5-9-2023

Prehistoric Hunter-Gatherers in the Philippines—Subsistence Strategies, Adaptation, and Behaviour in Maritime Environments

Alfred Pawlik
Ateneo de Manila University, apawlik@ateneo.edu

Riczar Fuentes
Ateneo de Manila University, rfuentes@ateneo.edu

Recommended Citation

Pawlik, A., & Fuentes, R. (2023). Prehistoric Hunter-gatherers in the Philippines—Subsistence strategies, adaptation, and behaviour in maritime environments. Frontiers in Earth Science, 11, 1-11. https://doi.org/10.3389/feart.2023.1110147 frontiers | Frontiers in Earth Science

TYPE Review
PUBLISHED 09 May 2023
DOI 10.3389/feart.2023.1110147

OPEN ACCESS

EDITED BY
Hao Li,
Institute of Tibetan Plateau Research (CAS), China

REVIEWED BY
Alexandra Van Der Geer,
Naturalis Biodiversity Center, Netherlands
Dimitris Sakellariou Hellenic,
Centre for Marine Research (HCMR), Greece

*CORRESPONDENCE
Alfred F. Pawlik,
apawlik@ateneo.edu
Riczar B. Fuentes,
rfuentes@ateneo.edu

RECEIVED 28 November 2022
ACCEPTED 17 April 2023
PUBLISHED 09 May 2023

CITATION
Pawlik AF and Fuentes RB (2023), Prehistoric Hunter-Gatherers in the Philippines—Subsistence strategies, adaptation, and behaviour in maritime environments.
Front. Earth Sci. 11:1110147.
doi: 10.3389/feart.2023.1110147

Prehistoric Hunter-Gatherers in the Philippines—Subsistence strategies, adaptation, and behaviour in maritime environments

Alfred F. Pawlik[1,2,3,4]* and Riczar B. Fuentes[1,2,5,6]*

[1]Department of Sociology and Anthropology, Ateneo de Manila University, Ricardo and Dr. Rosita Leong Hall, Loyola Heights, Quezon City, Philippines, [2]TRACES ASIA, Areté, Ateneo de Manila University, Loyola Heights, Quezon City, Philippines, [3]Department of Early Prehistory and Quaternary Ecology, Eberhard Karls Universität Tübingen, Schloss Hohentübingen, Tübingen, Germany, [4]National Museum of the Philippines, Manila, Philippines, [5]Department of Palaeoanthropology, Senckenberg Research Institute and Natural History Museum, Frankfurt am Main, Germany, [6]Research Centre "The Role of Culture in Early Expansions of Humans" (ROCEEH), Heidelberg Academy of Sciences and Humanities, Hölderlinstrasse, Tübingen, Germany

Archaeological research in the Philippines has produced a timeline of currently over 700,000 years of human occupation. However, while an initial presence of early hominins has been securely established through several radiometric dates between 700 ka to 1 ma from Luzon Island, there is currently little evidence for the presence of hominins after those episodes until c. 67 to 50 ka for Luzon or any of the other Philippine islands. At approximately 40 ka, anatomically modern humans had arrived in the Philippines. Early sites with fossil and/or artifactual evidence are Tabon Cave in Palawan and Bubog 1 in Occidental Mindoro, the latter situated in the Wallacean part of the archipelago. This paper presents an overview of the archaeological research on the prehistory of the Philippines from the Pleistocene until the Late Holocene and the arrival of the first farmers, presumably from Austronesian language groups approximately 4,000 years ago. Research on this topic has significantly intensified over the past 20 years and is providing a variety of evidence for the successful adaptation of those first islanders to maritime environments, the diversity of technological and subsistence strategies, and increasingly complex interrelationships across Island Southeast Asia.

KEYWORDS

hunter-gatherers and Fishers, maritime interaction, behavioural adaptation, pleistocene, holocene, Island Southeast Asia, Philippines

Introduction

The recent discovery and excavation of the *in-situ* fossil remains of a rhinoceros at the Rizal site in Kalinga, northern Luzon (Figure 1: 3), could confirm the presence of hominins in the Philippines during the early Middle Pleistocene and around 700 ka through a series of radiometric dates (Ingicco et al., 2018; 2020; Antoine et al., 2022). Archaeologists have long suspected a connection between stone tools found in northern Luzon and other parts of the Philippines that were possibly used by early hominins and fossils of an extinct Pleistocene megafauna from the same locations (Beyer, 1947; Koenigswald, 1958; Fox and Peralta, 1974; Fox, 1978; Shutler and Mathisen, 1979;

Ronquillo, 1981; Pawlik, 2001; Pawlik and Ronquillo, 2003; Dizon and Pawlik, 2010; Ingicco et al., 2018). However, a reliable stratigraphic correlation of fossil remains and lithic artifacts and/or reliable radiometric dating had been lacking until then. In the case of the Kalinga rhinoceros, cut marks on several bones, as well as broken bones, clearly show that the rhinoceros was slaughtered and that its nutritious bone marrow was extracted (Ingicco et al., 2018; 2020). Furthermore, several stone tools were found associated with the fossil.

For the remaining Middle Pleistocene and until the beginning of MIS 4, no securely dated evidence for human occupation has been currently reported. A metatarsal and a femur fragment together with several teeth were retrieved from Callao Cave near the Kalinga site (Figure 1: 11; Détroit et al., 2019). Initially identified as modern humans (Mijares et al., 2010), the fossils are now recognized as the remains of a diminutive pre-modern species, dubbed "*Homo luzonensis*". Several U-series dates on a human tooth and associated faunal remains produced ages of approximately 50 ka BP, while a single date obtained from a human metatarsal fragment showed a U-series age of 66.7 ka BP (Grün et al., 2014; Détroit et al., 2019). Questions about the reliability of early U-series dates, which also tend to be older than AMS 14C dates from the same area, have been raised for several sites in the region, including Callao and Tabon, while the ambiguity in the taxonomic identification of the Callao metatarsal added further uncertainty (Choa, 2018; O'Connell et al., 2018; Ono et al., 2023). Also, no artifacts were found associated with the fossil remains.

While the arrival of anatomically modern humans (AMH) in the sundaic part of the Philippines has been securely established at Tabon Cave in Palawan (Figure 1: 12) by several AMS dates to c. 39 ka to 33 ka (Choa et al., 2016; Choa, 2018), and less securely through U-series to as early as 47 ka (Détroit et al., 2004; O'Connell et al., 2018), evidence of the open sea crossing into the Wallacean islands of the Philippines has been found in the southwestern part of Mindoro. Mindoro, like most Philippine islands, lies east of Huxley's Line (Figure 1), the modification of the biogeographical boundary known as Wallace's Line, which separates the palaeobiogeographical region of Sundaland from the oceanic part of the Southeast Asian archipelago or "Wallacea" (Huxley, 1868). Its proximity to Palawan at the northeastern end of Sundaland suggests that it may have served as an entry point into the Wallacean part of the Philippines. Excavations of three sites, Bubog 1 and 2 on Ilin Island, San Jose, Occidental Mindoro, and Bilat Cave in nearby Sta. Teresa, Magsaysay, on the Mindoro mainland (Figure 1: 14), revealed, that Mindoro has been occupied by early modern humans during the Late Pleistocene and Holocene (Pawlik et al., 2014; Reyes et al., 2017; Pawlik and Piper, 2019; Pawlik, 2021). Bubog and Bilat are located less than 100 km from the enlarged Palawan landmass that was exposed due to the Pleistocene sea-level regressions, and it seems likely that migration of these early seafarers into the country's oceanic archipelago occurred via Palawan (Pawlik et al., 2014).

Chronology

The timeline of human occupation in the Philippines currently begins during the early stage of the Chibanian age (previously the unofficial *Middle Pleistocene*; Hornyak 2020) and MIS 17 (Figure 2). At the Kalinga site in Northern Luzon, a direct ESR/U-serial date of 709 ka ± 68 ka BP was obtained from the enamel of an almost complete though disarticulated skeleton of a rhinoceros, while the deposits beneath and above the skeleton were dated between 1.0 and 0.7 ma BP by OSL and Ar/Ar (Ingicco et al., 2018; 2020).

In Palawan, several caves have provided a combined chronological sequence from the Late Pleistocene onwards until the Holocene. The current oldest fossil remains of several individuals of an anatomically modern human (AMH) were found together with lithic assemblages in Tabon Cave in Palawan (Fox, 1970). A re-investigation of Tabon Cave in 2,000 revealed a human tibia and a right mandible fragment that were U-series dated 47 ka + 11/-10 ka BP and 31 ka + 8/-7 ka BP, respectively (Détroit et al., 2004), while the famous skull cap of "Tabon Man" was directly dated 16.5 ka ± 2 ka BP by U-series (Dizon and Pawlik, 2010). While the very high standard errors of the U-Series dates raise some concerns about their reliability, more recent AMS radiocarbon dates of hearth features suggest the beginning of the human occupation of Tabon Caves close to 40 ka cal. BP (Choa et al., 2016; Choa, 2018; Pawlik, 2021; Xhauflair et al., 2023).

From Pilanduk cave near Tabon (Figure 1: 12), AMS dates between 24 ka and 20 ka cal. BP have been reported, confirming human presence in Palawan during the peak of the Last Glacial Maximum (LGM). The reported associated fauna, particularly the remains of a tiger, indicate a connection to the extended landmass of the Sunda region (Ochoa et al., 2022). The only site in the Wallacean part of the Philippines that produced AMS dates for the LGM is Bilat Cave in southern Occidental Mindoro with 22 ka to 21 ka cal. BP (Ono, Pawlik, and Fuentes, 2020; Pawlik, 2021).

