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Fauna on the Floodplains: Late Holocene Culture and Landscape on the Sub-coastal Plains of Northern Australia

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ABSTRACT. This paper describes the faunal record from a late Holocene archaeological site located on the freshwater wetlands of the South Alligator River and compares it with that from the Adelaide River, in the Northern Territory. The information characterizes freshwater wetland resources and their use by Aboriginal people, providing a snapshot of life on the floodplains immediately prior to European contact. Although the two wetland systems appear similar, and extractive technology in the form of bone points is also similar, the faunal assemblages show that Aboriginal hunting strategies differed between the two areas. These differences can be explained by variations in regional topography and seasonality of site use.

Introduction

This paper compares two late Holocene faunal assemblages from different regions of the sub-coastal floodplains located in the Top End of the Northern Territory (Fig. 1). The information characterizes freshwater wetland resources and their use by Aboriginal people, providing a snapshot of life on the floodplains immediately prior to European contact. The paper presents new information about faunal remains and bone points recovered from the earth mound site of Kina on the South Alligator River, originally excavated in 1981 as part of the Kakadu Archaeological Project (Jones, 1985). The faunal assemblage was not analyzed in detail at the time; however, this has since been undertaken by Ken Aplin (2016). Aplin's results are compared with those of Brockwell (2009) from earth mounds on the Adelaide River. Although these two tropical freshwater wetland systems appear similar, their faunal assemblages show that Aboriginal hunting strategies differed between regions, although extractive technology in the form of bone points

is similar. Aplin's results demonstrate a dominance of fish in the Kina sequence, while Brockwell's study shows the upper levels of the Adelaide River sites are dominated by freshwater turtle. This paper seeks explanations for these differences and similarities.

Climate

The climate of northern Australia consists of a long dry season from about April to November and a shorter but intense wet season from about December to March. This regime affects the seasonal availability of both flora and fauna.

Geomorphology

The evolutionary history of the floodplains of the major river systems of the Top End of the Northern Territory is well understood from various geomorphic studies and is broadly similar between river systems (e.g., Clark & Guppy, 1988; Hope *et al.*, 1985; Woodroffe & Mulrennan, 1983; Woodroffe *et al.*, 1985, 1993). The floodplains were initiated

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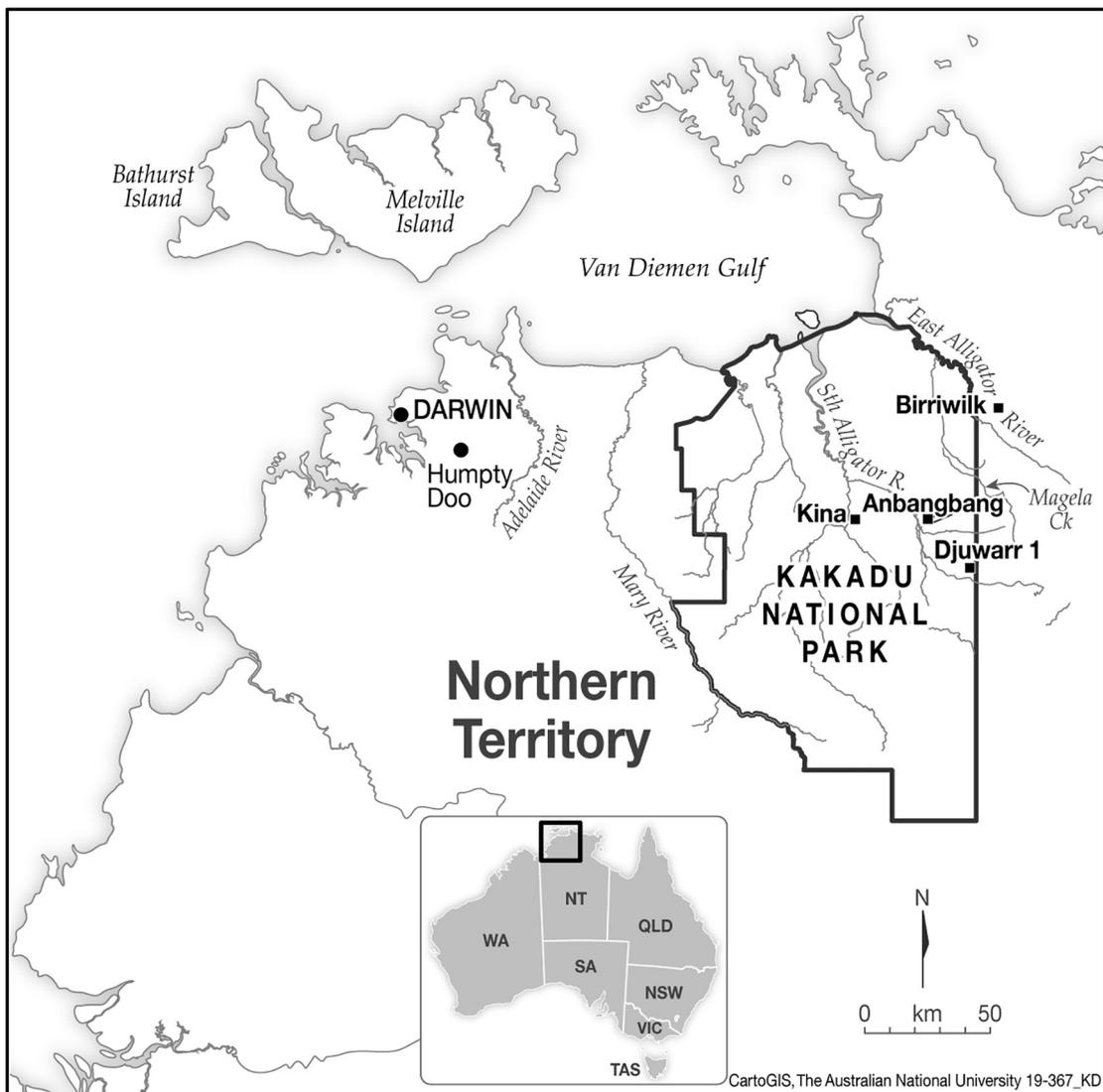


