Article

Two New Phoretic Species of Heterostigmatic Mites (Acari: Prostigmata: Neopygmephoridae and Scutacaridae) on Australian Hydrophilid Beetles (Coleoptera: Hydrophilidae) †

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Simple Summary: Heterostigmatic mites are globally very diverse, and many are generally phoretic or parasitic on insects. However, the Australian fauna of phoretic heterostigmatic mites is almost unexplored. Here, we describe two new species of Allopygmephorus and Archidispus (Acari: Prostigmata: Heterostigmata) found phoretic on semiaquatic beetles. Our findings report both genera for the first time from Australia.

Abstract: Many heterostigmatic mites (Acari: Prostigmata: Heterostigmata) display a wide range of symbiotic interactions, from phoresy to parasitism, with a variety of insects. Australia is expected to harbour a rich diversity of heterostigmatic mites; however, its phoretic fauna and its host associations remain mainly unexplored. We conducted a short exploration of Australian insect-associated phoretic mites in summer 2020 and found two new phoretic heterostigmatic species on a semiaquatic hydrophilid beetle species, Coelostoma fabricii (Montrouzier, 1860) (Coleoptera: Hydrophilidae). Here, we describe these two new species, Allopygmephorus coelostomus sp. nov. (Neopygmephoridae) and Archidispus hydrophilus sp. nov. (Scutacaridae), which both belong to the superfamily Pygmephoroidea. Both species are distinct from their congeners, with a plesiomorphic character, bearing a median genital sclerite (mgs). Our study reports both genera for the first time from Australia.

Keywords: systematics; Australia; symbiosis; mites; aquatic insects

1. Introduction

Heterostigmatic mites (Acariformes: Prostigmata) are morphologically diverse, and numerous species are associated with a variety of insects [1,2]. Their associations with insects vary from facultative or obligate phoresy to parasitism [1]. Many species are free-living, and sometimes hitchhike on insects to new environments, or reside in nests of social insects [2]. Some of them are highly host-specific and they sometimes exhibit special attachment site preferences on the hosts’ body, such as beneath the abdomen or thorax, between leg coxae, on cervix or wings, or under elytral spaces [3–5]. Females in phoretic species have generally evolved several morphological adaptations, such as a robust pair of legs I with consolidated tibiotarsi I associated with enlarged claws, which help them to firmly attach to their hosts during phoretic dispersal [1,6].

The superfamily Pygmephoroidea is one of the most diverse groups of Heterostigmata, with more than 1200 species within four families, Microdispidae Cross, 1965, Neopygmephoridae Cross, 1965, Pygmephoridae Cross, 1965, and Scutacaridae Oudemans,
Mites of this superfamily are generally fungivorous and many are generally found to be phoretic on beetles, bees, ants and termites [2,9–13] and, less frequently, on other arthropods or small mammals [13,14]. Exceptions are a few species of the family Microdispidae, which might be parasitoids of the insects on which they are phoretic [1]. Neopygmephoroidea mites encompass 26 genera with about 300 species [7,15,16], with a high number of mite species inhabiting nests of a wide range of ant species [17,18]. Many others are phoretic on saproxylic or coprophagous beetles [19–21]. Scutacarid mites include more than 24 genera with more than 800 species [7] that are very small (from 200 to 400 µm) in length and are typically recognized by their hemispherical shape. These mites are widely distributed in soil, decaying material, moss and humus [22]. Many of them display sexual dimorphism and sometimes phoretic morphs, in which only phoretic females have enlarged claws on legs I, allowing them to cling firmly to their host (mainly beetles, bees and ants) for phoretic dispersal [23,24].

