Arid Bronze Azure Butterfly

Workshop Report 2022

The Western Australian Biodiversity Science Institute

Acknowledgements

We acknowledge stakeholders for providing valuable feedback and thank workshop participants for their time, expertise and for sharing information in an open and respectful way.

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The Western Australian Biodiversity Science Institute

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COVER IMAGES: Newly emerged female arid bronze azure butterfly. Credit Andrew Williams, Department of Biodiversity, Conservation & Attractions

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Introduction

The Western Australian Biodiversity Science Institute (WABSI) is an independent, coordinating mechanism, fostering collaboration across sectors to address priority biodiversity science knowledge gaps. We facilitate end user driven, relevant research to create opportunities for meaningful change in biodiversity conservation and enable sustainable development.

In early 2022, representatives from industry approached WABSI, highlighting a lack of information available on the arid bronze azure butterfly (ABAB), a critically endangered butterfly species. The issue presents challenges for industry proponents, government and regulators in making informed decisions on potential development and land management. Despite several published guidelines and resources, significant knowledge gaps still exist.

On 18th May 2022, WABSI brought together stakeholders and experts and facilitated a workshop to better identify the knowledge gaps and establish consensus on priority areas for research. This report is a summary of the workshop discussions and sets out seven focus areas for priority research, as agreed by stakeholders. Further investment and research effort are now required to lift the level of understanding of this species and ensure better outcomes for all stakeholders.

WABSI's role in facilitating collaboration and engagement for the conservation of the ABAB is aligned with our strategic research priorities and nestles within our Ecosystem Processes and Threat Mitigation theme. Our efforts will create opportunities for further, focused research, to enable more informed decision-making for threat management and conservation to improve outcomes for all stakeholders.

1. Background and context

The arid bronze azure butterfly (ABAB; *Ogyris subterrestris petrina*; Figure 1) is listed as Critically Endangered under Australia's *Environment Protection and Biodiversity Conservation Act (1999)* and under *Western Australia's Biodiversity Conservation Act (2016)*. This listing is based on its severely fragmented and restricted geographic distribution. Publicly available information notes the current existence of only two sub-populations in Australia, both in the Western Australia's Avon Wheatbelt in the Shire of Mukinbudin–one within the Barbalin Nature Reserve (BNR), and the second located within a road and rail reserve c. 100km from the BNR (DBCA, 2020a).

The ABAB is known to have complex dependencies on other co-occurring species and specific habitat requirements. For example, the butterfly is obligately dependent on a sugar ant species (*Camponotus* sp. nr. *terebrans*) to complete its lifecycle—ABAB larvae live entirely within the ant's nest during their development (Figure 1).

The butterfly and its host ant are known to be extremely sensitive to clearing and habitat disturbance, disturbance from roadworks, off-road vehicles, mining and agricultural activities, and inappropriate fire regimes (Australian Government, 2015; Braby, 2000). However, the host ant is known to be a disturbance specialist so the context of the disturbance, including the magnitude, timing and mechanism, is important for conservation outcomes. It is clear that a robust understanding of the ABAB's biology and ecology is far from complete. Much of the ecological insight and context presented in this report is not underpinned by rigorous quantitative studies, but rather represents the detailed observations of field ecologists experienced with the ABAB system. The lack of information on the species makes decision-making for threat management and conservation difficult, especially when development or land management activities are proposed that could potentially impact the species directly or indirectly impact aspects of the ecosystem upon which it depends. These knowledge gaps represent a real opportunity for further research to help guide informed management, which will improve outcomes for all stakeholders.

A more complete coverage of the details of what is known on the species and its ecology is covered by 42 publications, including peer reviewed articles, reports, and other grey literature (Appendix I).

Figure 1. (a) Preserved arid bronze azure butterfly (ABAB) adult specimens showing female (top) and male (bottom) (Photo credit: Steve Brown); (b): Mature ABAB larva attended by a sugar ant worker (magnification × 6) (Photo credit: Timothy Gamblin).

2. Workshop structure and scope

In an effort to enable better decision-making outcomes for ABAB management, which balance ABAB conservation and proposed development/ land management activities, The Western Australian Biodiversity Science Institute (WABSI) organised a stakeholder workshop on 18th May 2022. The workshop process identified and invited as many relevant stakeholders in the State as possible, covering government, mining, environmental consulting, and research sectors.

