

ANCIENT CATAPULTS

SOME HYPOTHESES REEXAMINED

ABSTRACT

Recent summaries and overviews of the development of ancient catapults have mistaken working hypotheses for established fact. Key areas of misunderstanding include the invention of the catapult, the development of the torsion principle, the meaning of the terms *euthytone* and *palintone*, and the possible use of sling bullets as catapult missiles. A critical reexamination of these questions, setting them within the framework of the known facts, reveals the fragility of the accepted history of the catapult, as currently presented in general handbooks.

INTRODUCTION

In the field of classical archaeology, a new and interesting hypothesis can be useful in jogging a tired debate onto a new path for exploration.¹ But some hypotheses, attractive at first sight, turn out to be dead ends because they employ fundamentally flawed reasoning.

The study of ancient artillery provides a well-known example of a badly formulated hypothesis, and demonstrates the unwelcome consequences that can ensue. In 1867, a Greek text entitled Ἡρώνης χειροβαλλίστρας κατασκευὴ καὶ συμμετρία (“Heron, Construction and Dimensions of the Hand-Ballista,” nowadays usually called “Heron’s *Cheiroballistra*”) was published in a collection of ancient military treatises.² It appeared to describe the component parts of a small catapult. An initial attempt by the French engineer Victor Prou to build the device was condemned as fanciful,³ and his interpretation of the text was subsequently discredited by the German

1. I thank Michael Lewis and the editor of *Hesperia* for their comments on an earlier draft of this paper, and Aitor Iriarte for permission to reproduce his splendid palintone drawing as Figure 3. Figures 1, 2, and 4 appear by courtesy of Osprey Publishing Ltd.

Finally, I should like to record my debt to Dietwulf Baatz for assistance and advice over the course of 25 years, while acknowledging that he may not agree with everything in this paper. The technical treatises of Biton, Heron, Athenaeus Mechanicus, and

Apollodorus of Damascus are cited by the page numbers of Wescher 1867 (W), those of Philon by the page numbers of Thévenot 1693 (Th). All translations are my own.

2. Wescher 1867, pp. 123–134.

3. Prou 1877.

philologist Rudolf Schneider.⁴ Schneider's bold hypothesis, that the text labeled with the name of a catapult (for what else could a *cheiromballistra* be?) was, in fact, no such thing, effectively derailed the study of the iron-framed ballista and took it down a blind alleyway, where it remained for 60 years.

It could have ended otherwise. The fraternity of artillery scholars chose to favor Schneider's opinion over those of his critics, chiefly Karl Tittel, who urged that "the technical terms point unmistakably to the construction of an artillery-piece."⁵ It was only after the text was rescued by Eric Marsden that it was again taken seriously as a description of a catapult.⁶

If we are to maintain the rigor of our discipline, we must be careful to rein in the kind of "blue-sky" thinking that Schneider freely employed, or at least subject it to careful scrutiny. In particular, at a time when several authors have recently presented their versions of the development of the catapult for a wider readership, we must ensure that any hypotheses are firmly based on evidence, not on groundless speculation.

PROBLEM 1: THE INVENTION OF THE CATAPULT

The invention of the catapult has proved fertile ground for such speculation. This is the unfortunate result of a dearth of reliable evidence, which makes it difficult to place the subject on a scientific footing. Consider the catapult's first appearance in the Mediterranean world. Our assessment of this critical event relies on the judgment of the 1st-century B.C. Greek historian Diodoros. Writing about the preparations begun in 399 B.C. by Dionysios I for war with Carthage, he claimed that "the catapult was invented at that time in Syracuse."⁷ Indeed, when it was finally unveiled during the siege of Motya in 397 B.C., "this weapon created great consternation, because it was only invented at that moment."⁸

Earlier researchers took this statement literally, and debated whether Diodoros was writing about the fully developed torsion catapult, which derived its power from twin skeins of rope made of hair or sinew, or its predecessor, the *gastraphetes*, a handheld device based on the composite bow.⁹ Diodoros does not help; although he initially calls the device a *katapultikon*, a word used elsewhere to indicate the *gastraphetes*,¹⁰ he soon changes to *katapeltes*, the standard Greek term for a catapult.

4. Schneider 1906.

5. *RE* VIII.1, 1912, cols. 1040–1041, s.v. Heron [5] von Alexandria (K. Tittel). Crucially, Tittel's opinion was ignored by Schramm (1928, p. 228), who followed Schneider in claiming that "the term χειροβαλλίστρα is of Byzantine origin and has been inserted erroneously as the heading for a fragment from a technical lexicon."

6. Marsden 1971, pp. 206–210, although his analysis is badly flawed; cf. Campbell 2003, pp. 38–40.

7. Diod. Sic. 14.42.1: καὶ γὰρ τὸ καταπελτικὸν εὐρέθη κατὰ τοῦτον τὸν καιρὸν ἐν Συρακούσαις.

8. Diod. Sic. 14.50.4: καὶ γὰρ κατὰ πληξιν εἶχε μεγάλην τοῦτο τὸ βέλος διὰ τὸ πρότως εὐρεθῆναι κατ' ἐκείνον τὸν καιρὸν.

9. Torsion catapult: Schneider in

RE VII.1, 1910, col. 1304, s.v. Geschütze; followed by Schramm 1918, p. 18; Garlan 1974, pp. 166–168. Non-torsion *gastraphetes*: Tarn 1930, p. 104; Marsden 1969, p. 49. The developmental relationship between the two types of artillery is explained by Heron (see nn. 20 and 21, below).

10. The two terms are equated in Biton 6 (W 61–62).

Setting aside the ambiguity of terminology, it is clear that, even in ancient times, some confusion existed over the invention of the catapult.¹¹ The Roman encyclopedist Pliny the Elder followed an entirely different tradition in attributing to different nations the various artillery pieces known in his day: “Hunting spears and, among the artillery, the scorpion (were invented by) the Cretans, the catapult (by) the Syrians, the ballista and the sling (by) the Phoenicians.”¹²

This confusion extended also to the dissemination of the catapult across the Mediterranean world. The historian Livy, for example, writing around the same time as Diodoros, assumed that the heroic M. Furius Camillus would have thought in terms of catapults when he contemplated a siege of Antium in ca. 386 B.C., for he wrote that “such a powerful town could not be captured without great preparation of artillery and machinery.”¹³ In a similar vein, the Late Roman writer Vegetius soberly recorded that the men defending the Capitol against the Gauls in 390 B.C. were reduced to resprings their catapults with women’s hair when the original sinew-rope became worn out by continuous shooting.¹⁴

Neither Livy nor Vegetius saw any contradiction in introducing the torsion catapult (by definition, Livy’s *tormenta* must imply the fully developed machine) into Roman history at a time when the weapon was still in its infancy. Of course, no one would seriously consider taking Livy at his word in this passage. It is clear from the remainder of his narrative that artillery only entered the Roman consciousness from the time of the Punic Wars, and, even then, did not always suit the Roman style of combat.¹⁵ Likewise, Vegetius was obviously misled on this occasion, as on so many others.

So why should we retain the date of 399 B.C. in the history of the catapult? The answer is simple. Diodoros’s sources, ultimately drawing upon the eyewitness Philistos, clearly thought that the date was important as the moment when the catapult, still at the stage of the composite-bow-based *gastraphetes* and analogous bow-machines (Fig. 1), achieved widespread recognition. It seems perfectly possible that this machine was already under development, if we can trust the clues that the Hellenistic writer Biton has left for us.¹⁶ A dispassionate consideration of the literary sources, however, demonstrates that the torsion catapult lay some distance in the future, and that the impact of the bow-machine on the Mediterranean consciousness was a slow one.

It is significant that neither Thucydides nor Xenophon mentions catapults. Although their silence cannot prove that no catapults existed, it nevertheless complements the broad picture of the development of bow-machines in the years leading up to 399 B.C., when it received a fillip from

11. The point has already been made by Schellenberg (2006, pp. 15–16).

12. Plin. *HN* 7.201: *venabula et in tormentis scorpionem Cretas, catapultam Syros, Phoenicas ballistam et fundam [invenisse]*. I follow the text of Schilling’s edition (1977, p. 116, with p. 246, n. 7) as the most sensible. An alterna-

tive reading with altered punctuation attributes the hunting spears and the *scorpio* to a man named Pisaeus and the catapult to the Cretans.

13. Livy 6.9.2: *nisi magno apparatu tormentis machinisque tam valida urbs capi non poterat*.

14. Veg. *Mil.* 4.9. The story is also

found in Lactant. *Div. inst.* 1.20.27; Serv. on Verg. *Aen.* 1.720. Marsden (1969, p. 83) realized that this was an etiological myth.

15. See, e.g., Campbell 2006, pp. 94–95.

16. Noted in Campbell 2003, pp. 3–5; 2006, p. 50. See also n. 18, below.

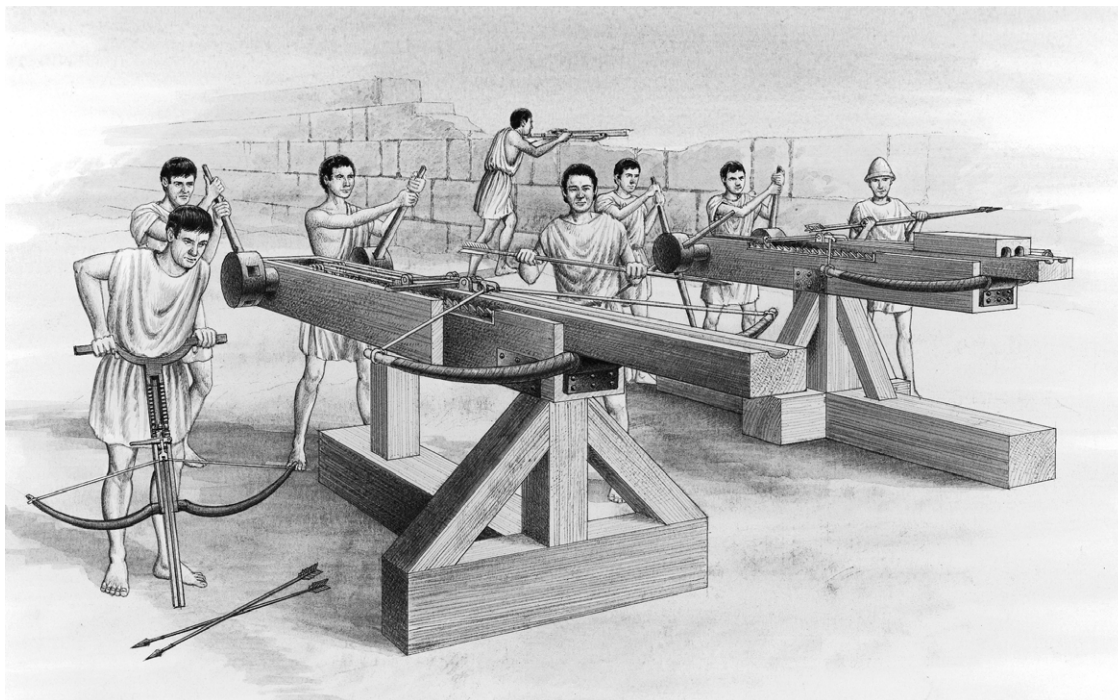


Figure 1. Reconstruction of the *gastraphetes* (left) and related bow-machines, based on the descriptions of Biton. Painting Brian Delf, from D. B. Campbell, *Greek and Roman Artillery 399 B.C.–A.D. 363*, p. 25, pl. A. © Osprey Publishing Ltd.