Figure 1. South Alligator River (Kina) and Adelaide River: location map (ANU Carto-GIS).

by post-Pleistocene sea level rise that flooded down-cut river valleys in the region. Subsequent processes of siltation led to the Big Swamp Phase when mangroves colonized the floodplains c. 8000–6000 years BP (Woodroffe *et al.*, 1985). Further siltation and coastal progradation cut off the tidal influence, mangroves retreated to river channels and the coast, and a period of transition initiated a mosaic of estuarine and freshwater environments that existed on the floodplains between about 5000–2000 years BP. This has been referred to as the Transition Phase on both the Adelaide River (Woodroffe *et al.*, 1993: 264) and in Kakadu (Clark & Guppy, 1988: 682). With the ponding of freshwater from the annual monsoon against cheniers, freshwater wetlands with their exceedingly rich floral and faunal resources became widely established on the floodplains from c. 2000 years BP, which is known as the Freshwater Phase.

Archaeology

Archaeologists have demonstrated the key importance of these floodplains to the pre-contact Aboriginal economy throughout the mid to late Holocene (cf. Allen, 1996; Baker,

1981; Brockwell, 1996, 2001, 2006, 2009; Brockwell & Akerman, 2007; Brockwell *et al.*, 2001; Guse, 1992; Hiscock, 1996, 1999; Hiscock *et al.*, 1992; Meehan *et al.*, 1985; Schrire, 1982). With the arrival of the Big Swamp Phase c. 7000 years BP, settlement in the Alligator Rivers Region was concentrated in rock shelters close to the northern floodplains around the East Alligator River and Magela Creek, exploiting the rich estuarine resources of the mangroves. Occupation continued there until the Transition Phase when the rockshelters were abandoned c. 3000 years BP, then reoccupied in the Freshwater Phase with the establishment of freshwater wetlands c. 1500 years BP. At the same time, open sites were established on the floodplain margins in the north and south of the region to take advantage of the exceedingly rich freshwater flora and fauna (Meehan *et al.*, 1985).

On the Adelaide River, which lacks the rockshelter formations of the Arnhem Land escarpment and its outliers, settlement was focused mainly on the floodplain margins from at least 4000 years BP, exploiting estuarine resources towards the end of the Big Swamp Phase (Brockwell, 2009). During the Transition Phase, the archaeology demonstrates

Table 1. Kina: cultural remains from excavation, as reported by Meehan *et al.* (1985: 149, table 7.5). The material from the two squares (SE and NE) is pooled for this summary.

excavation unit	depth below surface (cm)	sediment weight (kg)	stone artefacts (no.)	haematite (no.)	freshwater mussels weight (g)
1	12	74	84	1	545
2	28	77	123	—	720
3	45	77	229	1	301
4	63	80	79	—	35
5	78	80	99	—	26

exploitation of both estuarine and freshwater zones until the establishment Freshwater Phase c. 2000 years BP, at which time exploitation became focused on freshwater species (Brockwell, 2009; Brockwell & Akerman, 2007).

The Kina archaeological site

Kina is located beside a freshwater billabong on the eastern side of the South Alligator River and lies within Kakadu National Park, 200 km east of Darwin (Fig. 1). The site consists of extensive surface concentrations of archaeological material covering some 30,000 square metres, and several small discrete earth mounds containing stone artefacts, freshwater mussel shell and other cultural remains in a dark clay matrix (Meehan *et al.*, 1985: 117–119). Surface collection and excavation were undertaken and described in detail by Meehan *et al.* (1985: 148–152). This information is summarized below.

Three transects were set up across the site. The north-south traverse measured 210 m, while the two east-west traverses were 110 m and 100 m respectively. Systematic surface collections of 1 × 1 m were made every 10 m along transects by the project team members. A 5 × 5 m square was laid out over one earth mound and the material contained in each 1 × 1 m square was collected and bagged separately (Meehan *et al.*, 1985: 117). A test pit (1 m × 50 cm) was excavated into one of the mounds, in five excavation units measuring between 12–18 cm, and the deposit was sieved through 12 mm and 3 mm mesh (Meehan *et al.*, 1985: 149; Johnson & Jones, 1985: 33). Bedrock, on the laterite surface of the plain, was reached at 78 cm (Table 1). The mound had been disturbed by goanna burrows, and it is likely that the soil and archaeological remains throughout the pit were reworked. There was no marked stratigraphy, although the deposit changed from hard and compact in the uppermost level to soft, dark grey silt or clay containing freshwater mussel shell, and numerous charcoal particles. Along with the shell (*Velesunio* sp. and *Alathyia* sp.), stone artefacts were recovered, as well as two examples of mangrove shell (reported as *Geloina* sp.) in the lowermost cultural units. Some bone was recovered from the upper levels (0–36 cm below surface), including the carapace and other remains of long necked turtle, fish vertebrae and otoliths. A broken bone point was found in unit 1. A summary of the cultural remains from excavation of the Kina site is shown in Table 1 (based on Meehan *et al.*, 1985: 152, table 7.5). The Kina assemblage is lodged with the Museum and Art Gallery of the Northern Territory (MAGNT).

The Adelaide River archaeological sites

The Adelaide River earth mounds are located beside ephemeral lagoons on the western side of the floodplains of the lower Adelaide River, 60 km southeast of Darwin and 30 km northeast of the township of Humpty Doo, adjacent to the floodplains in an area of pandanus fringe (Fig. 1). Thirty-one earth mounds were recorded in this area (Brockwell, 2009: 33). Of these, two (HD1 and HD2) were located in 1968 by Carmel Schrire, and HD1 was subsequently excavated. Additional earth mounds were located in surveys in 1993 (MP1–MP6, NP1–NP20) (Brockwell, 2005). Five sites were excavated by SB in 1995 (MP2, MP5, MP6, NP19, NP20) and the deposit was sieved through 6 mm and 3 mm sieves. The excavations, discussed in detail in Brockwell (2009), yielded numerous stone artefacts, and two sites (MP2 and HD1) contained large quantities of well-preserved faunal remains from both the floodplains (fish and turtle) and open savanna species (goannas, wallabies, possums, and bandicoots). The Adelaide River collections are lodged with MAGNT.

