REPTILES & AMPHIBIANS

One's Trash is Another's Retreat: Reptiles and Amphibians beneath Dumped Materials in Western Sydney, New South Wales, Australia

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Abstract.—Mass dumping of unwanted materials is a serious issue in many regions; ironically, however, these materials inadvertently provide artificial refugia for herpetofauna. Over a period of 17 years, we have observed 26 species of squamates and 13 species of anurans in remnant bushland areas in western Sydney. Of these, 20 species of squamates from five families (Agamidae, Diplodactylidae, Elapidae, Scincidae, and Typhlopidae) and nine anuran species from three families (Hylidae, Limnodynastidae, and Myobatrachidae) were encountered by searching beneath dumped materials. This constitutes a large proportion of observed species (74%) using dumped materials as refugia, which reinforces to what extent such non-natural materials can be advantageously leveraged for detecting herpetofauna. In particular, our detections of three species of snakes, the Red-naped Snake (*Furina diadema*), Golden-crowned Snake (*Cacophis squamulosus*), and Blackish Blindsnake (*Anilios nigrescens*), were exclusively from searching under dumped materials. Two other species, the Yellow-faced Whipsnake (*Demansia psammophis*) and Smooth Toadlet (*Uperoleia laevigata*), were predominantly detected by lifting dumped materials.

Globally, habitat destruction is a leading cause of biodiversity loss and extinctions (e.g., Gonçalves-Souza et al. 2020; Bodo et al. 2021). Habitat degradation is an aspect of habitat destruction in which changes to the quality of a habitat are incurred without significant changes to the quantity or fragmentation of habitat. Consequently, however, the viability of habitats for certain taxa are affected (e.g., Hovel et al. 2021; Elbahi et al. 2023). For herpetofauna, loss of retreat sites resulting from activities such as firewood collection (Balaji et al. 2014; Michael et al. 2018) and rock removal for gardens (Michael et al. 2021; O'Sullivan et al. 2023) are substantive threats.

Concurrent with habitat degradation, pollution is an important worldwide environmental issue (e.g., Landrigan et al. 2018; MacLeod et al. 2021). In many regions, both issues are associated with mass dumping of unwanted materials (Du et al. 2021), which can have serious negative effects on soil (e.g., Sharma et al. 2018; Cahill 2020), pollute surrounding surface and groundwater (e.g., Kiessling et al. 2019; Vaverková et al. 2019), and aesthetically degrade sites (e.g., Limoli et al. 2019). However, because herpetofauna often do not distinguish natural refugia and human refuse, many ecological studies involve searching for reptiles and amphibians beneath ground debris, including artificial materials, as a key detection technique (e.g., Tietje and Vreeland 1997; Sutton et al. 1999; Hampton 2007; Michael et al. 2019).

From 2007 to the present, we have spent considerable time searching for herpetofauna across woodlands and forested sites in western Sydney, New South Wales, Australia (Fig. 1), identifying them to species using identification keys in Cogger (2018). We herein summarize our observations of 28 species of herpetofauna found under dumped materials. These materials varied considerably but typically included items such as mattresses, sheeting, tiles, corrugated iron,

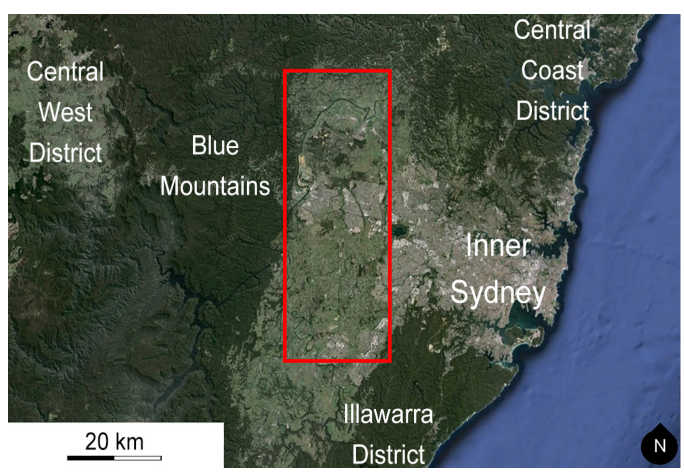

Figure 1. Study area (red outline) within the Greater Sydney region, New South Wales, Australia.

