The Xanten-Wardt Roman torsion catapult and catapult parts from Carlisle

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The Xanten-Wardt frame from a Roman torsion bolt-shooting catapult of the 1st century AD was discovered in 1999 in a gravel quarry in north west Germany at 51° 40' N, 6° 27' E. The site was once an arm of the Rhine, but is now the Südsee, a water-sport lake NNE of the Xanten Archaeological Park. The sumptuous official report on the find has now been published by Verlag Philipp von Zabern as *Xanten Berichte Band 18*: *Die Frühkaiserzeitliche Manuballista Aus Xanten-Wardt*.

This exciting discovery has added far more to our understanding of these machines than previous finds of catapult frame parts from Ampurias, Caminreal and elsewhere. Not only has the metal plating survived, but for the first time the wood of the frame and the front end of the slider and stock have been preserved. The iron and bronze plating includes the battle shields for the spring-cord, organic material from which has been identified by electron microscope as sinew rope. The four bronze washers and washer-bars are there, with one complete washer pin and two broken ones.

Fig. 1 The Xanten-Wardt frame after conservation (Maarten Dolmans)

Most of the Xanten-Wardt report is rightly devoted to the details of the long and painstaking recovery of the machine from its coffin of solidified sand, grit and pebbles. X-rays and CT scans were used to locate the buried parts, in order to guide the delicate task of removing the concretion. Exemplary is hardly a strong enough word for this superb, patient work of rescue and conservation. The one major loss, of the frame's left hand side-stanchion, is a bonus which allows a clear view of inner details like the iron plate and pair of rivets securing the stock to the centre stanchions; otherwise the frame parts are complete.

Fig. 2 The frame from the left, showing the missing side-stanchion (Maarten Dolmans)

My engineer collaborators Len Morgan and Tom Feeley have studied the machine, now on display in Xanten Museum, and have been given access to the official detailed plans. They have finished our reconstruction, which completes this torsion catapult as a winched bolt-shooter with a stand, as described in detail by Emperor Augustus' catapult engineer Vitruvius.

"All the proportions of these engines," Vitruvius states*, "are calculated from the proposed length of the bolt which that particular engine is intended to shoot: one ninth of this length gives the diameter of the holes in the frames through which are stretched the twisted sinews which hold the arms.*" It is important to compare the proportions of the Xanten-Wardt frame to the dimensions for the torsion bolt-shooting catapult given by Philon of Byzantium in his *Belopoiika* (written in the 3rd century BC) and by Vitruvius in Book X of his *de Architectura* of c. 25 BC. Philon's 5 ½ hole by 6 ½ hole proportions for frame height and width produce what Vitruvius terms an undersprung frame (*capitulum catatonum*), which is true of the larger Ampurias and Caminreal catapults.

