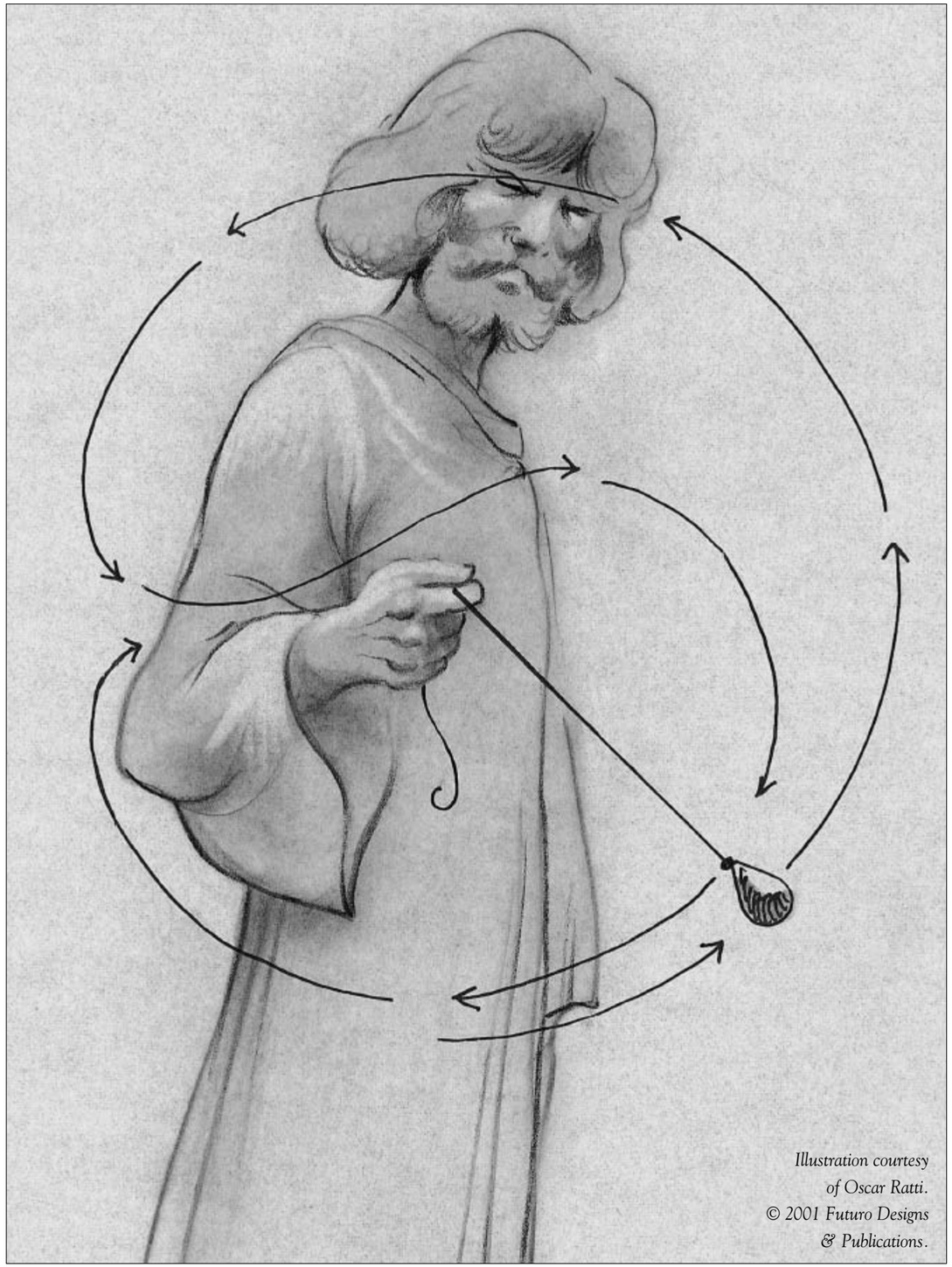

Illustration courtesy of Oscar Ratti. © 2001 Futuro Designs & Publications.

The Sling

Forgotten Firepower of Antiquity

Robert E. Dohrenwend, Ph.D.

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Abstract

The sling is mankind's second oldest projectile weapon after the throwing spear, and it is still in use today. Simple, cheap, easy to make and lethally effective at surprisingly long range, the sling is found almost everywhere in the world. As is the case with most simple weapons, its only drawback is the amount of time necessary to attain mastery of technique. In antiquity, it was an important military weapon. So, it is all the more surprising that comparatively little work has been done on the sling by modern scholars, and that so little is really known about this weapon among martial artists. This article is an attempt to survey our current knowledge of the sling, and to introduce the weapon to those training in the modern fighting arts.

Introduction

The sling was an important military weapon from the beginnings of organized warfare to the end of the Middle Ages. However, although it is one of the most effective missile weapons ever devised, it is generally neglected by military historians, receiving brief mention only in the most general terms when it appears at all. Detailed discussion of the sling has been relegated to a specialist literature that is both sparse and not easily available. This is all the more surprising when we consider the enormous literature dealing with the military use of archery. According to the few available studies, the sling out-ranged the bow, was more accurate, and easily as deadly. A sling can throw a lethal projectile almost a quarter of a mile, and in the hands of an expert, it is very accurate at distances up to a least 220 yards. Both the weapon and its ammunition are very inexpensive.

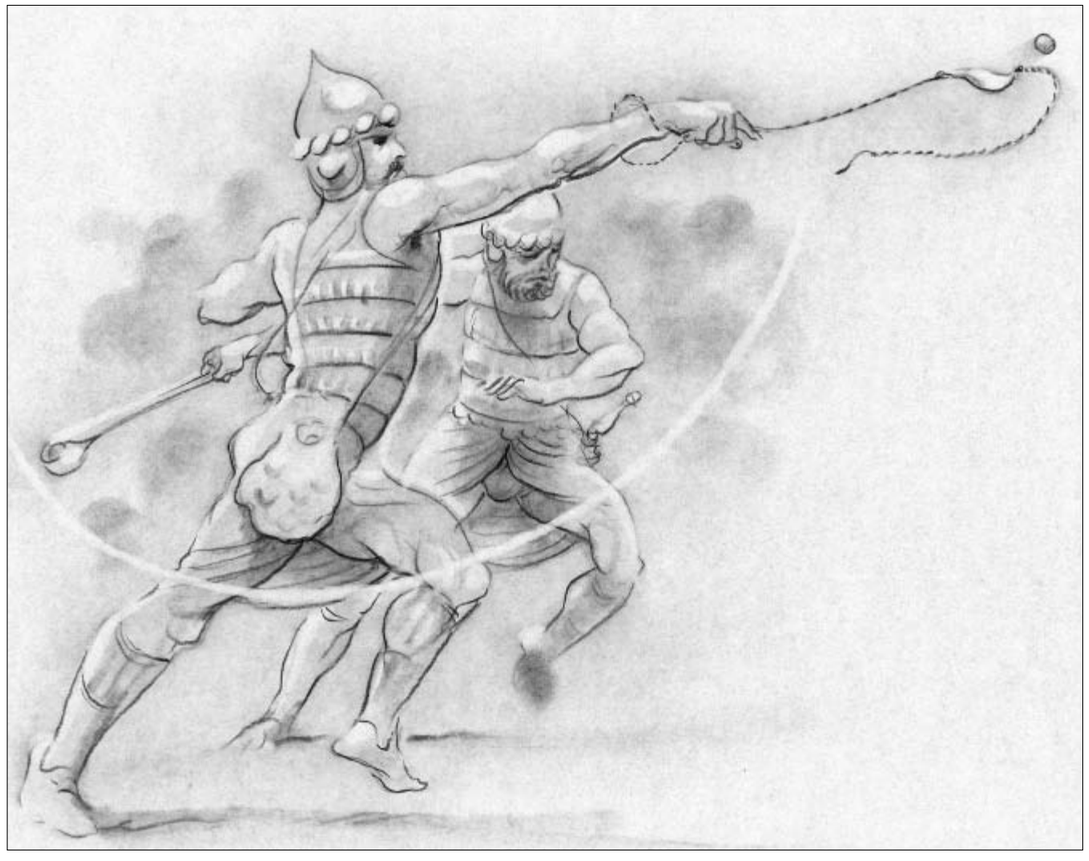
There are two basic types of sling: the hand sling and the staff sling. The staff sling seems to have been almost exclusively a military weapon, and was much less common than the hand sling. Although it has a very respectable antiquity, it would seem that it was less accurate and less powerful than the hand sling. We will not discuss the staff sling in the following discussion.

