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UNDERSTANDING ARCHAEOBOTANY THROUGH ETHNOBOTANY: AN EXAMPLE FROM GOONIYANDI COUNTRY, NORTHWEST, WESTERN AUSTRALIA

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Abstract

During archaeological excavation of Moonggaroonggoo, northwest Western Australia, ethnobotanical survey and botanical collection undertaken in collaboration with Traditional Owners helped to identify which plants were of economic importance, provided information on modern vegetative communities and documented narratives of contemporary Gooniyandi plant use. By extending the project's focus to include traditional ecological knowledge (TEK) in the cultural landscape beyond excavations, we identified distinct ecological areas of economic significance. Excavation in three rockshelters at Moonggaroonggoo revealed late Holocene deposits with limited preservation of plant remains. Therefore, the TEK was applied to another archaeological site located on Gooniyandi ancestral lands: Riwi. Collaborating with local experts to document local botany we contribute narratives on plant use in the present which have important implications for archaeological interpretations of past plant use. By engaging with macrobotanical remains as a form of material culture, we encourage a deeper understanding of plants and their socio-economic role in Aboriginal lifeways.

Introduction

Plants have played a fundamental role in human evolution and dispersal across the globe. Botanical knowledge and plant-based technologies are considered an integral part of the colonising repertoire required for the successful migration from Island Southeast Asia to Sahul (Australia, New Guinea and the Aru Islands) (e.g., Balme 2013). Aboriginal groups entering the tropical north at least 65,000 years ago (Clarkson et al. 2017) encountered some familiar Indo-Malaysian plants (Golson 1971) as well as unfamiliar Australian flora. In some instances new species required the development of specific knowledge and/or skills to be able to successfully incorporate them into people's diets and their plant-based technologies. Ecological knowledge undoubtedly aided the expeditious expansion of people across the Australian continent and played an important role in the colonisation of all major biomes by 40,000 years ago (Balme 2013; Florin and Carah 2018; O'Connell and Allen 2004, 2015).

Two archaeological sites located in the Kimberley region, northwest Western Australia (WA)—Carpenter's Gap 1 and Riwi (Figure 1)—provide exceptionally well-preserved evidence for past plant use. Analyses of the macrobotanical assemblages recovered from these sites show strong cultural preferences for monsoon rainforest taxa (Dilkes-Hall et al. 2019, in press [c]). Selective procurement of food plants from monsoon rainforest ecozones—where many fruiting species cluster—indicate that use of these sites occurred on a seasonal basis during wet/humid periods (Dilkes-Hall et al. 2019, in press [c]). Economic resource patterning plays an important role in the lifeways of Aboriginal groups and macrobotanical remains suggest subsistence strategies were developed to best engage with and exploit known and predictable plant resources.

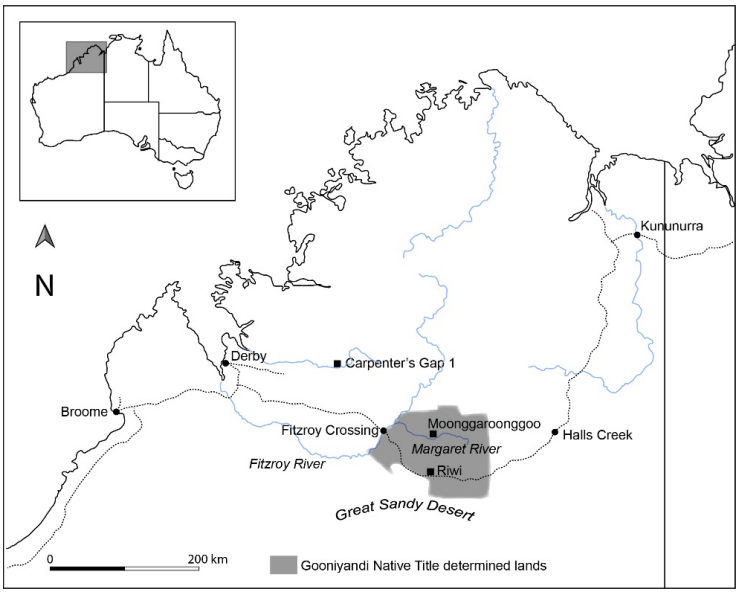

Figure 1 Location of the archaeological sites mentioned in text (modified from Dilkes-Hall et al. 2019). Native title determined lands after Kimberley Land Council (2019).

Today, despite negative impacts from European colonisation post-1788, Aboriginal people across northern Australia, as elsewhere, maintain links and intimate knowledge of Country and traditions associated with plant collection, processing, use and management (e.g., Crawford 1982; Davis et al. 2011; Edgar et al. 1997; Karadada et al. 2011; Nuggett et al. 2011; Paddy et al. 1993; Smith and Kalotas 1985; Wightman 2003). However, ethnobotanical records are disproportionate and, specifically, in the south central Kimberley little information was available for the Gooniyandi language group, constraining interpretations of plant use in the past at Riwi (Dilkes-Hall 2014).

Following the 2013 excavations of Riwi, Gooniyandi Traditional Owners expressed interest in excavating Moonggaroonggoo, a rockshelter located 47 km north of Riwi (Figure 1). During the early stages of the project Gooniyandi Traditional Owners identified ethnobotany[1] as a major focus of any future research (Maloney et al. 2017) presenting a unique opportunity to document the local knowledge and resources to aid in the interpretation of macrobotanical archives from the area.

