STIRLING RANGE POST-FIRE THREATENED INVERTEBRATE SURVEY REPORT

TARGETED RECONNAISSANCE SURVEY AND POST-FIRE IMPACT ASSESSMENT FOR THREATENED AND ENDEMIC INVERTEBRATES IN THE EASTERN STIRLING RANGE

Report prepared for

Department of Biodiversity Conservation and Attractions, Parks and Wildlife Service Albany

May 2021

Photo K. Bain: *Bertmainius colonus* closing her burrow door, Ellen Peak January 2021

Compiled by Dr. Karlene Bain, Python Ecological Services

Dr. Mark Harvey WA Museum

Sarah Comer, Department of Biodiversity Conservation and Attractions

Deon Utber, Department of Biodiversity Conservation and Attractions

Disclaimer

Citation

Bain, K., Harvey, M., Utber, D., Comer, S. (2021). *Stirling Range post-fire threatened invertebrate survey report. Targeted reconnaissance survey and post-fire impact assessment for threatened and endemic invertebrates in the eastern Stirling Range National Park*. Report prepared for Department of Biodiversity Conservation and Attractions, Parks and Wildlife Service Albany. Published by Published by Python Ecological Services, Walpole Western Australia, March 2021.

Contact

Dr. Karlene Bain
Python Ecological Services
PO Box 355 Walpole WA 6398 Email: draconis@wn.com.au

1. Background

The Stirling Range National Park (SRNP) contains a large number of threatened invertebrates, many of which have highly restricted distributions (short-range endemics) and occupy mesic habitats that are becoming more vulnerable due to drying climatic conditions. A large proportion of the SRNP was affected by bushfires in May 2018 and December 2019. In both instances, the fires burnt with an intense fire behaviour within southern facing slopes, gullies and montane peaks that are known to be home to threatened invertebrates (Harvey and Rix 2019).

In most cases, 80-100% of the distribution of these species was burnt during these two fire events and for some species, the entire extent of their known distribution was exposed to high-intensity fire. It is possible that the fires have caused the extinction of some of these species, and it is important that post-fire surveys are conducted thoroughly to document the impact of the fires and to provide an ability to track recovery or local extinctions as the fire-affected areas recover.

2. Survey Objectives

i. Assess the impact of the 2018 and 2019 bushfires on the persistence of known populations and availability of potential habitat for short-range endemic, threatened and conservation significant invertebrates in the SRNP in areas bounded by Toolbrunup Peak and Ellen Peak.

ii. Establish baseline data relating to area of occupancy and population demography parameters.

iii. Identify opportunities and parameters for a quantitative monitoring program for these taxa, to enable long-term assessment of population recovery and species trends.

3. Methods

3.1 Survey area

Surveys were undertaken within areas of the eastern Stirling Range National Park that were affected by the May 2018 and December 2019 fires. Toolbrunup Peak was the western-most area surveyed and Ellen Peak was the eastern-most area surveyed. Areas surveyed were those that contained either known occurrences of threatened and/or endemic invertebrates prior to the fires, or potentially suitable habitat for these (Figure 1).

Surveys systematically targeted habitat niches known to be critical for each of the target species, within the 2018 and 2019 fire -affected areas. Data that were used to identify these habitat niches included:

- Known locations of threatened and endemic invertebrates, sourced from the most up to date versions of the Western Australian Museum (WAM) collection database and the Department of Biodiversity Conservation and Attractions (DBCA) threatened fauna records (DBCA 2020, WAM 2020).
- Predictive models that identified areas in the South Coast Natural Resource Management Region most likely to contain mesic habitat suitable for short range endemic taxa (Neville 2002)
- Published literature such as taxonomic and ecological reference papers.
- Conservation Advice published online by the Threatened Species Scientific Committee (*Environment Protection and Biodiversity Conservation Act 1999, EPBC Act*).
- Recovery Plans and Interim Recovery Plans relevant to the area and/ or species.
- Unpublished reports available publicly.
- South Coast Threatened Invertebrate Recovery Team members.

A total of 192 km of traverses were walked through potential habitat across 17 survey areas (Table 1, Figure 1). A minimum of 10 rock and 10 sedge/ litter sites were sampled in each survey area, with the exception of those that were targeting host plants for insects and those that did not have these microhabitats present across a sufficient area for the intended replication. Within the sample sites 12 rocks, or 10 individual sedges and 10 litter samples contributed to a single pooled sample.

In total, 150 rock sites and 132 sedge/ litter sites were formally sampled between October 2020 and January 2021, and 85 rock sites and 70 sedge/ litter sites were sampled between April and May 2021. Additional micro-niches were searched opportunistically where they were encountered, e.g. clay banks, rock crevices, water seepages, logs, etc. The survey was designed to provide sufficient spatial replication of survey effort within each micro-niche to account for natural variability and un-identified influences on distribution and abundance of the target species.

Table 1: Survey effort for target species between October 2020 and May 2021

Date	Survey Area	Length of traverse (km)
27/10/2020	Mt Success	6.96
30/10/2020	Wedge Hill	7.79
31/10/2020	Kyanorup Eminence	8.56
17/11/2020	Yungermere East Gully	4.48
17/11/2020	Mt Success lowlands	6.98
18/11/2020	Mt Hassell lowlands	1.72
18/11/2020	Papa Colla Creek	8.96
18/11/2020	Ongarup lowlands	2.34
19/11/2020	Coyanarup Gully	8.48
20/11/2020	Yungermere	9.41
15/12/2020	Mt Hassell	5.71
16/12/2020	Toolbrunup	9.15
29/12/2020	Moongoongoonderup	5.27
13/01/2021	Bakers Knob	7.49
14/01/2021	Pyungorup Gully	7.55
15/01/2021	Pyungorup Peak/ Ellen Peak	10.65
22/01/2021	Bluff/ Cascades	8.97
28/01/2021	Ellen Peak Watershed	9.31
28/04/2021	Pyungorup and Ellen Peak	10.65
29/04/2021	Yungermere	9.11
7/05/2021	Toolbrunup	8.55
8/05/2021	Pyungorup Gully	7.33
9/05/2021	Moongoongoonderup	7.87
10/05/2021	Mt Hassell	6.73
11/05/2021	Wedge Hill	8.25
14/05/2021	Cascades/ Bluff Knoll	9.36
15/05/2021	Coyanarup Gully	4.72

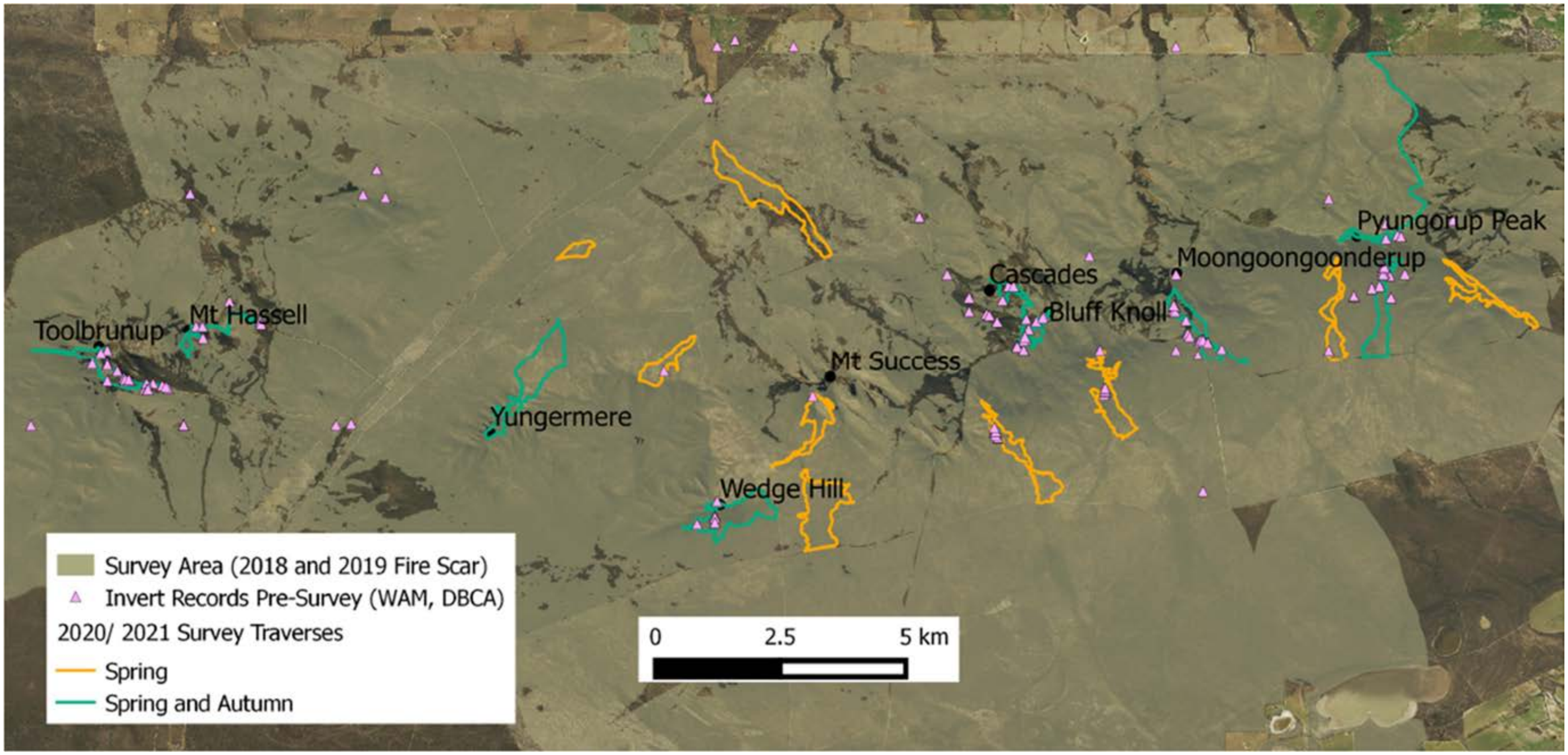


Figure 1: **Broad survey area, including known locations for target invertebrates (WAM 2020, DBCA 2020) and traverses surveyed between 27 October 2020 and 15 May 2021.**

3.2 Target Species

Species that were the focus for the surveys included invertebrates that are listed as threatened as well as non-listed endemic invertebrates that occur within the May 2018 or December 2019 fire-affected areas of the Stirling Range National Park (Table 2, Figure 1). Of the 40 target species, 39 had 100 % of their known distribution affected by the 2018/ 2019 fires (Table 2).

Table 2: Target species, conservation status, current known distribution and proportion of habitat affected by the May 2018 and December 2019 fires. Target species are ordered alphabetically within their taxonomic group (spiders, pseudoscorpions, harvestmen, millipedes, onychophorans, snails and insects). Conservation status is presented both for Western Australia (*Biodiversity Conservation Act 2016*) and the Commonwealth (*Environment Protection and Biodiversity Conservation Act 1999*) (P1 of 4).

Family	**Scientific Name**	**BC Act**	**EPBC Act**	**Current known locations**	**Proportion known records affected by the May 2018 and Dec 2019 fires (%)**
SPIDERS					
Stiphidiidae	*Baiami `sp. nov'*	NL	NL	Bluff Knoll and Toolbrunup Peak	100
Migidae	*Bertmainius colonus*	VU	VU	Cascades, Coyanarup Peak, Bluff Knoll, Wedge Hill, South Isongerup Track, Pyungorup Peak, Ellen Creek	100
Migidae	*Bertmainius pandus*	CR	NL	A single gully on Toolbrunup	100
Physoglenidae	*Calcarsynotaxus benrobertsi*	NL	NL	Pyungorup Peak and Ellen Peak	100
Idiopidae	*Cataxia colesi*	NL	NL	Toolbrunup Peak and Mt Hassell	100
Idiopidae	*Cataxia sandsorum*	NL	NL	Pyungorup Peak	100
Idiopidae	*Cataxia stirlingi*	NL	NL	Bluff Knoll, Wedge Hill, Moongoongoonderup, South Isongerup	100
Selenopidae	*Karaops toolbrunup*	NL	NL	Toolbrunup Peak	100
Salticidae	*Maratus sarahae*	CR	NL	Bluff Knoll and Ellen Peak	100

Table 2: Target species, conservation status, current known distribution and proportion of habitat affected by the May 2018 and December 2019 fires (P2 of 4).

Family	Scientific Name	BC Act	EPBC Act	Current known locations	Proportion known records affected by the May 2018 and Dec 2019 fires (%)
SPIDERS Continued					
Malkaridae	*Perissopmeros darwini*	NL	NL	Bluff Knoll, Pyungoorup Peak and Ellen Peak	100
Pycnothelidae	*Stanwellia* \`MYG420\`	NL	NL	Cascades, Bluff Knoll, Wedge Hill, Ellen Peak	100
Anamidae	*Teyl* \`MYG636\`	NL	NL	Isongerup Track and Pyungorup Peak	100
Archaeidae	*Zephyrarchaea melindae*	VU	NL	Toolbrunup Peak and Mt Hassell	100
Archaeidae	*Zephyrarchaea robinsi*	VU	NL	Bluff Knoll, Pyungorup Peak, Ellen Peak	100
PSEUDOSCORPIONS					
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* ‘Harms sp. Stirling Range 1\`	NL	NL	Toolbrunup Peak	100
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* \`Harms sp. Stirling Range 2\`	NL	NL	Cascades, Bluff Knoll, Wedge Hill, Pyungorup, Ellen Peak	100
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* \`Harms sp. Stirling Range 3\`	NL	NL	Toolbrunup Peak, Mt Hassell, Mabinup Creek, Mt Trio	62
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* \`Harms sp. Stirling Range 5\`	NL	NL	Pyungorup Peak	100
Garypidae	*Synsphyronus apimelus*	NL	NL	Toolbrunup, Mt Hassell, Bluff Knoll	100
HARVESTMEN					
Neopilionidae	*Megalopsalis epizephryos*	NL	NL	Bluff Knoll	100

Table 2: Target species, conservation status, current known distribution and proportion of habitat affected by the May 2018 and December 2019 fires (P3 of 4).

Family	Scientific Name	BC Act	EPBC Act	Current known locations	Proportion known records affected by the May 2018 and Dec 2019 fires (%)
MILLIPEDES					
Siphonotidae	`*Hesperisiphon*` `*peckorum*`	NL	NL	Toolbrunup Peak	100
Paradoxosomatidae	*Antichiropus* `DIP075`	NL	NL	Bluff Knoll and Toolbrunup Peak	100
Iulomorphidae	*Atelomastix danksi*	VU	NL	Toolbrunup Peak and creek	100
Iulomorphidae	*Atelomastix montana*	NL	NL	Coyanarup Peak, Ellen Track, South Isongerup Track, Pyungorup Peak,	100
Iulomorphidae	*Atelomastix poustiei*	VU	NL	Wedge Hill	100
Iulomorphidae	*Atelomastix tigrina*	VU	NL	Cascades and the south face of Pyungorup Peak	100
Iulomorphidae	*Atelomastix tumula*	VU	NL	Bluff Knoll walk trail	100
Metopidiotrichidae	*Australeuma `sp.`*	NL	NL	Toolbrunup Peak, Pyungorup Peak	100
Iulomorphidae	*Samichus* `Eastern Stirling Ranges`	NL	NL	Cascades, Bluff Knoll, South Isongerup, Ellen Track (lowlands)	100
ONYCOPHORANS					
Peripatopsidae	*Kumbadjena* `ONY04`	NL	NL	Pyungorup Peak	100
Peripatopsidae	*Kumbadjena toolbrunupensis*	NL	NL	Toolbrunup Peak	100

Table 2: Target species, conservation status, current known distribution and proportion of habitat affected by the May 2018 and December 2019 fires (P4 of 4).

Family	Scientific Name	BC Act	EPBC Act	Current known locations	Proportion known records affected by the May 2018 and Dec 2019 fires (%)
SNAILS					
Bothriembryontidae	*Bothriembryon glauerti*	P2	NL	Toolbrunup, Bluff Knoll, Ellen Track, Moongoongoonderup, South Isongerup, Pyungorup, Ellen Peak	100
Rhytididae	`sp. WAM 2295-69/WAM S10992`	CR	NL	Toolbrunup lowlands, Mt Success, Bluff Knoll, Ellen Track, Moongoongoonderup Peak, Isongerup, Pyungorup Peak, Ellen Peak	100
aff. Helicarionidae	`sp. WAM S71330`	NL	NL	Toolbrunup Peak	100
INSECTS					
Psyllidae	*Acizzia hughesae*	NL	NL	Ongarup Creek lowlands (North-East Track)	100
Psyllidae	*Acizzia mccarthyi*	VU	NL	Papa Colla Creek	100
Psyllidae	*Acizzia* sp. nov. *Acacia awestoniana*	NL	NL	Papa Colla Creek,	100
Dictyopharidae	*Austrorgerius* sp. nov Ellen	NL	NL	Bluff Knoll, Pyungorup Peak and Ellen Peak	100
Chrysomelidae	*Cudnellia* sp. nov.	NL	NL	Bluff Knoll summit	100
Pseudococcidae	*Pseudococcus markharveyi*	CR	CR	Pyungorup and Bluff Knoll	100
Triozidae	*Trioza barrettae*	EN	NL	Toolbrunup lowlands, Mt Hassell, Yungermere	100

3.3 Survey strategies/ techniques

Survey strategies were selected to maximise detection of target species and were non-lethal due to the threatened status of many of the species being surveyed, and the recent intense level of disturbance that populations have been exposed to (Table 3). As a standard across all species, a GPS track of the survey traverses was saved, GPS coordinates were captured for microhabitats surveyed (e.g. individual host plants, creek banks, sedge and rock samples), a uniquely identified GPS point was captured for all occupied sites, and this identifier was used to link the relevant geodata with images of habitat, images of target species, descriptions of habitat and site level species data (counts, age classes, burrow diameters etc) in the data spreadsheet. All sampling was completed under Scientific or Other Prescribed Purposes Licence number FO25000006-11 issued to the Western Australian Museum, with the author added to the list of WA Museum Staff and Research Associates for inclusion on the licence; and Regulation 4 Lawful Authority to drive a vehicle and take fauna within the Stirling Range National Park, issued October 2020.

Table 3: Targeted survey strategies and techniques for maximising detection of the target species and documenting baseline data relating to relevant population parameters (P1 of 7).

Family	**Target species**	**Selected survey strategy**	**Optimal survey timing**
SPIDERS			
Stiphidiidae	*Baiami `sp. nov'*	Crevices in or under soil banks, logs, stumps, or rocks were targeted in a search for the spider's horizontal sheet web of cribellate silk extending out from its retreat funnel (Gray 1981). All sheet webs were examined for occupants and counted if there was a living spider or spider remains consistent with *Baiami.*	Spring and autumn when environmental moisture is present.
Migidae	*Bertmainius colonus, Bertmainius pandus*	Searches were undertaken within moist creek banks, moist clay soils beneath tree root zones, and moist soil pockets beneath rock crags for small burrows that are capped with a thin lid that retains moisture and keeps out predators such as ants (Main 1991). Where encountered, active burrows were counted in an area 10 m along the creek bank and from the creek bed to a height of 2 m where safely accessible (2mx10m strip). The internal diameter of the burrow entrance was measured using a small tape measure. Defunct burrows were counted only where door remnants were still present (i.e. freshly defunct).	Burrows easier to see if door is slightly ajar during moist conditions. Males wander during autumn.
Physoglenidae	*Calcarsynotaxus benrobertsi*	Foliage of sedges (*Lepidosperma sp.*) and low shrubs was beaten into a white tray, and any suspended material and ground litter collected into a large sieve, with leaf material and debris sieved into the white tray as well as being visually examined for invertebrates. 10 sedges or shrubs were targeted at each sample location. Animals found were collected, examined with a hand lens, identified, photographed, and released.	Spring and autumn when environmental moisture is present.

Table 3: Targeted survey strategies and techniques for maximising detection of the target species and documenting baseline data relating to relevant population parameters (P2 of 7).

Family	Target species	Selected survey strategy	Optimal survey timing
SPIDERS Continued			
Idiopidae	*Cataxia colesi, Cataxia sandsorum, Cataxia stirlingi*	Searches were undertaken within mesic habitats and montane heathland for small palisade burrows with a fully open hole, no door, and adornment of a radial skirt of leaves and twigs (Rix *et al.* 2018). Where encountered, active burrows were counted and the internal diameter at the entrance of all active burrows was measured (using calipers and tape measure). Burrows were counted and measured in an area 1 m either side of a 10 m walked traverse (2mx10m strip) commencing from the first burrow detected. Age classes were assigned based on the internal diameter of the burrow entrances <3 mm recruits, 3-6 mm juvenile, 7-11 mm adult, >12 mm matriarch (Bain and Main 2004). Burrows sealed with silk and leaf material were counted as aestivating spiders, with no attempt made to measure the burrow diameter.	Burrows can be sealed with leaf material during summer if spiders are aestivating, which can make them less detectable during this period.
Selenopidae	*Karaops toolbrunup*	Searches were undertaken beneath rocks on the Toolbrunup scree slope. A minimum of 12 rocks were targeted at each site and any animals found beneath were collected, examined with a hand lens, identified, photographed, and released.	Spring and autumn when environmental moisture is present.
Salticidae	*Maratus sarahae*	Foliage of sedges (*Lepidosperma sp.*) and low shrubs was beaten into a white tray, and any suspended material and ground litter collected into a large sieve, with leaf material and debris sieved into the white tray as well as being visually examined for invertebrates. 10 sedges or shrubs were targeted at each sample location. Animals found were collected, examined with a hand lens, identified, photographed, and released.	Spring and autumn when environmental moisture is present.
Malkaridae	*Perissopmeros darwini*	Foliage of sedges (*Lepidosperma sp.*) and low shrubs was beaten into a white tray, and any suspended material and ground litter collected into a large sieve, with leaf material and debris sieved into the white tray as well as being visually examined for invertebrates. 10 sedges or shrubs were targeted at each sample location. Animals found were collected, examined with a hand lens, identified, photographed, and released.	Spring and autumn when environmental moisture is present
Pycnothelidae	*Stanwellia `MYG420`, Stanwellia `MYG634`*	Searches were undertaken in soil pockets within rock crevices and within clay banks for silk lined open-holed burrows, often with thin strands of silk around the opening. Where encountered, burrows were counted and the internal diameter of the burrow entrance of active burrows was measured for all burrows in an area 10 m along the habitat feature and from the ground to a height of 2 m (where safe to access) (2mx10m strip).	Detectable throughout the year.

Table 3: Targeted survey strategies and techniques for maximising detection of the target species and documenting baseline data relating to relevant population parameters (P3 of 7).

Family	Target species	Selected survey strategy	Optimal survey timing
SPIDERS Continued			
Anamidae	*Teyl `MYG636`*	Searches were undertaken for open-holed large burrows in sandy soils. Where encountered, burrows were counted, and the internal diameter of the burrow entrance measured for all active burrows in an area 1 m either side of a 10 m walked traverse commencing from the first burrow detected (2mx10m strip)	Detectable throughout the year.
Archaeidae	*Zephyrarchaea melindae, Zephyrarchaea robinsi*	Foliage of sedges (*Lepidosperma sp.*) and low shrubs was beaten into a white tray, and any suspended material and ground litter collected into a large sieve, with leaf material and debris sieved into the white tray as well as being visually examined for invertebrates. 10 sedges or shrubs were targeted at each sample location. Animals found were collected, examined with a hand lens, identified, photographed, and released.	Spring and autumn when environmental moisture is present.
HARVESTMEN			
Neopilionidae	*Megalopsalis epizephryos*	Foliage of sedges (*Lepidosperma sp.*) and low shrubs was beaten into a white tray, and any suspended material and ground litter collected into a large sieve, with leaf material and debris sieved into the white tray as well as being visually examined for invertebrates. 10 sedges or shrubs were targeted at each sample location. Animals found were collected, examined with a hand lens, identified, photographed, and released.	Spring and autumn.
PSEUDOSCORPIONS			
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* 'Harms sp. Stirling Range 1, 2, 3 and 4	Microhabitats were searched opportunistically including moist leaf litter, low vegetation, topsoil humus layer and beneath rocks (Pers com. Mark Harvey 2020). These species were also targeted during formal sedge/ litter and rock samples. At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. Any animals found were collected, examined with a hand lens, identified, photographed, and released.	Autumn to spring when environmental moisture is present.
Garypidae	*Synsphyronus apimelus*	Rocks were targeted for survey on the Toolbrunup scree slope. A minimum of 12 rocks were searched at each site and any animals found beneath collected, examined with a hand lens, identified, photographed, and released.	Autumn to spring when environmental moisture is present.

Table 3: Targeted survey strategies and techniques for maximising detection of the target species and documenting baseline data relating to relevant population parameters (P4 of 7).

Family	Target species	Selected survey strategy	Optimal survey timing
MILLIPEDES			
Iulomorphidae	*Atelomastix danksi, A.montana, A. poustiei, A. tigrina, A. tumula, Samichus `Eastern Stirling Ranges`*	Searches were opportunistically undertaken under logs, bark, under rocks and in leaf litter. These species were also targeted during formal sedge/ litter and rock samples. At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. All animals found were collected, examined with a hand lens, photographed, and released.	Most mobile after the first rains in autumn (dispersal). Males active autumn to spring. Dormant in driest periods (Edward and Harvey 2010).
Metopidiotrichidae	*Australeuma `sp.`*	Searches were undertaken under logs, bark, under rocks and in leaf litter. Leaf material and humus were collected into a large sieve and sieved into a white tray as well as being visually examined for invertebrates. At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. All animals found were collected, examined with a hand lens, photographed, and released.	Autumn to spring when a high level of environmental moisture is present
Paradoxosomatidae	*Antichiropus* `DIP075`	Searches were undertaken under logs, bark, under rocks and in leaf litter, especially in shrubland and forest. Leaf material and humus were collected into a large sieve and sieved into a white tray as well as being visually examined for invertebrates. At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. All animals found were collected, examined with a hand lens, photographed, and released.	Autumn to spring when a high level of environmental moisture is present.
Siphonotidae	*`Hesperisiphon` `peckorum`*	Searches were undertaken under logs, bark, under rocks and in leaf litter, especially in areas where fungi/ mushroom litter was present. Leaf material and humus were collected into a large sieve and sieved into a white tray as well as being visually examined for invertebrates. At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. All animals found were collected, examined with a hand lens, photographed, and released.	Autumn to spring when a high level of environmental moisture and fungal fruiting bodies are present.

Table 3: Targeted survey strategies and techniques for maximising detection of the target species and documenting baseline data relating to relevant population parameters (P5 of 7).

Family	Target species	Selected survey strategy	Optimal survey timing
ONYCHOPHORANS			
Peripatopsidae	Kumbadjena toolbrunupensis, Kumbadjena `ONY04`	Searches were undertaken under logs, bark, within rotten material in log crevices, under rocks and in leaf litter. Leaf material and humus were collected into a large sieve and sieved into a white tray as well as being visually examined for invertebrates. At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. All animals found were collected, examined with a hand lens, photographed, and released.	Autumn to spring when a high level of environmental moisture is present.
SNAILS			
Bothriembryontidae	*Bothriembryon glauerti*	Searches were undertaken under logs, bark, within rotten material in log crevices, under rocks and in leaf litter. Leaf material and humus were collected into a large sieve and sieved into a white tray as well as being visually examined for invertebrates. At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. All animals found were collected, examined with a hand lens, photographed, and released.	Autumn to spring when a high level of environmental moisture is present.
Rhytididae	`sp. WAM 2295-69/WAM S10992`	Searches were undertaken under logs, bark, within rotten material in log crevices, under rocks and in leaf litter. Leaf material and humus were collected into a large sieve and sieved into a white tray as well as being visually examined for invertebrates. At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. All animals found were collected, examined with a hand lens, photographed, and released.	Autumn to spring when a high level of environmental moisture is present.
aff. Helicarionidae	`sp. WAM S71330`	Searches were undertaken under logs, bark, within rotten material in log crevices, under rocks and in leaf litter. Leaf material and humus were collected into a large sieve and sieved into a white tray as well as being visually examined for invertebrates. At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. All animals found were collected, examined with a hand lens, photographed, and released.	Autumn to spring when a high level of environmental moisture is present.

Table 3: Targeted survey strategies and techniques for maximising detection of the target species and documenting baseline data relating to relevant population parameters (P6 of 7).

Family	Target species	Selected survey strategy	Optimal survey timing
INSECTS			
Psyllidae	*Acizzia hughesae, Acizzia mccarthyi*	Searches were undertaken for host plants *A. hughesae (Grevillea sp. Stirling Range), A. mccarthyi* and *A. veski* (*Acacia veronica*). The host species were not found within the scope of this survey (all defoliated), however where present, a small vacuum would be used to collect insects from the plants (Moir *et al.* 2005). Beating can also be used for *A. mccarthyi* and this was the preferred technique intended to be applied for this species due to the destructive nature of vacuum sampling.	Spring and summer.
Psyllidae	*Acizzia sp. nov. Acacia awestoniana*	Searches were undertaken for host plants *(Acacia awestoniana)*. Where these were encountered, the stems, underside of leaves, flowerheads and new growth were inspected visually using a hand lens (Pers com. Melinda Moir 2020). Up to 35 unburnt plants, 12 burnt plants and 20 seedlings were surveyed at each site, with 3 minutes spent searching per individual mature plant, and 1 minute per seedling. All individuals sighted within this period were counted. Nymphs were differentiated from adults in the counts.	Spring and summer.
Dictyopharidae	*Austrorgerius* sp. nov Ellen	Foliage of sedges (*Lepidosperma sp.*) and low shrubs was beaten into a white tray, and any suspended material and ground litter collected into a large sieve, with leaf material and debris sieved into the white tray as well as being visually examined for invertebrates. 10 sedges or shrubs were targeted at each sample location. Animals found were collected, examined with a hand lens, identified, photographed, and released. Care was taken to watch for movement of small planthoppers that look like triangular seeds (Pers com. Melinda Moir 2020).	Spring and summer.
Chrysomelidae	*Cudnellia* sp. nov.	In areas where Ericaceae plants such as *Leucopogon, Sphenotoma, and Andersonia* were present, foliage of 10 plants was beaten into a white tray and the collection examined with a hand lens, with any invertebrates photographed and released. Plants were also visually examined. Vacuuming techniques were not used due to their lethal nature.	Spring and summer.

