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Indigenous Knowledge of Rock Kangaroo Ecology in Western Arnhem Land, Australia

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Indigenous peoples of western Arnhem Land, central northern Australia, have detailed knowledge of the rock kangaroos of the region, species that are little known to science. Information about the ecology of the species is required for their conservation and management. Ethnoecological studies can assist senior indigenous people with transfer of knowledge and can give respect and meaningful employment to those involved. We used semidirected interviews in the regional vernacular, Bininj Kunwok, to record indigenous knowledge of the ecology of the four rock kangaroo species (Petrogale brachyotis, P. concinna, Macropus bernardus and M. robustus). Discussions focussed on habitat preferences, diet, activity patterns, reproduction, predation, and hunting practices. The ethnoecological knowledge of the rock kangaroo species was extensive, and both complemented and extended that reported in the scientific literature. In contrast to scientific understanding of taxonomy and ecology, consultants recognized the rock kangaroos as a natural group. They also described subtle differences in the species' comparative ecology. The methodology used proved highly successful and we recommend recording indigenous knowledge of the ecology of fauna species in the local vernacular wherever possible. This study is one of the most comprehensive ethnozoological studies of a group of species undertaken in Australia.

KEY WORDS: Indigenous Ecological Knowledge (IEK); ethnozoology; rock-wallaby; *Macropus*; *Petrogale*; Australia.

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INTRODUCTION

Indigenous peoples around the world have a rich body of knowledge about the ecology of local flora, fauna, and ecosystem processes, accumulated and applied through many generations of observation and experience. This local knowledge often far exceeds scientific knowledge and is being increasingly recognized as valuable for improving scientific understanding, conservation programs, and management practices (Berkes *et al.*, 2000; Moller *et al.*, 2004; Williams and Baines, 1993). For example, ethnoecological studies with local people of the Brazilian Pantanal found indigenous knowledge was able to bridge gaps in scientific knowledge (Calheiros *et al.*, 2000), and management of caribou has been improved by incorporating Inuit knowledge with scientific data (Beverly and Qamanirjuaq Caribou Management Board, 1996; Ferguson and Messier, 1997). There is also a growing literature on the links between indigenous languages and ecological knowledge, and the importance of recording indigenous ecological knowledge in local vernaculars, many of which are now endangered languages (Maffi, 2001).

In Australia, ethnoecological studies have documented indigenous names, classification systems, and uses of plants and animals in some regions (e.g., McKnight, 1999; Raymond *et al.*, 1999; Waddy, 1988). Others have involved indigenous people in biological surveys and threatened species work (e.g., Benshemesh, 1997; Burbidge *et al.*, 1988). Management programs that have incorporated both scientific and indigenous knowledge and involved Aboriginal traditional land owners in the process, such as for the Mala, an endangered hare-wallaby (*Lagorchestes hirsutus*) of the Tanami desert, are considered more successful than those conducted without such involvement (Johnson *et al.*, 1996). The Australian Federal Government states that 'maintaining and recording ethnobiological knowledge' is one of its objectives for biodiversity conservation (Environment Australia, 2001). Despite this, only a few studies have systematically recorded detailed Aboriginal knowledge of the biology and ecology of faunal species, and most of these have been conducted in arid and semiarid Australia (Baker and Mutitjulu Community, 1992; Finlayson, 1961; Geelen, 1999; Pearson, 1992; Tunbridge, 1991).

In parts of the Northern Territory such as Western Arnhem Land, many indigenous peoples did not move into large communities until the 1960s (Commonwealth of Australia, 1987). Consequently, there are still senior Aboriginal people who grew up on their estates who possess strong cultural heritage and knowledge of faunal species in the region. Yet many of these people are elderly and as a result indigenous ecological knowledge is now "suffering an escalating extinction phase" (Horstman

and Wightman, 2001). Senior Aboriginal people have custodial responsibilities for passing on knowledge but often encounter difficulty in doing so as young people often prefer to be in the larger communities and may view traditional knowledge as no longer relevant (Baker and Mutitjulu Community, 1992). If conducted as part of negotiated community collaborations, ethnoecological studies can assist senior custodians to make knowledge available to younger generations and can give respect and meaningful employment to those involved (Baker and Mutitjulu Community, 1992; Horstman and Wightman, 2001).

In the tropics of the Northern Territory, there is little scientific knowledge of the ecology of many mammal species and other vertebrate taxa (Strahan, 1995; Woinarski, 1992). One such group of animals that is poorly known to science is the kangaroos (family Macropodidae) that inhabit the rock country of the region (the short-eared rock-wallaby *Petrogale brachyotis*, nabarlek *P. concinna*, black wallaroo *Macropus bernardus*, and common wallaroo *M. robustus*). The nabarlek and short-eared rock-wallaby are small rock-wallaby species weighing less than 5 kg and the black wallaroo and common wallaroo are larger kangaroos (up to 22 kg and 47 kg respectively). Given recent reports of decline in populations of small mammal species in the region (Pardon *et al.*, 2003; Woinarski *et al.*, 2001) and the record of catastrophic extinction of small to medium-sized mammal species in other parts of Australia (Short and Smith, 1994), there is an urgent need for detailed information about the ecology of these species to ensure their conservation. Yet studying these species using scientific techniques is difficult because of their largely nocturnal and shy nature and the remote and inaccessible rocky areas they inhabit.

Since most of the sandstone rock country of the Northern Territory is Aboriginal-owned land (e.g., Arnhem Land) or in National Parks which are comanaged by Aboriginal people (e.g., Kakadu and Nitmiluk National Parks), the conservation of the rock kangaroo species largely depends on the management of these vast and poorly accessible rocky habitats by Aboriginal people. One of the rock kangaroo species, the black wallaroo, is found only on the Arnhem Land Plateau and its rocky outliers, an area entirely owned or comanaged by Aboriginal people. Peoples living in and adjacent to the sandstone rock country in the region have always hunted these rock kangaroo species for food (Altman, 1984; Press, 1988; Russell-Smith *et al.*, 1997). A study of the diet of Kunwinjku people at one outstation of western Arnhem Land found that mammals constituted up to 91% of their energy intake at some times of the year, and macropods (kangaroos and wallabies) made up more than half of the mammal species eaten (Altman, 1984). Given the importance of kangaroos as a food source,

generations of Aboriginal hunters have had extensive direct experience of observing them and their collective knowledge has been passed down from one generation to the next. The cultural and mythological significance of the species is also reflected in the abundance of stories and rock paintings about them (Chaloupka, 1993; Lewis, 1988; Taylor, 1996). Thus, this study aimed to record expert knowledge of the rock kangaroos from Aboriginal people in western Arnhem Land. Specifically we sought to gather information about aspects of the ecology of the rock kangaroo species such as their habitat preferences, diet, activity, reproduction, and predators, and to compare this information with existing scientific knowledge. We also recorded hunting practices that may affect land management and conservation of the species. A number of senior Aboriginal people in western Arnhem Land are keen for their knowledge to be maintained and passed down to future generations, and this project assisted with that process. It was also an ideal opportunity for indigenous knowledge to be used in a complementary manner with scientific knowledge to understand and, ultimately, manage and conserve these species.

