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RESEARCH ARTICLE

A 600-year-old Boomerang fragment from Riwi Cave (South Central Kimberley, Western Australia)

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ABSTRACT

A small fragment of a carefully shaped wooden artefact was recovered from Riwi Cave (south central Kimberley, Western Australia) during 2013 excavations. Directly dated to 670 ± 20 BP, analysis of the artefact's wood taxon, morphology, manufacturing traces, use wear, and residues, in addition to comparison with ethnographic examples of wooden technology from the Kimberley region, allowed for the identification of the tool from which it originated: a boomerang. In particular, this artefact most closely resembles the trailing tip of a hooked boomerang, providing rare insights into the presence of these iconic fighting and ceremony items in the Kimberley some 600 years ago.

ARTICLE HISTORY

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Introduction

Wooden implements constituted a major component of past hunter-gatherer-fisher toolkits around the globe. Unfortunately, the vast majority of these items have not survived the rigours of the archaeological record, resulting in researchers having to rely heavily on use wear and residue analyses of more enduring material culture items, such as lithics, bone, antler, tooth, and shell to identify the presence of wooden material culture in ancient contexts (e.g., Anderson 1980; Beyriès 1987; Hardy and Garufi 1998; Hardy and Moncel 2011; Keeley 1977, 1980; Lombard 2005; Shea 1980; Sussman 1988). Having said this, segments of wooden utensils have been recovered from contexts dating back to the Acheulean: examples include numerous small fragments of pine (*Pinus* sp.) wood exhibiting traces of work at Torralba, Spain (Biberson 1964; Howell 1962), a section of a pointed yew wood (*Taxus baccata*) staff measuring 38 cm long from Clacton-on-Sea, United Kingdom (Oakley et al. 1977), the 400,000-year-old Schöningen spears (Thieme 1997), and pointed sticks, clubs, game stakes, and bark trays from marshy Acheulean deposits at Kalambo Falls in southern Africa (Clark 1982). From Mousterian and Middle Stone Age contexts, three portions of a pointed shaft more than 2 m long made from yew at Lehringen, Germany (Perlès 1977), several trays or bowls (or similar such domestic items) dated to between 45,000 and 49,000 BP at Abri Romani, Spain (Carbonell and Castro-Curel 1992), a possible throwing stick from Middle Stone Age deposits of

Florisbad in southern Africa (Kuman and Clarke 1986), and several worked wooden fragments including a directly dated digging stick (40,986–38,986 cal. BP), and a possible poison applicator (also directly dated: 24,564–23,941 cal. BP) from Border Cave, southern Africa (d'Errico et al. 2012) have been recovered.

Wooden artefacts dating to Later Stone Age Africa have been reported from several southern African sites, and include digging sticks, link shafts, arrow points, clubs, and throwing sticks (see for example: Deacon and Deacon 1999; Fagan and Van Noten 1971), while in Europe the earliest known fragments of bows and arrows (made from pine heartwood) were found in a peat bog at Stellmoor, an Ahrensburgian site dated to the final Palaeolithic (Beckhoff 1968). Similarly, several bows made from elm dated to around 8,000 BP have been recovered at Holmegaard, Denmark (Beckhoff 1968; Cattelain 1997). From around this time, the survival rate of various wooden domestic and hunting implements in Africa, Europe, Asia, and the Americas increases exponentially making a comprehensive description of such artefacts herein impossible.

In Australia, in contrast, the recovery of wooden artefacts from archaeological contexts is exceedingly rare owing to the higher rate of plant decomposition on this continent (as compared with countries closer to the poles) resulting from higher rainfall, higher soil moisture content, and consequently, a multitude of destructive fungi and termites (Beck 1989; Nugent 2015; Swift et al. 1979). To date, less than 100 pieces

of wooden technology have been identified in Australian archaeological contexts (see Table 1).

The oldest examples consist of the 25 artefacts recovered from Wyrie Swamp in South Australia, and include boomerangs, one-piece spears (including one barbed example), two types of digging sticks, and pointed stakes. The peat context from which the Wyrie swamp artefacts were recovered was dated to between 12,398–11,270 cal. BP ($10,200 \pm 150$ BP; ANU 1292) and 10,375–9,628 cal. BP (8990 ± 120 BP; ANU 1293) (Luebbers 1975, 1978). A direct date was also obtained on one of the boomerang fragments: $9,430 \pm 150$ BP (ANU 1490) (Luebbers 1978:127).

All remaining archaeologically recovered wooden artefacts are significantly younger than the Wyrie Swamp collection. The next oldest example consists of a wooden bipoint dated by association to 2,151–1,894 cal. BP (Beta 28188) from Nara Inlet 1, Hook Island, North Queensland (Barker 1989, 1996, 2004), and a digging stick from a stratigraphic unit dated to 940 ± 60 cal. BP (Beta 46317) from Mordor Cave, Cape York Peninsula (David 1992). A boomerang discovered during dredging of the Clarence River, along with another found in conjunction with a spear point (this latter possibly constituting part of a multi-pronged fishing spear) were found during excavation of Trial Bay Creek, New South Wales. While the boomerang from Trial Bay Creek was directly dated to 480 ± 70 BP (ANU 1628), that from Clarence River was dated to only 281–157 cal. BP (140 ± 70 BP; GaK 1299) (McBryde 1977).

In the north, Schrire (1982:63–65) recovered 11 wooden implements including points, a message stick, a link shaft, and firesticks from the top level of the Paribari Midden, Arnhem Land. Also in western Arnhem land, a hafted adze made from ironwood (*Erythrophloeum chlorostachys*) was recovered from Argaluk Hill, Site 2, Oenpelli (now Gunbalanya) (Attenbrow 2008; Setzler and McCarthy 1950). No date – associated or otherwise – is available for this last artefact.

Surface finds include a digging stick found at the base of an overhang in Namadgi National park in the Australian Capital Territory (Argue et al. 2001). This specimen was identified as having been manufactured from *Acacia* sp. and was directly dated to 224 ± 50 BP (NZA 10301) (Argue 1995; Argue et al. 2001), while another digging stick was similarly found on the surface in the Diamantina National Park, Queensland (Simmons cited in Nugent 2015). Also discovered in a rockshelter was a hafted stone axe in Wollemi National Park in the Blue Mountains (Kelleher 2009), along with a firestick which was left in-situ at the discovery site (Taçon cited in Nugent 2015). A boomerang found in 1813–1814 during survey and construction work, along with a club found more recently, also hail from the Blue Mountains,

New South Wales (Attenbrow 2009). Finally, 54 wooden artefacts associated with the processing of possum and kangaroo skins (bark slabs and wooden pegs) were collected from three rockshelters located on the crest of the Victoria Range, Gariwerd (Grampian Ranges), Victoria (Gunn 2009). Gunn (2009:29) reports observing metal chopping marks on these artefacts indicating that they date to the contact period. Finally, Kelly (1968) reports observing numerous boomerangs (including hooked boomerangs), a throwing stick, a hafted adze, a club, a digging stick, and a tjurunga sitting on the surface in the area located between Sylvester Creek and the Mulligan River in southwest Queensland. In Australia then, most of the wooden artefacts recovered from archaeological contexts are weapons (unbarbed and barbed single-piece spears, bipoints, boomerangs, clubs), reflecting the ethnographically recognised use of hardwood for the manufacture of projectile technology on this continent (e.g., Davidson 1934; Gould 1970; Thomson nd. fieldnotes 1280-2, 1290-2, 1306-8; Warner 1937).

In this paper, we describe a worked fragment of a boomerang extremity recovered from Riwi Cave located in the south central Kimberley, Western Australia. This artefact constitutes the oldest directly dated boomerang piece recovered from a north Australian context, returning a result of 651–557 cal. BP (670 ± 20 BP; S-ANU 43337). The piece displays distinct signs of working at its proximal extremity indicating that an individual intentionally removed it from a larger artefact either during the course of initial manufacture, or at a time somewhat after it was created. Manufacturing traces, use wear, and residues were also observed, and together, allow us to reconstruct an event which occurred at Riwi Cave some 600 years ago. Needless to say, such an insight into the use life of an organic artefact of this antiquity in Australia is truly unique.

Context: Riwi Cave

Riwi is a southwest facing cave located in the Mimbi area of Gooniyandi country, south central Kimberley, Western Australia (Figure 1). Situated at the bottom of the Lawford Range (a Devonian limestone reef), and the edge of the Great Sandy Desert, Riwi is within the southern limits of the Australian summer monsoon, receiving 500 mm of rainfall per annum, most of which falls within the wet season between November and April (Bureau of Meteorology 1996:44). Broad scale mapping of the region shows that the dominant vegetation type within the Mimbi area is sclerophyll, and grades between woodland savanna, steppe, and grassland (Beard 1979).

