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Terrestrial fauna of granite outcrops in Western Australia

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Abstract

In our overview of the terrestrial animals associated with granite outcrops in Western Australia, we document relatively few animals which are known to be restricted to granite outcrops, despite the large area over which granite outcrops occur in Western Australia. The spider *Teyl* and the chironomid fly *Archaeochlus* are restricted to granite outcrops. Other spiders (*e.g. Rebilus*), some pseudoscorpions (*e.g. Synsphyronus*) and the embiopteran web-spinner (*Notoligotoma*) may be restricted to granite outcrops. No amphibians are restricted to granite outcrops, although many species use them for shelter or breeding, and some species seem to be restricted to the eastern extent of the granites along the south coast of Western Australia. Only four reptiles appear to be restricted to granite outcrops, the dragon (agamid) lizards *Ctenophorus ornatus*, *C. yinnietharra* and *C. rufescens*, and the gecko *Gehyra montium*, but many other species have been recorded from granite outcrops. Birds, being more mobile than other terrestrial vertebrates, range widely and no species are restricted to granites, although many species are found on granite outcrops. No mammals appear to be restricted to granite outcrops, although a number are rock specialists (*e.g.* rock wallabies *Petrogale* spp, long-tailed dunnart *Sminthopsis longicauda*, rock rats *Zyzomys* spp, rock ringtail possum *Pseudocheirus dahli*), and various other species use granite outcrops as well as other habitats. Although relatively few species of terrestrial animals appear to be restricted to granite outcrops, many animals are found in these specialised habitats, and it is clear that granite outcrops are important as a seasonal resource or temporary refuge for the fauna of the surrounding habitats. The fringing apron of granite outcrops is an important site of interaction between granite outcrops and their surrounding habitats, and must be preserved as vigorously as the granite outcrops themselves.

Introduction

One of the objectives of this symposium, and this issue of The Journal of The Royal Society of Western Australia, was to examine and hopefully explain the pattern of distribution of some animals and plants in Western Australia, with respect to the extensive granite outcrops that are a major geological feature of much of the State. Here, we overview the terrestrial animals associated with granite outcrops in Western Australia.

Granite outcrops form a complex part of the varied ecosystems in Western Australia, although they are often perceived as isolated rock forms jutting out of the surrounding landscape. Not only do they form a specialised suite of habitats for animals and plants in their own right (*e.g.* rock pools, meadows, exfoliating rock sheets, rock crevices) but they also merge with the surrounding habitats and form specialised edge habitats, the fringing apron. Thus, the flora and fauna associated with granite outcrops are not only those species adapted to survive and persist on the granite rock habitats, but include many species from the surrounding habitats that seek temporary or permanent refuge amongst the granite rocks, or on the fringing apron.

Even a cursory examination of published accounts of the fauna identified on granite outcrops reveals that an immense number of animals has been reported to be associated with granite outcrops on either a temporary or permanent basis (*e.g.* the Western Australian Museum Biological Survey reports; Lovell 1978; Dell *et al.* 1985; Anon, 1991; Hopper 1981), various unpublished reports of granite rock fauna and flora surveys, field guides to Western Australian animals (*e.g.* Storr *et al.* 1981, 1983, 1986, 1990; Storr & Johnstone 1985; Tyler *et al.* 1994) and more general guides to Australian animals (*e.g.* Strahan 1983; Wilson & Knowles 1988; Cogger 1992). This reflects the opportunistic or seasonal activities of many of these animals rather than any predilection or requirement for granite outcrop habitats. Therefore, for practical reasons, the scope of our investigation here has been limited to the terrestrial fauna restricted to granite outcrops in Western Australia.

Distribution of Granites

Granite outcrops are distributed widely throughout Western Australia. Although there does not appear to be a specific map of granite outcrops in Western Australia, the distribution of granite and sandstone landforms clearly indicates a widespread distribution of granite outcrop habitats over much of the western half of Western Australia, and sandstone habitats in northern, eastern and west-central Western Australia (Fig 1; see also Myers, 1997). Much of the western part, particularly the Yilgarn cratonic block, is covered by granite, and there are scattered patches of granite in the East and West Pilbara. There is a pronounced "V"-shaped patch of granite in the Kimberley, and scattered patches of granite

