Yalarrnga cross-cultural investigation of diet, management history and threats to *Petrogale purpureicollis*

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Research

DECLARATION

I declare that this thesis, as a whole or in parts, has not been submitted for a higher degree to any other university or institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

I wish to acknowledge the following assistance with the research detailed in this thesis: I wish to acknowledge the following assistance with the research detailed in this thesis:

Emilie-Jane Ens and Linda Beaumont for conceptualisation, experimental design, statistical analysis, and writing. Lance Sullivan in formulating questions and Drew Allen for help in statistical analysis. Karen Marais for and Nannette Hooker for plant identification.

All research carried out for this thesis was approved by Human ethics approval was required for this project and was approved by Macquarie University Human Ethics (reference number: 520221216242094)

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This thesis is formatted to meet the requirements of the Macquarie University. This includes the requirement of an abstract of 200 words, 2cm margins, 1.5x line spacing, figures and tables embedded within the text.

Abstract

This project aimed to understand the diet, management history and Yalarrnga perception of threats to the *Ngarlingarli Kurri* (Purple-necked rock-wallaby, *Petrogale purpureicollis*) on Yalarrnga Country. The project was instigated through collaboration with the Yalarrnga Country Rangers. The Yalarrnga are obligated to conserve the *Ngarlingarli Kurr,* as is a culturally significant species, meaning it is entwined with Yalarrnga culture and identity. Semi-structured interviews were conducted with Yalarrnga people to record their biocultural knowledge of the species. *S*cat content was assessed, using the micro-histological analysis, to determine diet at the functional group level. Analyses showed the *Ngarlingarli Kurri* selected across the functional groups browse, forbs, grasses and *Solanum* spp. even where species cover, presence and richness were low. Micro-histological scat analysis corroborated Yalarrnga knowledge of *Ngarlingarli Kurri* diet, suggesting that the species browses *Walmangu* (*Solanaceae* spp.*),* spinifex, and a range of other native species, as well as the invasive *Cenchrus ciliaris*. The threats to the *Ngarlingarli Kurri* identified by the Yalarrnga were over browsing by introduced herbivores, mining and land use change, predation by native and introduced species, changes in traditional fire regimes and a loss of Yalarrnga management on Country. This project contributes biocultural knowledge to the understanding *Ngarlingarli Kurri's* ecology.

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Thank you to all the Indigenous people who protect their Countries today as their ancestors did across deep time. So-called Australia always was and always will be Aboriginal Land. I acknowledge that sovereignty has never been ceded by the Yalarrnga people or any Indigenous people in Australia. Thank you to the Bindal and Wulgurukaba whose Country I live on, and the Wallumattagal clan of the Dharug Nation, whose Country I studied on.
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Contents

Abstract 2

Acknowledgements 3

1. Introduction 7

1.1 Indigenous biocultural knowledge in Australia 7

1.1.1 'Right-way' cross cultural science 8

1.1.2 Indigenous engagement with conservation on Yalarrnga Country 10

1.2 Yalarrnga culture, history, and entwinement with the Ngarlingarli Kurri 10

1.3 The Ngarlingarli Kurri: as known by western science 11

1.3.1 Ngarlingarli Kurri diet 12

1.4 Project question and aims 12

2. Methods 13

2.1 Study area 13

2.2 Yalarrnga Biocultural Knowledge of Ngarlingarli Kurri 15

2.2.1 'Right-way' consultation 15

2.2.2 Biocultural knowledge 16

2.3.3 Site selection 17

2.3 *Ngarlingarli Kurri* scat micro-histology 19

2.3.1 Scat collection and identification 19

2.3.2 Micro-histological analysis: Vegetation reference slides 20

2.3.3 Micro-histological analysis: scats 21

2.4 Floristic study of Ngarlingarli Kurri shelters sites 21

2.4.1 Survey area 22

2.4.2 Plant cover and presence surveys 22

2.4.3 Data recorded......23
2.5 Data analysis 24
2.5.1 Yalarrnga Biocultural Knowledge of *Ngarlingarli Kurri* 24
2.5.2 Scat micro-histology......24
2.5.3 Species richness......24
2.5.4 Functional group cover......25
2.5.5 Dissimilarity of species cover......25
2. Results......25
3.1 Yalarrnga Biocultural knowledge of Ngarlingarli Kurri 25
3.1.1 Overview of the *Ngarlingarli Kurri* to the Yalarrnga 26
3.1.2 Connection to the Ngarlingarli Kurri and Yalarrnga Country......26
3.1.3 Origins for knowledge of the Ngarlingarli Kurri......26
3.1.4 Traditional Yalarrnga management......27
3.1.5 Cultural stories of the *Ngarlingarli Kurri* 28
3.1.6 Yalarrnga perceptions of *Ngarlingarli Kurri* threats and management 29
3.1.7 Yalarrnga perception of the diet of the *Ngarlingarli Kurri*......31
3.2 Western scientific results of Ngarlingarli Kurri diet and plant surveys......32
3.2.1 Diet of the *Ngarlingarli Kurri* at the functional group level and ad-hoc species identification......32
3.2.2 Assessment of plant availability to the Ngarlingarli Kurri: Richness, cover and dissimilarity across surveyed rocky outcrops......35
3. Discussion......39
4.1 Yalarrnga knowledge and its connections with western science......39
4.1.1 Yalarrnga perception of *Ngarlingarli Kurri* Diet......39
4.1.2 Yalarrnga perception of threat to the NK......40
4.2 Western science: the interaction between diet and plant presence, cover, richness, and dissimilarity 43
4.2.1 Micro-histological analysis of diet......43
4.2.2 Species cover, richness, and dissimilarity 44
4.3 'Right-way' science-successes, challenges, and lessons 46
4.4 Limitations 46
4.5 Further research 48
4. Conclusion 48
5. References......49
Appendix

1. Introduction

The Australian landscape is increasingly being understood to have been deeply influenced by Indigenous land management prior to colonisation (Gammage, 2011). While this perception is becoming increasingly mainstream with texts such as Dark Emu entering the Australian cultural zeitgeist, as stated by Wiradjuri environmental scientist- Michael-Shawn Fletcher, the 'shackles of wilderness' remain embedded in the western psyche (Fletcher, Hamilton, et al., 2021; Pascoe, 2014). Yalarrnga and other Indigenous people posit that this perception of wilderness can blind environmental scientists to the deep relationships between people and Country. They highlight that Country itself holds knowledge that can inform contemporary land management. As explained by Yalarrnga Elder Hazel Sullivan:

> *No one comes to us grassroots people, no one asks us anything. You have people here for five minutes making decisions about the Country. They don't know the Country like we do.*

Indigenous oral histories record environmental patterns and changes deep into the past, and like western conservationists, express concern over the rapidly changing environment (Campbell et al., 2022; Nunn & Reid, 2016). Through right way, (otherwise known as two-way or cross-cultural) relationships, scientists and Indigenous people are now working together to understand the natural systems of Australia from pre- and post- colonial frameworks (Ens & Turpin, 2022; Hill et al., 2020). The background for this is Australia's shocking extinction record, loosing over 10% of endemic mammals since colonisation (Ziembicki et al., 2015). The high rates of species endemism combined with novel geological and geomorphological features, climate history and land management history means that different approaches to land management are required compared to those in other developed countries, to ensure a biodiverse future (Kearney et al., 2019; Ziembicki et al., 2015). Against this backdrop this study sought to record Yalarrnga biocultural knowledge of the *Petrogale purpureicollis*, known to them as the *Ngarlingarli Kurri*, a cultural keystone species, and investigate some Yalarrnga concerns for the species' ability to persist on their country.

1.1 Indigenous biocultural knowledge in Australia

A growing body of work is emerging showing the ways that Indigenous people have shaped their environments while maintaining high biodiversity (Fletcher, Hamilton, et al., 2021).

There is a body of academic discourse that aims to define the language and form of this relationship; however, it is clear that Indigenous people in Australia have a long physical, spiritual and cultural relationship with their Country in which both people and the environment have been impacted (Steffensen, 2020; Sutton & Walshe, 2021). From this, western scientists have become interested in understanding, recording, and implementing Indigenous land management knowledge and practices in order to return or preserve environmental health while also serving to support Indigenous cultural revival or maintenance (Campbell et al., 2022; McKemey et al., 2022). There is also growing scientific evidence that suggests the removal of Indigenous management from the landscape has contributed to declines in environmental health and biodiversity, mirroring advocacy of Indigenous people who have clearly and consistently affirmed that Country needs people for its health (Ens et al., 2016; Fletcher, Hall, et al., 2021). Additionally these works counter the pervasive perspective that Indigenous knowledges are inferior to knowledge derived from western academics, governments, and individuals and address the perception that Indigenous people in Australia did not change or impact their environment (Nakata, 2007; Suchet-Pearson et al., 2013). These changes are particularly notable through fire application to the landscape, which manipulated the locations of grasslands, woodlands and rainforests (Fletcher, Hall & Alexandra, 2021).

Additionally, Indigenous Peoples of Australia have called for non-Indigenous people, often described as western people, to reframe their understanding of the human-environment relationship, emphasising the long, sustainable relationship between the Indigenous Peoples and Country in Australia prior to colonisation (Hill et al., 2022; Woodward, 2020). Broadly, Indigenous Peoples within Australia have expressed that in their worldview, they do not decouple the person from the environment. Instead they view themselves as a part of it and it, of them, and they understand that human health is tied with the health of the environment (Fletcher, Hamilton, et al., 2021; Hill et al., 2022; Russell & Ens, 2020; Suchet-Pearson et al., 2013; Woodward, 2020). While there is considerable interest in and current work in cross-cultural ecology, it is still an emerging practice and needs deep consideration at interpersonal, community, academic and legislative levels to create guidelines of best practice and identify future directions for the field (Goolmeer, Skroblin, & Wintle, 2022; Woodward, 2020).

1.1.1 'Right-way' cross cultural science

Cross-cultural research is the collaboration between western scientists and Indigenous Peoples and has many forms. Its best practice is recognised as partnerships that are underpinned by a strong understanding of the Indigenous participants rights by both the western scientists and the Indigenous participants themselves (Goolmeer, Skroblin, & Wintle, 2022; McKemey et al., 2022). We have chosen to use the 'Right-way' science framework, a current, Australian based term to describe the ways that cross-cultural research best operates (McKemey et al., 2022). 'Right-way' science is just one iteration in an evolving field of knowledge dedicated to reflecting on the best ways to foster engagement between western scientists and Indigenous people and knowledges. Currently, western scientific literature focusing on the ecological knowledge held by Indigenous people around the world is variably referred to as: Traditional Ecological Knowledge (TEK), Indigenous Ecological Knowledge (IEK), and recently, Indigenous Biocultural Knowledge (IBK) (Cahir et al., 2018; Ens et al., 2015; Nadasdy, 1999). The method of conducting scientific studies that are conceived with and include Indigenous people to achieve mutual benefits is commonly known in the academic literature as 'Cross-cultural', 'Right-way science', 'Two-way science' or 'Two-eyed seeing' (McKemey et al., 2022; Reid et al., 2021; Vigilante et al., 2017).'Indigenous Biocultural knowledge' refers to the knowledge held by individuals and groups Indigenous to a specific country, 'biological' and 'cultural' are fused to acknowledge the inextricability of First Nations peoples' conceptions of culture and biology reference (Cahir et al., 2018). 'Right-way' research is based on the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) Code of Ethics and the United Nations Declaration on the Rights of Indigenous People (2007) (AIATSIS, 2020). There are no clear step-by-step processes outlined for 'right-way' science, however, the process has been deeply discussed and the following key themes have emerged from the literature:

1. Time given to 'yarning', that is informal conversations so that all groups understand each other (Cooke et al., 2022). Additionally time given to develop, deliver and report on projects (Ens et al., 2012).
2. Genuine collaboration between scientists and their Indigenous partners- moving away from extracting knowledge and towards co-development of knowledge (AIATSIS, 2020; Hill et al., 2020; McKemey et al., 2022).
3. A focus on culturally significant species (also known as cultural keystone species), that is, species that inform significant cultural practice, history and knowledge (Goolmeer, Skroblin, Grant, et al., 2022).

4. Formal protection of Indigenous partners though university ethics approval or similar processes to ensure adherence to the legal and ethical obligations of the researchers (AIATSIS, 2020; McKemey et al., 2022).
5. Transparency in how cross-cultural work was achieved has been highlighted as a necessity by western scientists, in order to grow knowledge of best practice in the field (McKemey et al., 2022).

1.1.2 Indigenous engagement with conservation on Yalarrnga Country

Conservation initiatives in Australia are increasingly incorporating Indigenous Biocultural Knowledge and concerns in their goals and implementation (Skroblin et al., 2022). However, these initiatives tend to be concentrated in areas that are defined by Indigenous Protected Areas (IPA's), privately owned conservation zones, and government protected areas (Ens et al., 2015). This study is based in Yalarrnga Country, in north-western Queensland, south of the Townships of Cloncurry and Mount Isa and north of Boulia. In this region, the relationships between environmental managers and the Indigenous Native Title holders are not strong, beyond some input into new mining activities in the region (pers. comm Lance Sullivan). Since the establishment of large-scale mining operations, relationships between the grazier station owners and Yalarrnga people have increased based on a mutual concern for the negative effects of mining on flora and fauna (pers. comm. Lance Sullivan). However, the relationship between Yalarrnga and their cultural-keystone species have never been addressed beyond "handshake" agreements (pers. comm. Lance Sullivan). This study sought to formalise the Yalarrnga perspectives of these relationships.

1.2 Yalarrnga culture, history, and entwinement with the Ngarlingarli Kurri

Little is written about Yalarrnga culture and history in the literature. The primary sources include text by an ethnographer, Roth, from 1897, written as he was stationed in Boulia (Roth, 1897). More recently works recorded the language and history with the Native Police (Breen, 2007; Davidson et al., 2019). Yalarrnga Country and people, were formally known across historical literature as 'Yulluna' and 'Yellunga'; are a tribal group with a discrete language. As Figure 1 shows, the Yalarrnga Native Title area crosses from the Selwyn ranges in north-western Queensland to the flatter area's north of Boulia (Curr, 1886; Davidson et al., 2018; Roth, 1897; *Yulluna : pictorial dictionary*, 2013). Yalarrnga language is part of the Pama–Nyungan language group that encompasses most of Australia (Breen, 2007). The region has a mix of area's that are exclusively and non-exclusively used by the Yalarrnga for cultural purposes. Yalarrnga people, like many other Indigenous groups, have a complex system of governance and relationships that are defined by kinship ties within moieties. The moieties found in Yalarrnga society are *Kangilangu, Marinangu, Pathingu, Thunpuyungu* (Roth, 1897; Desert Channels Queensland, 2013). While the names of the groups vary between languages, Yalarrnga moiety groupings are shared by the language and tribal groups that surround Yalarrnga Country and traditionally, Yalarrnga people married the 'right-skin' in those groups (Roth, 1897).