The objectives of the workshop were to (1) get an understanding of current knowledge of the ABAB, (2) identify challenges relating to the management of the species, and (3) document priority areas (knowledge gaps and issues impeding progress) that can be addressed by new collaborative research. A complementary goal was to also identify any additional stakeholders not identified as part of the initial process.

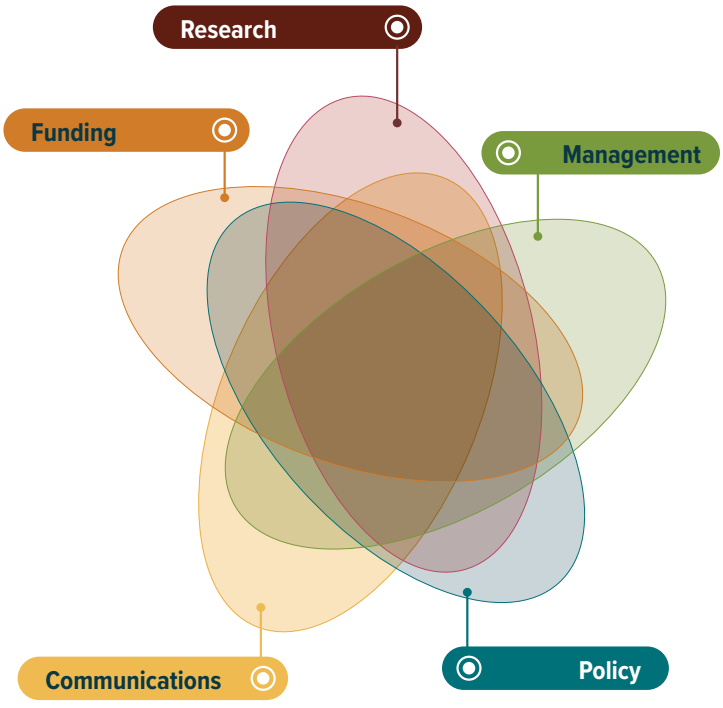

Figure 2. Solutions for butterfly conservation challenges can be grouped into research, management, policy, communications, and funding components, either alone or in various combinations.

The workshop was facilitated by Bruce Webber, Program Director at WABSI, with assistance from Vandana Subroy also from WABSI. Stakeholders who were able to attend the workshop (from a broader invite list) included:

Bill Bateman	Curtin University
Janine Cameron	Northern Star Resources Limited
Peter de San Miguel	Mineral Resources Limited
Alicia Dudzinska	Department of Mining, Industry Regulation and Safety (DMIRS)
Rodney Eastwood	Western Australian Museum
Timothy Moulds	Invertebrate Solutions
Paul Nevill	Curtin University
Josh Newton	Curtin University
Danielle Risbey	DMIRS
Neil Smith	Mineral Resources Limited
Melissa Thomas	Murdoch University
Peter-Jon Waddell	Department of Primary Industries and Regional Development
Andrew Williams	Department of Biodiversity, Conservation and Attractions

The workshop was undertaken as a single group facilitated discussion in an online forum. While the conversation was permitted to be free-flowing and agile, there was a focus on addressing the core issues of (1) the current knowledge of the ecology and biology of the ABAB, (2) challenges for management, (3) knowledge gaps, and (4) priority focal areas for future work. These discussions are summarised in Sections 3 and 4 of this report. In the process of refining feedback after the workshop, the priority focal areas have been grouped into five solution components (Figure 2): research (including social research), funding, communications, policy and management. WABSI's remit for finding solutions in this space relates specifically to the research category, as well as where the other four categories interact or overlap with research to improve outcomes.

In addition to those who attended the workshop, the following people also provided feedback on draft versions of this report:

Timothy Gamblin	Wilson Inlet Catchment Committee

3. Workshop discussion

The workshop discussion ranged from current knowledge on the ecology and biology of the ABAB to on-going research, survey methodology and eDNA techniques, knowledge gaps and issues related to data collection and sharing. The summary below reflects the extent of the discussion of various topics among the workshop participants. Some issues were discussed to a greater extent than others. We have deliberately avoided including citations to references in the information provided below because much of the insight is based on unpublished observations or the insight is not backed by rigorous quantitative studies. This intersection of biological knowledge gaps and the opportunity to improve decision making was influential in guiding the final prioritisation process (Section 4).