Table 3: Targeted survey strategies and techniques for maximising detection of the target species and documenting baseline data relating to relevant population parameters (P7 of 7).

Family	Target species	Selected survey strategy	Optimal survey timing
INSECTS Continued			
Pseudococcidae	*Pseudococcus markharveyi*	Searches were undertaken for host plants (*Banksia montana*). No unburnt plants were encountered, however where present, the survey technique for this species requires hand collection of insects directly from the plants, turning over leaves and searching the undersides, and within flowerheads and new growth (Pers com. Melinda Moir 2020). Counts for this species need to differentiate adults and nymphs and is possible capture the presence and abundance of egg sacs and parasitised individuals.	Late spring to autumn when adults are present.
Triozidae	*Trioza barrettae*	Searches were undertaken for host plants (*Banksia brownii*) and where found, the fine brown 'hairs' on the main stem, the underside of leaves and developing flowers were searched directly using a hand lens. Vacuuming using a small vacuum is the most effective method of collection of insects present. This technique was not used due to its lethal nature.	Spring and summer.

4. Results

4.1 Species summary

In two surveys (Spring and Autumn) undertaken between October 2020 and May 2021, 19 species of the 40 targeted were detected (Table 4). In all cases a high proportion of dead individuals were detected, and this was particularly the case in Spring 2020, when many species were dormant beneath the humus layer. Detailed species-specific data are presented in sections 4.2 to 4.8.

Table 4: Summary of detections (naïve occupancy and uncorrected estimates of abundance) for species targeted during the surveys (P1 of 3).

Family	Target Species	#occurrences found	#occurrences with live individuals	# Dead individuals	# Alive individuals
SPIDERS					
Stiphidiidae	*Baiami `sp. nov'*	12	8	28	59
Migidae	*Bertmainius colonus*	79	45	1037	114
Migidae	*Bertmainius pandus*	15	10	707	44
Physoglenidae	*Calcarsynotaxus benrobertsi*	0	0	0	0
Idiopidae	*Cataxia colesi*	15	12	27	144
Idiopidae	*Cataxia sandsorum*	17	17	32	117
Idiopidae	*Cataxia stirlingi*	54	46	152	324
Selenopidae	*Karaops toolbrunup*	0	0	0	0
Salticidae	*Maratus sarahae*	5	5	0	6
Malkaridae	*Perissopmeros darwini*	0	0	0	0
Pycnothelidae	*Stanwellia `MYG420`*	5	5	1	8
Anamidae	*Teyl `MYG636`*	17	17	0	22
Archaeidae	*Zephyrarchaea melindae*	0	0	0	0
Archaeidae	*Zephyrarchaea robinsi*	0	0	0	0

Table 4: Summary of detections (naïve occupancy and uncorrected estimates of abundance) for species targeted during the surveys (P2 of 3).

Family	Target Species	#occurrences found	#occurrences with live individuals	# Dead individuals	# Alive individuals
PSEUDOSCORPIONS					
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* ‘Harms sp. SR 1`	0	0	0	0
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* `Harms sp. SR 2`	0	0	0	0
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* `Harms sp. SR 3`	0	0	0	0
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* `Harms sp. SR 5`	0	0	0	0
Garypidae	*Synsphyronus apimelus*	3	3	0	4
HARVESTMEN					
Neopilionidae	*Megalopsalis epizephryos*	2	2	0	2
MILLIPEDES					
Iulomorphidae	*Atelomastix danksi*	27	18	89	537
Iulomorphidae	*Atelomastix montana*	29	10	270	183
Iulomorphidae	*Atelomastix poustiei*	13	3	171	48
Iulomorphidae	*Atelomastix tigrina*	25	13	119	90
Iulomorphidae	*Atelomastix tumula*	7	7	30	88
Iulomorphidae	*Samichus* `Eastern Stirling Ranges`	0	0	0	0
Metopidiotrichidae	*Australeuma `sp.`*	0	0	0	0
Paradoxosomatidae	*Antichiropus* `DIP075`	2	2	0	2
Siphonotidae	*`Hesperisiphon` `peckorum`*	0	0	0	0
ONYCHOPHORANS					
Peripatopsidae	*Kumbadjena toolbrunupensis*	0	0	0	0
Peripatopsidae	*Kumbadjena* `ONY04`	0	0	0	0

Table 4: Summary of detections (naïve occupancy and uncorrected estimates of abundance) for species targeted during the surveys (P3 of 3).

Family	**Target Species**	**#occurrences found**	**#occurrences with live individuals**	**# Dead individuals**	**# Alive individuals**
SNAILS					
Bothriembryontidae	*Bothriembryon glauerti*	69	17	242	72
Bothriembryontidae	*Bothriembryon brazieri*	14	6	26	19
Rhytididae	\`sp. WAM 2295-69/WAM S10992\`	0	0	0	0
aff. Helicarionidae	\`sp. WAM S71330\`	4	2	23	9
INSECTS					
Chrysomelidae	*Cudnellia* sp. nov.	0	0	0	0
Dictyopharidae	*Austrorgerius* sp. nov Ellen	0	0	0	0
Pseudococcidae	*Pseudococcus markharveyi*	0	0	0	0
Psyllidae	*Acizzia hughesae*	0	0	0	0
Psyllidae	*Acizzia mccarthyi*	0	0	0	0
Psyllidae	*Acizzia* sp. nov. *Acacia awestoniana*	9	7	0	1473
Triozidae	*Trioza barrettae*	0	0	0	0

4.2 Spiders

4.2.1 Baiami sp. nov

Baiami sp. nov is not currently listed as threatened under State or Commonwealth legislation but is known only from Bluff Knoll and Toolbrunup Peak from 15 records, 14 of which are dated September 1997 and occur on Toolbrunup Peak. One record dated May 2018 was found in the Bluff/Isongerup gully following the May 2018 fire (WAM 2020, DBCA 2020). The genus inhabits a retreat funnel that extends back into a hole or crevice in or under the soil bank, log, stump or rock from which they sling their sheet web (Gray 1981).

The genus *Baiami* was detected in 12 locations during the Spring 2020 and Autumn 2021 surveys and in eight of these locations, live individuals were recorded (Table 4, Figure 2). Those occurrences of *Baiami* on Toolbrunup Peak, Coyanarup Peak and Bluff Knoll/ Cascades are likely to be *Baiami sp. nov*. There are no recorded occurrences of the genus *Baiami* east of Moongoongoonderup Hill, which means the new records from Bakers Knob, Pyungorup Peak and Ellen Peak are potentially of interest. A specimen should be collected when conditions are dry enough to access the habitat. A closer investigation of the male palps is required to confirm identification. It was not possible to collect a male from these sites during the autumn survey to confirm species level identification, due to fast flowing water and slippery rocks.

Individuals of *Baiami* were most abundant on Toolbrunup Peak and Pyungorup Peak, where they had slung their sheet webs below an overhanging rock in a shaded and moist rocky crag (Figure 3). Only sheet webs with spider remains still within them were counted as dead individuals due to the potential risk of mis-identification of the species solely from web remains.

Table 4: Summary of detections for *Baiami* during the 2020/ 2021 surveys

Mountain	# Sites	#Sites with survivors	Dead	Alive	Comments relating to habitat
Toolbrunup	1	1	0	20	Rock Cairn in gully. Located by M. Harvey in May 2021
Coyanarup	2	0	4	0	Rocky slope adjacent to flowing creek and beneath marri/sheoak open woodland.
Bakers Knob	1	0	1	0	Dry clay bank on edge of dry creek bed.
Pyungorup Gully	4	3	19	24	Dry clay wall of gully adjacent to dry creek and shaded marri woodland within gully. In rock crevices. Spiders in retreats against the rock.
Bluff Knoll/ Cascades	2	2	2	10	Moist shaded clay bank adjacent to dry creek. Webs under rock with retreat up to rock.
Ellen Peak	2	2	1	5	Beneath rock in dry creek bed near summit

Figure 2: Locations of *Baiami sp.* detected during the 2020/ 2021 survey.

Figure 3: *Baiami sp.* detected in the upper gully of Pyungorup Peak, January 2021.

4.2.2 Bertmainius colonus

Bertmainius colonus is currently listed as vulnerable (VU) under the State's *Biodiversity Conservation Act 2016 (BC Act)*, and under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). The species is known to occur in shaded gullies and creek lines on the eastern massif (Harvey *et al.* 2015, Harvey and Rix 2019). Prior to this survey the species was known from 63 records (lodged specimens) dated April 2004 and March 2005, which were documented during surveys in 14 locations associated with the Cascades, Coynarup Peak, Wedge Hill, South Ellen Track, Moongoongoonderup Peak and Pyungorup Peak (WAM 2020). In addition, five active burrows were detected in the gullies south of Coyanarup (2 burrows) and Isongerup Peak (3 burrows) in March 2019, following the 2018 fire (Harvey and Rix 2019). The survey procedures and sites surveyed during the 2004/ 2005 and 2019 survey are not standardised and occurred across a smaller survey area than that surveyed in 2020, which makes it challenging to compare temporal and spatial data from the 2020/ 2021 surveys.

During the 2020/ 2021 surveys, *B. colonus* was detected in 79 locations and in 45 of these locations, small numbers of surviving individuals were recorded (Table 5, Figure 4). The species was detected in gullies and micro-niches associated with Yungermere, Wedge Hill, Mt Success, Kyanorup Eminence, Cascades and Bluff Knoll, Coyanarup Peak, Moongoongoonderup Peak, Bakers Knob, Pyungorup Peak and Ellen Peak (Figures 4 and 5). This is a larger area of occupancy than previously documented for this species, due to a broader survey effort.

Surviving spiders of *B. colonus* were most abundant on Mt Success, Kyanorup Eminence, Bluff Knoll (Cascades), Moongoongoonderup Peak, Bakers Knob, and Ellen Peak. Sites where the species was detected included moist and/ or mossy soil in rock crevices beneath large rocky crags, and in moist and shaded clay banks where active burrows occurred beneath roots or rocks that were stabilizing the bank and capturing moisture (Figure 5). A large proportion of the sites where this species was detected had suffered desiccation and erosion as a result of vegetation loss and water movement, and a high proportion of mortalities were detected (Figure 6). Overall, there were 1151 individuals of *B. colonus* detected during this survey, of which 114 (10 %) were alive. Further mortalities are likely to occur over winter if heavy rainfall events and further erosion events are prevalent.

In most cases, surviving spiders detected were larger adult spiders. Juvenile burrows were conspicuously defunct with burrow doors hanging open and burrows empty. The locations where juveniles were still present were those that had burnt in the less intense fire in May 2018 (e.g. Ellen Peak Gully) or those where occupied banks occurred within deeply incised sections of lowland creeks (e.g. Moongoongoonderup lowlands). In all cases where defunct burrows were counted, only those that were recently defunct (i.e. still had doors attached or fresh silk around the burrow entrance) and were clearly identifiable as *Bertmainius* were counted. These burrows are likely to have become defunct following the fire rather than during, given the presence of unburnt silk on the doors. The counts of dead spiders are therefore likely to be conservative, given a large number of spiders are expected to have died during the fire and their burrows may not have been viewed as recently defunct using the above definition.

Table 5: Summary of detections (counted and measured burrows) for *B. colonus* during the 2020/ 2021 survey.

Only positive detections are presented for 2020/2021 data (areas where the species was surveyed and burrows absent are not presented here). Only active burrows were measured to determine the likely age class of their occupant.

Mountain	# Sites	#Sites with survivors	Recently Dead 2020	Alive 2020	Matriarch (>6mm)	Adult (4-6mm)	Juvenile (2-3mm)	Recruit (1mm)
Yungermere	5	1	41	1	0	1	0	0
Wedge Hill	8	4	45	6	5	1	0	0
Mt Success	22	8	420	18	5	12	1	0
Kyanorup Eminence	10	5	153	12	8	4	0	0
Bluff Knoll/ Cascades	10	10	136	32	9	23	0	0
Coyanarup Peak	6	2	31	2	1	1	0	0
Moongoongoonderup	7	7	102	20	6	12	2	0
Bakers Knob	3	2	29	9	5	4	0	0
Pyungorup	4	2	32	2	0	2	0	0
Ellen Peak	4	4	48	12	4	8	3	0

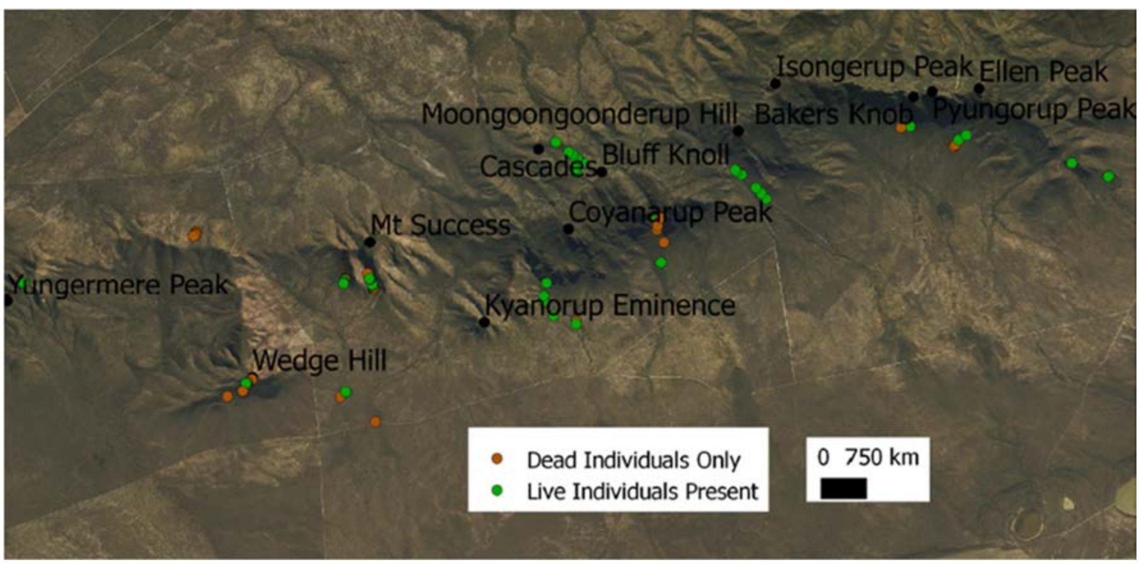


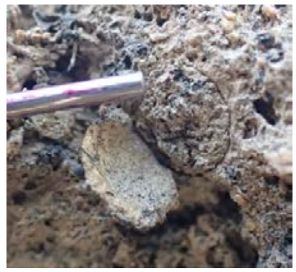
Figure 4: Locations of *B. colonus* detected during the 2020/ 2021 survey.

Mt Success - Shaded clay bank adjacent to creek

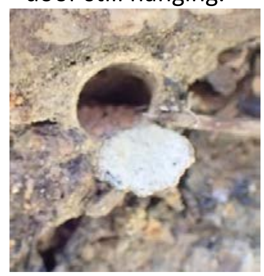
Active burrow

Recently defunct burrow with door still hanging.

Kyanorup Eminence – shaded clay bank within jarrah root zone



Active burrow with a new door. Old door still in place



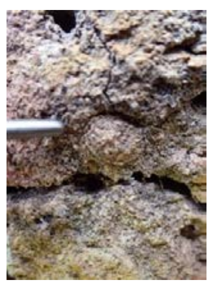
Recently defunct burrow.

Cascades – moist clay soil within rock crevices adjacent to creek

Active burrow

Defunct burrow

Moongoongoonderup- stable, moist clay bank



Active burrow

Defunct burrow

Ellen Peak - upper gully clay bank beneath root zone

Active burrow

Defunct burrow

Figure 5: Examples of microhabitats where *B. colonus* was detected.


Wedge Hill Rock crags within the main gully. Most soil pockets are dry and exposed


Mt Success dry and exposed creek bank


Yungermere (east gully) clay bank dry and crumbling, with woodland overstorey collapse into the creek


Kyanorup Eminence eroding bank


Kyanorup Eminence dead moss and evidence of soil washing down the bank


Burrow filled with eroded soil


Coyanarup Peak dry and crumbling creek bank


Coyanarup Peak shallow moss and clay beds within rocky crags dry, hard and cracking. Defunct burrows present.


Bakers Knob clay gully wall dry and hardened, exposed. Surviving spiders in recessed sections that still have some shade.

Figure 6: **Examples of sites where microhabitats have suffered desiccation and erosion after the fires. High mortality rates were documented at these sites.**

4.2.3 Bertmainius pandus

Bertmainius pandus is currently listed as critically endangered (CR) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act*. The species is known to occur in creek banks, with burrows occurring more frequently in shaded areas, especially under large marri trees (Harvey *et al.* 2015). Prior to this survey the species was known from nine records (lodged specimens) within a single gully on the eastern slope of Toolbrunup Peak (WAM 2020, DBCA 2020). The survey procedures and sites surveyed to obtain the historical data are not standardised and occurred across a smaller survey area than that surveyed in 2020/ 2021, which makes it challenging to compare temporal and spatial daa.

B. pandus was detected in 15 locations during the 2020/ 2021 survey and in 10 of these locations, live individuals were recorded (Table 6, Figure 7). The species was detected in gullies and micro-niches associated with Toolbrunup Peak and Mt Hassell (Figures 7 and 8). On Toolbrunup, burrows were detected in clay walls on the creek banks of the Toolbrunup gully (east of the walk trail). Surviving spiders were in stable, shaded sections of clay beneath small rocks, large marri roots or in areas where moss and lichen were alive. On Mt Hassell, burrows were detected in the north eastern (lowlands) gully, which is deeply incised with some stable clay banks beneath marri woodland. In addition, two active burrows were detected in the southern gully near the summit of Mt Hassell in shallow mossy soil within a large rocky crag. Those occurrences of *B. pandus* on Mt Hassell are of interest, as the species has not been recorded here before and this is a significant distance from the Toolbrunup gully. A specimen may be required to confirm identification, however there were only 3 individuals detected alive on Mt Hassell due to the intensity of fire behaviour in this location, and all were large adults that are likely to be females.

A large proportion of habitat for *B. pandus* on both Mt Hassell and Toobrunup Peak was dry and clay banks were exposed and crumbling. In some sections of the Toolbrunup gully, the woodland had been defoliated and trees had fallen into the gully, collapsing the creek banks (Figure 9). In some instances, surveys in these areas were hampered by access to the underlying banks and burrows may have been missed. As with *B. colonus,* a high proportion of mortalities were detected, and further mortalities may occur over winter if heavy rainfall events are prevalent, due to the exposed nature of the creek banks. Overall, there were 751 individuals of *B. pandus* detected during this survey, of which 44 (6 %) were alive.

In most cases, the surviving spiders detected were larger adult spiders (Table 6). Juvenile burrows were conspicuously defunct with burrow doors hanging open and burrows empty. The locations where smaller adults were present were those where the marri woodland canopy had not been completely defoliated and was still providing some shade. In all cases where defunct burrows were counted, only those that were recently defunct (i.e. still had doors attached or fresh silk around the burrow entrance) and were clearly identifiable as *Bertmainius* were counted. These burrows are likely to have become defunct following the fire rather than during, given the presence of unburnt silk on the doors. The counts of dead spiders are therefore likely to be conservative, given a large number of spiders are expected to have died during the fire and their burrows may not have been viewed as recently defunct using the above definition.

Table 6: Summary of detections (counted and measured burrows) for *B. pandus* during the 2020/ 2021 survey.

Only positive detections are presented for 2020/ 2021 data (areas where the species was surveyed and burrows absent are not presented). Only active burrows were measured to determine the likely age class of their occupant.

Mountain	# Sites	#Sites with survivors	Recently Dead 2020	Alive 2020	Matriarch (>6mm)	Adult (4-6mm)	Juvenile (2-3mm)	Recruit (1mm)
Toolbrunup Peak	10	8	657	41	20	21	0	0
Mt Hassell	5	2	50	3	3	0	0	0

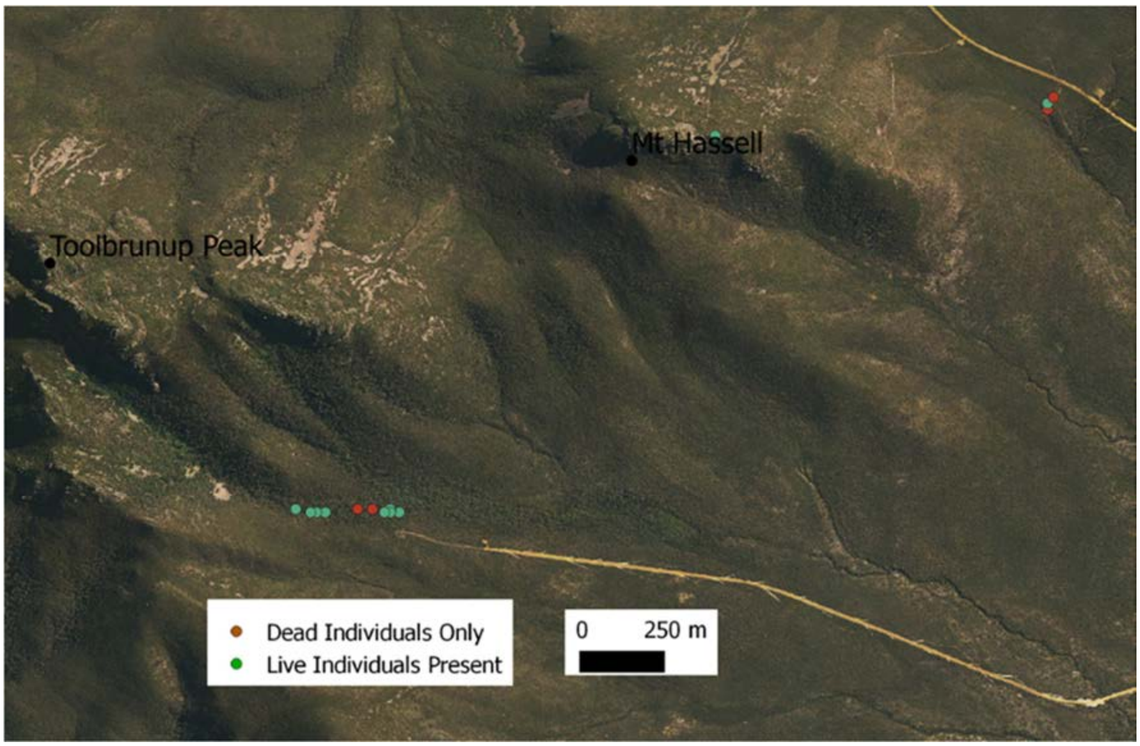


Figure 7: Locations of *B. pandus* detected during the 2020/ 2021 survey.

Toolbrunup gully

Active burrow

Defunct burrow

Mt Hassell lowlands – deeply incised gully

Active burrow

3 defunct burrows

Mt Hassell upper gully rock crag

Mt Hassell upper gully mossy soil bed

3 burrows – 2 defunct (pointer and top left) and one active (bottom right)

Figure 8: Examples of microhabitats where *B. pandus* was detected.

Mt Hassell lowlands exposed and eroding banks

Toolbrunup gully collapsing clay bank

Toolbrunup gully examples of exposed, eroding banks and areas where the overstorey has collapsed into the creek across the banks

Figure 9: Examples of sites where microhabitats have suffered desiccation, erosion or collapse after the fires. High mortality rates were documented at these sites.

4.2.4 Calcarsynotaxus benrobertsi

Calcarsynotaxus benrobertsi is not currently listed as threatened under State or Commonwealth legislation but is known only from Pyungorup Peak and Ellen Peak from four records between 2008 and 2012. On Pyungorup Peak, *C. benrobertsi* has been recorded under damp, shaded leaves of sedges (Lepidosperma sp.) within the southern gully, and on Ellen Peak it has been recorded in montane *Kunzea* heathland, under *Lepidosperma* sedges (Rix *et al.* 2009, WAM 2020). The species is known to occur in sympatry with *Zephyrarchaea robinsi* and *Perissopmeros darwini* (Rix *et al.* 2009).

A total of 81 sedge and montane shrub sites were sampled within the potential range of *C. benrobertsi* between October 2020 and January 2021 and 55 of these sites were resampled between April and May 2021 (Figure 21). At each site, a minimum of 10 sedges/ shrubs were targeted. The species was not detected within the parameters of this survey. In most cases, it was noted that while the sedges were regenerating, they were low and sparse, and there was a general absence of suspended leaf material or ground litter. Within the Pyungorup gully there were areas where leaf material had collected, associated with high velocity water movement down the creek line. In these areas there were consolidated pockets of leaf material, woody debris and humus, which were sieved. *C. benrobertsi* was one of the species searched for during this sampling process, which occurred across an additional three sites.

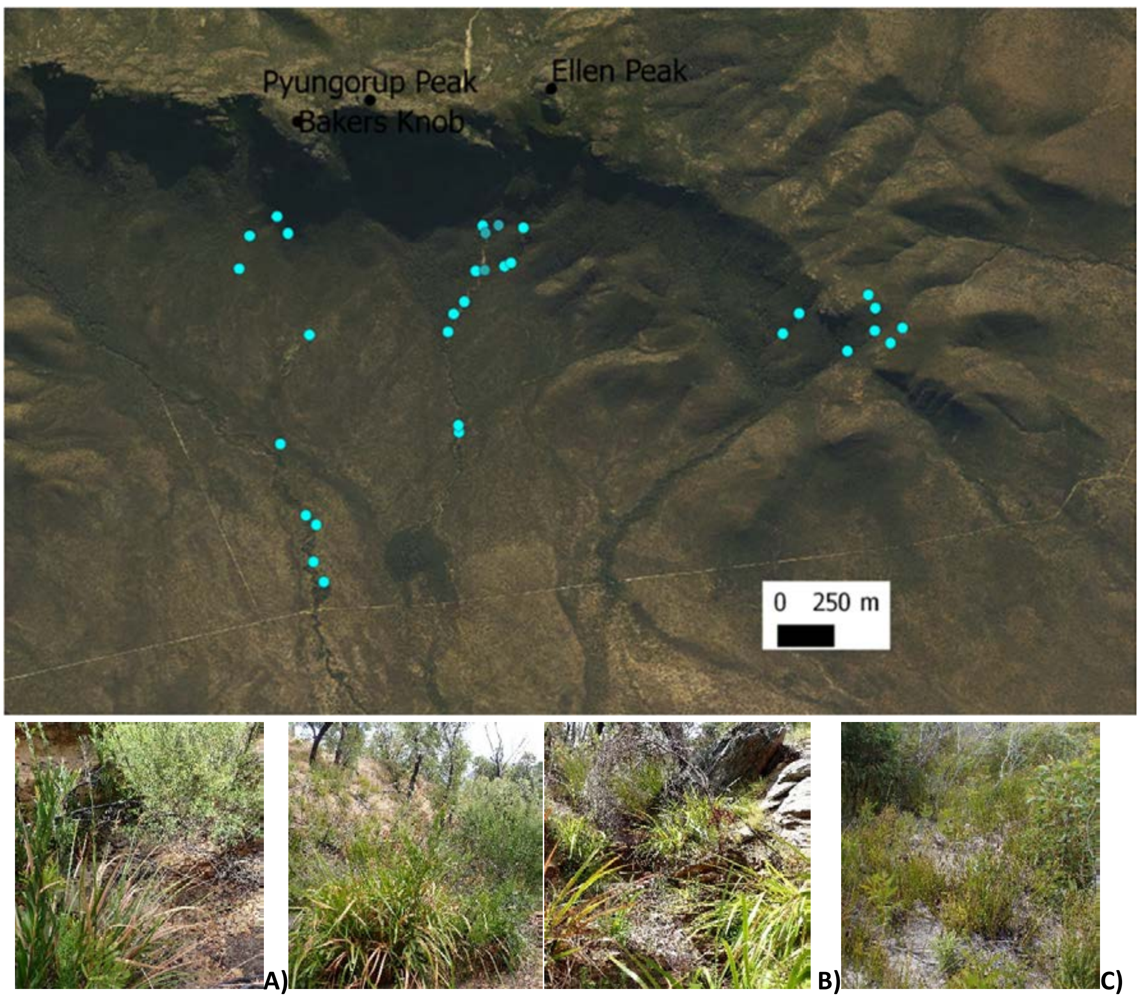


Figure 10: Locations sampled for *C. benrobertsi* and examples of potential habitat A) Bakers Knob, B) Pyungorup Gully, C) Ellen Peak

4.2.5 Cataxia colesi

Cataxia colesi is currently not listed under State or Commonwealth legislation. The species is known to occur in heavily shaded, mesic habitats above 500 m altitude and prior to this survey the species was known from 13 WAM lodged specimens on Toolbrunup Peak and Mt Hassell (Rix *et al.* 2018, WAM 2020). In April 2002 and April 2003, a post-fire survey of *Neohomogona stirlingi* was also undertaken, which documented presence/ absence and abundance of active burrows within quadrats (Bain and Main 2004). *N. stirlingi,* has since been taxonomically resolved into multiple species of *Cataxia* (Rix et al. 2018) and their unique distributions have been used to categorise the 2002/ 2003 records of *N. stirlingi* into likely records for *C. colesi*. The 2002/ 2003 survey was undertaken systematically using a similar approach to that applied in 2020/ 2021 and the approach to burrow counts and measurements for the 2020/ 2021 survey was modelled on the 2002/ 2003 survey. Temporal and spatial comparisons can therefore be made with caution, for example by accounting for variation in the effective area sampled to generate burrow density estimates, or by assessing the areas of occupancy and how these have changed. The burrow data collected in 2002/ 2003 were quadrat based burrow counts within eight 1mx1m quadrats, and the 2020/ 2021 data were strip based counts within 2 m x 10 m quadrats in all locations where individuals were encountered. For both surveys, the approach to searching for burrows included a series of walked traverses through potentially suitable habitat.