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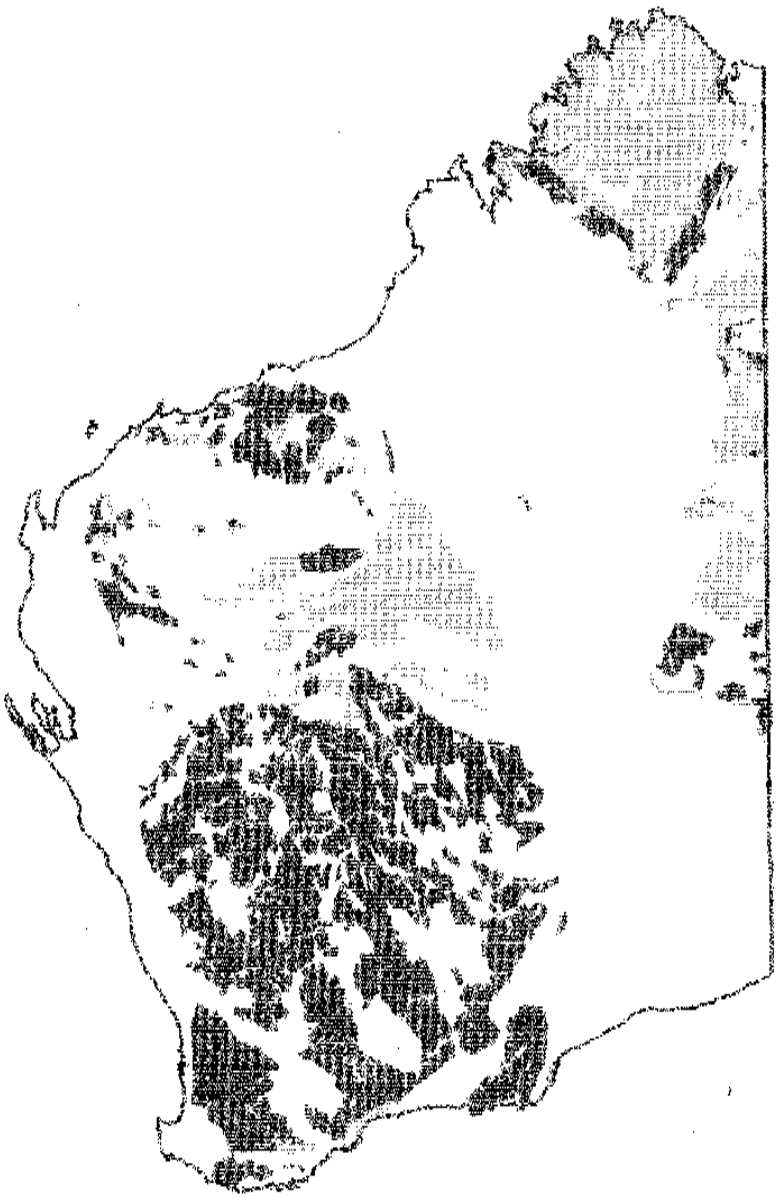

Figure 1. Distribution of granitoid (dark) and sandstone (light) landforms in Western Australia. Redrawn from the Hydrogeological Map of Western Australia, Geological Survey of Western Australia (1989); not shown are other Precambrian and Cambrian landforms (shale, limestone, dolomite, undifferentiated sedimentary, metamorphic, basalt, dolerite, volcanic and gneiss and Phanerozoic sedimentary rocks.

along the eastern border, particularly around the Musgrave Ranges.

The granite outcrops of Western Australia were formed in three major, distinct orogens, representing separate episodes of continental collision (see Myers 1997). The most extensive granite outcrops are part of the Yilgarn Craton, and were formed between 2700 and 2600 million years ago, by the melting of continental crust; these include the Pilbara granites, which are mostly buried by volcanic rocks and the Hammersley banded iron formations. The younger granite outcrops of the Kimberley and Gascoyne regions result from the colliding, about 2000 million years ago, of the Pilbara and Yilgarn continents (Gascoyne region, Capricorn orogen), and others (Kimberley region, Halls Creek and King Leopold orogens). More recently, granite was formed in the south of Western Australia in two distinct episodes of continental crust collision. The older of these, the Recherche granite, was intruded about 1300 million years ago by deformation of the Mawson Craton (South Australia and East Antarctica) and the West Australian Craton at the Albany-Fraser Orogen. Younger Esperance granite, about 1180 million years old, may be largely derived from another episode of compression between the Mawson and West Australian Cratons. The Musgrave granites formed at about the same time through deformation between the Mawson Craton and the North Australian Craton.

It is clear that the times of formation of these different groups of granite outcrops in Western Australia immensely pre-date the presence of existing species of terrestrial vertebrates and invertebrates, and so current

distributions of terrestrial animals on granite outcrops must reflect relatively recent (in geological time) evolutionary and dispersal patterns rather than relictual isolation of species on the various groups of granites.

Terrestrial Invertebrates

Consideration of the various terrestrial invertebrates indicates that only a few arthropods are known to be restricted to granite outcrops.

The mygalomorph spider *Teyl luculentus* is found in virtually all of the meadows, and also on the fringing apron, of granite outcrops in the wheatbelt and western Goldfields areas of south-western Australia (B York Main, *pers. comm*.). *Teyl* (Fig 2) is an ancient trapdoor spider genus and its distribution appears to be relictual, associated with the wetter, boggy meadows and aprons of granite outcrops; *T. luculentus* is doubtless a complex of species to be described (B York Main, *pers. comm*.). Main (1975) listed various granite rocks as habitats for *T. luculentus*, but some of those records now relate to new species, some restricted to specific rocks, as the genus is being revised; all *Teyl* are restricted to granite outcrops or granite-related habitats (apron, granitic soils; B York Main, *pers. comm*.). *Teyl* aestivates during the dry periods by encasing itself in its sealed burrow. A number of other mygalomorph spiders have been recorded from the fringing apron or outer edge of granite outcrops, including *Kwonkan* sp, *Merredinia damsonoides*, *Aganippe* sp, *Gaius* sp, Barychelidae sp, *Chenistonia tepper*i and *Aname diversicolor*, but are not restricted to granite outcrops (B York Main, *pers. comm*.).