3.1. Ecology and biology of the arid bronze azure butterfly (ABAB)

3.1.1. Knowledge of the ABAB, host ant, and biological interactions between them

- The arid bronze azure (*Ogyris subterrestris petrina*) is a very rare butterfly, listed as Critically Endangered
- Its geographical distribution is restricted and fragmented
- Currently four locations of the species are known. These are:
  1. The Barbalin Nature Reserve (BNR)
  2. A site about 100 km from the BNR
  3. Two subpopulations within 75 km of Kalgoorlie
  4. Details of numbers 2 & 3 cannot be revealed
  5. The closest distance between the (sub) populations is about 50 km and the farthest about 300 km
- The ABAB is a lycaenid butterfly (one of almost 6,000 species globally)
- Most lycaenid species have an association with ants
- The importance of the association varies from facultative to parasitic to obligate, with many lycaenids associating with only a single ant species
- The ABAB was first thought to associate with the ant species *Camponotus terebrans*, but it was later determined that the host ant species was distinct from *C. terebrans*
- The host ant has not yet been formally described as a species, and it is currently referred to as *C.* sp. nr. *terebrans* because of its similarity to *C. terebrans*
  - *C.* sp. nr. *terebrans* is now referred to as the 'pale form' of the sugar ant as it is paler than *C. terebrans*
  - A genetic analysis of the *C. terebrans* group has been proposed by an ant taxonomist and is currently being considered – it would require at least three gene sequences (wg, COI & LR)
- The ABAB has an obligate association with its host ant (Figure 3 (a))
- ABAB larvae live entirely in the ant's nest during their development
- Lycaenid caterpillars have three main organs on their skin (cuticle) involved in maintaining their association with ants (called ant-associated organs).
  1. The first called the *dorsal nectary organ* is on the seventh abdominal segment and produces amino acids and sugars, essential food resources for ants that primarily attract them to the caterpillars
     a) It has been recently discovered that there are other chemicals present in the dorsal nectary exudates produced by caterpillars that modify the dopamine pathways in ants' brains, making the ants "addicted" to the caterpillars and ensuring that the ants always stay near the caterpillars
     b) This addiction functions at an individual ant level
  2. Two other paired organs called *tentacular organs* on the eighth abdominal segment are normally held within the caterpillar's cuticle but can be 'everted'. They produce short chain hydrocarbons that mimic ant alarm pheromones, making the already addicted ants hyper alert to danger and vigilant protectors of the caterpillars
  3. There are also a series of small organs on the cuticle called *pore cupola organs* that produce long chain hydrocarbons that block part of the receptors on the ants' antennae rendering the ants incapable of recognising the caterpillar as a potential food item

Figure 3. *Camponotus* sp. nr. *terebrans* worker ants attending to (a) arid bronze azure butterfly (*Ogyris subterrestris petrina*) larva at the nest site (Photo credit: Andrew Williams, DBCA); and (b) Leafhopper (*Pogonoscopus lenis*) on the trunk of a salmon gum (Photo credit: Timothy Gamblin).

4. Caterpillars (and pupae) also have a subdermal structure between abdominal segments five and six that produces sounds and vibrations (stridulations). Caterpillars communicate with other caterpillars in the vicinity using stridulations so they can group together and be taken care of by ants more effectively
    a) The stridulations can be easily picked up by other caterpillars on the host plant
    b) Caterpillars also use these stridulations to communicate with ants since ants can also perceive them
    c) Stridulations are produced intermittently during the day, but because the attendant ants return to their nest at night, stridulations are especially initiated first thing in the morning to attract (call) ants back to the caterpillars to protect them from predators during the day

- Modifications of ABAB caterpillars from the general characteristics of lycaenid caterpillars described above:
    - The female ABAB lays eggs at the entrance to the ants' nests (Figure 4)
    - Eggs hatch in the evening. Newly hatched first instar ABAB larvae mimic the ant brood pheromones, causing the host ants to mistake them for their own larvae and carry them inside their nest
    - In the case of the ABAB–*C.* sp. nr. *terebrans* system, the ABAB caterpillars do not produce regular stridulations during the day as the host ants are nocturnal and will be in their nest during the day
    - Stridulations, will, however, be produced when required, especially for defence against predators
    - Rather than mimicking ant alarm pheromones, ABAB caterpillars mimic the stridulations of queen ants, to gain preferential treatment during nest defence. Such behaviour expectedly means that during a nest attack, the queen and the ABAB caterpillars may be preferentially attended to and taken to the safest part of the nest
    - ABAB caterpillars are carnivores that either eat their host ants' larvae and pupae or are kleptoparasites being fed by the ants via trophallaxis (mouth to mouth liquid exchange)
        - Evidence of carnivory or kleptoparasitism by ABAB caterpillars has been difficult to determine
        - Total ant nest larvae and pupae numbers may not be depleted by ABAB feeding because ABAB caterpillar development is timed to coincide with increased ant brood and alate development prior to ant nuptial flights. However, overall, the ABAB caterpillars are thought to be detrimental to the host ant nests
    - Once the caterpillars start eating or are fed by the ants, they acquire the ant-nest recognition cues and are accepted by the ants as a member of the ant nest