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Figure 2. A typical dumping site with a cluster of materials distributed across the ground. Photograph by Matthew Mo.

boards, and car frames (Fig. 2). To protect the subjects of our studies, we do not disclose locations or provide detailed description of sites.

Order Squamata

Over 17 years, we have found 26 species of squamates in western Sydney. This comprises 72% of the 36 squamate species recorded in the study area on the iNaturalist database[1] (iNaturalist 2024; Table 1). Twenty of those 26 species, 14 species of lizards from three families (Agamidae, Diplodactylidae, and Scincidae) and six species of snakes from two families (Elapidae and Typhlopidae), were detected by turning over dumped materials.

Family Agamidae.—Two agamids, the Jacky Dragon (*Amphibolurus muricatus*) and Eastern Bearded Dragon (*Pogona barbata*) (Fig. 3), were found beneath dumped materials, although we more frequently observed them basking during the day. Both juvenile and adult Jacky Dragons found beneath dumped materials used only corrugated iron or metal panels that had broken off car frames. All Eastern Bearded

[1] The list of herpetofaunal species recorded in the iNaturalist database for our study area was generated by filtering all records of the orders Squamata and Anura to the geographical extent of the rectangle shown in Fig. 1. The Order Testudines was not included as we did not consider turtles among herpetofauna likely to retreat beneath ground debris in the study area.

Table 1. Herpetofaunal taxa recorded in western Sydney, New South Wales, Australia, in the iNaturalist database (iNaturalist 2024) and those found beneath dumped materials in this study.

Taxon	Found in this study	Found under dumped materials
Reptilia		
Squamata: Agamidae		
Jacky Dragon (*Amphibolurus muricatus*)	Y	Y
Eastern Water Dragon (*Intellagama lesueurii*)	Y	—
Eastern Bearded Dragon (*Pogona barbata*)	Y	Y
Squamata: Carphodactylidae		
Broad-tailed Gecko (*Phyllurus platurus*)	Y	—
Thick-tailed Barking Gecko (*Underwoodisaurus milii*)	Y	—
Squamata: Diplodactylidae		
Lesueur's Velvet Gecko (*Amalosia lesueurii*)	Y	—
Eastern Stone Gecko (*Diplodactylus vittatus*)	Y	Y
Squamata: Pygopodidae		
Burton's Snake-lizard (*Lialis burtonis*)	—	—
Common Scaly-foot (*Pygopus lepidopodus*)	—	—
Squamata: Scincidae		
Red-throated Skink (*Acritoscincus platynotus*)	Y	Y
Greater Bar-sided Skink (*Concinnia tenuis*)	Y	Y
Eastern Striped Skink (*Ctenotus robustus*)	Y	Y
Copper-tailed Skink (*Ctenotus taeniolatus*)	Y	Y
Elegant Snake-eyed Skink (*Cryptoblepharus pulcher*)	Y	—
Cunningham's Spiny-tailed Skink (*Egernia cunninghami*)	Y	Y
Eastern Water Skink (*Eulamprus quoyii*)	Y	Y

(Table 1 continued)