The most common and conspicuous spiders of granites in the wheatbelt and goldfields are the large spiders found in vegetation around the granites *e.g.* the golden orb weaver (*Nephila edulis*), Christmas spider (*Gasteracantha minax*) and huntsman spiders (*Olios* sp). Many spiders are well adapted to living in granite outcrops, although not restricted to them, being also found in vegetation and under tree bark. The sparassid huntsmen spiders usually live in cracks and crevices of rocks, as well as under loose bark; they have a flattened cephalothorax and abdomen, with legs rotated forwards, making them adept at moving in narrow spaces in rock cracks and between slabs of exfoliating granite. The clubionid and gnaphosid sac spiders, *Rebilus*, *Hemicloea*, *Miturga* and some lycosids are often found under exfoliating granites, as also are redback spiders (*Latrodectus*). The relatively large *Rebilus* is a common spider under the exfoliating granites of the central wheatbelt in Western Australia; it is also found under bark on trees. In the higher rainfall south-western granites, it is replaced by *Miturga*, and in the lower rainfall eastern wheatbelt and goldfields it is replaced by the wolf spider *Pardosa* (Main, 1975). *Rebilus* has a flattened body, like the sparassid huntsmen spiders. The dorso-ventrally compressed selenopid spiders are found in rock piles and under bark. Some wolf spiders, and the dysderid spider *Ariadna*, are also found with *Teyl* in the boggy meadows and aprons of granite outcrops. *Ariadna* forms a silk tube, from which radiate silk threads.

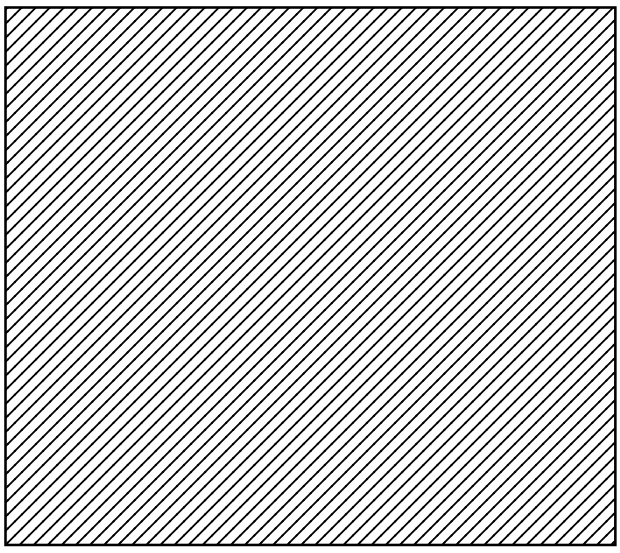

Figure 2. The burrowing mygalomorph spider *Teyl luculentus* is commonly found in small meadows on granite rocks and the seasonal boggy apron habitats (B York Main).

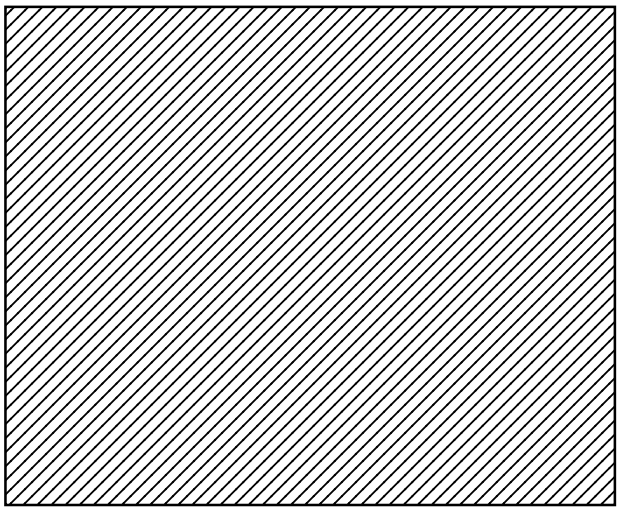

Figure 3. The pseudoscorpions *Synsphyronus* sp are known from granite outcrops, (D Elford, Western Australian Museum).

Some species of the pseudoscorpion genus *Synsphyronus* (Fig 3) may be restricted to granite outcrops; *S. elegans* Beier is known only from Yorkrakine Hill, *S. leo* Harvey is known only from Lion Island, Recherche Archipelago, and two undescribed species have been collected from other granite outcrops (M Harvey, *pers comm*). However, further collecting is needed to confirm that these species are definitely restricted to granite outcrops, since most species of *Synsphyronus* are found under the bark of trees, in leaf litter, and under other types of rocks (Harvey 1987).