1.3 The Ngarlingarli Kurri: as known by western science

Western science suggests that *Ngarlingarli Kurri (Petrogale purpureicollis)* distribution spans around 60,000 km^2 from its population epicentre near Mount Isa in north-west Queensland (Burbidge, 2016; Eldridge, 2012). In 2016, the population was estimated to be around 10,000 mature individuals dispersed into smaller colonies of 10-100, with colonies of up to 20 noted in the population epicentre (Burbidge, 2016). Colonies are believed to However, no rigorous population estimates have been undertaken, and not all colony locations are known (Burbidge, 2016). The population trend is considered to be decreasing with the its major threats considered to be habitat degradation by livestock and feral herbivores, predation by cats (*Felis catus)*, inappropriate fire regimes, habitat change and invasion by *Cenchrus cilaris* and mining driven habitat loss (Burbidge, Harrison & Woinarski, 2012). Most of this species' distribution is located across cattle stations and mining leases, with only few protected areas and one National Park (Boudjamulla National Park) across its range (Ezzy et al., 2020). It is assumed that populations are declining in the south-east and north-west of its range, where colonies are highly fragmented, and sizes are smaller (Burbidge, 2016; Eldridge, 2012). Previously, *Ngarlingarli Kurri* was classed as a subspecies of the Black-footed rock-wallaby *Petrogale lateralis* and significant genetic work was undertaken to determine its taxonomy (Eldridge et al., 2001; Johnson et al., 2001) .
The *Ngarlingarli Kurri* weighs approximately 5.7 and 7.1 kg for females and males respectively, making it a medium sized rock-wallaby (Johnson & Delean, 2002) . While adults are outside the risk category of 'critical weight range' mammal, juveniles are likely vulnerable to predation due to their size (Johnson & Isaac, 2009; Johnson & Delean, 2002). Additionally its distribution within the semi-arid, or low rainfall, regions was identified as a risk factor for those within the of 'critical weight range' (Johnson & Isaac, 2009). The species is classified as 'Vulnerable' under the Nature Conservation Act 1992 (NCA) and

'Near Threatened' by the ICUN Red List, it was last assed in 2014 when it was determined that the species is likely declining but could have larger stable populations across its distribution (Burbidge, 2014).

1.3.1 Ngarlingarli Kurri diet

There are no studies about the *Ngarlingarli Kurri* diet; however, individuals have been kept in captivity in the past and were fed a mixed diet lucerne hay *(Medicago sativa*), sweet potato (*Ipomoea sp.)*, cracked corn (*Zea sp.)* and green grass (undefined species) (Johnson & Delean, 2002). Most *Petrogale* species have a generalist diet, that changes seasonally relative to availability of the functional groups grasses, forbs (herbaceous plants) and browses (shrubs and trees) (Copley & Robinson, 1983; Creese et al., 2019; Dawson & Ellis, 1979; Horsup & Marsh, 1992; Lapidge, 2000; Short, 1989; van Eeden et al., 2011; White & Fleming, 2021). Micro-histological analysis has been employed in several studies of *Petrogale* diets, with mixed levels of plant identification ranging from functional group to species level (Creese et al., 2019; Tuft, 2010; van Eeden et al., 2011). Using micro-histology to study scats to asses diets has a long history of use in herbivorous mammals globally and within Australia (Pareja et al., 2021).

1.4 Project question and aims

Lance Sullivan (Yalarrnga elder and CEO of the Yalarrnga Country Rangers) identified the Ngarlingarli *Kurri* as a species of concern due to the ongoing restrictions of Yalarrnga traditional management techniques and competition with non-native animals, in particular the cattle (*Bos taurus*) grazing on Yalarrnga Country. The Yalarrnga Country Rangers are a recently created ranger group (2021), who seek to address destruction of their biocultural heritage on their Country. We then created a study in collaboration with the Yalarrnga Country Rangers to answer three key questions around the *Ngarlingarli Kurri* on Yalarrnga Country.

1. What is the Yalarrnga biocultural understanding of *Ngarlingarli Kurri* diet, threats and insights into past and present management for the species.
2. Using the micro-histological method, exploring *Ngarlingarli Kurri* presence of functional groups when within their diets contrasted with presence at shelter sites
3. The composition of plants at *Ngarlingarli Kurri* shelter sites

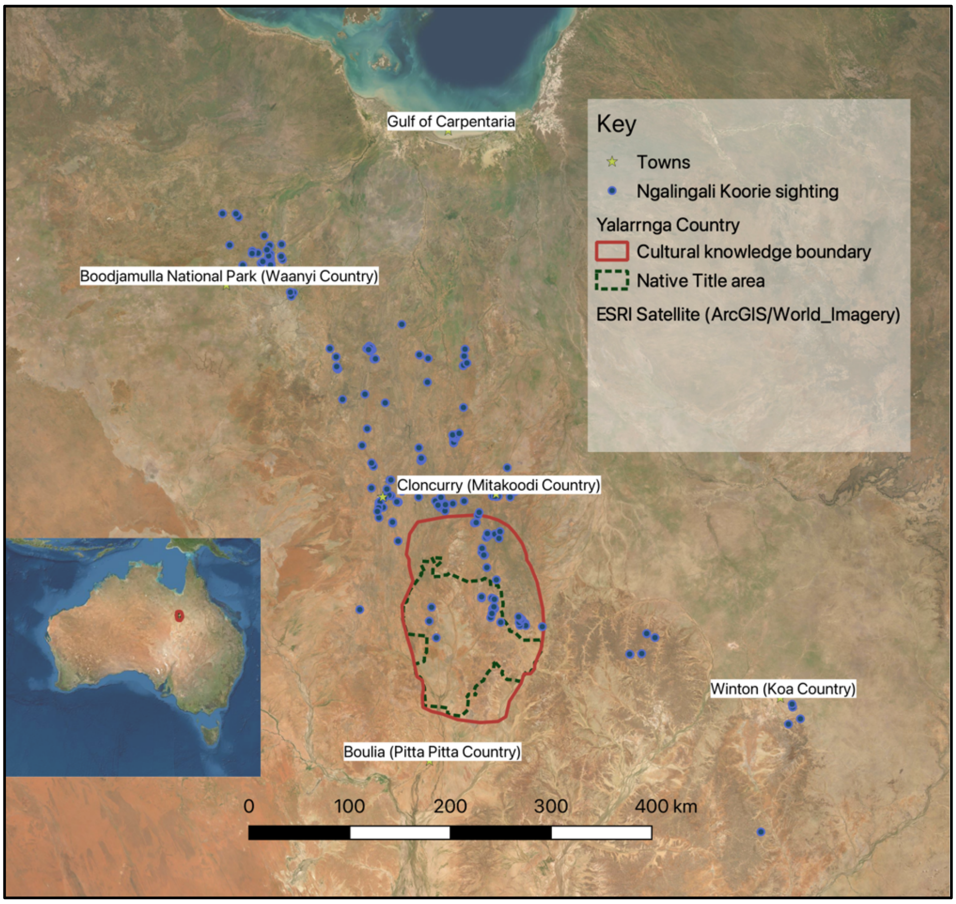
We used western research techniques to understand these questions. To understand Yalarrnga knowledge we preformed semi-structured interviews with knowledge holders and recorded the results. To understand the diet from a western scientific perspective we used the micro-histological method to identify the presence of functional groups within the *Ngarlingarli Kurri* diet. We then undertook rigorous plant cover surveys to a species and functional group level, to understand species cover, richness, presence, and dissimilarity across five *Ngarlingarli Kurri* shelter sites on Yalarrnga Country- to test if the presence of these functional groups in the diet corresponded with their availability on Yalarrnga Country. We worked with the Yalarrnga Country Rangers to identify and select sites known to be inhabited by the *Ngarlingarli Kurri*. While shelter sites are not the only foraging area, they are the primary foraging ground for the species.

We hypothesize that the Yalarrnga will help inform gaps in the knowledge of the *Ngarlingarli Kurri*, related to local perception of threat and diet. They will also provide insights into the past management of the species and contrast this with present management. Our application of western scientific techniques will seek to expand these knowledges and ground them in contemporary reality. We also seek to explore to similarities and differences in Yalarrnga and western scientific understandings of threat to the *Ngarlingarli Kurri*.

2. Methods

2.1 Study area

Yalarrnga Country is in north-western Queensland between the townships of Boulia, Mount Isa, and Cloncurry. This project defines Yalarrnga Country as the ‘Yulluna’ Native Title area (covering 10,050 km^2) joined with the surrounding areas that Yalarrnga knowledge holders have cultural practices and memory for (as identified by the Yalarrnga Country Rangers). Traditionally the Countries in the north-west Queensland, while distinct linguistically share, songlines, travel and trade routes, cultural sites and moiety categorisation (Davidson et al., 2018; Roth, 1897). This has led to overlapping regions of cultural knowledge and use (Davidson et al., 2019). Due to this, the participants in this study were of mixed descent and while they followed the patrilineal system to become Yalarrnga, they often had parents or grandparents who were members of the surrounding nations. This area of cultural knowledge covers 19,820 km2 and intersects with the neighbouring Kalkadoon and Mitakoodi Nations to the north and Koa and Pitta-pitta in the south, reflecting the range of knowledge held by the



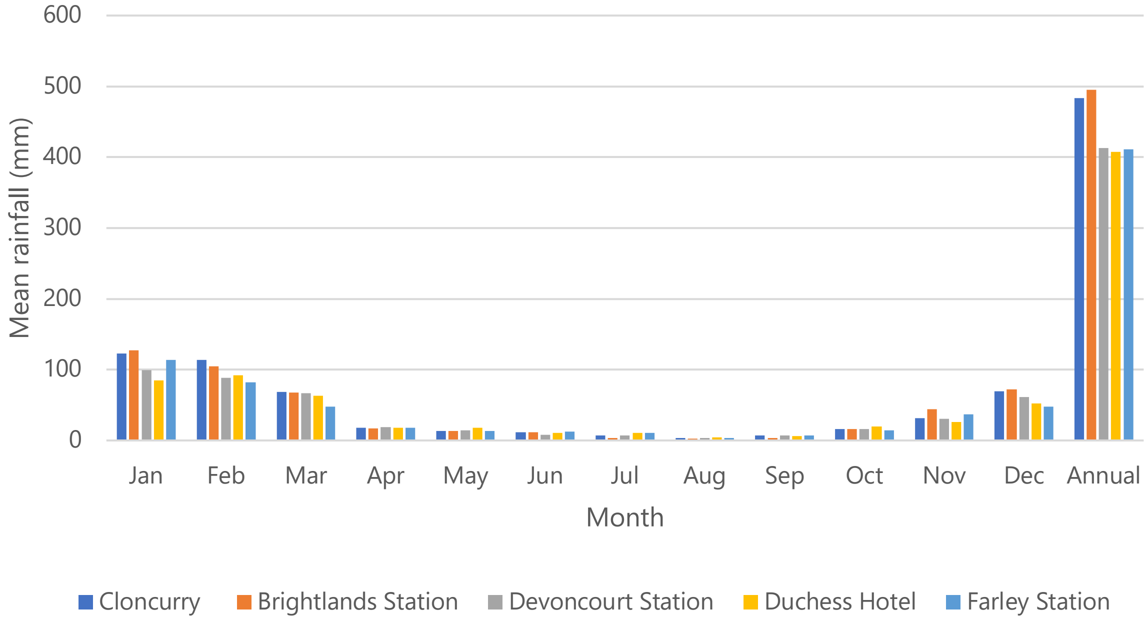
participants' ancestors. Today, no Yalarrnga person lives permanently on their Country as they have been financially outcompeted by cattle and mining leases. The majority of Yalarrnga Country is used for Brahmin cattle. A single sealed road runs from Duchess to Cloncurry and government-owned dirt roads service the rest of the area.

Figure 1. Map of Yalarrnga Country in relation to total Ngarlingarli Kurri sightings. Retrieved from the Atlas of Living Australia, 15th June 2022.

The Yalarrnga landscape is open and composed of sparse *Acacia*, *Eucalyptus* and *Corymbia* species woodland and patchily distributed *Triodia* species (Felderhof & Gillieson, 2006). Large rocky outcrops dot an otherwise flat landscape intersected by ephemeral creeks and rivers. Under the Interim Bioregional Regionalisation of Australia (IBRA) system. The regions of Yalarrnga Country that have *Ngarlingarli Kurri* were classified as the Northern Highlands the Mount Isa Inlier sub-region, and Mitchell Grass Downs in the south. Rainfall decreases from north to south across Yalarrnga Country and the study area, with the southern regions largely serviced by rain cells that pass through central Australia while the northern area receives some rainfall from the Gulf of Carpentaria (Source: Australian Bureau of

Metrology). As shown in Figure 2, the rainfall conforms strongly to the monsoonal wet-dry season pattern that dominates northern Australia.

Figure 1. Mean monthly rainfall across the study region. Data are from five north to south



weather stations that are presented from left to right. Cloncurry (Lat: 20.71° S; Lon: 140.52°) was the most northerly and Farley Station (Lat:21.37° S, Lon: 140.50° E) the most southerly.

2.2 Yalarrnga Biocultural Knowledge of Ngarlingarli Kurri

2.2.1 'Right-way' consultation

The 'right-way' science method requires research to centre on the needs and aims of the Indigenous group working with the researcher. For this project, Masters (research) student Ilona Papp undertook a consultation process with the Yalarrnga Country Rangers to determine the research aims and methods. This took the form of informal, unstructured conversations, or 'yarning', as described by Cook (2022), where the Yalarrnga Country Rangers and Papp discussed their concerns and needs and got to know each other. As this project involved a new relationship, the importance of these initial conversations cannot be underestimated as they built mutual trust and understanding. They laid the foundation for Papp to understand Yalarrnga culture which is essential for good relations and to avoid transgressing Yalarrnga cultural protocols.

In these conversations the Yalarrnga Country Rangers mentioned many species and areas of concern for their Country. The *Ngarlingarli Kurri* was highlighted as a species of significant cultural importance to the Yalarrnga, and deep concerns about its wellbeing were expressed.

The main threat to the *Ngarlingarli Kurri* on Yalarrnga Country was suggested to be a loss of Yalarrnga Traditional Management of the landscape and over-browsing by cattle. Papp then cross-checked with what had been recorded in western scientific literature, with budget limitations guiding possibilities, to ultimately refine the thesis questions and directions. Cultural safety is another important aspect of the 'right-way' process (McKemey et al., 2022; Woodward, 2020). Hence, the research on Yalarrnga Country was guided by the Yalarrnga Country Rangers to ensure cultural safety when traversing culturally significant areas and species. Finally, the incorporation of all Yalarrnga Traditional Knowledge was checked at multiple points by all Yalarrnga participants to ensure that no culturally sensitive or inappropriate information was been shared in this thesis.

The primary needs of the Yalarrnga Country Rangers were to investigate their environmental concerns, preserve cultural knowledge and develop working relationships with researchers and other groups. The primary need of Ilona Papp was to write a thesis. The project aimed to balance both needs. At times the depth and direction of this thesis outstrip specific Yalarrnga Country Rangers' needs; however, it is understood and supported by the Yalarrnga Country Rangers as necessary for academic submission. The Yalarrnga requested western scientific evidence to support their concerns; however, they do not require a Master's thesis. In this way, the project is 'right-way' as it attempts to balance the needs of the Indigenous group and the researcher (Cooke et al., 2022).

