

## The ‘Lyverye Arrowe’ – An archetypal military arrow of The Mary Rose

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A sample Mary rose approximation arrows made for testing (Photo: Ola Pettersson)

A contemporary inventory of the Mary Rose, eponymously called *The Anthony Roll*, lists the ship as containing 400 sheaves of “Lyverye Arrowes”<sup>1</sup>. A sheaf of arrows is usually 24, so some 9,600 arrows were potentially part of her stores. The Mary Rose Trust has examined and recorded 609 of the 1,054 recovered arrows. An arrow classified as AZ472/19 is one of the shafts that have survived almost 500 years of immersion in the murky waters of the Solent. It is an archetypal example of the ship’s *Lyverye Arrowes* or army issued arrows.<sup>2</sup>

### Mary Rose arrow dimensions

Although a broad spread of arrow lengths was recorded, the vast majority lie in the range of 715-854mm in a bimodal (double peaked) distribution of 740mm (yielding an approximate draw length of 30inches) and 790mm (yielding an approximate draw length of 28inches). If the median nock depth (6mm) and the median tip (cone for the arrowhead) length (22mm) is subtracted from the two modal values it gives estimated draw lengths of 712mm (28.03inches) and 762mm (30 inches) respectively. Arrow number AZ472/19 had an effective

draw length, which is from nock valley to the shoulder of arrowhead, of 758mm (29.84 inches). Of all of the 609 analysed arrows, the following measurements are given for the total length of the arrow (including the arrowhead cone and not subtracting the nock valley). 841 were 31, 190 were 29, 9 were 32.5, 8 were 28 and 6 were only 27.5 inches length.<sup>3</sup> Of *all* of the 1,054 arrows of The Mary Rose Trust, only 9 could have been drawn to 31 inches at the shoulder. These were of alder. It has been suggested that most of the Mary Rose's arrows were originally suitable to take a 31 plus inch draw and previously damaged through shooting. It is argued that the repaired arrows have been re-headed and thus necessarily shortened. Adherents to this theory point to the fact that some military arrows were known to have been re-shot such as at the Battle of Towton in 1461 when the Lancastrian arrows fell short due to a strong headwind. The opposing Yorkist archers gathered the arrows and shot them back, along with their own arrows. However, these were not repaired arrows and were still intact. It is unlikely that given the prevalence of arrow shafts facilitating a draw length of close to 30 inches that these could have once been longer. If this were the case only 9 of the large sample could have been new arrows. The re-heading theory is conjectural at best.

All of the Mary Rose arrow nocks are, as Roger Ascham wrote in his seminal work *Toxophilus* of 1545, 'double-nocked' for "double surety of the shafte". The modern understanding of double-nocked to have two carved string grooves in an 'x' shape used exclusively for speed shooting in order to facilitate faster nocking. The Tudor description refers to a reinforced cow horn sliver, some 2 inches long, glued in at a right angle to the string nock. Many of these horn slivers show no relationship to the shafts grain so it must be assumed that the glue was very strong and did not need further assistance from the properties of the wood's grain. The median nock depth of the Mary Rose's arrows is 6mm which gives a generous fit upon the string and reduces the possibility of dry loosing of the bow in the heat of battle, which is potentially catastrophic. Ascham again has advice for both military and recreational shooting.

*"The deep and long nock is good in war for sure keeping in of the string. The shallow and round nock is best for our purpose in pricking for clean deliverance of a shot"*<sup>4</sup>

Arrow number AZ472/19 show no sign of binding below the nock to reinforce the area. No trace of protective finish remains on the shaft other than the verdigris compound on the shaftment.

The median nock width dimension is just less than 3mm wide. With a high quality natural fibre string this will provides a good fit that is not too tight.<sup>5</sup> An overly large string in a narrow nock can split the shaft upon loosing as it acts like a splitting wedge, thus endangering the bow as its power is not directed to propelling the arrow.

### **Mary Rose arrow shaft design**

A number different shaft designs were employed but the bob-tailed profile (that is an arrow tapered from head to nock) is statistically the most prevalent at 268 of the sample. Of the rest, 168 shafts were parallel, 114 barrelled, 32 saddled (or hour glass shaped which was quite subtle) and 27 breasted. The differing arrow profiles seem to have been stored in chests together with no sign of segregation. Therefore, it is difficult if infer any specific roles or uses for particular shaft profile types. The bob-tailed arrows were generally around ½ inch at the shoulder when measured by the Trust. All measurements were taken when the arrows were still saturated and a deviation of 10% (in reduction) was suggested for the dry dimension in diameter. Length is more static.<sup>6</sup> The bob-tail design affords a very stable mount for the arrowhead to do its work because the shoulder of the shaft is the largest diameter of the shaft. An arrow hitting a target at an oblique angle can cause the arrowhead to shear from the shaft before the projectile has the chance to impart its kinetic energy and penetrate. This, to an extent, is mitigated by the bob-tailed design. Due to the shaft tapering wood is removed where not needed from the shaft to maximise velocity by reducing the projectile's weight and allowing the arrow to 'paradox' or flex around the bow's handle section.

