# INVERTEBRATES COLLECTED DURING THE SA DEPARTMENT FOR ENVIRONMENT & WATER MALKUMBA-COONGIE WETLAND WONDERS AND SCIENTIFIC EXPEDITION GROUP BIOLOGICAL SURVEY 1192, 20-30 MAY 2019

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## INTRODUCTION

The Coongie Lakes in South Australia's north and the associated Cooper Creek floodplains and swamps are formally recognized as a RAMSAR Wetland of International Importance. This included the agreement (signed by the Australian Government) to protect the wetlands and associated natural values, along with wetland habitats. The area also includes dune fields and gibber plains that now support threatened species also listed under Federal Environmental Legislation.

The Australian Government's National Landcare Program has supported a five-year project proposal from the South Australian Arid Lands Natural Resource Management Board (SAAL NRM Board) aimed at on-ground activities that maintain these values.

This project, titled *Malkumba-Coongie Wetland Wonders,* includes:

1. Assessing the extent and significance of impacts from exploration tracks and infrastructure development on surface flows and vegetation to guide future planning.
2. Region-wide pest animal control focusing on pigs and large feral herbivores.
3. Managing weed infestations with a focus on new strategic invasions to minimize further spread.
4. Assessing impacts of pest species on the natural systems and the effectiveness of managing these pests.
5. Improving our understanding of the extent and condition of the region's natural values.
6. Supporting a strategic adaptive management approach through the Lake Eyre Basin Partnership, as documented in the Dept. Environment, Heritage & Aboriginal Affairs review (1999).

Part of the Malkumba-Coongie Wetland Wonders project is to undertake five biological surveys of the RAMSAR area. This survey formed the first of these five surveys and resulted in, among a number of other outcomes, a total of 5,205 invertebrate specimens being collected from 16 sites (Lynch 2019).

The RAMSAR site supports six nationally and/or internationally listed species of conservation significance. These are the wetland-dependent and nationally endangered birds, Australian Painted Snipe and Curlew Sandpiper, and potentially the Night Parrot, plus terrestrial mammals, Dusky Hopping-Mouse, Plains Mouse, Kowari, Crest-tailed Mulgara (Ampurta). It contains a number of different wetland types, land systems and vegetation communities that are characteristic of the bioregion (Lynch 2019).

A substantial number of migratory birds periodically use the Coongie Lakes wetlands, including 18 species listed under international migratory bird agreements and 17 listed as 'Threatened'. These birds eat a variety of invertebrates. The site also supports the substantial breeding of other water birds and 55 species have been recorded breeding at the site since listing. The area provides breeding habitat and drought refuge for many species of water birds and fish. As water from the upper Cooper Creek in Queensland irregularly reaches Coongie Lakes, they rarely dry out completely (DEHAA 1999).

## SURVEY

### Innamincka Regional Reserve

The Innamincka Regional Reserve was established in 1988 and is over 1,155 km NNE of Adelaide (NE corner of the state of South Australia). Its eastern border is the South Australia/Queensland border. The reserve covers 13,818 km$^2$ and is a 'multiple-use' reserve. Within the natural habitat, the use of petroleum extraction as well as pastoral production is allowed.

The National Parks and Wildlife Act of 1972 requires a report on each regional reserve at intervals of no more than 10 years. The report of 1998 showed that the Innamincka Regional Reserve had been protected while significant wealth had been generated for South Australia. This has provided a stimulus for improved environmental management that largely met the objective of ecological sustainable use of resources; thus justifying the original decision to establish the reserve and protect its continued existence (DEHAA 1999).

### Weather

The Innamincka Bureau of Meteorology Station (BOM) Innamincka SA (Number: 017028, Lat: 27.72°S, Long: 140.76°E, elevation 53m Above Sea Level (ASL), opened in 1882. The mean annual rainfall recorded between 1882 and 2018 was 179.5 mm. The last big rains above the annual mean were in 2010 with 732.8 mm, 2011 with 380 mm, and in 2015 with 185.4 mm. During the last two years before this survey, very low rainfalls were recorded: 2017 had 83 mm and in 2018 zero rain fell before the BOM station closed in May 2018.

Moomba Airport Bureau BOM Station, (BOM Number: 017123, Lat: 28.10°S, Long: 140.20°E, Elevation 38m ASL, opened in 1995. The annual rainfall for 2018 at Moomba was 91.8 mm, (113 km SW of Innamincka by road). The mean annual rainfall (over last 23 years) was 164.1 mm. The mean rainfall for April was 6.8 mm (range 0.0–33.6 mm) and the mean rainfall for May was 10.2 mm (range 0.0–56.6 mm, over 24 years). The highest mean rainfall comes in February 26.1 mm (range 0.0–239.6 mm), (BOM).

Prior to this survey in May 2019, water from the February rains in Queensland had already partially filled the Coongie Lakes. These lakes were dry when visited at the end of February 2019. Since February 2019 more rain had resulted in a major flood on the Cooper Floodplains in SA.

The mean maximum May temperature for the period 1995 - 2018 was 23.9° C and the highest mean May temperature was 26.4° C (BOM 2019).

## Survey Team

The biological survey reported here was undertaken by 8 DEW employees and 14 members of the Scientific Expedition Group (SEG) members; a volunteer not-for-profit group. The survey took place over the period 20th to 30th May 2019.

Innamincka is ca. 1,060 km NNE of Adelaide as accessed via Pt Augusta and the Strzelecki Track. Team 1, was led by Cat Lynch (DEW) with Dave Armstrong (fauna), Graham Armstrong and Julian Reid (birds), Justin Jay (vegetation) and Beth Reid (DEW Graduate Ranger). The SEG Team 1 lead by Trent Porter, with Rick Porter, Gary Trethewey, Naomi West, Brian Swan, Annette Vincent (Invertebrates) and Helen Johnson. Team 1 was based at Cullyamurra Waterhole (CUL), *ca.* 22 km NEE by road from Innamincka.