the patronage of Dionysios I.¹⁷ If this reconstruction of events is correct, it is interesting that Biton describes two different types of bow-machine prior to that date,¹⁸ since according to Diodoros “catapults of every kind and a great number of other missile weapons were prepared” by Dionysios.¹⁹

PROBLEM 2: THE INVENTION OF THE TORSION PRINCIPLE

Our only source for the developmental trajectory of the catapult is Heron of Alexandria, who states that dissatisfaction with the performance of the hand bow led to the invention of the *gastraphetes*.²⁰ In a similar fashion, he alleges that dissatisfaction with the *gastraphetes* in turn led to the development of the torsion catapult.²¹ It is often assumed that the torsion catapult displaced the bow-machine,²² but neither Heron nor anyone else says this. Indeed, the work of Biton, which has been convincingly dated to ca. 155 B.C.,²³ demonstrates a continued interest in the *gastraphetes* at least until that time, and it remains a possibility that a similar design survived in the *arcuballista* mentioned by Vegetius.²⁴

17. Schellenberg (2006, p. 15) is right to question Marsden’s reliance on the *argumentum ex silentio* (Marsden 1969, pp. 49–50), but I believe that he is wrong to criticize Marsden’s reasoning as circular.

18. Biton 6 (W 61–64), on a *gastraphetes* built at Miletos; 7 (W 65–67), on

a “mountain *gastraphetes*” built at Cumae. See Campbell 2006, p. 50, for the likely dating.

19. Diod. Sic. 14.43.3: κατεσκευάσθησαν δὲ καὶ καταπέλται παντοῖοι καὶ τῶν ἄλλων βελῶν πολὺς τις ἀριθμὸς.

20. Heron *Bel.* 4 (W 75); the construction of the machine is described in

5–7 (W 75–81), and Heron names it a *gastraphetes* in 7 (W 81).

21. Heron *Bel.* 8 (W 81–82).

22. E.g., Marsden 1969, p. 63.

23. Lewis 1999.

24. Veg. *Mil.* 2.15, 4.21–22. Cf. Campbell 1986, p. 131.

Marsden developed a theoretical timetable for the development of the torsion catapult, beginning ca. 350 B.C. with his Mark I machine and moving through Mark II (“before 340”) and Mark III (“after 340/before 334,” with the stone-projector appearing in 334–331), before arriving at the fully developed Hellenistic catapult (Mark IVA, “arrow-shooting,” and Mark IVB, “stone-throwing”) in ca. 270 B.C.²⁵ As a working hypothesis, Marsden’s scheme has been useful, but his dates and stages are rather arbitrary. All we can say is that torsion catapults of some description were probably in storage at Athens by 330/29 B.C.,²⁶ and were definitely there by 306/5 B.C.²⁷ The design only reached maturity, however, under the patronage of the Ptolemies of Alexandria, when constructional rules were formulated to guarantee machines of the optimum design.²⁸

Schneider believed that Athens possessed torsion catapults already in ca. 350 B.C., on the basis of a fragment of an inscribed inventory of 363/2 B.C.²⁹ The inventories of the late 360s and 350s do not, however, specify torsion catapults in particular, nor does the broadly contemporary writer Aeneas Tacticus, in his one reference to catapults.³⁰ Indeed, in its infancy, the torsion catapult must have seemed rather unpromising, and may have required the sponsorship of a powerful patron to see it through to the functional stage. It seems possible, even likely, that Philip II of Macedon initially provided this patronage, but there is no direct evidence to prove this.³¹

Catapults are certainly mentioned in a fragment of an Athenian comedy lampooning Philip’s Macedonians as men who preferred warfare to fine dining. “Do you realize that your fight is against men who dine on sharpened swords, and gulp down flaming torches as a delicacy?” the playwright imagines them saying, and continues: “Then, right after the slave brings us Cretan arrows as an after-dinner snack, just like chickpeas, and the shattered fragments of spears, we use shields and cuirasses as pillows, with slings and bows at our feet, and crown ourselves with catapults” (Mnesimachos,

25. Marsden 1969, p. 43, where the scheme is presented in tabular form.

26. *IG* II² 1627, lines 328–341; conveniently quoted in Marsden 1969, p. 57. In particular, the presence of *πλαίσια καταπαλτων* (“frames of catapults”) suggests torsion catapults, *pace* Rihl (2007, p. 65); cf. Campbell 2008, p. 2.

27. *IG* II² 1487, lines 84–90; conveniently quoted in Marsden 1969, p. 70. Garlan (1974, p. 216) dates it to 307/6 B.C. The critical lines are 89–90, *ἕτερον [καταπάλ]την τρισπίθαμον νευρότονον*, specifying “another three-span catapult with sinew springs.”

28. Such appears to be the gist of *Philon Bel.* 3 (Th 50). Cf. Marsden 1969, p. 62.

29. *RE* VII.1, 1910, col. 1305,

s.v. *Geschütze*, citing *IG* II² 1422, line 9: *[σώρακοι καταπ]αλτων δύο*[o]. Marsden (1969, p. 65) dated the inscription to 371/0 B.C. and Garlan (1974, p. 172) to “vers 370/69”; 363/2 is proposed by Cole (1981, p. 218). The same entry appears in subsequent inventories: *IG* II² 120, line 37 (353/2 B.C.); 1440, line 48 (350/49 B.C.), the latter restored. Marsden preferred to translate the recurring phrase *σώρακοι καταπαλτων δύο* as “two boxes of catapult bolts” (followed by Garlan 1974, p. 172), on analogy with the boxes of arrows that were also in storage; but the inscription refers explicitly to “two boxes of catapults,” which surely indicates the machines or their components rather than ammunition. Cf. Tarn 1930, p. 105: “two catapults at Athens.”

30. *Aen. Tact.* 32.8: *ἄλλα τε καὶ καταπάλται καὶ σφενδόνας*. Tarn (1930, p. 105) observes that catapults were coupled with slings “doubtless as being the two weapons which would outrange a bow.” The same conjunction, not uncommon in the sources, is found in, e.g., *Arr. Anab.* 4.30.1; *Diod. Sic.* 17.42.1, 7.

31. Marsden (1977, p. 216) presented the case: “Efficient torsion catapults could only have been successfully produced, if time and suitable conditions had been made available for quiet research and then conduct of experiments. Considerable financial expenditure would have been essential, also. Philip II created the right situation in Macedonia.”

Philip fr. 7 K-A).³² But these are not necessarily torsion catapults, and could equally well be bow-machines.

It is commonly believed that Alexander the Great deployed torsion catapults. Indeed, this was one of the fixed points in Marsden's chronology.³³ In particular, the *petroboloi* (stone-projectors) that abruptly appear at Tyre in 332 B.C., and just as abruptly disappear again, are thought to have been torsion weapons.³⁴ But again there is no evidence to prove such a hypothesis.³⁵ A cache of stone balls from the so-called cenotaph of Nikokreon at Salamis (Cyprus), carefully rounded and many of them weight-marked, certainly suggests that torsion stone-projectors existed by 311 B.C., when the tumulus is thought to have been constructed.³⁶ But we arrive on firm ground only with the Athenian inventories of 306/5 B.C.³⁷ Most frustratingly, we must wait for over a century before the torsion catapult appears in sculpture, among the weapons depicted as spoils on panels from the stoas in the sanctuary of Athena at Pergamon, erected by Eumenes II (197–158 B.C.), probably late in his reign.³⁸

EXCURSUS: THE HELLENISTIC TORSION CATAPULT

The torsion arrow-shooter, which remained in use in more or less unaltered form into the Early Principate, is well known from modern reconstructions (Fig. 2). The bow of the bow-machine was replaced by two wooden arms and a torsion frame (πλινθίον or *capitulum*), which held two vertical springs. The torsion frame was fixed at the front of the stock (σῦριγξ or *canaliculus*), and a vertical winch was fixed at the rear. The grooved slider on which the arrow sat (διώστρα or *canalis fundus*) was free to run along the top of the stock, so that it could project through the torsion frame when the machine was at rest. Toward its rear was fixed a trigger mechanism, incorporating a claw (χείρ or *epitoxis*) that grasped the bowstring when the slider was fully forward; as the slider was winched backward, it pulled the bowstring with

32. Quoted by Ath. 10.421c. The fragment is thought to date from ca. 345 B.C. The critical last line reads καταπάλλταισι δ' ἐστεφανώμεθα.

33. Marsden 1969, p. 104: Alexander "owed his greater success to the superior siege-machines and artillery (especially the recently developed Mark IIIB stone-throwers)."

34. Diod. Sic. 17.42.7: τοῖς μὲν πετροβόλοις κατέβαλλε τὰ τεῖχη, τοῖς δ' ὀξυβελέσις ἀνείργε τοὺς ἐπὶ τῶν ἐπαλξεων ἐφεστῶτας; 43.1: τοὺς δ' ἐκ τῶν πετροβόλων φερομένους λίθους; 45.2: ὁ δ' Ἀλέξανδρος ἐπιστήσας ἐπὶ τοὺς ἀρμόζοντας τόπους τοὺς πετροβόλους καταπέλτας καὶ λίθους μεγάλους ἀφίει ἐσάλενε τὰ τεῖχη. Arrian (*Anab.*

1.22.2) is perhaps mistaken to record stone-projectors on the Macedonian siege towers at Halikarnassos in 334 B.C.: ταῖς μηχαναῖς ἀπὸ τῶν πύργων λίθων τε μεγάλων ἀφιεμένων.

35. Marsden (1969, pp. 61–62) argued that "these engines were almost certainly torsion stone-throwers, because I doubt whether even the most powerful non-torsion machines would have been worth using for this purpose" (i.e., battering the walls). But as it transpired, of course, the stone-projectors were *not* worth using for this purpose, and they completely disappear from the ensuing narrative.

36. Marsden 1973; cf. Campbell 2003, p. 19. The report appeared too

late to be discussed in Garlan 1974, and is not noted in Rihll 2007.

37. See n. 27, above. Perhaps also *IG II²* 1467, lines 48–56; conveniently quoted by Marsden (1969, pp. 56–57), who observes that "the form of the lettering in the inscription apparently belongs to the Lycurgean period, 338–326 B.C." Marsden's date is accepted by Rihll (2007, p. 79); the date of 306/5 is suggested by Garlan (1974, p. 217).

38. The relief has been frequently illustrated: e.g., Schramm 1918, p. 35, fig. 9; Marsden 1969, pl. 3; Baatz 1982, pl. 45:1; Campbell 2003, p. 22; Rihll 2007, p. 129, fig. 6.3. For the dating, see Webb 1996, p. 57.