Several heterostigmatic species favor moist habitats, and these are generally found on insects inhabiting semiaquatic habitats such as riverbanks, flood swamps and shorelines [25]. For example, the scutacarid genera Archidispus Karafiát, 1957, Imparipes Berlese, 1903, Pygmodispa Paoli, 1911 and Scutacarus Gros, 1845 can sometimes be found under the elytra or on other body surfaces of semiaquatic beetles. The genus Archidispus is predominantly phoretic on carabid beetles [9,26–30]; however, a handful of species have been recorded from Heteroceridae MacLeay, 1825, Hydrophilidae Latreille, 1802, and Staphylinidae Latreille, 1802, mainly dwelling in moist habitats [24]. Likewise, among neopygmephoroidea, the genus Allopygmephorus is well known for its members being hydrophiles and having evolved relationships with insects occupying moist habitats.

Although it has been predicted that Australia is home to a large diversity of heterostigmatic mites, with recent studies discovering a rich diversity of parasitic fauna [4,31,32], the phoretic fauna in Australia remain almost unexplored. The only reported Australian Pygmeephoroidea were found from soil samples, and their phoretic associations with host insects are mostly unknown. For example, apart from Scutacarus hydrophilus Mahunka, 1967, which was found to be phoretic on phorid and sciarid flies, Australian scutacarid species (30 species belonging to the genera Heterodispus Paoli, 1911, Diversipes Berlese, 1903, Imparipes, Pygmodispa and Scutacarus) are only known from soil samples [31]. The neopygmephoroidea fauna is even less explored (five species belonging to the genera Bakerdania Sasa, 1961, Pseudopygmephorus Cross, 1965, Trexodania Khaustov and Trach, 2014) with only Trexodania troxi (Mahunka and Philips, 1977) having been found on an Australian trogid beetle [31,33,34]. Therefore, more studies are required to obtain a better understanding of the diversity of phoretic heterostigmatic mites in Australia and their host associations.

Following a short exploration of insect hosts for heterostigmatic mites in summer 2020, we found several specimens of a semiaquatic hydrophilid beetle species, Coelostoma (Coelostoma) fabricii (Montrouzier, 1860) (Coleoptera: Hydrophilidae) to be heavily co-infested with two new heterostigmatic mite species, one each of Allopygmephorus and Archidispus. Here, we describe and illustrate these two new species, Allopygmephorus coelostomus sp. nov. (Neopygmephoroidea) and Archidispus hydrophilus sp. nov. (Scutacarididae) and report both genera for the first time for Australian mite fauna.

2. Materials and Methods

Mites were removed from their host beetles under a stereomicroscope using a fine brush. Subsequently, they were cleared in lactophenol, mounted in Hoyer’s medium and studied using a phase contrast microscope (model BX51, Olympus). All obtained specimens of both mite species were phoretic adult females attached to the host beetles’ sternite between the coxae. All specimens were collected by A. Katlav. The hydrophilid host beetles were identified with the help of Jason F. Mate (Department of Entomology, The Natural History Museum, London, UK) and Martin Fikacek (Department of Entomology, National Museum, Prague, Czech Republic). All measurements are given in micrometres for holotypes, as well as the measurements for five paratypes (in parentheses). Distances
between setae were measured from the base of one seta to that of another; setae represented by the acetabulum only are designated as ‘vestigial setae’ and those as long as the acetabulum or shorter are designated as ‘microsetae’. Terminology and chaetotaxy follow Lindquist [35]. The family classification of Pygmerophoroidea (Heterostigmatina) follows that of Khaustov [9].

The holotypes were deposited at the Queensland Museum, QLD, Australia. From each new species, two paratypes were deposited at the Acarological Collection, Department of Entomology, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran. The remaining mite and host beetle specimens were retained with the holotype.

3. Results
3.1. Family Neopygmeaphoridæ Cross, 1965

Genus Allopygmaphoros Cross, 1965.

Type species: Pygmeaphoros matthesi Krczal, 1959, by original designation.

Diagnosis: Adult female. Seta s2 absent, distance between pharyngeal pumps II and III short (less than half the length of pump III), setae ps2 absent, cupules ih absent, setae lb thickened, lanceolate with a notch or slit from about middle of seta to distal, genital sclerites ags and pgs (and sometimes mgs) present.