Archaeological work in the southern Kimberley region by Balme and O'Connor (see Balme 2000) has

Table 1. Wooden technology recovered from Australian contexts to date.

Age	Artefact/s	Wood taxon	Site
No date available/surface find	Digging stick	n/a	Diamantina National Park, Queensland
No date available/surface find	Numerous boomerangs (including hooked), a throwing stick, hafted adze, a club, a digging stick, a tjurunga.	n/a	Mulligan River, Queensland
No date available/surface find	Hafted adze	n/a	Wollemi National Park, Blue Mountains, New South Wales
No date available/surface find	Firestick	n/a	Wollemi National Park, Blue Mountains, New South Wales
No date available/surface find	Boomerang and club	n/a	Blue Mountains, New South Wales
No date/contact period	54 wooden artefacts associated with processing skins - bark slabs and wooden pegs	n/a	Victoria Rang, Gariwerd, Victoria
No date available/surface find	>38 wooden artefacts including wood shavings barbed and unbarbed points, fire sticks	n/a	Anbangbang I, Northern Territory
No date available No date/contact period	Hafted adze 11 wooden implements including points, a message stick, a link shaft, and fire sticks, along with numerous wooden shavings	<i>Erythrophleum chlorostachys</i> <i>Callitris intratropica</i> ; <i>Eucalyptus tetradonta</i> ?; <i>phoenicea</i> ?; <i>Owenia</i> ?; <i>Phyllanthus</i> ?; <i>Polyalthina holtzeana</i> ; <i>Phragmites australis</i> ; <i>Bambusa arnhemica</i>	Argaluk Hill, Site 2, Northern Territory Parbari Midden, Arnhem, Northern Territory
224 ± 50 BP (NZA 10301)	Digging stick	<i>Acacia</i> sp.	Namadgi National Park, Australian Capital Territory
281–157 cal. BP (140 ± 70 BP; GaK 1299)	Boomerang	n/a	Clarence River, New South Wales
Direct date: 480 ± 70 BP	Boomerang and spear point – possibly from a multi-pronged fishing spear	n/a	Trial Bay Creek, New South Wales
Associated date: 940 ± 60 cal. BP	Digging stick	n/a	Mordor Cave, Cape York Peninsula, Queensland
Associated date: 2,151–1,894 cal. BP (Beta 28188)	Bipoint	n/a	Nara Inlet 1, Hook Island, Queensland
Associated date: 12,398–11,270 cal. BP (10,200 ± 150 BP; ANU 1292) and 10,375–9,628 cal. BP (8990 ± 120 BP; ANU 1293); Direct date: 9,430 ± 150 BP (ANU 1490)	25 pieces of wooden technology, including boomerangs, one-piece spears, barbed spear, digging sticks, pointed stakes.	1 piece identified as: <i>Allocasuarina verticillata</i>	Wyrie Swamp, South Australia

been undertaken for over 20 years with both the support and participation of Aboriginal Traditional Owners across the area. Support for excavations at Riwi was received from Gooniyandi people following long periods of consultation both informally (with members of various communities associated with the Mimbi region) and, for the most recent excavations, formally (following discussions at Gooniyandi Native Title Group meetings). Members of the Gooniyandi community participated in all of the excavations and have contributed to the interpretation of materials recovered. In 1999, a 1 m² test pit (Square 1) was excavated (Balme 2000), and in 2013, three additional test pits (Squares 3, 4 and 5) were added, creating a 2 × 1 m trench in the centre of the shelter along with two additional 1 m squares (Figure 1). Each of the squares was excavated within 500 mm horizontal quadrants, using arbitrary units of 20 mm until bedrock was reached. Features were removed separately when encountered. All excavated materials from the 2013 excavations were dry sieved through nested 1.5 mm and 5 mm mesh screens, and bulk sediment samples were collected from each excavation unit. Cultural materials recovered from both

excavation seasons include lithics, faunal remains, charcoal, freshwater shellfish, emu eggshell, ochre, string, scaphopod beads, and uncharred macrobotanical remains. Exceptional botanical preservation at Riwi is the product of the dry, anaerobic, and alkaline sediments of the limestone cave.

Methods

The analysis of the cultural materials recovered from this site were undertaken with the consent and involvement of the Mimbi (Gooniyandi) community. The wooden artefact described below was first photographed at high resolution with a Canon EOS 400D digital camera, before being examined with a Zeiss 2000-C stereo microscope fitted with a AxioCam MRC5 camera, along with a Dino-Lite Pro AM413ZTAS digital microscope for traces of anthropogenic modification. The identification of both taphonomic and anthropogenic traces were based on criteria defined in the archaeological use wear literature (Chauvière and Rigaud 2005; d'Errico 1991, 1993; d'Errico et al. 2012; Fisher 1995; Kamminga

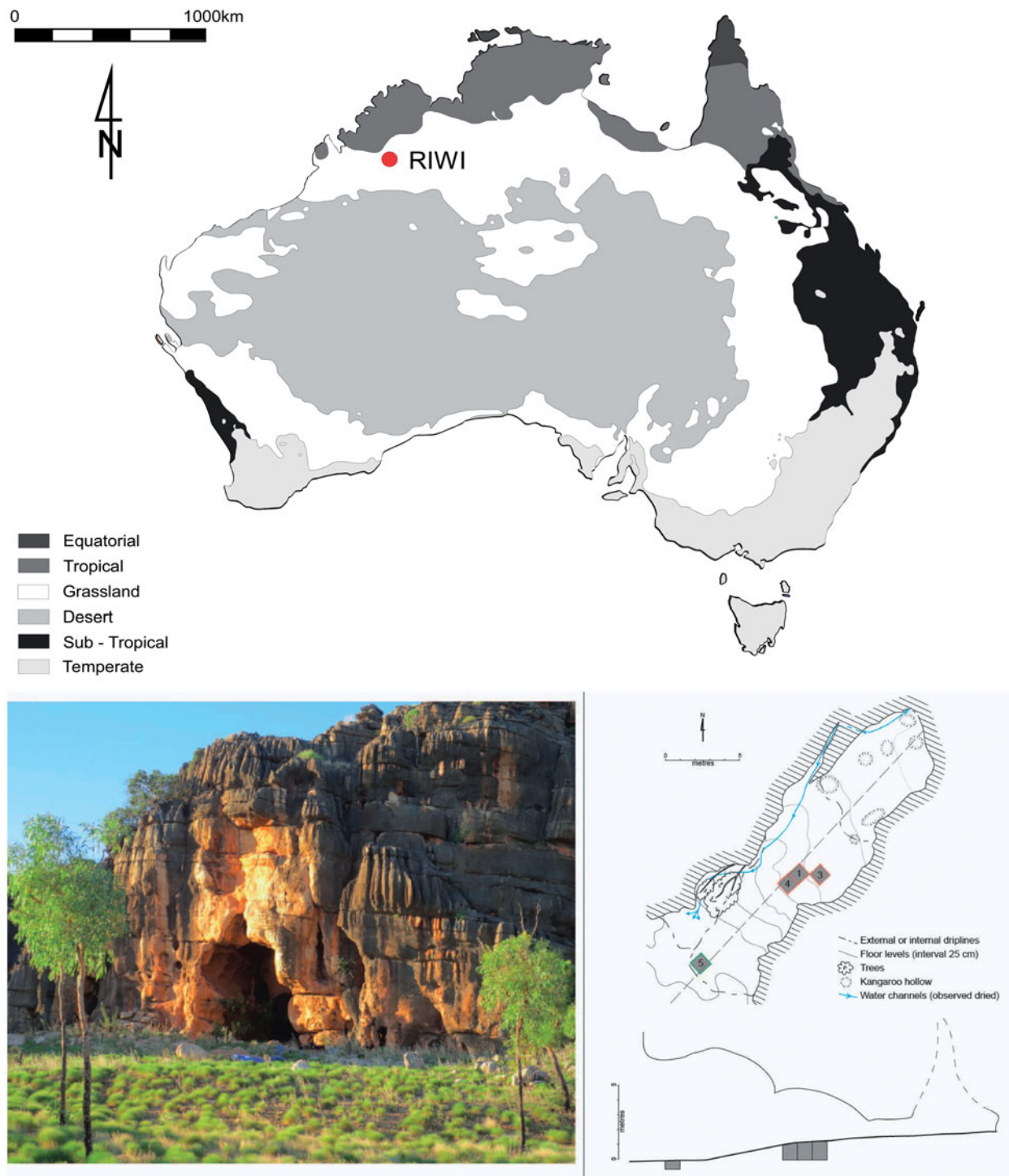


Figure 1. Location of Riwi Cave, view of the site, and site plan.

