



Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Plants before farming: The deep history of plant-use and representation in the rock art of Australia's Kimberley region[☆]

Peter Veth^{a, *}, Cecilia Myers^b, Pauline Heaney^c, Sven Ouzman^a

^a M257, Centre for Rock Art Research and Management, University of Western Australia, 35 Stirling Highway, Crawley, 6009 Western Australia, Australia

^b Dunkeld Pastoral Co. Pty Ltd Theda Station, PMB 14, Kununurra, 6743 Western Australia, Australia

^c Lettuce Create, 16 Chaucer Parade, Strathpine, Queensland 4500, Australia

ARTICLE INFO

Article history:
Available online xxx

Keywords:
Northern Australia's Kimberley
Plants and forager relationships
Archaeology and Aboriginal rock art
Pleistocene and Holocene transitions

ABSTRACT

The orthodox notion of agriculture cumulatively and inevitably developing from foragers' gathering practices is increasingly untenable. Recent archaeological, botanical and genetic research from Asia and Australia show precocious manipulation of plant resources that continue for millennia within a forager ideology and practice without culminating in 'agriculture'. Australia's Kimberley is an especially productive research region with a wide range of environmental niches on a topographically varied landscape that has had human settlement spanning over the last 50,000 years. Previously characterised as 'foragers' until contact with travellers from Indonesia and then Europeans over the last few hundred years; new research questions this simplistic characterisation of Aboriginal people, and suggests instead a particularly complex and enduring set of people-plant relationships. This complexity is given material witness in the form of Kimberley rock art, which stands out globally in having an enormous body of direct and indirect depictions of plants, including: grasses, trees, tubers; pigment-soaked plants imprinted on rock shelter walls; anthropomorphism of plants; and plant-based material culture such as digging sticks, dilly bags, and wood-hafted stone axe. These are more than simple illustrations of a forager economic base. Instead, rock art is a primary record of long-term sophisticated physical and symbolic manipulation of plants that fits neither into the simplistic categories of 'foraging' or of 'agriculture'. Rather, we have a society in which people actively chose not to pursue orthodox agriculture while according plants a central place in their lives.

© 2016 Elsevier Ltd and INQUA. All rights reserved.

1. The view from Australia: why was agriculture not adopted?

The perceived division between 'forager' and 'farmer' has often been emphasised in ethnographically-observed differences between Aboriginal and indigenous Melanesian lifeways (e.g. Lilley, 2000). But when we observe these lifeways archaeologically and environmentally, a very different understanding of human subsistence and culture emerges. For example, the Australian and Melanesian landmasses – and thus their human cultures – were contiguous until c. 8000 years ago (Pawley, 1998). New theoretical approaches which see subsistence change as punctuated rather

than gradual (e.g. Ullah et al., 2015), and early dates for northern Australia rock art with plant depictions (e.g. David et al., in press) raise the intriguing possibility that some tuberous, cormous and bulbous plants were manipulated physically and symbolically since the terminal Pleistocene. For example, the presence of c. 46 ka BP edge-ground stone axe flakes from the Kimberley (Hiscock et al., 2016), and the unrivalled ubiquity of 'staple food' plant species in the earliest Kimberley rock art (Welch, 2003), suggest greater sharing of forager and farmer traditions than previously thought. Indeed, as Gosden has persuasively argued "... different research traditions at work in the 'agricultural' north and the 'hunter-gatherer' south, lead us to create and see the evidence in a different light" (1995:816). In other words, both peoples in Australia and Melanesia were aware of agriculture in principle, and technical know-how was not an impediment. But in the south, people actively chose not to invest in an agriculturalist way of life. While working in Australia's Cape York Peninsula, Hynes and Chase (1982) introduced the concept of 'domiculture' – a highly organised

[☆] Guest Editors: Andrew Fairbairn (University of Queensland, Australia) and Ofer Bar Yosef (Harvard).

* Corresponding author.

E-mail addresses: peter.veth@uwa.edu.au (P. Veth), cecilia@dunkeldpastoral.com.au (C. Myers), pauline@lettucecreate.com (P. Heaney), sven.ouzman@uwa.edu.au (S. Ouzman).

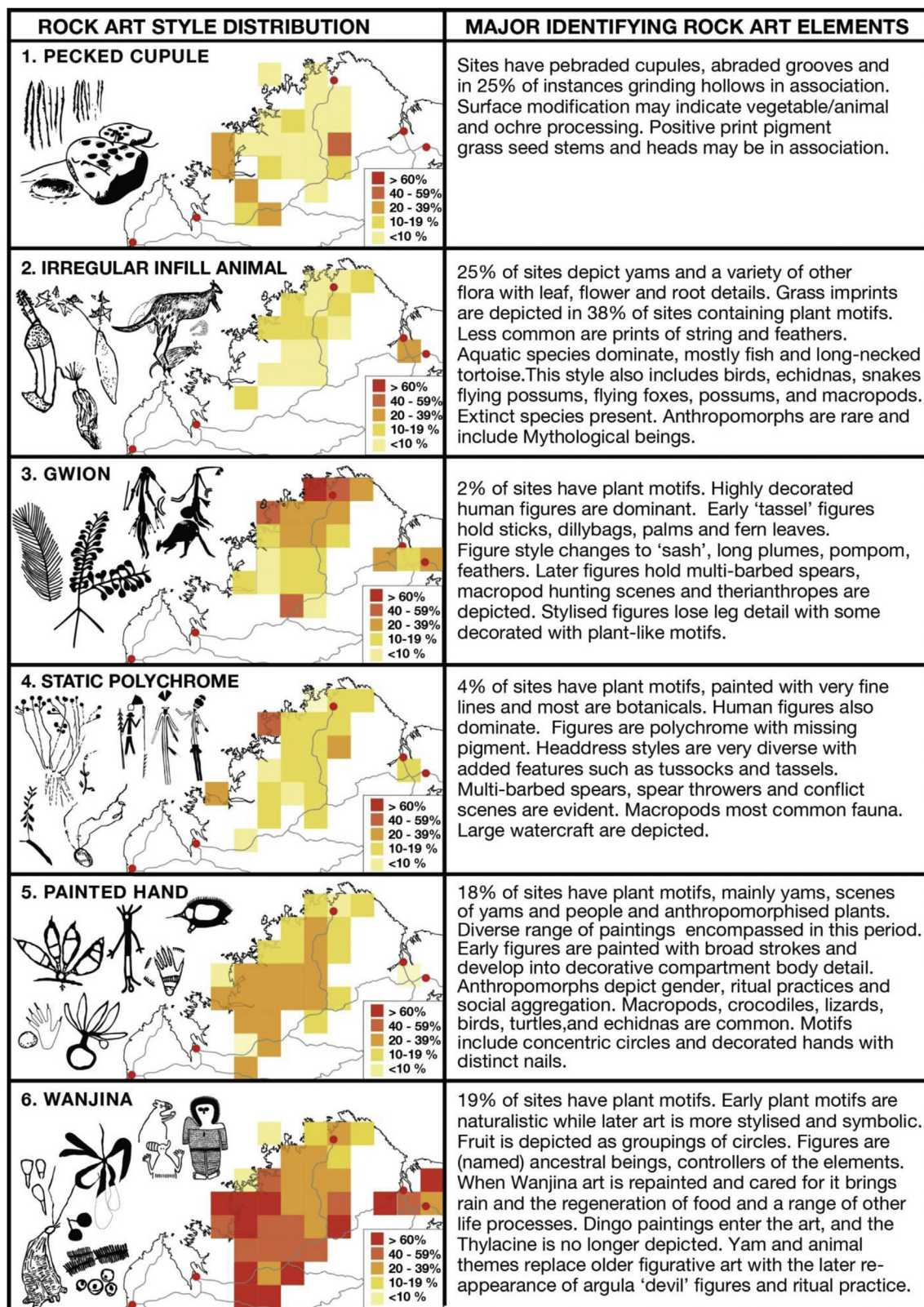


Fig. 2. Distribution of the six major Kimberley rock art styles in the study area with characterisation of iconography.

subsistence, we should use material evidence from the past to fully consider the roles of plants in peoples' economic, social and symbolic lives. We here profile and provide reasons for why plants have had such longevity and prominence in northern Australia's

foragers' rock art – an unusual feature in world forager rock arts. Accurate identification of plants depicted in rock art can remedy the lower visibility of plants in excavated contexts, and provide a picture of how early Aboriginal societies perceived and used plants.

Rock art is invaluable primary data that can add to a growing corpus of human-landscape reconstructions based on, for example, archaeobotanics, anthroecology, pollen and phytoliths. The rock art evidence also complements terrestrial dietary models developed from analysis of residues and use-wear on archaeologically resilient items such as bone, teeth and lithics. We now review the archaeological evidence for plant use in the Kimberley before moving to its rock art plant repertoire, which we identify, describe and place in environmental and social contexts. We conclude by theorising forager-plant relationships to unsettle and advance traditional models of agriculture.

2. Human use of plants in the Kimberley through time

Aboriginal occupation of the Kimberley extends back to c. 46–49 ka BP at the sites of Riwi, Carpenter's Gap 1 and Widgingarri (O'Connor, 1995; O'Connor and Veth, 2006; Balme and O'Connor, 2014; O'Connor et al., 2014; Balme pers. comm. 2016). Figs. 3 and 4 plot all available radiocarbon dates for rock shelter and open sites in the Kimberley bioregion. Collectively, these plots demonstrate early and repeated occupation at a relatively low level increasing until the Last Glacial Maximum (after O'Connor and Veth, 2006) when an occupation appears. Intriguingly, this apparent hiatus coincides with increased aridity inferred to have occurred by the end of the LGM from c. 18 – 16 ka BP, a scenario supported by new pollen sequences and dates from Black Swamp (Simon Haberle, pers. comm. 2015). Numbers of radiocarbon dates, used as a proxy for population size (after Williams et al., 2013, 2015), show significant increases by 8 ka BP and again at 4 ka BP. These are potentially important thresholds for the initiation of new Kimberley rock art styles.

It has been argued that rock art was an integral part of the colonising repertoire of the first people of Sahul, with regionalism

in style emerging by the terminal Pleistocene (see Lewis, 1988; Veth et al., 2011). Rock art style sequences for northern Australia proposed by Walsh (1994, 2000), Chaloupka (1993), and Chippindale and Taçon (1998) are being tested through major dating programs (see Veth et al., 2011; Jones pers. comm. 2015; and previously Watchman, 1987, 1993, 2000; Nelson et al., 1995; Morwood et al., 2010). Importantly, Chaloupka and Giuliani (1984), also Berry (2011) reported on Arnhem Land rock art that include painted yam figures (*Dioscorea bulbifera* and *Dioscorea transversa*). Their age was estimated at 6–4 ka BP by Lewis (1988) and Chippindale and Taçon (1998), and argued to reflect resource intensification. Significantly, this accords with a possible age bracket for Painted Hand style 'yam figures' in the Kimberley. Recently, Williams et al. (2015:12) have argued that resource abundance by the early to mid-Holocene resulted in the development of low-level food production that stimulated population growth.

Atchison and Head (2012) posit that the economic use of plants such as yams is likely to have great antiquity (see also Meehan 1989; McConnell and O'Connor 1997). They conclude that the active, regular use and maintenance of northern Australian yam patches influenced subsequent human settlement and mobility (*sensu* Terrell et al., 2003). Dilkes-Hall (2014) summarised previous macro-botanical and phytolith data from the Kimberley showing a major shift from rainforest taxa and deciduous trees (e.g. *Terminalia* sp., *Vitex glabrata*) from c. 45–30 ka BP, to arid-adapted grasses and spinifex from c. 25–11 ka BP, and a return to moist-adapted species (e.g. *Ficus* sp.) by the early Holocene.

A delayed broad spectrum resource revolution as advocated by Edwards and O'Connell (1995), whereby seeds and other 'lower ranked' species such as yams, were systematically exploited only by the mid-Holocene seems unlikely for the Kimberley. Instead, there is increasing evidence for the processing of a broad-based

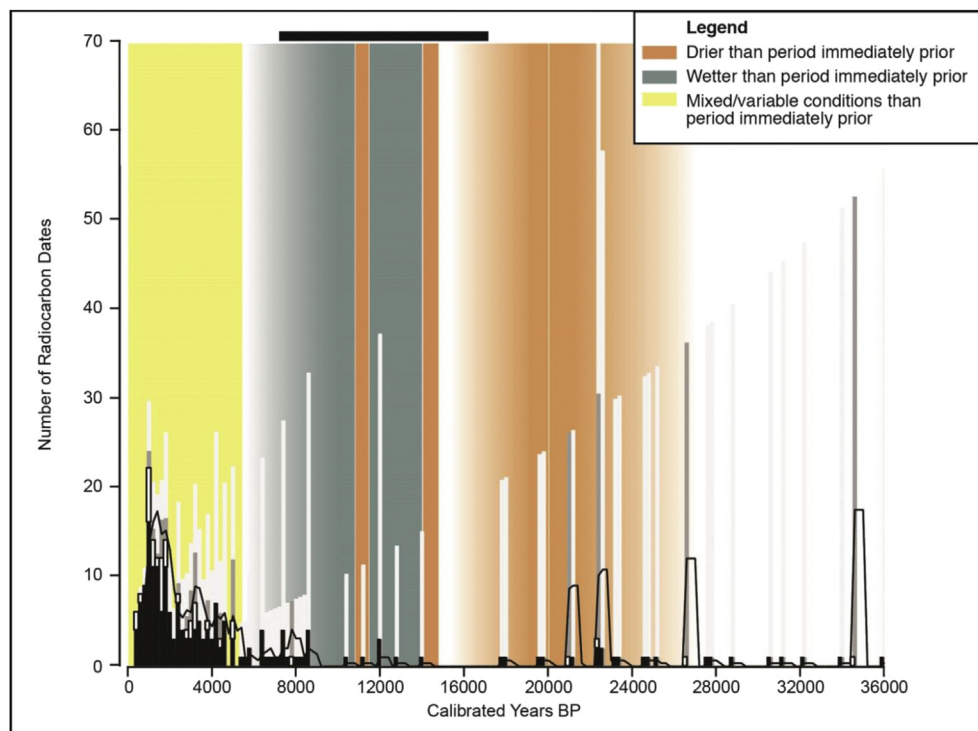


Fig. 3. Plot of radiocarbon dates from the Kimberley as of October 2015 (from Williams et al., 2013). Uncorrected calibrated dates are presented as a stacked bar chart (white ¼ open sites; black ¼ rock shelter sites). Taphonomic data corrections are presented as corrected open site data and as uncorrected rock shelter data (dark grey). 1600 year trend line in black. Open and rock shelter site data as pale grey bars. Palaeoclimate is interpreted from OZ-INTIMATE publications. Post-glacial sea-level rise is presented as horizontal black bar above the graph.

