Fishing in life and death: Pleistocene fish-hooks from a burial context on Alor Island, Indonesia

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The discovery of fish-hooks among grave goods associated with an adult female burial at the Tron Bon Lei rockshelter on the island of Alor in Indonesia are the first of their kind from a Pleistocene mortuary context in Southeast Asia. Many of the hooks are of a circular rotating design. Parallels found in various other prehistoric contexts around the globe suggest widespread cultural convergence. The association of the fish-hooks with a human burial, combined with the lack of alternative protein sources on the island, suggest that fishing was an important part of the cosmology of this community. The Tron Bon Lei burial represents the earliest known example of a culture for whom fishing was clearly an important activity among both the living and the dead.

Keywords: Southeast Asia, Indonesia, Pleistocene, fishing, burial, cosmology

Methods

Excavation: The deposit was excavated in approximate 5 cm excavation units (EUs)/spits within stratigraphic layers, such that where stratigraphic changes were observed, excavation followed the stratigraphy. Excavated sediments were wet sieved using a 1.5 mm mesh in order to recover very small bones, shells, and stone artefacts. Samples were dried prior to sorting. Charcoal and shell samples collected *in situ* for dating were plotted in plan and on sections.

Radiocarbon dating.

All radiocarbon dates for the Tron Bon Lei sequence are AMS dates. Single fragments of charcoal were selected for dating, and the surface removed with a scalpel. After gentle crushing, the samples were treated with a series of acid (HCl/ 1M/ 80^{o}C/ 30 min), base (NaOH/ 1M/ 80^{o}C/ 1 hour, changing until solution colourless) and acid (HCl/ 1M/ 80^{o}C/ 30 min) washes. Between each treatment the sample was washed with ultrapure water three times or until the solution remained colourless. The clean material was combusted in a sealed tube in the presence of CuO wire and Ag foil and the resultant CO_2 cryogenically collected and purified prior to graphitization over an iron catalyst in the presence of H_2 for measurement in a NEC single stage AMS at the Australian National University (Fallon et al. 2010). Dates were calculated following Stuiver and Polach (Stuiver and Polach 1977) using a $\delta^{13}C$ measured by AMS.

In the case of the shell hook layers of aragonitic nacre were removed from the hook and gently cleaned with a scalpel before leaching in 0.1M HCl to remove 10% of the original sample weight. The hook and other marine shell samples were tested for recrystallization. To identify whether recrystallization had occurred, x-ray diffraction (XRD) was used to detect whether calcite was present. Prior to dating the clean sample was ground to a fine powder to homogenise, and an aliquot taken for XRD. This subsample was further ground under acetone, dried and passed through a 0.17 μm sieve onto a quartz disk. XRD was performed at the ANU using a Siemans^{TM} D501 x-ray diffractometer operating at 40 kV and 40 mA using Cu Kα radiation, and a step size of 0.05^{o} and speed of 0.3 minutes per degree between 25–50^{o} 2θ on the Bragg Scale. Siroquant^{TM} was used to quantify the calcite content. The detection limit is c.0.3% calcite. The subsample reserved for dating was reacted with 85% H_3PO_4 in a Vacutainer^{TM} evacuated to 3x10^{-3} Torr, and the resulting CO_2 collected, graphitised and dated following the methods described for the charcoal samples.

A local ΔR has not been established for Alor, however, the nearest records suggest it is likely to be small. Two known age shells, from Southern Borneo and the south coast of Java (Southon et al. 2002), produce an average ΔR of 66 ± 49 ^{14}C years. Three surface dwelling foram samples immediately above historical tephra layers from southwest Java and between Sumba and Flores produce an average ΔR of 90 ± 40 ^{14}C years (Southon et

al. 2013). Although primarily examined for their post-bomb signal, two pre-bomb coral records, one from the Makassar Straight (Fallon & Guilderson 2008) and one from the Lombok Straight (Guilderson et al. 2008), have been created at bimonthly resolution from 1890 and 1937 respectively to 1954. After calculation of a 5 year weighted average for comparison to Marine13 (Reimer et al. 2013), the two records produce ΔR estimates of 20 ± 18 and 36 ± 24 ^{14}C years. O'Connor et al. (2010) dated pre-bomb life collected shells along the Kimberley coast of northern Australia, and calculated a ΔR of 58 ± 17 ^{14}C years. Taken together the results suggest a regional average ΔR of 32 ± 41 ^{14}C years.