Aspen (*populus tremula*) was by far the most common arrow wood found followed by birch (*betular pendula*). Both woods are stiff for their mass but birch is considerably denser. By contrast, of the 609 sampled arrows only one shaft was of ash. Surprisingly, this is contrary to Ascham's advice for military arrows. He states, "*Again alder blackthorn service tree beech elder asp (aspen) and sallow either for their weakness or lightness make hollow starting scudding gadding shafts. But birch hardbeam (hornbeam) some oak and some ash being both strong enough to stand in a bow and also light enough to fly far are best for a mean which is to be sought out in everything*"<sup>7</sup>

### **Mary Rose arrow Spine**

Measuring arrow spine for military arrows is not a good way to estimate the draw weight bow it was intended to be shot from. The bows of the Mary Rose were all of a heavy draw weight ranging from around 100lbs and upwards, based upon Dr. Kooi's computer models and approximations made by the late Roy King, bowyer to the Mary Rose Trust. Many bow were extremely heavy and some perhaps twice as heavy as the lightest bows. Based upon analysis of the skeletons and their personal effects, a theory has been put forward that a retinue of elite archers were onboard when she sank. This would explain the probable range of widely differing draw weights. During battle, if necessary, all men could be equipped with a bow that they were master of with the heaviest reserved for those skilled and strong enough to use them.<sup>8</sup> The arrows seem not to be segregated and personal experience has shown that all of the recovered styles of arrows will work well with bows of 100lbs and considerably higher.<sup>9</sup>

### **Mary Rose arrow fletchings**

Arrow AZ472/19 had fletches of 174mm (6.85 inches) as evidenced by the witness marks left on the bees wax/animal fat/verdigris binding compound. This also closely corresponds to the sample's median fletching length of 181mm (7 1/8 inches).<sup>10</sup> Experimentation has shown that greylag goose pinions do not allow for fletches to be cut much longer but swan can allow fletches of 8+ inches. Most medieval visual depictions of arrows show white fletchings which could be domesticated geese or swan.<sup>11</sup> The original height and shape of the fletchings of the arrow is uncertain as none have survived but practical experimentation has shown 5/8 inches at the highest point provides adequate steerage yet allows decent range. Near contemporary carvings of livery arrows on Prince Arthur's Chantry Chapel in Worcester Cathedral, shows a triangular fletch with a forward raked tail. Ascham also states 'the triangle fashion which is much used now-a-days both be good'.<sup>12</sup> This cut is very efficient to manufacture and avoids the distance robbing turbulence caused by a trailing rear edge to the feather that follows the natural vanes.



Above is a detail from the Withypool Tryptic (1514) of English origin. The fletchings are white of the long and low triangular type. Saint Ursula carries her attribute, an arrow.  
Image courtesy of Bristol Museum and Art gallery

Tests with approximation AZ472/19 arrows showed that those fletched with goose afforded an increase of 5 yards in maximum range to those fletched with swan and 10 yards to those fletched with domestic turkey. However, turkey is very unlikely to have been used being only an oddity in Henry's reign and the pinions would have had brown barred stripes feathers rather than the white domesticated kind we are familiar with. The Mary rose's arrows all have fletchings are bound on with fine silk, likely to have been red, around 6 turns

per 1 inch as defined via the witness marks on the compound on the shaftment. The red colour may have been to denote crown property in an effort to secure the arrows against misappropriation. The bindings were covered with an animal fat/beeswax and verdigris compound applied in layers. The outer layer had the highest verdigris concentration and accounts for the green hue. It has been suggested that colour is only due to their long emersion in salt water. However, the arrow depicted in the Wilton Diptych of 1395 shows a distinct green hue also and the painting demonstrates no signs of age related colour distortion as the pigments are naturalistic and clearly unaltered by time. Approximation arrows also exhibited a strong green hue on the compound covered shaftment.