Allopygmaphoros coelostomus Katlav and Hajiqanbar sp. nov. (Figures 1–4).

**Figure 1.** Allopygmaphoros coelostomus sp. nov. (a) dorsal view of gnathosoma; (b) ventral view of gnathosoma.

Type Material.

Holotype: female (QMS 120029), ex. under sternite between leg I and II coxae of C. fabricii; Loc. Vines Dr, Hawkesbury campus, Western Sydney University, Richmond, NSW, 33°36′45.6″ S 150°44′40.2″ E; coll. A. Katlav; 12 February 2020.

Paratypes: Four females (QMS 120030-2; TMU SP202206-AK2), same data as holotype.

Female. Length of idiosoma 198 (165–196), width 157 (133–176).

Gnathosoma (Figure 1): length of gnathosoma 28 (26–28), width 23 (20–24). Gnathosomal capsule (Figure 1a) slightly longer than wide; dorsally with two pairs of subequal pointed and smooth cheliceral setae cha 16 (13–15) and chb 14 (11–14); postpalpal setae (pp) 9 (9–10) setiform, smooth and pointed; dorsal median apodeme not visible; subcapitulum (Figure 1b) with one pair of smooth and pointed subcapitular setae su 11 (10–11), distance between setae cha–cha 14 (13–14), chb–chb 4 (4–5), su–su 11 (10–11); palps dorsally bearing two subequal pointed and smooth setae dFe 12 (11–12) and dGe 10 (9–10), ventrally with an accessory setigenous structure (ass), palpi terminating in sclerotized falciform claws; pharyngeal pumps (Figures 1b and 2a) including three striated pumps: pump 1 (php1) smallest bow-like, situated inside gnathosomal capsule; pump 2 (php2) strongly developed,
sub-elliptical; pump 3 (php3) bow-like, horizontal rectangular, slightly bigger than pump 1. Connection between php2 and php3 not discernible.

Figure 2. *Allopygmephorus coelostomus* sp. nov. (a) dorsal view of body; (b) ventral view of body; (c) seta 1b; (d) genital sclerites.

Figure 3. Right legs of *Allopygmephorus coelostomus* sp. nov. (a) leg I; (b) leg II; (c) leg III; (d) leg IV.
3.1.1. Differential Diagnosis

The new species is readily distinguishable from all other congeners (listed in Table 1) due to the presence of mgs. The remarkable shape of seta 1b (with a notch or slit in the distal half) has also never been described in any Allopygmephorus, but the same character was detected in A. persicus following a detailed microscopy (A. Khaustov; personal communication), although this was not depicted in its original description [36]. Outside the genus, the presence of mgs makes A. coelostomus sp. nov. somewhat close to Protoallopygmephorus heteroceri Khaustov and Sazhnev 2016. Nevertheless, the absence of setae v2 in A. coelostomus sp. nov. (present in Protoallopygmephorus), prominent solenidion ω1 (fused with tibiotarsus I in Protoallopygmephorus) and absence of setae ps3 (present in Protoallopygmephorus) in A. coelostomus sp. nov. makes it easily distinguishable from the genus Protoallopygmephorus.

3.1.2. Etymology

The species epithet "coelostomus" refers to the generic name of the hydrophilid host, Coelostoma Brullé, 1835.

Figure 4. Micrograph of Allopygmephorus coelostomus sp. nov., phoretic female (a) general view dorsally; (b) general view ventrally; (c) genital sclerites; (d) setae 1b with a notch or slit in the distal half.