During October 2016, excavations at Moonggaroonggoo saw six Gooniyandi Traditional Owners come together on Country. An unplanned aspect of the project was that it coincided with school holidays and several families from nearby Muludja community joined us presenting a window of opportunity for elders to engage with and teach children while on Country. Consequently, the ethnobotanical aspect of the project became twofold: to gather information to aid macrobotanical research; and to document Gooniyandi traditional ecological knowledge (TEK) and language.

This paper highlights the value of combining local TEK with archaeological investigations to help extract archaeobotanical information from its original intellectual framework, otherwise dominated by modern Western scientific traditions. We use the results to aid interpretation of Riwi's macrobotanical assemblage and discuss the implications of this research for understanding plant use in the past in the south central Kimberley. Finally, we give consideration to some of the differences between Aboriginal and Western scientific traditions that became apparent during this project in regards to the collection, storage, curation and dissemination of botanical knowledge.

[1] Defined here as the documentation of traditional ecological knowledge and language coupled with the collection of scientific voucher specimens.

Regional Setting

The unique Kimberley bioregion in the Australian Monsoon Tropics biome is one of the most stable and biodiverse landscapes worldwide (McKenzie et al. 1991; Pepper and Keogh 2014; Ward et al. 2005). The climate is dominated by the summer monsoon with high seasonality and high evapotranspiration rates producing distinct wet and dry seasons (Beard 1979; Wheeler and McBride 2005, 2012). Temperatures are high year round and 70% of precipitation is experienced from January to March, with areas in the extreme north exceeding 1300 mm per annum, though the south central Kimberley study area receives on average 500–400 mm of rain annually (Bureau of Meteorology 1996). Generally, vegetation in this intermediate rain fall zone is tolerant to semi-arid conditions and characterised by sparse low *Eucalyptus-Corymbia* woodlands and medium height *Triodia* grasslands (Beard 1979).

The Study Area

Moonggaroonggoo is an isolated limestone outcrop approximately 65 km east of Fitzroy Crossing (Figure 1). Gooniyandi people know the area surrounding Moonggaroonggoo as Larrmarloowa. European settlement of the Kimberley began in the 1880s and today the site is situated within the pastoral lease of Fossil Downs Station. Larrmarloowa is a place of great cultural and spiritual significance and many Dreaming narratives associated with geological formations are embedded within the surrounding landscape. Moonggaroonggoo is described by Gooniyandi Traditional Owners as an important camping area for ancestors who would always return to the site no matter how far they travelled for ceremonies and trade.

In the 1960s Ian Crawford (1964) visited the site with Gooniyandi people and described the rockshelters, rock art panels, ledge burials and collected surface stone artefacts. Moonggaroonggoo has multiple rockshelters around the base of the outcrop (Figure 2a). The three main rockshelters of archaeological interest are east facing and large enough to protect medium-sized groups of people from the elements. Shelters 1 and 2 are at ground level with rock fall forming a boundary between them (Figure 2b). Shelter 3 is situated approximately 35 m above ground level and overlooks the plains to the east towards the Margaret River (Figure 2b). Walls in each

rockshelter display paintings, although the most elaborate rock art decorates Shelter 3 and depicts waterlilies (*Nymphaea* spp.) (Figure 2c), suggesting enduring people-plant relationships. An ephemeral creek that flows during the wet season is located approximately 100 m east of the site. A large pool formed by the Margaret River, Mamandaya, is the closest permanent water source during the dry season, situated 1.8 km east of Moonggaroonggoo.

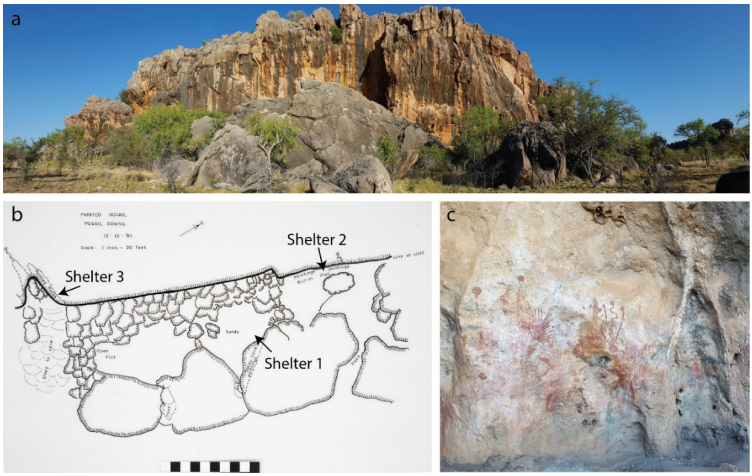

Figure 2 (a) Eastern face of Moonggaroonggoo, (b) Shelters 1, 2 and 3 (modified from Crawford 1964) and (c) Shelter 3 rock art showing painted depictions of waterlilies.

