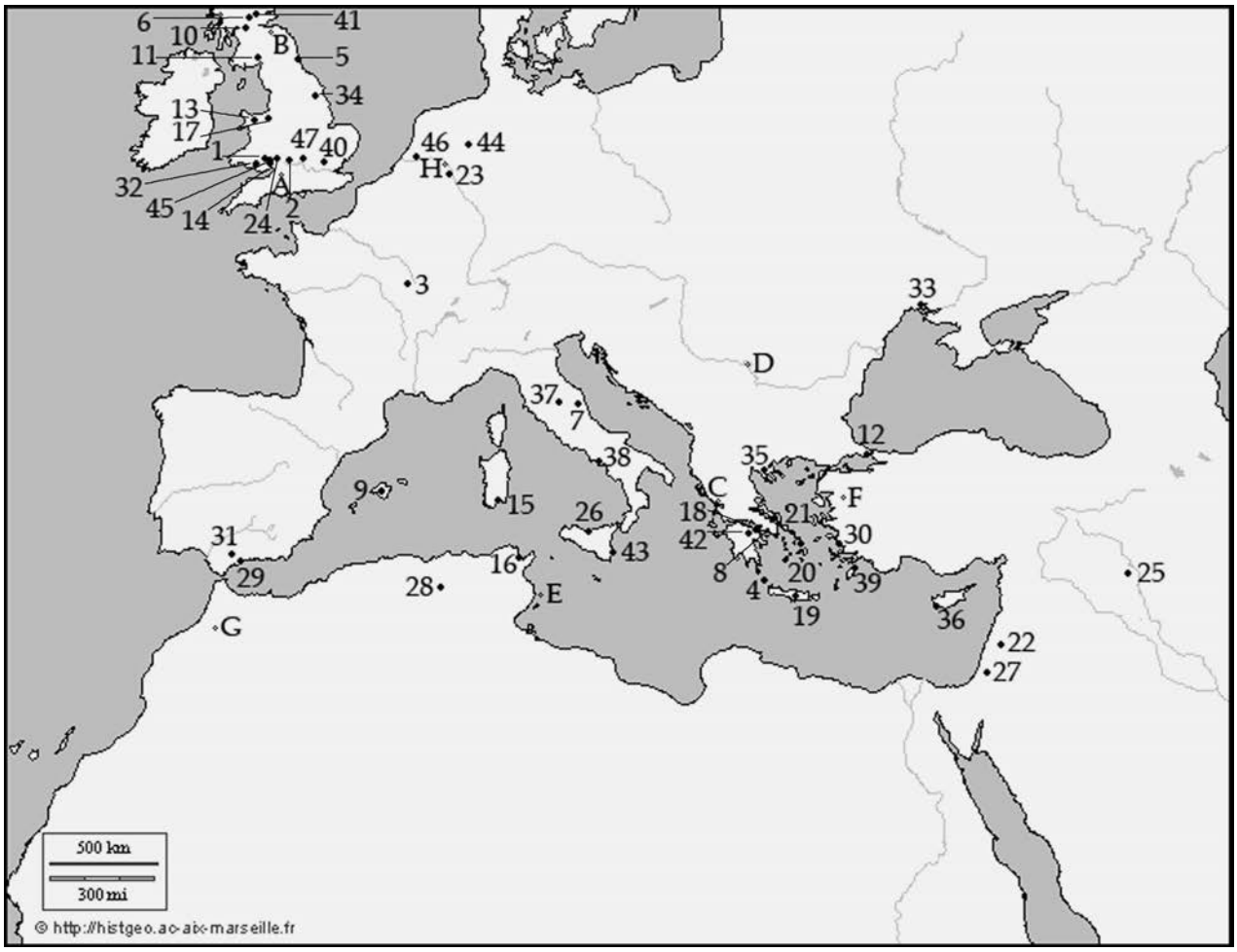

Map. Findspots of shot mentioned in this article.

1. Abergavenny (Wales)
2. Alchester (England)
3. Alesia (France)
4. Antikythera (Greece)
5. Arbeia (England)
6. Ardoch (Scotland)
7. Asculum (Italy)
8. Athens (Greece)
9. Balearic Isles (Spain)
10. Bar Hill (Scotland)
11. Burnswark (Scotland)
12. Byzantium (Turkey)
13. Caerhun (Wales)
14. Caerleon (Wales)
15. Cagliari (Sardinia)
16. Carthage (Tunisia)
17. Chester (England)
18. Corinth (Greece)
19. Crete (Greece)
20. Delos (Greece)
21. Eretria (Greece)
22. Gamla (Israel)
23. Gellep (Germany)
24. Gloucester (England)
25. Hatra (Iraq)
26. Himera (Sicily)
27. Jerusalem (Israel)
28. Lambaesis (Algeria)
29. Malaga (Spain)
30. Miletos (Turkey)
31. Munda (Spain)
32. Neath (Wales)
33. Olbia (Ukraine)
34. Old Winteringham (England)
35. Olynthus (Greece)
36. Paphos (Cyprus)
37. Perusia (Italy)
38. Pompeii (Italy)
39. Rhodes (Greece)
40. St Albans (England)
41. Strageath (Scotland)
42. Stymphalos (Greece)
43. Syracuse (Sicily)
44. Teutoberg Forest (Germany)
45. Usk (Wales)
46. Velsen (Holland)
47. Woodeaton (England)

Findspots of little catapult washer (< 150g calibres):

A. Bath (England)
B. Elginhaugh (Scotland)
C. Ephyra (Greece)
D. Gornea (Romania)
E. Mahdia (Tunisia)
F. Pergamon (Turkey)
G. Volubilis (Morocco)
H. Xanten (Germany)

Lead 'slingshot' (*glandes*)

Tracey Rihll

Glandes or μολυβδίδες/μολύβδαιναι (fig. 1a) were ordinarily made of a lead alloy and cast, in sequences of 3 or more, or in trees of 6[1] or more, into a shape and size that resembles an acorn, olive, or almond nut in its shell — hence the Latin name. Ordinarily they weigh *c.*30-40 gm and are *c.*30-40 mm long. Sometimes they are marked with an inscription or design (in relief). From the large unpublished collection in the British Museum (available on-line since December 2008), and the catalogues of other collections, I have constructed a database of over 1400 objects in an effort to analyse these objects systematically.

The sample

Glandes with given weight, which form the backbone of the study, come from many different collections, the chief being:

— 159 in the British Museum (Greco-Roman Department; mostly unpublished);
— 153 in Rome (Gorga collection; Cerchiai 1982-83);
— 109 excavated in and around Olynthus in the 1930s (Robinson 1941);
— 85 in Basel (Vischer 1866 to 1878);[2]
— 79 in the Nicosia Museum (Nicolaou 1977, 1979, 1980);
— 74 from Iberia (Días Ariño 2005);[3]
— 58 found in and around Miletos (Weiß 1997), and
— 48 in the Bibliothèque Nationale Paris (Froehner collection; Hellmann 1982).

The remainder come mostly from smaller public and private collections, such as 25 in the Ashmolean Museum (Foss 1974-75) and a similar number in the Canellopoulos collection (Empereur 1981), along with a few unpublished finds and small groups in other departments of the British Museum (Prehistoric and Roman Britain; Middle Eastern; Egyptian[4]).

Added too were 176 of Zangemeister's *Glandes plumbeae latine inscriptae* with weights that were not already in the database. They have a significantly higher mean, median and modal weight[5] and a much smaller range than the sample as a whole: they form a relatively consistent subset, distinguished not only by bearing inscriptions in Latin, but also by having a *c.*25% heavier mean weight and a nearly 100% heavier modal weight.

Glandes published without measurements were not included because no useful analysis can be done on them. This typically affects plain *glandes*,[6] but is true also of some inscribed specimens.[7] Since the objects are missiles, weight is crucial.

A steady stream of *glandes* is offered for sale on eBay (mostly from its American, British, Dutch and German branches) and those noted while I was compiling the database were included. Most seem to be new finds by metal detectorists in countries that were once part of the empire. Although unstratified and with unverified information, they should not be ignored. *Glandes* are likely to have been deposited on battlefields (the kind of

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1 See, e.g., the mould illustrated at Empereur 1981, 555.

2 I am grateful to J. Ma for information on the location of this material. Maiuri (1925) and Segre and Pugliese-Carratelli (1949-51) republished Visher's specimens from Kamiros.

3 This is the number with length or weight or both amongst the 95 that are discussed by Días Ariño 2005.

4 A large collection of 517 specimens has recently been recovered at Velsen. Discussion of types found and distribution map of findspots around the fort is given in Bosman 1995; also Bosman 1999.

5 The mean is the average value; the median is the middle value, with the same number of other values occurring either side of it; the mode is the most common value in a given set.

6 E.g., Munda: Pina Polo and Zanier 2006, 29. Only 109 of the *c.*500 *glandes* from Olynthus are in my data-base because only that number was published with sufficient details. Even the total number found is an estimate rather than a count.

7 Most entries in *IG* and *CIL* are not included in the database; e.g., *IG* XIV 2407 comprises 26 specimens for which only the inscription is recorded. This practice continues into recent times: e.g., Rouillard 1997, 68-70, is apparently a representative selection of the 90 or so specimens from Osuna now in the Louvre. Collectively they are stated to be 3.5 to 5.5 cm long and weigh 80 to 100 gm; the (maximum) length and width of each is given, but not the weight. Likewise, averages are given for the specimens found at Caminreal: Vicente *et al.* 1997, 195.

environment that detectorists frequent but archaeologists do not); indeed, it was 3 *glandes* found in open country that led to the discovery of the battlefield in the Teutoburg Forest.[8]

Description

Glandes are generally small and inconspicuous and are easily missed in excavation, but are easily found by metal detector, even after the excavators have finished (e.g., at Hala Sultan Tekke: Fisher *et al.* 1980, 481-82). As a class they are rather nondescript: most can be described in words such as 'grey, almond shape'. Colour may vary widely on the greyscale from white (usually caused by the decay of lead to lead oxide) to very dark grey, and from green (usually caused by the decay of copper in the alloy) to pink (sometimes attributable to iron corrosion). Very few *glandes* have been tested for metal composition.[9]

An inscription or design, if present, is often not obvious. Letters are typically a few millimeters high and wide, in low relief, and partially obscured by corrosion, abrasion or damage. Generally, letters on Greek specimens are smaller, neater and clearer than Roman. Letters may be in Greek, Latin, or other scripts (Hebrew and Cypro-Minoan have been suggested; Punic is rare but exists)[10] and may be written left to right or retrograde, on the same *glans*. Designs are very small, like those on gems or coins. Most of the specimens in our database have an inscription or design, but that was the reason for their collection and may not reflect the proportion of decorated to plain *glandes* in use in antiquity. Plain *glandes* in our database were usually purchased as part of a collection that included inscribed pieces, or were excavated and published alongside inscribed specimens. Acquisition records are valuable. Many details seen on British Museum specimens at the time of acquisition are no longer visible.