Idiosomal dorsum (Figures 2a and 4a): Anterior margin of tergite C covering posterior half of prodorsum; all dorsal plates ornamented with small dimples; stigmata subellipsoidal, associated with elongate atria with posterior tracheal branches; trichobothria clavate and smooth. All dorsal setae sharply pointed except seta e, which is distinctly stiff and blunt-ended. Setae sc2, c1, c2, d and e smooth, setae f, h1 and h2 with a couple of barbs. Posterior margin of tergite H protruded. Cupules ia on tergite D moderately elliptical; plates EF and H without cupules im and ih, respectively. Length of dorsal setae: sc2 17 (13–16), c1 21 (22–25), c2 20 (18–23), d 23 (24–26), e 17 (13–16), f 35 (35–40), h1 33 (31–34), h2 30 (30–32). Distances between dorsal setae: sc2–sc2 48 (47–50), c1–c1 49 (47–51), c2–c2 105 (103–115), c1–c2 28 (28–33), d–d 27 (27–34), e–e 71 (65–70), f–f 56 (55–61), e–f 9 (7–9), h1–h1 28 (22–29), h2–h2 49 (47–50), h1–h2 11 (12–14).

Idiosomal venter (Figures 2b and 4b). All ventral plates with numerous small dimples; posterior plate with higher density. Apodemes 1, 2 (ap1-2) and apsej well-developed and sclerotized, joined with appr; ap3 well-developed, ap4 moderately developed, both sclerotized, joined with appo; ap5 reduced. Posterior margin of posterior sternal plate weakly concave. All ventral setae pointed; setae 3a, 3b and 4a with a couple of barbs; other ventral setae smooth. Setae 1b pointed, with moderately large notch or slit in distal...
half (Figures 2c and 4c); pseudanal setae ps1 thickened and characteristically curved, ps3 thin and pointed, ps2 absent. Posterior margin of aggenital plate hook-like. Anterior genital sclerite (ags) small, triangular, median genital sclerite (mgs) developed, asymmetric, posterior genital sclerite (pgs) well-developed, triangular, larger than other genital sclerites (Figures 2d and 4d). Length of ventral setae: 1\(a\) 28 (26–29), 1\(b\) 26 (22–25), 2\(a\) 29 (23–27), 2\(b\) 28 (22–27), 3\(a\) 30 (26–29), 3\(b\) 30 (28–30), 3\(c\) 31 (24–26), 4\(a\) 35 (37–40), 4\(b\) 44 (41–45), 4\(c\) 33 (28–31), ps1 15 (13–16), ps3 20 (17–21).

Legs (Figure 3). Leg I (Figure 3a): setae formulae: Tr 1-Fe 3-Ge 4-TiTa 17(4) (number of solenidia in parentheses); tibiotarsus massive, terminating in large, sickle-like claw. All setae on tibiotarsus and genu smooth, pointed, except \(u'\) on tibiotarsus, thickened, spiniform and blunt-ended; solenidion \(\omega_1\) 10 (8–9) thickened, digitiform, \(\omega_2\) 5 (5–6) small and uniform, \(\varphi_1\) 6 (6–7) slender, \(\varphi_2\) 6 (5–7), moderately clavate, slightly thicker than \(\omega_2\). Setae \(d\) and \(l'\) on femur thickened, seta \(d\) stout, hook-like, seta \(l\) rod-shaped; seta \(v'\) on trochanter small, needle-like. Leg II. (Figure 3b): setae formulae: Tr 1-Fe 3-Ge 3-Ti 4(1)-Ta 6(1); with tongue-like empodium with pointed tip and a pair of slightly asymmetrical claws; all setae pointed, setae \(pv'\) on tarsus, \(v'\) and \(v''\) on tibia with some barbs; other setae smooth; solenidion \(\omega_1\) 14 (12–13) baculiform, \(\varphi_4\) 4 (4–5) small and weakly clavate. Leg III (Figure 3c): setae formulae: Tr 1-Fe 2-Ge 2-Ti 4(1)-Ta 5; with tongue-like empodium with pointed tip and pair of slightly asymmetrical claws; all setae pointed, except seta \(pv''\) on tarsus, bearing 2–3 barbs; tibial setae same as leg II; solenidion \(\varphi_4\) 4 (4–5) small and weakly clavate. Leg IV (Figure 3d): setae formulae: Tr 1-Fe 2-Ge 1-Ti 4(1)-Ta 6; with slender and spike-like empodium and a pair of thinner claws than legs II-III; all setae smooth and pointed except seta \(v''\) on tibia, with 1–2 barbs and blunt-ended; solenidion \(\varphi_4\) 4 (4–5) small and weakly clavate.