Historical Background

According to Ferrill (1985: 240), the sling appeared between 12,000 and 8,000 B.C.E. Other sources are more vague and only state sometime before 6,000 B.C.E. Anthropologist V. Gordon Childe demonstrated that a useful criterion for the division of Mediterranean Neolithic culture provinces is the choice of missile weapon, the exclusive use of either sling or bow (1951: 1-5). In Egypt, the sling appears only at the beginning of the XXth dynasty (1187-1069 B.C.E.) in the new kingdom (Yadim, 1963: 83). Apparently, choice of one precluded the development of skill or even interest in the other. There appears to have been no selective advantage of one over the other.

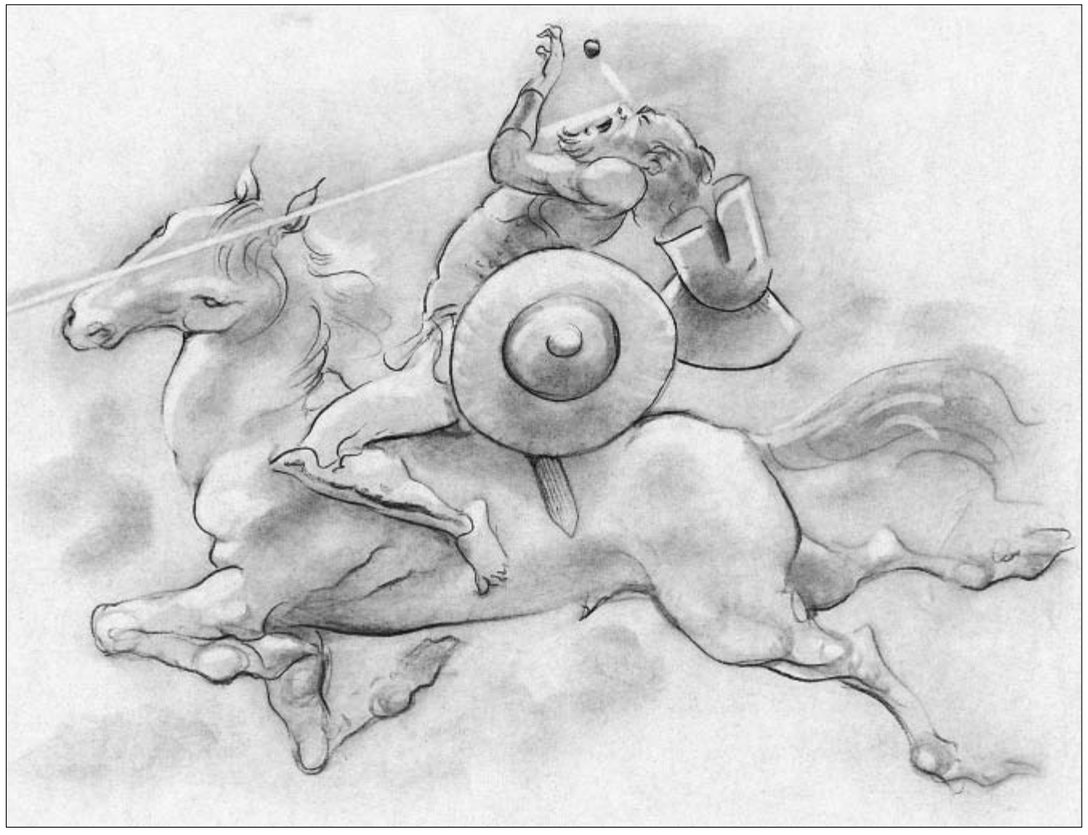
Slings appeared in Assyrian armies only in the 8th century B.C.E. in the reign of Tiglathpileser II (or possibly III), with the slingers operating in pairs behind the archers (Yadim, 1963: 296). The archers were the main combat arm of the Assyrian infantry, which used an advanced type of composite bow.

Sources describing the military use of the sling at later dates (i.e. Persian and Assyrian armies) often describe slingers as brigaded and deployed with archers in battle. Xenophon (1959: 78-79) is remarkable for the detail in which he discusses slingers; other ancient sources are less useful.



Assyrian Slingers and a Greek Cavalryman.

Charcoal drawings by Oscar Ratti.



In the Roman Republic, there were regular cohorts of slingers (Ferrill, 1985: 26). In the same period, "The Visigoths are said to have been excellent slingers" (De Hoffmayer, 1982: 89). Balearic slingers were used as mercenaries until the end of the medieval period (Korfmann, 1972: 7). Although slingers had less status in ancient armies than did heavy infantry, this does not necessarily reflect on their utility.

Slings were used in European armies until the 16th century, at which time they were often used to throw glowing coals and grenades (Demmin, 1893: 875). Heinrich VII's (1308-1313) expedition to Italy was accompanied by slingers. The Castilians used slings at Nájera (1367); Froissart (1901: 108) claims that they smashed in helms and bassinets. Froissart also asserts that the Castilian king had 30,000 infantry slingers in 1386 (De Hoffmayer, 1982: 213). Many slingshots were found at the site of the Battle of Aljubarrota (1385) (Reid, 1976: 21). The sling was last used in Europe for military purposes at the

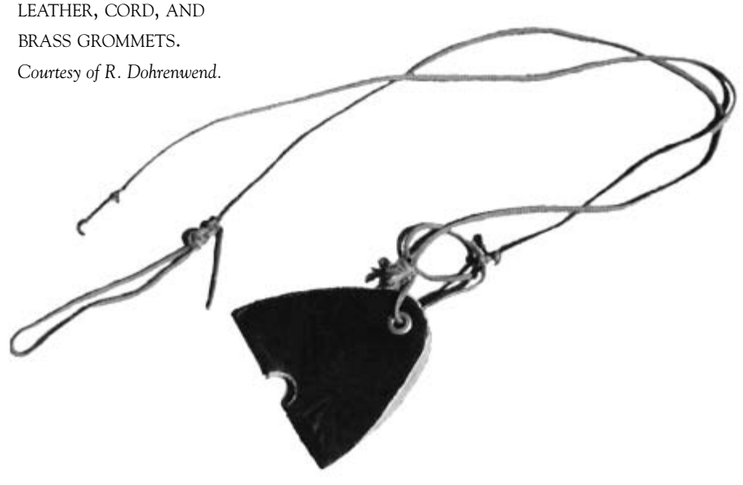
siege of Sancerre in 1572 by the Huguenots. These Huguenot slings were nicknamed *arquebuses de Sancerre* (Reid, 1976: 21). In Peru and Mexico, the Aztecs and Incas made very effective use of slings against the Spanish conquistadores (Mahr, 1964: 123; Friedrici, 1910: 289). The people's party during the minority of Louis XIV called themselves *La Fronde* (The Sling) in their contest against Anne of Austria and Cardinal Mazarin (Demmin, 1893: 875; Korfmann, 1972: 7).