METHODS

Bininj Kunwok is a collective term for a chain of mutually intelligible dialects (Kuninjku, Kune, Gundjeihmi, Kunwinjku, Mayali, and Kundedjnjenghmi) spoken by people living in western Arnhem Land and much of Kakadu National Park. The area encompasses much of the Arnhem Land Plateau (Fig. 1), a mass of resistant sandstone that rises abruptly from the flat plains to elevations up to 380 m. The Plateau and its outliers are comprised of rocky escarpments, outcrops, and platforms dissected by chasms and gorges, and are collectively described in Bininj Kunwok as *kuwarddewardde*, 'the rock country' or 'stone country.' The four rock kangaroo species are all found in this rock country and the black wallaroo is restricted in its distribution to this area. The Plateau is largely unoccupied by people today, but there are some small family-based communities or 'outstations' (~25 persons each) scattered throughout the area (Yibarbuk *et al.*, 2000).

We interviewed 14 individual indigenous consultants (who refer to themselves as *Bininj* 'Aboriginal people') between July 2002 and August 2004 at seven outstations in western Arnhem Land and Kakadu National Park where the consultants lived (Fig. 1). Nine of these interviews were conducted in three dialects of the local *lingua franca* Bininj Kunwok (Kundedjnjenghmi, Kune, and Kuninjku) facilitated and translated by one of the authors (MG). This allowed much more comprehensive discussion

Fig. 1. Map of central northern Australia, showing the outstations and communities where knowledge was recorded, and areas where each Bimij Kunwok dialect is spoken. The rocky Arnhem Land Plateau is shown by the 200 m elevation contour, and the area to the east of the marked boundary is Arnhem Land, a large tract of Aboriginal owned land.

of the topics than in the other five early interviews that were conducted in English. Interviews conducted in Bininj Kunwok were recorded on video and later transcribed and translated into English. Most interviews were conducted on a one-to-one basis, although other family members were also often present. A book of pictures and photographs of the kangaroo species in the region was used as an elicitation prompt. The knowledge of the ecology of the kangaroo species was largely 'public knowledge.' While we recorded some of the large body of traditional knowledge relating to the religious and cultural significance of rock kangaroos, our focus was on ecological knowledge of the species.

Selection of interviewees was deliberately nonrandom. Consultants chosen were recognized by the community to have knowledge and experience of rock kangaroos. Only men were interviewed. However, on many occasions comments were added by women present at the interviews. Men were chosen for interview because hunting is a male activity and it is through hunting that they have intimate knowledge of the habits of the animals. Intergenerational knowledge has also been passed down to them about the ecology of the species and how to hunt and prepare them. Two classes of men were interviewed; older men who used to hunt rock kangaroos with spears and young men who are still actively hunting the species with firearms. The low number of consultants interviewed reflects the few people who remain living on or near the sandstone country, and who have detailed knowledge and familiarity with the species. There were a further four indigenous informants in the area with extensive knowledge who could not be interviewed due either to their poor health or unavailability. This research did not attempt to examine the ethnography of rock kangaroos across the community, but sought to document 'expert' knowledge of the ecology of the species.

Unstructured interviews were conducted, with each consultant asked similar questions in an open discussion format. This style of semidirected interview, in which questions are presented in the context of discussion rather than a formal question and answer session, is effective because it allows more 'natural' conversation to occur and unanticipated insights to emerge (Huntington, 2000; Mackinson, 2001). Since local dialects use different names for the species, including names for different age classes and sexes, we often started conversations by recording the local species names and physical characteristics. The following topics were then discussed: the species' habitat preferences, activity and behavior, diet, predators, and hunting practices. Additional information about the diet of the species was obtained on two occasions by walking through rocky areas with consultants who identified plant species eaten by the kangaroos.

To accurately gather information about the distribution and change in abundance of the rock kangaroo species needed to assess their conservation status requires detailed use of maps, timelines, demography of the people involved, and knowledge of the local names for places in the region. A project is currently being conducted by the Northern Territory Department of Environment and Heritage to record this information for all mammal species from custodians in the region, thus it was not a focus of the present study. Furthermore, when this subject was raised with consultants, it was not found to be a topic to which they related from the same perspectives. As a general observation in western Arnhem Land, Aboriginal people have a phenomenological approach to animal populations: the animals are part of the environment and do not go away. However, there are supernatural and religious explanations for population changes, such as neglect of 'increase' ritual ceremonies.

The intellectual and cultural property rights over the knowledge recorded in this study remain clearly with the indigenous custodians of the knowledge. The research conformed to the Guidelines for Ethical Research in Indigenous Studies produced by the Australian Institute for Aboriginal and Torres Strait Islander Studies (AIATSIS), including development of a research agreement with the Northern Land Council and informed consent. Copies of the digital videos were returned to the communities involved and archived with AIATSIS. The knowledge was also developed into a bilingual storybook and teaching resource for the outstation schools in the region.

The data were collated by grouping answers from consultants by species and theme. Since consultants were not specifically asked the same questions, it was not possible to statistically analyse the proportion of consultants who gave a particular response. However, it was still useful to quantify and specify the number of consultants who gave a response, in order to show the strength of support for a comment and whether the knowledge is commonly held across the community. On most occasions, collective views emerged from the combined responses of the consultants. However, for topics where different opinions were given, the range of responses is described. Other studies have only included information corroborated by more than one interviewee (e.g. Henfrey, 2001). However we found noteworthy information was often raised by a single consultant and, given the small sample size available, this information has been included in the analysis but noted as being from a single consultant. In the results we note the number of consultants who gave a response in parentheses after the statement described, e.g., ($n = 3$).