Several sites on both sides of Huxley's Line have provided archaeological data that relate to the important transition from the Pleistocene to the Early Holocene and then throughout the Holocene. In Palawan, the earliest layers of Ille Cave in the north of the island (Figure 1: 13) are dated c. 14 ka to 12 ka, while its early Holocene layers have produced early human cremations dated c. 8 ka (Morwood et al., 2008; Lara et al., 2013). Three sites located in the southern part of Mindoro have produced a series of AMS radiocarbon dates with a combined record from fairly recent times to as early as c. 35 ka cal. BP. In Bubog 1 on Ilin Island just off the coast of San Jose, Occidental Mindoro, a dense stratified shell midden was dated from c. 4,000 cal. BP at the upper layers to 28 ka to 33 ka for the lowest layer of the shell midden. Underneath the shell midden, c. 2 m of silty terrestrial deposits containing lithic artifacts and the remains of pelagic fishes have been exposed although no absolute dates have been produced so far (Pawlik and Piper, 2019; Boulanger et al., 2019; Pawlik, 2021). The site was considerably disturbed by treasure hunters, and it is possible that its occupation went on until well after 4,000 BP. This is suggested by the stratified record from the neighboring site of Bubog 2 in c. 400 m distance that currently includes the Pleistocene/Holocene boundary and c. 11 ka to 12 ka BP to the Late Holocene and until the 16th century AD for several hearth features close to the surface (Pawlik et al., 2014; Pawlik and Piper, 2019). No radiocarbon dates have yet been obtained for the period between 12 ka and 27 ka BP in Bubog 1 and the time before and after the Last Glacial Maximum. The reason for this hiatus is currently undetermined although it is

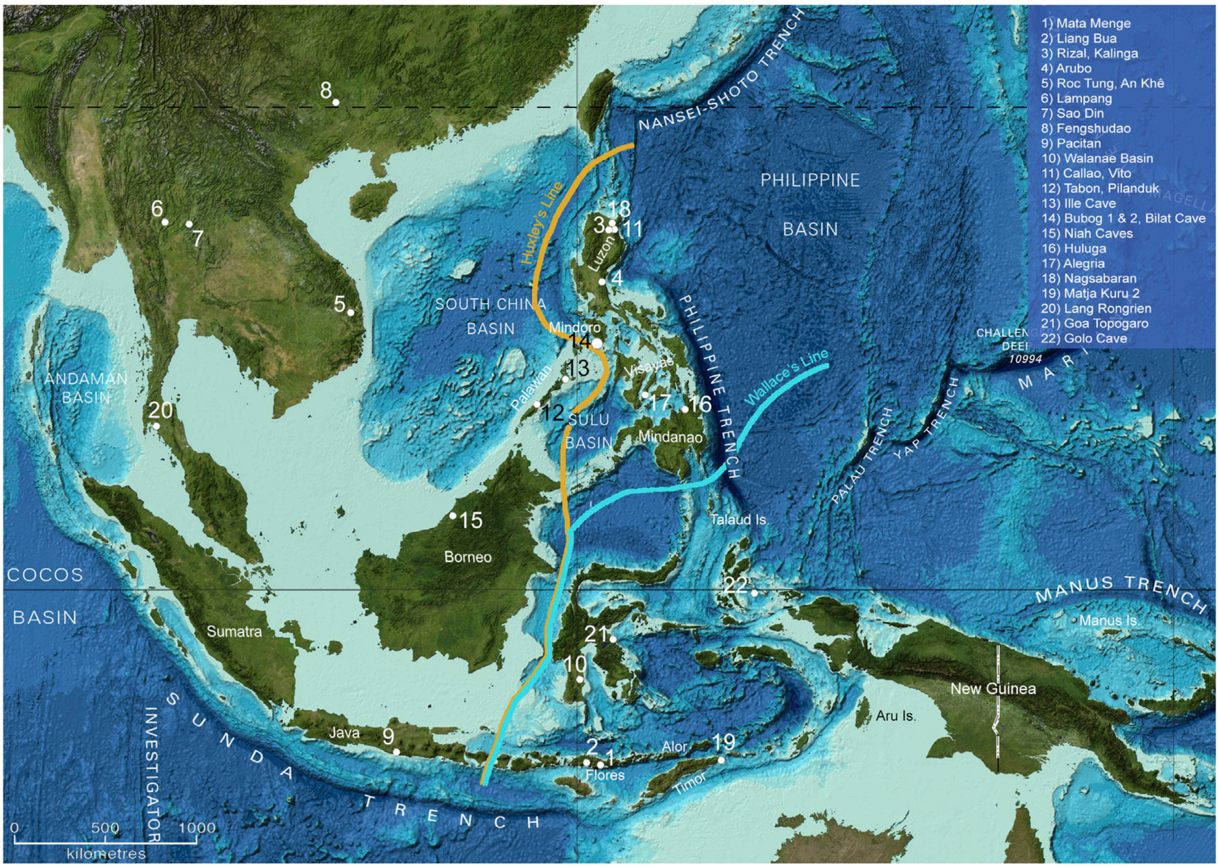

FIGURE 1
Map of Southeast Asia with locations mentioned in the text. 1) Mata Menge, 2) Liang Bua, 3) Rizal, Kalinga, 4) Arubo, 5) Roc Tung, 6) Lampang, 7) Sao Din, 8) Fengshudao, 9) Pacitan, 10) Walanae Basin, 11) Callao, 12) Tabon, Pilanduk, 13) Ille Cave, 14) Bubog 1 and 2, Bilat Cave, 15) Niah Caves, 16) Huluga, Cagayan de Oro, 17) Alegria, 18) Nagsabaran, 19) Matja Kuru, 20) Lang Rongrien, 21) Goa Topogaro, and 22) Golo Cave. The areas shown in light green indicate the exposed land areas of the Sunda shelf and Sahul during the Last Glacial Maximum at a sea level of approximately –130 m. Image reproduced from the GEBCO world map 2014, www.gebco.net.

possible that the Bubog sites were too high uphill around that time. At present, these are located just 35 m–42 m above sea level and can be reached by a 10-min walk from the shore. However, during periods of extremely low sea levels in the Pleistocene, the sites were approximately 150 m–170 m above sea level. Numerous other caves and rock shelters were probably exposed in the karstic formation of Ilin Island situated at lower elevations and much closer to the Pleistocene shore that was more attractive as campsites. Indications of human presence in the area during that time come from nearby Bilat Cave located on the mainland of Mindoro approximately c. 8 km from Bubog. Bilat is situated directly on the coast at 2 m–3 m above sea level and with two of its three entrances open onto the Ilin Channel. Here, AMS radiocarbon dates of 13 ka to 14 ka and 21 ka to 22 ka provided evidence for human occupation during and after the LGM (Pawlik and Piper, 2019; Pawlik, 2021).

Foraging as the main subsistence strategy of hunter-gatherer populations continued throughout the Late Holocene and after immigrant farming settlements were established in the Philippines (Hung 2008, 2019; Piper et al., 2009). In several cave sites in Peñablanca, Northern Luzon, such as Vito Cave (Figure 1: 11), a largely unchanged behavior of its occupants between 4,000 and 2,000 BP is observed (Fuentes, 2015). With the exception of the appearance of pottery in the archaeological record, subsistence strategies and lithic artifact manufacture and use remained constant. This introduction of pottery to Peñablanca after 4,000 BP probably reflects contact and material exchange between the indigenous foraging communities in the uplands and the newly arrived pottery-making farmers. The current earliest date indicating the arrival of the first Austronesian-speaking farming groups in the Philippines is a direct date on an upper 4th molar of *Sus scrofa* from the Nagsabaran shell midden site with 4,450 to 4,240 cal. BP (Figure 1: 18), and it is also the earliest known introduction of domestic pig although the bulk of the 14C dates from the lowest Layer 3 date between 4,000 and 3,800 cal. BP (Piper et al., 2009; Hung et al. 2011; Amano et al., 2013). This arrival appears to coincide with the climate anomaly and rapid cooling associated with the 4.2 Event and it is possible that the Austronesian Diaspora was triggered by this drastic climate change.

