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Throwing Stick to Spear Thrower - Study of Ethnographic Artefacts and Experimentation

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Little is known about the process of the invention of the prehistoric spear thrower which appeared around 25,000 years ago in Europe, although it may have emerged earlier on other continents. This innovative weapon had a late arrival in Australia from Papua New Guinea at the end of the late glacial maximum, and probably induced an adaptation in hand throwing spear technology used by local people. But could the spear thrower have also originated independently from older prehistoric technology on this continent? In this work, the hypothesis of a technological evolution from throwing sticks to the spear thrower is examined through several particular wooden Australian Aboriginal implements observed in ethnographic collections. Indeed, some traditional Aboriginal hooked throwing sticks from Coopers Creek might be a trace of a prehistoric throwing stick/spear thrower technological complex which has disappeared to be replaced by true specialised spear throwers from New Guinea, rendering them obsolete. Interestingly, other intersections between these two weapons could be found in the particular type of “on edge” built Aboriginal spear throwers from Northern Queensland where rare examples of spear throwers made from modified throwing sticks can also be found. Do they result from an adaptation of throwing sticks in contact with spear thrower importations from New Guinea or do they

reflect the continuity of an older, independent Indigenous Australian spear thrower invention? Experimental replicas and throwing tests have been used here to try to shed light on the potential and limits of such implements which could have been used simultaneously for both functions.

> Throwing sticks, alongside throwing stones, are among the oldest projectiles of humanity. It is highly probable that the first bipedal hominids, well before the rise of modern Homo sapiens, used simple implements made of modified natural branches as projectiles to defend themselves against predators, to repel rivals and to hunt small animals.

An evolution that might have let some traces in the features of some particular Australian Aboriginal wooden implements.

Background

Short review of the antiquity of the three main types of prehistoric projectile weaponry

The bow, an invention reflecting a new hunting environment

Among the prehistoric weapons, invention of the bow has probably come latest, although some stone points in South Africa could indicate that these implements were used as early as 64,000 years ago (Lombard and Phillipson, 2010). In Europe, possible fragments of bows from Germany were found at Mannheim-Vogelstang dated 16,000-18,000 years ago (Rosendahl et al., 2006), and at Stellmoor (Germany) dated around 12,000 years ago (Insulander, 2002). One of the oldest complete bows has been recovered in Northern Europe, on the Homegard Mesolithic site in Denmark dating from 8,000 BP (Sachers 2009). The Invention of bows replaced the use of spear throwers, reflecting a general human adaptation to a changing environment, with the exception of several regions where they are still in use (Davidson, 1936b). One of the main advantage of bows is that it allows hunters and warriors to carry even lighter projectiles (arrows) with a reduced length, to bring down more animals and to gain superiority against enemies. Indeed, the end of Palaeolithic and the Mesolithic are believed to be periods of growing conflict between humans (Guilaine and Zammit, 2001). This new weapon was also probably more well adapted to a new style of standing hunt which targeted smaller game in post glacial warming environments with higher forest cover.

Use of bows never spread to the interior of the Australian continent. Originating from Papua New Guinea, they were traded to the Torres Islands and North of Cape York where they have been put to only limited uses as ceremonial purposes (Davidson, 1936b). The reason for this is the isolation of the continent, which has only become known in Northern Australian in recent times.

The spear thrower, a new weapon of the ice age

The oldest example of spear thrower in Europe is dated from the Solutrean period (19,000-17,000 BP) and was discovered at the site of Combe-Sauniere (Cattelain, 1989).It is believed that this weapon appeared earlier in Europe during the Upper Palaeolithic around 30,000 BP. In Australia, the presence of this weapon is shown at rock art sites in the northern region which date between 6,000 and 10,000 BP (Lewis, 1988; Walsh, 1994; Walsh and Morwood, 1999; Chippindale et al., 2000). Indeed, this technology could have been passed to Australia by the Sahul land bridge during the late glacial maximum when sea level was lower (O'Connor, 2010). However, In some areas (e.g., South Eastern Australia, Welleslay islands) the Australian spear thrower has been found with a peg carved in the solid, which indicates the presence of an archaic technological step for this weapon on this continent and could precede the widespread type of composite spear thrower made of pegs glued to the shaft (Davidson, 1936b). Yet, it is possible that this weapon was invented even earlier on this continent, as the Mungo man (42,000 BP) displays arthritis which could have resulted from spear thrower use (Webb, 1989), although other activities (e.g., canoeing, knapping, fighting, stick throwing, or arm wrestling) could have caused a similar affliction.

This propelling system, when used to throw a spear at a high velocity and great distance, was particularly adapted to hunt large herbivores. A spear is set on a notch or a peg at one extremity of the thrower, which then pushes on the butt of the spear shaft. Held in the hand, the result is to extend the arm and thus increase the propulsion of the spear (Calvin, 1974).

The throwing power is increased, with a superior range compared to hand launched spears. This throwing system allowed people to hunt larger animals with tougher hides, such as bison, aurochs, or mammoths, but also offered the possibility

for the hunters to carry lighter projectiles than with hand thrown spears. This is an advantage for hunter-gatherers who are often on the move, looking for new resources with changing seasons. Here, we will study spear throwers consisting of a wooden stick mounted with a hook or a peg at one of their extremities. This type of spear thrower is called the “male spear thrower” and the peg can be either an added part made in different material (e.g., wood, bone, antler) or carved in solid, using a natural feature of a tree branch. Other kind of spear throwers can have a depression or a flat surface instead of a peg at their extremity and are called respectively female or neutral throwing spear. Spear throwers with a peg, flat surface, or depression carved from a solid piece of wood represent a primitive version of these implements, while composite spear throwers with the peg attached as a separate piece with resin and binding reflect more recent technology.

The throwing sticks: Some of the older projectiles of the world

Before going further, we need to define what are we calling a “throwing stick”: This term includes all projectiles made of one or several wood pieces, called blades, which are set at an angle of 0 to 180 degrees and thrown in the air or near the ground, travelling in rotation around their gravity centre, turning in a rotating plane and hitting a target like a blunt weapon. We will avoid the term “boomerang' because it corresponds to a very particular group of throwing sticks, with more restricted functions, in Australia (e.g., bird hunting, gaming). Indeed, this term needs to be restricted to shaped light throwing sticks with a returning trajectory because its common use in literature had led to confusion with non-returning hunting implements. The distinction between throwing sticks, which represent the larger group of prehistoric projectiles, and boomerangs, which belong to a more restricted specialised subgroup, is not the focus of this article and an attempt at such classification based on a more complete list of their characteristics has been started in recent years (Bordes, 2014).

On the other hand, we need to underline another surviving confusion sometimes found in older literature which often mistakes throwing sticks with spear throwers. This latter type of implement is used to propel a spear in a translational movement designed to hit a target as a piercing weapon. Even if the spear is also rotating also around its main axis (its shaft) along the displacement direction, this movement is very different from the throwing stick rotation which happens around an axis which is perpendicular to the projectile rotation plane and movement direction.

Throwing sticks, alongside throwing stones, are among the oldest projectiles of humanity. It is highly probable that the first bipedal hominids, well before the rise of modern *Homo sapiens*, used simple implements made of modified natural branches as projectiles to defend themselves against predators, to repel rivals and to hunt small animals. As wooden implements, prehistoric throwing sticks are rarely preserved, but several examples recovered on archaeological sites show that these weapons existed on the five continents (Hess, 1975; Bordes, 2014). Discovery of a double pointed wooden stick with possible throwing stick/digging stick function in Schoningen, Germany (Thieme, 1997) might confirm that these projectiles were in use well before spear thrower technology, hundreds of thousands of years ago. The great antiquity of throwing sticks in Europe is marked by a late Palaeolithic throwing stick in mammoth ivory which has been identified from the Gravetian period (23,000 BP) at Oblazowa, Poland (Valde-Novak, 1987). For more recent periods, explicit rock art in the Spanish Levant depict the use of throwing sticks in hunting scenes in the Mesolithic/Neolithic transition (Chopo cave, 8,000 BP) (Picazo et al., 2001; Bordes, 2014), and few Neolithic throwing sticks have been recovered in well preserved wet conditions (e.g. Egolzwil Switzerland, see Ramseyer, 2000), Chalain lake (France), Saint blaise (France), Braband (Thomsen and Jessen, 1902) and Roanes Skov (Andersen, 2009) (Denmark)). In Australia, if the discovery at Wyrie Swamp (Luebbers, 1975), dated from 11,000 BP, is the oldest for throwing sticks and boomerangs and the Panaramitee rock art style in South Australia (Flood, 1997) depicting these type of implements indicate that these weapons have been present far inland for at least 40,000 years, it allows us to suggest that the technology was already known by the first people who migrated here around 60,000 BP (O'Connor, 2010). The great diversity of throwing sticks found in Australia probably reflects tens of thousands of years of technological evolution and specialisation for different functions, which is unique on this continent because of its isolation, until the arrival of new weapons like the spear thrower before 10,000 BP. They range from very archaic implements like throwing clubs or double pointed sticks to more evolved throwing sticks with accentuated curvature and shaped sections to very specialised objects (Davidson, 1936a; Jones, 1996; Bordes, 2014).