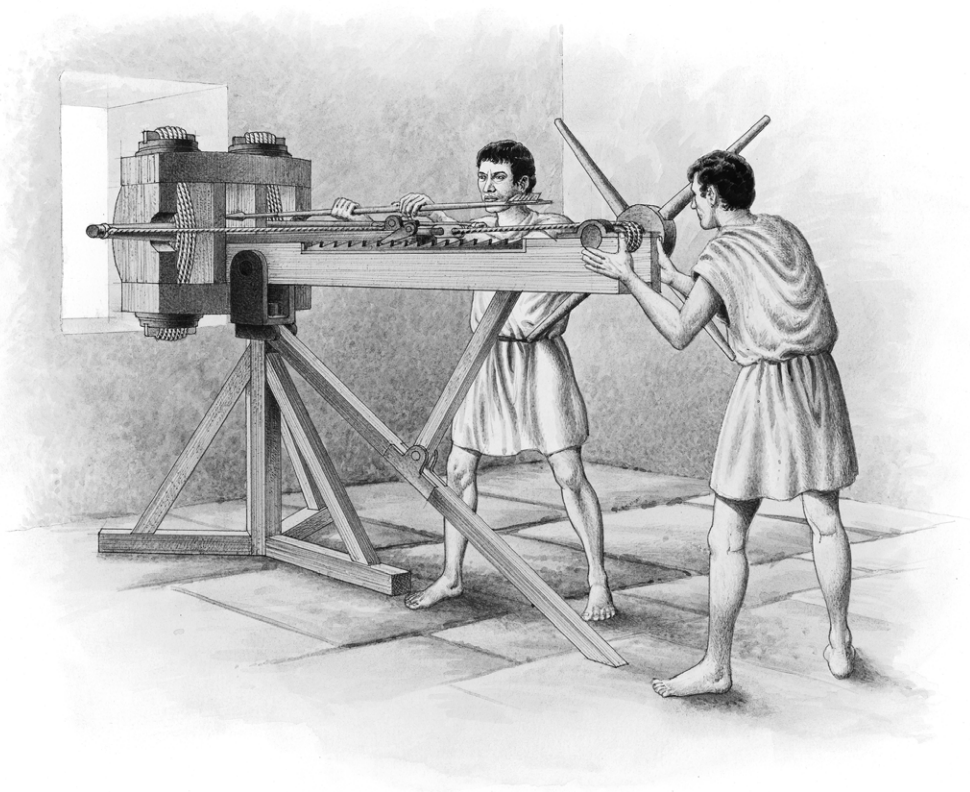


Figure 2. Reconstruction of the largest of the Ephyra catapults as a “four-foot” euthytone arrow-shooter, based on the descriptions of Heron and Philon. Painting Brian Delf, from D. B. Campbell, *Greek and Roman Artillery 399 B.C.–A.D. 363*, p. 26, pl. B. © Osprey Publishing Ltd.

it, thus spanning the machine. The trigger mechanism enabled the claw to release the bowstring in order to shoot the arrow. The entire machine sat on a base, to which it was connected by a tilt-and-swivel joint.

In a machine constructed mostly from timber, one of the few components that might be expected to survive in the archaeological record is the metal *χοινικίς* or *modiolus*, for which Marsden coined the term “washer.” Its use is explained by the Hellenistic technical writer Philon of Byzantium: “Bronze washers are fitted over the holes in the *peritreton*, and over the middle of these are placed the so-called iron levers, and the spring, having been wrapped around these, is stretched through the whole frame.”³⁹

Thus, the washer’s purpose was to hold the spring in place; and, as every two-armed catapult had two vertical springs, four washers were required. Each torsion spring was created, in the first place, by laboriously feeding the sinew-rope through one washer and down through the spring frame to the opposite washer, where it was pretensioned before feeding it around the iron lever and back up through both washers again, pretensioned again, and fed around the other lever. This process was repeated until no more sinew-rope could be forced through and a tight skein had been created. The wooden bow arm of the catapult was inserted through this skein.

39. Philon *Bel.* 23 (Th 60): ἐπὶ γὰρ τὰ τρήματα τῶν περιτρήτων χοινικίδες ἐφαρμόζονται χαλκαῖ, μέσαι δ’ ἐπ’ αὐταῖς αἱ καλούμεναι τίθενται ἐπιζυγίδες σιδηραῖ, περὶ ἃς ὁ τόνος καμφοθεὶς τεί-

νεται δι’ ὅλου τοῦ πλινθίου. The *peritreton*, or “perforated board,” which constitutes the top and bottom of the torsion frame, is Marsden’s “hole-carrier” (1971, p. 52, n. 28). He also coined the

term “lever” to translate the Greek ἐπιζυγίς, the “cross brace” around which the torsion spring was wrapped at the top and bottom as it was fed through each washer (1971, p. 53, n. 30).

Each catapult was tailored to a missile of particular size, and arrow-shooters were defined by the length of their arrows.⁴⁰ By the mid-3rd century, ancient artificers had decided upon an optimum set of proportions for the arrow-shooting catapult (and a different set for the stone-projector, defined by the weight of the stone shot), so that any given design could be scaled up to produce weapons of different calibers. The basic module was the thickness of the torsion spring, most easily expressed as the inner diameter of the washer through which the spring was fed. Thus, from any given washer, the size and caliber of the appropriate catapult may be calculated, and vice versa.⁴¹

The torsion springs were installed under extreme stress, but Philon laments the fact that “in the acts of shooting and repeated spanning, the spring becomes slackened and needs to be tightened again; for the range of shooting suffers on account of this loosening process. Now, it so happens that those wishing to tighten it are not able to apply the stretching vertically and in a straight line, but produce it by twisting, giving a twist more than is natural or proper.”⁴² In other words, instead of stripping the torsion springs down and starting the whole process again, the artilleryman could simply twist them to achieve a quick fix.

This was the job of the washer. It could be turned in order to twist the skein of sinew-rope, thus exerting more torsion and rejuvenating a slackened spring. Once turned, however, the washer required some mechanism to hold it in its new position. It is interesting that Philon describes the *peritreton*, prior to the torsion frame’s assembly, as being “drilled and perforated on every side and thickly covered with the holes that surround the circles.”⁴³ Schramm’s collaborator, Hermann Diels, astutely conjectured from this passage that a system of pinholes might have served to hold the washer in place. He was triumphantly vindicated by the archaeological finds.⁴⁴

Many examples of these washers have now come to light, largely thanks to the tireless efforts of Dietwulf Baatz.⁴⁵ The earliest datable examples were found in the ruins of a fortified farmstead near Ephyra in Epiros, destroyed by the Romans in 167 B.C. The total assemblage of 21 washers came from at least seven different weapons of various sizes.⁴⁶ Most interestingly, one set had been cast with a sequence of 15 ratchet teeth around

40. Thus, a “three-span” arrow-shooter was designed to shoot arrows measuring three spans in length (ca. 69 cm), while a “four-foot” arrow-shooter was considerably larger, having been designed for arrows measuring ca. 1.22 m. Hultsch (1882, p. 697, table II) estimates the span at 23.12 cm and the foot at 30.83 cm.

41. See Baatz 1979, pp. 74–75, for an exemplary discussion.

42. Philon *Bel.* 18 (Th 58). Cf. Heron *Bel.* 29 (W 110) for the same advice.

43. Philon *Bel.* 16 (Th 57): κεκενωμένον καὶ διασυγζόμενον πάντοθεν καὶ καταπεπικνωμένον τοῖς περιέχουσιν

τοὺς κύκλους τρήμασι. It is a reasonable assumption that Philon’s *kykloi* are the spring holes, although he elsewhere calls them *tremata*.

44. As noted by Schramm (1918, p. 43). Until the 1970s, the only known catapult remains from antiquity were those of the Ampurias catapult: see Schramm 1918, pp. 40–46. The four bronze washers, still with iron levers in place, were equipped with six pinholes, arranged in two groups of three; the counterplate (*hypothema*) on which each washer sat was equipped with sixteen equidistant holes, so that tiny adjustments of 7½° could be made.

45. See Baatz 1994c for the state

of play in that year. In the same year, two washers in Morocco were published (Boube-Piccot 1994, pp. 195–197), and further examples are now known from Zeugma in Turkey (Hartmann and Speidel 2003, p. 8, fig. 8) and Costești-Cetățuie in Romania (Gheorghiu 2005), as well as a fragment from Herlheim (Steidl 2006, p. 313, fig. 4:2) and a set of four from Xanten, still attached to the torsion frame (Schalles 2005).

46. Baatz 1982; Campbell 2003, pp. 13–14. The dating appears to derive from the historical record of Roman activities in that year (e.g., Livy 45.34), rather than from any scientific analysis.

the rim, instead of pinholes. This arrangement, which logically predated the adoption of pinholes, has also been recognized on two washers from the Mahdia shipwreck and another discovered at Sounion in 1900 but now lost.⁴⁷ Other known remains date broadly from the Roman era.

PROBLEM 3: THE DESIGN OF THE PALINTONE CATAPULT

When ancient Greek authors mentioned catapults, they occasionally differentiated between the “arrow-shooter” (ὄξυβελής) and the “stone-projector” (λιθοβόλος or πετροβόλος). Similarly, Roman authors of the Early Principate drew a distinction between the arrow-shooting *scorpio* and the stone-projecting ballista. Technically, the arrow-shooter was designated a euthytone (εὐθύτονος), whereas the stone-projector was a palintone (παλίντονος), reflecting a fundamental difference in design.

In addition, there was usually a difference in size. The smallest stone-projector in anything approaching common use was probably the 10-mina model, with which Philon begins his checklist of standard sizes.⁴⁸ He recommends it as a useful machine, not only to counter enemy artillery in a siege, but also to repulse a successful besieger during any ensuing street fighting.⁴⁹ But this was not a small machine: its stock was fully 4 m long. Furthermore, with a spring diameter of 11 dactyls (21.2 cm), the corresponding washers would have been larger than any so far discovered; in fact, they may well have been crafted out of wood, as Heron advises “for larger machines” (*Bel.* 20 [W 96–97]).

Archaeologists have found ample evidence of the stone shot used by palintones, and, with less certainty, the arrowheads from the missiles shot by euthytones. Beautifully finished stone balls of 10-mina caliber, for example, with an average diameter of 15 cm, have been discovered at Rhodes and Tel Dor.⁵⁰ However, the picture is complicated by the fact that the design of the palintone permitted it, on occasion, to shoot both sorts of missile.