In Asia, the sling was generally used by tribal peoples outside the direct influence of civilization centers. Normally these were pastoral peoples and, in fact, the weapon is often called the "shepherd's bow." This is especially true for East and Central Asia, where the sling was in recent use in Tajikistan, Kyrgyzstan, Afghanistan, the Indian mountains, the southern half of the Malaysian Peninsula, Guangdong Province in China, and Korea. It is also known in Indonesia and the Philippines. In Tibet, it was in regular military use up to the end of the last century, and the Tibetans were reported to be able to throw a stone 300 yards with one. Sir Aurel Stein found a sling in the Tsaidam Basin area, which is said to date from the 9th century C.E., and the weapon was in recent use by the Mongols in that area (Lindblom, 1940: 33-35).

In Europe, the sling was used in more modern times as a shepherd's weapon: in Dalmatia (18th and 19th centuries), the Alps (up to the 20th), England (up to the 19th), and the Balearic Islands (to the present) (Korfmann, 1972: 7). It is still in use in Spain, Syria, Palestine, Jordan, the Hejaz, north Africa, and the Canary Islands (Korfmann, 1972: 7). During the Spanish Civil War, at the Siege of Alcázar (Toledo), Loyalists threw grenades into the fortress with slings (Korfmann, 1973: 41).

The sling has been used as a hunting weapon, but it was more commonly used for protecting crops and livestock. Although there are pictures showing the weapon used to throw stones at birds in flight, it is not certain whether the

MODERN SLING MADE OF LEATHER, CORD, AND BRASS GROMMETS.
Courtesy of R. Dohrenwend.



birds were being hunted or merely chased away from gardens or fields. The accuracy required is very different for the two purposes.

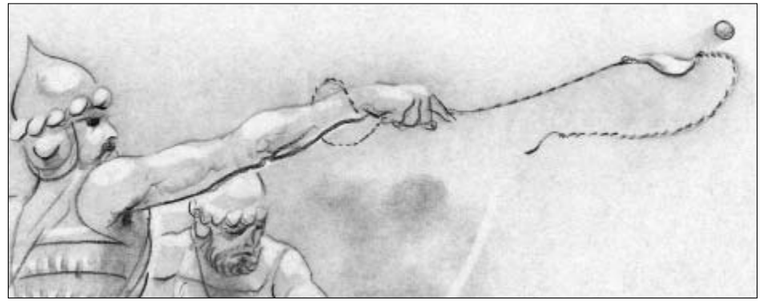
Most of the technical information available on slings comes from studies of the weapon as used in Europe or by primitive societies during the period of initial contact with Europeans. There are very few studies of this weapon as used in East or Central Asia, but its technical features and the analysis of its use as presented here should apply to all cultures. Like archery, the practical use of the sling was drastically curtailed by the introduction of modern firearms. Unlike archery with its enormous modern following, the use of the sling has not become a 20th century sport.

DESCRIPTION

The sling is one of the simplest of all weapons to make and its ammunition is extremely easy to make or find. Korfmann makes the point that slings were mostly found in areas where proper-sized stones and pebbles were readily available (1972: 10). The weapon consists of two strings connected to a pouch between them. The free end of one string has a loop or knot to keep it from sliding off the hand while the other end may either be left free to facilitate release or provided with a knot to increase control.

The sling may be made of a wide variety of substances. Plaited grass and a variety of woven materials have been used (Hawkins, 1847: 98; Lindblom, 1940: 7, 33-35; Mahr, 1964: 119; Korfmann, 1972: 4-5) and leather and wool were also common materials (Mahr, 1964: 119). Some slings were made of a single piece of leather for increased strength.

It is difficult to improve on the basic sling. Possibilities for doing so are limited to: (a) form of the projectile; (b) the length of the thongs, straps, or strings; or (c) superior materials and craftsmanship.



THROWING TECHNIQUES

The throwing techniques control the initial velocity at departure of the missile from the sling (departure velocity) and the angle of departure. Departure velocity is determined by the length of the path over which acceleration occurs, the uniformity of acceleration along that path, and the acceleration itself. The angle of departure is unaffected by departure velocity. We will examine three basic throwing techniques:

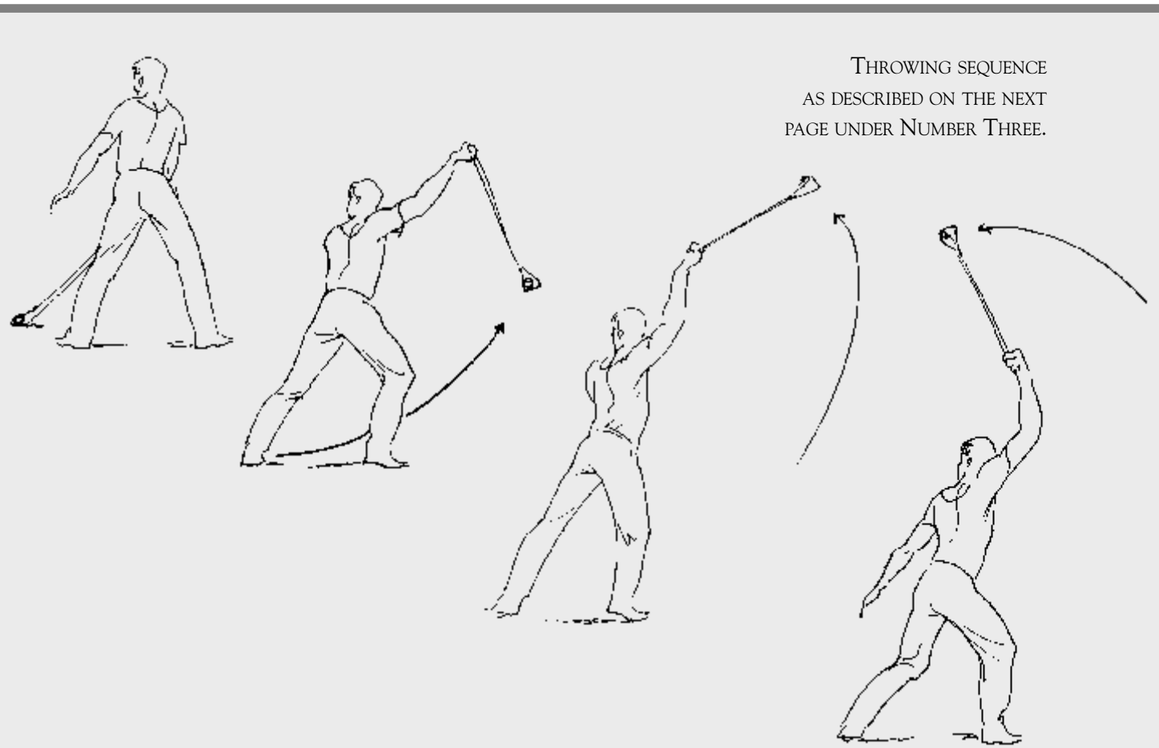
❶ Whirling the sling in a horizontal plane around a vertical axis extending from the ground up through the top of the head (around the head). After placing the stone (or other projectile) in the sling's pouch, the sling is raised above the slinger's head with the pouch held in the left hand, and the ends of the strings in the right hand. The pouch is released with a small toss to the side, and then whirled around the head with the right hand. The initial whirl is done with the wrist; at the second (or final) whirl, the arm straightens involving the elbow and shoulder. This accelerates the rotational speed while increasing the length of the arc described by the sling's pouch. At the proper moment, the end of one string is released. The pouch opens, and the projectile flies toward its target (Yadim, 1963: 364).