Use of throwing sticks by numerous indigenous people throughout the world to hunt a range of animals, from rabbit to buffalo, and for warfare suggests that they are efficient weapons which can claim a role in the prehistoric weaponry. As an example, a recent discovery of skeletal remains from a burial in New South Wales in Australia exhibiting evidence of fatal

trauma dating from 800 years ago shows that throwing sticks were efficient weapons and should not be underestimated when compared to spear and arrow damage (Westaway et al., 2016).

Coexistence between throwing stick and spear thrower technology in Australia

Setting apart the anecdotal use of the bow in Australia, let us focus on the similarities and differences between spear throwers and throwing sticks and their coexistence on the Australian continent. Each of these prehistoric weapons were adapted to different environments: throwing sticks being more adapted to use in open woodland and dry savanna without too many obstacles and on levelled ground, while spear throwers could be used in more closed woodland and humid environments, except in thick tropical forest which does not allow enough space to manipulate long spears (where bows or blowpipes are needed). Spear throwers can be seen as more adapted to big game like megafauna in Europe (e.g., bison, horses, and reindeer) hunted during the last glaciation or big game, such as kangaroos, in Australia, while throwing sticks are highly efficient on smaller fragile game like gazelle, rabbits, birds or bats. However, heavy throwing sticks are still capable of bringing down deer or kangaroos by breaking their legs (as well as breaking the legs of buffalo at short range in Africa), showing that these weapons were also playing a role in big game hunting (Bordes, 2014).

According to Davidson (1936b) and rock art dating in Northern Australia, spear throwers appear to be more recent then throwing sticks in Australia and have come to the continent from New Guinea. Indeed, this author emphasises the fact that this invention didn't spread in all regions of the Australian continent uniformly as some areas never adopted this new weapon (e.g., Tasmania). Some areas only used it minimally (e.g., Southern and South Eastern Australia and part of coastal Western Australia) while others used it extensively (e.g., central and inland Western Australia, Northern Queensland). Additionally, the strong presence of hand spears with points carved in plain wood indicate that the heavy spears used by Aboriginal people before the arrival of this new weapon did not have time to adapt to spear throwers. Indeed, light bamboo spears equipped with a foreshaft designed to be only used with spear throwers are coexisting in the same areas with more archaic heavy hand spears. Yet, In Australia, and on other continents (e.g., North America), the spear thrower as new weapon did not completely replace hand-spear throwing, but rather coexisted with it and completed the prehistoric hunter outfit. (Davidson, 1936b). For example, Southern Queensland seems to have been a patchwork of absent and minimal use of spear throwers (Davidson, 1936b).

Prehistoric rock art studies show that throwing sticks and spear throwers were also used differently according the changing environment at different periods in Northern Australia. In this region, throwing sticks are more frequently depicted in the older form and seem to have been used more intensively before 8,000 BP, during a dryer climate, and were replaced by the use of the spear thrower in a more later humid environment (Lewis, 1988).

Despite these differences, these two weapons coexisted for at least the last 10,000 years in Australia, if we refer to some ancient painting in Arnhem Land which shows scenes with hunters holding both type of implements (See Figure 1, left). In more recent historic times, Aboriginal hunters frequently carried both weapons, showing a complementary use as the throwing stick could also be kept either as a second projectile or as fighting weapon to be used at close quarters (See Figure 1, right). On another hand, weapons and tools with multiple functions are common in Australia as Indigenous people needed to minimise their burden during their frequent moves through their country. Some weapons can be used as tools (e.g., spear throwers or throwing sticks equipped with adze extremities, spear throwers that can be used as shields), as a close quarter melee weapon, as a projectile (throwing sticks) or as projectile launcher. In this context, it will be not surprising to observe the intersection of function between throwing sticks and spear throwers in particular Aboriginal implements.

Considering the conjoined use of multiple weapons in Australian prehistory and ethnology to propose a hypothesis for the invention of the spear thrower

The invention of the spear thrower from the throwing stick could have happened quite naturally since before the invention hunters were used to throwing spears burdened with other weapons and projectiles (e.g., clubs, throwing sticks, spare spears). It is easy to imagine that a hunter carrying a stick with a natural hooked end unintentionally attached it to the butt of spear ready to be launched, catapulting it at a longer distance never reached before with only hand throwing. This unknown discoverer would have taken advantage of this new feature of his stick to develop a new launching weapon. At the time of this invention, it is likely that no specialised spear thrower existed, and the first versions of these

implements could have simply been heavier hooked throwing sticks or hooked sticks originally designed for other functions. These first archaic ambivalent heavy throwing sticks/spear throwers might have been further abandoned for lighter more specialised spear throwers, losing completely their former projectile function. Could the invention of the spear thrower have happened this way? This possibility needs to be carefully investigated as it may have some implications for considering the spear thrower as a potential independent invention on the Australian continent.

Observation on ethnographic collections

Particular features of the hooked throwing sticks of Coopers Creek region

Two very different types of hooked throwing sticks existed in Australia (See Figure 2, top). One of the most famous types is the number seven, or beaked, throwing stick (See Figure 2, top, c) produced in a region located between Tennant creek and Katherine, especially by Warumungu people, and spread throughout all Northern Australia as far as Western Queensland and Kimberley or from Carpentaria Gulf to Southern Australian coast (Davidson, 1936a; Leroi-Gourhan and Deffontaines, 1949), (See Figure 4). However, it's probable that the maximum extension of this diffusion had been reached only in recent times because the specimens made on the boundaries of their diffusion zone often lack the flutings or are more crudely made (Davidson, 1936a).

These weapons called "Wirlki" or Beaked throwing sticks have a short beak-like feature extending the short distal blade (or following[1] blade) (See Figure 3). According to the observation of twenty objects of this type from the South Australian Museum, the angle between the following blade (distal blade) and the hook ranges from 50 to 85° with an average of 70°. Moreover, this beak is shaped and flattened in section and is too wide to be used as a peg to fit in a spear shaft butt. Its length, being a mean of 32% of the total wingspan, will also make this use difficult. These war throwing sticks are thrown like other kylie without beaks (See Figure 2, top, a-b), with curvature facing the target and the beak in the trailing edge (See Figure 3) because they are too fragile to endure direct impact even if this feature could be used in close fighting. One known function of this type of beak is to hook the enemy's shield edge and hit the enemy behind the shield with the throwing stick (Roth 1897; Spencer and Gillen 1927).

Another less common type of hooked throwing stick had been made in the Coopers Creek region near Lake Eyre, extending north-east in South West Queensland (See Figure 4). On the drawings reported by Davidson, it's possible to observe slightly curved throwing sticks, probably with circular or elliptical airfoil, having a short hook extending the following blade opposite to the holding blade and oriented toward the exterior of the curvature (See Figure 2, top, d-e).

We can measure on these particular objects presented by Davidson that the hooks are built with a rather sharper angle, around 20° (See Figure 2, bottom), so are not overlapping number seven beaked throwing sticks which have a more open angle (See Figure 2, top, c and Figure 3).

One of these throwing sticks has a very strange ringed notched central feature built in a narrower holding extremity, and seems to be fully decorated (See Figure 2, top, d and Figure 2, bottom left). The function of this feature is unknown and very distinct from central carved spear holders present on Papuan spear throwers (Davidson, 1936b) (See Figure 5). Actually, this notched feature seems to be unique to this type of implement and is not found on any other Australian throwing sticks nor Australian spear throwers. Could it be a notch system designed to attach a spear holder with binding?

The other throwing stick has a second very short hook (only 15% of the total wingspan) built at its elbow and a carved round holding extremity (See Figure 2, bottom right). With rather low shaped airfoil (circular or elliptical section) and low curvature, these throwing sticks seem to belong to a tradition older than the sophisticated grooved beaked number seven from the central desert. The distinction between these two types is reinforced by their places of origin which are too far apart to suspect a possible historical relationship (Davidson, 1936a) (See Figure 4).