The Embioptera (web-spinners), a small order of insects, are mainly tropical species but some occur in warm temperate climates, like the related termites and earwigs (Ross 1991). These small, slender insects, with a large head and eyes, live in silk tunnels which they weave

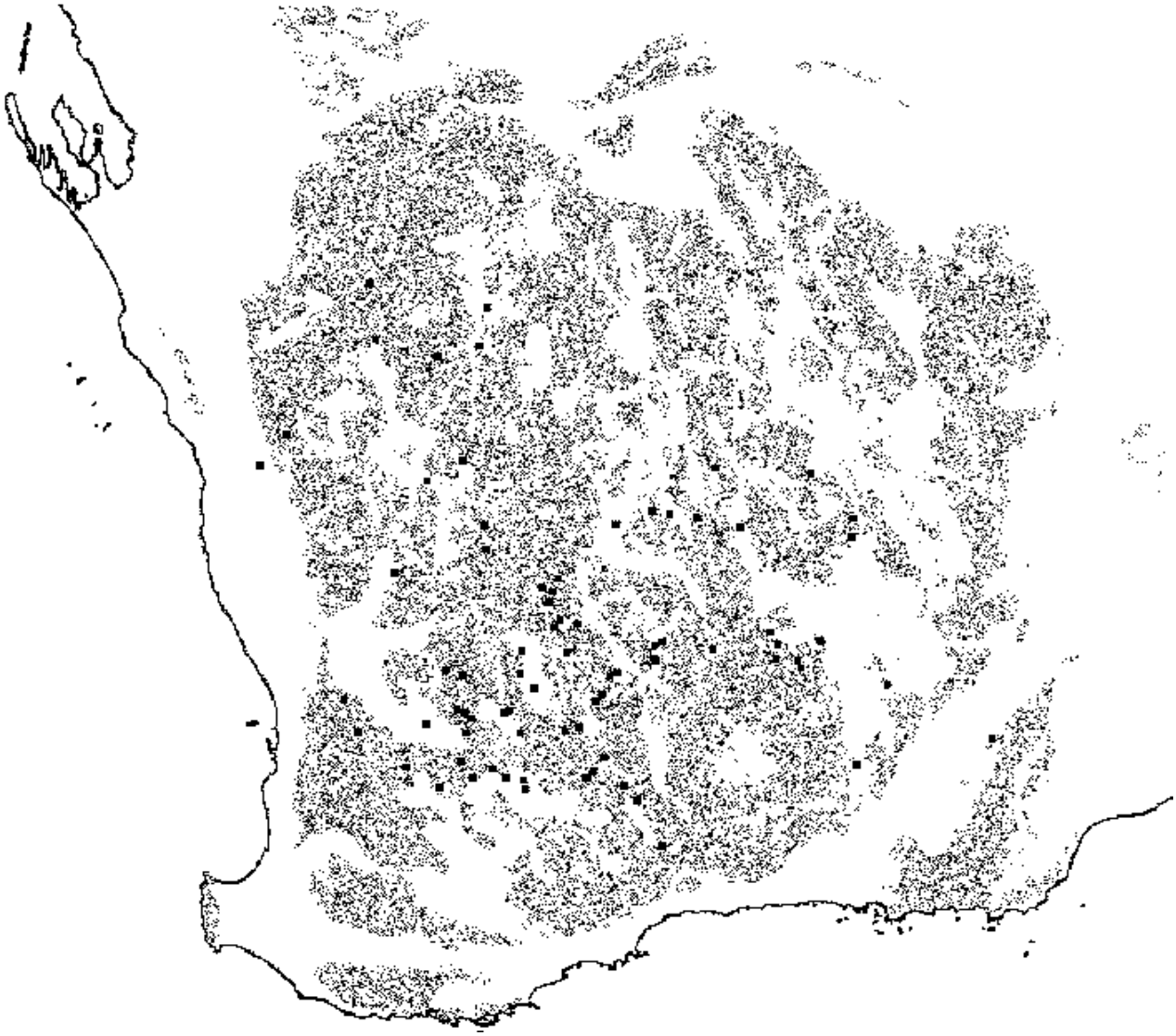

Figure 4. The distribution of *Archaeochlus brundini* and *A.* sp nov is restricted to the ancient granite outcrops in Western Australia (AGSO bedrock data, acid/intermediate intrusions; graphed using Arcview by staff of the Western Australian Museum).

using silk glands and spinning glands located on the front tarsi; they feed on vegetation. The embiopteran *Notoligotoma* may be restricted, in part, to granite outcrops. Ross (1991) states that "*Notoligotoma hardyi* and a complex of related species or races occur in south-western Australia, usually on the undersurfaces of exfoliated rock slabs on granitic outcrops of arid regions. In Perth, *N. hardyi* is common in crevices of old board fences in residential areas".

The aquatic invertebrates that occur in pools on granite outcrops are discussed by Bayly (1982, 1997). Another important aquatic habitat on granite outcrops is the temporary streams formed by seepages from the meadows on the outcrops. In these seepages are the larvae of *Archaeochlus*, an ancient genus of chironomid fly. *Archaeochlus* spp are restricted to granite outcrops in south-western Australia (Fig 4) and survive the dry period as a gravid adult female. The genus is also known from temporary streams in the Drakensberg Escarpment of southern Africa, and provides evidence of a Gondwanan connection between Australia and Africa. The two continental lineages are considered to antedate the breakup of Gondwanaland in the Upper Jurassic and have therefore been separated for a minimum of 120 million years (Cranston *et al.* 1987; Edward 1989).