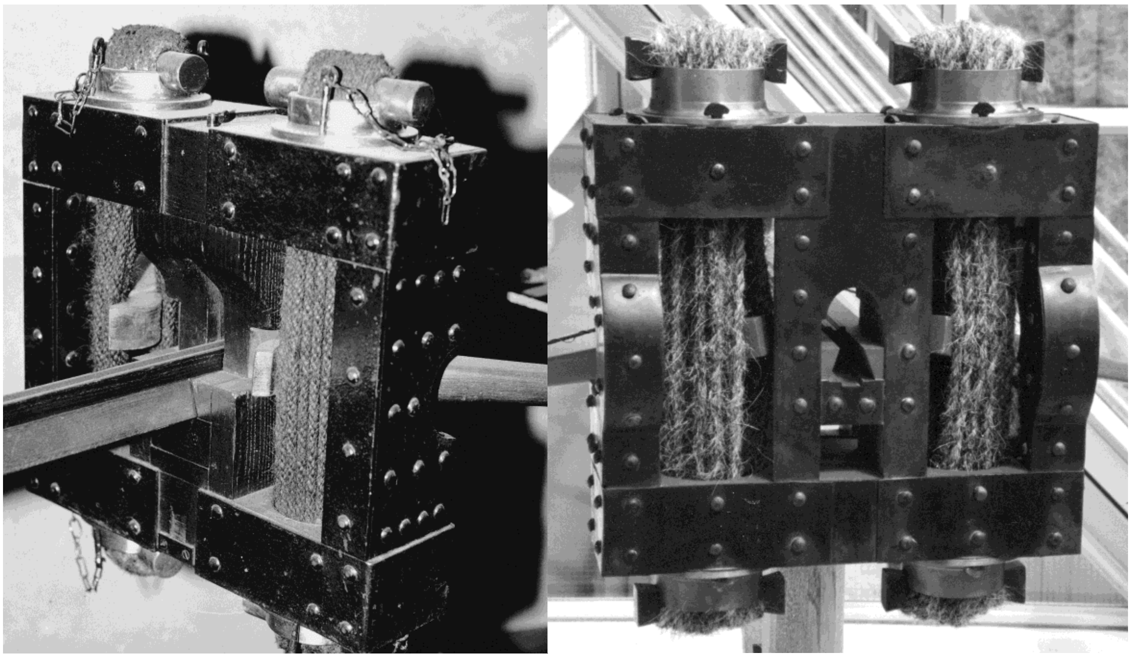

Fig. 3 (left) Schramm's reconstruction of the Ampurias frame, in the Saalburg Museum. (right) The Caminreal frame, reconstructed by Baatz in the Aalen Museum (Len Morgan).

So far no frame has been found which matches Vitruvius' square 6 hole by 6 hole proportions. The Xanten-Wardt example is the only one discovered which has an oversprung frame (*capitulum anatonum*) at 4.9 holes high by 4.6 holes wide. It is significant that the Ampurias and Caminreal frames also have an identical 4.9 holes height.

So we should probably regard the Xanten-Wardt catapult as proportionally of a regularly used height, but with a much reduced frame width. This is reflected in the narrowing of its side-stanchions, 3/8 holes wide as opposed to 5/8 on the others. The Roman engineers have cleverly compensated for this by making special outer reinforcing plates for the side-stanchions with added thickness in the centre where the cut-out for the arms occurs. The Xanten-Wardt machine also exhibits a reduced distance between the spring-holes and the side- and centre-stanchions. Vitruvius gives this as ¼ hole, as found on the Ampurias and Caminreal machines; Philon gives 5/8 hole. Furthermore, the Xanten-Wardt spring-holes have been mistakenly drilled slightly off-centre, as can be seen on the original frame and on our replica. This means that the spring-holes almost touch the side-stanchions, bringing the rope-springs in contact with them and ultimately causing the rope to wear.

Fig. 4 The mistake in drilling the spring-holes off-centre, which will lead to spring-rope wear.

The catapult, rescued from its tomb of concretions, is extremely elegant and superbly finished, with the side and front bronze plating given a neat edging, a purely decorative feature. It is a reminder to present day reconstructors of Roman catapults that far from being roughly finished, they were made to look highly impressive, as Philon urges. It is further proof of the Roman soldiers' great pride in the appearance of their equipment (Fig. 9 at end).

The machine bears a strong resemblance to the detailed bas-relief of a bolt-shooting catapult on the tombstone in the Vatican Museum of C. Vedennius Moderatus, who was appointed by Vespasian and Domitian as *arcitectus armamentarii imperialis* (Engineer of the Imperial Arsenal). The only major difference is that the Vedennius relief has an all-in-one battle shield whereas the Xanten-Wardt has two separate plates protecting the rope-springs. The Xanten-Wardt frame has one complete example of the hollow-eyed pins locking the washers, a type of pin previously known from the Vedennius relief.

Fig. 5 (left) The relief on C. Vedennius Moderatus' tombstone in the Vatican Museum.
(right) The reconstructed Xanten-Wardt frame from a similar angle.

The stock of the Xanten-Wardt catapult was permanently fixed to the frame, being clamped to it by two long bolts through the centre-stanchions; the Roman engineers confronted a major problem because the stock had somehow come adrift, perhaps splitting along the line of these bolts. An attempt was made to refit it, but the continued existence of the two clamping bolts made this impossible: to allow the tenon end of a new stock to be inserted they would have had to be removed, which would have involved dismantling the frame to enable new bolts to be driven through the centre-stanchion and stock, and their heads to be peened. This would have entailed several man-hours work in the *fabrica*, and may have been the reason why the damaged frame was put on one side; it would surely have been earmarked for dismantling in order to recover the valuable plating, washers etc. for reuse. It is unthinkable that these would have been thrown away. My interpretation of the square hole on the bottom edge of the larger Caminreal frame (Fig 6 below) and the Cremona battle-shield is that this was a hole for a wedge driven in from the front to clamp the stock to the frame, allowing the two to be separated quickly when the catapult was not in use. This appears to be the solution on these larger catapults to the problem of the Xanten-Wardt's fixed, all-in-one construction.

