ACT Government

THE SMALL ANT-BLUE BUTTERFLY *ACRODIPSAS MYRMECOPHILA* (WATERHOUSE AND LYELL, 1913) IN THE ACT

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Environment Division

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The Small Ant-blue butterfly *Acrodipsas myrmecophila* (Waterhouse and Lyell, 1913) in the ACT

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Executive Summary

The Small Ant-blue (*Acrodipsas myrmecophila*) is a tiny lycaenid butterfly endemic to Australia. Known breeding sites of the Small Ant-blue are associated with Coconut Ants in the *Papyrius nitidus* species complex, with which there is an obligate relationship. Ants carry or herd eggs and caterpillars into their nests, within fallen timber, stumps or standing trees. The caterpillar feeds on ant larvae and in return provide sap secretions to the ant.

In the ACT Small Ant-blues fly from October through to March. Males tend to fly around and perch in the canopy of eucalypt saplings near the Coconut Ant nest that contains the Small Ant-blue breeding colony; the females tend to walk around on the trunk and lower branches and leaves of the saplings. Males will also congregate on summits of nearby hills where they establish territories by perching on canopy foliage of eucalypts in wait for females. Females fly to these peaks to find suitable males to mate with.

The Small Ant-blue is widespread across south-eastern Australia but is rare and has a localised distribution. This butterfly is currently not listed at the state or federal level, except for Victoria where it is listed as Critically Endangered.

There is relatively little known about Small Ant-blue biology and ecology, while little is also known about the biology, ecology or taxonomy of its obligate ant host. Small Ant-blues and Coconut Ants are mainly found in woodland and open forest. The Small Ant-blue has not been seen for many years in Victoria, and the only other recorded breeding colonies in Queensland no longer exist; there are still active hilltopping sites in south-east Queensland and in New South Wales (*pers. Comm.* D. P. A. Sands). There are also isolated records from North Queensland and the Northern Territory. Breeding populations may still be undetected elsewhere, but they are likely to be few and far between. The ACT contains the only known active Small Ant-blue breeding colonies in the world.

This technical report describes how a citizen science project, utilising the Naturemapr platform, mapped over 350 Coconut Ant nests within the Canberra region and located five breeding colonies and one hilltopping site of the Small Ant-blue. The project also led to the realisation that there are at least two species of coconut ants in the ACT, including a previously unrecognised nationally widespread species.

This report also details the key habitat features for both the butterfly and ant, discusses what threatens these features and provides management guidance. Key management aims include:

- Retention of Coconut Ant colonies and the fallen timber they are utilising;
- Maintaining a 5-10% cover of eucalypt saplings, wattles or other shrubs and saplings on which sap-sucking homoptera are being attended by the Coconut Ants within the 100m around known breeding locations; and
- Minimising disturbance and damage to native tree, sapling and shrub vegetation at known and possible hilltopping sites.

1 General Description of the Butterfly, Eggs, Caterpillars and Pupae

Adult Small Ant-blue butterflies are dimorphic; females are on average 20 mm and have iridescent blue patches on the upperside of their wings, while males are on average 18 mm and lack the iridescent blue on their wings. On the underside of their wings, both sexes have a pale brown-grey wing overlaid with a pattern of brown features edged in white and dark brown, and each hindwing has two black and orange eyespots located at the tornus (Bond *et al.*, 2018).

Figure 1 Female Small Ant-Blue (wings open)

Figure 2 Male Small Ant-Blue (wings open)

Figure 3 Female Small Ant-Blue (wings closed)

Figure 4 Small Ant-blue Eggs

Small Ant-blue eggs are typical lycaenid eggs: they are 0.6 mm wide, 0.4 mm high, white, mandarin-shaped and have a densely and finely pitted surface (Braby, 2000). They are usually laid in clusters on a eucalypt sapling or on coarse woody debris, but always on a substrate closely associated with the Coconut Ant nest.

Small Ant-blue caterpillars, or larvae, go through several growth stages called instars. The first instars are a few millimetres long when they first hatch, with dark brown heads and white bodies (*pers. obs.*). As they progress to later instars they grow to about 14 mm and become mottled brown, with some green and white, on a pale background (Braby, 2000).

Small Ant-blue pupae are smooth, about 9 mm long (Braby 2000) and are pale brown in colour. When the adults emerge and leave their pupal shells behind, the pupal shells are golden brown and slightly translucent.

Figure 5 Small Ant-blue Caterpillar

Figure 6 Small Ant-blue Pupae

2 Current and Likely Past Distribution of Species

The Small Ant-blue is only known from a few locations both in the ACT and nationally.

