

REVIEW

A Review of Ethnographic Use of Wooden Spears and Implications for Pleistocene Hominin Hunting

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Wooden spears are amongst the earliest weapons known from the archaeological record, with broken and complete examples known from Middle and Late Pleistocene Eurasian, Australian and South American sites. They were manufactured and used by multiple species of *Homo*, including *H. sapiens*. This paper comprises the first systematic review of ethnographic data on the recent use of wooden spears for hunting and human violence. It confronts the historical racism underpinning the abuse of ethnographic data on wooden spears, including associations between the technology and the development of cognitive abilities in human evolution. The review demonstrates that wooden spears were used as thrusting and throwing weapons by recent societies in North America, South America, Africa, and Oceania, and continue to be used today by children as training tools in hunter-gatherer societies. Their use is recorded in a wide range of climates and environments, using a variety of different hunting strategies to target terrestrial and aquatic prey. Whilst acknowledging limitations of ethnographic datasets, Middle and early Late Pleistocene hominin hunting is reconsidered, briefly overviewing wooden spears in relation to the variety of climate and ecological settings in which Pleistocene hominins hunted, targeted prey, and the potential for delivery methods and hunting strategies. The results underscore the importance of systematic reviews when utilising ethnography in interpreting archaeological evidence: selective references in relation to the use of wooden spears have overlooked additional examples that point to a richness and variability of technology and behaviour that is invisible in the Pleistocene archaeological record.

Keywords: Palaeolithic archaeology; Middle Pleistocene; Wood technology; Ethnoarchaeology

1. Introduction

Wooden spears represent the earliest hunting technology in the archaeological record. Their archaeological rarity, likely largely due to preservation bias, has not dampened interest in their function and significance, with a spike in publications relating to their manufacture and use over the last decade (Fluck 2015; Garofoli 2015; Gaudzinski-Windheuser et al. 2018; Haidle 2009; Milks et al. 2016; Milks, Parker & Pope 2019; Salem & Churchill 2016; Schoch et al. 2015; Wilkins, Schoville & Brown 2014). One-piece wooden spears, thrust and/or thrown by hand, have typically been evaluated in relation to some key innovations that are considered to have improved on their design and performance. First, the innovation of hafting of tips of different materials including stone and bone to weapons, called 'composite weapons', may have improved wounding and/or weapon durability (e.g. Salem & Churchill 2016; Wilkins et al. 2012; Wilkins, Schoville & Brown 2014). Second, the innovation of 'complex projectiles' i.e. mechanically propelling a penetrating weapon

using a spearthrower or bow has been variously suggested to increase hunting distances, impact velocity, accuracy, and/or wounding over hand-delivered spears, although this is currently under debate (e.g. Bradfield et al. 2020; Coppe et al. 2019; Milks, Parker & Pope, 2019; O'Driscoll & Thompson 2018; Shea & Sisk 2010).

The earliest archaeological evidence of a wooden spear is a tip fragment shaped from yew, dated to Marine Isotope Stage (MIS) 11 from the site of Clacton-on-Sea, UK (ca. 424,000–375,000 Before Present [BP]) (Warren 1911; Oakley et al. 1977). Archaeological evidence of composite weapons may date to as early as MIS 13 (ca. 524,000–479,000 BP) in Africa (Wilkins et al. 2012), and MIS 7 (ca. 243,000–192,000 BP) or MIS 6 (ca. 191,000–131,000 BP) in Eurasia (Mazza et al. 2006; Villa & Lenoir 2009). Microfracture features on stone points from the Gademotta Formation further suggest that African hominins were utilising stone-tipped spears as hand-thrown spears during MIS 7 (Sahle et al. 2013). Faunal evidence from African contexts also demonstrates the use of stone-tipped throwing spears by MIS 5 (ca. 130,000–80,000 BP) and potentially as early as MIS 6 (O'Driscoll & Thompson 2018). However, with composite weapons likely already in use in Europe, Late Pleistocene Neanderthals continued to

use wooden spears during MIS 5e (Gaudzinski-Windheuser et al. 2018; Thieme & Veil 1985). *H. sapiens* populations also used hand-delivered wooden spears for hunting, fishing, and violence alongside a wide array of different weapon systems. The use of these weapons by *H. sapiens* populations is recorded archaeologically in the terminal Pleistocene and Holocene (Dillehay 1997; Luebbers 1975), and as will be covered in this review, a continuity of use through to recent periods is implied by multiple cases in the ethnographic record.

This paper provides the first review of known ethnographic uses of wooden spears for hunting and violence as a means of better understanding this weapon technology and its variable uses amongst recent populations. Groups described in the ethnohistoric record as having used wooden spears are not direct proxies for hominins that made and used such weapons. This review is not proposing that Pleistocene humans were behaviourally, cognitively, or physiologically the same as recent spear-using populations covered here. However, previous references to ethnographic data in relation to Pleistocene spear use have been problematically selective; it will be argued that this selectivity has underestimated the skills and knowledge of both recent spear-using populations, and, by extension, poorly framed previous perspectives on spear-using hominins in the past. The wide-ranging and global overview thus provides the first opportunity to evaluate Pleistocene spear technologies by hominin populations, inclusive of *H. sapiens*, in relation to a more complete ethnographic dataset. It provides a pool of data from which we can evaluate the technological capabilities and variable use of these weapons and it is not intended to be utilised to represent cognitive comparisons between Pleistocene hominins and recent groups who utilised these tools.

2. Historicising and Contextualising References to Ethnographic Wooden Spear Use

This section illustrates the problematic academic history linking so-called 'simple' technologies, including 'simple' weapons (cf. Shea & Sisk 2010) with cognitive abilities. The best-known examples of recent hunter-gatherers using wooden spears are the Aboriginal Tasmanians (Tasmania, Australia), and the Tiwi who inhabit Melville and Bathurst Islands (Northern Territory, Australia). The Tiwi and Tasmanians used wooden spears in terrestrial and aquatic hunting, and in interpersonal and collective violence (Goodale 1971; Robinson 1966; Roth 1890; Spencer 1914). Prior to colonial contact the Tiwi and Tasmanians did not manufacture composite spears or 'complex' projectiles. As a result of the lack of these technologies, their technocomplexes were determined to be 'simple' (e.g. Hiatt 1968; McGrew 1987; Oswalt 1976).

During the 19th and 20th centuries, Aboriginal Tasmanians were often interpreted as intellectually inferior on the basis of a false equivalence: that simple technologies reflect inferior intellects. Fritz Noetling, a German geologist and palaeontologist, (Noetling 1911: 64, emphasis added) wrote:

A modern mind cannot understand how it was possible that such a suitable material as the siliceous

rocks from which the implements were manufactured, was not also used for weapons. To us it seems unintelligible, why the Aborigines did not fix a suitable flake to a piece of wood, thus *producing a weapon far superior to the primitive wooden spear*. Yet this was apparently an invention the Tasmanian Aborigine never made. *His mind was just as unable to conceive the idea of providing the wooden spear with a stone head, as it was to chip the tero-na-watta on both faces...*

And more recently Rhys Jones (1977) wrote:

Like a blow above the heart it took a long time to take effect, but slowly but surely *there was a simplification ... a squeezing of intellectuality*. The world's longest isolation, *the world's simplest technology ...* Even if Abel Tasman had not sailed the winds of the Roaring Forties in 1642, were they in fact doomed—doomed to a *slow strangulation of the mind?*

These views together demonstrate both early and persistent racism, and abuse of the ethnographic record of wooden spears; these characterisations continue to reverberate in relation to both Australian archaeology and Aboriginal rights (Ryan 2012: xix; Taylor 2014). Seemingly 'simple' technologies likely represent an economical match to a given group's requirements (Read 2006; O'Driscoll & Thompson 2018), rather than as Diamond (1978) suggests a loss of culture due to isolation or low population levels. More importantly, the simple/complex paradigm is no longer a helpful framework (Cosgrove & Pike-Tay 2004; McNiven 2019; Vaesen et al. 2016), and in the case of wooden spears, it disregards the skill and practical knowledge underpinning the design, manufacture, and use of weapons that, as will be demonstrated in this review, were variously designed to be used as contact weapons, as multifunctional weapons, as thrown spears some of which were aerodynamically designed to be capable of long-distance flight, and were recorded to be lethal in hunting and violence.