Terrestrial Vertebrates

As with invertebrates, it is difficult to discern which terrestrial vertebrate species are restricted to granite outcrops, as a very large number of species of amphibians, reptiles, birds and mammals can be found associated with granite outcrops either permanently, temporarily or seasonally. No fishes, amphibians, snakes, birds or mammals are restricted to granite outcrops, but four lizards (three dragons and one gecko) are apparently restricted to granite outcrops (Table 1).

Table 1

Summary of the number of species of frogs, lizards and snakes found in Western Australia, indicating the number of species restricted to granite rocks (g) or rocks in general (r; usually sandstone or limestone). Based on Tyler *et al.* (1994), Storr *et al.* (1981, 1983, 1986, 1990), Wilson & Knowles (1988), and Cogger (1992).

FROGS	77 (0g, 5r)
Leptodactylidae	
Arenophyrne	1
Crinia	1
Geocrinia	5
Heleioporus	5
Limnodynastes	6
Megistolotus	1 (1r)
Metacrinia	1
Myobatrachus	1
Neobatrachus	8
Notoden	3
Pseudophryne	3 (1r)
Ranidella	5
Uperoleia	12
Hylidae	
Cyclorana	7
Litoria	18 (3r)
SNAKES	80 (0g, 0r)
Typhlopidae	
Ramphotyphlops	18
Boidae	
Aspidites	2
Morelia	7
Acrochordidae	
Chersydrus	1
Homalopsidae	
Cerberus	1
Fordonia	1
Myron	1
Colubridae	
Amphiesma	1
Boiga	1
Dendrelaphis	1
Elapidae	
Acanthophis	3
Cryptohis	1
Demansia	7
Denisonia	4
Furina	1
Notechis	5
Oxyuranus	1
Pseuchis	2
Pseudonaja	5
Rhinoplocephalus	6
Vermicella	11
LIZARDS	270 (4g, 25r)
Gekkonidae	
Crenadactylus	1
Diplodactylus	28 (2r)
Gehyra	9 (1g, 2r)
Heteronotia	3 (2r)
Nephrurus	6
Oedura	6 (2r)
Phyllodactylus	1
Pseudothecadactylus	1 (1r)
Rhynchoedura	1
Underwoodisaurus	1
Pygopodidae	
Aclys	1
Aprasia	8
Delma	10
Lialis	1
Pletholax	1
Pygopus	2
Scincidae	
Bassiana	1
Carlia	6
Cryptoblepharus	4 (1r)
Ctenotus	45 (5r)
Egernia	14 (2r)
Eremiascincus	2
Hemiergis	3
Lerista	27 (2r)
Menetia	4
Morethia	7
Notoscincus	2
Omolepida	2
Proablepharus	2
Sphenomorphus	4
Tiliqua	4
Agamidae	
Caimanops	1
Chelosania	1
Chlamydosaurus	1
Ctenophorus	17 (3g, 1r)
Diporiphora	11
Gemmatophora	4
Moloch	1
Pogona	3
Tympanocryptis	6
Varanidae	
Varanus	18 (5r)

Amphibians

None of the recorded 77 species of Western Australian amphibians (frogs) appear to be restricted to granite outcrops, based on their distributions or habitats, although a number of species are sometimes associated with rocks (including granites) as either adults or eggs/tadpoles (see Tyler *et al.* 1994). For example, adult treefrogs (*Litoria rubella*) will shelter in cracks in rocks; eggs and tadpoles of frogs, such as the kunapalari frog (*Neobatrachus kunapalari*), are often found in gnammas on granite outcrops, or in ponds around the apron of outcrops.

A notable relationship, however, exists in the close correspondence of the eastern-most extent of granites along the south coast of Western Australia with the eastern-most limit of the distributional range for a number of frogs (L Smith, *pers. comm.*). Examination of the distribution of Western Australian frogs (see Tyler *et al.* 1994) shows a reasonable correspondence for over 10 species with the easternmost extent of the granites at about Israelite Bay (Fig 5), which also coincides with the eastern limit of the south-western winter rainfall zone. This coincidence suggests that these species of frog, although not restricted to granites, might be limited in the eastern extent of their distribution by the absence of granite outcrops that either directly (as rock pools) or indirectly (as pools formed by run-off from rocks) provide suitable breeding sites elsewhere.

In contrast to no species being restricted to granite rocks, five frog species appear to be restricted to other rock habitats in the Pilbara and Kimberley regions of Western Australia (Table 1). The woodworker frog *Megistolotis lignarius* is always associated with rocks, being found beneath rock piles, on open escarpments or in caves (Tyler *et al.* 1994). The habitat of Douglas' toadlet *Pseudophryne douglasi* is permanent seeps or deep, shaded pools in deep gorges and canyons (Main 1965). Three treefrogs, the cave-dwelling frog *Litoria cavernicola*, Copeland's rock frog *L. copelandi* and the rockhole frog *L. meriana*, are found only near rock pools, caves or streams over rock in the Kimberley region.