- Other biological factors in the ant nest ecosystem include inquiline leafhoppers (*Pogonoscopus* spp.) and the Eucalyptus host trees
- *Camponotus* sp. nr. *terebrans*' association with smooth-barked eucalypts may be linked to their mutualistic association with the *Pogonoscopus* leafhoppers that feed on the tree sap (Figure 3 (b))
  - While it remains untested, it is theorised that leafhoppers offer a significant amount of energy to the ant colony even if only supplementary
  - The association with smooth-barked eucalypt species has been suggested to be because rough-barked eucalypts would make entry to the xylem and/or other fluids difficult due to the length of the leafhopper's proboscis (again, this theory remains untested).
- *Pogonoscopus* feed at night and produce an anal excretion (honeydew) that *C.* sp. nr. *terebrans* feeds on. In return, the ants protect the *Pogonoscopus* in their nest during the day and also at night while feeding on tree trunks.
- It has been observed that the *Pogonoscopus* also get preferential treatment in being defended by the ants during a nest attack.
- *Camponotus* sp. nr. *terebrans* may be able to live without the *Pogonoscopus* since they have other resources to feed on including nectar, extrafloral nectaries, honeydew from other hemipterans, etc.
- It is unclear how the *Pogonoscopus* species get into the *C.* sp. nr. *terebrans* nests
- At least two species of *Pogonoscopus* are associated with *C.* sp. nr. *terebrans* (*P. lenis* and *P. myrmex*)
- The taxonomy of *Pogonoscopus* is reasonably well known
- It is not known what role, if any, the *Pogonoscopus* play in ABAB development in the ant nest
- No detailed information is available on the distance over which an adult ABAB can disperse

3.1.2. Geographic range of the ABAB

- The potential range of ABAB could theoretically extend across the range of smooth barked eucalypt woodland habitat, which is vast
- However the range of ABAB is further constrained by habitat that is suitable for their host ant (*C.* sp. nr. *terebrans*; Figure 4)
- ABAB ants are not known to be found throughout the whole range of smooth barked eucalypt distributions
  - The northern extent of the distribution (of host ant populations) is likely limited by rainfall
  - Climatic factors could also be responsible for the southern limit of the distribution of host ant populations but that is not certain
- Rainfall patterns, soil types, drainage, temperature regimes, understorey cover, surrounding plant species, and the presence of open flight paths adjacent to nest trees all play a role in determining habitat suitability
- The closely related species, *C. terebrans* has a broad range occurring from very dense jarrah forest in the southwest to islands in heathlands that are inundated, implying, among other things that they do not necessarily depend on the occurrence of smooth barked eucalypts
- The range of *C.* sp. nr. *terebrans* and *C. terebrans* has been found to overlap
- No comprehensive survey has been carried out specifically for *C.* sp. nr. *terebrans* and very few past surveys have effectively separated *C. terebrans* records from those of *C.* sp. nr. *terebrans*
- Many sugar ant surveys have been conducted by ecological consultants in the Goldfields in the past year.
  - Some surveys have documented *C.* sp. nr. *terebrans* ants while others have not
  - One of the subsequent ABAB surveys that recorded *C.* sp. nr. *terebrans* ants have also found an ABAB population while the rest have not

Figure 4. *Camponotus* sp. nr. *terebrans* habitat (a) and nest (b), Photo credit: Rodney Eastwood; Close-up of *Camponotus* sp. nr. *terebrans* nest gallery structure (c) (Photo credit: Timothy Gamblin).