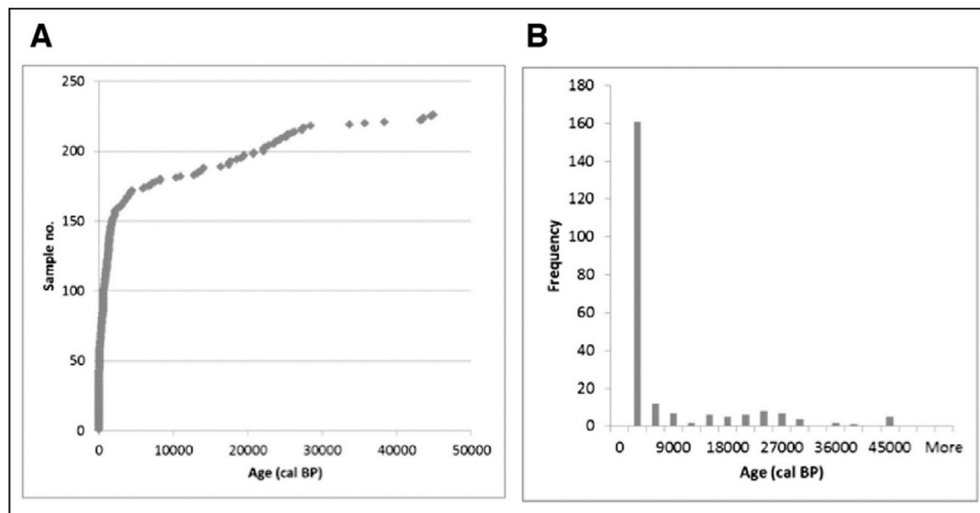


Fig. 4. Plot of radiocarbon dates for the Kimberley bioregion calibrated against SHCal13 (Hogg et al., 2013) using OxCal v4.2 (Bronk Ramsey, 2009).

suite of hard and soft coated seeds, palm and starchy resources by c. 35 ka BP. For example, residue and use-wear work by Hayes (2015) has identified starch on 21 grindstones from Madjedbebe in the Northern Territory; a site currently dated to > c. 55 ka BP. At

least three grindstones contained >200 starch grains, with at least two starch grain varieties identified on grindstone L49. The surrounding Kakadu region has ~238 economically important plant

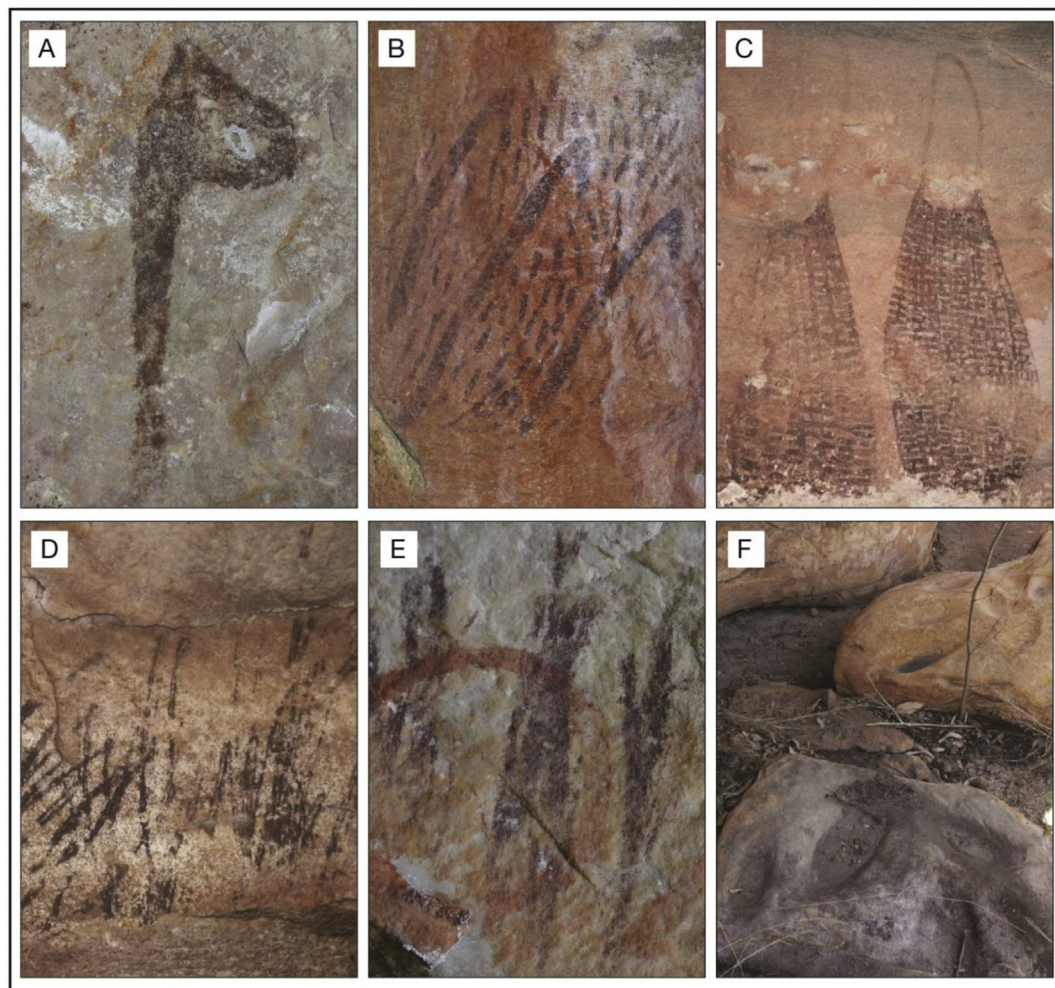


Fig. 5. Plant-based material culture in Kimberley rock art. A) Wood-hafted stone axe, B) Three hooked sticks, C) Two dilly bags, D) String imprints, E) Grass imprints, F) Grinding hollows.

species, some known to have been ground during the ethnographic period.

Although most macro-botanical remains from Riwi in the southern Kimberley occur in the last 7000 years, a small (c. 37–30 ka BP; [Dilkes-Hall, 2014](#)) Pleistocene sample has preserved. Further direct evidence for plant use at Riwi takes the form of wood shavings, a fire drill, string, and a wooden artefact ([Dilkes-Hall, 2014](#)), demonstrating the important role of plant-based technologies. The presence and significance of these “ecofacts” is amplified by the Kimberley’s plant-centric rock art. For example, depictions of dilly bags provide evidence for string production ([Fig. 5c](#)), which was also sometimes soaked in paint and imprinted on rock shelter walls ([Fig. 5d](#)). Such depictions occur in the earliest rock art styles – notably the Irregular Infill Animal and Static Polychrome – and to a lesser extent in the Elegant Action Figures sub-group within the ‘Gwion’ style (also called ‘Kwion’ and formerly ‘Bradshaw’). There are also depictions of wood-hafted stone tools ([Fig. 5a](#)), hooked sticks ([Fig. 5b](#)), and even paint-soaked grass and plant imprints ([Fig. 5e](#)). Grinding hollows ([Fig. 5f](#)) used for multiple purposes including plant food preparation are ubiquitous throughout Kimberley rock shelters. Tangential, but worth mentioning, are figurative and geometric depictions made from the wax of *Tetragonula* bees and possibly spinifex resin (Damian Finch pers. comm 2016). This wax contains organic material that can both be dated (e.g. [Nelson et al., 1995](#); [Morwood et al., 2010](#)) and contains palaeoenvironmental data. Essential to understanding human–plant interactions in this region is establishing a rock art chronology, which we now outline.







3. A new dating and sequencing of Kimberley rock art

To support our hypothesis that Aboriginal-plant relationships were early, intensive and sustained we propose a synthesis of

Kimberley rock art styles supported by associated archaeology and environmental data. This synthesis incorporates climatic cycles and models Aboriginal settlement and aggregation behaviours. A new campaign of dating Kimberley rock art (embedded into four major Australian Research Council Projects; see also [Aubert, 2012](#); [Huntley et al., 2015](#)) will provide a robust independent test of our hypothesis. Methods deployed by this campaign include: AMS dating of organics within pigments, oxalate-rich mineral crusts and mud-wasp nests; OSL dating of mud-wasp nests; Uranium–Thorium dating of carbonates and sulphate-rich mineral crusts; cosmogenic radionuclide dating of boulder scars; mineral halo growth rates as well as advanced characterisations of microbiological communities and their DNA. New assays are available and have been presented in recent conference papers ([Green et al., 2015](#); [Ross, 2015](#); [Travers, 2015](#) see [Jones, 2015](#) for cognate Arnhem Land data), or in PhD theses currently being released. Available dates ([Watchman, 1987, 1993, 2000](#); [Roberts et al., 1997](#); [Aubert, 2012](#)) allow us to propose an ‘intermediate’ chronology which aims to break the nexus between the ‘short chronology’, which sees all figurative art relegated to the Holocene (*sensu* [Rosenfeld, 1993](#)), and the ‘long chronology’ which, sees earlier art styles as predating the LGM ([Walsh, 2000](#)). This recasting recognises similarities between the rock art repertoires of the Kimberley and Northern Territory (cf. [Lewis, 1988](#)), which may have constituted an earlier unified cultural bloc – the subject of a new Australian Research Council project entitled *Kimberley Visions*.

Current analyses of attributes shared between some of these styles (e.g. [Travers, 2015](#)) and associated dates suggest these categories are more clinal than a phase sequence implies and that there may be reversals in the sequence (recursivity after [McDonald and Veth, 2013](#)). However, we believe the overall sequencing of the relative chronology stands. [Table 1](#) presents our synthesis of the

Table 1
Kimberley rock art styles in temporal environmental and behavioural contexts.

Style	Years BP	Behavioural and climatic cycles
 PECKED CUPULE	50,000–and ongoing	Lacustral phase with mosaics of rainforest, woodland and grasslands. Colonisation mode signalling – rock markings (e.g. cupule production and ongoing). Rock art reflects more of an open information exchange system.
 IRREGULAR INFILL ANIMAL	36,000–18,000	Lacustral shifting towards increasing aridity with movement of the ITCZ north. North-west Australian rock art style provinces established including early Irregular Infill Animal style. Rock art reflects emerging territoriality and mapping on to resource mosaics within different bioregions.
 GWION	18,000–14,000	Last Glacial Maximum with max. –130m sea levels, arid zone expansion and plains of Bonaparte Basin exposed. Highly stylised Gwion variants occur across Kimberley Plateau with isolates in the VRD. Rock art reflects dual system of local group identifying behaviour and long-distance exchange.
 STATIC POLYCHROME	14,000–9000	Re-establishment of the Monsoon by 14 ka and rapid loss of coastal plain due to level rise at Meltwater Phase 1a at 13.5 ka. Static Polychrome rock art shares some attributes across large areas of the North-west. Rock art continues to show long-distance connection from Kimberley across to Keep River and western Arnhem Land.
 PAINTED HAND	9000–5000	The Monsoon at its most active and southern reach between 7.5 and 5.5 ka. Early Holocene Wet Phase marked by inferred increasing human population. Evidence of clinal change in rock art from previous Static Polychrome to Painted Hand Period.
 WANJINA	5000 – present	ENSO intensification marked by greater volatility in summer rainfall and some drought. Evidence for economic innovation such as stone bifaces and then Kimberley Points and population growth. Stylistic diversity in Wanjin style reflects high degrees of territoriality and boundary marking. Likely reflects totemic estates and recent (Wunan) trade and exchange cycles.

temporal, environmental and behavioural context of the major Kimberley rock art styles.

Using climatic and environmental data, the OZ-INTIMATE palaeoclimate group has developed a 35,000 year continental record with an emphasis on the Tropics (Reeves, 2013a, 2013b). We hypothesise that different Kimberley rock art styles correlate with varying climatic regimes. This correlation is not environmentally-determined but recognises that significantly different settlement and mobility patterns are linked to different environmental settings (Veth et al., 2000; Whallon, 2006; Foley and Lahr, 2011; Bird and O'Connell, 2012). Predictable changes in a group's boundary maintenance and information exchange behaviours are often expressed and managed via different rock art styles, which constitute a specific coding of a group's self-image and subsistence that it transmits both internally and to other groups (e.g. McDonald and Veth, 2013a). For example, during pluvial periods a 'closed' information system with more emblematic group-identifying behaviour and higher stylistic heterogeneity is expected. In contrast, arid phases will result in an 'open' information system where more stylistically homogeneous schemes operate across permeable group boundaries and over large landscapes. We acknowledge that at the micro-scale such information-exchange dynamics may be more complex and that dual systems of both long-distance sharing and localised aggregation can create nodes of stylistically heterogeneous rock art (McDonald and Veth, 2012b; also McDonald and Veth 2013b). Taking all these factors in consideration, we now expand on the Kimberley rock art style synthesis, as presented in Table 1.

1. **Pecked cupule:** First, is a 'colonising repertoire' rock art represented by pecked cupules found across northern and central Australia. Long thought to be 'old', cupules from the north-west Kimberley sampled by new dating campaigns are returning terminal Pleistocene results (Green et al., 2015). Their production and rejuvenation is also assumed to have been ongoing at some sites and further dating will test this persistence of a single style across other style temporalities.
2. **Irregular Infill Animal style:** Early exemplars may be as old as similar figures from island SE Asia dated to 36 ka BP (Aubert et al., 2014). We note that taphonomic and site-formation issues likely significantly affected the terminal Pleistocene record. Geochemical and microbiological studies are addressing these taphonomic processes.
3. **Gwion:** This well-known anthropomorphic style complex in red/mulberry hues, including Elegant Action Figures (after Walsh, 1994, 2000), is currently dated by a single, much-debated OSL date < 17 ka BP (Roberts et al., 1997). Bert Roberts still contends the dated mud wasp nest sample is in direct association with the rock art, despite conflicting views (e.g. Aubert, 2012). The distribution of Gwions is large and extends from the King Leopold Ranges in the south into the Northern Territory in the east (Taçon et al., 1999). If this Pleistocene dating proves accurate, Gwion distribution may have continued across the Bonaparte Depression under what are now the Timor and Arafura Seas (see Lewis, 1988) – as sea levels were lower by 130 m during the LGM (Veth et al., 2016). This very wide posited original distribution may suggest a more open information network system during a relatively arid phase. This hypothesis is untested and we note that Elegant Action Figures appear to have a distinct northern distribution, which may indicate dual signalling systems. This proposed trend towards homogeneity in the rock art meshes well with available dating and the proposed timing for peak aridity during the LGM after 18

ka BP. A southern movement of the Inter-Tropical Convergence Zone (ITCZ) and re-establishment of the Indonesian Australian Monsoon is registered in Australia's north-west by 14 ka BP (Veth et al., 2016).