The surveys in 2002/ 2003 identified that the Mt Hassell population of *C. colesi* extended from the summit down the southern gully and into the saddle with a continuous distribution of burrows spanning approximately 200 m. Within the eight randomly sampled quadrats in this population, 327 burrows were counted, equating to a burrow density of 40.8 burrows/ m^2. The habitat on Mt Hassell in 2002/ 2003 was described as moist soil beneath regenerating eucalypts, and the burrows were widespread with clusters of different age classes associated with the shade of individual eucalypts (Bain and Main 2004). Age classes were assigned based on the internal diameter of the burrow entrances and aestivation was determined through assessment of external features of the burrow palisade. Of the burrows counted on Mt Hassell in 2002/ 2003, 19% were matriarchs (>12 mm), 15% were adults (>6 mm), 24% were juveniles, 31% were recruits (<3 mm) and 11% were sealed (Bain and Main 2004).

In contrast, for the 2020/ 2021 survey, *Cataxia* burrows were detected within seven 2x10 m strips, and all detections occurred in shallow mossy soil within rock crevices high up in the gully (Table 7, Figures 11, 12). A total of 98 active burrows were detected on Mt Hassell, equating to a burrow density of 0.7 burrows/ m^{2}.. Of the burrows detected, 4% were matriarchs, 49% were adults, and 47% were juveniles. No recruits were detected despite the exposed soil which resulted in a high detection probability. The low numbers of *Cataxia* burrows from within the southern gully on Mt Hassell and the complete absence of burrows from the saddle during the 2020/ 2021 survey suggests a significant reduction in area of occupancy and density for this species.

Burrow counts were not completed on Toolbrunup Peak during the 2002/ 2003 study however the survey did identify 12 occupied sites on the southern and eastern slopes of this peak. Two of these sites were still occupied during the 2020/ 2021 survey. A total of 88 active burrows were detected in nine sites on Toolbrunup Peak during the 2020/ 2021 survey. Micro-niches that were occupied by *C. colesi* included moist soil beneath water-shedding rocks, clay walls near the creek and stable moist soils within the marri root zone (Table 7, Figures 11, 12).

Burrows that had evidence of aestivation (leaf palisade material constructed over a silk sealed burrow entrance) were counted as aestivating individuals. The sealed palisades were not disturbed to measure the burrow entrances or to check for fresh silk beneath (surviving spiders), due to the stress the spiders had already experienced and the dry conditions within their habitat. It is likely however that some of these burrows may have been occupied by juvenile spiders and that some may have been defunct. Sealed burrows have NOT been included in burrow density estimates.

Table 7: Summary of detections for *C. colesi* in the 2020/ 2021 survey and burrow counts from the 2002/ 2003 survey (Bain and Main 2004).

Burrow density has been calculated for each mountain based on the total number of active burrows (excluding sealed burrows) and the effective sample area. Effective sample area for 2002/ 2003 relates to quadrat based counts across eight quadrats (1m x1m) and for 2020/ 2021 relates to strip based counts across 2mx10 m strips at each location. Only positive detections are presented for 2020/ 2021 data (areas where the species was absent are not presented).

Survey	Mountain	#occupied sites	Sample Area (m^2)	Burrow Density (burrows/ m^2)	Matriarch (>11mm)	Adult (7-11mm)	Juvenile (3-6mm)	Recruit (<3mm)	Sealed
2002/ 2003	***Mt Hassell***	***8***	***8***	***40.8***	***61***	***48***	***78***	***103***	***37***
2020/ 2021	Mt Hassell	7	140	0.7	4	48	46	0	15
2020/ 2021	Toolbrunup Peak	9	180	0.5	32	45	12	0	22

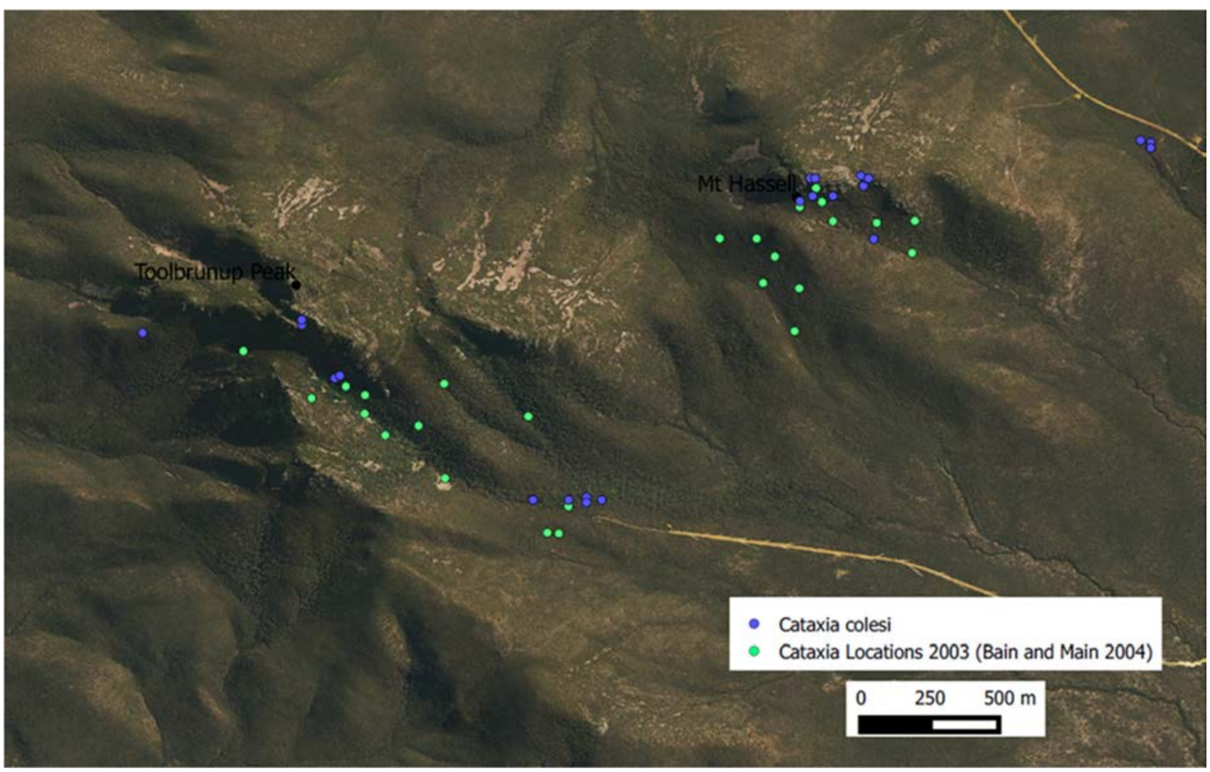


Figure 11: Locations of *C. colesi* detected during the 2020/ 2021 survey (blue) and during the 2002/ 2003 survey (green).

Mt Hassell rock crag upper gully near the summit.

Moist mossy soil within rock crevice

Active burrow and occupant

Mt Hassell lowlands – regenerating forest adjacent to creek line

Active burrow lowlands.

Toolbrunup moist clay wall at the edge of the gully.

Active burrow within Toolbrunup clay wall

Toolbrunup rock crag. Burrows in the watershed, usually beneath rocks that protect them from erosion and flooding

Active burrow beneath rock crag

Figure 12: Examples of microhabitats where *C. colesi* was detected.

4.2.6 Cataxia sandsorum

Cataxia sandsorum is currently not listed under State or Commonwealth legislation. The species is known to occur in upland riparian (mesic) eucalypt forest on the heavily shaded southern side of the range near Pyungorup Peak (Rix *et al.* 2018). Prior to this survey the species was known from 12 WAM lodged specimens in the Pyungorup Peak area (Rix *et al.* 2018, WAM 2020). In 2002/ 2003, a post-fire survey of *Neohomogona stirlingi* was also undertaken, which documented presence/ absence and abundance of active burrows (Bain and Main 2004). *N. stirlingi,* has since been taxonomically resolved into multiple species of *Cataxia* and their unique distributions have been used to categorise the 2002/ 2003 records of *N. stirlingi* into likely records for *C. colesi, C. sandsorum* and *C. stirlingi*. The 2002/ 2003 survey was undertaken systematically using a similar approach to that applied in 2020 and the approach to burrow counts and measurements for the 2020 survey was modelled on the 2002/ 2003 survey. Temporal and spatial comparisons can therefore be made with caution by accounting for variation in the effective area sampled to generate burrow density estimates, or by assessing the areas of occupancy and how these have changed.

C. sandsorum was detected in 21 locations in the Pyungorup-Ellen Peak area during the 2020/ 2021 survey, including 11 sites in the Pyungorup gully, 3 sites on the Ellen Peak summit and 7 sites in the eastern watershed of Ellen Peak (Table 8, Figure 13). Overall, 388 active burrows were detected, plus an additional 256 burrows that had evidence of an aestivating occupant. No attempt was made to measure the diameter of aestivating burrows or assess whether these spiders were alive, due to the damage to the closed palisade that is necessary to assess the freshness of the underlying silk and access the burrow opening. It is highly likely that a large proportion of the aestivating spiders were juveniles given they are prone to desiccation stress and the palisades for many of these were quite small. It is possible some of these burrows were defunct.

Sites where the species was detected included shaded marri woodland within a deep broad gully on the southern face of Pyungorup Peak with all burrows occurring between the gully wall and the creek bed. Burrows were detected in the clay creek bank, clay gully wall, sandy soil beneath small plants within the gully and in mossy soil pockets in rock crags in the upper gully. Burrows were also detected within a creek line in the eastern watershed of Ellen Peak and in this area, they were associated with rock and clay banks adjacent to the creek, and regenerating eucalypts immediately upslope of the creek. On the Ellen Peak summit, burrows were detected in montane heath land proximate to water shedding rock crags.

The 2002/ 2003 burrow density for *C. sandsorum* in the Pyungorup gully was 38 burrows/ m^2 with 22% of these occupied by matriarch or adult spiders, 27% by juveniles, 32% by recruits and 19% by aestivating spiders. In 2020/ 2021, the burrow density for the Pyungorup gully population of *C. sandsorum* was 0.7 burrows/ m^2, with 88% of burrows occupied by matriarch or adult spiders and 12% by juveniles. No recruits were detected, and a large proportion of detected burrows were occupied by spiders that were in aestivation.

Quadrat based burrow counts were not completed on Ellen Peak during the 2002/ 2003 study, however the traverse based survey identified 10 occupied sites in the eastern watershed of this peak. Most of these sites were still occupied during the 2020/ 2021 survey. In 2020/2021, the burrow density of *C. sandsorum* occupying the Ellen Peak watershed was 1.2 burrows/ m^2, with 96% of burrows occupied by matriarch or adult spiders and 4% by juveniles. No recruits were detected, and a large proportion of detected burrows were occupied by spiders that were in aestivation. For *C. sandsorum* detected on the Ellen Peak summit in 2020/2021, burrow density was 0.3 burrows/ m^2, with 79% of burrows occupied by matriarch or adult spiders, and 21% by juveniles. No recruits or aestivating spiders were detected.

Table 8: Summary of detections for *C. sandsorum* in the 2020/ 2021 survey and burrow counts from the 2002/ 2003 survey (Bain and Main 2004).

Burrow density has been calculated for each mountain based on the total number of active burrows (excluding sealed burrows) and the effective sample area. Effective sample area for 2002/ 2003 (2003) relates to quadrat based counts across eight quadrats (1m x1m) and for 2020/ 2021 relates to strip based counts across 2mx10 m strips at each location. Only positive detections are presented (areas where the species was absent are not presented here).

Survey	Mountain	#occupied sites	Sample Area (m^2)	Burrow Density (burrows/ m^2)	Matriarch (>11mm)	Adult (7-11mm)	Juvenile (3-6mm)	Recruit (<3mm)	Sealed
2002/ 2003	***Pyungorup Gully***	***8***	***8***	***31***	***32***	***36***	***83***	***97***	***58***
2020/ 2021	Pyungorup Gully	11	220	0.7	17	126	20	0	136
2020/ 2021	Ellen Peak Watershed	7	140	1.2	10	153	7	0	120
2020/ 2021	Ellen Peak Summit	3	60	0.3	7	8	4	0	0

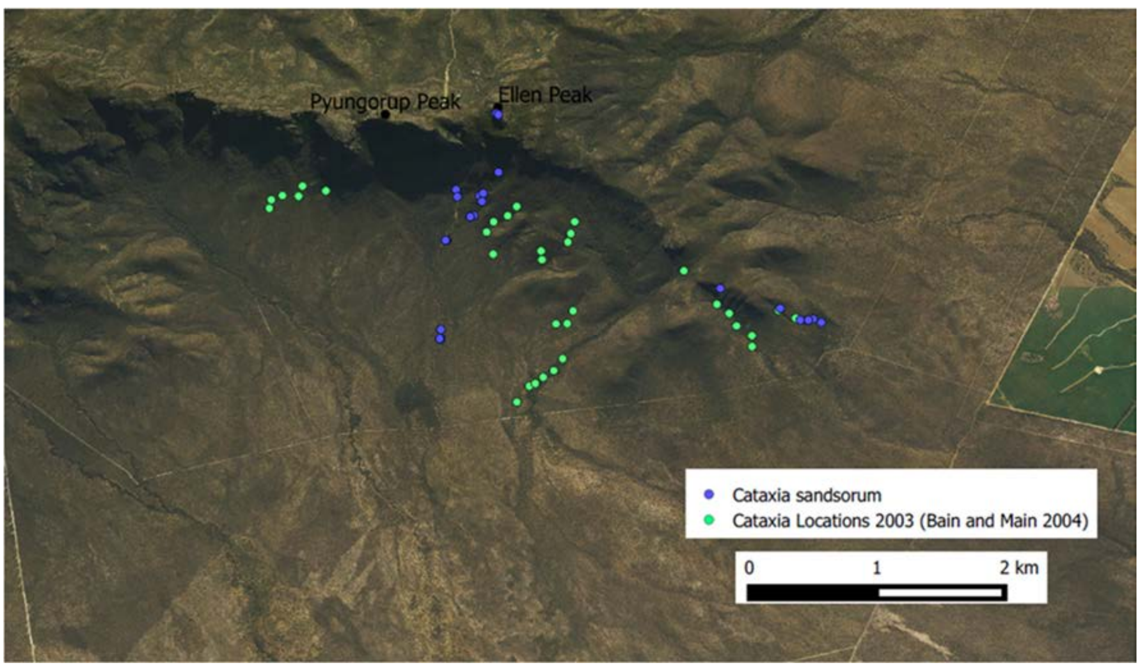


Figure 13: Locations of *C. sandsorum* detected during the 2020/ 2021 survey (blue) and during the 2002/ 2003 survey (green).

Pyungorup Gully burrows within the creek clay bank.

Active burrow within creek clay bank

Sealed burrow of an aestivating spider

Ellen Peak watershed regenerating eucalypts adjacent to the creek

Active burrow

Sealed burrow of an aestivating spider

Figure 14: **Examples of microhabitats where *C. sandsorum* was detected.**

4.2.7 Cataxia stirlingi

Cataxia stirlingi is currently not listed under State or Commonwealth legislation. The species is known to occur in montane heathland and eucalypt forest above 400 m altitude (Rix *et al.* 2018). Prior to this survey the species was known from 16 WAM lodged specimens confirmed from Bluff Knoll, Moongoongoonderup Peak and Isongerup Peak (Rix *et al.* 2018, WAM 2020). In 2002/ 2003, a post-fire survey of *Neohomogona stirlingi* was also undertaken, which documented presence/ absence and abundance of active burrows (Bain and Main 2004). *N. stirlingi,* has since been taxonomically resolved into multiple species of *Cataxia* and their unique distributions have been used to categorise the 2002/ 2003 records of *N. stirlingi* into likely records for *C. stirlingi*. Using these data, the 2002/ 2003 project identified populations of *C. stirlingi* on Wedge Hill, Mt Success, Bluff Knoll, South Bluff, Cascades, Coyanarup Peak, Kyanorup Eminence, Moongoongoonderup Peak, and South Isongerup Peak. The 2002/ 2003 survey was undertaken systematically using a similar approach to that applied in 2020 and the approach to burrow counts and measurements for the 2020/ 2021 survey was modelled on the 2002/ 2003 survey. Temporal and spatial comparisons can therefore be made with caution, for example by accounting for variation in the effective area sampled to generate burrow density estimates, or by assessing the areas of occupancy and how these have changed. The burrow data collected in 2002/ 2003 were quadrat based burrow counts within eight 1mx1m quadrats, and the 2020/ 2021 data were strip based counts within 2 m x 10 m quadrats in all locations where individuals were encountered. Both surveys involved searching for burrows along a series of walked traverses through potentially suitable habitat.

During the 2020/ 2021 survey, *C. stirlingi* was detected in 59 locations on Wedge Hill, Mt Success, Bluff Knoll, Cascades, Coyanarup Peak, Kyanorup Eminence, Moongoongoonderup Peak, and South Isongerup Peak (Table 9, Figure 15). Overall, 577 active burrows were detected, plus an additional 213 burrows that had evidence of an aestivating occupant. Of the active burrows, xx% were occupied by matriarch or adult spiders with a burrow diameter between 7 mm and 15 mm and xx% of burrows were occupied by juvenile spiders with a burrow diameter of 3-6 mm. No recruits were detected. No attempt was made to measure the diameter of aestivating burrows or assess whether these spiders were alive, due to the damage to the closed palisade that is necessary to assess the freshness of the underlying silk and access the burrow opening. It is highly likely that a large proportion of the aestivating spiders were juveniles and/ or defunct. Burrows were detected in moist sandy soils adjacent to creeks, beneath jarrah/ marri woodland, beneath small plants, in the watershed of large roots and, in clay creek banks in moist soil beneath overhanging rock or within rock crevices.

The distribution of the species in 2020/ 2021 seems to be relatively consistent with that documented during the 2002/ 2003 surveys, however the area occupied seems to have substantially decreased. For example, the habitat on Wedge Hill escaped the 2000 fire and during the 2002/ 2003 survey the population of *C. stirlingi* was described as covering the majority of the southern face of the mountain with burrows occurring in a scattered but continuous distribution from the summit through the southern gully to the lowlands, in montane heathland surrounding the gully and beneath rock crags midslope and upper slope on the southern face of the mountain (Bain and Main 2004). Within the gully, burrows occurred throughout the leaf litter, in the bark of the trees and anywhere there was bare soil, especially in areas near the edge of the gully where watershed from the rocks was common. In the montane heathland, burrow aggregations were associated with shrubs and water-shedding roots or rocks (Bain and Main 2004). In the 2020 survey there was a complete absence of burrows in the southern gully with the exception of areas near the summit, where the spiders were occupying small shallow pockets of soil within the rock crags. The deep leaf litter in the woodland has been completely lost and intense fire behaviour in the southern gully resulted in defoliation of the woodland.

The burrow density of *C. stirlingi* and the proportion of age classes present on Wedge Hill has also changed significantly. In 2002/ 2003, there was a burrow density of 22.75/ m^2, and of the 182 burrows counted, 51% were matriarchs and adults, 21% juveniles, 24% recruits and 4% were aestivating spiders. It is likely that juveniles, recruits and aestivating spiders would have been less detectable in the deep leaf litter which dominated the gully during the 2002/ 2003 surveys. In 2020, there was a burrow density of 0.2 burrows/ m^2, and of the 68 active burrows detected, 56% were matriarchs and adults (3 matriarchs) and 44% were juveniles. Given the absence of leaf litter in the gully during the 2020/ 2021 survey, and the open nature of the habitat, the detection probability for burrows would be expected to be high. It is possible that burrows were missed in the rock crags, given the challenging nature of survey in these precipitous and friable habitats, however these spiders are also likely to have been missed during the 2002/ 2003 surveys.

A substantial decrease in burrow density and area of occupancy was consistent across all sites that were surveyed in both 2002/ 2003 and 2020/ 2021 (Table 9, Figure 15). In the 2020/ 2021 survey, burrows were consistently detected in closer proximity to creek lines and watersheds and in most cases the proportion of burrows that were occupied by juvenile spiders was low.

Table 9: Summary of detections for *C. stirlingi* in the 2020/ 2021 survey and burrow counts from the 2002/ 2003 (2003) survey (Bain and Main 2004).

Burrow density has been calculated for each mountain based on the total number of active burrows (excluding sealed burrows) and the effective sample area. Effective sample area for 2002/ 2003 relates to quadrat based counts across eight quadrats (1m x1m) and for 2020/ 2021 relates to strip based counts across 2mx10 m strips at each location. Only positive detections are presented for 2020/ 2021 data (areas where the species was absent are not presented).

Survey	Mountain	#occupied sites	Sample Area (m^2)	Burrow Density (burrows/ m^2)	Matriarch (>11mm)	Adult (7-11mm)	Juvenile (3-6mm)	Recruit (<3mm)	Sealed
2002/ 2003	***Wedge***	***8***	***8***	***22.7***	***42***	***51***	***36***	***36***	***17***
2020/ 2021	Wedge	17	340	0.2	3	35	30	0	3
2002/ 2003	***Cascades***	***8***	***8***	***37.3***	***38***	***28***	***98***	***108***	***26***
2020/ 2021	Cascades	2	40	1.4	5	21	30	0	15
2002/ 2003	***Kyanorup***	***8***	***8***	***10.8***	***11***	***21***	***21***	***25***	***8***
2020/ 2021	Kyanorup	2	40	0.2	0	2	5	0	0
2002/ 2003	***Moongoon goonderup***	***8***	***8***	***42.2***	***26***	***16***	***113***	***124***	***59***
2020/ 2021	Moongoon goonderup	18	360	0.8	18	168	86	0	94
2020/ 2021	Bluff Knoll	2	40	0.2	5	4	0	0	6
2020/ 2021	Papa Colla	3	60	0.1	0	4	1	0	9
2020/ 2021	Mt Success	4	80	0.1	0	7	0	0	1
2020/ 2021	Coyanarup	11	220	0.5	14	62	43	0	32
2020/ 2021	Isongerup	4	60	0.6	6	31	1	0	63

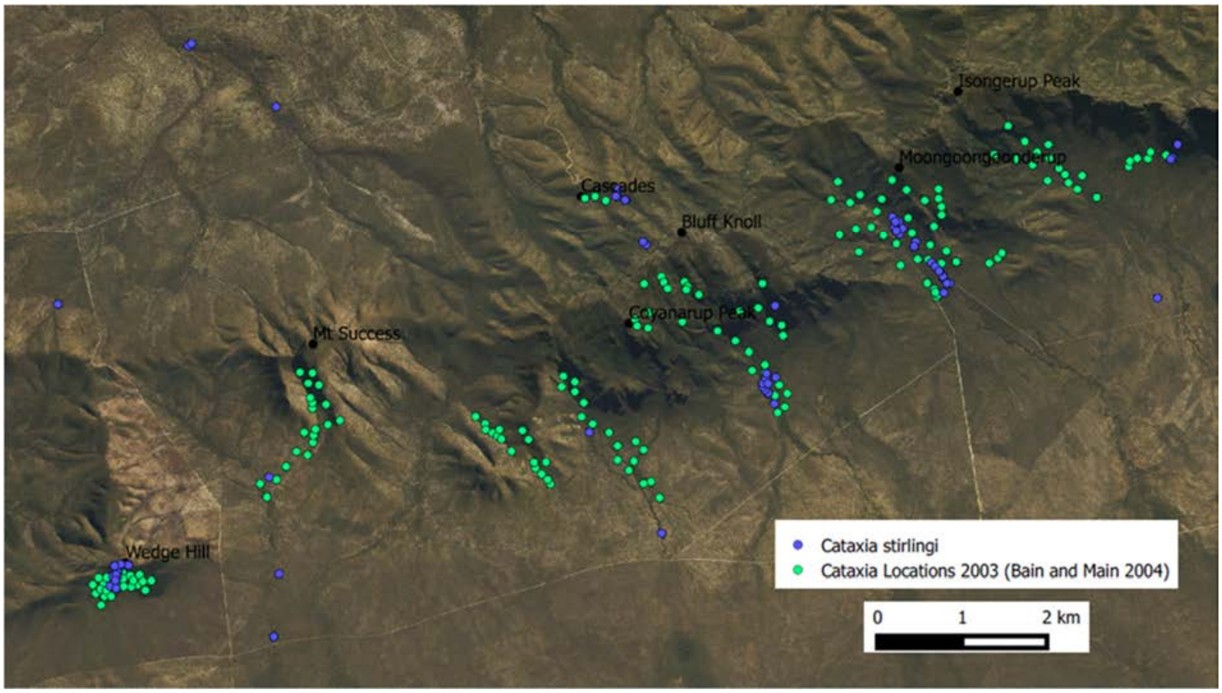
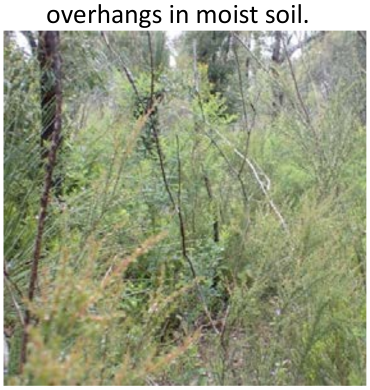


Figure 15: **Locations of *C. stirlingi* detected during the 2020/ 2021 survey (blue) and during the 2002/ 2003 survey (green).**

Wedge Hill burrows within rock crevices or beneath rocky overhangs in moist soil.

Active burrow

Sealed burrow of an aestivating spider



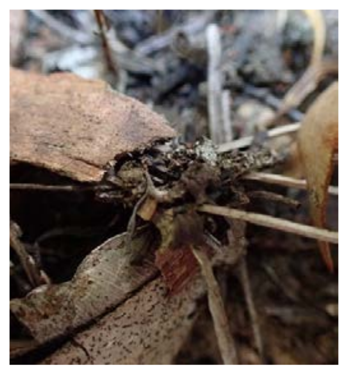
Coyanarup Peak soft moist soils at the base of a broad, deep creek

Active burrow

Sealed burrow of an aestivating spider

Moongoongoonderup Peak burrows within clay creek bank

Active burrow



Sealed burrow of an aestivating spider

Figure 16: Examples of microhabitats where *C. stirlingi* was detected.

4.2.8 Karaops toolbrunup

Karaops toobrunup is not currently listed as threatened under State or Commonwealth legislation but is known only from a single scree slope on Toolbrunup Peak (Crews and Harvey 2011). There are nine records of this species between 2004 and 2009, seven of which were from a single survey in 2009 (7 individuals). *K. toobrunup* is known to occur beneath rocks on the scree slope (Crews and Harvey 2011, WAM 2020).

A total of 13 sites were sampled for *K. toobrunup* in December 2020 and May 2021 (Figure 20). At each site, a minimum of 12 rocks were targeted. The species was not detected within the parameters of this survey.

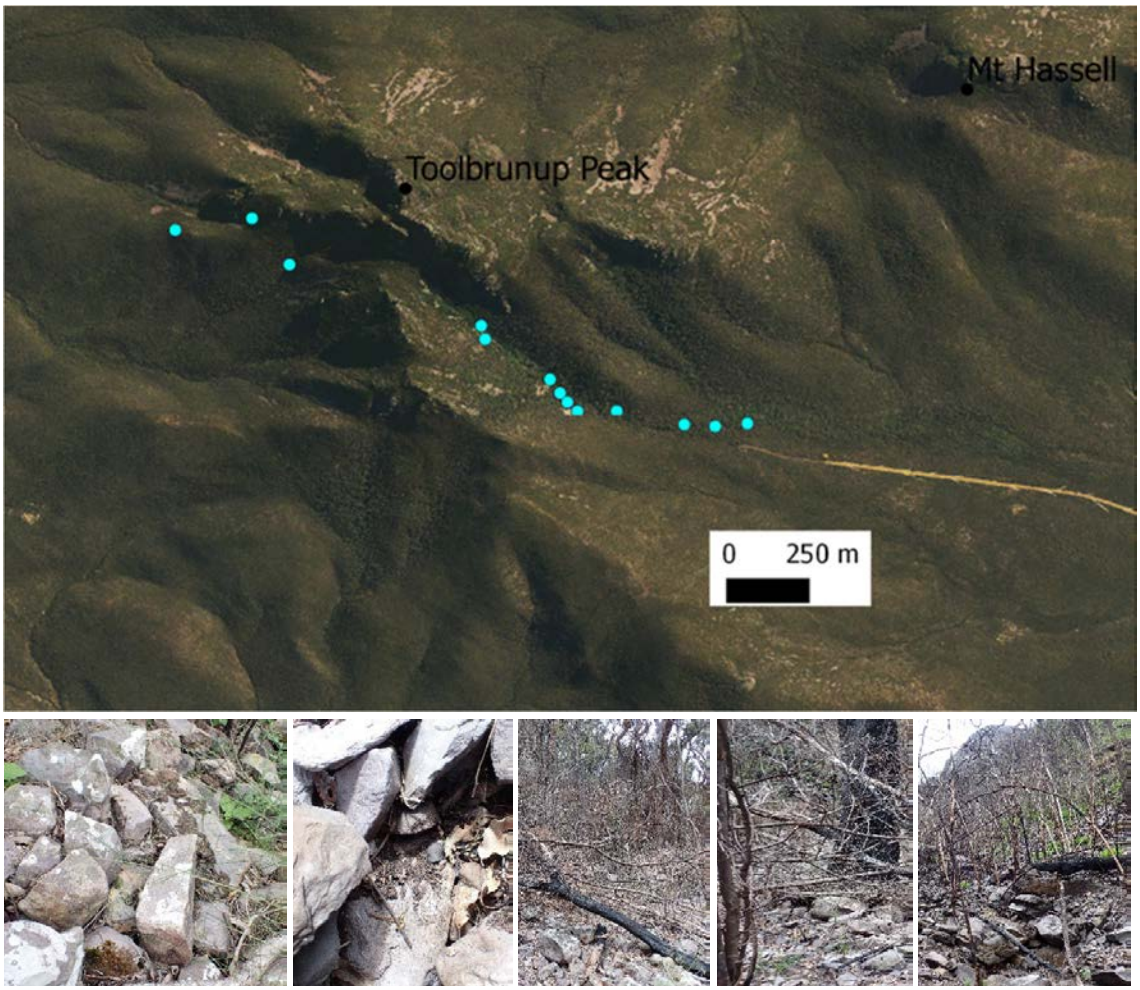


Figure 20: Locations sampled for *K. toolbrunup* on Toolbrunup Peak and examples of potential habitat.