3.1.1. Differential Diagnosis

The new species is readily distinguishable from all other congeners (listed in Table 1) due to the presence of mgs. The remarkable shape of seta 1\(b\) (with a notch or slit in the distal half) has also never been described in any *Allopygmephorus*, but the same character was detected in *A. persicus* following a detailed microscopy (A. Khaustov; personal communication), although this was not depicted in its original description [36].

Table 1. Information on the distribution and host and/or habitat associations of all known species of *Allopygmephorus*.

| Mite Species | Distribution | Host and/or Habitat | Reference |
|--------------|--------------|---------------------|----------|
| *Allopygmephorus bakaminae* Khaustov and Ermilov, 2008 | Russia | In wet soil | [37] |
| *Allopygmephorus baoshanensis* Gao, Zou and Ma, 1989 | China | Unknown | [38] |
| *Allopygmephorus brasiliensis* Mahunka, 1970 | Brazil | Litter and humus among roots surrounded by water | [39] |
| *Allopygmephorus chinensis* Mahunka 1975 | Hong Kong | Wet and rotting leaves | [40] |
| *Allopygmephorus cunae* Mahunka, 1970 | Brazil | Very wet decaying grass and detritus on river shore | [39] |
| *Allopygmephorus heterodactylus* Mahunka, 1973 | Ghana | Unidentified beetle; *Cercyon* sp. (Col.: Hydrophilidae) | [41] |
Table 1. Cont.

| Mite Species                  | Distribution          | Host and/or Habitat                                      | Reference     |
|-------------------------------|-----------------------|----------------------------------------------------------|---------------|
| Allopygmephorus matthesi      | Germany; Tanzania;    | Berosus luridus (Linnaeus, 1760), Coelostoma orbiculare | [41–43]       |
| (Krczal, 1959)                | Iran                  | (Fabricius, 1775), Enochrus quadrripunctatus (Herbst, 1797), H. lividus (Forster, 1771), Hydrobius fuscipes (Linnaeus, 1758), Hydrophilus caraboides (Linnaeus, 1758), Philydrus melanocephalus Kuwert, 1888 (Col.: Hydrophilidae); Heterocerus marginatus (Fabricius, 1787) (Col.: Heteroceridae); Dryops auriculatus (Geoffroy, 1785) (Col.: Dryopidae); Xyleborus sp. (Col.: Curculionidae: Scolytinae) |
| Allopygmephorus nanhuiensis  | China                 | Unknown                                                  | [38]          |
| (Gao, Zou and Ma, 1989)       |                       |                                                          |               |
| Allopygmephorus orientalis   | Malaysia              | Rotting wood and leaves                                   | [44]          |
| Mahunka and Mahunka-Papp, 1988|                       |                                                          |               |
| Allopygmephorus persicus     | Iran                  | Ceracryon laminates Sharp, 1873, Enochrus bicolor (Fabricius, 1792) (Col.: Hydrophilidae)                      | [36,45]       |
| Khaustov and Hajiqanbar, 2006|                       | Heterocerus fenestratus (Thunberg, 1784), Heterocerus flexuosus Stephens, 1828 (Col.: Heteroceridae); Drasterius bimaculatus (Rossi, 1790) (Col.: Elateridae); Augyles sp. (Col.: Heteroceridae) | [46,47]       |
| Allopygmephorus punctatus    | Russia; Iran          |                                                          | [46,47]       |
| Khaustov and Sazhnev, 2016    |                       | Heterocerus fenestratus (Col.: Heteroceridae); Drasterius bimaculatus (Col.: Elateridae); Augyles sp. (Col.: Heteroceridae) |               |
| Allopygmephorus spinisetus   | Russia; Iran          |                                                          | [46,47]       |
| Khaustov and Sazhnev, 2016    |                       | Heterocerus fenestratus (Col.: Heteroceridae); Drasterius bimaculatus (Col.: Elateridae); Augyles sp. (Col.: Heteroceridae) |               |
| Allopygmephorus tuberosus     | Bolivia               |                                                          | [48]          |
| Mahunka, 1969                 |                       |                                                          |               |
| Allopygmephorus coelostomus sp. nov. | Australia | Coelostoma (Coelostoma) fabricii (Col.: Hydrophilidae)         | This study |