Cultural materials recovered from Moonggaroonggoo's deposits include stone artefacts, vertebrate faunal remains, marine and freshwater shell, avian eggshell, ochre, charcoal and macrobotanical remains (Maloney et al. 2017). Details on the Moonggaroonggoo excavation, stratigraphy and chronology are provided in Maloney et al. (2017). The site dates from the late Holocene (2844–2737 cal BP) to the present (Maloney et al. 2017). Macrobotanical analysis of the Moonggaroonggoo assemblages revealed that only a small number of species were represented (n=6) and preferential preservation of *Celtis*

strychnoides endocarps (Dilkes-Hall in press [a]). These remains cannot be reliably linked to cultural activities and instead the assemblage is interpreted as reflecting the local vegetation surrounding Moonggaroonggoo (Dilkes-Hall in press [a]).

In contrast, the Riwi site has extraordinary preservation of macrobotanical remains, particularly in deposits dated to the mid- (7421–5905 cal BP) and late Holocene (915–668 cal BP to present) (Balme et al. 2019; Dilkes-Hall 2014; Dilkes-Hall et al. in press [c]), meaning there is temporal overlap between the late Holocene occupation at both Riwi and Moonggaroonggoo. Balme et al. (2019) provided details on the Riwi site, excavation, stratigraphy, chronology and archaeological remains. Analysis of Riwi's macrobotanical assemblage demonstrates that specific types of remains are clearly associated with past human activities, in particular that people targeted monsoon rainforest ecozones to collect food plants (Dilkes-Hall et al. in press [c]). However, the limited ethnobotanical information for the area has restricted interpretations to date, and Gooniyandi narratives are absent.

Methods

Six senior Gooniyandi Traditional Owners, June Davis (JD), Helen Malo (HM), Edna Cherel (EC), Mervyn Street (MS), Willy Cherrabun (WC) and Bobby Cherel (BC), together with archaeologists Tim Ryan Maloney (TRM) and India Ella Dilkes-Hall (IED-H), took part in botanical survey and plant collection during the 2016 excavations at Moonggaroonggoo. TEK of plant use was predominately recorded with the Gooniyandi women although the men joined in some discussions intermittently when relevant to their activities.

At the beginning of this research three primary locales of economic plant foods were identified by elders: the rockshelters and base of Moonggaroonggoo; the surrounding open plains (Birndirri); and Mamandaya waterhole (Figure 3). In the case of Moonggaroonggoo, each rockshelter and the base of the outcrop was surveyed by foot, while the surrounding plains were surveyed by a combination of foot and vehicle, and Mamandaya was surveyed on foot. A few hours per day over seven days of fieldwork were dedicated to discussing plants and

recording plant use(s). Photographs, voice recordings, videos and field notes were collected during these sessions.

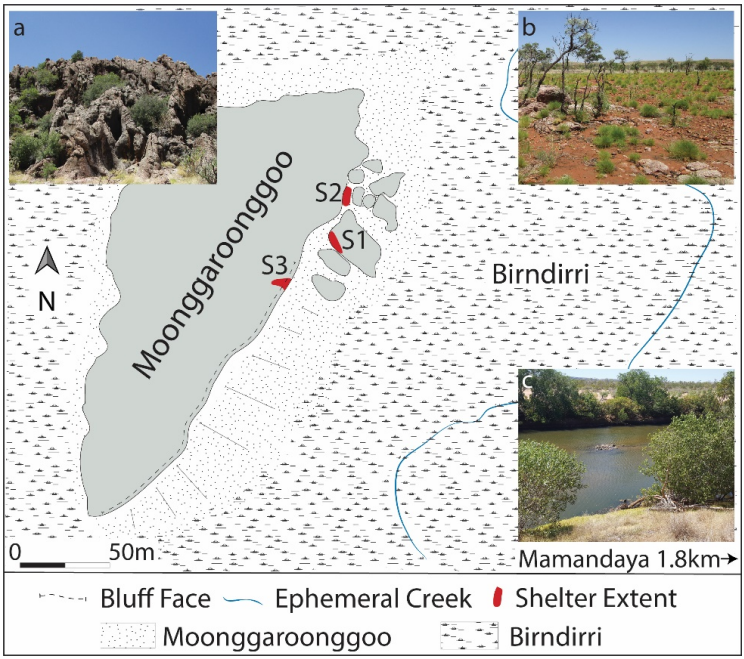

Figure 3 The three ecological zones identified by Gooniyandi elders: (a) Moonggaroonggoo, (b) Birndirri and (c) Mamandaya.

Fieldwork in the Kimberley is seasonal and takes place during the dry season (April to November) when the area is most accessible. However, the types of plants that can be collected at this time of year are restricted, as many plants do not retain flowers (necessary for identification purposes, see later) during these drier months. Plants identified as economically important, but not known to Gooniyandi elders taxonomically, were recorded and photographed before a sample was returned to Perth for identification following collection procedures developed by the Department of Biodiversity, Conservation and Attractions (2016). Field

identifications were assigned from a target taxa list compiled from key botanical resources (Beard 1979; FloraBase 2016; Wheeler 1992).

In the following sections taxonomic names are given with common names and Gooniyandi language names (when available) are provided in parentheses (but subsequently privileged) at first instance only at the request of Gooniyandi elders. All botanical information presented below has been provided by the Gooniyandi female co-authors and only where information has been provided by the male co-authors, is it cited as such.

As mentioned above, owing to preservation bias in Moonggaroonggoo's archaeological sites, plants documented as economically important were compared with taxonomically identified macrobotanical remains recovered from Riwi to determine which plants remain in use today, what their contemporary uses are and what types of environments they are collected from.

