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REVIEW ARTICLE

First Nations' interactions with underground storage organs in southwestern Australia, a Mediterranean climate Global Biodiversity Hotspot

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Abstract

Aims and background Underground storage organs (USOs) have long featured prominently in human diets. They are reliable year-round resources, especially valuable in seasonal climates. We review a significant but scattered literature and oral recounts of USOs utilised by *Noongar* people of the Southwest Australian Floristic Region (SWAFR). USOs are important to First Nations cultures in other geophyte-rich regions with Mediterranean climate, with specialist knowledge employed, and productive parts of the landscape targeted for harvest, with likely ecological interactions and consequences.

Methods We have gathered *Noongar* knowledge of USOs in the SWAFR to better understand the ecological role of *Noongar*-USO relationships that have existed for millennia.

Results We estimate that 418 USO taxa across 25 families have *Noongar* names and/or uses. Additionally, three USO taxa in the SWAFR weed flora are consumed by *Noongar* people. We found parallels in employment of specific knowledge and targeted ecological disturbance with First Nations' practice in other geophyte-rich floristic regions. We found that only in 20% of cases could we identify the original source of recorded USO knowledge to an acknowledged *Noongar* person.

Conclusion This review identified that traditional *Noongar* access to USOs is taxonomically and geographically extensive, employing specific knowledge and technology to target and maintain resource rich locations. However, we also found a general practice of 'extractive' documentation of *Noongar* plant knowledge. We identify negative implications of such practice for *Noongar* people and SWAFR conservation outcomes and assert ways to avoid this going forward, reviving *Noongar* agency to care for traditional Country.

Keywords Underground storage organ · Mediterranean climate region · *Noongar* · Southwest Australian Floristic Region · Caring for Country

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Introduction

Underground storage organs (USOs), such as tubers, rhizomes and bulbs are all components of a plant's root system architecture, functionally important for storage of water reserves, as well as nutrients and carbohydrates

utilisable during resprouting after fire, drought or herbivory (Freschet et al. 2021; Silveira et al. 2016). High numbers of USO plants occur in Mediterranean climate regions, which are characterised by mild, wet winters and hot, dry summers (Parsons and Hopper 2003; Procheş et al. 2006; Rundel et al. 2018). This is not surprising given USOs provide reserves for resprouting post-drought or following seasonally predictable fire events in such climatic regions (Rundel et al. 2018). They are also a common component in old, climatically buffered, infertile landscape (OCBIL) vegetation communities (Veldman et al. 2015), characterised by impoverished, low P edaphic conditions (Lambers et al. 2010; Silveira et al. 2021). Impoverished soils, combined with historic tectonic stability and minimal climatic disturbance have enabled a plethora of plant taxa with specialist survival traits, including USOs, to evolve in OCBIL regions (Lambers et al. 2010; Rundel et al. 2018; Silveira et al. 2021).

Of the five Mediterranean-type climate floristic regions – the Greater Cape (South Africa), southwestern Australia, Mediterranean Basin (southern Europe and northern Africa), California (USA) and central Chile—the former two, both OCBIL-dominated, exhibit the greatest diversity of plants with USOs (Hopper 2009; Hopper et al. 2021; Rundel et al. 2018; Silveira et al. 2021). USOs are a predictable, reliable and nutritious source of carbohydrates in First Nations' diets (Anderson 2005; Botha et al. 2020; De Vynck et al. 2016; Gott 2005; Walsh 1990) and their high caloric dietary contribution has been suggested as an important factor in human evolution (Anderson 2016; Deacon 1993; Dominy et al. 2008; Singels et al. 2016; Yeakel et al. 2007). While the Greater Cape region is particularly USO-rich, containing an estimated 2098 geophyte species (Procheş et al. 2006), our study focused on those of southwestern Australia (Fig. 1), where at least 686 are estimated to occur (Lullfitz et al. 2021a). USO-rich families in this region comprise Orchidaceae, Asparagaceae, Haemodoraceae, Colchicaceae, Cyperaceae and Hemerocallidaceae (Brown 2022; Hickman and Hopper 2019; Parsons and Hopper 2003; Pate and Dixon 1982). Here we have examined the nature and extent of First Nations interactions with USO taxa in southwestern Australia in light of such interactions in Mediterranean-type climate regions elsewhere.

Scale and scope of human USO interactions in Mediterranean-type climate regions

Generally, a high concentration of USO taxa in the native flora of Mediterranean-type climate regions appears to correspond with their extensive use by First Nations people (Anderson 2005; Archer 1994;

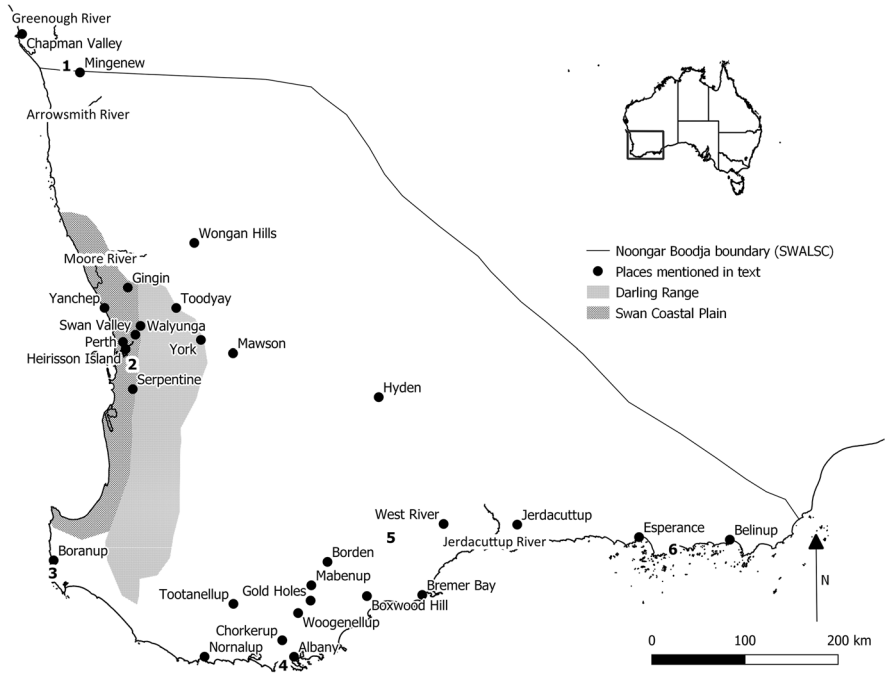

Fig. 1 Map of southwestern Australia and *Noongar Boodja* (Country) showing places mentioned in text. Also included are *Noongar* names recorded for staple USO, *Haemodorum spicatum*, demonstrating differing terms for the species according to dialect. Names recorded at each place (shown as numbers on the map) are: 1) *koolung* (Maggie Bell & Nellie Parker in Meagher 1974); 2) *bohn* (Grey 1841; Moore 1884); 3) *borana* (Glenn Whiteman & Wayne Webb, pers. comm.); 4) *miern* (LK, von Brandenstein 1988); 5) *kogarn* (Hassell 1975); 6) *quagarn* (Charlie Dabb in von Brandenstein 1988)

Botha et al. 2019, 2020; De Beer and Van Wyk 2011; De Vynck et al. 2016; Eoin 2016; Karous et al. 2021; Korkmaz et al. 2014; Nortje and van Wyk 2019; Singels et al. 2016; van Wyk and Gericke 2000), although this appears less so for the Mediterranean Basin than for California and the Greater Cape. In the Greater Cape, USOs are a year-round staple in the Khoe-San diet and are also valued for medicinal properties. They may be eaten raw or cooked and sometimes pounded prior to eating, taxon- and/or preference-dependent (Archer 1994; Botha et al. 2020; De Vynck et al. 2016; Eoin 2016; Singels et al. 2016; Van Wyk 2008). In California, USOs are second only to seeds in their importance as a plant food in traditional diets (Anderson 2005). In the Mediterranean Basin, USOs appear to be a lesser used plant component in comparison to leaves, fruits or seeds of wild plants (Geraci et al. 2018; González et al. 2011; Gras et al. 2020; Karous et al. 2021; Pieroni 2001), with the region of eastern Anatolia possibly a notable exception (Korkmaz et al. 2014). USO usage for food, medicine, dye and even as a pest poison is apparent across the Mediterranean Basin, but varies both at a regional and local scale (Biscotti et al. 2018; Geraci et al. 2018; Karous et al. 2021; Korkmaz et al. 2014; Tardío et al. 2006). Despite significant cultural destruction, Mapuche people in Chile and Argentine Patagonia (León-Lobos et al. 2022; Ochoa and Ladio 2015) still use a small selection of USOs for food.

Patterns of USO harvest

While a large number of USO taxa are utilised by First Nations peoples of Mediterranean-type climate regions, it would appear that certain taxa are favoured, and could be considered staples. In the Greater Cape, such taxa would include members of the Dioscoraceae and Iridaceae (Archer 1994; van Wyk and Gericke 2000), in California the Liliaceae and Asparagaceae (Anderson 2005), while Tardío et al. (2006) report that *Glycyrhiza glabra* (Fabaceae) is frequently targeted in the Mediterranean Basin. Species of Oxalidaceae, Santalaceae and Apiaceae are important in Patagonia (Ochoa and Ladio 2015), while in Chile, Alstroemeriaceae, Apiaceae, Asteraceae, and Dioscoreaceae are key taxa (León-Lobos et al. 2022).

In the Greater Cape, specific high-yielding 'geophyte hotspots' appear to have been targeted by First Nations Khoe-San people (Archer 1994; Botha et al. 2020; Singels et al. 2016). For example, Botha et al. (2020) found that the relatively fertile vegetation communities, riverine riparian woodland, sand fynbos and coastal dune-fynbos thickets produced highest USO harvest returns for contemporary Khoe-San descendents, suggesting that such areas may have been targeted by their ancestors. The authors found coastal dune-fynbos thickets especially productive post-fire, supporting a hypothesis that they were periodically burned by Khoe-San to increase productivity. Similarly, Anderson (2005) refers to regularly dug resource rich patches in grasslands, damp meadows, woodlands and forest, and describes both digging and burning as means of increasing resources at such patches. Long-standing use of dense patches of blue dicks (*Dipterostemon/Dichelostemma*) and Mariposa lilies *(Calochortus*) on California's Channel Islands is evident (Gill 2016; Gill et al. 2021). These findings suggest that across Mediterranean-type climate regions, First Nations people have targeted and promoted some particularly productive taxa and have also favoured fertile soils rather than those growing on less fertile soils. In particular, landscape and vegetation descriptions provided by Botha et al. (2020) and Anderson (2005) respectively suggest that such targeted locations constitute young, often disturbed, fertile landscapes (YODFELs) (Hopper 2009; Hopper et al. 2021).

Skills, knowledge, roles, technology

In the Greater Cape region, USOs, in the Dioscoreaceae and Iridaceae for example, would be dug primarily with a sharpened, and often highly-prized digging stick by Khoe-San women, who would carry a small bag to collect and transport them (Archer 1994; Eoin 2016; van Wyk and Gericke 2000). Some digging sticks may be weighted with a bored stone (Eoin 2016). In California, fire-hardened digging sticks were used by women as the primary means of traditional harvest of the many USO resources accessed by Indigenous peoples (Anderson 2005; Anderson and Lake 2016). Gill (2016) illustrates use of a digging stick in a photo and also a digging stick weight or doughnut stone used by Chumash people, described as "one of the most prevalent artifacts found on [California's] Channel Islands, and have been identified in dateable contexts to at least the last 7,500 years".

These bored stones are identical to those used in South Africa.

We found no reference in the literature to harvest digging implements or gender roles for the Mediterranean Basin, aside from an equal gender labour distribution in Tunisia (Karous et al. 2021). While Botha et al. (2020) report that a high level of skill is not required to dig for USOs among Khoe-San, they observed that those with more experience can yield higher returns. To maximise returns through targeting of known hotspots in appropriate seasons and post-fire periods and also to understand potential toxicity and uses requires Khoe-San to hold considerable specialist plant knowledge (Archer 1994; Botha et al. 2020; De Vynck et al. 2016; Nortje and van Wyk 2019; Singels et al. 2016). Additionally, Botha et al. (2019) found a high level of geographical specificity in plant knowledge among contemporary Khoe-San of the Greater Cape, which corresponds with a high spatial turnover of plant diversity. Conversely, although some narrow range endemic USOs are harvested in the Mediterranean Basin (Tardío et al. 2006), most harvested USO taxa are widely distributed albeit with localised usage and a requirement of specialist knowledge for safe, non-toxic consumption (Biscotti et al. 2018; Geraci et al. 2018; Karous et al. 2021; Korkmaz et al. 2014; Tardío et al. 2006). In this region, plant knowledge is often closely linked with use of local dialects (Biscotti et al. 2018), and it is primarily plant knowledge-holding Elders who harvest and consume USOs (Anderson 2005; Biscotti et al. 2018; Geraci et al. 2018; González et al. 2011; Karous et al. 2021; Tardío et al. 2006). Across all Mediterranean climate regions, authors raised concerns about loss of traditional plant knowledge (Biscotti et al. 2018; Botha et al. 2020; De Vynck et al. 2016; González et al. 2011; Ochoa and Ladio 2015; Tardío et al. 2006). In particular, González et al. (2011) and Ochoa and Ladio (2015) highlight potential means of revitalising intergenerational transmission to mitigate plant knowledge loss on the Iberian Peninsula and in Patagonia respectively.

It is evident that across all Mediterranean-type climate regions, First Nations peoples have utilised specific tools and knowledge to control and sustain USO procurement. Further, given extensive First Nations use of USOs across Mediterranean climate-type regions, pre- and early-colonial ecological disturbance associated with their harvest is likely to have been significant, particularly in the Greater Cape and California, in particular comprising digging of soil and use of fire to promote USO production.