The timing of the appearance and use of metal material culture is still understudied in the Philippines. Consequently, local archaeologists often use the term “metal age”. Radiocarbon-

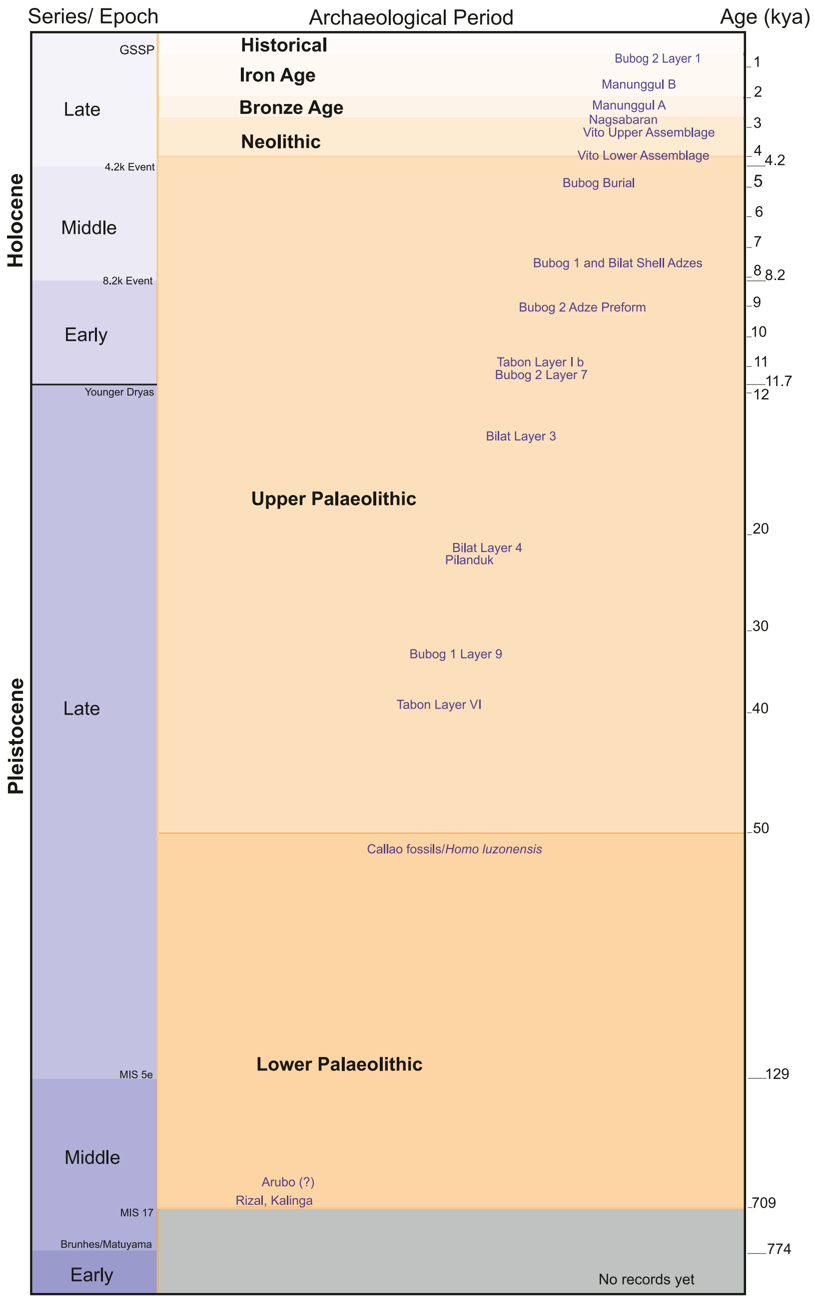

FIGURE 2
Chronology table of the Philippines with key sites.

based chronologies for the beginning of the bronze age and iron age like for the mainland of Southeast Asia are lacking (Higham et al., 2011). Robert Fox initially periodized a Bronze Age and an Iron Age based on findings and context association from Manunggul Chamber A and B at Tabon Caves (Berger and Libby, 1966); however, he later rejected the Bronze Age as a too-brief period after the returned 14C dates from the UCLA laboratory did not match his expectations (Fox, 1970). Instead, he proposed a "Metal Age" with two stages, Early and Late. The so-called *Ling-ling-o* pendants were hereby considered as a diagnostic ornament of the Early Metal Age in the Palawan sites. Early Metal Age burial sites would contain bronze and/or copper implements and stone tools, while iron objects would only appear in the Late Metal Age and after c. 2200 BP (Fox, 1970). Ironically, Fox's classification of Early Metal Age and Late Metal Age used the same criteria for Bronze Age and Iron Age and merely appear as a replacement of terms. Absolute dating remains an issue for the periodization of metal-bearing assemblages in the Philippines and more dates from good contexts are required.

FIGURE 3
(A) Flaked shell tools from Bubog 1; **(B)** Shell adze from Bubog 1; **(C)** Shell adze from Bilat Cave.

Material culture

Only a few lithic assemblages can be assigned to the early Palaeolithic. Together with the discovery of the rhinoceros, 57 lithic artifacts in close context with the fossil remains were retrieved. The relatively small flakes (< 100 mm in length) remain mostly unretouched and were mainly manufactured from siliceous rocks, such as chert, flint, or quartzite, as well as igneous rocks. The assemblages included cores and hammerstones, suggesting that at least some of the flakes were manufactured at the site (Ingicco et al., 2018; Ingicco et al., 2020). Microscopic use-wear analysis conducted by one of the authors (AP) indicated that some tools may have been used in butchering the rhinoceros and for other uses, e.g., processing of plants. Presumably of similar age is an early Palaeolithic assemblage that was reported from Arubo 1, General Tinio, Nueva Ecija, Central Luzon c. 300 km distance to Kalinga (Figure 1: 4). It contains several larger core tools with unifacial and bifacial modifications, including a bifacial hand axe and a cleaver (Pawlik, 2001; 2004; Dizon and Pawlik, 2010). Those and several other artifacts from Arubo exhibit a characteristically formal morphology, rather untypical for the Pleistocene and also Holocene lithic assemblages in the Philippines but similar to lithic tools from other early Palaeolithic sites in Southeast and East Asia such as Pacitan in Java (Figure 1: 9; Sémah and Sémah, 2012) and Mata Menge on Flores (Figure 1: 1; van den Bergh et al., 1996; Morwood et al., 1998; Brumm et al., 2006; Simanjuntak et al., 2010), as well as Roc Tung in Vietnam (Figure 1: 5; Derevianko et al., 2016), Lampang and Sao Din in Thailand (Figure 1: 6 and 7; Zeitoun et al., 2012), or Fengshudao in South China (Figure 1: 8; Huang, 1989; Schick and Zhuan 1993; Hou et al., 2000). On the other hand, while the Rizal and Arubo artifacts differ in size and morphology, similarities exist with regard to core preparation and morphology and the lithic raw material they were made of (Pawlik, 2004; 2021; Ingicco et al., 2018; 2020).

While no lithic or other artifacts had been found together with the fossil hominin remains at Callao Cave, the fossils of the oldest anatomically modern human (AMH) found in the Philippines at Tabon Cave in Central Palawan are associated with a stratified sequence of lithic assemblages (Fox, 1970). For the so-called Flake Assemblage V, Robert Fox proposed an age of c. 50 ka to 45 ka BP or even earlier, estimated through "age–depth" relationships to have an age (Fox, 1970). "Flake Assemblage IV" is reported from Tabon with an associated radiocarbon date of 37.1 ka to 32 ka cal. BP which appears to go fairly along with more recent radiocarbon dates on

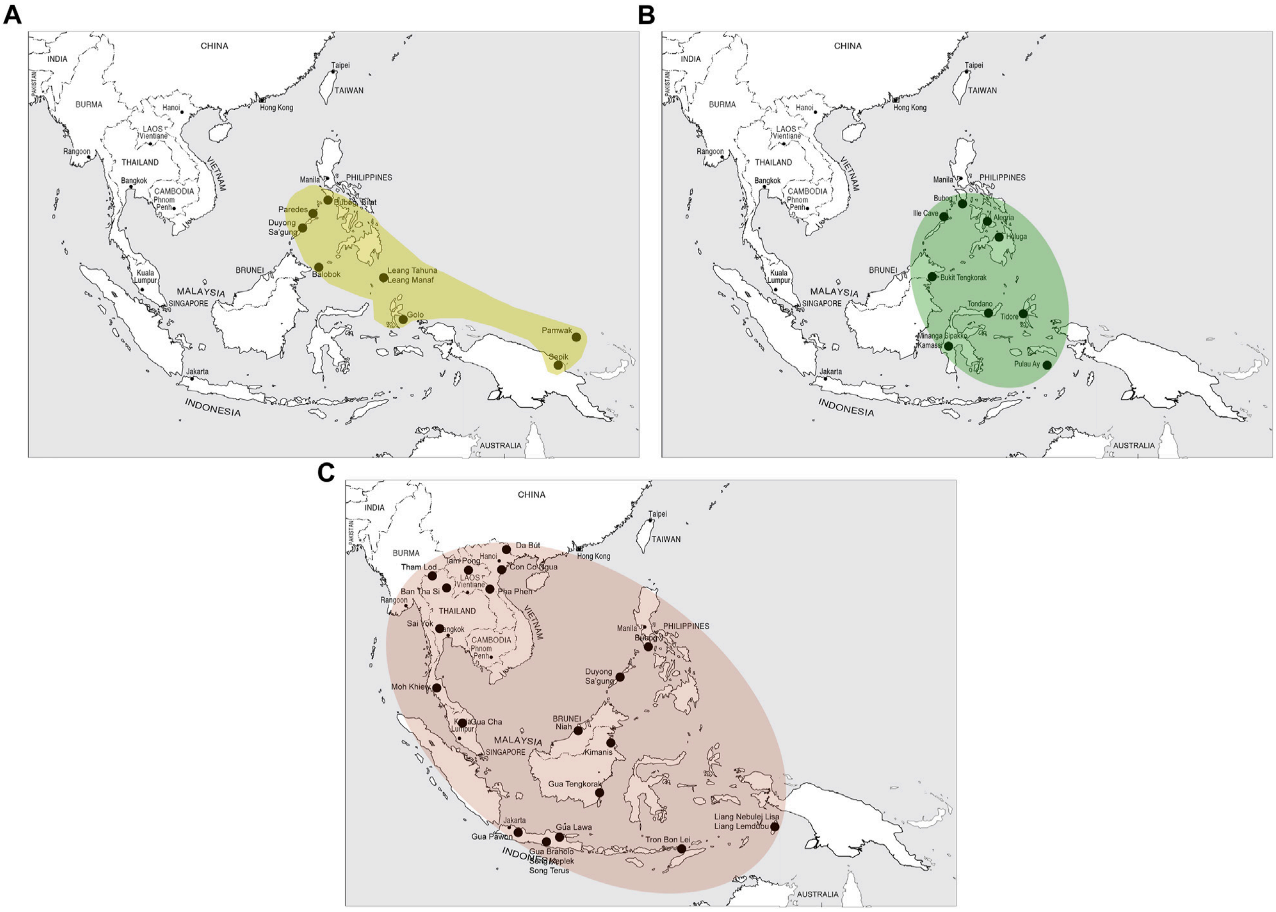

FIGURE 4
Interaction/distribution spheres. **(A)** Edge-ground shell adzes (after Pawlik et al., 2015); **(B)** Obsidian artifacts (after Reepmeyer et al., 2011; Neri et al., 2015); **(C)** Flexed burials (after Pawlik et al., 2019).