The slider and stock have been sawn off immediately behind the frame. This is most unfortunate, because if the rest of the stock and its fittings had survived it would have settled the controversy about whether this size of torsion bolt-shooter was a crossbow, as believed by Professor Dr Dietwulf Baatz and most of this report's contributors, or a far

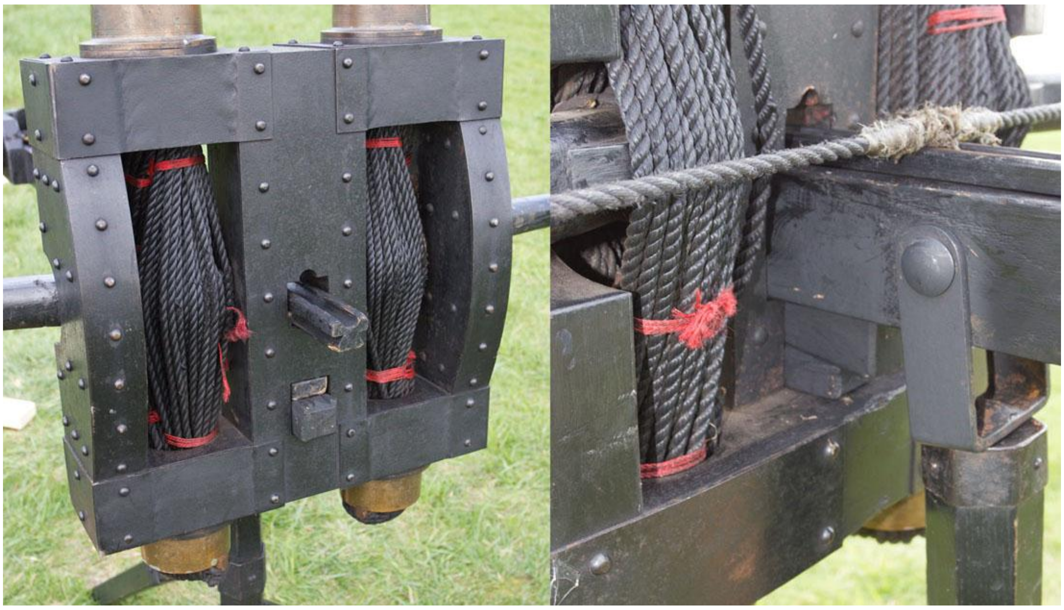

Fig. 6 A reconstruction by Len Morgan of a *scorpio maior* based on the Caminreal frame, showing the author's suggested wedge system clamping the stock to the frame. The upper wedge is permanently fixed to the underside of the stock. This allows quick separation of the stock from the frame, solving the problem of the fixed all-in-one stock and frame of the Xanten-Wardt *scorpio minor*.

Fig. 7 The front end of slider and stock, sawn off just behind the frame (Maarten Dolmans).

more powerful stand-mounted catapult wound up by a winch like its larger torsion brothers.

The description of the machine as a *manuballista* (hand catapult) in the title of the report and by some of its contributors is provenly incorrect, because at the time of the Xanten-Wardt machine the word *ballista* was only used for stone-throwers. The term *manuballista* belongs to the later design of bolt-shooter with an all-metal frame, of the type described in the *cheiroballistra* manuscript and first known from its appearance on Trajan's Column in the Dacian campaign of AD 101-102. The striking change of terminology that applied *ballista* to the metal frame bolt-shooters, as *manuballista* and *carroballista*, is explicable by the fact that they had borrowed the special offset *palintone* framework that gave the stone-thrower its increased power.

The Xanten-Wardt machine is a bolt-shooting *scorpio* catapult powered by torsion springs of sinew rope, which were mounted in a hardwood frame of European ash reinforced with bronze and iron plates. Torsion artillery was invented by Greek engineers in the 4th century BC, and the plated wood frame remained the standard construction until the introduction of the metal frame design. While the term *scorpio* was sometimes used in a general sense as an alternative to *catapulta*, it was frequently applied to the smaller sizes of bolt-shooting *catapultae*. The historian Livy lists *ballistae* and large *catapultae* amongst the booty taken by Scipio Africanus in Hannibal's base at Cartagena; he also records*"a vast number of larger and smaller scorpions and armour and weapons"*. The distinction which Hellenistic and Republican writers made between the larger sizes of bolt-shooters and scorpions is maintained by Vitruvius, who talks about the tuning of *catapultae*, *scorpiones* and *ballistae*. In his eyewitness account of the sieges of Jotopata and Jerusalem, Josephus uses a pair of Greek words for bolt-shooters, *katapeltai* (= *catapultae*) and *oxybeleis* ('sharp-firers' = *scorpions*). There is good evidence to identify the Three-span bolt-shooter as the *scorpio maior* (larger scorpion), and the One-cubit (Two-span) as the *scorpio minor* (smaller scorpion).