Nationally, the Small Ant-blue has been recorded at the following sites:

- Northern Territory:
  - Mt Burrell, Tipperary Station (Braby *et al.*, 2018).
- Queensland:
  - Near the Palmer River crossing, Cape York Peninsula (Eastwood, 1995).
  - Blackdown Tableland, Expedition Range (Coll. A. Atkins ANIC specimen).
  - Mount Moffat, Carnarvon NP (Monteith and Yeates, 1988)
  - Mount Beerburrum (Coll. L. Ring ANIC specimen)
  - Millmerran and nearby Leyburn – larvae found here but colony now extinct (Common and Waterhouse, 1981)
  - Mitchell (Edwards, 1948)
  - Near Brisbane (Braby 2000)
  - Near Toowoomba (Eastwood and Hughes, 2003)
- New South Wales:
  - Sydney (Waterhouse and Lyell, 1913; McCubbin, 1971)
  - Blue Mountains - current hilltopping site (Purvis, 2019; Braby 2000)
  - Pigeonhouse Mountain (Braby, 1998)
  - Monargo (Coll. Le Soeuf ANIC specimen)
  - Near Deniliquin (Common and Waterhouse, 1981)

        - Bolivia Hill (A. F. Atkins and C. G. Miller)
        - Dungog (Braby 2000)
        - Grafton area including Ramornie Hill (Coll. J. W. C. d'Apice, R. Eastwood, C. G. Miller, T. Morton, L. Ring ANIC specimens)
    - Victoria: Critically Endangered, currently no known breeding colonies or hilltopping sites.
        - Mount Piper and Broadford sites – formerly a breeding colony here but now extinct (*pers. comm.* F. Douglas); in 1997, Mt Piper was the only site where the Small Ant-blue still existed, all other Victorian sites extinct (New and Britton, 1997).
        - Ocean Grove (Waterhouse and Lyell, 1913) – former breeding colony site but long extinct (*pers. comm.* F. Douglas, D. P. A. Sands)
        - Dandenong Ranges district including Wandin (Waterhouse and Lyell, 1913)
        - Ringwood, Heathmont, Glen Waverley, Lilydale (Department of Sustainability and Environment, 2003)
        - Croydon Hills (*pers. comm.* F. Douglas)
        - Rainbow – formerly a breeding colony here but now extinct (*pers. comm.* F. Douglas)
- Australian Capital Territory:
    - One adult male collected from Uriarra Hill in November 1991 (Coll. R. A. Eggleston, ANIC specimen)
    - Currently active breeding colonies confirmed in four Canberra Nature Park reserves(*pers. obs.*).
    - One adult male observed hilltopping in another Canberra Nature park Reserve (Dec 2018, Bond unpublished data), and an adult female visiting a Coconut Ant colony in another Canberra Nature Park reserve.

The distribution of the Small Ant-blue is reliant upon the distribution of Coconut Ants in the landscape. It is likely that both the butterfly and the ant have been overlooked in many places, particularly given the small size, cryptic behaviour and localised distribution of the butterfly (Braby, 2000).

3 General Description of the Coconut Ant

Coconut Ants are members of the *Papyrius* genus. The common name is derived from the strong odour emitted by the ants when disturbed, reminiscent of coconut. The genus is endemic to Australia and Papua New Guinea and represented by two species and three subspecies: *Papyrius flavus, P. nitidus, P. nitidus clitellarius, P. nitidus oceanicus and P. nitidus queenslandensis.*

Two species of Coconut Ant have been recorded in the ACT as part of this study. The most common is morphologically identical to *Papyrius nitidus* but, as differences between this species and its three related subspecies are not clear, all collections of smooth, shiny, non-hairy ants with distinctive coconut odour made during this study are identified and referred to here as "*Papyrius nitidus* species complex".

The second, less common species of Coconut Ant collected around the ACT during the study is readily differentiated from *P. nitidus* due to the presence of long hairs on the head, body and gaster. As ant collections were made only from a very limited number of sites, it is likely that some Canberra Nature Map records labelled as *P. nitidus* are actually of this second species. However, based on collections made, the large majority of records will be of *P. nitidus* species complex, and it is this ant referred to when the term "Coconut Ant" is used in discussion of interactions with the Small Ant-blue.

Coconut Ant nests are generally associated with dead trees, fallen branches and stumps. Nests can be made in decaying wood or in the ground, and large colonies can develop in suitable situations. The ants characteristically construct carton byres from plant fibres to cover nest areas and trails. The ants forage on low vegetation and trees for homopteran honeydew, as well as on the ground (Shattuck, 1999).

The distribution of the Coconut Ant seems quite widespread in the Canberra area. Records within the Atlas of Living Australia indicate that the *Papyrius nitidus* species complex is widespread but scattered across Australia (ALA, 2019).

Figure 7 Coconut Ant

Figure 8 Coconut Ant Nest

4 Current Conservation Status and Why ACT Populations are Important

The Small Ant-blue is currently not listed at the state or federal level, except for Victoria where it is listed as Critically Endangered under the *Flora and Fauna Guarantee Act 1988* (Department of Environment, Land, Water and Planning (Victoria), 2018). In the Northern Territory Braby *et al.* (2018) considers the Small Ant-blue as Data Deficient but of potential conservation concern. In the ACT, the Small Ant-blue is currently under consideration for listing as a protected species.

The Small Ant-blue is widespread across south-eastern Australia but is rare and has a localised distribution. While the butterfly can be observed at isolated locations throughout its geographic range, these are often records of hilltopping males; breeding colonies are very localised (Braby *et al.*, 2018) and are rarely encountered. There are scattered contemporary locations for the butterfly across Queensland and NSW, and it is considered a rare and restricted resident in the ACT (Bond *et al.*, 2018).