Previous discussions

Glandes have been relatively neglected since the 19th c. The classic discussions are still those of Vischer (1878) and Zangemeister (1885), together with the short but rich entries on *glans* in Dar.-Sag. and P.-W., by Fougères and Liebenam respectively, but they are very dated because the number and known types of *glandes* have increased enormously in the interim. Thus, Henry (1970-71), in a strongly quantitative analysis,[11] synthesised a picture of stone, terracotta and lead slingshot in Italy, using the collections in Cagliari (almost 2000 specimens), Naples (224), Perusia (178), and Enna (107). Some collections have been published (e.g., Nicolaou 1977, Hellmann 1982, Cerchiai 1982-83) and *glandes* from some specific sites (e.g., St Albans [Greep 1987], Miletos [Weiß 1997], and Eretria [Brélaz and Ducrey 2003]).[12] A steady trickle of finds is reported in *SEG* and the *Revue archéologique*. T. Völling publishing a wide-ranging paper (1990) on Roman slingers, listing archaeological finds for that period. The present paper aims to offer a new synthesis which is focussed on the objects (not the inscriptions), includes Greek as well as Roman specimens, and analyses the statistically significant sample in the aggregate.

Methodological issues

1. Identification

Objects of this approximate shape, size and material are not necessarily missiles. F. Petrie identified objects of similar description as slingshot if they carried a design familiar on

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8 Vell. Pat. 2.117-20; Tac., *Ann.* 1.60-62; Cass. Dio 56.18-24. *Glandes*: T. Clunn 2005.

9 The only ones known to me to have been tested are from Thrace: Kuleff *et al.* 2006.

10 Carthaginian shot is preserved in the Louvre and the Museum of Artillery in Paris: Fougères 1609 n.5. Punic and Neo-Punic script has been read on *glandes* from Spain: see Garcia Garrido and Lalana 1991-93, nos. 13014.

11 He attempted to use the ratios of the circumference on the long and short axes (measuring along the elliptical curves), absolute length, and weight in gms, as a method to date anepigraphic *glandes*. His method makes a number of assumptions upon which the present paper casts doubt.

12 The last paper also discusses moulds found at Eretria, Olynthus, Delos, the Cimmerian Bosphorus, Piraeus, Miletos, Cyprus, Paris and Copenhagen. See also Poux and Guyard 1999.

glandes (anchor, star, thunderbolt, trident), and as weights if they did not.[13] This is not a solid basis for identification. Sfendonoid weights (σφενδόνη being Greek for sling) are so named from their resemblance to *glandes*. Sfendonoid objects of Bronze Age date have been found, for example, on the Cape Gelidonya and Uluburun shipwrecks (Bass 1967 and 1986), and at the Cypriote sites of Ayios Dhimitrios (Courtois 1983) and Hala Sultan Teke (Åström and Nicolaou 1980). Are these Bronze Age objects weights or slingshot? They are generally made of what appears to be polished haematite,[14] whereas *glandes* are ordinarily made of a lead alloy.

J.-Y. Empereur suggested that a lead alloy 'glans' (his no. 15) in the Canellopoulos collection is a 16-drachma weight because, although similar in shape, it carries symbols (an amphora surmounted by a rose with 6 petals) and an abbreviated name (ΕΠΑΜ) that "astonishingly resemble" coins made in the region.[15] Similar to Petrie's method, he is declaring a sfendonoid object a weight if it has a familiar numismatic design. J. Flemberg meanwhile drew attention to the coincidence of some designs found on 'glandes' with some of those stamped on amphora handles — which widens further the possibilities for interpretation.[16]

There may have been other (unknown) uses (beyond those of weight and slingshot) for objects of this approximate size, shape, weight and material. Further, objects made for one purpose may be used for another, especially if they are as similar as *glandes* and sfendonoid weights are.

Besides weights, *glandes* have at times been confused with clamps, lead-headed nails, a piece of a plaque, or 'other' lead objects (e.g., a number of those included in the Windridge Farm group are now considered not to be *glandes*[17]).

2. *Provenance*

Very few of the *glandes* in public and private collections have a good (or indeed any) provenance. Typically, any location mentioned in old acquisition records is approximate (e.g., "Corfu"). Because *glandes* are battlefield missiles, they are liable to be scattered across battlefields and around forts, towers and walls. They may also be found in settlements and graves, but caches and relatively dense concentrations are more likely to occur at military or strategic sites. Provenances of *glandes* acquired especially in the early 19th c. may have been deliberately falsified to try to improve their saleability; attribution to well-known battlefields, such as Marathon, are suspect, especially if *glandes* have not been found in the vicinity by archaeologists.

Likewise, provenances for *glandes* advertised on eBay or on the antiquities market may be deliberately falsified. In England and Wales (but not Scotland),[18] because they are made of base metal it is not illegal to search for *glandes* on open sites by metal detector, providing one has the landowner's permission to do so, nor is it illegal to keep, buy or sell any *glans* thus found. The situation is similar in some other European nations. In order to try to capture the historical data that this kind of material can supply, two schemes were launched recently in the United Kingdom: the UK Detector Finds Database (UKDFD), and the Portable Antiquities Scheme (PAS). Both invite the finder to record the basic details of the find (with a photograph if they wish) and the approximate findspot. The records are made available online, and summaries of PAS finds (including *glandes*) have been published in *Britannia* since 2004. The value of these schemes will increase over time as more detectorists are persuaded to record their finds before disposing of them or depositing them in private or public collections, and as scholars realise the potential of the data.[19] We may hope that other countries (e.g.,

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13 Petrie 1926. These objects are now in the Petrie collection at University College London.

14 E.g., those from Enkomi on display in the British Museum, a series of 7 ranging from 2.2 to 46.6 gm: GR 1897,0401.1400, 1399, 1397, 1395, 1568, 1402 and 1569.

15 Empereur 1981. See also *SEG* 42.428 for a report of a similar item.

16 Flemberg 1978, 84-85.

17 D. Thorold (pers. comm.).

18 The Treasure Act does not apply to Scotland, where all material found is property of the crown.

19 See two worked examples (button and loop fasteners, and cosmetic sets) in Worrell 2008.

Spain[20]) will set up similar schemes.

3. Variety of weight systems

The variety of weight systems in operation in antiquity is notorious. We still lack a comprehensive reference work on ancient weights.[21] Systems of weights and measures varied over time and space, but the evidence is much better for some areas and times than for others. Further, weight systems could vary in the same place over a relatively short time,[22] and two different standards could be in operation simultaneously in the same place.[23] This makes it difficult to identify a weight-like object *as* a weight simply on the basis of its weight — or to exclude such an identification. Analysis is not helped by weights which have been published without stating their current weight in a modern unit.[24] Metrological studies seem prone to not being completed.[25]

4. (Im)precision of ancient measures

If manufacturers were aiming to make their product a certain weight, how precise were they and how precise should we expect them to have been? Means and standard deviations are affected by outliers. There are 4 very pronounced outliers in my sample, separated from the rest by 50 gm: they weigh in at 190, 235, 444, and 506 gm.[26] A histogram of *glandes* less these 4 outliers returns a curve that is significantly right-skewed (indicating a tail towards the higher weights), but 85% of the sample specimens fall between 26 and 60 gm.[27]

Accuracy is a culturally determined notion and it is limited by the precision of the measuring equipment available. A weight in the Canellopoulos collection in reasonably good condition is clearly marked *MNA*. The closest known mna is the Attic, so one might expect this weight to weigh about 436 gm (the light mna, 100 drachmai) or 459 gm (the heavy mna, 105 drachmai). In fact it weighs 442 gm, which is 6 gm more than the first and 17 gm less than the second. Few people now or in antiquity would distinguish between this and a 'correct' weight: most modern kitchen scales cannot. The 7 weights at Olynthus marked M, weights in use when the city was sacked in 348 B.C., varied between 412.5 and 419.5 gm.[28] Taking the median, the mna that these weights measure was *c.*416 g. If the Chalcidian Federation employed the Attic standard, as is generally supposed, the town was working with extra light measures some 20-40 gm underweight.

Weights in regular use can change in value; even today weights submitted for testing are often found to be outside the permitted tolerances.[29] Accuracy is much harder in practice than it is in theory, but I am more sanguine than is H.-C. Meyer[30] about the potential of statistical analysis, because the preliminary results are good. Some of the inscribed *glandes* (e.g., the 17 ΔΙΔΥ *glandes*) were found in the same area and were probably made by one person at one time, so their variability is likely to reflect ancient production as well as any sample can. With that in mind, it is astonishing that the standard deviations of many of the inscribed shot are so small, relative to their mean weights: less than 10% for 32 out of 42 inscribed types, less than 5% for

20 Cf. Pina Polo and Zanier 2006, 29.

21 The classic treatment is Hultsch 1882. As Meyer points out (2007, 42), a full corpus of ancient weights is an urgent desideratum.

22 See, e.g., Hitzl 1996, especially 97-101, 136-40.

23 See, e.g., Meyer 2007, 48-50.

24 E.g., *IG* XIV 2417 comprises 31 items classified as weights; a couple are given with weight stated in gms, some are given with weight stated in Roman measures, while some are given with neither.

25 E.g., the many weights found at Olynthus (Robinson, *Olynthus* X, 447 n.1).

26 Three of the Osuna specimens are even heavier, at 555, 540 and 530 gm: Engel and Paris 1946, 451. Unfortunately, the statistical analyses were performed before the Osuna publication was accessible to me; they would rank as outliers had they been included.

27 Compare the range of 22.7 to 136.8 gm that Vischer (1878, 277-79) found with his sample of 84 specimens.

28 Robinson *Olynthus* X, 2384-90.

29 http://www.cambridgeshire.gov.uk/business/trading/services/lab.htm (viewed July 24, 2007).

30 Meyer 2007, 45.

18 types, and less than 3% for 7 types: ΑΝΔΡΩΝ, ΕΠΙΚΡΑΤΙΔΑΣ, ΖΩΙΛΟΥ, [Η]ΙΠΠΑΡΧΟΥ, ΚΛΕΟΝΙΚΟΥ, ΤΙΜΟΣ and ΦΙΛΙΠΠΟΥ. Particularly striking is ΖΩΙΛΟΥ at 2.1%, because the mean weight is unusually high (nearly 70 gm).[31] Of these 7 types, only ΤΙΜΟΣ is *known* to have come from one site at one time. The consistency is not a function of that alone, because others excavated from a single site show greater variation.[32] These objects were cast and finished by individuals lacking modern quality-control equipment or procedures.[33]

5. Holes

A small number of specimens have one or more small or tiny holes driven into (not through) them (see fig. 1b). Mention is rarely made of such features; these holes are easily missed by researchers (W. Vischer and D. M. Robinson are exceptions). On specimens that have not been cleaned, such holes may not be visible at all; when described in acquisition records, they may be called pits, casting flaws or suchlike;[34] yet upon close inspection they appear not to be accidental but intentionally created after casting (holes also occur in stone *glandes*, where they cannot be a casting flaw[35]).

6. Metal composition

Lead is the most common metal used, but it appears to be a lead alloy in most instances. Impure lead is a by-product of silver production[36] and would have been available in quantity. That lead was dense and made good bullets was perhaps an unintended consequence.[37] A few specimens are said to be or appear to be made of 'bronze' or a copper alloy. Two specimens in our database, both from Cyprus, have lead cores and bronze 'wings' from the mid casting line, making them resemble a UFO (see fig. 1c). These 'wings' would have improved the aerodynamic performance of the *glans* and its ability to penetrate the target, by adding cutting edges as well as weight. These composite specimens would have been more difficult to manufacture than single-metal *glandes*. An iron *glans* was found at Osuna.[38] The problem of identification re-emerges with iron specimens; they are also more likely to decompose in the ground than lead or bronze alloys.