1988; Rigaud 2006), as well as comparison with ethnographic wooden implements collected in the Kimberley area and curated by the Western Australian Museum (WAM). Selection of ethnographic implements for comparison was based on an initial survey of the Kimberley collection for any artefact types which exhibited an extremity of similar size and shape to the Riwi artefact. This process resulted in the selection of symmetrical and hooked boomerangs, spear-throwers, digging sticks, and an axe handle. Each of these items was then examined using a Dino-Lite Pro

AM413ZTAS digital microscope for manufacture and use traces, and their metrics recorded before their extremities were photographed with a Canon EOS 400D digital camera. The Riwi artefact was on hand throughout this process for direct comparison with the ethnographic material. As little ethnographic information is available for material culture of the Gooniyandi people, literature pertaining to the manufacture and use of wooden technology from surrounding Aboriginal groups is included here, and where present and available, Gooniyandi references are cited.

The Riwi Artefact

The Riwi wooden artefact was recovered from Square 3c, excavation unit 8 in the 2013 excavation season.

Dating

As the artefact was recovered from an excavation unit which is a mixture of stratigraphic units 1 and 2, it was decided that permission from the Mimbi community should be sought to directly date the piece. After obtaining this permission, the fragment was shaved with a scalpel on the proximal extremity to obtain a sample (10.4 mg) for analysis. Radiocarbon analysis was undertaken by the Australian National University's (ANU) radiocarbon laboratory using the single stage accelerator mass spectrometry (AMS) method. The resulting calibrated age range was 651–557 cal. BP (670 ± 20 BP; S-ANU 43337) at 95.4% probability calculated with the SHCal13 curve (Hogg et al. 2013) in OxCal version 4.2 (Bronk Ramsey 2009).

Wood Taxon

Whitau et al. (2016) used X-ray computed microtomography (μ CT) to identify the wood taxon from which the artefact was made. A non-invasive and expeditious method, μ CT utilises radiographic projections in conjunction with specialist software to reconstruct a sequence of 2D and 3D views *ad infinitum*. The piece was identified as originated from the Proteaceae family, and more particularly, the *Grevillea* and *Hakea* genera. Distinguishing between the two genera is difficult owing to a number of shared anatomical traits.

As reported by Whitau et al. (2016), there are currently 42 identified species and subspecies of *Grevillea*, and four species of *Hakea* in the Kimberley region (<http://florabase.dpaw.wa.gov.au/>). During the 2013 vegetation survey, four species of *Grevillea* were collected by Whitau within 50 km of Riwi Cave: *G. pyramidalis*, *G. refracta*, *G. wickhamii*, and an unknown *Grevillea* sp. While no *Hakea* species were collected, the survey was by no means exhaustive, and thus, it is cautioned that *Hakea* should not be ruled out. The wood artefact fragment is therefore identified as having been made from *Grevillea/Hakea* sp.

Manufacturing traces, use wear, and residue

The Riwi artefact measures 23.4 mm (width) \times 23.9 mm (length) \times 10.1 mm (depth) at its maximum dimensions, weighs 2.44 g, and is semi-circular in section at its mid-line (Figure 2). Numerous traces of manufacture are visible over the artefact's

surface, with a single continuous scrape mark consistent with a lithic cutting edge (a set of multiple, closely spaced, and parallel striations that are elongate, linear, and relatively narrow; Fisher 1995) on the left side of the ventral surface being the most prominent (Figure 3(B)). The majority of these scrape marks are orientated along the length of the artefact. Evidence that the artefact underwent fire hardening is also present, with signs of charring visible at low magnification (Figure 3(A) and (D)). Traces of a red residue consistent with a colourant were also observed on the ventral surface (Figure 3(D)). Both this residue and the traces of burning can be explained by the ethnographically recorded practice of firing wood during tool shaping, followed by the rendering of the item with a mixture of fat and red ochre which acted as a preservative (Gould 1970:37; Jones 2004).

The distal edge draws back in a fairly even curve and exhibits pronounced crushing, abrasion of the wood surface, and polish along this extremity (Figure 3(E) and (F)), while the opposing extremity (proximal) terminates in an irregular fracture. Unlike post-depositional fractures which present a flat plane (see for example, the Wylie Swamp boomerang fragment pictured in Luebbers 1975:39, Figure 1), this break is characterised by chop marks and chattering on all four surfaces below a snap fracture. Fractures exhibiting these characteristics on Palaeolithic osseous technologies are commonly known as worked fractures or '*déchets de sectionnement par raclage et flexion*' (Chauvière and Rigaud 2005; Rigaud 2006), and are known to be produced during the manufacture of projectile points, during repair or recycling, or their recovery in the hunting field when stuck fast in a carcass (e.g., Chauvière *in press*; Chauvière and Rigaud 2005; Langley 2015; Pétillon 2006). These fractures can be worked from one or more surfaces (including all four surfaces – dorsal, ventral, left, and right – as is the case here), and involves the removal of material by cutting or scraping in order to thin an area allowing the implement to be snapped by flexion. On the Riwi artefact, chop and chattermarks begin 15.7 mm below the proximal edge on the ventral surface and are clustered towards the left side. Marks are also seen 5.6 mm from the proximal edge on the dorsal surface, with a single large mark evident on the right side (Figure 3(G) and (H)). These traces indicate that the artefact was intentionally thinned before being snapped in order to remove it from a larger implement.

Careful examination of the dorsal (curved) surface reveals remnants of fluting \sim 5 mm in width and worn down through handling, use, and/or taphonomic processes (Figure 3(C)). No other signs of decoration were observed if one accepts that the red residue relates to the implements rendering with a

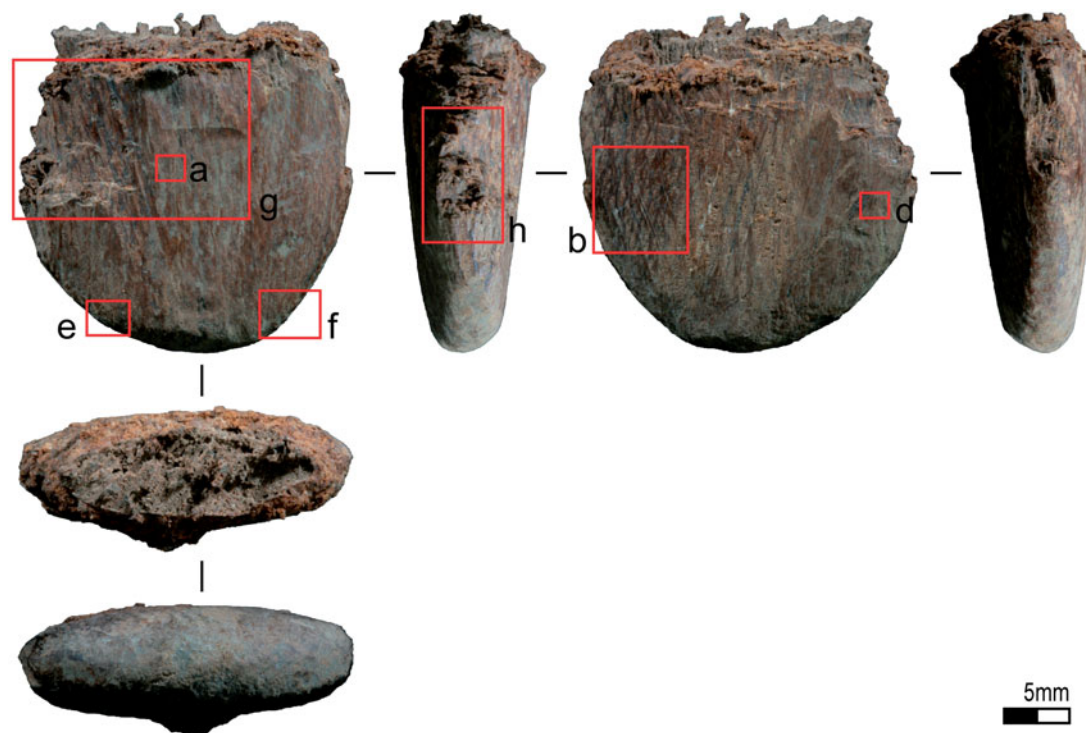


Figure 2. The Riwi artefact. Outlined locations refer to Figure 3.

protective balm, rather than reflecting painting of the finished implement. It should be noted, however, that numerous ethnographies of Australian wooden technologies note that many of these implements were decorated with red, white, yellow (and other) paints (e.g., Jones 2004; Spencer and Gillen 1904, 1927).

