Incursion of the bivalve *Potamocorbula faba* into northern Australia: a record from a Holocene archaeological site in Kakadu National Park

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Abstract

This paper reports the discovery of the estuarine bivalve species *Potamocorbula faba* at the archaeological site Ngarradj Warde Djobkeng in Kakadu National Park, Northern Territory. Although presently widespread and abundant in southeastern Asia, this species is not known to be living anywhere in northern Australia today, and neither is it known as a pre-Holocene fossil. Therefore, it must have made a temporary incursion into western Arnhem Land between 3300 and 3600 years ago.

Species profile

Potamocorbula faba is a medium-sized (maximum shell length 16.4 mm) member of the bivalve family Corbulidae (commonly known as basket clams). Its shell valves, which are more equivalve and relatively narrower than many other corbulids, are more or less equilateral (i.e. the beak is located at the centre of the dorsal margin), and are rather elongate – being broadly rounded anteriorly and subrostrate to truncate posteriorly. The ventral margin is more or less straight adding to the narrowness. The exterior is smooth or sculptured with low, concentric ridges, which are strongest marginally. A broadly rounded carina, which is more prominent on the left valve, extends from the beak to the postero-ventral margin. The right valve, which is slightly larger, has a prominent cardinal tooth in front of the sunken ligament at the beak internally. The left valve has a small anterior cardinal tooth and a large trigonal chondrophore with a median cleft containing a narrow ligamentary extension. The pallial line has the merest indication of a sinus posteriorly. The shell itself is pure white. It is polished externally and covered by a thin, glossy, brownish grey periostracum when live. The posterior quarter is often covered with a reddish brown mineralogical deposit which precipitates on it when it is in its normal life posture (i.e. buried vertically into the substrate with the posterior end uppermost). The retractile siphons consist of separate inhalant and exhalant tubes, both extremely short; the inhalant siphon is larger and brown and has a fringe of relatively long tentacles, whereas the exhalant siphon is smaller and pinkish with a fringe of relatively short tentacles. The labial palps are smaller than the gills.

Potamocorbula faba is a suspension feeder using the gills to sort particulate food out of the incoming seawater. It burrows shallowly (0–3 cm) in sandy mud in the intertidal and shallow subtidal zones in estuaries in southeastern Asia (Ambarwati & Trijoko 2011; Hariyadi *et al.* 2017). In fact, it is one of the most abundant bivalves in estuaries in Indonesia, with densities between 3549–10,000 individuals m^2 in the Kepetingan and Porong River estuaries (Ambarwati & Trijoko 2011). *Potamocorbula* species in general are highly tolerant of low oxygen concentrations and euthrophic environments (Thompson & Parchaso 2012), and *P. faba* is no exception as it can live in highly polluted situations (Ambarwati & Trijoko 2011: 168).

Prior to this report, *Potamocorbula faba* has never been recorded from Australia.

The taxonomy and nomenclature of corbulids in general are poorly known because the family has little commercial importance. We are aware that Huber (2010: 771) cursorily dismissed the specific name *faba* as "preoccupied" in *Corbula* but no replacement name has ever been proposed and, in fact, there is no preoccupation when *faba* is placed in the genus *Potamocorbula*. Moreover, Huber (2010; repeated in MolluscaBase 2019) considered *P. faba* synonymous with *P. fasciata*. We reject that synonymy, which comes with the supposition that *P. fasciata* is a "highly variable species in coloring and somewhat less in elongated shape" (Huber 2010). To us they are completely different species with the 'true' *P. fasciata* having a more rostrate spoon-shaped posterior extremity, a more convex ventral margin, a pallial line is relatively further from the margin of the valve and, most importantly, several broad reddish rays emanating from the beak (pers. obs.). Illustrations of 'typical' *P. faba* are given by Huber (2010: 470) from "Thailand-Vietnam" and by Poppe (2011: 386) from the Philippines. Significantly, the specimen illustrated by Poppe (2011) was collected at 20–22 m, which is considerably deeper than that known for *P. faba*. This corollary of our decision that *P. faba* and *P. fasciata* are different species is that we do not know the geographical distribution of either of them, other than both occur broadly in southeastern Asia.