Dark-flecked Garden Sunskink (*Lampropholis delicata*)	Y	Y
Pale-flecked Garden Sunskink (*Lampropholis guichenoti*)	Y	Y
White's Skink (*Liopholis whitii*)	Y	Y
Tree-base Litter Skink (*Lygisaurus foliorum*)	—	—
Yellow-bellied Three-toed Skink (*Saiphos equalis*)	Y	—
Weasel Skink (*Saproscincus mustelina*)	Y	Y
Eastern Blue-tongued Skink (*Tiliqua scincoides*)	Y	Y
Squamata: Varanidae		
Lace Monitor (*Varanus varius*)	Y	—
Squamata: Pythonidae		
Diamond Python (*Morelia spilota*)	Y	—
Squamata: Colubridae		
Green Treesnake (*Dendrelaphis punctulatus*)	Y	—
Squamata: Elapidae		
Common Death Adder (*Acanthophis antarcticus*)	—	—
Golden-crowned Snake (*Cacophis squamulosus*)	Y	Y
Yellow-faced Whipsnake (*Demansia psammophis*)	Y	Y
Red-naped Snake (*Furina diadema*)	Y	Y
Marsh Snake (*Hemiaspis signata*)	—	—
Tiger Snake (*Notechis scutatus*)	—	—
Red-bellied Blacksnake (*Pseudechis porphyriacus*)	Y	Y
Eastern Brown Snake (*Pseudonaja textilis*)	Y	Y
Bandy Bandy (*Vermicella annulata*)	—	—
Squamata: Typhlopidae		
Blackish Blindsnake (*Anilios nigrescens*)	Y	Y
Amphibia		
Anura: Hylidae		
Eastern Dwarf Treefrog (*Litoria fallax*)	Y	—
Broad-palmed Rocket Frog (*Litoria latopalmata*)	Y	Y
Peron's Treefrog (*Litoria peronii*)	Y	Y
Screaming Treefrog (*Litoria quiritatus*)	Y	Y
Tyler's Treefrog (*Litoria tyleri*)	Y	—
Verreaux's Frog (*Litoria verreauxii*)	Y	Y
Australian Green Treefrog (*Ranoidea caerulea*)	Y	Y
Anura: Limnodynastidae		
Eastern Banjo Frog (*Limnodynastes dumerilii*)	Y	—
Striped Marsh Frog (*Limnodynastes peronii*)	Y	Y
Coastal Banjo Frog (*Limnodynastes superciliaris*)	Y	—
Spotted Marsh Frog (*Limnodynastes tasmaniensis*)	Y	Y
Ornate Burrowing Frog (*Platyplectrum ornatum*)	Y	—
Anura: Myobatrachidae		
Common Eastern Froglet (*Crinia signifera*)	Y	Y
Smooth Toadlet (*Uperoleia laevigata*)	Y	Y

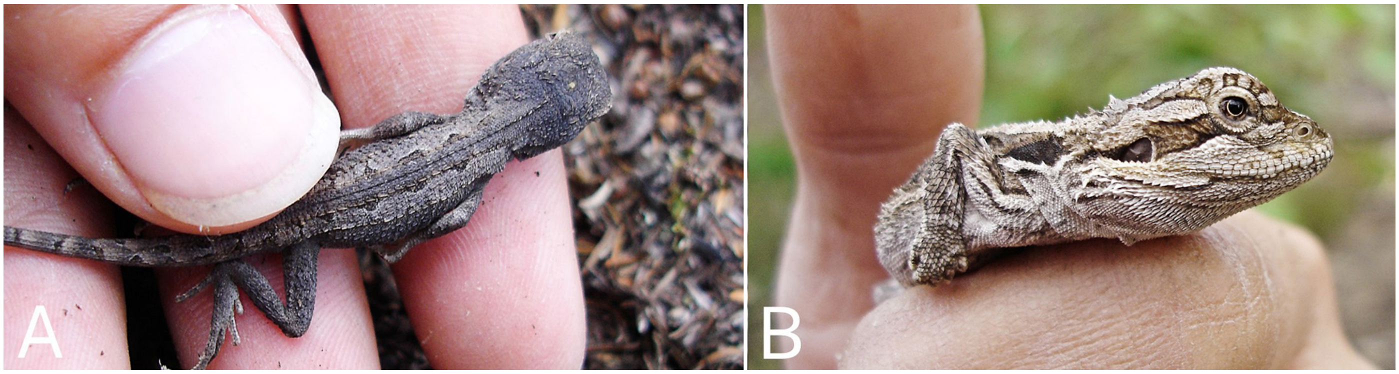

Figure 3. Dragons (Family Agamidae) found beneath dumped materials in the study area: Jacky Dragon (*Amphibolurus muricatus*) (A) and Eastern Bearded Dragon (*Pogona barbata*) (B). Photographs by Matthew Mo.