3.1.3. Biotic interactions and their reliance on climatic and soil-based drivers

- Exact habitat requirements for the host ant are still being determined
- The original population site of the ABAB at Lake Douglas was on a ridge with a rocky substrate
  - Subsequent subpopulation sites have been found on different soil types ranging from loamy to sandy
  - It seems that the original site was atypical and much effort may have been wasted searching in the wrong habitat/substrate for the ants
- Sandy soils likely make it easier for the host ants to nest
- There is a lack of knowledge about soil types that would best support ABAB and host ant populations, therefore soil type fidelity is an area requiring further research
- A mixed understory of flowering plants is key for the host ants and adult ABAB to access nectar sources when plants flower at different times of the year
- The presence of mixed-age smooth barked eucalypts is important to support nests of the host ant *C.* sp. nr. *terebrans*

- *Camponotus* sp. nr. *terebrans* have also been found to nest at the base of several other species of eucalypts with rough bark, and even under non-eucalypt shrubs
- In all known ABAB sites the majority of ant nests are on smooth barked eucalypts
- Regarding the now extinct ABAB population site at Lake Douglas near Kalgoorlie
  - This was the first population (and type locality) of ABAB discovered in the 1980s
  - Host ants and ABAB were very common at that site for many years
  - Something caused a depletion of host ant populations that led to a corresponding depletion of ABAB numbers
  - Thus, host ants' colonies may be particularly sensitive to certain kinds of disturbance
  - Human presence is thought to have played a role in the decline and extinction of the Lake Douglas population
  - Lake Douglas was a recreational reserve that allowed off-road vehicles including motorcycles in the reserve, and even had a portion cut up for mining
  - Corresponding with the ABAB disappearance, large numbers of meat ants (*Iridomyrmex purpureus*), which are a known threat to the *Camponotus* species, were found at Lake Douglas
    - Meat ants and the *Camponotus* species often co-occur and share the same food resources except that meat ants are diurnal while the *Camponotus* ants are nocturnal.
    - They are antagonistic to each other if they come into contact, especially in the early morning or late afternoon during the changeover times for both ant species
    - Disturbance, particularly from clearing and off-road vehicles during the day can alter the status quo and result in the *Iridomyrmex* overpowering the *Camponotus* ants
- Vertebrate presence can be beneficial to *C.* sp. nr. *terebrans* as this ant species has developed a method of extracting nitrogen from vertebrate urine
  - Just because vertebrate urine provides a nitrogen resource does not mean that introduced herbivores, such as cattle and rabbits, should be unreservedly allowed near *Camponotus* nests. Livestock at high densities, particularly cattle, would likely do more harm than good.
  - All livestock seek shelter and graze under tree and shrub canopies. This may lead to trampling and opening up of 'tree-based clumps', which may have consequences to *Camponotus* nest locations, however no evidence for such impacts has been observed.
- Fencing off an area to exclude all vertebrates could be detrimental to the *C.* sp. nr. *terebrans* unless vertebrate numbers are too high

3.1.4. Rarity of the ABAB

- The host ant *C.* sp. nr. *terebrans* is uncommon in Western Australia — only a few colonies have been found despite many hundreds of kilometres of surveying
- The ABAB, being an obligate parasite of *C.* sp. nr. *terebrans* nests makes it even more uncommon
- Conclusion: the ABAB is never going to be a common species
- Maintaining protected populations of the host *C.* sp. nr. *terebrans* is critical, as these ants could, in the future, host ABAB caterpillars

3.1.5. Threats

- Threats: habitat disturbance from land clearing, off-road vehicles, and livestock
- Lack of disturbance, however, may also be a threat:
  - *C. terebrans* is thought to be a disturbance specialist, requiring some disturbance to survive. However, it appears that the context, of the disturbance, including magnitude, timing and mechanism, is important. Natural disturbance regimes that may facilitate its presence include native grazing, kangaroo tracks, extreme weather, and fire.
  - Like *C. terebrans*, *C.* sp. nr. *terebrans* is also very likely a disturbance specialist (again, the context of disturbance is likely to be important) with some disturbance expected to have potentially positive effects up to a point
- Substantial and long-term disturbance, particularly during the day, can negatively affect *C.* sp. nr *terebrans* because of their nocturnal nature.
- Collection by amateur entomologists, collectors, or those seeking to sell rare species on the international market

3.2. Survey methodology

- Initial survey is conducted to find the host ants (not butterflies)
- It is important to examine the base of a variety of eucalypts in addition to smooth barked species for host ant nests
- If ants are found, the extent of the ant colony should be plotted
- Three surveys for ABAB are then conducted two weeks apart at the ant colony between mid-September and late October to find the butterflies (DBCA, 2020b)
- Difficult to predict exactly when the butterflies will be flying, but it is most likely between late-September to the end of October or into November. A second generation may fly in late March to May