Archaeological introduction

Ngarradj Warde Djobkeng is a rockshelter located within Mirarr Country on the northwestern margin of the Arnhem Land Plateau of the Northern Territory near the East Alligator River. The site was first recorded and excavated by Harry Allen in 1972 as part of the Alligator Rivers Environmental Fact-Finding Study, an initiative put in place to assess the archaeological potential of the soon-to-be Kakadu National Park (Kamminga & Allen 1973). Allen's 1972 test pit produced a rich archaeological assemblage and he returned in 1977 to conduct further excavations. The 1977 field season opened up a further 12 m^2 at the site, bringing the total area excavated to 13 m^2.

Archaeological material at Ngarradj Warde Djobkeng extends to a depth of 185 cm, and initial occupation of the site has been tentatively placed at 18,000–26,000 BP (Allen & Barton 1989). This report, however, focusses on finds recovered from the dense midden located in the upper Holocene aged layers of the site. The Ngarradj Warde

Djobkeng midden stretches across the sheltered portion of the rockshelter, beginning approximately 15 cm below the surface of the site, and extending to a depth of approximately 65 cm (Allen & Barton 1989). It is comprised primarily of faunal remains from estuarine environments and is heavily dominated by molluscs. Radiocarbon dates for the midden layers indicate that it was deposited rapidly over a 1100-year period between 4400 and 3300 cal BP. The six *Potamocorbula faba* specimens discussed in this report were located in the upper portion of the midden, towards the back of the shelter, in layers which ranged in depth from 10–25 cm. Radiocarbon dates for these layers suggests that these specimens were deposited between 3600 and 3300 cal BP.

The specimens from Ngarradj Warde Djobkeng

Six specimens of *Potamocorbula faba*, all single valves, were recovered from the midden at Ngarradj Warde Djobkeng (Table 1). These specimens are currently housed in the Archaeology Store at the Museum and Art Gallery of the Northern Territory (MAGNT; collection registration number AA 1997.002). The specimens within the Ngarradj Warde Djobkeng collection do not have individual numbers, so we have designated numbers 1–6 for them in Table 1 so they can be referred to individually.

One specimen (number 1) was collected during the 1972 phase of the excavation and five specimens (numbers 2–6) were collected during the 1977 phase.

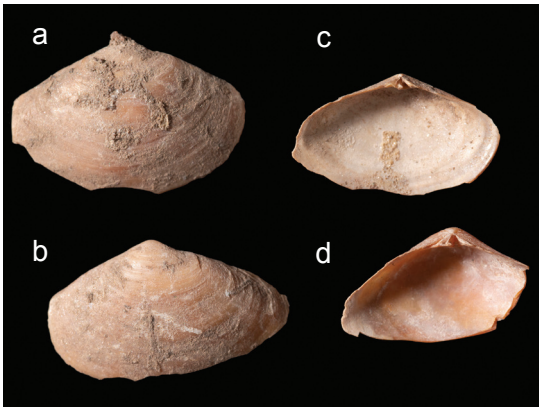

Figure 1. Representative specimens of *Potamocorbula faba* excavated from Ngarradj Warde Djobkeng (Kakadu National Park, Northern Territory), Museum and Art Gallery of the Northern Territory, Archaeology collection AA 1997.002. Details of shell form, full sample number, and full dimensions of all the specimens are given in Table 1. **a,** exterior of specimen no. 6, length 12.2 mm; **b,** exterior of specimen no. 5, length 12.7 mm; **c,** interior of specimen no. 3, length 10.8 mm; **d,** interior of specimen no. 2, length 9.8 mm. (MAGNT)

Table 1. Data for all the specimens of *Potamocorbula faba* excavated from Ngarradj Warde Djobkeng (Kakadu National Park, Northern Territory), Museum and Art Gallery of the Northern Territory, Archaeology collection AA 1997.002.