Value for conservation of geophyte flora and cultural connection with traditional Country

In California, Anderson (2005) highlights specific techniques such as burning and deliberate replanting utilised by Indigenous peoples to promote USO resources, with such techniques sometimes taught through traditional story. The author also points to declines in once plentiful traditional geophyte resource patches that have resulted from colonial introduction of farming practices, as well as land clearing for urban development, fire suppression and commercial overharvesting. Tardío et al. (2006) also mention the latter as a possible threat to wild USO resources in the Mediterranean Basin. Anderson (2005) further points to colonial-induced cessation of traditional digging practice as a cause for decline of some taxa in, for example, the Liliaceae and Alliaceae, arguing that traditional harvest has a renewing effect on USO production, a suggestion made by others (Denham 2008; Gott 2005; Pascoe 2014). Anderson (2005) also describes traditional targeted patch burning techniques in California to promote USO growth, minimising shade from taller shrubs and releasing soil nutrients, and suggests a renewal of traditional human tending as an appropriate conservation strategy for some monocot geophytes, an over-represented group in the Californian flora listed as threatened (Wilken 2006).

In a comparison of archaeological records and contemporary knowledge of Khoe-San plant usage, Botha et al. (2019) found evidence that contemporary plant usage reflects that of humans in the Greater Cape region up to 80,000 years BP, suggesting that the ecological processes associated with USO harvest have been present throughout this time. While anatomically modern human history of California and the Mediterranean Basin is shorter than the Greater Cape, Anderson (2005) suggests for California that humans may have continued such ecological processes that were previously carried out by now extinct megafauna such as ground sloths and the peccary, a scenario also plausible in the Mediterranean Basin. Moreover, other hominid species such as Neanderthals used digging sticks hardened with fire more than

170,000 y.o. in Tuscany, Italy (Revedin et al. 2020) (see Fig. 2).

As for all traditional First Nations resource use and sustenance, USO usage is an intrinsic component of Indigenous culture and cultural identity (Janke 2021), with relevant knowledge embedded in stories, songlines and artworks (Anderson 2005; Neale 2017) linked strongly with specific family and cultural groups and to which sharing protocols pertain (Janke 2021). While the effects of colonisation and modern-living continue to threaten intergenerational knowledge transfer of USOs (e.g. Anderson 2005; Biscotti et al. 2018; De Vynck et al. 2016), exploitation and disconnection of cultural knowledge more broadly from its rightful custodians remains a major source of harm to First Nations peoples (Janke 2021; Zurba et al. 2019).

Noongar USO interactions in the SWAFR

Previously we have conservatively estimated that at least 90 taxa are utilised by *Noongar* First Nations people (Lullfitz et al. 2021a). In this review, we have more comprehensively examined historic and

Fig. 2 First Nations use of digging sticks across three USO-rich Mediterranean climate regions, including a) *Miernanger* Elder, LK instructs AL on digging *Platysace deflexa* tubers with a *wanna*, Jerdacuttup, southwestern Australia (photo: SDH); b) exerpt of plate by Major Richard Shepherd from an 1846 painting by Deputy Assistant Commissary-General Neill in Brough Smyth 1878 p221 vol II, depicting *Menang* group, with women each holding *wanna*, Albany, southwestern Australia; c) 1884 photo of Khoe-San woman,lxaken-an (Mikki Streep) with her digging stick, Salt River, Greater Cape (from Skotnes 2007); d) 170,000 y.o. digging stick of *Buxus sempervirens*, constructed by Neanderthals in Tuscany, Italy (from Revedin et al. 2020)

contemporary literature as well as orally transmitted knowledge of Noongar co-authors (in particular, LK) and other Noongar colleagues, to more accurately record traditional Noongar interactions with southwest Australian USOs. The object of this task was to determine the significance of such interactions for both biodiversity conservation and for contemporary Noongar people. In particular, which taxa and locations were most heavily targeted pre-colonially, and can we use this knowledge to identify areas of intensive Noongar cultural use and ecological disturbance?

To this end, and based on First Nations USO usage in other Mediterranean-type climate regions, we have gathered and examined Noongar USO usage information to test the following hypotheses:

1. That *Noongar* First Nations USO usage was a significant ecological disturbance in the pre-colonial SWAFR;
2. That some taxa and specific, productive resource patches, usually on fertile soils, are more heavily targeted for harvest and promoted than those growing on less fertile soils;
3. That knowledge in relation to taxonomy, toxicity, productivity (e.g. in relation to water, nutrient availability) and phenology, technology and specific roles and lores have been applied by *Noongar* to control and sustain procurement of USOs; and
4. That reinvigoration of traditional USO knowledge and application can be beneficial for both conservation of SWAFR biological resources and for *Noongar* knowledge and identity.

Methods

An extensive systematic review of peer-reviewed literature of First Nations USO usage in USO-rich Mediterranean-type climate regions outside of southwestern Australia was undertaken (Anderson 2005; Archer 1994; Biscotti et al. 2018; Botha et al. 2019, 2020; De Beer and Van Wyk 2011; De Vynck et al. 2016; Eoin 2016; Geraci et al. 2018; Karous et al. 2021; Korkmaz et al. 2014; Nortje and van Wyk 2019; Ochoa and Ladio 2015; Singels 2020; Singels et al. 2016; Tardío et al. 2006; van Wyk and Gericke 2000). For each of the Mediterranean-type climate regions, Google Scholar searches were conducted using the terms "Indigenous", "First Nations", "ethnobotany", "cultural plant", "USO", "bulb", "rhizome", "root" and "tuber". In some instances, review of a document resulted in sourcing of further relevant literature, akin to snowballing methodology. Through this review we were able to determine the scale of First Nations USO usage and application of First Nations knowledge, technology and custom across Mediterranean-type climate regions. We were also able to detect some patterns in relationship to landscape and observations of others in relation to USO conservation practice.

Contemporary and historic literature from *Noongar* Boodja (Country) of southwestern Australia, as well as knowledge shared orally by contemporary *Noongar* Elders was reviewed to compare Noongar USO usage with First Nations USO usage in other Mediterranean-type climate regions. A wide range of contemporary accounts were consulted, including peer reviewed literature, published books on Noongar plant use (e.g. Hansen and Horsfall 2019), consultants' reports (e.g. Goode 2010) and localised studies of cultural plants (e.g. Wheatbelt NRM 2015). This search was carried out using both systematic and snowballing methods, including searches on both Google and Google Scholar, and literature already known to the authors. Search terms included "Noongar", "Nyungar", "Nyoongar", "ethnobotany", "cultural plant", "root", "USO", "bulb", "rhizome" and "tuber". Historic sources examined included the Exploration Diaries from 1827 to 1857 held by the Western Australian Government Department of Lands and Survey and State Library of Western Australia, as well as other early colonial accounts of *Noongar* custom (e.g. Hassell 1975). Documents were searched using the terms "dig", "stick", "yam", "bulb" and "root", as well as USO taxa names. Personal oral recollections of *Noongar* Elder author (LK) and other contemporary *Noongar* Elders and knowledge-holders with whom we have collaborated and that were recorded in interview transcripts and/or authors' field notes have also been included. This has been carried out in accordance with UWA Human Research Ethics Approval (reference number RA/4/20/6165). With the exception of LK, the amount of shared discussion time between authors and contributing Elders on Boodja ranged from one to six days. Noongar USO usage was discussed among other elements of Noongar TEK. The authors, including LK, have spent in excess of 100 days on Boodja together with other

coauthors herein, during which USO usage has been recorded among other traditional knowledge held by LK and belonging to the Knapp family.

Records of traditional *Noongar* interactions with USO taxa identified through this process, as well as activities associated with acquiring USO resources are recorded in Tables 1 and 2 respectively, and Fig. 3). A table of records where taxa names could not be resolved are included as supplementary material. Where 10 or more records of a taxon were found it was determined a possible staple. For each record, where applicable, we have indicated its relevance to each of our hypotheses. Place names mentioned herein are mapped in Fig. 1. Where locations, landforms or vegetation communities of *Noongar* USO acquisition have been recorded in sufficient detail, they have been categorised as either OCBIL, YODFEL or indeterminate (Fig. 4). This was based on the authors' intimate knowledge of both southwest Australian landforms and vegetation communities, as well as understanding of OCBIL theory (Hopper et al. 2021).

Results

We located 671 records of USO usage by Noongar people in southwestern Australia. Of these records, 20 related to use as medicine, three to use as dye, and the remainder to food. Included were specific references to 25 plant families, 52 genera, and 79 species (Table 1, Fig. 3), of which there were three introduced taxa. One entire genus (*Drosera*) and one species (*Platysace effusa*) we considered to be doubtful records (see authors' notes throughout Table 1). In addition, there were 45 mentions of *Noongar* USO usage for which the taxon name remains unresolved (see supplementary material). Taking into account records indicating *Noongar* usage of an entire genus (e.g. *Thelymitra* (Hansen and Horsfall 2019)), we estimate that at least 418 USO-bearing taxa have been utilised by *Noongar* people in southwestern Australia. Some taxa were specifically mentioned by contemporary knowledge holders or in the literature more frequently than others (Figs. 3 and 5). Table 2 details references in the literature to Noongar USO usage that are not plant taxon-specific.

Our review revealed that there were 127 records that provide insight into the scale and scope of Noongar USO interactions (Hypothesis 1) (Tables 1, 2, and supplementary materials). Such references provide insight to a large scale, abundance and breadth of acquisition of some taxa (e.g. Orchidaceae family, *Haemodorum* and *Platysace* genus) and in the case of *Geranium solanderi*, that this taxon is used sparingly, and therefore its likely small scale acquisition. Numerous descriptions of disturbed ground due to *Noongar* USO acquisition, and also of digging implements and techniques indicate soil disturbance at scale. Ninety two records refer to landscape patterns of USO harvest and interaction (Hypothesis 2). Such records relate to targeting of fertile soil or moist locations (e.g. *Platysace cirrosa*, *Dioscorea hastifolia*), promotion of productive populations through replanting (e.g. *Dioscorea hastifolia*) or firing (e.g. Orchidaceae), particularly at moist, fertile locations, occurrence of USO resource patches near campsites and travel routes. In addition, where locations, landforms or vegetation communities of *Noongar* USO acquisition have been described, we estimate that 70% are YODFELs and 30% are either OCBILs or indeterminable (Fig. 4). We found 1034 references to specific skills, knowledge, roles or technology relating to acquisition of USO resources in the literature and oral record, with some references imparting more than one piece of knowledge (eg a taxon's name and use) (Hypothesis 3). Such records relate to knowledge of a taxon's name, its use, and specifics relating to phenology, season of use, toxicity and specific methods for acquisition or promotion. There were also numerous records of this nature that were not taxon-specific. Of the 1034 references, there were only 213 where we could confidently identify the *Noongar* person who was the source of information provided (see Fig. 3 for those relating to specific taxa). Finally, we found twenty records that relate specifically to conservation of USO taxa (Hypothesis 4), including deliberate protection or replenishment of populations (e.g. *Dioscorea hastifolia*) and renewing effects of harvest (e.g. *Platysace deflexa*).

Based on frequency of mentions, we have identified 15 species, as well as the Orchidaceae family and *Haemodorum* (Haemodoraceae) genus as possible staples (Figs. 3 and 5). *Dioscorea hastifolia, Thysanotus patersonii, Platysace deflexa, Haemodorum discolor, H. spicatum* and *Typha domingensis* were particularly heavily mentioned. Of specific landscapes targeted for *Noongar* USO harvest, most

Table 1 Noongar Underground Storage Organ (USO) taxa recorded in historic and contemporary literature and oral history, arranged in alphabetical order of plant family. Authors' comments included in square brackets. Superscripts 1–4 refer to the four hypotheses detailed in the Introduction. *Where Noongar knowledge/name was shared orally with authors, only names of source individuals are shown, all except Lynette Knapp (LK), a co-author, are given in full

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Apiaceae Lindl.					
Daucus glochidiatus (Labill.) Fisch., C.A.Mey. & Ave-Lall	*Kwordiny* (Hansen and Horsfall 2019; Wheatbelt NRM 2009) [Possible confusion of Noongar name due to English name. Most likely refers to *H. discolor*, also referred to as 'wild carrot'].[3] *Mongming* (A.A. Hassell 1884 in Goode 2010)[3]	-	Referred to as 'wild carrot' (Wheatbelt NRM 2009)[3]	-	-
Platysace (no species given)	-	-	Tubers are edible (Meagher 1974, Wheatbelt NRM 2009)[3]	-	-
Platysace cirrosa Bunge	*Kanna* (Preiss in Abbott 1983)[3] *Karna* (Hansen and Horsfall 2019)[3] *Conna* (Drummond 1840a, 1843d, Drummond 1839 in Pate and Dixon 1982)[3] *Canna* (Drummond 1853)[3] [Drummond does not give species name but description enables *P. cirrosa* to be assigned with confidence] *Kahno* (Bindon 1996)[3] *Youck* (Bindon and Walley 1992) [Possibly applied as a generalised term for root vegetable, typically applied to *Platysace deflexa*].[3] *Yoork* (Bindon and Walley 1992) [Comment above applies].[3]	Tuber eaten as food and hydration (Noel Nannup)[3]	Tuber eaten raw as food and hydration (Drummond 1840a, 1843d; Moore 1884)[3]; tubers eaten raw or roasted (Hansen and Horsfall 2019)[3]; tubers eaten (Bindon 1996; Bindon and Walley 1992)[3]; tubers eaten raw (Drummond 1839 in Pate and Dixon 1982)[3]	*Makuru*, *Djilba* (winter months) and *Kambarang* (October to November) (Bindon and Walley 1992)[3] Harvested all year (Drummond 1839 in Pate and Dixon 1982)[1,3]	Moore (1884) (Perth June 1836) describes it growing in "fine, good country" near York, that it is highly palatable and approximately "as large as your fist".[1,2] Harvested from *Eucalyptus wandoo* woodlands (Bindon and Walley 1992).[2,3]