Heron states that, “of the devices that I have mentioned, some are euthytones, but others are called palintones; some call the euthytones scorpions from the resemblance in shape.” He goes on to explain that “the euthytones shoot arrows only, but some call the palintones stone-projectors because they discharge stones; but they also shoot arrows or both.”⁵¹ Indeed,

47. Mahdia: Baatz 1985. Sounion: Williams 1992.

48. Philon *Bel.* 6 (Th 51). The “10-mina” stone-projector was designed to shoot stones weighing ca. 4.4 kg; larger stones required larger stone-projectors. Philon lists machines designed for missiles weighing 10, 15, 20, 30, and 50 minae, and 1, 2, and 2½ talents, the last two following Drachmann’s emendation of the text (1954, p. 280). The data is tabulated in Campbell 2003, p. 18. Smaller

machines were, no doubt, used on occasion. Philon elsewhere recommends a two-mina stone-projector for the protection of sappers during tunneling work (*Pol.* 4.31 [Th 99]); with a spring diameter of 6.4 dactyls (12.4 cm), the torsion frame of such a machine was still over a meter high.

49. Philon *Pol.* 3.6 (Th 91), 4.17 (Th 98) (against enemy artillery), 3.26 (Th 93) (street fighting).

50. Rhodes: Laurenzi 1938, p. 33. Tel Dor: Shatzman 1995, p. 61. None

of the stone balls from Pergamon or Piraeus is as small as this.

51. Heron *Bel.* 3 (W 74): τῶν οὖν εἰρημένων ὀργάνων τὰ μὲν ἐστὶν εὐθύτονα, τὰ δὲ παλίντονα καλεῖται· τὰ δὲ εὐθύτονα τινες καὶ σκορπίους καλοῦσιν ἀπὸ τῆς περὶ τὸ σχῆμα ὁμοιότητος. τὰ μὲν εὐθύτονα οἷστοὺς μόνους ἀφήσι· τὰ δὲ παλίντονα ἐνιοὶ καὶ λιθοβόλα καλοῦσι διὰ τὸ λίθους ἐξαποστέλλειν· πέμπει δὲ ἥτοι οἷστοὺς ἢ καὶ συναμφοτέρα.

ancient authors occasionally describe palintones shooting arrows of unusual size.⁵² In practice, the crossover was probably around the 10-mina mark, as a palintone of this size could, in theory, handle an “arrow” of four cubits (6 feet, or 1.85 m), which was much too large for a euthytone.⁵³

A defining feature of the euthytone was the presence of a grooved *diostra* (or “slider”) to take the arrow. The machine’s two torsion springs, each one often called a “half-spring” (ἡμιτόνιον), were fixed “the width of the *diostra* apart,”⁵⁴ creating a rather narrow, squarish torsion frame, which was constructed in one piece. By contrast, each of the palintone’s torsion springs was constructed individually; the two units were held in a framework “resting on some beams and separated from each other by a little more than twice the length of one arm.”⁵⁵

There have been few modern reconstructions of the ancient stone-projector, and without exception their designers have followed Schramm in ignoring this last instruction. Appealing to the testimony of Philon for the width of the palintone’s stock, or “ladder” (κλιμακίς) in technical parlance, Schramm concluded that “the entire breadth of the ladder corresponds to the interval between the spring frames.”⁵⁶ Thus, he simply replicated the narrow design of the euthytone’s torsion frame.⁵⁷

Schramm drew a discreet veil over the fact that his interpretation of the palintone’s torsion frame did not meet Philon’s requirement that “the length of the bowstring is two-and-a-tenth times the length of a bow arm.”⁵⁸ In fact, it is clear from Schramm’s drawings that his bowstring was actually two-and-a-fifth times the length of a bow arm.⁵⁹ This is an important deviation. Although it is clear that the bowstring was intended to arrest the movement of the arms, and in the process dissipate the slight

52. During the siege of Massilia in 49 B.C., the defenders used their largest ballistas to shoot “twelve-foot pointed shafts” (Caes. *B Civ.* 2.2). The significance is missed by Rihll (2007, p. 192), who believes that “the rarity of the very large sharps . . . suggests that the Massiliotes had their own engineering traditions.” On the contrary, they were simply using stone-projectors to shoot pointed beams of a weight equivalent to that of the usual stone missiles.

53. Athenaeus *Mechanicus* (W 8) mentions a palintone shooting a four-cubit arrow. It is perhaps no coincidence that the Athenian inventory of 306/5 B.C. includes a “catapult, complete, for throwing stones and shooting arrows of four cubits, [the work of?] Bromios”: [καταπά]λτην πετροβόλον καὶ ὅζ[υβε]λῃ - - - [τε]τραπάχηον ἐντελῇ Βρομίου[υ ἔργον?] (*IG II*² 1487, lines 84–86). In practice, the largest euthytone was probably designed to shoot arrows with a length of four feet (ca. 1.22 m),

pace Rihll (2007, p. 292); the largest of the Ephyra washers came from a machine of this caliber (see Fig. 2 for a reconstruction).

54. Heron *Bel.* 26 (W 104): τὰ δύο ἡμιτόνια εἰς ἓν πλινθίον σύγκειται, ἀπέχοντα ἀλλήλων τὸ τῆς διώστρας πλάτος. This can be seen in Figure 2.

55. Heron *Bel.* 22 (W 99): κείμενα ἐπὶ τινων κανόνων, καὶ ἀφεστῶτα ἀπ’ ἀλλήλων μικρῷ μείζον διπλάσιον τὸ τοῦ ἐνὸς ἀγκῶνος μήκος.

56. Diels and Schramm 1918, p. 36, n. 1; cf. Schramm 1918, p. 55. To support his hypothesis, he further postulated that Heron had drawn his observations from a 20-mina palintone, in which the ladder was 63 cm wide, “a little more than double the elbow-length of a man. Probably Heron had this catapult in mind, and he meant the length of the elbow, not the length of the bow arm.”

57. The design of Schramm’s palintone has been repeated in, *inter alia*,

Marsden 1971, p. 56, fig. 20; Campbell 2003, p. 16; Rihll 2007, p. 79. Indeed, Marsden’s reliance on Schramm’s reconstruction even led him to claim rashly that Heron had created a false impression of the positioning of the torsion springs (1971, p. 54, n. 31).

58. Philon *Bel.* 11 (Th 53–54): τὸ δὲ τῆς νευρᾶς μήκος διπλάσιον καὶ ἔτι δεκατημορίῳ τοῦ ἀγκῶνος μήκους πλέον.

59. In their discussion of this passage, Diels and Schramm (1918, p. 16, n. 1) make no mention of the problem, which is only apparent from their plate 4. Iriarte (2003, p. 126) has independently observed that, in Schramm’s reconstruction, a bowstring of the length prescribed by Philon is too short: “The arms could have travelled about 16° more and, which is more important, the task of stopping them would have to be performed by the sling itself and not by the counter-stanchions, as it should have been.”

residual energy, it is equally clear that the inner end of each bow arm came to rest against a component called the heel pad (ὑποπερνίς).⁶⁰ Schramm's version of the palintone, equipped with Philon's length of bowstring, would not permit this to occur.

It is worth noting here that Schramm drew upon a third ancient source, namely the artillery chapters of Vitruvius's *De architectura* and the description of the Roman ballista found there. But the crucial passage where Vitruvius describes the *regulae* (rods) connecting the two spring frames together is hopelessly garbled; and, in truth, the badly mutilated state of the Latin text ought to have dashed any hopes of using it as an independent check on Heron and Philon.⁶¹ Nevertheless, Schramm's familiar design of torsion frame has been widely accepted, despite the fact that he was obliged to alter some of Vitruvius's figures and disregard others to make them fit.⁶²

Many attempts have been made to divine the meaning of the terms εὐθύτονος (straight-stretched) and παλίντονος (backward-stretched), in order to understand the difference between the two types of catapult.⁶³ Schneider originally suggested that in the euthytone the torsion rope was wrapped only once around the torsion frame, whereas in the palintone it was wrapped around several times, but he later recanted, wisely.⁶⁴

In fact, the names seem originally to have been applied to hand bows. In the *Iliad*, the hero Teucer's bow was a τόξον παλίντονον, indicating that it was a recurve bow of composite construction.⁶⁵ By analogy, the self bow of simple construction (like the English long bow) might well have been designated a τόξον εὐθύτονον. The Danish scholar Aage Drachmann suggested that the shape of the front of the euthytone, viewed from above, emulated the smooth curve of the self bow, while Schramm's version of the palintone, with the twin torsion springs angled to project slightly forward, emulated the double bulge of the composite bow.⁶⁶

Schramm also recognized that the origin of the terms lay in the archer's vocabulary, but he concluded that the euthytone was "a straight-ahead, direct-shooting catapult," whereas the palintone "stood behind a shelter, or shot against targets that stood behind a shelter," and thus employed plunging fire.⁶⁷ Although this philosophy continues to attract adherents,

60. Heron *Bel.* 17 (W 93); Philon *Bel.* 35 (Th 66).

61. Vitruvius 10.10–12, on artillery; 10.11.6, on the *regulae*. On the difficulties of deciphering Vitruvius, see Wilkins 2003, p. 55.

62. Iriarte (2003, pp. 127–132) makes substantially the same point.

63. Lammert (*RE* X.2, 1919, col. 2482, s.v. Katapulta) noted with resignation that "the ancients give no explanation of these two terms"; cf. Garland 1974, p. 223, n. 2. Rihll's translation of εὐθύτονος as "easy-spring" (2007, p. 271) is baffling; in any case,

she has misunderstood the significance of the term (cf. Campbell 2008, p. 2), even imagining (2007, p. 68) that a euthytone could have in-swinging arms.

64. Schneider 1905; *RE* VII.1, 1910, col. 1310, s.v. Geschütze.

65. *Il.* 8.266, 15.443; cf. Odysseus's bow in *Od.* 21.11, 59. The term is also employed by Herodotus (7.69) to differentiate the bows of the Arabians from those of the Ethiopians.

66. Drachmann 1963, p. 188: "The *euthytonon* . . . is the long-bow showing a single curve; the *palintonon* . . . is the cupid's bow with a straight middle and

two arms showing double curves." This theory was adopted (without acknowledgment) by Marsden (1971, p. 45), from where it has passed into the general literature.

67. Schramm 1918, p. 14, n. 1. Barker (1920, p. 84), attributing the argument to Rüstow and Köchly, already demonstrated the unsuitability of this theory. Unfortunately, having realized that there must have been a *structural* difference between the two types of catapult, he nevertheless concluded that the difference was actually only one of size.