In 2010, I had the opportunity to look in detail at two artefacts related to this type in the South Australian museum collection. Their registered area of origin is Queensland, which can include Coopers Creek district, extending between North East of South Australia and South west Queensland (See Figure 4). Examination reveals that their hooked extremities are rounded and conic in a similar way to the two objects visible on Davidson drawing (Davidson 1936a, p 95, fig 8), allowing them to be inserted into a spear butt (See Figure 6). These artefacts are slightly different from the type of hooked throwing stick from the Coopers Creek region described by Davidson (Davidson, 1936a, p 95, fig 8) as they have a

more evolved, wider biconvex section and sometimes have a more pronounced curvature. Additionally, these examples do not include specific gripping arrangements on the blade (See Figure 2, bottom right). According to these features, including a similar value for the hook angle (See Figure 6, top), these two objects seem to be closely related to the type of archaic hooked throwing stick from the Coopers Creek region described by Davidson (Davidson, 1936a, p 95, fig 8). However, they are designed to be used as projectiles with greater range because of their enhanced aerodynamic section and the absence of a carved handling extremity, which breaks rotation. However, their engraved decoration suggests a possible ceremonial function.

From the ethnological information provided by Davidson (1936a) about these particular hooked throwing sticks, we know that they have been considered as ceremonial objects in the last two hundred years. This symbolic use is confirmed by a very large fully painted ceremonial example exhibited in the South Australian Museum which is so large and heavy (more than two meters long and likely weighing several kilograms), that it would be impossible to wield efficiently, even more so as a projectile (See Figure 7, top). However, interestingly, this museum artefact has the same shape as the smaller older model presented by Davidson (1936a), including a variation of the notched feature at mid length (See Figure 2, bottom left).

The main question brought to surface by scrutiny of these particular hooked throwing sticks from Coopers Creek area is: could it be possible that these types of implements have accumulated the dual functions of throwing stick and spear thrower, before later losing both these practical functions in favour of ceremonial purposes?

Both hooked sticks in Davidson's drawing (Davidson, 1936a, p 95, fig 8) (See Figure 2, bottom), alongside those examined in South Australian Museum (See Figure 6), seem to be curved enough to be stable in flight as throwing sticks and their round hooks could have been fitted into the butt of spear shaft, allowing a possible simultaneous use as spear throwers.

From this, it is possible to suggest that for an older period, where the spear thrower had not yet acquired the status of a fully specialised hunting tool, heavier hooked sticks could have been used to achieve this function and that this type of throwing stick could be an ancient trace of this conversion. Coopers Creek hooked throwing sticks could be then considered as multi-functional, archaic weapons from which other types of specialised spear throwers might have evolved. Indeed, an indication of their probable ancient origins is that their hook is carved in the solid wood, which rationally precedes composite spear throwers made with a peg attached to a shaft with cement glues. In more recent periods, it's possible that this type of archaic hooked throwing stick/spear thrower would have gradually improved to specialise solely as a spear thrower, progressively losing its projectile capability.

These particular type of implements can be viewed as evidence of an environment where people needing both kinds of hunting weapons developed a multi-purpose object. For the highly mobile hunter-gatherer lifestyle, multi-function tools and weapons are advantageous. Such tools are common among Australian Aboriginal people and other indigenous societies around the world, because they reduce the effort needed, compared to constructing a complete set of highly specialised tools.

Other possible intersections between throwing sticks and spear throwers: "On edge" built spear throwers and throwing sticks converted into spear throwers from Cape York, North Queensland

Another point on the intersections between throwing sticks and spear throwers could be found in the type of spear throwers found in Cape York and North Queensland. These implements are made as far north as Cape York, for example by the Wik people (McConnel, 1953; Sutton, 1993; Nugent, 2015), but also in North Central West Queensland by the Mitakoodi and Kalkadoon and as far South as the Pitta Pitta people in the Boulia district (Roth, 1897; Davidson, 1936b) (See Figure 4). Indeed, most of the spear throwers in the world are built with a narrow or broad flattened lath surface perpendicular to the peg, as is the case with many different local types in Australia (See Figure 8, left). However, this unique type of spear thrower from Cape York (Northern Queensland) is built with the lath surface parallel to the peg (Davidson, 1936b). Their section is biconvex but almost flat and fine.

They are often carefully crafted and sometimes equipped with highly decorative baler shell, which is useful as a handle stop and spear holder (See Figure 8, right). Pegs are set rather consistently at an angle of approximately 45° from the spear thrower body. According to their size and weight, they seem to be suited for throwing heavy spear. These types are

functional and have been used by Aboriginal people from these regions for the same purpose as other types (e.g., hunting, hostilities) There seems to be no real advantage of having this specific spear thrower lath surface orientation, because during the preparation phase, when the spear butt is engaged on the peg, it is more difficult to lay the shaft comfortably on the lath edge than on a broader flat surface.

Why did some Aboriginal people from Queensland use this particular type of spear thrower?

The function as a fire saw (Roth, 1897) can be considered, in a similar way as is done with the edges of leaf spear thrower types in central Australia (Jones 1996). However another element to make an hypothesis about their function can be found in the closely related objects from a limited nearby region:

Some types of curved spear thrower, which appear at first glance to be variations of the same type, are from Bloomfield river to cape Grafton in the coastal North Queensland region (See Figure 4) (Davidson, 1936b). They also share the "on edge" built spear thrower tradition of binding the peg with a tendon or natural plant fibre through a drilled hole in the extremity, which is unique to this region (See Figure 9, bottom right). Careful examination on these implements reveal that they are so similar to throwing sticks, made through the addition of a peg on a modified extremity, that they are probably either throwing sticks converted into spear throwers or are spear throwers which are directly derived from these curved projectiles (See Figure 9).

One object of this type which was examined at the Pitt Rivers Museum of Oxford, England, can be considered as a biconvex crescent shaped throwing stick converted into a spear thrower, with a peg attached using rattan strip and fixed with a natural resin mix (See Figure 9, bottom). Two other similar objects can also be seen in the South Australian museum (See Figure 9, top). This interpretation is based on the fact that these implements are lacking any additional features usually designed for spear throwers (e.g., elaborate grip) and are indistinguishable from a regular throwing stick, apart for the added peg on the modified extremity. A more striking feature is their thicker biconvex section which renders them heavier than "on edge" built spear throwers from Cape York, which have finer flat sections. It clearly shows that they are derived from throwing stick technology because a thick biconvex section seems to be useless on a specialised spear thrower as it needs to be light and fine enough to be wielded efficiently. From this, it can be considered that "on edge" built spear throwers might have evolved from throwing sticks converted to spear throwers that have been straightened and lightened.

However, the important difference with Coopers Creek hooked throwing sticks is that, in the case of throwing sticks converted into spear throwers, the peg is set facing the interior of the curve. This setting allows them to be used in the standard way as shown by a test on a replica of this type of implement (see experiment below). They are also distinct from Coopers Creek hooked throwing sticks by the composite, separately attached peg, fixed with cement glue and binding (rattan) which suggests that they have been made in a more recent period.

Experimentation

Experimentation with "on edge" built spear throwers from North Queensland

Tests conducted with one of my replicas modelled on a type of "on edge" spear thrower from North Queensland, examined at the Pitt River Museum (See Figure 10, top and middle), confirm that they are fitted to launch heavy spears. As this spear thrower is quite heavy (411 g, See Table 1) some light spears (mass<150 g) broke during the experimentation while two heavier spears made of wood or bamboo, equipped with dense wood foreshaft, have been used with greater success (mass>150 g, See Table 1).