4.2.9 *Maratus sarahae*

Maratus sarahae is currently listed as critically endangered (CR) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act*. The species in known to occur under damp, shaded leaves of sedges (*Lepidosperma sp.*), in sympatry with *C. benrobertsi, Z. robinsi, P. darwini*, and the harvestman *M. epizephyros* (Waldock 2013). Prior to this survey the species was known from 13 records on Bluff Knoll and Ellen Peak, where spiders had been collected on *Sphenotoma sp.,* in montane heathland and in low vegetation where suspended leaf material was present (Table 10, WAM 2020).

A total of 81 sedge and montane shrub sites were sampled within the potential range of *M. sarahae* between October 2020 and January 2021 and 55 of these sites were resampled between April and May 2021 (Figure 21). At each site, a minimum of 10 sedges/ shrubs were targeted. In most cases, it was noted that the sedges and shrubs were regenerating, but they were low and sparse, and there was a general absence of suspended leaf material or ground litter. Despite the relatively low availability of suitable habitat, *M. sarahae* was detected in four sample sites during the spring survey and one site during the autumn survey (Table 10, Figure 21). Microhabitats occupied included an unburnt pocket of mature sedge of in the upper gully of Cyanorup Peak, a clay bank adjacent to a densely vegetated section of creek line in the upper gully of Cyanorup Peak, low regenerating sedgeland near the Bluff Knoll summit, within a leaf litter sample in the upper Pyungorup gully and in regenerating *Sphenotoma* and sedge shrubland in the saddle between Ellen Peak and Pyungorup Peak (Figures 21, 22). In addition, DBCA personnel observed two individuals on East Bluff and 'several' individuals on Pyungorup Peak in summit sedge habitat in January 2021 (Pers com. Sarah Barrett 2021).

Table 10: Summary of detections for *M. sarahae* during the 2020/ 2021 survey and a summary of historical specimen data available (WAM 2020)

Only positive detections are presented for 2020 data (areas where the species was surveyed and absent are not presented).

Mountain	**#Sites with survivors**	**2009 WAM**	**2012 WAM**	**2015 WAM**	**2020**	**2021**	**Comments relating to habitat**
Bluff Knoll	1	3	2	1	3	0	Low sedges in gully south of walk trail, near the summit (1M), observed in sedgeland by DBCA (2M)
Coyanarup	2	NS	NS	NS	3	0	Southern gully. Large unburnt sedges on the edge of the creek (1M, 1F) and on a clay bank adjacent to a densely vegetated section of creek (1F).
Pyungorup Gully	2	NS	NS	NS	1	0	Dry creek bed near summit within a litter sample (1M).
Pyungorup Peak	2	1	NS	NS	3		2009 WAM value is from Ellen Peak, 2020 observed in summit sedge by DBCA personnel, 2021 montane heath and sedge in Pyungorup-Ellen Peak saddle

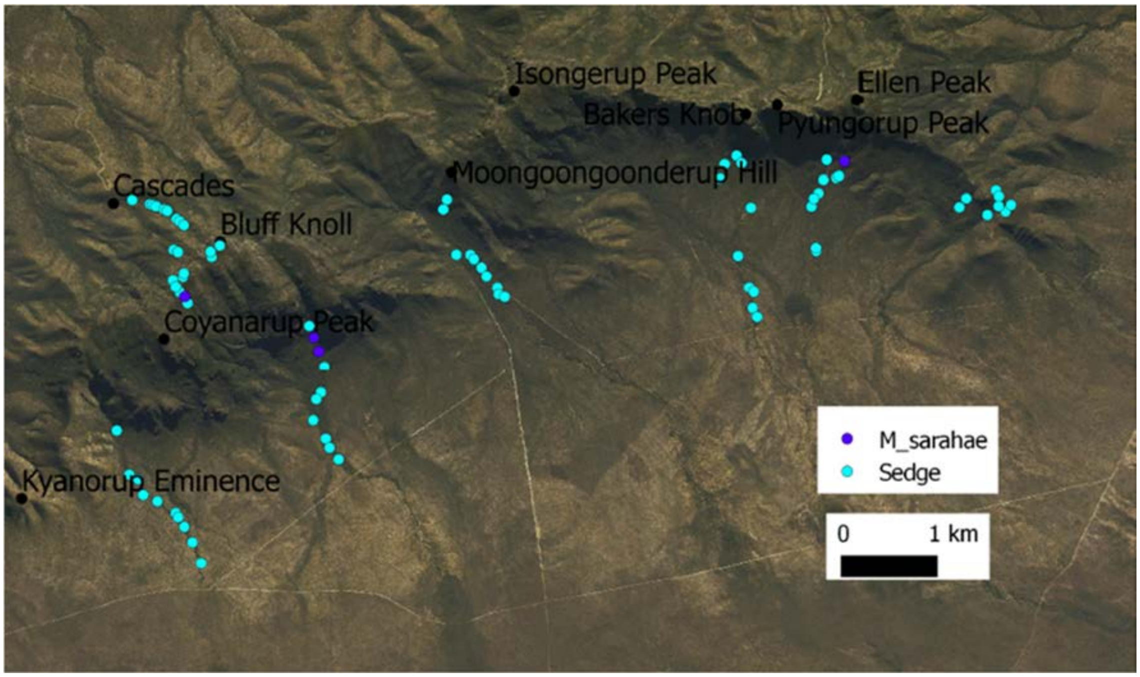


Figure 21: **Locations of *Maratus sarahae* detected during the 2020/ 2021 survey and sedge sites sampled.**

Bluff Knoll sedgeland near sumitx. Regenerating sedges.

Pyungorup Gully leaf material that had been washed down stream and collected within a creek bend with some unburnt sedges.

Coyanarup Peak upper gully unburnt pocket of sedge

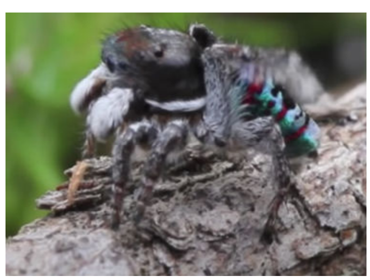


Figure 22: **Examples of microhabitats where *M. sarahae* was detected.**

4.2.10 Perissopmeros darwini

Perissopmeros darwini is not currently listed as threatened under State or Commonwealth legislation but is known only from a single pit fall collection in 1996 from within a shaded, mesic creek line on the south face of Pyungorup Peak (Barrett 1996, Rix *et al.* 2009). The species occurs in sympatry with C. *benrobertsi* and *Z. robinsi* which are known to occur in mesic creek lines on Bluff Knoll, Pyungoorup Peak and Ellen Peak (Rix *et al.* 2009).

A total of 81 sedge and montane shrub sites were sampled within the potential range of *P. darwini* between October 2020 and January 2021 and 55 of these sites were resampled between April and May 2021 (Figure 21). At each site, a minimum of 10 sedges/ shrubs were targeted. The species was not detected within the parameters of this survey. In most cases, it was noted that while the sedges and shrubs were regenerating, they were low and sparse, and there was a general absence of suspended leaf material or ground litter. Within the Pyungorup gully there were areas where leaf material had collected, associated with high velocity water movement down the creek line. In these areas there were consolidated pockets of leaf material, woody debris and humus which were sieved. *P. darwini* was one of the species searched for during this sampling process.

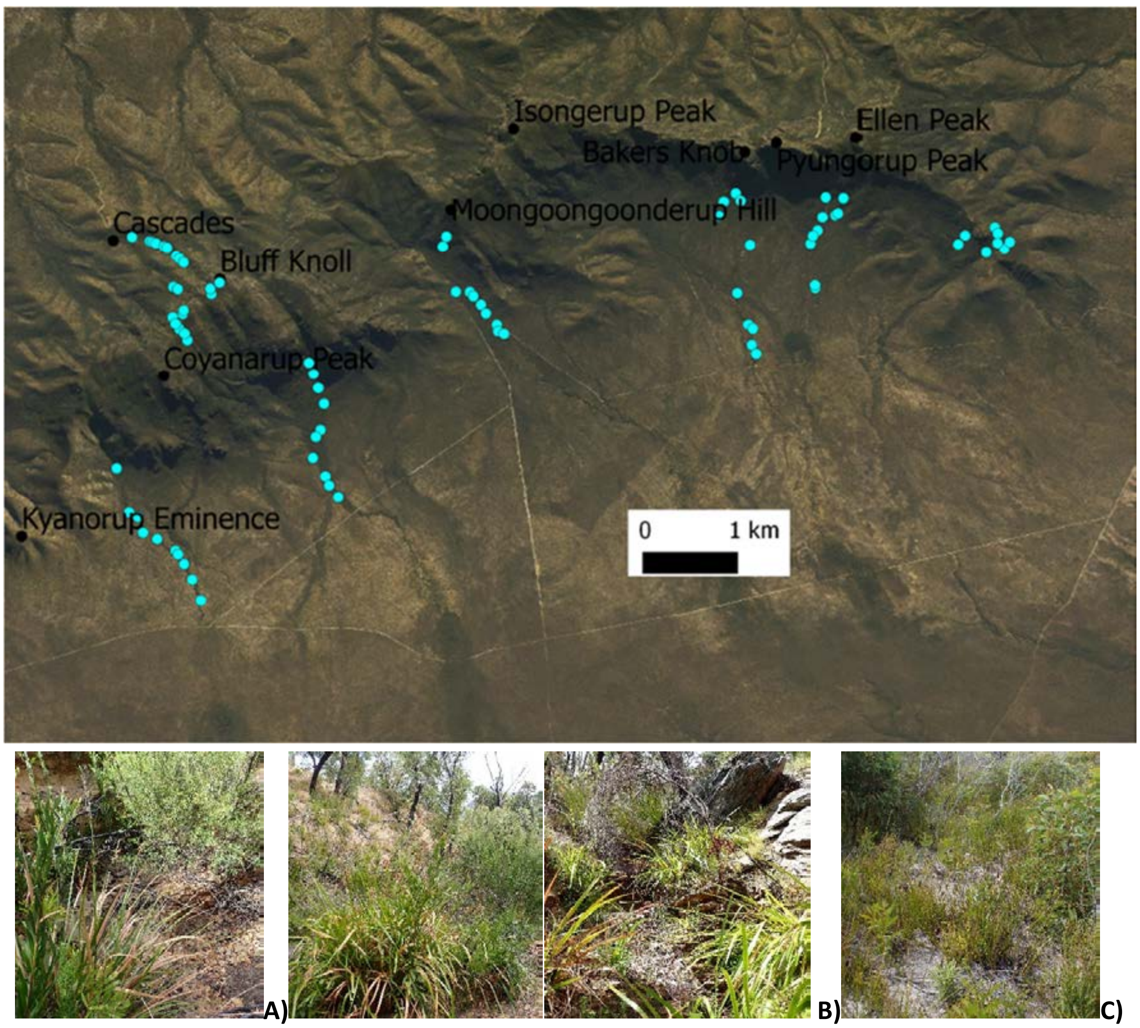


Figure 23: Locations sampled for *P. darwini* and sympatric species, and examples of potential habitat A) Bakers Knob, B) Pyungorup Gully, C) Ellen Peak

4.2.11 Stanwellia `MYG420 (=stirlingensis)`

Stanwellia stirlingensis is not currently listed as threatened under State or Commonwealth legislation. The species is known to occupy pockets of moist soil protected by overhanging rock or within litter and moss (Main and Gaull 1992). Prior to this survey *S. stirlingensis* was known from 12 WAM lodged specimens confirmed from Cascades, Bluff Knoll, Wedge Hill and Ellen Peak.

This genus was detected in 5 locations between October 2020 and January 2021, and between April and May 2021. Burrows were located in microhabitats on Wedge Hill, Mt Success, Bluff Knoll, and in the Pyungorup Gully (Table 11, Figure 24). A total of 8 active burrows were detected, and burrows occurred in moist soil within protected rock crevices, between sheet rock in rock crags, and within clay soils near creek lines. Burrows with fresh white silk around the burrow entrance were treated as active burrows and those with dirty, degraded silk were treated as defunct. Many of the sites where this species occurred also had *Bertmainius* present.

Table 11: Summary of *Stanwellia* detections during the 2020/ 2021 survey.

Mountain	#Sites	#Active Burrows	#Defunct Burrows	Burrow Diameter (mm)		
				1	2	3
Wedge Hill	1	1	0	0	0	1
Mt Success	1	2	0	0	2	0
Bluff Knoll	2	4	1	1	2	1
Pyungorup Gully	1	1	0	0	1	0

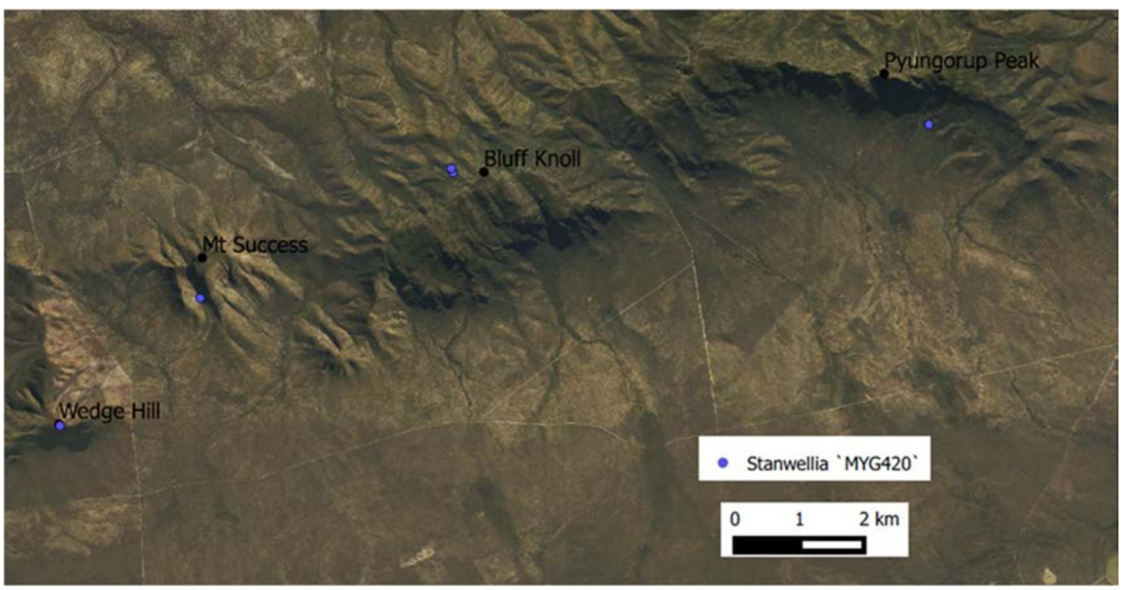


Figure 24: Locations of *Stanwellia* detected during the 2020/ 2021 survey.

Wedge Hill shallow mossy soil pocket | Mt Success clay bank

Pyungorup Gully | Bluff Knoll clay bank near walk trail

Figure 25: Examples of microhabitats where *Stanwellia* was detected.

4.2.12 Teyl `MYG636`

Teyl `MYG636' is not currently listed as threatened under State or Commonwealth legislation. The species is known to occupy open sandy patches (Pers com. Mark Harvey 2020, WAM 2020) and prior to this survey was known from only 3 WAM lodged specimens confirmed from the Isongerup and Pyungorup Peak lowlands.

This genus was detected in 16 locations between October 2020 and January 2021, and between April and May 2021. Burrows were located on Yungermere, Wedge Hill, Mt Success, Coyanarup Peak, Toolbrunup, Moongoongoonderup lowlands and the Ellen Peak watershed (Table 12, Figure 26). A total of 21 active burrows were detected, and burrows occurred in sandy soils in open heathland areas, or in sandy soils beneath woodland vegetation (Table 12, Figure 27). Identification was based on burrow appearance and while care was taken to differentiate between *Teyl* and *Proshermacha,* which has a similar burrow appearance, mis-identification is possible, especially in the summit areas where Teyl have not previously been recorded.

Table 12: Summary of *Teyl* detections during the 2020/ 2021 survey

Mountain	**# Sites**	**# Active Burrows**	**Burrow Diameters (mm)**	**Comments on habitat**
Yungermere	7	12	12- 16	Burrows in soft bed of dead moss overlaying sandy soils beneath a low defoliated woodland.
Wedge Hill	2	2	15, 19	Soft brown soils mid slope and in the lowlands at the base of the hill.
Mt Success	2	2	15, 16	Sandy flat bank near an inundated creek bed.
Coyanarup Peak	1	1	14	Southern lower gully in yellow sandy soil
Moongoongoonderup	2	2	14, 19	Shaded grey-brown sands adjacent to flowing creek and beneath jarrah/sheoak woodland
Ellen Peak watershed	1	1	16	Open sandy soil amongst rock outcrops.

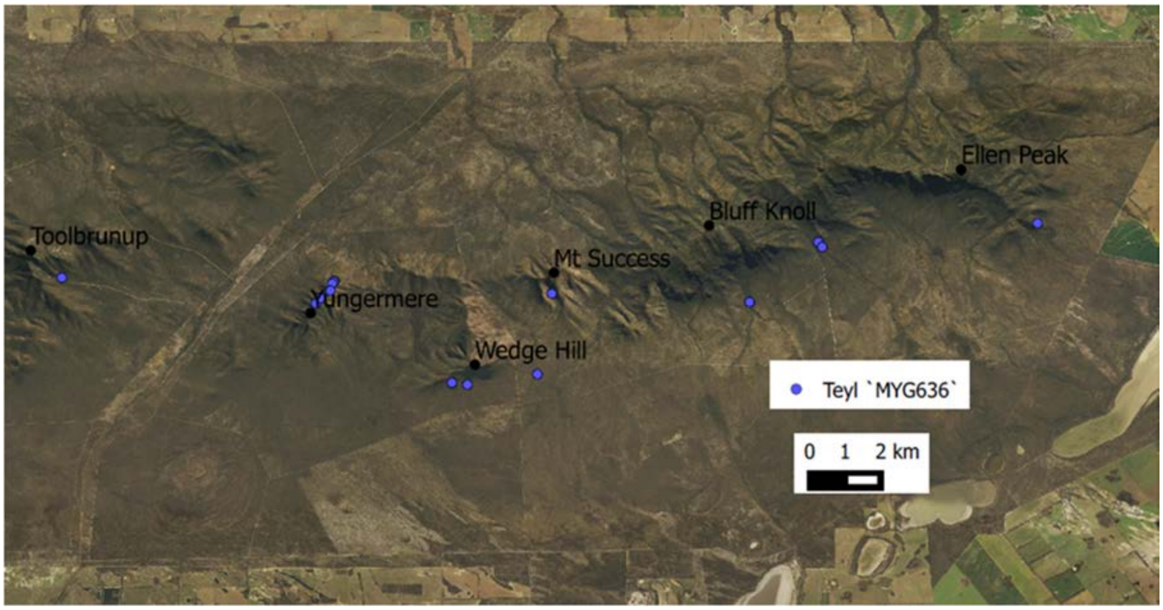
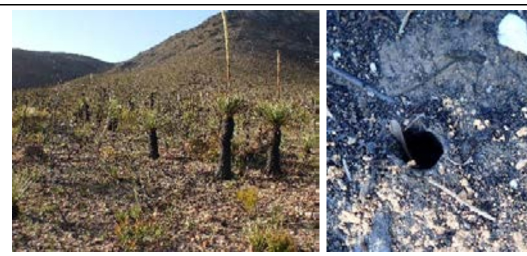


Figure 26: Locations of *Teyl* detected during the 2020/ 2021 survey

Yungermere summit. Burrows in soft sandy soils beneath low (defoliated) woodland



Wedge Hill lowlands. Burrows in dry soft sandy soil within open heath

Mt Success. Burrows in sand in montane heath adjacent to mid gully creek

Coyanarup gully. Burrows in soft yellow soils near the creek.

Moongoongoonderup lowlands. Burrows in soft sand near creek.

Ellen Peak Watershed. Burrows in dry sandy soil beneath marri woodland

Figure 27: Examples of microhabitats where *Teyl* burrows were detected.

4.2.13 Zephyrarchaea melindae

Zephyrarchaea melindae is currently listed as vulnerable (VU) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act*. The species is known to occur in suspended litter within sedges (*Lepidosperma sp*.) and low shrubs in montane heathland habitats (Rix and Harvey 2012). Prior to this survey, the species was known from three specimen records, two on Mt Hassell in June 2009 and November 2011, and one on Toolbrunup Peak in June 2009 (Rix and Harvey 2012, WAM 2020).

A total of 21 sedge and montane shrub sites were sampled within the potential range of *Z. melindae* in December 2020 and May 2021 (Figure 28). At each sample site, a minimum of 10 sedges/ shrubs were targeted. The species was not detected within the parameters of this survey. It was noted that while the vegetation was regenerating, the plants were low, there was minimal foliage present and there was a general absence of suspended leaf material or ground litter.

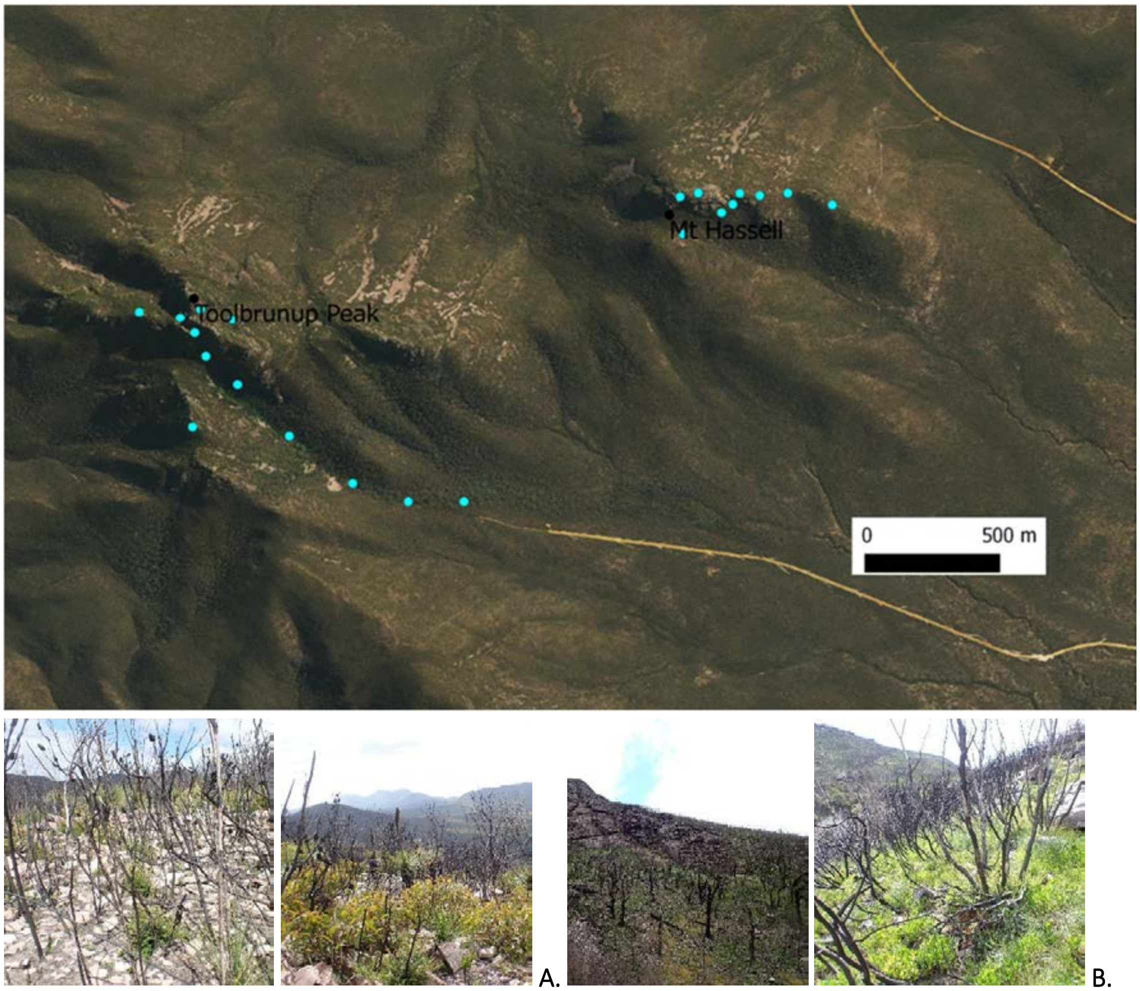


Figure 28: Locations sampled for *Z. melindae* and images of the regenerating vegetation on A. Mt Hassell and B. Toolbrunup Peak

4.2.14 Zephyrarchaea robinsi

Zephyrarchaea robinsi is currently listed as vulnerable (VU) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act*. The species in known to occur in montane heathland habitats and along mesic, shaded creek lines, in sympatry with *C. benrobertsi, P. darwini*, and *M. sarahae* and *M. epizephyros* (Rix and Harvey 2012, Waldock 2013). Prior to this survey the species was known from seven records on Bluff Knoll, Pyungorup Peak and Ellen Peak, where they occurred in montane heathland and in creek line sedges (Rix and Harvey 2012, WAM 2020).

A total of 81 sedge and montane shrub sites were sampled within the potential range of *Z. robinsi* between October 2020 and January 2021 and 55 of these sites were resampled between April and May 2021 (Figure 21). At each site, a minimum of 10 sedges/ shrubs were targeted. The species was not detected within the parameters of this survey. In most cases, it was noted that while the sedges and shrubs were regenerating, they were low and sparse, and there was a general absence of suspended leaf material or ground litter.

Table 13: Summary of data available for *Z. robinsi* (2008-2021)

Mountain	#Sites with survivors (2020)	Nov 2008 WAM	July 2011 WAM	April 2015 WAM	2020/ 2021	Comments relating to habitat (2008-2015)
Bluff Knoll	0	NS	3	1	0	Montane heathland. 3 juveniles in 2011, 1 adult male in 2015.
Pyungorup Peak	0	1	NS	NS	0	Sedges along creek line (1J)
Ellen Peak	0	2	NS	NS	0	Montane *Kunzea* heathland (2J)

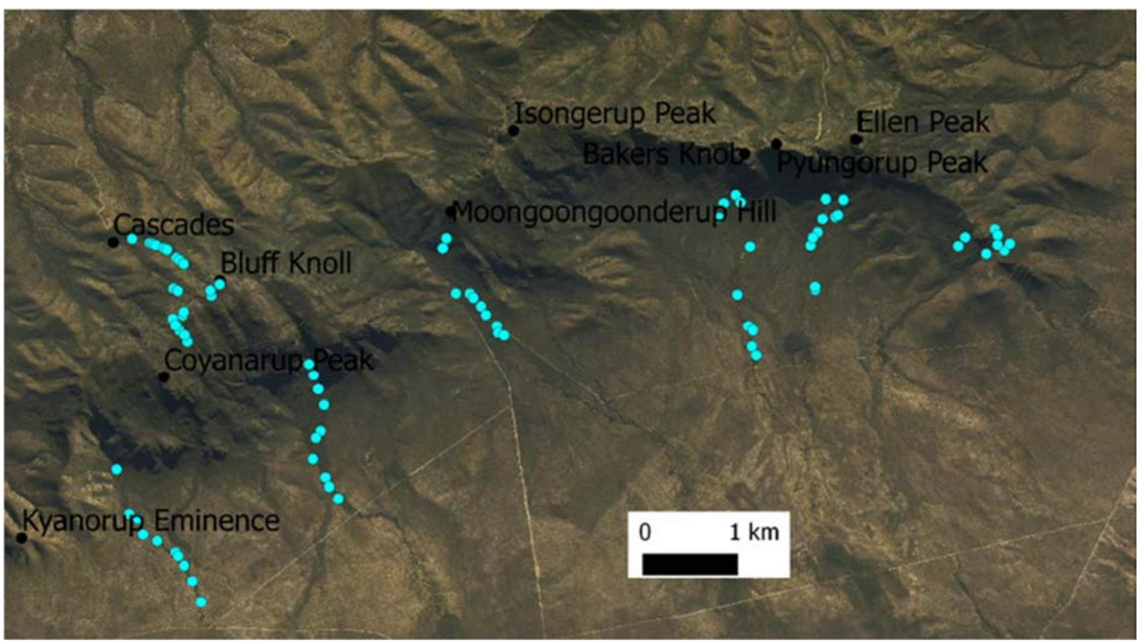


Figure 29: Locations sampled for *Z. robinsi*

4.3 Pseudoscorpions

4.3.1 Pseudotyrannochthonius 'Harms sp. Stirling Range 1`

Pseudotyrannochthonius 'Harms sp. Stirling Range 1` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur on the Toolbrunup scree slope where it is known from three WAM specimen records collected in October 2013, September 2017 and January 2019 (WAM 2020).

A total of 14 sites were sampled in November 2020 and again in May 2021, in areas containing habitat that was potentially suitable for *P. 'Harms sp. SR1'*, including the locations of the three WAM specimens (Figure 30). At each site, a minimum of 12 rocks were targeted. The species was not detected within the parameters of this survey.