In order to highlight the comparative ecology of the rock kangaroo species, data are presented by ecological theme rather than by species. Some translated quotes are given to highlight particular points and Linnean

species names replace local species names in these translations. Existing scientific knowledge about each ecological theme is described throughout the results in brief point form to allow comparison with the indigenous knowledge. Comparison of the knowledge bases in this way was not provided in order to validate the indigenous knowledge against the scientific knowledge but to use the two 'tool boxes' in tandem; to learn about the species from the similarities and differences existing between the two knowledge systems. In the text, description of the 'rock kangaroos' refers to all four species (the nabarlek, short-eared rock-wallaby, black wallaroo, and northern wallaroo). There is also often reference to two pairs of species: the small rock-wallaby species of the *Petrogale* genus (nabarlek and short-eared rock-wallaby) and the larger wallaroo species of the *Macropus* genus (black wallaroo and common wallaroo).

RESULTS

Language and Knowledge

In general, consultants gave similar accounts of the ecology of the different rock kangaroos. They viewed the rock kangaroo species as a natural group, with many aspects of their ecology such as diet, reproduction, and predators described similarly. However, they also described subtle differences between the ecology of each species or between the pairs of rock kangaroos (the nabarlek and short-eared rock-wallaby, and the black wallaroo and common wallaroo). The information was detailed and reflected great familiarity with the species. Each person gave their own insights based on their unique experiences and direct observations of the animals, but respondents also provided information on diet based on their examination of faeces and the gut contents of hunted animals. Some consultants were more familiar with and had a greater depth of knowledge about some individual species, and discussion sometimes focussed on a particular species as a result of the consultant's interest. Some knowledge may have been passed down intergenerationally, however consultants did not separately identify information they knew from direct experience from that which they had been told.

In each Bininj Kunwok dialect there are many names for the rock kangaroo species (Table I). For the smaller rock-wallaby species a single name is used, whereas for the larger wallaroo species (in which the sexes are far more conspicuously morphologically distinct) separate names are used for the males and females. Each rock kangaroo species was clearly recognized as distinct, and there were also names given to some age classes such as

Table 1. Bininj Kunwok Names for Rock Kangaroo and Other Kangaroo Species in Western Arnhem Land

Scientific name	Common name	Kundedjnjenghmi name	Kuninjku name	Kune name	Moiety	Subsection affiliation	Ritualistic name	Hopping verb
<i>Macropus bernardus</i>	Black Wallaroo	Barrk(♂) Djukerre(♀)	Nadinem(♂) Djukerre(♀)	Barrk(♂) Djukerre(♀)	Duwa	Balang(♂) Belinj(♀)	Wirridjum manarbo (large ♂) Manburlarl kalerkyikarime (small ♂) Wirridjumwarre(♀)	-mulbardme
<i>Macropus robustus</i>	Common Wallaroo	Kanbulerri(♂) Narrubad (juvenile ♂) Wolerrk(♀) Kurruubu (synonym for ♂)	Kalkberd(♂) Wolerrk(♀)	Namarr(♂) Wolerrk(♀)	Duwa	Kamarrang(♂) Kamanj(♀)		-njedjme(♂) -mulbardme(♀)
<i>Petrogale brachyotis</i>	Short-eared Rock-wallaby	Badbong(♂ + ♀) Badkurruyul (large ♂) Nabarlek(♂ + ♀)	Badbong(♂ + ♀) Badkurruyul (large ♂) Nabarlek(♂ + ♀)	Badbong(♂ + ♀) Badkurruyul (large ♂) Nabarlek(♂ + ♀)	Yirridjdja	Ngarridj(♂) Ngarridjdjan(♀)	Andjumbirilbirilil	-mulbardme
<i>Petrogale concinna</i> <i>Macropus agilis</i>	Nabarlek Agile Wallaby	Komobolo(♂ + ♀) Meribbe(♀) Warradjangkall(♂) Nakornborrin (juvenile ♂) Nakurdakurda (large ♂)	Kornobolo Meribbe(♀) Warradjangkall(♂) Nakornborrin (juvenile ♂) Nakurdakurda (large ♂)	Kornobolo Meribbe(♀) Warradjangkall(♂)	Duwa Duwa		Dolhwarrambu Nabohnadjarde	-mulbardme -lurhlurlime
<i>Macropus anilopinus</i>	Antilopine Wallaroo	Kalaba(♂) Djamubuk (juvenile ♂) Karndayh(♀) <i>not in range</i>	Kandakidj(♂) Karndayh(♀)	Kalaba(♂) Karndayh(♀)	Yirridjdja	Ngarridj(♂) Ngarridjdjan(♀)		-nawudme(♂) -djarrwahime(♀)
<i>Onychogalea unguifera</i> <i>Lagorchestes conspicillatus</i>	Northern Naitail Wallaby Spectacled Hare-wallaby	Ngabudj <i>not in range</i> Ngolomorro Wularia Wurlungurluh	Ngabudj Wularia Wurlungurluh	Ngabudj Ngolomorro	Yirridjdja			

large males, as well as ceremonial names. Different verbs were used to describe the hopping movements for each species or groups of species, and the moiety and subsection affiliations⁴ of each species were also recorded (Table I).

- Biningj classification of the species was clearly the same as the scientific nomenclature (Strahan, 1995).
- The scientific literature recognizes that the species inhabit similar rocky habitats but describes the two pairs of closely related species of each genus as having more similar ecology, rather than the four species being associated as a group (Strahan, 1995).

Physical Characteristics

Consultants described the nabarlek and short-eared rock-wallaby as being very similar in appearance, but the short-eared rock-wallaby as larger. For both rock-wallaby species males and females were described as looking similar, with males tending to be larger. When asked about the specific diagnostic features they used to separate the rock-wallaby species, consultants suggested that the short-eared rock-wallabies have dark underarms ($n = 5$), the nabarlek's snout is shorter ($n = 2$), the short-eared rock-wallaby has white on its cheeks ($n = 1$), and the short-eared rock-wallaby's forehead was finer/longer ($n = 1$). Consultants all described the male black wallaroo as being black and larger than the lighter colored female. The common wallaroo was always described as the largest of the rock kangaroos and the female common wallaroo was described as grey, similar in color to the female black wallaroo ($n = 4$).

- Similarly the scientific literature describes differences in size and some color markings between the two rock-wallabies (Menkhorst, 2001), as well as the fact that the nabarlek jumps with its tail held high and arched over its back and suggestions that it continually replaces its molar teeth (Churchill, 1997; Sanson *et al.*, 1985; Strahan, 1995).
- The male common wallaroo is sometimes reported to be darker than the female (Strahan, 1995).