Dragons found beneath any ground debris, artificial or natural, were juveniles.

One other agamid, the Eastern Water Dragon (*Intellagama lesueurii*), also was found in the study area, but never under dumped materials. This species was regularly sighted throughout the 17 years, particularly near watercourses.

Family Diplodactylidae.—One diplodactylid gecko, the Eastern Stone Gecko (*Diplodactylus vittatus*) (Fig. 4), was found beneath dumped materials. These materials were typically sheets of corrugated iron or tiles. This species was also detected during the day beneath loose rocks and at night while spotlighting.

One other diplodactylid gecko, the Lesueur's Velvet Gecko (*Amalosia lesueurii*), also was found occasionally in the study area but was restricted to sandstone outcrops along the peripheries. This species was detected either by spotlighting, looking into sandstone crevices, or lifting rocks but never beneath dumped materials. Similarly, two other species of geckos in the family Carphodactylidae, the Broad-tailed Gecko (*Phyllurus platurus*) and Thick-tailed Barking Gecko (*Underwoodisaurus milii*), also were found in sandstone outcrops at the peripheries of the study area but never detected under dumped materials.

Figure 4. An Eastern Stone Gecko (*Diplodactylus vittatus*), the only species of gecko (families Diplodactylidae and Carphodactylidae) in the study area found beneath dumped materials. Photograph by Matthew Mo.

Family Scincidae.—Eleven species of skinks were found beneath dumped materials (Fig. 5), the most frequently encountered were Eastern Striped Skinks (*Ctenotus robustus*), Copper-tailed Skinks (*C. taeniolatus*), and Weasel Skinks (*Saproscincus mustelina*). The eight other species, the Red-throated Skink (*Acritoscincus platynotus*), Cunningham's Spiny-tailed Skink (*Egernia cunninghami*), Eastern Water Skink (*Eulamprus quoyii*), Greater Bar-sided Skink (*E. tenuis*), Dark-flecked Garden Sunskink (*Lampropholis delicata*), Pale-flecked Garden Sunskink (*L. guichenoti*), White's Skink (*Liopholis whitii*), and Eastern Blue-tongued Skink (*Tiliqua scincoides*), also were found beneath dumped materials but were more frequently detected basking or active during the day. Skinks exploited a diverse range of dumped materials with no clear preferences.

Two other skinks, the Elegant Snake-eyed Skink (*Cryptoblepharus pulcher*) and Yellow-bellied Three-toed Skink (*Saiphos equalis*), also were found in the study area but never beneath dumped materials. The former was frequently observed active on natural and man-made walls, whereas the latter was occasionally found beneath fallen logs (Mo 2022).

Family Elapidae.—We found five species of elapids in the study area, with individuals of each species found beneath dumped materials (Fig. 6). Red-naped Snakes (*Furina diadema*) were exclusively found beneath corrugated iron and plastic sheets (Mo 2019a). At one site, at least one Red-naped Snake was found whenever the same sheet of corrugated iron was lifted (Mo 2019b). We found only one Golden-crowned Snake (*Cacophis squamulosus*) in a retreat under a discarded tractor tire. Yellow-faced Whipsnakes (*Demansia psammophis*) were found most frequently beneath corrugated iron and plastic sheets and less frequently beneath rocks; we cnountered only two active individuals. Red-bellied Blacksnakes (*Pseudechis porphyriacus*) and Eastern Brown Snakes (*Pseudonaja textilis*) were more frequently found basking or active but were occasionally found in refugia beneath

Figure 5. Skinks (Family Scincidae) found in the study area beneath dumped materials: Red-throated Skink (*Acritoscincus platynotus*) (A), Eastern Striped Skink (*Ctenotus robustus*) (B), Copper-tailed Skink (*C. taeniolatus*) (C), Cunningham's Spiny-tailed Skink (*Egernia cunninghami*) (D), Eastern Water Skink (*Eulamprus quoyii*) (E), Greater Bar-sided Skink (*E. tenuis*) (F) (continued on next page).

disused wooden slats and discarded carpets. Juveniles of both species were detected solely by lifting dumped materials.