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Platysace deflexa (Turcz.) C.Norman	*Yoowak* (Knapp et al. 2021g)[3] *Youlk* (Treasy Woods) [3] *Youaq* (von Brandenstein 1977)[3] [Possibly refers to *P. trachymedioides*, misnamed by von Brandenstein as *P.effusa*] *Joowaq* (von Brandenstein 1977)[3] [See comment above] *Youcka* (Hansen and Horsfall 2019)[3] *Youck* (Hassell 1975; Hassell and Davidson 1935; Hassell 1936 and Hassell 1975 in Pate and Dixon 1982)[3] *Youk* (Hassell 1975; Hassell and Davidson 1935)[3] *Youlk* (Hansen and Horsfall 2019)[3] *Yug* (Hansen and Horsfall 2019)[3]	Tuber eaten and carried as food and hydration (Knapp & Yorkshire in Knapp et al. 2021g, LK, Carol Pettersen, Aden Eades, Eliza Woods, Eugene Eades, Treasy Woods)[1,3]	Tubers eaten and carried as food and hydration (Hassell 1975; Hassell and Davidson 1935)[1,3]; tubers eaten raw or roasted (Hansen and Horsfall 2019; Hassell 1936; Hassell 1975 in Pate and Dixon 1982)[3]	Tubers swell to their biggest in summer and are smallest in winter (Knapp & Yorkshire in Knapp et al. 2021g).[3] Harvested all year (Hassell 1936; Hassell 1975 in Pate and Dixon 1982).[1,3]	Knapp & Yorkshire in Knapp et al. (2021g) describe harvest method, that multiple tubers are harvested at once, and are carried when travelling and therefore found along traditional paths.[1,2,3] LK explains that digging to depth is required to harvest tubers, and that sandy soil with underlying gravel is most productive (Lynette Knapp in Lullfitz et al. 2021a)[1,2,3] and edges of granite outcrops also targeted (LK 25/1/22).[1,2,3] LK also observed that *P. deflexa* appears to grow prolifically in disturbed places such as roadside gravel pits.[3,4] Phylogeographies of *Platysace deflexa* and *P. trachymenioides* are indicative of human assisted gene flow between populations (Lullfitz et al. 2020).[1,2] Lullfitz et al. (2021a) found that harvest of tubers had a homogenising effect on tuber size and age, released soil nutrients, and successfully established a new population.[2,4] Lullfitz et al. (2021a) also found site-based differential responses to harvest, indicating that some populations offering easy digging were more conducive to tuber production than others.[2,4] Hassell (1975) described the root system and harvest method, also that tubers were savoured by south coastal Noongar people she lived among, who would camp close to patches and intensively harvest them. She described women and children harvesting on "sandy plain" near the Jerdacuttup River. [1,2,3] Pate and Dixon (1982) suggest that Aboriginal digging for tuber harvest a likely means of bud stimulation in vegetative reproduction through damage to roots, giving *P. deflexa* and *P. maxwellii* as examples, but making a general reference.[2,4]
Platysace effusa (Turcz.) C.Norman [Doubtful record]	*Tjubuka* (von Brandenstein 1977) *Tjuubak* (von Brandenstein 1977, 1988) *Joo(w)ak* (von Brandenstein 1977)	No known use of this plant (Knapp & Pettersen in Lullfitz et al. 2020)[3]	Tuber eaten as food (von Brandenstein 1977) – [Likely misidentified by von Brandenstein 1977. Possibly refering to *P. trachymenioides,* although also described as an orchid, which is also incorrect]	-	-

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Platysace maxwellii (F.Muell.) C.Norman	*Karno* (Abbott 1983; Archer 2015; Bindon 1996, Maggie Bell & Nellie Parker in Meagher 1974; Meagher 1974 in Pate and Dixon 1982)[3] *Kukine* (Archer 2015; Drummond 1843d)[3] *Koon* (Hansen and Horsfall 2019)[3] *Kona* (Hansen and Horsfall 2019)[3] *Conna* (Bindon 1996)[3] *Yook* (Hassell 1936 in Abbott 1983)[3] [Misapplied in interpretation of historical record, which doesn't coincide with this species' range] *Youck* (Hassell 1936 in Abbott 1983)[3] [Comment above applies]	Tuber eaten raw for food or hydration, or roasted for food (Maggie Bell & Nellie Parker in Meagher 1974)[3]	Tuber eaten raw for food or hydration, or roasted for food (Archer 2015, Bindon 1996; Meagher 1974 in Pate and Dixon 1982)[3]	Harvested all year (Maggie Bell & Nellie Parker in Meagher 1974; Meagher 1974 in Pate and Dixon 1982)[1,3]	Drummond (1843d) describes it as "highly esteemed" and "growing in abundance" at Wongan Hills.[1,2] Meagher (1974), on observation of Maggie Bell and Nellie Parker harvesting 3–4 km SE of Mingenew, August 1967, describes that large numbers (84 from one plant) of round tubers were dug with a digging stick from about 50 cm below ground. She described a preference for young tubers (Bindon 1996; Meagher 1974).[1,3] [See Pate and Dixon (1982) comment under *P. deflexa*]
Platysace trachymenioides F.Muell	*Joo(w)ak* (von Brandenstein 1977)[3] [Possibly also referring to *P. deflexa*, as misnamed by von Brandestein as *P. effusa*] 'Desperation *yoowak*' (LK)[3]	Tuber eaten but not as palatable as *P. deflexa* (LK) [3]	Tuber eaten as food (von Brandenstein 1977)[3] [Misidentified as *P. effusa*, most likely referring to *P. trachymenioides* as latter grows extensively in geographical area]	-	(See entry under *P. deflexa* re phylogeography)
Araliaceae Juss					
Trachymene coerulea	-	-	Tuber mashed as medicine (Hansen and Horsfall 2016)[3]	-	-
Asparagaceae Juss					
Dichopogon spp.	-	-	Tubers eaten raw, possibly roasted (Cribb and Cribb 1975 in Pate and Dixon 1982) [3]	Harvested anytime (Cribb and Cribb 1975 in Pate and Dixon 1982)[1,3]	-
Dichopogon capillipes	*Adjiko* (Nannup 2018 in Hansen and Horsfall 2019)[3]	-	Tubers eaten raw, steamed in earth oven or roasted (City of Joondalup 2019)[3]	-	-
Dichopogon fimbriatus	*Chorker* (LK)[3] Yam (LK)[3]	Tubers eaten raw as food and for water, can also be roasted (LK)[3]; tubers eaten (Aden Eades)[3]	Tubers eaten raw (Low 1991 in Hansen and Horsfall 2019)[3]	Tubers would be dug in summer when they become swollen (LK, Mabenup) [3] Harvest tubers once flowering finished, late spring to early summer (LK)[3]	LK recalls digging up and eating tubers as a child with siblings when camping under woodland at Mabenup and a nearby lakeside camp where it grew in sandy soil "back a bit from the water". She indicated tuber size of 10 cm long by 2–3 cm diameter, recalled being scolded for picking its flowers as a child, and described how leaf shape helped plant to gain water. She also referred to *Chorkerup* as named after this USO, having been informed of this by her uncle, Harold Mcevoy.[1,2,3,4] LK describes expected flowering time and that tubers swell during hot, summer months. She also describes importance of not harvesting while in flower to enable seed production.[3,4]
Dichopogon preissii	-	-	Tubers eaten raw (Cribb and Cribb 1987 in Hansen and Horsfall 2019)[3]	-	-

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Lomandra (no species given)	-	-	Creamy, white leaf base eaten after roasting and pounding (WA Museum in Goode 2010)[3]	-	-
Sowerbaea laxiflora	-	-	Rhizome eaten raw, steamed or roasted (City of Joondalup 2019)[3]	-	-
Thysanotus (no species given)	-	Only twining species are eaten (LK)[3]	Tubers are eaten (Daw et al. 2020, SERCUL n.d.; Wheatbelt NRM 2009)[3]; all tuberous taxa eaten (Meagher 1974; Oates 1977 in Pate and Dixon 1982)[3]; Tubers of a twining species eaten (Drummond 1842c)[3]	Harvested during summer and autumn (Meagher 1974; Oates 1977 in Pate and Dixon 1982)[3]	Tubers of a twining species on the Moore River eaten (Drummond 1842c).[2,3]
Thysanotus manglesianus	*Adjiko* (Hansen and Horsfall 2019)[3] *Tjunguri* (Hansen and Horsfall 2019; Perth NRM 2015)[3]	-	Tubers eaten raw, steamed in earth oven or baked (City of Joondalup 2019; Perth NRM 2015)[3]; tubers pounded and baked as cakes (Perth NRM 2015)[3]; Tubers eaten (Coppin 2008)[3]	-	-
Thysanotus patersonii	*Djoonga djoonga* (Knapp & Yorkshire in Knapp et al. 2021c)[3] *Djungala* (LK, Carol Pettersen)[3] *Tjunguri* (City of Joondalup 2019; Daw et al. 2020; Hansen and Horsfall 2019; SERCUL n.d.)[3] *Tjungoori* (Bindon 1996, City of Joondalup 2019, Maggie Bell & Nellie Parker in Meagher 1974, Pate and Dixon 1982)[3] *Tjanguri* (Goode 2010)[3]	Tuber eaten for food and hydration (LK, Gail Yorkshire, Terry Yorkshire, Carol Pettersen, Noel Nannup, Ralph Kickett)[3]; tubers eaten raw (Knapp & Yorkshire in Knapp et al. 2021c).[3]	Tubers eaten raw or roasted (City of Joondalup 2019; Daw et al. 2020; WA Museum in Goode 2010; Low 1991 in Hansen and Horsfall 2019; SERCUL n.d.; Wheatbelt NRM n.d.)[3]; tubers eaten (Coppin 2008; Meagher 1974; Oates 1977 in Pate and Dixon 1982)[3]; tubers best eaten just prior or immediately after flowering (SERCUL n.d.)[3]; tubers eaten raw (Bindon 1996).[3]	Just before or after flowering (Daw et al. 2020).[3] Swells in summer and best eaten then, although not eaten if flowering (LK)	Size and shape of tubers varies with water availability (Knapp & Yorkshire in Knapp et al. 2021c).[2,3]
Thysanotus thyrsoideus	*Adjiko* (Nannup 2018 in Hansen and Horsfall 2019)[3]	-	Tubers eaten roasted (Bindon 1996; Barrett and Tay 2016 in Hansen and Horsfall 2019)[3]	-	-
Asteraceae Bercht. &J.Presl					
Microseris walteri	*Woorine* (Hansen and Horsfall 2019)[3] [Possibly applied as a generalised term for root vegetable, typically applied to *Dioscorea hastifolia*]	-	Tubers eaten raw, roasted or steamed in earth oven (Hansen and Horsfall 2019)[3]; tubers eaten raw or roasted (Cribb and Cribb 1975; Oates 1977 in Pate and Dixon 1982).[3]	Harvested during dry season (Cribb and Cribb 1975; Oates 1977 in Pate and Dixon 1982).[3]	-
Colchicaceae DC					

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Burchardia spp.	*Cara* (Pate and Dixon 1982)[3]	-	Tuber eaten as food, raw or roasted (Drummond 1842a, b, c, d, e; Oates 1977 and Lampert; Sanders 1973 in Pate and Dixon 1982)[3]	Eaten in summer and autumn (Drummond 1842a, b, c, d, e; Oates 1977 and; Lampert and Sanders 1973 in Pate and Dixon 1982)[3]	-
Burchardia congesta	*Kara* (Daw et al. 2020; Hansen and Horsfall 2019; Perth NRM 2015, SERCUL n.d.)[3]	Aware of others eating, but not eaten by Knapp family (LK, Tootenellup).[3]	Tuber eaten as food, usually roasted (Bindon 1996; City of Joondalup 2019; Coppin 2008; Daw et al. 2020; Hansen and Horsfall 2019, Perth NRM 2015, SERCUL n.d.)[3]; tuber eaten raw (Daw et al. 2020)[3]	November to December, following flowering (Daw et al. 2020)[3]	Tubers are at 10–20 cm depth, and only eaten when > 4 mm diameter (Daw et al. 2020)[3]
Burchardia multiflora	*Cara* (Hansen and Horsfall 2019)[3] *Kara* (WA Museum in Goode 2010)[3]	-	Tuber eaten as food, usually roasted (Bindon 1996, WA Museum in Goode 2010; Hansen and Horsfall 2019).[3]	-	-
Wurmbea spp.	-	-	Corm of some species eaten (Coppin 2008)[3] [See comment for *Wurmbia dioica*]	-	-
Wurmbea dioica	-	-	Corm eaten, probably roasted (Cribb and Cribb 1987; Low 1991 in Hansen and Horsfall 2019, Cribb and Cribb 1975; Oates 1977 in Pate and Dixon 1982).[3] [No Noongar oral history known to authors, despite frequent mentions in literature]	-	-
Convolvulaceae Juss					
Convolvulus angustissimus R.Br	*Taaruuk* (Oates 1977 in Pate and Dixon 1982)[3]	-	Tuber cooked and kneaded into dough before eating (Hansen and Horsfall 2019)[3]; tuber eaten roasted and pounded (Oates 1977 in Pate and Dixon 1982)[3]	Harvested in winter (Oates in Pate and Dixon 1982)[3]	-
Ipomoea (no species given)	-	-	Tubers are eaten (Wheatbelt NRM 2009)[3]	-	-
Cyperaceae Juss					
Bolboschoenus spp.	-	-	Rhizomes eaten (Coppin 2008)[3]	-	-
Bolboschoenus caldwellii (V.J.Cook) Sojak	*Waakal Ngarnak* (Collard 2009 in City of Joondalup 2019)[3]	-	Rhizomes eaten after roasting and pounding (Cribb and Cribb 1975; Oates 1977 in Hansen and Horsfall 2019; Pate and Dixon 1982)[3]	-	-
Eleocharis sphacelata R.Br	*Goorgogo* (Hansen and Horsfall 2019)[3]	-	Rhizome eaten raw or roasted by many Indigenous Australian groups (Coppin 2008; Hansen and Horsfall 2019)[3]	-	-