⁴Throughout Arnhem Land, Aboriginal people organize the natural and spiritual world into two named, patrilineally inherited moieties (*duwa* and *yirridjdja*) and eight 'subsections' (marriage classes which mesh with the moiety system). Aboriginal people in western Arnhem Land incorporate all macropod species into this system based on the religious view that at the time of creation all animals were previously in human form and have since transmuted into all the animal species of the region.

Habitat Use

All consultants considered the rock country to be the main habitat of the nabarlek and short-eared rock-wallaby, and that they sleep in caves and crevices in the rocks ($n = 14$). Opinions differed over whether nabarleks and short-eared rock-wallabies use rainforest patches. Some consultants stated that they did not use rainforests ($n = 2$), one described them using rainforest in the tops of gorges, and another said they use rainforests dominated by the large, endemic tree *Allosyncarpia ternata*. Many consultants specifically described the nabarlek as living “deep in the rock country” ($n = 7$), and others went further to say “they live away from human scent” ($n = 3$). Several consultants also separately referred to nabarlek living near *Blepharyocarya depauperata* trees, although the reason for proximity to this particular plant species was not specified.

The black wallaroo and common wallaroo were always described as living in the rock country, usually sheltering in caves during the day ($n = 14$). It was also suggested that black wallaroos rest in other habitats such as *Triodia* hummock grass, rainforest patches, under trees, and in sandy creek beds. When asked whether the common wallaroo uses the same habitats as the black wallaroo, some consultants described them as using the same rocky areas, whereas others suggested the common wallaroo is also found “in more open places,” “on the soil,” and “lower down on the margins of the rock country.” One consultant explained the difference as temporal: “They would meet up at night. But not in the day time, they would be in different places” (LBN). Some also suggested the common wallaroo changes habitat with season, moving up into the rock country in the wet season ($n = 2$). Caves, overhangs, the shade of *Terminalia carpentariae*, *Calytrix brownii* thickets, and rainforests were also mentioned as resting places for the common wallaroo.

- Scientific knowledge of the habitat use of the short-eared rock-wallaby and nabarlek is limited, but they are known to live sympatrically in broken cliffs, scree slopes, gorges, and boulder piles (Churchill, 1997; Press, 1988).
- The black wallaroo is known to inhabit the steep rocky escarpments and heavily dissected sandstone country of the Arnhem Plateau (Parker, 1971; Press, 1989), and the common wallaroo is found associated with rocky ranges, hills, scree slopes, scarps, ridges, and plateaux across Australia (Press, 1989; Strahan, 1995). The wallaroo species are known to live sympatrically (Press, 1988), but no specific differences in habitat or resting places are recorded in the literature.

Diet

Consultants identified over 35 plant species consumed by the rock kangaroo species (Table II). In the interviews, consultants collectively described 29 species. When asked about the diet of one of the kangaroo species, each consultant recalled between two and six plant species, often describing in detail the part of the plant that is eaten, the season of consumption and sometimes the feeding behavior associated with a particular plant. Additional plant species were identified when we walked through rocky areas with consultants and discussed the uses of the various plant species found. For example, during one walk a single consultant recognized 22 plant species as dietary items of the rock kangaroos.

Many consultants described the rock kangaroos as having the same diet. One consultant summarised this saying, "They all eat the same food, such as *Terminalia carpentariae*" (JR). Yet there were also some differing opinions about whether a plant species was eaten by a particular kangaroo species. In general, consultants stated that all the rock kangaroos eat grass, leaves, fruit and yams (tubers). Most consultants claimed the grass *Triodia microstachya* to be a major food item of all the rock kangaroos ($n = 9$). As well as the various *Triodia* species, consultants mentioned 18 other plant species eaten by the short-eared rock-wallaby and/or nabarlek, which were also described as digging for yams ($n = 3$).

Many people said black wallaroos eat *Triodia*, other grasses, leaves, flowers and/or fruit of various tree species, and mentioned the shrub *Solanum echinatum* as one of its favorite foods ($n = 4$).⁵

The black wallaroos were also said to dig up yams and long yams (*Dioscorea transversa*) ($n = 5$). The most unusual dietary item described for the black wallaroo was the 'djilawanbed,' a giant millipede that lives in *Allosyncarpia ternata* forest. This was described by one of the senior consultants on several occasions as being eaten only by the black wallaroo and not by other kangaroos—"in the *Allosyncarpia* groves, it eats them. It bites the long body of the grub and carries it off. It sees them crawling around and eats them. It belongs to the black wallaroo" (LBN).

Many of the same plants eaten by the other rock kangaroos were also described for the common wallaroo. However, it was also said to consume several grass species that are eaten by the plains kangaroo species ($n = 3$), and to dig for yams on softer ground ($n = 3$). When asked whether the diet of the two wallaroo species differs in any way, one consultant suggested the

⁵"When it eats the *Solanum echinatum* plant it closes its eyes, not eating with open eyes otherwise the sharp spikes of the plant would pierce its eyes. Its like eating chilli, chomping away with its eyes closed and it keeps going eating this plant until they get fat. That is the food of the black wallaroo." (JK)

Table II. Plants Eaten by Four Rock Kangaroo Species According to Indigenous Knowledge in Western Arnhem Land