7. Corrosion effects, etc.

Lead and copper alloys, like iron, gain weight through corrosion. Cleaning with chemical agents to remove any oxide patina that formed during deposition (not recommended today) causes weight loss and accelerates corrosion. Metal objects lose weight in the ground if some of the metal is dissolved during deposition, developing a relatively shiny surface often recorded as "smooth", "glossy" or "polished" in acquisition records. Both effects impact on the weight and lend support to the argument that we should allow reasonable tolerances around any proposed weight 'centres' or 'limits'.

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31 Standard deviation, mean weights and sample sizes, are as follows: Andron no. 1: 0.2 gm, 37.1 gm, 3; Andron no. 2: 0.6, 78.7, 3; Epikratidas: 0.7, 38.1, 5; Zoilou: 1.4, 68.1, 5; Hipparkhou: 1, 35, 3; Kleonikou: 0.9, 33.5, 3; Timos: 0.4, 25.2, 8; Philippou: 0.8, 29.5, 10.

32 E.g., the ΔΙΔΥ shot. In this case, the mean weight is 42.5 gm, the median 39 gm, and the standard deviation is 4 gm (= 9% of its mean weight); or the ΚΛΕΟΒΟΥΛΟΣ, ΟΛΥ and ΧΑΛ shot from Olynthus, with sample size, mean weight and standard deviation of 9, 28.3 gm, 2.9 gm; 7, 28.2 gm, 4 gm; and 4, 22.1 gm, 2.3 gm, respectively.

33 Whether they possessed those concepts is another issue: Varoufakis 1999.

34 Vischer nos. 5 and 19; Olynthus 2183, 2200, 2260, 2294, and 2303. From the photograph, 2177 and 2229 seem to have one, but Robinson does not note it. 'Air-hole' on a specimen found at Torone, e.g., Cambitoglou *et al.* 2001, 726 on 18.4.

35 E.g., British Museum GR 1868,0110.64, PR 1960,0403.3154.

36 Some 2 kg of lead per drachma of silver from the Laurion ores: Rihll 2001.

37 See Lawton (2004, 1235) for comparative performance of stone, iron and lead shot penetrating iron armour. A study of the logistics of supplying missile troops is needed.

38 Engel and Paris 1906, 451.

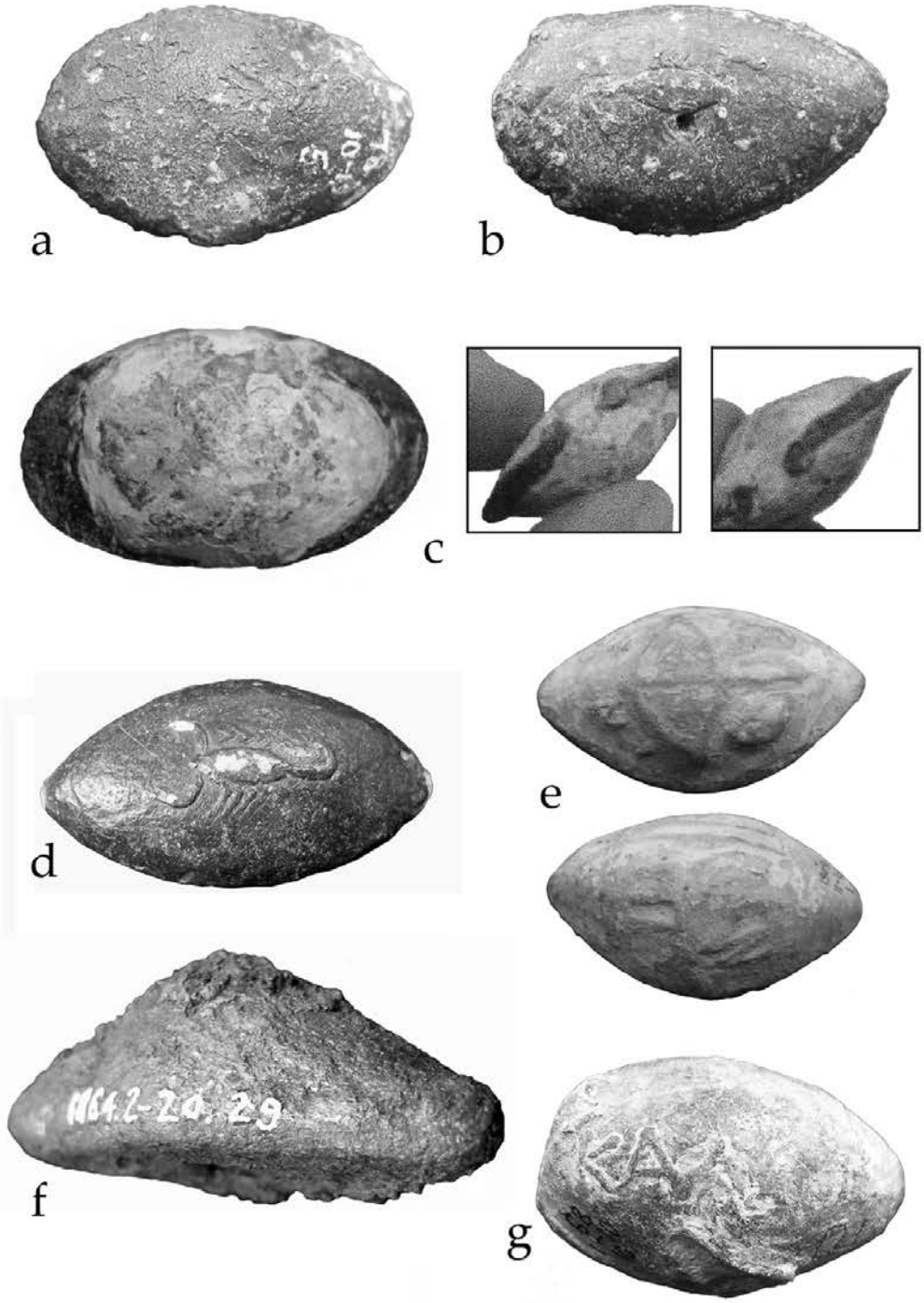

Fig 1a. GR1878,1019.5 (a typical plain *glans*) (author).
Fig. 1b. GR1861,1024.33 (showing hole) (author).
Fig. 1c. 'UFO' type (eBay photographs) (author).
Fig. 1d. British Museum GR 1868.0110.6 (scorpion) (author).
Fig. 1e. British Museum GR 1909.1115.1 (both sides; complex design) (author).
Fig. 1f. British Museum GR 1864.0220.29 (triangular) (author).
Fig. 1g. British Museum GR 1868,0110.10 rev (oblique cut) (author).

8. Inscriptions[39]

As *glandes* are generally small, any message carried by them must be short. On a sample of 299 inscribed specimens, B. Henry found that 80% had just 1 or 2 words, 2% had 6 words, and the highest number of words (found on a single specimen) was 7.[40] Inscriptions are very problematic. Many of the problems are akin to those familiar to papyrologists: "one is not sure of having read a letter correctly unless he has first guessed the word, of having read the word correctly unless he has a general idea of the meaning of the sentence";[41] and "it is, in fact, not possible to agree with oneself from one day to another".[42] To give some specific examples, before the BABYPTA type was recognised, one was read as BABYPΣA.[43] The Tryphon *glans* has been read in almost as many ways as the number of people who have tried to read it.[44] Even previously documented types can be problematic. For example, recent finds at Torone were typed as NA/MEP(τας) or NA/MEP(τιδας) on the basis of the appearance of these (uncommon) names in the *Lexicon of Greek Personal Names* IIIA and II;[45] but previous publications of *glandes* with these letters (all from the same part of the world) took them in the order MEP/NA, after Robinson interpreted the letters as an abbreviation for Mekyberna, the port of Olynthus. Now, however, there is a MEP/NA from Osuna (Spain), together with two MCP specimens, which may be alternative versions of MEP.[46] Neither of the current hypotheses to explain MEP/NA fits a Spanish context, and which side is the obverse and which the reverse is still an open question. Names occur in a variety of cases and spellings, as is to be expected. Nominative, accusative, and genitive cases have all been documented, as well as incorrect lengths of vowels and the frequent omission of letters (especially final). For example, from the Olynthus area of the mid- to late 4th c. B.C. we have ΚΛΕΟΒΟΛΟ, ΚΛΕΟΒΟΥΛΟ, ΚΛΕΟΒΟΥΛΟΥ, and ΚΛΕΙΒΟΥΛΟΥ reported.[47] If they are all correctly read, they may refer to anywhere between one and four individuals. Typographical errors also occur. For example, of the shot marked ΑΘΗΝΑΙΩΝ found at Olynthus and Mekyberna, one had a simple typographic error, missing the eta: ΑΘΝΑΙΩΝ.[48]

In our sample, proportions of plain to inscribed *glandes* show no obvious pattern. At Miletos, 25 plain and 35 inscribed *glandes* were found (Weiß 1997); at Sykoula, 32 plain and 6 inscribed (*SEG* 49 [1999] 586); at Olbia, 5 plain and 3 inscribed (*SEG* 48 [1998] 1021); and at Olynthus, about 200 plain were found alongside some 500 inscribed (Robinson 1941). Why were some *glandes* marked and others not? It is generally supposed that names on *glandes* are those of:

a. the maker,
b. the user,
c. the commander of the unit of users,
d. the intended target, or
e. the institution (e.g., the legion) or State that commissioned it.

Only rarely is sufficient information provided to choose between these options: e.g., ΣΩΚΡΑΤ /

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39 This is the only aspect of *glandes* for which there is a relatively large literature, which it is not my intention to list. Most works on inscriptions concern a given type, specimen or collection, and attempt to tease out their particular prosopographical or historical significance, sometimes with scant regard for the methodological issues (e.g., Tuck 2005).

40 Henry 1970, vol. 2, Table on 60.

41 Giorgia Pasquali, quoted by Youtie (1963, 24).

42 Youtie 1966, 256.

43 Reinach 1889 corrects Longpérier's error.

44 See, e.g., *SEG* 42.1417.

45 *Torone* vol. 1 (2001) 723-26. *Glandes* marked MEP/NA were excavated at nearby Olynthus; another was reported from Potideia (*SEG* 50.621), others were seen at Dion by W. K. Pritchett, and more reported to Hammond at Pydna (Pritchett 1991).

46 Días Ariño 2003 nos. 89, 86 and 87, respectively.

47 *SEG* 52 (2002) 647 (Torone); Robinson 2202-12 (Olynthus); *SEG* 45 (1995) 806 (Stageira); *SEG* 48 (1998) 844 (Stageira), respectively.

48 Robinson 1941 no. 2182: Athnaion.

ΕΠΟΗΣΕΝ ('Sokrates made [it]').[49] The natural desire of scholars to associate a name on a *glans* with a known individual (cf., e.g., Feugère 1994, 7) favours commander of the unit. But other inscribed everyday objects record information about (i) production, (ii) contents (e.g., weight or other measure), (iii) distribution, or (iv) ownership (Harris 1993), and we should assume one or other of these for *glandes*. Occasionally words that are not names occur: e.g., ΔΕΞΑΙ ('catch!'),[50] which is sarcasm, not irony (Guarducci 1970, 522); those launching missiles are shooting them *at* one another and are trying to *wound* rather than humour them.