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Ficinia nodosa	*Waakal Ngarnak* (Collard 2009 in City of Joondalup 2019)[3] *Yangjet* (Perth NRM 2015)[3]	-	Rhizomes eaten (Perth NRM 2015)[3]; rhizomes eaten, probably roasted (Hansen and Horsfall 2019)[3]	-	-
Lepidosperma gladiatum	*Kerbeyen* (Knapp et al. 2021d)[3] *Qaerbany* (von Brandenstein 1988)(LK)[3] *Garbyne* (Moore 1842 in von Brandenstein 1988)[3] *Kerbein* (Abbott 1983; Daw et al. 2020; Goode 2010; Hansen and Horsfall 2019; SERCUL n.d., Preiss in von Brandenstein 1988)[3] *Kerben* (Izaac Webb in Kalotas 2009)[3]	Leaf base eaten raw (Vernice Gillies & Izaac Webb in Kalotas 2009, Knapp & Yorkshire in Knapp et al. 2021d) (LK, Doc Reynolds)[3]	Leaf base eaten raw or roasted (Coppin 2008; Daw et al. 2020; Hansen and Horsfall 2019; SERCUL n.d.; von Brandenstein 1988)[3]	All year (Daw et al. 2020)[1,3]	Grows where there is fresh water (Knapp & Yorkshire in Knapp et al. 2021d).[2,3] Palatability highest when soil is moist (Daw et al. 2020).[2,3]
Machaerina articulata (R.Br.) T.Koyama	*Wuargyl (Ngarnak Kuiarch)* (Perth NRM 2015)[3] *Waagyl Ngarnak* (Hansen and Horsfall 2019)[3] *Wardaruk* (Fanny Balbuk in Bates n.d.)[3] [Bates does not give species name but description enables *M. articulata* to be assigned with confidence]	-	Rhizomes eaten after roasting (Perth NRM 2015)[3]	-	-
Schoenoplectus validus	*Waakal Ngarnak* (Collard 2009 in City of Joondalup 2019) [3]	-	Rhizomes recorded as eaten by Indigenous Australians outside of Noongar Country (Coppin 2008; Hansen and Horsfall 2019)[3]	-	-
Dennstaedtiaceae Lotsy					
Pteridium esculentum	*Manya* (Hansen and Horsfall 2019)[3] *Munda* (Hansen and Horsfall 2019)[3] *Moondan-gurnang* (Lyon 1833 in Abbott 1983)[3] *Karbara* (Bindon and Chadwick 1992 in Hansen and Horsfall 2019)[3] *Moondark* (Bindon and Chadwick 1992 in Hansen and Horsfall 2019)[3]	Rhizome not eaten, but can eat emerging fronds when brown (LK)[3]	Rhizome eaten as food after roasting and removing fibres (Coppin 2008; Daw et al. 2020; Hansen and Horsfall 2016, 2019; Kalotas 2009)[3]; rhizome eaten (Grey 1841)[3]	-	-
Dioscoreaceae R.Br					
Dioscorea (no species given)	-	-	Tuber is eaten (Grey 1841; Meagher 1974, Wheatbelt NRM 2009)[3]	-	-

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Dioscorea hastifolia	*Wuagarn* (von Brandenstein 1988)[3] *Warran* (Grey 1841; Meagher 1974; Moore 1884; Moore 1884; Hammond 1933 in Pate and Dixon 1982; Stokes 1841, Moore 1842 in von Brandenstein 1988)[3] *Warrein* (Preiss in Abbott 1983)[3] *Warrain* (Bindon 1996, 1997; Bindon and Walley 1992, Tommy Bimbar 1916 in von Brandenstein 1988)[3] *Adjikoh* (Bindon 1997)[3] *Adtjikoh* (Hammond 1933)[3] *Warryn* (Hammond 1933)[3] *Warrany* (Wheatbelt NRM 2009)[3] *Woorine* (Hansen and Horsfall 2019)[3] *Wyrang* (Drummond 1842b)[3] *Worrain* (Maggie Bell & Nellie Parker in Meagher 1974)[3] *Warrine* (Bindon and Walley 1992; Coppin 2008; Daw et al. 2020)[3] *Adjuka* (Roe 1847 in Hercock 2014)[3] *Wararn* (Little 1994)[3]	Tuber roasted and pounded prior to eating (Maggie Bell & Nellie Parker in Meagher 1974)[3]	Tuber eaten as food (Bindon 1997; Coppin 2008; Daw et al. 2020; Drummond 1840b, 1842b; Grey 1841; Hallam 2014; Hammond 1933; Hansen and Horsfall 2019, Roe 1847 in Hercock 2014; Moore 1884; Oldfield 1865; Stokes 1841; von Brandenstein 1988; Wheatbelt NRM 2009)[3]; tuber roasted and pounded prior to eating (Bindon 1996, Hammond 1933; Moore 1884 in Pate and Dixon 1982).[3]	October to November following winter rains (Daw et al. 2020) [3] *Kambarang* (October to November) (Bindon and Walley 1992)[3] Harvested summer and autumn (Hammond 1933; Moore 1884 in Pate and Dixon 1982)[3]	Described as a long tuber (Hammond 1933, on observation of Maggie Bell & Nellie Parker harvesting 3–4 km SE of Mingenew, August 1967, Meagher 1974)[3], growing at about 1.5–2 m, dug by women with a digging stick (Bindon and Walley 1992; Daw et al. 2020; Little 1994; Meagher 1974, on observation of Maggie Bell & Nellie Parker harvesting 3–4 km SE of Mingenew, August 1967).[1,3] Described replanting of shoots and root tips following harvest (Bindon and Walley 1992; Daw et al. 2020; Hallam 1989)[2,3,4], deliberate establishment of new populations (Hallam 1989)[1,2], and that large rock piles removed from soil during tuber harvest remain visible in Walyunga NP, with rock removal making future digging easier (Daw et al. 2020).[1,2,3] Described as a highly savoured (Drummond 1840a; Grey 1841; Hammond 1933; Roe 1846; Roe 1847 in Hercock 2014; Stokes 1841)[1] staple food (Drummond 1840a; Roe 1846 in Hercock 2014)[1,2], intensively harvested in patches (Grey 1841; Hallam 1983, 1989, 2014; Hercock 2014; Moore 1835, 1884; Stokes 1841)[1,2] from very fertile soils (Grey 1841, Wollaston 1848–56 in Hallam 2014; Moore 1835)[2,3] on tributary of Swan River west of Darling Range (Moore 1884),[2] on Greenough River, heavily settled by *Noongar* people (Stokes 1841)[2], in alluvial valleys around Gingin (Bindon 1996; Hallam 1983, 2014; Moore 1835)[2], and in the Chapman Valley (Roe 1846 in Hercock 2014).[2] Described as growing best in moist locations among loose rocks of the Darling Ranges (Hammond 1933)[2,3], favouring rocky outcrops (Bindon 1997; Grey 1841).[2] Hallam (1989) described prolific patches maintained through intensive, continual harvest and management, that were a key pre- and early-colonial enabler [along with *Typha* patches] of Whadjuk sedentary settlement patterns on and north of the Swan Coastal Plain (Hallam 1989, 2014),[1,2,3,4] citing Chauncy's map of the Swan Valley showing "warran holes" (Hallam 2014)[1,2]. Hallam (1989) links labour investment in these patches with proprietary and harvest rights, suggesting that, given women's primary responsibility for root harvest, that resource patches maintained through female line in *Whadjuk Noongar* society (Hallam 1989, 1991).[1,2,3]

Droseraceae Salisb

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Drosera sp. (no species provided) [Doubtful record]	*Boon* (Meagher 1974)	-	Tubers eaten (?) (Meagher 1974)	-	On misrecording of *Drosera* as food/medicine: -Drummond (1842a) commented on misrecording of Drosera as food/medicine that "I observe that you quote, under *Drosera stolonifera,* some remarks by Dr. Lindley respecting the supposed esculent nature of the tubers of that plant; but Dr. Milligan is speaking of the roots of *Haemodorum paniculatum* and *spicatum,* and other individuals of that genus; for the natives do not use any roots of the species of *Drosera* for food: though, if they should prove useful as a dye, they may be obtained in any quantities."[3] -Drummond (1842c) commented "the *Bhon* is the root of *Haemodorum Spicatum* of Brown, and it is the plant alluded to by Dr. Lindley under *Drosera,* but it is a mistake; the natives do not use the roots of any species of *Drosera* as food."[3]
Drosera spp. [Doubtful record]	*Boon* (Hammond 1933 in Pate and Dixon 1982)	-	Tuber eaten raw or roasted (Hammond 1933 in Pate and Dixon 1982)	Harvested summer and autumn (Hammond 1933 in Pate and Dixon 1982) [Confusion caused by misapplication of Noongar name *Boon* to *Drosera* spp.]	-
Drosera macrantha [Doubtful record]	*Boon* (Goode 2010; Hansen and Horsfall 2019)	-	Tubers eaten raw or roasted (Hansen and Horsfall 2019); tubers eaten (Hansen and Horsfall 2019); medicinal (Hansen and Horsfall 2019) [Likely a misapplied reference to *H. spicatum* due to misapplication of Noongar name in (Meagher 1974)]	-	-
Geraniaceae Juss					
Geranium spp.	-	-	Taproots cooked and eaten (Coppin 2008)[3]; taproot eaten (Grey 1841)[3]	-	-
Geranium solanderi Carolin	*Wardi wardi* (LK, Treasy Woods, Averil Dean, Carol Pettersen, Eugene Eades)[3] *Wardie* (Hassell 1975; Hassell and Davidson 1935)[3] *Terrat* (Pate and Dixon 1982)[3] *Kwertiny* (Whitehurst 1997)[3] [Possible confusion of Noongar name due to English name. Most likely refers to *H. discolor*, also referred to as 'wild carrot'] *Kwordiny* (Hansen and Horsfall 2019)[3] [Comment above applies] *Quirting* (Hassell 1975 in Hansen and Horsfall 2019)[3] [Comment above applies] *Very* (Drummond 1843c)[3] *Vere* (Drummond 1843c)[3]	Tuber eaten as medicine (LK, Carol Pettersen, Treasy Woods, Averil Dean; Eugene Eades).[3]	Tuber eaten (Drummond 1843c; Hansen and Horsfall 2019)[3]; tuber eaten as medicine (Hansen and Horsfall 2016; Hassell 1975; Hassell and Davidson 1935)[3]; tuber eaten roasted (Oates 1977; Lampert and Sanders 1973 in Pate and Dixon 1982)[3] [Drummond 1843a, b, c, d does not give species name but description enables *G. solanderi* to be assigned with confidence]	Harvested anytime (Oates 1977 & Lampert and Sanders 1973 in Pate and Dixon 1982)[1,3]	Drummond (1843c) observed that it was eaten, but rarely, by Noongar around Toodyay where it grows on "all the grassy hills".[1,3] Hassell (1975) describes as used "only very sparingly for medicinal purposes".[1,3] Not used often, only if genuinely needed for medicine (LK).[1,3,4]

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Pelargonium drummondii Turcz	-	-	Taproot eaten roasted (Low 1991 in Hansen and Horsfall 2019)[3]	-	-
Haemodoraceae R.Br					
Anigozanthos genus (all species)	*Cudditch* (LK)[3] *Quuditch* (LK)[3] *Yonger mar* (LK) [LK describes as a modern *Noongar* translation from English name][3]	Stem base of all species can be eaten (LK) [3]	Rhizome eaten raw or roasted (City of Joondalup 2019; Hansen and Horsfall 2019)[3]	-	-
Anigozanthos flavidus	*Cattitch* (Drummond 1843b)[3] *Cathah* (Drummond 1843a) [3] *Koroylbardang* (Moore 1884) [based on Moore's description of "The tall green-flowered Anigozanthus."] [3]	Stem base eaten as food (LK)[3]	Rhizome eaten as food (Drummond 1843a, b)[3]	-	-
Anigozanthos rufus	*Yaungur-maatt* (Charlie Dabb in von Brandenstein 1988)[3]	Stem base eaten as food (LK)[3]	-	-	-
Anigozanthos manglesii	*Yaungul-maatt* (von Brandenstein 1988)[3] *Krulbrang* (Preiss in Abbott 1983, Bennett 1991 in City of Joondalup 2019)[3] *Kurulbrang* (Bennett 1991 in City of Joondalup 2019; Perth NRM 2015)[3] *Nollamara* (Collard 2009 in City of Joondalup 2019)[3] *Yonga Marra* (Bennett 1991 in City of Joondalup 2019)[3] *Knulbora* (Hansen and Horsfall 2019)[3] *Yonga maar* (Wheatbelt NRM 2009)[3] *Koroylbardang* (Moore 1884)[3] *Kuroolberny* (Collard 2009 in City of Joondalup 2019)[3]	Stem base eaten as food (LK)[3]	Rhizome is eaten (Buller-Murphy, nd in Goode 2010; Perth NRM 2015)[3]	-	-
Anigozanthos viridis	*Koroylbardany* (Perth NRM 2015)[3]	-	Rhizome eaten (Perth NRM 2015)[3]	-	-
Anigozanthos humilis	-	Stem base eaten as food (LK)[3]	-	-	-
Anigozanthos gabrielae	-	Stem base eaten as food (LK)[3]	-	-	-