Designation	Type of wood	Mass (g)	Wingspan/length (cm)	Mean thickness (mm)/type of section	Height/ Wingspan ratio (curvature)	Hook/peg angle (degree)
Replica of "on edge" built spear thrower	Acacia aneura	411	72	7.5/Biconvex	0	53
Replica of hooked throwing stick from Coopers Creek N°1	Green oak (Quercus Ilex)	343	62	15/Biconvex	0.23	30

Replica of hooked throwing stick from Coopers Creek N°2	Buxus	344	62	13/Biconvex	0.15	21
Replica of hooked throwing stick from Coopers Creek N°3	Buxus	423	71.5	25/Elliptic	0.1	25
Replica of throwing stick converted in spear thrower N°4	Accacia homophylla	412	63	14.5/Biconvex	0.13	66
Wood spear with dense wood foreshaft	Spruce (shaft) Buxus (foreshaft)	220	235	15/circular	NA	NA
Bamboo spear with dense wood foreshaft	Bamboo (shaft) Tea tree (foreshaft)	186	217	14.5/circular	NA	NA

TABLE 1 : CHARACTERISTICS OF EXPERIMENTAL LAUNCHING IMPLEMENTS AND SPEARS
NA: NON APPLICABLE

Experimentation also showed that the standard technique with the spear in the same vertical plane as the spear thrower lath and peg is not at all comfortable. It also showed that the baler shell handle is probably designed as an aiming balance, a handle stop, and for aesthetic purposes, rather than to be used as a spear holder with the shaft laying on the top of it. Indeed, the baler shell is not always present on this type of spear thrower (See Figure 8, right) and can be shifted up or down relative to the lath in variations of this type, showing that the top of the shell is not always designed to be aligned with the peg to support the spear. In fact, the technique of spear throwing needs to be adapted and the spear shaft can be shifted slightly off the peg handle axis and the shaft can block against the side of the shell handle efficiently (See Figure 10, bottom left). This technique seems to be similar to those used with the spear throwers in Papua New Guinea (Davidson 1936b) which can be used either vertically or horizontally (See Figure 10, bottom right). Vertical throwing style when the shaft is off the peg handle axis, launching the spear in a slow movement, is similar to other heavy Australian heavy spear throwers (e.g., leaf shaped spear throwers from central Australia).

Experimentation with converted throwing sticks into spear throwers

Experimentation with the converted throwing sticks show that they can also be used for heavy spears and that the off-axis, one-hand technique already used for “on edge” built spear throwers is preferred (See Figure 11). Indeed, trying to set the spear shaft on the extremity of the concave edge (inside the curvature) of the throwing stick is very uncomfortable and slippery. However, the fact that these implements are thicker (See Table 1) than “on edge” built spear throwers rendered their handling with the loaded spear even more difficult, especially using the vertical launching style. The horizontal launching style was easier and more natural because it's also the way of launching throwing sticks and proved more efficient as less effort is needed to bring the spear thrower weight sideways (See Figure 12, right) than over shoulder (See Figure 12, left). However, the weight of the implement used here (412 g, See Table 1) added to the weight of spears tested (> 150 g, See Table 1) seriously limited the range and spear energy, and make it difficult to keep the spear thrower and projectile together for several minutes, thus also probably limiting its usefulness for ambushing game in real hunting situation.

Another way to use this type of spear thrower is to launch it with both hands which has proved more successful when tested than the single hand technique. This technique is described in detail in the next section, and is the only successful way of using Coopers Creek hooked throwing sticks to launch spears.

The converted throwing stick can be successfully launched reaching a medium range (30-50m) and keeping a good stability in flight, but with a small breaking effect from the projection peg (launching the throwing stick in a similar way as figure 14, 5-9) (see also video 1 in supplementary material). The fixed peg was resistant enough not to shatter on impact with on soft ground. This second experiment showed that the converted throwing stick did not lose its property as a projectile, hence proving that this type of implement can have both functions.

Experimentation with hooked throwing stick replicas based on Coopers Creek type

Compared to the previous implement type used, the disadvantage of this type of spear thrower/throwing stick is that the hook is oriented towards the exterior of the curvature, setting the elbow as an awkward location to position the spear shaft when trying to use it as spear thrower in the same way as “on edge” built spear throwers (See Figure 12, bottom left). On other hand, throwing sticks benefit from being curved which ensures a certain stability in flight. This curvature can be either gradual or elbow shaped, according to their form. To solve this problem, I managed to set the hook into the butt of the spear and to set its shaft on the exterior of the curvature, different techniques of launching were tried.

One possibility was to use only one arm (or blade) of the throwing sticks and hold it at the elbow. Indeed, that could be the reason for the existence of a double-hook object on Davidson’s drawing (Davidson, 1936a, p 95, fig 8) (See Figure 2, bottom right). The user would then have the choice of gripping the elbow using the end hook or at the holding end to use the elbow hook. This technique was unsuccessful because the length of the spear thrower, formed by only one arm (or blade), of the throwing stick was too short to be efficient and was even harmful because of the other arm (or blade) turning against the thrower during launching and hitting the launching arm painfully.

As a second possibility, I tried the same one handed launching technique as used with the “on edge” built spear thrower and with the converted throwing stick by shifting the spear shaft off the elbow axis and using it to support the spear in position. However, the thickness of the throwing stick’s biconvex section prevented the thrower from holding the spear stable in this position, and the same problem as with the converted throwing stick tested with one hand, was encountered.

Confronted by this issue, another possibility was to completely rethink the standard way of holding a spear thrower and the spear and to try a different solution. Indeed, if holding both the spear thrower/throwing stick and the spear with only one hand is difficult, why not use both hands, one to hold the spear thrower and the other to hold the shaft of the spear? In this new technique, the hook was inserted into the butt of the spear while holding the spear thrower/hooked throwing stick with right hand and using the left hand to keep the shaft on the exterior of the elbow which could be used as a guide for the spear when launched (See Figure 13). This two handed technique is not unknown in Australia as long or heavy spears can be supported partially by the hand of the non-throwing arm until the moment the throwing arm is brought back and the spear, supported by the peg of the spear thrower, becomes poised in the air just as the throw is commenced. However, such a procedure can interfere with the freedom of action necessary for accurate and forceful throwing (Davidson, 1936b). This technique was also tried, either holding the shaft of the spear with the second hand until the launching, or releasing it just before the launching movement when the spear butt briefly supported by the peg and about to fall (See Figure 13, right).

In a first set of throwing tests, when the left hand is kept on the spear shaft until the launching of the spear, I observed that a certain amount of pressure was needed with this hand to firmly keep the butt of the spear against the peg, as is the case with the one handed technique. Achieving coordination between the application of pressure by the left hand on the spear butt against the spear thrower peg and the launching motion with the right hand was quite challenging and many attempts suffered from a lack of power. Nevertheless, this technique was enough to reach a short range (20-30 m). At first, the trajectories of the spear were often not optimal to hit a target but with training they improved and became acceptably efficient.

In a second set of throwing tests, I attempted to release the spear shaft with the left hand just before triggering the launching movement with the right hand, when the spear is still poised in the air but still in contact with the spear thrower peg, similar to the technique used by indigenous Australians reported by Davidson (1936b) (See Figures 13-14). This latter method proved very successful because the spear’s weight always maintains a good pressure between the spear butt and spear thrower peg, allowing the recovery of the throwing energy obtained with the one-handed technique on classical spear throwers. The lack of accuracy which resulted from the very short aiming time can probably be compensated with training.

I also tried both previous launching methods with two different positions: vertically, with the stick and spear passing over the shoulder, and horizontally, with both passing on the right side. I found that the horizontal position was more comfortable because of the superior weight of hooked throwing sticks, which require more effort to use over the shoulder (See Figure 13, top). This horizontal movement seems also to be more natural with hooked throwing sticks as it is the classic movement of launching throwing sticks too. This horizontal technique using both hands was very comfortable to

hold before launch and succeeded in throwing spears at mid-range (30-50m) (See Figure 13, bottom and Figure 14). As can be guessed, throwing spears with hooked throwing sticks which have accentuated curvature (See Figure 12, top left N°1, Table 1, N°1) were more difficult compared with those having lower curvature (See Figure 12, top left N°2-3, Table 1, N°2-3).

The success of this original launching technique with both hands was a bit surprising at first; however, after contemplation it seemed to be rational that an intermediary object between the throwing stick and spear thrower was likely used with a launching technique that was different from those used for either specialized implements.

At the end of the spear launching sequence (See Figure 14, 1-4) the hooked throwing stick used to discharge the spear changes its function and can become a projectile itself. Indeed, it can be very quickly armed in position behind the back (See Figure 14, 5-6) to be launched consecutively with equal accuracy at the same distance (50 m) (See Figures 14, 7-9) (See also video 2).

Considering that the curvature is a key factor for the stability of throwing sticks as projectiles, it was not surprising to observe the order of efficiency between these experimental objects: N°1 throwing stick proved to be more efficient and more stable in flight than N°2 and N°3 throwing sticks (See Figure 12, top left, Table 1). Consequently, despite the adaptation of the throwing technique, hooked throwing sticks with less curvature proved better adapted to throw spears and the one with accentuated curvature was more suited to use as projectile, showing the change of function depending on this feature. This divergence of use probably explains the transitional nature of these ambivalent hooked throwing sticks/spear throwers which evolved with time to specialize, finally maintaining only one function.