Team 2 was led by Rob Brandle (DEW) with Brian Blaylock and Jo Blaylock (birds), Rick Davies (vegetation). SEG Team 2 was led by Jill Tugwell, with Jarryd Holmes, Michael Bennell, Kevin Burrett, Rick Davies, and Andrew Barr. Team 2 was based at the Mudera Cootera Bore (MUD), 44 km SSE of Innamincka by road.

## METHODS

The two teams surveyed four main habitat types at the CUL an MUD site locations; dune, inter-dune swale, gibber plain and floodplain/swamp. Two lines of six macropits, 10 m apart, were set out at 16 sites. The micropits were set up approximately 2 m away from the macropits, thus two lines of six micropits per site (total of 12 micropits per site). Each micropit was labelled and three quarters filled with 95 % ethanol. They were checked everyday and topped up with 95 % ethanol when needed.

Macropits were checked by teams for vertebrates at dawn and sunset each day. The micropits were left open for four nights before being closed and brought back to Adelaide where the Formicidae (ants) were identified to genus, using Shattuck's '*Australian Ants*' (1999. The Collembola (springtails) numbered by description and the 'other invertebrates' were sorted by their common names by the author.

The eight sites that were surveyed by the Cullyamurra Waterhole based team were named CUL 01-08. The sites CUL 01, 05, 06, and 08 were put out 22 May and left open for four nights before being brought in on 26 May. The other sites CUL 02, 03, 04, and 07 were put in on 23 May and brought in on 27 May.

The eight sites surveyed by the Mudera Cootera Bore based team were named MUD 01-08 and all were put out on the 22 May and brought in on 27 May 2019.

Opportune invertebrates were collected during the survey and from the macropits at the end of the survey. All specimens were stored at the SA Museum Entomology Section.

## RESULTS

### Climate during survey

As the BOM site at Innamincka Airport was closed in May 2018, the weather data was taken from Moomba Airport. The average daily maximum temperature was 28.5° C (range 27.8–29.2° C) while the average minimum was 13.05° C (range 11.8–13.5° C).

Those sites put in a day later had an average daily maximum temperature of 26.8° C (range 22.1–28.7° C) while the average minimum was 12.6° C (range 11.8–13.5° C), (BOM 2019).

No rain fell during the survey period. The average annual rainfall over the last 8 years at Moomba Airport was 38.85 mm (range 7.5–105 mm). No rain fell in January and February 2019. With 13 mm in March and 0.2 mm in April. At the beginning of May a total of 6.2 mm fell on May 1 and 2. Thus 30 days prior to the survey 6.6 mm fell and 60 days prior to survey 19 mm had been recorded. For the 90 days prior to the survey, still only 19 mm recorded (BOM 2019). Note: at Innamincka, rain was recorded on 2 April 2019, 26 mm, and on 22 April 2019, 11 mm (C. Lynch, pers. comm.).

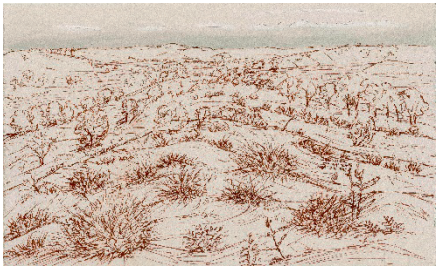
## Vegetation

The Cooper Creek and Coongie Lakes wetland system are recognised for their high biodiversity and natural features. The 16 sites surveyed covered the four main habitat types in the area: dune, inter-dune swale, gibber plain and floodplain/swamp (Lynch 2019).

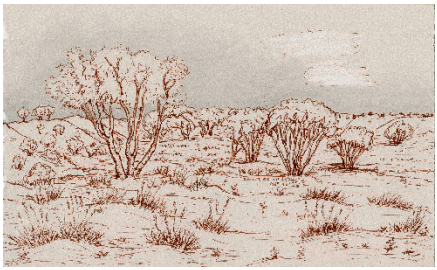
**Table 1:** Site name, GPS Location, landform and vegetation.

| Site | Location | Landform & Vegetation |
|---|---|---|
| **Cullyamurra Waterhole, Innamincka Regional Reserve (CUL)** | | |
| **CUL01 Base Camp** | Lat. 27° 41' 45.2"S Long. 140° 59' 46.0"E | Flood Plain |
| **CUL01-01** | Lat. 27° 41' 15.2"S Long. 140° 59' 43.4"E | Clay flood plain, Coolibah trees |
| **CUL01-02** | Lat. 27° 50' 57.0"S Long. 140° 50' 59.0"E | Sand dune, Spinifex, sparse herbaceous cover |
| **CUL01-03** | Lat. 27° 47’ 50.0"S Long.140° 52' 13.0"E | Sand dune, Spinifex, sparse herbaceous cover |
| **CUL01-04** | Lat. 27° 50' 42.0"S Long. 140° 50' 06.2"E | Sandy, edge of swale, White wood and grasses |
| **CUL01-05** | Lat. 27° 45' 12.6"S Long. 140° 46' 28.0"E | Over sandhill, Cane grass and Spinifex |
| **CUL01-06** | Lat. 27° 44' 53.1"S Long. 140° 46' 41.0"E | Gibber plain, ephemeral herbs and grasses |
| **CUL01-07** | Lat. 27° 50' 56.0"S Long. 140° 51' 21.0"E | Clay flood plain, Coolibah trees |
| **CUL01-08** | Lat. 27° 45' 08.8"S Long. 140° 46' 18.0"E | Gibber plain |
| **Mudera Cootera Bore, Innamincka Regional Reserve (MUD)** | | |
| **MUD01-01** | Lat. 27° 41' 8.96''S Long. 140° 59' 46.7"E | Dune, sandhill, Cane Grass, hummock grassland |
| **MUD01-02** | Lat. 27° 49' 50.5"S Long. 140° 51' 2.46"E | Sand plain, Senna shrubland |
| **MUD01-03** | Lat. 27° 47' 55.3"S Long. 140° 52' 10.8"E | Swamp, Old Man Saltbush shrubland |
| **MUD01-04** | Lat. 27° 50' 42.3"S Long. 140° 50' 40.6''E | Dune slope, *Triodia* |
| **MUD01-05** | Lat. 27° 46' 10.3"S Long. 140° 53' 58.3"E | Swamp, herb/grassland |
| **MUD01-06** | Lat. 27° 44' 53.5''S Long. 140° 46' 40.7''E | Creek channel/flood plain, Coolibah open woodland |
| **MUD01-07** | Lat. 27° 45' 17.5''S Long. 140° 53' 50.3''E | Dune, sandhill, Cane Ggrass, hummock grassland |
| **MUD01-08** | Lat. 27° 44' 37.3''S Long. 140° 52' 24.0''E | Creek channel/flood plain, Coolibah open woodland |