Unfortunately, much of the ethnohistorical data pertaining to the use of wooden spears consists of accounts that were recorded unsystematically. Perhaps more significantly some of those doing the recording, including George Augustus Robinson, had direct roles in the disenfranchisement, internment, displacement, and genocide of indigenous peoples (e.g. Flood 1999; Ryan 2012). Underestimations of population sizes and misrepresentations of cultures and technologies went hand in hand with an agenda to remove indigenous populations from land coveted by colonial settlers. As other researchers have already highlighted (e.g. Ryan 2012; Whittaker, Pettigrew & Grohsmeyer 2017), these subjective interpretations of cultures and technologies were then recycled by subsequent researchers (Jones 1977; McGrew 1987). In particular, wooden spears made and used by Aboriginal Tasmanians were considered a cornerstone of a 'simple' technocomplex and thus have played a leading role in proposals that Aboriginal Tasmanian population sizes were small and already declining at the point of European

contact, exculpating colonists from the impacts of displacement, introduced diseases, and genocide.

Several researchers are working to right these historical wrongs, addressing the scientific racism underpinning interpretations of human culture (e.g. Athreya & Rogers Ackermann 2019; Porr & Matthews 2019; Read 2006), while others are re-evaluating the idea that wooden spears are a 'simple' technology (e.g. Garofoli 2015; Haidle 2009). The ethnographic accounts of the use of wooden spears by recent populations demonstrate that wooden spears cannot be representative of cognitive abilities. The underlying complexity of this technology, including the earliest archaeological examples, becomes even clearer when considering design features such as point of balance, offsetting of the tip, selection and organisation of wood as a raw material, and the ethological knowledge likely required to effectively use these weapons (Conard et al. 2015; Schoch 2014; Schoch et al. 2015; Thieme 1997; Veil 1991). There are productive questions that do not rely upon the theoretical bridging of cognitive capacities (or 'behavioural modernity') with material culture (Shea 2011). For example, it is worthwhile to empirically evaluate the performance capabilities and adaptive advantages and disadvantages of different weapon systems, in turn allowing us to evaluate 'behavioural variability' through time and space (Shea 2011; Shea & Sisk 2010).

3. Archaeological Evidence of Wooden Spears

The archaeological sample of untipped wooden spears is small in comparison with almost every other category of Pleistocene human artefacts: from the entire Middle Pleistocene (MP) there are 11 well-accepted complete spears or spear fragments from the sites of Clacton-on-Sea ($n = 1$) and Schöningen ($n = 10$) (Schoch et al. 2015; Thieme 1997; Warren 1911). Although additional possible examples have been proposed from a number of Middle Pleistocene sites, none have preserved well enough to be certain of their anthropogenic origin and/or function (Schoch et al. 2015). From the early Late Pleistocene, the Neanderthal site of Lehringen (Germany) dating to MIS 5e, yielded one complete spear alongside the remains of a straight-tusked elephant and stone tools, and potentially a second spear at the site was destroyed during fertiliser extraction before the significance of the site was recognised (Adam 1951; Gaudzinski 2004; Thieme & Veil 1985). Further relevant hominin artefacts include wood remains that had been interpreted to potentially represent spear shafts or broken wooden spear tips but remain disputed, including examples from Kärlich-Seeufer, Cannstatt I, Bilzingsleben (Germany), and Torralba (Spain) (Biberson 1964; Bosinski 1995; Bosinski 2006; Freeman 1975; Gaudzinski et al. 1996; Mania & Mania 1998; Santonja 2013; Schoch et al. 2015; Wagner 1995).

There are also archaeological examples known from sites attributed to *H. sapiens*. Amongst the multitude of culturally modified wooden finds at the Late Pleistocene site of Monte Verde II (Chile), recently dated to ca. 14,500 cal BP, are two possible complete wooden spears consisting of refitting fragments and a distal fragment of a third possible spear (Dillehay 1997; Dillehay et al. 2015). The objects bear tool facets and evidence of polishing, have

symmetrically pointed distal tips, and possibly bear traces of charring, especially at the distal points, interpreted as fire-hardening. Another example of a wooden spear comes from Wylie Swamp, a terminal Pleistocene peat bog site in Southern Australia (Luebbers 1975). The site yielded 25 wooden artefacts dating to between $11,911 \pm 356$ to $10,071 \pm 167$ cal BP and included the earliest known boomerangs, two barbed spears that are also the oldest examples of their kind, digging sticks and a 'short simple spear' suggested to be made of she-oak (*Casuarina stricta*) (Dodson 1977; Flood 1999; Luebbers 1975; Luebbers 1978). The Late Stone Age site of Gwisho B in Zambia produced multiple types of wooden artefacts, most made of locally available hardwoods including Rhodesian Teak (*Baikiaea plurijuga*) (Fagan & van Noten 1971; Fagan, van Noten & Vynckier 1966). The wooden finds from Gwisho B include digging sticks, wooden arrowheads and a possible broken point of a wooden spear. Radiocarbon dates on three of the wooden finds from Gwisho B place the site somewhere between 3998 ± 70 and 5487 ± 98 cal BP. The drawing of the broken point (Fagan and van Noten 1971: Figure 11, n.7) measures around 140 mm in length and around 25 mm in diameter at its broken end but unfortunately further details of the find are not published and an assessment of the object on the basis of the illustration is difficult. However, the morphology is consistent with the distal points of wooden spears. There is an additional broken artefact (Fagan & van Noten 1971: Figure 11, n.5) which looks like it could be a spear shaft, with a maximum diameter of 23 mm and smooth, straight sides and bevelled breaks on both ends. However, if a spear shaft, it could have been for a composite spear, with a tip of stone or another material.

Pleistocene wooden spears have been hypothesized to have been utilised primarily as thrusting weapons and relatively ineffective if thrown by hand. As projectiles, it has been variously suggested that they would have been difficult to throw, to have been thrown at low velocities, to have had low impact energies, and if used as throwing weapons, to have been limited to effective throwing distances of 5–10 metres (Berger & Trinkaus 1995; Boëda, Geneste & Griggo 1999; Churchill 1993; Shea & Sisk 2010). These hypotheses, particularly in relation to distances and hunting strategies argued to relate to the use of spears, rest almost exclusively on a selection of ethnographic and ethnohistoric sources. Recent experiments using Pleistocene wooden spear replicas have evaluated:

- Their accuracy and velocities when thrown by skilled throwers (Milks, Parker & Pope 2019).
- The forces and energies when utilized as thrusting weapons, with the aim to better evaluate their effectiveness as hunting weapons (Coppe et al. 2019; Gaudzinski-Windheuser et al. 2018; Milks et al. 2016).
- Their ability to damage bones of small and medium sized mammals when used as both throwing and thrusting spears (Gaudzinski-Windheuser et al. 2018; Milks 2018a).