Verdigris is easily harvested by suspending copper over, and not in vinegar (Photo: Author)

Livery arrows were usually stockpiled for long periods before a forthcoming campaign or battle and the necessity for the binding compound becomes apparent. The following is from an inventory of Henry VIII's goods held within the Crossbowe Chambre at Calais.

*Packe threde: Glewe for bows and arrows: Petir Oyle di gallon: Salarmoniac oone lib di: Quick silver iii lb: Grene coporas (verdigris) oone lib: Rosalgare iij lb: Camphere (camphor for moth proofing) oone lb.*<sup>13</sup>

The list contains a number of fungicidal and insect repellents to help preserve the vulnerable feathers from attack whilst in storage as the ingredients promote longevity of the binding and feathers. Interestingly records survive of Henry V ordering silk for fletching bindings for the Agincourt campaign. Given the delicate size of the binding's witness marks imprinted on the verdigris compound it is easy to see that fine thread was used. A well preserved section

of shaftment with bindings is contained in a late medieval reliquary, designed by Hans Holbien the Elder in 1497, with a glass window in the rear and held in The Victoria and Albert Museum and Gallery. It purports to contain an arrow fragment from one of the many arrows that pierced Saint Sebastian. Of course, if it is a real relic it is considerably older!

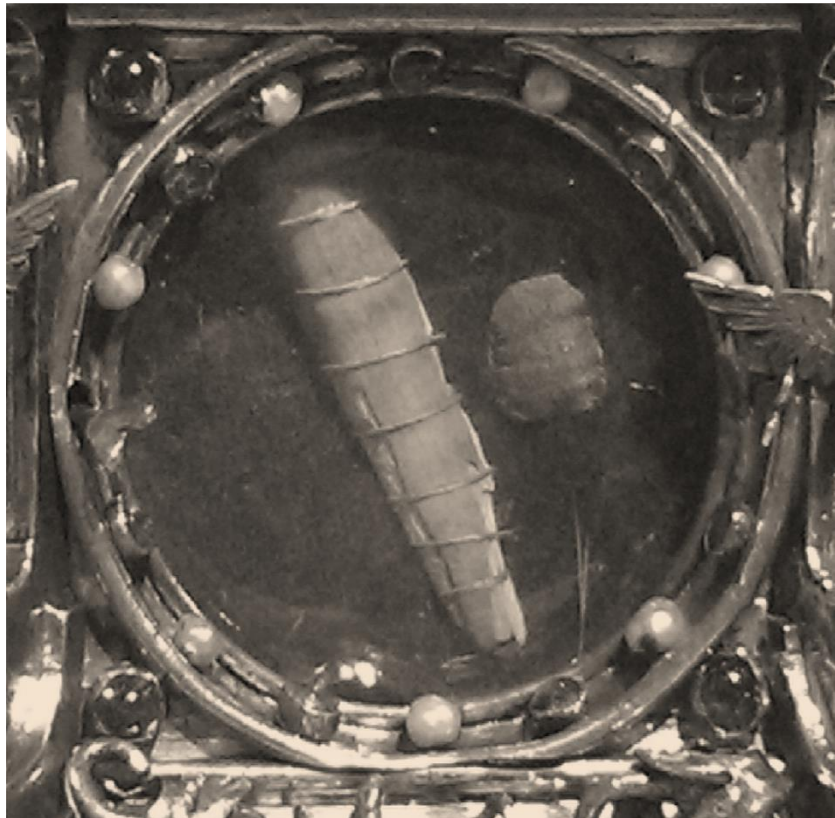
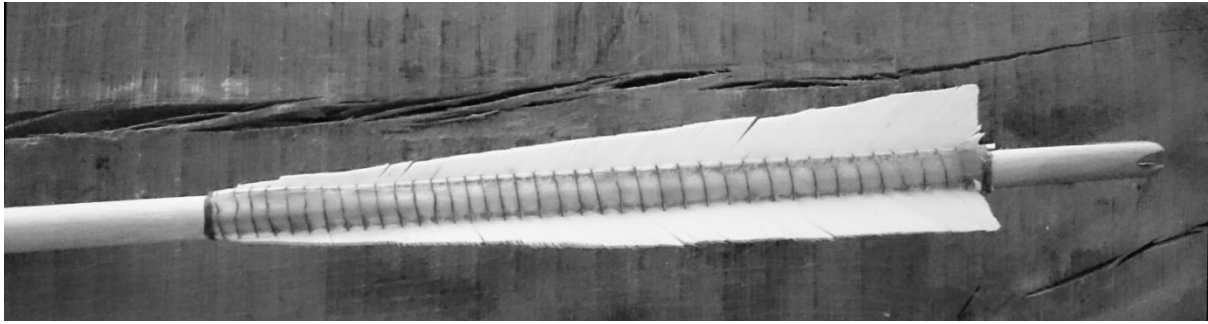