Outside the genus, the presence of mgs makes A. coelostomus sp. nov. somewhat close to Protoallopygmephorus heteroceri Khaustov and Sazhnev 2016. Nevertheless, the absence of setae ω2 in A. coelostomus sp. nov. (present in Protoallopygmephorus), prominent solenidion ω1 (fused with tibiotarsus I in Protoallopygmephorus) and absence of setae ps3 (present in Protoallopygmephorus) in A. coelostomus sp. nov. makes it easily distinguishable from the genus Protoallopygmephorus.

3.1.2. Etymology

The species epithet “coelostomus” refers to the generic name of the hydrophilid host, Coelostoma Brullé, 1835.

Key to the world species of Allopygmephorus

1. With three solenidia on tibiotarsus I ................................................................. 2
   - With four solenidia on tibiotarsus I ......................................................... 3
2. Seta e subequal to setae h1 and h2, pgs absence .................................................. A. nanhuiensis Gao, Zou and Ma, 1989
   - Seta e about half the length of h1 and h2, pgs presence .................................. A. chinensis Mahunka 1975
3. Seta 1a, modified, with very long barbs; Setae f, h1 and h2 blunt-ended ................................................................. A. bakaminae Khaustov and Ermilov, 2008
   - Seta 1a normality; Setae f, h1 and h2 pointed or blunt-ended .......................... 4
4. Tibiotarsus I with a weak-stalked small claw .......................................................... 5
   - Tibiotarsus I with a normal or large claw ....................................................... 6
5. Solenidion ω2 on tibiotarsus I long, approximately more than half the length of segment; ω2 > ω1, φ1 ≈ φ2 ................................................................. A. cunae Mahunka, 1970
13. Solenidia \( \omega \) on tibiotarsus I shorter than half the length of segment; \( \omega 2 \approx \omega 1, \varphi 1 > \varphi 2 \) ................................. A. brasiliensis Mahunka, 1970

6. Setae c1, c2 and d basally thickened, bulbiform; ps2 absence ................................................................. A. orientalis Mahunka and Mahunka-Papp, 1988

S 2 on tibiotarsus I short than half of the seta \( \varphi 1 \) and \( \varphi 2 \) ................................. A. baoshanensis Gao, Zou and Ma, 1989

- Setae h1 > h2; solenidia otherwise .............................. 13

12. Solenidia \( \omega 1 > \varphi 1 > \varphi 2 > \omega 2 \) on tibiotarsus I; seta \( e \) shorter than half of the seta \( f \)................................................................. A. matthesi Kraczal, 1959

- Solenidia \( \omega 1 > \omega 2 \approx \varphi 2 > \varphi 1 \) on tibiotarsus I; seta \( e \) about half the length of seta \( f \) ................................................................. A. heterodactylus Mahunka, 1973

- Solenidia \( \omega 1 < \omega 2 \approx \varphi 2 > \varphi 1 \) on tibiotarsus I; seta \( e \) about half the length of seta \( f \) ................................................................. A. heterodactylus Mahunka, 1973

3.2. Family Scutacaridae Oudemans, 1916

Genus Archidispus Karafiat, 1959.
Type Species: Archidispus minor (Karafiat, 1959), by original designation.