Chronology

Adelaide River. The cultural assemblages on the Adelaide River date back to c. 4000 years BP and relate to the environmental phases of the evolution of the floodplains covering the Big Swamp, Transition, Freshwater, and Contact Phases (Table 2) (Brockwell, 2009: 36–38; Brockwell *et al.*, 2009). The dates from the Freshwater Phase fell into two clusters and were divided for analysis into the Early Freshwater Phase from c. 2000, and the Late Freshwater Phase from c. 750 years BP (Brockwell & Akerman, 2007: 114). For the purposes of this paper, we will be examining the faunal assemblage from the Late Freshwater Phase only, making it comparable with that of Kina.

Kina. A charcoal sample dated by Meehan *et al.* (1985) from unit 4 (45–63 cm) produced a date of 425–153 cal. BP (ANU 3212) (Brockwell *et al.*, 2009: 71; Jones & Johnson, 1985: 41). Meehan *et al.* (1985) postulated an earlier basal age, perhaps around 500–1000 BP, based on the occurrence of mangrove shell at the bottom of the pit, although Hope *et al.* (1985: 233–236) posited an earlier transition (c. 1400 BP) to freshwater conditions from their geomorphic studies of the neighbouring floodplain. A more recent dating of another charcoal sample, also from unit 4, places the Kina assemblage at 268–14 cal. BP (Wk 38070). A sample of estuarine shell (*Geloina* sp.) from the basal unit 5 (63–78 cm) produced a date of 330 ± 27 BP (uncalibrated, Wk 38068). These dates fall within the Late Freshwater Phase described for the Adelaide River (Brockwell, 2009: 36–38; Brockwell & Akerman, 2007: 114) (Table 2).

Table 2. Chronological phases and radiocarbon dates of earth mound sites (after Brockwell, 2009: 36–38; Brockwell & Akerman, 2007: 114; Brockwell *et al.*, 2009). AR = Adelaide River, SAR = South Alligator River (Bronk Ramsey, 2013; Reimer *et al.*, 2013; Stuiver & Polach, 1977; Stuiver *et al.*, 2005).

phase	area	site & spit no.	lab. no.	material	depth below surface (cm)	C-14	cal. BP 68.2% confidence	cal. BP 95.4% confidence
Contact	AR	NP19	Wk 5580	<i>Geloina</i> sp.	5–7	Modern	—	—
Late Freshwater	SAR	Kina	ANU 3212	Charcoal	45–63	280 ± 40	—	425–153
	SAR	Kina	Wk 38068	<i>Geloina</i> sp.	63–78	330 ± 27	—	—
	SAR	Kina	Wk 38070	Charcoal	45–63	206 ± 20	300–14	293–9
	AR	MP2/5	Wk 5581	Charcoal	22–26	350 ± 70	460–310	510–150
	AR	MP6/5	Wk 6668	Bone	10–15	434 ± 56	510–340	530–310
	AR	MP5/11	Wk 7400	Charcoal	36–41	630 ± 60	639–537	659–517
Early Freshwater		MP2/7	Wk 8452	Charcoal	31–35	460 ± 130	600–460	750–150
	AR	MP2/10	Wk 6374	Turtle carapace	42–47	2040 ± 260	2350–1650	2750–1350
	AR	MP2/13	Wk 5582	Charcoal	53–59	1880 ± 210	2050–1550	2350–1350
	AR	HD1/3	Wk 6373	Turtle carapace	10–19	2027 ± 77	2070–1870	2180–1750
Transition/Big Swamp	AR	HD1/9	Wk 5957	<i>Geloina</i> sp.	49–56	3880 ± 60	3950–3740	4050–3660
	AR	HD1/11	Wk 5796	<i>Geloina</i> sp.	62–69	4060 ± 60	4200–3990	4300–3890

Materials, methods, and identifications

Five major groups of vertebrates might be represented in an assemblage from the Top End—fish, frogs, reptiles, birds, and mammals. Each of these vertebrate groups has a distinctive skeletal anatomy and, with undamaged bones, virtually any bone can be allocated to one of the five groups. Fragmentation of bone results in a loss of diagnostic morphological features. However, for some classes of remains textural features allow even very small fragments to be allocated to a higher taxonomic category. For example, fish bone typically has a ropey or flaky texture that derives from a contrasting mode of bone formation to other vertebrates, and fragments of turtle carapace and plastron show a distinctive surface texture coupled with a spongy internal structure that remain visible down to quite small fragments. By contrast, for other groups of vertebrate fauna, the ability to identify fragmented remains depends on how much morphology is preserved. Fragments that retain some part of an articular surface are usually identifiable at least to higher taxon and often to lower level (genus or species), whereas small fragments derived from long bone shafts are rarely identifiable below family level.

Kina faunal assemblage

The Kina surface and excavated faunal assemblage was analysed by KA. Each fragment was examined microscopically for surface modifications caused by human intervention including manufacturing marks and use-related wear or damage, cut and tooth marks, and percussion marks, as well as signs of post-depositional degradation including corrosion associated with root contact, and pitting caused by microbial activity (Aplin, 2016).

Quantification of taxonomic and burning categories was performed by count (number of individual specimens—NISP) and weight (to the nearest 0.01 g). NISP values are used in preference to a Minimum Number of Individuals (MNI—the smallest number of original animals needed to

account for all of the recovered remains) because the small samples available from the majority of the analysed sites dictate that the likelihood of recovering multiple fragments of any one individual is extremely low.