These experiments help test hypotheses about weapon performance, but an overview of ethnohistoric and eth-

nographic data on wooden spear use will add key data to debates including the suitability of this weapon for different hunting strategies, prey sizes and types, and use in various ecological settings.

Although ethnohistoric and ethnographic uses of spears have played roles in theories about archaic hominin and *H. sapiens* hunting technologies and strategies, including in comparative analysis (Churchill 1993; Gaudzinski-Windheuser et al. 2018; Oakley et al. 1977; Shea & Sisk 2010; White, Pettitt & Schreve 2016), no publication has yet provided a systematic overview of what is known from ethnohistoric and ethnographic records about this longest-serving weapon. Previous overviews of weapons that include ethnographic data on spear use have not focused specifically on wooden spears or were geographically limited (Churchill 1993; Davidson 1934a; Ellis 1997; Hitchcock & Bleed 1997; Palter 1977). In the case of Churchill's (1993) influential review, the dataset must have excluded a number of sources that are key to understanding the range of both estimated and recorded throwing distances, spear designs, delivery methods, environments and prey documented to have been hunted with wooden spears. Based on these selective ethnographic data, wooden spears have been characterised as primarily contact thrusting or short-range throwing spears, to have been limited to large prey, limited in potential hunting strategies, and only effective in particular environments (Berger & Trinkaus 1995; Gaudzinski-Windheuser et al. 2018; Lieberman et al. 2009). However, this characterisation, based on selective data, fails to account for the full range and diversity of uses, impeding our understanding of the technological, social, behavioural, and cultural diversity of the deep human past (French 2019). This paper seeks to rectify this by providing a systematic review of ethnographic and ethnohistoric accounts of functional wooden spears that were utilized in hunting and violence. It provides an accompanying open access database using DOI versioning that facilitates future additions and corrections to the dataset (Milks 2020), whilst maintaining the integrity of the original dataset upon which this paper is based.

4. Materials and Methods

4.1. Materials

The materials for the ethnographic literature review included text-based sources located through indexes and bibliographies in the existing literature, as well as electronic databases. Electronic databases searched included the Smithsonian National Museum of Natural History (Collections Search Center and SIRIS), Anthropological Index Online (The British Museum), Ethnographic Video Online (Alexander Street), British Library Images Online, eHRAF World Cultures, JSTOR and Proquest Social Science Database. Bibliographies of the sources pulled from these searches were also consulted for further identification of sources.

4.2. Methods

Electronic databases were searched for text-based, image and video content. Keyword searches included 'spear' OR 'spears' AND 'wood' OR 'wooden'. Results relat-

ing to composite weaponry, including hafted wooden points, and/or to weapons of other categories (e.g. spearthrower/darts or bow/arrows) were not included. Research focused on English-based texts, included results on any geographical location, and published in any period. Photographs were used in a small number of cases to identify the use of wooden spears, but drawings/paintings were not included as a source, as these are unreliable. A manual index search of all volumes of *The Handbook of North American Indians* was also undertaken. Bibliographies of publications citing ethnographic and ethnohistoric accounts of the use of wooden spears (e.g. Churchill 1993; Davidson 1934a; Davidson 1934b; Ellis 1997; Oakley et al. 1977; Waguespack et al. 2009) were screened for relevant ethnographic publications, and these publications were scanned for relevant data. Fishing with wooden spears was not recorded if sources did not also include examples of use of wooden spears for terrestrial hunting and/or interpersonal violence, because this was outside the scope of the original study, which focused on comparing ethnographic data and the archaeological record of Middle Pleistocene hunting. However, the database includes a column for fishing, and use of spears for fishing was recorded when encountered in the literature included in the review. Future versions of the database can thus also incorporate further data on use of wooden spears for fishing.

The search resulted in 60 individual publications and museum database records totalling 76 entries (with some sources containing data on multiple groups). Publication dates ($n = 52$) ranged from 1798 through 2002, with a median date of 1941. Text sources were read thematically for data on delivery method (thrusting and/or throwing by hand); use for hunting and/or violence; prey; wood selection; manufacturing techniques; decoration; morphometrics; throwing distances; and additional weapon technologies including the use of composite and complex projectiles.

A given group's location was estimated on the basis of available data for that group's location and distribution, and thus should be treated as an estimate. Climate classifications are based on these generalised locations and were determined using the Köppen-Geiger climate classification map and should also be treated as estimates. Further ecological data, giving context to use of wooden spears, are referenced appropriately in text. Species designations for prey listed in the literature have been inferred on the basis of the species and subspecies known to be present in a given group's location.

Cultural/group names are included where possible, but unfortunately ethnohistoric accounts may have left this information out, misattributed group names, and/or given names that may not be meaningful to those being reported on. For example, publications on Aboriginal Tasmanian groups often treat these as a single category, even though it is well understood that Tasmania was inhabited by multiple groups with different languages and cultures (Robinson 1966). If a group name was not provided and a geographical region was given instead, the group name in some instances was assigned 'NA'. Cultural

names have tended to reflect those in the original publications, though where known by the author, names reflecting indigenous preferences were used instead.

If the data in a given category were unclear or not made available in a publication, then 'NA' was entered (i.e. 'NA' represents missing data in that publication). In cases of recording of use of complex projectiles, composite weaponry, and other types of weapons, if these data were encountered they were recorded, but they were not explicitly searched for; therefore, an NA in these instances should not be considered to represent a lack of these data in a given publication. In the dataset provided with this publication, for clarity about the sources of different data, each publication consulted for a given group is displayed as a unique record, and therefore groups may have multiple entries. Similarly, publications that mention different cultural groups have multiple entries if the data were presented as such. Instances where children utilise wooden spears for toys or for learning tools and then 'graduate' to composite spears in adolescence, for example amongst BaYaka foragers and Chabu forager-farmers (Sheina Lew-Levy, pers. comm; Dira & Hewlett 2016), are not included in the dataset or analysis as this is not representative of true hunting in these societies. The significance of this is briefly discussed in Section 6.

This paper does not cover the manufacturing techniques of wooden spears, and nor is it an analysis of the morphometrics of ethnographic wooden spears. This paper deliberately avoids the use of descriptive statistics in the analysis of wooden spear use, though in some instances, patterns

are highlighted. This is because ethnohistoric records are frequently unclear, there may be further unidentified instances of wooden spear use, and there are differences in the quality and types of data recorded in the 19th and early 20th centuries in comparison with data recorded in later periods. The aim of this review is not to distil the use of wooden spears into a single description, but rather to elucidate the variety of functions, prey, and environments in which they were recorded to have been used.

A limitation of this study is that the search involved English language results only, and there are likely many additional studies in other languages with relevant information. In addition, there are sure to be English language omissions, and as with all ethnohistoric and ethnographic literature, there are potential problems regarding the accuracy of data recorded. Future versions of the open dataset will reflect additions and corrections to any errors (see **Data Availability** below).