**CUL 01**

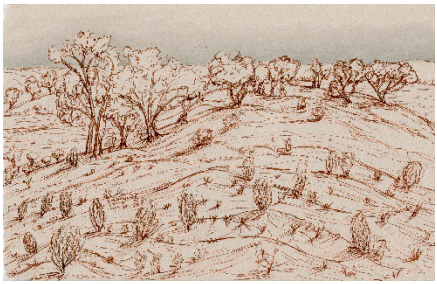


**CUL 02**

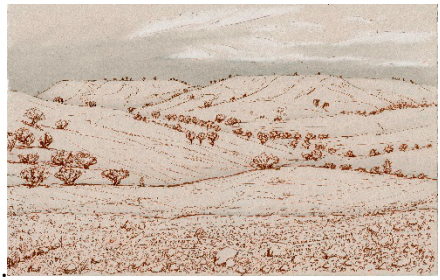


**CUL 03**

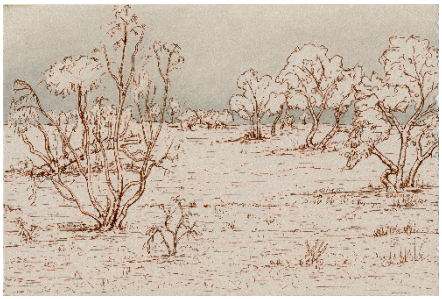
**CUL 04**



**CUL 05**



**CUL 06**



**CUL 07**

**CUL 08**

**Figure 1:** Cullyamurra Waterhole sites; pen & ink drawings by Annette Vincent.

## Invertebrate Abundance (Micropits and Opportune)

A total of 5,373 invertebrate specimens were collected (micropits and opportune) from the 16 sites during the survey, an average of 336 per site (range of 154–706) per site (Tables 2 and 6). Two micropits were not counted, one micropit was empty and the other micropit was too near a nest and contained over 4,400 small *Iridomyrmex* ants.

A total of 833 specimens were gathered during the opportune collecting (Table 2).

The greatest abundances of invertebrates came from the micropits and opportune sites of the Cullyamurra area. At CUL 03, a site of sand dunes, spinifex with a sparse herbaceous cover, a total of 706 specimens were collected; 22% of invertebrates captured from all the CUL sites. Next in abundance was CUL 07, a site of clay flood plain with Coolibah trees; 510 specimens, 16% of specimens collected from Cullyamurra sites. The other Cullyamurra sites ranged from 215–418 specimens (6.7% to 13% of total).

The most abundant site from the Mudera sites was MUD 02 a sand plain, Senna shrubland, with 349 specimens collected forming 16% of the total collected from Mudera sites. The next most abundant was MUD 05, a swamp and herb grassland site, where 310 specimens were collected; 14% of Mudera site specimens. Other Mudera sites ranged from 154–307 specimens (7%–14% of total).

In total 2,255 specimens were collected from the six dune sites, with an average of 376 per site. Specimens collected from the two edges of swale sites totalled 744 with an average of 372 per site. The specimens collected from the two Gibber plain sites totalled 622 with an average of 311 per site. The six flood plain/swamp sites totalled 1,752 specimens with an average of 292 per site (Tables 1, 2, 3 and 4).

**Table 2:** Summary of Invertebrates collected during the Survey (Micropits and Opportune).

| **MICROPITS** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CUL Sites** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **Sites** |
| **Formicidae** | 72 | 86 | 349 | 125 | 177 | 60 | 338 | 131 | **1338** | **52.5** | **8** |
| **Collembola** | 3 | 32 | 18 | 11 | 19 | 46 | 17 | 33 | **179** | **7.0** | **8** |
| **Other Inverts** | 105 | 116 | 158 | 155 | 124 | 160 | 109 | 108 | **1035** | **40.6** | **8** |
| **Total/site** | **180** | **234** | **525** | **291** | **320** | **266** | **464** | **272** | **2,552** | | |
| **MICROPITS** | | | | | | | | | | | |
| **MUD Sites** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **Sites** |
| **Formicidae** | 173 | 148 | 43 | 113 | 132 | 56 | 122 | 195 | **982** | **50.1** | **8** |
| **Collembola** | 11 | 9 | 103 | 10 | 60 | 2 | 32 | 7 | **234** | **11.9** | **8** |
| **Other Inverts** | 67 | 183 | 86 | 65 | 103 | 84 | 87 | 97 | **772** | **39.4** | **8** |
| **Total/site** | **251** | **340** | **232** | **188** | **295** | **142** | **241** | **299** | **1,988** | | |
| **OPPORTUNE** | | | | | | | | | | | |
| **Sites** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **Sites** |
| **CUL** | 35 | 88 | 181 | 104 | 98 | 60 | 46 | 24 | **636** | **76.4** | **8** |
| **MUD** | 56 | 9 | 29 | 34 | 15 | 12 | 39 | 3 | **197** | **23.6** | **8** |
| **Total no.** | | | | | | | | | **833** | | |