The distinctive lenticular otoliths of ariid catfish feature prominently in the assemblage. To determine whether otoliths were from the same fish, up to three measurements were taken from each otolith, depending on the degree of completeness; otolith symmetry was also recorded but no two otoliths seem close enough in size and shape to be derived from the same individual.

Macropodidae. Three molar fragments from the surface collection are confidently allocated to the agile wallaby (*Notamacropus agilis*), which is the only intermediate sized macropodid in tropical Australia (Aplin *et al.*, 2016; Goodfellow, 1993). None of the excavated bone fragments tentatively identified as coming from mammals are large enough to be from agile wallabies.

Pteropodidae. Two species of flying foxes are found in western Arnhem Land today, the black flying fox (*Pteropus alecto*) and the little red flying fox (*Pteropus scapulatus*). Foley (1985) reported remains of both species in the Angbangbang 1 surface sample. Two fragmentary limb bones are present in the Kina excavated collection. Both appear too small to be black flying fox and they are tentatively referred to *P. scapulatus*. Both species are known to congregate in multiple dry-season camps within Kakadu National Park (Tidemann *et al.*, 1999). Camps of *P. scapulatus* within Kakadu are most often located in patches of monsoon forest (Friend & Braithwaite, 1985).

Muridae. At least two species are represented. One is a small rat, represented by an upper incisor and a fragmentary femur; these are the size of the Western Chestnut Mouse (*Pseudomys nanus*) but they might also be referred to various other similar sized species. The second taxon is a larger animal, represented by a distal tibia; this is comparable in size to the Dusky Rat (*Rattus colletti*), found only on

the monsoonal subcoastal plains of the Northern Territory, and eaten by Aboriginal people (Goodfellow, 1993). It probably represents this species or the Brush-tailed Rabbit Rat (*Conilurus penicillatus*), an arboreal rat of the northern savanna landscape (Burbidge & Woinarski, 2016).

Varanidae. A moderately large species of *Varanus* is represented by a vertebra and one limb element in Square SE. These might be referable to any of the three large monitors that occur in the western Arnhem Land region - Gould's monitor (*Varanus gouldii*), Merten's water monitor (*Varanus mertensi*), or the yellow-spotted monitor (*Varanus panoptes*). As all *Varanus* species are very similar in their skeletal morphology, there is currently no set of criteria on which to base species identifications.

Meehan *et al.* (1985: 147) reported the presence of goanna burrows in the Kina mound deposit and noted the possibility that people may have dug into the mound in the past to locate animals undergoing seasonal aestivation.

Pythonidae. Two conjoined vertebrae from Square NE/3 are from a moderately large python. Candidate species include the black-headed python (*Aspidites melanocephalus*), the water python (*Liasis fuscus*) and the olive python (*Liasis olivaceus*). The vertebrae are complete enough for identification but this not been attempted due to lack of access to sufficient reference material.

Chelidae. The small fragments of carapace and plastron, and fragmentary bony elements do not permit lower level determination. Several species of Chelidae are known to occur in the freshwater lagoons and streams of northern Australia. The most commonly observed is the long-necked turtle (*Chelodina rugosa*), but short-necked turtles are also present—northern snapping turtle (*Eelseya dentata*), pig-nosed or Fly River turtle (*Carettochelys insculpta*) and yellow-faced turtle (*Emydura tanybaraga*) (Cogger, 2018).

Teleost fishes. A total of 58 species of fishes have been recorded in the rivers of the Alligator River systems, the largest tally for any single river system in tropical Australia (Pusey *et al.*, 2017). Of these, 15 or more can attain adult lengths of 30 cm or more, making them likely targets for Aboriginal subsistence strategies.

The fork-tailed catfishes (family Ariidae) are readily recognizable archaeologically from their robust, lenticular otoliths (Acero & Bentacur, 2007), the highly distinctive nodular surface texture to the dorsal cranial bones, and their robust and distinctive dentigerous bones. Three species of ariid catfish are recorded in the regional river systems, with the most common taxon being the salmon catfish, *Sciades leptaspis*. This species can reach 100 cm in length but individuals around 30–50 cm are more commonplace. It is found in the estuarine, lowland, and floodplain environments. Like most ariid catfish, *S. leptaspis* has high salt tolerance and it can move freely between the marine and freshwater environments.

No other fish taxa were recognizable among the fragmentary remains but further study with access to more complete reference collections might allow additional remains to be determined.

Adelaide River faunal assemblages

The Adelaide River faunal assemblages were analysed by SB. Preliminary identifications were based on broad categories such as mammal, bird, reptile, fish, etc. Categories such as large and small mammals, most likely macropods, possums and rodents, and birds were identified by long bones. Species identifications of mammals, birds, and reptiles were made mainly on teeth, jaws, and vertebrae. Those identified to species level include Agile Wallaby (*Notamacropus agilis*), Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*), Northern Brown Bandicoot (*Isodon macrourus*), Dusky Rat (*Rattus colletti*), and Northern Blue-tongue Lizard (*Tiliqua scincoides*). Other identifications were to family only.

Fish species were identified on skeletal elements, such as vomer, dentary, premaxilla, articular, maxilla, quadrate, hyomandibular, opercular, preopercular, urohyal, cleithrum, post-temporal, pterygiophores, supra-cleithrum, spines, and vertebrae (Barnett, 1978: 37; Colley, 1990: 213).

Most of the faunal remains from the Adelaide River sites were very fragmented and came from the 3 mm fraction, rather than the 6 mm sieve. For example, MP2 yielded an estimated 12.4 kg of faunal remains from the 3 mm sieve, most of it unidentifiable. Consequently MNI analysis was not used because the skeletal elements available did not allow a calculation of minimum numbers. There were, for example, no fish otoliths present. NISP analysis also seemed inappropriate because of the fragmented nature of the remains. Given this situation, it was decided the best method available was to calculate the weight of each taxon. This was compared directly to weight of taxonomic classes from Kina. The disadvantage of this method is that larger animals may be over-represented in the relative abundance of fauna (Peres, 2010: 27). However, as the fauna from the sites was mainly from small taxa, this possibility was reduced.