The range of inscriptions is large and growing, but note that this is most directly affected by the activities of forgers, who respond to market demand.

9. Designs

Glandes with the same design typically come from more varied sources than *glandes* with the same inscription (for example, scorpions have been found from Sicily to Rhodes, Byzantium to the Nile Delta), but there seems to be no standardised mental image of what the design *should* look like.[51] A comparison of different scholars' readings with pictures or by personal autopsy of the *glans* highlights this interpretative flexibility, and it becomes possible to group different readings under the same heads, resulting in a relatively short list of design types:

Anchor
Axe (double)
Bow (braced) and arrow
Bull head (boukefalos)
Club?
Copulation scene
Dagger (may also be interpreted as a sword, or lines on the main axes)
Eagle in flight?
Fly (or may be interpreted as a bee or wasp)
Horse?
Olive?
Oval within an oval?
Scorpion (or may be interpreted as a crayfish, etc.)
Snake
Spearhead (or may be interpreted as an arrow)
Star (or may be interpreted as some kind of flower)
Thunderbolt (or may be interpreted as chevrons or fishbones or even a stylised *thyrsos*)
Trident (3- or 5-pronged when in good condition; or may be interpreted as a fork)
Trophy?
Winged thunderbolt

Six of these 20 types are poorly preserved and known through a single example in our sample (indicated above with a question mark). Many are represented by fewer than 10 specimens in our sample of 1,400. None could be called common (thunderbolts and winged thunderbolts together total 56). Most of these designs are at the scale of a gem and sometimes have a gem-like quality of engraving (fig. 1d); thunderbolts, however, can be very chunky and coarse. A few *glandes* have a different design on each side; of 31 thunderbolts, for example, on the reverse one has a possible scorpion, 4 a star, 4 an anchor, and one a spearhead. By far the most complex specimen known to me is BM GR1909,1115.1, which is graced with KN, ΦΣ, a boukefalos, and a ram's head, all separated by what looks like a bow and (long) arrow on one side, and, on the other, M and N separated by a trident, with two horizontal lines above (fig. 1e); made of clay, it weighs just 9 gm.

10. Shapes

Acorn, almond (shell), olive and lozenge are common descriptors for *glandes*, serving well in most cases as analogues of the size and shape. The Latin name *glandes* (= acorns or nuts) testifies to the antiquity of the analogy. Being cast of a metal with a low melting point, *glandes* could be made of any size and shape desired.[52] The drag coefficient is lowest for what B. Lawton (2004, 1247) calls an 'airship hull' shape. Assigning a shape to a *glans* is very sub-

49 Michaelidou-Nicolaou 1972, Museum of Nicosia no. 25.

50 See Parsons 1943 for the excavation of specimens of this type.

51 Drawings can make things look clearer than they really are, and are biased in favour of the drawer's interpretation. Photographs, on the other hand, can miss much on a curved object such as this and marks in relief may show only in raking light; the object may have to be repositioned to show the full picture.

52 See Bosman 1995 for an extreme case, using nothing more sophisticated than a campfire and a finger in damp sand.

jective: in the literature there are a variety of typologies based on putative shape (and none):[53]
— "Almond" is the default because most *glandes* are wider than they are thick, like the typical almond, and most *glandes* have more or less pointed ends, again like the typical almond (nearly 800 specimens).
— "Acorn" indicates that one end of a *glans* is distinctly bigger than the other; it also applies to those sometimes described as tear-drop shape (23 specimens);
— "Olive" indicates maximum width and thickness are the same or very similar, and that both ends are of the same size and decidedly rounded (25 specimens);
— "Biconical" indicates the *glans* resembles 2 cones stuck together at their bases (20 specimens);
— "Octahedron" indicates 2 pyramids stuck together at their bases, or decidedly flattened faces (11 specimens);
— "Slug" indicates the *glans* has one flat side (which tends to associate with an otherwise rounded or 'triangular' profile) and rounded ends (74 specimens); this is the second most common shape, occurs in a variety of collections, and, if inscribed, is usually in Latin.
— "Other". This category (39 specimens) is for those that will not fit into the other categories. It includes spherical or almost spherical (10), a very regular and distinctive oval cushion shape (7),[54] distinctly egg-shaped items (3), the 'UFO type' with bronze wings (2), 8- or 9-faceted specimens that are probably not *glandes* (2), and other shapes that are none of the above. Osuna shows the greatest variability at a single site.[55]

Note that ballista balls come in a similar variety of shapes. The most common type is spherical. Ovoid, 'triangular', and spheres with one flat side all occur amongst the collection of more than 1300 stones at Gamla.[56] Balls with one flat side are also known from elsewhere (e.g., Osuna, Hatra, Old Paphos). They may be for hand-throwing rather than for shooting from ballistae, but the fact that some *glandes* (which no one thinks were intended to be thrown directly by hand) have one flat side suggests that one should keep an open mind on the issue. Gamla produced some 'triangular' stones, difficult to interpret; this shape is also found amongst *glandes* (e.g., BM GR1864,0220.29 is distinctly triangular in profile: fig. 1f).[57]

A small but significant number of *glandes*[58] have an oblique slice at one end, producing a small flat surface on an otherwise curvaceous object, as if part of the shot had been cut off. These are usually described as dents. In some such cases there is a bulge adjacent, where the material was pushed aside, in others the appearance of shearing, as if the shot has fractured and part of it became detached (e.g., BM GR 1868,0110.10rev: fig. 1g). The same feature is found on some ceramic specimens (e.g., BM GR 1868,0110.68; 1913,0526.342).

Perhaps in antiquity there was round lead shot too but it has been misidentified. For example, a mould to make 6 small and 1 large round shot was found on the Pnyx in Athens, together with 4 spheres described as lead weights (which, oddly, were not connected with the mould by the excavator, nor were their weights given).[59] A bronze mould to make 8 spheres each of *c.*8 mm diameter, and three moulds to produce single spheres of 12 mm, were found at Corinth.[60] Round bronze balls found at Himera were identified as shot by their first editor (*SEG* 45, 1365).

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53 E.g., Bosman, who recognises 5 types; Henry, who recognises 9 (including subtypes); and Völling, who recognises 10 different types (including subtypes).

54 This shape has been identified with Carthage: Völling 1990, 41. It is made of terracotta and is significantly larger than (more than twice as large as) the typical *glans*.

55 I do not understand how Völling (1990, 57) could classify all of these within his type III. Similar variety is found amongst the Burnswark specimens, which differ greatly in weight and shape. Christison (1899, 215) observed that, even where specimens were of almost the same weight, "the difference in form was so great that they could not have been cast in the same mould".

56 Holley forthcoming.

57 It is classified in my database as a 'slug' because of its flat bottom.

58 British Museum: GR 1861,1024.35, 1861,1024.37, 1861,1024.41, 1868,0110.45a. Miletos: Weiss 1997, 1l, 1m, 1n, I6c, 4m, 4q, 5r, 5s. Burnswark: Christison 1899, 214, the ones labelled 620, 550, 370 and 925.

59 Davidson 1943, items 19-22 (spherical lead 'weights') and 39 (mould). All were found in the filling of the third period of the Pnyx, so may be dated to 350-325 B.C.: Rotroff and Camp 1996.

60 Davidson, 1952, nos. 1576-79 and pl. 94.

while one round lead and two bronze balls were found at Olynthus.[61] Fourteen spherical shot were found at Gellep.[62] Small numbers of round shot (lead and clay) have been found in England and Scotland.[63] Other round shot found hither and yon tends to be associated with whatever musket-carrying armies are known or presumed to have been in the area (those of Napoleon are a popular guess for much of continental Europe), but that would not work for Burnswark (Scotland), so the "two or three" *glandes* "of more rounded form, possibly musket balls" were attributed to Duke Hamilton's army which Bishop Pococke presumed passed by in the 17th c.[64] A medium-size lead ball in store at Caerleon (Wales), lacking stratified provenance, could be from either the Roman conquest or the 'English' civil wars.[65] A lead ball 9 cm in diameter excavated at Torone was imagined to be grapeshot from a cannon, date unknown.[66]

11. Fakes

An earlier generation of scholars was rather quick to condemn specimens as fakes if they perceived a mistake in the spelling or syntax of the inscription, or if their interpretation of the inscription(s) led to a contradiction with their knowledge of the history or individual(s) they thought it concerned. Much was read into a few letters. A text of obscure meaning was liable to be preferred to simple interpretations of mis-spelled words. What gave substance to those concerns was the discovery in the 19th c. that some enterprising Italians, having access to original moulds, were making specimens for sale to scholars and museums. That killed the interest of scholars like Mommsen who did some of the early work on *glandes*.

Scientific tests of the lead may be able to differentiate ancient from modern pieces and suggest provenance if the isotope field for the ore used has been mapped and if the item was not made of mixed lead (caches of scrap that could or would have gone back into the melting pot are known for lead [e.g., at Miletos], as for more precious metals[67]). The only *glandes* to have been tested, as far as I know, come from Thrace (Kuleff *et al.* 2006).

A couple of shot from Spain have letters punched rather than in relief (Yebenez 1999). It would be good to have a test of their authenticity before accepting this as a (rare) ancient practice: ordinarily, inscriptions and designs are in relief, standing proud of the surface of the *glans*.

12. Ceramic glandes

With the exception of those in the British Museum, ceramic shot are not included here. Typically they are moulded and of baked clay. They are thought to have superseded lead shot in some quarters of the Roman empire, but the production and use of both clay and lead shot is attested for Britain,[68] where the legions might have been involved in locating and exploiting

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61 Olynthus X, 2571-73. Robinson says of the first that "this was probably not used as a slingstone", but gives no reason; he goes on to suggest it was "a counter in some game".

62 Völling 1990, 35-36; these specimens are dated to the reign of Diocletian (49 n.44). They weigh between 70 and 117 gm (53 Abb. 31).

63 Greep 1987, figs. 9-10 and Appendix 1.

64 Christison 1899, 215 (round *glandes*; note that higher on the same page, along with "about a dozen that are small and somewhat rough", they were omitted from further discussion), 211 (Duke of Hamilton).

65 This unpublished 280 gm lead ball was found at Usk in an unstratified context (Caerleon Museum 82-10H U69II). *Legio XX* was based near Usk at a fort called Burrium in A.D. 55-65, before moving to Isca (Caerleon): Arnold and Davies 2000, 10-13. But Usk was also attacked and burnt by the Welsh forces under Owain Glyndwr in A.D. 1402, and the Battle of Usk/Pwll Melyn occurred in 1405 (Davies 1993, 201), so it could belong to that era. Interestingly, 280 gm is roughly equivalent to 64 drachmai, the cube root of which is 6.5; the spring-diameter of a catapult to shoot it would be 138 mm — almost exactly the average size of 3 of the washers at Ephyra (136 mm).

66 Cambitoglou *et al.* 2001: findspot 271, 'grapeshot' 726.

67 Lead is found near Olynthus, in Laurion, Siphnos, Thasos, Cyprus, Euboia, Myndus (Caria), Ephesus, and along the S shore of the Black Sea: Robinson (1941) 420 and n.149.