4. **Static Polychrome style:** known to be subsequent to Gwions on the basis of painted superimpositioning, bear some similarities to the Hooked Stick Figures of Arnhem Land (Lewis, 1988) dated to c. 9 ka BP (David et al., in press) and may correlate with the onset and intensification of the NW Monsoon.
- 5 & 6. **Painted Hand and Wanjin styles:** Following the onset of the NW monsoon, conditions would favour more territorially bounded rock art styles and our model predicts an increase in stylistic heterogeneity and boundary signalling. This we expect to find in the complex but under-researched Painted Hand (formerly 'Clawed Hand') and Wanjin styles. We expect Wanjin to exhibit boundary signalling through high stylistic diversity and high density of aggregation locales over the last 4 ka BP (cf. Fig. 4).

On current evidence we suggest that the most adequate temporal framework for understanding Kimberley plant depictions are optimally scaled at the 'intermediate' level – whereby both terminal Pleistocene and Holocene elements are repeatedly produced across periods of demonstrable climatic, environmental and social change. This temporal, spatial and iconographic contextualising of Kimberley plant rock art allows us to investigate its cultural contexts and, ultimately, what this means for future understandings of forager-plant relationships and our larger understanding of 'agriculture'.

4. Kimberley rock art's unique record of early and continuing plant use

These cultural contexts begin, literally, at the rock face in the form of plant paintings. Depictions of plants are found throughout the Kimberley sequence, often in large numbers, albeit at differing frequencies. Plants are depicted in ~15% of rock art sites documented to date (Welch, 2003 reports 10% from a smaller sample). This is an extremely high percentage for world forager rock arts, which are usually dominated by depictions of humans, animals, geometrics, and items of material culture. Plants are usually absent (at least in visually obvious ways) or depicted in low numbers. Hodgson and Helventson (2006:27) note that: "Animals are one of the major subjects for the Palaeolithic artists in Europe, plants are not depicted, at least not in any recognisable form." Plants are usually rarely depicted (e.g., see Fig. 6; also Malotki and Weaver, 2001; Duncan and Diaz-Granados, 2004:182 for the Americas; Loubser and Zietsman, 1994; Mguni, 2009; Henning, 2011; Hubbard, 2013 for southern Africa; see also Hernbrode and Boyle, 2013 for North American agriculturist rock art). Global forager rock arts sometimes present plants through plant-implicated material culture such as dwellings made of organic material (e.g. Lenssen-Erz, 2004:141), rare depictions of maps showing botanical subjects (e.g. Smith, 1982) and even indirectly through events such as volcanic eruptions (e.g. Nomade et al., 2016) that could affect climate and plant resource bases. Going beyond literal depiction, some forager rock art paint 'recipes' are known to have incorporated plant materials as binders (e.g. Rowe, 2001). It is possible that some apparently plant-less forager rock arts do encode information about plants in ways unintelligible to us without relevant ethnographic information (cf. Skoglund, 2012). For example, the vibrant geometrics painted on the houses of Tukano farmer-foragers in South America were inspired by hallucinations induced by *yaje* (*Banisteriopsis caapi*; Reichel-Dolmatoff, 1971). Additionally, sophisticated excavation in painted rock shelters in the USA's south-west by Boyd and Dering (1996) has

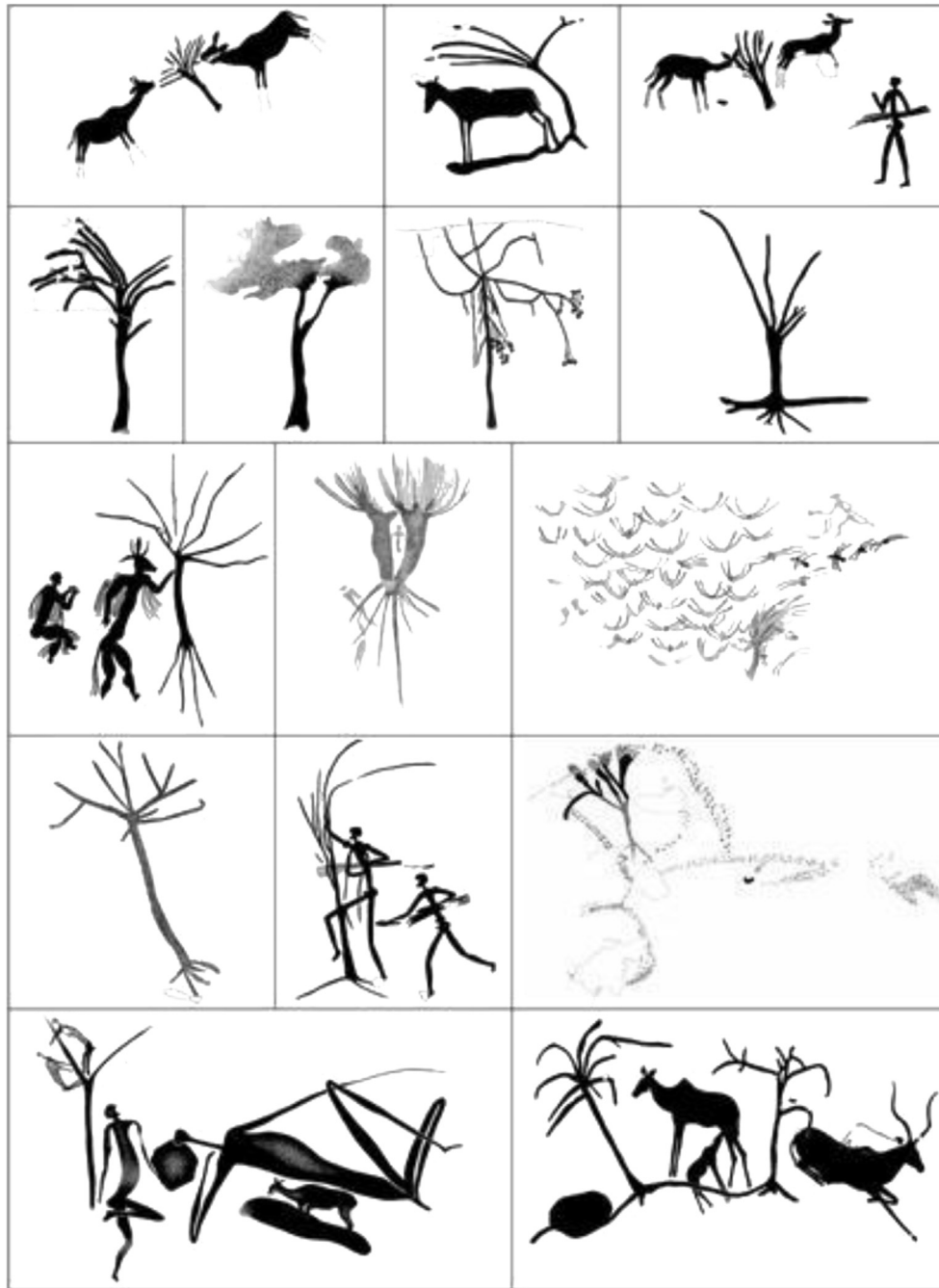


Fig. 6. Depictions of plants in Zimbabwean forager's rock art (from Mguni, 2009:141).

linked macrobotanical remains of hallucinogenic and medicinal plants to rock paintings on the rock shelter's wall (see Akers et al., 2011 for a Spanish instance).

These examples notwithstanding, plant depictions are rare in forager rock arts and present a conundrum. We know plants often contributed the bulk of a forager group's food resources (e.g. Cordain et al., 2000) but are rarely depicted in rock art. In contrast, many insignificant animal food resources are over-represented in the accompanying rock art (e.g. Vinnicombe, 1976). This mismatch between economic life and iconographic representation alerts us to data set bias. Specifically, plant depictions and their absence should make us mindful of bias in inferring economy and gender (e.g. Hays Gilpin, 2013; LaPierre and Garfinkel, 2013). Although a subject for much fuller and more nuanced attention, the

treatment of gender, plants and subsistence behaviour remains a key issue. We simply note here that we disagree with dichotomies such as 'woman-the-gatherer' and 'man-the-hunter'. Indeed, we question the worth of identifying and isolating a single gender, largely informed by modern or ethnographic constructions of sex and gender, and would prefer to see a more networked approach in which different categories of people are involved in subsistence as an extractive and as a social process. This process will have different gendered 'pulses' and identities depending on a specific activity that we synchronically isolate, but as a process it is likely to be multi- and even cross-gendered. Furthermore, researchers are justifiably aware that rock art is seldom a simple 'depiction' of an external entity. Rather, decisions to depict or not to depict something are informed by a plethora of as-yet imperfectly

understood cognitive and cultural processes. This makes it necessary for us to explain how we identify and classify ‘plants’ in Kimberley rock art.

4.1. Identifying depictions of plants in Kimberley rock art

Kimberley rock art has many motifs that to an outsider's eye might look like a ‘plant’ but which may have been intended as something else by the image-maker. We combine an insider's (emic) insight using ethnobotanical knowledge, with an outsider's (etic) knowledge using iconographic analysis of rock art and identification of actual plants based on anatomical details, morphology and reproductive organs, to identify plant depictions. We note that botanical identifications in the Kimberley and elsewhere tend to have focused on the above-ground parts of plants. But foragers would have been intensely interested also in the below ground edible parts and root systems. Thus, our identifications are conservative and contingent and we are aware of the many pitfalls in using ethnography and analogy (e.g. Stahl, 1993; Chapman and Wylie, 2015). For example, past human processes of perception and representation may be different to the point of incommensurability with how we ‘see’ today (cf. Ouzman, 2001). The limitation is that we as non-foragers must use some kind of analogical framework to understand forager life and art, while simultaneously realising that forager societies were dynamic and that the temporal reach of modern ethnographies may be limited. More specific problems include Aboriginal people having multiple different identifications for similar rock art motifs (Welch, 2003). Conversely, the same word may be used for more than one plant species. Crawford (1982:17) acknowledges differing emic taxonomies, noting that “important edible plants are known by several different names” and that “there are cases in which the Aboriginal term used by one group of Aborigines has been adopted and used by another group for a different plant.” An example of multiple identifications is the plant depicted at Wanalirri, an important site in Wanjin mythology related to a flood (Fig. 7a; Akerman, 2016). This depiction was recorded by some researchers as representing *kulangi* (*V. glabrata*) and by others as showing *gooloy/cooloy* (*Buchanania obovata*). Both species are ‘plums’ – *kulangi* is a black plum and *cooloy* a green plum. Most etic identifications label it a tree “branch”, while Crawford (1968:41) describes it as the “eatable root of the native plum tree”. Modern ethnographies suggest the root of

young *B. obovata* plants was eaten, but not that of *V. glabrata* (Karadada et al., 2011).

Despite the challenges inherent in interpreting plant depictions, such as those at Wanalirri, identification is possible using a three-stage approach. First, we assume that important food and raw material plants are likely to have been depicted and that a list of common food plants will act as a useful initial guide for candidate species in the rock art record. Crawford (1982) and Karadada et al. (2011) describe 96 and 106 plant foods respectively from Kalumburu and Wunambal Gaambera country in the north Kimberley; and Vigilante et al. (2013) record 127 plant food species from the north Kimberley islands. Each study notes a more select group of

Table 2

Some Kimberley plant species preferred by Aboriginal people from the north and west Kimberley.

Crawford (1982)	Petri (2011)	Vigilante et al. (2013)	Common name
<i>Vitex glabrata</i>	<i>Vitex glabrata</i>	<i>Vitex glabrata</i>	Black plum
<i>Dioscorea transversa</i>	<i>Dioscorea transversa</i>	<i>Dioscorea transversa</i>	Long yam
<i>Nymphaea</i> sp.	<i>Nymphaea</i> sp.		Waterlily
<i>Buchanania obovata</i>		<i>Buchanania obovata</i>	Green plum
<i>Dioscorea bulbifera</i>		<i>Dioscorea bulbifera</i>	Round/cheeky yam
<i>Ipomoea</i> sp.		<i>Ipomoea abrupta</i>	Bush potato
	<i>Cyperus bulbosus</i>	<i>Cyperus bulbosus</i>	Bush onion
<i>Ampelocissus acetosa</i>		<i>Ampelocissus acetosa</i>	Native grape

preferred plants that were regarded as prized or “first class food” (Petri, 2011:23). These are listed in Table 2. While they may not necessarily comprise staples, we suggest they have been important economically or socially, and were depicted in the rock art.

The second stage in identifying plant depictions is to further narrow down preferred plants using historic ethnography such as Elkin (1930), the 1938–1939 Frobenius Institute Kimberley Expedition (Schulz, 1956; Petri, 2011), and Coate's 1940s work (Coate, n.d.). These researchers were taught the identity of specific motifs in rock art sites by Aboriginal guides. A selection of these plant

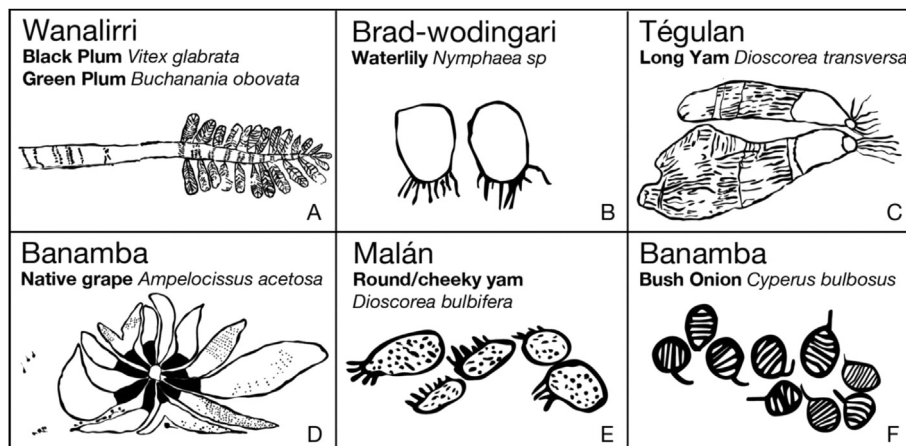


Fig. 7. Ethnographic identification of plants depicted in Kimberley rock art. Note that the Aboriginal names refer to the rock art site at which the plant motifs are painted and not to the plant motifs.

motifs is shown in Fig. 7, providing a good correlation with the 'preferred' foods shown in Table 2.

The third stage in identifying plant motifs is formal iconographic analysis whereby we look for clear distinguishing botanical characteristics and for repeated, identifiable attributes that resemble plants identified in ethnography. Thus, the 'waterlilies' shown in Fig. 8 are a good example of a visual fit between actual plants and rock painting. Conversely, the waterlilies in Fig. 7b may not resemble waterlilies to outsiders but were identified as such by knowledgeable Aboriginal guides; suggesting a visual code to which we are not privy. To further complicate matters, Fig. 7d was also identified – by a botanist as depicting *Clitoria australis*. We are, however, fortunate in that Kimberley rock art contains a very large population of very detailed plant images making the identification of plants with some confidence possible and plausible. Figs. 8 and 9 provide examples of plant depictions from all the major rock art styles in the study area. Fig. 8 shows plant motifs that are identifiable throughout the rock art sequence, and which were identified ethnographically.