Aiming to shed light on throwing spear invention, it is concluded that heavier hooked throwing sticks are good candidates to be their precursor. As throwing sticks preceding the invention of spear throwers and show a great diversity in Australia, indicating their great antiquity on this continent, some prehistoric traces of the intersection between these two weapons might exist amongst the features of recent ethnographically studied implements. Presence of hooked throwing sticks in the Coopers Creek area in more recent times which are only used for a ceremonial function is intriguing, as one wonders if they had any other lost practical use in the distant past which might perpetuate in this particular hook feature in this isolated region. Taking into account the cylindrical morphology of the extremities of these hooks, one proposed hypothesis here is that they could have been used as spear throwers. Their manufacture, with hooks carved in solid wood, and absence of direct relation between these and beaked throwing sticks from Central Australia, can suggest that their origin is more likely to belong to an indigenous technology which predates the Papuan composite spear thrower from the end of the last glacial period.

Other intersections between throwing sticks and spear throwers can be found in North Queensland. Indeed, the presence of “on edge” Cape York spear throwers, and their tendency of converting throwing sticks to spear throwers in a Coastal sub region, might indicate that some weapons traditionally served both functions in the distant past. However, the composite building of these implements, where the peg is attached with resin and binding, indicates it is a more recent distinct technology than was used for the solidly carved Coopers Creek hooked sticks, and may mean that they were developed at the time of the spear throwers arrival in Northern Queensland from Papua New Guinea. Do these two implements result from the influence of an older tradition locally adapted for using throwing sticks as spear throwers? Or was the spear thrower composite technology imported from Papua New Guinea? The Coopers Creek river system might have contributed towards a cultural link between these two regions and allowed the exchange of ideas and tool technologies.

A first set of experimentation has explored the use of “on edge” built spear throwers to confirm that their stable holding and launching relies on the spear being set “off axis”, similar to the way that spear throwers are used in Papua New Guinea.

A second set of experimentation showed that throwing sticks converted to spear throwers with a peg placed inside the curvature can likely be used in the same way, although with limited efficiency. Further launching tests tended to show that the classic spear thrower launching technique cannot be easily applied and that another technique using both hands can be used. Successful throwing stick flights show that these implements can also be uses as projectiles, despite the presence of the attached peg.

A third set of experimentation with replica hooked throwing sticks from Coopers Creek, with hook placed on the outside curve, showed that the classic spear thrower one handed launching technique cannot be applied at all, and that the technique using both hands must be used. Additionally, it showed also that these implements can be used as projectiles, hence proving that the double function is possible. The limitation in power and in accuracy of the two-handed technique for spear throwing and rotation breaking due to the hook, implies that these hooked sticks could have rapidly specialized as straight spear throwers. Indeed, the curvature and weight of throwing sticks helps to stabilise them during flight, but these features make the positioning of the spear awkward and slow down launching speed when they are used as a spear thrower. This results in a divergence of features which cannot cohabit in the same implements when optimization of each function is the goal, leading us to consider hooked throwing sticks as a potential unstable technological step on the way toward the invention of the specialised spear thrower.

However, this specialisation might never have happened for the Coopers Creek hooked throwing stick, because new, already optimized, composite spear throwers may have diffused south from Cape York, rendering them obsolete and limiting their use to ceremonial purpose. Fortunately, this latter use may have avoided the complete disappearance of these implements and allowed their survival until recent history.

These results allow us to consider that hooked throwing sticks from Coopers Creek could be seen as preserved evidence of an intermediate weapon and might be a trace of the early conversion of throwing sticks to spear throwers in Australia. In this case, they would be a unique reflection of the invention of this new technology in the prehistoric world.

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Dr Philip Jones, Curator of the South Australian Museum to have allowed me to examine some throwing stick collection in 2010.
My wife Mathilde, for some experimental photo and video.

CONVERTED THROWING STICK (LUC BORDES)

HOOKED THROWING STICK (LUC BORDES)

1 Attacking/following blade: for bipale throwing sticks, the two blades are not aerodynamically equivalent. The one with its exterior edge compared to the curvature travelling with a greater angle before the other is called the attacking blade. The other is called the following blade. The attacking blade travels with a much greater angle than the following blade and gets more of an aerodynamic lift, all other parameters being the same. This is the blade which is handled in the common Australian Aboriginal style of throwing, curvature facing the target, but could be sometimes be used differently.

Keywords throwing stick
weapon
spear

Country Australia

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Sources for images

Fig 10. Replica of one “on edge” spear thrower of Queensland (middle) after one example from Pitt river museum, wingspan 72 cm (top). Shifted way of handling the spear thrower and shaft (bottom left). A Papuan man using the spear shifted technique, holding the projectile against the holder (http://www.thudscave.com/npaa/tips/pngthrow.htm) (bottom right).

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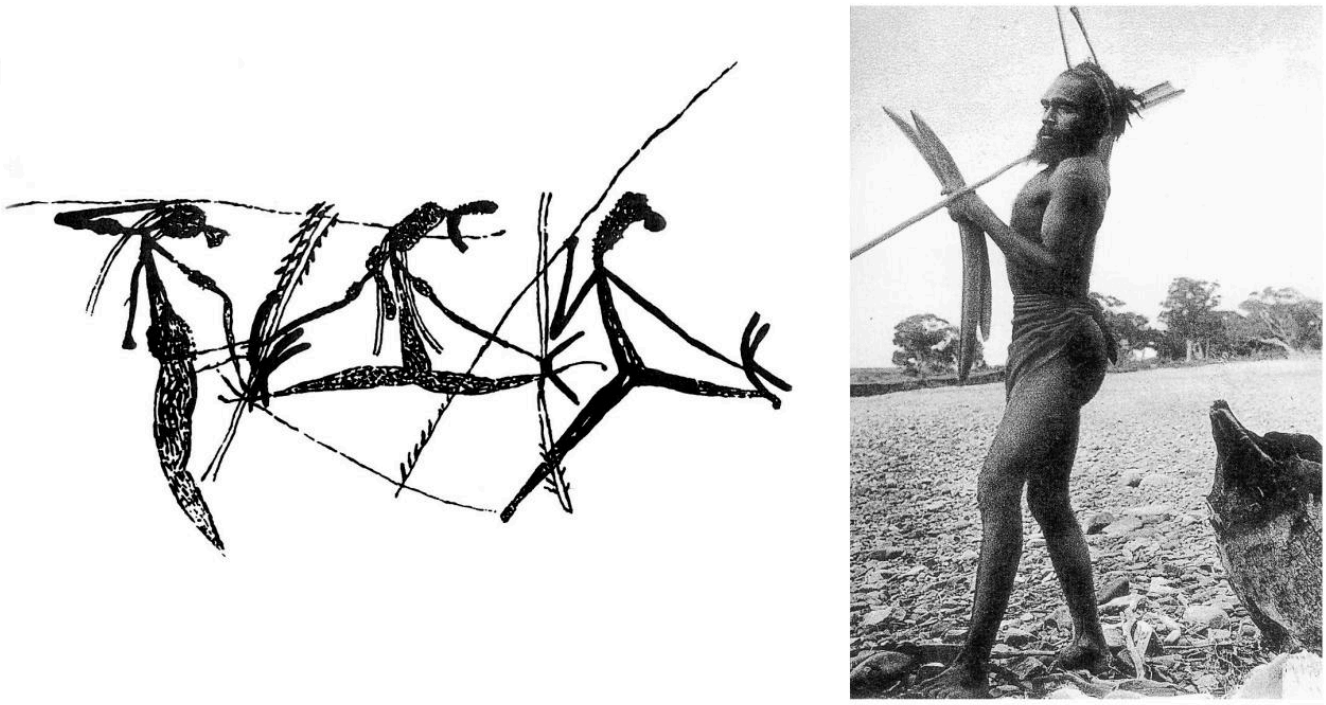

FIG 1. HEADWATERS OF TWIN FALL CREEK. THREE HUMAN FIGURES BEING EQUIPPED WITH HEADDRESS, SPEARS AND BOOMERANGS (LEWIS, 1996) (LEFT). ABORIGINAL MEN CARRIED BOTH A SPEAR THROWER AND A PAIR OF THROWING STICKS (RIGHT) (JONES, 1996).