2.2.2 Biocultural knowledge

Semi-structured interviews were undertaken with three Yalarrnga knowledge holders. These participants were selected by the Yalarrnga Country Rangers and cross-approved by other Yalarrnga people. The selection was based on their cultural authority to share information and knowledge of Country. Twelve questions were constructed to understand the biocultural perceptions of: known diet; management of the *Ngarlingarli Kurri* habitat; perceived threats; connections to the landscape or other species.

To add context a series of knowledge foundation and personal identifier questions were also asked. The questions were designed to understand where participants' biocultural knowledge had come from about how their Country had changed over time.

The twelve questions were approved by Macquarie University Human Ethics (reference number: 520221216242094) and can be found in Appendix 1. Interviewees were paid $100 per hour for their interviews. Lance Sullivan provided translation and cultural support to explain the interview process to participants and how free, prior, and informed consent works in the relationship between the Yalarrnga and researchers. He was paid at a rate of $100 per hour. The cultural support was provided to ensure that participants did not feel pressured to engage in ways they were not comfortable to do so and had a proper understanding of their rights and the researchers' obligations as required by the Human Research Ethics Approval and AIATSIS Code for Indigenous Research (2020). All participants provided written consent for their name and other details provided in this thesis to be published in acknowledgment of their knowledge and willingness to participate in this research. The Yalarrnga Country Rangers assisted, as per their request, with on Country plant and scat surveys. At this time, a list of plants they perceived to be eaten by the *Ngarlingarli Kurri* was recorded.

Table 1. Yalarrnga participants who shared biocultural knowledge of the *Ngarlingarli Kurri*.

Name	**Age**	**Gender**
Lance Sullivan	51	Male
Hazel Sullivan	74	Female
Selwyn Sullivan	29	Male

2.3.3 Site selection

Five sites were chosen by the Yalarrnga Country Rangers to sample for *Ngarlingarli Kurri* scats (Figure 3 and 4). The sites represent places where the *Ngarlingarli Kurri* had been seen. Additionally, these sites are culturally significant. Site choice was also limited by accessibility, as much of Yalarrnga Country does not have sealed or dirt road access which was required for this project. These sites where checked in August 2022 to ensure *Ngarlingarli Kurri* shelter presence.

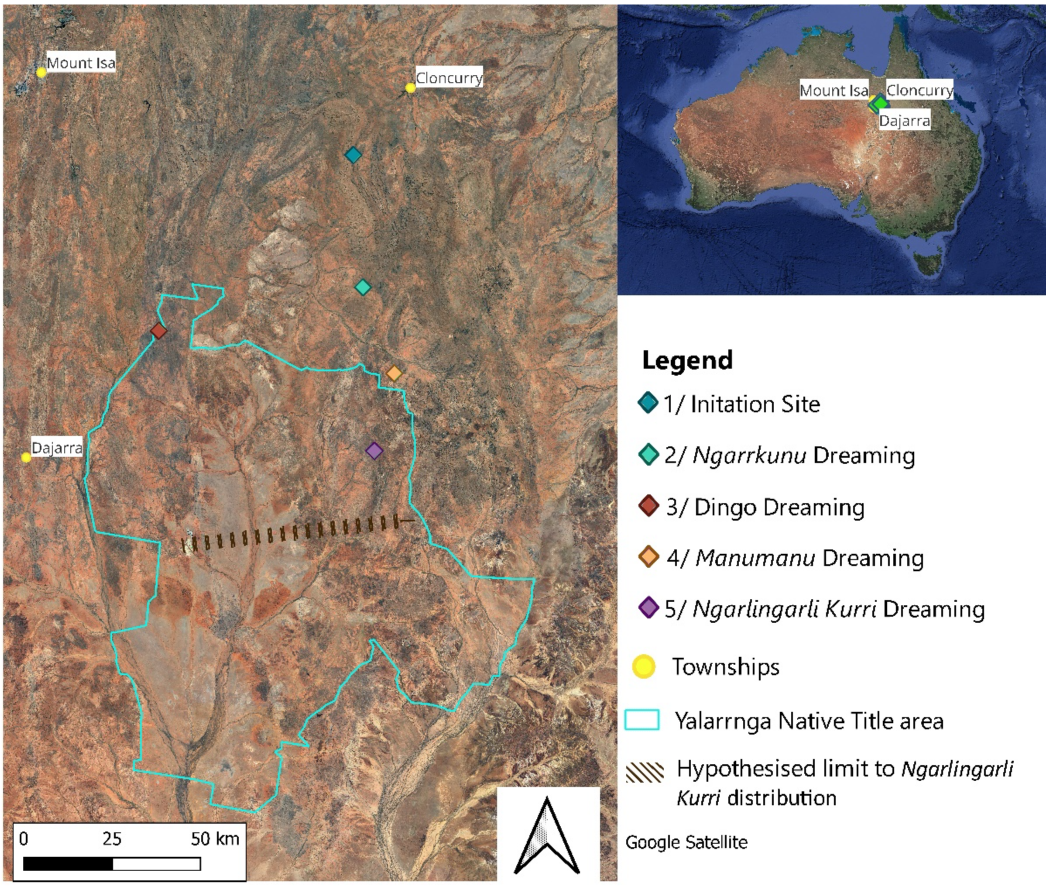


Figure 3. Overview of sites selected for surveying for the *Ngarlingarli Kurri* across Yalarrnga Country. The Yalarrnga Country Rangers hypothesised the southern distribution limit of *Ngarlingarli Kurri.* Yalarrnga cultural knowledge of the *Ngarlingarli Kurri* distribution extends beyond the Yalarrnga Native Title area.

Each site represented a single rocky outcrop peak. Some sites had some continuity between rocky outcrops peaks, but most were discrete outcrops emerging from flat planes. Sites were a minimum of ten kilometres from each other to ensure independence of samples. This distance was based on the maximum distance travelled by other *Petrogale* species and behavioural observations of *Petrogale* species that suggest strong observance of home range once territory is established (Horsup, 1994; Ruykys et al., 2011; Telfer & Griffiths, 2006).

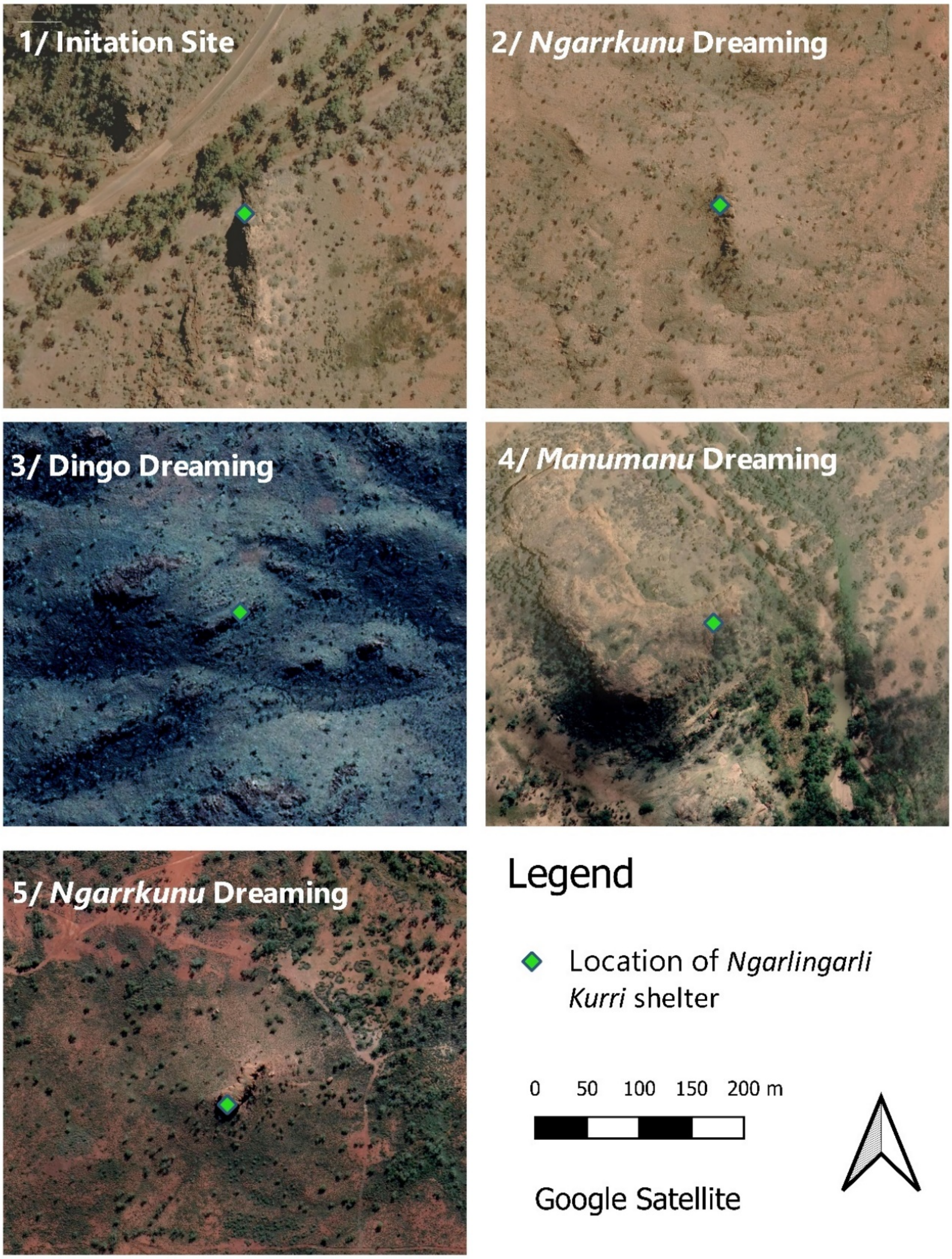


Figure 4. Location of primary *Ngarlingarli Kurri* shelters at survey sites chosen by the Yalarrnga Country Rangers.

2.3 *Ngarlingarli Kurri* scat micro-histology

2.3.1 Scat collection and identification

Scat surveys were conducted on five rocky outcrops shown in Figure 3 and 4 that were identified by the Yalarrnga Country Rangers as *Ngarlingarli Kurri* habitat - the only rock-wallaby (*Petrogale* spp.) on Yalarrnga Country. *Ngarlingarli Kurri* scats were identified by their distinctive shape, which is long and tapered, similar to other *Petrogale* spp. scats (see Appendix 2)(Rowland, 2012). The shape and size of the *Ngarlingarli Kurri* scat differs from all other sympatric mammals on Yalarrnga Country. All scats chosen for collection were fresh in appearance, which was determined by the presence of a slightly shiny dark coating, an overall dark brown colour and high structural integrity (Creese et al., 2019; Hohnen et al., 2016). One scat was collected from 10 separate 'clumps' at each site, for a total of 10 per site. All scats were collected during December 2022 and stored in ethanol (following Creese et al., 2019) until analysis in the Cross-cultural Ecology laboratory at Macquarie University in March 2023.

2.3.2 Micro-histological analysis: Vegetation reference slides

Vegetation reference slides were created for species identified by the Yalarrnga Country Rangers as either culturally significant or part of the *Ngarlingarli Kurri* diet. The Yalarrnga Country Rangers reported sighting the *Ngarlingarli Kurri* travelling to water and browsing on the flats. To reflect this observation we collected plants from the outcrops, flats and the edges of water ways and flats.

To process each plant, we clipped the edges and opened a vein to expose the mesophyll and allow the chemicals to easily impregnate the leaf and separated the mesophyll from the epidermis (Lapidge, 2000; Tuft, 2010). Then we placed the sample in a labelled ethanol vial for future processing in the lab. On return to the lab, each plant specimen was clipped into two pieces that included all portions of the plant. While some studies finely chop the vegetation reference material to mimic the sizes in scats, we chose to keep larger sections to ensure that epidermal cell patterns where visible beyond small sample sizes. The skins of fruits were also removed carefully for treatment and mounting. The samples where then soaked in 42 g L^{-1} Sodium Hypochlorite for 24 hours, or until the mesophyll was digested. This time was shorter in more delicate plants. Then the cuticle was peeled away from the leaf, the remainder stained with blue food dye, rinsed in tap water until clear and mounted in Glycerine (Norbury, 1988; Tuft, 2010; van Eeden et al., 2011). The slides were then sealed with clear nail polish (van Eeden et al., 2011). The researcher, Papp, familiarised themselves with the reference slides to enhance later scat analysis, as viewer familiarity with the reference library improves identification rates (Tuft et al., 2011).

2.3.3 Micro-histological analysis: scats

We have drawn the method for scat processing from Tuft (2010) and van Eeden, Di Stefano and Coulson (2011), as both reported plant fragment identification rates above 90%. In the laboratory, each scat was first gently broken up by hand, with any seeds separated and counted for identification via microscope (Hohnen et al., 2016). The scats were then soaked for up to 24 hours, or until 90% was visibly bleached, in 42 g L^{-1} Sodium Hypochlorite, or liquid bleach (Tuft, 2010; van Eeden et al., 2011). The material was strained through a 250-µm screen while washing thoroughly with running tap water. The 250- µm was determined by Tuft (2010) who found that this size produced the most identifiable pieces. Any remaining seeds where removed, counted, and identified. Three samples of 0.02 g were removed randomly from the material, stained with blue food dye and rinsed before being mounted on slides with corn syrup (Norbury, 1988; Tuft, 2010). The slides were then sealed with clear nail polish (van Eeden et al., 2011). Functional group presence was recorded by looking across slides in transects in 10x magnification, moving to higher magnification when needed. Functional groups were identified following the guidelines by Tuft (2010) who stated that browse species have thicker cell walls, forb species have thin cell walls and small stomata, and grasses are identifiable by their elongated crenulated cells. We cross referenced these guidelines with our plant reference library. We noted that grass species were also distinct with their thin cell walls and parallel venation and were often seen in scats in rectangular segments. Forb species with trichomes are common in this geographic region, and these features, along with thin cell walls, were easy to distinguish. Fruiting species were also easily identifiable through distinct patterns on the skins of their fruits, the fragments of which were prominent in scats.

2.4 Floristic study of Ngarlingarli Kurri shelters sites

Systematic vegetation surveys were conducted at the study sites to understand the availability of forage for the *Ngarlingarli Kurri* at their shelters. This was required to determine if the *Ngarlingarli Kurri* has forage preferences to a species, genus, family, or functional group level. We used percent cover estimates to assess plant species cover and presence, which we refer to as ‘availability’ (following Chieppa et al., 2020).

Table 2. The location of primary *Ngarlingarli Kurri* shelters across sites and the total number of quadrats surveyed at the site.