Reptiles

Although many lizards and snakes have been collected under exfoliating slabs or rocks on granite outcrops (see Storr *et al.* 1981, 1983, 1986, 1990; Wilson & Knowles 1988; Cogger 1992), only four species of lizards appear to be restricted to granite outcrops.

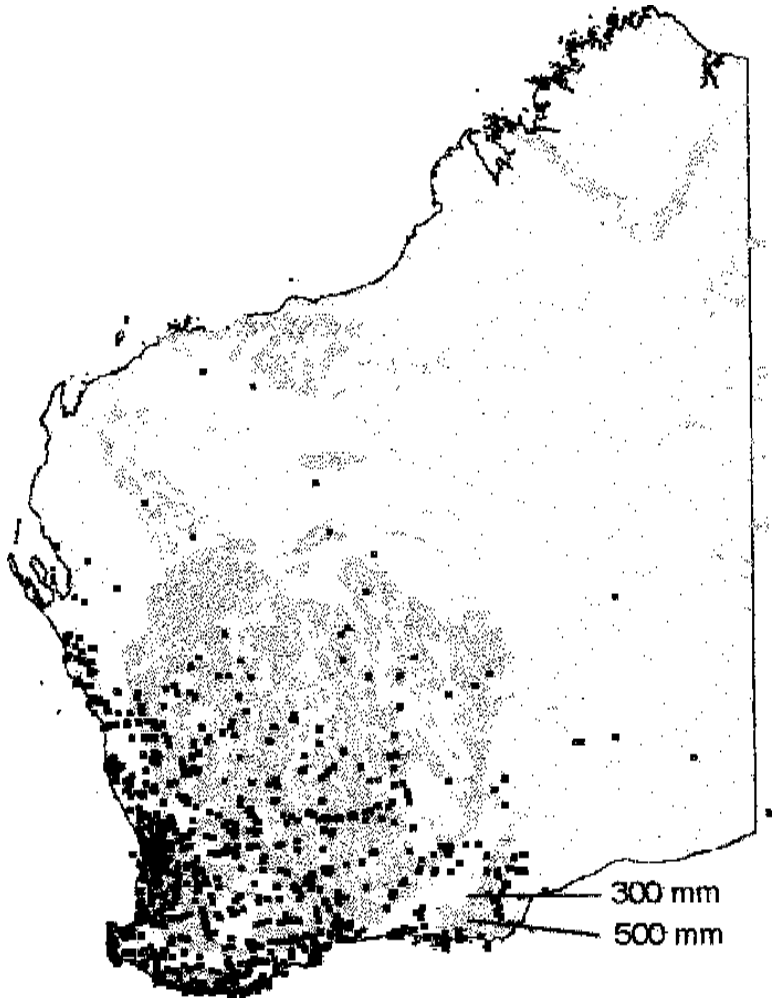

Figure 5. Relationship between eastern distributional limits for 13 species of Western Australian frogs and the eastern extent of granite outcrops; the eastern limits of the south west winter rainfall zone (annual rainfall 300 and 500 mm isohyets) are also indicated. The species of frogs are; *Crinia georgiana, Heleioporus eyrei, Limnodynastes dorsalis, Litoria adelaidensis, Litoria cyclorhynchus, Myobatrachus gouldii, Neobatrachus albipes, Neobatrachus kunapalari, Neobatrachus pelobatoides, Pseudophryne guentheri, Pseudophryne occidentalis, Ranidella insignifera* and *Ranidella subinsignifera.* Distributional data (total sample size is 6925) from records of the Western Australian Museum; frog localities are plotted over the acid / intermediate intrusions (AGSO bedrock data, acid / intermediate intrusions; graphed using Arcview by staff of the Western Australian Museum).

The most obvious lizards restricted to granite outcrops are some of the *Ctenophorus* dragons. The ornate dragon, *Ctenophorus ornatus,* is commonly found on granite outcrops of the semiarid and subhumid zones of southwestern Western Australia, where it favours expanses of bare rock strewn with exfoliations and loose rocks (Bradshaw 1971). It is restricted to certain granites of the Yilgarn and the Esperance and Recherche regions by cold temperatures and aridity, and does not occur on the Pilbara, Musgrave or Kimberley granites (Fig 6A). Other species of *Ctenophorus* occur in these granite regions, some of which are also restricted to granites. In the Pilbara, the Yinnietharra rock dragon (*C. yinnietharra*) is known only from or near low granite outcrops, and the rusty dragon (*C. rufescens*) is found on granite outcrops in the Musgrave Range region of Western Australia (Fig 6A). In contrast, other saxicolous *Ctenophorus* dragons in the Pilbara, particularly the ring-tailed dragon (*C. caudicinctus*) but also to a lesser extent the Western netted dragon (*C. reticulatus*), are found more widely on the other rock forms such as volcanic and banded iron formations, as well as granite outcrops.