The clearest evidence is found in Philon's discussion of the choice of size for Dionysius of Alexandria's winched, stand-mounted, torsion repeating catapult: he calls it a *skorpidion*, a small scorpion, "*not much larger than a One-cubit machine, and not much smaller than a Three-span*." Both sizes are by implication winched, stand-mounted scorpions. A Three-span scorpion had a spring-hole diameter of 4 Greek dactyls = 77mm and a bolt 36 dactyls = 69cm long. A One-cubit or Two-span machine had a spring-hole of 2$2/3$ dactyls = 51mm diameter, and a bolt 24 dactyls = 46cm long. Philon states that Dionysius' bolt was only one dactyl longer than that of the One-cubit machine at 25 dactyls = 48cm long. In comparison the Xanten-Wardt torsion catapult has a spring-hole diameter of 2 1/3 dactyls = 45mm, and a bolt 9 x 45 mm = 40.5cm long. This makes it slightly smaller than a One-cubit/Two-span, as a One-and-Three-Quarters-span.

The internal diameter of the washers mounted on the frame decided the maximum amount of the spring-rope that could be crammed in, and can be regarded as the calibre of the catapult. The 45mm diameter of the Xanten-Wardt washers is similar to the two washer finds from the Tunisian Mahdia shipwreck (Mahdia no. 3, 45 mm), and Volubilis in Mauretania (no. 467, 44 mm). During the Carlisle Castle Green Millenium Excavations of 1998-2001 two blocks of iron-bound ash were found in the demolition layer of a military workshop or store dated to c. AD 140. They were tentatively identified as parts of a catapult, possibly the hole-carriers from a Vitruvian catapult frame. Tim Padley, Keeper of Archaeology at Tullie House Museum, kindly allowed me to place Wood Block 27 next to the Xanten-Wardt reconstruction and the official 1:1 plan of the German find.

Fig. 8 Iron-bound ash block 27 from the Carlisle Millennium Project, next to the 1:1 plan of the Xanten-Wardt hole-carrier (photo A.W., by kind permission of Tullie House Museum, Carlisle). The dimensions of the Xanten-Wardt hole-carrier are 208 x 87 mm.

They are the same in size and outline, the two Carlisle hole-carriers being in the early stages of construction, with the spring-holes and other details yet to be cut. This suggests that standardised catapult plans were distributed to *fabricae* throughout the empire. The Carlisle objects are the first known parts of a catapult framework to be identified in Britain; up to now the only British artillery finds, apart from the hundreds of boltheads, have been the washer from the spring at Bath (40 mm diameter) and the one from Elginhaugh fort, Scotland (34 mm).

So there is now growing evidence of the popularity of bolt-shooting catapults of 45 mm spring-hole calibre from the Republican to Imperial periods, the Xanten-Wardt and Carlisle examples probably having the same frame proportions. The dates for the finds are: Mahdia c. 80 BC, Xanten-Wardt mid 1st century AD, Carlisle c. 140 AD and Volubilis late 2nd to early 3rd century AD. The later Volubilis washer could have come from a catapult of either the wood frame or the metal *manuballista/cheiroballistra* type: there is no reason to believe that the wood frame type ceased production on the introduction of the metal frame. The Carlisle examples show a date overlap of some 40 years, but may of course have been manufactured several years previous to their loss. The wood frame design would have been far easier to construct, and less costly in time and materials.

The critical question concerns the identification of torsion bolt-shooting catapults of this 45 mm calibre. Were they, as Professor Dr Baatz continues to believe, so small that they were not winched like their larger brothers, but were crossbows cocked by stomach pressure or other methods? The interpretation of smaller torsion catapults of this spring diameter as weapons lacking a winch and stand was sparked off by Baatz in his 1974 *Saalburg Jahrbuch* article on the finds from Gornea and Orşova, and repeated in his 1978 article in *Britannia*. It flatly contradicts Heron of Alexandria's authoritative statement, in his description of the development of artillery, that torsion catapults developed so much power that the stomach-bow's withdrawal-rest had to be replaced with a winch, with a pulley-system added for the larger machines. Baatz later told me in a letter that his interpretation is based on the theoretical possibility that a Roman engineer could have picked up the idea of loading by stomach pressure from Heron's description of the early Greek stomach-bow, and applied it to a small torsion catapult.