There is relatively little known about Small Ant-blue biology and ecology (as for the rest of the *Acrodipsas*). They have an obligate relationship with Coconut Ants, but there is also little known about Coconut Ant biology, ecology, or taxonomy. The presence of a Coconut Ant colony does not in itself enable Small Ant-blues to establish a breeding colony, or that once established the colony will persist for a long time (Beardsell, 1994), so there are obviously other important factors at play for the butterflies in their selection of breeding sites.

Small Ant-blues and Coconut Ants are mainly found in woodland and open forest, vegetation types that have been extensively cleared and/or altered by grazing and changed fire regimes, particularly in south-eastern Australia. The Small Ant-blue has not been seen for many years in Victoria, and the only other recorded breeding colonies in Queensland no longer exist; however there are still active hilltopping sites in south-east Queensland and in New South Wales (*pers. comm.* D. P. A. Sands). Breeding populations may still be undetected elsewhere, but they are likely to be few and far between. The ACT contains the only known active Small Ant-blue breeding colonies in the world; we are fortunate enough to have located several breeding colonies so far; and crucially for future conservation plans, there has been (and continues to be) an extensive mapping of known Coconut Ant distribution in the ACT thanks to a dedicated citizen science effort.

The ACT populations of both the Small Ant-blue and the Coconut Ant are critically important on an international scale.

5 Survey Methodology Employed to Locate Breeding Sites

Coconut Ants make distinctive nests where they construct conspicuous byres of detritus on logs and trees. Given that Small Ant-blues rely on the presence of Coconut Ant nests, searching and locating ant nests was successfully used to locate Small Ant-blue breeding colonies.

New and Britton (1997) found Coconut Ants to be localised and uncommon, and failed to find ant colonies in Victoria through direct searching. Nevertheless we decided to proceed with this search method for them in the ACT. We were able to draw upon enthusiastic and skilled citizen scientists who dedicated a large search effort to the project; it is also possible that the generally open eucalypt habitat in the ACT made for easier searching compared to the Victorian sites. Britton (1997) came to the conclusion that pitfall traps were not optimal for detecting Coconut Ants because of the ants' tendency to remain close to the immediate area of the colony, having conducted an extensive pitfall trapping exercise over several years only 20-25 metres from a Coconut Ant colony without recording them in the pitfall traps.

The search for Coconut Ant nests was commenced in early spring before the start of the ACT butterfly season. The search initially focused on reserves close to the original sighting of an adult female by volunteer Christine Darwood during the previous season. The search method was a direct visual search conducted by walking slowly through reserves and looking for the distinctive byre the Coconut Ants construct around their nests on the ground, on logs and on tree and sapling trunks. Once such structures were located, the identity of the ant was able to be confirmed by crushing an individual ant to release its highly distinctive odour.

Once it was confirmed that the ants and their nest were indeed Coconut Ants, each ant nest location record was uploaded to Canberra Nature Map. The Coconut Ant nest and associated structures was then carefully searched for any evidence of *Acrodipsas* breeding: checking for the presence of old eggshells on substrates part of or near the ant nests; the presence of larvae near the surface of the ant nest or under logs or rocks in the vicinity of the ant nest; and the presence of pupae or pupal shells on substrates part of or near the ant nests.

This method continued to be employed after the butterfly flight season had commenced, but more targeted visual searches of known Coconut Ant nests during suitable weather (27 – 34°C, sunny, calm to moderate winds) were conducted to look for flying adult Small Ant-blue butterflies close to the Coconut Ant nests and associated vegetation; additional breeding sites were located using this method. All records of Small Ant-blue breeding colonies were submitted to Canberra Nature Map.

6. Notes on ACT Habitat Features of Small Ant-blue

6.1 Breeding habitat

The most important habitat is the breeding habitat, which can only occur within the Coconut Ant distribution. We now have a reasonably good idea on this area with the ongoing mapping of Coconut Ant nests via Canberra Nature Map. Small Ant-blues appear to prefer large Coconut Ant colonies which appear in open sunny sites in eucalypt woodland and open eucalypt forest in the lowlands of the ACT – please refer to the ACT Butterfly Field Guide (Bond *et al.*, 2018) for a habitat map showing this on page 159. This map is reproduced below in Figure 9.