68 E.g., 6000 were found at the legionary fort at Lambaesis (Curle 1911, 56), and specimens have been found across Britain: e.g., Abergavenny, Caerhun, Caerleon, Neath, Ardoch, Bar Hill, Strageath, Alchester, Chester, Gloucester, Old Winteringham, Woodeaton: see Greep 1987, Appendix 2.

lead deposits.[69] Many of issues raised above are relevant for ceramic shot. One notable difference is that ceramic examples can be remarkably small and light — as little as 7 gm (*c.*1/4 of an ounce); another is that they cannot be found by metal detector; a third is that they are even easier to miss, and deterioration is more complete. Still, the most complex *glans* known to me is a tiny ceramic specimen apparently from Turkey (BM GR 1909,1115.1; fig. 1e), and one of the most consistent types is the cast ceramic 'cushion' type, known from Malaga and Carthage.[70] The Royal Albert Memorial Museum (Exeter) possesses what looks like a clay version of one of the British Museum's largest lead specimens.[71]

13. Post-deposition behaviour

These items are not simply dropped: if they miss their targets (which is more likely than not[72]), they will hit the ground with force, sometimes burying themselves in the process. In addition, their small size and high density make them vulnerable to downward movement through root action or the burrowing of animals.

14. Difficulty of dating

Present methods offer no intrinsic way to date *glandes*. Museum and private specimens lacking a specific provenance (as the majority do) float in time. Even if they have a provenance, they may lack a stratigraphy, or it may be unreliable. Speculation is possible if there is an inscription, but that is not necessarily reliable or categorical for dating (thus, on the basis of nothing more than the name inscribed upon it, the Tissaphernes shot has been argued to be the earliest[73]). The current orthodoxy is that lead shot went out of general use during the 2nd c. A.D.[74] What may be *glandes* are liable to be identified as something else if they appear to come from an unorthodox context.[75] We need to tackle the dating problem head on, for the orthodoxy rests on no firm foundation. Thirty years ago, the orthodoxy was that lead *glandes* had gone out of use at the turn of the 1st c., an idea that R. W. Davies traced back to 1899.[76] Mr. F. Haverfield ("Quarterly notes on Roman Britain," *The Antiquary*, March 1899) suggested that the use of lead *glandes* ceased about the end of the 1st c. A.D. because Roman authors make no mention of lead slingshot after 70, and the few sources who specify the material used by slingers from Hadrian onwards say it was stone. When he wrote, only a single *glans* had been found in Britain.[77] Christison observed that "the rather scanty literary evidence is entirely in favour of this as a permanent change", but added "it seems very unaccountable, and must be taken as a sign of degeneracy in the Roman armies".[78] He thought it unlikely that such a

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69 Nash-Williams 1954, 7 with references in n.3, and 105; note the presence of Asturian cohorts (Table p. 9). See also Arnold and Davies 2000, 101, on C. Nipius Flavianus/Ascanius, and 102-3 for LEG XX VV stamped tiles at three lead-processing sites. The twentieth legion was based at Deva (Chester), near the ores of Flintshire. See also Whittaker 2002, especially 210 on artisan soldiers.

70 British Museum Greek and Roman Department 1864,0115.1 (Carthage), 43 gm; British Museum Prehistory and Roman Britain Department 1964,1201.959-64 (Malaga), which weigh 44-52 gm and are made of different clay (one tan, the rest pink).

71 Striated biconical shot, RAMM acc no. 5/1946/452, found apparently at Syracuse. Those from Lambaesis are also relatively large and heavy: e.g., British Museum GR1925,0511.1 measures 64 mm and weighs 121 gm.

72 See Goldsworthy's (1996, 187) comparative data; the hit rate was probably between 5% and 25%.

73 Foss 1975.

74 Bishop and Coulston 2006, 135.

75 E.g., a biconical lead object found about 1 km from the fort and camp site at Dalginross, with a cavalry-harness *phalera*, a pin and a hemispherical boss (therefore a military assemblage), has been identified as a weight. It has 3 punched conical 'dots' in a T-formation, which have been interpreted as all that remains of a quincunx, indicating 5 *unciae*, which is about what this damaged and pitted specimen weighs: Tomlin 2008, 388. Alternatively, it may be a larger calibre *glans*, with holes.

76 Davies 1972, 104. He went on to suggest that they were being used as shrapnel, shot in bags from onagers, as late as the 3rd c. A.D.

77 Christison 1899, 213 n.1.

78 Ibid. 215-16. The quote continues: "when we consider the superiority of lead — from the ease with which it can be cast of any required shape or weight, and its greater range — over the primitive pebble from the brook".

change took place quickly and universally in the armies,[79] and wondered whether the then 'unique' find of 67 *glandes* excavated at Burnswark were in fact mediaeval, before concluding that they were probably Roman.[80] In the last generation, a number of 'anomalous' specimens, found in late 3rd-/early 4th-c. layers at Arbeia and Vindolanda, for example, led to a stretching of this alleged British exceptionalism over an improbable three centuries. But now that *glandes* have been found on the Continent in a Late Roman context, at Gellep, the idea may be shelved permanently.[81]

Provenance offers the promise of a date if the provenance can be directly related to the literary record (some, such as Corinth,[82] St Albans,[83] and most sites in Gaul,[84] as well as Burnswark, cannot). *Glandes* found in fields are datable only if the field is firmly identified with an attested battle (the debate over Munda and Alésia may serve as examples[85]). In the case of strategic locations where armies clashed repeatedly, such as Mantineia (known battles in 418, 362, 207 B.C.) and Thermopylae (480, 279, 191 B.C.), one needs more. *Glandes* found at known sites of sieges are more easily dated, especially if the siege was successful or the city deserted: e.g., Olynthus (Robinson 1941), Sulla's sieges of Athens (Davidson 1943) and Pompeii (Jones and Robinson 2005), or clashes during the Civil Wars at Perusia (Hallett 1977) and Osuna (Días Ariño 2005); but at poorly documented sites the dates often have to remain approximate: e.g., Burnswark (Davies 1972), Stymphalos (Williams and Gourley 2008, 249-50), and Velsen (Bosman 1995, 99; 1999), while at cities subjected to more than one known siege there may be two or more alternatives: e.g., Jerusalem (Shatzman 1989, 463), Eretria,[86] and Enna.[87]

Ways forward

1. Analysis of the weight of glandes

Statistical analysis of the weight of *glandes* offers the prospect of solving a variety of problems. For example, it can be used both to identify and to distinguish individuals named on *glandes*, especially in problematic cases. Consider the *BABURTA* type. A *glans* with an inscription read as ΘABYKTA was alleged to be a fake because it appears to be a mis-spelling of BABYPTA supposedly perpetrated by a 19th-c. fraudster.[88] However, handwritten or hand-carved majuscule beta and theta, on the one hand, and kappa and rho, on the other, can look very similar. The mean weight of the 12 *BABURTA* examples with weights now known (some of which were not known when the allegation of fraud was made) is 39.3 gm; the standard deviation is 1.4 gm. The ΘABYKTA specimen weighs 40.3 gm, which is just 1 gm ($^{1}/_{25}$ of an ounce) more than the mean and significantly less than the standard deviation for this type. If this is a fraudster's work, it is remarkable that he managed to reproduce the weight *to the gram*, especially since this was in an era when no one was much interested in the weights. Analysis of the weights suggests that the error in the letters (if there is an error in the manufacture, rather than in the reading) is ancient, not modern.

An example of using weights for distinguishing relates to the name ΑΝΔΡΩΝ. Although there are only 6 specimens with this name in our database, they are remarkably consistent

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79 This seems to be the germ of the idea that the Roman armies in Britain were equipped in an exceptional way.

80 Christison 1899, 213 unique, 216 medieval, 217 Roman.

81 Arbeia SFL 39 and 115 (I owe my knowledge of these shot to W. Griffiths). For Vindolanda, see Bishop and Coulston 2006, 206. For Gellep, see Völling 1990, 49 (14 of Diocletianic date). See also Greep 1987, 192 and Griffiths 1989, 269.

82 Davidson 1952, 199-200.

83 Greep 1987, 184.

84 Feugère 1994, 10: e.g., Le Mas d'Agenais, whence the MANL shot (7, 18).

85 Munda: Pina Polo and Zanier 2006, 40 with references in n.13. For Alésia, see Reddé 2003.

86 Schmid 2000 for 86 B.C. (Sulla), Brélaz and Ducrey 2003 for 198 B.C. (the Second Macedonian War).

87 The Piso shot relate to the slave revolt of *c.*136 B.C., but this city was also the site of battles in 396 (Dionysios), 307 (Agathokles), 277 (Pyrrhos), and 214 B.C. (the Romans).

88 CMBN1065; Hellmann 1982 no. 10.

within two classes: three specimens have an average weight of 37 gm and a standard deviation of 0.2 gm, while the other three have an average weight of 79 gm and a standard deviation of 0.6 gm. Clearly they belong in two separate categories. The lighter specimens were found in Cyprus (Nicolaou 1977, 211-12), the heavier three are in the Canellopoulos collection (Empereur 1981, 556). The latter lack provenance, but from their weights there is no reason to associate them with the Cypriot finds.

This kind of analysis could also help associate missiles with armies and help place named individuals on one side or the other. For example, of the types found at Olynthus, *glandes* bearing the name of known Macedonians were relatively consistent (for ΦΙΛΙΠΠΟΥ, standard deviation of shot was 2.7% of mean weight; for [Η]ΙΠΠΟΝΙΚΟΣ, it was 3.4%), but those marked Ολυ(νθιαν) or Καλ(κιδιαν) were relatively inconsistent (14.2% and 10.4%, respectively).[89] On this basis, we might assign the Kleoboulos type *glandes* not to an otherwise unattested general of Philip, as Robinson does (p. 428) simply on the basis of the number of shot found here, but to the defenders, because the standard deviation of shot with this name is 10.4% its mean weight, which is exactly the same as the Chalcidian *glandes* and more than three times that of shot bearing the names of incontrovertible Macedonian leaders. By the same method, ΤΙΜΟΣ (1.4%) would be assigned to the Macedonian forces.[90] However, ΜΕΡΝΑ or ΝΑΜΕΡ has a standard deviation that is 7% of the type's mean weight, falling inconveniently between the small variability figures for known Macedonians, on the one hand, and the large variability figures for known defenders, on the other. Thus the method fails for this type.[91]

2. *Analysis of the metal*

If scientific tests of the lead are undertaken and the *glans* was not made of recycled lead, its precise composition could help with provenance and authenticity. Lead isotope signatures have been identified for several ore fields (e.g., Laurion, Siphnos, the Chalcidike),[92] with which samples could be compared.

3. *Analysis of holes*

Vischer suggested that the holes in two of his specimens (nos. 5 and 19) might have been made to hold messages, citing instances where sources mention that messages were sent across enemy lines via slingshot. This seems implausible (these holes can be a mere 2 mm wide and deep; see fig. 16): it is simpler to scratch the message on the shot if one wants to use it as a messenger.