3.3. On-going research

- A proposal to carry out phylogeographic analysis on the ABAB has been lodged with the DBCA and data is being gathered for this study

3.4. eDNA techniques to detect the ABAB

- PhD work commencing in this area
- Interest from the mining sector in using eDNA for terrestrial detection of species
- Terrestrial eDNA studies are picking up but still lag behind marine and freshwater eDNA work
- Appropriate substrates that work in terrestrial systems need to be found
  - Soil is not really a good substrate for detection as it is exposed to the UV radiation of the sun and to the elements
- Substrates to detect host ant and ABAB populations could be the soil around the nest, potentially the air within the ant's nest, swabs from the base of the tree etc.
- Need to think of other detection methods in addition to eDNA, for example the physical detection of ABAB eggs (or egg remains) at the base of the tree, gas chromatograph analysis of air samples from ant nests

3.5. Knowledge gaps

- Range limits of the distribution of the host ant species *C.* sp. nr. *terebrans*, and, therefore, the ABAB and drivers of this distribution
- Habitat requirements for the host ant species *C.* sp. nr. *terebrans* including the drainage patterns, rainfall, understorey
- Uncertainty whether ABAB can utilise *C. terebrans* as a host ant
- Data for places where host ants are expected to be found but are not found are also important to collect to understand reasons for the suitability (or otherwise) of the habitat
  - This includes data on habitat that was suitable in the past but no longer so
  - Reconsidering which vegetation maps, and hence the scale of mapping, are used to define suitable habitat may be worth considering (e.g. rangeland system mapping vs Beard vegetation maps).
- Lack of knowledge in departmental assessor group
- Lack of knowledge among environmental consulting personnel – incorrect assessments made

3.6. Data collection

- Trained researchers doing work on-ground is important to fill knowledge gaps
  - Acknowledgement that this may not be realistic or feasible owing to the vastness of the potential survey area and the lack of financial resources
  - Most survey is currently being undertaken by environmental consulting companies on behalf of their clients or mining companies who may need to clear land in possible ABAB habitat
  - Closing knowledge gaps would also help in the predictions of the likelihood of a site being able to support ABAB populations. For example, as specific vegetation (trees/shrubs) and soil types favoured by *Camponotus* species become known, those attributes could be checked against known inventory sites, and habitat type preferences may be determined. Knowing if or where that habitat type is common within a land system could then be used to help plan future ABAB surveys
  - Finding more ant colonies particularly in National Parks would mean that future translocations of ABAB females or ABAB eggs could be undertaken (but only after a thorough understanding of such a translocation, including the nature of its risks and rewards and likelihood of success)

3.7. Data sharing

- Potentially no issues regarding data sharing by proponents undertaking field surveys for the ABAB system
- Data sharing encouraged in some companies but perhaps not all companies that are relevant stakeholders?
- Problems if site data are made available to the public. May be abused by unscrupulous collectors of rare butterflies

4. Priority focal areas

Towards the end of the discussion, workshop participants were asked to identify priority focal areas for future work that will improve management of the arid bronze azure butterfly. Seven priority focal areas were identified (Table 1). They have been tentatively ascribed to the five solution categories (Figure 2). The list in Table 1 is simply a numbered list and not a ranked list (i.e., the priority focal areas have not been ranked against each other). Details on each of the priority focal areas are given below the table.

Focal Area 1: Appointment of a dedicated entomologist/invertebrate ecologist at DBCA

The appointment of a dedicated entomologist/ invertebrate ecologist of high calibre for the State, to oversee and be the point of contact of all research related to the ABAB and assess review and approvals, was seen to be important. EPA approvals and the approvals sent to other government agencies such as DMIRS usually default to the Department of Biodiversity Conservation and Attractions (DBCA) for technical advice. Therefore, having a full-time appointee in this role at DBCA would allow for coordination between departments, provide access to expertise, and also ensure consistency in assessments and outcomes across proposals.