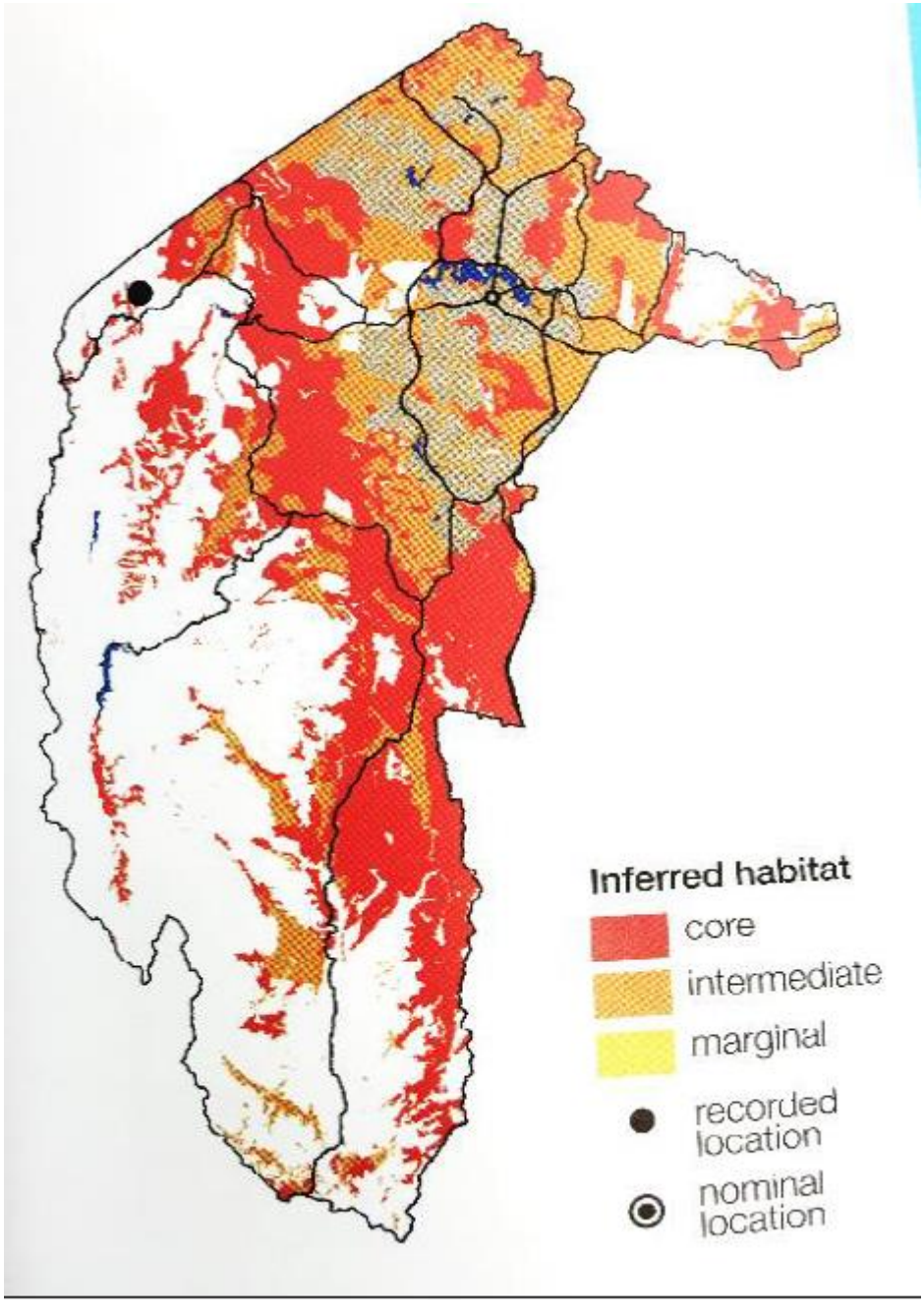
6.2 Hilltopping sites

Hilltopping sites are important places in the landscape for butterflies due to their role in courtship and mating, and it would be reasonable to expect key hilltopping sites to be near breeding sites, with New and Britton (1997) suggesting such summits would be within a 10 km radius of suitable breeding habitat. However as so little is known of the species, any of the lowland summits in the ACT (but particularly those in or near Canberra Nature Park reserves which contain Coconut Ant colonies)

would be in contention. Despite locating several breeding colonies, there is only one recorded site for hilltopping Small Ant-blues, in a reserve currently without any known Small Ant-blue breeding colonies).

Small Ant-blues may also be observed dispersing through the landscape as they move between breeding habitat and hilltopping sites.

Figure 9 **Inferred Small Ant-blue Habitat** from Bond et al 2018 p 159



7. Relationship with the Coconut Ant and How that Helps Define the Species Distribution

Due to the obligate relationship that the Small Ant-blue has with the Coconut Ant, the distribution of the Coconut Ant will dictate the potential Small Ant-blue breeding habitat distribution.

The Small Ant-blue is dependent on the Coconut Ant and they have an ecologically complex relationship. The Small Ant-blue caterpillar provides important nutrients to the ants and the ants protect the caterpillars, while in return the caterpillar lives inside the ant nest and feeds on the ant brood in a predatory relationship (New and Britton, 1997). The Coconut Ant is a widespread species in the ACT and builds nests largely in fallen timber in long unburnt, but heavily grazed woodlands and open forest. The ants forage honeydew from leafhoppers and other sap-sucking bugs that feed on wattles, eucalypts and other plants, so having diversity and abundance of wattles and eucalypt saplings within the ant colonies is of importance.

Coconut Ant nests are quite distinctive and, through Canberra Nature Map, citizen scientists have reported 375 Coconut Ant colonies so far, largely within Canberra Nature Park (Canberra Nature Map, 2019). Encouragingly, colonies have been found within timber imported into Canberra Nature Park as part of an ACT Government woodland restoration program (Kristy Gould pers. Comm). Work in Victoria has found that Coconut Ants seem to have specific habitat requirements for their nests, preferring sites in open eucalypt woodland and open forest with less than 25% projected foliage cover (Beardsell, 1994), with some coarse woody debris, *Eucalyptus* or *Acacia* saplings which host sap-sucking insects for them to harvest, on well-drained slopes and ridges.