Comparison with Kimberley ethnographic implements

In total, eight spearthrowers, 13 adult boomerangs, two children's or toy boomerangs, three digging sticks, and an axe handle were examined at the Western Australian Museum for comparison to the Riwi artefact. The axe handle was immediately ruled out as a suitable match for the Riwi artefact as these components are made of a single piece of bark folded back on itself, and thus neither the raw material nor the depth of the butt end of this tool matched the recovered artefact.

The proximal extremity (handle) of the spearthrowers display largely similar manufacturing and use traces to the artefact, in particular, crushing and abrasion along the curved edge (Figure 4(A–C)). Several of these implements also exhibit traces of a red colourant over their surfaces. These extremities, however, are significantly larger in both width and depth at 0.5 mm from the proximal edge than the Riwi piece, averaging 36.4 mm in width \times 9.3 mm in depth against the Riwi artefacts 14.8 mm (w) by 5.8 mm (d) at this same point from the tip. They also exhibit a flattened oval section as opposed to the

semi-circular section of the Riwi artefact. As a number of the curated spearthrowers had lost their wooden peg and/or lashing at the distal extremity, it was also possible to examine this section for similarities to the Riwi artefact. While this extremity is much closer in terms of size (averaging 11 mm in width and 6.9 mm in depth at 0.5 mm from the tip), the traces of manufacture and use differ significantly. Finishing of the extremity ranges between rough shaping (Figure 4(D)) and more precise rendering (Figure 4(E)), with cross-sections ranging between oval and circular. All feature a perforation that ranges in diameter and location (4–16 mm) down from the distal extremity. Those spearthrowers on which the lashing has either partially (such as that shown in Figure 4(F)) or completely (Figure 4(D) and (E)) disappeared display remnants of the resin used to fix the peg to the spearthrower body (see example in Figure 4(E)).

Incidentally, one of these spearthrowers (E3022) displays a worked fracture similar to that found on the Riwi artefact, however, it constitutes the extremity of the spearthrower. Having observed this evidence, it was considered whether the Riwi artefact could represent a distal extremity of a spearthrower removed during manufacture or repair, however, this possibility was dismissed on the basis of the following factors. First, the Riwi piece exhibits no evidence for a perforation or any other sign (such as residue) of a peg having been attached. Second, if the section had been removed prior to the construction of a perforation, it would not have accrued the amount of use wear evident on the Riwi artefact. Finally, while a section of a spearthrower may be removed as part

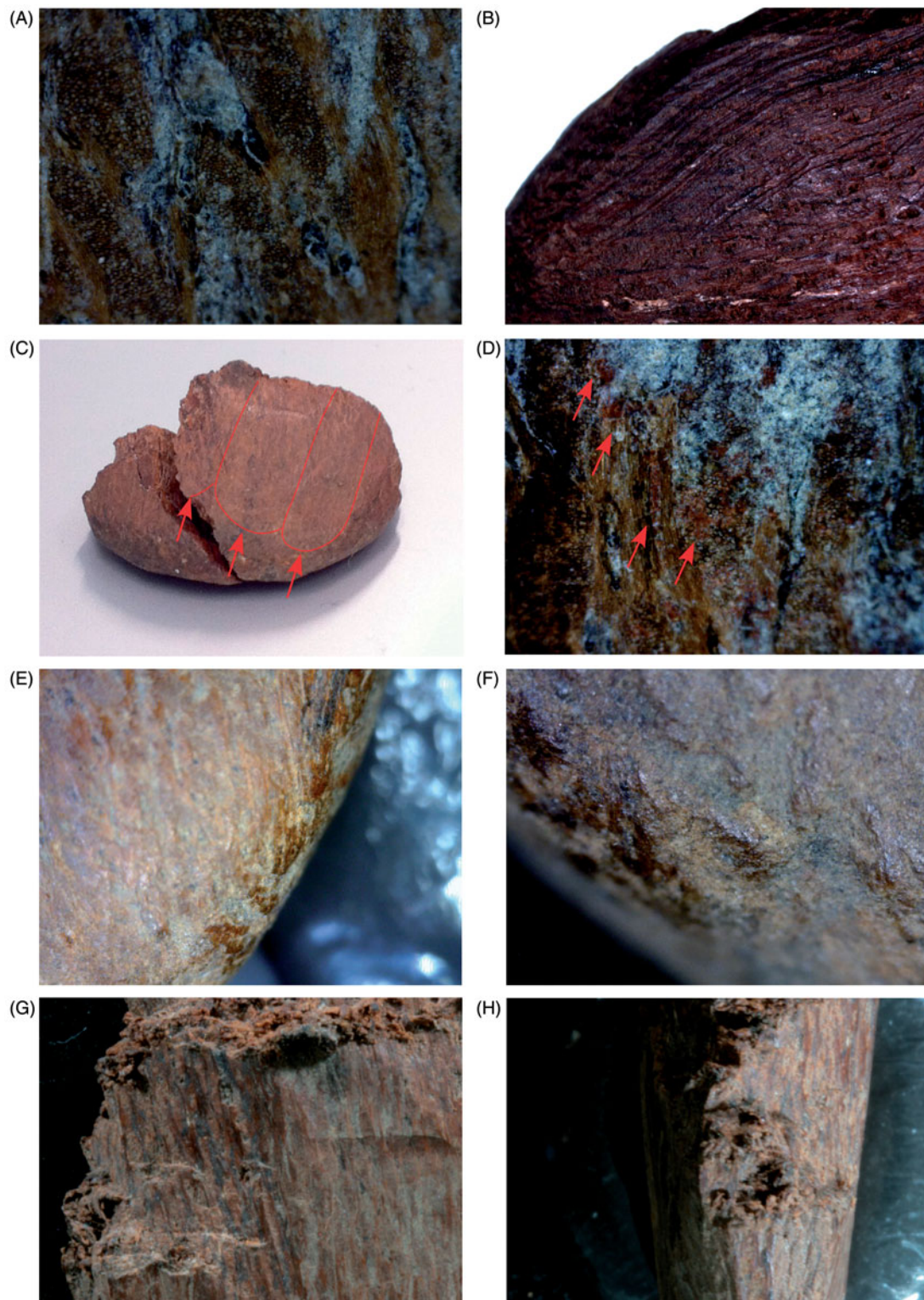


Figure 3. Details of manufacture and use traces found on the Riwi artefact: (A) View of surface showing evidence for heating (200 \times); (B) View of a longitudinal scrape mark made with a lithic edge (65 \times); (C) Remnants of fluting (outlined in red) on the dorsal surface; (D) Red colourant residue indicated by red arrows. Ash is also visible in the top portion of this image (200 \times); (E) Distal edge showing crushing and polish (50 \times); (F) Polish at distal edge (100 \times); (G) Chattering and chop marks on Left side (50 \times); (H) Chop marks on right side (50 \times).

of repairs, no sign of the longitudinal (along the grain of the wood) fracturing which might prompt this kind of work (an example is shown in Figure 4 F) is evident on the Riwi artefact.