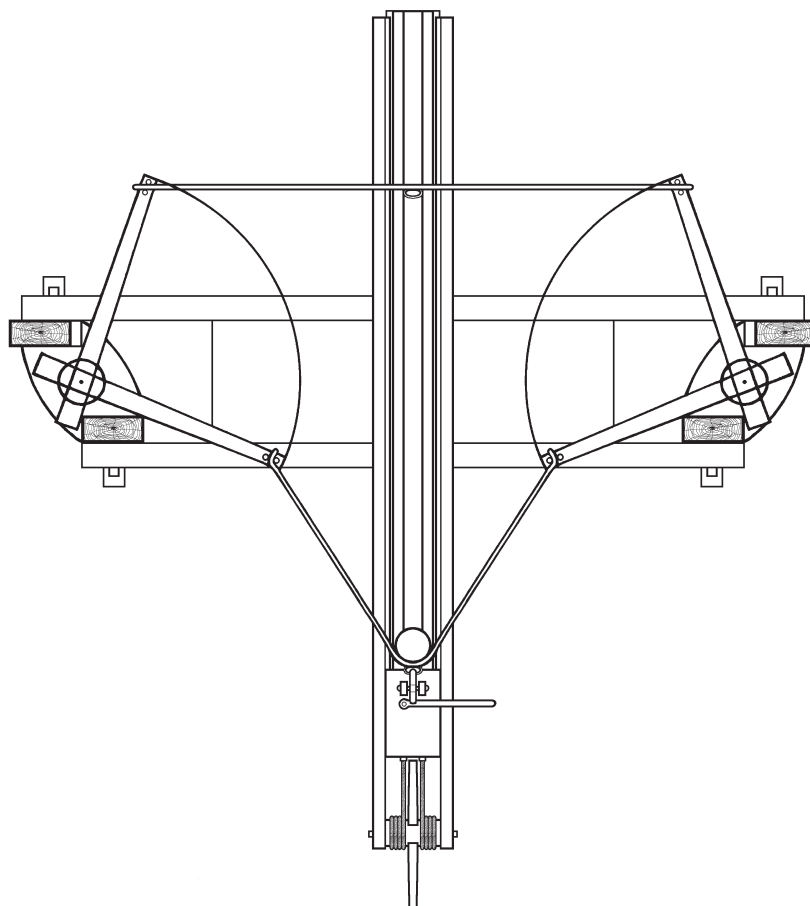


Figure 3. Reconstruction of the palintone torsion frame, following the suggestions of French researchers. Cutaway view from above showing the action of the inswinging arms. Drawing Aitor Iriarte

it was effectively discredited by Baatz, who has argued persuasively that “the stone-thrower was employed over relatively short distances as ‘flat-trajectory artillery,’ just like the arrow-shooter.”⁶⁸

In archery, a more obvious difference between the recurve bow and the self bow is that, at rest, the ends of the recurve bow (the “ears”) project forward. This was long ago noted by French scholars, who maintained that “when the two arms pointed away from the operator, this was a palintone catapult, by analogy with the oriental bow of the same name. When the two arms pointed toward the operator, as in the common bow, this catapult was called a euthytone by the theoreticians, in contrast to the other one.”⁶⁹ Or, stated differently, in the palintone “each arm swings inside the frame on either side of a middle position, and the total field of movement must be free; from that follows the impossibility of implementing the spring frame of the *catapultula* [i.e., the euthytone], where the stanchions would intrude in the field of movement.”⁷⁰

This solution, at once etymologically elegant and strikingly logical, has come to be known as “the inswinging theory,” in which the catapult arms point forward when at rest, and are drawn inward during the spanning process (Fig. 3).⁷¹ Such an arrangement makes perfect sense of Heron’s wide gap between the two torsion springs, in contrast to the narrow gap in the euthytone design, and employs a bowstring of Philon’s

68. Baatz 1994b, p. 143. Schramm’s “plunging fire” theory is rehashed by Rihll (2007, pp. 138–139), who fails to address the problems of reconciling indirect targeting with a requirement for pinpoint accuracy; cf. Campbell 2008, p. 3.

69. DarSag V, 1919, pp. 364–365, s.v. tormentum (A. de Rochas); cf. de Rochas 1884, pp. 783–784, n. 1.

70. Choisy 1909, vol. 1, p. 302; cf. DarSag V, 1919, p. 371, s.v. tormentum (G. Lafaye), where the palintone is described as “a catapult in which the bowstring was attached to the *internal* extremities of the two arms, instead of the *external* extremities, as in the euthytone.”

71. Iriarte 2003; cf. Campbell 2003, pp. 41–42.

prescribed length. Nevertheless, it was consigned to oblivion by Schramm, whose influence in artillery studies ensured that it was his own hypothesis that endured.⁷²

EXCURSUS: THE NEW ROMAN ARTILLERY TERMINOLOGY

It is disappointing that, forty years after Marsden's books first appeared, a Roman military scholar can still write that "there is some confusion among ancient and modern works about the terminology applied to Roman artillery,"⁷³ for Marsden supplied the key to understanding that terminology. To begin with, it is clear that catapults of Hellenistic types still held sway during the Early Principate. Describing the Roman army of A.D. 66–74, the historian Josephus uses the same vocabulary as earlier writers: during their campaigns in Judea, he writes, the Romans "set up arrow-shooters (ὄξυβελεῖς) and catapults (καταπέλται) and stone-projectors (λιθοβόλα) and every device for shooting."⁷⁴ This selection of Greek terms mirrors the Latin terms used by Vitruvius, who states that he had been "made responsible for the construction and repair of ballistas, scorpions, and the rest of the artillery" by the emperor Augustus.⁷⁵ Vitruvius equates the *scorpio* with the *catapulta* as an arrow-shooter, although elsewhere he lists them separately, as if they were distinct from one another.⁷⁶ Nevertheless, his description makes it clear that both were euthytone. Meanwhile, the term *ballista*, which appears to have originated in Sicily, where the Romans acquired their first experience of artillery, had entered the Latin language as a synonym for palintone.⁷⁷ Unfortunately, other Roman authors are less specific in their references to artillery, preferring the blanket term *tormenta* (torsion machines) or, even more vaguely, *mechanai* (machines).

By the end of the 1st century A.D., we begin to see the passing of the old Hellenistic machines and the advent of a new order. The last certain example of a euthytone appears in a relief on the tombstone of C. Vedennius

72. Cf. Schramm's dismissive comments about "the French group" (1918, pp. 12–13). The preeminence of the Schramm-Marsden hypothesis ensured that the French palintone theory was ignored even by Callebat and Fleury (1986). Besides Iriarte 2003, which presents a convincing case, I had only ever seen this theory mentioned in Hall 1956, p. 711. See now Hart and Lewis 2010, p. 262, which embraces the design with inswinging arms, but suggests that it appeared only around A.D. 100.

73. Southern 2007, p. 213. The same sentiment can be found in other works.

74. Joseph. *BJ* 3.80: τοὺς τε ὄξυ-

βελεῖς καὶ καταπέλτας καὶ λιθοβόλα καὶ πᾶν ἀφετήριον ὄργανον τιθέασιν.

75. Vit. 1.*prae*f.2: *ad apparationem ballistarum et scorpionum reliquorumque tormentorum perfectionem fui praesto.*

76. Vit. 10.10.6, where he claims to have described *catapultarum rationes* ("the rules of catapults") at the end of the section on the *scorpio*. In 1.1.8, however, he refers to *ballistarum catapultarum scorpionum temperaturas* ("the tuning of ballistas, catapults, and scorpions"); cf. 10.13.6–7, 15.4, and 16.1 for various permutations. Pliny (*HN* 7.201) also lists the three machines separately (see n. 12, above), as does Livy (26.47) in a well-known catalogue of Carthaginian machines captured at

New Carthage in 209 B.C.: *catapultae maximae formae centum viginti, minores ducentae octoginta una; ballistae maiores viginti tres, minores quinquaginta duae; scorpionum maiorum minorumque et armorum telorumque ingens numerus* ("120 catapults of the largest dimensions, 281 smaller ones; 23 larger ballistas, 52 smaller ones; larger and smaller scorpions and a huge number of weapons and projectiles").

77. The Sicilian origin is noted by Taillardat (1963, p. 100), who links the verb with bombarding, rather than dancing, *contra* Shipp 1961, p. 149. I am grateful to Michael Lewis for reminding me of this reference.

Moderatus at Rome.⁷⁸ Having served 10 years as a legionary, Moderatus transferred into the Praetorian Guard, probably during the upheavals of A.D. 69. He served a further eight years to qualify for an honorable discharge, but was retained as an engineering specialist for the next 23 years; his tombstone probably dates to ca. A.D. 100. Similarly, the last certain reference to the Hellenistic stone-projecting ballista is provided by Tacitus, writing during the reign of Trajan. In his chronicle of the events of A.D. 69, he describes how, during the second battle at Cremona, “a ballista of remarkable size, belonging to the Fifteenth Legion, was knocking down the enemy line with enormous stones.”⁷⁹

By the time of Ammianus Marcellinus in the mid-4th century, however, the Romans were employing the one-armed *onager* as their stone-projector, while the ballista seems to have been used only as an arrow-shooter, a task previously given to the euthytone.⁸⁰ This new vocabulary for artillery is also found in Vegetius.⁸¹

The reason for the change in terminology was clear to Marsden, who had revealed the true significance of Heron’s *cheiroballista* as an iron-framed palintone arrow-shooter.⁸² He was struck by certain similarities between the *cheiroballista* and the artillery pieces depicted on Trajan’s Column in Rome, dating broadly from the period around A.D. 110; although they were arrow-shooters, their wide palintone torsion frames qualified them for the term *ballistae*. Indeed, archaeological discoveries since Marsden’s day have confirmed that such scaled-up versions of Heron’s *cheiroballista* existed during the time of the Late Roman Empire.⁸³

It seems clear that, from the reign of Trajan onward, palintones supplanted euthytone as the preferred catapults for shooting arrows; this, after all, was a capability that they had always possessed. Nevertheless, the changeover continues to cause confusion.⁸⁴ It is worth noting that the observations offered above on the design of the palintone support the case for inswinging arms on these arrow-shooters as well.⁸⁵

The *onager*, on the other hand, has suffered the same fate in modern scholarship as the Hellenistic stone-projector. Its construction from mostly

78. *CIL* VI 2725; *ILS* 2034. The relief is often illustrated: see, e.g., Schramm 1918, p. 36, fig. 10; Marsden 1969, pl. 1; Baatz 1979, p. 71, fig. 5; Campbell 2003, p. 24; Rihl 2007, p. 214, fig. 9:9.

79. Tac. *Hist.* 3.23: *magnitudine eximia quintae decimae legionis ballista ingentibus saxis hostilem aciem proruebat*. Cassius Dio (64.14), reporting the same event, introduces the ballista as a *mechanema*, perhaps to emphasize its size, before reverting to the standard term, *mechane*.

80. Amm. Marc. 19.1.7, 5.1, 5.6, 7.2, 7.5–7; 20.7.2, 7.10; 23.4.1, 4.3; 24.2.13, 4.16 (*ballista*); 19.2.7, 7.6–7; 20.7.10; 23.4.4, 4.7; 24.4.16, 4.28; 31.15.12 (*onager*). Ammianus (23.4.7)

claims that the *onager* had previously been known as a scorpion, *quoniam aculeum desuper habet erectum* (“because it has its sting raised up above it”).

81. E.g., Veg. *Mil.* 4.9: *onagri vel ballistae ceteraque tormenta* (“onagers or ballistas and the other artillery”); 4.22: *ballistae onagri scorpiones arcuballistae* (“ballistas, onagers, scorpions, bow-ballistas”); 4.29: *ballistae vero et onagri* (“ballistas and onagers”); 4.44: *onagris ballistis scorpionibus iacula invicem diriguntur et saxa* (“onagers, ballistas, and scorpions shooting, in turn, darts and stones”). At 4.22, Vegetius explains that, by scorpion, he means the *manuballista* (which is etymologically identical to the *cheiroballista*). On the *arcuballista* (“bow-ballista”), see n. 24, above.