Plant species	Growth form ^a	Kangaroo species that consumes it ^b	Notes
<i>Acacia difficilis</i>	S	BW ^c	Leaves and flowers eaten
<i>Acacia latescens</i>	T	BW ^c SE ^c	Fallen seeds eaten
<i>Alloteropsis semialata</i>	G	CW ^c	Fleshy white roots eaten
<i>Aristida</i> sp.	G	CW ^c	Eaten when young, but when it is large it pokes them in the eye and they choke on the seeds
<i>Alyxia tropica</i>	S	BW ^c	Fruit and flowers eaten
<i>Blepharocarya depauperata</i>	T	BW, NB, SE	Leaves and fruit eaten
<i>Buchanania obovata</i>	T	BW, NB, CW ^c , SE ^c	Fallen fruit eaten
<i>Decaschistia byrnesii</i>	S	BW, NB, CW, SE ^c	Leaves eaten, dig tubers sometimes
<i>Dioscorea transversa</i>	C	BW	Dig up long yams to eat
<i>Eriachne trisetata</i>	G	CW ^c , BW ^{cd} , SE ^{cd}	Eaten when young
<i>Ficus platypoda</i>	T	BW, NB ^c , CW ^{cd} , SE ^d	Leaves and fruit eaten
<i>Ficus subpuberula</i>	T	BW, CW ^c , SE ^c	Leaves and fruit eaten throughout the year
<i>Ficus virens</i>	T	BW ^c , SE ^c	Leaves and fruit eaten
<i>Fimbristylis composita</i>	D	CW ^c	
<i>Flagellaria indica</i>	C	BW ^c , CW ^c	
<i>Gardenia fucata</i>	T	BW, NB ^c , SE	Leaves eaten
<i>Ipomoea abrupta</i>	C	SE ^c , NB ^c	Dig up roots to eat
<i>Melodorum rupestre</i>	C	BW, NB, CW ^c , SE ^c	Leaves eaten
<i>Memecylon arnhemensis</i>	S	BW ^c , NB ^d	Leaves eaten
<i>Murdannia</i> sp.	H	BW ^c	Finger like roots are eaten
<i>Pandanus basedowii</i>	T	BW	New central leaves are eaten
<i>Pavetta brownii</i>	T	BW ^c , CW ^c	Many species eat the leaves but really CW food. Often see tracks to it because so many are eating it, and male CWs fight for it
<i>Persoonia falcata</i>	T	BW ^c , CW ^c	Fruits eaten
<i>Pouteria arnhemica</i>	T	BW ^c , CW, SE ^c	Leaves and fruits eaten
<i>Pouteria pohlmanniana</i>	T	BW ^c , CW ^c	Leaves eaten
<i>Schizachyrium</i> sp.	G	CW ^c	
<i>Solatum</i> sp. (<i>echinatum</i> , <i>clarkiae</i> and <i>asymmetriphyllum</i>)	S	BW, CW, SE ^{cd}	Favourite BW food, eat leaves and flowers in wet season
<i>Sorghum</i> sp. (annual)	G	BW ^c , CW ^c	Eaten when young
<i>Sterculia quadrifida</i>	T	BW ^c , NB ^c	Fruit/seeds eaten in the wet, thunder season
<i>Terminalia carpentariae</i>	T	BW, NB, CW, SE	Fruit/seeds eaten
<i>Terminata ferdinandiana</i>	T	BW, NB, CW ^c , SE ^c	Fruit/seeds eaten
<i>Triodia plectrachnoides</i>	G	BW ^c , NB ^c , CW ^c , SE ^c	Eaten when both young and old
<i>Triodia microstachya</i>	G	BW, NB, CW, SE	Important food for all rock kangaroos—eaten throughout the year. Shoots, seeds and seedheads eaten

Table II. Continued

Plant species	Growth form ^a	Kangaroo species that consumes it ^b	Notes
Anbodjub ^e	G	BW ^c	Another rock Spinifex species eaten
Andarlkbang ^e	S	BW ^c	Sandstone shrub with white flowers eaten
Andortkbakbak ^e		BW ^c	
Anngarranjgarranj ^e	G	BW	Little fingerlike tubers eaten
Ankarrarndjalkkarrarndjalh ^e	G	BW ^c	Another rock Spinifex species eaten
Djilawanbed grub		BW ^c	Eats this giant millipede that lives in <i>Allosyncarpia ternata</i> forest

^aC: climber, D: sedge, G: grass, H: herb, S: shrub, T: tree.

^bBW: Black Wallaroo *Macropus bernardus*, CW: Common Wallaroo *Macropus robustus*, SE: Short-eared Rock-Wallaby *Petrogale brachyotis*, NB: Nabarlek *Petrogale concinna*.

^cDescribed as eaten by only one consultant.

^dDescribed as eaten by one consultant, but not eaten by another.

^eIdentification of this plant is still unknown.

common wallaroo eats “dried out grass, the dead grass which has rotted down.”⁶ Consultants also specified that the common wallaroo does not eat *Pandanus basedowii*, *Ficus platypoda*, or the ‘djilawanbed’ millipede.

- The view of Bininj that the diet of the rock kangaroos is largely the same contrasts with the scientific understanding that the wallaroos are grazers and the smaller rock-wallabies have a larger component of browse in their diet (Dawson, 1989).
- The diet of the short-eared rock-wallaby and nabarlek is suggested by some scientists to be the major mechanism of niche separation between the two species. Both species are described as eating a range of grass and browse (tree and shrub) species, but the nabarlek, which has unique molar replacement, is thought to be more of a grazer, eating predominantly fern and sedges in the dry season (Sanson *et al.*, 1985).
- In contrast to the broad diet described by consultants, in the scientific literature the common wallaroo is reported to consume grass (Ellis *et al.*, 1977; Taylor, 1983). There are no scientific records of the diet of the black wallaroo.

⁶He also said; “They eat separately, but still eat similar things, *Solanum echinatum*, but common wallaroos tend to eat ‘softer’ foods of the open bushland, but black wallaroos can too. We say that the black wallaroos eat the foods which appear after burning” (LBN).

Water Use

A range of opinions was given about the use of water by the different rock kangaroo species, with some consistent themes emerging between the rock-wallabies and between the wallaroos. Many consultants suggested the smaller rock-wallaby species stay amongst the rocks and find water there from dew, puddles, or seeps after rain ($n=6$). However, one consultant suggested, “it stays in the rocks. It doesn’t drink.” Rock-wallabies were said to use lower areas and creeks in the rock country to drink, but not to come down to large sandy creeks ($n=7$). However, one consultant described them using sandy billabongs if they are really desperate for water.

All consultants agreed that black wallaroos and common wallaroos come down from the rocks primarily at night to drink from creeks, rivers, and billabongs. Some suggested that the black wallaroo only comes down in the dry season ($n=2$), and one described this as follows: “It comes down to drink at the creek. It comes down at night. When it rains, it drinks the pools of water on the top of the rocks. It doesn’t come down. It only comes down in the hot dry season to drink” (DjNg). Another consultant mentioned them digging for water when really thirsty.

- There are no reports in the literature of whether the short-eared rock-wallaby and nabarlek drink free-standing water. However, reports of other rock-wallaby species drinking water lying amongst the rocks (Geelen, 1999), ‘sucking’ rocks (Tunbridge, 1991), travelling to drink water at dry times (Lim *et al.*, 1987), or not needing to drink surface water (Kennedy and Heinsohn, 1974) are similar to the range of options given by consultants.
- Large kangaroos are commonly reported to come down to water-holes to drink, yet the common wallaroo can also survive in areas without surface water (Croft, 1981).

Activity and Behavior

Consultants agreed that rock kangaroos hide or rest in caves during the day and come out at dusk to forage through the night and early morning ($n=12$). Occasionally it was mentioned that they move about in the day, and the rock-wallabies come out and play after rain ($n=2$).