**Invertebrate abundance in Micropits**

The total number of invertebrates from the micropits from 16 sites was 4,540 with an average of 284 specimens/site (range 142–525). The greatest abundance of invertebrates was found at the CUL 03 (525), a sandy edge of a swale site with ephemeral herbs. The second most abundant was CUL 07 (464) a clay flood plain with Coolibah trees. This site was very close to the highway and clouds of dust were sent over the survey site from the frequently passing road trains, (about every ten minutes). The third most abundant was MUD 02 (340) a sand plain of *Senna* shrub land, followed by CUL 05 (320) that was over a sand hill with cane grass and spinifex. The other site, CUL 04 (291), was on the edge of a swale that had whitewood and grasses. The site MUD 08 had (299), a creek channel, flood plain with Coolibah and open woodland and MUD 05 had (295), a swamp with herbs and grassland.

The *abundance* of the two Gibber plain sites, CUL 08 (272) and CUL 06 (266) are either side of the mean (269) of the 16 sites. Two of the sand dunes sites, MUD 01 (251) and MUD 07 (241), were both cane grass hummock grasslands. Three more sand dune sites CUL 02 (234), CUL 03 (525) and MUD 04 (188) all had spinifex, and the former two had a sparse herbaceous cover. The last sand dune site CUL 05 (320) had cane grass and spinifex (**Tables 1 and 2**).

The swamp site MUD 03 (232) had old-man saltbush and shrubland and the other swamp site MUD 05 (295) was swamp and herb grassland. The flood plain site CUL 01 (180) had young Coolibah trees. The lowest abundance of this survey was MUD 06 (142) a creek channel and floodplain of open woodland Coolibah trees.

When grouping the four main vegetation types together: (Tables 1 and 2).

1. The six dune sites totalled 1,759 (average/site 293).
2. The two edge of swale and sand plain sites totalled 631 (average/site 315).
3. The two Gibber plain sites totalled 538 (average/site 269).
4. The six clay floodplain/swamp sites totalled 1,612 (average/site 269).

**Formicidae Family (ants) Abundance and Richness (micropits)** (**Table**s **3 & 4**)

The Formicidae (ants) totalled 2,320 (51.1% of invertebrates captured in micropits).

- The six dune sites totalled 1,020 specimens (43.9%).
- The two inter-dune swale sites 273 (11.8%), the two Gibber plain sites 191 (8.2%).
- The six creek channel/flood plain/swamp sites totalled 836 specimens (36%).

Total *richness* of the survey for Formicidae was 13 genera. Cullyamurra Waterhole area had a total of 11 genera represented, (range 4–9 per site). Two specimens of *Leptogenys* were found, one each at CUL 03 (sand dune, spinifex, with a sparse herbaceous cover) and MUD 05 (swamp, and herb cover). Only one specimen of *Odontomachus* was found at the Gibber plain site CUL 08. These two genera were also found on the Arkaroola survey (Vincent 2011).

Mudera Cootera Bore had a total of 12 genera represented from the eight sites (range 4–9 per site). Two genera *Solenopsis* and *Tapinoma,* (both very small specimens), were found at two sites, MUD 08, a creek channel/flood plain and MUD 04, a dune slope with *Triodia*. These genera were not collected at any of the CUL sites.

**Table 3:** Invertebrates collected in Micropits at Cullyamurra Waterhole (CUL) sites.

| MICROPITS | CUL Sites | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Formicidae Genera** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **No. Sites** |
| ***Camponotus*** | 8 | 3 | 2 | | 1 | | | 3 | **17** | **1.3** | **5** |
| ***Doleromyrma*** | | 15 | 11 | 2 | 21 | | | | **49** | **3.7** | **4** |
| ***Iridomyrmex*** | 13 | 16 | 195 | 31 | 33 | 5 | 299 | 30 | **622** | **46.5** | **8** |
| ***Leptogenys*** | | | 1 | | | | | | **1** | **0.1** | **1** |
| ***Melophorus*** | 13 | 12 | 7 | 11 | 20 | | | 4 | **67** | **5** | **6** |
| ***Meranoplus*** | | | | | 2 | | | | **2** | **0.1** | **1** |
| ***Monomorium*** | | 28 | 12 | 53 | 34 | 14 | 3 | | **142** | **10.6** | **6** |
| ***Odontomachus*** | | | | | | | | 1 | **1** | **0.1** | **1** |
| ***Pheidole*** | 38 | 7 | 119 | 27 | 62 | 40 | 32 | 90 | **415** | **31** | **8** |
| ***Rhytidoponera*** | | | 2 | 1 | 1 | | 3 | 2 | **9** | **0.7** | **5** |
| ***Tetramorium*** | | 7 | | | 3 | 1 | 1 | 1 | **13** | **1** | **5** |
| **Total no.** | **72** | **86** | **349** | **125** | **177** | **60** | **338** | **131** | **1,338** | | **8** |
| **No. Genera** | **4** | **7** | **8** | **6** | **9** | **4** | **5** | **7** | **11** | | |

| **Collembola** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | | **No. Sites** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total no.** | **3** | **32** | **18** | **11** | **19** | **46** | **17** | **33** | **179** | | **8** |
| **No. Taxa** | **2** | **7** | **4** | **1** | **2** | **4** | **4** | **3** | **9** | | |