5. Results

5.1. Distribution

The distribution of the recent use of wooden spears includes examples from North America, South America, Africa, and Oceania (**Figure 1**). The use of hunting with wooden spears is recorded for all of these, but the use of wooden spears for violence was not found for groups in Africa or South America. Locations include groups practicing a variety of subsistence strategies from mobile hunter-gatherers to subsistence farmers. The location markers for each record were compared with climate reconstructions



Figure 1: Global distribution of ethnographic accounts of the use of wooden spears listed in the accompanying database. Map produced using Zeemaps©. The online interactive map can be found in the figshare collection: <https://doi.org/10.6084/m9.figshare.c.5085284.v1>.

for the period 1901–1925, following the Köppen-Geiger climate classification map (Rubel & Kottek 2010). This time period was chosen as it was the earliest time span from which Wladimir Köppen produced a map based on observed data, and corresponds best to the earlier ethnographic accounts in the study. As regional temperatures and precipitation can change over time, this should be understood as an estimate. This comparison reveals that climates in which the spears were recorded to have been used includes all of the main climates (**Table 1**) including equatorial (A), arid (B), warm temperate (C), boreal (D) and polar (E), and also includes the full range of possible precipitations including desert (W), steppe (S), fully humid (f), summer dry (s), winter dry (w) and monsoonal (m). Temperatures ranged from hot (h) to polar tundra (T). Equatorial ($n = 21$) and arid climates ($n = 19$) were both well represented, followed by warm temperate climates ($n = 16$). The least commonly represented climates for use of wooden spears were boreal and polar climates.

Climates where wooden spears were documented to have been used in hunting primarily in equatorial and temperate climates, with a few examples in arid and polar climates, altogether encompassing forested, steppic, and savannah ecologies. The hunting grounds of the Mbuti are the Ituri Forest, an African tropical rainforest (Carpaneto & Germi 1989). The Admiralty Islands in the Pacific Ocean are characterised by lowland rainforests, while the Wichí (Mataco)

inhabited the dry tropical grassy plains of the Gran Chaco in South America (Alvarsson 1988). The Ticuna (also called Magüta, Tucuna, Tikuna, or Tukuna) live in the Amazonian rainforest (Nimuendajú 1952) while the Guayaki lands in present-day Paraguay are characterised by a mixture of subtropical forests and lowland grasslands (Clastres 1972). The Tlingit on the Pacific Northwest Coast (Canada, USA) inhabited temperate rainforests (Emmons & De Laguna 1991). Tasmanian Aboriginal populations also hunted in temperate rainforests, as well as in open woodland and grassland (Hiatt 1967; Hiatt 1968; Lloyd 1862; Roth 1890). The Tiwi inhabit Bathurst and Melville Islands off the north coast of Australia, which have a variety of different ecologies including open eucalyptus forest and woodlands, grasslands, and swamps, whilst the marine species including dugong were likely hunted in shallow, coastal marine habitats, including sea-grass beds. Both the Tiwi and Tasmanians actively managed grasslands including the use of fire to improve visibility of prey (Hiatt 1968) and to lure them to eat emerging shoots of grass after the fires (Hart & Pilling 1960). The Kaska inhabit subarctic boreal forests in northeastern British Columbia, southeastern Yukon and southwestern Northwest Territories (Honigmann 1954).

5.2. Prey

Prey documented in ethnohistoric and ethnographic sources as having been hunted with wooden spears include terrestrial and aquatic species (**Table 2**). The list of animals

Table 1: Climates (Köppen-Geiger classification) in which wooden spears are evidenced to have been used, and number of groups represented for each classification. See accompanying dataset for references: <https://doi.org/10.6084/m9.figshare.c.5085284.v1>.

Climate Classification Code	Climate description	Number of groups represented
Am	Equatorial monsoonal	3
Af	Equatorial rainforest	9
As	Equatorial with dry-summer characteristics	2
Aw	Equatorial with dry-winter characteristics	7*
BSh	Arid, steppe, hot	4*
BSk	Arid, steppe, cold	3*
BWh	Arid. desert, hot	11*
BWk	Arid. desert, cold	1
Cfa	Warm temperate, fully humid, hot summer	1
Cfb	Warm temperate, fully humid, warm summer	8*
Csa	Warm temperate, dry summer, hot summer	1
Csb	Warm temperate, dry summer, warm summer	6
Dfc	Boreal, fully humid, cool summer	2
Dsb	Boreal, dry summer, warm summer	1
ET	Polar, tundra	1

* Several entries in the database pertaining to Australia likely represented multiple groups, and therefore the count by source is an underestimate.

includes those in the following Orders: Crocodilia, Artiodactyla, Casuariiformes, Perissodactyla, Diprotodontia, Peramelemorphia, Sirenia, Carnivora, Rodentia, and Proboscidea. Prey indicated to have been hunted by thrusting the spears include deer, crocodile, wild pig, tapirs, peccaries, and jaguar (Alvarsson 1988; Blackwood 1935; Goodwin 1977; Hardman 1889; Nimuendajú 1952). In some of these cases, associated strategies include disadvantaging the animals and/or use of traps before spear thrusting. Prey indicated to have been hunted with thrown spears include kangaroo, wallaby, pigs, likely emu, and possibly bandicoot, tapirs, peccaries and jaguars (see **Table 2** for scientific species names; Alvarsson 1988; Goodale 1971; Hardman 1889; Hart & Pilling 1960; Hiatt 1968; Lloyd 1862; Morris 1964; Moseley 1877; Nimuendajú 1952). The Kaska, inhab-

iting north western Canada, reportedly hunted bear using wooden spears (Honigmann 1954), though it is unclear in the source consulted whether this was the American black bear (*Ursus americanus*), the North American brown bear (*Ursus arctos*), or both.

Following prey size classes defined by Bunn (1982), prey hunted with wooden spears span the entire range of size classes (**Figure 2**). Overall there are more species reportedly hunted with wooden spears that fall into smaller prey size classes (Size Classes 1 and 2), contradicting the characterisation of spears (including tipped and untipped) as being best suited to hunt larger prey (Churchill 1993). Animals in Size Class 1 (<23 kg) and Size Class 2 (23–113 kg) on the prey capture list include the pademelon, wallaby, wombat, beaver, white-tailed deer, emu, forester kangaroo, peccary,

Table 2: Prey hunted with wooden spears. See accompanying dataset for references: <https://doi.org/10.6084/m9.figshare.c.5085284.v1>.