The charcoal samples appear adequately well preserved, containing >c. 50 %C, whilst the shell hook contained no measurable calcite.

Treatment and measurement of the fish-hooks

Hooks A and B were coated with calcium carbonate which obscured their outer surface. These two hooks were immersed in dilute acetic acid of 3% for 20 minutes and were then washed repeatedly in water to remove remaining acid residues. This procedure was repeated twice. Unfortunately, delamination of Hook A occurred and it separated into three pieces. This hook, and Hook C which was broken during excavation, were reconstructed by gluing the laminated fragments with Paraloid B-72 dilute in acetone in a 20% concentration.

The rotating hooks were measured using digital callipers to two decimal places. Length was measured in two axes (Figure 10: 1 and 2). Width was measured at right angles to this measurement through the maximum dimension of the hook (Figure 10: 3). The width of the hook at the bend was measured (Figure 10: 4). Thickness was measured in three positions (Figure 10: 5,6 and 7) in order to assess if the thickness at the bend was greater than towards the point and end of the shaft. The gape was measured to assess the distance between the shaft and the point (Figure 10: 8).

Function of the bend and the gape in rotating hooks

The stress on a hook is greatest at the bend and can be reduced by thickening the hook at this point, reducing the length of the shank, and making the point more circular to disperse the stress (Reinman 1967; Allen 1996) as evident in the Alor examples (Figure 7)**.** The gape in rotating hooks is also critical to hook performance and function.

Rotating hooks with narrow gapes have been found to be stronger and to hold the fish more securely than those with wider gapes, but have the disadvantage that more time is required to remove the hook from the fish (Allen 1996). Johannes (1981) noted in Palau that rotating hooks with the narrowest gape were selected for fishing in the deepest waters where large prestige fish were the target prey.

Faunal quantification, fish size estimates

Percentage of marine versus non-marine vertebrate fauna is based on NISP and is calculated as the percentage of the total vertebrate fauna in the whole faunal assemblage (49,968 NR). Fish size estimates are based on direct comparison between the archaeological specimens and specimens in the Australian National University reference collection.

Thirteen bony fish families and one subclass of cartilaginous fish (Elasmobranchii) were identified in the Tron Bon Lei assemblage. The herbivore families identified were Balistidae (triggerfishes), Acanthuridae (surgeonfishes, tangs, and unicornfishes), Scaridae (parrotfishes), Ostraciidae (boxfishes) and Diodontidae (porcupinefishes). Within carnivore families, Serranidae (sea basses and groupers) yielded the largest numbers, followed by Labridae (wrasses), Lethrinidae (emperors), Lutjanidae (snapper), and Belonidae (needlefishes). Although the families identified are predominantly from reef/near shore environments, Scombridae (tunas, mackerels and bonitos) and Carangidae (jacks and trevallies), families that include pelagic species, were identified in the bottom layers (Layer 11, 12 and 13), coinciding with an increase in the percentage of carnivore families compared to herbivore/omnivore taxa (Figure S1) (Samper Carro et al. 2016).