Only one gecko is apparently restricted to granite outcrops. *Gehyra montium* (Fig 6B) occurs only on the granite outcrops of the Musgrave Range region of east Western Australia, having a similar distribution as the rusty dragon (*C. rufescens*). One other gehyra gecko, the spotted dtella *G. punctata,* is a saxicolous species that is restricted in part to granite rocks, but also occurs on other rock forms (Fig 6B), like the ring-tailed dragon (*C. caudicinctus*). Two diplodactyline geckos, *Diplodactylus wilsoni* and *D. wombeyi,* and *Heteronotia spelea* are rock-dwellers in the Pilbara region. Another wide-spread gehyra gecko, the spotted dtella *G. variegata,* is predominantly arboreal, but in the western part of its range (*i.e.* Western Australia) is both arboreal and saxicolous, under exfoliating rocks on granite outcrops. A similar dichotomy of arboreal and exfoliating granite

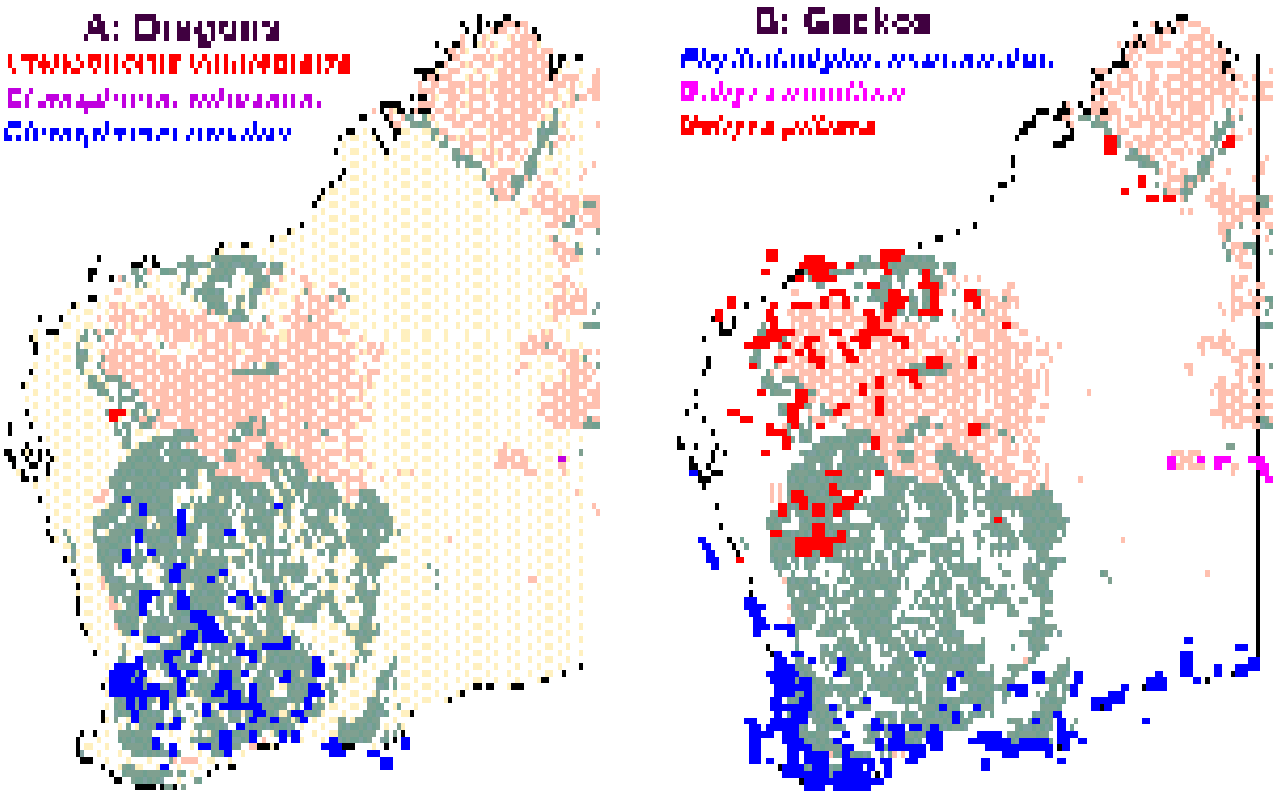

Figure 6. A: Distribution of *Ctenophorus ornatus* (n = 802 records), *C. yinnietharra* (n = 19) and *C. rufescens* (n = 25) with respect to granite landforms in Western Australia. **B**: Distribution of *Phyllodactylus marmoratus* (n = 1337), *Gehyra punctata* (n = 696) and *Gehyra montium* (n = 83) with respect to granite landforms in Western Australia. Distributional data from the Western Australian Museum; localities are plotted over the acid/intermediate intrusions (dark; corresponding roughly to granitoid in Fig 1) and proterozoic sediments (light; corresponding roughly to sandstone in Fig 1). AGSO bedrock data; graphed using Arcview by staff of the Western Australian Museum.

habitats is observed for the marbled gecko *Phyllodactylus (Christinus) marmoratus* (Fig 6B), with the coastal and island populations tending to use limestone and granite rocks more than trees. Similarly, the marbled velvet gecko (*Oedura marmorata*) is both arboreal and saxicolous.