4.2. Classifying plant depictions in Kimberley rock art

Our identification of Kimberley plant depictions is conservative and assumes a level of diagnostic precision that may be affected by variability in style, execution, rock surface, and purposeful alteration of shape to incorporate other themes such as plant-human confluences. We classify our plant depictions according to Walsh's methods (1994, 2000), in which we use four attributes: (style, colour, size and infill) to attribute motifs to one of the major rock painting styles (Fig. 2; Table 1). Motifs are then divided into six subject groups, one of which is 'flora'. 'Flora' motifs are placed in

one of three categories – yam (12 types), fruit (4 types), and botanicals (six types). Yam motifs have an ovoid tuberos shape, sometimes with an uneven 'frilled' base with short radiating lines at one end (e.g. Fig. 7c). These may also have vines with attached leaves or may be more circular in shape and occur in 'strings' (e.g. Fig. 9b). Fruits are identified as clusters of small round objects, often attached to a line that probably represents a branch. In the Wanjina style, fruits are often not attached to a branch but are painted in large arrays (e.g. Fig. 7e, f). 'Botanical' is the term applied to motifs that do not fit readily into the previous two categories and includes: fern, leaf, vine and floral shapes. Eight other 'elements' are then defined from yams, botanical and fruit categories. This approach has broadly been followed by Welch (2003:1) who lists "flowers, leaves, stems, branches, fruit, vines, inflorescences, roots and tubers" as the plant parts represented in Kimberley rock art. We present this classificatory schema in Fig. 10.

In addition to plant depictions, Walsh (2000) notes that grass and other plants covered in paint and impressed onto a rock shelter wall (e.g. Fig. 5e) are prevalent in the Irregular Infill Animal style. This accords well with the Arnhem Land sequence, in which grass prints feature in the early Naturalistic style, which Chaloupka speculates (1993:92) were made "at a time when cereals probably formed an important part of the staple diet". This speculation has empirical support in the c. 35 ka BP seed grinding at Madjedbebe (Hayes, 2015). Further comparative data include the frequencies of grinding hollows at Kimberley rock art sites. Following the broad style chronology presented we have grinding hollows/areas in: 35% of Pecked Cupules sites, 5% at Irregular Infill sites, 2% at Gwion sites, 5% at Static Polychrome sites, 7% at Painted Hand sites, and 11% at Wanjina sites.

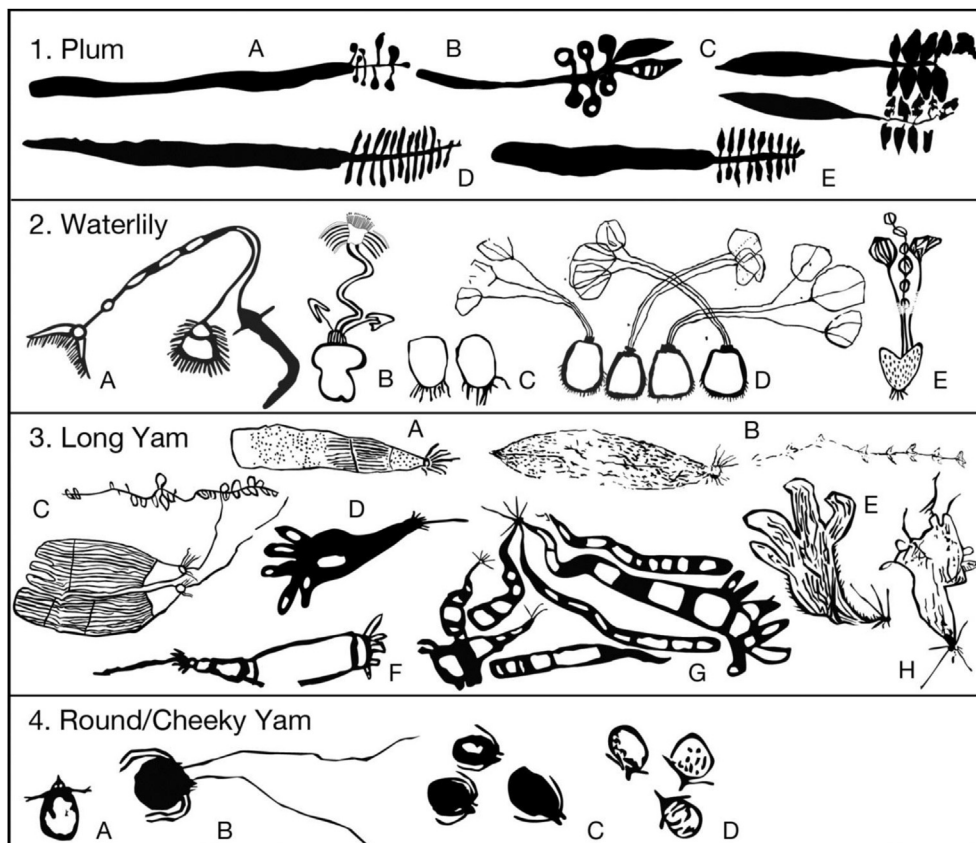


Fig. 8. Examples of commonly recurring identifiable plant motifs from the major Kimberley rock painting styles.

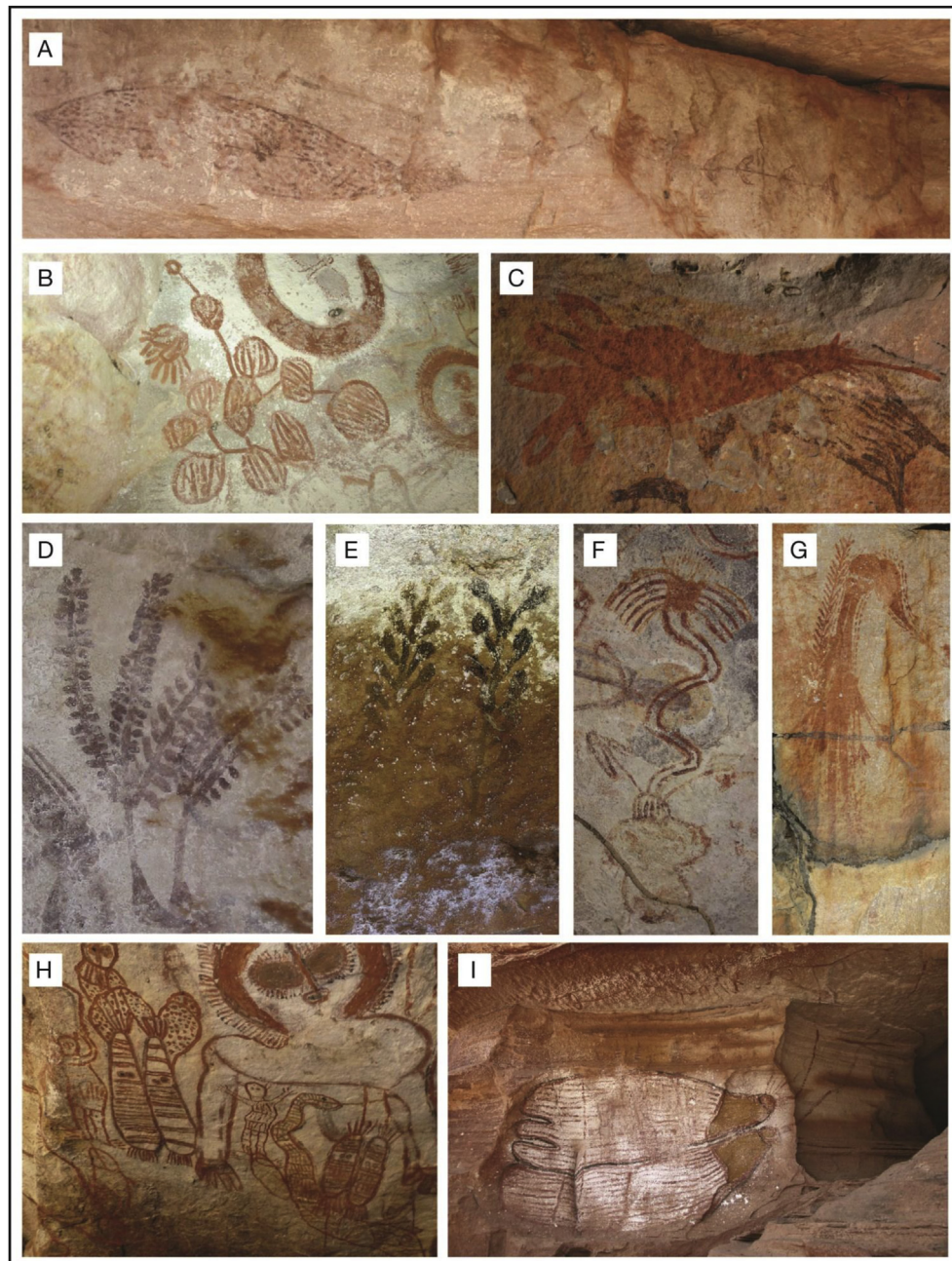


Fig. 9. Plants depicted in Kimberley rock art. A) Irregular Infill Animal Period style tuber with tendrils, vine and leaves, B) Wanjina style string of yams, C) Painted Hand style yam, D) Gwion style plant, E) Painted Hand style sprig of fruit motifs, F) Painted Hand style lily G) Gwion style human figure with fern leaf, H) Wanjina style 'yams with eyes' associated with human figures, I) Wanjina style yams with tendrils, vine and leaves.

It is thus possible to identify plant motifs despite stylistic variations and without invoking the fallacy of ethnographic analogic reasoning. The number of such plant depictions is in the thousands, suggesting an accrued memory bank of collecting and even cultivation or 'management' practices (see [Atchison and Head, 2012](#)). Kimberley rock art is a visual store and memory of such management practices. If commensal relationships were developed with key plant species (e.g. *Dioscorea*) from the terminal Pleistocene/early Holocene then the precursors for horticultural innovation and increasing plant dependency, seen with *Dioscorea* and *Taro* in Highland PNG sites like Kuk from 10 ka BP ([Fullagar et al., 2006](#)), were likely in place in northern Australia before the sundering of Sahul. As [Denham et al. \(2009:38\)](#) conclude:

"We develop a heuristic framework to illustrate the bundling and transformation of plant exploitation practices in tropical regions of northern Australia and New Guinea during the Holocene. Recent differences in forms of plant exploitation in Australia and New Guinea originated through the accumulation of different emphases rather than being borne of a fundamentally different way of living in the world. We do not deny difference in the recent past or present, for it is certainly there, but we are guarded in extrapolating differences of kind into the more distant past".

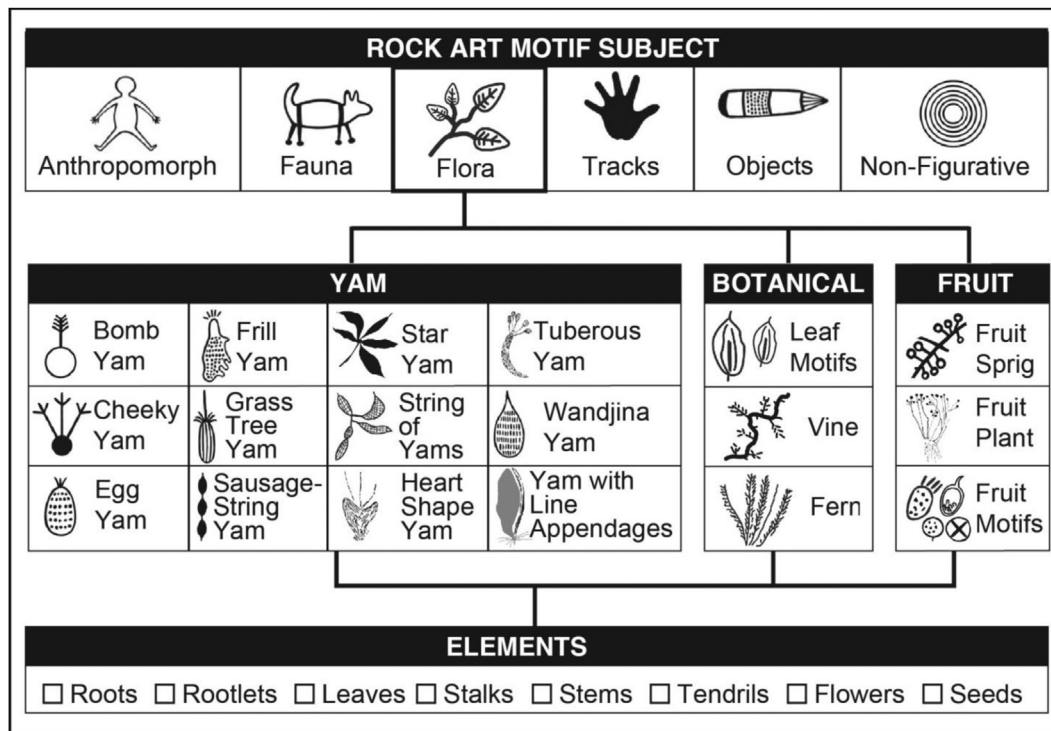


Fig. 10. Visualisation of how Kimberley plant motifs are identified and classified.

5. The cultural context of Kimberley plant depictions

The unusually high proportions of plants depictions in Kimberley rock art militates against these being mundane representations of food sources. Indeed, the significance of plants in the religious and cultural lives of Aboriginal people is well-demonstrated (e.g. Elkin, 1930; Crawford, 1968; Walsh, 1988; Petri, 2011; Coate, n.d.). Walsh (n.d.) states that “the most frequently recurring secondary totemic themes associated with the Wandjinas involves yams, bush fruit”. Petri (2011:23) describes how some plant foods like lilies, *nalgo* (bush onion) and yams “play a certain role in the mythical traditions of the tribe.” Representations of some of these species are even found in stone arrangements – deliberately constructed patterns/images using rocks (e.g. Randolph, 2011) – associated with rock art sites (e.g. Wurdim-odngari described by Elkin (1930) and Petri (2011, 2015). Examples include stones arranged into the shape of the hairy rooted yam (Walsh, n.d.) and the grapevine root (Love 1936), in addition to non-botanical subjects.