Image courtesy of the Victoria & Albert Museum

Fine tread does not separate the vanes unduly and thus reduces drag. Experimentation has shown that the binding compound can be heated and brushed over the bindings and allowed to cool. If care is not taken, capillary action can cause the compound to creep up the feather's vanes which stiffens them so they lose the ability to spring back to position. However, brushing from rear to front can minimise this. The result is a little uneven but the compound is easily smoothed by running the fletchings over steam. This leaves the surface very smooth to the point where the silk can barely be felt. Steaming has two further benefits as it rejoins any splits in the fletchings as a result of binding and potentially kills any feather mites that would destroy the feathers over time.





(Photo: Author)

The shaftment of an approximation arrow with the verdigris, animal fat and wax compound over the silk bindings. Mute swan pinions were used on this arrow.

### **Mary Rose arrowheads**

It is quite possible that arrow number AZ472/19 was armed with an arrowhead known as a M2 according to Jessop's taxonomy of arrowheads.<sup>14</sup> This type of head is also depicted in the carvings on Prince Arthur's chantry chapel in Worcester Cathedral, livery arrows being one of his emblems.

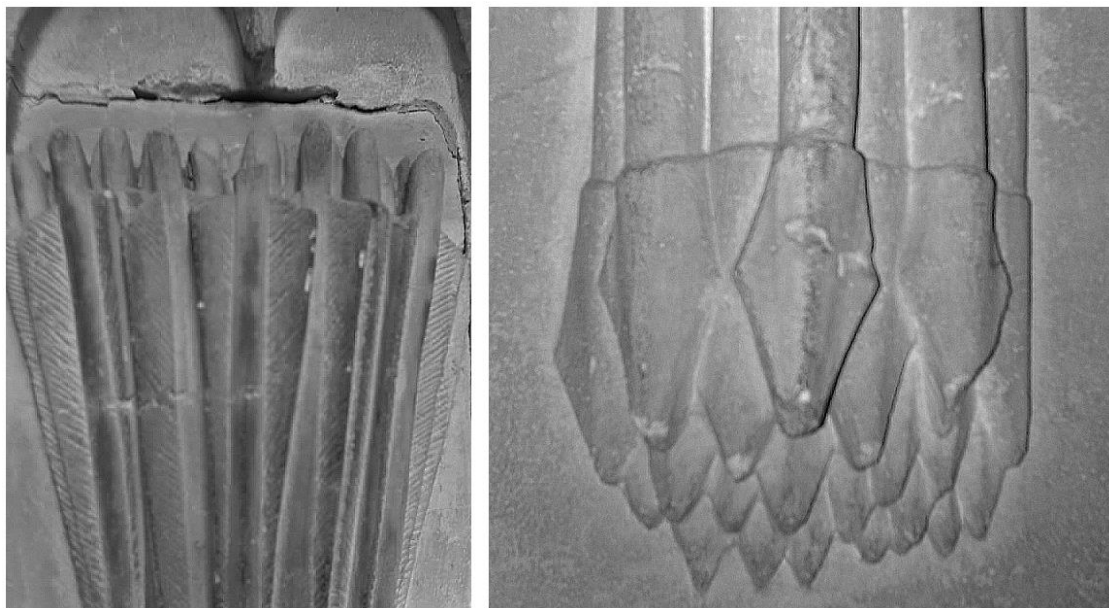


Image courtesy of the Dean and Chapter of Worcester Cathedral

This type of head has also been excavated from Porchester Castle and dated to around the mid-16 Century and conceivably been part of the supplies intended for Henry's fleet. The M2 is relatively quick to produce because although the sockets must be forged by hand some production is semi-automated and substantially faster than the Type 16.<sup>15</sup> My test, conducted with A Aston, has shown that whilst the Type M2 is very effective against unarmoured targets it is



not as effective against either maille or plate armour as other designs of head. The arrows of the Mary Rose would be far less likely to penetrate the breastplates to any depth of the type excavated from the wreck if the French were armoured in such a way. It is quite possible, by the way the breastplates were stacked together during the action that they were not intended for onboard use but as supplies for land armies. However, the Mary Rose arrows were potentially deadly against sailors who were likely to have been unencumbered by heavy armour in order to swiftly climb rigging or avoid certain drowning under the weight of the ferrous armour.<sup>16</sup> Even the 500, or so, soldiers would not have been in full harness and susceptible to French missiles over much of their bodies. The Anthony Role lists the other ships ship, not just the Mary Rose, as possessing longbows so it is likely that mariners used the weapons as well as soldiers.<sup>17</sup>



(Photo: Ethan Wilson)

In tests the Type M2 (circled) consistently performed less effectively against a half carcass of pig that was armoured with multi layered linen and riveted steel maille than other heads mounted on arrow number AZ472/19 approximations.

