grounds

[74] Another, admittedly slight, possibility for explaining the extremely high cavalry rations is that soldiers may not necessarily have had to use up the whole of their monthly ration, particularly since the cost of food was deducted from their wages (Polybius VI. 13.15). Perhaps the amounts given by Polybius represent a maximum allowance and/or the amount per head that the state allowed to the quartermaster, using it as a ‹rule of thumb› for provisioning the army.

[75] Presumably the *opilionus* in this context is a head shepherd in charge of flock management, not the man actually out with the sheep. Note too that the *vilica*, a woman, gets the same ration as the men.

[76] On the basis of data from Methana, Forbes, unpublished field notes. Cf., White, Roman Farming, pp. 238–239.

again, this must have been a daily ration, since it would have been too little for a week or a month. It seems that the chain gang got little apart from bread and wine, and they received a larger portion of wine than the regular farm labourers (de Agr. 57).

The flour content of the most basic bread is about ⅔–¾ of the weight of the loaf (see Appendix, p. 79). Four Roman pounds of bread contain 0.87–0.98 kg flour; five Roman pounds contain 1.09–1.23 kg flour (see Table 3). For a ‹very active› adult male the wheat flour in 4 Roman lb. of bread (assuming a nearly 100% extraction flour) would have provided basically all of the total daily calories required (98%); for an ‹exceptionally active› adult male it would have supplied 86% of the total requirement. During the vine digging, a period of especially heavy labour, their increased ration of 5 Roman lb. of bread would have supplied the total energy requirement of an ‹exceptionally active› adult male (107%). These levels of rationing sound very high, but the figures may be deceptive if taken at face value because these low status slaves seem to have been given little to eat except bread and wine.

On the whole, the Roman grain ration figures that exist for labourers and soldiers have energy values similar to the Greek ‹standard ration› which seems to have been used in similar circumstances. The day to day energy needs of workers and armies are variable as different jobs need to be done, and rations such as these adequately cover even the periods of highest activity. The similarity of the rations of the army and Cato's working slaves also suggests that the Romans may have used a basic ‹rule of thumb› for the estimation of projected consumption similar to that suggested for the Greeks. Possibly it too originated on farms and in households and at some stage made its way to state-level usage.

In contrast, the Roman *frumentationes*[78] of 5 *modii* per month are not in conformity with the rations given to soldiers or labourers. Instead, they parallel the grain handouts described in the Samian decree (see above, p. 59), although the quantity given out was larger in Samos. Normally, the *frumentationes* went to adult males, women were excluded except for widows; in other words, they were received by heads of households. The conclusions of RICKMAN and BRUNT that the amount of grain provided was enough partially to support a family (see note 78) is substantiated by our calculations of energy value: 5 modii of wheat per month would have supplied 24% of the estimated total household requirement.[79] It is, however, too much

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[77] Cf., the modern Messenian bread consumption of about 0.31 kg per day (ASCHENBRENNER, MME, p. 59) and the modern Methanites' consumption of about 0.57 kg per day (FORBES, unpublished field notes).

[78] For a full account of the evidence for the *frumentationes* and the details of distribution see, RICKMAN, The Corn Supply of Ancient Rome, Chapter VII, and BRUNT, Italian Manpower, p. 382.

[79] The hypothetical household that we have used (see p. 49) would, in fact, have been eligible for two rations under the *frumentationes* in some periods since it includes a male child over

to have been consumed by one person; even for an ‹exceptionally active› man this amount would have comprised 97% of total calories required, and for a man with more normal calorific needs it is ridiculously high. As with the Greek data, rations intended for family consumption are not easily identified as partaking of a unified standard.

IV. The Modern Greek Data

Information on modern Greek grain consumption is surprisingly difficult to come by since ethnographers have rarely studied diet in any detail. When such modern data are available, however, they prove to be most useful, since it is possible to get a much better overall picture of food habits than can be obtained for classical times. In Greece, most of the same cultigens that were important in antiquity are important at present (in spite of some relatively recent additions from America and the Far East[80]), and thus most of the important staple foods are the same as well. By looking at the diet of modern Greek farmers we can at least shed light on, if not provide final answers to, such problems as the role of grain in the ancient diet, the range of foods eaten, and the effects of social factors (status, income, age, sex, etc.) on individual diets. In this regard, the modern material may also serve as a warning, since it reveals how much detail is lacking from our knowledge of the many factors influencing ancient dietary patterns, and may thus counteract the tendency of the investigator to overgeneralise. Again, it must be stressed that the modern data do not allow us to reconstruct ‹ancient diets› with any degree of precision – there is simply not enough ancient data to do this. They are most useful as general indicators of the potential range of variables that need to be considered when studying even a single aspect of diet; and, they provide a good check on our assumptions about the eating habits of the past. In other words, they bring the picture more clearly into focus but do not restore all the missing pieces. For this paper, we have made use of three modern Greek studies, all centred on different areas and done at different times.

The earliest study used was made by ALLBAUGH in the vicinity of Khania, Crete in 1947–8.[81] In spite of its age, this work still provides the most detailed information available on diet in modern Greece; ALLBAUGH had a large team and nutrition was one of the major emphases of the study. The diets of both rural and town dwellers were analysed,[82] though the sample contained more rural families. One possible dif-

11 years (see n. 26): this would have provided 48% of their estimated total household calorie requirement.

[80] The major ones are, from America: potatoes, tomatoes, maize, some legume and curcurbit species (although the most important legumes are native); from the East: citrus fruits, rice, cotton (which provides an important seed oil).

[81] ALLBAUGH, Crete: A Case Study of an Underdeveloped Area (1953).

[82] There were no proper ‹urban› dwellers in this study owing to the small scale of ‹urban›

ficulty with using this material for comparison to ancient diets is that the disruptions of the war caused changes in food habits, and at that time some commodities were still rationed – thus less grain than normal may have been consumed.

ALLBAUGH described the Cretan diet as consisting generally of «olives, cereal grains, pulses, wild greens and herbs and fruit, together with limited quantities of goat meat and milk, game and fish»[83] (see Table 5). Cereals, even at this time, still made the largest contribution of any food to calorie intake, supplying on average 39% of total calories consumed (and 47% of total protein). The cereals in question were mainly wheat and barley and were generally eaten in the form of bread made with high extraction flour (85–100% extraction rate). In addition some commercial macaroni and a fair amount of home-made *chondros*[84] were also consumed, but very little rice was eaten due to its wartime scarcity. The only non-cereal commodity (also a non-traditional one) within the ‹starch niche› eaten in large quantities was potatoes, which provided on average 4% of all calories consumed and were eaten more among the rural than among the town families.[85]

Second in importance after cereals in the average calorie intake was olive oil, which provided about 29% of the total calories consumed. These two groups (cereals and oil) together provided ⅔ of the total calorie intake.[86] The Cretans, however, were said to eat a large amount of oil, even compared to the rest of Greece.[87]

The average per capita intake for this sample was found to be 2,554 calories per day (i. e., incorporating all sectors of the population). Predictably, because of higher activity levels, average energy intake was higher in rural areas than in towns: 2,565 cal. per day for the former, 2,549 cal. per day for the latter. Furthermore, in the rural sample income differences were shown to affect calorie intake: the highest income group consumed on average 3,065 cal. per day, the middle group 2,544 cal. per day, and the lowest group 2,393 cal. per day. The highest income group ate considerably more meat and dairy products and proportionally more of everything else than the two lower groups.[88] In general, ALLBAUGH found that these levels of calorie intake

areas, ALLBAUGH, Crete, p. 124. We have generally used the data referring to rural inhabitants for this study, assuming their diet to be more like that in antiquity.