Results

Moonggaroonggoo

The Moonggaroonggoo rockshelter complex is described by JD as a night-time camp. Many plants growing around the base of the limestone outcrop were identified as economically important species. Fruiting food plants such as *Carissa lanceolata* (conkerberry, *biriyali*) (Figure 4a), *Ficus aculeata* (sandpaper fig, *yimarli*), *F. platypoda* (rock fig, *banggirndi*) (Figure 4b), *Flueggea virosa* (white current, *garn.gi*) (Figure 4c) and *Vitex glabrata* (black plum, *girndi*) (Figure 4d) were recorded in close proximity to all three rockshelters. Each of these plants produce edible fruits. Young *Cochlospermum fraseri* (kapok, *wanggoo*) plants grow around the outcrop and produce roots which are roasted, and eaten. Large *Celtis strychnoides* (celtis, *minthiwili*) trees grow amongst extensive limestone boulders providing shade and fruits which are eaten by birds and sometimes children.

Figure 4 Examples of economic plant species at Moonggaroonggoo: (a) biriyali, (b) banggirndi, (c) young garn.gi plant with HM, (d) girndi, (e) jirndiwili, (f) bambira and (g) rain stick being made by MS from the white wood of bambira.

Species associated with plant-based technologies were also identified. The lightweight woods of *Erythrina vespertilio* (bat's wing coral tree, *jirndiwili*) (Figure 4e) and *Gyrocarpus americanus* (helicopter tree, *jarlarloo*), which grow out from cracks in large rock boulders around the site, are used to make coolamons (carrying vessels), and the leaves of both plants can be burnt to repel mosquitoes. The red seeds of jirndiwili are also collected and threaded onto string for personal ornaments. Fire is created using the traditional friction method with fire sticks made from *Clerodendrum floribundum* and/or *Premna acuminata* (fire stick tree, *goonggala*) plants that grow within Shelter 2. *Atalaya hemiglauca* (whitewood, *bambira*) (Figure 4f) grows amongst the boulders between Shelters 1 and 2 and its timber is used for digging sticks (*gananyi*), fighting sticks (*moowoorroo*) and ceremonial objects such as rain sticks (Figure 4g) created by MS and WC for rain making ceremonies.

Birndirri

At the time of botanical survey Birndirri appeared particularly barren, with a hot fire having recently been through the area (Figure 3b). JD spoke of this late dry season fire as being 'wrong time', 'not good' and 'too hot'. These types of fires have catastrophic effects on undergrowth, shrubs and trees, which in turn affects native fauna populations (Preece 2002).

The Birndirri vegetation comprises scattered *Eucalyptus/Corymbia* tree steppe dominated by *Triodia* grassland, the bright green hummocks signifying regrowth after the recent fire (Figure 5a). *Eucalyptus-Corymbia* species growing on the plains are the major sources of fuel for campfires. Also on the sparse plains *Bauhinia cunninghamii* (bauhinia, *joowoorljidi*), a large sprawling tree, provides pockets of shade and its seeds can also be threaded onto string for necklaces. *Corymbia cadophora* subsp. *cadophora* (twin-leaf bloodwood, *yilangi*) was identified as an important food resource providing sugarbag (honey, *ngalinya*) and galls (bush coconut, *balabi*) (Figure 5b). Although yilangi does not produce edible fruit, balabi, induced by a female scale insect (genus *Cystococcus*), are edible, nutritious and highly sought after.

Figure 5 Examples of economic plant species from Birndirri: (a) *Triodia* grassland with a stand of wiliriny, (b) balabi and (c) lambilambi.

An important medicinal plant, *Senna venusta* (cockroach bush, *lambilambi*) (Figure 5c), grows on Birndirri. Lambilambi leaves and branches are boiled in water and the liquid used to bathe wounds and sores. The burnt bark of *Grevillea pyramidalis* (caustic bush, *wiliriny*) (Figure 5a) is used to darken the skin for ceremonies and the caustic sap is used in scarification rituals. Wooden tools, such as boomerangs and fighting sticks, are made from *Hakea arborescens* (yellow hakea, *booroowa*) trees (MS pers. comm.). Soft *Triodia* species are important sources of resin used primarily in the production of composite tools.

In stark contrast to the many fruiting species recorded around Moonggaroonggoo, not a single fruit bearing species of economic importance was recorded on our survey across Birndirri.

Mamandaya

On the high river banks looking down at Mamandaya the water is so clear that fish are visible swimming below. Mamandaya is described as a dry season day camp by JD with people walking the 1.8 km from Moonggaroonggoo in the early morning to avoid the heat and spend the day by the water collecting bush tucker, catching and cooking up crocodiles, fish, mussels, cherrabun (freshwater prawns) and turtles while relaxing on the terraced river banks. The banks are lined with economic plant species (Figure 6a). Botanical survey of this area was limited by the steepness of the riverbanks; however, riparian taxa that are economically important were pointed out from above.

Figure 6 Examples of economic plant species found at Mamandaya: (a) eastern side of river bank, (b) garn.gi, (c) goorroomba and (d) gooroo.