Group	Location	Prey
Kimberly	Kimberly, Western Australia	crocodile (<i>Crocodylus</i> sp.) kangaroo (<i>Macropus</i> sp.) emu (<i>Dromaius novaehollandiae</i>)
Aboriginal Tasmanians (multiple sub-groups)	Tasmania, Australia	Forester kangaroo (<i>Macropus giganteus tasmaniensis</i>) wombat (<i>Vombatis ursinus tasmaniensis</i>) pademelon (<i>Thylogale billardieri</i>) bandicoot (<i>Isodon obesulus</i> , <i>Perameles gunnii</i>)
Tiwi	Melville and Bathurst Islands, Australia	wallaby (<i>Macropus agilis</i>) (also called 'kangaroo' in certain publications). 'sea dwellers' = possibly dugong (<i>Dugong dugon</i>) † possibly crocodile (<i>Crocodylus porosus</i>) † domestic pigs (<i>Sus scrofa</i>) ‡
Admiralty Islanders	Admiralty Islands, Papua New Guinea	wild pig (<i>Sus scrofa</i>)
Kaska	Northeastern British Columbia, southeastern Yukon, Canada	bear (<i>Ursus arctos</i> / <i>Ursus americanus</i>) beaver (<i>Castor canadensis</i>)
Cherokee	Southeastern USA	white-tailed deer (<i>Odocoileus virginianus</i>)
Guayaki, Ynarö group	Paraguay	white-lipped peccary, (<i>Tayassu pecari</i>) jaguar (<i>Panthera onca</i>) capybara (<i>Hydrochoerus hydrochaeris</i>)
Ticuna	Brazil, Peru, Columbia	white-lipped peccary, (<i>Tayassu pecari</i>) jaguar (<i>Panthera onca</i>)
Wichí (Mataco)	Bolivia, Argentina	tapir (<i>Tapirus terrestris</i>) Chacoan peccary (<i>Catagonus wagneri</i>) jaguar (<i>Panthera onca</i>)
Bubis (Edeeya) *	Bioko, Equatorial Guinea	Ogilby's Duiker (<i>Cephalophus ogilbyi</i>), Red River Hog (<i>Potamochoerus porcus</i>), forest buffalo (<i>Syncerus caffer nanus</i>) porcupine (<i>Atherurus africanus</i>), primates (species unclear)
Mbuti	Congo region	African elephant (<i>Loxodonta cyclotis</i>)

† Also known to be hunted with metal pronged spears by the Tiwi.

‡ Colonists who attempted unsuccessfully to inhabit the Tiwi islands introduced domesticated pigs, cattle, horse and water buffalo, with feral populations of these animals remaining to this day (Woinarski et al. 2003).

* It is unclear which species the Bubi hunted with their wooden spears, as they also hunted with slings (Colell, Maté and Fa 1994), and later with firearms, and sources consulted are conflicting; thus the Bubi prey list should be treated with caution. Body mass data are based on averages for given species (Boitani and Bartoli 1983; Damuth 1987; Garland 1983; Grubb et al. 2000; Grzimek 1972; Jenkins & Busher 1979; Le Mar & McArthur 2005; Marsh 1989; Mayer & Wetzel 1987; 1986; Mones & Ojasti 1986; Pasitschniak-Arts 1993; Poole 1982; Seymour 1989).



Figure 2: Selection of sizes of prey hunted with wooden spears in ethnohistoric and ethnographic literature in comparison with an average male *H. sapiens*. From left: African forest elephant (*Loxodonta cyclotis*), kangaroo (*Macropus giganteus*), white-tailed deer (*Odocoileus virginianus*), beaver (*Castor canadensis*). Image composed by the author using silhouettes from phylopic.org. *Loxodonta cyclotis* silhouette created by Richard Ruggiero, vectorised by Zimices, available with a Creative Commons Attribution-ShareAlike 3.0 Unported license: <https://creativecommons.org/licenses/by-sa/3.0/>.

jaguar, capybara, wild pig/boar, and depending upon which bear species were hunted by the Kaska, possibly also the American black bear (see **Table 2** for scientific species names). Size Class 3 animals (113–340 kg) include the tapir, which inhabits forests and rainforests in South America (Alvarsson 1988), and possibly the grizzly bear if hunted by the Kaska (Honigmann 1954). Size Class 4 animals (340–907 kg) include crocodiles hunted in the Kimberly region of Western Australia (Hardman 1889) and possibly dugong hunted by the Tiwi (Goodale 1971). The African forest elephant, reportedly hunted in the past by Mbuti using wooden spears, falls between Size Classes 5 (907–2,721 kg) and 6 (>2,721 kg) (Carpaneto & Germe 1989 and references therein; Turnbull 1965). There is a lack of clarity in sources consulted (see accompanying dataset) regarding which technologies the Bubi in Bioko used to target different prey, and so the prey they potentially exploited using spears (**Table 2**) should be treated with caution.

Prey represent an array of animals with different behaviours and social structures, including both herd and solitary animals. The prey represented have a variety of predator responses, including both fight and flight responses. Several of the prey targeted with wooden spears are fast-moving, including the forester kangaroo and emu which can reach speeds of 71 km/h and 50 km/h respectively (Grzimek 1972; Penny 2002).

5.3. Use in Violence

Most cases of the use of wooden spears for violence are confined to North and Central America, and Oceania, while no examples were found from South America or Africa (**Table 3**). Only in Australia and the Admiralty Islands does the use of wooden spears for violence overlap with their recorded use for hunting. Gifford (1931: 30) reports that amongst the Kamia, 'only two warriors, very brave and fleet of foot' used these spears, which also served as standards. The Māori from New Zealand used spears as thrusting weapons and occasionally hand-thrown weapons in conflict, which were reported as lethal (Tregear 1904). The Tiwi used their heavy hand-thrown wooden spears in collective violence against settlers, including plain and barbed wooden spear designs which were reportedly capable of penetrating through human torsos, vertebrae, arms, and

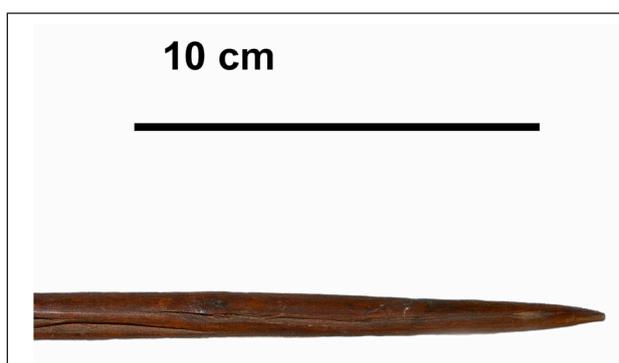


Figure 3: Photograph of one of the remaining Aboriginal Tasmanian spears. Spear held in the Tasmanian Museum and Art Gallery (M.2724). Photo: author's own, courtesy of the Tasmanian Museum and Art Gallery.

legs (Goodale 1971; Morris 1964). Spear throwing was used in the settlement of disputes amongst the Tiwi, typically in socially mediated retribution with intent to injure rather than kill, and it was considered just as skilful to dodge thrown spears as to throw them (Hart & Pilling 1960). While the Tiwi are generally reported as using spears as hand-thrown weapons, one account of collective violence against a settler tentatively suggests they may have used them as thrusting spears as well (Morris 1964). There are numerous accounts that Tasmanian spears (**Figure 3**) were used in violent encounters and their lethality to humans is demonstrated through reports of penetration through a settler's pelvis and torso as well as through a boot and into the foot (Roth 1890). These accounts support the ability of wooden spears of relatively light masses to lethally wound humans. The use of Tasmanian throwing spears in violence is also confirmed by the presence of a broken spear, removed from the body of a deceased settler during the so-called 'Black War', now held at the Tasmanian Museum and Art Gallery in Hobart (pers. obs.).

5.4. Delivery

This review is only concerned with hand-delivered spears, with two possible delivery methods: thrusting using one or both hands and throwing by hand like a javelin (**Table 4**). Delivery methods were unfortunately rarely recorded in relation to wooden spears, but a few key patterns emerge.

Table 3: Groups recorded to have used wooden spears for violence. See accompanying dataset for references: <https://doi.org/10.6084/m9.figshare.c.5085284.v1>.