Site	Name	Location	Number of $2m^2$ quadrats surveyed
1	Initiation Site	-20.8850, 140.3501	68
2	*Ngarrkunu* Dreaming	-21.2150, 140.3996	100
3	Dingo Dreaming	-21.3568, 139.8532	92
5	*Manumanu* Dreaming	-21.4257, 140.5002	81
4	*Ngarlingarli Kurri* Dreaming site	-21.6235, 140.4599	87

2.4.1 Survey area

A 2.25 ha grid was surveyed to span the likely home range of *Ngarlingarli Kurri* from the rocky-outcrop shelter locations to the flat plateau below (Figure 4). The centre of the 2.25 ha survey was located at the primary *Ngarlingarli Kurri* shelter at the outcrop (Figure 3 and 4). Primary shelters were determined by the large volume of scats found at the entrance of deep rocky tunnels into outcrop faces. Additionally, the *Ngarlingarli Kurri* are curious and would often emerge making it easy to identify shelters.

2.4.2 Plant cover and presence surveys

Species cover was estimated by laying a $1m^2$ wooden square, with a $10cm^2$ internal grid pattern for measuring cover to 1% (Huenneke et al., 2001). A $1m^2$ quadrat size has been used by other researchers for plant cover estimates in similar semi-arid regions where the vegetation is relatively sparse and the ground cover is relatively large in size (Huenneke et al., 2001). At 15 m intervals along each transect, the wooden square was placed to the left of and the number of holes covered by each species was counted and recorded. All species visible in each hole up to 1.3m above the ground surface were recorded based on expected browsing height of *Ngarlingarli Kurri* from similar studies (Creese et al., 2019). The wooden

Figure 5. The *Ngarlingarli Kurri* at its Dreaming site. It's primary shelter is located at the top centre of the picture.

square was then flipped forward, and the process repeated to get cover estimates across $2m^2$. To standardise, the same person collected all cover data.

2.4.3 Data recorded

Percent cover, to 10 cm^2, was recorded for each species whose forgeable elements lay below 1.3 m to the substrate (that being ground or an elevated rock). We determined 1.3 m would be the maximum likely reach of the *Ngarlingarli Kurri* while browsing, based on other similar studies (Creese et al., 2019). We also recorded which functional group the species belonged to, using three categories: grasses, browse, and forbs, as these where the groups present and these classifications are in line with many rock-wallaby and broader macropod diet studies

(Arman & Prideaux, 2015; Copley & Robinson, 1983; Lapidge, 2000). Grasses were defined as all members of the Poacea and Cyperacea families. In other studies, Cyperacea would have been classified in a functional group called sedges but due to their low total cover we pooled them into the grass grouping (Tuft, 2010). Herbaceous plants were classified as forbs, while all woody plants were classified as browses. Plants whose species where unknown in the field, where collected and pressed for later identification.

2.5 Data analysis

2.5.1 Yalarrnga Biocultural Knowledge of *Ngarlingarli Kurri*

Only three Yalarrnga were interviewed in this study. Quotes related to each research question were manually extracted from transcribed interviews and combined to synthesise available Yalarrnga knowledge on *Ngarlingarli Kurri* and its diet, threat, and management history and aspirations. This follows the structure outlined by Grounded theory analysis whereby we used open ended questions to obtain Yalarrnga knowledge of the *Ngarlingarli Kurri* (Noble & Mitchell, 2016).

2.5.2 Scat micro-histology

We compared the presence and absence of plant functional groups by calculating the mean number of times each functional group was present across and scats and then across all sites. Presence was marked by a single appearance of each group within a scat sample. Presence at sites was determined by the presence of a functional group at the quadrat level.

2.5.3 Species richness

Species richness was determined from the number of different species in each quadrat across the site. We used a Welches ANOVA, or 'Test for Equal Means in a One-Way Layout' was performed on species richness data using from the R package *stats*, v.22.12.0 (Team, 2022; Welch, 1951). Data was square root transformed to normalise but remained positively skewed. However**,** we had 394 data points so normality can be assumed due to central limit theorem (Kwak & Kim, 2017). We then used pairwise-tests, with a Holms adjusted p-value, to determine variation between sites. The data failed Levene's test for homogeneity of variance across groups from the Car package in R (Weisberg, 2019). However, there were

394 data points, so normality was assumed due to central limit theorem (Kwak & Kim, 2017).

2.5.4 Functional group cover

Functional group cover was determined for the mean percent forbs, grass, bare ground for each site, using quadrat baseline data. The data failed Levene's test for homogeneity of variance across groups from the *Car* package in R, so we applied a Welch's ANOVA, or 'Test for Equal Means in a One-Way Layout' (Welch, 1951). To measure differences between sites we used pairwise t-test with a holm's adjustment on the p-values. The data was positively skewed but normality was again assumed due to central limit theorem (Kwak & Kim, 2017).

We used a Fisher's Exact Test for count data, to determine variation in presence of browse or outcrops in each quadrat across all sites. We then applied the Fisher's exact test in between sites. We could not use the Welch's ANOVA on percent cover for these groups due to their low presence in quadrats, which lead to a 0-inflated data set. For all tests we used the R package *stats* (v.22.12.0) (Team, 2022).

2.5.5 Dissimilarity of species cover

We tested for dissimilarity of species cover across all sites with a Bray-Curtis dissimilarity matrix using the 'vegdist' function from the *vegan* package in R (v.22.12.0) (Oksanen et. al 2023). We used the mean cover of each species at each site to determine dissimilarity.

2. Results

3.1 Yalarrnga Biocultural knowledge of Ngarlingarli Kurri

This study involved the Yalarrnga people who are associated with the Yalarrnga Country Rangers. It is important to note there are other Yalarrnga who were not involved with the study. Three individuals were interviewed: Lance, Hazel and Selwyn Sullivan, who identify as culturally permitted to speak publicly about the *Ngarlingarli Kurri* and the Yalarrnga biocultural knowledge associated with it. This permission is either due to their age or totemic association to the species.

Lance Sullivan is considered to be the Elder patriarch and Hazel Sullivan to be the Elder matriarch for cultural business, because of lived experience of being passed knowledge from the "old people". Selwyn Sullivan, the third interviewee, is totemically linked to the

Ngarlingarli Kurri, meaning he too can speak for it. Lance Sullivan was considered the primary holder of the stories and knowledge associated with the *Ngarlingarli Kurri*, as passed on to him directly by his Uncles Tom and Clem Sullivan.

3.1.1 Overview of the *Ngarlingarli Kurri* to the Yalarrnga

Lance Sullivan describes the Yalarrnga as desert tribal people, a perspective he extends to his Country. He states that the Yalarrnga have long understood that persistence of life is challenging on their Country and have strict protocols around what can be eaten and how it can be eaten. This extended into a generalised understanding that if life is hard for Yalarrnga people, it must be hard for the *Ngarlingarli Kurri* and other animals too. Lance Sullivan explained that in Yalarrnga language *Ngarlingarli* means wallaby and *Kurri* means red ochre, so together this means red-ochre wallaby, named for distinctive red-purple tint on its neck and face. The *Ngarlingarli Kurri* are totemic, meaning they are considered their "… *brother or sister, like family*". Lance Sullivan stated that the *Ngarlingarli Kurri* are danced for, sung for, and bled for in yearly increase ceremonies. For Yalarrnga there are many animals that they do not eat, including the *Ngarlingarli Kurri* (never) and emu (never), with other wallaby species only being consumed in "*hard times*".

3.1.2 Connection to the Ngarlingarli Kurri and Yalarrnga Country

All participants (n=3) indicated that they spent some time growing up near the *Ngarlingarli Kurri*; however, none currently live on Yalarrnga Country. Selwyn Sullivan had remained in the township of Boulia, which is about 100 km south of the *Ngarlingarli Kurri* distribution, and works on Country with the mines. The two oldest participants, Lance and Hazel, grew up and worked on cattle stations across Yalarrnga Country which ceased in the mid-1980s. Lance and Hazel left the region and now live in Townsville around 800 km east, although both hope to return to their Country. All participants indicated that they continue to visit and stay on Yalarrnga Country when possible.

3.1.3 Origins for knowledge of the Ngarlingarli Kurri

The three participants indicated that they learnt from older Yalarrnga about the *Ngarlingarli Kurri.* Hazel Sullivan's comments were reflective of the group:

We'd sit around the campfire and have stories, that is what we did, practically all our lives… the knowledge, handed down by the old people. You know, they taught us everything.

Additionally, the participants mentioned learning through corroborees and ceremony:

At corroboree time, that is when the stories of the animals are passed on then. You really start to take notice of what's around you, especially the different species. Cause the old fellas used to say, "oh this is a different one from that one. He lives over there; he lives over that way. He hunts this way; he hunts that way." It differs too, the Ngarlingarli corroboree is different from Kangaroo corroboree, or other wallaby corroboree. (Lance Sullivan)

Selwyn Sullivan mentioned that he had "been told to keep an eye on them, to make sure they are still on our country, as they are thinning out over the years". He also noted that he comes across the species when he is checking on Yalarrnga rock paintings on rocky outcrops. Lance Sullivan also stated that he had observed the species since childhood, driven by his cultural obligation to protect it.

3.1.4 Traditional Yalarrnga management

Prior to and in the earlier years of colonisation the Yalarrnga employed fire management (n=2), and specifically burnt in mosaic fire patterns for "*fresh pick*" (young grass shoots) for the *Ngarlingarli Kurri* (n=1). This practice dwindled until ending sometime in the 1980's, when the Yalarrnga where no longer working on their Country as station hands. The complexity and details in the cultural rules about what individuals and groups could and could not take from Country were reiterated by two participants. One also highlighted that Yalarrnga had very strict protocols around water protection and management that would have benefited the *Ngarlingarli Kurri* and other species. During on Country surveys for this project, Lance Sullivan identified soakage's close to *Ngarlingarli Kurri* colonies. Soakage's are small bodies of water that remain through the dry season and, according to Lance Sullivan, sometimes needing to be dug for. He stated that he had observed macropods digging for water and thought that the *Ngarlingarli Kurri* might utilise the soakage's too. One participant indicated that they did not know how the Country was traditionally managed for the *Ngarlingarli Kurri*.

All participants stated that the *Ngarlingarli Kurri* was not eaten and has never been eaten as a "cultural thing" (Selwyn Sullivan).

They are celebrated as a brother; they are part of our kinship totem. They are highly sacred to us. (Lance Sullivan)

One participant indicated that wallaby species generally were protected, but some species could be occasionally eaten, in particular places, after appropriate ceremonies had taken place. Two participants stated that the Yalarrnga previously ate kangaroo (both *Macropus giganteus* and *Osphranter rufus)*. It was mentioned by one participant that *Ngarlingarli Kurri* joeys appear at the same time as those of the grey (*Macropus giganteus)* and red kangaroo (*Osphranter rufus)*, becoming visible in the wet season (November to March). This knowledge is linked to protocols around hunting limitations for kangaroos during joey season, which totally restricts the already limited hunting of females.

3.1.5 Cultural stories of the *Ngarlingarli Kurri*

Only Lance Sullivan spoke in specific detail for the cultural aspects of *Ngarlingarli Kurri* knowledge.

He stated that the *Ngarlingarli Kurri* is associated with men's business including initiation rights. Lance Sullivan conducts increase rites to ensure the ongoing health of the species.

Kurri also refers to the ochre with the young boys going through the lore, so he plays an important part of that mythology… He is putting yilpinji [ochre paint in a specific style] *on this face, you know, to attract his females and that's the corroboree and that is what it is about*. (Lance Sullivan)

Ngarlingarli Kurri behaviour is also displayed by male dancers during corroboree with one interviewee describing that they dance the *Ngarlingarli Kurri* brushing away flies from their faces. Flies are thought by the Yalarrnga to carry the scent of humans. As Lance stated:

You know, when we are hunting the Kangaroo, those big reds and that, they are more in danger of being hunted. So, our corroboree is like, he has a habit of grabbing flies and smelling them. To the wallaby, they don't bother him, he just brushes them and sits there and eats.

Two participants culturally linked the *Ngarlingarli Kurri* with other macropod species, explaining that there are multiple Dreaming sites on Yalarrnga Country that are associated with other wallabies and by extension the *Ngarlingarli Kurri*.

Figure 6. Painting supplied by Lance Sullivan, detailing the Lost Boys *Tjukapa* (Dreaming) site, the routes, and stories between the Ngarlingarli Kurri and other Dreaming stories

Figure 7. The *Ngarlingarli Kurri* Dreaming site. This outcrop has a sister outcrop 300 m to the north that is also a part of the *Ngarlingarli Kurri* Dreaming. This site is still used as part of corroborees, men's initiation rituals and increase rites are preformed to ensure the longevity of the *Ngarlingarli Kurri*. This image shows the heavy dominance of *Triodia* species in the landscape.

3.1.6 Yalarrnga perceptions of *Ngarlingarli Kurri* threats and management

All three participants indicated that they did not believe that their Country is being managed correctly. All participants stated that no Yalarrnga person has control over how their Country is currently managed.

Mining on Yalarrnga Country was listed as a concern by all participants. This fear was linked to recent destruction of a cultural heritage site by mining. All three participants noted that the noise from mining likely impacted the *Ngarlingarli Kurri*, alongside the removal of their outcrop habitat.

Cattle presence was thought to impact on fruit bearing plants, and hence, impact on *Ngarlingarli Kurri* population stability (n=1). Two participants noted that over-browsing had caused a decline in the number of fruit trees on Yalarrnga Country. This trend was noticed at old camp sites that were known for their abundance of fruiting and other cultural plants (n=1). One participant thought that declines in fruit-bearing plants may be resulting in increased competition between cattle and the *Ngarlingarli Kurri*. Lance Sullivan noted:

> *I used to see biggest of them [*Ngarlingarli Kurri*] when I camped and did corroboree. I'd see them eating and drinking but not anymore.*

While one participant thought the *Ngarlingarli Kurri* did not go onto the flats, and stuck to the rocky outcrops, the other two thought that the *Ngarlingarli Kurri* utilised resources beyond the outcrop. Native grasses in general were held in high regard by Lance Sullivan, who perceived that landscape level mismanagement had driven the overtake of "rubbish plants" on the plains, driving down the abundance of native grass species and causing increase in *Cenchrus ciliaris* (Buffel Grass) and other weeds.

Feral species, including pigs, (*Sus scrofa)* and camels (*Camelus dromedarius)* were mentioned by two Yalarrnga, who both linked their presence to general landscape degradation. Predators were listed as a concern by all participants, specifically feral dogs (*Canis lupus familiaris)*, cats (*Felis catus)* and dingos (*Canis lupus dingo*). Two participants stated that the curious nature of the *Ngarlingarli Kurri* made it high risk for predation, and one cited that the corroboree about flies detailed above was evidence of this.

Two participants believed that the people undertaking management decisions did not know the Country well. Hazel Sullivan said:

> *No one gets back to the grassroots people, no one asks us questions.*

Lance and Hazel both believed that Yalarrnga management and knowledge would help improve the management for the *Ngarlingarli Kurri*. They also stated that they wanted more research done on *Ngarlingarli Kurri* and reiterated their concern about the species.