Food plants growing around Mamandaya include biriyali, garn.gi (Figure 6b), *Ficus* spp. and *Nauclea orientalis* (Leichardt pine, *marroora*). Plants used to manufacture tools include booroowa, marroora, *Melaleuca* spp. (paperbark, *goorroomba*) (Figure 6c), *Terminalia* spp. and *Tinospora smilacina* (snakevine, *jalaroo*). Goorroomba is used primarily for food conservation/storage and cooking. *Barringtonia acutangula* (freshwater mangrove, *gooroo*) (Figure 6d) bark is used as a fish poison and in small doses as a medicinal treatment for lesions. Other plant species important for medicine, fuel and/or shade include *Acacia*, *Corymbia* and *Eucalyptus* species.

Mamandaya also supplies aquatic plants of economic importance. Two species of waterlilies, *Nymphaea macrosperma* (*thanggari*) and *N. violacea* (*garringarri*), produce edible seeds, stems and roots, although these species were not encountered during fieldwork.

Overall, 33 economically important plants across the three ecological zones were identified during survey (Table 1). Twelve taxa were recorded around Moonggaroonggoo, while Mamandaya recorded the highest number of economic plants (n=19). The lowest number of taxa, seven, was recorded for Birndirri. Some taxa are present across more than one ecological zone.

Comparing Ethnobotany and Archaeobotany

Comparison of the results from the modern botanical survey with Riwi's archaeological macrobotanical remains shows that 12 of the 33 economically important plant taxa documented during the survey are identified in Riwi's archaeological record. These represent species from each of the three contemporary ecological zones (Table 1; Figure 7).

Table 1 Economic plants grouped by surveyed ecological zones with Gooniyandi language name, documented use/s, and presence/absence in Riwi's macrobotanical sequence marked X. Key for documented uses: AS-Ashes of bark used for mixing with chewing tobacco; F-Food; FC-Food conservation/storage; FN-Nectar; FW-Witchetty grub; FU-Fuel; IRP-Insect repellent plant; M-Medicinal; R-Ritual/ceremonial; PO-Personal ornamentation; POI-Poison; PBT-Plant-based technologies (e.g., wooden tools, rope, rafts, shelter, cooking, bedding, resin etc.); SI-Seasonal indicator; SH-Shade tree; SL-Sugar leaf; SU-Sugar bag.

Ecological zone	Taxonomic name	Gooniyandi name	Uses	Riwi
Moonggaroonggoo	*Atalaya hemiglauca*	Bambira	PBT, R, SI	
(rockshelters and	*Carissa lanceolata*	Biriyali	F, R, M	
base of outcrop)	*Celtis strychnoides*	Minthiwili	SH	X
	Clerodendrum floribundum	Goonggala	PBT	
	Cochlospermum fraseri	Wanggoo	F	
12 taxa	*Erythrina vespertilio*	Jirndiwili	PO, PBT, SI	
	Ficus aculeata	Yimarli	F	X
	Ficus platypoda	Banggirndi	F	X
	Flueggea virosa	Garn.gi	F	X
	Gyrocarpus americanus	Jarlarloo	IRP, PBT, T	
	Premna acuminata	Goonggala	PBT	X
	Vitex glabrata	Girndi	F	X
Birndirri	*Bauhinia cunninghamii*	Joowoorljidi	FN, PO, SH, SU	
(surrounding open	*Corymbia cadophora* subsp.	Yilangi	R, SU	
plains)	*cadophora*	Balabi (gall)	F	X
	Eucalyptus-Corymbia spp.		FU, FW, M, R, SU	X
	Grevillia pyramidalis	Wiliriny	R	
7 taxa	*Hakea arborescens*	Booroowa	FN, M, PBT	
	Senna venusta	Lambilambi	M	X
	Triodia spp.	Ngirri, warloowarloo, warrwa	PBT	X
Mamandaya	*Acacia* spp.		F, FW, M	X
(Margaret River	*Barringtonia acutangula*	Gooroo	M, POI	
waterhole)	*Bauhinia cunninghamii*	Joowoorljidi	FN, PO, SH, SU	
	Carissa lanceolata	Biriyali	F, R ,M	
	Eucalyptus camaldulensis	Bilirndi	M, POI, SU	
19 taxa	*Eucalyptus microtheca*	Goorlaalal	AS, FU, R, SL, SU	
	Eucalyptus-Corymbia spp.		FU, FW, M, R, SU	X
	Ficus coronulata	Joorloowoo	F	
	Ficus virens		F	
	Ficus spp.		F	X
	Flueggea virosa	Garn.gi	F	X
	Hakea arborescens	Booroowa	FN, M, PBT	
	Melaleuca leucadendra	Winthawoorroo	FC, PBT, R, SU	
	Melaleuca spp.	Goorroomba	FC, PBT, SU	X
	Nauclea orientalis	Marroora	F, PBT, SH	
	Nymphaea macrosperma	Thanggari	F	
	Nymphaea violacea	Garringarri	F	
	Terminalia spp.		PBT	X
	Tinospora smilacina	Jalaroo	PBT	

Figure 7 Macrobotanical remains recovered from Riwi documented as economic plants: (a) *Acacia* sp. Type A pod, (b) *Celtis strychnoides* endocarps, (c) *Eucalyptus-Corymbia* gall, (d) *Eucalyptus-Corymbia* capsule, (e) *Ficus* spp. fruits, (f) *Flueggea virosa* seeds, (g) *Melaleuca* spp. paperbark, (h) *Premna acuminata* endocarp, (i) *Senna* sp. seed, (j) *Terminalia* sp. Type A endocarp, (k) *Triodia* cf. *pungens* spikelets and (l) *Vitex* cf. *glabrata* endocarps.