Alternatively, holes drilled out in a specimen could be explained as either crooked practice if it is a weight (to sell underweight; the hole(s) would probably have been filled with wax, coloured to resemble the rest of the object), or to hold poison if it is a *glans*. Medical writers tell readers what to do in the case of extraction of poisoned missiles and there is no reason in principle why this should not relate to drilled *glandes* as well as arrowheads. For Paul of Aegina (7th c. A.D.?), βέλη (missiles) were made of iron, bronze, tin, lead, glass, horn, bone, stone, reed or wood, and were round, triangular, square or flat (6.88.1). He writes (6.88.9):

> One has to recognise [stones, trumpet-shells, *glandes* or similar objects embedded in the flesh] by the swelling being jagged and uneven to the touch, by the fact that the wound is not all in a straight line but [becomes?] larger, that the flesh appears to be crushed and livid, and that there is pain accompanied by heaviness. One has to prise those missiles up and lift them with levers or with the spoon-shaped end of the wound probe, if the wound allows for them, and extract them with a tooth forceps or a root forceps.[93]

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89 One of Philip's generals was called Hipponikos: Dem., *Phil* III 58. Sample size, mean weight and standard deviation for ΦΙΛΙΠΠΟΥ: 10, 29.5 gm, 0.8 gm; [Η]ΙΠΠΟΝΙΚΟΣ: 15, 31.6 gm, 1.1 gm; ΟΛΥ: 7, 28.2 gm, 4 gm; Καλ: 4, 22.1 gm, 2.3 gm. One may speculate that the relative consistency of their missile weights helped the Macedonians win this fight, since consistency is the key to accurate missile delivery.

90 ΚΛΕΟΒΟΥΛΟC: 8, 28.3 gm, 3.1 gm; ΤΙΜΟΣ: 8, 25.2 gm, 0.4 gm.

91 ΜΕΡΝΑ/ΝΑΜΕΡ: 8 gm, 28 gm, 2 gm.

92 See Kuleff *et al.* 2006.

93 Salazar 1998, 183-84. She observed (178) that Paul's description recalls long-range gunshot wounds.

Vischer's specimen no. 19 is particularly pertinent for this hypothesis: it has the word σωσα on one side and an image of a snake on the other. The hole is directly beneath the snake (cf. fig. 1b with a hole directly beneath a scorpion). The doctor treating the casualty would discover, on extracting the bullet, that it had been carrying poison. Just when he thought his job was done, the shooter challenged him again to save his patient: σῶσα[ι]. Celsus' advice in such a case was: 'if the missile is also poisoned, do exactly the same, but more promptly if possible, and give the treatment for poison drinks or snakebite'.[94] Philon (*c.*200 B.C.) mentioned 'Arabian poison', a mussel poison, mistletoe, the venom of lizards, vipers and asps, naphtha, and fish-glue as toxins to contaminate waters and anoint missiles.[95] Scientific analysis of any traces of organic matter in such holes *before* washing, and certainly before conservation, could test the hypothesis that they may have been used to carry poison.

Are *glandes* catapult ammunition?

I have previously (2007, 92) observed that *c.*20% of surviving catapult washers come from little catapults, ones small enough to be wielded by individual footsoldiers (rather like crossbows in later ages), and that machines of this size were built to shoot missiles about 1 ft. long if a sharp, or of 40 gm weight if a 'stone'. I suggested that *glandes* could have been catapult ammunition, without excluding the possibility that they were also thrown with a hand-sling, as has traditionally been supposed. My hypothesis was based on 8 arguments (ibid. 92-104):

1. Livy (38.29.6) reports that a *glans* may be sent from a certain kind of sling pouch 'as if from a bowstring' (*glans ... velut nervo missa excutiatur*). How could a *glans* be shot by a bowstring? Perhaps the term 'sling' could stand for the 'slingstring' of a stone-thrower catapult, as it did with the mediaeval stonebow (cf. fig. 2).[96] The same flexibility of meaning was apparent in Apollodoros' comment that some people called one-armed stone-throwers (i.e., onagers) slings.[97]

2. Human slingers can adjust their throw to deal with whatever nature provides at hand, but two-armed catapults are less adaptable.[98] Catapults constructed according to the surviving formulae were made to shoot a missile of a given calibre, so the design process began with the missile weight (for stone throwers) or missile length (for sharp-casters).[99] The catapult would

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Onasander (*Strategikos* 19.3) described the condition as it was perceived by a medical non-specialist: 'the missile ... penetrates the flesh very deeply, so that it even becomes invisible and the swelling closes over it'. Locking forceps for such extractions have been found: Jackson 2005, 209. With regard to the other items Paul mentions as 'sling' ammunition, 40-mm-long shell-shaped lead 'weights' have appeared on eBay.

94 Celsus, *de Med.* 7.5 (around the turn of the era).

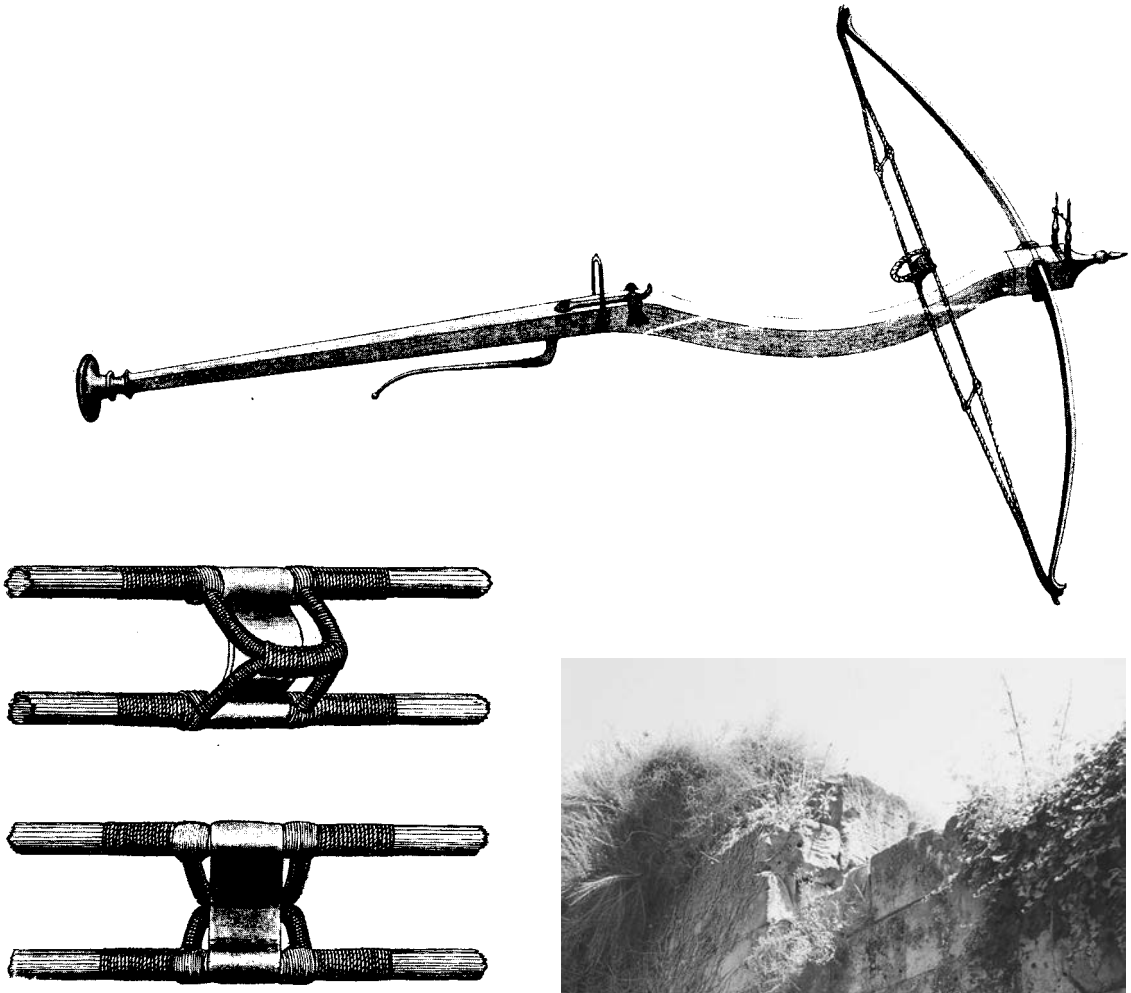
95 Philon, *Poliorketika* B 53 = 90.14-24 Th.

96 Rihll 2007, 98-104. Sling for stonebow: Ampmartinois (1583), quoted in Payne-Gallwey (1995, 158). The same sort of device seems to be implied in the inventories for the Byzantine expeditions against Crete in the 10th c., where 'Roman' bows are described as having 'double strings' (τοξαρέας Ῥωμαΐας σὺν κόρδων διπλῶν): Pryor and Jeffreys 2006, 557. Compare the stonebow's slingstring (fig. 2). The same sort of device existed in South America: Völling 1990, 27 (he notes the Livy passage at n.52) and Abb.4.

97 [Heron Byz.] *Poliorketika* 44.38-39: οἱ λιθοβόλοι μονάγκωνες οὕς τινες σφενδόνας καλοῦσιν. An onager is a mechanised staff sling.

98 The one-armed onager, by contrast, is a very accommodating design, being able to launch whatever will fit in the sling.

99 The formulae apply to the two-armed palintone and euthytone designs. Thus it was (and still is) possible to construct a whole catapult following ancient instructions, to shoot ammunition of a given weight (calibre); and it is possible to reconstruct a catapult from a washer alone. Fortunately, the washer was often made of bronze, which survives relatively well in the ground, and over 30 different catapults have been identified on the basis of surviving washers: Rihll 2007. Add examples from Zeugma (Hartmann and Speidel 2003) and Acholshausen (Steidl 2006; I am grateful to H.-J. Schalles for a copy of this article).



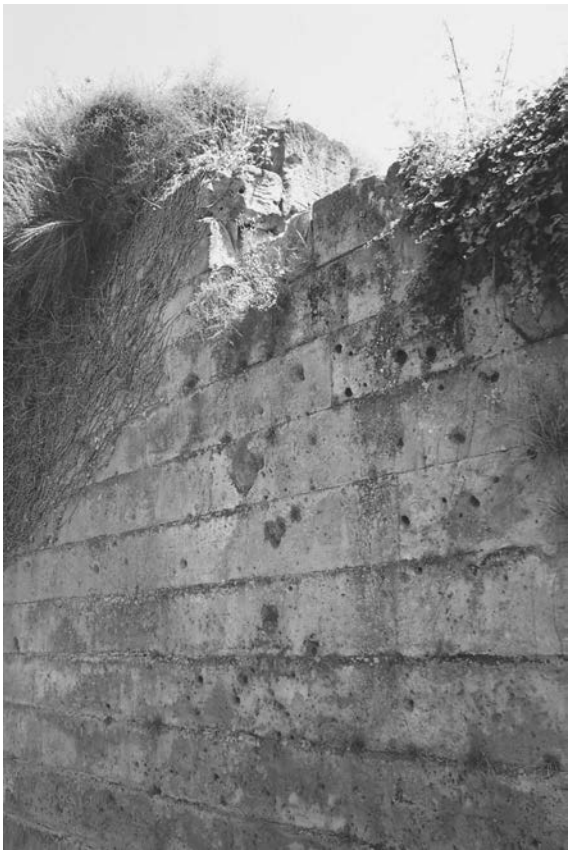


Fig. 2. Stonebow and slingstring (from Payne-Gallwey 1903, pp. 157 and 193).
Fig. 3 (right). Impact craters on walls of Pompeii (author).

perform best, and last longer, with ammunition of the specified size. *Glandes* correspond individually and *en masse* to calibres of archaeologically attested catapults. In my sample of lead *glandes* with recorded weights up to 440 gm (a total of 906), 35% or 315 fall into the 8-drachmai range, which is the calibre of the Volubilis catapults; another 216 (24%) fall into the 10-drachmai range, which is the calibre of the Mahdia 3 catapult; a further 212 (23%) fall into the 6-drachmai range, which is the calibre of the Bath and Xanten catapults. These three calibres (6-10 drachmai or 26-44 gm range) could shoot *c.*82% of all *glandes* in our sample. The 19 *glandes* that are lighter would fit the Ephyra 6 and Elginhaugh catapults, while the 93 glandes (10%) around a heavier 15-drachmai weight would fit the Gornea 1 and Gornea 3 catapults, and another 40 *glandes* around 20-drachmai weight would fit the Ephyra 4, Ephyra 7, Gornea 2, and Pergamon catapults. In total, the above-mentioned catapults could have shot 99% of the *glandes* in our sample.