Numerous consultants claimed that nabarleks and short-eared rock-wallabies stomp their feet ($n=5$). This was described as the rock-wallabies dancing ($n=3$), e.g.: “You know that this one . . . it has its own dance. You know how we humans have songs and dances, well so do they (the rock wallabies). They all come out and they dance ‘stomp’. Yes, they dance and

sing and the other wallabies in the rocks hear them and come out and dance. They go stomp stomp stomp, 'yey' they call out" (TN).

There was only limited discussion about the species' territories and fidelity to den sites. However, the black wallaroo was said to use a range of shelter sites ($n=2$) and some consultants described always seeing the same black wallaroo in the same area ($n=2$). Black wallaroos were said to have territories ($n=2$): "They stay in the same place forever. It might go off to another place to eat and drink but then comes back to its territory. If another wallaroo comes into the area the owner says 'get lost' and the foreigner is afraid to sit down there. (In his territory) he has a female partner and might find another within his area. Each male has his female" (LBN). The rock-wallaby species were described as using a range of dens ($n=2$) and one consultant explained this as a predation-avoidance strategy. Some commented that the rock-wallabies and black wallaroo get tired if they have to move around on the flat ground for long ($n=3$).

There was consensus amongst consultants that the condition of the rock kangaroos becomes poor and some of their fur falls off in the late dry season. This phenomenon was commonly described for the wallaroos ($n=6$) and also for the rock-wallabies ($n=3$). Several consultants pointed out that the condition of the animals improves again when feed becomes abundant in the wet season. This improvement in condition was also described in terms of the marrow in the bones being full at this time: "When the rain starts, the first storms, well their fur grows back again. When the spear grass is up, their fur is healthy. On the upper body, the fur appears thick ... it breaks the grass down and eats the flowers of the grass. That's when we say the black wallaroos are at their peak. It eats grass and gets fat, lots of marrow and is healthy. That's when it has fat and plenty of bone marrow" (LBN).

The behavioral patterns of the rock kangaroos that Bininj described were similar to those reported for these or other macropod species in the scientific literature:

- Rock kangaroos rest during the day and come out at dusk to forage through the night and early morning (Parker, 1971; Sanson *et al.*, 1985; Strahan, 1995).
- Rock-wallabies use a range of diurnal shelters (Batchelor, 1980; Jarman and Bayne, 1997).
- The hind foot thump is a common behavior in macropods (Coulson, 1989).
- The change in condition of the fur, bone marrow, and fat deposits of rock kangaroos with season has not been reported in the literature for the rock kangaroo species but is concordant with the low weights

in the dry season and the gains in weight at the onset of the wet season found in the agile wallaby (*M. agilis*) (Bolton *et al.*, 1982).

Mating and Reproduction

All consultants who talked about mating in the rock kangaroos corroborated that the species form pairs: “The male and female live together. He never leaves her. He follows the same female” (MK). However, it was also mentioned that the males sometimes take another female. In both the black wallaroo and common wallaroo, males were described as fighting with other males over females ($n=6$). Similar fighting between male rock-wallabies was also described ($n=2$). Several people stated that the rock kangaroos mate at any time of the year ($n=4$), while others referred to them mating in the wet season and having large joeys in the dry season ($n=3$). It was agreed that like other kangaroo species, the rock kangaroos carry their young in the pouch and look after them until they reach a size at which they become independent.

- Fighting between male rock kangaroos and females looking after pouch young until a certain size are common behaviors documented for macropods (Coulson, 1989; Delaney, 1997; Jarman and Bayne, 1997).
- The suggestion by consultants that breeding can occur at any time of year is concordant with the continuous breeding found in other rock-wallaby species such as *P. assimilis* (Delaney, 1997). The peak in joey numbers in the dry season described by consultants supports Sanson *et al.*’s (1985) suggestion that the nabarlek is a seasonal breeder.
- Although Bininj commonly claimed that males and females move around in pairs, lifelong monogamy was not necessarily assumed. Scientific reports also vary over whether rock-wallabies are monogamous with some studies suggesting they exhibit facultative long-term monogamy (Barker, 1990; Horsup, 1994) and others that they are polygamous (Batchelor, 1980; Laws and Goldizen, 2003).

Predators and Associations with Other Species

Consultants consistently suggested that the Oenpelli python (*Morelia oenpelliensis*) is a predator of nabarleks, short-eared rock-wallabies and young black wallaroos ($n=9$). The details of the method of attack were also consistent: “It strikes and then coils itself around with its long body. It attacks it. If it doesn’t kill it by striking, it coils itself around the kangaroo and kills it. It crushes it to death” (DjNg).

Eagles were identified as predators of rock-wallabies ($n = 5$) and sometimes of black wallaroo and common wallaroo joeys ($n = 3$). One consultant specified that the wedge-tailed eagle (*Aquila audax*) attacks the eyes of the kangaroo. Opinion was divided about whether dingoes (*Canis lupus dingo*) take rock kangaroos. Some said that the rock-wallabies are taken ($n = 3$) and another stated that black wallaroos are taken, while others suggested that rock-wallabies are too fast and the dingo can not catch them amongst the rocks ($n = 3$). The dingo was sometimes described as preferring common wallaroos or the kangaroos that live on the plains (*Macropus agilis* and *M. antilopinus*) ($n = 3$).

Associations between the black wallaroo and birds were mentioned on several occasions ($n = 4$). The most common story told was of a bird that sings out to the black wallaroo to warn it when people are coming to hunt it. The other story is of a bird that cleans the ticks off the black wallaroo: "They don't have lice but ticks in their groins and rump area and in their ears. A little bird bites off the ticks for them. It is the *djang* 'dreaming' for the black wallaroos ... it calls out 'yuk yuk yuk yuk, yukkko.' It picks off the ticks on its groin and holds onto the wallaroos and chatters away saying maybe 'there's a kangaroo there (let's go!).' We used to see them on the wallaroos. It's a bird called *yirlinkirrkirr*. A little bird. It works for a long time crawling over them tirelessly" (LBN). Further questioning suggested the bird removing the ticks is the sandstone shrike-thrush (*Coluricincla woodwardi*), which is found in similar rocky habitats to the rock kangaroos.

- Pythons, white-bellied sea-eagles (*Heliaetus leucogaster*) and wedge-tailed eagles are reported as predators of rock-wallabies in other parts of Australia (Geelen, 1999; Sanson *et al.*, 1985). Dingoes are known to take kangaroos (Robertshaw and Harden, 1989), but there are also suggestions in the literature that the common wallaroo may escape predation because of its agility in the rocky terrain it inhabits (Croft, 1987). The literature also describes cats preying on rock-wallabies (Geelen, 1999; Spencer, 1991), which was not mentioned by consultants.
- There are no records of a symbiotic relationship between wallaroos and bird species.