Group	Location	Source
Tula	Southern USA	(Swanton 1946)
Chickasaw	Southeastern USA	(Swanton 1946)
Shoshone	Western USA	(Steward 1941)
Sinkyone of S Fork of Eel River	Northwestern USA	(Driver 1939)
Eastern Apache, Chiricahua	Southwestern USA	(Opler 1941)
Western Apache	Southwestern USA	(Buskirk 1986; Goodwin & Basso 1971)
Yuma	Southwestern USA	(Drucker 1937; Forde 1931)
Mohave	Southwestern USA	(Stewart 1947)
Yaqui	Southwestern USA, Northwest Mexico	(Drucker 1941)
Maricopa	Southwestern USA, Northwest Mexico	(Spier 1933)
Pima	Southwestern USA, Northwest Mexico	(Drucker 1941)
Yavapai (Northwestern)	Southwestern USA, Northwest Mexico	(Drucker 1941)
Multiple	Mainland Australia	(Davidson 1934a; Davidson 1934b; Hayden 1979)
Aboriginal Tasmanians	Tasmania, Australia	(Noetling 1911; Roth 1890)
Tiwi	Tiwi Islands, Australia	(Cameron 1998; Fredericksen 2002; Hart & Pilling 1960)
Marquesans	Marquesas Islands, French Polynesia	SIRIS database; see accompanying dataset
Marshall Islanders	Marshall Islands	(Erdland & Neuse 1914)
Chuuk (Truk)	Truk Islands, Micronesia	(Bollig 1927)
Māori	New Zealand	(Tregear 1904)
Admiralty Islanders	Admiralty Islands, Papua New Guinea	(Moseley 1877)
Massim	Trobriand Islands, Papua New Guinea	(Malinowski 1920)
Samoans	American Samoa, Polynesia	Smithsonian CSR database; see accompanying dataset
Malekula	Republic of Vanuatu (Formerly New Hebrides)	(Deacon & Wedgwood 1934)
Dugum Dani	Western New Guinea	(Heider 1970; Heider 1974)

For hunting megafauna and dangerous animals, thrusting was reported to be used (Alvarsson 1988; Hardman 1889; Nimuendajú 1952) sometimes in conjunction with trapping or netting. Spear thrusting is also recorded for smaller prey animals such as deer and wild pig (Goodwin 1977). In one instance, in relation to the Chuuk (Truk Islands, Micronesia) it was mentioned that thrusting spears had both ends sharpened, with both ends utilised (LeBar 1964). Throwing was recorded for hunting kangaroo, emu, wallaby, wild pig, and possibly bandicoot (Goodale 1971; Hardman 1889; Hart & Pilling 1960; Hiatt 1968; Lloyd 1862; Morris 1964; Moseley 1877), and in one case is associated with the use of poison (Nimuendajú 1952).

Both thrusting and throwing were utilised for within-group and group-group violence. The most frequently recorded cases of the use of thrown wooden spears for violence are of the Tiwi and Aboriginal Tasmanian peoples. Ethnographic data on distances of hand-thrown spears have been discussed in detail in a previous

publication (Milks, Parker & Pope 2019 SI), but these distances include both wooden and composite spears. It is worth noting in this review that distance estimates (both aimed and distance throws) for Aboriginal Tasmanians, whose spears weigh between 242 and 845 grams (Milks 2018a) range from 30 to 100 metres (Lloyd 1862; Robinson 1966; Roth 1890). Although the upper limit may be exaggerated, the throwing of relatively lightweight spears at considerable distances for hunting and violence is relayed in multiple sources. The Tiwi also threw plain as well as barbed wooden spears. An experiment conducted by Spencer (1914) recorded throwing distances with a spear weighing 1814 grams selected on the basis of its 'average' size. Nine Tiwi threw this spear to distances between 31.8 and 43.7 metres, not aiming at a target. The Tasmanian and Tiwi literature together demonstrate the capabilities of both lightweight and heavy wooden spears to be thrown for distance (contra Churchill 1993).

Table 4: Delivery methods recorded for wooden spears. See accompanying dataset for references: <https://doi.org/10.6084/m9.figshare.c.5085284.v1>.

Group	Location	Thrusting	Throwing
Ituri Mbuti	Democratic Republic of Congo	Likely	NA
Desert Diegueño	Mexico, USA: Ensenada, Mexico; Escondido, California	Yes	No
Maricopa	Mexico, USA: Northwest Mexico; Southwest USA (Gila River Indian Reservation, Pinal County, AZ, United States)	Yes	NA
Eastern Apache, Chiricahua	USA: Arizona	Yes	No
Western Apache	USA: Arizona	Yes	No
Tula	USA: Arkansas	Maybe	Maybe
Obispeño and Purisimeño Chumash	USA: California (Morro Bay to Malibu)	NA	Yes
Shoshone	USA: Nevada, Utah, Idaho	Yes	NA
Sinkyone of S Fork of Eel River	USA: Northwest California	Yes	Maybe
Mattole	USA: Northwest California (Cape Mendocino)	Yes	Maybe
Chickasaw	USA: Southeast	Maybe	Yes
Cherokee	USA: Southeast	Yes	NA
Yuma	USA: Southern California (Fort Yuma Reservation)	Yes	No
multiple	Australia: mainland	Yes	Yes
Aboriginal Tasmanians	Australia: Tasmania	Unlikely	Yes
Tiwi	Australia: Tiwi Islands	Maybe	Yes
Marshall Islanders	Marshall Islands	Yes	Yes
Chuuk (Truk)	Micronesia: Truk Islands	Yes	Yes
Māori	New Zealand	Yes	Yes
Admiralty Islanders	Papua New Guinea: Admiralty Islands	No	Yes
Tinputz	Solomon Islands	Yes	NA
Dugum Dani	Western New Guinea	Yes	Yes
Mataco	Gran Chaco region, Bolivia, Argentina	Yes	Yes
Ticuna	Brazil; Columbia; Peru	Yes	Yes

In many cases the same spears were reported to have been used in both delivery methods, making them multifunctional weapons (Clastres 1972; Horne and Aiston 1924; Krieger 1926; Tregear 1904). There are also groups that used different designs for different delivery methods. For example, the Ticuna in South America poisoned the tips of their hand-thrown wooden spears and had different designs for thrusting (called a *dë*) than for throwing (called a *va:ma'gu*) (Nimuendajú 1952). Regardless of delivery method, wooden spears were almost always used alongside other types of weapons including composite spears tipped with stone, bone, horn, metal, stone, glass, shark teeth or stingray spines (e.g. Blackwood 1935; Bollig 1927; Davidson 1934a; Driver 1939; Goodwin & Basso 1971; Gould 1970; Hardman 1889; Hayden 1979; Moseley 1877; Nimuendajú 1952; Opler 1941; Smith 1893; Tregear 1904) and in some of these cases it is stated that wooden spears were the primary weapon in the near past, only replaced by composite weapons more recently. Bow/arrows, spearthrowers, clubs and throwing sticks are also reported to have been used alongside untipped

wooden spears (e.g. Buskirk 1986; Drucker 1937; Goodale 1971; Hayden 1979; Spier 1933).

5.5. Hunting Strategies

In only 10 publications were specific data on hunting strategies associated with wooden spears clearly described. The strategies included multiple predation, in other words the capture of multiple animals within a single hunting event (Gentry Steele & Baker 1993; Kingsley, Günther & Kirby 1897) and the hunting of single animals (Turnbull 1965). Hunters hunting alone is described (Lloyd 1862), as is communal hunting, sometimes involving the entire community (Goodwin 1977; Hiatt 1968; Kingsley, Günther & Kirby 1897; Lloyd 1862; Thomson 1850).