Discussion

Archaeobotanical Implications

Gooniyandi knowledge (hereafter *binarri*) documented herein provides valuable narratives on past diet, subsistence strategies, mobility and several archaeobotanical signatures of plant exploitation. Riwi's macrobotanical assemblage offers an opportunity to compare the ethnobotanical results and examine plant use in the past. This approach is not an attempt to ignore the dynamic aspects of socio-cultural systems that stretch deep into the past but rather highlight and acknowledge binarri as a primary source of information to aid in interpretations of archaeological macrobotanical materials.

Plants observed during botanical survey and identified in Riwi's macrobotanical remains serve a variety of purposes, including primary food sources, and also secondary food sources such as sugarbag and witchetty grubs, food conservation/storage, fuel, medicine, plant-based technologies and shade, as well as fulfilling certain ceremonial roles (Table 1). Plants from each ecological zone are represented at Riwi (Table 1) suggesting that people exploited a broad resource base. Of the 12 taxa represented at Riwi that were documented during the survey, five are important food plants (*Acacia* spp., balabi, garn.gi, girndi and figs [*Ficus* spp.]), the latter three of which are monsoon rainforest food plants recorded growing in the immediate vicinity of Moonggaroonggoo (Figure 7f, l and e). Similarly, garn.gi and figs were recorded growing across the limestone range at Riwi (Whitau et al. 2017). In the southern Kimberley, monsoon rainforest plants have a very restricted distribution (McKenzie et al. 1991) and their direct association with limestone ranges and outliers indicates these geological formations were likely important in patterns of subsistence and mobility.

Figs and girndi are abundant in the mid- and late Holocene deposits at Riwi suggesting they were important food plants, while garn.gi was recovered only in small quantities in the site's late Holocene deposits (Dilkes-Hall et al. in press [c]). Dilkes-Hall et al. (in press [c]) suggest use of the site occurred seasonally, as these species fruit during *yidirla* (wet season) (Davis et al. 2011). To prevent spoilage, seasonally abundant fruits were collected and stored dry in paperbark (*Melaleuca*

spp.; JD pers. comm.); fragments of the latter were also recovered from Riwi (Figure 7g). Different parts of girndi are represented (whole fruits, whole endocarps, fragmented endocarps and calyces), indicative of fruit processing activities (Dilkes-Hall et al. in press [b]).

Acacia sp. Type A pods (Figure 7a) were recovered from Riwi's mid- and late Holocene deposits, although more numerously in the former (Dilkes-Hall et al. in press [c]). In comparison, very few *Acacia* sp. seeds were recovered. JD says people would gather the beans (pods), cook them in the hot sand and eat the seeds. A cooking and consumption practice such as this would leave only the pods as waste by-product to be incorporated in the archaeobotanical record, as observed at Riwi.

Balabi is an insect-induced gall with a hard outer layer and an edible coconut-like inner lining that is eaten with the grub (Semple et al. 2015; Yen et al. 2016). Balabi have important nutritional value (Miller et al. 1993; Semple et al. 2015; Yen et al. 2016) and JD recalled stockmen relying on balabi when water was not available on long droving trips. Preserved in the late Holocene deposit at Riwi is one hard, woody outer layer of balabi with the distinct small apical hole (Figure 7c).

The retention of ecological binarri to the present, and the archaeological evidence from Riwi, demonstrate continuity of Gooniyandi subsistence practices through time. Specifically, the presence and quantities of girndi and figs in both mid- and late Holocene deposits show a strong cultural preference for these food plants stretching back around 7000 years. By comparing ethnobotanical results with macrobotanical remains that represent food plants we have improved interpretations of which plants were likely used in the past for food and provided Gooniyandi narratives for these macrobotanical remains.

The medicinal plant, lambilambi (*Senna* sp. [Figure 7i]), is represented at Riwi by seeds and papery pods. Lambilambi leaves and branches are boiled to make medicine from this plant. At Riwi, people may have discarded plant parts not used medicinally, leaving seeds and pods as archaeobotanical signatures.

Other types of macrobotanical remains from Riwi provide evidence of plant-based technologies. *Triodia* is represented in the site by spikelets, leaves and roots. *Triodia* species provide resin and the important role of resin production is exemplified by three Gooniyandi words used to differentiate different types of *Triodia* used for resin; *ngirri* (small round spinifex), *warloowarloo* (soft spinifex) and *warrwa* (large round spinifex). To extract resin, whole clumps of *Triodia* are threshed and resin dust is separated from chaff (e.g., large and small plant fragments such as spikelets, leaves and roots) by winnowing and yandying (Pitman and Wallis 2012:112). At Riwi, the different plant parts of *Triodia* may represent waste products from resin extraction also indicated by resin adhering to a tula adze (Balme et al. 2019:44). Alternatively, *Triodia* is used at Riwi as a wrapping (Balme 2000:4) and its presence may also indicate fibre manufacture to create string (Pitman and Wallis 2012), seven pieces of which were recovered from Riwi's Holocene deposits.