hearth features of 39 ka to 32 ka cal. BP (Choa 2016). By at least 35 ka BP, modern humans had traversed from Palawan and the Sunda region into Mindoro Island and the Wallacean part of the Philippines and adapted to dominantly maritime-oriented subsistence strategies, and produced some of the earliest flaked shell tools dated 31 to 28 cal. BP (Pawlik et al., 2014; Pawlik and Piper, 2019; Pawlik, 2021).

In general, there is limited apparent production of formal stone tools until the Late Holocene (Patole-Edoumba, 2002; 2009; Pawlik and Ronquillo, 2003; Pawlik, 2010; 2012; 2021; Patole-Edoumba et al., 2012; Pawlik et al., 2014; Fuentes, 2019). Several authors have suggested that the lack of formality and sophistication of Southeast Asia's lithic industries was due to a scarcity of lithic raw materials of adequate quality and the alternative use of abundant organic raw materials like bamboo and wood (Narr, 1966; Solheim, 1970; Hutterer, 1977; White, 1977; Pope, 1989; Schick and Zhuan, 1993; Forestier, 2000; 2003; Dennell, 2009; Xhauflair, 2014; Xhauflair et al., 2016). On the other hand, artifacts made of lithic materials with good or satisfactory knapping quality, including flint, jasper, or even obsidian, are not uncommon (e.g., Beyer, 1947; Fox, 1970; Charoenwongsa 1988; Pawlik, 2004; 2010; Moore and Brumm, 2007; Moore et al., 2009; Ono et al., 2010; Neri et al., 2015; Fuentes et al., 2019; Pawlik and Piper, 2019; Ono et al., 2020; Xhauflair et al., 2020; Fuentes et al., 2021), and long-distance exchange systems existed for obsidian probably since the Late Pleistocene (Reepmeyer et al., 2011; Neri et al., 2015; Pawlik, 2021). Bamboo, wood, and other plants were certainly important parts of the prehistoric technologies of ISEA, and this is supported by several use-wear and residue analyses. However, tools made of these materials are yet to be identified in the archaeological record and, if ever, were perhaps just an addition to lithic toolkits instead of a replacement, such as the bone tools found in the region (Barton et al., 2009; Pawlik, 2010; 2012; Xhauflair, 2014; Barton, 2016; Xhauflair et al., 2016; Xhauflair et al. 2017; Xhauflair et al. 2023; Fuentes et al., 2019; Fuentes et al. 2020; Fuentes et al. 2021; Ono et al., 2021).

Although artifactual evidence of Pleistocene bone tools in Southeast Asia is rather sparse, it has been suggested that bone technologies already arrived together with the first modern humans reaching Southeast Asia and were carried by them into the Wallacean part of Island Southeast Asia (ISEA) (Anderson, 1990; 1997; Olsen and Glover, 2004; Barton et al., 2009; Rabett and Piper, 2012; Piper and Rabett, 2014; O'Connor et al., 2014; Pawlik and Piper, 2019; Ono et al., 2021). In the Philippines, there is limited evidence for bone technology in the Late Pleistocene and Early Holocene. Notable is a bone fishing gorge from Bubog 1 which is considered part of the technology used for open sea bait fishing that was retrieved from currently undated deposits below the lowest shell midden layer and AMS dated between 33 ka to 28 ka cal. BP (Boulanger, 2015; Boulanger et al., 2019; Pawlik and Piper, 2019). Together with the base of a hafted point from Matja Kuru 2 in East Timor (Figure 1: 19) dated c. 34 ka cal. BP, this is currently the earliest evidence of bone technology east of Huxley's Line (O'Connor et al., 2014; Pawlik and Piper, 2019) although similarly old bone artifacts have been reported from the Sahul region (Allen et al., 2016; Ono et al., 2020; Ono et al., 2021). Older bone artifacts were found in the Sundaic parts of Southeast Asia at Lang Rongrien in Thailand (Figure 1: 20) dated c. 42 ka cal. BP and Niah Caves in Borneo, c. 45 ka (Figure 1: 15; Anderson, 1990; 1997; Rabett et al., 2006; Ono et al., 2021), while hafted bone points appeared on the east coast of Central Sulawesi in Goa Topogaro (Figure 1: 21) in the Terminal Pleistocene (Ono et al., 2020; Ono et al., 2021).

Another resource that has likely played an important role in Late Pleistocene technology in the ISEA region is shell. Tools made of shells have been found across ISEA in Java, Borneo, Palawan, Mindoro, Flores, East Timor, Maluku Islands, the Bismarck Archipelago, and in Oceania and were often interpreted as scraper-like implements (Willems, 1939; van Heekeren, 1972; Solheim 1975, 1992; Bronson and Glover, 1984; Glover, 1986; Arifin, 2004; Bulbeck, 2004; Simanjuntak and Asikin, 2004; Szabó et al., 2007; Morwood et al., 2008). At Bubog 1, an assemblage of modified, flaked, and fragmented shell artifacts was retrieved from its lowest shell-midden layer, composed of numerous valves of the bivalve *Geloina coaxans.* Two shell tools were directly AMS radiocarbon dated 31 ka to 28 ka cal. BP (Figure 3A), while associated *Conus* and *Strombus* shells produced dates between 33 ka to 31 ka cal. BP (Pawlik and Piper, 2019). The use of *Tridacnidae* or giant clams for tool making is archaeologically evident in ISEA since the Early Holocene (Hardy and Hardy, 1969). While flaked artifacts have been occasionally observed, for instance in both Bubog sites on Ilin Island, hafted edge-ground shell adzes appear as the more common tool form and are found across the Philippines, Maluku Islands, and in Melanesia (Fox, 1970; Glover, 1986; Spriggs 1989; Spriggs 1997; Bellwood, 1997; Bellwood et al., 1998; Szabó & Summerhayes, 2002; Szabó, 2005; O'Connor et al., 2006; Pawlik et al., 2015). In Mindoro, two *Tridacna* adzes from Bilat Cave and Bubog 1 on Ilin Island were directly dated between 7.5 ka and 7.3 ka cal. BP (Figures 3B, C; Pawlik et al., 2015; Pawlik and Piper, 2019). The recovery of a *Tridacna* adze preform from Bubog 2 on Ilin Island directly AMS-dated c. 9 ka cal. BP suggests that local production of large *Tridacna* tools already existed in the Philippines during the Early Holocene (Pawlik and Piper, 2019; Pawlik, 2021).

Use-wear analyses employing low and high-power microscopy have identified the use of mostly unretouched flakes across ISEA on a variety of different materials such as bone, wood, rattan, and bamboo, as well as implements for hunting gear. Those studies have also demonstrated the usefulness of seemingly simple, unretouched flakes for various working processes and activities, as well as the application of advanced technologies, such as composite tools and resinous adhesives (Pawlik, 2001; Davenport, 2003; Pawlik, 2004; Teodosio, 2005; Pawlik, 2006; Xhauflair and Pawlik, 2010; Pawlik, 2012; Xhauflair, 2014; Fuentes, 2015; Xhauflair et al., 2016; Xhauflair et al., 2017; Fuentes et al., 2019; 2020; 2021; Fuentes and Pawlik, 2020; Xhauflair et al., 2020). At Bubog 1 and 2, unmodified igneous beach pebbles were utilized in several ways but mainly as hammers to open the larger marine shells like *Strombus, Trochus,* and *Lambis* for consumption, indicated by the diagnostic pitted surfaces that were caused by recurring blows (Pawlik et al., 2014; Pawlik and Piper, 2019). Some of the hammerstones were later reused as weights for fishing nets or fish traps (Skakun et al., 2014; Boulanger, 2015; Boulanger et al., 2019; Pawlik and Piper, 2019), while use-wear traces on several hammerstone fragments with sharp edges indicated that they were not discarded once broken but used as tools for the working of harder organic materials (Fuentes and Pawlik, 2020). This illustrates an efficient use of available resources, but also the importance of traceological analysis in evaluating seemingly simple lithic assemblages rather than just looking at them from a technological perspective. While none of the few bone tools reported from the Philippines have been subjected to traceological analysis so far, use-wear studies have been conducted on the Bubog shell adzes and preform made from giant clam, showing that they were used for heavy-duty activities, and on flakes produced from the mangrove shell *Geloina coaxans* from the lowest shell midden layer of Bubog 1 (Pawlik et al., 2015; Benz, 2016; Pawlik and Piper, 2019). The *Geloina* flakes were used for the processing of hard and soft materials, similar to 30 ka old limpet shells from Golo Cave on Gebe Island (Figure 1: 22; Szabó and Koppel, 2015). The artifacts from Bubog and Golo not only date the manufacture of shell tools back to before the LGM but they also demonstrate their versatility for various purposes.