The projectile reaches its maximum velocity very quickly. Romans were trained to release projectiles at the sling's first turn (Ferrill, 1985: 36). Apparently, three revolutions to gain speed before release was considered normal elsewhere. Further revolutions add very little additional velocity at an unacceptable cost in muscular exhaustion. All other factors being equal, the velocity for a particular sling will be determined by its length, which determines the length of the path over which the projectile accelerates.

❷ Whirling the sling in a vertical plane initially around a horizontal axis extending parallel to the ground through the wrist, then involving the entire arm for power in the final rotation. Once again, the projectile reaches its maximum velocity very quickly (two revolutions); and, all other factors being equal, the velocity for a particular sling will be determined by its length. Depending on the direction of rotation, the projectile may be released at either the top or bottom of the swing. If the release is at the bottom of the swing, it is difficult to involve the entire arm for power unless the sling is relatively short. Otherwise, it will strike the ground before release. This technique does not seem as strong as the first.

❸ Beginning with the sling pouch containing the projectile on the ground in front of the slinger, the sling is whipped backwards and up behind the slinger to describe a complex, curved, vertical path that arcs upwards. As it descends, the sling is given a straight, sidearm acceleration toward the target. This technique is somewhat similar to cracking a whip, and imparts a greater acceleration to the projectile than the two techniques described above, and gives the greatest height and distance. This technique may also be adapted to an overhand throw (Blaine, 1960: 31-34).

There is no standardization of throwing techniques, so others are possible and some techniques have been described that appear to be recent developments (Savage, 1984: 39-44). These seem to be more involved or weaker than those described above and would seem to be less suitable for military applications where maximum range and impact are required. They might possibly have applications for close work, throwing from cover, rapid response, or closer accuracy. Or they might not.



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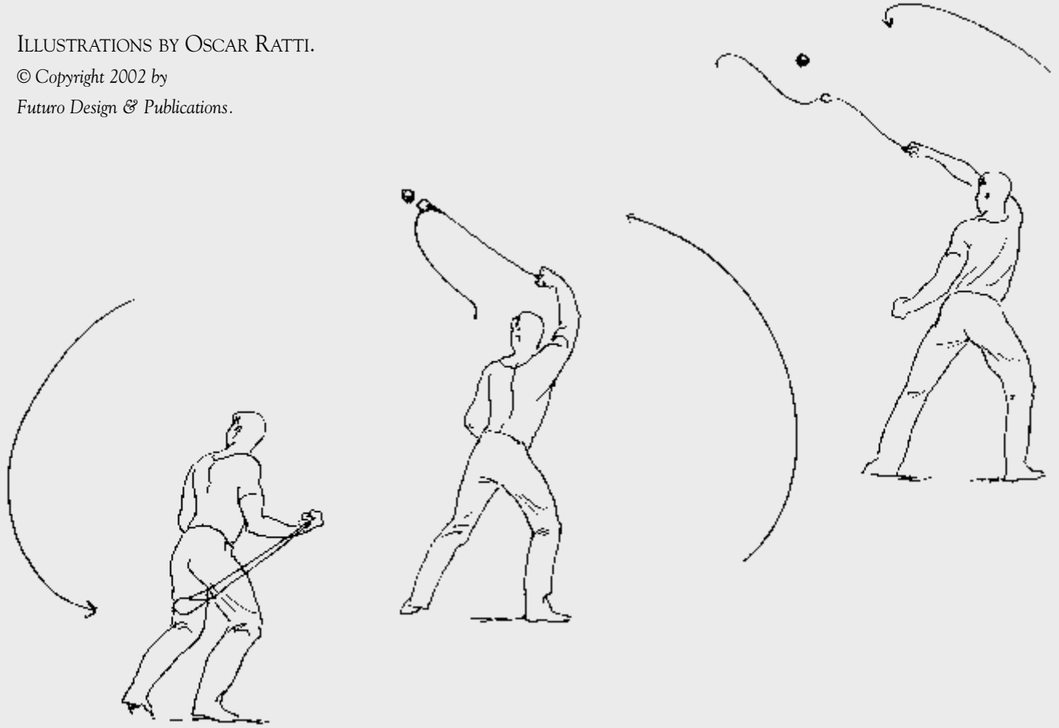


ILLUSTRATIONS BY OSCAR RATTI.

SLING BALLISTICS

PROJECTILES

These vary widely in size, shape, and materials; and include smooth stones, egg-shaped stones, limestone, sun-dried clay ovoids and biconical projectiles, and cast lead. Missiles were originally spherical, becoming biconical, and then ovoid or egg-shaped after 4,000 B.C.E. (Korfmann, 1973: 38). Near Eastern projectile dimensions vary from 0.5 to 6.5 ounces; 0.3 to 4 inches (diameters of 0.8 to 2 inches) (Korfmann, 1973: 38). A lead Greek sling stone had twice the range of the heavy stones used by the Persians (Warry, 1980: 62). Lindblom states that the Greeks used lead as early as the 5th century (1940: 9). Balearic slingers were known to use heavier projectiles than normal. Stones were used during the Roman Empire, while lead was used during the Republic (Watson, 1969: 61). It would appear that the Republic had more effective slingers than the Empire. The usual range of weights is between 0.7 to 1.75 ounces (Korfmann, 1973: 38). Romans of 40 B.C.E. used a lead projectile that measured 2 inches on its long axis and weighed 1.4 to 2.1 ounces (Mahr, 1964: 120). Maximum weight has been estimated at between 11.5 to 15.7 ounces (Korfmann, 1973: 39). Lead sling projectiles similar to the Roman glandes were used frequently even in the Middle Ages in northern Italy and Germany (Demmin, 1893: 876).

TABLE I Typical Sling Projectile Weights Compared to a Baseball

											Baseball
Grams	10	20	30	40	50	60	70	80	90	100	142
Grains	154	308	463	616	772	924	1081	1232	1390	1545	2185
Ounces	.35	.70	1.0	1.4	1.76	2.1	2.47	2.8	3.1	3.5	5.0

VELOCITY AND TERMINAL EFFECT OR IMPACT

There are a lot of questions yet to be answered about the dynamics of a sling projectile in flight, so that the following is only a very crude analysis of external and terminal ballistics. To determine the theoretical effect of a thrown sling stone, we must have some idea of its velocity on impact.