7.1 Biology and life history the Coconut Ant in the ACT and its relevance to the Small Ant-blue

Knowledge about Coconut Ant biology and life history is vital as it underpins the existence of the Small Ant-blue, and understanding these factors can better inform conservation management.

Coconut Ants have a distinctive smell of coconut oil which is particularly strong when the ants are disturbed; this scent is secreted from their anal glands, and these chemicals have been well-studied with the likelihood that they are produced for defence (Britton, 1996). It is probable that the Small Ant-blue females use this scent to locate suitable sites for laying eggs and the presence of Small Ant-blues has been shown to induce excitement in Coconut Ants (McCubbin, 1971).

Coconut Ants build a distinctive carton or byre of fine plant detritus over their nests and foraging trails. The benefit of byre-covered trails is not fully understood, but may protect the ants, and possibly the butterfly larvae, from parasitic flies and wasps. The ant colonies are located in the ground, in dead wood on and in trees. Their nests seem to be polydomic, so nests in different pieces of coarse woody debris may well be linked by a network of underground tunnels and chambers (Britton, 1996). Coconut Ant workers have been observed carrying brood to new sites, and sporadic incidence of brood and alates across nests suggests considerable mobility as well as the likely linkages between colony subunits (New and Britton, 1997). Coconut Ant colonies may be large, and one used by Small Ant-blues for their breeding colony was estimated as equivalent to the size of a tennis court (*pers. comm.* F. Douglas).

Coconut Ants are most active during the warmer parts of the year, but will still leave the nest to forage during winter. They rarely forage beyond the immediate nest area but will move between various underground and surface parts of the nest (Britton, 1997; New and Britton, 1997).

Substantial rains after warm weather provide suitable conditions for alates to emerge and disperse to establish new colonies, and alates were observed at several Coconut Ant sites over the 2018-19 season, including more than once at certain nests.

Coconut Ants usually locate their nests close to their food as they need to forage on homopteran insects to obtain the honeydew that these sapsuckers produce, and these insects were found to occur on saplings of predominantly *Eucalyptus* and *Acacia* (New and Britton, 1997) around the Coconut Ant nests. In the ACT we also found Coconut Ant nests near (and foraging on) *Cassinia*, *Allocasuarina*, *Daviesia* and *Dodonaea*. There are also records of Coconut Ants foraging on bracket fungus and apple under artificial conditions (McCubbin, 1971; Waterhouse and Lyell, 1913), and on exudates from glands on phyllodes of *Acacia pycnantha* (Britton, 1996).

Further research is required into Coconut Ants to determine their phenology, at what age their colonies die out, and more information on their colonisation of sites (Britton, 1997). The Coconut Ant is also the attendant ant for the Fiery Jewel *Hypochrysops ignitus* (not recorded from the ACT) and the ant has the same obligate relationship with the Bronze Ant-blue *Acrodipsas brisbanensis* (recorded from the ACT and nearby in NSW). However due to the confused taxonomic status of the Coconut Ant species complex, it is unknown whether it is the same species of Coconut Ant which hosts each species of butterfly.

7.2 Coconut Ant taxonomy

Coconut Ant taxonomy has had little work since the two species (and three subsequent subspecies) that now comprise the genus were first described in the 1860's (Mayr, 1862, 1865). In a major revision of the genus *Iridomyrmex*, Shattuck (1992) described the genus *Papyrius* and transferred into it two species and three subspecies: *Papyrius flavus, P. nitidus, P. nitidus clitellarius, P. nitidus oceanicus and P. nitidus queenslandensis.* Although little is known about the taxonomy of these taxa, there has been no revision of the genus since.

Due to the underdeveloped state of the taxonomy, a cautious approach is required in the identification of specimens. There is no information available for *P. flavus* beyond the original brief description (Mayr, 1865) and no images nor valid specimens are extant. While original descriptions and images of *P. nitidus* and the three subspecies exist, differences between *P. nitidus* and its three subspecies appear to be subtle, and characters used to delineate the taxa may be unreliable.

The majority of collections of *Papyrius* made around the ACT as part of this study have been identified as "*P. nitidus* species complex". Faced with the same taxonomic hurdle, the identity of the specimens collected as part of earlier Victorian studies has not been fully determined and they are reported as *Papyrius 'nitidus'* (Britton, 1996). It is likely that the *P. nitidus* species complex will eventually be resolved into a number of valid species which may or may not follow from the current designations, but this work is yet to be done.

The remaining collections from the ACT not identified as *P. nitidus* species complex appear to be a distinct taxon which is likely to be an undescribed species, although many previous collections of the ant are present in the Australian National Insect Collection (ANIC) at CSIRO Black Mountain. Characters used to differentiate the second taxon, designated here as "*Papyrius species A*" are presented in Table 1.