| **Other Inverts Common Name** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **No. Sites** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ant Lion** | | | | | | 1 | | | **1** | **0.1** | **1** |
| **Beetle** | 1 | 1 | 1 | 5 | 3 | 11 | 3 | 2 | **27** | **2.6** | **8** |
| **Bug** | 87 | 43 | 43 | 54 | 59 | 87 | 61 | 91 | **525** | **50.8** | **8** |
| **Caterpillar** | | 2 | | 1 | | | | | **3** | **0.3** | **2** |
| **Cockroach** | | | | | | 1 | | | **1** | **0.1** | **1** |
| **Cocoon** | | 1 | 7 | 4 | | | | | **12** | **1.2** | **3** |
| **Fly** | 8 | 16 | 30 | 22 | 11 | 22 | 19 | 7 | **135** | **13.1** | **8** |
| **Grasshopper** | | | 1 | | | 1 | | | **2** | **0.2** | **2** |
| **Mite** | 1 | 41 | 58 | 54 | 40 | 16 | 15 | 1 | **226** | **21.9** | **8** |
| **Moth** | | | 2 | 1 | | | | | **3** | **0.3** | **2** |
| **Pseudoscorpion** | 1 | | | 1 | | | | | **2** | **0.2** | **2** |
| **Robber Fly** | | 2 | 1 | | | | | | **3** | **0.3** | **2** |
| **Silverfish** | | 1 | 1 | 2 | | 9 | 4 | 3 | **20** | **1.9** | **6** |
| **Spider** | 6 | 4 | 4 | 3 | 2 | 2 | 3 | 2 | **26** | **2.5** | **8** |
| **Stick Insect** | | | 1 | | | | | | **1** | **0.1** | **1** |
| **Termite** | | 2 | 3 | 3 | 7 | 1 | 2 | 1 | **19** | **1.8** | **7** |
| **Thrip** | | 1 | 2 | | | | | | **3** | **0.3** | **2** |
| **Wasp** | 1 | 2 | 4 | 5 | 2 | 9 | 2 | 1 | **26** | **2.5** | **8** |
| **Total no.** | **105** | **116** | **158** | **155** | **124** | **160** | **109** | **108** | **1,035** | | **8** |
| **No. Taxa** | **7** | **12** | **14** | **12** | **7** | **10** | **8** | **8** | **17** | | |

**Table 4:** Invertebrates collected in Micropits at Mudera Cootera Bore (MUD) Sites.

| MICROPITS | MUD Sites | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Formicidae Genera** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **No. Sites** |
| ***Camponotus*** | 1 | | | | | | | | **1** | **0.1** | **1** |
| ***Doleromyrma*** | 6 | 6 | | 11 | | | 2 | | **25** | **2.5** | **4** |
| ***Iridomyrmex*** | 51 | 25 | 29 | 56 | 37 | 3 | 75 | 188 | **464** | **47.3** | **8** |
| ***Leptogenys*** | | | | | 1 | | | | **1** | **0.1** | **1** |
| ***Melophorus*** | 17 | 29 | 8 | 2 | 11 | 7 | 14 | 2 | **90** | **9.2** | **8** |
| ***Meranoplus*** | 1 | | | 1 | | | 4 | | **6** | **0.6** | **3** |
| ***Monomorium*** | 81 | 69 | | 7 | 44 | 22 | 3 | 1 | **227** | **23.1** | **7** |
| ***Pheidole*** | 3 | 8 | 6 | 24 | 38 | 23 | 16 | | **118** | **12** | **7** |
| ***Rhytidoponera*** | 4 | 11 | | 2 | | 1 | 3 | | **21** | **2.1** | **5** |
| ***Solenopsis*** | | | | | | | | 2 | **2** | **0.2** | **1** |
| ***Tapinoma*** | | | | 10 | | | | | **10** | **1** | **1** |
| ***Tetramorium*** | 9 | | | | 1 | | 5 | 2 | **17** | **1.7** | **4** |
| **Total No.** | **173** | **148** | **43** | **113** | **132** | **56** | **122** | **195** | **982** | | **8** |
| **No. Genera** | **9** | **6** | **3** | **8** | **6** | **5** | **8** | **5** | **12** | | |

| **Collembola** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | | **No. Sites** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total No.** | **11** | **9** | **103** | **10** | **60** | **2** | **32** | **7** | **234** | | 8 |
| **No. Taxa** | **3** | **3** | **5** | **5** | **3** | **2** | **1** | **3** | **8** | | |

| **Other Inverts Common Name** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **No. Sites** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Beetles** | | 3 | 1 | 1 | 11 | 6 | 6 | 3 | **31** | **4.2** | **7** |
| **Bug** | 34 | 69 | 32 | 28 | 48 | 31 | 39 | 46 | **327** | **44** | **8** |
| **Caterpillar** | 1 | | | | | | | 1 | **2** | **0.3** | **2** |
| **Centipede** | | | | | | | | 1 | **1** | **0.1** | **1** |
| **Cocoon** | | | | | 5 | | | 3 | **8** | **1.1** | **2** |
| **Earwig** | | | | | 1 | | | | **1** | **0.1** | **1** |
| **Fly** | 2 | 21 | 14 | 7 | 8 | 9 | | 16 | **77** | **10.3** | **7** |
| **Grasshopper** | | | | | 1 | | | 1 | **2** | **0.3** | **2** |
| **Mite** | 22 | 76 | 25 | 21 | 16 | 35 | 29 | 20 | **244** | **32.8** | **8** |
| **Moth** | 1 | 1 | | | | | | | **2** | **0.3** | **2** |
| **Robber Fly** | | | | 1 | | | | | **1** | **0.1** | **1** |
| **Scorpion** | | | | 1 | | | | | **1** | **0.1** | **1** |
| **Silverfish** | 1 | | 1 | | 1 | | | | **3** | **0.4** | **3** |
| **Spider** | 5 | 3 | 2 | 1 | 3 | 1 | 1 | 3 | **19** | **2.6** | **8** |
| **Stick Insect** | | | | | | | | 1 | **1** | **0.1** | **1** |
| **Termite** | | 4 | 1 | | | | 2 | 2 | **9** | **1.2** | **4** |
| **Thrip** | | 1 | | 3 | | | | | **4** | **0.5** | **2** |
| **Wasp** | 1 | 5 | 10 | 2 | 9 | 2 | 10 | | **39** | **5.2** | **7** |
| **Total No.** | **67** | **183** | **86** | **65** | **103** | **84** | **87** | **97** | **772** | | **8** |
| **No. Taxa** | **8** | **9** | **8** | **9** | **10** | **6** | **6** | **11** | **18** | | |