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Haemodorum (no species given)	Mene (Grey 1841)[3] *Ngool-ya* (Grey 1841)[3] *Mudja* (Grey 1841)[3] *Quardine* (Drummond 1842c)[3] *Gnoally* (Drummond 1842c; Hopper and Lambers 2014)[3] *Jagget* (Drummond 1842c)[3] *Brilgarnung* (Hopper and Lambers 2014)[3] *Djanbar* (Hopper and Lambers 2014; Moore 1884)[3] *Dtowta* (Grey 1841; Hopper and Lambers 2014) [3] *Arnu warra* (Hopper and Lambers 2014)[3] *Nguto* (Hopper and Lambers 2014; Moore 1884)[3] *Brigo* (Moore 1884)[3] *Mini* (Moore 1884)[3] *Djakat* (Moore 1884)[3]	-	Bulb is eaten (Coppin 2008; Meagher 1974; Moore 1884; Backhouse 1843; Hassell 1936 in Pate and Dixon 1982; Wheatbelt NRM 2009)[3]; bulb of seven or eight species eaten, mild when cooked, acrid when raw (Drummond 1840b)[3]; bulb of several species eaten (Bindon 1996)[3]	Harvested all year (Daw et al. 2020; Moore 1884, Backhouse 1843; Hassell 1936 in Pate and Dixon 1982)[1,3]	Whole genus described as a very important food source, with 7–8 species providing a readily accessible, nutritious meal at any time (Drummond 1840a, 1842c).[1] Grey (1841) describes *Nan-ga* as meaning "the beard, the roots and bottom parts of certain bulbs which the natives eat" [referring to *H. spicatum* and *H. discolor*].[3]
Haemodorum discolor	*Kwerdiny* (LK, Knapp & Yorkshire in Knapp et al. 2021e; Whitehurst 1997)[3] *Quardiny* (von Brandenstein 1988)[3] *Quirting* (Hassell 1975; Hassell and Davidson 1935)[3] [Hassell does not give species name but description enables *H. discolor* to be assigned with confidence] *Quardiny* (SWALSC 2010)[3] *Koordiny* (Whitehurst 1997)[3] *Kwardiny* (Whitehurst 1997)[3] *Kwarrein* (Little 1994)[3] *Gwardine* (Grey 1841; Hopper and Lambers 2014)[3] [may also apply to *H. laxum*, sister species to *H. discolor*]	Bulb eaten as food (Kevin Reynolds, Doc Reynolds, Treasy Woods, Averil Dean, Gail Yorkshire, Henry Dabb, Carol Pettersen, Aden Eades, Eliza Woods)[3] and medicine (Treasy Woods)[3] bulb eaten roasted on ashes, preferred over *H. spicatum* (LK)[3]; Spicy bulb eaten (Knapp & Yorkshire in Knapp et al. 2021e)[3]	Chilli-flavoured bulb pounded into cakes and baked (Hassell 1975)[3]; bulb eaten as a digestive (Hassell 1975)[3]; very hot when eaten raw, cooked on coals or in hot ashes (Whitehurst 1997)[3]; bulb used (Grey 1841)[3]	Best to eat late spring to early summer (LK)[3]	LK describes that it grows in sand and gravel soils often with prostrate *Banksia* species, inland from coast. Her family ate it near Bremer Bay, Borden and Mabenup, where she recalls seeing many being roasted in the ashes at once. She still eats it regularly now.[1,2,3] Hassell (1975) describe harvesting with women from 15–20 cm below ground.[3] Hammond (1933) described as "growing in sandy country".[2,3]
Haemodorum laxum	*Quardine* (Drummond 1842c)[3] [Drummond refers to the roots of *Haemodorum planifolium* (an eastern Australian species, but likely referring to *H. laxum*, a sister species to *H. discolor*]	-	-	-	-
Haemodorum paniculatum	*Madge* (Drummond 1842c)[3] *Madja* (Moore 1842 in Abbott 1983; Moore 1884 in Hansen and Horsfall 2019; Hopper and Lambers 2014; Moore 1884)[3] *Mudja* (Grey 1840, p89; Grey 1840 in Abbott 1983)[3] *Mutta* (Maggie Bell & Nellie Parker in Meagher 1974)[3]	Bulb usually roasted, very spicy raw (Maggie Bell & Nellie Parker in Meagher 1974).[3]	Bulb eaten raw or roasted as food (Daw et al. 2020; Drummond 1842c; Hansen and Horsfall 2019)[3]; flavouring for blander foods (Hansen and Horsfall 2019) [3]; roasted bulb and leaf base used to treat dysentery (Lassak & McCarthy 2001 in Hansen and Horsfall 2019)[3]; bulb made into tea and paste for use as medicine (Hansen and Horsfall 2019).[3]	-	-

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Haemodorum simplex	*Djakat* (Hopper and Lambers 2014)[3] [name assigned with caution based on description by Moore 1884]	-	Bulb eaten (Hopper and Lambers 2014; Moore 1884)[3]	September to October (Hopper and Lambers 2014; Moore 1884)[3]	-
Haemodorum simulans	*Mutta* (Hansen and Horsfall 2019, Hopper and Lambers 2014, Maggie Bell & Nellie Parker in Meagher 1974)[3]	Bulb usually roasted, very spicy raw (Maggie Bell & Nellie Parker in Meagher 1974).[3]	Bulb eaten raw or roasted as food (Daw et al. 2020; Hansen and Horsfall 2019)[3]; flavouring for blander foods (Daw et al. 2020; Hansen and Horsfall 2019)[3]; roasted bulb and leaf base used to treat dysentery (Lassak and McCarthy 2001 in Hansen and Horsfall 2019)[3]; bulb made into tea and paste for use as medicine (Hansen and Horsfall 2019).[3]	-	-

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Haemodorum spicatum	*Mearn* (Nind 1831; von Brandenstein 1988)[3] *Miern* (LK, von Brandenstein 1988)[3] *Mirni* (von Brandenstein 1988)[3] *Miernity* (von Brandenstein 1988)[3] *Mirnidyi* (von Brandenstein 1988)[3] *Mein* (Hassell and Davidson 1935; Meagher 1974)[3] [Hassell and Davidson do not give species name but description enables *H. spicatum* to be assigned with confidence] *Meen* (Bindon 1996; Meagher 1974)[3] *Meernes* (Meagher 1974)[3] *Mene* (Meagher 1974)[3] *Me-ne* (Grey 1841)[3] *Mini* (Moore 1884)[3] *Meerne* (Nind 1831)[3] *Mardja* (SERCUL n.d.)[3] *Bhon* (Bindon 1996; Bindon and Walley 1992; Drummond 1842c; Meagher 1974)[3] *Martje* (Bindon and Walley 1992)[3] *Mardje* (Bindon and Walley 1992)[3] *Matje* (Preiss in Abbott 1983, Bennett 1991 in Hansen and Horsfall 2019)[3] *Bohrn* (Moore 1884 in Hansen and Horsfall 2019, Moore 1884)[3] *Borhn* (Perth NRM 2015)[3] *Bohn* (Grey 1841; Moore 1884)[3] *Djanbar* (Moore 1884 in Hansen and Horsfall 2019)[3] *Koolung* (Bindon 1996, Maggie Bell & Nellie Parker in Meagher 1974) [3] *Mean* (LK, Daw et al. 2020; Meagher 1974)[3] *Gorgon* (von Brandenstein 1988)[3] [von Brandenstein does not give species name but description enables *H. spicatum* to be assigned with confidence] *Quagany* (Gordon Harris in von Brandenstein 1988)[3] [Comment above applies] *Quagarn* (Charlie Dabb in von Brandenstein 1988)[3] [Comment above applies] *Boon* (Hammond 1933)[3] *Boorn* (Little 1994)[3] *Born* (Izaac Webb in Kalotas 2009)[3] *Mirn* (Vernice Gillies in Kalotas 2009)[3] *Borana* (Glenn Whiteman; Wayne Webb)[3]	Bulb eaten as food (Little 1994, Treasy Woods)[3] and medicine (Treasy Woods)[3]; bulb can be eaten raw but better cooked (roasted on ashes) to take away tartness (LK)[3]; warning against eating too much (Treasy Woods in Hopper and Lambers 2014)[3]; bulb eaten cooked (Izaac Webb in Kalotas 2009)[3]; can be used as a dye (Izaac Webb in Kalotas 2009)[3]; flavouring for meat (Izaac Webb in Kalotas 2009)[3]	Bulb roasted, pounded into cakes and eaten as food (Daw et al. 2020; Nind 1831, SERCUL n.d.)[3]; bulb used as a colouring agent (Hansen and Horsfall 2016, SERCUL n.d.)[3]; bulb eaten raw or roasted as food (Bindon 1996; Bindon and Walley 1992; Bird and Beeck 1988; Collie 1832; Daw et al. 2020; Drummond 1842c; Hammond 1933; Hansen and Horsfall 2019; Meagher 1974; Moore 1884; Perth 2015; SERCUL n.d.; von Brandenstein 1988)[3]; flavouring for blander foods (Bindon and Walley 1992; Coppin 2008; Daw et al. 2020; Hansen and Horsfall 2019)[3]; roasted bulb and leaf base used to treat dysentery (Lassak & McCarthy 2001 in Hansen and Horsfall 2019; Perth NRM 2015)[3]; bulb made into medicinal tea and paste (Hansen and Horsfall 2016, 2019; Perth NRM 2015)[3]; used to treat dysentery (SERCUL n.d.)[3]; bulb eaten roasted (Moore 1884, Backhouse 1843; Hassell 1936 in Pate and Dixon 1982)[3]; bulb pounded and mixed with earth before eating (Grey 1841)[3]	Best during summer but eaten all year (LK)[1,3] Best to eat late spring to early summer (LK).[3] All year (Grey 1841; Moore 1884)[1,3]	Eaten extensively by Mierningar/Menang people, especially at Two People's Bay, an intensively used place of trade and could still be eaten even if a person's totem (LK).[1,2,3,4] Described as plant from which Meirningar/Menang people get their name (LK, Hopper and Lambers 2014; Vernice Gillies in Kalotas 2009)[1,3], and a staple food of Menang and other Noongar people (LK, Grey 1841; Hopper and Lambers 2014; Vernice Gillies in Kalotas 2009; Moore 1884; Nind 1831).[1,3] Its spiciness would promote salivation, leading to discoloration of the mouth and chin (LK). [3] Described as growing in sandy country (Hammond 1933; Moore 1884)[2,3], but confined to coastal areas (Nind 1831).[2,3] Method of preparation of it and other *Haemodorum* for eating by grinding with earth from termite nest (Bindon 1996; Hopper and Lambers 2014; Collie 1834, Backhouse 1843; Grey 1841; Nind 1831 in Meagher 1974).[1,3] Observation of strict *Noongar* law prohibiting harvest when in flower or seed, describing this stage as "mother of [eg] *Bohn*" [also refers to other taxa] (Grey 1841 in Hallam 2014).[3,4] Description of *Noongar* person near Esperance carrying bulbs in a bag (Green 1989 in Hopper and Lambers 2014) Moore (1884) and Grey (1841) described *mimi* and *me-me* as the layers of the root resembling skin of an onion.[3]
Macropidia fulginosa	*Nollamora* (Hansen and Horsfall 2019)[3]	-	-	-	-

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Tribonanthes genus (no species given)	*Jitta* (Bindon and Walley 1992)[3] *Djettah* (Moore 1884; Hammond 1933 in Pate and Dixon 1982)[3]	-	Tubers eaten (Bindon and Walley 1992)[3]; tubers eaten raw or roasted (Moore 1884; Hammond 1933 in Pate and Dixon 1982)[3]; tubers of a pink-flowered species that occurs around granites eaten (Bindon and Walley 1992).[3]	Harvested in summer and autumn (Moore 1884; Hammond 1933 in Pate and Dixon 1982).[3] Makuru (June to July) (Bindon and Walley 1992)[3]	-
Tribonanthes australis	*Jitta (*Bindon 1996*)*[3]		Tuber is eaten (Bindon 1996).[3]		
Tribonanthes longipetala	*Djoobuk* (Ned Mippy in Hickman and Hopper 2019)[3]	-	-	-	-
Hemerocallidaceae R.Br					
Caesia (no species given)	*Karhrh* (Meagher 1974; Moore 1884)[3]	-	Tubers eaten (Meagher 1974)[3]; tubers eaten raw or roasted (Meagher 1974; Oates 1977 in Pate and Dixon 1982)[3]	-	-
Caesia micrantha	*Karhrh* (Hansen and Horsfall 2019)[3] *Karr* (Bindon 1996)[3]	-	Tubers eaten roasted (Meagher 1974 in Goode 2010, Meagher 1974 in Hansen and Horsfall 2019)[3]; tubers eaten raw (Bindon 1996)[3]	-	-
Chamaescilla corymbosa	*Yam* (LK)[3] *Murrinye* (LK) [LK describes this as a generic word for food]	Tuber eaten as food (LK)[3]	Tubers eaten as food (Archer 2010; Hansen and Horsfall 2019)[3]	-	-
Dianella revoluta	*Mangard* (SERCUL n.d., Wheatbelt NRM 2016)[3] *Mangarel* (Perth NRM 2015)[3]	-	Rhizome eaten as food raw, roasted or steamed in earth oven (City of Joondalup 2019; Hansen and Horsfall 2016, Perth NRM 2015, SERCUL n.d., Wheatbelt NRM n.d.)[3]; rhizome eaten roasted after pounding (Bindon 1996; Hansen and Horsfall 2019)[3]; decoction of rhizome medicinal (Hansen and Horsfall 2016)[3]	-	-
Hypoxidaceae R.Br					
Pauridia spp.	-	-	Corms of some species eaten (Coppin 2008)[3]; corms eaten raw (Oates 1977 in Pate and Dixon 1982)[3]	-	-
Pauridia vaginata	-	-	Corms eaten when roasted (Hansen and Horsfall 2019)[3]	-	-
Iridaceae Juss					
**Moraea setifolia* (L.f.) Druce	*Wild onion* (LK)	Bulb eaten (LK, Gail Yorkshire) [3]	-	-	-
**Watsonia* sp.	-	Bulb eaten (Harley Coyne) [3]	-	-	-
Juncaceae Juss					