Results

Kina: general results

At Kina, the faunal remains come from a surface collection and from a test pit excavation into the mound. Preservation of the remains is reasonable, and this is probably due to the relatively high concentration of molluscan shell in the deposit, thereby buffering any natural acidity. The surface and excavated assemblages are dominated by the remains of fish, among which fork-tailed catfish (family Ariidae) are prominent. Other taxa that are represented in smaller quantities include freshwater turtle, agile wallaby, flying foxes, monitor lizards, a python, and several kinds of rodents. A small number of worked and utilized bone implements are described.

Kina: surface collection

Bone and/or shell were recovered from 17 of the surface collection sampling units described above (see Table 2). The surface bone assemblage consists of 35 individual pieces weighing a total of 45.9 g. Eighteen of the 35 pieces are either complete or fragmentary fish otoliths, three are fragments of mammal teeth, and the remainder are fragments of fish or mammal bone.

Physical state of remains. The bone fragments and otoliths show signs of physical degradation including surface root

Table 3. Kina: taxonomic composition of the faunal remains recovered from the surface collection. Data are summarized by NISP and weight (g).

sample ID	NISP						weight (g)					
	Hyriidae	Ariidae	Teleost indet.	Chelidae	Agile Wallaby	mammal indet.	Hyriidae	Ariidae	Teleost indet.	Chelidae	Agile Wallaby	mammal indet.
SC G1A	—	2	—	—	—	—	—	0.37	—	—	—	—
SC G1E	—	2	1	—	—	—	—	0.07	0.04	—	—	—
SC G1L	—	1	—	—	—	—	—	0.31	—	—	—	—
SC G2D	—	1	—	—	—	—	—	2.40	—	—	—	—
SC G2E	1	—	—	1	—	—	10.36	—	—	0.05	—	—
SC G2L	—	3	—	—	—	—	—	1.82	—	—	—	—
SC G3A	—	2	—	—	1	—	—	1.52	—	—	0.01	—
SC G3B	—	1	2	—	—	—	—	0.68	0.14	—	—	—
SC G3C	—	2	1	—	1	—	—	1.19	0.06	—	0.10	—
SC G3E	1	1	1	—	—	—	23.44	0.52	0.18	—	—	—
SC G4B	—	1	—	—	1	—	—	0.29	—	—	0.07	—
SC G4C	—	1	2	—	—	—	—	0.09	0.10	—	—	—
SC G4E	—	1	1	—	—	—	—	0.88	0.14	—	—	—
SC G4L	—	2	—	—	—	—	—	0.32	—	—	—	—
SC G5A	—	1	—	—	—	—	—	0.03	—	—	—	—
SC G5D	—	1	—	—	—	—	—	0.37	—	—	—	—
SC G5E	—	—	—	—	—	1	—	—	—	—	—	0.14
total	2	22	8	1	3	1	33.8	10.86	0.66	0.05	0.18	0.14

channeling and exfoliation. Calcined fragments are less damaged. Two fragments of freshwater mussel (*Velesunio* sp.) weigh 10.4 g and 23.4 g. The larger fragment from SC G3E shows evidence of utilization along one margin.

Taxonomic composition. The surface collection assemblage is dominated by fish remains (83% of total by NISP and 97% by weight; Table 3) with the most common items being the distinctive lenticular otoliths (18 examples) of Ariidae (forktail or hardhead catfish). Other remains include one fragment of freshwater turtle (family Chelidae) carapace or plastron, three fragments of molars of agile wallaby, and one small fragment of a mammal long-bone shaft. Metrics showing size and shape attributes of the sample of ariid catfish otoliths in the Kina surface collection sample are shown in Table 4.

Kina: excavated assemblages

Small quantities of faunal remains are available from five excavated units in Square NE (labelled NE1–5) and four excavated units in adjacent Square SE (labelled SE1–SE5). Only vertebrate remains have been analysed.

Table 4. Kina: metric attributes (mm) of ariid catfish otoliths in surface collection.

	length	depth	thickness
n	10	12	15
average	10.75	9.83	5.88
minimum	8.00	7.00	3.10
maximum	15.95	13.55	10.50
stand. dev.	2.12	1.73	1.95

There is no obvious pattern in the vertical distribution of remains with the largest quantity found in Level 4 of Square NE and Level 1 of Square SE. When the samples are pooled by unit across the two squares the quantity of vertebrate remains varies from 6.4 to 12.9 g per unit, with the greatest quantities in each of Unit 1 and 4.

Physical state of remains. The physical state of the remains is broadly consistent with the surface collection sample and there is no obvious sign of progressive degradation with depth. The relatively good preservation state of the vertebrate remains is probably due in large part to the presence in Units 1–3 of abundant mollusc remains that may have buffered the natural acidity of the soil (Table 2).

Taxonomic composition. Fish are dominant at all levels in both squares by both NISP and weight (Tables 5 and 6). Ariid catfish are represented in almost all levels, identified either from their otoliths, tooth bearing elements, or distinctive cranial plates that bear a linear, nodular ornamentation. No other fish taxon could be identified with certainty from the fragmentary remains.

Turtle remains are present in small quantities in four out of five levels in Square NE but are absent from Square SE. Other groups of vertebrates are represented by occasional fragments, including moderately large individuals of python and goanna, a medium-sized mammal (possum-sized), flying foxes (*Pteropus* spp.), and small to medium-sized rodents.

None of excavated bone fragments tentatively identified as coming from mammals are large enough to be from agile wallabies. Ariid catfish are proportionally less abundant in the excavated samples than in the surface collection, presumably because of the high visibility and robusticity of these distinctive objects. A total of 10 ariid otoliths are present in the excavated samples; these are consistent in size with those collected on the surface of the deposit (Table 7).

Table 5. Kina: taxonomic composition of the excavated faunal remains recovered from Squares NE and SE. Data are summarized by NISP.