Hunting and Fire

Although consultants stated that fire is not used to hunt rock kangaroos in drives as it is for the kangaroo species that live on the plains ($n = 5$), some recounted that fire is used to flush the rock kangaroos from the rocks:

“We light fires in the *Triodia* grass to flush them out. We see them coming out when we light the fires. They climb up higher on the rocks and watch the flames. We shoot them” (DjNg). Consultants also described using fire to create new growth that is an important food source for the kangaroo species.

Consultants suggested that few rock kangaroos are now hunted. Two of the main young hunters at outstations on the Arnhem Land Plateau described hunting only a few black wallaroo and even fewer rock-wallabies each year. Antilopine wallaroos (*M. antilopinus*) and agile wallabies (*M. agilis*) are the main kangaroo species that continue to be hunted. While questions were not asked specifically about the conservation status of the species, it was clear from the discussions that the rock kangaroo species are still considered abundant in the rock country. One consultant describing the nabarlek said, “they are still numerous but no one is out looking for them in the caves where they live” (LBN).

DISCUSSION

Reflections on Indigenous and Scientific Knowledge

Bininj have detailed ecological knowledge of the rock kangaroos in western Arnhem Land. The many names used for each of the species reflect great familiarity and depth of knowledge. The ethnoecological knowledge was largely consistent with, and in many subject areas, more extensive than that currently recorded in the scientific literature. Indeed, the high level of concordance between the two knowledge bases was striking (Table III). There were only two incidences of contradiction between the indigenous and scientific data; Bininj described the common wallaroo as eating fruit and seeds of browse species and as monogamous, which contrasts with descriptions in the scientific literature. However, in this case the literature is based on non-tropical subspecies of the common wallaroo (Ellis *et al.*, 1977; Taylor, 1983) and it is possible that future research on the northern subspecies may indeed support the indigenous knowledge.

Much indigenous knowledge about the rock kangaroos is noteworthy, particularly given the lack of scientific data on these species (Table III). For example, the morphological similarities of the nabarlek and short-eared rock-wallaby have made scientific survey of the nabarlek difficult (Churchill, 1997), but the diagnostic features that Bininj use to separate these two rock-wallaby species may assist with future survey work. Similarly, indigenous knowledge recorded about the comparative ecology of the rock kangaroos will assist research into how these species coexist in the same areas.

Table III. Comparison of Indigenous Ecological Knowledge (IEK) and Scientific Ecological Knowledge (SEK) for the Four Rock Kangaroo Species of Central Northern Australia

	<i>P. brachyotis</i>		<i>P. concinna</i>		<i>M. bernardus</i>		<i>M. robustus</i>	
	IEK	SEK	IEK	SEK	IEK	SEK	IEK	SEK
Habitat use								
Use rocky habitats	+	+	+	+	+	+	+	+
Use rainforests	+/-	?	+/-	?	+	+	+	+
Use woodlands	+/-	+	+/-	+	+/-	+	+	+
Rest in caves	+	+	+	+	+	+	+	+
Rest in sandy creek beds	-	?	-	?	+	?	+	?
Diet								
Eat grass	+	+	+	+	+	?+	+	+
Eat browse leaves	+	+	+	+	+	?	+	+
Eat browse fruits/seeds	+	+	+	?	+	?	+	-
Dig and eat yams	+	?	+	?	+	?	+	?
Water use								
Use large creeks	-	?	-	?	+	?	+	?
Get water amongst rocks	+	?+	+	?+	+	?	?	?+
Drink free water	+/-	?-	+/-	?+/-	+	?+	+	+
Activity								
Emerge at dusk to forage nocturnally	+	+	+	+	+	+	+	+
Use a range of shellers	+	?+	+	?+	+	?+	+	?
Behavior								
Stomp hind feet	+	+	+	?+	?	?+	?	+
Lose condition seasonally	+	?	+	?	+	?+	+	?+
Fidelity to small home range	+	?+	+	?+	+	?	?	+
Reproduction								
Mate anytime of year	+	?+	+	?+	+	?+	+	+
More joeys in dry season	+	?	+	+	+	?	+	?
Stay with one female	+	?+/-	+	?+/-	+	?	+	-
Males fight over females	+	?+	+	+	+	?+	+	+
Predators and sympatry								
Oenpelli python	+	?	+	?	+	?	+	?
Wedge-tailed eagle	+	?+	+	+	+	?+	+	+
Dingo	+/-	?	+/-	?	+/-	?+/-	+/-	+/-
Bird sympatry	-	?	-	?	+	?	?	?

Note. +, occurs in this species; -, does not occur in this species; +/-, differing opinions about whether it occurs in this species; ? not known for this species; ?+, not known for this species but found to occur in other similar species; ?-, not known for this species but found not to occur in other similar species; ?+/-, not known for this species and differing opinions about whether it occurs in other similar species.

Sources for SEK: (Bolton *et al.*, 1982; Churchill, 1997; Coulson, 1989; Croft, 1981; Croft, 1987; Delaney, 1997; Geelen, 1999; Jarman, 1994; Kennedy and Heinsohn, 1974; Lochman, 1987; Press, 1988; Press, 1989; Sanson *et al.*, 1985; Strahan, 1995; Taylor, 1983; Tunbridge, 1991).

Consultants' knowledge is by its nature local knowledge reflecting what Bininj observe in their area rather than providing generalizations about these species (as is often a goal of science). For example, *Triodia microstachya* was claimed by consultants to be a major food item for the short-eared rock-wallaby. Yet short-eared rock-wallabies are certainly present in

many areas without *Triodia* sp. (Churchill, 1997). Conversely, there was no mention by consultants of the fern *Marsilea crenata* postulated by scientists to be an important dietary item for the nabarlek based on findings at one site (Sanson *et al.*, 1985), perhaps indicating too much emphasis has been placed on findings from this one location. This study highlights that we should be equally wary of extrapolating scientific or indigenous knowledge recorded at a single location.

Some of the information given by consultants suggested that there may be biases in the scientific techniques used to understand aspects of the ecology of species such as rock kangaroos. The most striking example was the broad range of dietary items of the rock kangaroos described by consultants. Bininj described the rock kangaroos eating grass, flowers, seeds, leaves and fruit of trees, and yams. Certainly rock-wallabies are reported to include many of these high-protein items in their diet (Geelen, 1999; Horsup and Marsh, 1992; Pearson, 1992), but this is a far more diverse diet than generally reported for large kangaroos (Dawson, 1989). The diverse and protein rich diet suggested for the wallaroos by consultants may reflect the relatively high diversity of fruit trees and yams available in the tropical north (Egan and Williams, 1996; Taylor and Dunlop, 1985), particularly in the rocky country (Freeland *et al.*, 1988). Alternatively, it may be that scientific techniques used to determine diet, namely cuticle analysis in which the leaf particles in faeces or stomach samples are examined, do not identify items such as flowers, seeds, fruits, and yams (Jarman, 1994).