The head had a tendency to gather the links and thus dissipate the impact energy over a larger area. The Type 16 was more effective but the Type 9 heavy bodkin, a design commonly used some 100 years earlier at the height of plate armour, sometimes achieved 8 inches of penetration, albeit. The riveted maille approximation was based upon the gauge and ring diameter of a fragment excavated from the Mary Rose (83A0153AD).<sup>18</sup> However, without armour the M2 armed arrows were easily capable of breaking ribs and penetrating to lethal depths in the vast majority of shots. All testing was carried out with 135 lb draw weight self yew bows. All shooting was carried out at a range of 25 yards. The penetration an arrow achieves is in large part proportional to its initial velocity as is the distance. The table below shows the best distances shot at Warbow Wales shoots with Mary Rose self-yew approximation bows and, as importantly, natural strings of hemp or linen. The table (below) shows these distances achieved whilst shooting on flat ground using approximation Lyverye arrowes. Environmental factors also play an important part in maximum range and account for small anomalies in distance, most notably with the 3 which is less than 2 despite a higher draw weight bow.

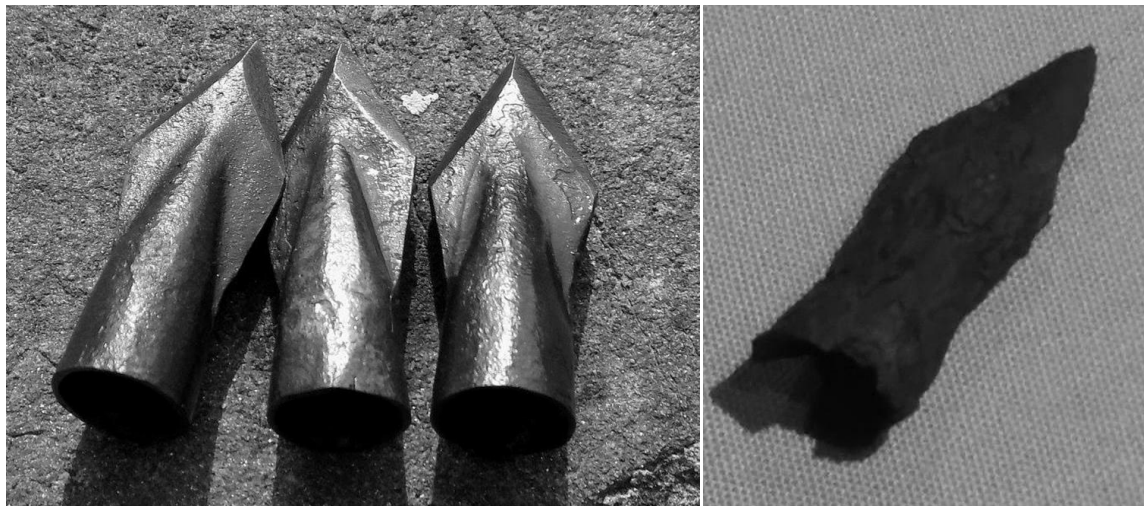
<b><i>Mary Rose approximation self yew warbow Using a hemp or linen string</i></b>	<b><i>Mary Rose Approximation Lyverye arrowe Distance achieved in yards</i></b>
1. Italian yew 105 lbs @ 30"	199
2. Welsh yew 120 lbs @ 30"	252
3. Italian yew 145lb @ 30"	242
4. English yew 160 lbs @ 30"	255

All distances shot at Warbow Wales shoots

It is possible that other types of head were used. The Mary Rose Trust has also suggested a closely barbed arrowhead called a Jessop's Type 16 as a potential candidate. Ascham refers to the arrowheads with "little barbs" of narrow diameter heads designed to maximise penetration for "when a man shooteth at his enemy, he desireth rather that it should enter far, than stick fast."<sup>19</sup> Whatever heads were fitted it is probable they were glued onto the shafts.