Furthermore, in the Kimberley region, the soft lightweight wood of *Erythrina verspertilio* is cited as

being used to create light, long, and slender spear-throwers (Akerman 2006:329, 333; Scarlett 1985:23). Blundell's (1975:422) research with Worora and Ngarinjin also documents corkwood, a common name for *E. verspertilio*, as a primary type of wood used in the manufacture of spearthrowers (Atlas of

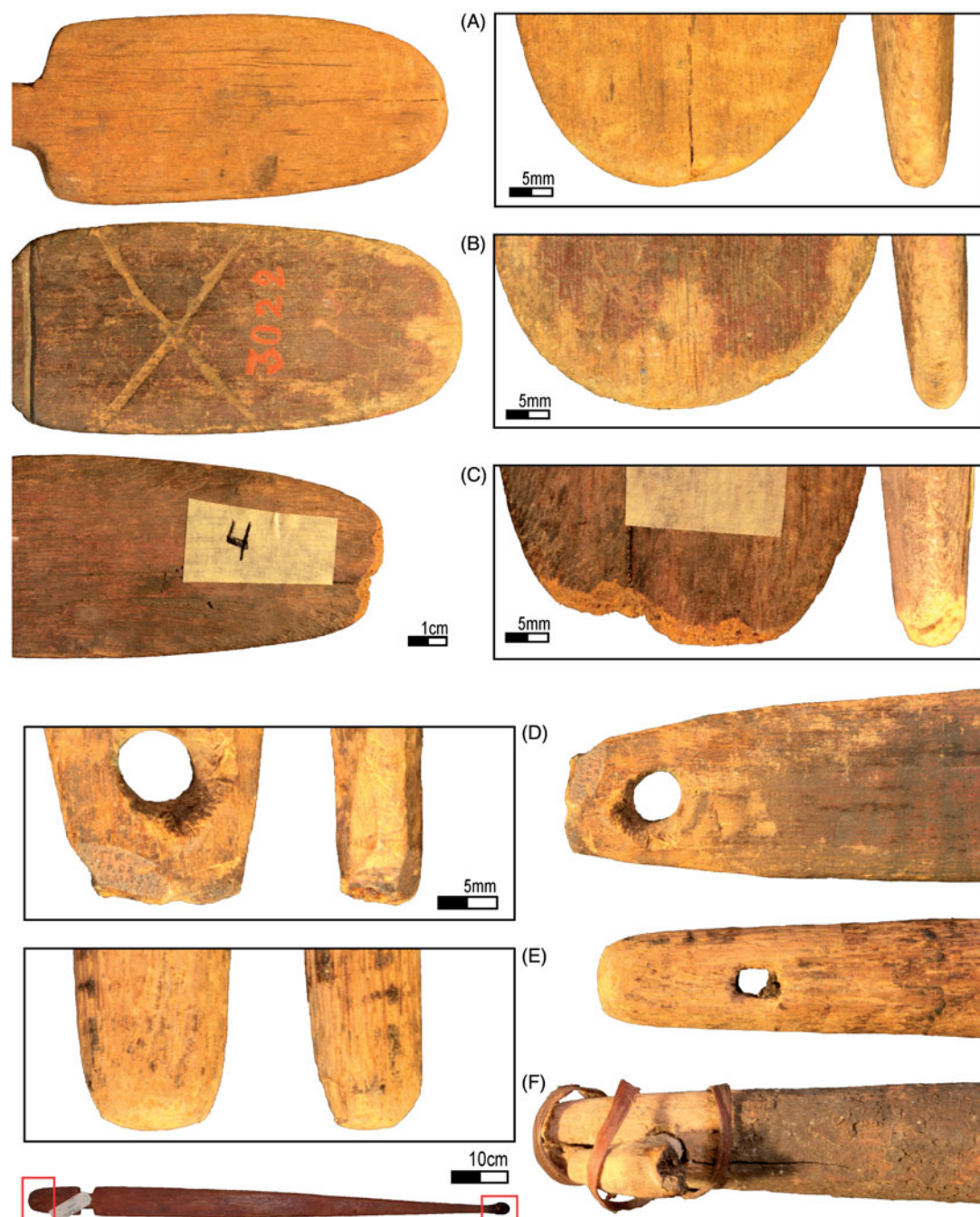


Figure 4. Examples of Kimberley spearthrower extremities. (A) Proximal extremity of spearthrower A290; (B) Proximal extremity of spearthrower E3022; (C) Proximal extremity of spearthrower E6332; (D) Distal extremity of spearthrower E3022; (E) Distal extremity of spearthrower A14111; (F) Distal extremity of spearthrower A22644.

Living Australia 2015), while Scarlett (1985:23) records the use of *E. versperilio* to make spearthrowers when working with the Kija in east Kimberley. Common to north Western Australia, the leaf or paddle shape spearthrower, has a plano-convex cross-section, gum knob handle for grip, and is incised with parallel or zig zagging grooves for decoration (Davidson 1936b:465–467). The end of the spearthrower that holds the spear is fitted with a peg made from hardwood which is then lashed with animal sinew and reinforced with resin (Akerman 2006:333). These lightweight wood types documented for the manufacture of Kimberley spearthrowers is

distinctly different from that used in the manufacture of the wooden artefact recovered from Riwi. Consequently, we do not believe that the Riwi artefact originated from a spearthrower.

The three Kimberley digging sticks examined range in total length between 149.5 mm and 126 mm. One example (E6344; Figure 5, 3) is decorated with red and white paint, while the other two display evidence for having been kept and preserved by Europeans after collection from their original owners (E5176 has a drilled hole through one extremity to facilitate hanging and both this specimen and A5550 exhibit traces of a substance visually consistent with

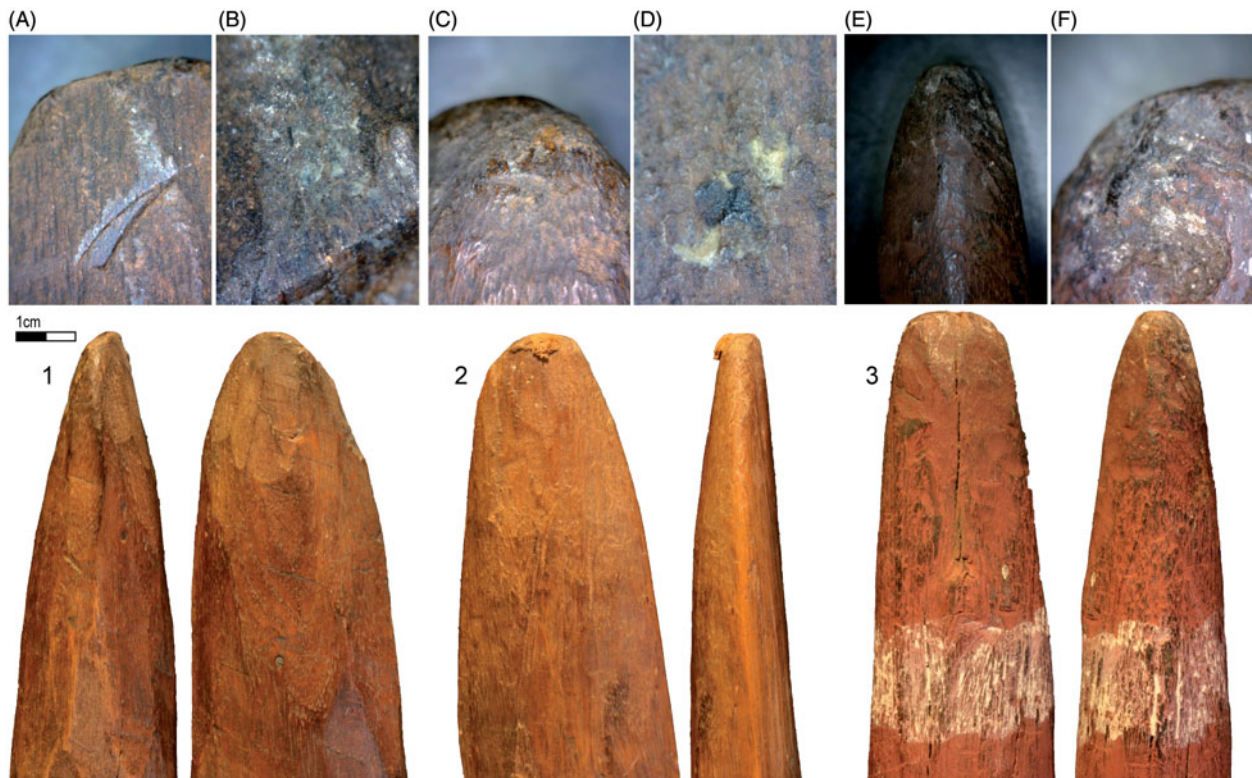


Figure 5. Examples of Kimberley digging stick extremities: (1) Digging stick E5176; (2) Digging stick A5550; (3) Digging stick E6344. (A) Whittling mark 50 \times ; (B) Beeswax? and possible white pigment residue 175 \times ; (C) Crushing and polish 20 \times ; (D) Beeswax? residue 50 \times ; (E) Crushing 20 \times ; (F) Pigment residues and polish 50 \times .

a beeswax based resin - commonly used by Europeans for maintaining wooden items: [Figure 5\(B\) and \(D\)](#)). Despite these setbacks, manufacturing and use traces remain easily identifiable at low magnification. Both extremities display scars from the whittling of the bevelled ends ([Figure 5\(A\)](#)), along with crushing, chipping, and mushrooming of the extremity accrued through repeated impact with the ground ([Figure 5, 1–3](#)). Polish was also found on these extremities ([Figure 5\(C\)](#)). These use traces are more pronounced than those observed on both the spearthrower extremities described above, as well as the Riwi artefact. As found for the spearthrowers, both the morphology (bevelled) and metrics (average width 15.3 mm width \times 7.4 mm depth at 0.5 mm from the tip) differ significantly from the Riwi artefact, therefore ruling out these implements as the origin tool type.