82. See n. 6, above.

83. See Campbell 2003, pp. 37–40, for a summary.

84. Rankov (2007, p. 61), for example, imagines that the machines on Trajan’s Column are *catapultae*, Gilliver (2007, p. 128) considers them *scorpionnes*, and Rance (2007, p. 360) claims that the *catapulta* was renamed the *ballista* in the 4th century. The glossary in Sabin, van Wees, and Whitby 2007 perpetuates similar misconceptions.

85. The case for inswinging arms in the Roman iron-framed arrow-shooter is most fully stated by Iriarte (2000); cf. Campbell 2003, pp. 41–42, where the configuration of the Hatra ballista’s torsion frame is taken as confirming it.

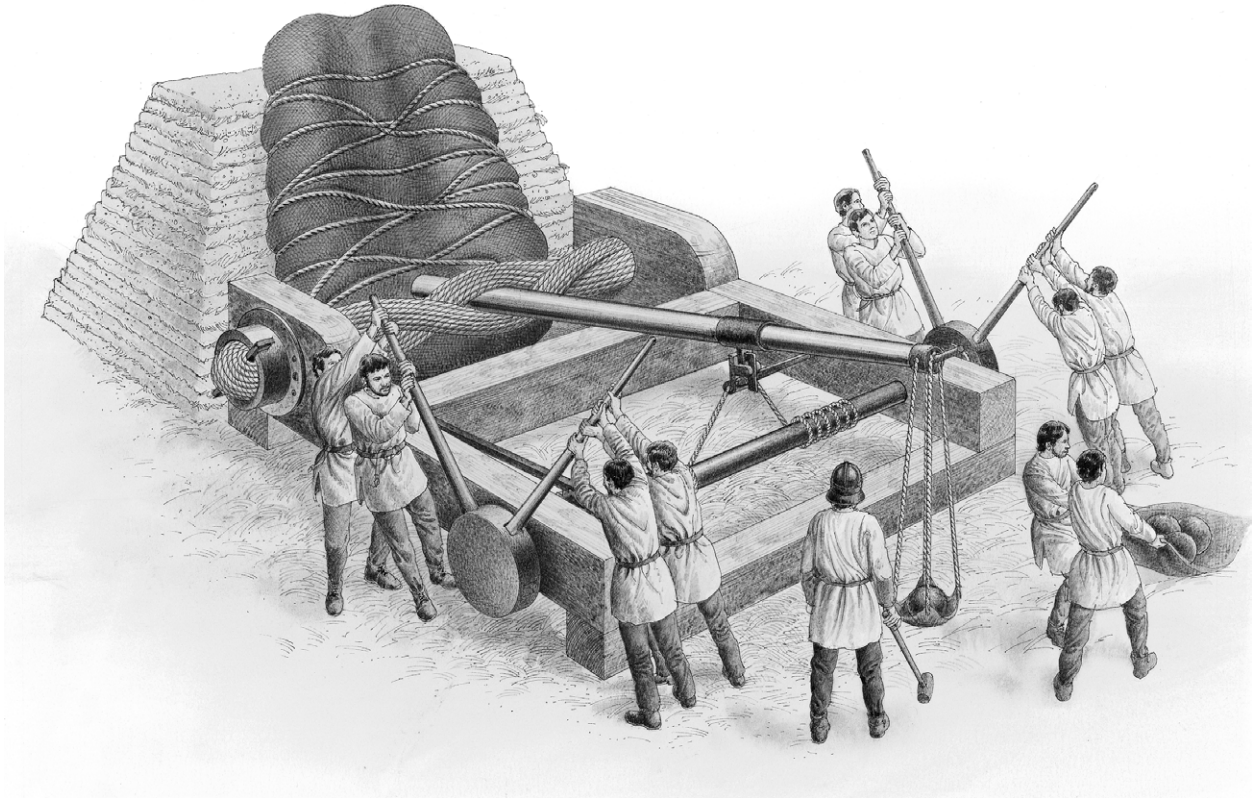


Figure 4. Reconstruction of the *onager*, following de Reffye's interpretation of the description by Ammianus Marcellinus. Painting Brian Delf, from D. B. Campbell, *Greek and Roman Artillery 399 B.C.–A.D. 363*, p. 32, pl. G. © Osprey Publishing Ltd.

organic materials means that physical remains are unlikely to survive, so its elucidation depends upon the study of the ancient written sources, in particular the description by Ammianus Marcellinus.⁸⁶ As in the case of the Hellenistic stone-projector, a brilliantly perceptive French design was sidelined by inferior German and English versions; consequently, most modern reconstructions of the *onager* follow the interpretation of Sir Ralph Payne-Gallwey, rather than the design proposed by Verchère de Reffye (Fig. 4), which seems to me, at any rate, to be eminently more likely.⁸⁷

The design of the *onager* as a mechanized staff-sling is often thought to have been a late development, but Philon was aware of one-armed stone-projectors.⁸⁸ Unfortunately, he gives no details, and our next glimpse of the machine comes over three centuries later, in the work of the emperor

86. Amm. Marc. 23.4.4–7; unjustly dismissed as “nonsense” by Rihll (2007, p. 246), who unfortunately does not attempt to explain the *onager*.

87. Payne-Gallwey [1903–1907] 1958, appendix, pp. 10–18; followed by Marsden (1971, pp. 249–265), and by all modern reconstructions. De Reffye's version, built for Napoléon III, was displayed in the Musée de Saint-Germain: see “Les modèles d'armes romaines,” pp. 232–233, fig. 1; cf. DarSag V, 1919, p. 369, s.v. *tormentum* (A. de Rochas). Schramm (1918, p. 13) criticized de

Reffye for “permitting his imagination a freedom not justified in the interests of science.”

88. Philon, *Pol.* 3.10 (Th 91): τοῖς πετροβόλοις ἄνω βάλλοντας τοῖς παλιντόνοις καὶ τοῖς μοναγκώσι (“shooting upward with stone-projectors, both palintones and one-arms”). I am grateful to Michael Lewis for pointing out the possibility that Philon is here recommending “plunging fire” against a besieger's shelters and machinery (πρὸς δὲ τὰς στοὰς καὶ τὰ μηχανήματα).

Trajan's engineer Apollodorus of Damascus. While describing a peculiar ramming contraption, he refers to a component "that, when bored through, will take washers and skeins of sinew and, in the middle, a long arm, like the one-armed stone-projectors that some call slings."⁸⁹

It was perhaps at this stage, when arrow-shooters had gone over to the palintone design, and euthytone had disappeared from the mainstream, that the one-armed machine usurped the name *scorpio* (scorpion), which had hitherto indicated the euthytone. In his *Scorpiace*, written ca. A.D. 210, Tertullian describes how the creature, "rising up in an arching attack, draws its hooked sting up like a torsion machine; from this feature, they call the war machine a scorpion, that shoots its missiles by retracting."⁹⁰ He seems to liken the scorpion's tail to a one-armed torsion machine of the same name, in exactly the same way that Ammianus does, although by the latter's day the machine had become known as the *onager*.

PROBLEM 4: SLING BULLETS AS CATAPULT MISSILES

A radical new theory, expounded in a recent book about ancient catapults, holds that "it may be that *glandes*, lead slingshots, were invented for catapults, and were only afterward used for hand slinging too."⁹¹ This curious hypothesis has now been restated more forcefully, and underpinned by the contents of "a database of over 1400 objects."⁹² The author, Tracey Rihll, presents 17 arguments, which I shall evaluate in turn.

1. Rihll begins with an event that occurred during the Roman siege of Same in 188 B.C., when the consul M. Fulvius Nobilior drafted Peloponnesian slingers on account of their superiority to the Balearic slingers usually employed by Roman generals. Livy attempts to convey a sense of the power and accuracy of their slinging by likening it to a bowshot: "The bullet is cast as if it were shot from a bowstring."⁹³ Rihll, however, has taken Livy literally, and asks, "What sort of *glans* is shot by a bowstring?" Her answer is "catapult shot."⁹⁴ She then suggests that the "bowstring" in question belonged to a stone-projecting catapult, because "the term 'sling' could stand for the 'slingstring' of a stone-thrower catapult."⁹⁵ (She returns to this theme in argument 8, below.) This argument, relying on a meaning that Livy probably never intended, seems to be based on a simple misunderstanding.

Taking a slightly different tack, Rihll has also claimed that a passage in Arrian's Ἐκταξίς κατὰ Ἀλάνων provides evidence for "stone-thrower

89. Apollod. Mech. Pol. W 188: ταῦτα τρηθέντα χοινικίδας λήψεται καὶ στροφὰς νεύρων καὶ ἀγκῶνα μέσον μακρόν, οἳ εἰσὶν οἱ λιθοβόλοι μονάγκωνες οὓς τινες σφενδόνας καλοῦσιν.

90. Tert. *Scorp.* 1.1.1–2: *arcuato impetu insurgens hamatile spiculum in summo tormenti ratione stringit. unde et bellicam machinam retractu tela vegetantem de scorpio nominant.*

91. Rihll 2007, pp. 91–92.

92. Rihll 2009, p. 147. In compiling the database, Rihll has favored inscribed sling bullets over plain ones; as a result the collection "may not reflect the proportion of decorated to plain *glandes* in use in antiquity" (p. 148). Nevertheless, she is to be congratulated for her industry, and we may hope that, through some academic agency, the

data will be made available to a wider public.

93. Livy 38.29.6: *glans . . . velut nervo missa excutiat.*

94. Rihll 2007, p. 98; cf. p. 313, n. 20: "The present hypothesis explains this statement by Livy, which has hitherto been found baffling."

95. Rihll 2009, p. 160.

tension catapults, that is, crossbows shooting bullets.”⁹⁶ Arrian, however, simply recommends his men “to shoot missiles and stones from machines, and missiles from bows.”⁹⁷

2. Having observed that each ancient catapult was designed to shoot a missile of a particular caliber, Rihll attributes significance to the fact that lead *glandes* conform to various discrete weight classes.⁹⁸ She seems to imply that, if *glandes* were only for throwing from a sling, they would exhibit a more random spread of weights and sizes, but she forgets that in mass-produced items intended for the same purpose some degree of standardization is only to be expected.⁹⁹ Her assurance that “*glandes* correspond individually and *en masse* to calibers of archaeologically attested catapults” begs the question, for she has not established that her theoretical 20-drachma, 10-drachma, 8-drachma, and 6-drachma stone-projectors ever existed.¹⁰⁰ This argument is confounded by circular reasoning.

3. Rihll alleges that “*glandes* seem to have been invented at about the same time as the catapult.” Even if synchronicity could be demonstrated, such a correlation would not necessarily imply a causal relationship. But are there any grounds to suspect a synchronous development in the first place?