83 ALLBAUGH, Crete, p. 99.

84 Cretan *chondros* (= *trachanas* in mainland Greece) is coarsely ground wheat boiled in either sweet or sour milk until all the milk is absorbed, and then left to dry in the sun. When dry it is broken up and stored. It keeps for quite a long time; we have stored it for as long as four years. *Chondros* or *trachanas* provides a means by which farmers can preserve surplus milk during the milking season. We suspect that this product is what is meant by *chondros* in ancient Greek contexts in at least some cases. A similar product called *kisk* or *kusuk* is made throughout the Middle East, FAO, Wheat in Human Nutrition, pp. 65–66.

85 ALLBAUGH, Crete, pp. 106–108.

86 ALLBAUGH, Crete, p. 131.

87 ALLBAUGH, Crete, pp. 100, 111.

88 ALLBAUGH, Crete, pp. 127–129.

were perfectly adequate for a highly active rural population, with no indications of malnutrition.[89] However, these figures represent only average consumption; the actual range of calorie intake was very wide.[90]

Another interesting feature in this study is that householders' estimates of their own consumption, especially for staples, were considerably higher than their actual recorded consumption. The average consumption of cereals was measured at 128 kg per person per year, but estimated at 166 kg by the subjects themselves.[91] Some of this difference may be attributable to expected losses in storage and processing, but the amount is too great to be accounted for by this factor alone. It is likely that the discrepancy arises because householders were purposely estimating generously to ensure that there would be enough.

The Minnesota Messenia Expedition, carried out in the mid-1960's, includes two studies which provide information on modern Greek diet and grain consumption: the study of the regional agricultural economy by VAN WERSCH, supplemented by ASCHENBRENNER's village ethnography.[92] Messenia is a particularly rich and productive area of Greece, and because of this the modern diet has certain non-traditional features. A considerable amount of the carbohydrates consumed come from potatoes, rice and commercial pasta.[93]

VAN WERSCH based his estimate of ancient (Bronze Age) per capita grain consumption upon the modern Messenian maximum wheat flour consumption rate of 200 kg per year, which divided by the extraction rate of 0.85 = 235 kg whole grain per person per year. The normal flour consumption rate is probably considerably lower than VAN WERSCH's maximum; in calculating ancient grain consumption he assumed that people ate more grain than at present. He also assumed a diet composed of 70% barley and 30% wheat and, allowing for the sectors of the population who would have eaten less than an adult male, arrived at a per capita estimate of 160 kg per person per year.[94] Although a considerable amount of barley was eaten in ancient Greece, we have no evidence from antiquity for what proportion of barley in relation to wheat was eaten. Even the classical grain distribution figures are in *either* barley meal *or* wheat. The amount of barley eaten probably varied immensely, both regionally and with class and income level. In spite of the methodological difficulties, VAN WERSCH's estimate of 160 kg is in accord with the modern consumption estimates. It is, however, much lower than the ancient grain distribution figures that we possess.

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[89] ALLBAUGH, Crete, pp. 118–120, 134.

[90] The range extended from 829 calories per day on average for the lowest 10% of consumption rates to 5,707 calories per day on average for the highest 10% of the intake range, ALLBAUGH, Crete, p. 507.

[91] ALLBAUGH, Crete, p. 107.

[92] McDONALD and RAPP, The Minnesota Messenia Expedition (1972).

[93] ASCHENBRENNER, MME, p. 59.

[94] VAN WERSCH, MME, p. 185.

The study on Methana, conducted by FORBES, 1972–1974, was concentrated on the traditional subsistence agriculture practised by the farmers living on the peninsula. The results are as yet unpublished. Some dietary information was collected, but not in the quantified detail found in ALLBAUGH's study.

In Methana the greater portion of carbohydrates, indeed of food, is provided by wheaten bread. Some *trachanas* (= Cretan *chondros,* see note 84) is also consumed. Pasta and rice are very rarely eaten, and potatoes are occasionally served in small amounts as a vegetable side dish. Besides bread, the basic diet consists mainly of olive oil, wine, and boiled weeds, supplemented by dried beans, vegetables and pickled olives. Meat and cheese are less frequently consumed, and even then are generally eaten only in small quantities. The diet is fairly similar to that which ALLBAUGH found in Crete.

The data from which the grain consumption figures of 150–200 kg per person per year (before milling) are derived come from household consumption estimates, and thus include elements of the population which eat less than adult males. These are, however, householders' own ‹rule of thumb› estimates. They are not based on measured consumption. It is interesting that the range incorporates ALLBAUGH's householders' estimate, but not his consumption measurement. It is quite likely that the amount of grain eaten on Methana is somewhat less than the amount ‹counted on›.[95]

The other major contributors of energy to the Methana diet are olive oil, as in Crete, and wine. The household ‹rule of thumb› for olive oil consumption is 50 kg per person per year (1 kg of olive oil is just over 1 litre). Relatively large amounts of pickled olives also seem to be eaten. Home-made *retsina* (ca. 12% ethanol content) is drunk at the rate of over 1 litre per day by adult males; considerably less is drunk by women. For a 65 kg adult male, this amount of wine would provide about 700 calories per day.

V. The Modern Data Applied to Ancient Grain Consumption

It is clear that all of the modern Greek ‹rule of thumb› grain consumption figures are considerably lower than the ancient ration figures available. Even if we use the modern maxima for comparison (since most of the ancient figures are for adult males) the modern rates of consumption do not even approach the ancient ‹rules of thumb› for rationing. The one notable exception is the administrators on Cato's estate. Although they were slaves themselves, they had high status positions among the rest of

[95] The amount of grain stored, however, is much more than the amount expected to be consumed. Generally farmers store all of the wheat that they harvest, and even if they eventually sell off some, they still keep two years' grain supply in reserve, if possible. To give some idea of the enormous quantities that may be stored, one household of two adults and a very small girl put away 2½ metric tonnes of wheat one year.

the slaves, and therefore may have received more of the more desirable foods such as oil and cheese, but less grain than the other slaves. Comparing the modern data to the ancient ‹family rations› is more difficult still, since we do not know how many the latter were supposed to feed or what level of support was intended. Also, the various ancient figures are not consistent enough to make wide ranging assumptions. The Samian decree is the only ‹family ration› which may intend a high level of support. Taking this as an example of the difficulties involved, if we divide the projected annual handout of 902 kg by 4 (the number of adult appetites in our hypothetical household), we get a per capita figure of about 225 kg per year, at the very top of the modern per capita range. If this were supplemented with grain from the citizens' own resources, the figure goes completely beyond the limits of modern consumption.