Table 1 Comparison of *Papyrius nitidus* species complex and *Papyrius species A*

***Papyrius nitidus* species complex**	***Papyrius species A***
Morphologically very similar to images of type specimens of *Papyrius nitidus* as well as the three subspecies. Morphologically similar ants determined as *P. nitidus* have been widely collected across Australia and are well represented in the ANIC collection.	Morphologically distinct from those ants in the *Papyrius nitidus* species complex. Similar morphotypes are present in the ANIC collection, collected from WA, SA, ACT and NSW. Based on the number of collections of this taxon in the ANIC collection, *Papyrius species A* is not as common as *Papyrius nitidus*.
Head, mesosoma and gaster smooth and glossy, with sparse, short, appressed pubescence only. No long, erect setae present on head, mesosoma, petiole or gaster.	Head, mesosoma and gaster smooth and glossy with sparse, short, appressed pubescence as well as long erect setae present on head, pronotum, petiole and gaster. A few short erect setae present on mesonotum and propodeum.
Smaller ant, with head width less than 1 mm, typically 0.80 – 0.85 mm.	Larger ant, with head width greater than 1 mm, typically 1.00 – 1.10 mm.
Colour variable, ranging from brown/orange to dark brown.	Colour variable, ranging from light brown to very dark brown.
Nests usually associated with dead timber, stumps and fallen logs. Relatively fine, cohesive carton material typically used at nest sites, covering trails on tree trunks and used to construct byres. Ant trails on the ground are occasionally entrenched.	Nests usually associated with dead timber, stumps and fallen logs. Cohesive carton material typically not used around nests, and no covered trails or byres have been observed. Loose aggregations of relatively coarse particles typically used to block cracks and holes in logs, and used to create mounds on the ground as sheltered areas for ant activity. No entrenched ant trails have been observed.
Found in eucalypt open woodland, woodland, and open forest. Colonies in forest tending to be small, while open, grazed, grassy sites with little litter favour development of larger colonies which may be in the order of 20 m in diameter.	Found in eucalypt open woodland, woodland, and open forest. Nests tend to be found in sites dominated by litter and woody debris. Nests tend to be relatively small and discrete. No extensive colonies have been observed.

Multiple nuptial flight events were observed of both species during the 2018-19 season, and the timing of these is likely determined by a series of factors including rain and temperature (Nield, 2017). Of the six known Small Ant-blue breeding colonies, six are in colonies of *Papyrius nitidus* species complex.

8. Biology and Life History of Small Ant-blue Particularly as it Relates to Management of the Species

For a physical description of each life stage, please refer to section 1.

There is generally a paucity of information about the biology of the *Acrodipsas* genus as a whole, and information on any of the ant-blue species is valuable. Braby (2016) has the Small Ant-blue flying from September to April nationally (and Braby *et al.*, 2018 also has July for the NT). In the ACT they

fly from October through to March, and they are a bivoltine species; the 2018-19 butterfly season witnessed a strong peak in abundance in late October with a spectacular mass emergence recorded at one breeding colony, and a second generation peaking in late summer. Adults emerge from pupae on hot, sunny days before midday, and initially rest with their wings closed. Waterhouse and Lyell (1913) noted that Coconut Ants will run over the freshly-emerged adults without disturbing the butterflies, but we made observations where the Coconut Ants attacked the butterflies.

Males tend to fly around and perch in the canopy of the eucalypt saplings near the Coconut Ant nest that contains the Small Ant-blue breeding colony; the females tend to walk around on the trunk and lower branches and leaves of the saplings. Males will also congregate on summits of nearby hills where they establish territories by perching on canopy foliage of eucalypts in wait for females. Females fly to these peaks to find suitable males to mate with, and most hilltopping occurs from late morning to late afternoon, particularly during warm to hot weather when temperatures exceed 28°C and there is little wind (Department of Sustainability and Environment, 2003). Courtship and mating are simple and brief (Braby, 1998).

While the longevity of adults is unknown (New and Britton, 1997), it is suspected that adults are short-lived as many observations are of fresh adults (*pers. comm.* F. Douglas) and they have been recorded as living for about a week in Victoria (McCubbin, 1971); we observed several worn specimens during the 2018-19 ACT season. Adults can be cryptic, with females in particular easily missed, and they are not attracted to flowers.

It is probable that the female Small Ant-blue responds to a chemical cue from the Coconut Ants when she selects her oviposition site, as the proximity of butterfly oviposition to ant colony is necessary for the larvae to be found by ants (New and Britton, 1997). Eggs are usually laid in groups, ranging in number from a few eggs up to about 50 eggs, with most observations around 40 or so eggs per group. Sands (1979) noted that a single female can lay between 40-50 eggs in one session. They are laid onto substrates (logs, stumps, trunks of saplings) close to Coconut Ant nests anywhere from ground level up to 180 centimetres off the ground. They are laid directly onto open surfaces and also carefully laid in crevices in the bark. They are tended by Coconut Ant workers and sometimes the ants build a byre over the eggs (Britton 1996). Most eggs hatch within 14 days, but they can last for as long as 5 weeks.

Larvae develop within the Coconut Ant nest where they eat the ant brood (myrmecophagous), but little is known of this stage of their development (Braby, 2000; Eastwood and Fraser, 1999). When the first instars hatch from the egg, they are carried into the nest by the ants; as the larvae develop into later instars they are herded rather than carried by the ants. The larvae can be quite mobile and will move when disturbed, and have been observed out of the nest at night. They overwinter as larvae in the ant nest. While larval development of the spring generation appears to take about 4-7 weeks in Victoria (New and Britton, 1997), it seems that the spring and late summer generations differ in developmental time.