We have seen that attempts to fix the date of the catapult’s invention are fraught with difficulty. Rihll perhaps has the traditional date of 399 B.C. in mind.¹⁰¹ Yet her previous argument assigns individual *glandes* to particular torsion devices, so she is presumably alluding here to the invention of the torsion catapult, an event that is likewise difficult to date with any accuracy.¹⁰² What then of the “invention” of the *glans*? Curiously, given that this is a matter of fundamental importance to her hypothesis, Rihll fails to address the issue. Since we have the clear testimony of Xenophon (*An.* 3.3.16) that the lead sling bullet was well established among the Rhodians in 401 B.C., it seems unlikely that it was originally designed for catapults.¹⁰³ The argument is simply misconceived.

4. Rihll’s fourth argument rests on the assumption that “*glandes* (at least, the inscribed and decorated specimens) appear to be issued by a central

96. Rihll 2007, p. 224.

97. Arr. *Ektaxis* 25: καὶ βέλη τε ἀπὸ μηχανῶν καὶ λίθους ἀφίεσθαι καὶ βέλη ἀπὸ τόξων. Arrian commonly refers to catapults simply as “machines.”

98. Rihll 2009, p. 162. Without access to Rihll’s database, the reader cannot independently check this conclusion, although the following remarks give some indication of her classification: “Ordinarily they weigh c. 30–40 gm” (p. 147); “85% of the sample specimens fall between 26 and 60 gm” (p. 150); “35% or 315 fall into the 8-drachmai range, . . . another 216 (24%) fall into the 10-drachmai range, . . . a further 212 (23%) fall into the 6-drachmai range” (p. 162). She also mentions “93 *glandes* (10%) around a heavier 15-drachmai weight . . . and

another 40 *glandes* around 20-drachmai weight” (p. 162). Hultsch (1882, p. 135) pegged the Attic drachma at 4.366 g.

99. Cf. Richardson 1998, p. 46: “Experiment shows that there is an optimum weight range of slingshot for a given sling,” an observation that explains any perceived standardization.

100. Under the heading “Some Ancient Catapult Dimensions,” Rihll (2007, p. 290, table A.2) lists “Philonian Palintones” of 4, 6, 8, 16, and 24 drachmas, evidently on the basis of sling bullets, for Philon never mentions these sizes. As we have seen (n. 48, above), Philon’s smallest palintone was actually the 10-mina stone-projector, designed for shot weighing 1,000 drachmas.

101. Cf. Rihll 2007, p. 26 (“The

catapult seems to have a clear origin in time and space. To wit: 399 B.C. or thereabouts, on the island of Sicily”). The same date is repeated elsewhere (pp. xi, xxii, 202).

102. See p. 000, above; *pace* Rihll (2007, p. 89), who writes, “The two-armed torsion catapult was almost certainly in existence by 326 B.C.”

103. Rihll does not cite the Xenophon passage. She does, however, question (2009, p. 157) the prosopographical dating of the so-called Tissaphernes bullet, which Foss (1975, p. 30) concluded was “issued by Tissaphernes [satrap of Lydia] between 401 and 395,” although she does not elaborate on her objection. See now Ma 2010, which came to my notice only after this article had gone to press.

authority.”¹⁰⁴ As she is attempting to demonstrate that they are catapult missiles, her implication seems to be that sling bullets would only be issued in this way if they were intended to be shot from a catapult. Nowhere does she attempt to prove either of these proposals, however, and they remain only her opinion.

5. Rihll’s fifth argument rests on her observation that “the workmanship invested in the mould is quite fine in most Greek and some Roman” *glandes*, coupled with her opinion that such a degree of workmanship would be misplaced in a sling bullet but justifiable in a catapult missile.¹⁰⁵ For this argument to succeed, it must be shown that the makers and users of *glandes* in antiquity shared this opinion, something that Rihll does not attempt to demonstrate.

Rihll’s thinking about lead bullets was perhaps influenced by an awareness of large-caliber stone balls, which were often finished to a high degree of workmanship. But the reason for this attention to detail has more to do with ancient perceptions of aerodynamics than with aesthetics, and there is nothing to suggest that the arrowheads shot from euthytone catapults were of a particularly high quality. This argument fails because it imposes a modern perception upon the ancient evidence.

6. With Rihll’s sixth argument, we finally come to the crux of the matter. Ancient writers occasionally allude to the fact that a sling bullet could penetrate the flesh.¹⁰⁶ The locus classicus is a remark by Onasander, writing around A.D. 57, that “the sling is the most dangerous weapon used by the light-armed troops, because the lead bullet is the same color as air and is unnoticed in its flight, so that it strikes the unprotected bodies of the enemy unseen, and not only is the impact itself violent, but also the missile, heated by the friction of rushing through the air, penetrates the flesh very deeply, so that it cannot even be seen and the point is quickly closed over.”¹⁰⁷

Onasander is explicit that a bullet hurled from a sling could inflict an injury of this type, but Rihll denies it, claiming that the bullet “lacks sufficient velocity.”¹⁰⁸ She prefers to believe that such bullets were shot from a catapult: “If we are told that someone suffered a penetrating injury from a sling-shot-like missile, then we can confidently deduce the presence of at least one little stone-thrower catapult, because that is the only ancient weapon that could have been responsible for causing it.”¹⁰⁹

Assessing this argument requires establishing both the actual velocity of a bullet hurled by a sling and the velocity required to penetrate human flesh. Neither of these has yet been satisfactorily measured. Although Rihll refers to the ballistic tests carried out in 1997–1998 by the Royal

104. Rihll 2009, p. 162.

105. Rihll 2009, p. 162.

106. E.g., Livy 38.21.11, where Rihll (2007, p. 102) is convinced that “his description of the wounds caused—shot buried in the flesh—demonstrates the use of small catapults,” although she presents no proof to support this conclusion.

107. Onasander, *Strat.* 19.3: ἡ δὲ τῆς σφενδόνης ἄμυνα χαλεπωτάτη τῶν ἐν τοῖς ψιλοῖς ἐστίν· ὅ τε γὰρ μόλιβδος ὁμόχρους ὦν τῷ ἀέρι λανθάνει φερόμενος, ὥστ’ ἀπροοράτως ἀφυλάκτοις τοῖς τῶν πολεμίων ἐπιπίπτειν σώμασιν, αὐτῆς τε τῆς ἐμπτώσεως σφοδρᾶς οὔσης καὶ ὑπὸ τοῦ ροίζου τριβόμενον τῷ ἀέρι τὸ βέλος ἐκπυρῶθὲν ὡς βαθυτάτῳ

δύεται τῆς σαρκός, ὥστε μὴδ’ ὁρᾶσθαι, ταχὺ δὲ καὶ τὸν ὄγκον ἐπιμύειν.

108. Rihll 2009, pp. 162–163.

109. Rihll 2007, p. 104; cf. p. 100: “Slingers are not capable of inflicting penetrating injuries of this order; they simply cannot achieve the velocities necessary.”

Armouries in Leeds, she misrepresents the results. Far from demonstrating that “a good slinger can consistently reach a velocity of 30–31 m/s, with best performance of 32 m/s,”¹¹⁰ the slinger in this test recognized that he had performed poorly, because (in his own words) “I have not learned to sling within a sling-using culture, or because I am inept at it.”¹¹¹ We may consequently treat his achievements as an absolute minimum. Baatz, on the other hand, thought it quite likely that the sling could achieve an initial velocity of 75 m/s, which we may treat as an absolute maximum until such time as it is either confirmed or disproved.¹¹² As far as the required velocity to penetrate human flesh is concerned, Rihll relies on studies based on spherical lead shot.¹¹³ Such shot is a poor analogue for *glandes*, and we are entitled to believe that it would behave differently, until proven otherwise. This argument fails because neither of its key premises can yet be verified.

7. Turning to the decoration found on many *glandes*, Rihll suggests that certain motifs “may indicate the type of machine for which they were made.” Here some indication of the date and provenance of the bullets in question would be helpful. For example, in order to evaluate the likelihood that “those marked with a scorpion could be for a scorpion catapult,” it would be useful to know where those bullets originated and when they were deposited.¹¹⁴

Another of her examples is more clear-cut. If we are really to believe that “the thunderbolt (*fulmen*) could be for the *fulminalis* (the thunderbolt or ‘lightning’ ballista),”¹¹⁵ then no *glandes* marked in this way should predate the introduction of this type of catapult. In fact, the term *ballista fulminalis* is found only in a late, anonymous work known as *De rebus bellicis*, where it seems to denote a late relation of the Roman iron-framed ballista.¹¹⁶ But *glandes* marked with the thunderbolt motif are found in earlier contexts,¹¹⁷ which makes the association most unlikely. In any case, as she has failed to prove that *glandes* were catapult missiles, this line of argument is purely academic.

8. Rihll states that, technically speaking, any missile shot by “a one-armed or a two-armed mechanical stone-thrower, was despatched by sling.”¹¹⁸ She does not elaborate on this, but elsewhere she claims that “since any stone-thrower employs a sling to project the missile . . . , Apollodoros, Paul, and other people who called a stone-thrower a sling, were, technically,

110. Rihll 2007, p. 101 (m/s = meters per second).

111. Richardson 1998, p. 47. He does not record the number of attempts that contributed to the lowest, highest, and average velocities quoted on p. 48.

112. Baatz 1990, p. 60.

113. Rihll 2007, p. 101; although elsewhere she concedes (2009, p. 162) that “*glandes* with a fairly sharp point do not need to travel as quickly as would spherical shot to overcome the elasticity of the skin.”

114. Rihll 2009, p. 163. Curiously,

having begun by proposing that *glandes* were designed to be shot from a palintone, Rihll now switches to the euthytone scorpion. She cannot mean the *onager*, as she elsewhere (2007, p. 249) condemns Ammianus’s “erroneous belief” that the machine had ever been called a scorpion. (See n. 80, above, for Ammianus’s terminology.)

115. Rihll 2009, p. 163.

116. *De rebus bellicis* 18; cf. Marsden 1971, pp. 244–246. Rihll (2007, p. 242) interprets the machine otherwise, supposing that it was not a torsion

catapult, but drew its power from “a sort of very powerful elastic band.”

117. Rihll’s database would no doubt provide more accurate data, but Feugères illustrates a Spanish thunderbolt bullet thought to have derived from a Pompeian context and another from Athens that is surely earlier (DarSag II.2, 1896, p. 1610, figs. 3624, 3628, s.v. glans). Parsons (1943, p. 242, fig. 26) illustrates thunderbolt *glandes* from Athens that he links with the Sullan siege operations of 87–86 B.C.

118. Rihll 2009, p. 163.

correct in their usage.”¹¹⁹ Furthermore, she takes it as self-evident that when Strabo mentions a sling, he is simply “doing what Apollodoros and Livy and others were doing, to wit using ‘sling’ to mean slingstring.”¹²⁰

The implication seems to be that, because Apollodoros of Damascus mentions “the one-armed stone-projectors that some call slings,”¹²¹ all mentions of slings must therefore refer to stone-projecting catapults. This is clearly a logical fallacy. Nor do her other witnesses strengthen the argument: the Byzantine medical writer Paul of Aigina, to whom Rihll appeals as one of the “people who call a stone-thrower a sling,” says no such thing,¹²² and her appeal to Livy is simply a restatement of argument 1, rebutted above.