Following Churchill's (1993) categories of hunting strategies, wooden spears were found to be associated with disadvantage hunting (Alvarsson 1988; Blackwood 1935; Goodwin 1977; Hiatt 1968; Kingsley Günther, & Kirby 1897), ambush hunting (Hiatt 1968), approach hunting (Lloyd 1862; Goodale 1971), and pursuit hunting (Turnbull 1965; Hiatt 1968). The only strategy not found mentioned

explicitly in the literature was encounter hunting. Wooden spears are reported to be utilised in conjunction with other technologies including fire, traps, poison, hunting blinds, and the use of grass to trip animals (Alvarsson 1988; Blackwood 1935; Goodale 1971; Goodwin 1977; Hart & Pilling 1960; Hiatt 1968; Lloyd 1862; Nimuendajú 1952; Robinson 1966). In a few instances, publications mention that multiple spears would be carried at once (Bass, Collins & King 1798; Moseley 1877). The Tasmanians also stuck wooden spears into the ground on known kangaroo paths, as they would then spear themselves whilst jumping (Hiatt 1968), a strategy also reported elsewhere for the use of composite spears (Hitchcock & Bleed 1997). Although clear accounts of hunting strategies are rare, the evidence is that hand-delivered wooden spears were utilised with nearly all known strategies and associated technologies.

6. Contextualising Pleistocene Hunting Technologies

Going forward, the use of ethnographic analogy for Pleistocene hunting behaviours and technologies needs to be considered carefully, not only because of potential physiological and behavioural differences, but also because of the colonialist history of the use of ethnographic data in human evolutionary studies. One solution, proposed by scholars working to decolonise human origins, is to desist from representing early humans as primitive. By reframing in this way, the use of ethnographic analogy to more accurately represent necessary skills and abilities in use of technologies becomes less problematic (Athreya & Rogers Ackermann 2019). It is also important to avoid ‘cherry-picking’ ethnographic examples to support a given model (French 2019). This final section aims to explore the data in this review to provide a fuller means of contextualising Pleistocene hunting, whilst recognising that certain aspects of behavioural and physiological differences and similarities between *H. sapiens* and other species of *Homo* remain under debate.

6.1. Climate and Ecology

The Eurasian Pleistocene hominins who manufactured and utilised the early examples of wooden spears occupied a wide range of ecologies, climates, and terrains, including densely forested regions in full interglacials, coastal regions in both glacial and interglacial periods, and open steppe and tundra (e.g. Benito et al. 2016; Churchill 2014; Hosfield 2016; Roebroeks & Soressi 2016; Stewart et al. 2019). Archaeological wooden spears and evidence of their use have been found in a diversity of environments including from warm, closed-canopy forested environments (Gaudzinski-Windheuser et al. 2018), and cool steppic, open woodland (Urban & Bigga 2015). While on the one hand, non-analogue ecologies may limit our ability to make direct comparisons between the suitability of wooden spears during the Pleistocene in relation to those made and used by recent *H. sapiens* societies, the data in this paper demonstrate a diversity of climates, ecologies, and terrains in which wooden spears were utilised. The representation of the use of this weapon in these varied environments indirectly supports

hypotheses that wooden spear use could have played a role in very early hunting and/or ‘power scavenging’ by Early and Middle Pleistocene *Homo*, including in Africa (e.g. Bunn & Gurtov 2014; Bunn & Pickering 2010). However, it does appear likely that the type of environment would impact upon delivery method, as throwing distances may be more limited in closed forested environments than in open woodland or grasslands (Dira & Hewlett 2016; Kortlandt 2002).

6.2. Prey

Examples of taxa exploited by hominins in the Eurasian Middle Pleistocene include equids (*Equus mosbachensis*, *Equus ferus* sp.) cervids (*Cervus elaphus*, *Praemegaceros* sp., *Axis* sp., *Dama clactoniana*, *Rangifer tarandus*, *Megaloceros* sp.), suids (*Sus scrofa*), bovids (*Bison priscus*, *Bos primigenius*, *Ovis ammon antiqua*, *Bison schoetensacki*), hippopotamus (*Hippopotamus amphibius*), rhinoceros (*Stephanorhinus kirchbergensis*, *Stephanorhinus hemitoechus*), bear (*Ursus deningeri*) and proboscideans (*Elephas [Palaeoloxodon] antiquus*, *Mammuthus* sp.) (Barsky & de Lumley 2010; Gaudzinski et al. 2005; Orain et al. 2013; Parfitt & Roberts 1999; Rodríguez-Hidalgo et al. 2015; Scott 1986; Tuffreau et al. 1995; Van Kolfschoten, Buhrs, & Verheijen 2015). In addition to exploitation of large mammals there is also evidence of Middle and Late Pleistocene pre-*sapiens* hominin modification of smaller prey such as rabbit, crow and tortoise, and larger marine mammals including dolphin and seals (Blasco & Peris 2012; Finlayson et al. 2012; Hardy et al. 2013; Stringer et al. 2008). The wide range of prey types and sizes in this ethnographic review, including both terrestrial and marine resources, demonstrates that hand-delivered wooden spears are not limited to either small or large game procurement, and are capable of killing a variety of animals of different size classes and with differing behaviours and ecologies. ‘Throwing sticks’ from Schönningen (Thieme 1997; Schoch et al. 2015; Conard et al. 2020), which could have been used in hunting of smaller terrestrial, aquatic and avian fauna, further extends the potential hunting technologies utilised by Middle Pleistocene *Homo*.

6.3. Delivery

Recent experimental research on Pleistocene wooden spear use highlights that in skilled hands, these replica weapons are functional as both thrusting and throwing spears (Rieder 2001; Milks et al. 2016; Gaudzinski-Windheuser et al. 2018; Milks, Parker & Pope 2019). The debate about the origins of throwing in human evolution has been protracted, but Longman and colleagues (2020) highlight how the inclusion of reference studies of modern athletes have served to produce a new synthesis which supports throwing activities amongst Pleistocene hominins. The use of athletes in studies is an alternative way of crediting the people of the deep past with technological skill and experience; similarly, by excluding assessments of technologies on the basis of sedentary and unskilled members of WEIRD (Western Educated Industrialised Rich Democratic; Henrich, Heine & Norenzayan 2010) societies and basing interpretations upon data from a fuller picture

of use by recent spear-using populations, a clearer assessment of spear use emerges. Based upon design, Pleistocene wooden spears could have served as thrusting weapons, as hand-thrown weapons, and/or as multifunctional implements (Milks et al. 2016; Gaudzinski-Windheuser et al. 2018; Milks, Parker & Pope 2019). They would also have been important tools for self-defence against dangerous animals in Pleistocene landscapes (Serangeli et al. 2015), and perhaps even as expedient digging tools (Schoch et al. 2015). The weapon can be characterised by versatility in design in terms of length, diameter, mass, morphology and balance point, adaptable to the environment, the hunter, and the hunted (Milks 2018a).