The most obvious explanation for the apparently very high grain consumption in antiquity is that grain made up a larger proportion of total calories consumed than it does at present. What has taken the place of large quantities of grain in the modern diet? The answer probably lies in increased olive oil consumption. The actual amount of olive oil consumed in antiquity is not known. In Plutarch's and Athenaeus' lists of the *syssitia* contributions oil is not included, and there is some indication, from its place in the more elegant *epaiklon* course of the meal, that the Spartans considered it something of a luxury. Cato's farm labourers were given only 1 sextarius of oil per month, just over half a litre (0.539 L = a weekly consumption rate of 0.1348 L), supplemented by quite large amounts of pickled olives which are high in oil (Cato, de Agr. 58). This is only about 1/7 the amount that the Methanites depend on, about 1 litre per week (0.959 kg).[96] The Cretans whom ALLBAUGH studied counted on about the same quantity as the Methanites (0.872 kg per week), but they actually consumed only just over ½ L per person per week (0.593 kg), though even this figure is high compared to Cato's slaves' rations.[97] Unfortunately, one cannot take Cato's slaves as typical ancient consumers of olive oil; it is likely that higher status groups would have eaten considerably more than they.

Because of the dearth of information it is not possible to quantify oil consumption in antiquity. The meagre evidence that does exist suggests that oil consumption was substantially lower and that the extra calories needed were obtained largely from grain. There are many likely reasons for postulating lower oil consumption. Olive oil is, and always has been, an expensive commodity. Modern varieties of olives are probably more productive than their ancient cousins, and modern presses are cer-

[96] We have found that the same ‹rule of thumb› for olive oil consumption was applied elsewhere in the Southern Argolid; 1980 fieldwork.

[97] The amounts counted on in both Methana and Crete also included oil not intended for alimentary use, i. e., for gifts, soap making, household lubricant and, in the case of the Cretans, lighting, see ALLBAUGH, Crete, p. 107. However, the same principle found with grain consumption estimates, of counting on an extremely generous expected consumption rate, may be in operation with olive oil as well.

tainly very superior to those in use in classical times and can extract considerably more oil from the fruit. Also, in addition to being used for food, olive oil was required for a number of domestic and industrial purposes in antiquity, many (though not all) of which are now served by oils from other sources, notably petroleum products. Certainly in modern worldwide dietary patterns, the consumption of fats and oils increases sharply as standard of living rises, while the consumption of ‹starchy staples› (including cereals) declines.[98] It is quite likely that this synchronic trend operated diachronically as well. It is normally assumed that there was a generally lower standard of living in antiquity than at present, and it is reasonable to expect that diet mirrored this difference in living standards. At present, however, it is not possible to define the reciprocal roles of grain and olive oil in the classical diet more specifically.

Another problem, that takes shape more clearly as a problem when we attempt to dovetail ancient and modern grain consumption data, is the application of average per capita grain consumption figures to ancient populations. This exercise has been popular among scholars from the time of Beloch and Boeckh in the late nineteenth century, and often, modern researchers are still working directly from their calculations. A specific example may illustrate the dangers that lie in wait for even the best of scholars attempting to use such figures without scrutinising the assumptions upon which they are based.

In an extremely informative and recent article on Roman imperial grain trade, G. E. Rickman has attempted to calculate the amount of grain consumed annually by the city of Rome.[99] Using Beloch's old average per capita grain consumption estimate of 3⅓ *modii* per month,[100] he has estimated the corn needs of Rome's population of one million at «more than a quarter of a million tons».[101] Using our figures for wheat weights applied to Rickman's data, this consumption estimate results in a figure of 269,768 metric tonnes of wheat per year needed to feed the city.

Now, it is notoriously difficult to calculate the size of an ancient urban population, but it is even more difficult to determine the demographic composition of an ancient city – and some knowledge of the latter is an essential (if often disregarded) prerequisite for the formulation of average per capita grain consumption estimates. For this reason we have generally avoided using them, in spite of their popularity with classical scholars. From the available data it is only possible to make a crude attempt at computing average per capita grain consumption for classical antiquity. However, a brief excursus is necessary in order to outline the two possible ways of

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[98] FAO, Energy and Protein Requirements, pp. 20–21.

[99] Rickman, The Grain Trade under the Roman Empire, Roman Seaborne Commerce, MAAR 36 (1980), pp. 261–275.

[100] Beloch, Bevölkerung, pp. 393–412; Rickman, Grain Trade, p. 263, note 21.

[101] Rickman, Grain Trade, p. 263.

approaching average per capita consumption in our data in order to make it comparable with RICKMAN's study. The results of both approaches are rather unsatisfactory because, as we have shown, the ancient grain distribution figures concern very specialised groups and are thus not easily applied to other sectors of the population.

Using as a rather shaky foundation the hypothetical household outlined on p. 49, we calculate the mean of their total calorific requirements (15,495 calories per day) at 2583 calories per person per day. If, as the ancient evidence seems to indicate, grain composed about 70–75% of the diet, then: 75% × 2583 = 1937 calories per day contributed by grain. If this were wheat, it would represent an average per capita consumption rate of 0.58 kg per person per day, that is, 212 kg per year.

However, this figure is probably very much too high for two reasons: 1) as has already been noted (n. 26), the FAO values for juvenile calorific intake are often considered excessively high, and 2) it is not possible to assume, as we have done for this computation, that this hypothetical household is representative of the ancient Roman population. For an accurate reflection of the structure of the Roman population it should probably have fewer adults and more children, resulting in lower average per capita consumption.[102]

It is also possible to work more directly from the ancient grain distribution figures.[103] If we were to take the Greek ‹standard ration› as equivalent to a maximum adult male consumption rate (see p. 55), we could calculate the grain requirements of the rest of our hypothetical household by looking at what percentage of the calorific requirement of the adult male each household member has, and assuming that he or she will consume this same percentage of the adult male grain allowance, as shown in the table below:

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[102] Like nearly all societies on the other side of the ‹demographic transition› from our own, ancient Rome had comparatively high fertility and mortality, resulting in a relatively high proportion of children, which lowers average per capita consumption figures since children eat less than adults. The hypothetical household detailed on p. 49 is thus certainly over-representative of adults for the ancient Roman population. In studies where similar attempts have been made to calculate average per capita grain consumption using as a basis hypothetical families of two adults and two children, the same problem exists, cf., JARDÉ, Céréales, pp. 133–135; CRAWFORD, Kerkeosiris, p. 129. Moreover, if such a household unit were normal in a pre-‹demographic transition› society, that population would be in steady decline, so it is therefore, demographically, a very unrealistic model, see P. HAGGETT, Geography: A Modern Synthesis, 3rd ed. (1979), pp. 157–160.