3. *Glandes* seem to have been invented at about the same time as the catapult.

4. Slingers are normally self-supplying, whereas *glandes* (at least, the inscribed and decorated specimens) appear to be issued by a central authority. There is no current model for the logistics implied by hand-slingers using *glandes*.

5. The workmanship invested in the mould is quite fine in most Greek and some Roman cases. Why would anyone invest this kind of effort and expertise to produce shot for slingers, the lowest ranking unit on the battlefield, when they could always use stones picked up off the ground? By contrast, it is not difficult to explain the time and effort if they are ammunition for catapults, the most expensive and 'high-tech' equipment in the arsenal.

6. *Glandes* could penetrate the body, as is demonstrated by archaeology[100] and literary sources. Livy (38.21) tells how the Galatians were enraged and terrified by 'the barb of an arrow or a *glans* that had hidden itself in the flesh through a wound that appeared small'. Celsus (*Med.* 7.5.4) tells how to extract missiles such as 'a lead *glans* or a stone or suchlike that has penetrated the skin and become fixed within'; he draws the analogy of pulling teeth. Yet such penetrating injuries can hardly be caused by shot dispatched by a hand-sling, because it lacks sufficient velocity. A velocity of about 49 m per second (111 mph, 163 ft. per second) is needed for a blunt projectile to break human skin. From modern ballistic testing equipment, a hand-slinger was able consistently to achieve only about 30 m per second (68 mph).[101] *Glandes* with a fairly sharp point do not need to travel as quickly as would spherical shot to overcome the elasticity of the skin (which is quite extraordinary[102]), but there is a big difference between 30 and 49 meters per second. Philon's advice to recruit doctors experienced in catapult injuries when preparing for a siege indicates that the sorts of wounds created by catapult ammunition

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100 Hood 1960-61, 19, missed by Moog 2002. This grave, found with a *glans* lying between the ribs of its occupant, has not yet been fully published. Another possible example is tomb 10 on Antikythera: Martis *et al.* 2006. A single *glans* in a grave could be the cause of death rather than a deliberately deposited grave good (for which one might reasonably expect a bag of shot).

101 Richardson 1998, who found the best velocity for a sling was 32 meters per second, and 38 for a staff sling. These and other results (including those of D. Baatz) are discussed in Rihll 2007, 100-1, with references to other works on wound ballistics in nn. 31-32 and 34-35. Experienced enthusiasts on the Slinging.org website claim figures up to 40 meters per second, measured by a variety of methods: see, e.g., the discussion at http://slinging.org/forum/YaBB.pl?num=1195572094 . A consequence of these velocities is that the range of hand-launched slingshot cannot be as far as is sometimes claimed. Two hundred meters (a good performance even amongst the unverified figures claimed on the above website) seems a reasonable figure for a Roman soldier, and *effective* range would be less (re-enactors achieve significant damage only at very short ranges). Compare Payne-Gallwey 1903/1995, 199, on the stonebow: "if held at an angle of 45 degrees, a good bullet crossbow will throw a 1/2 oz. lead bullet to an extreme range of 300 yards, and if shot at a metal target at 20 yards, more than half of the bullet will be flattened".

102 When toughness is plotted against modulus, skin performs better than almost all other natural materials. See Lawton 2004, 1215-28, for the mechanics of wound ballistics, projectile motion through tissue, penetration, and the probability of incapacitation given a hit. The last may be compared with what Celsus says (*De Med.* 5.26).

were distinctly different from other kinds of wounds.[103] Further, ancient shot penetrated other things besides human skin. Small craters in city walls, such as those around the Herculaneum Gate at Pompeii (fig. 3), must have been created by small missiles hitting the wall at velocities greater than can be achieved by hand.[104] Over 300 *glandes* that missed their target during Sulla's attack on the city in 89 B.C., together with stone ballista balls that had done likewise, have been found in the House of the Vestals behind the gate.[105]

7. The principal designs on *glandes* may indicate the type of machine for which they were made. This could explain the relatively small number of design types despite the size of the sample and the *potential* range of types (compare coinage, or the variety of inscriptions on *glandes*). For example, those marked with a scorpion could be for a scorpion catapult; the thunderbolt (*fulmen*) could be for the *fulminalis* (the thunderbolt [or 'lightning'] ballista); the trident could be for the *tragularii*;[106] the spearhead could be for catapults that also shot what we call sharps.[107] Could the 'bow and arrow' on the specimen illustrated in fig. 1e perhaps be a representation of a stonebow or tension catapult? Where there are two apparently distinct sizes of *glandes* with the same design, they could correspond to larger and smaller versions of that type of catapult (cf. Livy 26.47 on the munitions captured at Carthage: larger scorpions and smaller scorpions, large catapults and small catapults, large ballistae and small ballistae). Collectively, *glandes* of this larger size make up the *c.*90-140 gm subset in our database. Of these, two have a scorpion, one a trident, and 8 a thunderbolt or winged thunderbolt design.

8. Any stone-thrower, human or mechanical, employs a sling to project the missile. Thus it is technically accurate to say that a missile thrown by a hand-slinger, a staff-slinger, a one-armed or a two-armed mechanical stone-thrower, was dispatched by sling.

A number of further arguments for associating *glandes* with catapults may be added:

9. That *glandes* were *intended* for hand-slinging seems to be an historic assumption. When Burnswark was excavated, the only discussion in English about slingers was an 18th-c. work on the manners, customs and arms of the English, and it seemed "to rest [its assertions] on the questionable translation of *balisterii*, when used by early [mediaeval] writers, as slingers".[108] When Christison interrogated the sources for himself, he came to doubt whether the sling was used at all in mediaeval times; *contra* Strutt, he found no reference to 'the ordinary sling' in mediaeval documents, and noted its absence also, for example, from the Bayeux tapestry (216-17). This led him to reject a possible mediaeval source for the *glandes* found at Burnswark, concluding they were probably Roman. Had *balisterii*[109] been reckoned "artillerymen" in 1898-99, *glandes* might have been interpreted as catapult ammunition from the start.

Why should anyone manufacture slingshot for hand-slingers? That it was done to provide a consistent size and/or weight of missile is countered by the variability of *glandes* found: thus, from the Civil War battle sites of Asculum and Perusia, where slingers are not conspicuous in

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103 *Poliorketica* C 72. Doctors are among the specialists in the Rhodian naval lists (unlike slingers).

104 See Lawton 2004, 1232 fig. 24.15, for comparison of the resistance of limestone, masonry and brick to penetration by missiles, and the kind of striking velocities required to make an impact.

105 M. Burns, pers. comm.. See Jones and Robinson 2005.

106 Vegetius (2.15) talks of troops called the *tragularii*, who shot *tragulae* from *manuballistae* and *arcuballistae* (hand ballistas and bow ballistas, respectively).

107 *Logkhas* is an obvious candidate for such a sharp (see, e.g., Jos., *BJ* 3.167). For the launcher, 'catapult' seems to have been distinguished from sharp-caster (*oxybeles*) in some periods and places (e.g., in Vespasian's army: Jos., *BJ* 3.80). The fly design on *glandes* may be the μυῖας to which Diodoros Siculus (31.38) refers, 'flies' being used against the Rhodians in *c.*155 B.C. Μύας, mice, is a very similar word and may be confused with it in the manuscript tradition: Dennis 1981, 5. Parts of his argument are disputed by Pétrin 1992, especially 271-73.

108 Christison 1899, 217. The work was J. Strutt, *The manners, customs and arms of the English down to Henry VIII* (London 1775-76).

109 On which see now Brennan 1980, Donaldson 1989 and 1990, and Southern 1989. The apparent contrast with the eastern half of the empire could hardly be greater; see, e.g., Hoffmeyer 1966, especially 125-52; Dennis 1985.

the literary accounts yet *glandes* have been found in quantity,[110] we have examples of 6 of Völling's 10 types, with weights ranging from *c*.20 to over 150 gm.[111]

Slings are ancient and ubiquitous. Many cultures had slings and slingers who used pebbles and small stones in the form nature provides. This is true also of the classical period. Josephus (*BJ* 4.20-80) left an account of the siege of Gamla, a site relatively untouched before recent excavation; he reports there were slingers on the defenders' side, and many pebbles suitable for slinging have been found, but no *glandes*.[112] In classical times, and only during classical times, and only in the Greco-Roman cultures, people went to the trouble and expense of making *glandes*. Why was that so, if at the same time slingers were using stones?[113]

A few ancient texts are cited to support the current orthodoxy about slingers using lead shot. In chronological order they are:

(A) Xen., *Anab.* 3.3.15-18 (4th c. B.C.). Pressed by Persian light-armed who could 'shoot arrows and sling stones so far that neither our Cretans nor our hand-throwers can reach them to retort', Xenophon suggested that 'we need slingers at once'.[114] He continued:

> I am told that there are Rhodians in our army, that most of them understand the use of the sling, and that their missile carries no less than twice as far as those from the Persian slings. For the latter have only a short range because the stones that are used in them are as large as the hand can hold; the Rhodians, however, are versed also in the art of slinging leaden bullets (Loeb transl.).[115]

Then comes an extended discussion of incentives to entice men to make and use such slings, and a corps of 200 'slingers' is duly formed, overnight.[116] This passage is problematic evidence for hand-slinging with *glandes*. In the first sentence Xenophon says that the Persian archers and slingers can outdistance Cretan archers, and in the third that the Persian slingers have a short range because they throw roughly pound-weight stones. It implies that Cretan archers had an extremely short range — in which case whence their reputation? The slings in question were apparently made of sinew (3.4.17: νευρά) — not the plant fibres selected by most slinging cultures. Why was sufficient sinew for 200 slings available at very short notice? It is not impossible that by 'slings' Xenophon is referring to stonebows, for Rhodes commissioned early designs and maintained a good reputation in catapult construction. Rhodian slingers may appear as specialists in Thucydides, but they are conspicuous by their absence from the Rhodians' own

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110 *Molybdainai* are mentioned in the account of the last stage of the siege of Perusia; slingers are not mentioned as such (App., *BC* 5.36). This is not the only one of Völling's references to *funditores* (summarised in 55-56, Liste 3) that does not actually mention slingers; their presence is *deduced* from the missiles it is supposed they used. In contrast, inscriptions on the *glandes* found in the area indicate the presence of *legiones* IV, VI, XI and XII (and less certainly VIII and XIX) at Perusia, and IV, IX, X and XV at Asculum: Keppie 1984, 125 and 69, respectively. Munda is another battlefield producing *glandes* in quantity, yet there is no mention of slingers in the literary account: [Caesar] *BHisp.* 29-31.