Ethnographic accounts linked to rock art and stone arrangements describe the creation of particular plants; their spread through the landscape; rules and taboos about eating and preparing plant foods; and ceremonies associated with the ritual increase of plant foods. For example, Schulz (1956) and Walsh (1988) describe part of the story associated with Kalingi-odin, a site with numerous plant motifs such as *kanmangu* yams (*D. transversa*). Painted at this site is a now-indistinct motif representing the rock pigeon Banbarnga who was responsible for carrying the seed of the *kanmangu* yam – represented as a faint sinuous yellow line – to the site, which then became an important place for increase ceremonies associated with *kanmangu*. There are also supernatural beings associated with plants such as Wurulawurula the “yam spirit” and Nganjalanjanjala “spirit-man of the harvest” (Akerman, 2016). Coate (n.d.) describes Wurulawurula as a yam painting site, and as the yam distributor, planter, and eater. He translates ‘wurula’ as “to stretch forth the hand, the one who plants out the yams. A gardener, planter” and

ngandjalangandjala as “green hand, a planter”. Crawford (1968) describe Warulu as “spirits of the harvest”, who make yams by defecating and describes one further yam spirit called Ungamin who controlled the largest yams, and the Warulu controlled the smaller ones. The planting of yams is also recorded ethnographically across northern Australia. Crawford (1982), working in the north Kimberley, describes how the head of the *kanmangu* yam (*D. transversa*) was broken off and replanted. Chaloupka (1993), working in Arnhem land, records the same process, also with *Dioscorea*. O'Connor and Veth were shown similar practices on Rankin Island in 1984 (see O'Connor et al., 2007).

While the expression of these beliefs, linguistic traces and sentiments will have changed; they demonstrate two things. First, the management of plant resources was a recognised and significant subsistence activity. Second, plants are more than just food. Whilst valuable information about daily life, climate, and ecology is available through studies of plant depictions, ethnographic data signals the need for a dual approach that both records vital mundane details while integrating this information into complex cultural contexts. We provide two examples of such integration in the form of plants depicted as accoutrements to human figures, and ‘yam people’.

5.1. Plants depicted as accoutrements to human figures

Interestingly, plant depictions occur much less frequently during the Gwion and Static Polychrome styles (Fig. 16), which are dominated by paintings of humans and associated material culture. Only 2–4% of sites across the different figure groups contain stand-alone plant motifs, in contrast to the overall figure of 15% for the Kimberley. But this shift from discrete depictions of plants is offset by numerous examples of plant-like objects held by or near human figures (e.g. Fig. 11a, b). This is particularly evident within the earliest figure groups, in which 15% of sites contain motifs associated with what has been interpreted as plant material; including held objects (Fig. 11a, b) and plant-like accoutrements (e.g. Fig 11c,

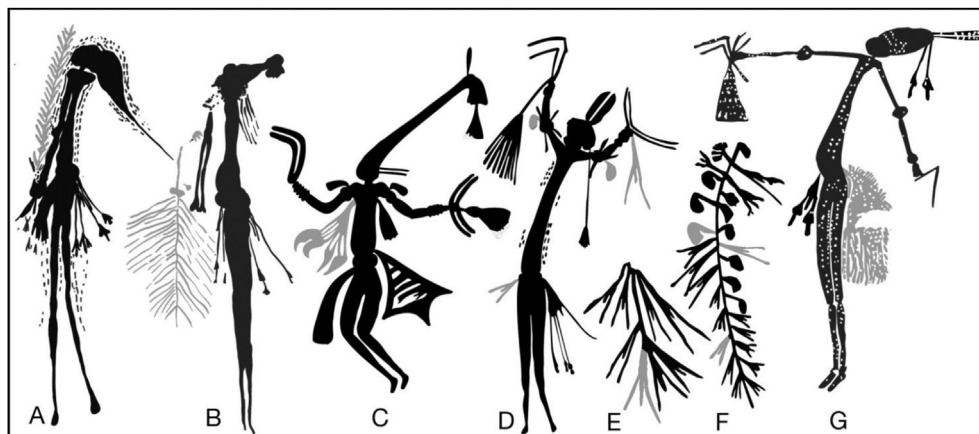


Fig. 11. Plant-like motifs (indicated in grey) associated with Gwion style human figures.

d, g). Further, rare stand-alone plant motifs from other figure groups (Fig. 11e, f) show a marked similarity to plant-like forms associated with human figures (e.g. Fig. 11c, d) and may thus represent plants use to make clothing and accoutrements. Pettigrew (2011) has argued that boab (*Adansonia gregorii*) seed-pods are central to decorative dress. Another view is that some accoutrements represent animal skins (e.g., waist decoration in Fig. 11c).

More direct evidence for plant use during this time comes from depictions of plant-based material culture such as the wood-hafted stone axes in Fig. 12a, b. There is an unusually high frequency with which female figures (especially Elegant Action Figures) are depicted in association with longish lines interpreted as digging sticks (e.g. Fig. 12c). These female figures exhibit breasts, invariably oriented to one side, lack a headdress, and hold different objects to more slender human figures interpreted as males, who tend to hold spears, boomerangs, and ceremonial objects. Female-associated objects usually include dilly bags (Figs. 5c and 12c) and digging sticks (Fig. 12c). Ethnographic support for this interpretation comes from Crawford's (1982) description of women heading out to forage with two types of digging sticks – a shorter stick for prising rocks out of hard soil and a longer one for digging in soft soils. He notes that the Tree Featherflower (*Verticordia cunninghami*) was the preferred timber for making digging sticks. Whilst sticks were used for a diversity of purposes such as hunting goanna (*Varanus* sp; e.g. Hayden, 1979), digging up tubers is well-recorded. For example, Crawford (1982) presents a photograph of a woman from Kalumburu using a digging stick to extract the edible *yamu* lily (*Thysanotus tuberosus*). Petri (2011) describes women in the 1930s using digging sticks thus: "The women get the most diverse kinds of edible roots out of the ground with their digging sticks. They know how to handle these primitive implements astonishingly deftly and skilfully." Veth (1980) recorded Kukadja and Jaru women near the shores of Lake Gregory tracing the tendrils of *D. bulbifera* to cracks in the earth near small trees and digging these out with end-flattened Land Rover axes. The presence of digging sticks in Gwion style rock art known to be superimposed by Wanjina, Painted Hand and Static Polychrome styles, is modelled to date to the early Holocene and possibly into the Pleistocene. Stand-alone depictions of plants decline during this time though some examples are known (e.g., Fig. 13). These motifs are usually small and do not appear to correlate closely to known plant foods. The close association of plant motifs with human figures in the Gwion style suggests that the human-plant relationship continues and that numerical preponderance is not necessarily the sole arbiter of a motif class' importance, economically or symbolically. This human-

plant identification is intensified to a logical extreme in the distinctive phytomorphs or 'Yam People' rock paintings of northern Australia.

5.2. 'Yam people'

Chaloupka (1993) and Berry (2011) consider 'yam figures' to be an important category of Arnhem Land rock art. *D. bulbifera* and *D. transversa* were identified as the basis for these phytomorphs (part-human, part-plant confections). Chaloupka considered them as early evidence for a yam culture similar to those seen in West Africa and New Guinea. Yam figures include both animals and humans exhibiting yam parts or yam attributes that Chaloupka (1993) argues evolved out of simple stand-alone yam motifs (e.g. Lewis, 1988). Welch (2003) describes similar paintings in the Kimberley that range in length from 50 cm to over 10 m, while Crawford (1968) provides drawings from Kuri Bay of anthropomorphised *kanmangu* style yams. Walsh (n.d.) notes that yam figures are uncommon in the Kimberley (but see Fig. 14). He nevertheless divided them into two categories: "a) Motifs that are highly stylized and essentially yams with limbs" (e.g. Fig. 14a, b) and "b) schematised, stick figure-like anthropomorphs with variations of distinctive yam heads" (e.g. Fig. 14c, d). Fig. 14e, f are examples of 'yams with eyes' from the Wanjina style.

Anthropomorphing of plant motifs suggests close symbolic identification with plants from at least the early-to mid-Holocene. The symbolic attention given to what was also an important food source suggests a level of systematic plant exploitation and possibly management not previously modelled for Australian foragers. As Atchison and Head (2012) note, systematic harvesting of yams, even in more difficult rocky terrains with lower energetic yields, would have created increasing human-yam co-dependency and, we suggest, co-identification. In Fig. 15a, b we present another type of 'yam figure' visually similar to Chaloupka's (1993) Arnhem Land examples. These images are located among a complex series of very fine lines – Chaloupka's 'vines' – connecting objects, including shapes similar to cheeky yam (*D. bulbifera*) depictions. Most of these figures occur in pre-Wanjina rock art although anthropomorphised plants do occur in recent art.

The socio-symbolic integration of plant motifs speak of the centrality of certain plants to Aboriginal people who actively managed them in physical and cultural ways. Through the under-utilised plant record displayed in Kimberley rock art, we now reconsider the larger Kimberley rock art corpus and also the implications plant depictions have for our understanding of the

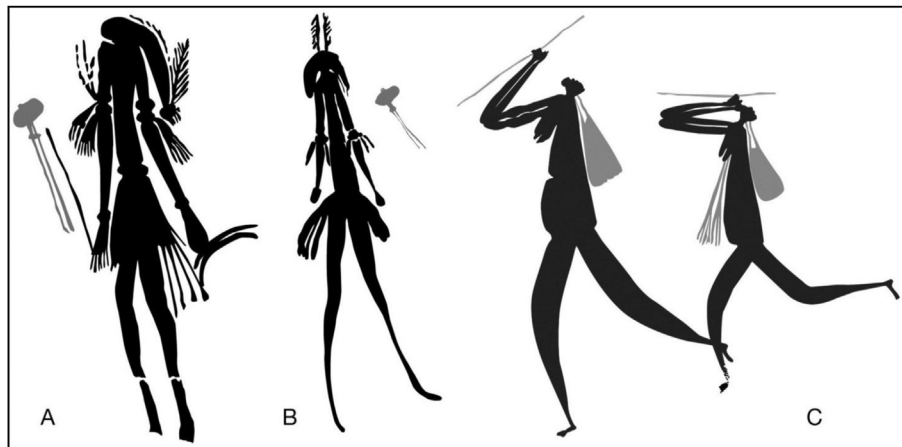


Fig. 12. Human figures with wood-hafted stone axes, digging sticks and dilly bags (indicated in grey).

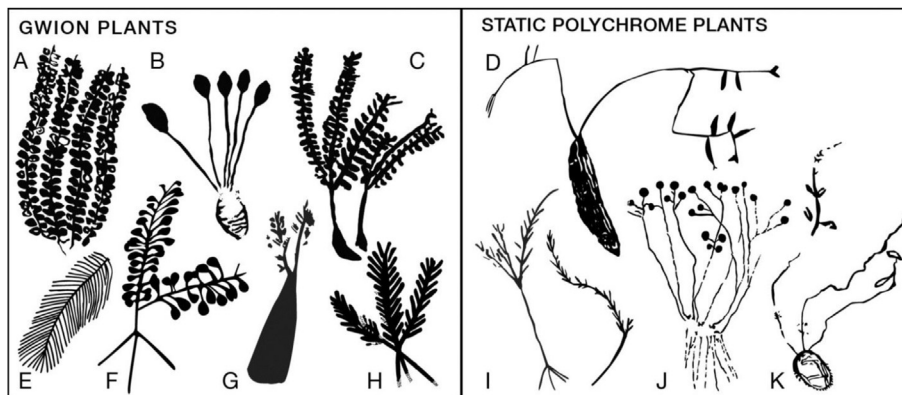


Fig. 13. Stand-alone depictions of plants in Gwion and Static Polychrome styles.

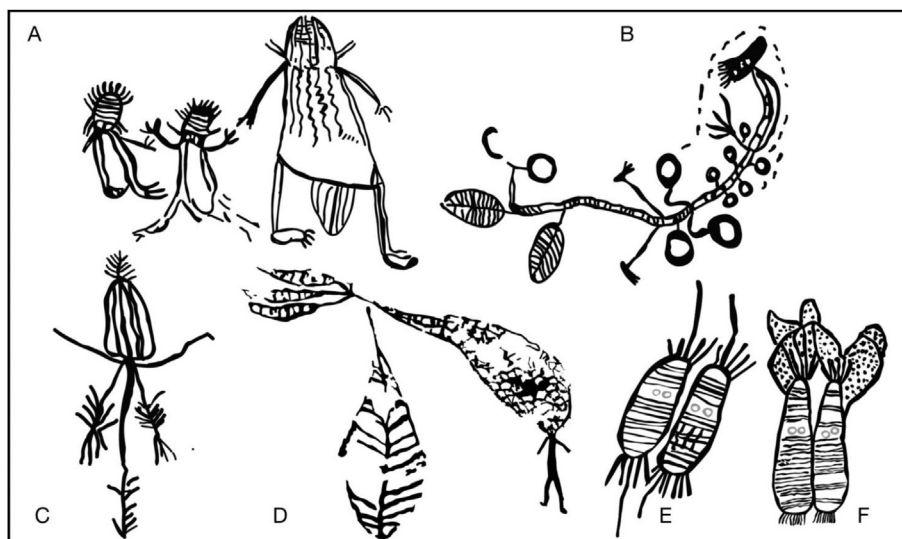


Fig. 14. Yam and human 'phytomorph' depictions in north Australian rock art with yam elements.

absence of agriculture in Australia among such a plant-centric people.

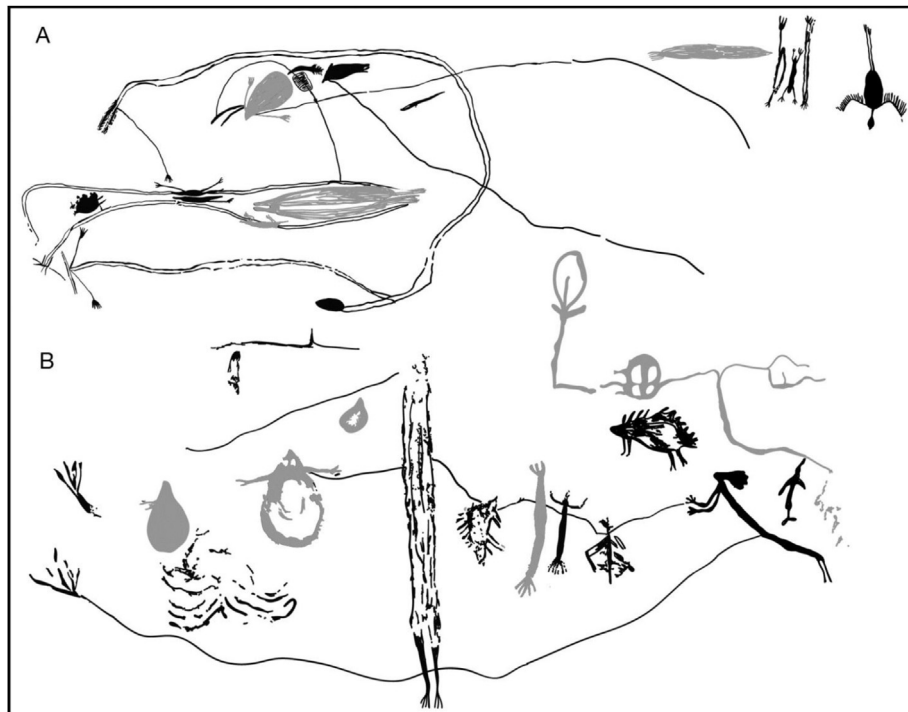


Fig. 15. Depictions of very fine lines interpreted as 'vines' that connect objects, animals, birds, people and shapes similar to cheeky yam (*Dioscorea bulbifera*).