[103] An approach similar to that of BELOCH and JARDÉ, but keeping in mind that these data represent distribution, not consumption.

household member	calorie requirement	% of adult male requirement	maximum wheat consumption, kg per year
adult male, 20–39	3337	100	306
adult female, 60–69	1947	58	177
adult female, 20–39	2434	73	223
male child, 13–15	3237	97	297
female child, 10–12	2350	70	214
child, 7–9	2190	66	202
		total	1419
		mean	237

If we calculate the mean of these hypothetical grain consumption rates, we arrive at an average per capita consumption rate of 237 kg wheat per year, or 2169 calories per day provided by wheat. This estimate, however, is even less reliable than the first, partly because it is subject to the same inherent demographic error (see p. 70), but also because it is based on a figure for grain distribution, not actual consumption. Therefore, we strongly feel that this estimate must be viewed only as a maximum.

To return to RICKMAN's figures on the feeding of Rome, assuming as he does, a population of 1 million, but using our average per capita grain consumption estimates, we arrive at a figure for the grain needs of Rome of 212,000 metric tonnes per year by the lower, somewhat more realistic, per capita consumption estimate, and 237,000 metric tonnes by the higher (maximum) estimate. As we have already stressed, the average per capita grain consumption estimates are most likely both too high. Thus, the figure of 269,768 metric tonnes which results from the use of RICKMAN's consumption estimate represents an over-estimate of grain needed by Rome of at least 57,768 metric tonnes (or about 27%), compared to our lower figure. Considering that such large numbers are involved, this is not a vast discrepancy, but 27% is certainly a high potential statistical error; and, especially since our figure (212,000 m. t.) is also certainly too high, the actual percentage of error must be even greater. If we were to attempt to use average per capita estimates of consumption such as these for drawing conclusions about, for example, trade or shipping, an error of this magnitude could prove extremely misleading.[104]

VI. Conclusions

This study has not produced hard and fast answers to the many questions that exist about ancient grain consumption. It has, however, achieved some significant results

[104] More modestly, calculations of this sort also show what vast differences can occur in final figures when even only slightly differing starting figures are used – another cautionary tale.

which we shall summarise here, concluding with a note on the use of grain distribution data by the ancient historian.

Because flour weighs less than whole grain per unit of volume, care is necessary in comparing volumes of flour/meal and whole grain, or comparing volume and weight measurements. Among the Greeks, an allowance of 1 *choenix* of wheat (0.839 kg) per man per day seems to have been considered ‹standard›, especially for armies, but it is not clear at present how widespread the actual use of the ‹standard› ration was. That some standard was in general operation may also be indicated by the fact that in the manumission from Delphi, the grain that the freed slave was supposed to give to his ex-mistress (0.412 kg per day, a smaller quantity than the 1 *choenix* standard), would have supplied a similar percentage of the calorie requirements of an elderly woman as the above ration would have supplied for an adult man. In the Roman data, the basic rations of the army (0.895 kg wheat per man per day) and of Cato's slaves (ca. 0.929 kg wheat per man per day) are both very close to the Greek ration of 1 *choenix* of wheat, indicating that perhaps a similar internal standard was in operation.

If one examines the calorific values of the Greek and Roman ‹standard allowances›, one finds that they provided a generous supply of energy for an adult male operating at a very high level of activity. The allowance is excessive, however, for an adult male working at a lower activity level and, consequently, too large for any sector of the population needing less food than active adult males. A provision of this size insured that any group to whom it was given would have had enough food at the worst times and in the most difficult circumstances, even if they would have had more than enough at the best times and in the easiest circumstances. This amount also would have allowed for any wastage losses that might have occurred in storage and preparation.

The Greek and Roman ‹standard› rations were not minimum consumption allowances as many scholars have suggested. They were, in fact, distribution allowances, and almost maxima at that. This is a very important distinction, for what a man is given as an allowance may not be what he actually eats; i. e., rations cannot be considered identical with consumption. Along the same lines, a number of the ancient rations documented are so large that they cannot be considered to have been the grain allowance for (or worse, the grain consumed by) one man alone, but must have been intended to feed, at least in part, a household. It is noteworthy, too, that a higher status did not always carry higher grain rations with it. In the Malla inscription (see note 35) status differences between troops and officers were expressed in differential cash wages, and all the men were given the same grain rations. Also, among Cato's slaves, the higher status slaves actually received less grain than the lower status ones, although the former may have received larger quantities of more desirable foods (wine, oil, dairy products, etc.).

The modern Greek consumption data, particularly those presented in ALLBAUGH's study of Crete and FORBES' study of Methana also seem to indicate that the expected rate of consumption is higher than the actual rate of consumption. A generous sufficiency, similar to that of the ancient (expected) consumption rates is counted on to cover the times when most energy is needed, as well as storage and preparation losses. However, the proportion of grain in the modern Greek diet is substantially lower than in antiquity, probably because more olive oil is eaten at present.

The ancient expected rate of consumption for adult males, high though it seems to be, should not be confused with storage allowances, which may have been considerably higher. In other words, though a farmer may have stored his grain using 1 *choenix* of wheat per person per day as a ‹rule of thumb› to calculate what he anticipated his family would eat, he may also have stored far more grain than the amount needed for one year's consumption at that rate if he were able to do so. At least in modern Methana, storage strategies seem to be based more on maximum expected production than on maximum expected consumption.[105]

Since the ancient evidence on grain consumption is very scanty – and the situation is far worse for other food items – it is difficult to hazard a guess as to what proportion of the total calories consumed were provided by cereals. If pressed, given the presently available evidence, we would suggest that grain contributed about 70–75% of the calories in the ‹average classical diet›. The Greek and Roman ‹standard› allowances provided about (or just over) this percentage range of the calorie requirement of an ‹exceptionally active› adult male. Also, this percentage range is close to the present day global maximum for grain consumption, even where grain is a very large proportion of the diet (see p. 56). It does not seem likely that the proportion of grain in the ancient Greek or Roman diet would normally have been higher than 70–75%, except in the cases of very low status (or unusual) groups, e.g., chained slaves. It is probable that most people had sufficient resources to be able to eat some foods other than cereals, and it is very likely that they welcomed some variety in an otherwise bland, grain-based diet.[106] Indeed, for some, gathered or grown food supplements may have helped to eke out a limited supply of grain; foods such as: wild greens (e.g., mustard, dandelion, amaranthus, black nightshade, etc.),[107] mushrooms, bulbs,[108] pickled olives, dried figs, and assorted vegetables. Certainly Plato considered gathered foods to be standard fare among poorer country folk: «both bulbs and greens they will boil, the kind that are (eaten) boiled in the

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[105] Forbes, Ethnoarchaeology: A Case Study, unpublished paper.