	NISP								
	Ariidae	Teleost indet.	Chelidae	Pythonidae	<i>Varanus</i>	medium-sized mammal	Muridae	<i>Pteropus</i>	mammal indet.
NE1	3	5	1	—	—	—	—	—	1
NE2	12	23	2	—	—	1	1	—	3
NE3	1	11	—	2	—	—	1	—	1
NE4	5	65	2	—	—	—	—	—	5
NE5	1	35	1	—	—	—	—	1	3
SE1	4	12	—	—	1	—	—	1	4
SE2	—	—	—	—	—	—	1	—	—
SE3	2	26	—	—	2	—	—	—	2
SE4	2	3	—	—	—	—	—	—	1
NE and SE pooled									
1	7	17	1	0	1	0	0	1	5
2	12	23	2	0	0	1	2	0	3
3	3	37	0	2	2	0	1	0	3
4	7	68	2	0	0	0	0	0	6
5	1	35	1	0	0	0	0	1	3
total	30	180	6	2	3	1	3	2	20

Bone artefacts. Two definite and one probable bone artefacts are identified within the submitted samples. Two came from Square NE Unit 1; one from Square NE Unit 4. Meehan *et al.* (1985: 150) mentioned a “broken bone point” from Unit 1, no doubt the same specimen.

The example from Square NE/1 is a fragment of a bone point that has been produced by scraping. The fragment weighs 0.02 gm and is formed on unburnt bone. The raw material appears to be a sliver of cortical bone of a mammal or reptile. The fragment is 16.1 mm long and is ovate in cross-section at the base, measuring 4.45 mm in width and 3.25 mm in perpendicular thickness. The tip shows no obvious use-related wear or damage.

The specimen from Square NE/4 is a fragment of bone point; the surface of the bone fragment is partially obscured

Table 6. Kina: taxonomic composition of the excavated faunal remains recovered from Squares NE and SE. Data are summarized by weight (g).

	weight (g)								
	Ariidae	Teleost indet.	Chelidae	Pythonidae	<i>Varanus</i>	medium-sized mammal	Muridae	<i>Pteropus</i>	mammal indet.
NE1	1.8	0.59	0.48	—	—	—	—	—	0.02
NE2	4.21	2.00	0.49	—	—	0.30	0.01	—	0.20
NE3	0.06	1.34	—	0.29	—	—	0.22	—	0.01
NE4	1.50	8.77	1.54	—	—	—	—	—	0.33
NE5	1.39	4.12	0.44	—	—	—	—	0.07	1.10
SE1	2.50	3.92	—	—	0.54	—	0.33	—	0.34
SE2	—	—	—	—	—	—	0.12	—	—
SE3	0.15	3.12	—	—	0.94	—	—	—	0.27
SE4	0.10	0.49	—	—	—	—	—	—	0.10
NE and SE pooled									
1	4.30	4.51	0.48	0	0.54	0	0.33	0	0.36
2	4.21	2.00	0.49	0	0	0.30	0.13	0	0.20
3	0.21	4.46	0	0.29	0.94	0	0.22	0	0.28
4	1.60	9.26	1.54	0	0	0	0	0	0.43
5	1.39	4.12	0.44	0	0	0	0	0.07	1.10
total	11.71	24.35	2.95	0.29	1.48	0.30	0.68	0.07	2.37

by a thin encrustation thus creating some uncertainty about the extent of modification and/or usage. It weighs 1.2 g and has a maximum length of 16.0 mm but the presumed functional tip is broken off. The maximum width of 4.5 mm is observed at the base where the cross-section is ovate, with a perpendicular thickness of 2.8 mm. It is manufactured from an unburnt sliver of a long-bone shaft, most likely of a medium-sized mammal, possibly a brushtail possum.

The probable specimen from Square NE/1 is a burnt but otherwise unmodified teleost bone. The fragment weighs 0.05 g and has a maximum length of 11.6 mm, maximum width of 4.7 mm. All ridges and edges are covered with a network of fine scratches and polish, indicating heavy utilization.

Adelaide River: excavated assemblages

There is marked variation in species between the top and bottom of the Adelaide River deposits reflecting changing conditions on the floodplains during the Big Swamp Phase, through the Transition and Freshwater Phases, until contact. Estuarine shell is located at the base, which was replaced by increasing quantities of fish bone. The upper layers are dominated by large quantities of turtle remains, with glass and metal objects on the surface (Brockwell, 2009). However, for the purposes of this analysis, we present results from the Late Freshwater Phase only to make the Adelaide River assemblages comparable with the Kina assemblage dated to the same chronological period (Table 2).

Table 7. Kina: metric attributes (mm) of ariid catfish otoliths in the excavated samples.

	length	depth	thickness
n	8	9	10
average	12.08	10.24	5.60
minimum	9.50	8.30	3.50
maximum	14.35	12.60	7.20
stand. dev.	1.77	1.56	1.14



Figure 2. Adelaide River bone points (Adelaide River collection, MAGNT; photograph by Darren Boyd).

Physical state of the remains. The fragmented nature of the fauna means that much of it remains unidentified. As the analysis examines the distribution of fauna by weight through the deposits, it must be borne in mind that the results can be regarded only as gross indicators of foraging strategies. The fragmented state of the faunal remains and the amount that could not be identified, as well as the taphonomic factors (extremes of wet and dry seasons, exposure on open sites, trampling by feral buffalo) in operation at the sites, mean that delicate species are probably under-represented or entirely undetected.