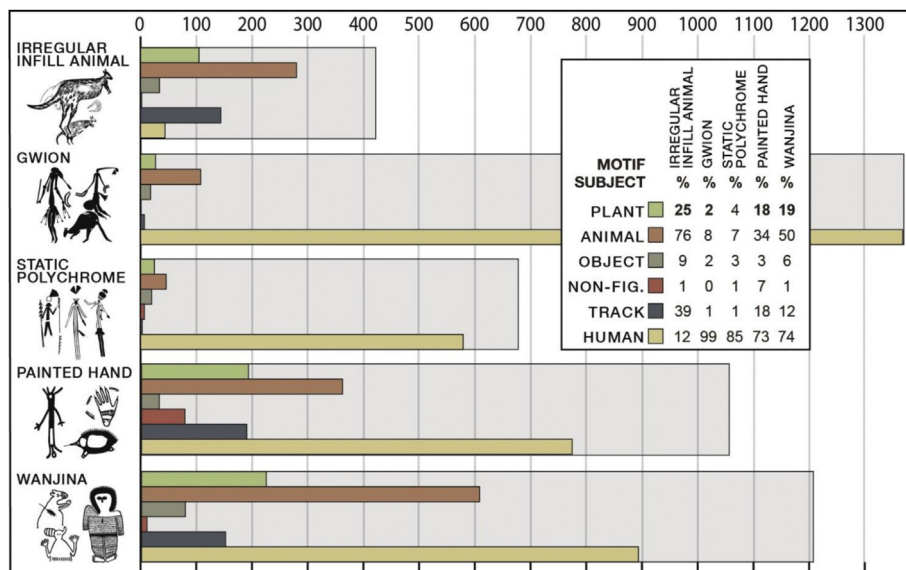


Fig. 16. Plot of Kimberley rock art motifs by subject and style (n = 3750 sites).

6. Stylistic variations in plant depictions and their relationship to Kimberley rock art modelling

In synthesising Kimberley rock art styles, climate phases and predicted social dynamics we have made a case for the longevity and re-occurrence of key plant species and elements through all art styles, suggesting plants' importance as economic and social referents. Before concluding we examine the frequency and proportions of plant depictions in all Kimberley rock painting styles – data we present as Figs. 16 and 17. Fig. 16 shows the dominance of human figures, which occur at between 73% and 99% of sites in all rock painting styles bar the earliest Irregular

Infill Animal style. In this earliest art, animal motifs dominate, occurring in 76% of all sites. Plant depictions occur in 25% of Irregular Infill Animal sites recorded – the highest percentage for any of the rock art styles.

In Fig. 17 the plant motif category is broken down into four major plant types (fruit, botanical, yam and grass imprint). For the Irregular Infill Animal style nearly half the plant depictions are yams (49%) and 38% are grass prints. Interestingly, Chaloupka (1993) states that yams are absent from this early art in Arnhem Land. The other two categories, 'fruit' and 'botanical' register the lowest values for the entire rock art sequence, at 9% and 4% respectively. That grass prints appear only to have been made

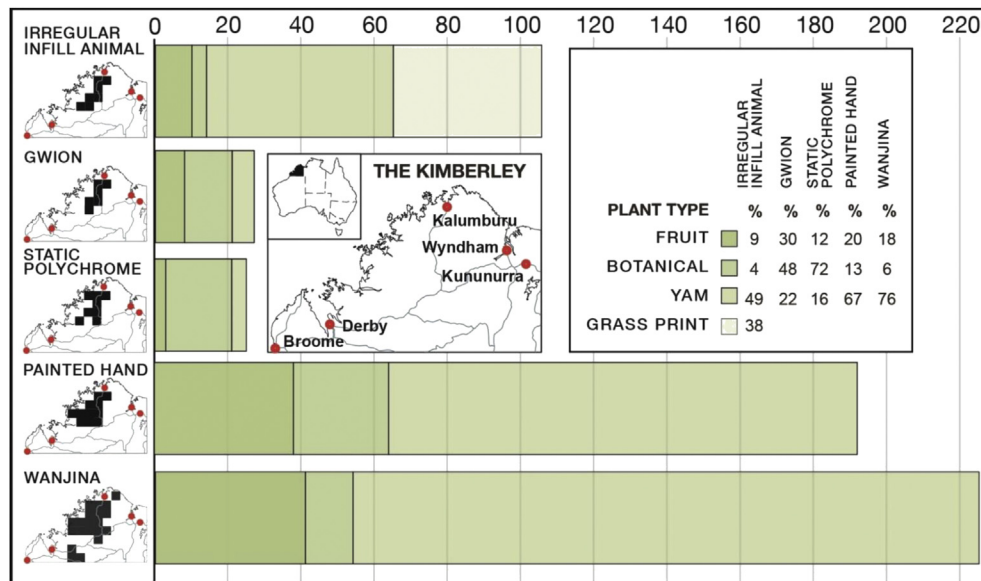


Fig. 17. Plot of Kimberley plant motifs by type and style ($n = 3750$ sites).

within this earliest art style is intriguing and suggests a central role for grass fibre and seeds in the economy.

This sequence and frequency of plants in rock art accords with residue and use-wear studies from associated archaeological work in the Tropics and Pilbara which show:

- Seed-grinding was practiced by 35 ka BP (Hayes, 2015);
- Basal platforms with evidence for grinding may have been used for processing grass stems for use in, for example, string and nets/dilly bags, in addition to seed damper (Dilkes-Hall, 2014; Morse et al., 2014); and
- Amorphous portable basal platforms were used for fibre, vegetable, animal meal and ochre processing tasks (Gorecki et al., 1997; Veth et al., 1997).

This early period is the establishment phase of the shared Tropics/Non-Pama-Nyungan Language Family bloc whereby regional Pleistocene economies and social systems are seen to emerge by approximately 30 ka BP (see Balme et al., 2009; Veth et al., 2011). It may be that the focus on higher ranked fauna; tubers, seeds and corms; and fibrous technology in the early art encapsulates a shared resource-acquisition strategy for people exploiting new habitats that included mosaics of rainforest, woodland and grassland with different structures and staples (e.g., Veth and Walsh, 1988) to those the early colonisers would have known from Wallacea.

During the subsequent Gwion and Static Polychrome styles there is a reduction in stand-alone plant depictions, which occur at 2% and 4% of sites, respectively. Significantly, however, plants are commonly integrated into the composition of human forms as dress and accoutrements for the very first time (Fig. 11). We hypothesise that changes in the environment may correlate with changes in depictions of the human form, towards more standardised formal types with depictions of more reliable and available plants. Such shifts remain to be tested but we propose would be linked, in this instance, to peak aridity of the Last Glacial Maximum by 18 ka BP. Later shifts would be associated with the return of the Indo-Australian Monsoon by c. 14 ka BP, and punctuated sea-level rises that submerge huge areas of northern Australia; sometimes rapidly (e.g. Meltwater Phase 1a Ward et al., 2015) by 13,500 BP. Merging plant iconography with the dominant human forms

precisely during this time of increased aridity and climatic volatility is not, we suggest, a coincidence. This focus on the human form both as individual, in groups, and in collective behaviour might be expected during periods of long-distance information exchange and unity (Gwion style). This would be followed by increasing territoriality, with new levels of group boundary formation (Static Polychrome) and greater stylistic heterogeneity by the early Holocene, as LGM conditions ameliorate. That the art displays a risk-minimising strategy during colder and lower rainfall epochs has been recorded elsewhere from northern Australia (McDonald and Veth, 2006). That people and plants are merged in such intimate ways is consistent with a relational ontology and how people become bio-social beings (cf. Ingold and Pálsson, 2013).

Subsequent Painted Hand style sites have a relatively high proportion of plants (~18%) with yams making up 67% of all plant motifs and fruit 20% (Fig. 17). This style is modelled to fall within the early Holocene when rainforest taxa, deciduous trees (*Terminalia* sp. and *V. glabrata*), vine thickets and wet grass species increased in frequency (see McConnell, 1997; Wallis, 2000, 2001).

Interestingly, the most recent Wanjina style contains similar proportions of plants (19%) and humans (74%) to Painted Hand style – despite clear differences in iconography and context. Fruit and yams at 18% and 76% of plant types are similar to those recorded in Painted Hand at 20% and 67%. These congruencies are predicted to some extent, as there appears to be clinal emergence of the latter through time. Earlier ‘switches’ in the art are seen to be more marked (but see Travers, 2015). The broad climatic phases described by Dilkes-Hall (2014) incorporate both styles. However, the OZ-INTIMATE palaeoclimate group (Reeves et al., 2013a; Williams et al., 2015) makes a distinction after 4 ka BP when conditions become mixed and variable and during which the bulk of dated Wanjina rock art was made (Morwood et al., 2010). The ^{14}C record and time-series data presented in Figs. 3 and 4 and in Williams et al. (2015) for the Tropics suggests a significant increase in site occupation from c. 4 ka BP. We expect increasing levels of regional rock art stylistic diversity at this time, likely reflecting sea level stabilisation from after 7.5 ka BP, increasing population numbers, new levels of territorial boundedness, the emergence of contemporary totemic estates, consolidation of regional exchange networks, and the expression of these in the Wunan trade and exchange system. Key plant species depicted in the rock art take a

central role in the economic and sacred life of Wanjina-associated peoples of the Kimberley (Akerman, 2016).

7. Conclusions and implications for understanding Aboriginal Australian plant management

The archaeobotanical record for Tropical Australia during the Pleistocene is patchy (Denham et al., 2009) making it difficult to address fundamental questions such as whether there was an early reliance on tubers, roots and corms (see also Jones and Meehan, 1989). Whether there was a move toward an incipient state of the 'co-dependency' which saw these become cultigens in nearby Papua New Guinea is a fascinating but as-yet unanswered issue. However, the unique insights provided by Kimberley rock art provide robust and independent data on the selective processes by which Aboriginal people targeted plant resources (after Terrell et al., 2003). Supporting archaeological evidence such as the ubiquity and early appearance of ground stone axes (Hiscock et al., 2016) – possibly used for land clearance, and of grinding hollows and patches in many shelters, provide an independent but parallel line of evidence for early human–plant interactions.

The earliest Kimberley rock art styles are conservatively dated to the terminal Pleistocene (Green et al., 2015; Travers, 2015) and plant iconography is present through all rock art styles until contact with Europeans in the last 200 years. Indeed, Wanjina art – with plant depictions – is still produced today. Together with cognate rock art from Arnhem Land, this provides the earliest and longest tradition of plant representation by foragers currently known in the world. This fact must inevitably raise questions about the level of reliance and dependence on a broader suite of plant foods from the earliest occupations (cf. Hayes, 2015), and about the increasing co-dependence and incipient management of specific plant resources through time. While not assuming *a priori* that all species were highly ranked staples with outstanding energy returns (cf. Atchison and Head, 2012), nevertheless the same plant groups are repeatedly portrayed through successive, and sometimes significantly changed styles from the terminal Pleistocene right through to the ethnographic period. The decreased proportions of plant depictions in the Gwion and Static Polychrome styles is not interpreted as a decrease in their relative contributions to diet or social significance. The intimate inclusion of plant iconography in the form of accoutrements, apparel and hand-held material culture suggests instead a shift in world view.

Our analysis of 3750 sites demonstrates that plant iconography has been persistent and is represented in 15% of all sites. The proportions of plant depictions varies from as high as 18–25% in the earliest Irregular Infill Animal style and later Wanjina styles to as low as 2% in Gwion. The proportions of different plants, such as grass seeds, fruit and yams also change significantly. These changing depictions of plants may be a proxy for major changes in climate and vegetation structure and concomitant changes in how people constructed identity and managed territory. Indeed, simplistic notions of agriculture as an inevitable end point to be reached after a certain period of plant management are here challenged by a much more complex environmentally and socially fluid context in which people were aware of agriculture but chose not to pursue it.

While there has been a 'sliding scale' of views about the levels of Aboriginal colonists' capabilities to exploit plants in Sahul, some of which were endemic to SE Asia (e.g. Yen, 1995), there is a growing consensus about the highly developed maritime skills, focus and economic base of early founding groups arriving across the island archipelagos from the west and north. As Kealy et al. (2015) argue in their review of the island archaeology between Sunda and Sahul "... one is encouraged to view the seas of Wallacea not as barriers,

but as simply different yet permeable surfaces across which humans travelled, evolving and adapting to an increasingly marine orientated form of life as they went".

On entering the largest and most arid continent ever colonised by anatomically modern foragers (Veth, 2005), a focus on plants for food and perishable technologies is predicted within a generalist colonising mode (cf. Denham et al., 2009). Stands of tubers, roots and corms would have provided reliable resources for groups expanding through the sub-tropical to semi-arid biomes of the vast Kimberley region, which has always been fringed by deserts. In the rock art of the Kimberley we see the historic and symbolic imprints of these pathways which were to become the totemic lattice of the Wanjina and eventually, in their human form, the Wunan trade and exchange cycle which linked all groups from the desert to the sea. These 'seeds of dispersal' become the very lifelines of Kimberley lore, mythology and creation.