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Juncus pallidus	-	Leaf base eaten (Wayne Webb in Kalotas 2009)[3]	Leaf base eaten (Hansen and Horsfall 2019)[3]	-	-
Juncaginaceae Rich					
Cycnogeton genus (species not given)	-	-	Tubers eaten raw or roasted (Coppin 2008)[3]	-	-
Cycnogeton huegelii	-	-	Tubers eaten raw or roasted (Bindon 1996; Coppin 2008 in Hansen and Horsfall 2019)[3]	-	-
Cycnogeton lineare	-	-	Tubers eaten raw or roasted (Bindon and Walley 1992; Hansen and Horsfall 2019)[3]; tubers eaten roasted (Cribb and Cribb 1975; Oates 1977 in Pate and Dixon 1982)[3]	Harvested anytime (Cribb and Cribb 1975; Oates 1977 in Pate and Dixon 1982)[1,3]	-
Malvaceae Juss					
Malva preissiana Miq	-	-	Tuber eaten as food in SA (Rippey and Rowland 1995 in Hansen and Horsfall 2016)[3]	-	-
Marsileaceae Mirb					
Marsilea drummondii	*Ngalkoo* (Nannup 2018 in Hansen and Horsfall 2019)[3]	-	Some Indigenous groups pound rhizome and roast as cakes (Hansen and Horsfall 2019)[3]	-	-
Marsilea mutica	*Ngalkoo* (Nannup 2018 in Hansen and Horsfall 2019)[3]	-	Some Indigenous groups pound rhizome and roast as cakes (Hansen and Horsfall 2019)[3]	-	-
Montiaceae Raf					
Calandrinia spp. (*C. primuliflora* group)	-	-	Tuber eaten raw or roasted (Cribb and Cribb 1975 in Pate and Dixon 1982).[3]	Harvested winter and spring (Cribb and Cribb 1975 in Pate and Dixon 1982).[3]	-
Orchidaceae Juss					

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Orchidaceae family (no taxa specified)	Many and varied names (Nind 1831; Hammond 1933 in Pate and Dixon 1982)[3] *Djubak* (Moore 1884; von Brandenstein 1988)[3] *Karh-rh* (Moore 1884)[3]	Tubers eaten (LK, Larry Blight)[3]	Tubers eaten raw or roasted (Nind 1831; Hammond 1933 in Pate and Dixon 1982)[3]; tubers of numerous taxa eaten (Drummond 1842d; Grey 1841)[3]	October (Moore 1884, vocab p22) [3] October–November (Daw et al. 2020)[3]	LK describes expected flowering time and that tubers swell during hot, summer months.[3] She also describes importance of not harvesting while in flower to enable seed production.[3,4] Drummond (1842d) reported that "many of the *Orchidaceae* produce roots which are much sought after by them as food"[1,2,3] Reference to early colonists' descriptions of large gatherings of *Whadjuk* and *Yuid Noongar* people lasting several weeks at Yanchep wetlands to eat prolific tubers growing in areas burned in previous season. *Pyrorchis nigricans, Pterostylis recurva* and *Thelymitra* spp. were among most common (Daw et al. 2020).[1,2,3] Description of tubers in kangaroo skin bag carried by *Noongar* woman (Peron 1809 in Hallam 1983).[1] Moore (1884) stated *Djubak* found mostly in "sandy soil of [rocky ground]"[2] and reported women dig tubers using a digging stick (Bindon 1996).[3]
Caladenia genus (all species)	*Kar* (Collard 2009 in City of Joondalup 2019)[3] *Kararr* (Collard 2009 in City of Joondalup 2019)[3]	-	All *Caladenia* tubers eaten raw or roasted (Hansen and Horsfall 2019)[3]	-	-
Caladenia arenicola	*Cara* (Perth NRM 2015)[3]	-	Roots eaten baked or roasted, sometimes pounded into cakes (Perth NRM 2015)[3]	-	-
Caladenia flava	-	Tuber eaten as food (Eugene Eades, Eliza Woods)[3]	Tuber eaten raw or roasted (Hansen and Horsfall 2019)[3]	-	-
Cryptostylis ovata	*Wild potato* (LK)[3] *Yam* (LK)[3] *Murrinye* (LK)[3] [LK describes this as a generic word for food]	Tuber eaten as food (LK, Larry Blight, Wayne Webb)[3]	-	-	-
Diurus genus (all species)	*Djubuk* (LK, Lorna Knapp) [3] *Cara* (Hansen and Horsfall 2019)[3] *Djubak* (Nyungar Wardan Katijin Bidi—Derbal Nara, nd in Hansen and Horsfall 2019)[3]	Tuber eaten, a favourite (LK, Lorna Knapp)[2,3]	Tuber eaten raw or roasted (Coppin 2008; Hansen and Horsfall 2019)[3]	-	-
Eriochilus dilatatus	-	Tuber eaten (LK, Treasy Woods)[3]	-	-	-
Gastrodia lacista	*Koon* (Whitehurst 1997 in Hansen and Horsfall 2019)[3]	-	Tuber eaten raw or roasted (Cribb & Cribb 1987 in Hansen and Horsfall 2019).[3]	-	-
Lyperanthus serratus	*Carra* (Drummond 1842d)[3]	Tuber eaten as food (LK, Tootenellup) [3]	Tuber eaten as food (Bird and Beeck 1988; Daw et al. 2011; Drummond 1842d)[3]	-	-
Prasophyllum (no species given) [Tubers of all *Prasophyllum* have likely been eaten by Noongar people]	*Chokern* (when immature) (Nind 1831 in Meagher 1974)[3] *Naank* (when old) (Nind 1831 in Meagher 1974)[3] *Tuboc* (Bindon 1996; Nind 1831 in Meagher 1974)[3]	Tuber roasted prior to eating (Maggie Bell & Nellie Parker in Meagher 1974)[3]	Tuber eaten roasted (Bindon 1996)[3]	-	Described as a " wild potato", with a single tuber found 25 cm deep, dug by women with a digging stick (Bindon 1996)[1,3], and usually roasted prior to eating (Meagher 1974, on observation of Maggie Bell & Nellie Parker harvesting 8 km SE of Mingenew, August 1967).[3]

Table 1 (Continued)

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Prasophyllum fimbria	*Djubak* (Meagher 1974)[3]	-	Tuber eaten as food (Meagher 1974 in Hansen and Horsfall 2019)[3]	-	-
Prasophyllum giganteum	*Tubac* (Drummond 1842d)[3]	-	Tuber eaten (Drummond 1842d)[3]	-	-
Pterostylis mutica	-	-	Tubers eaten (Lim 2016 in Hansen and Horsfall 2019)[3]	-	-
Pterostylis recurva	*Rattle Orchid* (LK)[3] *Kara* (City of Joondalup 2011 in Hansen and Horsfall 2019)[3] *Kararr* (City of Joondalup 2011 in Hansen and Horsfall 2019)[3]	Tuber eaten, a favourite (LK) [2,3]	Tuber eaten raw or roasted (Hansen and Horsfall 2019) [3]; tuber eaten (Daw et al. 2020).[3]	-	[See Daw et al. (2020) under Orchidaceae family entry]
Pterostylis vittata	*Kararr* (Hansen and Horsfall 2019)[3]	-	Tuber eaten roasted or baked, sometimes pounded into cakes (City of Joondalup 2019)[3]	-	-
Pyrorchis nigricans	*Wild potato* (LK)[3] *Djubak* (Bindon and Walley 1992; Coppin 2008; Daw et al. 2020)[3] *Djubag* (Bird and Beeck 1988)[3]	Tuber eaten as food (LK, Treasy Woods, Averil Dean, Aden Eades, Stan Loo)[3]	Tuber eaten raw or roasted, sometimes pounded into cakes (City of Joondalup 2019; Coppin 2008)[3]; tuber eaten (Bindon and Walley 1992; Bird and Beeck 1988; Daw et al. 2020; Hansen and Horsfall 2019).[3]	Kambarang (October to November) (Bindon and Walley 1992; Daw et al. 2020)[3]	LK described digging to eat the tuber on observation of it growing at Gold Holes [a campsite and permanent waterhole in *Eucalypt* woodland] [3] [See Dawe et al. (2020) under Orchidaceae family entry]
Thelymitra genus (all species)	*Joobuk* (Hansen and Horsfall 2019)[3] *Tuboc* (Nind 1831)[3] *Chokern* [refers to lifestage prior to tuber maturity] (Nind 1831)[3] *Naank* [refers to late lifestage] *(*Nind 1831*)*[3]	-	Tubers of all species eaten raw or roasted (Hansen and Horsfall 2019)[3]; Tubers eaten when roasted (Nind 1831)[3]	-	[See Dawe et al. (2020) under Orchidaceae family entry]
Thelymitra (no species given)	*Joobuk* (Moore 1884 in Goode 2010)[3]	-	Tuber is eaten (Daw et al. 2020, Moore 1884 in Goode 2010)[3]	-	-
Thelymitra canaliculata	-	-	Tuber is eaten (Drummond 1842d)[3]	-	-
Thelymitra crinita	*Walyamur* (LK, Carol Pettersen) [3]	Tuber eaten as food (LK, Treasy Woods, Averil Dean, Carol Pettersen)[3]; a favourite (LK, Carol Pettersen)[2]	Tuber is eaten (Daw et al. 2011)[3]	-	-
Thelymitra fuscolutea	-	-	Tuber is eaten (Drummond 1842d) [3]	-	-
Thelymitra graminea	*Taaliny* (Hansen and Horsfall 2019)[3]	-	-	-	-
Thelymitra villosa	-	-	Tuber is eaten (Drummond 1842d)[3]	-	-
Polygalaceae Hoffmans. & Link					
Comersperma virgatum	*Bibi djet* (Knapp & Yorkshire in Knapp et al. 2021a)[3]	Long, white taproot is medicinal (Knapp & Yorkshire in Knapp et al. 2021a)[3]	-	-	-

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Portulacaceae Juss					
Portulaca oleracea	-	-	Taproot eaten cooked (Coppin 2008)[3]	-	-
Ranunculaceae Juss					
Clematis spp.	*Taaruuk* (Oates 1977 in Pate and Dixon 1982)[3]	-	Tuber eaten roasted and pounded (Oates 1977 in Pate and Dixon 1982)[3]	Harvested in winter (Oates 1977 in Pate and Dixon 1982)[3]	-
Clematis linearifolia	*Taaruuk* (Daw et al. 2020)[3]	-	Tuber roasted and pounded into cakes (Coppin 2008; Hansen and Horsfall 2019)[3]	-	-
Clematis pubescens	*Duruk* (Doc Reynolds)[3] *Daarook* (Knapp & Yorkshire in Knapp et al. 2021b)[3] *Chorker* (LK, referring to her father's term, OH11.6 K&B)[3] [Possibly applied as a generalised term for root vegetable, also applied to *Dichopogon fimbriatus* by Knapp family]	Rhizome eaten, taste's spicy (Doc Reynolds)[3], rhizome eaten (LK)[3]	Tuber eaten after roasting (Bindon 1996, Barrett & Tay 2016 in Hansen and Horsfall 2019)[3]	Harvest during summer when not flowering (LK).[3]	Grows prolifically around Albany and eastward from there (LK).[3] Rhizomes are a main bush tucker food which could be harvested once flower had died off (LK).[1,3,4]
Typhaceae Juss					
Typha spp.	-	-	Rhizomes of two taxa eaten (Grey 1841; Hallam 1989)[3]	Rhizomes accessible in summer and autumn (Daw et al. 2020)[3]	-

Scientific name of taxon	Noongar names applied to taxon*	Noongar use of taxon shared through oral history (or in literature where source individual could be identified)*	Noongar use of taxon recorded in literature	Harvest season	Context of use shared through oral history and in literature
Typha domingensis	*Yandyett* (Moore 1884)[3] *Yanjidi* (Moore 1884 in Hallam 1991, Moore 1884)[3] *Yandyait* (Drummond 1842e)[3] *Yaindyert* (von Brandenstein 1988)[3] *Yandijut* (Drummond in Abbott 1983, Bennett 1991 in Hansen and Horsfall 2019, Drummond in von Brandenstein 1988)[3] *Yanjet* (Bindon 1996, Bindon and Walley 1992, Jack Davis 1969 in von Brandenstein 1988)[3] *Yanget* (Jack Davis in Abbott 1983, Bennett 1991 in Hansen and Horsfall 2019, Glauert in von Brandenstein 1988)[3] *Yunjeedie* (Grey 1841 in Abbott 1983, Bennett 1991 in Hansen and Horsfall 2019, Grey 1841 in von Brandenstein 1988)[3] *Yunjid* (Grey 1841 in Abbott 1983, Grey 1841 in Hallam 1991, Bennett 1991 in Hansen and Horsfall 2019, Grey 1841 in von Brandenstein 1988)[3] *Tanjil* (Hassell 1936 in Abbott 1983, Bennett 1991 in Hansen and Horsfall 2019, Hassell 1936 in von Brandenstein 1988)[3] *Yanjidi* (Moore 1842 in Abbott 1983, Bennett 1991 in Hansen and Horsfall 2019, Moore 1842 in von Brandenstein 1988)[3] *Yangeti* (Daw et al. 2020, Bennett 1991 in Hansen and Horsfall 2019, SERCUL n.d.)[3] *Lirimbi* (Bennett 1991 in Hansen and Horsfall 2019)[3] *Jetta* (Moore 1884 in Hansen and Horsfall 2019)[3] *Jandyait* (Moore 1835)[3] *Yandjet* (Whitehurst 1997)[3]	Rhizome eaten as food (Doc Reynolds)[3]; Bullrush used as food (LK)[3]	Rhizome eaten as food (Bindon and Walley 1992, Coppin 2008, Daw et al. 2020, Drummond 1836, 1842e, Backhouse 1836 in Hallam 1991, Hansen and Horsfall 2016, Meagher 1974, Moore 1884)[3]; rhizome pounded and baked as cakes (Bindon 1996; Daw et al. 2020; Drummond 1842e; Eyre 1845; Grey 1841; Grey 1841 in Hallam 1991; Hallam 2014; Hansen and Horsfall 2019; Moore 1884; SERCUL n.d.)[3]	Toward end of Bunuru (March) (Bindon and Walley 1992)[3] April to May (Moore 1884)[3]	Observed growing near Esperance (Eyre 1845), and described as a staple food (Drummond 1836; Eyre 1845; Moore 1884)[1,2], intensively harvested (Moore 1884)[1,2], and growing on seasonally inundated alluvial soils and creeks (Drummond 1836; Eyre 1845; Moore 1884)[2], always available but best harvested after wetlands dry and are burned (Eyre 1845, Grey 1841; Moore 1884 in Hallam 2014,;Moore 1884)[1,2,3] [See also Hallam (1989, 2014) under *Dioscorea* entry]
**Typha orientalis*	-	-	All uses and names applied to *T. domingensis* apply to *T. orientalis*, an introduced species (Daw et al. 2020; Hansen and Horsfall 2019)[3]	-	-