Specimen no. (and form)	Sample no.	Dimensions - max. shell length x width (mm)	Comment
1 (single right valve)	NWD'72 B1 Spit 3	10.3 x 7.6	Posterior end missing completely
2 (single left valve)	NWD'77/1 SQ1 D layer 2	9.8 x 5.9	Anterior and ventral margins broken
3 (single left valve)	NWD'77/1 SQ1 E4 (west)	10.8 x 6.3	Ventral margin broken
4 (single right valve)	NWD'77/1 SQ1 E5 (north)	12.5 x 7.8	Postero-ventral margin broken
5 (single left valve)	NWD'77/1 SQ1 G-K6	12.7 x 7.3	Ventral margin broken
6 (single right valve)	NWD'77/1 SQ1 G-K6	12.2 x 7.7	Ventral margin broken

The longest specimen (number 5) (Figure 1b) has a maximum shell length of 12.7 mm. The most intact specimen is number 3 (Figure 1c). The smallest specimen (number 2) (Figure 1d) has a maximum shell length of 9.8 mm, but this specimen has extensively broken anterior and ventral margins so it would have been larger in life. Indeed, all the specimens are broken to some degree (Figure 1). From (a) the smoothness of the interior of each shell valve, (b) the intactness of the hinge teeth and chondrophore (which would have been abraded and/or broken off soon after death), and (c) the complete lack of encrusting organisms (animals like barnacles, tubeworms and bryozoans colonise shells very soon after the death of the mollusc that formed them), we conclude that they were all collected live and the damage now evident on them occurred as they were being opened by the gatherers. No delamination, or micro-cracks, or charcoal remains are present on any of the shell valves suggesting they were not directly fired to get them open (though they could have been boiled in water).

Discussion

The layers in which these specimens were found date to a period when environmental conditions in the region of the East Alligator River were significantly different to those in the area today. Rising sea levels initiated by shifting climatic conditions during the transition from the Pleistocene to the Holocene triggered a series of substantial environmental and geomorphological changes across the entire Alligator Rivers Region (Woodroffe *et al.* 1985). These rising sea levels flooded the low-lying continental shelf which connected Australia to New Guinea and resulted in a marine intrusion into the incised river valleys across the northern portion of the continent. This marine influence resulted in the development of extensive tidal flats and brackish water swamps along these river systems which were gradually colonised by mangrove forests (Woodroffe *et al.* 1988). By 6800 BP, extensive mangrove forests were present along the river systems in this region (Woodroffe 1988). The stabilisation of sea levels around 6000 BP was accompanied by an increased level of sedimentation in these river systems (Woodroffe *et al.* 1985). Unable to keep up with this increase in sediment, these extensive mangrove forests began to decline and were gradually replaced by freshwater sedges and grasses (Clarke & Guppy 1988). In some areas of the region, sediment levees began to accumulate around the mangrove forests during this period, leading to the development of hypersaline swamps/floodplains flanking the river system (Hope *et al.* 1985).

The specimens described here were deposited during this final transition period, as the region moved from brackish water swamps to freshwater wetlands. The landscape surrounding the site of Ngarradj Warde Djobkeng during this time would have been a mosaic environment. Stands of mangroves, and brackish water swamp-like conditions would have still been present along the rivers in the region, however, newly formed large permanent bodies of freshwater dominated by grasses and sedges would have also been present around the site.

Conclusion

It is probable that Aboriginal people around the East Alligator River gathered *Potamocorbula faba* for food, as is done presently by people in Indonesia (who often use this species for the commercial traditional dish called *lontong kupang*, the raw ingredient of *krupul* and *petis*, as well as for animal food (Ambarwati & Trijoko 2011; Hariyadi *et al.* 2017)).

Middens formed by traditional gatherers of shellfish are particularly good sources for recording shifts in distributions of molluscs beyond their 'natural range'. Good examples of this are the southern New Zealand limpet *Cellana denticulata* that had an incursion into northeastern New Zealand during the Holocene (Willan 1974) and the eastern African nerite *Nerita textilis* that had an incursion into eastern Indonesia during the Pleistocene (Eichhorst & Szabo 2004); it seems that sometime between 35,000 years ago and the end of the Holocene, 10,000 years ago, the latter vanished from Indonesian waters, or at least became too rare to turn up in middens (Eichhorst 2016: 577).

The occurrence of *Potamocorbula faba* in western Arnhem Land is significant because this represents the first example of a mollusc that had a natural incursion into Australia (in this case, presumably from the southern coast of New Guinea) in historical times, but then failed to persist. It is certain that *P. faba* is not living in Arnhem Land, or anywhere else in northern Australia, today. The size of the temporary population will never be known, but its demise is probably related to the change from brackish water swamps to freshwater wetlands through the Holocene period.

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