Having dismissed axe handles, spearthrowers, and digging sticks as likely origins for the Riwi artefact, boomerangs provided a final tool category for comparison. Both extremities of seven hooked (fighting) boomerangs, six symmetrical (returning and non-returning) boomerangs, and two children's or toy boomerangs were examined. While variation in finish (whittled, abraded, fluted, painted) and extremity morphology exists in the studied dataset ([Figure 6](#)), all boomerangs exhibit the same use wear. As can be seen in both [Figures 6 and 7](#), boomerangs display a

consistent suite of damage to their extremities: chipping, crushing, rounding, polish of raised areas, and short, fine striations which are situated at a 90° angle to the wing axis. This wear pattern appears unique to the throwing weapons and was found on all 15 boomerangs (including the children's versions) examined for this study. A brief viewing of the larger collection of Kimberley boomerangs curated at the Western Australian Museum suggests that this pattern would be found on all utilised implements, and consequently, may be used to help identify fragments of boomerang extremities in the future. Armed with this knowledge, the use wear visible on the Riwi fragment was reviewed and the boomerang damage suite was identified on the artefact (Compare [Figure 7](#) with [Figure 2 and 3](#)).

Metrically, boomerang extremities are much closer to that of the Riwi artefact than those found on spearthrowers and digging sticks ([Table 2](#)). Symmetrical boomerang extremities ranged between 7.8 mm and 26.4 mm in width with triangular section morphologies slimmer at 5 mm from the tip than those of a more oval section (Compare [Figure 6\(A\) and \(B\)–\(D\)](#)), however, the smaller tip of the trailing wing on hooked boomerangs ([Figure 6\(E\)–\(H\)](#)) were found to be most similar to the Riwi artefact's dimensions (ranging between 11.38 mm and 20 mm in width and 2–7.5 mm in depth at 5 mm from the tip; Riwi: 14.8 mm [w] by 5.8 mm [d]). The

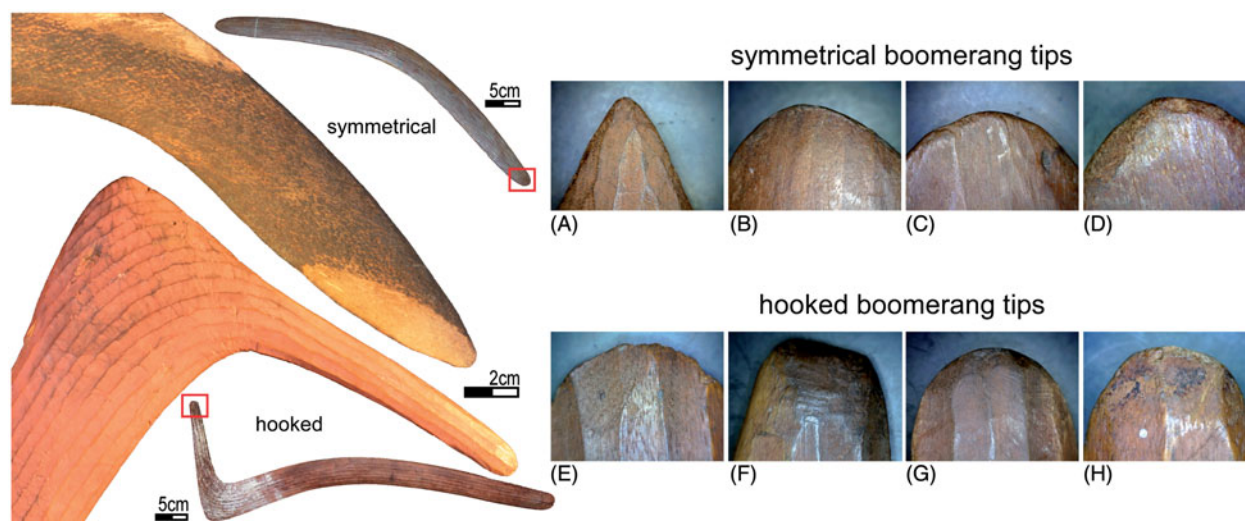


Figure 6. Detail of symmetrical (A–D) and hooked (E–H) boomerang extremities showing common morphologies and damage (A–E at 30 \times ; F at 20 \times ; G at 25 \times ; H at 50 \times).

semi-circular section and roughly straight sides of the hooked boomerang tip also fits more closely to the morphology of the Riwi artefact, than those of the symmetrical boomerang. This comparison is best demonstrated in Figure 8, which pictures the Riwi artefacts next to the trailing wing tip of a Kimberley hooked boomerang (A10624). As can be seen in these images, the similarities in size, shape, finish (fluting on the Kimberley boomerang and remnant fluting on the Riwi artefact), and wear pattern are striking.

In summary, based on size, cross-section morphology, manufacturing trace, and use wear, it appears that the Riwi artefact originated from a boomerang extremity. While we cannot rule out that it came from a children's boomerang (these toys being smaller in their overall dimensions), we argue that it more likely originated from the tip of the trailing wing of a hooked boomerang. Further support for this conclusion is presented in the following section.

Discussion

While identification of the Riwi artefact as a boomerang extremity was primarily based on the comparison of the piece with Kimberley material, information contained within Australian ethnographies provides further support for this conclusion.

Boomerangs, along with throwing-sticks and spearthrowers, are an important class of wooden tool and are recorded in the ethnographic literature of Aboriginal groups located throughout the Kimberley region, including for the Bardi, Bunuba, Gooniyandi, Jaru, Kija, Ngarrinjin, Walmajarri, and Wunambel (Blundell 1975; Davidson 1936a, 1936b; Lowe 2005:92; Scarlett 1985; Sculthorpe 2015; Smith and Kalotas 1985; Wightman 2003). An illustration produced by Davidson (1936a:89) mapping returning,

non-returning, and hooked boomerang distribution in the Kimberley region notes that boomerangs are 'lacking' in the northern Kimberley coastal country. Blundell's (1975:419–420) research supports this finding and records that both Worora and Ngarrinjin Aboriginal groups did not traditionally produce boomerangs but instead received these items from surrounding groups via trade and exchange networks. Similarly, McCarthy (1939:81–82) reports that fluted and hooked boomerangs were manufactured in regions to the southeast and northeast of the Kimberley, and traded into this latter region (also see Davidson 1936a; Davidson and McCarthy 1957; Roth 1897). Berndt and Berndt (1988:128) note that exchange networks that criss-cross the Kimberley were important for trading goods, specifically citing boomerangs as an item moved along these pathways. In fact, the Lungaa of the east Kimberley 'say they cannot make boomerangs properly: they prefer to import them from the east, west, or southwest' (Berndt and Berndt 1988:128). Indeed, McCarthy (1939) reports that an Ungarinjin man at Walcott Inlet, Northern Kimberley, was witnessed as having in his possession a hooked boomerang. This item he believed to be 'magical... no doubt, because of its strangeness; no boomerangs of any sort were made or used by this tribe' at this time (McCarthy 1939:82).

Despite the apparent preference for importing boomerangs, peoples located in the Kimberley (as elsewhere), cited *Acacia* as commonly selected for the production of boomerangs (see Jones 2004:19; Spencer and Gillen 1927), although it was not exclusively used, and other wood types with similar mechanical properties were also often chosen. *Grevillea* and *Hakea*, of the Proteaceae family, produce strong hard wood and are often cited for the manufacture of boomerangs (e.g., Lowe 2005:92; Smith and