Pupae are often in groups and pupation occurs within or close to the Coconut Ant nest. The pupae are attached by their tail and a central girdle to walls of ant galleries, within cracks of stumps or logs, or between sapling trunks and bark. In Victoria, the first pupae occurred in September, and in the ACT pupae were found in October. Pupal cases do not last for very long after adults have emerged (New and Britton, 1997), but in the ACT we found pupal cases at least several months old at some of the Small Ant-blue breeding sites.

9. Management Guidelines: what are the essential habitat features for the butterfly, what could threaten these features and how could they best be managed

The critical habitat features for the Small Ant-blue are essentially the habitat features required for the survival of the Coconut Ant. However, the Coconut Ant is a poorly understood complex of species and it is unclear why the Small Ant-blue is found in some ant colonies but not all.

Based on the requirements of the Coconut Ant, habitat for the successful breeding of the Small Ant-blue seems to require;

- sap-sucking insects
- mature and sapling eucalypts, young wattles or other understorey plants that support sap-sucking insects
- fallen timber
- an open eucalypt forest or woodland habitat within a sympathetic matrix of low land-use intensification
- Coconut Ant colonies

Threats to these features include:

- Loss of Coconut Ant colonies. The Small Ant-blue is completely dependent on the presence of the Coconut Ants to breed, and so the presence of Coconut Ants is critical.
- Changed fire regimes. Fire is a direct threat to fallen timber resources, and is a direct threat to the survival of colonies of the Coconut Ant and the Small Ant-blue. Due to the fragmented nature of the eucalypt forest and woodland that is their habitat, this makes their colonies vulnerable to disturbance events such as fire, and possibly harder for the butterfly to recolonise sites from isolated source populations. For example, Braby *et al.* (2018) note that inappropriate fire regimes as a threat to the Small Ant-blue in the Northern Territory and Parr and Andersen (2008) found that *Papyrius* was very sensitive to fire in northern Australian savannah.
- Weeds that may choke out Coconut Ant nests or outcompete the flora they rely on. Obvious local contenders are Blackberry and African Love Grass, while Braby *et al.* (2018) list grassy weeds as a threat in the Northern Territory. Blackberry control recently occurred in the vicinity of one of the known Small Ant-blue sites and was subject to particular conditions in order to protect the ant and butterfly.
- Significant change to the structural complexity of the woodland and forest such that there is a loss of understorey plants that support sap sucking insects important for foraging Coconut Ants. Change could be brought about by factors including too much or too little herbivore grazing pressure.
- Intensification of land use in the surrounding matrix. For example, intensive grazing pressure around the Broadford site in Victoria, and land use change from pastoral agriculture to residential development at the Ocean Grove site (also in Victoria) were both thought to be important contributing factors to the loss of Small Ant-blue populations at those sites (Department of Sustainability and Environment, 2003). In the ACT, clearing and fragmentation of habitat for urban development is the key threat concerning the matrix around the Small Ant-blue breeding sites.
- Increased density and closer proximity of human habitation to reserves and sites with Small Ant-blue colonies, resulting in accelerated rates of habitat disturbance that come as part of that change – for example firewood collection, weed invasion,

recreational pursuits etc.

- Surface soil disturbance, affecting both vegetation structure and directly disturbing Coconut Ant colonies. Soil disturbance may be a result of activities such as contractors undertaking work within reserves.
- Invasive ants. The introduction of exotic ant species is a potential threat to Coconut Ant colonies.

Another threat unrelated to habitat is that of butterfly collection. Due to its rarity, Small Ant-Blue butterflies, caterpillars, pupae or their eggs are sought after by unscrupulous collectors and can be lucrative on the black market, or subject to overzealous collectors wanting many specimens for their (or friends') collections. As a result, many butterflies could be collected from breeding locations in a relatively short time. This threat is particularly important in the case of the Small Ant-blue as its colonies occur as small, sedentary populations in relatively accessible areas. Consequently, an appropriate level of control of information pertaining to the location of Small Ant-blue colonies, habitat and occurrence in the ACT must be maintained, and these information controls should be incorporated into formulating and enacting any management plan for this species.

9.1 Management guidelines

General Conservation

- Conserve and manage Small Ant-blue and Coconut Ant sites appropriately for the needs of these species.

- Retain and manage eucalypt forest and woodland in good condition where possible in the matrix surrounding the reserves containing Small Ant-blue colonies.

- Be alert to new incursions of exotic ant species and make a priority for control any incursions within woodland patches supporting Small Ant-blues

- Maintain appropriate levels of control over information related to the location of breeding sites and hilltopping sites to minimise the risk of illegal collection

Breeding Habitat Conservation

- Protect the fallen and dead standing timber housing ant colonies in which the Small Ant-Blue is known to breed during prescribed burning, weed control or other management activities.

- Try to protect timber housing ants in which Small Ant-blues have been recorded during wildfire events

- Provide extra vigilance against illegal removal of fallen timber in those reserves in which the Small Ant-blue is known to occur

- If fallen timber appears to be limited in the area of a known butterfly containing ant colony consider importing large eucalypt logs to the site.

- Addition of timber should be considered as a remediation measure immediately after fire or some-other events results in the major loss of fallen timber at a Small Ant-blue breeding location.