[106] Certainly in Methana today strongly flavoured foods such as very bitter greens and bulbs, pickled olives and garlic are considered very desirable as something to enliven the normal staple fare of bread and oil.

[107] See note 10.

[108] For example, grape hyacinth bulbs, which are a very popular spring vegetable in Greece today.

countryside».[109] And, as has already been noted, both olive oil and wine are high in calories, so that even if consumed in smaller amounts than at present,[110] they would still have made significant contributions of calories. Since we know that a variety of foods other than cereals was eaten in antiquity, even by relatively poor people, it does not seem unreasonable to suggest that the non-cereal component in the diet might ‹normally› have supplied around 25–30% of the energy. However, there are many variables for which we cannot presently account; and the amount of grain consumed certainly varied with such factors as age, sex and income.

The incomplete ancient historical evidence for grain consumption clearly cannot provide us with detailed consumption rates for all socio-economic sectors of the Greek and Roman population, or for all periods, areas and environments, for as we have seen, the ancient sources tell us about the grain consumption patterns of a few, special, restricted groups. And, it is clear from even the single example we have analysed – RICKMAN's use of BELOCH's average per capita consumption figure – that it is very difficult to extract more generally applicable paradigms from the ancient data alone. Here the modern Greek comparative material is most enlightening, for it provides information on the possible range of diversity and the most important variables relating to grain consumption in a broadly similar economic and environmental context. Here we have tried to explain what the few ration figures that we have for the ancient classical world mean in terms of consumption, and whose diet they really represent.

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 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.

APPENDIX:
Experiments in the Processing of Wheat and Barley (L. F.)

In 1979 and 1980 I carried out a series of experiments processing wheat and barley by means of primitive techniques. I weighed known volumes of both naked wheat

[109] Plato, Republic, II. 372c: καὶ βολβοὺς καὶ λάγχανά γε, οἷα δὴ ἐν ἀγροῖς ἑψήματα, ἑψήσονται. Cf. note 10.

[110] Wine in classical antiquity was, of course, diluted with water when served.

and hulled barley samples and ground the wheat on a saddle quern. The particular quern I used was from the aceramic Neolithic levels at Jericho and is presently in the collection of the School of Archaeology, University of Liverpool. The barley I ground on a large sandstone block with a wooden pestle. My results are summarised below.

sample description	volume	net weight
English, organically grown, autumn-sown wheat, *Triticum vulgare*, commercial quality, very clean.	1 L	782.2 g
English, autumn-sown, two rowed, hulled barley, *Hordeum distichon var. trifurcatum*, fodder quality, reaped by combine harvester, not cleaned, numerous hull and rachis fragments included. Grown near Scorriton (near Newton Abbot), S. Devon.	1 L	587.0 g

milling results	weight	volume
wheat		
before grinding	270 g	0.345 L
after grinding	255.65 g	0.5 L
extraction rate = 94.6%		
barley		
before grinding	c. 75 g	0.1 L
after grinding	c. 75 g	0.15 L
after winnowing and sifting	c. 45 g	0.07 L
extraction rate = 60%		

comparative weights of flour and grain	volume	weight
wheat		
whole grain	0.5 L	391.1 g
flour	0.5 L	255.65 g
255.65 g (flour weight) = 65.4% of 391.1 g (wheat weight)		
barley		
whole, hulled grain	0.5 L	375 g
flour, after grinding	0.5 L	250 g
flour, after winnowing and sifting	0.5 L	321.43 g
250 g (unsifted flour) = 66.6% of 375 g (whole grain)		
321.43 g (sifted flour) = 85.7% of 375 g (whole grain)		

Barley was eaten in Greece in considerable amounts until quite recently.[111] Although naked (free-threshing) forms of barley are documented in ancient contexts,[112] and despite the fact that naked barley is easier to process domestically than hulled, among the examples of classical grain handouts that we possess, barley was always given out in the form of *alphita,* a ground product, not in the form of whole grain as with wheat. This suggests that hulled barley was in general use and that it had been processed to remove the inedible hulls (lemma and palea) before distribution. Coarse barley flour, without the hulls, weighs less per unit of volume than does whole, hulled barley.

It was only after a number of disastrous experiments that I found a way to remove the hulls from barley. First I tried pounding and grinding both roasted and unroasted barley on a stone saddle quern, in a stone mortar with a stone pestle, and in a ceramic mortar with a ceramic pestle. In all cases the grain was broken and the hulls were either not sufficiently removed or were pulverised. I found it impossible to sift out hull fragments without losing a considerable quantity of the endosperm that stuck to it. Finally I discovered that if unroasted barley was first pounded, then rubbed (more or less in one operation) on a stone surface, but with a wooden pestle (weight ca. 280 g), the hulls came off mostly unpulverised with a minimum of endosperm sticking to hull fragments. The end product was a coarse barley flour containing large lemma and palea fragments, which could then be removed by winnowing and sifting.

Similarly, Harlan has reported successful results in removing the hulls from wild einkorn using a large wooden mortar and pestle.[113] He found that the hulls could be more easily detached from roasted than from unroasted cereal, but that the roasted grains fragmented more easily.

Another possible method of processing hulled cereal (often used for removing the hulls from rice) is to soak it, steam or boil it, and then dry it in the sun. This process is similar to the way in which bulgur is made. Apparently, after drying, the hulls can be fairly easily removed and winnowed out.[114] I have not tried this, however, with barley; and at present in the Near East bulgur is made with naked wheat. More experimentation with various methods of processing hulled barley is clearly very necessary.

For the calculations in this study I have used my measurement of hand-ground barley meal (0.643 kg per L), because the ancient figures are for *alphita,* not whole grain. There are, however, some severe difficulties involved, and I am not fully con-

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[111] Allbaugh, Crete, p. 106. I was told by informants in the southern Argolid (1980) that well within living memory certain types of biscuits (κουλουράκια) were made entirely with barley flour, and that for bread, barley flour was often mixed with wheat flour.

[112] Renfrew, Palaeoethnobotany, pp. 70–71.

[113] Harlan, A Wild Wheat Harvest in Turkey, Archaeology 20 (1967), pp. 199–200.