Discussion and conclusion

Wallacea has been occupied by various hominins for one million years. The excavation of a rhinoceros in context with traces of butchering and a lithic assemblage produced the currently earliest securely dated evidence of the presence of hominins in the Philippines at around 700 ka BP (Ingicco et al., 2018; 2020). The open site of Arubo 1 could be of similar age although it remains undated and there are finds of choppers, chopping tools, and flakes reported from other open-air sites in Cagayan and Kalinga (Fox and Peralta, 1974; Pawlik and Ronquillo, 2003; Dizon and Pawlik, 2010), and also a small assemblage of choppers and chopping tools from Cagayan de Oro on Mindanao Island (Neri, 2006). After these episodes on Luzon Island, no presence of hominins is currently recorded until the onset of MIS 4. However, south of the Philippines, the presence of an unidentified hominin in Wallacea was manifested in an excavation in South Sulawesi at the site of Talepu in the Walanae Basin of South Sulawesi where lithic artifacts associated with large mammals including Stegodon were recovered and dated between 200 ka to 100 ka BP (van den Bergh et al., 2017). This indicates that hominins were very likely present in the southern parts of the Wallacean region during the transitional period from the middle to the late

Pleistocene. The archaeological record of the Philippines from the Pleistocene until the end of the Mid-Holocene currently remains fragmentary and most research has focused only on certain areas of Luzon, Palawan, and Mindoro, while major parts of this diverse archipelago remain largely unexplored as of today. Furthermore, for the Late Pleistocene and Early/Mid-Holocene records, almost all archaeological materials have been acquired from caves and rock shelters, while no open-air sites are currently known from this period. While one reason for this fragmentary record can certainly be seen in the limited amount of archaeological research conducted in the Philippines so far, particularly for the coastal areas during the Pleistocene, we must also assume that the majority of settlements and camps, whether located near the shore or inside low-lying caves and rock shelters have, meanwhile, disappeared due to rising sea level in the Holocene.

Modern humans migrated into ISEA at least 45,000 years ago and may have reached the Philippines by c. 40,000 years ago. Considering a potential migration route from Borneo and Palawan, Mindoro may have served as an entry point for human migration into the Wallacean part of the Philippines. Those first modern human islanders developed new organic and inorganic technologies, sophisticated fishing strategies, social and ideological thought, and expanded maritime interaction and movements. The Bubog and Bilat sites in Mindoro have delivered evidence for open seafaring and long-distance movements of people, as well as the transfer of material and immaterial culture, between the islands and the mainland of Southeast Asia over the last 35,000 years. Various findings hereby link Mindoro and other Philippine islands to technological and social networks spanning from the SE-Asian mainland to as far as Near Oceania (Figure 4). This includes a variety of modern behavioral traits such as open sea fishing, long-distance acquisition of obsidian, and also the emergence of a diversity of burial rituals (Piper et al., 2011; Reepmeyer et al., 2011; Pawlik et al., 2014; 2019; Pawlik, 2015; Neri et al., 2015; Boulanger et al., 2019; Pawlik and Piper, 2019; Shipton et al., 2019). While early evidence for cremation has been discovered in the Early Holocene deposits of Ille Cave (Lara et al., 2013; 2016), a tightly flexed burial was uncovered at Bubog 1 and directly AMS-dated c. 5,200 years ago (Pawlik et al., 2019). Although poorly preserved and despite the absence of grave goods, it could be identified as an organized burial where stone slabs were intentionally placed at the bottom of the burial pit and also used to cover the interment. This kind of flexed burial is widespread on the Southeast Asian mainland and the Sunda region, dating back to as early as 31,000 BP (Maloney et al., 2022), and was probably adopted from there (Pawlik et al., 2019). The behavioral, cultural, and ideological traits identified in Mindoro and Palawan predate the "Austronesian Diaspora" and the arrival of early farming populations in the Philippines at approximately 4,500 to 4,000 BP, considerably (Thiel, 1987; 1990; Bellwood, 1997; 2005; 2017; Simanjuntak, 2008; 2017; Piper, 2016; Pawlik and Piper, 2019).

The Philippine archipelago's proximity to Borneo, Sulawesi, and Taiwan provided a strategic position to facilitate movements of people, material culture, technologies, and innovations across Mainland and Island Southeast Asia. This connectivity between populations over long distances enabled the dissemination of information and ideas along a widespread maritime network that was established and utilized long before the arrival of early farming populations in the Late Holocene. During the Late Pleistocene and Early Holocene, the Philippine islands were inhabited by fisher-hunter-gatherer groups that were well adapted to various inland and coastal environments and capable of responding to changing climates. Their toolkits included handheld and hafted implements made of chert, obsidian, igneous rocks, bone, and shell that were employed in a diversity of functions and activities on various materials. Tropical plants, hereby, played a particularly important role. Together with evidence for a long-distance acquisition of raw material, this puts the cliché of a simple and unchanging technology that has been repeatedly brought forward for the prehistory of this region into question. The bearers of these technologies not only used the available materials for every conceivable purpose but also had the nautical skills to exploit the marine fauna of the open sea and to reach remote islands and coasts. By the Late Pleistocene, they had already successfully adapted to marine environments and efficiently used its rich resources and established maritime networks across Sunda and Wallacea, sharing material culture and knowledge with various communities living in the region.

Author contributions

Both authors contributed to conception and design of the study. AP and RF wrote the first draft of the manuscript. Both authors contributed to manuscript revision, read, and approved the submitted version.

Acknowledgments

AP and RF received support from the University Research Council and the School of Social Sciences of the Ateneo de Manila University and the Areté Sandbox Residency. RF is grateful to the Senckenberg Society for Nature Research, the Werner Reimers Foundation, and the Daimler and Benz Foundation for jointly awarding the Southeast Asia Biocultural Evolution Research Fund.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Allen, H., Langley, M. C., and Tacon, P. (2016). "Bone projectile points in prehistoric Australia: Evidence from implements, ethnography, and rock art," in *Osseus projectile weaponry: Towards an understanding of Pleistocene cultural variability*. Editor M. C. Langley (Dordrecht: Springer), 209–218.

Amano, N., Piper, P. J., Hung, C., and Bellwood, I. (2013). Introduced domestic animals in the neolithic and metal age of the Philippines: Evidence from nagsabaran, northern Luzon. *J. Isl. Coast. Archaeol.* 8, 317–335. doi:10.1080/15564894.2013.781084

Anderson, D. (1990). *Lang Rongrien, a Pleistocene rockshelter: A Pleistocene-Early Holocene archaeological site from Krabi, Southwestern Thailand*. Philadelphia: The University Monograph Museum.

Anderson, D. (1997). Cave archaeology in Southeast Asia. *Geoarchaeology* 12, 607–638. doi:10.1002/(sici)1520-6548(199709)12:6<607::aid-gea5>3.0.co;2-2

Antoine, P., Reyes, M., Amano, N., Bautista, A., Chang, C., Claude, J., et al. (2022). A new rhinoceros clade from the Pleistocene of Asia sheds light on mammal dispersals to the Philippines. *Zoological J. Linn. Soc.* 194 (2), 416–430. doi:10.1093/zoolinnean/zlab009

Arifin, K. (2004). *Early human occupation of the east kalimantan rainforest*. PhD thesis. Australian National University.

Barton, H. (2016). "Functional analysis of stone tools from the west mouth," in *Archaeological investigations in the Niah caves, sarawak. The archaeology of Niah caves, sarawak, volume 2*. Editors G. Barker and L. Farr (Cambridge: McDonald Institute Monographs. McDonald Institute of Archaeological Research).

Barton, H., Piper, P. J., Rabett, R., and Reeds, I. (2009). Composite hunting technologies from the terminal Pleistocene and early Holocene, Niah cave, Borneo. *J. Archaeol. Sci.* 36, 1708–1714. doi:10.1016/j.jas.2009.03.027

Bellwood, P. (2005). *First farmers: The origins of agricultural societies*. Oxford: Blackwell Publishing.

Bellwood, P. (2017). *First islanders: Prehistory of human migration in Island Southeast Asia*. New York: John Wiley and Sons.

Bellwood, P., Nitihaminoto, G., Irwin, G., Waluyo, A., and Tanudirjo, D. (1998). "35,000Years of prehistory in the northern moluccas," in Bird's Head approaches *(modern quaternary research in Southeast Asia 15)*. Editor G. J. Bartstra (Rotterdam: Balkema), 233–275.

Bellwood, P. (1997). *Prehistory of the indo-Malaysian archipelago*. Canberra: Australian National University Press.

Benz, A. (2016). *Considerations on function and significance of early Holocene Geloina artefacts from Bubog 1, Mindoro Occidental, Philippines*. Bachelor of Arts thesis, University of Bonn.

Berger, R., and Libby, W. F. (1966). UCLA radiocarbon dates V. *Radiocarbon* 8, 467–497.

Beyer, H. O. (1947). Outline review of philippine archaeology by islands and province. *Philipp. J. Sci.* 77, 3–4.