The most species/taxa rich Cullyamurra site was nine at CUL 05. This site ran over a sand hill with cane grass and spinifex present. The highest *richness* in the Mudera sites was nine at MUD 01, a dune sandhill, with cane grass and hummock grassland (**Tables 3 & 4**).

The least rich site was MUD 03 with three genera present. This was a swamp with old-man saltbush and shrubland. Here *Iridomyrmex* formed (67%) of the total Formicidae present at this site. Two sites CUL 01 and CUL 06 only had four genera present, *Pheidole* dominated at both sites, CUL 01 (53%) and CUL 06 (67%) respectively (Tables 3 and 4).

**Arthropoda Sub-class Collembola (Springtails) Abundance and Richness**

Collembola specimens totalled 413 (9.1% of total specimens captured in micropits from all the 16 sites) with 9 descriptions.

- The six dune sites totalled 122 (29.5% of total Collembola captured).
- The two, edge of swale/inter-dune sites 20 (4.8%).
- The two Gibber plain sites 79 (19.1%), and the six creek channel/flood plain and swamp sites totalled 192 (46.5%), (**Tables 2, 3 & 4**).

**Other Invertebrates (Common Name) Abundance and Richness**

The 'other Invertebrates' totalled 1,807 specimens (39.8% of total specimens captured in micropits) with 20 common names/taxa represented.

- The six dune sites totalled 617 specimens (34.1%),
- The two inter-dune sites totalled 338 (18.7%).
- The two Gibber plain sites totalled 268 (14.8%).
- The six creek channel/flood plain and swamp sites totalled 584 specimens (32.3%), (**Tables 2, 3 & 4**).

The total diversity for 'other invertebrates' was 20 common names/taxa from the 16 sites. The highest was CUL 03 with 14, the sandy edge of swale with ephemeral herbs. In the Cullyamurra sites the richness ranged from 7–14 and in the Mudera sites ranged 6–11.

Bugs, mites and spiders were collected from all 16 sites. Beetles, flies, and wasps were collected from 15 sites. Termites were found at 11 sites and silverfish at 9 sites. There were only three common names/taxa, i.e., bugs, flies, and spiders, that occurred with more than one specimen at all eight sites at CUL. At the MUD sites, the bugs and mites had more than one specimen at all eight sites. Some 23 other invertebrate places had only one specimen of a specific common name at CUL sites and 21 places at MUD sites.

During the survey only one specimen of ant lion, cockroach, and stick insect, were found at the CUL sites. While only one specimen each of centipede, earwig, grasshopper, robber fly, scorpion, and stick insect were found at MUD sites (Tables 3 and 4).

**Opportune collecting**

After sorting and counting the opportune specimens, there were a large number of beetles, including some amazing looking weevils, (Vincent 2019) that had been collected from the bottom of the macropits at the end of the survey. An overall total of 833 opportune specimens were collected from 16 sites. Formicidae specimens numbered 256 (30.7%) of the total specimens collected by opportune methods. Other invertebrates numbered 577 (69.3%) of the total opportune specimens collected (**Tables 5 & 6**).

The total opportune collected at CUL sites was 636 with Formicidae 211 (33%) and other invertebrate 425 (67%) of the specimens collected (**Table 5**).

The total opportune collected at MUD sites was 197 with Formicidae 45 (23%) and other invertebrate 152 (77%) specimens collected (**Table 6**).

**Table 5:** Opportune collections at Cullyamurra Waterhole (CUL) sites.

| OPPORTUNE | CUL Sites | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Formicidae Genera** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **No. Sites** |
| ***Camponotus*** | 14 | 10 | 4 | 23 | | 2 | | 6 | **59** | **9.28** | **6** |
| ***Iridomyrmex*** | 1 | | 96 | | 33 | | | | **130** | **20.44** | **3** |
| ***Leptogenys*** | | | 1 | | | | | | **1** | **0.16** | **1** |
| ***Melophorus*** | | | | 1 | | | | | **1** | **0.16** | **1** |
| ***Monomorium*** | | 1 | | | | | | | **1** | **0.16** | **1** |
| ***Odontomachus*** | | | | | | | | 2 | **2** | **0.31** | **1** |
| ***Pheidole*** | | | | | | 1 | 2 | | **3** | **0.47** | **2** |
| ***Rhytidoponera*** | | 1 | 4 | 2 | | | 5 | 2 | **14** | **2.2** | **5** |
| **Total No.** | **15** | **12** | **105** | **26** | **33** | **3** | **7** | **10** | **211** | | |
| **No. Genera** | **2** | **3** | **4** | **3** | **1** | **2** | **2** | **3** | **8** | | |