Irrespective of the evidence quoted above for the smaller scorpion torsion catapults as winched and stand-mounted, the complete survival of the wood and metal of the Xanten-Wardt frame enables fully accurate replicas to be made, and settles the argument. There are now three copies of our Xanten-Wardt reconstruction in use by re-enactment groups, two in Britain by the Roman Military Research Society and the Ermine Street Guard, and another in Holland fielded by Pax Romana (Coh XV Vol C.R./Classis Augusta Germanica). They have been made with millimetre accuracy by Len Morgan and Tom Feeley from the official plans, and with help, through Maarten Dolmans, from the Xanten-Wardt report's contributors, Alexander Zimmerman and restorer Jo Kempkens. The arms, winch and stand are derived from Vitruvius' description and measurements; we are in the process of manufacturing the curved arms described by Vitruvius.

The simple, critical test is to discard our reconstruction's support stand and then attempt to hold the weapon steadily in the aim; next try loading it by stomach or muscle power, inserting the bolt, lifting it back into the aim, all this repeated time and time again as required on the battlefield. Without a support stand this is impossible. The point of balance is immediately behind the frame. With a stand and levered winch, operators of whatever stature and muscle power can keep reloading and aiming for indefinite periods. The use of the support stand meant that the first two hours of continuous shooting trials of my personal copy of the reconstruction could be carried out by my friends Tom and Eleanor aged twelve and ten; of course the pullback was reduced for safety reasons.

The above evidence for the Xanten-Wardt torsion catapult and those of similar calibre as Smaller Scorpions with winches and stands does not appear to be given space in the Xanten-Wardt report. The end of the report presents the reader with a curious reconstruction as a hand-held catapult loaded by pressing the extended slider vertically down into the ground, apparently using the weight of the machine plus downward pressure by the operator. There is a ratchet track mounted out of sight underneath the slider, a misinterpretation of the surviving remains of the stock, and a system for which there is absolutely no ancient evidence. The photographs of it being aimed show a re-enactor holding the stock with his left hand, with a curved shoulder-piece resting against his right shoulder; he has to take the weight of the weapon by raising his left leg onto a large box, and supporting his left elbow on his left knee. This strange box support system confirms that there is a weight problem. The vertically mounted shoulder-piece cannot be used to apply stomach pressure. If the contributors to the Xanten-Wardt report believe the catapult to be a crossbow, why did they not reconstruct the stock from Heron's clear description and diagram of the stomach-bow, using side ratchets and the curved horizontal withdrawal-rest with end handles?

“*The object of artillery-construction*,” states Heron, “*is to project a missile over a long distance at a given target and deliver a powerful blow*.” Philon advises, “*We must direct most of our research, as we have frequently emphasised, to achieving long range and to hunting down the features of engines which lead to power*.” A stomach-bow can only generate a fraction of the power of a winch, and cannot fulfil the requirements of these definitions.

The Xanten-Wardt frame of a torsion bolt-shooting *scorpio* is the most important catapult find made so far in two centuries of research. It is regrettable that this excellent report of its skilful recovery and conservation not only gives it an incorrect title, but also follows Professor Baatz’ personal theory that downgrades it to a crossbow.

Fig. 9 (left) Xanten-Wardt scorpion fielded by Pax Romana, demonstrating the Roman army’s pride in the impressive appearance of all its equipment (Maarten Dolmans). (right) Line up of catapults at the field tests for armour penetration supervised by Dr David Sim at Northampton in April 2011. In the foreground is the Xanten-Wardt *scorpio minor* next to the black *scorpio maior*.

Acknowledgements

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Augusta Germanica). Our thanks to Tim Padley, Keeper of Archaeology at Tullie House Museum, Carlisle for his help and for making the catapult part available to us.

Further reading

Hellenistic predecessors of Roman bolt-shooters are described in Duncan B. Campbell's *Greek and Roman Artillery 399 BC-AD 363* (Oxford 2003). Eric Marsden's classic *Greek and Roman Artillery: Technical Treatises* (Oxford 1971, reprinted 1999) has the texts and translations of Philon, Vitruvius and Heron. I have discussed the reconstruction of Vitruvius' *catapulta*, with a revised text and translation in "Scorpio and Cheiroballistra" : *Journal of Roman Military Equipment Studies* Volume 11 (2000), 77-101. Chapter 6 "Reconstructing the bolt-shooter" in my *Roman Artillery* (Princes Risborough 2003) is also relevant. The full title and publisher of the Xanten-Wardt report is given in the second paragraph of this article.