- A 5-10% cover of eucalypt saplings, wattles or other shrubs and saplings on which sap-sucking homoptera are being attended by the Coconut Ants should be maintained or enhanced in the immediate vicinity of known breeding locations, (i.e. up to 100m from nest site). This may require control of herbivores, supplementary planting or coppicing of some of the eucalypts present.

- Blackberries and other weeds that threatened to smother either the fallen timber or homoptera food plants need to be controlled.

- Avoid further fragmentation or reduction in size of the woodland patches in which breeding sites occur

- Avoid disturbance of sites from such things as new infrastructure or recreational tracks or amenities

Hilltopping Site Conservation

- Minimise disturbance and damage to native tree, sapling and shrub vegetation at known and possible hilltopping sites

- Avoid prescribed burns on hill tops during the breeding season (October – March) and protect small trees and saplings.

Research and Monitoring

- Conduct further research on the ecology and biology of Small Ant-blues and Coconut Ants to better understand their requirements.

- Continue community involvement in monitoring of Small Ant-blue and Coconut Ant sites.

9.2 Formal Protection status

The *Nature Conservation (Protected Native Species) List 2015 (No. 1),* allows native invertebrates to be protected under the *Nature Conservation Act 2014.*

To be eligible to be listed in the rare category on the protected native species list, a species must be rare in the ACT as evidenced by at least one of the following criteria:

(a) The species has a small distribution [area of occupancy and/or extent of occurrence].
(b) There is a single and/or small population in the ACT.

Note: Assessment against this criterion should take into account the variability of the population and historic abundance.

(c) The species is endemic to the ACT and/or the surrounding bioregions of which the ACT is a part.
(d) The species has an estimated population of less than 10,000 individuals across its extent of occurrence and a significant proportion of the known total population occurs in the ACT.

The ACT contains all of the known breeding locations of the Small Ant-blue. In recent decades it has only been very occasionally recorded across Australia, despite a fairly active lepidopterist community, with a total observed population of only a few hundred individuals. The largest ever aggregation of about 100 butterflies was recently recorded in the ACT. Thus Criteria (d) is clearly met, and it is appropriate for the species to be listed as rare.

The *Nature Conservation Act 2014* also provides for the listing of threatened species at either a national or regional scale. A species cannot be listed as both a protected and threatened species. Penalties for harming threatened species are larger than those for a protected species. There is insufficient known about the national range of the Small Ant-blue to support a national assessment. At a regional level there is not the data to be able to show a significant decline. Thus listing as a threatened species would need to have criteria relating to size of regional occurrence (distribution) or total population size.

It is recommended that Small Ant-blue be listed as a rare species under the *Nature Conservation Act 2014,* and that consideration be given to changing this status to a threatened category after information from next season's survey and monitoring study has been collated.

9.3 What ongoing monitoring of the species should occur?

There should be an ongoing search for and monitoring of Coconut Ant colonies, and an ongoing search for and monitoring of Small Ant-blue colonies focusing on the Coconut Ant nests. This needs the continued involvement of citizen scientists, as this was critical for last season's success. These citizen scientists are highly skilled, keen and knowledgeable observers able to contribute greatly to search effort in their local patches, and as such are an invaluable asset to the success of future monitoring. It would be beneficial to expand the citizen scientist team to cover more ground and enable more thorough observation, but this will have to be done carefully due to threat of butterfly collection; new volunteers would have to be carefully selected, and understand the sensitivity of information about breeding and hilltopping sites. It may be useful to conduct another training day for newcomers, and/or pair them up with current volunteers in the field.

Large area monitoring is a recommended option for rare species, especially if they have dynamic use of the landscape; once the area has been defined it can be searched for the focal species during the appropriate flight period of target species (Van Swaay et al, 2015). Searching areas with known

Coconut Ant nests during the Small Ant-blue flight period yielded observations of new butterfly colonies with less intensive search effort than looking for signs of breeding evidence or larvae during the non-flight period.

In addition to the chance of locating new Small Ant-blue breeding colonies, there is also the possibility of the discovery of Bronze Ant-blue colonies. Like the Small Ant-blue, this species also has an obligate relationship with the Coconut Ant, although it is unknown if it is the same species as the Small Ant-blue relies on. Bronze Ant-blue has been recorded from Mt Ainslie and Mt Coree (Bond *et al.*, 2018). There is sufficient difference in size and colour of the pupae (New and Britton, 1997) to separate Bronze Ant-blue pupae from those of the Small Ant-blue, but there is very little known of the larval stages of the Bronze Ant-blue.

In addition to the ongoing monitoring, there is the possibility of setting up some trap nests to monitor Coconut Ants and Small Ant-blues in a less intrusive manner than searching ant nests, and it would enable greater tracking of aspects of biology like larval development (Britton, 1997).

10. Glossary

Alate – a winged ant of the reproductive caste

Bivoltine – producing two broods in the one year

Dimorphic - occurring in or representing two distinct forms.

Homopteran – A group of bugs that have uniform forewings and includes aphids, scale insects and leafhoppers

Myrmecophily - symbiosis with ants

Myrmecophagous – feeding on ants

Polydomic – the same insect colony is occupying more than one nest

Tornus - the inner or anal angle of the wing of an insect

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