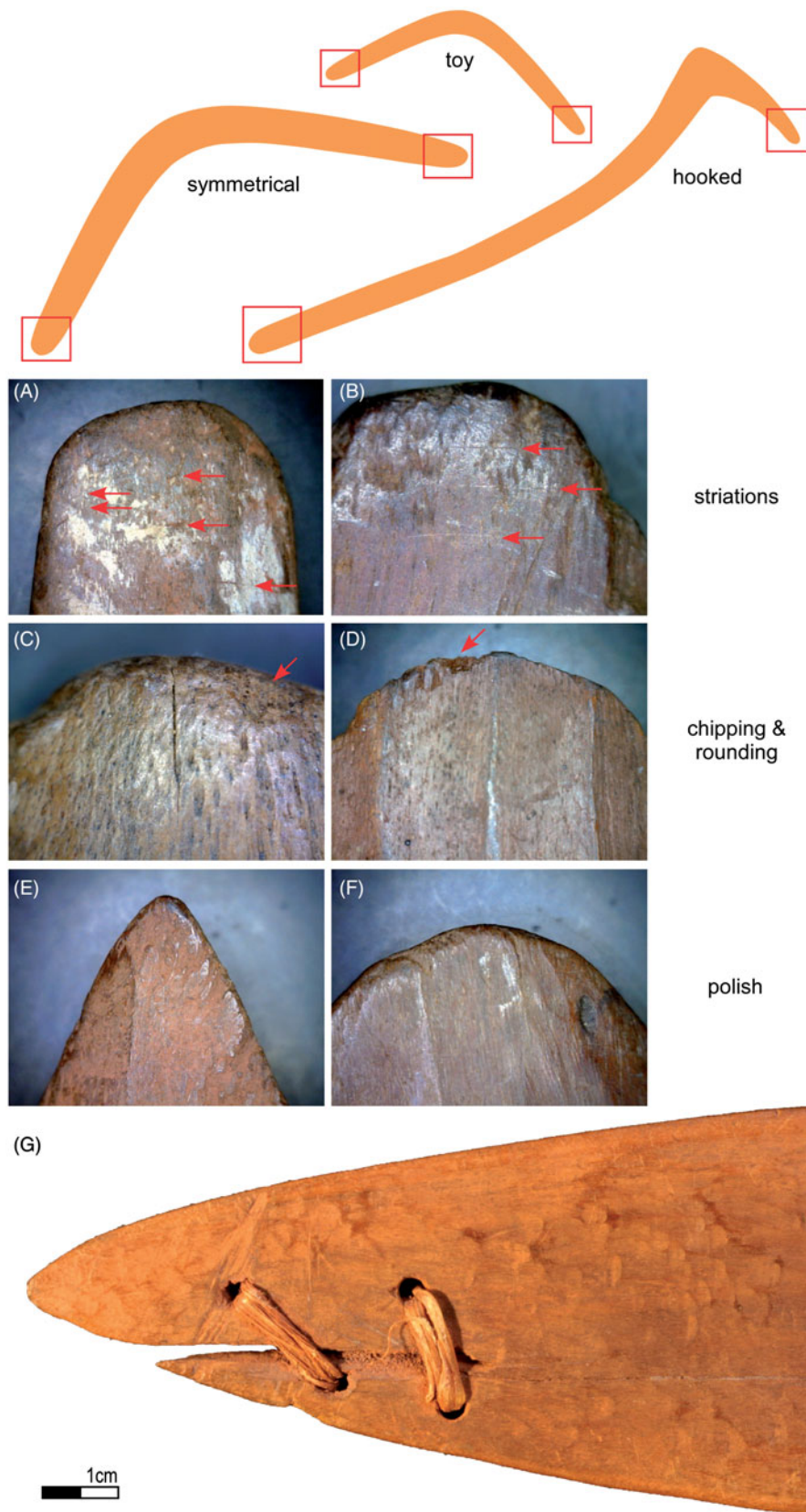


Figure 7. Common damage types observed on Kimberley boomerang extremities: (A and B) short, fine striations at a 90° angle to wing axis; (C and D) chipping and rounding of the tip edge; (E and F) polish on raised areas of the wing extremity; (F) Example of common repair method, here seen on a symmetrical Kimberley boomerang (A10657).

Kalotas 1985:344; Wightman 2003:56–58). Unfortunately, no documentation for boomerang manufacture is available for the Gooniyandi, so we turn to documentation of surrounding groups. In the

west Kimberley, Bardi are recorded as sourcing two species of *Hakea*, *H. aborescens* and *H. macrocarpa* for boomerang production (Smith and Kalotas 1985:334, 344). In the east, Kija use three species of

Table 2. Metrics for Kimberley wooden implements examined for this study (all curated in the Western Australian Museum). All measurements taken 5 mm from extremity edge except otherwise stated. Spearthrower distal extremities stated as “n/a” were unable to be measured owing to lashing and/or resin covering area.

Artefact	Width (mm)		Depth (mm)	
Riwi Artefact	14.8		5.8	
Axe Handle	16.5		2.7	
A22920 (Mount Elizabeth)				
Digging Sticks	Extremity 1 Width (mm)	Extremity 1 Depth (mm)	Extremity 1 Depth at tip (mm)	Extremity 2 Depth at tip (mm)
A5550 (Lombadina Mission)	16.3	5.8	3.8	5.4
E5176 (Lombadina Mission)	18.6	8.9	7.1	9.7
E6344 (Pender Bay)	15.4	10.4	6.7	4.4
Spearthrowers	Proximal extremity width (mm)	Proximal extremity depth (mm)	Distal extremity Width (mm)	Distal extremity Depth (mm)
A290 (Broome)	21	6.1	n/a	n/a
E3022 (Isdel Ranges/Collier Bay)	34.2	6.8	13.1	7.2
E6332 (Pender Bay)	32.1	8.5	n/a	n/a
E3828 (Isdel Ranges)	29.3	8	n/a	n/a
E3023 (Isdel Ranges/Collier Bay)	28.3	7.4	11.3	7.2
A22866 (Kimberley General)	51.6	11.89	12.3	7.7
A22644 (n/a)	46	16.7	8.8	5.1
Symmetrical Boomerangs	Trailing wing Width (mm)	Trailing wing Depth (mm)	Trailing wing Depth at tip (mm)	Leading wing Depth at tip (mm)
A83 (Derby)	10.2	3.4	1.9	3.4
A4935 (Derby)	11.2	4.3	2	6.3
E237 (Derby)	14.1	2.2	1.1	2
A120 (Derby)	7.8	2.2	0.8	1.6
A127 (Derby)	8.4	2.1	0.9	3.2
A4822 (Turkey Creek)	20.6	6.7	3.3	7.8
Children's symmetrical boomerangs	Trailing wing Width (mm)	Trailing wing Depth (mm)	Trailing wing Depth at tip (mm)	Leading wing Depth at tip (mm)
4235 (Kimberley General)	10	3.4	1.8	3.4
4235a (Kimberley General)	12.4	3.4	2.5	3.1
Hooked Boomerangs	Leading wing Width (mm)	Leading wing Depth (mm)		Leading wing Depth at tip
E12111 (Halls Creek District)	13.6	3.1		1.5
A23516 (n/a)	15.3	3.9		1.7
A10625 (King Leopold Range)	17.4	2		0.9
A25900 “Wilgee” (Halls Creek District)	13.4	4.2		2
A22920 (n/a)	15.7	7.5		4.2
A10624 (Bulliluna District)	20	7.1		2
A11704 (Kimberley General)	11.3	5		1.1

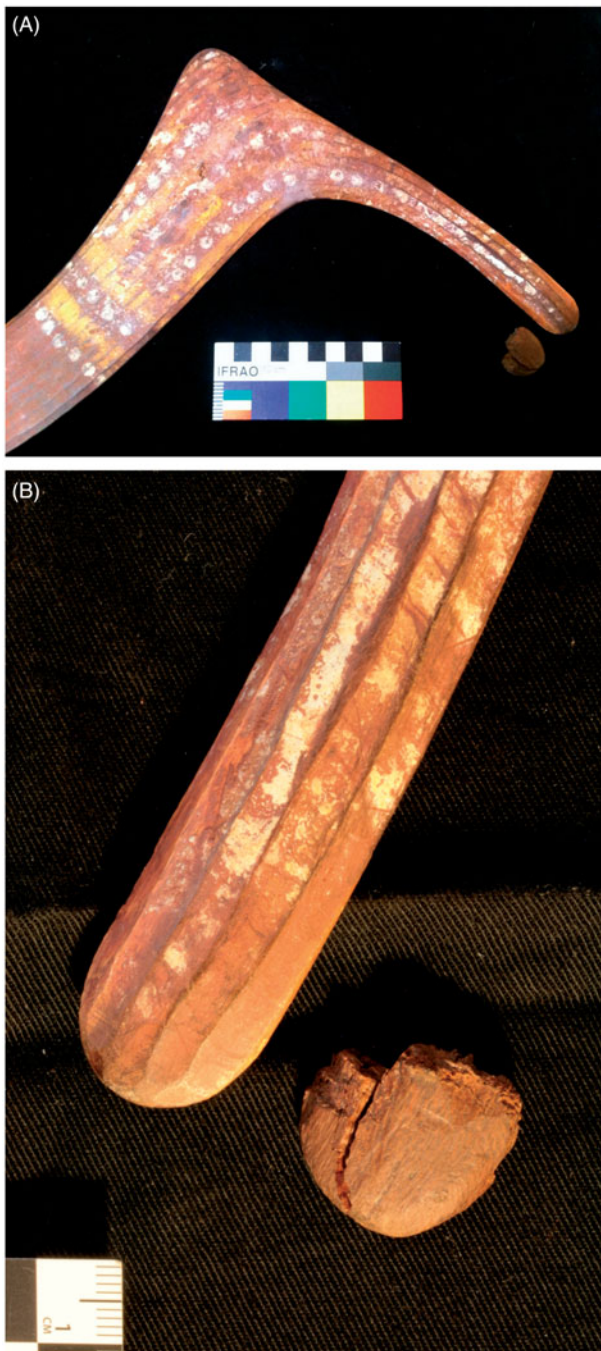


Figure 8. Comparison of the Riwi artefact to the leading wing tip of a Kimberley hooked boomerang (A10624).