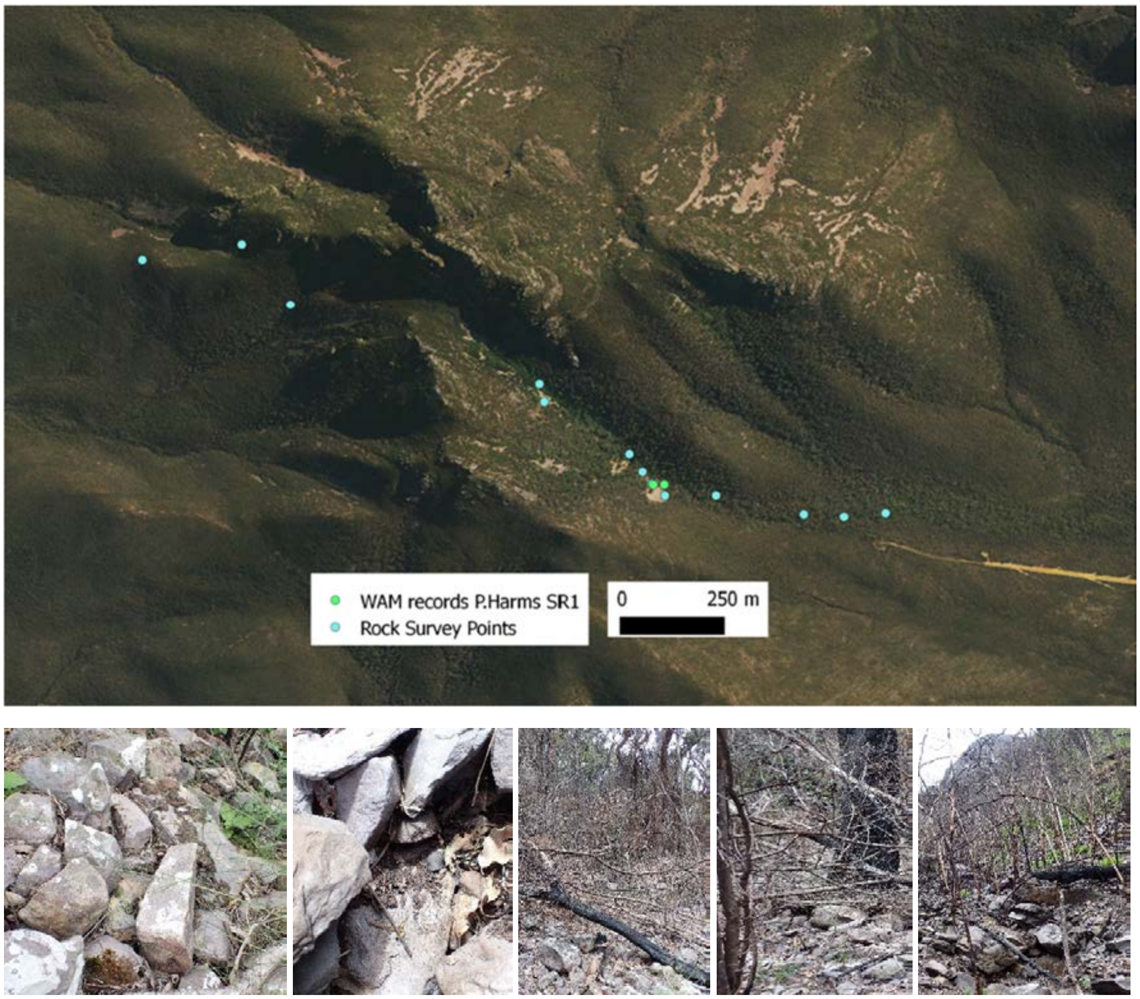


Figure 30: Locations sampled for *P. 'Harms sp. Stirling Range 1'*, and examples of potential habitat on Toolbrunup Peak.

4.3.2 Pseudotyrannochthonius 'Harms sp. Stirling Range 2`

Pseudotyrannochthonius 'Harms sp. Stirling Range 2` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur under rocks and in moist leaf litter, low vegetation and the topsoil layer. *P. 'Harms sp. SR2'* is currently known from 16 WAM records collected between 2008 and 2018 from under rocks in litter samples from Cascades, Bluff Knoll, Wedge Hill, Pyungorup, Ellen Peak (Harms 2013, WAM 2020, Table 14).

A total of 93 rock/ litter sites were sampled in areas between Wedge Hill and Pyungorup Peak between October 2020 and January 2021, and 55 of these sites were resampled between April and May 2021. These sites included the locations of the 16 WAM records and contained habitat that was potentially suitable for *P. 'Harms sp. SR2'* (Figure 31). At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. The species was not detected within the parameters of this survey. The only pseudoscorpion detected during the surveys was an individual of *Austrochthonius* collected from within a leaf litter sample in the southern gully of Coyanarup Peak.

Table 14: Summary of specimen data available for *P. 'Harms sp. SR 2`* (WAM 2020)

Mountain	June 2008	Oct 2013	Comments
Cascades	2	NS	1F, 1J
Bluff Knoll	2	10	2008: 1M, 1F under rocks, 2013: 5M, 1F, 5J
Wedge Hill	1	NS	1F
Pyungorup Peak	3	12	2008: 1M, 2F under rocks, 2013: 2M, 3F, 7J from Tulgren funnels
Ellen Peak	7	NS	7F

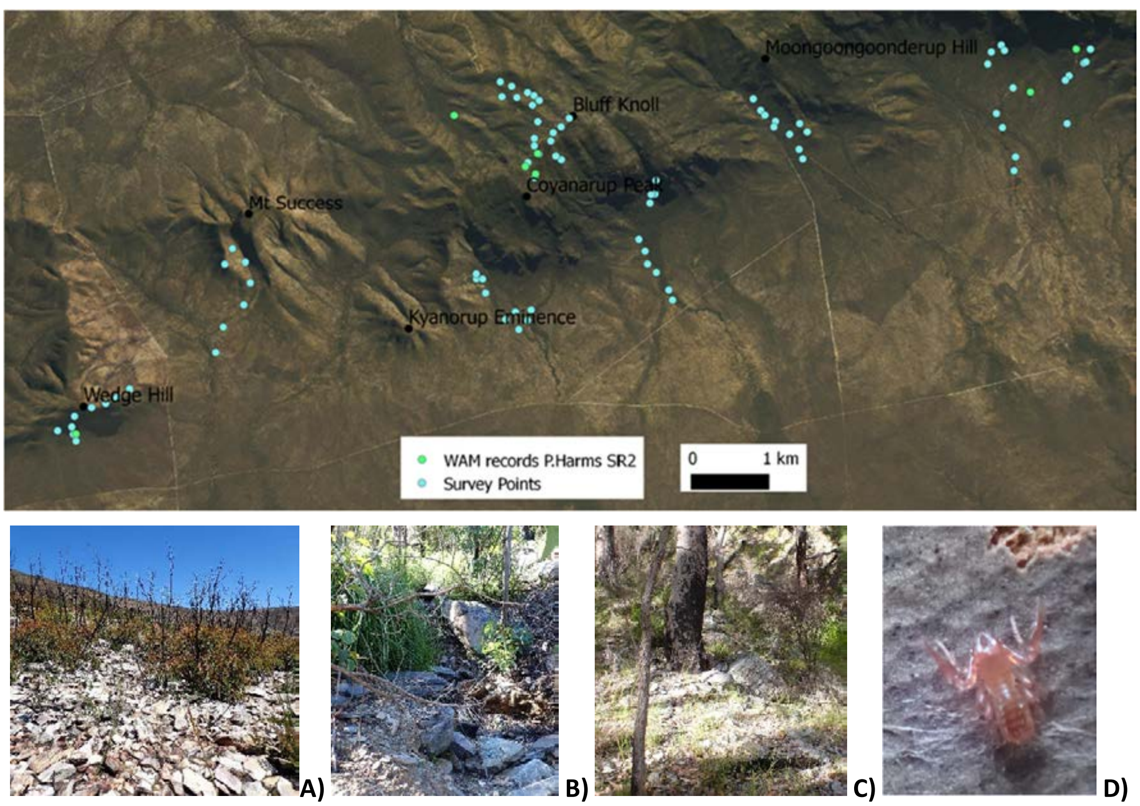


Figure 31: Locations sampled for *P. 'Harms sp. Stirling Range 2'*, examples of potential habitat on A) Wedge Hill, B) Bluff Knoll and C) Pyungorup, and D) detection of *Austrochthonius*.

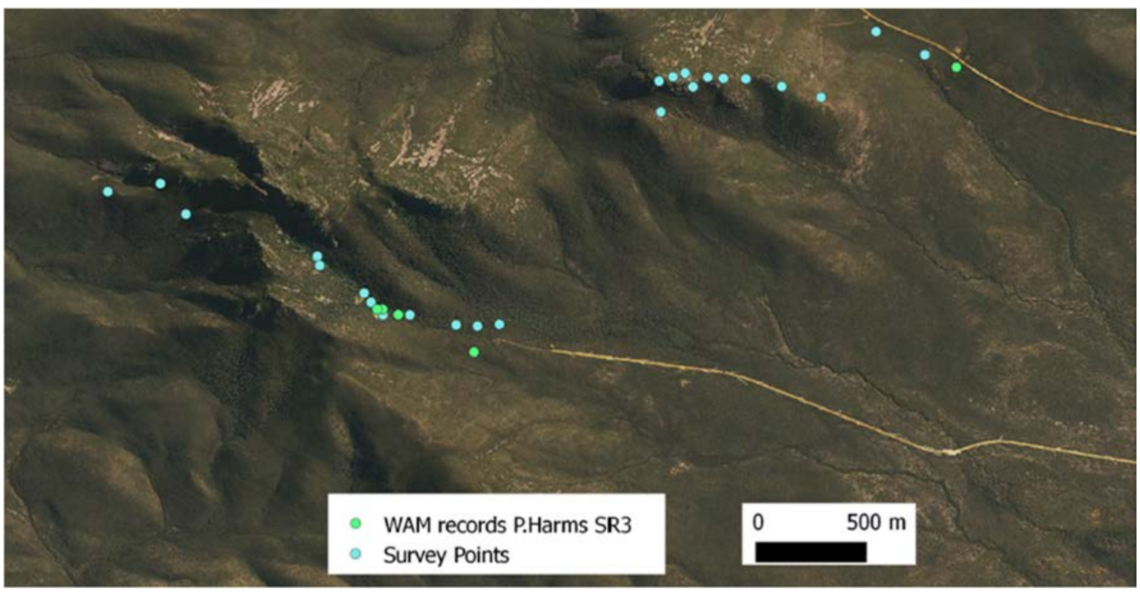
4.3.3 *Pseudotyrannochthonius 'Harms sp. Stirling Range 3`*

Pseudotyrannochthonius 'Harms sp. Stirling Range 3` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur under rocks and in moist leaf litter, low vegetation and the topsoil layer. *P. 'Harms sp. SR3'* is currently known from 21 WAM records collected between 2008 and 2018 from under rocks in litter samples from Toolbrunup Peak, Mt Hassell, Mabinup Creek and Mt Trio, 13 of these records are within the survey area (Harms 2013, WAM 2020, Table 15).

A total of 28 rock/ litter sites were sampled on Mt Hassell and Toolbrunup Peak in November and December 2020, and again in May 2021 (Figure 32). These sites included the locations of 11 of the 13 WAM records and contained habitat that was potentially suitable for *P. 'Harms sp. SR3'* (Figure 31). At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. The species was not detected within the parameters of this survey.

Table 15: Summary of specimen data available for *P. 'Harms sp. SR 3`* (WAM 2020)

Mountain	June 2008	Oct 2013	Sept 2017	Nov 2018	Comments
Mt Hassell	NS	4	NS	NS	1M, 3F from suspended leaf litter within sedges and within dead *Xanthorrhoea*
Toolbrunup	6	5	1	3	2008: 1M, 1F, 4J from under rocks and within *Xanthorrhoea* litter, 2013: 2M, 3F under rocks, 2017: 1F under rock, 2018: 1M, 2F under rocks at base of scree




A)


B)

Figure 32: Locations sampled for *P. 'Harms sp. Stirling Range 3'*, examples of potential habitat on A) Mt Hassell, B) Toolbrunup Peak

4.3.4 Pseudotyrannochthonius 'Harms sp. Stirling Range 5`

Pseudotyrannochthonius 'Harms sp. Stirling Range 5` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur under rocks and in moist leaf litter, low vegetation and the topsoil layer (Harms 2013). *P. 'Harms sp. SR5'* is currently known from a single record from a collection made from under a rock in April 2015 in the Pyungorup Gully (WAM 2020).

A total of 25 rock/ litter sites were sampled in the Pyungorup gully in January 2021, and again in May 2021 (Figure 32). These sites included the locations of the single known WAM record (Figure 32). At each survey site, a minimum of 10 leaf/ humus material collections were sieved and a minimum of 12 rocks were searched under. The species was not detected within the parameters of this survey.

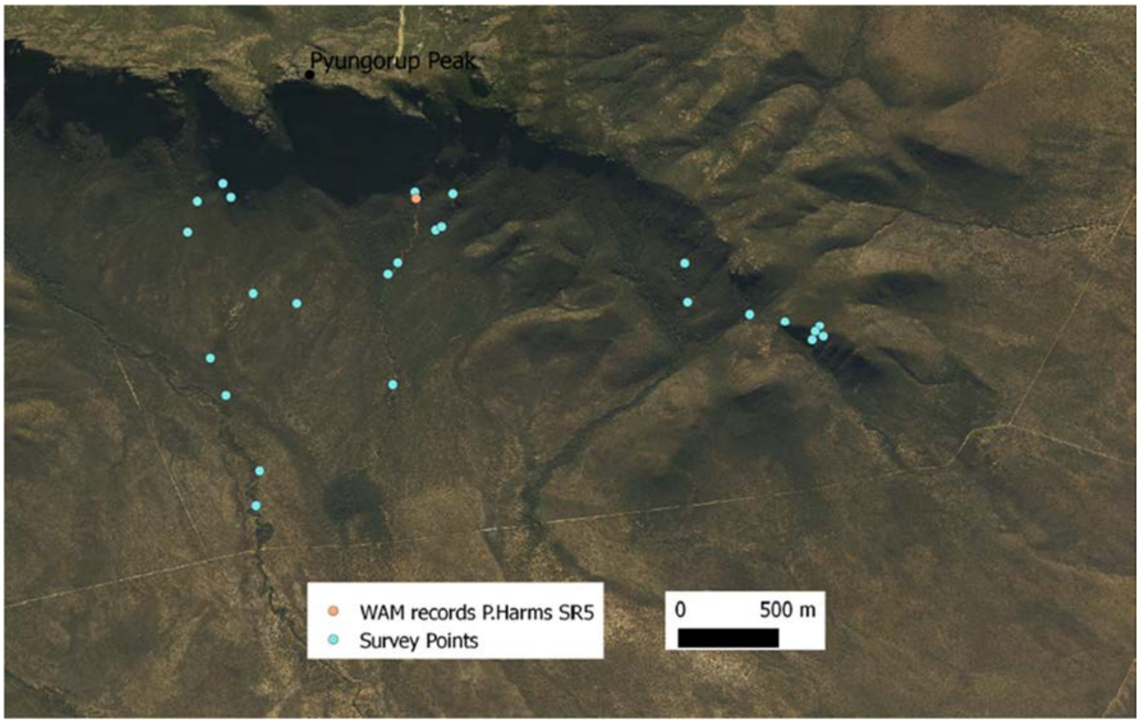


Figure 32: Locations sampled for *P. 'Harms sp. Stirling Range 5'*, examples of potential habitat on Pyungorup Peak

4.3.5 Synsphyronus apimelus

Synsphyronus apimelus is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur beneath rocks on scree slopes (Harvey 1987). The species is known from 14 WAM records collected between 1989 and 2020 from Toolbrunup, Mt Hassell, Bluff Knoll (WAM 2020, Table 16).

Between October 2020 and January 2021, 78 rock sites were sampled in areas between Toolbrunup Peak and Bluff Knoll containing habitat that was potentially suitable for *S. apimelus.* In May 2021, 62 of these sites were re-surveyed (Figure 33). At each survey site, a minimum of 12 rocks were targeted. The species was detected on Mt Hassell and Toolbrunup, and a total of four individuals were found (Table 16).

Table 16: Summary of detections for *S. apimelus* during the 2020/ 2021 survey and a summary of historical specimen data available (WAM 2020)

Mountain	May 2002	Jun 2004	Jul 2005	Dec 2010	Jan 2011	Aug 2016	Mar 2018	Nov 2018	April 2020	Nov 2020	May 2020
Mt Hassell	NS	NS	NS	NS	NS	1	NS	2	NS	2	0
Toolbrunup	30	8	1	1	3	NS	1	NS	1	1	1
Bluff Knoll	7	NS	NS	NS	NS	NS	NS	NS	0	0	0

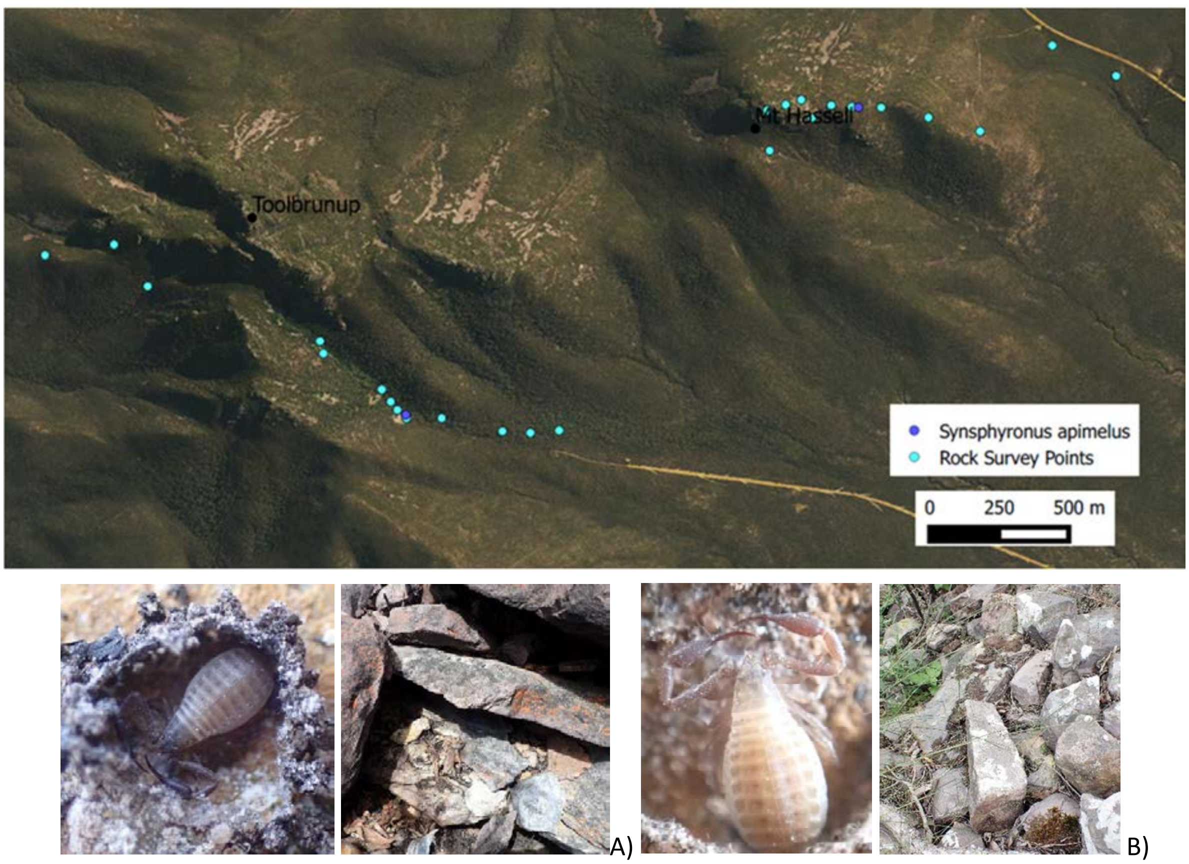


Figure 33: Locations of *Synsphyronus apimelus* detected during the 2020 surveys, WAM specimen locations (1989-2020) and sites sampled 2020. Examples of habitat searched A) Mt Hassell B) Toolbrunup Peak

4.4 Harvestmen

4.4.1 Megalopsalis epizephryos

Megalopsalis epizephryos is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur under damp, shaded leaves of sedges (*Lepidosperma sp.*), in sympatry with C*. benrobertsi, Z. robinsi, P. darwini and M. sarahae* (Taylor 2011, Waldock 2013). Prior to this survey, the species was known only from five WAM specimen records from wet pit fall taps on Bluff Knoll (WAM 2020, Table 17).

A total of 81 sedge and montane shrub sites were sampled within the potential range of *M. epizephyros* between October 2020 and January 2021 and 55 of these sites were resampled between April and May 2021 (Figure 34). At each site, a minimum of 10 sedges/ shrubs were targeted. The species was detected in November 2020 in the Pyungorup gully and in May 2021 in the mid Cascades gully. In both instances individuals were within sieved leaf litter samples. Identification was confirmed visually by Dr Mark Harvey (Table 17, Figure 34).

Table 17: Summary of detections for *M. epizephyros* during the 2020/ 2021 survey and a summary of historical specimen data available (WAM 2020)

Mountain	Mar 2006	April 2014	Nov 2020	May 2021	Comments
Bluff Knoll	6	11	0	1	2006: 3 records, 1M, 5J from wet pitfalls; 2014:2 records, 1M, 10J from wet pitfalls; 2021 within sieved litter sample
Pyungorup	NS	NS	1	0	2020 within sieved litter sample

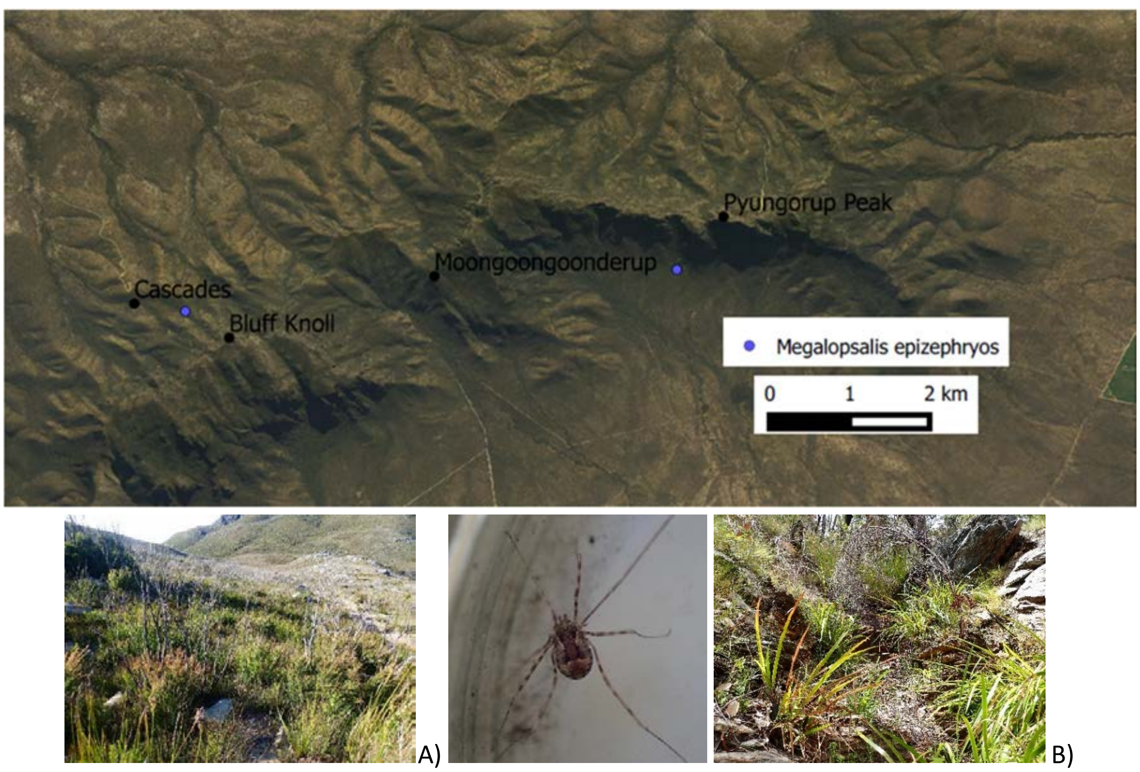


Figure 34: Locations *M. epizephyros* detected during the Spring 2020 and Autumn 2021 surveys, WAM specimen locations (2006-2014) and sites sampled 2020/ 2021. Examples of habitat searched A) Bluff Knoll B) Pyungorup Peak

4.5 Millipedes

4.5.1 `Hesperisiphon` `peckorum`

`Hesperisiphon` `peckorum` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur in fungi/mushroom litter and within rotten logs (Black 1994, Framenau *et al.* 2008, WAM 2020). Prior to this survey, the species was known only from four specimen records collected from Toolbrunup Peak walk trail in June 1992 (WAM 2020).

Toolbrunup Peak was surveyed in December 2020 and May 2021, and each time a 9.15 km was walked in a traverse, within the gully and adjacent montane areas, searching for rotting logs, leaf litter and other moist micro-niches that are potentially suitable for *H. peckorum.* A total of 24 sedge and rock sites were formally sampled (10 sedge/ shrub and 12 rocks targeted at each site) and additional micro-niches were searched opportunistically where they were encountered. The species was not detected within the parameters of this survey.

4.5.2 Antichiropus `DIP075`

Antichiropus `DIP075` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur in leaf litter, beneath rocks and beneath bark in shrubland and forest (Framenau *et al.* 2008). Prior to this survey, the species was known only from a single specimen record collected Bluff Knoll in October 2017 (WAM 2020).

Bluff Knoll and the Cascades were surveyed in January 2021 and May 2021. During each of these surveys, 8.97 km was walked in traverses through areas associated with the walk trail, summit, gully and creek lines, searching for leaf litter, rocks in moist or shaded areas, trees with flaking bark, rotting logs, and other moist micro-niches that are potentially suitable for *A. `DIP075`.* A total of 32 sedge and rock sites were formally sampled (10 sedge/ shrub and 12 rocks targeted at each site) and additional micro-niches were searched opportunistically where they were encountered. The species was not detected in the Bluff Knoll or Cascades surveys. The species however was found during surveys on Mt Hassell in May 2021. A total of 22 sedge, rock and litter sites were sampled and *A. `DIP075'* was detected at two sites near the Mt Hassell summit. In one instance within a litter sample and in the second instance beneath a rock (Figure 35).

Figure 35: Locations *Antichiropus 'DIP075'* detected during the Spring 2020 and Autumn 2021 surveys

4.5.3 Atelomastix danksi

Atelomastix danksi is currently listed as vulnerable (VU) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act*. The species is known to occur in creek banks in litter alongside a seasonally dry creek bed and under eucalypt logs (Edward and Harvey 2010). Prior to this survey the species was known from 10 records of specimens collected between 1993 and 2005 in wet pitfall traps or hand collected from within leaf litter from Toolbrunup Peak (Barret 1996, WAM 2020, Table 18).

Toolbrunup Peak was surveyed in December 2020 and May 2021, and each time 9.15 km was walked in a traverse, within the gully and adjacent montane areas, searching for rotting logs, leaf litter and other moist micro-niches that are potentially suitable for *A. danksi.* A total of 24 litter and rock sites were formally sampled (10 litter samples and 12 rocks targeted at each site) and additional micro-niches were searched opportunistically where they were encountered. A total of 626 individuals were detected on Toolbrunup Peak and Mt Hassell. Of these, 537 individuals (86%) were alive and most of the surviving individuals were detected during the autumn survey, due to higher moisture levels. During the spring/ summer survey this species was dormant within the humus and soil layers. *A. danksii* was detected in 29 locations during the survey, 21 on Toolbrunup Peak and eight on Mt Hassell (Figure 36, Table 18). On Toolbrunup, 505 surviving individuals were detected within moist leaf litter and under rocks in the creek bed, in montane heath areas beneath large rocky crags, beneath rocks and in rock crevices (Figures 37). On Mt Hassell, 32 surviving individuals were detected in montane heath, eucalypt regrowth and rock outcrops near the summit and in the southern gully between Mt Hassell and Toolbrunup Peak (Figure 37). The species has not previously been recorded on Mt Hassell.

Table 18: Summary of detections for *A. danksi* during the 2020/ 2021 survey

Mountain	# Sites	#Sites with survivors	Dead	Alive	Comments relating to habitat
Toolbrunup	21	16	61	505	Within litter and under rocks within a broad creek bed under defoliated marri woodland, and at the base of rock crag.
Mt Hassell	8	4	28	32	Within litter in areas of dense regrowth, and under rocks upslope of the western gully, on the northern face and in the saddle between Mt Hassell and Toolbrunup Peak.