Terminalia species produce a gum that does not require processing but is used in similar ways to *Triodia* resin. A variety of *Terminalia* species are known to be economically important food plants to Aboriginal groups in the eastern (Bardi) and western (Kija and Jaru) Kimberley (Edgar et al. 1997; Scarlett 1985; Smith and Kalotas 1985; Wightman 2003). Edible *Terminalia* fruits have a stony drupe which are the only types of macrobotanical remains at Riwi identified from these plants (Figure 7j). Although edible *Terminalia* fruits were not documented with Gooniyandi elders due to seasonal availability *Terminalia* spp. macrobotanical remains are likely to represent the discarded inedible portion of these fruits.

Another important technology is the ignition and use of fire. A common method used to create fire today is the fire-drill, which consists of two separate pieces of wood, one operating as a hearth stick and the other, moving component, the drill (Akerman 1998; Clarke 2012; Davidson 1947). A hearth stick is most often made from a soft lightweight wood, while the twirling drill, requiring more strength, is fashioned from a harder timber (Clarke 2012). A fire drill recovered from Riwi's late Holocene deposits has been identified as Lamiaceae (Whitau et al. 2016). Gooniyandi elders indicate that the wood species is likely to be either *Clerodendrum floribundum* or *Premna acuminata*, both

soft lightweight woods belonging to the Lamiaceae family and commonly used in the fire-drill method.

A fragment of a wooden artefact from Riwi, directly dated to 651–557 cal BP (S-ANU 43337), was argued by Langley et al. (2016) to be the trailing tip of a hooked boomerang. Scarce literature available on Gooniyandi boomerang manufacture led Langley et al. (2016) to conclude, perhaps erroneously, that the artefact was probably traded into the region from southeast or northeast Kimberley. This interpretation was discussed with MS who produced photographs of his birth place, a spot on Gooniyandi Country situated underneath a boomerang tree, booroowa (*Hakea arborescens*). The booroowa tree in the photograph has a calloused scar which MS says is where a limb was removed to manufacture a boomerang.

Identification of the wood taxa used to manufacture the wooden artefact by Whitau et al. (2016) was proposed to be *Grevillea/Hakea* sp., corresponding with MS' TEK. Further investigation has brought to light a photograph taken in 1969 of senior Gooniyandi man, Jack Bohemia, making a hooked boomerang (Bohemia and McGregor 1995:6). Five Gooniyandi words are recorded for the different types of boomerangs that are manufactured, including *wirlgi*, a word used exclusively for hooked boomerangs.

Wood shavings, interpreted as evidence for wood working, were also recovered from Riwi (Whitau et al. 2016:540) and a boomerang is stencilled on the wall of the cave. Coupled with MS' narrative suggesting that boomerangs were made on Gooniyandi Country, we propose that it is likely that boomerangs were made in the southern Kimberley over at least the last 600 years, as they were in contemporary times.

Wood shavings, often described as waste products, are one way to observe people's engagement with wooden artefact manufacture in the past that would otherwise remain largely invisible archaeologically. Unfortunately, it was not possible to taxonomically identify the wood shavings recovered from Riwi but their presence may attest to wood working activities occurring on site.

Gooniyandi elders report other uses for these so-called 'waste products'. For example, while preparing a ceremonial rain stick made of bambira (Figure 4g), MS and WC discussed how the wood shavings being removed were traditionally collected and stuck to the body and threaded into hair for ceremonies. Here, the use of wood shavings as body decoration plays an important function in ceremonial activities, a use that is almost impossible to determine without the knowledge of local Aboriginal people.

Activities documented with Gooniyandi elders for this research are unlikely to be identical to those that occurred at Riwi in the past. Instead we suggest that binarri is a primary source of information for the interpretation of archaeobotanical material and provides insights that should not be neglected. Here, collaboration with Gooniyandi elders has recorded narratives which are often overlooked that aid and enrich the interpretations of archaeobotanical remains. Furthermore, we see great value in using ethnobotanical research as a platform for recording and maintaining Gooniyandi language survival, a language described as endangered (McGregor 1990).

Ethnobotanical Implications

The development of the ecological sciences, particularly in northern Australia, is considered relatively young (Horstman and Wightman 2001). Cultural activities and interactions with plants create dynamic relationships that take place in specific landscapes and environments (Hynes and Chase 1982:38). The biologically unique Australian flora is intimately linked to Aboriginal worldviews and much can be learned from engaging with local TEK. The importance of plants in Aboriginal lifeways is demonstrated by their incorporation into rock art (Veth et al. 2018; Welch 2003) and Dreaming narratives (Hercus 2012). Modern Western philosophy that posits humans as having ownership and control over nature can be at direct odds with Aboriginal worldviews that place custodianship above ownership and value interrelatedness (Pierotti and Wildcat 2000). Here we examine some important differences between binarri and modern Western botanical knowledge that were highlighted by this research.

To identify and classify angiosperms a flowering specimen is required to observe species' specific microscopic

morphological characteristics (Chong 1994), and thus vouchered herbaria specimens rarely include fruits, seeds, woody plant parts or roots. These incomplete archives are at odds with binarri which places importance on the entire plant (flowers, fruits, leaves, bark, wood and roots) and the different ways in which constituent parts of one plant are used.

Knowledge of a plant derived from diagnostic characteristics of a pressed herbarium sample is very different from knowledge of a plant in its natural environment. TEK encompasses the ability to identify a particular plant across different stages of life, across seasons, with and without defining characteristics such as flowers and leaves. It acknowledges the different properties that the specific parts of a plant may have and how they can be used for different purposes.