Boulanger, C. (2015). Etude des comportements de subsistance d'un site australo-mélanésien: Bubog I (île d'Ilin, Mindoro, Philippines) *ca.* 11000-4000 ans BP. Ichtyofaune, crustacés décapodes et grands mammifères. *Master's Dissertation*. Paris: Muséum national d'Histoire naturelle.

Boulanger, C., Ingicco, T., Piper, P. J., Amano, N., Grouard, S., Ono, R., et al. (2019). Coastal subsistence strategies and mangrove swamp evolution at Bubog I rockshelter (Ilin Island, Mindoro, Philippines) from the Late Pleistocene to the mid-Holocene. *J. Isl. Coast. Archaeol*. 14 (4), 584–604. doi:10.1080/15564894.2018.1531957

Bronson, B., and Glover, I. (1984). Archaeological radiocarbon dates from Indonesia: A first list. *Indones. Circ.* 12, 37–44. doi:10.1080/03062848408729585

Brumm, A., Aziz, F., van den Bergh, G., Morwood, M., Moore, M., Kurniawan, I., et al. (2006). Early stone technology on Flores and its implications for Homo floresiensis. *Nature* 441 (1), 624–628. doi:10.1038/nature04618

Bulbeck, D. (2004). "Divided in space, united in time: The Holocene prehistory of South Sulawesi," in Quaternary Research in Indonesia*: 129-66*. Editors J. M. Pasveer and S. Keates (Leiden: A.A. Balkema).

Choa, O. (2018). *A geochemical history of Tabon Cave (Palawan, Philippines). Environment, climate, and early modern humans in the Philippine archipelago*. PhD thesis. Paris: Muséum national d'histoire naturelle.

Choa, O., Lebon, M., Gallet, X., Détroit, F., Sémah, F., Jago-on, S., et al. (2016). Stable isotopes in guano: Potential contributions towards palaeoenvironmental reconstruction in Tabon Cave, Palawan, Philippines. *Quat. Int.* 416, 27–37. doi:10.1016/j.quaint.2015.12.034

Davenport, D. R. (2003). *A functional analysis of Southeast Asian - pacific island flaked stone tools. BA hon. Thesis*. Canberra: Australian National University.

Dennell, R. W. (2009). *The palaeolithic settlement of Asia*. New York: Cambridge University Press.

Derevianko, A., Su, N. K., Tsyvbankov, A., and Doi, N. G. (2016). *The origin of bifacial industry in Southeast Asia*. Novosibirsk: IAET SB RAS Publishing.

Détroit, F., Dizon, E., Falgueres, C., Hameau, S., Ronquillo, W., and Sémah, F. (2004). Upper Pleistocene *Homo sapiens* from the Tabon cave (palawan, the Philippines): Description and dating of new discoveries. *C.R. Palevol* 3, 705–712. doi:10.1016/j.crpv.2004.06.004

Détroit, F., Mijares, A., Corny, J., Daver, G., Zanolli, C., Piper, P., et al. (2019). A new species of Homo from the Late Pleistocene of the Philippines. *Nature* 568, 181–186. doi:10.1038/s41586-019-1067-9

Dizon, E. Z., and Pawlik, A. (2010). The lower palaeolithic record in the Philippines. *Quat. Int.* 223-224, 444–450. doi:10.1016/j.quaint.2009.10.002

Forestier, H. (2000). De quelques chaînes opératoires en Asie du Sud-Est au Pléistocène supérieur final et au début de l'Holocène. *L'Anthropologie* 104, 531–548. doi:10.1016/s0003-5521(00)80025-4

Forestier, H. (2003). "Des outils nés de la forêt. De l'importance du végétal en Asie du Sud- Est dans l'imagination et l'invention technique aux périodes préhistoriques," in *Peuplements anciens et actuels des forêts tropicales: Actes du séminaire-atelier*. Editors A. Froment and J Guffroy (Paris: IRD Editions), 315–337.

Fox, R. B., and Peralta, T. (1974). "Preliminary report on the paleolithic archaeology of cagayan valley, Philippines, and the cabalwanian industry," in Proceedings of the First Regional Seminar on Southeast Asian Prehistoric Archaeology, Manila: National Museum, June 26-July 4, 1972, 100–147.

Fox, R. B. (1978). "The philippine paleolithic," in *Early paleolithic in South and East Asia*. Editor F. Ikawa-Smith (Paris: Mouton), 59–85.

Fox, R. B. (1970). *The Tabon caves*. Manila: National Museum of the Philippines.

Fuentes, R. (2019). *Detecting microscopic aspects of late Pleistocene to early/mid Holocene lithic technology in Island Southeast Asia: Perspectives from north and central Sulawesi*. PhD Dissertation. Tübingen: Dept. of Prehistory and Quaternary Ecology, University of Tübingen.

Fuentes, R., Ono, R., Aziz, N., Sriwigati, A. N., Sofian, H. O., Miranda, T., et al. (2021). Inferring human activities from the late Pleistocene to Holocene in Topogaro 2, central Sulawesi through use-wear analysis. *J. Archaeol. Sci. Rep.* 37, 102905. doi:10.1016/j.jasrep.2021.102905

Fuentes, R., Ono, R., Carlos, J., Kerfant, C., Miranda, T., Aziz, N., et al. (2020). Stuck within notches: Direct evidence of plant processing during the last glacial Maximum to Holocene in north Sulawesi. *J. Archaeol. Sci. Rep.* 30, 102207. doi:10.1016/j.jasrep.2020.102207

Fuentes, R., Ono, R., Nakajima, N., Nishizawa, H., Siswanto, J., Aziz, N., et al. (2019). Technological and behavioural complexity in expedient industries: The importance of use-wear analysis for understanding flake assemblages. *J. Archaeol. Sci.* 112, 105031. doi:10.1016/j.jas.2019.105031

Fuentes, R. B., and Pawlik, A. F. (2020). "Not formal but functional: Traceology and the lithic record in the Philippines," in *Hunter-gatherers tool kit: A functional perspective*. Editor J. Gibaja-Bao (Newcastle upon Pyne: Cambridge Scholars Publishing), 290–308.

Fuentes, R. B. (2015). *Use-wear analysis of lithic artefacts from Vito cave in Peñablanca, cagayan, northern Luzon, Philippines*. Diliman, Quezon City: Master's thesis, University of the Philippines Archaeological Studies Program.

Glover, I. C. (1986). Archaeology in eastern Timor, 1966–67. *Terra Australia 11*. Canberra: Australian National University Press.

Grün, R., Eggins, S., Kinsley, L., Moseley, H., and Sambridge, M. (2014). Laser ablation U-series analysis of fossil bones and teeth. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 16, 150–167. doi:10.1016/j.palaeo.2014.07.023

Hardy, J., and Hardy, S. (1969). Ecology of *Tridacna* in Palau. *Pac. Sci.* 23, 467–472.

Higham, C., Higham, T., Ciarla, R., Douka, K., Kijngam, A., and Rispoli, F. (2011). The origins of the bronze age of Southeast Asia. *J. World Prehistory* 24, 227–274.

Hou, Y., Potts, R., Yuan, B., Guo, Z., Deino, A., Wang, W., et al. (2000). Mid-pleistocene acheulean-iike stone technology of the bose basin, south China. *Science* 287, 122.

Huang, W. (1989). Bifaces in China. *Hum. Evol.* 4 (1), 87–92. doi:10.1007/bf02436422

Hung, H. C., Carson, M., Bellwood, P., Campos, F., Piper, P., Dizon, E., et al. (2011). The first settlement of remote Oceania: The Philippines to the marianas. *Antiquity* 85, 909–926. doi:10.1017/s0003598x00068393

Hung, H. C. (2019). "History and current debates of archaeology in Island Southeast Asia," in *Encyclopedia of global archaeology*. Editor C. Smith (Berlin, Germany: Springer Nature), 1–22.

Hung, H. C. (2008). *Migration and cultural interaction in southern coastal China, taiwan and the northern Philippines, 3000 BC to AD 100: The early history of the austronesian-speaking populations*. PhD thesis. Canberra: Australian National University.

Hutterer, K. L. (1977). "Reinterpreting the SoutheastSoutheast Asian paleolithic," in Sunda and Sahul, Melanesia and Australia*: 31-71*. Editors J. Allen, J. Golson, and R. Jones (New York: Academic Press).

Huxley, T. H. (1868). On the classification and distribution of the alectoromorphae and heteromorphae. *Proc. Zoological Soc. Lond.* 1868, 294–319.

Ingicco, T., Reyes, M. C., de Vos, J., Belarmino, M., Albers, P., van den Bergh, G. D., et al. (2020). Taphonomy and chronosequence of the 709 ka Kalinga site formation (Luzon Island, Philippines). *Sci. Rep.* 10, 11081. doi:10.1038/s41598-020-68066-3

Ingicco, T., van den Bergh, G., Jago-on, C., Bahain, J. J., Chacón, M. G., Amano, N., et al. (2018). Earliest known hominin activity in the Philippines by 709 thousand years ago. *Nature* 557, 233–237. doi:10.1038/s41586-018-0072-8

Koenigswald, G. (1958). Preliminary report on a newly discovered stone age culture from northern Luzon, philippine islands. *Asian Perspect.* 2, 69–70.

Hornyak, T. (2020). Japan puts its mark on geologic time with the Chibanian Age. *Eos - Earth & Space Science News* 101. doi:10.1029/2020EO139453

Lara, M., Lewis, H., Paz, V., and Ronquillo, W. (2016). "Implications of pathological changes in cremated human remains from Palawan, Philippines, for island Southeast Asian archaeology," in *The routledge handbook of bioarchaeology in Southeast Asia and the pacific islands*. Editors M. Oxenham and H. R. Buckley (London: Routledge), 339–359.