3.1.7 Yalarrnga perception of the diet of the *Ngarlingarli Kurri*

For all three participants, their knowledge about *Ngarlingarli Kurri* diet came from Elders and from some personal observations and was mixed within the group. Lance Sullivan had the greatest knowledge, based on his observations of this species over his lifetime. Additionally, he was the only participant to be interviewed on Country and was able to compile a list of species eaten, alongside many traditional language names (Table 3). Lance Sullivan also said that they "ate a lot of different things".

Ngamayanti (Spinifex; *Triodia* spp.) was identified by all participants as a food source of the *Ngarlingarli Kurri,* alongside the more general comment of "native grasses". The roots of plants were mentioned as well (n=2). *Walmangu* (Bush tomato; *Solanaceae* spp.) was noted as being a staple in the diet of the *Ngarlingarli Kurri*, and that they would eat all parts of the plant but preferred the fruits (n=2). No particular *Walmangu* species was identified. Selwyn additionally stated that the *Ngarlingarli Kurri* was an omnivore, eating insects alongside plants.

Table 3. Plants identified as food sources of the *Ngarlingarli Kurri* by the Yalarrnga Country Rangers during on-Country plant surveys. Species are listed from what is perceived as most (top) to least (bottom) important to the *Ngarlingarli Kurri*. This list was not considered to be the only foods eaten. Rather, it represents species that had been personally observed to be eaten or were based on passed knowledge. It was generally perceived that the *Ngarlingarli Kurri* had a broad diet.

Yalarrnga name	Common name	Scientific name	Comments about species
Walmangu	Bush tomato	*Solanaceae* spp.	Identified as a dietary staple. All parts are eaten with a preference for fruit. This is known from observation and stories, as the *Ngarlingarli Kurri* could compete with the Yalarrnga in the past for this food. For the Yalarrnga various *Walmangu* species were a dietary staple, particularly in the dry season or harder times.
Ngamayanti	Spinifex	*Triodia* spp.	Identified as a dietary staple. Grass blades and seeds are eaten, while digging to the roots occurred in the dry season, or when plant diversity is low. This species is culturally significant and has associated lore and ceremonies.
Dubai	Mitchell grass	*Astrebla* spp.	Identified as a favoured plant by all macropods in the region and found on the plains but not on the rocky outcrops. This genus is culturally significant with lore and ceremonies. It was identified as threatened by

			over browsing and landscape mismanagement.
Kukapi	Bottle washers	*Enneapogon* spp.	The grass blades have been seen to be eaten, by the Ngarlingarli Kurri and other macropods. For the Yalarrnga they used to light fires because it is very flammable. Some species of Enneapogon were included in the catch-all name *dubai*.
No language name	Buffel grass	*Cenchrus ciliaris*	Introduced grass, identified as a threat to the landscape but also a food source for the Ngarlingarli Kurri and other macropods.
Unknown	-	*Senna artemisioide s subsp. oligophylla*	The Ngarlingarli Kurri was seen eating the pods and leaves. The language name unknown, but it was identified as a food with the seeds being ground for damper.
Munyeroo	Wild onion	*Cyperus bulbosus*	A presumed food, as other macropods had been viewed eating the plant and digging at the root bulb. Found around rivers and sometimes in dry gullies. Culturally significant food source for Yalarrnga.
Cuyucuyu	Native cucumber	*Cucumis argenteus and Cucumis melo*	Culturally significant food source for Yalarrnga.
Yalpungu	Native blackberry	*Carissa lanceolata*	Culturally significant food source for Yalarrnga.
Unknown	Rock fig	*Ficus platypoda*	Ngarlingarli Kurri scats were found around the base of one. Found on rocky outcrops in low abundance. Culturally significant.
Wartatji	Wild orange	*Capparis mitchellii*	Culturally significant food source for Yalarrnga.

3.2 Western scientific results of Ngarlingarli Kurri diet and plant surveys

3.2.1 Diet of the *Ngarlingarli Kurri* at the functional group level and ad-hoc species identification

Presence-absence search of plant functional groups in *Ngarlingarli Kurri* scats revealed that browse, forb, grass was observed more often in the scats at sites (Figure 8). Most scats analysed contained at least one fragment of a grass, forb and browse species with a mean presence of 0.88 ± 0.05 (standard error), and all fragments contained at least 2 functional groups. Whereas only 0.15 ± 0.02 of the 2 m^2 quadrats contained all three functional groups, 0.49 ± 0.03 contained 2 functional groups and 0.36 ± 0.03 contained only 1 functional group.

We found that grass species where commonly present in scats and across sites with a mean presence of 1 ± 0.00 scats and 0.99 ± 0.01 at sites. Browse species were present in mean 0.88 ± 0.05 of scats and 0.23 ± 0.02 at sites. Forbs where also always present in scats but where only present at 0.58 ± 0.02 at sites. This trend, of some groups having a contrast in presence between scats and sites was pronounced for *Walmangu* (bush tomato, *Solanaceae* spp*.)* which was present in a mean of 0.67 ± 0.07 of scats but recorded in only mean 0.05 ± 0.01 of quadrats within the five sites. *Walmangu* was most frequently found at Dingo Dreaming with a mean presence of 0.11 ± 0.03 where it was also present a mean of 1 ± 0.00 scats. The *Ngarlingarli Kurri* Dreaming site had the lowest mean presence of *Walmangu* within scats 0.33 ± 0.17, while present in a mean of 0.03 ± 0.02 quadrats. Presence of *Walmangu* was slightly lower at *Manumanu* Dreaming with a mean of 0.02 ± 0.01, where it was also found within a mean of 0.44 ± 0.18 of scats.

We identified the browse species *Terminalia aridicola subsp. aridicola* and *Acacia chisholmi* within scats (Table 2). *Terminalia aridicola subsp. aridicola was* fruiting at the time of the scat and plant surveys, and *Ngarlingarli Kurri* were commonly found to eat the fruits and occasionally the leaves of the plant when available at the site. At the two sites in which the *Terminalia aridicola subsp. aridicola* was present, Initiation Site and *Ngarrkunu* Dreaming, the seeds or skin of fruits were found in a mean of 0.8 ± 0.13 and mean of 0.5 ± 0.17 of scats respectively. At Dingo Dreaming the species was present in 1 scat, or mean 0.10 ± 0.10, but was not found in any quadrat or physically sighted during plant surveys. *Acacia chisholmi* seeds and leaves where found in n=3 scats, or a mean presence of 0.06 ± 0.03, across two sites- Dingo Dreaming and *Ngarlingarli Kurri* Dreaming. We also found known and unknown seeds present in 0.82 ± 0.06 scats samples, and samples containing unknown flower heads in a mean of 0.67 ± 0.07 scats. *Pterocaulon serrulatum* was found in three scats at the *Ngarlingarli Kurri* Dreaming sites and did not appear in any quadrats surveyed, however it was sighted during surveys on the lowlands.

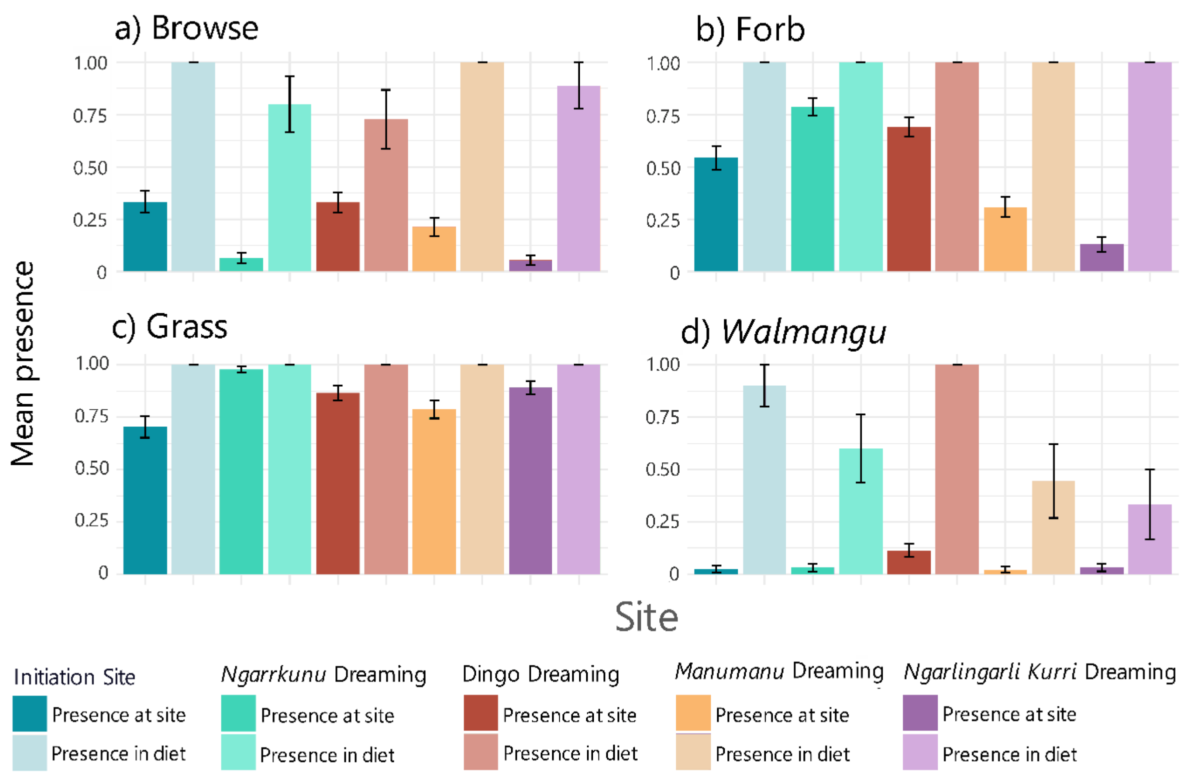


Figure 8. Presence of *browse, forb, grass or Walmangu* in *Ngarlingarli Kurri* diets compared with their presence at sites. The y-axis shows the mean presence, across diet and site, with standard error bars. The presence in diet was determined by the mean number of scats that contained a browse, forb, grass or *Walmangu* species. The presence at sites was determined by the mean percent of times a $2m^2$ quadrat contained a browse, forb, grass or *Walmangu* species across a site.

Table 4. List of flora species that were identified in scats. Identification was ad-hoc and does not include all species eaten. Scats were also inspected for specific species mentioned by the Yalarrnga. Table two shows those that were identified in this ad-hoc way. These results are not reflective of frequency of consumption. However it can be noted that fruiting species where commonly consumed. As indicated by the Yalarrnga, we found the fruiting *Walmangu* and the grasses *Kukapi* (*Enneopogon* spp.), *Ngamayanti (Trioda* spp.*)* alongside another native grass *Eriachne mucronate.* We found that the *Ngarlingarli Kurri* also ate the invasive *Cenchrus ciliaris* (Buffel Grass).

Species	**Browse**	**Forb**	**Grass**	**Seeds**	**Culturally significant[1]**	**Notes**
Acacia chisholmi	X			X	X	Found leaves, seeds and remnants of seed pods in three scats.
Cenchrus cilaris			X			Commonly sites and in scats.
Enneapogon **spp**.			X		X	Commonly sites and in scats.

Eriachne mucronate			X		X	Commonly sites at sites and in scats.
Portulaca oleracea		X		X	X	Seeds found in scats; species was not present in any plant surveys but was sighted on adjacent flats.
Pterocaulon serrulatum		X			X	Found in two scats.
Solanacea sp,		X		X	X	Commonly found, exact species unknown. Leave parts and fruit skin and seeds found in scats.
Terminalia aridicola subsp. aridicola	X			X	X	Commonly found when available at the sites, fruit size is 2-3 cm and fleshy. Fruit skin and leaves found in scats
Triodia molesta			X	X	X	Commonly sites in scats, including seeds and seed heads.

[1] Cultural significance is defined as a species known to and used by Yalarrnga people, as defined by the Yalarrnga Country Rangers during plant surveys on country.

3.2.2 Assessment of plant availability to the Ngarlingarli Kurri: Richness, cover and dissimilarity across surveyed rocky outcrops

Species richness

Across all sites we found significant variation in species richness (Welches ANOVA $F_{4,182}$=79.42, p<0.0001). The *Ngarlingarli Kurri* Dreaming site had the lowest species richness, with a median species richness of 1 unique species per quadrat (range: 1 to 5). Dingo Dreaming had the highest species richness with a median of 4 unique species per quadrat (range: 1 to 8). These two sites were also the only sites whose species richness was significantly different to all other sites (Figure 9). Results from pairwise t-tests showed that several sites had significant variation of means between them (Figure 9).

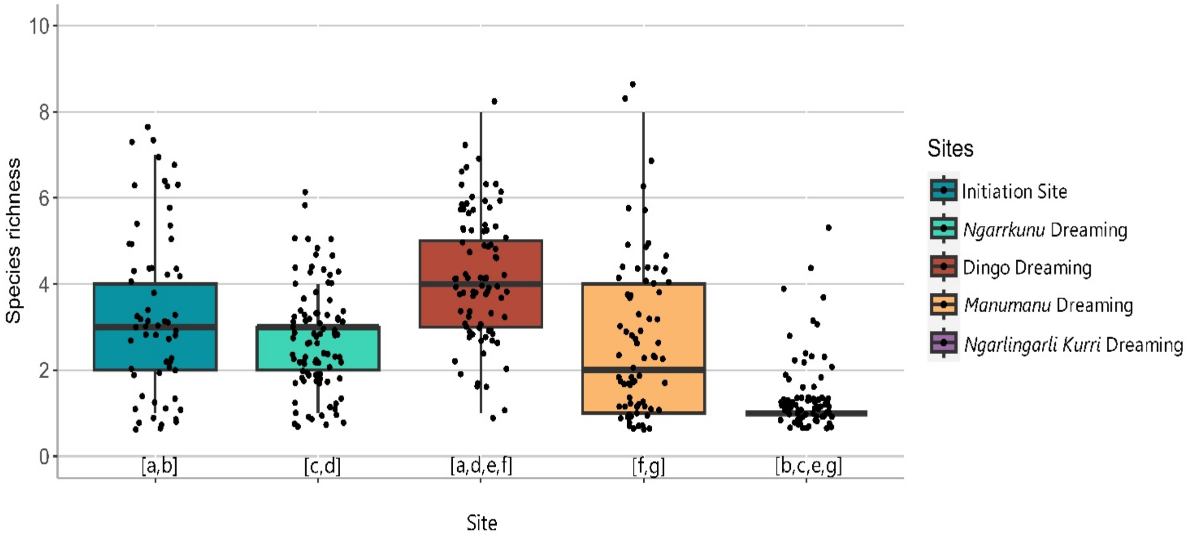


Figure 9. Variation in species richness across *Ngarlingarli Kurri* survey sites on Yalarrnga Country. The y-axis represents species richness. The cross shaped points represent the species richness for each quadrat surveyed in the site. The boxplots central band represents the median with the top and bottom of the boxes representing the 25th (upper quartile) and 75th (lower quartile) percentiles respectively. The whiskers represent the total range of species richness per quadrat across the site. The letters (a-g) denote which sites had significant variance of means in species richness from each other.