Records contemporary to the Mary rose show the Calais armoury held “Glewe for bowes and arrows”. This would suggest that fletching glue was used to attach the feathers prior to binding and the arrowheads as well.<sup>20</sup> Some of the Some Mary Rose arrow shafts had traces of oxidised copper on their cones where the head attaches and may have been deliberately mixed in with the glue, perhaps as a preservative. Gluing on the arrowhead aids in penetration as it reduces the tendency for the momentum of the shaft upon impact opening out the cone of the arrowhead, thus dissipating energy.<sup>21</sup>

There is no evidence of the arrowheads being pinned as the cone of the shafts does not exhibit any holes. It is likely that any arrowhead fitted to the recovered arrows would have been able to pass through the ½ inch diameter holes in the leather spacers of arrow bags also excavated. As no heads have survived in any reasonable state of preservation the matter is conjectural. Given the diversity of arrow shafts and dimensions it is not improbable that a variety of head types were used. *The Anthony Roll* offers no further clues either.

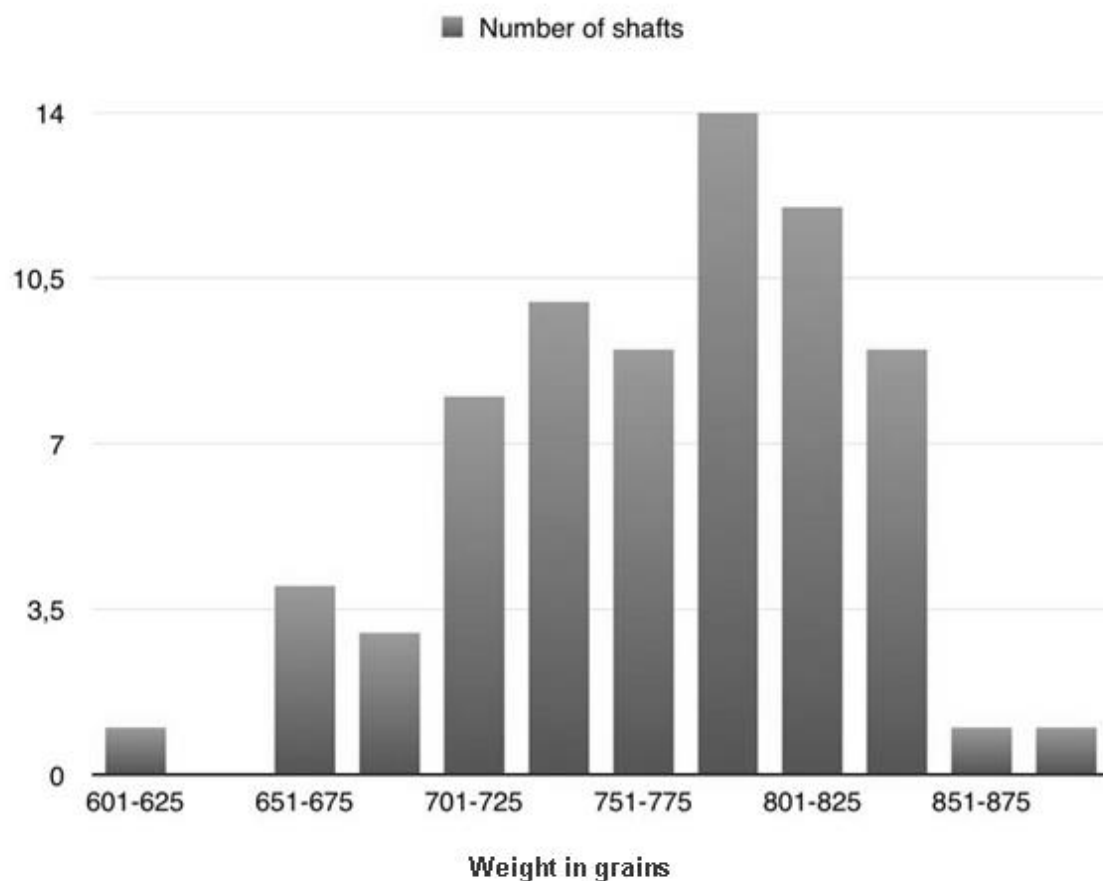


Approximation Type M2 heads by Miloslav Križan and an extant M2 arrowhead found at Porchester Castle (photo: Ed Harris)

### **Mary Rose arrow weight**

The Mary Rose Trust, in its authoritative publication, *Weapons of Warre*, suggests an overall weight of a typical arrow (that is, of aspen and on 30 inches of draw length like AZ472/19) as weighing 45 grams plus the arrowhead. A Type M2 made by master arrowsmith Hector Cole MBE weighs around 6 grams. The Mary Rose estimates the approximate weight of some arrows as little as 40.5 grams including a light head.<sup>22</sup>