Family Typhlopidae.—The Blackish Blindsnake (*Anilios nigrescens*) was the only typhlopid found in the study area and was detected exclusively beneath dumped materials (Fig. 7), typically sheets of corrugated iron, tiles, or plastic sheets (Mo 2019a).

Order Anura

Over the same 17-year period, we have found all 13 of the species of anurans recorded in the study area on the iNaturalist database (iNaturalist 2024; Table 1). Nine of the 13 species in three families (Hylidae, Limnodynastidae, and Myobatrachidae) were detected by turning over dumped materials.

Family Hylidae.—Five species of hylids, the Australian Green Treefrog (*Ranoidea caerulea*), Broad-palmed Rocket Frog (*Litoria latopalmata*), Peron's Treefrog (*L. peronii*), Screaming Treefrog (*L. quiritatus*), and Verreaux's Frog (*L. verreauxii*) (Fig. 8), were found beneath a diverse range of dumped materials with no apparent preferences. All also were readily found at night by spotlighting, and Australian Green Treefrogs and Verreaux's Frogs occasionally were found beneath loose rocks and natural logs.

Two other hylids, Eastern Dwarf Treefrogs (*L. fallax*) and Tyler's Treefrogs (*L. tyleri*), also were found in the study area but never beneath dumped materials. These species were regularly sighted by spotlighting at night or during the day near watercourses (Mo 2022).

Family Limnodynastidae.—Two species of Australian groundfrogs, the Striped Marsh Frog (*Limnodynastes peronii*) and Spotted Marsh Frog (*L. tasmaniensis*), were found beneath dumped materials (Fig. 9). Similar to the treefrogs, both used a diverse range of materials with no clear preferences. They also were readily found at night by spotlighting and from lifting loose rocks and natural logs.

Three other groundfrogs, the Eastern Banjo Frog (*L. dumerilii*), Coastal Banjo Frog (*L. superciliaris*), and Ornate

Figure 5 (cont.). Skinks (Family Scincidae) found in the study area beneath dumped materials:, Dark-flecked Garden Sunskink (*Lampropholis delicata*) (G), Pale-flecked Garden Sunskink (*L. guichenoti*) (H), White's Skink (*Liopholis whitii*) (I), Weasel Skink (*Saproscincus mustelina*) (J), and Eastern Blue-tongued Skink (*Tiliqua scincoides*) (K). Photographs by Matthew Mo.

Burrowing Frog (*Platyplectrum ornatum*), also were found in the study area but never beneath dumped materials. Both species were regularly sighted by spotlighting paddocks and woodland areas (Mo 2022). These frogs typically excavate underground burrows (Knight 2013; Robinson and Thomson 2016), which would explain our inability to detect them by turning over dumped materials and natural ground debris.

Family Myobatrachidae.—Two species of Australian waterfrogs were found beneath dumped materials (Fig. 10), Smooth Toadlets (*Uperoleia laevigata*) exclusively under discarded wooden boards, whereas the Common Eastern Froglet (*Crinia signifera*) was found under a diverse range of materials with no clear preferences. Both species also were detected at night by spotlighting.