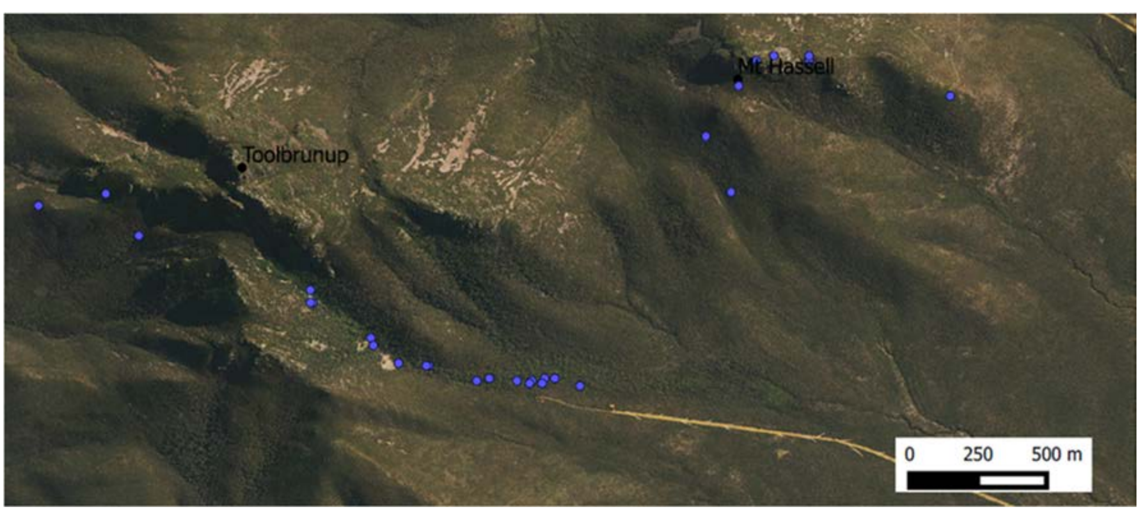
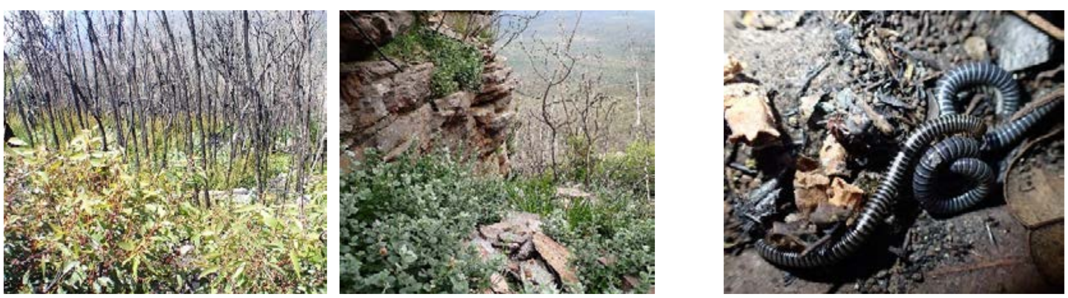


Figure 36: Locations of *A. danksi* detected during the 2020/ 2021 survey.

Toolbrunup within creek line

Toolbrunup within a defoliated section of creek line where leaf fall had accumulated in the creek bed



Regenerating gully between Mt Hassell and Toolbrunup, and rocky crags near the summit of Mt Hassell

Figure 37: Examples of microhabitats where *A. danksi* was detected.

4.5.4 Atelomastix montana

Atelomastix montana is currently not listed under the State's *BC Act* or the Commonwealth's *EPBC Act*. The species is known to occur within leaf litter and under logs (Edward and Harvey 2010). Prior to this survey the species was known from 18 records of specimens collected between 1996 and 2019 in wet pitfall traps, tulgren funnels or hand collected from within leaf litter from Coyanarup Peak, Moongoongoonderup Peak lowlands and Pyungorup Peak (Barret 1996, WAM 2020, Table 19).

A total of 196 litter and rock sites were formally sampled within the range of this species between October 2020 and January 2021, and 132 sites were resurveyed in April and May 2021. At each site, 10 litter samples and 12 rocks targeted, and additional micro-niches were searched opportunistically where they were encountered.

A. montana was detected in 29 sites during the survey, with occupied sites occurring in the Mt Success lowlands, Wedge Hill gully, Coyanarup Peak gully, Kyanorup Eminence gully, Moongoongoonderup lowlands, and Pyungorup gully (Figure 38, Table 19). Microhabitats where the species was detected included within rocky crags, beneath overhanging rocks where leaf litter would have accumulated prior to the fire, beneath rocks, in rock crevices and in exposed sandy soils where ground leaf litter and logs had been burnt away. Surviving individuals were detected mostly in Autumn due to the moister conditions and were associated with unburnt or regenerating sedges, leaf litter within and adjacent to creek areas and within shaded recesses of rock crags (Figure 39). During the spring/ summer survey this species was dormant within the humus and soil layers and a high abundance of dead individuals were detected on Moongoongoonderup Peak and Coyanarup Peak in dry exposed sites that had been intensely burnt, and where there was a complete absence of leaf litter and woody material on the ground.

Table 19: Summary of detections for *A. montana* during the 2020/ 2021 survey.

Mountain	# Sites	#Sites with survivors	Dead	Alive	Comments
Wedge Hill	3	1	12	1	Crevices within rock crags in the upper gully. Intense fire behaviour resulted in complete removal of vegetation and leaf litter.
Mt Success	2	0	5	0	This site was not resurveyed in autumn.
Kyanorup Eminence	3	0	7	0	This site was not resurveyed in autumn.
Cyanorup Peak	5	1	47	3	Crevices within rock crags and in ground litter beneath unburnt sedges in the lower gully. These sites were not resurveyed in autumn.
Moongoongonderup	14	7	189	177	All survivors were detected in May 2021 beneath regenerating and patchily burnt sedges and in leaf litter beneath thicket vegetation in the lower gully.
Pyungorup Gully	2	1	10	2	Beneath dry litter under an overhanging rock.

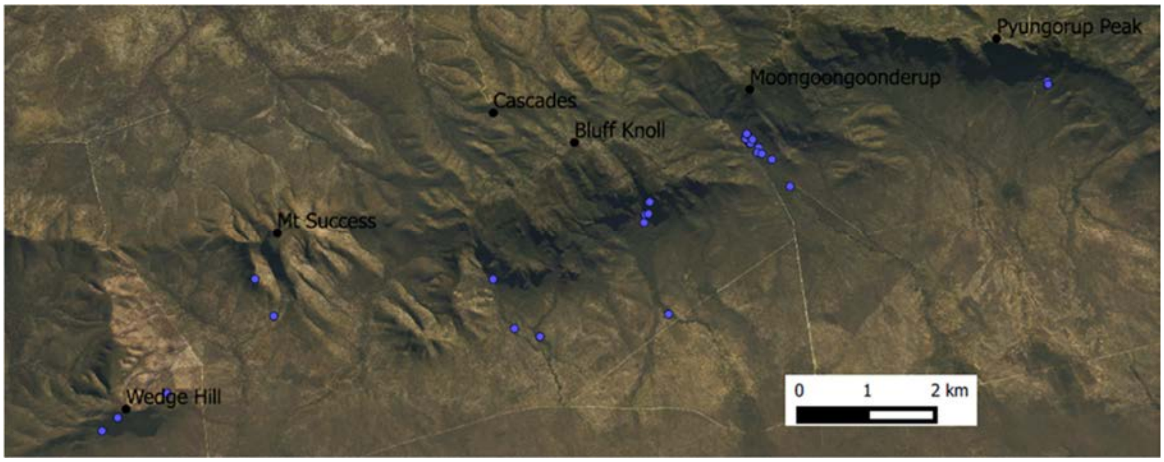


Figure 38: **Locations of *A. montana* detected during the 2020/ 2021 survey.**

Mt Success. Recently dead within a shallow, exposed creek line.

Wedge Hill. Alive within the shaded recesses of a rock crag near the summit

Kyanorup. Recently dead within recesses of a clay bank adjacent to a dry creek bed.

Coyanarup Peak. Live individual in ground litter beneath unburnt sedges in lower gully.

Moongoongoonderup Peak. Brown sandy soil beneath regenerating marri/ sheoak woodland

Pyungorup Peak. Live individuals within litter in a section of moist mildly burnt gully.

Figure 39: **Examples of microhabitats where *A. montana* was detected.**

4.5.5 Atelomastix poustiei

Atelomastix poustiei is currently listed as vulnerable (VU) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act*. The species is known to occur in a deeply dissected gully shaded by relatively tall eucalypt trees. Under logs, leaf litter and bark (Edward and Harvey 2010). Prior to this survey the species was known from four records on Wedge Hill between 1997 and 2004 (WAM 2020, Table 20)

A total of 12 litter and rock sites were formally sampled on Wedge Hill in both October 2020 and May 2021. At each site, 10 litter samples and 12 rocks were targeted, and additional micro-niches were searched opportunistically where they were encountered.

A. poustiei was detected in 13 locations on Wedge Hill during the 2020/ 2021 survey (Table 20, Figure 40). A total of 218 individuals were detected, 48 (22%) of which were alive. All of the surviving individuals were detected during the autumn survey, due to higher moisture levels. During the spring/ summer survey this species was dormant within the humus and soil layers. Dead individuals were detected mid slope in the gully beneath rocky crags, in the lower spur between gullies in areas where leaf litter is likely to have been present, beneath rocks on a scree slope on the eastern spur, and on exposed soil within defoliated sheoak woodland in the upper gully (Figure 40). Surviving individuals were detected in autumn beneath fallen marri bark, beneath rocks and in watershed within rocky crags (Figure 40). Wedge Hill was exposed to high intensity fire, including within the gully system, which had previously been long unburnt. The fire defoliated the woodland and removed all ground litter.

Table 20: Summary of detections for *A. poustiei* during the 2020/ 2021 survey.

Mountain	# Sites	#Sites with survivors	Dead	Alive	Comments
Wedge Hill	13	3	170	48	Mid slope in gully beneath rocky crags, lower spur between gullies, scree slope on eastern spur, and sheoak woodland in upper gully. All defoliated and dry with an absence of ground litter. Surviving individuals located beneath fallen marri bark, beneath rocks and in watershed within rocky crags.

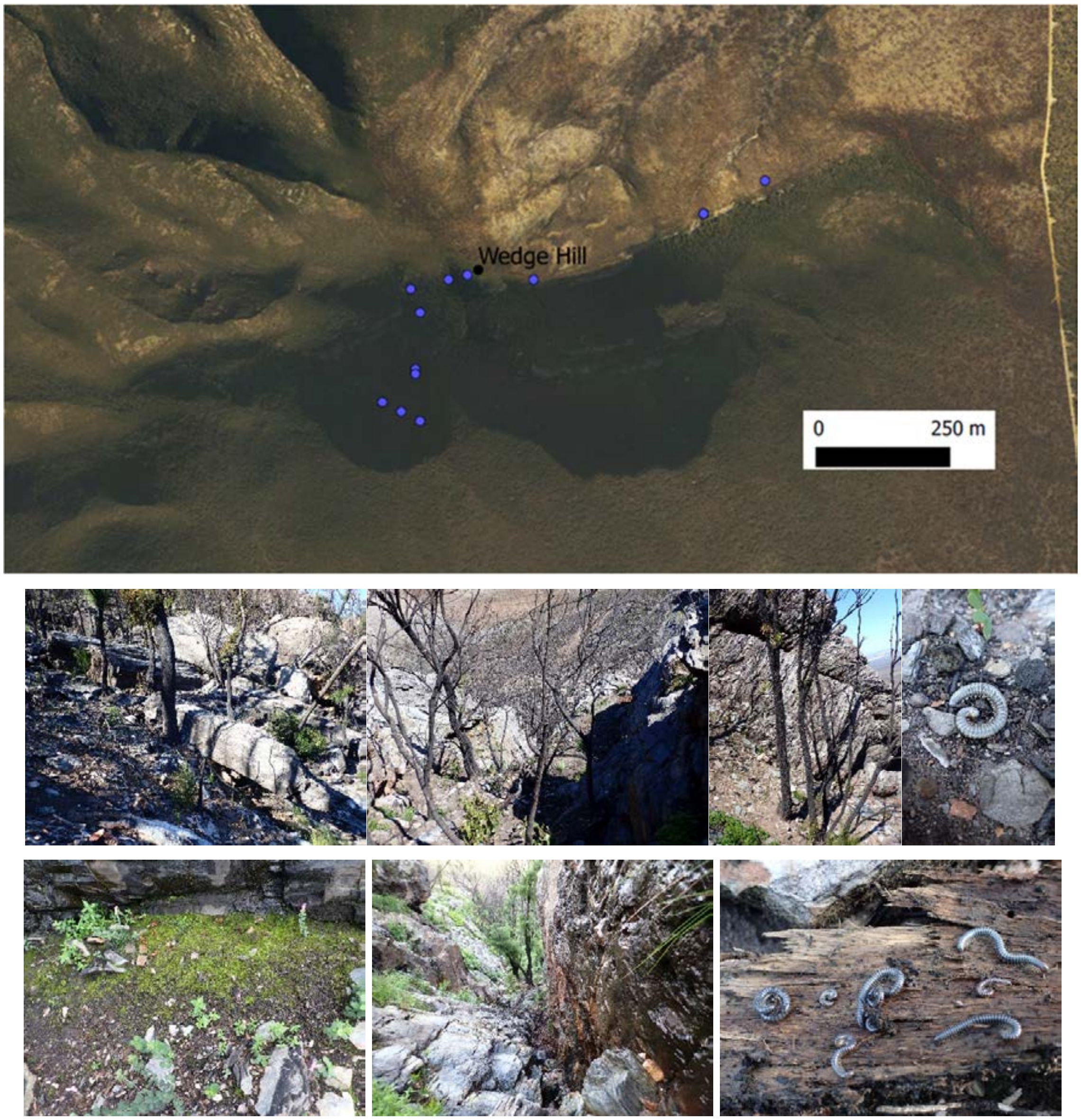


Figure 40: **Locations of *Atelomastix poustiei* detected during the 2020/ 2021 survey and examples of habitat occupied in a) Spring 2020 and b) Autumn 2021.**

4.5.6 Atelomastix tigrina

Atelomastix tigrina is currently listed as vulnerable (VU) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act*. The species is known to occur within leaf litter and under rocks (Edward and Harvey 2010, WAM 2020). Prior to this survey the species was known from 21 records of specimens collected between 1996 and 2019 in wet pitfall traps, tulgren funnels or hand collected from under rocks in the Cascades and the southern gully of Pyungorup Peak (Barret 1996, WAM 2020, Table 21). The 2019 specimens were part of a survey in March 2019, following the May 2018 fire where numerous individuals were detected alive under rocks and logs on the south face of Pyungorup Peak (Harvey and Rix 2019).

A total of 196 litter and rock sites were formally sampled within the range of this species between October 2020 and January 2021, and 132 sites were resurveyed in April and May 2021. At each site, 10 litter samples and 12 rocks targeted, and additional micro-niches were searched opportunistically where they were encountered.

A. tigrina was detected in 26 sites during the 2020/ 2021 survey (Figure 41, Table 21). A total of 209 individuals were detected, 90 (43%) of which were alive. Most surviving individuals were detected during the autumn survey, due to higher moisture levels. Surviving individuals were detected within deep, protected rock crevices, beneath rocks and in leaf litter associated with creek lines, in leaf litter within rock crevices and beneath unburnt patches of sedges (Figure 42).

Table 21: Summary of detections for *A. tigrina* during the 2020/ 2021 survey.

Mountain	# Sites	#Sites with survivors	Dead	Alive	Comments
Yungermere	7	1	85	3	Survivors detected within deep rock crevices.
Bluff Knoll/ Cascades	4	2	4	16	Beneath rocks and in leaf litter within and adjacent to the creek, as well as squashed by walkers on the Bluff Knoll walk trail.
Pyungorup Peak and Gully	12	6	21	60	In leaf litter within rock crevices and beneath an unburnt patch of sedges.
Ellen Peak Watershed	5	5	13	18	Beneath rocks within the creek bed and adjacent to it beneath regenerating eucalypt woodland.

Figure 41: Locations of *A. tigrina* detected during the 2020/ 2021 survey.

Yungermere, Individuals alive within unburnt section of rocky crag. Leaf litter still present in crevices

Cascades gully in leaf litter near creek and beneath marri woodland.

Pyungorup gully in leaf litter under sedges, beneath an overhanging rock. This pocket escaped the fires.

Ellen Peak watershed beneath a small pile of leaf litter within rocks in the creek bed

Figure 42: Examples of microhabitats where *A. tigrina* was detected.

4.5.7 Atelomastix tumula

Atelomastix tumula is currently listed as vulnerable (VU) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act*. The species is known to occur in moist jarrah and marri forest with a relatively thick understorey (Edward and Harvey 2010). Prior to this survey the species was known from three records in 2004 of specimens collected by hand from the Bluff Knoll walk trail (Table 22 WAM 2020).

A total of 41 litter and rock sites were formally sampled within the range of this species in January 2021 and resurveyed in May 2021. At each site, 10 litter samples and 12 rocks targeted, and additional micro-niches were searched opportunistically where they were encountered.

A. tumula was detected in seven sites during the 2020/ 2021 survey (Table 22, Figure 43). A total of 118 individuals were detected, 88 (75 %) of which were alive. Most surviving individuals were detected during the autumn survey, due to higher moisture levels. Surviving individuals were detected within leaf litter and under rocks in mildly burnt sections of the Cascades gully (Figure 42).

Table 22: Summary of detections for *A. tumula* during the 2020/ 2021 survey.

Mountain	**# Sites**	**#Sites with survivors**	**Dead**	**Alive**	**Comments**
Bluff Knoll/ Cascades	7	4	4	88	Within leaf litter and beneath rocks adjacent to creek line. Often located in groups with *A. tigrina*

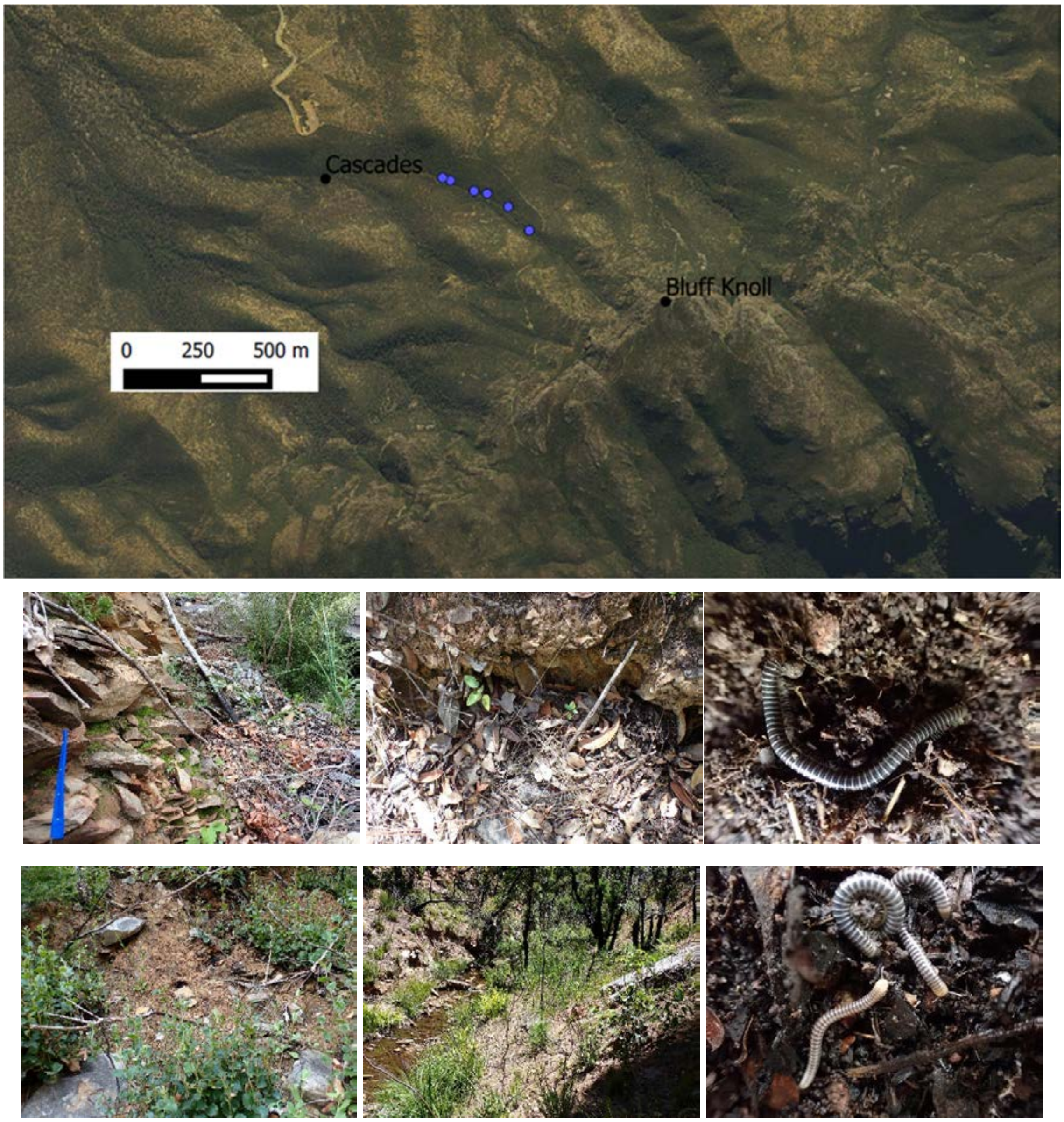


Figure 43: **Locations of *A. tumula* detected during the 2020/ 2021 survey and examples of microhabitats occupied in the Cascades gully.**

4.5.8 Australeuma `sp.`

Australeuma `sp.` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur in leaf litter within gullies. Prior to this survey the species was known from only three specimen records, one from sieved leaf litter samples on the Toolbrunup summit in April 2009 and two from Tulgren funnel collections within mesic creek line on Pyungorup Peak in August 2009 (WAM 2020).

Toolbrunup Peak was surveyed in December 2020 and May 2021 and the Pyungorup Peak gullies were surveyed in January 2021 and May 2021. During each of these surveys, a total of 88 sedge, rock and litter sites were formally sampled (10 sedges/ shrubs, 10 litter samples and 12 rocks targeted at each site) and additional micro-niches were searched opportunistically where they were encountered. The species was not detected within the parameters of this survey.

4.5.9 Samichus `Eastern Stirling Ranges`

Samichus `Eastern Stirling Ranges` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur beneath bark, under logs or under rocks (Framenau *et al.* 2008, WAM 2020). Prior to this survey, the species was known only from four specimen records collected in January 2006, from the Cascades and the Moongoongoonderup/ South Isongerup Peak lowlands (WAM 2020).

Moongoongoonderup Peak and areas near South Isongerup were surveyed in December 2020 and May 2021. Bluff Knoll and the Cascades were surveyed in January 2021 and May 2021. During these surveys, 57 rock sites were formally sampled (12 rocks targeted at each site) and additional micro-niches were searched opportunistically where they were encountered. The species was not detected within the parameters of this survey.

4.6 Onychophorans

4.6.1 Kumbadjena `ONY04`

Kumbadjena `ONY04` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur in permanently moist habitats such as rotting logs and leaf litter. Prior to this survey, the species was known only from two specimen records on Pyungorup Peak, one in July 2013 and one in October 2016, both from sieved litter samples (WAM 2020).

In January 2021, 24.3 km was walked in a traverse, within the Pyungorup Peak area, searching for rotting logs or leaf litter likely to be suitable for *K. `ONY04`*. These traverses were re-surveyed in April and May 2021. The species was not detected within the parameters of this survey. It was noted that logs that were on the ground had either recently fallen as a result of the fire, or if they were on the ground during the fire, they had been charred and the rotting material within them burnt away. There were however two logs on Pyungorup that were identified for follow up survey, due to the presence of deep crevices in the trunk and the possibility of individuals of *K. `ONY04`* retreating into the core of the log or beneath the log during the fire and finding refuge here during the subsequent dry summer (e.g. Figure 44). Within the Pyungorup gully there were also areas where leaf material had collected, especially those associated with high velocity water movement down the creek line or where canopy had been scorched during the fire resulting in leaf fall. In these areas there were consolidated pockets of leaf material, woody debris and humus which were sieved. *K. `ONY04`* was one of the species searched for during this sampling process.

Figure 44: Potential habitat identified for *K. `ONY04`* in the Pyungorup Peak area

4.6.2 *Kumbadjena toolbrunupensis*

Kumbadjena toolbrunupensis is not currently listed as threatened under State or Commonwealth legislation. Permanently moist habitats such as rotting logs and leaf litter (Sato *et al.* 2018). Prior to this survey, the species was known only from a single specimen record (2011) in a shallow gully on Toolbrunup Peak (WAM 2020).

In December 2020, 9.15 km was walked in a traverse, within the Toolbrunup Peak area, searching for rotting logs or leaf litter likely to be suitable for *K. toolbrunupensis.* This traverse was re-surveyed in May 2021. The species was not detected within the parameters of this survey. It was noted that logs that were on the ground had either recently fallen as a result of the fire, or if they were on the ground during the fire, they had been charred and the rotting material within them burnt away. There were several logs near the creek that were identified for follow up survey, due to the presence of deep crevices in the trunk (e.g. Figure 45). There was minimal leaf litter within the Toolbrunup gully at the time of the survey, however collapsing trees and leaf fall associated with scorched and defoliated overstorey is contributing to a return of this microhabitat within the gully and surrounds.

Charred Log

Defoliated sections of the gully which need time for leaf litter accumulate again and contribute to suitable micro-niches

Figure 45: Potential habitat identified for *K. toolbrunupensis* in the Toolbrunup gully.

4.7 Snails

4.7.1 Bothriembryon glauerti

Bothriembryon glauerti is currently not listed under the State's *BC Act* or the Commonwealth's *EPBC Act* but is listed as priority fauna (P2) on a list of poorly known species that is administered by the Department of Biodiversity, Conservation and Attractions. The species is known to occur within moist micro-niches such as leaf litter, logs, rock seepages. Prior to this survey the species was known from six DBCA records dated between 1969 and 1997 from surveys and opportunistic collections on Toolbrunup Peak, Bluff Knoll, Coyanarup Peak, Pyungorup Peak and Ellen Peak (DBCA 2020).

A total of 242 litter, sedge/ shrub and rock sites were formally sampled between October 2020 and January 2021 and 150 of these sites were resampled between April and May 2021. Surveys targeted areas containing moist micro-niches that are potentially suitable for *B. glauerti.* At each site, a minimum of 10 litter samples and 12 rocks were surveyed and additional micro-niches were searched opportunistically where they were encountered.

B. glauerti was detected in 69 locations during the survey, with 17 occupied sites occurring on Kyanorup Eminence, Bluff Knoll/ Cascades, Coyanarup Peak, Moongoongoonderup Hill, Bakers Knob, Pyungorup Peak, Pyungorup Gully and Ellen Peak Watershed (Table 23, Figure 46). In total 314 individuals were detected and of these, 72 (23%) were alive (Table 23). Locations where individuals of *B. glauerti* were detected alive included within moist watersheds, adjacent to moist creek lines, within rock crags, and in leaf litter within deep protected sections of gullies (Figure 47).

B. brazieri (P2) was also detected on Toolbrunup Peak, Mt Hassell and Yungermere Peak. This species was detected in 19 locations, 9 of which contained surviving individuals. A total of 64 individuals were detected, and 35 of these (55%) were alive.

Table 23: Summary of detections for *B. glauerti* during the 2020/ 2021 survey

Mountain	# Sites	#Sites with survivors	2020/21 Dead	2020/21 Alive	Comments
Kyanorup Eminence	2	0	2	0	Watershed at the base of rock crags.
Bluff Knoll/ Cascades	1	1	14	8	Low sedge gully near the summit, within rock crags, rock crevices and beneath regenerating shrubs.
Coyanarup Peak	6	0	9	0	Rocky slope adjacent to a flowing creek, beneath marri/ sheoak woodland.
Moongoongoonderup	17	8	79	44	Edge of flowing creek, moist mossy area beneath dead bullich and sheoak, beneath sedges adjacent to creek, in rocky watersheds, and in leaf litter.
Bakers Knob	12	1	29	1	On edge of creek and beneath rocks.
Pyungorup Gully	17	6	76	18	Edge of broad gully adjacent to creek, in jarrah/marri woodland. In ground litter within rock cairns, and within creek bed.
Pyungorup Peak	1	1	5	1	Beneath regenerating montane heath on summit.
Ellen Peak Watershed	8	0	28	0	Within and upslope of creek, beneath rock crag

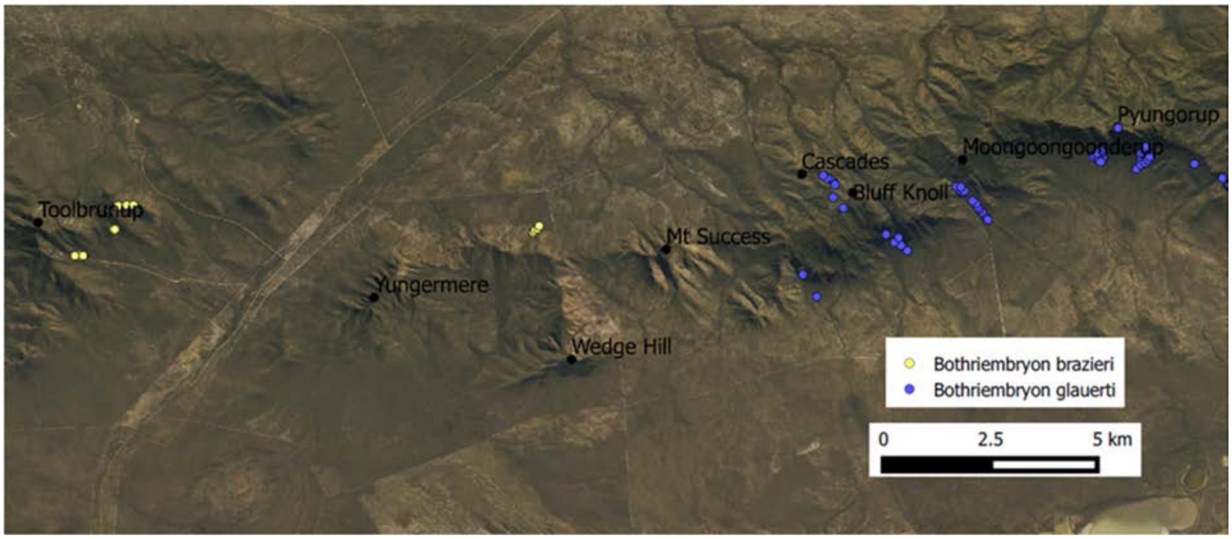


Figure 46: **Locations of *B. glauerti* detected during the 2020/ 2021 survey.**

Upper Cascades gully, adjacent to creek in leaf litter beneath rapidly regenerating woodland

Kyanorup Eminence. Dead individuals within a marri woodland upslope of the creek.

Bakers Knob. Live individuals detected within a mildly burnt section of the creek where vegetation was recovering rapidly.

Pyungorup Peak. Live individuals within deep gully.