Lara, M., Lewis, H., Paz, V., and Solheim, W. G. (2013). Bone modifications in an early Holocene cremation burial from palawan, Philippines: Bone modifications in a cremation burial from the Philippines. *Int. J. Osteoarchaeol.* 5 (5), 637–652. doi:10.1002/oa.2326

Maloney, T., Dilkes-Hall, I., Vlok, M., Octaviana, A., Aubert, M., Priyatno, A. A. D., et al. (2022). Surgical amputation of a limb 31,000 years ago in Borneo. *Nature* 609, 547–551. doi:10.1038/s41586-022-05160-8

Mijares, A., Détroit, F., Piper, P., Grün, R., Bellwood, P., Aubert, M., et al. (2010). New evidence for a 67,000-year-old human presence at Callao cave, Luzon, Philippines. *J. Hum. Evol.* 59, 123–132. doi:10.1016/j.jhevol.2010.04.008

Moore, M. W., and Brumm, A. (2007). Stone artifacts and hominins in Island Southeast Asia: New insights from Flores, eastern Indonesia. *J. Hum. Evol.* 52, 85–102. doi:10.1016/j.jhevol.2006.08.002

Moore, M. W., Sutikna, T., Morwood, M., and Brumm, A. (2009). Continuities in stone flaking technology at Liang Bua, Flores, Indonesia. *J. Hum. Evol.* 57, 503–526. doi:10.1016/j.jhevol.2008.10.006

Morwood, M., O'Sullivan, P., Aziz, F., and Raza, A. (1998). Fission-track ages of stone tools and fossils on the east Indonesian island of Flores. *Nature* 392, 173–176. doi:10.1038/32401

Morwood, M. L., Sutikna, T., Saptomo, E. W., Westaway, K. E., and Awe Due, R. (2008). Climate, people and faunal succession on Java, Indonesia: Evidence from song gupuh. *J. Archaeol. Sci.* 35, 1776–1789. doi:10.1016/j.jas.2007.11.025

Narr, K. (1966). *Die frühe und mittlere Altsteinzeit Süd-und Ostasiens*. Munich: Francke. Handbuch für Urgeschichte.

Neri, L. A. (2006). A possible Palaeolithic site in northern Mindanao. Hukay. *Bull. Archaeol. Stud. program* 10, 25–37.

Neri, L. A., Pawlik, A. F., Reepmeyer, C., Mijares, A., and Paz, V. (2015). Mobility of early islanders in the Philippines during the terminal pleistocene/early Holocene boundary: PXRF-analysis of obsidian artefacts. *J. Archaeol. Sci.* 61, 149–157. doi:10.1016/j.jas.2015.05.005

Ochoa, J., Carlos, J., Lara, M., De Leon, A., Choa, O., Cabrera, P., et al. (2022). Tropical island adaptations in Southeast Asia during the Last Glacial Maximum: Evidence from Palawan. *Antiquity* 96 (389), 1072–1086. doi:10.15184/aqy.2022.88

O'Connor, S., Robertson, G., and Aplin, K. (2014). Are osseous artefacts a window on perishable material culture? Implications of an unusually complex bone tool from the late Pleistocene of East Timor. *J. Hum. Evol.* 67, 108–119. doi:10.1016/j.jhevol.2013.12.002

O'Connell, J., Allen, J., Williams, M., Williams, A., Cooper, A., Spooner, N. A., et al (2018). When did *Homo sapiens* first reach Southeast Asia and Sahul? *PNAS* 115 (34), 8482–8490. doi:10.1073/pnas.1808385115

S. O'Connor, M. Spriggs, and P. Veth (Editors) (2006). *The archaeology of aru islands, eastern Indonesia* (Canberra: Australian National University Press). Terra Australis 22.

Olsen, S. L., and Glover, I. C. (2004). The bone industry of Ulu Leang 1 and Leang Burung 1 rockshelters, Sulawesi, Indonesia, in its regional context. *Mod. Quat. Res. Southeast Asia* 18, 273–299.

Ono, R., Fuentes, R., Pawlik, A., Amano, N., and Sofian, H. O. (2021). Development of bone and lithic technologies by anatomically modern humans during the late Pleistocene to Holocene in Sulawesi and Wallacea. *Quat. Int.* 596, 124–143. doi:10.1016/j.quaint.2020.12.045

Ono, R., Fuentes, R., Pawlik, A., Sofian, H. O., and Aziz, N. (2020). Island migration and foraging behaviour by anatomically modern humans during the late Pleistocene to Holocene in Wallacea: New evidence from Central Sulawesi, Indonesia. *Quat. Int.* 554, 90–106. doi:10.1016/j.quaint.2020.03.054

Ono, R., Pawlik, A., and Fuentes, R. (2020). "Island migration, resource use, and lithic technology by anatomically modern humans in Wallacea," in *Pleistocene archaeology - migration, technology, and adaptation*. Editors R. Ono and A. Pawlik (London: IntechOpen), 1–27.

Ono, R., Soegondho, S., and Yoneda, M. (2010). Changing marine exploitation during late Pleistocene in northern Wallacea: Shell remains from leang sarru rockshelter in talaud islands. *Asian Perspect.* 48 (2), 318–341.

Ono, R., Sofian, H. O., Fuentes, R., Aziz, N., Ririmasse, M., Geria, I. M., et al. (2023). Early modern human migration into Sulawesi and Island adaptation in Wallacea. *World Archaeol.* 2023, 1–15. doi:10.1080/00438243.2023.2172074

Patole-Edoumba, E. (2009). A typo-technological definition of tabonian industries. *Bull. Indo-Pacific Prehist. Assoc.* 29, 21–25. doi:10.7152/bippa.v29i0.9473

Patole-Edoumba, E. (2002). *L'industrie Lithique Préhistorique de Débitage des Philippines de la Fin du Pleistocène à l'Holocène Moyen*. PhD thesis. Marseille, France: University of Aix-Marseille I.

Patole-Edoumba, E., Pawlik, A., and Mijares, A. (2012). Evolution of prehistoric lithic industries of the Philippines during the Pleistocene. *Comptes Rendus Palevol* 11 (2–3), 213–230. doi:10.1016/j.crpv.2011.07.005

Pawlik, A. (2012). Behavioural complexity and modern traits in the philippine upper palaeolithic. *Asian Perspect.* 51 (1), 22–46. doi:10.1353/asi.2012.0004

Pawlik, A., Crozier, R., Fuentes, R., Wood, R., and Piper, P. (2019). Burial traditions in early mid-holocene Island SoutheastSoutheast Asia: New evidence from bubog-1, Ilin island, Mindoro Occidental. *Antiquity* 93, 901–918. doi:10.15184/aqy.2018.190

Pawlik, A. (2015). "Detecting traits of modern behavior through microwear analysis. A case study from the philippine terminal Pleistocene," in Emergence and Diversity of modern human Behavior in palaeolithic Asia*: 182-200*. Editors Y. Kaifu, M. Izuho, A. Ono, H. Sato, and T. Goebel (Post Station: Texas A&M University Press).

Pawlik, A. (2010). Have we overlooked something? Hafting traces and indications of modern traits in the philippine palaeolithic. *Bull. Indo-Pacific Prehistory Assoc.* 30, 35–53. doi:10.7152/bippa.v30i0.12029

Pawlik, A. (2001). "Is there an early palaeolithic in the Philippines? New approaches for lithic analysis in the Philippines," in *Australasian connections and new directions. Research papers in anthropology and linguistics, vol. 5*. Editors M. Horrocks and P. Sheppard (Auckland: University of Auckland), 255–270.

Pawlik, A., and Piper, P. J. (2019). The Philippines from *c.* 14,000 – 4,000 cal BP in regional context. *Camb. Archaeol. J.* 29 (1), 1–22. doi:10.1017/s0959774318000306

Pawlik, A., Piper, P. J., Wood, R., Lim, K., Faylona, M., Mijares, A., et al. (2015). Shell tool technology in Island SoutheastSoutheast Asia: An early middle Holocene Tridacna adze from Ilin island, Mindoro, Philippines. *Antiquity* 89, 292–308. doi:10.15184/aqy.2015.3

Pawlik, A., and Ronquillo, W. (2003). The palaeolithic in the Philippines. *Lithic Technol.* 28 (2), 79–93. doi:10.1080/01977261.2003.11721004

Pawlik, A. (2021). Technology, adaptation, and mobility in maritime environments in the Philippines from the Late Pleistocene to Early/Mid-Holocene. *Quat. Int.* 596, 109–123. doi:10.1016/j.quaint.2020.11.007

Pawlik, A. (2004). The palaeolithic site of Arubo 1 in central Luzon, Philippines. *Bull. Indo-Pacific Prehistory Assoc.* 24, 3–12.

Pawlik, A. F., Piper, P. J., Faylona, M., Padilla, S., Carlos, J., Mijares, A., et al. (2014). Adaptation and foraging from the terminal Pleistocene to the early Holocene: Excavation at Bubog on Ilin island, Philippines. *J. Field Archaeol.* 39 (3), 230–247. doi:10.1179/0093469014z.00000000090

Piper, P. J. (2016). "Human cultural, technological and adaptive changes from the end of the Pleistocene to the mid-Holocene in Southeast Asia," in *The routledge handbook of bioarchaeology in Southeast Asia and the pacific islands*. Editors M. Oxenham and H. R. Buckley (London: Routledge), 24–44.