In contrast to the relatively low number (4) of lizards restricted to granite rocks, a larger number (30) are restricted to sandstone rocks, or rocks in general (Table 1). Compared to one gecko restricted to granites, 9 species are restricted to sandstone or rocks in general. Compared to 3 dragons restricted to granites, only one additional species *C. caudicinctus* is restricted to rocks in general. Although no skinks were restricted to granites, about 10 species are restricted to other rocks. Finally, a number of goannas are restricted to rocky areas, particularly the sandstones of the Kimberley.

Birds

Birds, being generally more mobile than other terrestrial vertebrates, are less likely to be restricted to specific habitats, such as granite outcrops. Thus, although many species of bird have been recorded on granite outcrops (*e.g.* McKenzie *et al.* 1973; Dell & Johnstone 1976; Dell 1977; Youngson & McKenzie 1977; Hopper 1981; Dell *et al.* 1985), no species are restricted to them. In fact, the dominant shrubs and mallees in the fringing apron around the rocks appear to be the main attractant to these birds, such as honey-eaters, and so granite rocks are exceptionally rich in honey-eater species compared with most wheatbelt habitats. Granite rocks represent one of the few habitat types that have not experienced extensive habitat destruction for agriculture and this increases their attractiveness to bird species (Hopper 1981). Water, when available in rock pools and gnammas, also attracts a number of bird species to granite outcrops.

Mammals

As with amphibians and birds, there are apparently no mammals restricted to granite outcrops, although a number of species are restricted to rocky areas. Rock wallabies (*Petrogale* spp) are an obvious example, being found in rocky habitats, including but certainly not exclusive to granite outcrops (Strahan 1983). The long-tailed dunnart (*Sminthopsis longicaudata*) is found in rugged, rocky areas of central Western Australia, and its long tail and striated foot pads apparently aid in rock climbing (Burbidge *et al.* 1983). Rock rats (*Zyzomys argurus, Z. woodwardi*) always are associated with rocky outcrops, particularly sandstones, of the Pilbara and

Kimberley. The rock ringtail possum (*Pseudocheirus dahli*) is found exclusively in rock outcrops of the Kimberley (Nelson & Kerle 1983).

Conclusions

Although granite outcrops occur over a large area of Western Australia, especially the western Yilgarn and Pilbara regions, very few species of terrestrial animals are apparently restricted to them. A few terrestrial arthropods, primarily *Teyl* spiders and the insect *Archaeochlus*, are known to be restricted to granites, which are presumably relictual habitats for these ancient genera. Some species of *Synsphyronus* pseudoscorpion and the embiopteran insect *Notoligotoma* may also be restricted to granite outcrops. Only four lizards are known to be restricted to granite outcrops, three dragons *Ctenophorus ornatus, C. yinnietharra* and *C. rufescens*, and the gecko *Gehyra montium*.

In contrast to the sparse list of species known to be restricted to granite outcrops, a very large number of terrestrial animals have been reported from granite outcrops. It is clear that granite outcrops are important as a seasonal resource for many animals or as a temporary refuge for the fauna of the surrounding habitats. In this regard, the fringing apron of modified habitat surrounding granite outcrops is an especially important aspect of the interaction between granite outcrops and their surrounding habitats, and must be preserved as vigorously as the granite outcrops themselves.

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Granite outcrops of Western Australia are inselbergs and monoliths made from granite that are found across much of Western Australia. Rising abruptly from the surrounding landscape they create a variety of microhabitats for plants, and provide seasonal resources and refuge for a range of animals. These areas thus have rich biodiversity and many endemic species.Â * Hopper, S.D., Brown, A.P. and Marchant, N.G. (1997) Plants of Western Australian granite outcrops, "Journal of the Royal Society of Western Australia", vo.80:141-158 * Withers, P.C. and Edward D.H. (1997) Terrestrial fauna of granite outcrops in Western Australia, "Journal of the Royal Society of Western Australia", vol.80:159-166. External links. While Western Australia covers one third of the Australian continent, over half of the nationâ€™s biodiversity hotspots and a significant percentage of its unique flora and fauna thrive here. As well as being home to iconic Australian animals, such as red kangaroos and crocodiles, Western Australia has 141 of Australiaâ€™s 207 mammal species, 439 reptile species, 1,600 fish species and more than 12,000 species of wildflowers â€“ making it the largest collection of wildflowers in the world. Life in the ocean.Â Life in the outback. In the central heart of Western Australia lies the Golden Outback â€“ the largest expanse of outback in the country. Here, wide-open desert landscapes and plunging gorges provide natural habitats for a vast array of wildflowers and wildlife Location: Granite outcrops of the Southwest Australian Floristic Region, Western Australia. Methods: Twenty-four tetraploid individuals of the granite endemic Stypandra glauca were sampled from each of 12 granite outcrops: 7 from a mesic environment and 5 from the semi-arid region. Phylogenetic reconstruction and divergence-dating was achieved using Bayesian and parsimony analyses of chloroplast haplotypes from 90 individuals.Â Although the climatic conditions differ between outcrops in this study, our results indicate that outcrops in both regions have harboured S. glauca throughout climatic changes, accentuating the value of these habitats to biodiversity conservation under future changing climate. Related items. Showing items related by title, author, creator and subject.