It has been shown that, for the same impact energy, a heavy projectile traveling slowly does more damage to a living target than a light projectile traveling rapidly (Taylor, 1977: 12-14; O'Conner, 1949: 309). It takes an impact energy of about 70 footpounds* to cause a fracture of most bones of the human body, but less than 2 footpounds to pierce the human body (Gabriel & Metz, 1991: 61). A 2-ounce projectile traveling at 200 feet per second will have an impact energy of 82 footpounds. It is generally agreed that on impact, sling stones could easily penetrate the body of an unarmored man. Biconical sling stones were deadlier than arrows against leather armor (Lindholm, 1940: 7; Mahr, 1964: 123; Korfmann, 1972: 15; Korfmann, 1973: 40), and could cause lethal injury even if they failed to penetrate the armor.

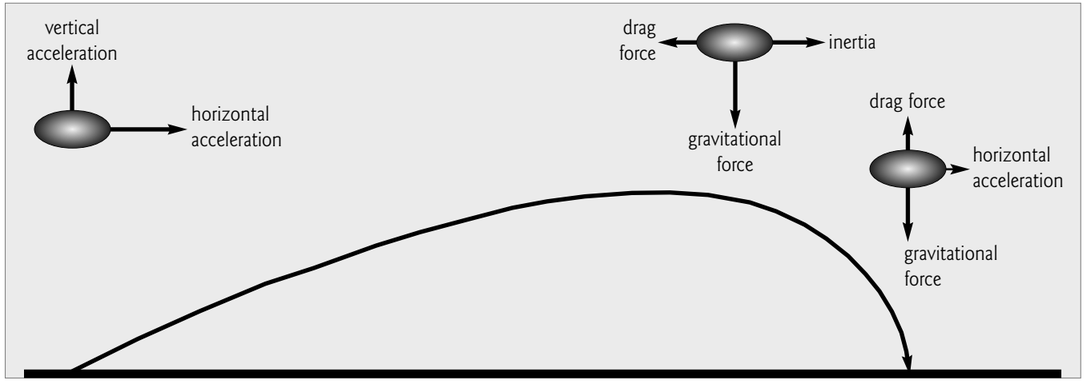
Hatcher discovered that momentum was a far better indicator of the terminal effect of a projectile than kinetic energy (Josserand & Stevenson, 1972: 148-159). He found that if he combined it with the cross-sectional area of the projectile and a shape factor, he arrived at a formula for relative stopping power (RSP), which was an excellent predictor of comparative impact effectiveness. Using momentum instead of kinetic energy increases the relative significance of the weight of the projectile, which increases the effectiveness of sling stones relative to modern bullets. When we multiply by the cross-sectional areas, which are larger for sling projectiles than for bullets, we increase that relative effectiveness by at least 2 to 4 times. Initially we will neglect the shape factor in our calculations, while recognizing that it too will act to increase the relative effectiveness of sling missiles by an additional small amount, possibly by as much as 25 percent.

From the physical point of view, there are three forces acting on the stone that determine its velocity on impact: the force of the throw, the force of gravity, and the force of drag (air resistance). The force of the throw is applied to the stone only while it is within the sling; and for maximum range, the stone must leave the sling as the sling attains its greatest velocity. Once the stone leaves the sling, gravity and drag are the only forces on the stone, both acting to decelerate it. The initial force on the stone is a function of the speed of the sling at the moment the stone departs it; the force applied by gravity is constant for all practical purposes; but the force of drag is far more complex and far more important than gravity. The stone's inertia, size, shape, and roughness are also important. The stone's inertia determines its resistance to the forces retarding its motion, i.e. gravity and drag, while the other features determine the effectiveness of drag.

To attempt to calculate drag forces on a sling projectile, even idealized, would be extraordinarily difficult (McDonald, 1960: 463-465; Hatcher, 1962: 549-589), not least because the drag force constantly varies with the velocity of the projectile. As our only purpose is to demonstrate the effectiveness of the ancient sling as a weapon, we will take a simpler approach. Although it is difficult to economically measure the initial or departure velocity of a sling projectile, and the measurement or calculation of drag is extremely difficult, it should be relatively easy to use published values in simple calculations to obtain useful estimates of possible impact velocities and momentum. We will use these estimates to examine two very different tactical situations: (1) high trajectory "plunging" fire and (2) low trajectory "flat" direct fire.

IDEALIZED TRAJECTORY OF A SLING PROJECTILE

This illustration shows the main forces acting on a sling projectile at three significant points on its trajectory. The initial impetus is given by the force of the throw and the inertia (mass) of the projectile maintains the forward and upward motion.



** footpound = unit of energy equal to the work done by a force of one pound when its point of application moves thorugh a distance of one foot in the direction of the force.

PLUNGING FIRE

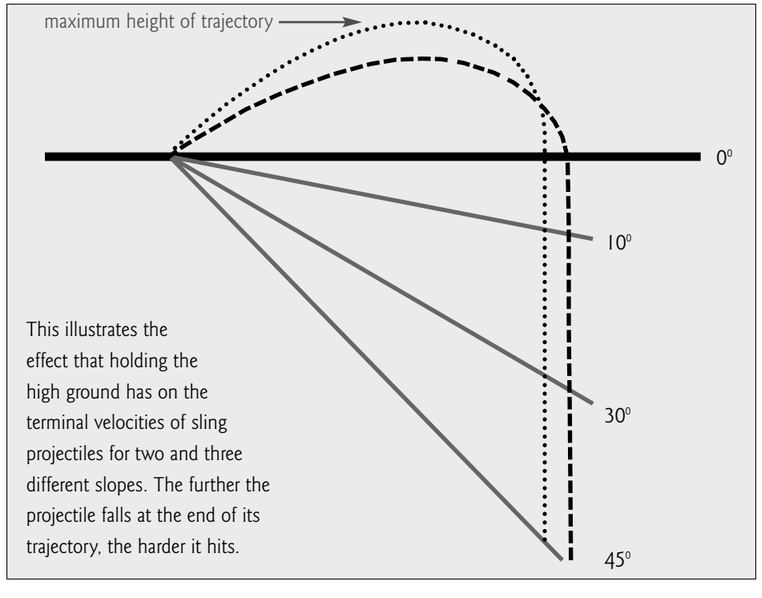
In this situation, the projectile is accelerated at a high angle, describing a trajectory of the shape shown. At the trajectory's peak, the two retarding forces have greatly reduced the velocity's horizontal component and the vertical component is zero. That is, the projectile is at rest from the point of view of vertical velocity. Then it starts to fall, and its velocity at impact is now almost exclusively determined by the forces of gravity and drag and the distance it has to fall, gravity acting to accelerate the stone and drag to retard it. When the two forces balance, the stone reaches its terminal velocity. Although a falling sling projectile will never reach more than a fraction of its terminal velocity in any real situation, there are practical situations in which it can reach a substantial fraction of that velocity and the velocities and terminal impact of plunging fire may far exceed that of direct fire with the sling.

As we examine plunging fire, we will look at two effects, the slope of the land and the weight of the projectile. Assuming a maximum range of 330 yards, and a maximum height of 127 yards, we get the following estimated impact velocities and energies and momentum for a 2 ounce projectile thrown out above four different slopes (as our purpose here is to examine the effect of slope only, I have neglected the complexities of air resistance for these first few seconds of fall):

TABLE II
Slope Effect on Impact

SLOPE	Terminal Velocity	Impact Kenetic Energy	Impact Momentum	Relative Increase in Impact Momentum
0° (level ground)	128 ft/sec*	30 footpound	0.52 lb/sec	1.00
10°	192 ft/sec	75 footpound	0.78 lb/sec	1.50
30°	224 ft/sec	130 footpound	0.91 lb/sec	1.75
45° (100%)	288 ft/sec	170 footpound	1.18 lb/sec	2.27

* ft/sec = feet per second



This illustrates the effect that holding the high ground has on the terminal velocities of sling projectiles for two and three different slopes. The further the projectile falls at the end of its trajectory, the harder it hits.