| **Other Invertebrates Common Name** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **No. Sites** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Beetle** | | 55 | 53 | 52 | 47 | 17 | 19 | 6 | **249** | **58.59** | **7** |
| **Bug** | | | 3 | 8 | 2 | 11 | 3 | 3 | **30** | **7.06** | **6** |
| **Caterpillar** | | | 3 | | | | | | **3** | **0.71** | **1** |
| **Centipede** | | | | | | 1 | | | **1** | **0.24** | **1** |
| **Cockroach** | | | | | | 1 | 1 | | **2** | **0.47** | **2** |
| **Earwig** | | | | | | 9 | | | **9** | **2.12** | **1** |
| **Fly** | | | | | | 4 | | | **4** | **0.94** | **1** |
| **Grasshopper** | | | 1 | 2 | 3 | | 1 | 1 | **8** | **1.88** | **5** |
| **Insect?** | | | | | 1 | | | | **1** | **0.24** | **1** |
| **Mite** | | 1 | 4 | 9 | 2 | | | | **16** | **3.76** | **4** |
| **Moth** | | 4 | 1 | | | | | | **5** | **1.18** | **2** |
| **Scorpion** | | | | | 1 | | | | **1** | **0.24** | **1** |
| **Spider** | 20 | 12 | 8 | 5 | 9 | 10 | 13 | 3 | **80** | **18.82** | **8** |
| **Wasp** | | 4 | 3 | 2 | | 4 | 2 | 1 | **16** | **3.76** | **6** |
| **Total No.** | **20** | **76** | **76** | **78** | **65** | **57** | **39** | **14** | **425** | | |
| **Common Name/Taxa** | **1** | **5** | **8** | **6** | **7** | **8** | **6** | **5** | **14** | | |

**Cullyamurra Waterhole (CUL) Sites**

Opportune Formicidae specimens were collected at all 8 CUL sites. The genus *Iridomyrmex* formed 20.4% of Formicidae and occurred at three CUL sites. With the next highest abundance of 9.3%, *Camponotus* occurred at six sites and the solitary *Rhytidoponera* 2.2% occurred at five sites.

The opportune collecting was dominated by the presence of beetles; 58.6% of total other

invertebrates at CUL sites. Beetles occurred at seven sites, only CUL 01, the clay flood plain with Coolibah trees site, had no opportune beetles. Spiders 18.8% occurred at all sites with the greatest number at CUL 01 (a flood plain site), with 20 specimens; prompting the question, "*Do spiders eat the beetles?*". Bugs 7% and wasps 3.8% occurred at 6 sites. Grasshoppers 2% occurred at five sites and mites 3.8% occurred at four CUL sites (**Table 5**).

**Mudera Cootera Bore (MUD) Sites**

Opportune Formicidae specimens were collected from five MUD sites, with 80% being *Iridomyrmex* from four sites and *Rhytidoponera* collected from two sites. No opportune Formicidae specimens were collected from MUD 02, MUD 05 and MUD 07.

Opportune beetle specimens were collected from all eight MUD sites; 51.5%. The greatest abundance of beetles was at MUD 01 (27), MUD 04 (20) and MUD 07 (29); all dune sites. Opportune collecting of spiders 21 (13.8%) was from six MUD sites (**Table 6**).

**Table 6:** Opportune collections at Mudera Cootera Bore (MUD) Sites.

| **OPPORTUNE** | **MUD Sites** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Formicidae Genera** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **No. Sites** |
| ***Iridomyrmex*** | 20 | | 5 | 7 | | 4 | | | **36** | **80** | **4** |
| ***Melophorus*** | 2 | | | | | | | | **2** | **4.44** | **1** |
| ***Monomorium*** | | | 2 | 2 | | | | | **4** | **8.89** | **2** |
| ***Nylanderia*** | | | | | | | | 1 | **1** | **2.22** | **1** |
| ***Rhytidoponera*** | | | | 1 | | 1 | | | **2** | **4.44** | **2** |
| **Total No.** | **22** | | **7** | **10** | | **5** | | **1** | **45** | | 5 |
| **No. Genera** | **2** | | **2** | **3** | | **2** | | **1** | **5** | | |

| **Other Invertebrates Common name** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** | **%** | **No. Sites** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Beetle** | 27 | 4 | 8 | 20 | 12 | 5 | 29 | 2 | **107** | **51.52** | **8** |
| **Bug** | | | | 1 | | | | | **1** | **0.76** | **1** |
| **Caterpillar** | | 2 | | 1 | | | 4 | | **7** | **3.79** | **3** |
| **Centipede** | 1 | | 1 | | | | 1 | | **3** | **0.76** | **3** |
| **Cockroach** | | | 3 | | | | | | **3** | | **1** |
| **Fly** | | | | | | | 1 | | **1** | **0.76** | **1** |
| **Grasshopper** | | | | | | | 1 | | **1** | **0.76** | **1** |
| **Insect?** | 1 | | | | | | | | **1** | | **1** |
| **Mite** | | | | 1 | | | | | **1** | **0.76** | **1** |
| **Moth** | | | 1 | | | 1 | | | **2** | **0.76** | **2** |
| **Scorpion** | 1 | 1 | | | | | | | **2** | | **2** |
| **Spider** | 4 | 2 | 9 | | 3 | 1 | 2 | | **21** | **4.55** | **6** |
| **Thrip** | | | | 1 | | | | | **1** | **0.76** | **1** |
| **Wasp** | | | | | | | 1 | | **1** | **0.76** | **1** |
| **Total No.** | **34** | **9** | **22** | **24** | **15** | **7** | **39** | **2** | **152** | | |
| **Common Name/Taxa** | **5** | **4** | **5** | **5** | **2** | **3** | **7** | **1** | **14** | | |

## DISCUSSION

During this survey the total number of vertebrate animals trapped, caught, or sighted was 184 (excluding invertebrates). This number included only one species of amphibian (total 48 specimens), 16 specimens found at CUL sites and 32 specimens at MUD sites.

Mammals were represented by 14 species, with eight species found at CUL sites, 12 species at MUD sites and opportune sightings three species. Total number of mammals, 49 specimens captured (or sighted), 22 were found at CUL and 23 at MUD sites, with four opportune (Lynch 2019).

Reptiles were represented by 25 species, with 16 species at CUL and 18 at MUD sites, with four species opportune. The total number of reptiles captured was 87, with 33 from CUL sites and 43 from MUD sites and 11 opportune (Lynch 2019).