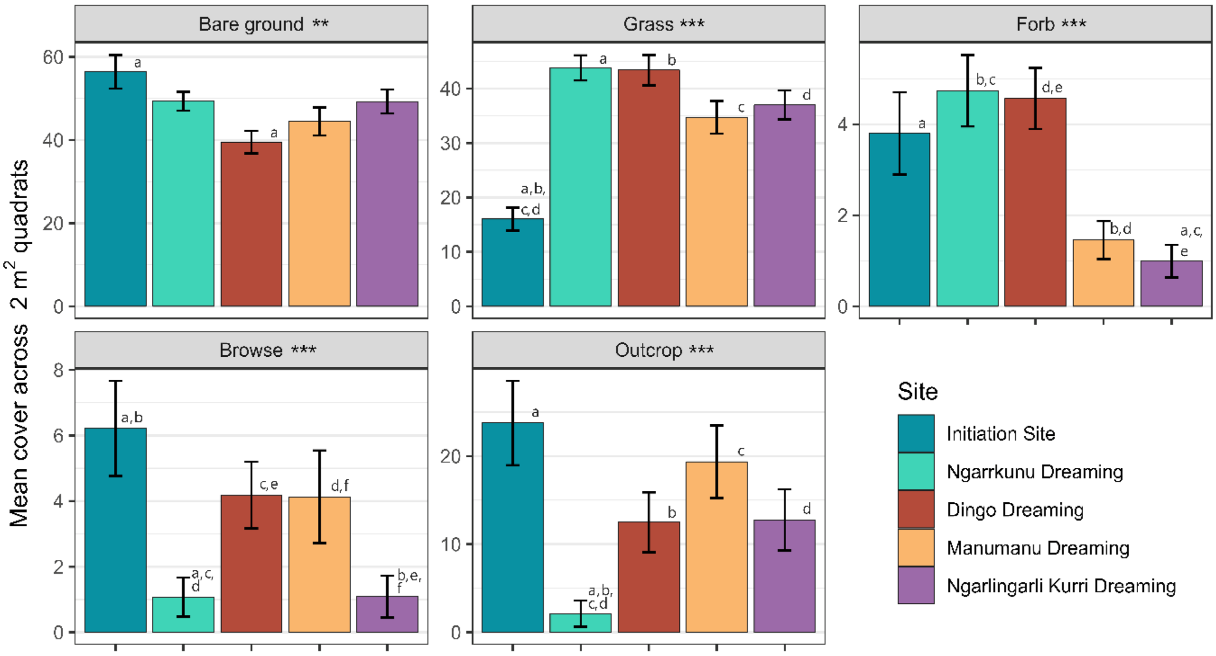
Cover of flora functional groups, bare ground, and outcrops

The mean percent cover of bare ground and the flora functional groups, forbs and grass, varied significantly across sites ($p \leq 0.01$; Figure 10). Additionally, we found mean browse and rocky outcrop presence also varied significantly across sites (Figure 10).

Mean grass cover was lowest at the Initiation site, which also showed significantly lower grass cover when compared with all other sites in pairwise t-tests (all $p<0.0001$.) The other four sites had no significant differences in mean grass cover between them. Forb cover varied across and between sites, with *Manumanu* Dreaming and *Ngarlingarli Kurri* Dreaming having significantly less forb cover than *Ngarrkunu* Dreaming and Dingo Dreaming ($p\leq0.002$, pairwise t-tests). Additionally, *Ngarlingarli Kurri* Dreaming varied from Initiation site ($p=0.03$, pairwise t-test). Bare ground cover was relatively stable across sites, with only two sites showing significant variation (Initiation site and Dingo Dreaming, $p=0.007$, pairwise t-test).

Ngarrkunu Dreaming had the lowest total outcrop presence, varying significantly from all other sites ($p \leq 0.01$, Fisher's Exact Test). Figure 10 shows browse presence at *Ngarlingarli Kurri* Dreaming and *Ngarrkunu* Dreaming was significantly lower than all other sites, $p \leq 0.003$ (Fisher's Exact Test).

Figure 10. The mean cover, with standard error bars, of bare ground, grass, forbs, browse



and outcrop rock across the five survey sites on Yalarrnga Country. For **Bare ground, Grass** and **Forb** a Welches ANOVA was performed on mean percent of cover across all sites. Due to low counts for **Browse** and **Outcrop** a Fisher's exact test, with a simulated p-value based on 2000 replicates, was run on a count of their presence in quadrats. The stars on the graph refer to the significance of these tests, with *=p ≤ 0.05; **=p ≤ 0.01; ***=p ≤ 0.001. **Bare ground**: $F_{4,21}$=3.8, p= 0.005; **Grass:** $F_{4,226}$=25.2, p< 0.0001; **Forb:** $F_{4,216}$=3.8, p< 0.0001; **Browse:** p=0.0005, **Outcrop:** p=0.0015. The letters above the columns in each graph, refer to the pairs of sites that had a significant difference between them. For **Bare ground, Grass** and **Forb** pair-wise t-tests, with a holm's adjustment on the p values were used to test significant differences in mean percent cover. For **Browse** and **Outcrop** Fishers exact tests were run between pairs of two sites

Table 5. Mean percent cover of browse, forb, grass and bare ground across sites with standard error.

Site	**Average of browse**	**Average of forb**	**Average of grass**	**Average of bare ground**
Initiation Site	16.30 ± 3.67	9.97 ± 2.30	42.07 ± 4.93	25.08 ± 3.21
Ngarrkunu Dreaming	2.20 ± 1.22	9.68 ± 1.60	89.50 ± 4.51	26.26 ± 2.87
Dingo *Dreaming*	9.56 ± 2.29	10.43 ± 1.48	99.20 ± 5.06	21.68 ± 2.26
Manumanu Dreaming	10.25 ± 3.46	3.62 ± 1.02	86.09 ± 5.96	21.78 ± 2.40
Ngarlingarli Kurri Dreaming	2.50 ± 1.45	2.28 ± 0.82	84.77 ± 5.11	29.06 ± 3.35

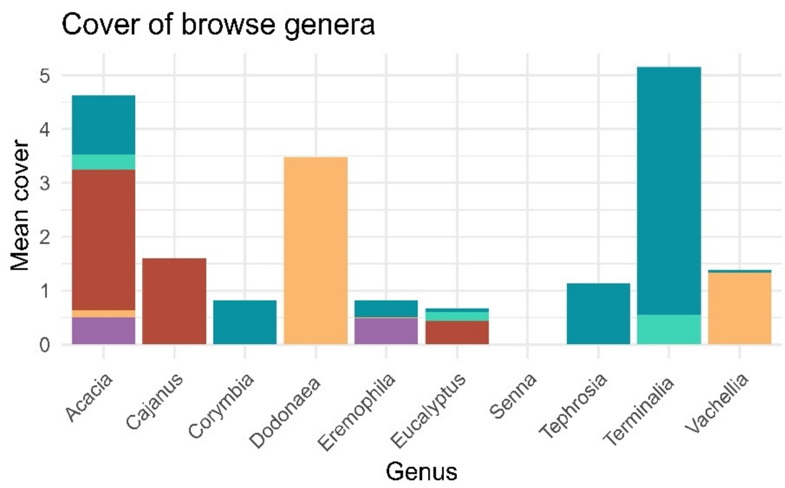
Flora dissimilarity- at functional group and species scales

There was a range of dissimilarity of species cover between sites (0.141- 0.842, Bray-Curtis dissimilarity, Table 3.3). The lowest dissimilarity was found between the *Ngarlingarli Kurri* Dreaming and the *Ngarrkunu* Dreaming (Bray-Curtis: 0.141, Table 3.3).

Manumanu Dreaming was moderately dissimilar to all sites (Bray-Curtis: 0.53- 0.0.63, Table 3.3). The grasses *Triodia molesta, Cenchrus ciliaris, Enneapogon polyphyllus* were the only species found in all sites. The forb genera present at all sites were *Corchorus*, *Boerhavia* and *Solanum* and for browses, the *Acacia* genus was found across all sites (Figure 11). In total we recorded 59 unique species across the five sites, with 29 only being recorded at a single site.

Table 6. Bray-Curtis dissimilarity using mean species cover across sites surveyed on Yalarrnga Country. The Bray-Curtis index ranges from 0-1 with 0 meaning there is no dissimilarity of species and species cover and 1 meaning total dissimilarity of species and species cover, 0.5 is treated as intermediate dissimilarity.

	Initiation Site	**Dingo Dreaming**	***Ngarrkunu* Dreaming**	***Ngarlingarli Kurri* Dreaming**
Dingo Dreaming	0.586	-	-	-
***Ngarrkunu* Dreaming**	0.836	0.842	-	-
***Ngarlingarli Kurri* Dreaming**	0.787	0.823	0.141	-
***Manumanu* Dreaming**	0.5332	0.623	0.632	0.574



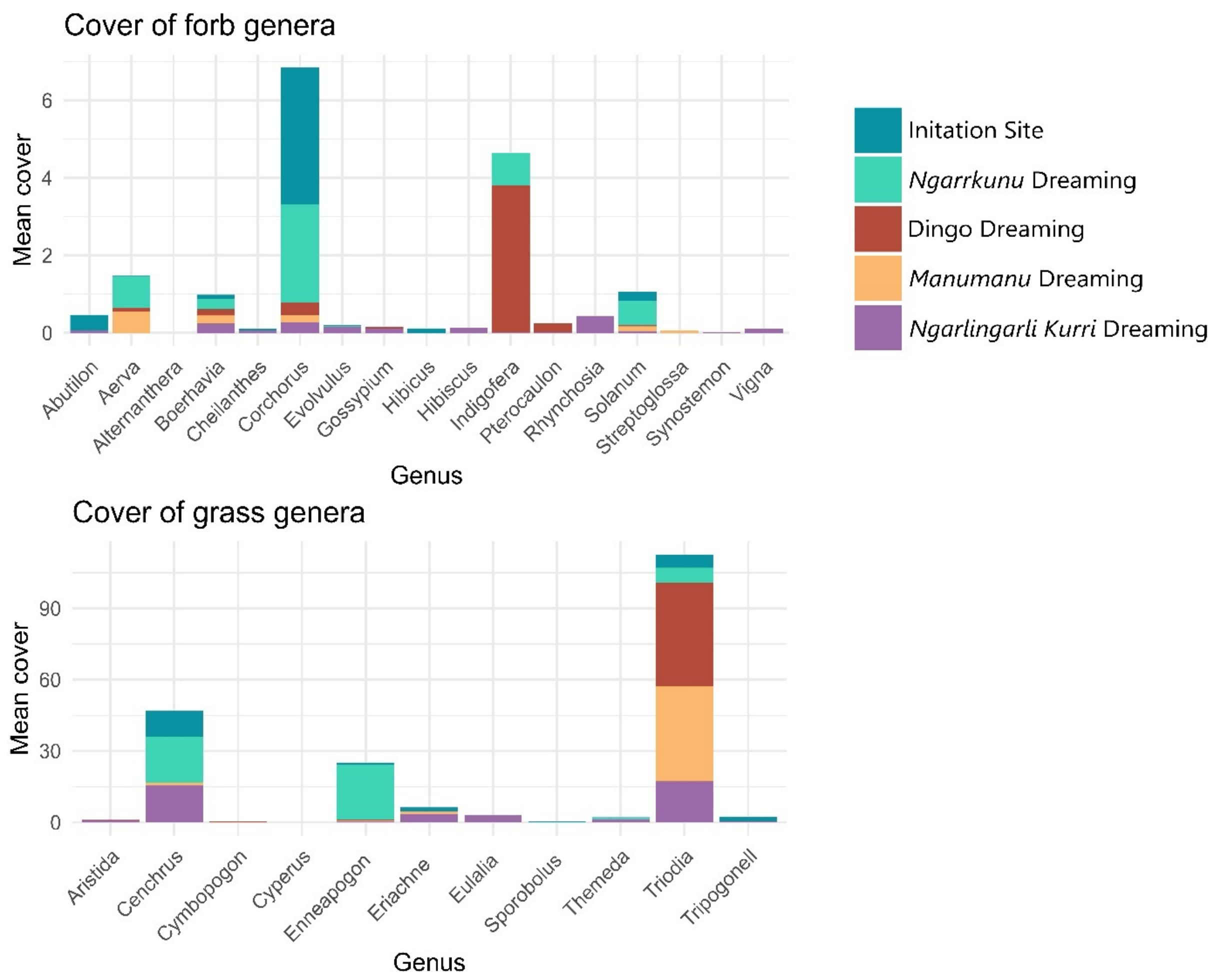


Figure 11. Mean cover of different flora genus, from the functional groups browse, forb and grass across sites. The x-axis is each genus found across all sites and the y-axis is the mean cover percentage of the genus.

3. Discussion

4.1 Yalarrnga knowledge and its connections with western science

We found that the Yalarrnga Country Rangers used a combination of personal observations and cultural stories to successfully locate *Ngarlingarli Kurri* shelter sites on their Country. Additionally, we found that Yalarrnga perceptions of diet, threat and management issues related to the *Ngarlingarli Kurri* aligned with the western scientific knowledge created by this study and findings from other studies.

4.1.1 Yalarrnga perception of *Ngarlingarli Kurri* Diet

The Yalarrnga identified the *Walmangu* as a significant part of the *Ngarlingarli Kurri* diet, which we confirmed through micro- histological analysis. We identified *Walmangu* consumption at all sites, even when total presence at the site was low. The presence of *Walmangu* corroborates with other studies in similar biomes, were *Petrogale xanthopus* was found to consume *Solanum petrophilum* during the summer and early autumn (Copley & Robinson, 1983). The perception of the *Ngarlingarli Kurri* eating "lots of different things" (Lance Sullivan) was also confirmed as we found 87.6% of all samples had the presence of a mix of grass, browse and forb species. The Yalarrnga identified *Ngamayanti* (spinifex) as a part of diets which we also confirmed. *Ngamayanti* seeds and flowers were also found in scats, however, we found no evidence of *Ngamayanti* roots which may have been due to the season as it was not "hard times". During ad-hoc species identification we found the native grass species *Eriachne mucronate* and *Kukapi (Enneapogon* spp.*)*. This corroborates the Yalarrnga concern for the simplification of grasslands for the *Ngarlingarli Kurri*. A deeper investigation at the species level is required to understand which native grasses the *Ngarlingarli Kurri* selects for and against.

That both the Yalarrnga and the *Ngarlingarli Kurri* require the *Walmangu*, the Yalarrnga for cultural reasons and the *Ngarlingarli Kurri* as a part of their diet, highlights the need to understand its dynamics in the landscape for its persistence. Additionally, that the Yalarrnga correctly identified species that the *Ngarlingarli Kurri* consumed shows the efficacy of using biocultural knowledge in western scientific investigations into the diets of animals that Indigenous people are familiar with (Telfer & Garde, 2006; Telfer & Griffiths, 2006). There were several species mentioned by the Yalarrnga that we did not find during scat analysis, however this could be attributed to season and poor identification by the researchers (Table 3.1). In general, we found the guidance by the Yalarrnga around diet was similar to what we found using the micro-histological method. It should be noted that seeking to corroborate Indigenous knowledge using western science is considered to be disrespectful by some (Gratani et al., 2011; Nadasdy, 1999). However, in this case it was considered useful by the Yalarrnga to demonstrate that their knowledge of the *Ngarlingarli Kurri* could be validated (Gratani et al., 2011).