In 2015 Mr. Ola Pettersson conducted a short study on weight distribution of 1/2 to 3/8 inch tapered Swedish aspen shafts made to a typical Mary Rose pattern like MR AZ472/19 armed with a light Type M 2. It is also notable that he also used aspen and not tulipwood which is a New World wood frequently sold as ‘yellow poplar’ or ‘poplar’ but not actually of the populus genus at all. Therefore it is a poor choice for approximations. He concluded that the mean 30 1/2inch (drawlength not overall) tapered aspen shaft (1/2 to 3/8 inch), 2inch horn insert, goose fletched, bound with silk thread and one layer of glue (used in place of the binding compound), will weigh about 769 grains (50 grams) without a head. However, the various densities of the wood gave a range of weights from 600 grains (39 grams) to almost 900 grains (58 grams) distributed along a typical bell shaped curve. Extremes in density were present but about 70% weighed between 715-823 grains (46-53 grams) without heads.



Mr. Pettersson points out that his use of Swedish aspen, as opposed to English, may have skewed the results towards lighter or heavier weights. It is likely that

wood of a Scandinavian origin has a heavier density than that of the same British species due to the harsher growing conditions that retard growth but either would result in a 'bell shaped' distribution curve. However, it is known that aspen suitable for arrow shafts was a diminishing resource for more than a century before the Mary Rose sank. Aspen was also used for clog production throughout the Middle Ages. Henry V felt it necessary to have issued a proclamation (4 Henry V c.3 of 1416) restricting its use to military arrow production due to concerns about its supply. Those convicted of violating the law were subject to a hundred shilling (£5) fine, half of which was paid to the Fletcher's Guild.<sup>23</sup> The country of origin of the Mary Rose's arrow wood is, as yet, unknown but many of the bows are known to be made from imported timber. As non-indigenous timber was used for the bows (either for supply or performance reasons) Swedish aspen, therefore, cannot be ruled out as the material of some of the extant arrows.

## **Discussion**

Why did a minuscule number of the Mary Rose's arrows facilitated a draw of 31 plus inches when the vast majority drew to 30 inches or considerably less? Indeed, drawing a bow longer than it has been accustomed to work to potentially endangers it and certainly induces more permanent deformation, known colloquially as string follow. Deliberately having a small number of arrows that are longer than the vast majority seemingly makes no sense. It is possible that the few longer shafts were for fire arrows in order to keep the flame away from the archers hand. All of the long shafts were of elder which has fire resistant qualities, like oak, yet is lighter. Fire arrows are inevitably heavy due to the combustible material and supporting metal work so elder may have been a good choice to keep weight down.

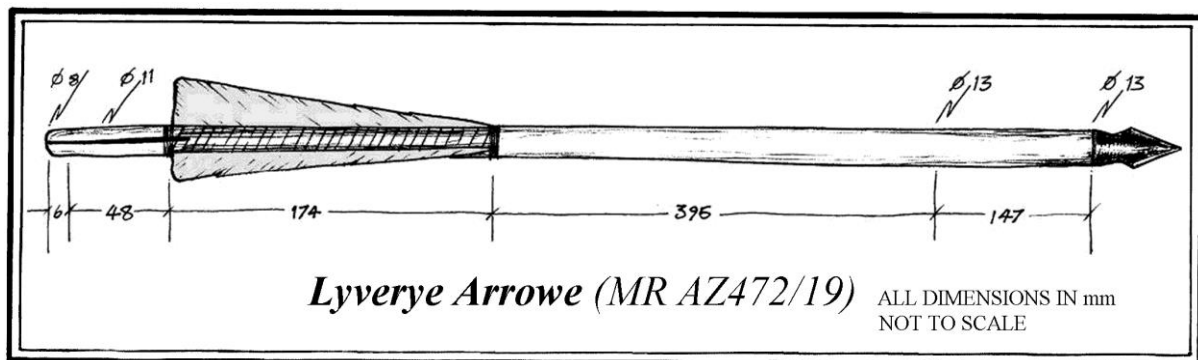
However, it is likely the longer shafts were due to a very prosaic reason. The shafts that draw to over 30 inches are anomalous and may well be caused by inaccuracy in the marking out/making due to quality control errors by the fletchers. Given the nature of high volume production of handmade artefacts this is to be anticipated. The arrows were made in an environment of time constraints and a lack of materials. It was clearly not worth the small amount of extra time it takes to align the grain to the horn sliver which is nowadays seen as essential with approximation arrows. An insight into the nature of material constraints is demonstrated by the many shafts where the grain does not run the full length of the arrow which is not ideal and weakens the shaft. The wasted wood if grain run-off was cause for quality based rejection was clearly insupportable.