It is, of course, illogical to suggest that, because *glandes* are normally shot from a sling, they must also be shot from any machine that employs a sling. But Rihll compounds her error by stating that all stone-projectors were fitted with a “sling,” for on closer inquiry it transpires that the palintone was in fact equipped with a τοξίτις (bowstring) or a νευρά (tendon cord).¹²³ It is only the *onager* that is equipped with a *funda* (sling), and naturally so, as it is a mechanized staff-sling. Rihll’s argument, having proceeded from faulty premises, is quite mistaken.

9. Rihll’s next argument centers on her belief that, if some slingers were content to use stones, then all should have been similarly satisfied, and none should ever have used lead bullets.¹²⁴ Again, this is a formal fallacy, erroneously concluding that if some are true, all must be true. As she presents the argument at great length, however, it is worth looking more closely at the evidence.

Rihll first casts doubt on the usual interpretation of sling bullets discovered at sites of ancient sieges for which no explicit mention of slingers can be found in the literary sources. She cites the example of the siege of Perugia in 41–40 B.C., “where slingers are not conspicuous in the literary accounts yet *glandes* have been found in quantity”; furthermore, she criticizes those who would argue that slingers were involved in the siege, because “their presence is *deduced* from the missiles it is supposed they used.”¹²⁵

119. Rihll 2007, p. 104.

120. Rihll 2007, p. 229. No passage of Strabo is cited, but Rihll perhaps intended the geographer’s description of the famous Balearic slingers, who wear “three slings, of plaited rushes or hair or sinew, around their heads; the long-stringed for long shots, the short-stringed for shots at short range, and the middle one for mid-range” (3.5.1 [C168]: σφενδόνας δὲ περὶ τῇ κεφαλῇ τρεῖς μελαγκρανίνας ἢ τριχίνας ἢ νευρίνας· τὴν μὲν μακρόκωλον πρὸς τὰς μακροβολίας, τὴν δὲ βραχύκωλον πρὸς τὰς ἐν βραχεὶ βολάς, τὴν δὲ μέσην πρὸς τὰς μέσας). For other mentions of slingers by Strabo, see Pritchett 1991, pp. 23–25.

121. See n. 89, above.

122. Paul (6.88.9) gives instructions

for removing missiles carefully, “since stones or trumpet shells [!] or lead bullets or similar objects often thrown from a sling penetrate by force and by being angular” (ἐπεὶ δὲ καὶ λίθοι πολλάκις ἢ κήρυκες ἢ μόλιβδοι ἢ τοιαῦτά τινα ὑπὸ σφενδόνης βαλλόμενα καταπίρεται τῇ τε βίᾳ καὶ τῷ γωνιωμένῳ τυγχάνειν).

123. τοξίτις: Heron *Bel.* 24, 30 (W 102, 110–111); νευρά: Heron *Bel.* 24 (W 101); Philon *Bel.* 11 (Th 54). Heron was, of course, well aware that in this instance the “bowstring” was actually a woven strap (30 [W 111]): ἡ δὲ τοῦ παλιντόνου πλατεῖα γίνεται καθάπερ ζώνη (“that belonging to the palintone is made broad, like a belt”). Marsden (1971, p. 161, n. 24) takes great pains to explain that, although the

palintone’s bowstring was flat like a belt, the Greeks used the same word as that used for the arrow-shooter’s bowstring. Cf. the comments of Baatz (2009, p. 262), who considers it likely that the most effective catapult bowstrings were manufactured not from animal fiber but from plant fiber, which is less elastic.

124. Rihll 2009, pp. 163–165.

125. Rihll 2009, pp. 163–164 and n. 110, citing Appian (*B Civ.* 5.36), who writes that the besieged ἡμύνοντο λίθοις καὶ τοξεύμασι καὶ μολυβδαίναις σὺν πολλῇ θανάτου καταφρονήσει (“defended themselves with stones and arrows and sling bullets, with utter contempt for death”). It is surely special pleading to deny the presence of slingers and to posit the presence of machinery instead.

A similar criticism is leveled against Plutarch, for allegedly recording “only the munitions, not the launcher” in his description of Antony’s army repelling a Parthian attack in 36 B.C.¹²⁶

Rihll then returns to her theory that any mention of a sling “could equally refer to a small *lithobolos*, whose ‘bowstring’ was a slingstring.”¹²⁷ Three passages are cited as examples: one from Polybios, where the missile from a *cestrosphendone* is “hurled like a lead bullet from a sling”;¹²⁸ one from Onasander, already discussed above;¹²⁹ and one from Xenophon, who equips his Rhodian troops with slings (σφενδόνα), explaining that “the Rhodians know how to use lead bullets, too.”¹³⁰ This is essentially a repetition of the same point made in previous arguments, and we have already seen that no ancient author would have described the bowstring of a stone-projector (nor, for that matter, an arrow-shooter) as a “sling.”

10. Rihll correctly points out that one ancient source does indeed mention “the use of *glandes* as catapult ammunition” during Sulla’s siege of Piraeus in 86 B.C.¹³¹ Appian records that “Sulla killed many by means of catapults shooting twenty of the heaviest lead bullets at once, and shook Archelaus’s tower and made it insecure.”¹³² Unfortunately, the interpretation of the passage in question is far from straightforward.

Marsden thought it “more probable that these catapults were firing salvos than that each shot twenty balls simultaneously, like grape-shot.”¹³³ Rihll, on the other hand, suggests that Sulla’s artillerymen employed “either a one-armed design, so that the shot were loose in the sling, or a barrel of some sort, so that they were contained until fore of the framework.”¹³⁴ The second of her suggestions has little to recommend it, but the first may actually have worked, because the one-armed *onager* used a sling rather than the bowstring of the conventional catapult.¹³⁵ In any case, it was obviously the sheer novelty of the event that caused Appian to record it, and it would be unwise to extrapolate to all catapults and lead bullets from this single, poorly understood instance.

11–13. The remaining arguments are even less satisfactory. Rihll asks, “Why did the Roman army not recruit and employ hand-slingers as a specialized force?” and “Where on their person are [legionaries] supposed to have kept caches of *glandes* as they marched into battle?”; she also

126. Rihll 2009, p. 165, citing Plut. *Ant.* 41. Plutarch, however, first writes (41.4) ἄρτι δ’ αὐτοῦ καθιστάντος εἰς τάξιν τὰ ὅπλα καὶ δι’ αὐτῶν τοῖς ἀκοντισταῖς καὶ σφενδονήταις ἐκδρομὴν ἐπὶ τοὺς πολεμίους παρασκευάζοντος (“just when [Antony] was arranging the heavy infantry in line and preparing the javelineers and slingers to run out through them against the enemy”). When, therefore, he contrasts the number of Roman casualties with those of the Parthians, οὐκ ἐλάττονας δὲ ταῖς μολυβδίσι καὶ τοῖς ἀκοντίοις πληγὰς λαβόντες (“who had received no fewer blows from the [Roman] lead

bullets and javelins”), he is clearly referring to the javelineers and slingers mentioned previously.

127. Rihll 2009, p. 165.

128. Polyb. 27.11.7: καθαπερεὶ μολυβδὶς ἐκ τῆς σφενδόνης ἐφέρετο.

129. Onasander *Strat.* 19.3; quoted in n. 107, above.

130. Xen. *Anab.* 3.3.17: οἱ δὲ Πρόδιοι καὶ ταῖς μολυβδίσιν ἐπίστανται χρῆσθαι.

131. Rihll 2009, p. 165.

132. App. *Mith.* 34: ὁ Σύλλας ἐκ καταπελτῶν ἀνὰ εἴκοσιν ὁμοῦ μολυβδαίνας βαρυτάτας ἀφιέντων ἔκτεινε τε πολλούς, καὶ τὸν πύργον Ἀρχελάου

κατέσεισε καὶ δυσάρμοστον ἐποίησεν.

133. Marsden 1969, p. 111.

134. Rihll 2007, p. 185.

135. This is not to endorse the questionable theory of Moses Hadas, adopted by Roy Davies (1971, pp. 108–109), who wrote that “the Roman gunners were accustomed to put small pebbles in a bag or to bake them into a ball of clay. On impact the bag or clay would burst and the stones would be hurled in all directions at a high velocity.” It is doubtful whether this effect could have been achieved by these means.

observes that “Xenophon associates becoming a slinger with disarmament.”¹³⁶ I cannot see how any of these points supports a case for *glandes* as catapult ammunition.

14. Rihll’s next argument, that “ancient illustrations of hand-slingers show objects much larger than the typical lead *glans* in the sling,” again falls into the trap of false logic. Simply because some slingers appear not to use lead bullets does not necessarily prove that all slingers avoided their use. But the argument also raises a more fundamental issue involving the use of pictorial sources, for in a different context Rihll excuses the large handrails in the depiction of the bridge over the Danube on Trajan’s Column, on the grounds that “if they had been drawn to scale they would be invisible.”¹³⁷ If so, we can hardly attribute special significance to similar depictions of oversized sling pouches.

15. Rihll then turns to Appian’s description of the naval battle at Nau-lochos (36 B.C.), which began with “missiles such as stones, incendiaries, and arrows, hurled by machine and by hand.”¹³⁸ She believes that Appian means that the missiles were thrown “by hand-held sling and hand-held bow, as opposed to by mechanical sling and mechanical bow,” so it is not entirely clear why this passage has relevance to *glandes* as catapult missiles.¹³⁹ It is worth noting, however, that when Appian says “by hand,” he may very well mean that the stones were thrown, literally, by hand; the incendiaries and arrows could have been shot from bows, although clearly there were catapults on board as well, to shoot the device known as the *harpax* (App. *B Civ.* 5.118).

16–17. Rihll’s final arguments can be swiftly dispatched. First, she suggests that the differences in the shapes of *glandes* indicate their use by different machines (a variation of argument 7), although, as noted above, she has failed to establish that they were intended for machines in the first place. Second, she suggests that, because Balearic slingers were famed for hurling stones, *glandes* must have been shot from catapults (a variation of argument 9).

We are left, then, with a superficially intriguing hypothesis, which, like the hypothesis of Schneider mentioned at the beginning of this essay, fails for lack of any supporting evidence. When all of our sources point to the use of *glandes* as sling bullets, and none hints at their use as catapult missiles, we can conclude with some degree of certainty that they were not intended to be shot from catapults. Sulla’s gambit at Piraeus can be put down to the general’s ingenuity, rather than to any long-standing artillery tradition.

136. Rihll 2009, p. 166.

137. Rihll 2007, p. 211. Broadly the same point is made by Bishop and Coulston (2006, pp. 1–22), who note that the study of such representations must take into account stylization, sculptors’ mistakes, and artistic license.

138. App. *B Civ.* 5.119: βέλη τὰ μὲν ἐκ μηχανῆς, τὰ δ’ ἀπὸ χειρῶν, ὅσα λίθοι καὶ πυρφόρα καὶ τοξεύματα.

139. Rihll 2009, p. 166.

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