Focal Area 2: Detailed, empirical ecological research

Fine-scale, detailed, empirical ecological research is needed to build knowledge on:

1. The ABAB, its host ant *C.* sp. nr. *terebrans*, and their mutualisms
2. The taxonomy of the host ant *C.* sp. nr. *terebrans*
3. Interactions and the association between the ABAB and *C. terebrans*, if any
4. Understanding the genetic variation in species' populations across the different sites to enable (among other things) eDNA assays to be designed appropriately

Table 1. Priority focal areas for arid bronze azure butterfly management from workshop discussions

No.	Priority area of focus	Solution category				
		Research	Management	Policy	Funding	Communications
1	Appointment of a dedicated entomologist/invertebrate ecologist at the DBCA	•	•		•	
2	Detailed, empirical ecological research	•			•	
3	Data collection on species' distribution	•	•		•	
4	Revise/update existing DBCA survey guidelines for the ABAB and its host	•	•			•
5	Training sessions for those conducting host ant and ABAB population surveys		•		•	•
6	Further education of assessors		•	•	•	•
7	Develop a formal one page factsheet on the ABAB for industries operating in likely ABAB habitat zone	•	•			•

Focal Area 3: Data collection on species' distribution

An essential, aggregated data set needs to be collected with the help of trained land managers, ecological consultants, and others to understand the distribution of the species as well as any species with which there is a significant dependence. Detailed inputs on the vegetation, soil type(s), and rainfall and other climatic variables at each site would be important to collect.

Focal Area 4: Revise/update existing DBCA survey guidelines for the ABAB and its host

- Standardise guidelines and make them clear, evidence-based, justifiable, transparent, accountable, and free from multiple interpretations
- The subterranean fauna sampling guidelines could be examined while developing revised guidelines for the ABAB system
- Updates to be included:
  - new information on the ABAB and its host ant
  - information on how to recognise the host ant species (crucial but missing from current guidelines), noting that the WA Museum provides identification service for ants and has an in-house expert on *Camponotus* species
  - guidelines need to emphasise competent surveying for the host ants and correctly identifying them after which surveying for the butterflies need to be carried out
- These revised guidelines could possibly be extended to develop guidelines for the sampling of conservation significant species, which are not covered by existing shortrange endemic invertebrate fauna survey guidelines

Focal Area 5: Training sessions for those conducting host ant and ABAB population surveys

Mandate training requirements and conduct training sessions for people conducting host ant and ABAB population surveys to help them gain proficiency in the proper survey technique including, among other things, being able to correctly identify the host ant nests and potentially suitable habitat for the ants and the ABAB. Such training will be beneficial to land managers and environmental consultants to populate data on the distribution of this species.

- The training session conducted for surveying the Graceful Sun-moth (*Synemon gratiosa*) over a decade ago was given as an example. These training sessions were well-received, and the surveys conducted as a result of those sessions produced good data on Graceful Sun-moth populations across the Swan Coastal Plain.
- The logistics of Perth-based consultants attending training sessions in the Wheatbelt or the Goldfields would need to be considered, but such a training would still be feasible.

Focal Area 6: Education of assessors

More thorough education of assessors in government agencies was also deemed important to help assessors broaden their knowledge of the species and better understand survey results presented to them when assessing clearing permits.

Focal Area 7: Develop a formal one-page factsheet on the ABAB for industries operating in likely ABAB habitat zones

Development and distribution of a formal one-page factsheet for industry was considered to be essential to help raise awareness for all industries that operate in the likely ABAB habitat zone. The factsheet would need to emphasise the Critically Endangered status of the ABAB and also include pictures of the butterfly, host ant, and the host ants' nests to enable them to be identified.

5. Stakeholder contacts

Workshop participants were also asked for names and details of other stakeholders who would be essential to future work in the ABAB system. They are listed below, along with other stakeholders who were originally identified but not able to attend the workshop.

1. **Kym Abrams**, Terrestrial Ecosystems Branch, Department of Water and Environmental Regulation (zoologist, approvals stakeholder)
2. **Raphael Didham**, CSIRO & UWA (community ecologist, entomologist)
3. **Martin Dziminski**, DBCA (threatened species management)
4. **Timothy Gamblin**, Wilson Inlet Catchment Council (ABAB ecologist)
5. **Celine Mangan**, Mineral Resources (industry stakeholder)
6. **Melinda Moir**, DPIRD (Pogonoscopus taxa specialist)
7. **Brian Hetrick**, formerly Curtin University (now retired) (ant ecologist)
8. **Katherine Hope**, Regional Leader Conservation, Kalgoorlie, DBCA (rangelands ecologist)
9. **Matt Williams**, (ABAB ecologist)
10. **Mark Wong**, UWA & CSIRO (ant ecologist)

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