Grevillea: *G. pyramidalis*, *G. pteridifolia*, and *G. striata*, along with the same two species of *Hakea* used by Bardi (Wightman 2003:56–58). To the southeast, Jaru use two taxa specifically selected for the manufacture of boomerangs *G. striata* and *H. aboroscens* (Wightman 2003:113–114). Finally, to the south of Gooniyandi, Lowe (2005:92) documents two genera of plants chosen by the Walmajarri to produce boomerangs as *Grevillea* and *Hakea*. Hence, the available ethnographic information regarding wood selection for boomerang manufacture is consistent with the Riwi artefact's taxonomic identification.

Returning and non-returning boomerangs are fashioned from curved tree trunks or branches while

the hooked or fighting boomerang (*wirlki*) – which we believe this artefact to originate from – is created from the junction of a tree trunk and root. This section creates a more pronounced angle and ensures that the maximum strength of the wood is located at the hooked section which takes the force of impact when thrown (Akerman 1998:13; Jones 2004:18). Wood is worked fresh when it is easier to carve as the hygroscopic nature of wood results in rapid moisture loss, resulting in warp and/or brittleness (Kamminga 1988:28). Stone adzes are used to achieve the rough shape of the boomerang with hand held scrapers employed to finalise the shape (Kamminga 1988:28). The careful use of fire (producing dry or moist heat) to aid the manufacture of wooden tools is also well documented, with this process resulting in the wood becoming supple, and it is in this state that defects are manipulated out and the required shape achieved (Akerman 1998:10; Kamminga 1988:28; Roth and Etheridge 1897:102, 142). The final product is rendered on multiple occasions over time with a mixture of animal fat and ochre to retain moisture equilibrium, combating warping and splitting (Jones 2004; Kamminga 1988:28).

While the manufacturing processes are similar for all three boomerang types (returning, non-returning, and hooked), balance, flight, and function differ substantially (see Cotterell and Kamminga (1990) chapter 7 for a detailed discussion on boomerang aerodynamism and the motion of projectiles). The hooked boomerang is reported as being particularly effective for interpersonal conflict as it catches on the shield (or other item) which is held up to protect the person at whom it was thrown, and instead of simply being ward off as in the case of more symmetrical boomerangs, it swings round on the beak, striking the individual about the neck (Spencer and Gillen 1927). Although the boomerang is most commonly associated with hunting and warfare, it is well documented as a multipurpose tool and its many functions include the creation of and tending to fire, as musical instruments, in ceremonial dance, and as a substitute for a digging stick for procuring plant foods and numerous burrowing animals (Berndt and Berndt 1988:23; Jones 2004:17; McCarthy 1961:348; Spencer and Gillen 1927).

Many stunning examples of decorated boomerangs, engraved, painted, and burnt, exist and often decoration is documented as playing a crucial function for ceremonial activities and land rights (Jones 2004:16–17; MacKenzie 2011:1). Having said this, while respectfully acknowledging the ceremonial aspect of boomerang decoration, Jones (2004:32) suggests that fluted longitudinal carvings often observed on hunting (non-returning) boomerangs may play more of a technological function by reducing air drag and surface tension. In flight, fluting on a

boomerang causes turbulence in the laminar boundary of air creating a smaller vortex behind the object, and thus, minimising drag, much like dimples on a golf-ball improve the accuracy of flight path (Mehta 1985:186). Consequently, the fluting observed on the Riwi artefact may have had both a decorative and functional role in the use life of the implement from which it came.

Details of the maintenance of wooden technology found in the ethnographic literature further support our conclusion that the Riwi piece is consistent with having originated from a boomerang. This deduction was based on the following observations. First, digging stick and projectile point extremities were carefully maintained through the systematic cutting or grinding away of material using a series of finer and finer grindstones (Gould 1970; Mountford 1941; Thomson 1964; Worsnop 1897). For both of these pieces of equipment, a sharp edge (digging stick) or point (projectile point) was essential to the continued efficiency of the tool, and neither were commonly allowed to accrue the intensity of wear observed on the distal extremity of the Riwi artefact. Second, the sectioning of a portion of a tool extremity almost 25 mm in length is not only inconsistent with the available ethnographic descriptions of tool repair for these particular implements (e.g., Thomson 1964), but would also result in the reduction of the tools far more quickly than necessary. That is, rather than the least amount of material being ground away to produce a renewed edge, far more material than required was removed in a single event, significantly shortening the use life of the implement.

Thus, with digging sticks and projectile points ruled out, we are left with three forms of weaponry in which weight, balance, and appearance – as the most likely reasons for the removal of portion the size of the Riwi artefact – are extremely important: boomerangs, throwing-sticks, and spearthrowers. As was shown above, both the morphology and the wood taxon of the Riwi artefact do not match the characteristics of either a throwing-stick or a spearthrower, however, it does match that of a boomerang. Given that we have such a small piece of this artefact, it is difficult to identify if it originally constituted the trailing or leading wing of a boomerang, though its overall morphology (including surface angle from proximal edge, surface contour, and edge curvature) suggests that it was most likely a tip of the trailing wing of a hooked boomerang – as argued above. This distinction is important as hooked boomerangs are often cited as having been used in ceremony (see Jones 2004 for example), and consequently, it might be assumed that their appearance and performance was especially important. While a boomerang extremity may be altered during manufacture, the repair of these weapons did not

involve removal of material; for example, Worsnop (1897:129) reports that, “in the process of manufacture they are scraped, chipped, and smoothed as experimental testing suggests, and the weapon is not considered finally completed until the experiments are successful and it has come back in the manner desired by the maker”. Instead, boomerangs broken in use were repaired through the drilling of holes on either side of the split section, through which sinew was threaded in order to tie the section together (Jones 2004; see example of such a repair in Figure 7: G). Having said this, Spencer and Gillen (1927:533–534) report that they observed the trimming of hooked boomerangs broken in use within the Arunta territory. In this instance, however, the whole shoulder (beak) of the weapon was removed rather than a small portion of the extremity, transforming the implement into a functional throwing stick.

Alternatively, the implement from which the Riwi artefact originated may also have been altered if/when it moved from being a purely functional tool to having a ceremonial aspect, as is known to occur for such boomerangs (Jones 2004). In such a scenario, the removal of a portion of the trailing wing, the section which was heavily decorated and central to its performance in the ceremonial arena, is then explained in terms of an implement whose appearance/performance was not exactly as was desired by its owner. Along these same lines and given that the boomerang from which the artefact came was most likely traded into the region, it might have been the case that the person/s who received the weapon held aesthetic values slightly different to those who manufactured the tool (differing communities of practice). In this case, the latter person/s may have trimmed the extremity so that its appearance conformed to their idea of suitable weapon form. Given that the repair of boomerangs is undertaken in an entirely different manner, as described above, either of these last two scenarios seems the most likely option at this time.

Importantly, as ethnographers report that fluted and hooked boomerangs were observed in the Kimberley, were traded into the area from other regions to the southeast or northeast, the Riwi artefact also provides tentative evidence that these trade routes, witnessed by Europeans within the last 200 years, were in similar use several hundred years previous.

Conclusion

In this paper, we have described a truly unique find – a boomerang extremity deliberately removed from a weapon tip and discarded at Riwi Cave some 600 years ago. While it cannot be ruled out that this

artefact originated from a children's boomerang, the gathered evidence (morphology, decoration, use wear, ethnographic comparison) strongly supports its origin as a hooked fighting boomerang. Such identification not only provides insight into the wooden technological repertoire of those who visited Riwi Cave, but also information of a type rarely found in the Australian archaeological record. That this artefact is also the oldest directly dated wooden weapon found in the northern regions of Australia, is an additional aspect of its importance to Australian archaeology.

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