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Supplementary figures

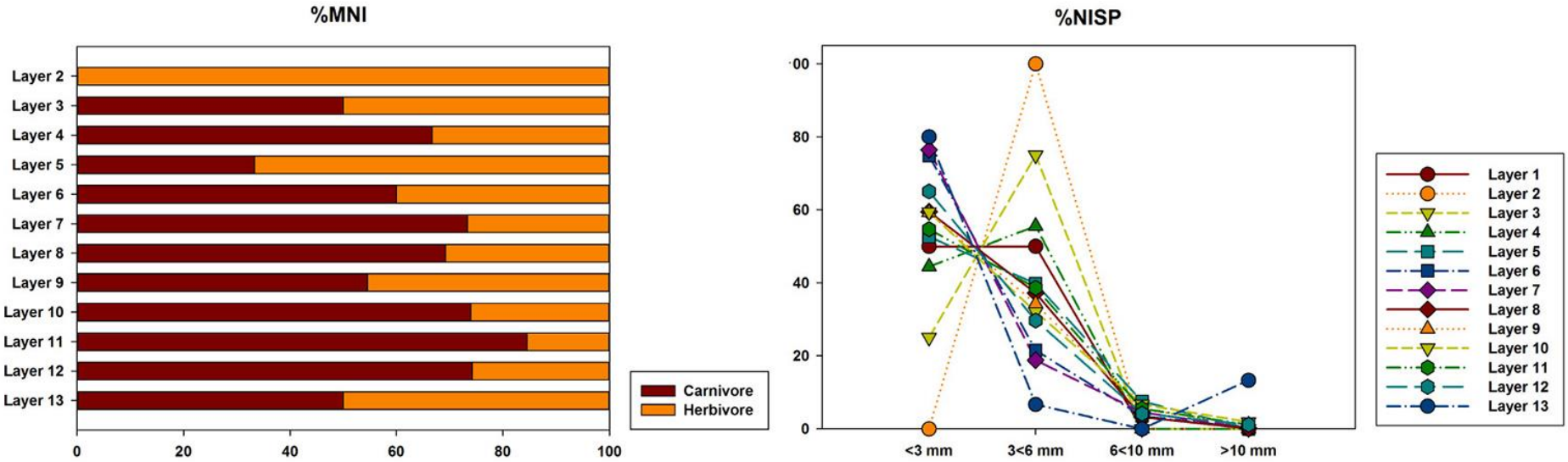

Figure S1. Left: MNI grouped according to carnivore and herbivore families (see Samper Carro et al. 2016 for assignment of families to trophic group); Right: Percentage of NISP for each vertebral corpora size class in each layer from Tron Bon Lei Pit B

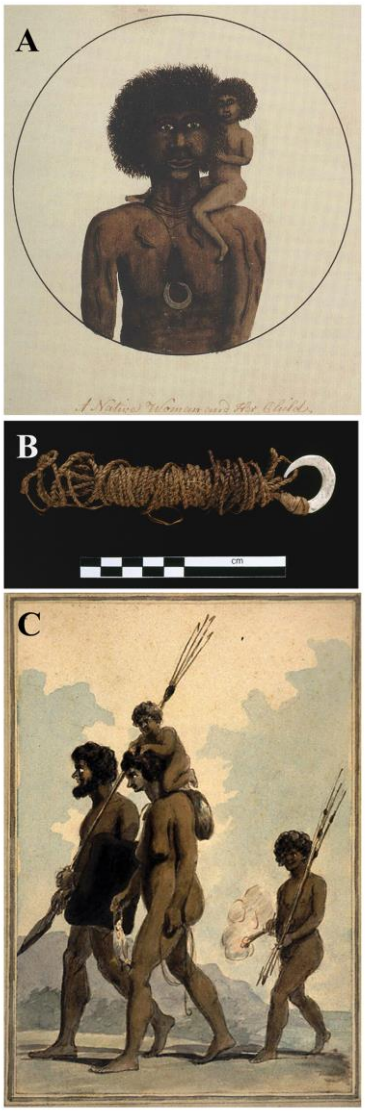

Figure S2. Upper panel: 'A Native Woman and Her Child', Artist unknown, attributed to 'Port Jackson Painter'. Middle panel: Bone fish-hook and line from Lake Tyers, Victoria, MoV reg. no. X1599-co). Reproduced courtesy of the Museum of Victoria. Lower panel: 'A Family of New South Wales' by William Blake (engraver) from a sketch by Governor King (Reproduced courtesy of the Australian Museum Research Library).