While indigenous and scientific observations of ecology may often correlate, the explanation of why a particular animal behavior occurs may differ significantly. For example, rock-wallabies stomping their hind feet is a common behaviour reported for rock-wallaby and kangaroo species (Coulson, 1989). Bininj understood this behavior culturally as the rock-wallabies dancing.⁷ However, it is understood by scientists to be either threatening another animal or an alarm signal given by an individual in response to disturbance by a possible predator (Batchelor, 1980; Coulson, 1989).

Reflections on the Data

For some subject areas consultants gave common responses, whereas for other themes there were varied or contradictory responses. This

⁷ A closely related rock-wallaby species (*P. burbidgei*) was similarly described by a naturalist as stamping its feet vigorously while repeatedly turning, "literally dancing!" (Lochman, 1987).

variation may arise for several reasons. Firstly, the information reflects the personal experience of the consultant and some of the apparent contradictions may stem from differences between the areas where the consultants live and environments in which the animals were observed. For example, differences in answers about whether the rock-wallabies use rain-forest habitats may reflect the different types of vegetation present—the *Allosyncarpia* vine forests that were said to be used by some consultants are not present in other areas where consultants said the rock-wallabies did not use rainforests. Secondly, opinions may not be contradictory but rather reflect the range of habits of a species. In the case of the range of water use options described for the rock-wallabies (dew, seeps, puddles, creeks, or not drinking), they may all be used at different times or in different places. Indeed, this variation is also found in the literature for other rock-wallaby species (Geelen, 1999; Lim *et al.*, 1987; Tunbridge, 1991).

The one subject area where new information was received in each additional interview, and saturation was probably not reached, was diet. Many plant species were only described as dietary items by a single consultant and there was obviously a limit to the number of plant species recalled by each consultant. Thus, it was unclear from interviews whether apparent differences in the diet of the species were real or just reflected the limitations of recall. The information about rock-wallaby diet could be verified with direct questions about individual plant species in follow up interviews or group discussions (Henfrey, 2001), and by accompanying more of the consultants on walks through the rock country to record the plant species eaten by the kangaroos. However, it is still possible that variation between responses reflects a regional abundance of a particular plant species, and therefore the greater importance of that plant in the diet of kangaroos in that area.

Management Implications and Synthesis

Descriptions of hunting and use of fire provided some information about land management practices and the sustainability of rock kangaroo harvest levels in the region. Consultants described fire being used differently for these rock kangaroo species from the fire drives recorded for hunting the kangaroo species of the plains (Bowman *et al.*, 2001; Vigilante, 2004; Yibarbuk *et al.*, 2000). Fire is still used to create new growth for the kangaroos and to flush the rock kangaroos from the rocks. It is clear from this and other reports (Vigilante, 2004) that the sandstone country vegetation is periodically burnt. The reports here from consultants did not suggest any seasonality in the burning.

Although the conservation status of the species was not a specific focus of the study, it was evident that consultants regarded all of the rock kangaroo species as being abundant in the rock country. Discussions suggested that the current harvest levels for these species in the region are very low. Probably less than ten black wallaroos are hunted in the region each year and almost no rock-wallabies are hunted. The low number of animals being hunted reflects reduced hunting effort as outstation communities are increasingly relying on store foods rather than a reduced abundance of rock kangaroos in the area. There was no suggestion that the nabarlek is rare or had disappeared from areas as thought by some scientists (Lundie-Jenkins and Findlay, 1997; Sanson *et al.*, 1985). This may be due to local abundance of the species persisting in the consultants' country and the contraction in the species' range may only currently be in more marginal rocky areas on the edge of the species' range. The statement by one consultant that nabarlek "are still numerous but no one is out looking for them in the caves where they live" highlights the difficulty of assessing status from local knowledge. Few people are living in and moving around the rock country. There is only a scattering of outstations in this region and people are no longer reliant on hunting the species for food. Thus it is unclear whether descriptions of species being abundant reflect recent observation or past recollection. Travelling the various estates of the rock country with the Aboriginal land owners and checking sites where the species are thought to be abundant would be the best way to accurately assess the status of the species, as was successfully done for the black-footed rock-wallaby (*Petrogale lateralis*) in central Australia (Pearson, 1992).

Indigenous knowledge that extends or contrasts with scientific understanding can be used to create hypotheses and models that can be tested with field data. In this study the indigenous knowledge of the comparative ecology of the rock kangaroos suggested many hypotheses that warrant investigation, notably:

1. Nabarlek live deep in the rocky country, further from human scent than the short-eared rock-wallaby.
2. The nabarlek and short-eared rock-wallaby eat similar foods and this is not a mechanism of ecological separation.

Comparison between indigenous knowledge and existing scientific knowledge also raised hypotheses about the ecology of these northern tropical species compared to similar species in other regions of Australia:

1. The diet of the wallaroos is more diverse and includes higher proportions of protein rich browse items than kangaroo species in more temperate or arid areas.

2. All macropods in the tropics lose their fur and have decreased bone marrow in the late dry season.

Sadly, for many parts of Australia there is no longer access to the extensive indigenous ecological knowledge that once existed. However, the wealth of local knowledge held by land managers and natural historians should also be recognized as useful and similarly employed in the formulation of hypotheses to drive scientific research.

This research represents one of the most comprehensive ethnozoological studies of a group of species undertaken in Australia. It was cost effective and far superior to the information that could have been gathered in a short-term scientific project. Importantly, it also afforded senior custodians respect and acknowledgement of their knowledge. Cross-disciplinary collaborations amongst ecologists, linguists, and social scientists working together with indigenous communities are extremely important in ethnoecological studies. In those communities where a traditional language is still spoken, the depth of local ecological knowledge is expressed more extensively and vividly in the vernacular. Potential for incorporating indigenous knowledge into conservation and management programs is particularly great for the north of Australia, where there is a paucity of scientific knowledge and the landscapes being managed remain largely intact. However, as the senior Aboriginal people who carry extensive ecological knowledge die, the opportunities for recording knowledge and assisting with inter-generational transfer of knowledge are fast being lost.

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