*Where source is listed as name only with no date, refers to Noongar Elder or cultural informant who collaborated on this research. Information was provided during the research period

Table 2 References to Noongar use of Underground Storage Organs in historic and contemporary literature that do not refer to specific plant taxa. Authors' comments included in square brackets. Superscripts 1–4 refer to the four hypotheses detailed in the Introduction

Noongar names applied to USO harvest technique or implement	English translation	Context of use shared through oral history and in literature
Nan-ga (Grey 1840) [likely refers specifically to *Haemodoraceae*][3] *Jil-bee* (Hammond 1933)[3]	Roots of a plant	-
Niran (Whitehurst 1997)[3] *Neer-ran* (Grey 1840)[3]	To plant in the ground	-
Berniny (Whitehurst 1997)[3] *Bean* (Grey 1840)[3] *Bin-gur* (Grey 1840)[3] *Mat-ta-goor-no* (Grey 1840)[3] *Pi-an-gur* (Grey 1840)[3]	To dig	-
Yurang (Moore 1884)[3]	To shake, rub, clean and prepare roots for eating	-
Mandju (Moore 1884)[3]	Decayed roots	-
Yudangwinnan (Moore 1884)[3]	The act of pounding roots	-
Wanna (von Brandenstein 1977, Moore 1842 in von Brandenstein 1988)[3] *Waann* (von Brandenstein 1977)[3] *Wana* (Douglas 1976 in von Brandenstein 1988)[3] *Wan-na* (Grey 1840 in von Brandenstein 1988)[3] *Uana* (Salvado 1851 in von Brandenstein 1988)[3] *Moora* [part of digging stick] (Whitehurst 1997)[3] *Wan* (Whitehurst 1997)[3]	Digging stick (without reference to gender)	Species from which wood is acquired for digging sticks include *Eucalyptus marginata* (Perth NRM 2015),[3] *Eucalyptus redunca* (Bindon 1996)[3] and *Agonis flexuosa* (Webb 2019).[3]
Waan (von Brandenstein 1988)[3] *Wana* (von Brandenstein 1988; Whitehurst 1997)[3] *Warna* (Wheatbelt NRM 2009; Whitehurst 1997)[3] *Wanna* (Hassell and Davidson 1935, Wayne Webb in Kalotas 2009, Moore 1884)[3] *Wonna* (Hammond 1933)[3]	Digging stick (belonging to women)	Digging sticks belonging to women described as considerable in length (LK, Hammond 1933; Hassell 1975; Meagher 1974; Moore 1884; Nind 1831),[1,3] sharpened on one or both ends and hardened with fire (LK, Moore 1884; Nind 1831; Wheatbelt NRM 2009)[1,3], used for digging up of plant roots (LK, Hammond 1933; Hassell 1975, Roe 1836 in Hercock 2014, Meagher 1974, Moore 1884; Nind 1831, Wheatbelt NRM 2009), [1,3] and any other digging, including water holes, animal traps, building *mias* (shelters), graves and may also be used as a weapon (LK, Bates 1938 in Hallam 1991; Hammond 1933; Hassell 1975; Hassell and Davidson 1935; Nind 1831) and to check a burrow for snakes or *karda (*Varanid lizards) (LK).[1,3] It is a universal tool, traditionally carried by all Noongar women (LK).[1,2,3] Taxa from which wood is acquired for women's digging sticks includes *Acacia* (Wheatbelt NRM 2009)[3], *Agonis flexuosa* [saplings] (Wayne Webb in Kalotas 2009)[3] and *Acacia acuminata* (LK).[3]
Waan (Wheatbelt NRM 2009)[3]	Digging stick (belonging to men)	-

Table 2 (continued)

Noongar names applied to USO harvest technique or implement	English translation	Context of use shared through oral history and in literature
Cote (Nind 1831)[3]	Bag for carrying small items, including USO foods	Women carry a kangaroo skin bag in which they carry food, including plant roots (Nind 1831).[1,3]
-	-	LK described a general practice of marking USOs with a sturdy twig in the ground when flowering, then returning to dig it up after completion of flowering/seeding.[1,3,4]
-	-	Gathering of roots carried out by women and children, who would eat some during course of day activities and take remainder to their camp (Meagher 1974).[1,3]
-	-	*Whadjuk Noongar* woman, Fanny Bulbuk managed a carbohydrate resource patch on Heirrison Island, Perth (Bates 1938 in Hallam 1991).[2,3]
-	-	[On alluvial soil near watercourse, east of York] Roe (1836) in Hercock (2014) described numerous holes dug by *Noongar* women in search of roots.[1,2,3]
-	-	Nind (1831) described gender roles of south coastal Noongar men and women, including women collecting roots or crayfish and men procuring fish or game.[3] He further described a portion of roots being eaten, while the rest are taken to camp to share with men and children, also reporting that men also collect some roots.[1,3]
-	-	Nind (1831) described that young south coastal *Noongar* children would be responsible for digging edible roots close to their camp.[1,2,3]
-	-	SWALSC (2010) described fishing being traditionally carried out by *Noongar* men, while women gather yams and other plant foods.[3]
-	-	Hammond (1933) described "the grubbing of roots [as] a job for the women and children" and that an "abundance of roots" [would be returned to camp].[1,3]
-	-	Eyre (1845) described two Noongar women and a child digging roots in "sandy and barren" country covered with shrubs west of Esperance.[2,3] [Most likely observed digging of Platysace deflexa in kwongkan sandplain]
-	-	Moore (1884) described a *Menang Noongar* woman carrying a bag containing roots which would be eaten after roasting and pounding.[1,3]
-	-	Moore (1884) described *Noongar* man, *Beelycoomera* demonstrating planting a native root.[3,4]

Table 2 (continued)

Noongar names applied to USO harvest technique or implement	English translation	Context of use shared through oral history and in literature
-	-	Hallam (2014) commented that Moore [1884] noted correlations between regular activities related to management of resource patches [including *Dioscorea* and *Typha*] and *Whadjuk* and *Yuid Noongar* patterns of settlement and movement, and that defined paths led to digging grounds.[1,2,3]
-	-	Hallam (2014) reported that yam grounds [likely *Dioscorea*] were protected from fire.[2,3,4]
-	-	In a grassy, fertile valley near Toodyay, Roe in 1836 in Hercock (2014) reported families digging for edible roots while men were away hunting for kangaroos.[2,3]
-	-	On the Canning River, Wilson (1829) reported a *Noongar* man showing him various edible roots as well as the technique for digging them.[1,3]
-	-	Roe (1835) in Hercock (2014) described a *Wardandi Noongar* camp in valley floor near Nornalup as "to which were strewed the flat granite stones that had been used by the occupants as mortars on which to pound their roots and seeds."[1,2,3]
-	-	Grey (1841) in Hallam (1991) described "often stumbl[ing] on a large party of [women], scattered about in the forest, digging roots and collecting the different species of fungus." [1,2,3]
-	-	Grey (1841) described *Noongar* women and children on the Arrowsmith River digging for roots until they had "a sufficient quantity.. for their purpose", then walking a short distance to a water hole where they sat and cooked them.[1,2,3,4]
-	-	Grey (1841) described the contents of *Noongar* woman's bag including a "flat stone to grind roots, earth to mix with pounded roots..[and] roots collected during the day".[1,3]

frequently mentioned were alluvial soils, wetlands and riparian areas in relation to *Dioscorea hastifolia, Typha domingensis, Lepidosperma gladiatum* and *Thysanotus patersonii*. Fertile woodlands (especially of *Eucalyptus wandoo*) were mentioned in relation to *Platysace cirrosa, Dichopogon fimbriatus* and Orchidaceae. Coastal sand was cited in relation to *Haemodorum spicatum*, while gravelly sand was mentioned in relation to *H. discolor* and *P. deflexa* (Fig. 4). Some commonly used species had multiple Noongar names across their distribution, varying with dialects (e.g. *Haemodorum spicatum*, Fig. 1).

While use of the roots of *Nuytsia floribunda* as well as various *Eucalyptus* (Myrtaceae) taxa are well known by Noongar Elders and recorded in the historic and contemporary literature, as they do not include a USO as such, we have not included these in detail in our analysis. Roots of some Eucalypt species

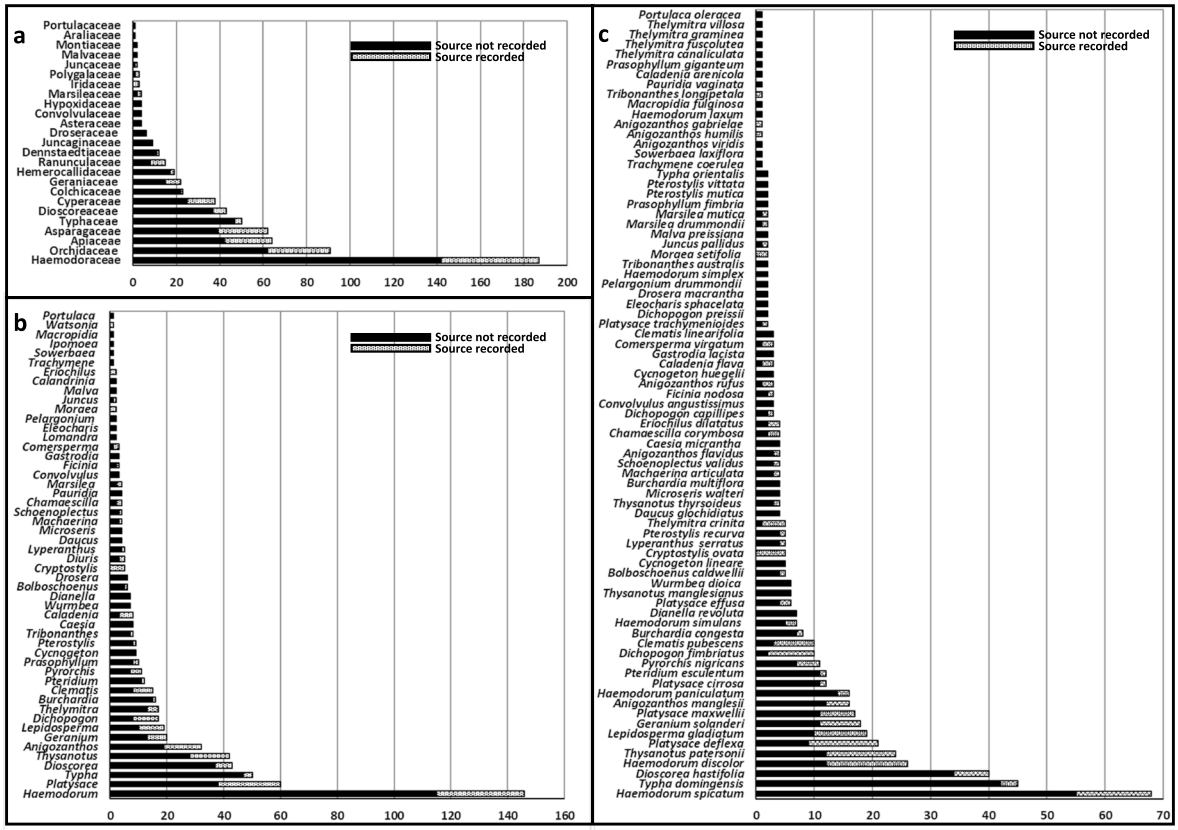

Fig. 3 Number of mentions in literature or contemporary oral record of southwest Australian USO taxa utilised by *Noongar* people. Specific families, genus and species shown as a, b and c respectively. Also shown for each taxon are the quantity for which the original *Noongar* knowledge holder can or can not be identified

can provide access to water, and also have edible bark (Bindon 1996, Maggie Bell & Nellie Parker in Meagher 1974, von Brandenstein 1988), while the haustoria of *N. floribunda* may be eaten as a sweet treat (Coppin 2008; Daw et al. 2020; Hassell 1975; Knapp et al. 2021f; Meagher 1974, Wheatbelt NRM 2009). Noongar Elder, Noel Nannup (in Hansen and Horsfall 2019) also commented that only women are allowed to dig the roots of *N. floribunda.*