Acknowledgements

We thank and acknowledge the Aboriginal Traditional Owners of the Kimberley for permissions and partnership to work on their lands and rock art. In particular Jacob Burgoo, Dolores Cheinmora, George Djommery, Campbell Ellenbrae, Freddy Jagamarra, Billy King, Scotty Martin, David Mowaljarlai, Mary Pandilow, Manuela Punan, Dicky Tataya, Mimi Tdeerwin, Hector Tunggal, Dicky Udmurra, Sam Woolagoodja, and Dickie Yandit, who worked with Grahame Walsh and shared with him their knowledge, culture and beliefs. We thank Roderick Walsh, Pam Walsh and Maria Myers for access to the Takarakka Nowan Kas Rock Art Archive and Dunkeld Pastoral Co Pty Ltd for financial and logistical support for fieldwork and research. We acknowledge supporters, field assistants and helicopter pilots, including Susan Bradley, John and Anne Koeyers, Peter and Pat Lacey, and Russell and Peta Timms. We thank the many volunteers who gave freely of their time and expertise. They include: Sue Ball, Helen Bunning, Di England, Narelle Hall, Meg Hornabrook, Debbie Holt, Butch and Robin Maher, Nick Sundblom, Peter Turnbull, Toby Ware and Val Woodland who assisted with fieldwork and digitising fieldnotes and images so that vital databasing and analysis could be conducted. Linda Papa, UWA Librarian, provided expert assistance with references. The Kimberley Foundation Australia, The University of Western Australia, and the UWA Centre for Rock Art Research + Management provided financial, logistical and in-kind support. We thank Kim Akerman for discussion and sharing of images and data, Jane Balme, Sue O'Connor and Peter Hiscock for sharing archaeological excavation data, Simon Haberle for sharing environmental data, Tristen Jones for rock art dating discussion, and Matthew Barrett, Peter Kendrick and Kevin Kenneally for ethnobotanical review. We thank Andrew Fairbairn and Ofer bar Yosef for organising the seminar entitled: *The Expansion of Farming in East Asia, Sunda and Sahul: Did foragers adopt agriculture?* seminar and the invitation to contribute to the volume. Finally, we thank Kim Akerman, Judith Hammond, Peter Kendrick, Kevin Kenneally and David Welch for comments on an earlier version on this manuscript. Colleagues and students at UWA are thanked for their comments on a seminar presentation of this paper. The two anonymous *Quaternary International* reviewers are thanked for their insights and constructive comments.

References

- Akerman, K., 2016. *Wandjina: Notes on Some Iconic Ancestral Beings of the Northern Kimberley*. Hesperian Press, Perth, W.A.
- Akers, B.P., Ruiz, J.F., Piper, A., Ruck, C.A.P., 2011. A prehistoric mural in Spain depicting neurotropic psilocybe mushrooms? *Economic Botany* 65 (2), 121–128.

- Atchison, J., Head, L., 2012. Yam landscapes: the biogeography and social life of Australian *Dioscorea*. *The Artefact* 35, 59–74.
- Aubert, M., 2012. A review of rock art dating in the Kimberley, Western Australia. *Journal of Archaeological Science* 39 (3), 573–577.
- Aubert, M., Brumm, A., Ramli, M., Sutikna, T., Saptomo, E.W., Hakim, B., Morwood, M.J., van den Bergh, G.D., Kinsley, L., Dosseto, A., 2014. Pleistocene cave art from Sulawesi, Indonesia. *Nature* 514 (7521), 223–227.
- Balme, J., Davidson, I., McDonald, J., Stern, N., Veth, P., 2009. Symbolic behaviour and the peopling of the southern arc route to Australia. *Quaternary International* 202 (1–2), 59–68.
- Balme, J., O'Connor, S., 2014. Early modern humans in Island Southeast Asia and Sahul: adaptive and creative societies with simple lithic industries. In: Dennell, R., Porr, M. (Eds.), *Southern Asia, Australia, and the Search for Human Origins*. Cambridge University Press, Cambridge, pp. 164–174.
- Berry, M., 2011. Dissecting Yams: 'Yam Figures' in the Rock Art of Kakadu. Australian National University (Unpublished Master of Liberal Arts dissertation).
- Bird, D.W., O'Connell, J.F., 2012. Human behavioral ecology. In: Hodder, I. (Ed.), *Archaeological Theory Today*, second ed. Polity Press, Cambridge, pp. 37–61.
- Boyd, C.E., Dering, J.P., 1996. Medicinal and hallucinogenic plants identified in the sediments and pictographs of the Lower Pecos, Texas Archaic. *Antiquity* 70, 256–275.
- Bronk Ramsey, C., 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51 (1), 337–360.
- Chaloupka, G., 1993. *Journey in Time: the World's Longest Continuing Art Tradition*. Reed, Chatswood, N.S.W.
- Chaloupka, G., Giuliani, P., 1984. Gundulku Abel Gundalg Mayali Flora (Unpublished report for the Northern Territory Museum of Arts and Sciences).
- Chapman, R., Wylie, A. (Eds.), 2015. *Material Evidence: Learning from Archaeological Practice*. Routledge, London.
- Chase, A.K., 1989. Domestication and domesticity in northern Australia: a social perspective. In: Harris, D.R., Hillman, G.C. (Eds.), *Foraging and Farming: the Evolution of Plant Exploitation*. Routledge, Oxon, pp. 42–54.
- Chippindale, C., Taçon, P.S.C., 1998. The archaeology of rock-art. In: Chippindale, C., Taçon, P.S.C. (Eds.), *The Many Ways of Dating Arnhem Land Rock Art*. Cambridge University Press, Cambridge, pp. 90–111.
- Coate H.H.C., n.d. Unpublished notes. Copy held by M. Myers, North Carlton.
- Cordain, L., Brand Miller, J., Eaton, S.B., Mann, N., Holt, S.H.A., Speth, J.D., 2000. Plant-animal subsistence ratios and macronutrient energy estimations in worldwide hunter-gatherer diets. *American Journal of Clinical Nutrition* 71 (3), 682–692.
- Crawford, I.M., 1968. *The Art of the Wandjina: Aboriginal Cave Paintings in Kimberley, Western Australia*. Oxford University Press, Melbourne, Vic.
- Crawford, I.M., 1982. Traditional Aboriginal Plant Resources in the Kalumburu Area: Aspects in Ethno-economics. Records of the Western Australian Museum Supplement, Supplement No. 15. Western Australian Museum, Perth, W.A.
- David, B., Barker, B., Petchey, F., Delannoy, J.-J., Geneste, J.-M., Rowe, C., Eccleston, M., Lamb, L., Whear, R., 2013. A 28,000 year old excavated painted rock from Nawarla Gabarnmang, northern Australia. *Journal of Archaeological Science* 40 (5), 2493–2501.
- David, B., J.-J. Delannoy, R. Gunn, L. Brady, F. Petchey, J. Mialanes, E. Chalmis, J.-M. Geneste, I. Moffat, K. Aplin and M. Katherine. in press. Determining the age of paintings at JSARN–113/23, Jawoyn country, central-western Arnhem Land plateau. In B. David, P. Taçon, J.-J. Delannoy and J.-M. Geneste (eds), *The Archaeology of Rock Art in Western Arnhem Land, Australia*. ANU Press, Canberra.
- Denham, T., Fullagar, R., Head, L., 2009. Plant exploitation on Sahul: from colonisation to the emergence of regional specialisation during the Holocene. *Quaternary International* 202 (1–2), 29–40.
- Diaz-Granados, C., Duncan, J.R., 2004. *The Rock-art of Eastern North America: Capturing Images and Insight*. University of Alabama Press, Tuscaloosa.
- Dilkes-Hall, E., 2014. An Archaeobotanical Analysis of Macrobotanical Remains at Riwi in the South Central Kimberley Region, Western Australia (Unpublished Honours thesis). The University of Western Australia, Perth, W.A.
- Edwards, D., O'Connell, J.F., 1995. Broad spectrum diets in arid Australia. *Antiquity* 69 (265), 769–783.
- Elkin, A.P., 1930. Rock-paintings of north-west Australia. *Oceania* 1 (3), 257–279.
- Foley, R.A., Lahr, M.M., 2011. The evolution of the diversity of cultures. *Philosophical Transactions: Biological Sciences* 366 (1567), 1080–1089.
- Fullagar, R., Field, J., Denham, T., Lentfer, C., 2006. Early and mid-Holocene tool-use and processing of taro (*Colocasia esculenta*), yam (*Dioscorea* sp.) and other plants at Kuk Swamp in the highlands of Papua New Guinea. *Journal of Archaeological Science* 33 (5), 595–614.
- Gorecki, P., Grant, M., O'Connor, S., Veth, P., 1997. The morphology, function and antiquity of Australian grinding implements. *Archaeology in Oceania* 32 (2), 141–150.
- Gosden, C., 1995. Arboriculture and agriculture in coastal Papua New Guinea. *Antiquity* 69 (265), 807–817.
- Green, H., Gleadow, A., Veth, P., Ouzman, S., Finch, D., 2015. Uranium-series dating of bracketing mineral accretions associated with Kimberley Rock Art. In: Paper Presented at Australian Archaeological Association, Fremantle, Western Australia.
- Hayden, B., 1979. Palaeolithic Reflections: Lithic Technology and Ethnographic Excavation Among Australian Aborigines. Australian Institute of Aboriginal Studies, Canberra, A.C.T.
- Hayes, E., 2015. What was Ground? A Functional Analysis of Grinding Stones from Madjedbebe and Lake Mungo, Australia (Doctoral Thesis). University of Wollongong, Wollongong.
- Hays-Gilpin, K., 2013. Gender and prehistoric rock art. In: Bolger, D. (Ed.), *A Companion to Gender Prehistory*. Wiley-Blackwell, Malden, pp. 122–141.
- Hennig, H., le Clus, F., 2011. Why are so few plants depicted in rock art? *Digging Stick* 28 (3), 1–4.
- Hernbrode, J., Boyle, P., 2013. Flower world imagery in petroglyphs: hints of Hohokam cosmology on the landscape. *American Indian Rock Art* 40, 1077–1092.
- Hiscock, P., O'Connor, S., Balme, J., Maloney, T., 2016. World's earliest ground-edge axe production coincides with human colonisation of Australia. *Australian Archaeology* 82 (1), 2–11.
- Hodgson, D., Helvenston, P.A., 2006. Hunting disguises, ritual and animals in Palaeolithic art: a response to critics: reply by the authors to the discussion of their paper, the emergence of the representation of animals in palaeoart. *Rock Art Research* 23 (1), 26–40.
- Hogg, A.G., Hua, Q., Blackwell, P.G., Niu, M., Buck, C.E., Guilderson, T.P., Heaton, T.J., Palmer, J.G., Reimer, P.J., Reimer, R.W., Turney, C.S.M., Zimmerman, S.R.H., 2013. SHCal13 southern hemisphere calibration, 0–50,000 years cal BP. *Radiocarbon* 55 (4), 1889–1903.
- Hubbard, P., 2013. Plants in rock art: some thoughts from Zimbabwe. *Digging Stick* 30 (1), 16–17.
- Huntley, J., Aubert, M., Ross, J., Brand, H.E.A., Morwood, M.J., 2015. One colour, (at least) two minerals: a study of mulberry rock art pigment and a mulberry pigment 'quarry' from the Kimberley, northern Australia. *Archaeometry* 57 (1), 77–99.
- Hynes, R.A., Chase, A.K., 1982. Plants, sites and domesticity: Aboriginal influence upon plant communities in Cape York Peninsula. *Archaeology in Oceania* 17 (1), 38–50.
- Ingold, T., Pálsson, G., 2013. *Biosocial Becomings: Integrating Social and Biological Anthropology*. Cambridge University Press, Cambridge.
- Jones, R., Meehan, B., 1989. Plant foods of the Gidjinali: ethnographic and archaeological perspectives from northern Australia on tuber and seed exploitation. In: Harris, D.R., Hillman, G.C. (Eds.), *Foraging and Farming: the Evolution of Plant Exploitation*. Unwin Hyman, London, pp. 120–135.
- Jones, T., 2015. The Northern running figures of the East Alligator River Region, Western Arnhem Land: radiocarbon age determinations for a geographically bounded rock art style. In: Paper Presented at Australian Archaeological Association, Fremantle, Western Australia.
- Karadada, J., Karadada, L., Goonack, G., Mangalamara, G., Bunuck, W., Karadada, L., Djanghara, B., Mangalamara, S., Oobagooma, J., Charles, A., Williams, D., Karadada, R., Saunders, T., Wightman, G., 2011. *Uunguu Plants and Animals: Aboriginal Biological Knowledge from Wunambal Gaambera Country in the North-west Kimberley, Australia*. Wunambal Gaambera Aboriginal Corporation, Wyndham, W.A.
- Kealy, S., Louys, J., O'Connor, S., 2015. Islands under the sea: a review of early modern human dispersal routes and migration hypotheses through Wallacea. *The Journal of Island and Coastal Archaeology* (00), 1–21. <http://dx.doi.org/10.1080/15564894.2015.1119218>.
- LaPierre, K., Garfinkel, A., 2013. A numeric scratched rock art drawings women's work? *American Indian Rock Art* 40, 263–276.
- Lenzen-Erz, T., 2004. The landscape setting of rock-painting sites in the Brandberg, Namibia: infrastructure, Gestaltung, use and meaning. In: Chippindale, C., Nash, G. (Eds.), *Pictures in Place: the Figured Landscapes of Rock-art*. Cambridge University Press, Cambridge, pp. 131–150.
- Lewis, D., 1988. *The Rock Paintings of Arnhem Land, Australia*. BAR International Series 415, British Archaeological Reports, Oxford.
- Lilley, I., 2000. So near and yet so far: reflections on archaeology in Australia and Papua New Guinea, intensification and culture contact. *Australian Archaeology* 50, 36–44.
- Loubser, J.N.H., Zietsman, P.C., 1994. Rock painting of postulated *Brunsvigia* sp. (Amaryllidaceae) at Thaba Bosiu, western Lesotho. *South African Journal of Science* 90, 611–612.
- Love, J.R.B., 1936. *Stone-age Bushmen of To-day: Life and Adventures Among a Tribe of Savages in North-western Australia*. Blackie and Son, London.
- Malotki, E., Weaver, D.E., 2001. *Stone Chisel and Yucca Brush: Colorado Plateau Rock Art*. Kiva, Walnut, CA.
- McConnell, K., 1997. Palaeoethnobotanical Remains of Carpenter's Gap Site 1, the Kimberleys, Western Australia (Unpublished MSc thesis). Research School of Pacific and Asian Studies, Australian National University, Canberra, A.C.T.
- McConnell, K., O'Connor, S., 1997. 40,000 year record of food plants in the Southern Kimberley Ranges, Western Australia. *Australian Archaeology* 45, 20–31.
- McDonald, J.J., 2008. Dreamtime Superhighway: An analysis of Sydney Basin rock art and prehistoric information exchange. In: *Terra Australis* 27. ANU EPress, Canberra. <http://eprints.anu.edu.au/ta27>.
- McDonald, J., Veth, P., 2009. Dampier archipelago petroglyphs: archaeology, scientific values and national heritage listing. *Archaeology in Oceania* 44, 49–69.
- McDonald, J., Veth, P. (Eds.), 2012a. *A Companion to Rock Art*. Wiley-Blackwell, Malden.
- McDonald, J., Veth, P., 2012b. The social dynamics of aggregation and dispersal in the Western Desert. In: McDonald, J., Veth, P. (Eds.), *Companion to Rock Art*. Wiley-Blackwell, Malden, pp. 90–102.
- McDonald, J., Veth, P., 2013a. Rock art in arid landscapes: Pilbara and Western Desert petroglyphs. *Australian Archaeology* 77, 66–81.