[114] FAO, Wheat in Human Nutrition, p. 65.

vinced of the validity of this figure. 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 in antiquity.[115] 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: The FAO Food Composition Tables for International Use[116] assume a normal extraction rate for hulled barley of 60–70% for the purpose of computing calorific values; and the extraction rate of my sample of coarse barley flour fell at the bottom of this range, at 60%. 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.

Moreover, the weight per unit of volume of a ground product and its relationship to the original volume of grain is very difficult to measure for two reasons: 1) a given volume of grain increases in volume when it is ground into flour, and 2) a given weight of flour varies in volume depending upon how much it is tamped down. In the tables on p.76 it is shown that after grinding, the volume of the barley flour was 50% more than the volume of whole grain, though the weight remained constant. Even after sifting and winnowing, the volume of flour was still 70% of the original volume of grain, although the weight was only 60% of the original weight. The flour volumes here are as close as possible to the middle of the range of possibilities, i.e., if the flour had been stirred the volume would have been greater; if the flour had been thoroughly tamped down the volume would have been smaller. It is unlikely that the ancient distributors of *alphita* would have tamped down the flour to its minimum volume, thus giving the recipients considerably more than if they filled containers without tamping.[117] However, the potential variation of flour volume makes it difficult to ascertain the weight normally contained per volumetric unit.

It is obvious, too, that more work needs to be done on the volume increase that takes place when grain is ground into flour, since the meagre results from these experiments are not sufficient even to make accurate general statements, let alone draw wider-reaching conclusions. Nor do I know for certain why a volume increase occurs. Since this phenomenon is not a problem relevant to modern milling, which operates only in units of weight, I have not yet found it mentioned in works on modern grain processing. Among ancient historians, only Moritz[118] has noted that flour weighs less per unit of volume than whole grain, and he was working with extraction

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[115] Modern authorities who claim that they do know, mostly on the basis of Pliny, NH XVIII. 72ff., have never tried it!

[116] FAO, Food Composition Tables for International Use, Table 2, item 16.

[117] Cf., Moritz, Grain Mills and Flour, pp. 185–6.

[118] Moritz also found, partly as a result of his own experiments with a Romano-British rotary quern, that a given volume of flour weighed less than the same volume of wheat, Grain Mills and Flour, p. 187: «a given volume of flour nowadays weighs approximately ⅔ of the weight of the same volume of wheat». My results were similar, see the tables on p. 76.

rates, not grain consumption. Because my samples were small and only one set of experiments was performed, the results are of limited statistical value. Many more experiments on larger samples are needed before we have truly credible results.

Because some of the ancient ration figures are for bread, I also found it necessary to experiment with bread to determine bread weight/flour weight proportions. Pliny (NH XVIII. 87) claims that it is a *lex certa naturae* that army bread *(panis militarius)* – presumably a very basic recipe of high extraction wheat flour, salt, water and perhaps leavening – weighs ⅓ more than the grain that goes into it, i.e., the weight of the flour is 75% of the weight of the loaf. In modern commercial bread in the U.K., the flour makes up about 60–65% of the weight.[119] In my experiment using commercial 100% whole wheat flour (probably Canadian or American wheat in origin) with the addition of a few grammes of salt and leavening and the minimum amount of water necessary, the flour made up ⅔ (66.6%) of the weight of the bread. It made no difference to the flour: bread weight ratio how the bread was baked: one lot I baked as an ordinary loaf in a oven; another lot I baked as flat ‹pita› bread. Flat bread is made by rolling the risen dough into circles about .5 cm thick and 15–20 cm in diameter. It is cooked on a very hot griddle for about 30 seconds on each side and then flung directly onto an open flame, whereupon it instantly and dramatically inflates with steam into a spherical ‹balloon›. The resulting bread has a pocket inside. This is not the only method of producing flat bread; many different techniques are used, the essential factors being a short baking time and very high heat.

The main reason for differences in the flour: bread weight proportions of Pliny's army bread, modern English commercial bread and my wholemeal bread is that different strengths of flour were used in each case. The stronger the flour, the more moisture it can absorb, and thus the greater the weight of bread a given weight of flour will make.[120] Strong flours are high in gluten, and thus normally high in protein, since gluten is a general term covering the complex protein mixtures, insoluble in water, that make up about 85% of wheat protein.[121] In general, strong flours are made from harder wheats, while weak flours are made from softer wheats.[122] The flour in Pliny's *panis militarius* was weaker than the flour that I used, and did not absorb as much water in bread making.[123] Thus, the weight of the flour was a larger

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[119] FAO, Wheat in Human Nutrition, p. 62; Davidson and Passmore, Human Nutrition and Dietetics, 7th ed., p. 171.

[120] FAO, Wheat in Human Nutrition, p. 57. For a good illustration of the difference in the rising capabilities of strong and weak flour, see Renfrew, Palaeoethnobotany, pl. 14, where loaves made of equal quantities of strong and weak flours are shown. The moisture absorbtion capacity may also be affected by the amount of bran in the flour.

[121] FAO, Wheat in Human Nutrition, p. 26; and cf. Table 2.

[122] FAO, Wheat in Human Nutrition, p. 42.

[123] This, incidentally, brings into question Jasny's conclusion (formed mostly on literary evidence) that the normal wheat grown in classical antiquity was a durum variety, The Wheats of Classical Antiquity, pp. 53 ff.; cf., Moritz, Grain Mills, pp. xxiii-xxiv. Durum is a very hard

proportion of the weight of the finished loaf. This is not surprising, since generally winter sown wheat is softer than spring sown wheat.[124] My flour was probably American or Canadian spring sown hard wheat, and the Mediterranean wheat from which Pliny's bread was made was almost certainly a softer winter sown variety. In this study, when calculating weights of flour from weights of bread I have used Pliny's figure: that is, the weight of flour = 75% of the weight of bread, assuming that in classical antiquity slightly softer, weaker flours than those made from the American and Canadian wheat varieties we use today were in fairly general use.

The calorific value of basic bread comes from the flour it contains. Flour *does not* lose calories or any significant amount of other nutritive elements when it is made into bread.[125] I stress this here in order to correct a misunderstanding on the part of D. W. ENGELS in his otherwise excellent study of the logistics of the Macedonian army.[126] When calculating the daily rations needed by a Macedonian soldier he thought that (1) «many calories are lost in the production of bread» and (2) a given weight of grain produces a lower weight of bread: «so that 3.5 lb of bread, manufactured from 3.9 lb of grain, would have to be consumed to obtain 3600 digestable calories».[127] In fact, as we have seen, it is necessary to add considerable amounts of water to flour in order to make it into bread, so that the bread weighs more than the flour or grain (in the case of high extraction flour) that it was made from. Essentially, the calories in the flour are ‹diluted› when water is added and it is made into bread (see n. 125).[128] Thus, ENGELS' 3.9 lb of grain, assuming a high extraction flour, would actually make 5.2–5.9 lb of bread, depending on the strength of the flour. This amount would have an energy value of about 28,657 calories!