Discussion

In this review, we have gathered *Noongar* knowledge of USOs in the SWAFR to ascertain the ecological role of *Noongar*-USO relationships. Based on a review of First Nations relationships with USOs in other Mediterranean-type climate regions, we proposed four hypotheses, comprising 1) that *Noongar* First Nations USO usage was a significant ecological disturbance in the pre-colonial SWAFR; 2) that some taxa and specific, productive resource patches, usually on fertile soils, are more heavily targeted for harvest and promoted than those growing on less fertile soils; 3) that knowledge in relation to taxonomy, toxicity, productivity (eg in relation to water, nutrient availability) and phenology, technology and specific roles and lores have been applied by *Noongar* to control and sustain procurement of USOs; and 4) that reinvigoration of traditional USO knowledge and application can be beneficial for both conservation of SWAFR biological resources and for *Noongar* knowledge and identity. We found support for all of these hypotheses, particularly identifying that traditional *Noongar* access to USOs is taxonomically and geographically extensive (Hypothesis 1), employing specific knowledge and technology (Hypothesis 3) to target and maintain resource rich locations

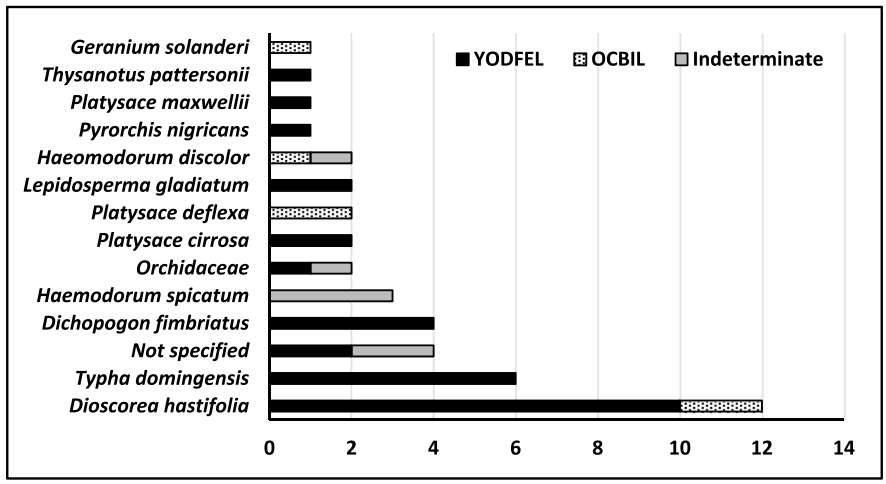

Fig. 4 Number of mentions of *Noongar* utilised USO taxa where description of landform or vegetation community enabled categorisation of habitat to OCBIL, YODFEL or indeterminate. Recorded descriptions categorised as YODFEL habitat included 'river', 'coastal', 'Eucalypt woodland', 'fertile', 'wetland', 'moist/damp soil' and 'alluvial' while OCBIL habitat included 'sand/gravel', 'moist among rocks' and 'hills' and 'forest', and 'sandplain', 'sandy country' and 'sand among rocks' were deemed indeterminate

(Hypotheis 2). Further we suggest that reinvigoration and employment of such knowledge is likely to have both conservation and social benefits (Hypothesis 4).

Scale

Our review has revealed evidence of extensive traditional *Noongar* USO use across a wide array of taxa (418 in 25 families), and the full geographic breadth of *Noongar Boodja,* which strongly supports our first hypothesis (Tables 1, 2 and supplementary material; Figs. 1, 3 and 5). Numerous accounts of extensive digging, sometimes at depths of more than a metre (e.g. for *Dioscorea hastifolia*), carrying of USOs when travelling, and robust, specifically-crafted *wanna* (digging sticks) all suggest that such interactions were substantial in scale and a significant ecological disturbance in pre-colonial southwestern Australia. That USO resources, while seasonally variable, are often available year-round suggests their value as fallback resources during scarcity of seeds, fruit or meat, which also supports this. Similar to the Greater Cape Region, this likely reflects the high diversity and prevalence of USO-bearing taxa within the SWAFR. In addition, we suggest that the finding of Botha et al. (2019) that contemporary Khoe-San plant use is representative of continual human use of up to 160,000 years in the Greater Cape is likely also in southwestern Australia for the length of Noongar occupation (i.e. more than 50,000 years (Tobler et al. 2017)), which Hallam (1989) also suggested based on archaeological evidence from the Swan Coastal Plain. Archaeological studies focused on detection of plant residues on Noongar grinding implements may help to shed further light on temporal scale.

Resource hotspots

In support of our second hypothesis, very frequent mentions in the literature of some *Noongar*-utilised USO taxa of southwestern Australia (eg *Dioscorea hastifolia*; Orchidaceae family; Figs. 3 and 5) indicate that some taxa are, or were in the past, more heavily targeted than others by *Noongar*, and that particular methods such as replanting and burning have been utilised to promote their growth (Daw et al. 2020; Hallam 1989, 1991, 2014) also providing support for Hypothesis 3. *Noongar* Elders of today still know soil, plant community and landscape conditions that will yield best USO crops (e.g. Knapp & Yorkshire in Knapp et al. 2021c), and mentions in the literature suggest that most targeted locations are YODFELs rather than OCBILs (Hopper 2009) (Fig. 4). In the Greater Cape Region, Khoe-San specifically target several staple taxa and also 'resource hotspots' to maximize USO returns for effort (Archer 1994;

Fig. 5 USO taxa identified as *Noongar* staples, including a) tuber of *Platysace cirrosa*; b) *P. cirrosa* growing in typical *Eucalyptus wandoo* woodland habitat, Mawson; c) *Platysace maxwellii* growing in dune at salt lake edge, Hyden; d) *Platysace deflexa* growing on fringe of granite outcrop with *gnamma* (water hole), Jerdacuttup; e) tubers of *P. deflexa*; f) *Typha* sp. in wetland, Woogenellup; g) *Typha domingensis* rhizomes (photo: Barbara Dodson); h) *Clematis pubescens* (photo: Knapp et al. 2021b); i) *Pterostylis recurva* in flower, West River; j) tuber of *P. recurva* held by *Wadandi* Elder, Wayne Webb, Boranup; k) *Thelymitra crinita* in flower, Boxwood Hill; l) tuber of *Thelymitra* sp.; m) *Pyrorchis nigricans* in flower, Belinup; n) flower of *Thysanotus patersonii*; o) twining vine of *T. patersonii*, ready to harvest; p) tubers of *T. patersonii* (photo: Kingsley Dixon); q) *Noongar* built rock garden of *Dioscorea hastifolia*, Serpentine; r) tubers of *D. hastifolia*; s) tuber of *Geranium solanderi* held by *Noongar* Elder, Averil Dean, Boxwood Hill; t) *Lepidosperma gladiatum* on coastal dunes near Yanchep; u) leaf base of *L. gladiatum*; v) *Wudjari* Elder, Gail Yorkshire holding *Haemodorum spicatum*, Esperance; w) *Mierningar* Elder, LK holding *Haemodorum discolor*, SC looking on, Boxwood Hill; x) *H. spicatum* in typical sandy soil habitat, Perth. (All photos by SDH or AL, unless otherwise indicated)

Botha et al. 2020; De Vynck et al. 2016; Singels et al. 2016). Descriptions of such locations, including coastal dunes and riparian woodlands are suggestive of YODFELs (Hopper 2009). Botha et al. (2020) also found that highly productive geophyte patches occur in recently burned sand and limestone fynbos vegetation. Anderson (2005) reports maintenance of USO resource patches through burning and replanting in First Nations California, again in landforms suggestive of YODFELs.

Knowledge, skills, technology

Detailed *Noongar* knowledge, skills, technology and custom are revealed in the literature and held by contemporary Elders in relation to sustained, safe and efficient acquisition of USO resources providing strong support for our Hypothesis 3. As in California and the Greater Cape, the primary responsibility for USO harvest and resource patch maintenance lies with women (Anderson 2005) and is linked closely with settlement patterns (Hallam 1989) and family travel routes (LK). Hallam (1989, 1991) suggested that this likely equates to proprietal rights to such patches being inherited through the female line, with which author, LK agrees, as women usually controlled access to resource patches. Also like Californian First Nations and Khoe-San women, a *wanna* for digging USOs and a *cote* (bag) for carrying them were both essential possessions of pre-colonial *Noongar* women.

Specific knowledge and skills relating to harvest techniques, taxonomy, productive habitat and phenology are evident. That Grey (1840) recorded a specific *Noongar* word, *Nan-ga*, to describe the sand-binding roots of the *Haemodorum* genus (Smith et al. 2011), which translates to 'beard of the mearn' (von Brandenstein 1988 gives ngarnak = beard, hanglet) is an illustration of the detailed science contained in Noongar traditional knowledge, which also clearly articulated the sandy soils preferred by this genus, still well-understood by Elders today, who also note its co-occurrence with other *kwongkan* (sandplain) taxa, such as prostrate *Banksia* (Proteaceae) (LK). Detailed accounts of mixing the bulbs with termite earth to increase palatability are analogous with the specific skills for efficient and safe consumption of USO taxa among Khoe San (Botha et al. 2020). As evident in other USO-rich regions (e.g.Biscotti et al. 2018; Botha et al. 2019) we also note a high degree of geographic specificity of Noongar USO knowledge, illustrated by at least six geographically specific names for *Haemodorum spicatum* (see Fig. 1). In biodiversity conservation practice, this highlights the importance of including people and knowledge local to the relevant dialect group on whose traditional land a project is focused. Another novel parallel with Khoe San, are Noongar Elders' accounts of introduced weed USO taxa (e.g. LK's consumption of *Moraea setifolia*) demonstrating adaptability to new conditions resulting from colonization (Nortje and van Wyk 2019).

A concerning finding of this review was that for only 20% of the Noongar knowledge relating to USOs in the literature could we identify the *Noongar* person from whom the information was originally sourced. This was not confined to historical accounts, but was also the case for a substantial component of the contemporary literature. This separation of USO knowledge from its custodians has potential to perpetuate the disempowerment effects of colonisation already experienced by *Noongar* people and families, through removal of agency and confusion of identity that otherwise would have come from intergenerational knowledge transfer and connections to specific places and plant species. Further, it often fails to record complex and subtle relationships between First Nations people, landscapes and plant communities or taxa, and thus largely mitigates against interpreting ecological effects of traditional management. Conversely, where *Noongar* collaborators have been identified in literature as genuine and equal partners, and specific plant knowledge is attributed to individuals, families who have been impacted by damaging effects of colonisation are able to identify their ancestors, empowering revival of knowledge, skills, connection, cultural identity and agency to care for traditional Country.

Conservation

Noongar custom dictates rules about resource conservation. This strongly supports our fourth hypothesis. Harvesting USOs outside of a plant's reproductive phenological phase is well known among contemporary Elders and is still observed (e.g. LK's observations of *Dichopogon fimbriatus*).This behaviour was also recorded historically by Grey (1841) in Hallam (2014). In addition, only harvesting resources when needed (e.g. LK's comment regarding *Geranium solanderi*) is also closely observed.

That most places heavily targeted as USO resource hotspots are in YODFELs concurs with Lullfitz et al. (2021b), who found that among south coast *Noongar,* intensive day to day activities are carried out traditionally in YODFELs while access restrictions often apply to OCBILs. Given the often fragile soils and vulnerable, specialist plant taxa of OCBILs compared to YODFELs (Hopper et al. 2021, 2016), concentrating soil disturbance and digging of plants in YODFELs is a means of sustaining plant resources and ultimately, conserving biodiversity.

As Anderson (2005) recorded among First Nations in California, and has been found elsewhere in Australia (Gott 2005), Hallam (1989, 2014) highlighted a likely promoting effect on USO resource taxa populations, supported by references to specific methods for harvest (Knapp & Yorkshire in Knapp et al. 2021g, Maggie Bell & Nellie Parker in Meagher 1974) and propagule replanting (Bindon and Walley 1992). In an earlier study (Lullfitz et al. 2021a), we found that harvest of *Platysace deflexa* tubers promoted population renewal, which aligns with LK's observation of its prominence in disturbed gravel pits. The many references to *Noongar* carrying of USOs when travelling also concurs with genetic homogeneity among *P. deflexa* and *P. trachymenioides* populations found by Lullfitz et al. (2020), and suggests that Noongar

use of some USO resources may have influenced current population distributions, and even expanded their range.

We have estimated that at least 418 USO-bearing taxa may have been utilised by *Noongar* people in southwestern Australia. That we found 45 mentions of *Noongar* USO usage in the literature for taxa that could not be identified, and also through our own experience of identifying previously unrecorded taxa during Elder-botanist collaborative field visits, we suggest that this figure possibly remains a significant underestimate. As both Nortje and van Wyk (2019) identified in Namaqualand and Pate and Dixon (1982) previously in the SWAFR, a lack of adequate botanical identification in the historic literature makes it fraught with possible misidentification of cultural taxa and can perpetuate early errors, as we have seen in the literature relating to *Drosera* (Droseraceae) (see Table 1). Just as Meagher (1974) suggested, our experience is that substantial unrecorded plant knowledge remains among Elders of the *Noongar* community.

Based on our review findings, we suggest several critical elements for successful and respectful exploration of traditional plant knowledge to inform biodiversity conservation. These are (1) Elder leadership, (2) inclusion of individuals with good plant identification skills, potentially through taking vouchered herbarium specimens, and (3) consideration of traditional gender-based roles. Transmission of plant knowledge held by contemporary knowledge holders is most accurate through shared experience on Country, enabling both correct taxon identification and for traditional and scientific knowledge holders to jointly explore their collective understanding of a plant's conservation requirements (e.g. disturbance response, phenology or population genetics relating to human use), thus maximising its value for information relating to biodiversity conservation strategy. Imperative in any documentation of this process is a clear link to individual knowledge holders and the knowledge that they share. This approach avoids separation of First Nations knowledge from First Nation families, the rightful holders of such knowledge, and, if required, encourages intergenerational 'waking up' of knowledge inextricably linked to cultural identity for current and future First Nations people. Given that *Noongar* USO harvest is primarily a female domain, appropriate gender-based protocol is also imperative to prevent cultural harm and maximise knowledge accuracy. We suggest that inclusion of each of these elements can set us on a path to more meaningful, inclusive conservation approaches into the future.

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