Piper, P. J., Hung, H., Campos, F., Bellwood, P., and Santiago, R. (2009). A 4000 year-old introduction of domestic pigs into the Philippine Archipelago: implications for understanding routes of human migration through Island Southeast Asia and Wallacea. *Antiquity* 83, 687–695.

Piper, P. J., Ochoa, J., Robles, E., Lewis, H., and Paz, V. (2011). Palaeozoology of palawan island, Philippines. *Quat. Int.* 233, 142–158. doi:10.1016/j.quaint.2010.07.009

Piper, P. J., and Rabett, R. J. (2014). "Late Pleistocene subsistence strategies in Southeast Asia and their implications for understanding the development of modern human behaviour," in *Southern Asia, Australasia and the search for modern human origins*. Editors R. Dennell and M. Porr (Cambridge: Cambridge University Press), 118–134.

Pope, G. C. (1989). Bamboo and human evolution. *Natural History* (October), 1–15.

Rabett, R. J., and Piper, P. J. (2012). The emergence of bone technologies at the end of the Pleistocene in Southeast Asia: Regional and evolutionary implications. *Camb. Archaeol. J.* 22 (1), 37–56. doi:10.1017/S0959774312000030

Reepmeyer, C., Spriggs, M., Lape, P., Neri, L., and Ronquillo, W. (2011). Obsidian sources and distribution systems in Island SoutheastSoutheast Asia: New results and implications from geochemical research using LA-ICPMS. *J. Archaeol. Sci.* 38, 2995–3005. doi:10.1016/j.jas.2011.06.023

Reyes, M., Ingicco, T., Piper, P., Amano, N., and Pawlik, A. (2017). First fossil evidence of an extinct cloud rat (*Crateromys paulus*) (chordata: Mammalia: Rodentia, muridae) from Ilin island, Mindoro (Philippines): Insights on crateromys paulus diversity and crateromys systematics. *Proc. Biol. Soc. Wash.* 130, 84–97. doi:10.2988/17-00012

Ronquillo, W. (1981). *The technological and functional analyses of lithic flake tools from Rabel Cave, Northern Luzon, Philippines*. Manila: National Museum.

Schick, K. D., and Zhuan, D. (1993). Early paleolithic of China and eastern Asia. *Evol. Anthropol.* 2, 22–35. doi:10.1002/evan.1360020105

Sémah, A. M., and Sémah, F. (2012). The rainforest in Java through the Quaternary and its relationships with humans (adaptation, exploitation and impact on the forest). *Quat. Int.* 249, 120–128. doi:10.1016/j.quaint.2011.06.013

Shipton, C., O'Connor, S., Reepmeyer, C., Kealy, S., and Jankowski, N. (2019). Shell adzes, exotic obsidian, and inter-island voyaging in the early and middle Holocene of Wallacea. *J. Isl. Coast. Archaeol.* 15, 525–546. doi:10.1080/15564894.2019.1581306

Shutler, R., and Mathisen, M. (1979). Pleistocene studies in the cagayan valley of northcrn Luzon, Philippines. *J. Hong Kong Archaeol. Soc.* 8, 105–114.

Simanjuntak, T., and Asikin, I. N. (2004). Early Holocene human settlement in eastern Java. *Bull. Indo-Pacific Prehistory Assoc.* 24, 13–29.

Simanjuntak, T. (2008). *Austronesian in Sulawesi*. Depok: Center for Prehistoric and Austronesian Studies.

Simanjuntak, T., Sémah, F., and Gaillard, C. (2010). The palaeolithic in Indonesia: Nature and Chronology. *Quat. Int.* 223-224, 418–421. doi:10.1016/j.quaint.2009.07.022

Simanjuntak, T. (2017). "The western route migration: A second probable neolithic diffusion to Indonesia," in *New perspectives in Southeast Asian and pacific prehistory*. Editors P. Piper, H. Matusmura, and D. Bulbeck (Canberra: Australian National University Press), 201–211. Terra Australis 45.

Solheim, W. G., II (1992). "Nusantao traders beyond Southeast Asia," in *Early metallurgy, trade and urban centres in Thailand and Southeast Asia*. Editors I. C. Glover, P. Suchitta, and J. Villiers (Bangkok: White Lotus), 199–212.

Solheim, W. G., II (1970). Prehistoric archaeology in eastern mainland Southeast Asia and the Philippines. *Asian Perspect.* 13, 47–58.

Solheim, W. G., II (1975). The Nusantao and south China. *J. Hong Kong Archaeol. Soc.* 6, 108–115.

Szabó, K., Brumm, A., and Bellwood, P. (2007). Shell artefact production at 32,000–28,000 BP in Island Southeast Asia. *Curr. Anthropol.* 48 (5), 701–723. doi:10.1086/520131

Szabó, K., and Koppel, B. (2015). Limpet shells as unmodified tools in Pleistocene Southeast Asia: An experimental approach to assessing fracture and modification. *J. Archaeol. Sci.* 54, 64–76. doi:10.1016/j.jas.2014.11.022

Szabó, K., and Summerhayes, G. (2002). "Lapita worked shell artefacts: New data from early lapita," in *Fifty years in the field: Essays in honour and celebration of richard shutler jr's archaeological career: 91-100*. Editors C. Sand, S. Bedford, and D. Burley (Auckland: New Zealand Archaeological Association Monograph).

Szabó, K. (2005). *Technique and practice: Shell-working in the western pacific and Island Southeast Asia*. Doctoral thesis. Canberra: Australian National University.

Teodosio, S. (2005). *A functional analysis of the Arubo stone tools*. Master thesis. Quezon City, Philippines: University of the Philippines Diliman.

Thiel, B. (1990). Excavations at musang cave, northeast Luzon, Philippines. *Asian Perspect.* 28, 61–81.

Thiel, B. (1987). Excavations at the lal-lo shell middens, northeast Luzon, Philippines. *Asian Perspect.* 27 (1), 71–94.

Van den Bergh, G., Li, Bo, Brumm, A., Grün, R., Yurnaldi, D., Moore, M., et al. (2017). Earliest hominin occupation of Sulawesi, Indonesia. *Nature* 529, 208–211. doi:10.1038/nature16448

Van den Bergh, G., Mubroto, B., Aziz, F., Sondaar, P., and De Vos, J. (1996). Did Homo erectus reach the island of Flores? *Bull. Indo-Pacific Prehistory Assoc.* 14, 27–36. doi:10.7152/bippa.v14i0.11585

Van Heekeren, H. R. (1972). *The stone age of Indonesia*. Second edition. The Hague: Martinus Nijhoff.

White, J. P. (1977). "Crude, colourless and unenterprising? Prehistorians and their views on the stone age of Sunda and Sahul," in Sunda and Sahul: Prehistoric Studies of Southeast Asia, Melanesia and Australia*: 13–30*. Editors J. Allen, J. Golson, and R. Jones (London: Academic Press).

Willems, W. (1939). Merkwaardige praehistorische schelpartefacten van Celebes en Java. *Cult. Indie* 1, 181–185.

Xhauflair, H., Jago-on, S., Vitales, T., Manipon, D., Amano, N., Callado, J. R., et al. (2023). *The invisible plant technology of Prehistoric Southeast Asia: Indirect evidence for basket and rope making at Tabon Cave, Philippines, 39-33,000 years ago*. San Francisco, California: PLOS ONE. D-22-21195, in press.

Xhauflair, H., Pawlik, A., Gaillard, C., Forestier, H., Vitales, T. J., Callado, J. R., et al. (2016). Characterisation of the use-wear resulting from bamboo working and its importance to address the hypothesis of the existence of a bamboo industry in prehistoric Southeast Asia. *Quat. Int.* 416, 95–125. doi:10.1016/j.quaint.2015.11.007

Xhauflair, H., Pawlik, A., Jago-on, S., Callado, J. R., Tandang, D., Palconit, T., et al. (2020). Plant processing experiments and use-wear analysis of Tabon Cave artefacts question the intentional character of denticulated stone tools in prehistoric Southeast Asia. *J. Archaeol. Sci. Rep.* 30.

Xhauflair, H., and Pawlik, A. (2010). Usewear and residue analysis: Contribution to the study of the lithic industry from Tabon cave, palawan, Philippines. *Ann. dell'Università Ferrara Museol. Sci. Nat.* 6, 147–154.

Xhauflair, H. (2014). *Plant use in the subsistence strategies of prehistoric hunter-gatherers in Palawan Island assessed from the lithic industry*. PhD thesis. Paris: Muséum national d'histoire naturelle.

Xhauflair, H., Revel, A., Vitales, T. J., Callado, J. R., Tandang, D., Gaillard, C., et al. (2017). What plants might potentially have been used in the forests of prehistoric Southeast Asia? An insight from the resources used nowadays by local communities in the forested highlands of palawan island. *Quat. Int.* 448, 169–189. doi:10.1016/j.quaint.2017.02.011

Zeitoun, V., Forestier, H., Auetrakulvit, P., Khaokhiew, C., Rasse, M., Davtian, G., et al. (2012). Discovery of a prehistoric site at Sao Din (Nanoi, Nan province, Northern Thailand): Stone tools and new geological insights. *Comptes Rendus Palevol* 11, 575–580. doi:10.1016/j.crpv.2012.06.007