The daily per capita ration that ENGELS considers necessary for the Macedonian army was 3 lb of bread. This could have been made (using Pliny's flour: bread proportion) from 2.25 kg wheat, and would have provided, by my calculations, an exceedingly generous allowance of 3416 calories per man per day.[129]

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wheat producing a very strong flour. Had Pliny been thinking of durum wheat, his *panis militarius* should have had a lower proportion of flour than my bread. Also, contra MORITZ, Grain Mills, p. xxv, granular durum flour makes excellent bread, and at least in the S. Argolid and Methana is preferred for making bread to proper bread wheats.

[124] FAO, Wheat in Human Nutrition, pp. 41–42.

[125] FAO, Wheat in Human Nutrition, pp. 34–35, 62; DAVIDSON and PASSMORE, Human Nutrition and Dietetics, 7th ed., p. 171.

[126] ENGELS, D. W., Alexander the Great and the Logistics of the Macedonian Army, 1978.

[127] ENGELS, Alexander, p. 124.

[128] In the case of porridge, which ENGELS thinks ‹loses› even more calories than bread (Alexander, p. 124), more water is added than in breadmaking, and the calories in the grain are subsequently further diluted.

[129] This is just under the total calorific requirement of an ‹extremely active› adult male (3822 calories per day). I would consider this estimate of rationing rates too high.

Furthermore, it seems for several reasons that the Macedonian army was more likely to have carried whole grain rather than bread or flour. First, whole grain keeps better under difficult storage conditions, with less staling, deterioration in quality, or infestation by insects or micro-organisms, than either bread or flour.[130] Second, for an army on the march, the weight of supplies is an important consideration. If they carried their staple food in the form of whole grain rather than bread, they would only have to move ⅔–¾ as much weight as if they carried bread. Third, grain probably took up less space than either bread or flour.

Soldiers given whole grain could easily have made leavened or unleavened flat bread in small groups (or individually) quite speedily with very little equipment. Grain could have been ground on ‹portable› saddle querns[131] and flat bread baked over an open fire on hot rocks (often used for flatbread today)[132] or on ceramic or metal griddles.[133] In my experience, unleavened flatbread, made the same way I have described for leavened flatbread, takes about 45 minutes (minimum time) to mix, ‹prove›, and bake. Leavened flatbread takes longer, about 2 hours (depending on the temperature), to mix, ‹prove›, and bake. I cannot estimate the amount of time that grinding would have taken. Although it is a tedious and fairly time consuming process, continual practice would have given an expertise that I can in no way approximate.

The experiments I have done so far have indeed been helpful in the interpretation of ancient grain processing practices. However, it is abundantly clear that more work of this kind, hopefully producing a series of consistent results, will considerably enhance the precision of studies such as this one. These experiments have at least shown that it is not enough merely to postulate the way in which a commodity might behave under primitive processing conditions and techniques, and that to study ancient cereal products it is necessary to have some basis in practical experience.

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[130] FAO, Wheat in Human Nutrition, pp. 34, 92.

[131] Like the relatively lightweight χειρόμυλαι described by Xenophon as suitable for use by armies, Cyropaed. VI. 2.31, and analogous to the small rotary querns carried by Roman soldiers, see Moritz, Grain Mills, pp. 17, 104.

[132] FAO, Wheat in Human Nutrition, p. 60.

[133] Griddles such as the pottery ones found in the Athenian Agora (often identified as ‹corn parchers›) would work admirably for flatbread, see Sparkes and Talcott, Athenian Agora XII, pp. 228–9, pl. 96 (nos. 1983, 1988, 1987). Cf., the similar griddles from Corinth dating to the reign of Tiberius, Wright, Hesperia 49 (1980), p. 155, pl. 31, no. 77, cf., p. 170.

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TABLE 1:

Ancient Measures and Their Modern Equivalents

Ancient units		*modern equivalents*
	GREEK	
	dry volume	
4 *kotylae* = 1 *choenix*		1 Greek *choenix* = 1 Litre
48 *choenikes* = 1 *medimnos*		1 Attic *choenix* = 1.087 L
1 *hekteus* = 1/6 *medimnos* = 8 *choenikes*		
1 *hemihekteus* = 1/12 *medimnos* = 4 *choenikes*		
	liquid volume	
12 *kotylae* = 1 *chous*		1 *kotylae* = 0.25–0.27 Litre
	weight	
		1 Aeginetan *mina* = 602.6 grammes
	ROMAN	
	dry volume	
16 *sextarii* = 1 *modius*		1 *sextarius* = 0.539 Litre*
		1 *modius* = 8.62 L*
	liquid volume	
6 *sextarii* = 1 *congius*		1 *sextarius* = 0.546 Litre
8 *congii* = 1 *amphora* (quadrantal)		
	weight	
		1 Roman pound = 327.45 grammes

* See, DUNCAN-JONES, ZPE 21 (1976), pp. 51–52.

TABLE 2:

Calorie and Nutrient Content of Wheat and Barley, per 100g.

		grammes				milligrammes				
	calories	water	protein (N × 5.83)	fat	total carbohydrate (including fibre)	calcium	iron	thiamine	riboflavin	nicotinic acid
hard wheat	332	12	13.8	2.0	70	37	4.1	0.45	0.13	5.4
soft wheat	334	12	10.5	1.9	74	35	3.9	0.38	0.08	4.3
barley	332	12	11.0	1.8	73	33	3.6	0.46	0.12	5.5

source: FAO, Wheat in Human Nutrition, p. 18.

TABLE 3:

Ancient Grain Distribution and Modern Grain Consumption

source	description of recipient	ancient measure	volume (litres)	weight (kg)
Greek ‹standard› rations	adult male	1 *choenix* per man per day (Attic)	1.087	0.839
Rations of Spartans at Sphacteria (Thucyd. IV. 16.1)	adult male	2 *choenikes alphita* per man per day (Attic)	2.174	1.4
Mykonos cook (SIG³ 1024,14) Spartan Kings (Htd. VI. 57.3)	adult male	2 *choenikes alphita* per man per day	2	1.286
Delian stonemasons (IG XI. 158,37 ff.)	adult male (+ family or assistant?)	1½ *choenikes* wheat per man per day (Attic), or	1.6	1.26
		3 *choenikes alphita*	3.3	2.1
Spartan *syssitia* contribution (Plut., Lycurg. 12.2)	adult male	1 *medimnos alphita* per man per month	48	30.9
Samian rations (SIG³ 976)	adult male + household (?)	2 *metra* (= *medimnos*?) per month *sitos* (= wheat)	96	74.112
Freedman's support of his ex-mistress, Delphi (Collitz and Bechtel 1884)	elderly female	4 *hemihekteis* wheat per month	16	12.352
Donation of Epamonidas, Akraephia (IG VII. 2712)	adult male	1 Boiotian *kophinon* (= 9 Attic *choenikes*)	9.783	7.55
Athenian prisoners at Syracusae (Thucyd. VII. 87.2)	adult male	½ *choenix sitos* per man per day	0.5	0.386
Soldiers blockaded by Cassander in Pydna (Diod. Sic. XIX. 49.2)	adult male	5 *choenikes* per month	5	3.86
Rations of Spartan slaves at Sphacteria (Thucyd. IV. 16.1)	adult male	1 *choenix alphita* per man per day	1.087	0.698
Rations of Roman and allied infantry (Polyb. VI. 39.13)	adult male	⅔ Attic *medimnos* wheat per man per month	34.784	26.9
Rations of Roman cavalry (Polyb. VI. 39.13)	adult male	(7 Attic *medimnoi* barley)*, 2 *medimnoi* wheat per man per month	104.35	80.559