Of the few bowmen who are capable of mastering Mary Rose draw weight

longbows many report they are able to perform a cleaner loose at 30 inches, as opposed to longer draws. This is due to having more range of motion left for their fingers to clear the string sharply. With a bow tillered to 30 inches, which can be safely made shorter than a bow to accommodate a longer draw, can equal or improve upon the performance of a longer draw.<sup>24</sup>

Clearly it is a modern custom to consider the standard draw length for warbow shooting as 32 inches. Much of this is due to the BL-BS Standard Arrow, which inspired interest in Anglo/Welsh military archery in the early days of the heavy longbow's resurgence. More recent experimental archaeology with accurate approximation bows, strings and arrows has giving us an insight into the considerable effectiveness of this weapon system.

*Lyverye Arrowe AZ472/19* is illustrated schematically here.



(Illustration: Author)

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<sup>1</sup> Stirland, A *Raising the Dead: The Skeleton Crew of Henry VIII's Great Ship, the Mary Rose*, Wiley, 2000, p.122

<sup>2</sup> Hildred, *Weapons of Warre*, The Mary Rose Trust 2010, p. 665

<sup>3</sup> Soar, H *Straight and True, a Select History of the Arrow*, Westholme Publishing 2012, p.101

<sup>4</sup> Ascham, R *The English Works of Roger Ascham: Preceptor to Queen Elizabeth*, White, Cochrane and Co., 1815, p.140

<sup>5</sup> Testing by the author and A. Aston have found a full length hemp string of under 2mm in diameter capable of repeated shooting with bows over 150lbs in draw weight.

<sup>6</sup> Soar, *Ibid.* p.100

<sup>7</sup> Ascham, *Ibid.* p.138.

<sup>8</sup> Stirling, *Ibid.* p. 129

<sup>9</sup> Heavy longbowman, Joseph Gibbs has had good results from shooting ½ inch bobtailed arrows under 50gms in weight out of a 170lb longbow. Traditionally this would be regarded as too light an arrow but neither the bow or archer suffers any ill effects.

<sup>10</sup> Hildred, *Ibid.* p. 688.

<sup>11</sup> The authors tests with heron pinions has shown they provide a decent sized and effective fletching although this unlikely to have been used on any scale. Eurasian crane would also have been available to medieval fletchers and both birds would have been unwelcome as they predated fish.

<sup>12</sup> Ascham, *Ibid.* p.145.

<sup>13</sup> Davies, J *Military Archery & the Inventory of King Henry VIII*, Journal of the Society of Archer-Antiquaries (Volume 44), 2001, p.31

<sup>14</sup> Jessop, O *A New Artefact Typology for the Study of Medieval Arrowheads*, University of Durham, 1996,

<sup>15</sup> Personal correspondence with Master Arrowsmith Hector Cole MBE

<sup>16</sup> Childs, D *Tudor Sea Power: The Foundation of Greatness*, Seaforth Publishing, 2009, p. 82

<sup>17</sup> Stirling, *Ibid.* p. 123

<sup>18</sup> Hildred, *Ibid.* p. 843. The testing was undertaken with the presumption that the French forces were armed in a similar fashion to Henry VIII's. It is possible leather jerkins served as armour mariners but would provide little protection from arrows.

<sup>19</sup> Ascham, *Ibid.* p.131.

<sup>20</sup> Davies, *Ibid.* p.31

<sup>21</sup> Tests by M. Stretton, who experimented with the penetrative qualities of both unglued and epoxy resin bonded arrowheads, showed the glued heads to be more effective at penetration against plate. However, unglued heads could be even more effective against lightly or un-armoured targets. The penetrative power would still be ample yet the arrowhead could easily remain embedded within the body even if the shaft was removed. A Type 16 would amplify this effect due to the barbs.

<sup>22</sup> Hildred, *Ibid.* p. 686

<sup>23</sup> Grew, F & De Neergaard, M., *Shoes and Pattens: Finds from Medieval Excavations in London*, Paul Meekins Military & History Books 2004, p99

<sup>24</sup> Author's personal experience and correspondence with archers such as J. Gibbs, A. Aston and C. Hood who have moved to a shorter draw of 30 inches. The archers range in height from 5 foot 8 inches to over 6 foot. Thanks to Neil Lang for providing a very knowledgeable sounding board for various theories.