Assuming an impact velocity of 192 feet per second, we may make an initial appraisal of the effect of increasing the weight of sling projectiles on their effectiveness. The different units were selected as we are comparing projectile weights to literature values in grams and to impact energies and momentum from firearms ballistics data published in the United States in British Engineering Units. These differences in units will not affect the validity of our conclusions, as we are only interested in comparative values.

TABLE III

Weight at Impact (grams)	Kenetic Energy at impact (footpounds)	Momentum at impact (lb / sec)	Relative Stopping Power (no units)
50	60	0.66	1.32
100	130	1.32	3.30
200	250	2.64	7.92
300	380	3.95	13.82
400	510	5.28	—
450	570	5.93	—
Cartridge			
32 ACP*	00-129	0.25-0.28	—
.38 Special	260 (military load)	0.55-0.53	0.41
.357 Magnum	535-583	0.87-0.81	0.63
.44 Magnum	971	1.45	1.50
.45 ACP**	356-405 (full metal jacket)	0.88-0.85	0.94-0.90
.223 (Mil)	1290	0.80	—
7.62x39 Soviet***	1527	1.30	0.58

* ACP = automatic centerfire pistol
** .45 ACP = round for the Colt 1911
*** round for the AK47 rifle.

From the table above it is obvious that even lighter sling projectiles have momentum equivalent to modern revolver bullets, and the momentum of heavier sling projectiles exceed those of the two most common military rifle cartridges in use today. In terms of relative stopping power, they are a great deal more effective. Based on these comparisons of momentum, even the 1.75 ounce projectile would be extremely effective on impact. We conclude that the heaviest projectile that a slinger could propel to a useful height was the best to use for plunging fire, and that the heaviest projectiles used could far exceed the terminal effect of modern military small arms.

DIRECT FIRE

When a projectile is thrown directly at a target, gravity and drag act only to reduce the terminal effect of the stone at impact, so terminal effect is strictly a function of the initial velocity imparted to the stone, its density, size, shape, and roughness, and the range to target. We will ignore most of these factors in the analysis that follows, but the reader should remember that they are determinant.

As the weight of the projectile increases, its momentum at departure increases up to the point where the weight starts to reduce the rotational speed

of the sling at the instant of release. For a while, the effect will be compensatory, but eventually there will be a net decrease in momentum. This means that the range of weights giving maximum momentum should correspond to the range of most commonly observed weights for sling projectiles discovered in archeological investigations.

To examine the effect of low trajectory, direct fire sling projectiles, we need to have some idea of the initial velocity imparted to such projectile at the instant it leaves the sling, along with an estimate of the average rate at which it loses that velocity while traveling to an estimated maximum range of 109 yards.

Gabriel and Metz state that their experiments (poorly described and admittedly, the efforts of minimally trained slingers) show that the maximum initial velocity obtainable by a sling pouch attached to a 2.5 foot sling was 120 feet per second (1991: 75). But here we have a problem. A major league baseball pitcher can launch a 5 ounce (2,187 grain or 142 gram) baseball at 100 mph or 146 feet per second, unaided by a sling. This would indicate that the values estimated by Gabriel and Metz are far too low to be of any value. So initially, we will assume a velocity at departure of at least 150 feet per second (maximum 200 feet per second), and a percentage loss in velocity of 15 percent over the 109 yards range. For the impact of a 2 ounce projectile, these values give us an impact velocity of 127 feet per second, (maximum 170 feet per second) and an impact momentum of 0.52 lbsec (maximum of 0.72 lbsec), which is about that of a .38 Special revolver.

* lbsec (poundsecond) = An English engineering unit for momentum

Our baseball figures above lead us to suspect that a substantially heavier missile could be thrown without forcing us to significantly lower our velocity figures. This would of course increase the terminal effect of the sling projectile. We have to assume that a sling projectile could hit at any attitude, but an estimate of the average impact area as nearly one square inch is probably not too far off. So if we include this reasonable estimate of the cross section, we can multiply our impact momentum by a relative factor which gives us an impact effectiveness (relative stopping power = 1.02), which exceeds that of a .357 Magnum at the muzzle. No wonder the sling in skilled hands was such a fearsome weapon. Goliath had just as much chance against David as any Bronze Age warrior with a sword would have had against an adolescent armed with a .45 automatic pistol.

Accuracy

Gabriel and Metz state that even minimal accuracy (no standard given) results in a reduction of velocity by as much as 15 percent. Remembering that training and experience count for a lot with a weapon like the sling and that Gabriel and Metz have been found wanting, we nevertheless can show that velocity of departure has an important effect on accuracy, and that the slinger's timing and release are critical to get a straight cast from the sling to the target.

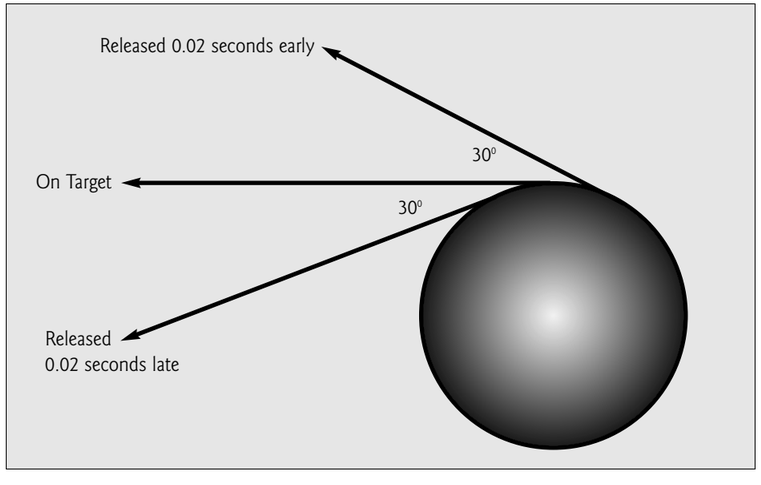
As a first approximation, we may say that the projectile leaves the sling at a tangent to the arc of a circle for all three throwing styles. What is the angular velocity of the sling at that instant? Assuming the low departure velocity reported by Gabriel and Metz of 120 feet per second and an effective radius of

3 feet for the circular arc followed the sling at release, the sling rotates about 6 times per second. So it only takes 0.02 second to make a 30° difference in the angle of departure. If we use more realistic figures for departure velocity, it takes even less time for significant changes in departure angle to occur, and the probability increases that shots will be off target.

This means that if the sling is whirling horizontally, all other things being equal, this short time available for precise aim will cause lateral deviation from your line of aim. You may adjust elevation by changing the angle of the plane of the circle described by the sling. As the whipping style ends in a horizontal arc, these remarks apply to that style as well. If the sling is whirling vertically, it is easier to control lateral deviation, but it will be harder to correct for elevation.