Herbaria systematically catalogue plant specimens, and accompanying collection information, in large, closed access storage facilities. At the WA Herbarium a small proportion of the collection is open to the public, with access to the complete comprehensive collection restricted via access protocols aimed at preserving (e.g., temperature control) and quarantining the large botanical collection from outside threats (e.g., insect infestation, disease). In this way the herbarium acts as 'gatekeeper' reserving exclusive access for botanical specialists and researchers.

In contrast, this research demonstrates how inclusive and how a part of everyday life binarri is, particularly in regards to food gathering practices that are deeply embedded in socio-cultural practices. On Gooniyandi Country the 'herbarium' is the surrounding environment and binarri is freely accessed by spending time with knowledgeable elders who maintain, pass down, and share binarri as part of their cultural obligations. No one is excluded and children, both girls and boys, are essentially botanists in their own backyard. Learning about the bush from her grandmother JD recalled:

> She [grandmother] usually picks out the plants even when we used to go out when it's raining. After the rain we used to walk behind Fossil, go and look for bush, little tubers, and I used to ask them what this plant? And they used to give us the names.

Gooniyandi people do not learn about the bush from Western text books and botanical literature, they learn by being on Country with their elders and experiencing the surrounding environment to learn the names and uses of economic plants and understand how plants change through each season. Some plants have important socio-symbolic roles, such as the waterlilies depicted in the rock art in Shelter 3 (Figure 2c) that act as visual representations of TEK.

Access to information provides knowledge and, as mentioned above, physical access to plant specimens housed in herbaria cannot be achieved without permits and permissions. Likewise, botanical literature is often very specific, hard to locate and rarely open access. For Gooniyandi elders, who do not belong to educational institutions, journal subscription costs can be prohibitive. Furthermore, access requires a computer, computer skills and internet access which, for Traditional Owners living in remote communities, is rare and typically not a viable option. Not only is gaining access to these resources challenging, understanding the botanical literature is complicated by the use of botanical Latin and scientific jargon making the knowledge therein cryptic. Furthermore, difficulties associated with changing botanical names, botanical misidentifications, misspellings, typographical errors, common names applying to multiple species, plant attributes changing over the course of a year and the application of DNA has complicated the field of botanical classification (Gott 1989) and makes learning and access to this type of knowledge by Aboriginal peoples in particular incredibly difficult.

Knowledge is also subject to change. The arrival of Europeans to the Kimberley in the 1880s led to rapid and thorough Aboriginal dispossession as lands were quickly taken up for pastoral pursuits (Altman 1980; Smith 2000). Severing Aboriginal connections to Country by removing people from their lands brought about the end of traditional land management practices, which has, and continues to have, serious consequences for TEK, and disastrous consequences on native

flora and fauna. Impacts from uncontrolled fire, and the introduction of invasive plants and animals remain genuine concerns of the elders who worry about the continuation of binarri and the next generation. Invasive plants (e.g., *Cenchrus ciliaris* [buffel grass], *Ptilotus nobilis* [mulla mulla] and *Vachellia farnesiana* [prickly mimosa]) are frequently encountered across Birndirri. These plants are constant reminders to Gooniyandi people of the detrimental changes pastoralism has had on the landscape (Australian Broadcasting Corporation 2011).

The implications for changes in land use coupled with climate change have, and will have, on binarri is surely profound, as the ability to predict resources becomes more uncertain (Leonard et al. 2013). This is not considered a problem of the future. Today, plants resonate the real-time consequences of climate change which has wide ranging effects on predictability and the ability to pass on accurate knowledge:

> Food was plentiful all the time, in those days but now it's hard to look for anything, you say oh this the season now, you go and look for that particular fruit, but there's nothing there. And even them bush orange, this is the season for it to, you know, be hanging on a tree and ripening but there's nothing. Had a look last year and they only had flowers and no fruit came on. [JD]

Predictable and reliable plant resources are considered by Gooniyandi elders as important for future generations as they were for their ancestors who utilised plant availability and predictable economic resources to survive harsh landscapes and to pattern their movements (Dilkes-Hall et al. in press [c]). Elders worry that their youth lack engagement with bioculture as they rarely get to spend quality time with elders in the bush because of schooling arrangements and financial pressures, which affects access to Country due to lack of vehicles and transport expenses. We recognise how fortunate we were to be able to engage with younger people through this research, but this is not often the case.

Conclusions

This paper presented the results of documenting TEK with Gooniyandi Traditional Owners to help understand macrobotanical archives. By shifting the focus from the archaeological site to the wider cultural landscape, and conducting botanical survey and collection activities with Gooniyandi elders, we recorded plants of local economic importance and compared them with Riwi's macrobotanical record. Specifically, we demonstrated the applicability of coupling local TEK with archaeobotanical research to deliver more meaningful interpretations formed using Gooniyandi narratives.

This research shows there is great value in collaboration with local Aboriginal groups and we encourage similar collaborative interpretations of archaeological macrobotanical assemblages to develop an improved understanding of the role of plants in Aboriginal lifeways through time. Importantly, this research acts as a reservoir of binarri for younger generations engaged on Country who can continue to record/revisit/re-record Gooniyandi narratives to identify patterns of change and gauge resilience and flexibility of binarri into the future.

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