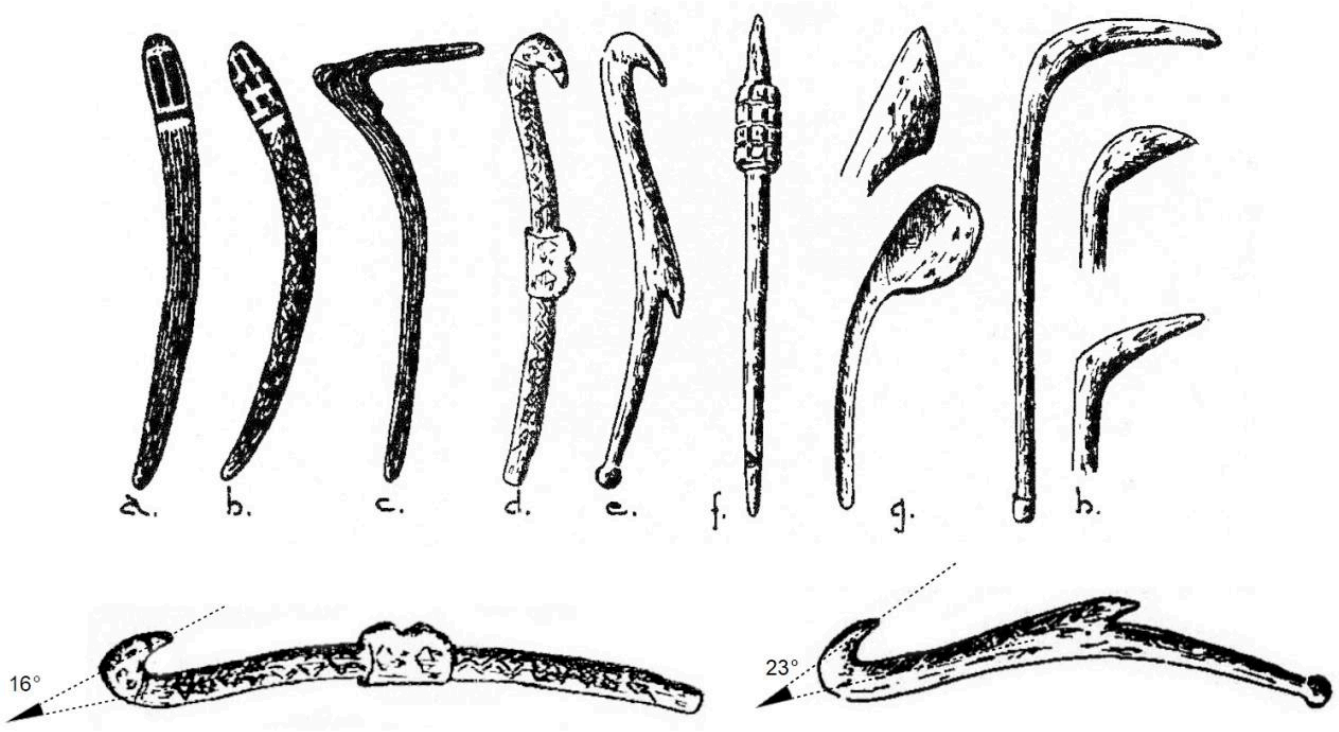

FIG 2. DIFFERENT KIND OF AUSTRALIAN THROWING STICKS PRESENTED IN DAVIDSON'S PAPER (DAVIDSON, 1936A)(TOP): DESERT CENTRAL KYLIES (A & B), WIRLKI BEAKED THROWING STICK (C) COOPERS CREEK HOOKED THROWING STICKS (D & E), PINEAPPLE CLUB (F), LIL LIL THROWING STICK FROM SOUTH EAST AUSTRALIA (G), MARPUNGY (H). HOOK ANGLES MEASURED ON HOOKED THROWING STICKS D AND E (BOTTOM): WITH A CENTRAL UNKNOWN NOTCHED FEATURE (LEFT) AND SECOND SMALL HOOK ON ELBOW (RIGHT).

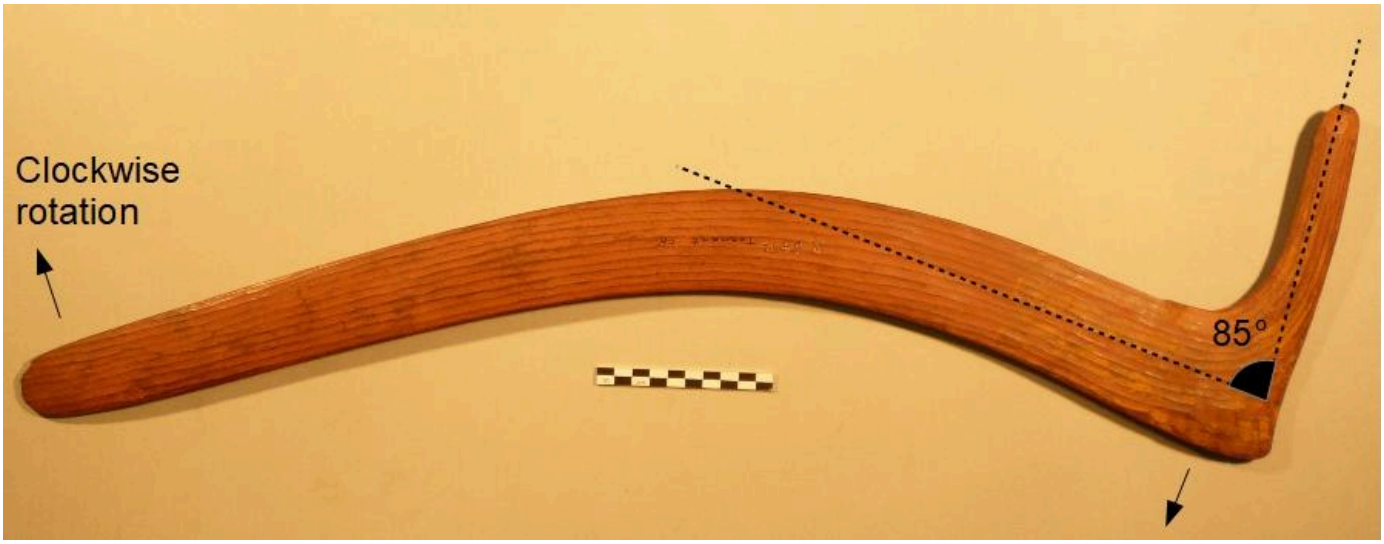

FIG 3. VIEW OF THE INTRADOS OF A TYPICAL CENTRAL AUSTRALIAN THROWING STICK CALLED “WIRLKI”. MASS 480 G. (SOUTH AUSTRALIAN MUSEUM). NOTE THAT THE ROTATION DIRECTION OF THIS PROJECTILE IS CLOCKWISE. EXTRADOS/INTRADOS: THE FACE OF A THROWING STICK THAT IS DIRECTED TOWARD THE GROUND OR THE OUTSIDE OF TRAJECTORY DURING THE FLIGHT IS CALLED INTRADOS OR LOWER FACE. THE OTHER FACE, THE UPPER FACE, THAT CAN BE SEEN BY THE THROWER IS CALLED EXTRADOS OR UPPER FACE. THE EXTRADOS IS MORE OFTEN DECORATED.