111 Völling 57 Liste 5, for types; p. 36 for weights.

112 A. Holley, pers. comm. I thank him for sending me a copy of his report on the Gamla ballista balls (of which more than 1000 were found on site), and D. Syon for permission to cite it in advance of publication.

113 There are also sources attesting to people famed as slingers using stones rather than *glandes*: Diod. Sic. 5.17.1 and 19.109.2 (the Balearic islanders used stones); Livy 38.29.4 (the Achaeans used beach pebbles).

114 νῦν γὰρ οἱ πολέμιοι τοξεύουσι καὶ σφενδονῶσιν ὅσον οὔτε οἱ Κρῆτες ἀντιτοξεύειν δύναται οὔτε οἱ ἐκ χειρὸς βάλλοντες ἐξικνεῖσθαι ... σφενδονητῶν τὴν ταχίστην δεῖ.

115 ἐκεῖναι γὰρ διὰ τὸ χειροπληθέσι τοῖς λίθοις σφενδονᾶν ἐπὶ βραχὺ ἐξικνοῦνται, οἱ δὲ Ῥόδιοι καὶ ταῖς μολυβδίσιν ἐπίστανται χρῆσθαι.

116 Note the *also* (και); the Rhodians have experience in using lead bullets *in addition to* (presumably) using the normal ammunition of slingers. The point seems to be that regular ammunition is a given size (larger) and has a given range (Korfmann 1973, 40, cites comparative evidence on the large hand-slung stone's ability to kill a horse and break a sword at 30 paces). Lead bullets have purportedly twice the range, because they are significantly smaller. However, the famous Balearic slingers changed their sling, rather than their ammunition, in order to achieve different ranges: Diod. Sic. 5.18; Strabo 3.5.1. See also Whitby 2004, 217-18, who, to explain Xenophon's odd incentives, suggests the slingers were servants.

naval records.[117] Close examination of the passage suggests that Xenophon's memory was imperfect (e.g., the Cretan archers of 3.3.15 are Scythian archers by 3.4.15). This should not surprise, for he may have been writing this account some 30 years after the events.[118] In any case, the question is not 'Did hand slingers use lead *glandes*?' The question is, 'For whom were *glandes* invented and manufactured?' Once invented and deployed, anyone could have used them for other purposes; in particular, hand slingers could have re-used them as ammunition.

(B) Polyb. 27.11.7 (2nd c. B.C.): the kestros 'was shot like a lead bullet from a sling' (καθαπερεὶ μολυβδὶς ἐκ τῆς σφενδόνης ἐφέρετο). This does not attest the use of *glandes* by hand-slingers; it could equally refer to a small *lithobolos*, whose 'bowstring' was a slingstring (see above).

(C) Onasander 19.3 (1st c. A.D.):

> the ammunition of the sling (σφενδόνης) is the most deadly of those used by light-armed troops (τοῖς ψιλοῖς). For the lead, being the same colour as the air, is invisible in flight ... The missile ... penetrates the flesh very deeply, so that it even becomes invisible and the swelling quickly closes over it.

Onasander clarifies ψιλοί at 17.1, where he specifies javelin-throwers, archers and slingers (ἀκοντιστὰς, τοξότας and σφενδοντὰς). There he means men using manual weapons because he talks of javelin–throwers needing running space and slingers needing space to whirl their slings. However, since hand-slingers cannot launch a blunt missile with sufficient velocity to bury it in flesh as here described, section 19 must refer to shot delivered by mechanical means (whether he knew it or not).[119] Light-armed does not, in and of itself, preclude little catapults.[120] It is possible that Onasander did not realise that only mechanically-launched missiles could bury themselves in flesh.

(D) Plut., *Ant.* 41 (1st/2nd c. A.D.):

> whenever the Roman light-armed troops (ψιλοί) sallied out against the Parthians, they sustained many arrow wounds, but the Parthians were worsted by the *molybdides* and javelins (ταῖς μολυβδίσι καὶ τοῖς ἀκοντίοις) of the Romans and withdrew.

This does not attest use by hand-slingers: it specifies only the munitions, not the launcher. Antony's expeditionary force was very well equipped when it set out; he left 300 wagons' full of siege equipment behind in his haste (*Ant.* 38).

(E) App., *Mith.* 5.31 (1st/2nd c. A.D.). Two slaves 'inscribed on lead stones' everything that the defenders were doing and 'shot them at the Romans with slings' (πεσσοῖς ἐκ μολύβδου πεποιημένοις ἐγγράφοντες . . . ἠφίεσαν ἀπὸ σφενδόνης). This passage does not attest to the use of *glandes* by hand-slingers. First, it refers to missiles called lead stones; indeed, it suggests the kind of stone size implied by the visual evidence for slingers. Second, the reported message (i.e., 'tomorrow the infantry will launch a sally against your workers and the cavalry will attack the Roman army on both sides') is much too long to fit on a *glans*. The same applies to other messages on lead reported of this siege.

(F) Paul of Aegina 6.88.9 (7th c. A.D.) includes *glandes* in a list of sling missiles. This does not attest to the use of *glandes* by hand-slingers since the sling could belong to a mechanical launcher.

10. Appian (*Mith.* 5.34) mentions the use of *glandes* as catapult ammunition: Sulla's troops shot 20 of the heaviest *molybdides* from his catapults simultaneously (ἐκ καταπελτῶν ἀνὰ εἴκοσιν ὁμοῦ μολυβδαίνας βαρυτάτας ἀφιέντων). Relatively large *molybdides* excavated in

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117 Rhodian naval records: Segre 1936 (I owe this reference to J. Ma). Slingers are absent but catapult-bearers, archers and a doctor are mentioned: 1.11b, 30, 33. On Rhodes' reputation with catapults, see Rihll 2007, 73, 87, 109, 117-22, and 148.

118 Cawkwell 2004.

119 Moog 2002 interprets the same facts to argue that ancient reports are exaggerated because hand-slingers cannot do the sort of damage reported. See above, point 6 on p. 162.

120 See Rihll 2007, 102 on Livy 38.21.14 and 38.22.5, with n.39 on pp. 314-15.

Athens have been associated with the Sullan siege (the ΔΕΞΑΙ type); they weigh *c.*95-115 gm.[121]

11. If hand-slings were as good as claimed, and if they could outdistance the bow, why did the Roman army not recruit and employ hand-slingers as a specialized force?[122] Even on campaigns such as Arrian's against the Alans, which was furnished with "an exceptionally high proportion of auxiliary archers to protect the heavier infantry from cavalry",[123] slingers are not mentioned in the dispositions.

12. If legionaries are supposed to have been slinging *glandes*, such as those inscribed LEG XII,[124] where on their person are they supposed to have kept caches of *glandes* as they marched into battle, and at what point in an engagement are they supposed to have thrown them?

13. Xenophon associates becoming a slinger with disarmament: Cyrus allowed willing allies to keep whatever arms they bore, but forced unwilling allies to surrender their arms and serve as slingers.[125] By the time they got to Babylon, there were innumerable slingers. Neither Cyrus' alleged action nor Xenophon's explanation makes sense if slingers bore a significant weapon.

14. Ancient illustrations of hand-slingers show objects much larger than the typical lead *glans* in the sling or (if no slingshot is visible) pouches that appear greatly oversized for a typical lead *glans*.[126]

15. If lead bullets were commonly shot from catapults, why is this not clearer from the textual record?[127] This depends on what we understand by certain key terms and what assumptions we make. The words βέλη and *tela* cover a multitude of types of missile. Appian (*BC* 5.12.119) says that stones, fire-lances and arrows are examples of missiles thrown by machine and by hand (βέλη τὰ μὲν ἐκ μηχανῆς τὰ δ'ἀπὸ χειρῶν ὅσα λίθοι καὶ πυρφόρα καὶ τοξεύματα). Do we suppose that Roman troops threw fire-lances and arrows as they might throw, say, javelins?[128] Here 'by hand' surely does not mean 'grasped by the fingers', but by hand-held sling and hand-held bow, as opposed to by mechanical sling and mechanical bow. Mechanical slings and bows are known otherwise as stone-throwing and sharp-casting catapults.

16. Use as catapult ammunition could explain some of the variations in shape: the almond shape would have sat nicely in a sling pouch of a stonebow device, while the slug would have been stable in a flat channel of a catapult slider when launched from a dual-function catapult (one that could shoot stones and sharps).

17. Finally, a classic reference to hand-slinging (Diod. Sic. 5.17-18) refers explicitly to large *stones*, not *glandes*. It asserts that the best ancient hand-slingers disabled those they hit, and

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121 Parsons 1943.

122 Goldsworthy 1996, 19 and 186; compare archers.

123 Ibid. 234.

124 de Minicis 1844, 48-52.

125 Xenophon went on to observe (*Cyr.* 7.4) that slingers were very useful in combination with other troops in certain circumstances.

126 Völling 1990 reproduces most Roman representations. For Greek ones, see the Beazley archive (e.g., BM 1843.11-3.40, 1896.6-21.3, E285; Bologna Museo Civico Archeologico 204; New York Metropolitan Museum 10.210.11; Munich Antikensammlungen 2104) or Brélaz and Ducrey 2003, 23 fig. 4, 24 figs. 3-4.

127 We label catapults 'artillery' and assume correspondingly-sized ammunition, but it has become clear that there were little catapults too: Campbell (1986, 128-32) and Baatz (1999) argued for the existence of little catapults. See now Rihll 2007, 91-105. Both Campbell and Baatz assumed that such a hand-weapon would only have shot sharps, but there is no reason in principle why it should not have launched shot (bullets). In mediaeval times there was a stonebow as well as a crossbow, shooting marble-sized stones, not along a slider but across empty space, as the 'stock' of this weapon curved down out of the way, like a Roman crossbow brooch which perhaps reproduces the design of the weapon (see fig. 3). Ricochet off the fore sight is not noted as a problem with these mediaeval weapons.

128 This has implications for the hand-thrown stone. Griffiths (1992, 8) showed that hand-thrown stones have a short range, up to 31 m on the flat, which is about the same range as a *pilum*: Goldsworthy 1996, 183. Griffiths's findings suggest very limited use for the hand-thrown stone except in defence of a fortified position. It is hard to imagine their usefulness in the situation described by Appian, the early stage of a naval battle before the ships drew close.

that more ordinary hand-slingers, such as Josephus' Jews, 'produced nothing but noise when their pebbles struck men well protected by armour.' This is again inconsistent with penetrating injuries in flesh and impact craters in walls. The inference is that those craters and injuries were caused not by hand-slingers but by catapults, shooting *glandes*.

T.E.Rihll@swansea.ac.uk Dept. of Classics, Ancient History & Egyptology, Swansea University

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