Figure 47: **Examples of microhabitats where *B. glauerti* was detected.**

4.7.2 Rhytididae `sp. WAM 2295-69 `

Rhytididae `sp. WAM 2295-69` is currently listed as critically endangered (CR) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act*. The species in known to occur in moist micro-niches such as leaf litter, logs, rock seepages (Mitchell and Newell 2009). Prior to this survey, the species was known from 19 records dated 1969 to 2008, from surveys in the Toolbrunup lowlands, on Mt Success, Bluff Knoll, Moongoongoonderup Peak and lowlands, Isongerup Peak, Pyungorup Peak and Ellen Peak (DBCA 2020). Targeted surveys in March 2019, following the May 2018 fire detected two juveniles alive under rocks on the south face of Pyungorup Peak (Harvey and Rix 2019).

A total of 242 litter, sedge/ shrub and rock sites were formally sampled between October 2020 and January 2021 and 150 of these sites were resampled between April and May 2021. Surveys targeted areas containing moist micro-niches that are potentially suitable for *Rhytididae.* At each site, a minimum of 10 litter samples and 12 rocks were surveyed and additional micro-niches were searched opportunistically where they were encountered. The species was not detected within the parameters of this survey.

4.7.3 aff. Helicarionidae `sp. WAM S71330`

aff. Helicarionidae `sp. WAM S71330` is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur in moist micro-niches such as leaf litter, logs and rock seepages on Toolbrunup Peak (Pers com. Mark Harvey 2020). Prior to this survey, there were no formal records of this species in the spatial databases (DBCA 2020, WAM 2020).

A total of 24 litter and rock sites were formally sampled in November 2020 and again in May 2021. At each site, 10 litter samples and 12 rocks were targeted, and additional micro-niches were searched opportunistically where they were encountered.

During the survey, *aff. Helicarionidae `sp. WAM S71330`* was detected in four locations on Toolbrunup Peak (Table 23, Figure 48). The species was detected under rocks in the Toolbrunup gully and adjacent to the walk trail in areas with full defoliation of canopy. Live individuals were detected adjacent to the creek and south of the scree slope in area with some surface moisture. In total 31 individuals were detected and nine of these were alive (Table 24).

Table 24: Summary of detections for *aff. Helicarionidae `sp. WAM S71330`* during the 2020/ 2021 survey

Mountain	# Sites	#Sites with survivors	2020 Dead	2020 Alive	Comments
Toolbrunup	4	1	31	9	Under rocks in the Toolbrunup gully and adjacent to the walk trail near the scree slope.

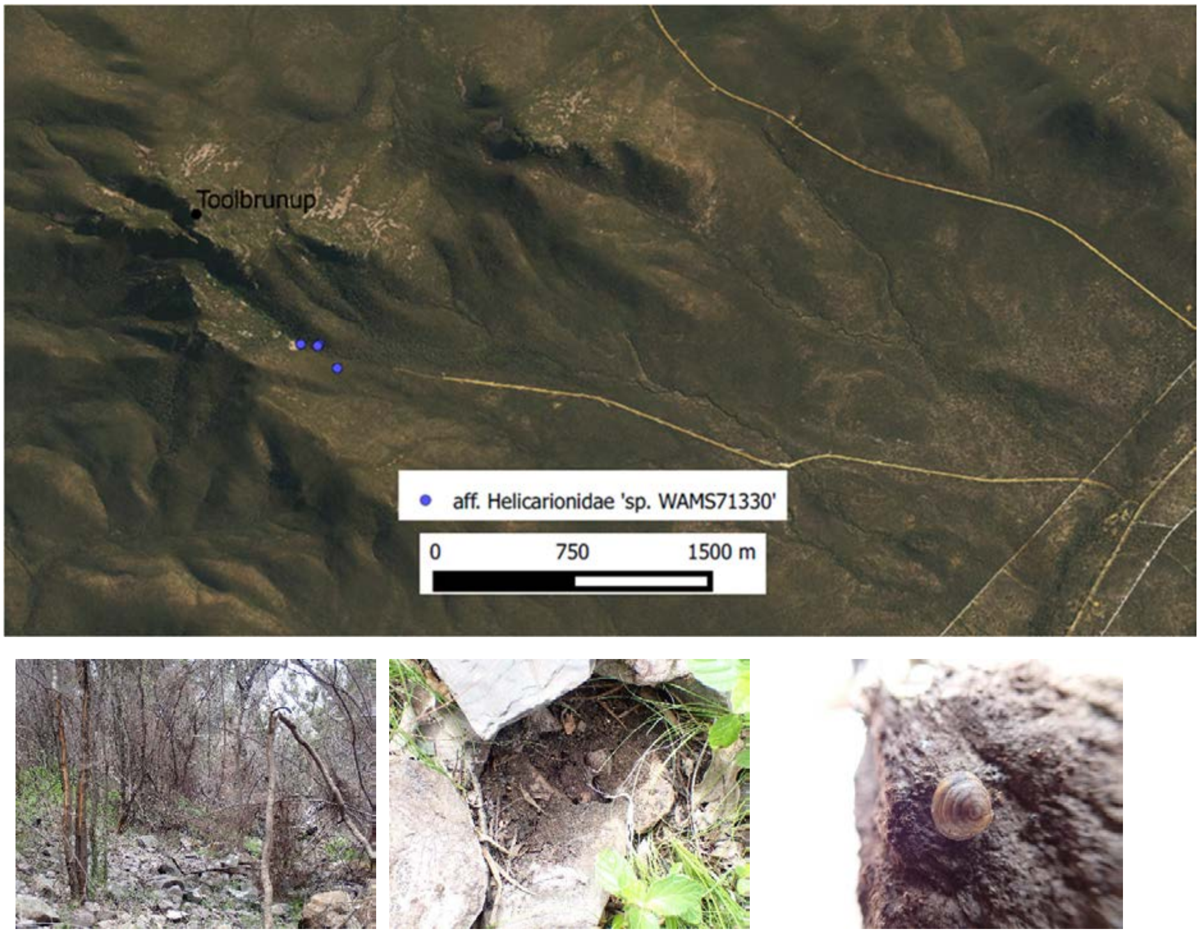


Figure 48: **Locations of *aff. Helicarionidae `sp. WAM S71330`* detected during the 2020/ 2021 survey and an example of occupied habitat.**

4.8 Insects

4.8.1 *Acizzia hughesae*

Acizzia hughesae is currently not listed under the State's *BC Act* or the Commonwealth's *EPBC Act*. The species is associated with host plant *Grevillea* sp. 'Stirling Range' and has been previously detected in the Ongarup Creek lowlands (Taylor and Moir 2014, Pers com. Melinda Moir 2020). Known populations of *Grevillea* sp. 'Stirling Range' were visited within the 2018 and 2019 fire-affected areas and the habitat searched for plants of the host species that had escaped the fire, or regenerating seedlings (Figure 49). No unburnt plants or seedlings of the host species were found, and insects were therefore not sampled during the 2020/ 2021 survey.

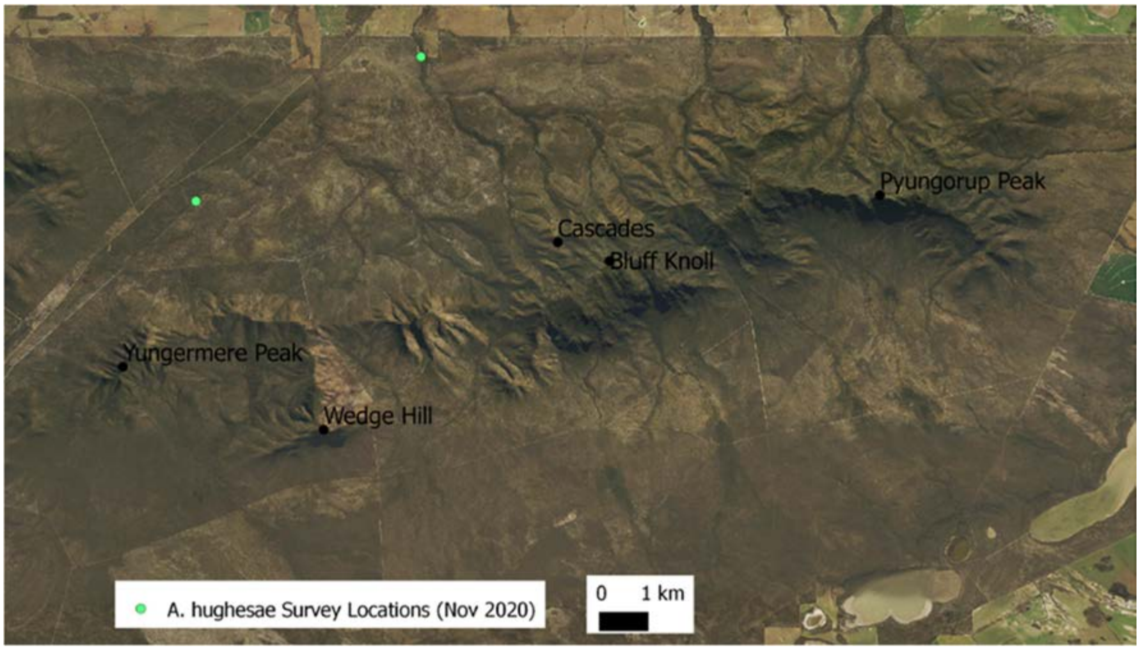


Figure 49: Known populations of the host species that were surveyed for *A. hughesae* during the 2020/ 2021 survey, and examples of habitat searched.

4.8.2 Acizzia mccarthyi

Acizzia mccarthyi is listed as vulnerable (VU) under the State's *BC Act*, and is not listed under the Commonwealth's *EPBC Act.* The species is associated with host plant *Acacia veronica* and has previously been detected in this species within marri woodland in the Papa Colla Creek system (Taylor and Moir 2014, Pers com. Melinda Moir 2020). Known populations of *Acacia veronica* were visited within the 2018 and 2019 fire-affected areas and the habitat searched for plants of the host species that had escaped the fire, or regenerating seedlings (Figure 50). 12 locations were searched, and no unburnt plants or *s*eedlings of the host species were found. The insects were therefore not sampled during the 2020/ 2021 survey.

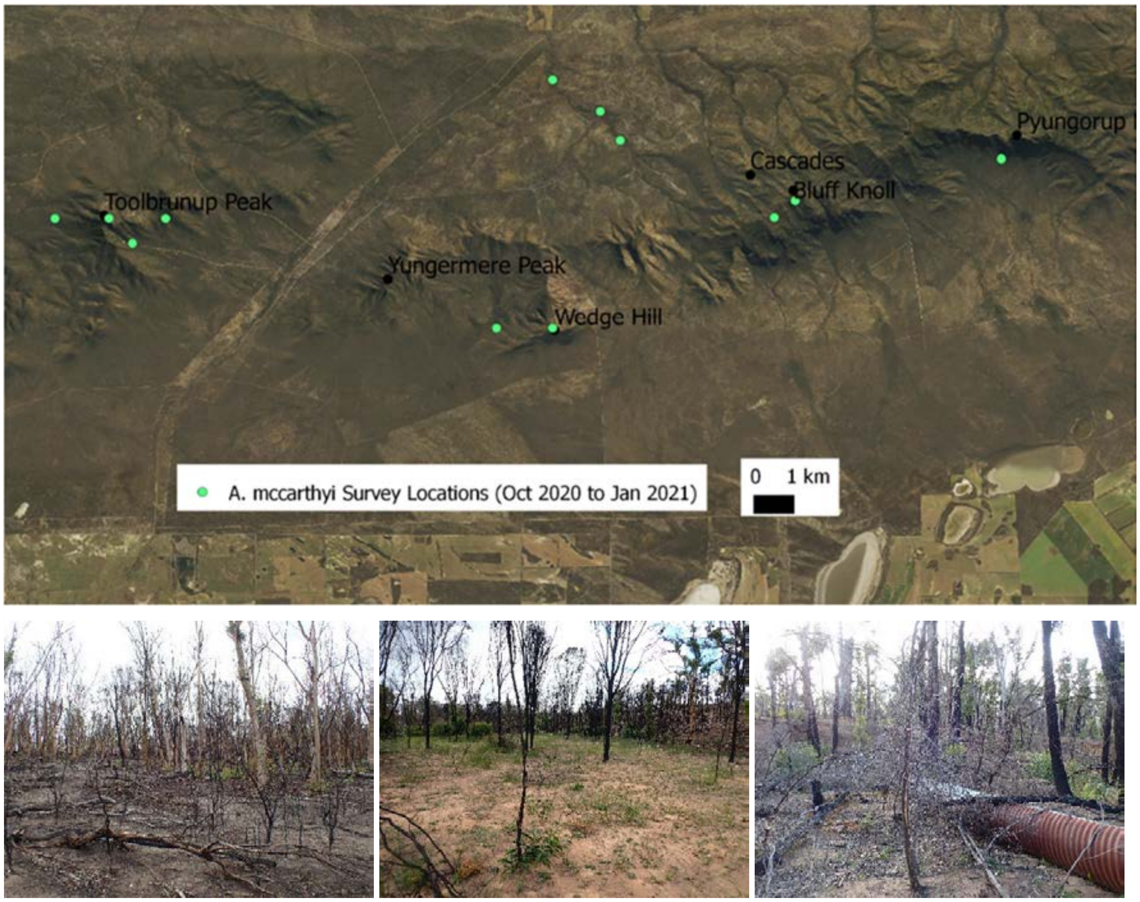


Figure 50: Known populations of the host species that were surveyed for *A. mccarthyi* during the 2020/ 2021 survey, and examples of habitat searched.

4.8.3 Acizzia sp. nov. Acacia awestoniana

Acizzia sp. nov. Acacia awestoniana is currently not listed under the State's *BC Act* or the Commonwealth's *EPBC Act*. The species is associated with host plant *Acacia awestoniana,* which occurs in open wandoo woodland on the lower slopes of hills or in sandy clay loam over siltstone and quartz in flat areas adjacent to drainage lines (Luu and Brown 2013, Pers com. Melinda Moir 2020). Known populations of *Acacia awestoniana* were visited within the 2018 and 2019 fire-affected areas and the habitat searched for plants of the host species that had escaped the fire, or regenerating seedlings (Figure 51).

During the survey 165 plants that had escaped the fire or been partially burnt, 929 burnt plants and 20 new seedlings were documented across 10 sites. Of those host plants documented, 88 unburnt plants, 110 burnt plants and 20 seedlings were surveyed for *Acizzia sp. nov. Acacia awestoniana.* The insects were detected at nine sites and a total of 1473 individuals were counted during 614 minutes of survey time (3 minutes/ plant, 1 minute/ seedling) (Table 25, Figure 51, 52). All individuals detected were on the stems and underside of leaves of unburnt adult plants and all occurred on areas of fresh growth (Figure 52). Most individuals detected were nymphs, with only seven adults counted.

Table 25: Summary of detections for *Acizzia sp. nov. Acacia awestoniana* during the 2020/ 2021 survey

Site ID	Host Plants Total (Sampled)			*Acizzia* counted		Comments
	Unburnt	Burnt	Seedling	Nymphs	Adults	
1	3 (3)	33 (33)	0	71	2	All insects found on new growth. Plants large and bushy.
2	7 (7)	7 (7)	0	0	0	Limited (if any) fresh growth on any of the plants. All plants 0.5-0.8m.
3	0	20	0	0	0	All plants burnt and dead. Some were >2m.
4	35 (35)	84 (12)	12 (12)	694	3	Plants to 3m. Unburnt plants healthy with lots of new growth.
5	112 (35)	549 (12)	4 (4)	660	2	Large proportion of unburnt plants are partially burnt. Dense wandoo litter may be inhibiting germination or detection of seedlings. Plants to 3m.
6	1 (1)	335 (12)	3 (3)	15	0	Most of population burnt. Plants to 3m.
7	1 (1)	0	0	11	0	Single plant. 2.2m high. Partially burnt.
8	2 (2)	0	0	8	0	2 adult plants. 1.4m high. Both partially burnt
9	2 (2)	14 (12)	1 (1)	7	0	Surviving adults both partially burnt. Plants to 3m.

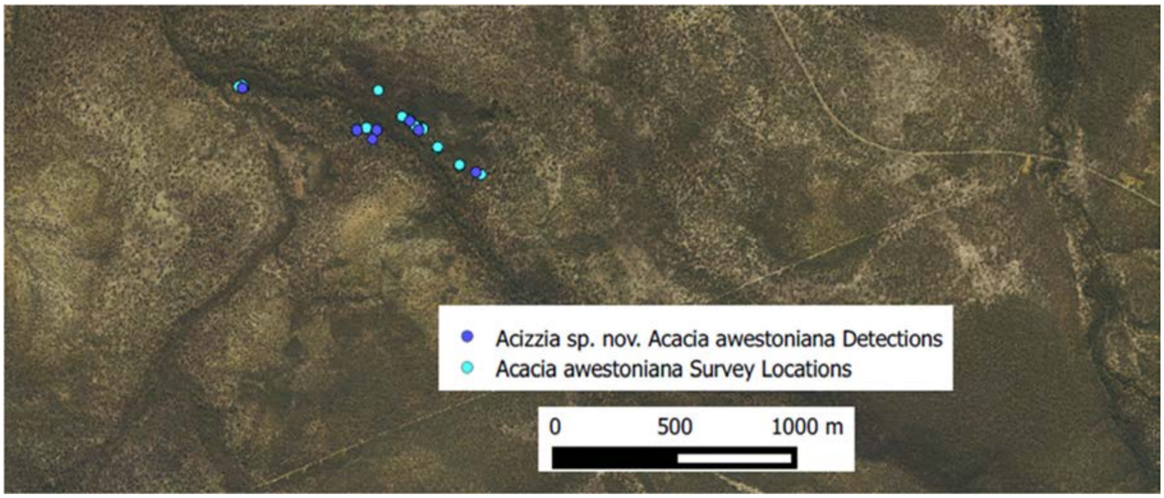


Figure 51: **Detections of *A. sp. nov. Acacia awestoniana* during the 2020/ 2021 survey, and locations surveyed.**

Patchily burnt areas of *Acacia awestoniana* in Papa Colla Creek with nymphs under leaves and on the sticky stems of unburnt plants

Patchily burnt area of *Acacia awestoniana* and an adult on the underside of a leaf

Figure 52: **Examples of habitat occupied by *A. sp. nov. Acacia awestoniana* during the 2020/ 2021 survey.**

4.8.4 Austrorgerius sp. nov Ellen

Austrorgerius sp. nov Ellen is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur in leaf litter under damp, shaded sedges (*Lepidosperma sp.*), in sympatry with *C. benrobertsi, Z. robinsi* and *M. sarahae* on Bluff Knoll, Pyungorup Peak and Ellen Peak (Pers com. Melinda Moir 2020).

A total of 81 sedge and montane shrub sites were sampled between October 2020 and January 2021 and 55 of these sites were resampled between April and May 2021 (Figure 53). At each site, a minimum of 10 sedges/ shrubs were targeted. The species was not detected within the parameters of this survey. In most cases, it was noted that while the sedges and shrubs were regenerating, they were low and sparse, and there was a general absence of suspended leaf material or ground litter.

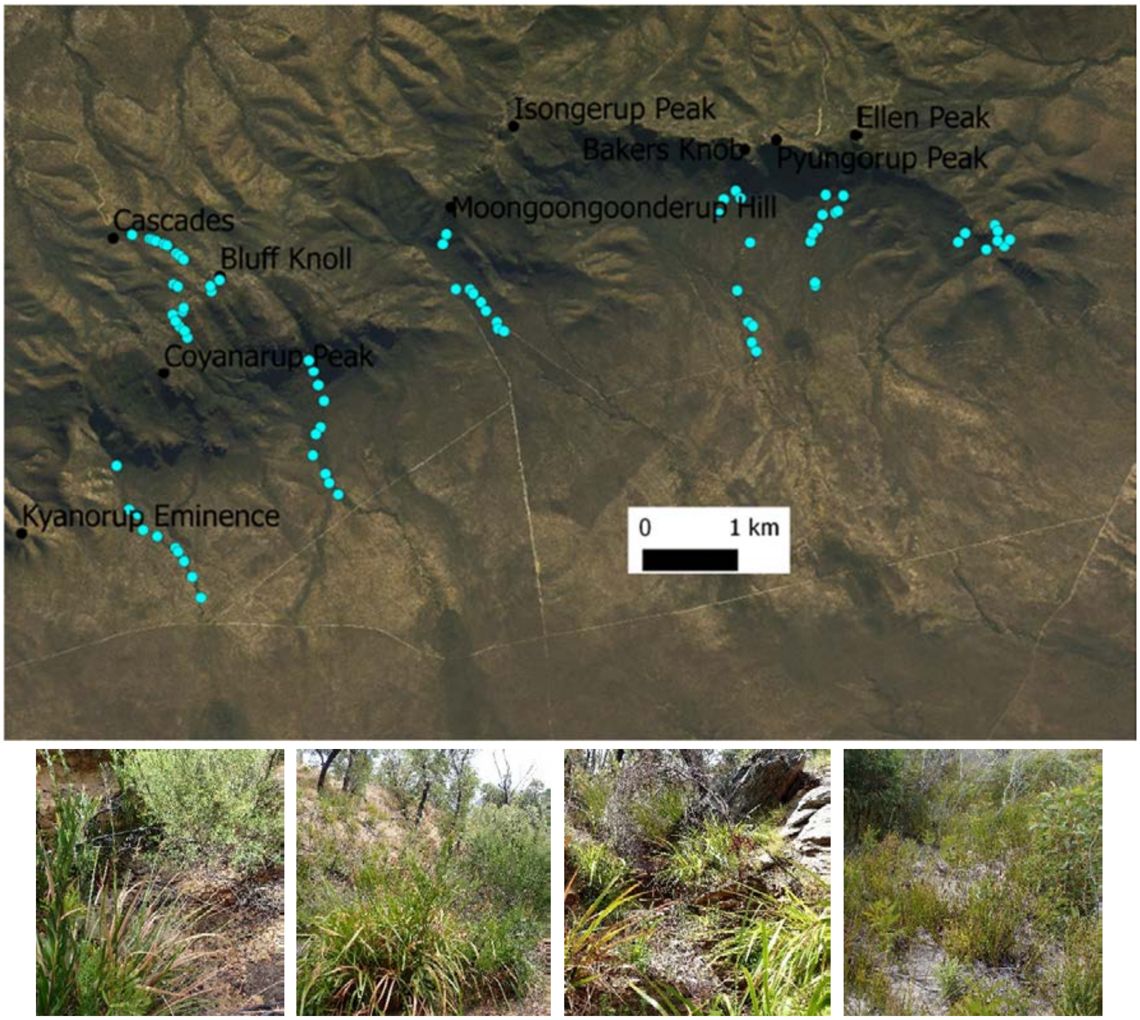


Figure 53: Locations sampled for *Austrorgerius sp. nov Ellen* and sympatric species, and examples of potential habitat.

4.8.5 Cudnellia sp. nov.

Cudnellia sp. nov. is not currently listed as threatened under State or Commonwealth legislation. The species in known to occur on Ericaceae plants (*Leucopogon, Sphenotoma,* and *Andersonia*) on the summit of Bluff Knoll and along the eastern massif to Ellen peak (>900 m alt) (Moir *et al.* 2014, Pers com. MLM 2020).

A total of 94.59 km was walked in traverses through areas of the eastern massif associated with the lowlands, gullies, creek lines, and summits between Bluff Knoll and Ellen Peak. In areas where Ericaceae plants were present, these were opportunistically sampled between October 2020 and January 2021 and between April and May 2021, for *Cudnellia sp. nov*. The species was not detected during these samples. Most locations containing Ericaceae were in montane areas where the fire behaviour had been intense, and regrowth was low. There were fragments of metallic green beetle shell detected within leaf litter samples in the gullies, which may have been washed into the gullies or been a result of individuals taking refuge, but none of the fragments could be confidently identified as *Cudnellia* (Figure 54).

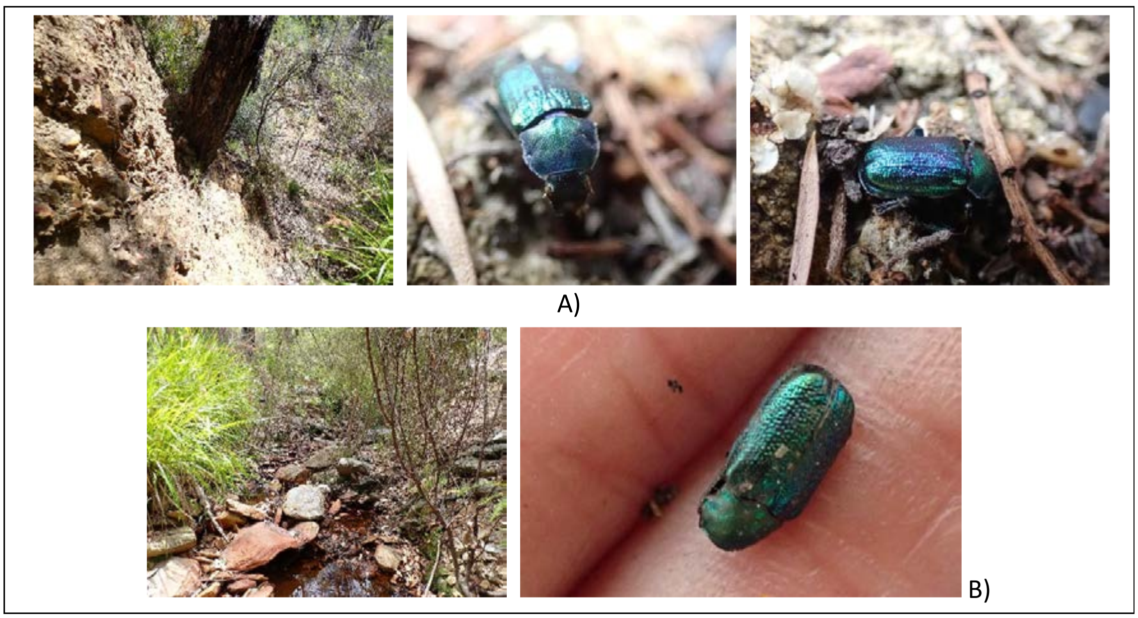


Figure 54: Fragments of beetle integument found within the gullies of A) Bluff Knoll and B) Pyungorup Peak. None could be confidently identified as *Cudnellia sp. nov.*

4.8.6 Pseudococcus markharveyi

Pseudococcus markharveyi is listed as critically endangered under the State's *BC Act*, and critically endangered under the Commonwealth's *EPBC Act.* The species is associated with host plant *Banksia montana* which is also listed as critically endangered at a State level. *P. markharveyi* is known to occur among the fine brown 'hairs' on the main stem, undersides of leaves and developing flowers of the host plants and has been previously collected on Bluff Knoll and Pyungorup Peak (Gullen *et al.* 2013, DBCA 2020). The species is currently known from five records, two on Bluff Knoll and three on Pyungorup Peak (DBCA 2020, Table 26, Figure 55).

All known populations of *Banksia montana* were burnt in the 2018 and 2019 fires (Pers.com Sarah Barrett 2020). There were small numbers of seedlings present in the Bluff Knoll and Pyungorup Peak sites, and each seedling encountered was searched for *P. markharveyi*. *P. markharveyi* was not detected during the 2020/ 2021 survey and the sites will be an ongoing priority for survey as seedlings continue to re-establish.