- McDonald, J., Veth, P., 2013b. The archaeology of memory: the recursive relationship of Martu Rock art and place. *Anthropological Forum* 23 (4), 367–386.
- McDonald, J.J., Veth, P., 2006. Rock art and social identity: a comparison of graphic systems operating in arid and fertile environments in the Holocene. In: Lilley, I. (Ed.), *Archaeology of Oceania: Australia and the Pacific Islands*. Blackwell, Oxford, pp. 96–115.
- Meehan, B., 1989. Plant use in a contemporary Aboriginal community and prehistoric implications. In: Beck, W., Clarke, A., Head, L. (Eds.), *Plants in Australian Archaeology*. Anthropology Museum, University of Queensland, St. Lucia, Qld, pp. 14–30.
- Mguni, S., 2009. Natural and supernatural convergences: trees in southern African rock art. *Current Anthropology* 50 (1), 139–148.
- Morse, K., Cameron, R., Reynen, W., 2014. A tale of three caves: new dates for Pleistocene occupation in the inland Pilbara. *Australian Archaeology* 79, 167–178.
- Morwood, M., Walsh, G., Watchman, A., 2010. AMS radiocarbon ages for beeswax and charcoal pigments in North Kimberley rock art. *Rock Art Research* 27 (1), 3–8.
- Nelson, D.E., Chaloupka, G., Chippindale, C., Alderson, M.S., Southon, J.R., 1995. Radiocarbon dates for beeswax figures in the prehistoric rock art of northern Australia. *Archaeometry* 37 (1), 151–156.
- Nomade, S., Genty, D., Sascio, R., Scao, V., Féruiglio, V., Baffier, D., Guillou, H., Bourdier, C., Valladas, H., Reigner, E., Debard, E., Pastre, J.F., Geneste, J.-M., 2016. A 36,000-year-old volcanic eruption depicted in the Chauvet-Pont d'Arc Cave (Ardeche, France)? *PLoS One* 11 (1), e0146621. <http://dx.doi.org/10.1371/journal.pone.0146621>.
- O'Connor, S., 1995. Carpenter's gap rockshelter 1: 40,000 years of aboriginal occupation in the Napier Ranges, Kimberley, WA. *Australian Archaeology* 40, 58–59.
- O'Connor, S., Maloney, T., Vannieuwenhuysen, D., Balme, J., Wood, R., 2014. Occupation at carpenter's gap 3, Windjana Gorge, Kimberley, Western Australia. *Australian Archaeology* 78, 10–23.
- O'Connor, S., Zell, L., Barham, A., 2007. Stone constructions on Rankin Island, Kimberley, Western Australia. *Australian Archaeology* 64, 15–22.
- O'Connor, S., Veth, P., 2006. Revisiting the past: changing interpretations of Pleistocene settlement subsistence and demography in northern Australia. In: Lilley, I. (Ed.), *Archaeology of Oceania: Australia and the Pacific Islands*. Blackwell, Oxford, pp. 31–47.
- Ouzman, S., 2001. Seeing is deceiving: rock art and the non-visual. *World Archaeology* 33 (2), 237–256.
- Pawley, A., 1998. Locating proto oceania. In: Pawley, A., Ross, M., Osmond, M. (Eds.), *The Lexicon of Proto Oceanic: The Culture and Environment of Ancestral Oceanic Society*. Australian National University Press, Canberra, A.C.T., pp. 17–34.
- Petri, H., 2011. *The Dying World in Northwest Australia*. Hesperian Press, Carlisle, WA.
- Petri, H., 2015. Ritual increase activities in the Kimberleys. In: Akerman, K. (Ed.), *Cologne to the Kimberley: Studies of Aboriginal Life in Northwest Australia by Five German Scholars in the First Half of the 20th Century*. Hesperian Press, Carlisle, WA, pp. 171–182.
- Pettigrew, J., 2011. Iconography in Bradshaw rock art: breaking the circularity. *Clinical and Experimental Optometry* 94 (5), 403–417.
- Randolph, P., 2011. Some indigenous stone arrangements in the south of Western Australia. In: Bird, C., Webb, R.E. (Eds.), *Fire and Hearth Forty Years on: Essays in Honour of Sylvia J. Hallam*. Western Australian Museum, Perth, WA, pp. 50–60.
- Reeves, J.M., Barrows, T.T., Cohen, T.J., Kiem, A.S., Bostock, H.C., Fitzsimmons, K.E., Jansen, J.D., Kemp, J., Krause, C., Petherick, L., Phipps, S.J., 2013a. Climate variability over the last 35,000 years recorded in marine and terrestrial archives in the Australian region: an OZ-INTIMATE compilation. *Quaternary Science Reviews* 74, 21–34.
- Reeves, J.M., Bostock, H.C., Ayliffe, L.K., Barrows, T.T., De Deckker, P., Devriendt, L.S., Dunbar, G.B., Drysdale, R.N., Fitzsimmons, K.E., Gagan, M.K., Griffin, M.L., Haberle, S.G., Jansen, J.D., Krause, C., Lewis, S., McGregor, H.V., Mooney, S.D., Moss, P., Nanson, G.C., Purcell, A., van der Kaars, S., 2013b. Palaeoenvironmental change in tropical Australasia over the last 30,000 years – a synthesis by the OZ-INTIMATE group. *Quaternary Science Reviews* 74, 97–114.
- Reichel-Dolmatoff, G., 1971. *Amazonian Cosmos: The Sexual and Religious Symbolism of the Tukano Indians*. University of Chicago Press, Chicago.
- Roberts, R., Walsh, G., Murray, A., Olley, J., Jones, R., Morwood, M., Tuniz, C., Lawson, E., Macphail, M., Bowdery, D., Naumann, I., 1997. Luminescence dating of rock art and past environments using mud-wasp nests in northern Australia. *Nature* 387 (6634), 696–699.
- Rosenfeld, A., 1993. A review of the evidence for the emergence of rock art in Australia. In: Spriggs, M., Fankhauser, B.L., Smith, M.A. (Eds.), *Sahul in Review: Pleistocene Archaeology in Australia, New Guinea and Island Melanesia*. Dept. of Prehistory, Research School of Pacific Studies, Australian National University, Canberra, A.C.T., pp. 71–80.
- Ross, J., 2015. Change and continuity. In: Paper Presented at Paper Presented at the 10th Workshop of the Science Advisory Council. Kimberley Foundation Australia, Melbourne, 11 November.
- Rowe, M.W., 2001. Physical and chemical analysis. In: Whitley, D.S. (Ed.), *Handbook of Rock Art Research*. AltaMira Press, Walnut Creek, Calif, pp. 190–220.
- Schulz, A., 1956. Northwest Australian rock paintings. *Memoirs of the National Museum of Victoria* 20, 7–57.
- Skoglund, P., 2012. *The Significance of Trees: an Archaeological Perspective*. Archaeopress, Oxford.
- Smith, C.D., 1982. The emergence of 'maps' in European rock art: a prehistoric preoccupation with place. *Imago Mundi* 34, 9–25.
- Stahl, A.B., 1993. Concepts of time and approaches to analogical reasoning in historical perspective. *American Antiquity* 58 (2), 235–260.
- Taşon, P.S.C., Brockwell, S., 1995. Arnhem Land prehistory in landscape, stone and paint. *Antiquity* 69 (265), 676–695.
- Taşon, P.S.C., Mulvaney, K., Fullagar, R., Head, L., 1999. "Bradshaws" – an eastern province? *Rock Art Research*, 16 (2), 127–129.
- Terrell, J.E., Hart, J.P., Barut, S., Cellinese, N., Curet, A., Denham, T., Kusimba, C.M., Latinis, K., Oka, R., Palka, J., Pohl, M.E.D., Pope, K.O., Williams, P.R., Haines, H., Staller, J.E., 2003. Domesticated landscapes: the subsistence ecology of plant and animal domestication. *Journal of Archaeological Method and Theory* 10 (4), 323–368.
- Travers, M., 2015. *Continuity and Change: Exploring Stylistic Transitions in the Anthropomorphic Figures of the Northwest Kimberley Rock Art Assemblage and the Varying Contexts of Rock Art Production* (Unpublished PhD dissertation). University of New England, Armidale.
- Ullah, I.I.T., Kuijt, I., Freeman, J., 2015. Toward a theory of punctuated subsistence change. *Proceedings of the National Academy of Sciences* 112 (31), 9579–9584.
- Veth, P., 1980. *An Archaeological Survey of Sturt Creek, Kimberley*. Third Year Honours Report for Dr C. Amsden. Unpublished report, UWA. Copies Held by AIATSIS and the KLC, Perth.
- Veth, P., 2005. Cycles of aridity and human mobility: risk-minimization amongst late Pleistocene foragers of the Western Desert, Australia. In: Veth, P., Smith, M.A., Hiscock, P. (Eds.), *Desert Peoples: Archaeological Perspectives*. Blackwell Publishing, Malden, MA, pp. 100–115.
- Veth, P., Fullagar, R., Gould, R., 1997. Residue and use-wear analysis of grinding implements from Puntutjarpa Rock shelter in the Western Desert: current and proposed research. *Australian Archaeology* 44, 23–25.
- Veth, P., O'Connor, S., Wallis, L.A., 2000. Perspectives on ecological approaches in Australian archaeology. *Australian Archaeology* 50, 54–66.
- Veth, P., Stern, N., McDonald, J., Balme, J., Davidson, I., 2011. The role of information exchange in the colonisation of Sahul. In: Whallon, R., Lovis, W.A., Hitchcock, R.K. (Eds.), *Information and its Role in Hunter-gatherer Bands*. The Cotsen Institute of Archaeology Press of UCLA, Los Angeles, pp. 203–220.
- Veth, P., Walsh, G., 1988. The concept of 'staple' plant foods in the Western Desert region of Western Australia. *Australian Aboriginal Studies* 2, 19–25.
- Veth, P., Ward, I., Manne, T., 2016. Coastal feasts: a Pleistocene antiquity for resource abundance in the maritime deserts of north west Australia? *The Journal of Island and Coastal Archaeology* 1–16. <http://dx.doi.org/10.1080/15564894.2015.1132799>.
- Veth, P.M., McDonald, J.J., 2011. Rock art on the canning stock route. In: La Fontaine, M., Carty, J. (Eds.), *Ngurra Kuju Walyja: One Country, One People: Stories from the Canning Stock Route*. MacMillan, South Yarra, Vic, pp. 396–403.
- Vigilante, T., Toohey, J., Gorring, A., Blundell, V., Saunders, T., Mangolamara, S., George, K., Oobagooma, J., Waina, M., Morgan, K., Doohan, K., 2013. Island country: Aboriginal connections, values and knowledge of the Western Australian Kimberley islands in the context of an island biological survey. *Records of the Western Australian Museum Supplement* 81, 145–182.
- Vinnicombe, P., 1976. *People of the Eland: Rock Paintings of the Drakensberg Bushmen as a Reflection of their Life and Thought*. University of Natal Press, Pietermaritzburg.
- Wallis, L.A., 2000. *Phytoliths, Late Quaternary Environment and Archaeology in Tropical Semi-arid Northwest Australia* (Unpublished PhD thesis). Archaeology and Natural History, Research School of Pacific and Asian Studies, Australian National University, Canberra.
- Wallis, L.A., 2001. Environmental history of northwest Australia based on phytolith analysis at carpenter's gap 1. *Quaternary International* 83–85, 103–117.
- Walsh, G., 1988. *Australia's Greatest Rock Art*. E.J. Brill/Robert Brown & Associates, Bathurst, N.S.W.
- Walsh, G., 1994. *Bradshaws: Ancient Rock Paintings of North-west Australia*. Edition Limitée, Geneva.
- Walsh, G., n.d. Unpublished notes. Copy held by M. Myers. North Carlton.
- Walsh, G.L., 2000. *Bradshaw Art of the Kimberley*. Takarakka Nowan Kas Publications, Toowoong, Qld.
- Ward, I., Larcombe, P., Veth, P., 2015. A new model for coastal resource productivity and sea-level change: the role of physical sedimentary processes in assessing the archaeological potential of submerged landscapes from the northwest Australian continental shelf. *Geochronology* 30 (1), 19–31.
- Watchman, A., 1993. Evidence of a 25,000-year-old pictograph in Northern Australia. *Geochronology* 8 (6), 465–473.
- Watchman, A.L., 1987. Preliminary determinations of the age and composition on mineral salts on rock art surfaces in the Kakadu National Park. In: Ambrose, W.R., Mummery, J.M.J. (Eds.), *Archaeometry: Further Australasian Studies*. Australian National University, Canberra, A.C.T., pp. 36–42.
- Watchman, A.L., 2000. Micro-excavation and laser extraction methods for dating carbon in silica skins and oxalate crusts. In: Ward, G., Tuniz, C. (Eds.), *Advances in Dating Australian Rock-markings: Papers from the First Australian Rock-picture Dating Workshop*. Occasional Aura Publication 10. Australian Rock Art Research Association, Melbourne, Vic, pp. 35–39.
- Welch, D., 1990. The bichrome art period in the Kimberley, Australia. *Rock Art Research* 7, 110–124.
- Welch, D., 1993. Stylistic change in the Kimberley rock art, Australia. In: Lorblanchet, M., Bahn, P.G. (Eds.), *Rock Art Studies: The Post-stylistic Era or where Do We Go from Here?* Oxbow Monograph 35, Oxford, pp. 99–113.

- Welch, D., 2003. Plant motifs in Kimberley rock-art, Australia. *Before Farming* 2003 (4), 1–13.
- Welch, D., 2007. Bradshaw art of the Kimberley. In: Donaldson, M., Kenneally, K.F. (Eds.), *Rock Art of the Kimberley: Proceedings of the Kimberley Society Rock Art Seminar Held at the University of Western Australia, Perth 10 September, 2005*. Kimberley Society, Perth, W.A., pp. 39–56.
- Whallon, R., 2006. Social networks and information: non-“utilitarian” mobility among hunter-gatherers. *Journal of Anthropological Archaeology* 25 (2), 259–270.
- Williams, A.N., Ulm, S., Cook, A.R., Langley, M.C., Collard, M., 2013. Human refugia in Australia during the last glacial maximum and terminal Pleistocene: a geo-spatial analysis of the 25–12 ka Australian archaeological record. *Journal of Archaeological Science* 40 (12), 4612–4625.
- Williams, A.N., Ulm, S., Turney, C.S.M., Rohde, D., White, G., 2015. Holocene demographic changes and the emergence of complex societies in prehistoric Australia. *PLoS One* 10 (6), e0128661. <http://dx.doi.org/10.1371/journal.pone.0128661>.
- Yen, D.E., 1995. The development of Sahul agriculture with Australia as bystander. *Antiquity* 69 (265), 831–847.