6.4. Hunting Strategies

A variety of hunting strategies are known to be practiced by human hunters, with a complex interaction between environment, climate, prey size and behaviours, weaponry and number of humans hunting. Social hunting, also called communal or cooperative hunting, indicates a social structure that looks similar to those of recent hunter-gatherers. Social hunting by hominins is often inferred by archaeological evidence of humanly-modified faunal remains of prime-age large mammals, particularly with limited carnivore damage, and/or human modifications underlying such damage, suggesting primary access to prey (e.g. Smith 2013; Starkovich & Conard 2015). It is argued that prime-age animals, particularly herding ungulates with a flight response and/or extremely large animals, are most likely to have been killed by social hunting strategies, whether by humans or other animals (Churchill 1993). Advantages of social hunting include an increased harvest from kills, either by improving success rates, by enabling the hunting of larger prey and/or facilitating the taking of multiple animals (Gentry Steele & Baker 1993) with ethnographic data showing a correlation between hunting large game and group cooperation (Roebroeks 2006). Social hunting is adaptive because it spreads risk (Hawkes, O'Connell & Jones 1991) and increases meat intake, which facilitates sharing large meat packages, increasing fitness for the entire group (Boesch & Boesch 1989). Social hunting can be small-scale with two to five members of the hunting group, or large-scale, with five or more hunters (Gentry Steele and Baker 1993), though the degree of planning depth necessary for either is arguable given that many species without language practice social hunting. Humans hunt alone as well, and particularly for smaller and solitary prey hunting in singly or in small groups this can also be a highly effective strategy, though this is rarely discussed in the literature on archaic human hunting strategies. Human hunters take single kills as well as multiple kills, called 'multiple predation', which is strongly associated with social hunting (Gentry Steele & Baker 1993). Multiple predation, or the taking of two or more animals in a single hunting episode, includes mass kills from a single hunt and kills taken one after another within the context of a single hunting foray. Similar to the taking of large adult prey, multiple predation is a strategy that increases fitness for the group.

The dominant model of Early and Middle Pleistocene hunting proposes that hominins armed with hand-delivered spears were limited to close-range group hunting, often proposing a dependence on disadvantage strategies reliant upon landscape features, using spears that were too heavy and/or difficult to throw, at least from distances over 5–10 metres (e.g. Boesch & Boesch 1989; Churchill 1993; Gaudzinski-Windheuser et al. 2018; Lieberman et al. 2009; Rodríguez-Hidalgo et al. 2017; Shea & Sisk 2010; White, Pettitt & Schreve 2016). This is contrasted with *H. sapiens*, who with the innovation of complex projectile technologies have been argued to have possessed niche broadening technologies facilitating longer distance hunting of a greater range of prey using a variety of hunting strategies in a wider range of environments (e.g. Shea & Sisk 2010). Key to this model are the aforementioned purported limitations of hunting technologies available to Pleistocene hominins on the basis of ethnographic data (Bunn & Gurtov 2014; Churchill 1993; Lieberman et al. 2007). White and colleagues (2016) propose the use of ambush and disadvantage group hunting by Late Pleistocene Neanderthals, involving the use of landscape features. Evidence for socially organised power scavenging and/or hunting during the Middle Pleistocene has been argued for Eurasian sites including Qesem Cave, Israel (Stiner, Barkai & Gopher 2009), Schöningen, Germany (e.g. Starkovich & Conard 2015), and Boxgrove, UK (e.g. Parfitt & Roberts 1999; Smith 2013). While patterns of Middle and early Late Pleistocene prey exploitation do largely appear to follow this model, this review demonstrates that almost the full range of hunting strategies were employed with wooden spears, and thus hunting technologies available to these hominins were likely less limiting than previously proposed. Observed patterns in hunting strategies are not likely attributable, at least not entirely so, to limitations of hand-delivered spears. While Neanderthals, like *H. sapiens*, likely did utilise thrusting spears to hunt prey (Gaudzinski-Windheuser et al. 2018) this review further demonstrates that thrusting and throwing spears can be utilised side-by-side and evidence of one function does not rule out use of another (see also Milks 2018b). Experiments show that Pleistocene spears are similar to the mass of modern-day javelins, perform well in flight at medium distances when thrown by a skilled thrower, and impact with significant kinetic energy in comparison to complex projectiles (Milks, Parker & Pope 2019; Rieder 2001). The ethnographic data in this review demonstrate the potential for significant throwing distances for both lightweight and heavier wooden spears in the Pleistocene, beyond that which has been shown experimentally thus far. Experiments comparing the wounding capabilities of wooden weapons in comparison with stone-tipped weapons further demonstrate that the depth of penetration into ballistic gelatine is not significantly different, although the latter may produce larger wound cavities (Salem & Churchill 2016; Waguespack et al. 2009; Wilkins, Schoville & Brown 2014). However, it is unclear from the above experiments whether differences relate to material property differences, weapon tip shape, cutting edges, or kinetic energy.

7. Conclusion

The Middle Pleistocene hominins that manufactured and used the earliest examples of wooden spears in Europe had different physiologies, and likely different behaviours, to those of recent spear users reviewed in this ethnographic survey. This paper demonstrates that Pleistocene *Homo* was armed with spears that, on the basis of ethnographic evidence, were less limiting than previously assumed. This review has sought to provide a deeper and richer dataset on these weapons, in particular to guard against 'cherry picking' ethnographic examples to support a given hypothesis.

Previous studies that have based an assessment of the performance of Pleistocene spears on experimental use by unskilled participants effectively deskills people of the deep past, recent past, and present who utilized and/or continue to utilize hunting spears. The ethnographic record suggests that hunting and weaponry skills are deeply embedded in experience honed over a lifetime, beginning in childhood with games, observation, practice, and experience (Dira & Hewlett 2016; Lew-Levy et al. 2017; MacDonald 2007). In both BaYaka (Republic of Congo) and Chabu (Ethiopia) societies, who use metal-tipped spears for hunting, wooden spears are used by the youngest children to learn to throw, and even to 'spear' small prey including butterflies and rats (Sheina Lew-Levy, pers. comm.; Dira & Hewlett 2016). Therefore, we cannot adequately replicate a technology on the basis of a few years of experience trying to utilise replicated technologies; researchers must acknowledge the limitations of evaluating prehistoric technologies on the basis of our own hands-on experience. Although we should treat ethnographic data as limited in its ability to build reliable analogies it is also imperative to not discount ethnographic data on the basis that it is not corroborated by the experience of present-day archaeological and anthropological researchers living in WEIRD societies. By approaching ethnohistoric and ethnographic accounts broadly, taking into account variability, we can limit the tendency to flatten the past. Overall, the ethnographic record demonstrates a richness and variability of culture that is invisible in the archaeological record. With ethnographic reviews, a broader picture of potential variability of material culture and behaviour expands, and when used sensitively these data help us to better understand technologies and their social contexts. The ethnographic record can provide a relevant and powerful third perspective on the archaeological record of human evolution when used sensitively and when approached holistically. Alongside experimental programmes determining the properties of technologies, ethnographic enquiries continue to act as a check on our frameworks of interpretation and, increasingly, challenge the assumptions and biases we each bring to technologies used in the human deep past.

Data Accessibility Statement

All data supporting this review are available as a .csv file in a collection on figshare. The csv file titled Ethnography Wooden Spears V.1 was that which formed the basis for this publication. The dataset has been shared as part of

a collection, enabling future additions and corrections to be shared in the collection as a new version, while maintaining the original dataset. The dataset can be accessed at and cited as: Milks, A. 2020. Ethnography of Wooden Spears. figshare. Collection. <https://doi.org/10.6084/m9.figshare.c.5085284.v1>.

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