Discussion

This study demonstrates that dumped materials are being used as refugia by a large proportion (29 of 39 species, 74%) of herpetofauna detected in our study area. Considering the threat that firewood collection and bushrock removal poses to habitat viability for herpetofauna (Balaji et al. 2014; Michael et al. 2018, 2021; O'Sullivan et al. 2023), materials dumped in natural areas provide artificial refugia that somewhat compensate for losses of natural alternatives. This benefit is ironic considering the triple-bottom-line impacts associated with dumping human refuse in natural areas (Limoli et al. 2019; Vaverková et al. 2019; Cahill 2020). Although the introduction of these materials into the environment is not intended for the benefit of herpetofauna, these scenarios mirror some conservation strategies for threatened herpetofauna that involve placement

Figure. 6. Elapids (Family Elapidae) found in the study area beneath dumped materials: Golden-crowned Snake (*Cacophis squamulosus*) (A), Yellow-faced Whipsnake (*Demansia psammophis*) (B), Red-naped Snake (*Furina diadema*) (C), Red-bellied Blacksnake (*Pseudechis porphyriacus*) (D), and Eastern Brown Snake (*Pseudonaja textilis*) (E). Photographs by Matthew Mo.

Figure 7. A Blackish Blindsnake (*Anilios nigrescens*), the only species of blindsnake (Family Typhlopidae) found in the study area. Photograph by Matthew Mo.

of artificial refugia in some habitats (e.g., Zappalorti and Reinert 1994; Pereira-Ribeiro et al. 2017; Cowan et al. 2021).

Despite the many negative aspects of dumped materials, this study reinforces results of other studies (e.g., Glorioso and Waddle 2014; Čeirāns and Nikolajeva 2017; Madani et al. 2023) showing how such materials can be advantageously leveraged for detecting herpetofauna. Among the species found under dumped materials, three species of snakes, the Red-naped Snake, Golden-crowned Snake, and Blackish Blindsnake, were found exclusively under dumped materials. At other localities, we have found Golden-crowned Snakes to be readily detectable by spotlighting (M. Mo and E. Mo, unpubl. data); however, biodiversity records in the Atlas of Living Australia (2024) indicate that this species is very uncommon within our study area, explaining why we detected only one individual, which we would have missed if we had not searched beneath dumped materials. Although we did not maintain detailed count records for this study, two other species, the Yellow-faced Whipsnake and Smooth Toadlet, were detected primarily under dumped materials. Thus, the availability of such artificial refugia played an important role in the detection of these species.