Taxonomic composition. The following information is summarized from Brockwell (2009: 91–108). A sample of 5961.0 g of faunal remains was examined from MP2, of which 1448.5 g was identifiable in the Late Freshwater Phase (Tables 2 and 8). The range of fauna includes the remains of both floodplains and woodland taxa. Freshwater turtle is the dominant taxon represented in the Late Freshwater Phase, mainly carapace fragments that have been identified as long-necked turtle (*Chelodina rugosa*). This freshwater species typically inhabits swamps, billabongs, and waterholes across northern Australia today (Cogger, 2018). Other taxa include large and small mammals, including macropodids, possums, and rodents, as well as birds, snakes, goannas, and fish. Fauna identified to species level include the remains of the Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*), Dusky Rat (*Rattus colletti*), Barramundi (*Lates calcarifer*), Forktail Catfish (Ariidae), and Threadfin Salmon (family Polynemidae).

There were only 8.9 g of faunal remains in MP5, 2.0 g of which could be identified in the Late Freshwater Phase. A limited number of taxa were represented at this site, including goanna, turtle, fish, and forktail catfish (Table 8).

The total weight of faunal remains in MP6 is 1839.1 g, of which 45.4 g was identifiable in the Late Freshwater Phase. A similar range of fauna was present as at MP2, consisting of macropodid, rodent, bird, reptile, snake, goanna, freshwater turtle and fish. The only fauna identified to species level were barramundi (*Lates calcarifer*), and forktail catfish (Table 8).

Bone artefacts. Twenty-seven bone points were recovered from the Adelaide River excavations, however only two were from the Late Freshwater Phase, one from MP2 (spit 6) and one from MP6 (spit 3). These bone points are described in detail in Brockwell & Akerman (2007) (Fig. 2).

Discussion

Wetland systems situated on the coastal plains of northern Australia are of recent origin, dating from the stabilization of post-Pleistocene sea level rise c. 6000 years BP. The floodplains associated with major rivers have evolved through a sequence of mangrove forests and saline mudflats to freshwater wetlands from c. 2000 years BP. As freshwater wetlands are highly productive ecosystems home to a diverse variety of fauna and flora, they were a focus of food and material culture extraction for Aboriginal populations in the late Holocene (Brockwell, 1983). Faunal species available from the wetlands differ according to location, though generally they include mammals, waterbirds and their eggs, reptiles and their eggs, fish, and shellfish, which can be classified as seasonal staples.

Analysis of the of Adelaide River sites (Brockwell, 2009; Brockwell & Akerman, 2007) suggests that, in the Late Freshwater Phase, the sites of MP2, MP5 and MP6 continued to be occupied from the Early Freshwater Phase when they were first established (Table 2). An increase in the discard rate of stone artefacts in the same phase indicates lower residential mobility perhaps reflecting the increased productivity of the floodplains. Faunal assemblages are dominated by the remains of turtles (> 80 %) with lesser quantities of fish (Table 8). The proportion of woodland fauna is low, and estuarine shellfish and marine species are absent (Brockwell, 2009: 104, 107). The small quantities of fish in Late Freshwater Phase assemblages represent the end point of a decline that follows a peak representation of fish remains (at around 60%) during the Transition Phase c. 4000 BP to 2000 BP, when the floodplains were a mosaic of estuarine, freshwater, and hypersaline flats (Brockwell & Akerman, 2007).

Table 8. Adelaide River and Kina: proportions of vertebrate fauna for the Late Freshwater Phase by weight (after Aplin, 2016; Brockwell, 2009).

site	mammal	bird	reptile	turtle	fish	wt (g)
Adelaide R/MP2	3%	1%	1%	85%	10%	1448.5
MP5	0%	0%	6%	77%	17%	2.0
MP6	1%	1%	1%	82%	15%	45.4
Adelaide R total	3%	1%	1%	85%	10%	1495.9
Kina surface	2%	0%	0%	1%	97%	45.7
excavation	7%	0%	4%	7%	82%	44.2
Kina total	7%	0%	3%	5%	85%	89.9

The composition of the Kina faunal assemblage does not conform with this regional model. In particular, the quantity of fish bone in the site greatly exceeds that of all other vertebrate groups and, while turtle is present in several levels, it does not comprise the dominant class of faunal remains at any point within the sequence (Table 8; Aplin, 2016). This makes the Kina faunal assemblage more like the Adelaide River assemblages dated to the Transition Phase, which were also dominated by fish. The substantial quantities of freshwater shellfish in the Kina deposit reported by Meehan *et al.* (1985) also seem at odds with the general model.

A broadly contemporaneous faunal assemblage was reported by Shine *et al.* (2013) from the upper levels of the Birriwilk site on the East Alligator River. Although this is a rockshelter rather than a mound site, it is positioned adjacent to Birriwilk Lagoon. Excavation units 8–12 of the Birriwilk site date to c. 300–150 years BP. The faunal assemblage from these levels consists of 36% fish bone (with Ariidae well-represented), 16% turtle and 48% unidentified, with the latter category probably made up of fragmentary turtle bone, as well as smaller quantities of mammal remains and other reptile bone. Only small quantities of shellfish were found in this deposit, which clearly presents an aggressive chemical environment for preservation. This assemblage differs from the Kina assemblage mainly in the higher representation of turtle remains and, in this respect, it conforms more closely to Brockwell and Akerman's (2007) expectation for a Late Freshwater Phase assemblage.

Foley (1985) reported the taxonomic composition of two collections made from loose surface contexts in two rockshelter sites in Kakadu National Park—Anbangbang I and Djuwarr I. Both assemblages were dated no older than 1200 years BP (Jones & Johnson, 1985) and presumably dated from the Contact and/or the Late Freshwater Phases, as defined by Brockwell (2009; Brockwell & Akerman, 2007). Both contained small quantities of turtle and fish bone, the latter dominated by the remains of ariid catfish. However, these exceptionally well-preserved assemblages differ from each of the Kina and Birriwilk assemblages in the much greater abundance of flying foxes, bandicoots, and terrestrial reptiles (especially Agamidae and Varanidae), as well as the presence of a wide variety of other mammals and birds. The majority of these taxa are usually still recognizable in highly degraded assemblages, typically from fragmentary teeth and foot bones in the case of bandicoots, fragments of dentaries and teeth in the case of flying foxes, and fragmentary dentaries and vertebrae in the case of the

reptiles (Foley, 1985). The contrast between the two sets of assemblages is thus unlikely to be due entirely to differential preservation, and more likely reflects a greater emphasis on the faunal resources of the wetland system adjacent to each of the Kina and Birriwilk sites.