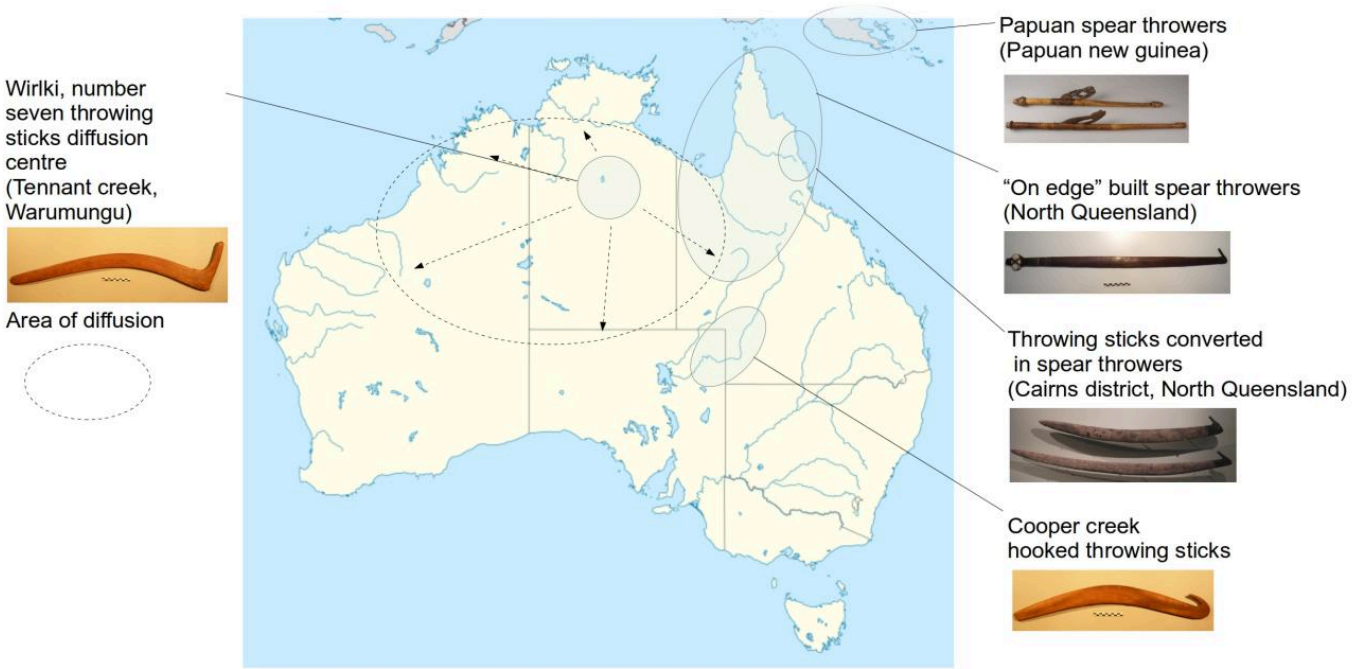

FIG 4. AUSTRALIAN REGIONS OF DISTRIBUTION OF THE IMPLEMENTS DISCUSSED IN THIS WORK (DAVIDSON, 1936A-B).

FIG 5. EXAMPLE OF PAPUA NEW GUINEA SPEAR THROWERS (FEMALE SPEAR THROWER TYPE) WITH SPEAR HOLDER. DIFFERENT PARTS, HANDLING, SPEAR HOLDER, AND SPEAR STOP (FEMALE) ARE INDICATED. NOTE THAT THE HOLDER IS SET OFF THE SPEAR STOP AXIS TO ALLOW SPEAR LOADING.

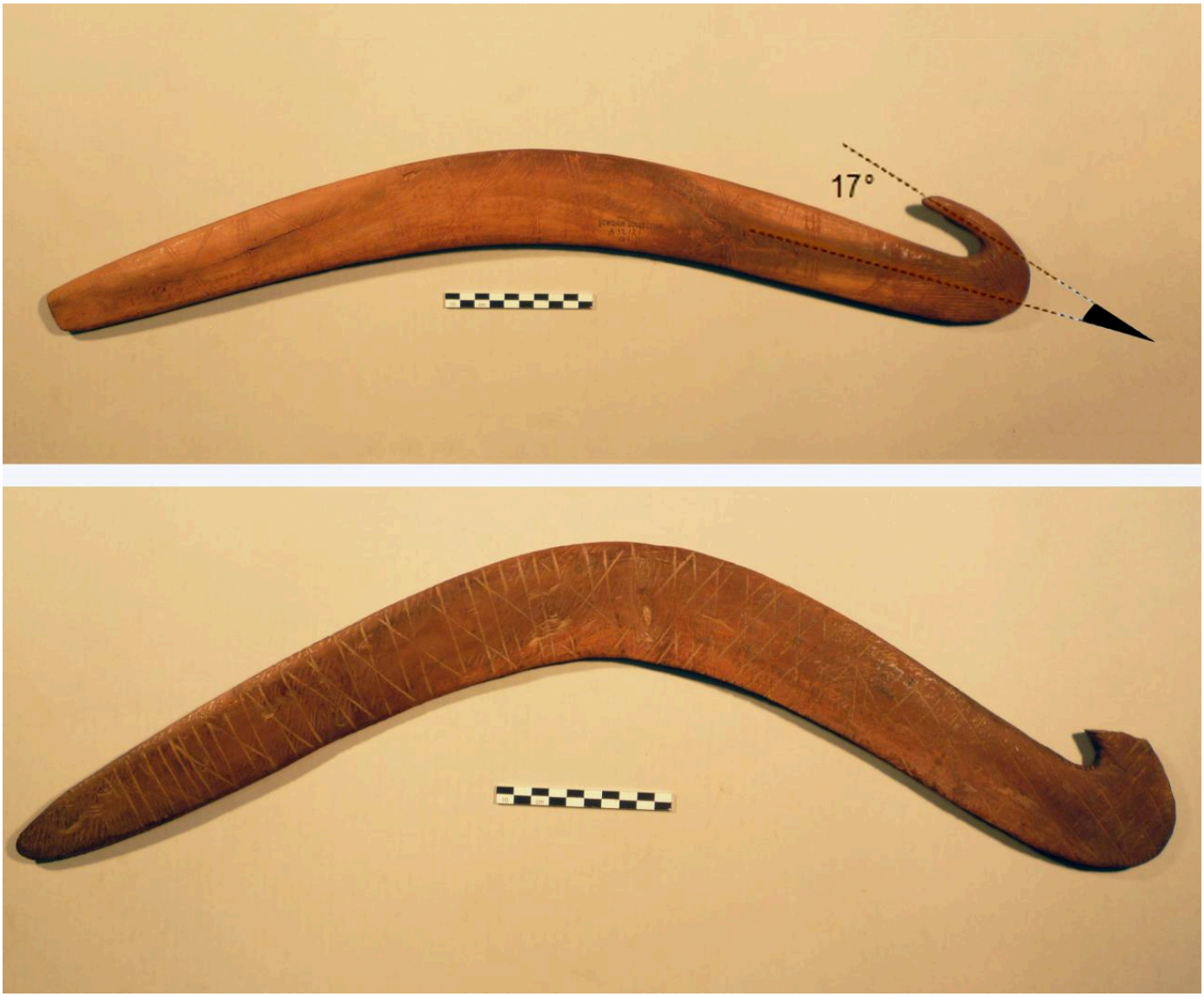

FIG 6. EXAMPLE OF A HOOKED THROWING STICK FROM QUEENSLAND. NOTE THE END OF THE TAPERED HOOK IN A CONIC SHAPE, MASS 360 G, WINGSPAN 64 CM (TOP), AND VALUE OF THE HOOK ANGLE HAD BEEN INDICATED. ANOTHER EXAMPLE WITH A BROKEN HOOK SHOWS THAT THE CURVATURE OF THESE THROWING STICKS COULD BE MORE OR LESS ACCENTUATED. MASS 410 G, WINGSPAN 65 CM (BOTTOM), (SOUTH AUSTRALIAN MUSEUM).

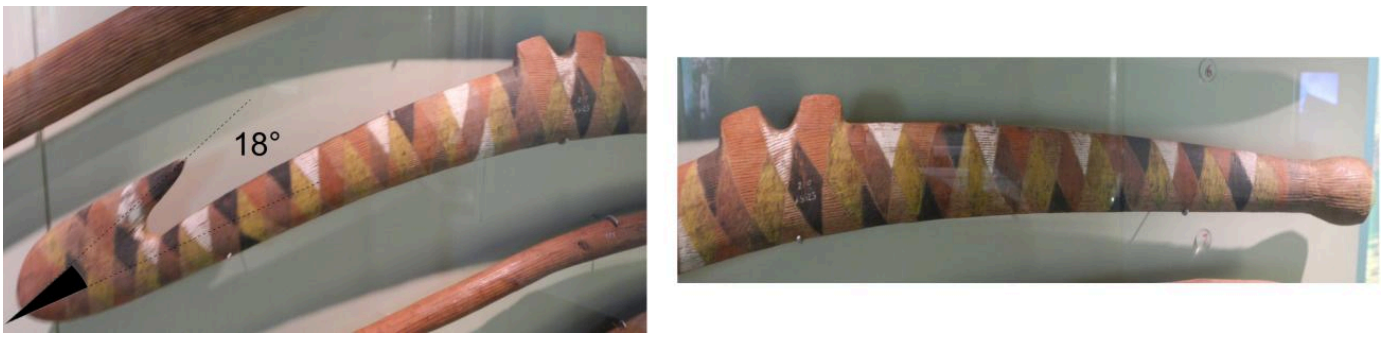

FIG 7. DISTAL HOOKED SECTION AND PROXIMAL HANDLING SECTION OF A LARGE CEREMONIAL PAINTED THROWING STICK EXHIBITED IN THE SOUTH AUSTRALIAN MUSEUM, HAVING A NOTCHED FEATURE BUILT AT THE ELBOW (SOUTH AUSTRALIAN MUSEUM), DISTAL HOOKED PART (LEFT) AND PROXIMAL HANDLING PART (RIGHT).