Hubrecht says that modern slingers reliably hit a target slightly larger than one square yard at a distance of more than 220 yards in the Balearic Isles, but his statement seems to be based on hearsay, rather than direct observation (1964: 93). His exact words are: "On inquiry, I learned that a trained slinger could hit an object a square meter [approx. 1 yard] in size at a distance of 200 meters [220 yards]"; so we must take this claim with a grain of salt. Range estimates by untrained men are notoriously unreliable. Demmin's assertion that primitive peoples armed with the sling were able to resist 19th century soldiers armed with firearms (see below) would seem to indicate that considerable accuracy was possible (1893: 876). Echols states that the Irish used slings up to modern times for war and then for sport, and that a good Irish slinger could hit a shilling as far away as he could see it (1950: 228). Illustrations dating from the Middle Ages show slingers casting single missiles at birds in flight. Throwing at such targets would indicate that a high order of accuracy was possible.

The anecdotal evidence is compelling that the sling can be used with impressive accuracy. However, sling techniques must be practiced until instinctive. There is no time to consciously judge your point of release. Some people will learn to use a sling accurately with relative ease, most will require a lot of practice. The sling is a difficult weapon to learn to use properly.



Three angles of departure 30 degrees apart, resulting from difference of 0.02 seconds in the time of release. One projectile thrown early, one thrown late, and one on target. A high degree of accuracy requires a high level of skill.

Range

A variety of estimates have been given of the effective range attainable with a sling. Gabriel and Metz state that ancient slingers were only able to *lob* (italics mine) missiles into enemy formations at distances not exceeding 200 yards, and that these had nuisance value at best (1991: 75). However, they also state that small shot (size not given) could be thrown for up to 75 yards with an almost flat trajectory, surely velocities indicative of a very useful extreme range for higher angled fire. Ferrill estimates range at 220 yards or more (1985: 25). The Romans trained at targets (*scopae*) at 200 yards (Watson, 1969: 60). Nineteenth century Tibetans are said to have been able to sling stones to distances exceeding 300 yards (Lindblom, citing Hooker, 1940: 34).

Xenophon says that his slingers out-ranged Persian archers, possibly a range of 330 yards (1959: 81). Connolly estimates sling range as in excess of 380 yards (1981: 49). Demmin mentions "slings, whose range often exceeds 500 paces," and he goes on to say that "Wild people have retained them, and some of them can, with their help, even manage to withstand the fire of carbines" (1893: 876). In expert hands, Hogg estimates this range to be at about 500 yards under ideal conditions (1968: 30). Reid says that he cast a 9-ounce stone ball 60 yards, and 3- and 4-ounce balls to 100 yards (1976: 21). This for an untrained man using a "crude modern sling." Korfmann describes actual observation of untrained slingers reaching a distance in excess of 250 yards using "pebbles selected at random," and he estimates maximum range as 436 yards (1973: 37). The author, an untrained but enthusiastic slinger, has easily thrown beach stones past targets at a known distance of 200 yards.

Gabriel and Metz represent one extreme opinion (but they are not very reliable on slings), while Hogg represents the other. Korfmann is probably the most dependable source, but to be conservative, a tentative value of 380 yards will be taken here to represent the maximum effective range of a sling projectile.

Rate of Fire

Range and rate of fire were important not only from a military point of view, but also for the protection of livestock. Modern man assumes that the shepherd of southern Europe and the Middle East had to contend mainly with wolves, but the lion (*Panthera leo*) was common in North Africa and the Middle East right up to the end of the 19th century. In the second millennium B.C.E., the lion's range extended into southern Europe (mainly the Balkan Peninsula), Anatolia, and possibly into southern Ukraine. Earlier fossil remains of lions have been found as far north as Poland.

A lion is a much more robust animal than a wolf, and much harder to kill, and like the wolf, the lion is a co-operative hunter. The problem with lions was how to drive them away from your flock without causing a charge. A lion can cover 100 yards from a standing start in 4 seconds, so provoking a charge meant a rapid demotion from shepherd to cat food. So a long-range weapon to shower lions with stones must have seemed useful. I wonder how often it worked. Certainly there was considerable incentive to become proficient and throw a lot of stones as fast as possible from as far away as possible.

Experiments indicate that a sustainable rate of fire of one shot per 10 seconds is a reasonable value for an inexperienced slinger. An experienced slinger could undoubtedly add a few more shots per minute to that rate. We will conservatively assume a maximum sustainable rate of fire to be seven shots per minute.

Relative Effectiveness

The Index of Relative Theoretical Lethality (IRTL) as developed by Dupuy (1985: 27) was used to assess the effectiveness of the sling as a military weapon relative to the other weapons commonly used before the 19th century. The formula reflects the modern military theorist's preoccupation with firepower, and is less sensitive to accuracy, and least sensitive to changes in effective range.

IRTL = R x T x E x rf x A x r

- **R** = rate of fire: strike/hour (0.5 rate per minute x 60) = 210 (maximum sustainable rate 7 per minute x 60 = 420)
- **T** = targets/strike (relative accuracy) (assume 0.5 average for all ranges)
- **E** = relative effectiveness (assume armored [0.5] vs. unarmored [0.9] target)
- **rf** = range factor (1 + [.001 x effective range (meters)]
- **A** = accuracy (1 sq. yd @ 180 yrds; depends on experience, training, etc.) = 1.0
- **r** = reliability (assume 1.0)

TABLE IV – Theoretical Lethality Index for the Sling

R	T	Range	rf	Unarmored Target	Armored Target
120	0.5	400	1.63	88.0	48.8
180	0.5	300	1.55	125.4	69.6
180	0.5	350	1.59	128.6	71.4
180	0.5	400	1.63	132.0	73.2
210	0.5	350	1.59	150.3	83.4 (best estimate)
300	0.5	300	1.55	209.2	116.2
420	0.5	350	1.59	300.5	166.9 (max. estimate)

TABLE V – Comparative Index of Relative Theoretical Lethality*

Weapon	IRTL	Ratios**	
Mauser rifle	600	4.00	
Sling	300	2.00	maximum estimate
Handbow	225	1.50	
Sling	150	1.00	best estimate
Crossbow	70	0.47	
Flintlock musket	40	0.26	
Javelin	36	0.24	
Hand-to-hand	32	0.21	
Flintlock rifle	27	0.18	
Matchlock	19	0.13	

* IRTL = Index of Relative Theoretical Lethality (or TLI = Theoretical Lethality Index), an empirical number used for comparing the combat effectiveness of various weapons, devised by the late Colonel R.E. Dupuy.

** IRTL of weapon relative to best estimate of IRTL for sling.

Although tentative, the calculations in Tables IV & V indicate that the sling was a very effective weapon when compared to the other weapons available to ancient or medieval warriors. The sling would appear to have been about two-thirds as effective as a hand bow, and these two weapons were far superior to anything else available in this regard up to the 19th century. In combination with the ballistic information, it justifies the conclusions that the sling was a formidable addition to the armory of any ancient/medieval army, and that it would have been well worth while developing tactics allowing its most effective use in the field.

Tactical Considerations

This kind of analysis was unavailable to classical and medieval slingers and their commanders. However, they knew their weapons' limits, characteristics, and performance even if they could not then have known the physical principles underlying that performance. All other things being equal (they never are), our hypothetical slinger wants to produce an impact effect as high as possible. This means that he should select sling, projectiles, and his tactical situation accordingly. When we look at ancient and medieval battles, we find that this is exactly what he did.