weight per person per year	calories per day	% calorie requirement ‹very active› adult male (3337)	% calorie requirement ‹exceptionally active› adult male (3822)	% calorie requirement ‹moderately active› adult male (2852)	% calorie requirement total household (15495)	other comments
306	2803	84	73	98	–	
510	4641	139	121	163	30	
469	4270	127	111	149	28	
459	4204	126	110	147	31	% of cal. req. adult man + adult woman (5771) = 73
765	6961	209	182	244	45	% cal. req. man + woman = 121
376	3416	102	89	120	–	
902	8251	247	216	–	53	
150	1375	–	–	–	–	% cal. req., 52 kg, age 60–9: ‹very active› (1947) = 71 ‹mod. active› (1664) = 83
–	–	–	–	–	–	calorific value: 25225
141	1289	39	34	45	–	
47	430	13	11	15	–	
255	2320	70	61	81	–	
327	2990	90	78	105	–	
980	8969	269	235	314	–	

source	description of recipient	ancient measure	volume (litres)	weight (kg)
Rations of allied cavalry (Polyb. VI. 39.13)	adult male	(5 Attic *medimnoi* barley)*, 1⅓ *medimnoi* wheat per man per month	69.57	53.7
Cato's slaves: workers, winter (de Agr. 56)	adult male (?)	4 *modii* wheat per man per month	34.48	26.619
Cato's slaves: workers, summer (de Agr. 56)	adult male (?)	4½ *modii* wheat per man per month	38.79	29.945
Cato's slaves: administrators (de Agr. 56)	adult male and female	3 *modii* wheat per man per month	25.86	19.964
Cato's slaves: chain gang, normally (de Agr. 56)	adult male	4 Roman pounds bread per man per day	–	1.3098
Cato's slaves: chain gang, vine digging (de Agr. 56)	adult male	5 Roman pounds bread per man per day	–	1.63725
Roman *frumentationes* (also, OGIS II. 533, Ancyra)	household	5 *modii* wheat (per man) per month	43.1	33.273
Crete, 1947–8 (Allbaugh)	average per capita	–	–	–
Messenia, mid-1960's Van Wersch	present upper limit wheat consumption	–	–	–
	estimated average per capita consumption (70% wheat, 30% barley) for antiquity	–	–	–
Methana 1972–4 Forbes	average per capita (householders' rule of thumb)	–	–	–

* The barley here has not been included in the following computations since it was probably not for human consumption.

weight per person per year	calories per day	% calorie requirement ‹very active› adult male (3337)	% calorie requirement ‹exceptionally active› adult male (3822)	% calorie requirement ‹moderately active› adult male (2852)	% calorie requirement total household (15495)	other comments
653	5979	179	156	210	–	
319 } 339	2964	89	78	104	–	
359	3334	100	87	117	–	
240	2223	67	58	78	–	
359	3281	98	86	115	–	
448	4101	123	107	–	–	
399	3704	111	97	130	24	
128 (166)**	1171 (1519)**	--	–	–	–	actual p. c. cal. consumed = 2554 actual % of diet grain = 39
235	2150	64	56	75	–	
160	1464	44	38	51	–	
150–200 (wheat)	1373–1830	52***	46***	–	–	

** Householders' estimates.
*** Based on a 65 kg adult with an energy requirement of 3500 and 4000 calories per day respectively.

TABLE 4:

Monthly Grain Prices from the Delian Account for 282 B. C. (IG XI. 158.37ff.).

modern month	*Delian month*	*grain*	*price per medimnos*
Jan.–Feb.	Lenaion	wheat	7 dr.
Feb.–March	Hieron	wheat	6 dr., 3 ob.
March–April	Galaxion	wheat	6 dr., 1 ob.
April–May	Artemesion	wheat	4 dr., 1 ob.
May–June	Thargelion	wheat	6 dr., 5 ob.
Aug.–Sept.	Metageitnion	wheat	7 dr.
Sept.–Oct.	Bouphonion	wheat	10 dr.
Oct.–Nov.	Apatourion	*alphita*	4 dr.
Nov.–Dec.	Aresion	*alphita*	5 dr.
Dec.–Jan.	Poseidonion	*alphita*	5 dr.

TABLE 5:

Measured Food Consumption and the Contribution of Various Foods to the Diet (Based on the Diets of 128 Families, 1 Week, Fall Season), Crete, 1948.

	Quantity per person per week (pounds)	Contribution of food groups to selected nutrients (%)									
		Energy	Protein	Fat	Calcium	Iron	Vit. A	Thiamin	Riboflavin	Niacin	Ascorbic acid
Cereals	5.4	39	47	5	17	41	*	54	35	56	–
Potatoes	2.5	4	4	*	3	5	1	10	7	8	18
Pulses & nuts	.8	7	17	2	14	22	*	17	11	5	1
Milk & cheese[a]	.7	3	5	5	27	2	4	1	10	7	*
Meat, fish, eggs	1.2	4	19	6	13	11	13	5	14	10	1
Oils & fats	1.3	29	*	79	*	*	2	–	–	–	–
Fruits & olives	4.2	8	3	3	9	11	6	5	8	5	9
Tomatoes & citrus fruits	1.8	1	2	*	2	2	36	3	5	4	33
Vegetables	2.3	2	3	*	15	6	38	5	10	5	38
Sugar	.2	2	*	*	*	–	*	–	–	*	*
Bev.-except milk	.4	1	–	–	–	–	–	–	–	–	–
Total	20.8	100	100	100	100	100	100	100	100	100	100

* Less than 0.5 per cent.

[a] Milk equivalent figure upon which percentage figures are computed is 17 ounces. Source: Sample Survey of Crete, Form I a, Seven-Day Diet.

source: ALLBAUGH, Crete, Table A49, p. 506.