FIG 8. SPEAR THROWERS FROM DIFFERENT REGIONS OF AUSTRALIA, FROM TOP TO BOTTOM: 1-4 CENTRAL AUSTRALIA, 5 NORTH AUSTRALIA, 6 SOUTH AUSTRALIA, MURRAY RIVER, 7 NORTH AUSTRALIA, 8 SOUTH AUSTRALIA, MURRAY RIVER (LEFT). THREE “ON EDGE” BUILT SPEAR THROWERS OF THE QUEENSLAND REGION (SOUTH AUSTRALIAN MUSEUM) (RIGHT).

FIG 9. TWO THROWING STICKS TRANSFORMED INTO SPEAR THROWERS FROM THE CAIRNS DISTRICT, NORTH QUEENSLAND (SOUTH AUSTRALIAN MUSEUM) (TOP), THROWING STICK TRANSFORMED INTO A SPEAR THROWER FROM QUEENSLAND (PITT RIVER MUSEUM) (MIDDLE) AND DETAIL OF THE PEG BINDING WITH RATTAN AND RESIN (BOTTOM).

FIG 10. REPLICA OF ONE “ON EDGE” SPEAR THROWER OF QUEENSLAND (MIDDLE) AFTER ONE EXAMPLE FROM PITT RIVER MUSEUM, WINGSPAN 72 CM (TOP). SHIFTED WAY OF HANDLING THE SPEAR THROWER AND SHAFT (BOTTOM LEFT). A PAPUAN MAN USING THE SPEAR SHIFTED TECHNIQUE, HOLDING THE PROJECTILE AGAINST THE HOLDER (HTTP://WWW.THUDSCAVE.COM/...) (BOTTOM RIGHT).

FIG 12. EXPERIMENTAL IMPLEMENTS USED IN SPEAR THROWING TESTS (TOP LEFT): HOOKED THROWING STICK WITH BICONVEX SECTION AND ACCENTUATED CURVATURE (1), HOOKED THROWING STICK WITH BICONVEX SECTION AND LOW CURVATURE (2), HOOKED THROWING STICK WITH ELLIPTICAL SECTION AND CENTRAL NOTCHED FEATURE (3), THROWING STICK CONVERTED IN SPEAR THROWER WITH ATTACHED PEG (4). HANDLING A HOOKED THROWING STICK WITH VERTICAL ONE HAND THROWING STYLE (BOTTOM LEFT). HANDLING THE CONVERTED THROWING STICK WITH HORIZONTAL ONE HAND THROWING STYLE (RIGHT).

FIG 11. REPLICA OF A CONVERTED THROWING STICK, WINGSPAN 63 CM (TOP). HOLDING A CONVERTED THROWING STICK INTO SPEAR THROWER WITH SHIFTED ONE HAND STYLE (BOTTOM).

FIG 13. USING TWO HANDS STYLE TO LAUNCH SPEAR WITH HOOKED THROWING STICKS: VERTICAL STYLE WITH HOOKED STICK HAVING CENTRAL NOTCHED FEATURE AND LOW CURVATURE (TOP) AND HORIZONTAL STYLE WITH HOOKED THROWING STICK WITH ACCENTUATED CURVATURE (BOTTOM).

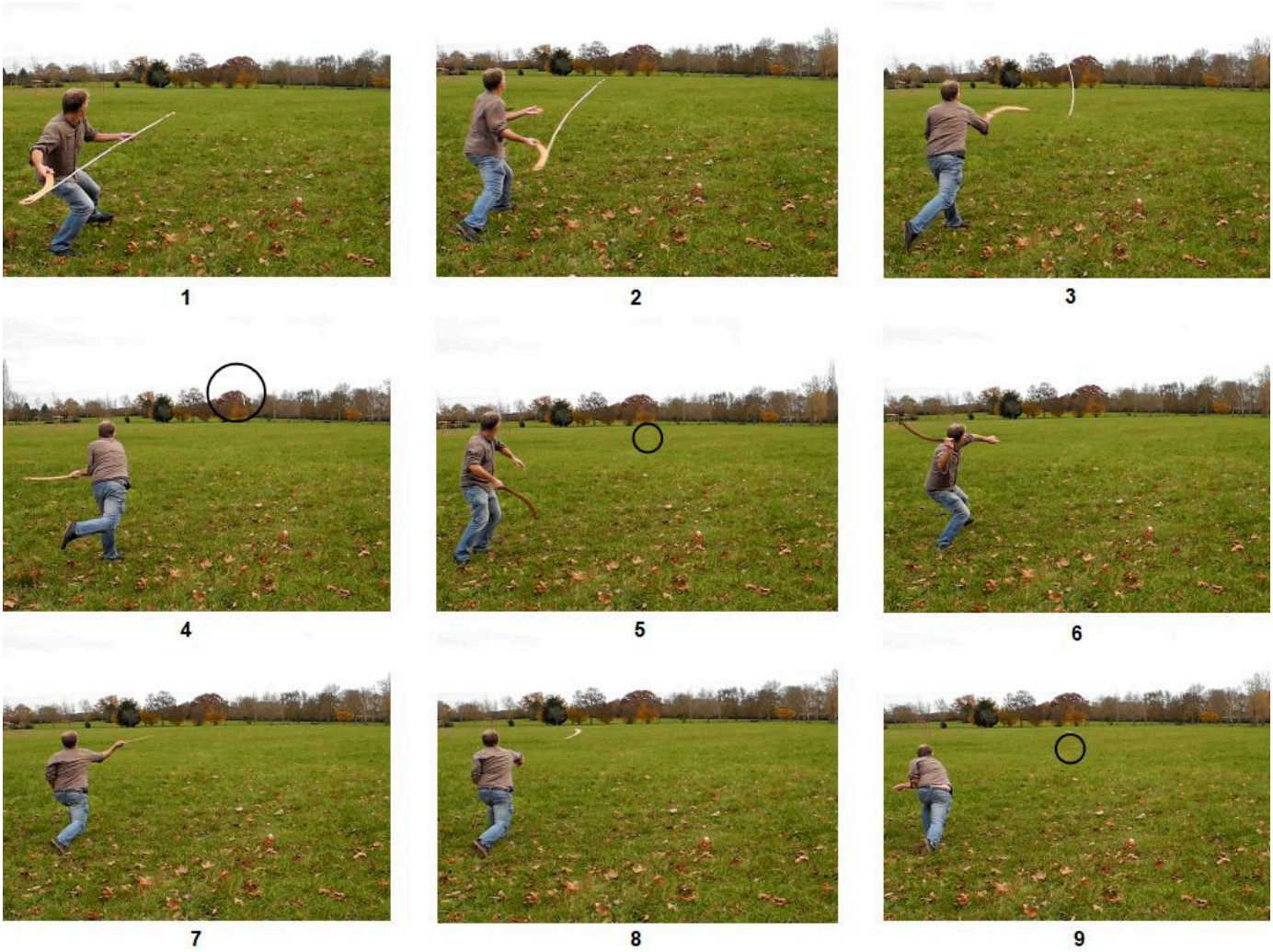

FIG 14. SEQUENCE OF LAUNCHING A SPEAR WITH A HOOKED THROWING STICK IN THE TWO HANDED HORIZONTAL STYLE, AND CONSECUTIVE USE OF THE THROWING STICK AS A PROJECTILE: PREPARATION OF SPEAR LAUNCHING WITH THE RIGHT HAND HOLDING THE HOOKED THROWING STICK AND THE LEFT HAND HOLDING THE SPEAR SHAFT (1), LAUNCHING THE SPEAR WITH SIMULTANEOUS RELEASE OF THE LEFT HAND FROM THE SHAFT (2), DEFORMATION OF THE SPEAR AFTER RELEASE (3), SPEAR ON ITS WAY AND RECOVERING FROM DEFORMATION (4), THE SPEAR HIT THE GROUND AS THE PREPARATION OF THE LAUNCHING OF THE THROWING STICK IS INITIATED (5), ARMING THE THROWING STICK BEHIND THE BACK (6), LAUNCHING FORWARD MOVEMENT (7), RELEASE OF THE THROWING STICK (8), THROWING STICK ON ITS WAY TO THE TARGET (8). (SEE ALSO VIDEO 2 OF THE SEQUENCE)