Table 26: Historical detections of *P. markharveyi*

Mountain	# Sites	Count Feb 2012	Count Dec 2012
Bluff Knoll	2	3	24
Pyungorup	3	10	32

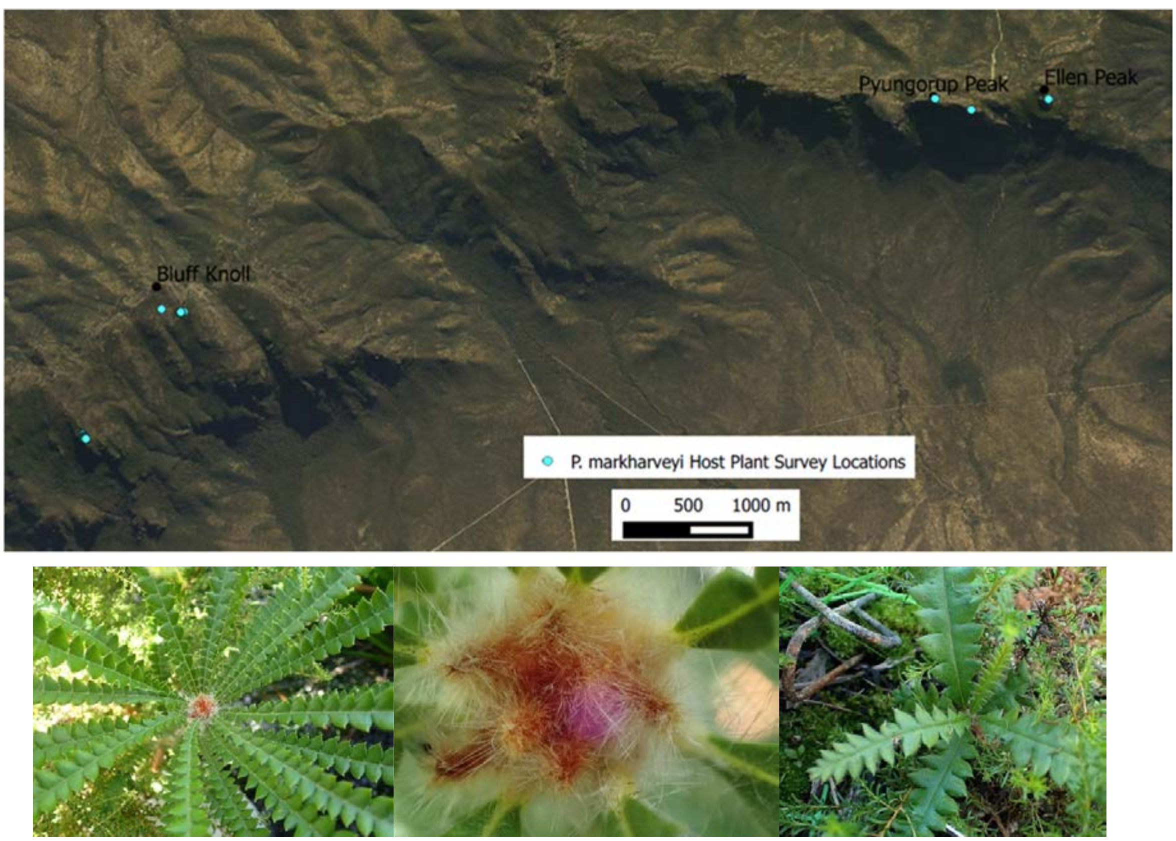


Figure 55: Known populations of *Pseudococcus markharveyi* that were surveyed during the 2020/ 2021 survey, and examples of habitat searched

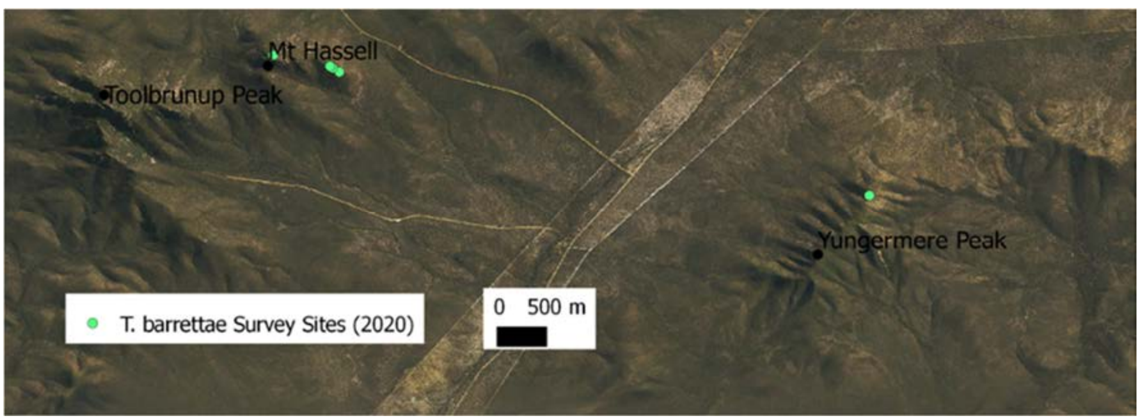
4.8.7 Trioza barrettae

Trioza barrettae is listed as endangered under the State's *BC Act* and is not listed under the Commonwealth's *EPBC Act*. The species is associated with host plant *Banksia brownii* (Taylor and Moir 2014) and has been previously detected in the Toolbrunup lowlands, on the Mt Hassell summit and Yungermere Peak summit (Taylor and Moir 2014*, DBCA 2020*). Known populations of *B. brownii* were visited within the 2018 and 2019 fire-affected areas and the habitat searched for plants of the host species that had escaped the fire, or regenerating seedlings (Figure 56).

In total 8 small seedlings of *B. brownii* were found during the survey and all were assessed for the presence of *T. barrettae* (Table 27). The species was not found, and these sites will be a priority for re-survey as the seedlings grow.

Table 27: Summary of detections for *Trioza barrettae* during the 2020/ 2021 survey

Mountain	# Sites	Host Plants		*Trioza* counts	Comments
		# Unburnt	# Seedlings		
Mt Hassell	3	0	6	0	Plants within sandy rocky soil, amongst eucalypt regrowth. Dead Banksias dense. Abundant banksia seedlings (3 species). Full canopy defoliation. Seedlings of *B. brownii* are scattered
Yungermere	1	0	2	0	North eastern corner of summit. Full canopy defoliation. No plants identifiable



A) B)

Figure 56: Known populations of the host species that were surveyed for *Trioza barrettae* during the 2020/ 2021 survey, and examples of habitat searched on A) Mt Hassell and B) Yungermere.

5. Discussion

Increased pressure from fire

The impact on fire on invertebrates can be challenging to assess, due to rarity of targeted survey and monitoring programs, limited information relating to species distributions, ecological requirements, life history traits and population dynamics, and even less information relating to species level fire responses. These challenges are often compounded for threatened species and short-range endemic taxa, such as those targeted during this survey, due to their confined distributions within disjunct habitats, specific habitat requirements, poor dispersal abilities and low fecundity (Harvey 2002).

Of the 40 species targeted in this survey, all are endemic to the Stirling Range National Park and are dependent on specific ecological features such as deep moist gullies, dense leaf litter, decaying logs, scree slopes and specific species of host plants. Many of these ecological features have been naturally protected from fire historically. For example, fire burns over the top of moist gullies and generally does not burn down into the gullies because of the moisture differentials, scree slopes are protected from fire due to a lack of vegetation to carry the fire, leaf litter and logs that have reached the state where they are suitable for these relic species usually occur in parts of the landscape that do not burn under normal conditions.

The bushfires that occurred in the Stirling Range National Park in May 2018 and December 2019 burnt with a high intensity that bypassed edaphic barriers such as moisture, rocks, and logs. The fire behaviour, in combination with dry conditions in the gullies, contributed to these habitats burning under hotter conditions and more completely than would normally be the case. For 39 of the 40 target species, their entire known distributions were within the fire-affected areas and all known occurrences of these species were burnt at least in part. In some instances, occurrences of these species were burnt in both fire events.

Impacts on populations – mortality, area of occupancy and density

Of the 40 species surveyed, only 19 were detected and for those that were detected, high proportionate mortalities were evident. For example, 90% of *B. colonus* (VU) and 94% of *B. pandus* (CR) burrows were recently defunct.

For species where large proportions of recently dead individuals were detected, it is reasonable to assume that mortalities were either a direct result of the fire, e.g. as a result of animals being burnt or affected by radiant heat, or as an indirect result of modified habitat conditions following the fire. Many of the defunct burrows of *Bertmainius* had become so following the fire as a result of desiccation and erosion due to vegetation loss during the fire and water movement post fire. In locations where surviving spiders were present, they were often in small, shaded recesses in the bank or beneath water gathering roots or rocks, in small pockets of stable substrate within a broader bank of dry and crumbling clay. In most cases, the creek banks were exposed due to loss of vegetation structure in the surrounding area and the substrate in these areas was open and dry. Active burrows were sealed tight, protecting the spiders from desiccation. Further mortalities are likely to occur over winter however if heavy rainfall events are prevalent and contribute to erosion events. In a number of locations, summer rainfall and associated water movement had already resulted in the complete collapse of clay banks or mobilized soil on the surface of the banks such that it had filled burrows or removed the substrate that they were previously constructed in.

For some groups, especially millipedes and snails, the probability of detection of surviving individuals was influenced significantly by seasonal conditions, with the majority of survivors detected in autumn due to higher environmental moisture. It is likely that surviving individuals were aestivating within the deeper soil/ humus layers during the spring/ summer component of the survey. Habitats where dead individuals were found in high abundances included areas where vegetation and leaf litter had been burnt away, in exposed rock cairns and beneath rocks in dried out parts of the gully. Surviving individuals were found within deep, protected rock crevices, beneath rocks and in accumulating leaf litter associated with creek lines and within rock crevices and beneath unburnt patches of sedges.

For some species that were not detected, low availability of required habitat in the post-fire environment is likely to be a factor. For example, logs that were on the ground had either recently fallen as a result of the fire, or if they were on the ground during the fire, they had been charred and the rotting material within them burnt away. This may reduce potential habitat for groups such as onychophorans, litter dwelling pseudoscorpions and millipedes. Similarly, a number of species are known to be associated with suspended leaf litter collecting in mature *Lepidosperma* sedges, such as *C. benrobertsi, M. sarahae (CR), P. darwini, Z. robinsi* (VU), *Z. melindae* (VU), *M. epizephyros,* and *A. sp. nov Ellen*. There were several small pockets of unburnt sedges in the Pyungorup and Coyanarup gullies, but otherwise sedges were generally low and sparse and suspended leaf material was absent. Similarly, ground litter was rare other than in areas that had been defoliated by the fire, in which case dry leaf material was accumulating rapidly, especially within creek beds at the bottom of the gullies. These areas are likely to provide some ground habitat for litter dwelling species such as millipedes, pseudoscorpions, and snails as the surrounding vegetation recovers.

Despite the relatively low availability of suitable habitat, *M. sarahae* (CR) was detected in five sample sites during the survey. In all cases the surviving individuals were associated with patchily burnt sedges or in areas proximate to large rock cairns or tall gully walls, which would have provided some protection from radiant heat and possible refuge during the fire for these more mobile spiders.

A number of the species that were not detected during this survey are host-dependent and their survival is reliant on the survival and health of the populations of their host species. This is of concern for species such as *Acizzia hughesae*, *Acizzia mccarthyi* (VU), *Pseudococcus markharveyi* (CR) and *Trioza barrettae* (EN), given all known plants of their host species burnt, resulting in an absence of available habitat. It is unknown if and how long these host-dependent species can survive in the absence of their hosts, or at what point they can recolonise seedlings. Given the isolation of all populations of these species, recovery may require intervention if and when host plants become available for recolonisation.

Acizzia sp. nov. Acacia awestoniana was the only host-dependent species detected alive during the survey and this was due to a proportion (13 %) of the host plants (*Acacia awestoniana*) not burning. All insects were found on new growth on adult plants that had not burnt and despite the presence of seedlings, no insects were detected on these. Follow up surveys will be critical in all host species populations where seedlings are establishing to determine at what point the host-dependent insects begin feeding on these.

While data were available for pre-burn distributions for many of the target species, and in some instances, there were counts of individuals, the lack of consistency in survey methods and target sites/ species made it difficult to make temporal and spatial comparisons of these parameters. In addition, historical and current survey results are likely to be confounded by unmanaged variables such as seasonality, dryness and surveyor experience, which contribute to variation in the probability of detection for many of the target species. For some species however, a similar level of survey effort has been undertaken and comparisons can be cautiously made.

An example is the genus *Cataxia* which was intensively surveyed in 2002/ 2003 as *Neohomogona* (Bain and Main 2004). Surveys occurred within many of the same areas as the current survey and survey techniques were similar, with the exception of the size of quadrats within which burrows were counted in each location. Comparisons have been made by taking into account the difference in effective sample area. Spiders of *Cataxia* are deep burrowing and are expected to be more resilient to fire than many of the other target species, given their ability to retreat deeper beneath the ground to escape radiant heat as well as previously demonstrated burrow sealing behaviour that protects spiders during unfavourable environmental conditions (Bain and Main 2004).

In all three species surveyed, a significant reduction in area occupied and burrow density can be inferred between 2002 and 2021. Burrows were widespread and abundant in occupied habitat during the 2002/ 2003 surveys, despite a recent fire in 2000. The main factor influencing their distribution during these surveys was moisture, as it still seems to be, but burrows occurred on the southern face of the mountains in a scattered but often continuous distribution from the summits through the southern gullies to the lowlands, in montane heathland surrounding gullies and beneath rock crags midslope and upper slope on the southern face of the mountains (Bain and Main 2004). During the 2020/ 2021 surveys, burrows were still present on the same mountains, but they were confined to an alarmingly smaller area (see figures 11, 13, 15) and in most cases were concentrated higher up the gullies and more proximate to creek lines or other moist features such as water-shedding rock crags. In addition, in all cases where quadrat data were available across the 2002/ 2003 and 2020 surveys, the burrow density had decreased significantly (Tables 7, 8, 9). For *C. colesi* on Mt Hassell and *C sandsorum* on Pyungorup Peak, burrow densities had declined to below 2% of the 2002/ 2003 density estimates. For *C. stirlingi*, burrow densities had declined below 4% of the 2002/ 2003 density estimates in all surveyed populations. Such a marked declines in burrow density are unlikely to be attributable solely to the recent fires and are likely to be a cumulative result of changing climate, drying conditions and disturbance events such as fire. The consistent trend across all populations for which data are available however suggests that these species are in decline, which is a concern given the relative resilience of this species in comparison to others targeted during this survey. Further work is required to quantify these changes in a more statistically robust manner.

For some species, the 2020/ 2021 survey increased the known area of occupancy due to more intense survey effort. For example, there were 19 new occurrences documented for *B. colonus* (VU) within the known distribution for this species. These new occurrences equate to small areas of burrowing substrate occupied by the spiders within the known distribution for the species and do not alter the overall level of threat for this species, given the low abundance of individuals detected. For *B. pandus* (CR) an increase in the known distribution was documented with an occurrence detected on Mt Hassell. This species was previously known only from Toolbrunup Peak. Outcomes of the survey also resulted in an extension of the known distribution and area of occupancy for several species including *Atelomastix danksii* (VU)*,* Atelomastix tigrina (VU), Bothriembryon glauerti (P2), Megalopsalis epizephyros and for the genus *Baiami.* In each of these cases, the more complete data may contribute to a better understanding of population structure and capacity for recolonisation and recovery.

Concepts of population viability

For many of the species targeted during this survey, understanding of population viability is limited. Although deterministic, stochastic, environmental, demographic, and genetic processes can all have complex and interacting effects on extinction risk, these processes tend to operate in a hierarchical fashion determined by the size of the remnant population. Furthermore, habitat disturbance can exacerbate intrinsic risk factors and accelerate population declines. All of the species targeted in this survey have a small population size made up of multiple occurrences that are physically isolated from each other. Despite their limited dispersal abilities, movement between microhabitats on the same mountain may be possible. Movement between microhabitats on different mountains is unlikely to be possible without intervention. Consideration of population viability may therefore come down to consideration of individual occurrences, especially for species such as those of *Bertmainius* that are known to move only small distances (<1 m) from the maternal burrow before constructing their own burrow.

For long lived trapdoor spiders such as *Bertmainius* and *Cataxia*, populations with more than 20 matriarchs in close proximity are considered capable of maintaining a viable population (Main 1987). Matriarchs are defined as ‘female spiders that have produced a number of generations of offspring’ and usually equate to the spiders occupying burrows with the largest entrance diameter (Main 1987). For *Bertmainius*, matriarch spiders occupy burrows with an entrance >7mm and for *Cataxia,* matriarch spiders occupy burrows with an entrance >11mm (Pers com. Barbara York Main 2003, Bain and Main 2004).

Application of Main's proximity test determined that only one of the *Bertmainius* populations meets the criteria, and that is the Toolbrunup population of *B. pandus.* Proximity is not defined by Main (1987), and in this instance, sites containing occupied burrows occur in eight disjunct clay banks that are spread across a linear distance of 400 m (average distance apart 57.4 m, range 12.1 - 222.6 m). The *B. colonus* populations on Bluff Knoll/ Cascades and Moongoongoonderup do not meet the criteria in terms of matriarch spider abundance, but they do if both matriarch and adult spiders are considered, however these populations span larger linear distances of 1113 m and 1149 m respectively (average distance apart 123.5 m, range 24.7 – 372.3 m).

For *Cataxia*, two populations meet the population viability test, including *C. colesi* in the Toolbrunup gully and *C. stirlingi* in the Moongoongoonderup gully. As for *Bertmainius,* the occurrences of *Cataxia* consist of clustered burrows in discrete parts of the gully that are separated by areas that are unoccupied and often contain unsuitable habitat. On Toolbrunup, the population of *C. colesi* consists of five occurrences that span a linear distance of 2190 m (average distance apart 437.8 m, range 71.9-1025.9 m). In the Moongoongoonderup gully, the population of *C. stirlingi* consists of 10 occurrences that span a linear distance of 1301 m (average distance apart 162.6 m, range 79.3-329.4 m). For *Cataxia*, additional populations meet the population viability test if both matriarch and adult spiders are considered. These include the populations of *C. sandsorum* on Pyungorup Peak and Ellen Peak, and populations of *C. stirlingi* on Coyanarup Peak and South Isongerup Peak. Spiders of *Cataxia* are likely to be more mobile than the smaller *Bertmainius,* but their burrow establishment behaviours are the same, with spiderlings moving only a small distance from the maternal burrow. Relatively small distances between occurrences could therefore be isolating in terms of metapopulation structure, particularly if the area occupied by the spiders in these areas is contracting, as seems to be the case for *Cataxia*.

In all instances the detection rate for the remaining 35 target species was much lower than that for the burrowing mygales. There are no estimates of what minimum population size or structure is needed to maintain viable populations for these groups and additional temporal data are needed to better understand the current status of populations, track fire response and recovery, and support population viability analyses. This is of particular relevance given predictions for drying climate, an associated increase in fire frequency and intensity (Bradstock 2010, Cary et al. 2012) and the potential for these changes to increase pressure on already stressed populations, permanently modify habitat availability and result in local or species level extinctions.

6. Management Implications

All species targeted in this survey occur within high elevation communities or mesic environments and as such their populations were already under pressure from the effects of drying climate prior to the recent fires. For 39 of the 40 species targeted during this survey, their entire known distributions were within the fire-affected areas and all known occurrences of these species were burnt.

Of the species targeted by this survey, 21 were undetectable and may be locally extinct. Hopefully, future surveys determine otherwise, as the mesic environments recover from the recent fires. For the 19 species that were detected, the broad scale and intensive nature of the survey resulted in an increase in knowledge relating to occupancy patterns, distribution, and current population status. In some instances, such as for *Baiami*, *Bertmainius* and *Atelomastix*, additional populations were discovered that contribute to an increase in known area of occupancy and/ or distribution. All of the species that were detected however had experienced significant losses as a direct or indirect result of the fires, with the entirety of their available habitat burning and high mortalities recorded. Many of the more severely affected species now require targeted monitoring and management to support recovery.

Development and implementation of a structured and consistent long-term monitoring plan is critical to track population level response and recovery and to identify where intervention is required to prevent extinction. In addition, given the likelihood of more intense and more frequent fires as the climate continues to dry, it is crucial to understand to what extent these factors affect threatened and endemic taxa and identify opportunities for moderating negative effects and building resilience in species and communities that are at risk of being lost.

Understanding population trends, identification of threatening processes, population viability thresholds and establishment of criteria for intervention require a much deeper understanding of populations and patterns than a single survey can generate. The following outcomes of this survey require additional focus and should form part of the basis for a long-term monitoring/ management plan:

- For host-dependent species, follow up surveys will be critical to track recovery of the flora population and to determine whether any of the insects survived the fire. Highest priorities include those where the entire known population of host species were burnt burnt e.g. for *Pseudococcus markharveyi* (CR), *Trioza barrettae* (EN), *Acizzia mccarthyi* (VU), and *Acizzia hughesae*. However, follow up surveys will also be important for *Acizzia sp. nov. Acacia awestoniana,* where adult plants have survived and seedlings of the host species are establishing, to learn as much as possible about post-fire survival and utilisation of host plant resources by these insects.

- All species detected during this survey had small disjunct populations and high levels of mortality. For the burrowing spiders of *Bertmainius* and *Cataxia,* most populations are on the threshold of being non-viable, if they are not already, due to the small number of reproductively mature females alive in each site and the significant distances separating occupied sites. For most other species this is also likely to be the case and close attention is needed to track recolonisation and ensure that these populations are protected while they are recovering. Another lethal disturbance event during the recovery period is likely to contribute to local extinctions.

- A marked and concerning decline in burrow density and area of occupancy were detected for all species of *Cataxia* and this is likely to be a cumulative result of drying conditions and fire events. Quadrat level data are available for these species throughout the Stirling Range National Park and could be used to quantify these changes and contribute to conservation status recommendations. It is likely that these species require listing as threatened fauna.

- A conservation status review is also likely to be required for many of the more severely affected species as more population-level data become available. For example, *Acizzia hughesae* is not currently listed, and is dependent upon host species *Grevillea* sp. 'Stirling Range' which had its entire known distribution burnt during the 2018 and 2019 fires.
- For those species that were not detected as a result of habitat modification and subsequent lack of available habitat, additional surveys are required, as habitats recover, to determine survivorship and population status. For example, as sedges regrow, as suspended leaf litter and ground leaf litter become more available, as log crevices accumulate leaf material and fallen debris, detection probability for species associated with these micro-niches may increase if they are persisting in the post-fire environment.
- Specimens are required to confirm identification of *Baiami* detected in the Pyungorup gully. There are currently no records of this genus east of Moongoongoonderup Hill and if confirmed, these detections mark a significant increase in the known distribution for this genus. Access to rock crags occupied by this genus in the Pyungorup gully can be achieved only when the creek is not flowing.
- Data collected during surveys should be proactively used to identify opportunities for increasing understanding of population viability, moderating impact of threatening processes and building resilience within persisting populations and mesic environments. Actions could include:
    - Careful management of critical habitat in the post-fire environment and protection from additional or interactive threats. For example, exclusion of native and introduced herbivores from areas where host plants are regenerating.
    - Careful management of unburnt areas adjacent to the recently burnt areas that may provide refuge for threatened and endemic species, and opportunities for translocations.
    - Protection of areas of critical habitat from additional fire during the recolonisation/ population recovery period
    - Protection of areas of critical habitat from future extensive and intense fire through active management of fire in surrounding areas that will contribute to heightened protection.
    - Building an understanding of metapopulation structure and opportunities for increasing connectivity for those species with limited dispersal mechanisms.
    - Identification of population viability thresholds and establishment of criteria for intervention for species that are considered a priority for management and conservation.
    - Identification of appropriate management interventions in response to population viability thresholds and triggers, such as translocations.

Most populations of the species that were found to be persisting during this survey, are on the threshold of being non-viable with limited opportunities for natural recolonisation. This is due to lack of reproductive individuals and substantial distances separating known occurrences. Given the apparent impact of the 2018 and 2019 fires on threatened and endemic invertebrate taxa, and the likelihood of additional fire events of this nature within the mesic environments of the Stirling Range National Park, targeted monitoring and proactive management with clearly defined intervention thresholds and actions are critical to support recovery and prevent further extinctions.

7. References

Bain, K., Main, B. Y., O'Shea, J., and Prince, J. (2004). Population demographics, general biology and conservation of the mygalomorph spider *Neohomogona stirlingi* Main in the Stirling Ranges, Western Australia. Submitted in Partial fulfillment of Master of Science (Zoology) School of Animal Biology, University of Western Australia, March 2004.

Barrett (1996). A Biological Survey of Mountains in Southern Western Australia. Report prepared for Department of Conservation and Land Management in conjunction with Australian Nature Conservation Agency National Reserves System Cooperative Program (Project No. AW03). September 1996. South Coast Regional Office, Albany.

Barrett (2016). Montane Heath and Thicket of the South West Botanical Province, above approximately 900 m above sea level (Eastern Stirling Range Montane Heath and Thicket Community). Interim Recovery Plan 2016-2021 for Interim Recovery Plan No. 370. Perth.

Bradstock, R. A. (2010). A biogeographic model of fire regimes in Australia: current and future implications. *Global Ecology and Biogeography* 19, 145–158.

Cary, G. J., Bradstock, R. A., Gill, A. M., Williams, R. J. (2012). Global change and fire regimes in Australia. In 'Flammable Australia: fire regimes, biodiversity and ecosystems in a changing world'. (Eds RA Bradstock, RJ Williams, AM Gill) pp. 149–170. (CSIRO Publishing: Melbourne).

Crews, S. C., and Harvey, M. (2011). The spider family *Selenopidae* (Arachnida, Araneae) in Australasia and the Oriental Region. *ZooKeys* 99, 1–103.

Department of Environment and Conservation (2016) Abridged Threatened Species Nomination Form for *Pseudococcus markharveyi* (*Banksia montana* mealybug).

Department of Environment and Conservation. (DRAFT). Stirling Range Rhytidid Snail (Undescribed Rhytidid species (WAM 2295-69)) and Stirling Range Trapdoor Spider (*Moggridgea sp.* (BY Main 1990/24.25)) Recovery Plan 2010-2019.

Edward, K. L., and Harvey, M. S. (2010). A review of the Australian millipede genus *Atelomastix* (Diplopoda: Spirostreptida: Iulomorphidae). *Zootaxa*. 2371, 1-63.

Framenau, V. W., Moir, M. L., and Harvey, M. S. (2008) Terrestrial Invertebrates of The South Coast NRM Region of Western Australia: Short-Range Endemics in Gondwanan Relictual Habitats. Report prepared for South Coast NRM. Published by WA Museum.

Gilfillan, S., Mitchell, P., Newell, J., Danks, A. and Comer, S. (2009). South Coast Threatened Species and Ecological Communities Strategic Management Plan, Department of Environment and Conservation, Albany.

Gray, M. R. (1981). A revision of the spider genus Baiami Lehtinen (Araneae, Amaurobioidea). *Records of the Australian Museum* 33(18): 779–802

Gullan, P. J., Moir, M., & Leng, M. (2013). A new species of mealybug (Hemiptera: Pseudococcidae) from critically endangered Banksia montana in Western Australia. *Records of the Western Australian Museum*, 28(020), 13-20.

Harms, D. (2013). A new species of Pseudotyrannochthonius Beier (Pseudoscorpiones: Pseudotyrannochthoniidae) from the Warrumbungle Range, New South Wales. *Memoirs of the Queensland Museum*, 58(1), 23-32.

Harms, D. and Harvey, M.S. (2013). Review of the cave dwelling species of Pseudotyrannochthonius Beier (Arachnida: Pseudoscorpiones: Pseudotyrannochthoniidae) from mainland Australia, with description of two troglobitic species. *Australian Journal of Entomology* 52: 129–143.

Harvey, M. S. (1987). A revision of the genus Synsphyronus Chamberlin (Garypidae: Pseudoscorpionida: Arachnida). *Australian Journal of Zoology*, Supplementary Series, 126.

Harvey, M. S. (2002). Short-range endemism in the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* 16, 555-570.

Harvey, M., Main, B., Rix, M. and Cooper, S. (2015). Refugia within refugia: *in situ* speciation and conservation of threatened *Bertmainius* (Araneae: Migidae), a new genus of relictual trapdoor spider endemic to the mesic zone of south-western Australia. *Invertebrate Systematics* 29: 511-533.

Harvey, M. S, and Rix, M, G. (2019). A Survey of Populations of Threatened Invertebrates Following Fire in the Stirling Range National Park. A report submitted to the Department of Biodiversity, Conservation & Attractions Albany Field Office. May 2019c.

Luu, R., and Brown, A. (2013). Stirling Range Wattle (*Acacia awestoniana*) Interim Recovery Plan 2013–2018. Interim Recovery Plan No. 333. Department of Environment and Conservation, Western Australia.

Main, B. Y. (1991). Occurrence of the trapdoor spider genus *Moggridgea* in Australia with descriptions of two new species (Araneae: Mygalomorphae: Migidae), *Journal of Natural History* 25, 383-397.

Main, B. Y., and Gaull, K. (1992) Response of trapdoors to fire in the Stirling Range. Report on a post-fire monitoring study.

Mitchell, P., and Newell, J. (2009) Stirling Range Rhytidid Snail (Undescribed Rhytidid species (WAM 2295-69) and Stirling Range Trapdoor Spider (Moggridgea sp. S (BY Main 1990/24, 25)) Recovery Plan 2010-2019. July 2009. South Coast Region, Department of Environment and Conservation, 120 Albany Highway, Albany WA 6330.

Moir, M. L., Brennan, K. E. C., Majer, J. D., Fletcher, M. J., and Koch, J. M. (2005). Toward an optimal sampling protocol for Hemiptera on understorey plants. *Journal of Insect Conservation* 9, 3–20.

Moir, M. L., Hughes, L., Vesk, P. A. and Leng, M. C. (2014) Which host-dependent insects are most prone to coextinction under changed climates? *Ecology and Evolution* 4, 1295-1312.

Moir, M. L., Coates, D. J., Kennington, W. J., Barret, S. R., and Taylor, G. S. (2016) Concordance in evolutionary history of threatened plant and insect populations warrant unified conservation management approaches. *Biological Conservation* 198, 135–144.

Neville, S. (2002). Identifying and mapping potential invertebrate refugia on the South Coast of Western Australia. South Coast Refugia Project. A report prepared for Department of Conservation and Land Management by Ecotones and Associates, Denmark WA.

Rix, M. G., Roberts, J. D. and Harvey, M. S. (2009). The spider families *Synotaxidae* and *Malkaridae* (Arachnida: Araneae: Araneoidea) in Western Australia. *Records of the Western Australian Museum* 25, 295-304.

Rix, M. G., and Harvey, M. (2012). Australian Assassins, Part II: A review of the new assassin spider genus Zephyrarchaea (Araneae, Archaeidae) from southern Australia. *ZooKeys*, 191, 1-62.

Sato, S., Buckman-Young, R. S., Harvey, M. S., & Giribet, G. (2018). Cryptic speciation in a biodiversity hotspot: Multilocus molecular data reveal new velvet worm species from Western Australia (Onychophora: Peripatopsidae: Kumbadjena). *Invertebrate Systematics*, 32, 1249-1264.

Taylor G. S., and Moir M. L. (2009) In threat of co-extinction: two new species of *Acizzia* Heslop-Harrison (Hemiptera: Psyllidae) from vulnerable species of *Acacia* and *Pultenaea*. Zootaxa 2249, 20-32.

Taylor, C. K. (2011). Revision of the genus *Megalopsalis* (Arachnida: Opiliones: Phalangioidea) in Australian and New Zealand and implications for phalangioid classification. *Zootaxa* 2773, 1–65.

Taylor, G. S., and Moir, M. (2014). Further evidence of the coextinction threat for jumping plant-lice: three new *Acizzia (Psyllidae*) and *Trioza (Triozidae*) from Western Australia. *Insect Systematics and Evolution* 45, 283-302.

Waldock, J. (2013) A review of the peacock spiders of the *Maratus* mungaich species-group (Araneae: *Salticidae*), with descriptions of four new species. *Records of the Western Australian Museum* 28, 066–081

Wondzell, S. M., and King, J. G. (2003). Postfire erosional processes in the Pacific Northwest and Rocky Mountain regions. *Forest Ecology and Management* 178, 75–87.