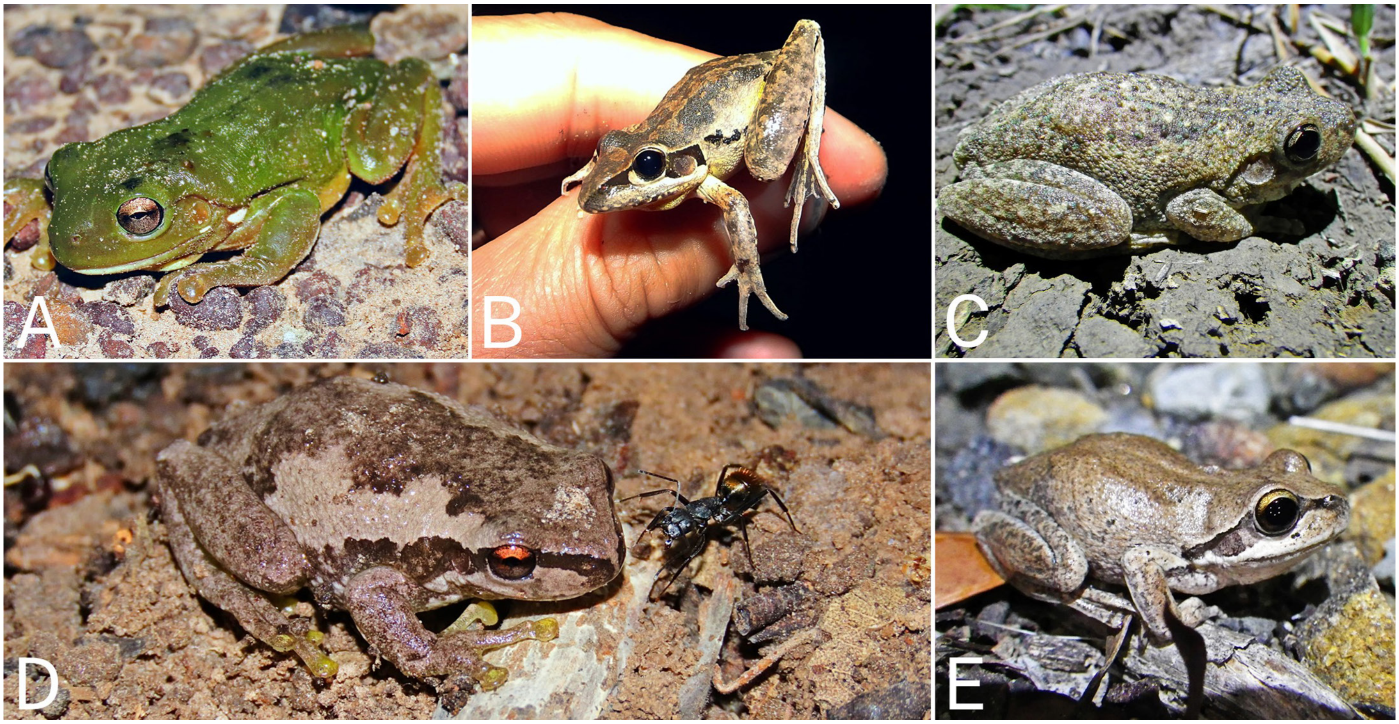

Figure 8. Treefrogs (Family Hylidae) found in the study area beneath dumped materials: Australian Green Treefrog (*Ranoidea caerulea*) (A), Broad-palmed Rocket Frog (*L. latopalmata*) (B), Peron's Treefrog (*L. peronii*) (C), Screaming Treefrog (*L. quiritatus*) (D), and Verreaux's Frog (*L. verreauxii*) (E). Photographs by Matthew Mo.

Figure 9. Australian groundfrogs (Family Limnodynastidae) found in the study area beneath dumped materials: Striped Marsh Frog (*Limnodynastes peronii*) (A), and Spotted Marsh Frog (*L. tasmaniensis*) (B). Photographs by Matthew Mo.

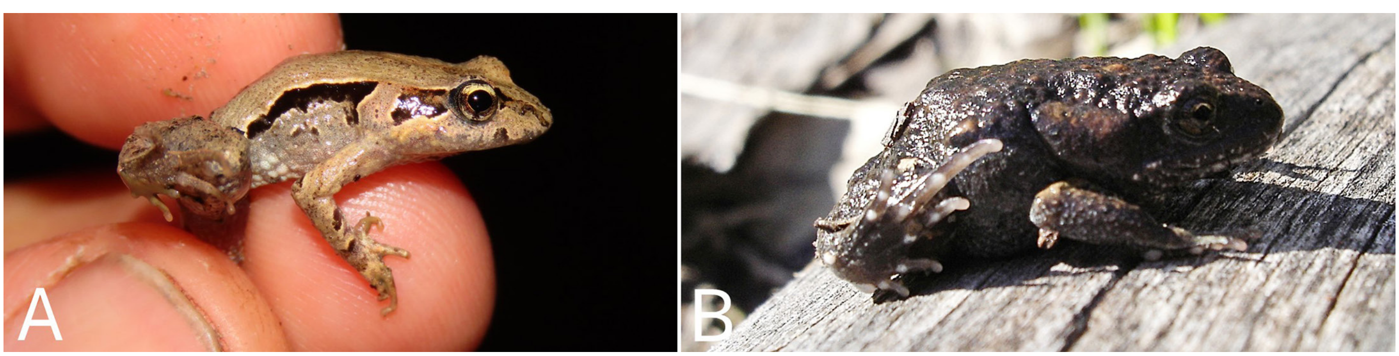

Figure 10. Australian waterfrogs (Family Myobatrachidae) found in the study area beneath dumped materials: Common Eastern Froglet (*Crinia signifera*) (A), and Smooth Toadlet (*Uperoleia laevigata*) (B). Photographs by Matthew Mo.

Acknowledgements

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