4.1.2 Yalarrnga perception of threat to the NK

The Yalarrnga participants noted three key threats acknowledged by other rock-wallaby studies- predation by cats and dingos, over browsing by cattle and changed fire regimes (Lavery et al., 2021).

Predation

The Yalarrnga considered cats and dingos to be of concern due to the naturally curious and low threat response by the *Ngarlingarli Kurri*. They explained this through behavioural observations of the *Ngarlingarli Kurri* expressed through a corroboree, where it does not "brush away flies" carrying their scent. This corroboree explains that the *Ngarlingarli Kurri* is not fearful of humans, as the kangaroo is. The concern for cat predation can be corroborated by studies in arid regions in which rock-wallabies were found in the stomachs of cats, hypothesised to be driven by food stress (Anderson et al., 2021; Read et al., 2018). Dingo predation was also highlighted by the Ngaanyatjarra people in Warbuton (Pearson & The Ngaanyatjarra Council, 1997), Western Australia and there has been rock-wallabies found in the stomachs of dingos, however it is noted that dingo predation is unusual on rocky outcrops (Doherty et al., 2019; Pearson & The Ngaanyatjarra Council, 1997).

Predation risk has been shown to impact the foraging behaviour of the *Petrogale pencillata* and cats have been sighted on camera traps on Yalarrnga Country, suggesting that cats may be causing pressures on the *Ngarlingarli Kurri* (Botma et al., 2020, Jarad Barnes, unpublished data 2023). The Yalarrnga are unlikely to support 'wild dog' culling programs as they consider the Dingo to be a culturally significant species, with the Dingo Dreaming site forming a part of a Dingo song line that they are also culturally obligated to protect like many other Indigenous nations (Philip, 2020). It is thought that the presence of Dingo's can mediate feral cat presence and predation opportunities- however this idea is contested (Bannister et al., 2015). What has been observed is little overlap between cats and Dingo's core home ranges, meaning that Dingo presence and knowledge of Dingo presence by the Yalarrnga could inform cat reduction programmes in the future (Bannister et al., 2015).

Over browsing by cattle with a specific concern for fruiting browse was one of the drivers of the project. We did not explore this directly; however, our results suggest that if cattle are reducing fruiting browse and forb presence within *Ngarlingarli Kurri* ranges, there could be implications for *Ngarlingarli Kurri* health and population dynamics. If present, this trend would occur on flats below rocky outcrops where *Ngarlingarli Kurri* foraging grounds have the potential to interact with preferred cattle browsing areas (Squires, 1982). During times of environmental stress over browsing of woody shrubs by cattle has been shown to cause a longer-term reduction in shrub abundance, meaning that the *Ngarlingarli Kurri's* reliance on browse species might be particularly affected during the droughts that are common on Yalarrnga Country (Read, 2004). There is potential for pressure to be placed on the *Ngarlingarli Kurri* by cattle, which if occurring, could drive range increases and increase potential for predation as they are driven to forage in less complex, and therefore, higher risk habitats (Botma et al., 2020; Lavery et al., 2021).

Fire regimes

Interestingly, the Yalarrnga recognised the *Ngarlingarli Kurri* as a naturally vulnerable species with limits to their distribution (Figure 3), statements that are affirmed by western science (Eldridge, 2011; Lavery et al., 2021). This understanding of vulnerability is reflected in the traditional lore that they are not to be eaten. Notably, the Yalarrnga management practices pay special attention to this species. Previously, when living on country, they deliberately burnt rocky outcrops to maintain *Ngarlingarli Kurri* health and prohibited the species as a food source. It is of interest that the species was considered to need protection. The Yalarrnga generally stated that the loss of Yalarrnga management (particularly traditional fire regimes) was causing Country-wide declines in native species, including the *Ngarlingarli Kurri*. Prescribed fire management is considered beneficial to mammals across northern Australia, with studies that collaborated with Indigenous partners showing its efficacy in improving mammal populations (Radford et al., 2020; Shaw et al., 2021). However, given that the *Ngarlingarli Kurri* largely occurs on cattle stations, the benefits of fire regimes on *Ngarlingarli Kurri* resources may be negated by grazing pressures (Tuft et al., 2012)

Monitoring opportunities

Lance Sullivan had noted observed declines in the *Ngarlingarli Kurri* across time, in line with the general scientific consensus that endemic mammal species are declining across Australia (Ziembicki et al., 2015). Selwyn Sullivan reiterated these concerns, stating that he had "*been told to keep an eye on them, as they are thinning out over the years*". This informal monitoring by the Yalarrnga on their country could inform future research of baseline populations prior to and since colonisation. The elder participants noted that the *Ngarlingarli Kurri* were seen on the flats and outcrops, while the younger participants only noted their presence on outcrops. This observation highlights that intergenerational monitoring is vital, as it can has potential to show behavioural changes over time of species that may have been triggered from changing threats and resource availability. Western scientists have also affirmed the need to work with Indigenous people on Indigenous controlled lands, to improve conservation outcomes for *Petrogale* species (Lavery et al., 2021).

Management implications

Management of the *Ngarlingarli Kurri* on Yalarrnga Country is complex. This complexity is driven by the domination of the landscape by landholders who use the country for cattle grazing and mining operations with the no protected areas. The Yalarrnga Country Rangers ability to monitor and manage for the species is limited by their ability to influence private operations. While cultural heritage sites are recognised, there are legislative limitations to recognising culturally significant species as cultural heritage and management relies on listing under the Environment Protection and Biodiversity Conservation (EPBC) Act 19 (Robinson et al, 2021). As the *Ngarlingarli Kurri* is not listed as Threatened under the EPBC act as of 2023, there are little legislative mechanisms that the Yalarrnga can rely on to trigger their protection.

Those interviewed did not completely reject continued presence of cattle or mining but expressed their desire to limit the activities to protect the *Ngarlingarli Kurri.* The perception of grazing is driven by the longstanding working history of Yalarrnga with cattle on their Country. They have lived memory of working with the landholders, to some degree, to manipulate cattle presence to protect their biocultural heritage across their Country. At this time, they also applied traditional fire management. Allowing the Yalarrnga to re-introduce traditional fire regimes to their country and protect their biocultural heritage which notably includes fruiting browse species, could potentially have positive impacts on *Ngarlingarli Kurri* persistence on Yalarrnga Country.

4.2 Western science: the interaction between diet and plant presence, cover, richness, and dissimilarity

4.2.1 Micro-histological analysis of diet

We found that the *Ngarlingarli Kurri's* diet consisted of all functional groups studied (grasses, forbs and browses) a finding that aligns with other studies of *Petrogale* and Yalarrnga perceptions of diet (Copley & Robinson, 1983; Creese et al., 2019; Dawson & Ellis, 1979; Tuft et al., 2011). Grass was the most common functional group available in both sites and scats (Figure 8), being present in almost all quadrats across all sites, and in every scat analysed across all sites. Alongside the native grass species, we found the presence of the invasive species Buffel grass (*Cenchrus cilaris)* at 4 of the 5 sites. This finding shows that grass species both dominate the rocky outcrops and are integral in the diet of the *Ngarlingarli*

Kurri. Buffel Grass, while found in the diet, is known to outcompete other species. As the *Ngarlingarli Kurri's* diet relies on all functional groups and a variety of grasses it's high presence at sites might pose a threat to the diversity required by the wallaby.

Forb species were found in all scats, even when relative presence and cover across sites was low (Figure 8). Other studies have highlighted the importance of forb species in *Petrogale* diets, where they consume fewer forbs when they are no longer abundant seasonally (Dawson & Ellis, 1979; White & Fleming, 2021). We found evidence that the *Ngarlingarli Kurri* ate the forb species *Portulaca oleracea, Pterocaulon serrulatum and Solanaceae* spp. These species had a low total cover across sites, but this discrepancy can be attributed to an ad-hoc species identification method. Forb genera presence and cover changed across the sites with *Corchorus*, *Boerhavia* and *Solanum* appearing at every site. Most common forb genera across all sites had stellate hairs, making it difficult to perform species identification of fragments.

Browse species were considered to be important in the diet of the Yellow-footed rock-wallaby (*Petrogale xanthopus)* in South Australia and New South Wales, consisting of 44% of their diets during droughts (Dawson & Ellis, 1979). We found that browses were present in the diet of the *Ngarlingarli Kurri* at much higher levels than would be suggested from their presence within sites. Of interest is that presence of browse species in scats is relatively consistent across sites even though some sites (*Ngarlingarli Kurri* Dreaming and *Ngarrkunu* Dreaming) had a significantly lower total browse cover than other sites. Some explanations for this that while browse species cover is low on rocky outcrops, these species can increase on the lowlands, meaning they are available to the *Ngarlingarli Kurri* but were not captured within our surveys.

While we found a high number of fruits in the diet of the *Ngarlingarli Kurri*, it was the Yalarrnga who highlighted the *Walmangu* and the importance of fruiting species, meaning that we made slides and deliberately looked for the species potentially biasing the results. However, it is likely that when seasonally available, fruiting species form a large part of the diet of the *Ngarlingarli Kurri*. Our results generally affirm other studies, including dentition studies, that the *Ngarlingarli Kurri* is likely a mixed browser with some flexibility in diet (Arman & Prideaux, 2015).

4.2.2 Species cover, richness, and dissimilarity

While this project does not quantify proportions eaten of either functional groups or species, our results on species cover, richness and dissimilarity show that regardless of variation presence in diet of functional groups remains relatively similar across sites (Figure 10). Across the sites, species richness values varied significantly yet even at the *Ngarlingarli Kurri* Dreaming site, where species richness was low the *Ngarlingarli Kurri* diet still contained all three functional groups in similar proportions to the *Ngarlingarli Kurri* at other sites alongside *Walmangu.* Our measurement of species richness due to our use of small 2m^2 quadrats can also explain the patchiness in species distribution across sites. The highest species richness values were recorded at Dingo Dreaming, which also had the lowest total bare ground cover (Figures 10 and 11). Dingo dreaming also had the lowest presence of browse in diets and lowest total browse cover (Figure 8 and Figure 10). At *Ngarlingarli Kurri* dreaming, where mean forbs cover was lowest and species of richness was lowest, we still found that all scats contained a forb species, showing that the *Ngarlingarli Kurri* likely selects for forbs. Dingo Dreaming and *Ngarlingarli Kurri* Dreaming where also dissimilar in species composition to one another (0.823), highlighting that regardless of species richness and composition, the *Ngarlingarli Kurri* will still select for browses, forbs, grasses and *Walmangu* species, showing that potentially the breadth of species selection within this functional groups is broad (Figure 8). Selection for browse species that we identified included *Acacia* species, specifically *Acacia chisholmi*, with *Acacia* species were found across all sites. *Acacia chisholmi* is another species that overlaps with the *Ngarlingarli Kurri* and Yalarrnga cultural identity, meaning the tree has songs and ceremonies associated with it. Traditionally the Yalarrnga used the highly resinous tree to make a glue for spears and other objects. While Acacia species are common in the landscape, alongside *Acacia chisholmi,* The Yalarrnga Country Rangers identified *Acacia chisholmi* as species that required special protections. While species selection may be broad, the *Ngarlingarli Kurri Ngarlingarli Kurri* clearly selected for the *Terminalia aridicola subsp. aridicola* when available.

While their wide dietary breadth can protect them against competition from other species, both native and non-native herbivores have been demonstrated to have dietary overlaps with *Petrogale* species in other locations (Creese et al., 2019; Dawson et al., 1992). In other *Petrogale* studies it has been demonstrated that there is potential for dietary overlap with the sympatric Euro's (*Osphranter* species), in particular *Osphranter robustus,* which is found on Yalarrnga Country, as they share but are not spatially restricted to rocky outcrop habitats (Creese et al., 2019; Lavery et al., 2021; White & Fleming, 2021). Understanding foraging dynamics and interaction with other herbivores across sites will be an important next step in synthesise knowledge of their diet knowledge with conservation in the future (White & Fleming, 2021).

4.3 'Right-way' science-successes, challenges, and lessons

In our adherence to the guidelines suggested by other researchers for working with Indigenous partners we created a positive working relationship with the Yalarrnga Country Rangers and other Yalarrnga people. We found the importance of 'yarning' cannot be underestimated as it built a strong foundation of trust and understanding that allowed for a successful project (Cooke et al., 2022). We found the cross-cultural work to be deeply based on strong interpersonal relationships (Ens et al., 2015). Ensuring we followed cultural and academic protocols allowed for clear boundaries to be maintained and understood by all parties. The formal academic process of explaining and obtaining 'Prior Free and Informed Consent' was integral for the Yalarrnga to understand their rights within the process, without which trust would not have been built as successfully (AIATSIS, 2020).

The major challenges experienced were the overwhelming number of concerns held by the Yalarrnga. They listed many species and environmental factors of concern in the initial 'yarning' stages, making it challenging to narrow it to specific research questions. Yalarrnga knowledge, like other Indigenous knowledge systems, is not fragmented into sections. Stories about NK were taught through corroboree, ceremony and other stories about Country and kinship relationships. The Western scientific model of reductionism is difficult to apply in conjunction with Yalarrnga knowledge systems. The limited time frame of this project did not allow for some important concerns to be addressed, such as the impact of cattle browsing. Financial and logistical concerns of the Yalarrnga Country Rangers posed an additional challenge. They had no housing on their Country, meaning all field work had to be undertaken while camping which was not optimal given the time of year the field work was conducted. Strong familial responsibilities and cultural responsibilities also limited the time that Yalarrnga could be on Country participating in this project. Western scientific researchers would bode well from familiarising themselves with the work of other cross-cultural ecologists to ensure they understand best practice and the expectations and limitations held by prospective Indigenous communities they seek to work with (Cooke et al., 2022; Ens et al., 2012).

4.4 Limitations

Our choice to sample 2.25 ha likely does not represent the entity of *Ngarlingarli Kurri* foraging grounds, meaning, it cannot be used to estimate total volume of taxa or functional groups eaten contrasted with availability, as possible for other studies (Tuft et al., 2011).

Instead, we can only provide a snapshot of rocky outcrop plant cover and presence to contrast with diet presence. Range dynamics of other *Petrogale* species are elliptical in shape and including specific foraging grounds on the flats below (Botma et al., 2020; Molyneux et al., 2011; Ruykys et al., 2011). Without a thorough understanding of the range dynamics of specific *Ngarlingarli Kurri*, it is difficult to fully quantify their selection rates. In addition to this, the species level identification was restricted to plants identified by the Yalarrnga, and as such adds bias to these results.