In the same way, the occupants of Kina and Adelaide River sites are clearly foraging the same set of vertebrate fauna from the freshwater wetlands and surrounds, just in different proportions. Therefore, the differences between these assemblages probably relate to differential availability of wetlands resources due to environmental differences between regions and/or seasonality.

We suggest here that both explanations are probable. The topography of the two floodplains where the sites are located differs. Kina is located next to a perennial backwater swamp whereas the Adelaide River mounds are located next to a discrete seasonal water body (Brockwell, 2001). Both turtles and fish are foraged from the northern wetlands in the early, mid and late dry season (Brockwell, 1989: 249, table 7.1). Fish are particularly easy to catch in the late dry season when they become stranded in pools of water and billabongs on the floodplains. Kina is located below the wet season flood level, and so would have been occupied only during the mid to late dry season when flood waters had retreated (Meehan *et al.*, 1985). Whereas the Adelaide River sites were probably only occupied in the early dry season as the adjacent lagoon dries out by the middle of the year (Brockwell, 2006).

The ethnographic evidence confirms that traditional owners of the South Alligator River occupied floodplains sites in the mid to late dry season, where they exploited a variety of aquatic resources, obtaining different items from different sites, according to season and resource availability (Meehan *et al.*, 1985). Waterlilies, spike rush, freshwater turtles, file snakes, and various fish species (barramundi, catfish, and mud cod) were exploited at Kina. In the wet season, they foraged the open woodlands on the higher ground behind the floodplains, hunting possums and wallabies and gathering yams and wet season fruits. During the late wet season, they returned to the floodplains and harvested geese, cormorants, and goose eggs (Meehan *et al.*, 1985).

The absence of larger wallaby remains in the Kina assemblage is puzzling, especially as Meehan *et al.* (1985: 147–148) interpret the construction of the mound as being largely a product of accumulation of termite mound material imported specifically to roast wallaby-sized game in earth

ovens. Presumably the same method was used to roast catfish and other smaller game items but the quantities of oven materials required may be considerably smaller; if so, the estimates of rate of accumulation of the mound through this mechanism may require revision.

The otoliths from the Kina excavation are consistent in size with those from the surface collection (Table 7). This fact suggests that similar size fish were being targeted over time, perhaps using a consistent method of capture. Interestingly, and unlike Kina, otoliths are missing entirely from the Adelaide River assemblages (Brockwell, 2009: 94), although they are a common feature of the faunal collections from excavated shell middens in the Darwin Harbour region (Bourke, 2000). It seems that because they are made of aragonite, a crystalline form of calcium carbonate, they are prone to decay in acidic conditions even though the cranial bones surrounding them may survive (Colley, 1990: 214). Like the Darwin Harbour shell mounds, the presence of otoliths in the Kina excavation is likely due to favourable alkaline preservation conditions created by the presence of shell (Meehan *et al.*, 1985: 150).

Comparison of bone artefacts

Small bipoints made of bone are present throughout the archaeological record of the Adelaide River sites (Brockwell & Akerman, 2007). Their use continued into recent times as components of single and multi-pronged spears used to hunt aquatic resources, such as fish, tortoises, and water snakes (Spencer, 1914: 357). They have also been recorded as being used as sorcery items and worn in nasal septa (Akerman, 1995). Most of the bone points from the Adelaide River sites are from the Transition Phase (c. 4000–2000 years BP) when highest proportion of fish remains were recorded. Thus, these bone points have been attributed as barbs on fishing spears (Brockwell & Akerman, 2007).

Within Kakadu National Park, the site of Anbangbang 1 produced numerous small bipoints in loose surface deposits that date to within the last 1200 years (Jones & Johnson, 1985: 60–61). Schrire (1982) also reported numerous bone bipoints, unipoints, and spatulate points from her excavations in rockshelters north of Kakadu.

Two of the modified bones from Kina are comparable to this regional sample of bipoints, although neither of them is sufficiently complete to be certain of its original form. In particular, the maximum widths of around 3–5 mm for the Kina points are consistent with the Adelaide River samples (Fig. 2; Brockwell & Akerman, 2007; Langley, 2018). Similarly, they were most likely used as components of fishing spears, given the high proportion of fish remains at the Kina site.

The third example from Kina is a utilized but otherwise unmodified fish bone. It presumably represents an example of expedient use of a natural element of suitable shape. This clearly represents a different class of implement to the bipoints and, to our knowledge, there are no comparable specimens from other regional sites. However, careful examination of other assemblages is likely to reveal other examples of expedient use of fish bone for penetrative functions.

Conclusion

This paper has described a faunal assemblage from the earth mound site of Kina located on the edge of the South Alligator River floodplains and compared it with those from the Adelaide River floodplains. These assemblages attest to Aboriginal foraging from freshwater wetlands in the late Holocene, immediately prior to contact. While the sites contain the same range of fauna, and similar extractive technology in the form of bone points, they demonstrate a different emphasis on subsistence strategies; Kina (South Alligator River) has a higher proportion of fish remains, while the Adelaide River sites contains a higher proportion of turtle remains.

These differences appear not to be due to preservational factors but rather the result of differences in topography and seasonality of occupation between the two river systems. Fish and turtle are traditionally caught from the wetlands in the dry season. The billabong next to the Adelaide River sites is ephemeral and dries out by mid dry season. Kina lies next to a perennial water body, which can be used late into the dry season when fish are easily caught in shallow pools of water. The comparison of these faunal assemblages emphasises the point made previously by Brockwell (2001: 336–337) that post 2000 years BP, although the freshwater floodplain systems of the Top End appear superficially similar, there are differences that have led to distinct archaeological land use patterns. Future investigations should take this into account.

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