The sling has certain advantages over the bow. The sling is useful in any terrain, and an expert can use it with one hand. This means that a slinger can throw while carrying a shield; but an archer cannot shoot while so encumbered. The sling was the weapon of choice for indirect fire on a fortified position (Yadim, 1963: 297) and slingers often began a battle at extreme range, using indirect fire. The sling is less sensitive than a bow to weather influences. Ammunition is almost always available. The sling has the minor disadvantage that it is impossible to use within or from thick vegetation. It is not a practical weapon for forest fighting. Until relatively modern times, however, fighting was generally avoided in forests or heavy cover.

Mahr (1964: 124) makes an observation that tends to clarify a great deal of conflicting data concerning the employment of slingers. It is simply that there were two very different kinds of slingers. The first was the specialist slinger, trained to the weapon from childhood and capable of great accuracy and force (velocity). The sling had other purposes than strictly military and hunting uses, and these other uses provided the training that the best slingers received while still very young. These non-military uses kept the sling alive in more primitive areas of the world right through the period of contact with firearms (Lindblom, 1940: 5). To this day, the sling is still used in some areas for hunting, herding, individual protection, etc. (Lindblom, 1940: 5-25).

The Balearic and Rhodian slingers were excellent examples of this type of specialist slinger brought up with their weapon, and they were used in the role of sharp shooters or snipers. There were never very many of these specialists available relative to other types of soldiers, but they made far better use of the sling than any other troops. Specialist slingers could either be organic to larger formations, or brigaded separately.

The second type of slinger was the relatively untrained peasant, or urban worker. Armed with the inexpensive sling, these low status soldiers were given limited training and were used to produce mass fire at the beginnings of battles. Their hail of sling stones at extreme range produced an effect similar to that of the beaten zone of a modern machine gun, if of much lower lethality. The Romans also attempted to develop this skill as an additional arm for normal infantry (Watson, 1969: 51), but it would seem that these efforts met with indifferent success. The trained legionnaire was more valuable as heavy infantry than light artillery and not sufficiently well trained as a slinger to take up a sniper's role. Davies mentions the sling as a Roman cavalry weapon (1989: 142).

A good tactician will position slingers to get the maximum fall possible on any given battlefield, so it was of great advantage to a commander to position his slingers as high above the enemy as possible. Even a 10-degree slope doubled the impact energy of the falling stones, and more importantly, those projectiles could be a hazard that horses would not face. If properly sited slingers could eliminate the dangers of a cavalry charge across an ancient battlefield, they earned their pay.

Taking the high ground ensured maximum effective (slant) range, and it kept the slingers out of range of "counter-battery" fire. The increased slant range meant that the slingers could bombard their opponents at maximum range, break up tight formations, and enormously increase the fatigue of enemy offensive movement. This was a critical consideration in the days when combat effectiveness depended upon physical strength and speed, and is still tactically important today.

The sling was also a naval weapon, being used from small fighting tops in Egyptian galleys (Yadim, 1963: 252). Once again, we see that slingers were placed as high as possible above the fighting.

There is some confusion concerning the deployment of slingers in battle. Slingers were stationed close to archery units, when present, and were usually stationed behind the archers, one indication that slings had greater range. Gabriel and Metz state that slingers had to be "deployed in mass" to be effective (1991: 75), but Ferrill states that slingers were stationed further apart than archers and did not form a compact line (1985: 25). Trajan's column shows slingers in compact formation with short slings. The amount of space required per slinger depends to a great extent on the length of his sling. With a three-foot sling, there would have to be a minimum distance of nine feet between each slinger to avoid fouling each other's sling or injuring another slinger. Untrained slingers would have to take a relatively open formation, probably a straight line deployed in front of the heavy infantry. An untrained slinger would be a hazard to himself and everyone around him in a dense, compact formation. Even specialist slingers would have to keep an open formation just to have enough room to swing their slings safely. Balearic slingers carried three lengths of sling (Korfmann, 1972: 13) and apparently used the length most suitable for the distance that they had to throw. If specialist troops were delivering high angle, indirect fire, they may have been deployed in several lines.

Gabriel and Metz also state that slinger formations were normally

ANALYSIS OF SLING THROWING IS NOT ENOUGH TO BRING TRUE SKILLS AND UNDERSTANDING OF THIS ANCIENT WEAPON. HERE DR. ROBERT DOHRENWEND PRACTICES VARIOUS TECHNIQUES IN THE WIDE OPEN SPACES IN HIS BACK YARD.

smaller than other combat formations, and were used mostly at the beginning of a battle (1991: 75). I think that this timing would be obvious, since once close-quarter combat was joined, it would be very difficult to select and hit the proper targets. In a defensive role, slingers would open the battle at their extreme range; keeping up fire until the enemy came close enough to be dangerous; then they would retire, either off to the sides, or through the ranks of the heavy infantry. Slingers were generally unarmored and would be extremely vulnerable at close quarters. This is the slinger used as light artillery, a role that they often took at the beginning of a battle.

In an offensive role, specialist slingers would be used as light-infantry skirmishers and snipers, screening movement and concentrating fire on enemy officers, horses, and missile troops. In this role, they could only be used where vegetation or rough terrain gave them protection from cavalry. They could also be used to deliver opening barrages on the assault target, continuing their fire on that target from behind the advancing heavy infantry. Once battle had been

joined, they could direct their fire on enemy reinforcements and on the missile troops supporting the enemy heavy infantry. According to Caesar, slingers were also used to repel enemy elephants that would not willingly face showers of sling stones (1976: 226).

Archers and slingers must expose themselves to use their weapons effectively. A first priority in any battle would be to eliminate enemy firepower. So, to use his sling effectively, he had to either be out or range enemy slingers and archers or be shielded from them. If trapped and abandoned by their own heavy troops, as happened in Pompey's army during the Roman Civil War (Caesar, 1976: 153), slingers and archers were defenseless against regular infantry and were often massacred. A slinger depended upon height, distance, movement, cover, or his own heavy troops for his protection. He could generally outrun heavy infantry, but not cavalry. In rough terrain, however, or under the protection of heavy infantry, he was safe from horse troops. Foot or horse caught in rough terrain by slingers occupying high ground were in for a rough time.

Conclusions

The sling has always been an extremely effective weapon. It is a long range, hard-hitting, accurate weapon with a variety of tactical and civilian uses. It is very light weight, unobtrusive, inexpensive, and its ammunition is easy to obtain and generally free. It is also silent and the ultimate concealable weapon. Its only disadvantage would seem to be the very long period of training and practice required to become acceptably proficient.

The sling has always been a difficult weapon. It has so many obvious advantages over other projectile weapons that it would be difficult to account for its extreme lack of popularity today were it not for the long period of practice necessary to attain proficiency. It can also be a dangerous weapon for the beginner and his surroundings, requiring extensive open ground for safe practice. This requirement is another significant obstacle to a resurgence in its popularity.

The relative isolation of the tribal peoples using slings at the periphery of Asian civilizations may account in large part for the neglect of this weapon by martial artists and martial arts historians. Requiring immense practice to attain proficiency, the hierarchies of these civilizations would rather see their peasant/slave/serf classes at "productive" work than acquiring weapons skills that might lead to a deplorable independence. A formidable and inexpensive personal weapon, absolute governments would rather not see the sling in common use.

These factors may have acted to restrict the sling to the margins of major Asian societies and would help account for the almost complete absence of any discussion of the sling in descriptions of Asian martial traditions. This does not mean that the weapon wasn't there nor that it wasn't used, but rather that we have a major gap in our knowledge of the Asian fighting arts. The weapon has been badly neglected by the modern historian, and today offers an attractive subject for research.

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