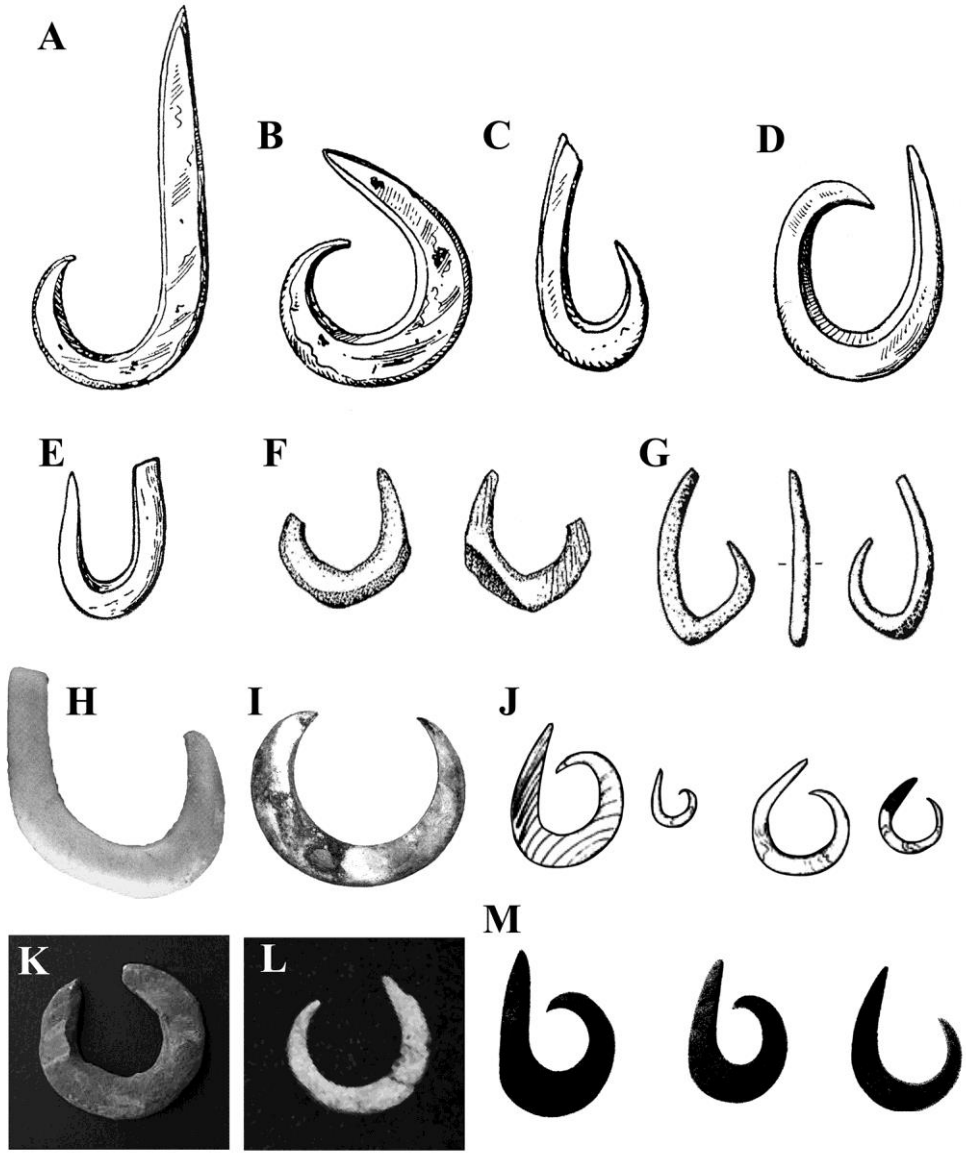

Figure S3. Examples of single piece fish-hooks from around the world manufactured without augmentation of the shaft to attach a line: (A-C) North and South America (Anell 1955); (D) Tahitian (Anell 1955); (E) Prehistoric Europe (Anell 1955); (F-G) Single piece shell fish-hooks from the Kamgot archaeological site, New Ireland, Papua New Guinea (Szabó 2007); (H) Tonga (Burley & Shutler 2007); (I) Ecuador rotating shell fish-hook (Bearéz et al. 2012); (J) Espíritu Santo Island, Mexico, shell fish-hook (Fujita 2014) (K) RH-10 site Qurum, rotating shell fish-hook (Santini 1987); (L) Chumash fish-hooks, Californian coast (Hoover 1973); (M) Historic Chumash bone fish-hook, Californian coast, photo H.H. Huey, Alamy.