This study can be considered preliminary, as longitudinal study across the entire distribution of the *Ngarlingarli Kurri* across all seasons is needed to fully begin to quantify selection rates for the species. Due to time constraints and the total length of the project we were able to survey once during December to January, which is during the wet season of Yalarrnga Country. Plant composition and availability is likely to changes across the seasons of Yalarrnga Country. Plant composition and availability is also likely to change spatially across the distribution of the *Ngarlingarli Kurri*, as rainfall increases, and fire regimes change across latitude. To fully understand the diet of the *Ngarlingarli Kurri* across its entire distribution, sampling outside of Yalarrnga Country is required, to understand the fundamentals of the diet of the *Ngarlingarli Kurri*. The interaction between threats is also likely to differ across the entire distribution of the *Ngarlingarli Kurri*.

This study explored Yalarrnga perception of threat, elucidating local knowledge from station managers and mining companies would broaden the understanding of how the *Ngarlingarli Kurri* is managed for on Yalarrnga Country. This, combined with Yalarrnga understandings, can be used to better plan for *Ngarlingarli Kurri* conservation on Yalarrnga Country in the future. As the land is all privately owned, working with landowners is integral to the success of *Ngarlingarli Kurri* conservation (Kearney et al., 2022; Smith & Allen, 2021). Additionally, we only spoke with 3 Yalarrnga knowledge holders, extending this study to other Indigenous knowledge holders of the *Ngarlingarli Kurri* could add further insights into the species.

We did not address the proportion of unknown plants within scat samples. It is difficult to estimate the number of species present in each sample, as we did not attempt to differentiate between fragments. Building photo libraries of fragments to group them into species, even if unknown, is an extensive task and there was no time. It must be emphasised that those identified were largely species highlighted as potential food sources by the Yalarrnga, meaning our identification results without caution could be interpreted as the most significant or only plants eaten by the *Ngarlingarli Kurri.* A major limitation is that we provide no understanding of how large this bias is- which could be better understood by including the proportion of known to unknown plant fragments.

Additionally, there is a layer of positive bias whereby Yalarrnga were only highlighting species that are also significant to themselves. As recorded in Table 3, all the plant species mentioned were also culturally significant meaning they had songs, stories, and dreaming's for them. There are likely other plant species eaten by the *Ngarlingarli Kurri* not utilized by the Yalarrnga that are eaten frequently by the *Ngarlingarli Kurri* not been remembered by the interviewees. There could also be knowledge of other plants, knowledge of threat and management activities that have been withheld by the Yalarrnga for cultural reasons.

4.5 Further research

As this species' ecology is understudied ample future research opportunities exist including:

1. Identifying primary colonies and gene flow and population health to provide target management for the species (Lavery et al., 2021)
2. Exploring the effects of predation (Anderson et al., 2021)
3. Understanding the range dynamics
4. Quantifying the overlap in diet and landscape use patterns of the *Ngarlingarli Kurri* and cattle
5. Understanding the interaction between fire and plant availability on Yalarrnga Country and across the *Ngarlingarli Kurri* range
6. Longitudinal monitoring to better understand predictors of colony health
7. Application of the 'Cultural Keystone' model of species protection to the *Ngarlingarli Kurri* on Yalarrnga Country.

4. Conclusion

The micro-histological study, combined with Yalarrnga knowledge, suggested that the *Ngarlingarli Kurri* diet was not dissimilar from other *Petrogale* species (Copley & Robinson, 1983; Creese et al., 2019; Lapidge, 2000; Tuft et al., 2011). Additionally, The Yalarrnga perception of threats to the *Ngarlingarli Kurri* was aligned to the western scientific understanding of threat to other *Petrogale* species (Lavery et al., 2021). The work to uncover the complex dynamics of the *Ngarlingarli Kurri* conservation on Yalarrnga and other Countries is far from finished. We started from the foundations laid by Yalarrnga matriarch Hazel Sullivan:

Our old people, they were born there and walked the country, they hunted there. That's the knowledge, handed down by the old people. You know they taught us everything.

Cross-cultural science offers the opportunity for Traditional Owners and western scientists to work together to unpack the histories of Country and understand the complex environmental issues that have arisen since colonisation. To understand the Yalarrnga perspective this projected required the integration of knowledge learnt through listening to stories and connections found in Yalarrnga Country. The Yalarrnga are deeply concerned about the health of their Country with Hazel Sullivan stating:

They call it progress, what they do to the Country but they are killing the habitat of our animals that have been there forever. Everything that has been brought in, it's killing the Country, it is taking the goodness.

Through working together, we recorded old and new knowledge of the *Ngarlingarli Kurri*, in the hopes for its conservation in the future.

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Appendix:

Appendix 1. The script of the questions asked during biocultural interviews. Each partipiant was asked this list of questions in this order and their answers were audio recorded.

Knowledge Foundation and Identifier Questions

1. What is your name?
2. Where is your country?
3. How old are you?
4. Did you grow up near the *Ngarlingarli Kurri?*
5. How do you know about the *Ngarlingarli Kurri*?

Diet questions

6. From your understanding, what does the Purple-necked rock-wallaby eat?

    a) How do you know this?

Management questions

7. In the past, did you or someone else in your community keep the land healthy for the *Ngarlingarli Kurri*?

    a) If yes, how do you know this?

8. Do you know how the *Ngarlingarli Kurri* Country is kept healthy today?

    a) If yes, what do you think about this? This is done in a right-way?

9. Do you eat the *Ngarlingarli Kurri* or did your ancestors?

    a) If yes, are there any times you cannot eat the Purple-necked rock-wallaby?

    b) If again yes, why can't they be eaten then?

Species interconnections

10. Is the *Ngarlingarli Kurri* connected to other plants, animals, seasons, waterholes, soakage's or weather patterns etc?

a) If yes, can you explain how or why it is connected?

11. Do you know any cultural stories of the Purple-necked rock-wallaby that you are allowed to share?

    a) If yes, what is/are the story/ies?

Threats

12. Is there anything or anyone that threatens the *Ngarlingarli Kurri* wallaby?

    a) If no, why do you think this?

    b) If yes, why do you think this?

    c) What threats do you see and how long have they been present?

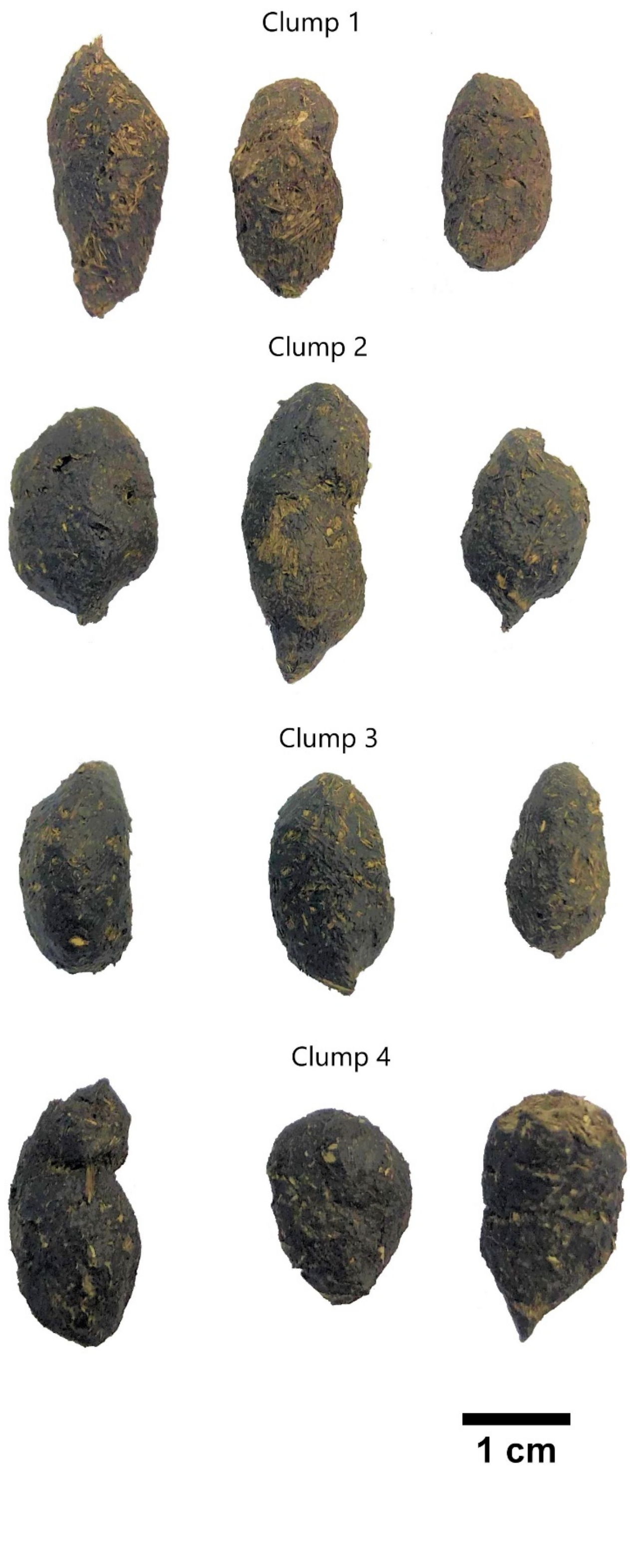
    d) How is this threat dealt with, and have these actions changed over time?

    e) Where did you learn about this?

Other comments?

13. Is there anything more you would like to share today?

Appendix 2. A variety of *Ngarlingarli Kurri* (*Petrogale purpureicollis*) scats organised into discrete clumps. This image shows the variation in size and shape across clumps, as well as the regular conformation to the distinctive tapering and visible plant matter on the surface of the scat. These are features found amongst other rock-wallabies. We used scats similar in



colour to clump 3, these represent fresh scats shown by the black shiny outer coating.

Appendix 4. The number of quadrats a species occurs in at each site. Each species was counted once per quadrat regardless of actual abundance or cover. The table is listed from the most common across all sites to the least common and when equally weighed, in alphabetical order.

Species	**Initiation site**	***Ngarrkunu* Dreaming**	**Dingo Dreaming**	***Manumanu* Dreaming**	***Ngarlingarli Kurri* Dreaming**
Triodia molesta	16	92	42	37	76
Cenchrus ciliaris	30	1	70	27	1
Enneapogon polyphyllus	2	11	81	3	3
Indigofera linifolia		51	44	1	
Corchorus sericeus subsp. Densiflorus	16	9	29	6	3
Eriachne mucronata	15	4		22	6
Indigofera linnaei		43			
Enneapogon lindleyanus	13	8	4	7	
Evolvulus alsinoides	1	3	5	11	1
Aerva javanica	1	1	12		6
Unknown Malvaceae 4 (Corchorus genus)	17			3	
Abutilon leucopetalum	14			3	
Acacia chisholmi			15	1	1
Aristida nitidula				15	
Boerhavia pubenscens		4	5	2	2
Cajanus acutifolius			13		
Terminalia aridicola subsp. aridicola	10	2			
Dodonaea stenophylla				11	
Tephrosia virens	11				
Tripogonella loliiformis	9			2	
Eulalia aurea				10	
Cenchrus setiger				8	
Solanum echinatum	1	1	6		
Sporobolus australasicus	4		1	1	2
Themeda triandra			8		
Acacia melleodora			7		
Cheilanthes brownii	3			4	

Solanum ellipticum		2		2	3
Solanum senticosum	1		5		1
Vachellia nilotica	1			6	
Gossypium australe		2		4	
Hibicus coastesii	6				
Unknown Malvaceae 4	6				
Acacia acradenia	5				
Corymbia terminalis		1	1	1	2
Cyperus carinatus	5				
Unknown Santalum sp.	1			4	
Cymbopogon bombycinus		2	2		
Eremophila latrobei	3				1
Themeda arguens				4	
Unknown Malvacea 2	1			3	
Boerhavia repleta	3				
Eucalyptus leucophylla	1	1	1		
Pterocaulon serrulatum		1		2	
Synostemon rhytidospermus				3	
Unknown Fabaceae 1		3			
Unknown Malvacea 1	3				
Unknown Poaceae 1				3	
Vigna lanceolata				3	
Acacia cambagei	1			1	
Aristida contorta		2			
Corymbia aspera	2				
Hibicus sturtii				1	1
Pterocaulon sphacelatum	1	1			
Rhynchosia minima				2	
Streptoglossa odora					2
Acacia lysiphloia		1			
Acacia monticola		1			

Alternanthera denticulata			1		
Corymbia terminali	1				
Dodonaea lanceolata			1		
Eremophila mitchelli				1	
Eucalyptus pruinosa			1		
Ficus platypoda			1		
Senna artemisioides subsp. oligophylla					1
Sporobolus actinocladus			1		
Unknown Malvaceae 3		1			
Unknown Yam sp. 1				1	
Unknown Yam sp. 2				1	

Appendix 5. Final ethics approval from

Office of the Deputy Vice-Chancellor (Research)

Research Services
Research Hub, 17 Wally's Walk
Macquarie University
NSW 2109 Australia
T: +61 (2) 9850 7987
http://www.research.mq.edu.au/
ABN 90 952 801 237
CRICOS Provider No 00002J

17/10/2022

Dear Dr Emilie Ens,

Reference No:520221216242094

Title: 12162 Indigenous Biocultural Knowledge of the Purple necked rock wallaby

Thank you for submitting the above application for ethical and scientific review. Macquarie University Human Research Ethics Committee HREC Humanities & Social Sciences Committee considered your application.

I am pleased to advise that ethical and scientific approval has been granted for this project to be conducted by Dr Emilie Ens and other personnel: Miss Ilona Papp Dr Emilie Ens Associate Professor Linda Beaumont**.**

Approval Date: 17/10/2022
This research meets the requirements set out in the *National Statement on Ethical Conduct in Human Research* (2007, updated July

2018) (the *National Statement*). **Standard Conditions of Approval:**

1. Continuing compliance with the requirements of the *National Statement,* which is available at the following website: http://www.nhmrc.gov.au/book/national-statement-ethical-conduct-human-research
2. This approval is valid for five (5) years, subject to the submission of annual reports. Please submit your reports on the anniversary of the approval for this protocol.
3. All significant safety issues, that adversely affect the safety of participants or materially impact on the continued ethical and scientific acceptability of the project, must be reported to the HREC within 72 hours.
4. Proposed changes to the protocol and associated documents must be submitted to the Committee for approval before implementation.

It is the responsibility of the Chief investigator to retain a copy of all documentation related to this project and to forward a copy of this approval letter to all personnel listed on the project.

Should you have any queries regarding your project, please contact the Ethics Secretariat on 9850 4194 or by email

ethics.secretariat@mq.edu.au

The HREC Humanities & Social Sciences Committee Terms of Reference and Standard Operating Procedures are available from the Research Office website at: https://www.mq.edu.au/research/ethics-integrity-and-policies/ethics/human-ethics

The HREC Humanities & Social Sciences Committee wishes you every success in your research. Yours sincerely,

Dr Karolyn White
Chair, HREC Humanities & Social Sciences Committee

This HREC is constituted and operates in accordance with the National Health and *Medical Research Council's (NHMRC)National Statement on Ethical Conduct in Human Research (2007, updated July 2018)* and the *CPMP/ICH Note for Guidance on Good Clinical Practice*