The vegetation type, the amount of water from recent rains and the aspect of the sites had determined the abundance of invertebrates. Many reptiles, frogs and carnivorous mammals eat invertebrates. Without following the abundance of the invertebrates and learning just what they eat, it is assumed that many reptile, frog and mammal species would not survive if food was not available in the form of invertebrates.

Many factors could have influenced the results in the CUL and MUD sites. For example, did the CUL sites receive slightly more rain than the MUD sites or were more trees in flower at the CUL sites? Or is it just that the MUD sites are further from the source of water and the flooding of the Cooper Creek?

It is important to note that the CUL sites are all within 12 km of the Cooper Creek, whereas the MUD sites are 20 to 30 km south, away from the Cooper Creek.

The largest abundance of invertebrates was Formicidae*:* CUL (52.5%) and MUD (50.1%), (Table 2). The high abundance of *Iridomyrmex* and *Pheidole* at CUL sites (46.5% and 31% respectively) while MUD had (47.3% and 12% respectively). The *Melophorus* and *Monomorium* were more abundant at MUD (9.2% and 23.1% respectively) than CUL (5% and 10.6% respectively). *Melophorus* and *Monomorium* are heat loving and it is possible that they benefitted from MUD sites having a warmer aspect than CUL sites, (see Tables 3 and 4).

The CUL sites had a larger abundance of bugs (50.8%), flies (13.1%) and spiders (2.5%) whereas at the MUD sites, bugs were (44%), flies (10.3%) and spiders (2.6%). The abundance at MUD sites of mites (32.8%) and wasps (5.2%) was greater than CUL sites: mites (21.9%) and wasps (2.5%). The overall richness of Formicidae*,* Collembola and 'other invertebrates' at the CUL and MUD sites was very close, (Table 3 and 4).

The order of abundance of the sites shows the importance of vegetation. The greatest abundance from the micropits was at site CUL 03, a sand dune and spinifex site. A large number of *Iridomyrmex*, *Pheidole,* flies and mites were collected here and this site had the greatest abundance among the opportune collecting sites. CUL 03 also had the highest richness of all the CUL 'other invertebrates' (with 14 taxa), as well as the highest diversity of Formicidae with 8 genera, (Table 3).

Second in abundance of invertebrates was site CUL 07, a clay/flood plain with Coolibah trees. This site had the largest number of *Iridomyrmex*, with a Formicidae richness of five and 'other invertebrates' richness of eight, (Table 3).

The total abundance drops considerably to MUD 02, a sandy plain with Senna shrubland. This site, (of the MUD sites) had the highest abundance of invertebrates (340), and the highest abundance of bugs (69) and mites (76). It is possible the bugs and mites were feeding on the Senna flowers present. The richness of Formicidae at MUD 02 was six and the richness of 'other invertebrates' was nine, (Table 4).

The MUD 06 site, a floodplain of Coolibah open woodland, had the lowest abundance of invertebrates (142) of all of the 16 sites. The CUL 01 (180) was the second to lowest in abundance, also a clay flood plain of Coolibah trees. The richness of Formicidae and 'other invertebrates' at MUD 06 and CUL 01 are close, (Tables 3 and 4). It is possible that flooding from Cooper Creek waters may be needed to stimulate growth and food supply on these floodplains before a higher abundance and richness of invertebrates can develop.

In contrast, two sand dune and spinifex sites are very different in Formicidae abundance. CUL 03 (349) has four times the abundance of CUL 02 (86), noting that CUL 03 had very large numbers of *Iridomyrmex* and *Pheidole,* both aggressive dominant genera. Yet the richness of Formicidae and 'other invertebrates' are close, (Table 3).

The two sites CUL 01 and CUL 07 both clay, floodplain, with Coolibah trees. CUL 01 has only 39% of the total abundance of CUL 07. Yet the richness of Formicidae*,* and 'other invertebrates' is close, (Table 3). The only obvious difference was that CUL 07 was near the gravel highway and during the survey time, clouds of dust from the passing road trains, settled over the site about every ten minutes. It is not possible to ascertain how, if at all the dust influenced the results.

It is interesting to note that the two Gibber plain sites CUL 06 (266) and CUL 08 (272) were very close in total abundance of invertebrates. These two sites were on either side of the average abundance (269) per site. The Formicidae abundance in the CUL 06 was 46% less than CUL 08. Whereas, the abundance of 'other invertebrates' is reversed, CUL 06 has 67% more than CUL 08.

The dune, sand hill, cane grass, and hummock grassland sites MUD 01 and MUD 07 had similar total abundance. However CUL 05 was situated over a sand hill of cane grass and had spinifex present, and had approximately 30% more total abundance. The protection from predators that spinifex offers may have played a role in the increased abundance of 'Other Invertebrates'. The Formicidae richness for the three sites was very close. The other invertebrate richness ranged from 6–8, (Tables 3 and 4).

In the micropits, the aggressive *Iridomyrmex* genus totalled 46.8 % of the total Formicidae, occurring at all 16 sites. *Pheidole* totalled 23 % at 15 sites. *Melophorus* totalled 6.8 % at 14 sites. *Monomorium* totalled 15.9 % at 13 sites and *Rhytidoponera* 1.3 % at 10 sites. Of the other invertebrates the bugs totalled 47.2 %, mites 26 % and spiders 2.5 % occurred at all 16 sites. Beetles 3.2 %, flies 11.3 % and wasps 3.6 % occurred at 15 sites, (Tables 3 and 4).

Collembola (springtails) were found at all 16 sites with an average abundance per site of 26 (range 2–103), 43.3 % found at CUL sites and 56.7 % found at MUD sites, (Table 3 and 4). Collembola multiply profusely in pools after rain and many invertebrates eat them.

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