Diagnosis: Adult female. Seta 1a thickened, blunt-ended and smooth, setae 3b, 4a and 4b smooth, thickened at basal half and pointed, genital sclerites (at least ags and pgs) present, pharyngeal pumps II and III with short distance from each other, setae \( ps2 \) absent. Archidispus hydrophilus Khadem-Safdarkhani and Hajiqanbar sp. nov. (Figures 5–8).

Type Material.

Holotype: female (QMS 120025), ex. under sternite between legs coxae of C. fabricii (Montrouzier, 1860) (Coleoptera: Hydrophilidae); Loc. Vines Dr, Hawkesbury campus, Western Sydney University, Richmond, NSW, 33°36’45.6" S 150°44’40.2" E; Coll. A. Katlav; 12 February 2020.

Paratypes: Four females (QMS 120026–8; TMU SP202206-1AK1), same data as holotype.

Description.

Phoretic female. Length of idiosoma 207 (223–229), width 182 (159–197).

Gnathosoma (Figure 5): length of gnathosoma 33 (32–34), width 28 (24–27). Gnathosomomal capsule (Figure 5a) slightly longer than wide; with a weak longitudinal dorsal median apodeme in posterior half; dorsally with two pairs of subequal, pointed and moderately barbed cheliceral setae \( ch1 \) 12 (20–22) and \( ch2 \) 22 (19–21); \( pp \) evident in some specimens (not discernable in holotype); subcapitulum (Figure 5b) with one pair of pointed and smooth setae \( su \) 11, distance between seta \( ch1-ch1 \) 13, \( ch2-ch2 \) 22, \( su-su \) 10; palpi compressed to gnathosomal capsule, dorsally bearing two subequal, pointed, indistinctly-barbed setae.
Pharyngeal system (Figure 5a) bearing one smooth and two striated pumps: pump 1 (php1) smallest and bow-like, pump 2 (php2) strongly developed, cylindrical, pump 3 (php3) developed and sub-pentagonal.

Figure 5. Archidispus hydrophilus sp. nov. (a) dorsal view of gnathosoma; (b) ventral view of gnathosoma; (c) seta sc1.
The species epithet 'kazuyoshikurosai' means water-loving and refers to the humid environment in which the hydrophilid host beetle of this species and most likely the species itself dwell.

**Figure 6.** *Archidispus hydrophilus* sp. nov. (a) dorsal view of body; (b) ventral view of body.

**Figure 7.** Right legs of *Archidispus hydrophilus* sp. nov. (a) leg I; (b) leg II; (c) leg III; (d) leg IV.
Idiosomal dorsum (Figures 6a and 8a): Tergite G weakly dimpled, other tergites smooth; prodorsal shield (PrS) entirely covered by tergite C, with one pair of clavate trichobothria (sc1) (Figure 5c) bearing minute barbs, and two pairs of subequal setae c2 and sc2 (visible in pressure-mounted slides with removed tergite C); anterior of base of seta sc1 with two subequal, horn-like protrusions (Figure 5c); cupuli ia and ih visible on tergites C and H, respectively; setae c2 posterolaterally inserted into c1 and bearing a sclerotic alveolar canal; all dorsal setae moderately pointed and barbed; length of dorsal setae: v2 7 (7–8), sc2 6 (6–8), c1 36 (32–34), c2 39 (36–39), d 44 (40–42), e 49 (42–48), f 44 (36–38), h1 61 (61–62), h2 57 (53–56). Distances between dorsal setae: c1–c1 61 (59–63), c2–c2 117 (120–136), c1–c2 36 (36–38), d–d 92 (92–94), e–e 140 (138–146), f–f 60 (58–62), e–f 41 (41–43), h1–h1 36 (34–38), h2–h2 101 (98–105), h1–h2 35 (30–34).

Idiosomal venter (Figures 6b and 8b). Apodemes 1–4 (ap 1–4) and sejugal (apsej) well developed; ap1, ap2 and apsej fused with pre-sternal apodeme (appr); ap3 and ap4 fused with post-sternal apodeme (appo); secondary transverse apodeme (sta) weakly developed, posteriolar ap2, crossing appr; apodemes 5 (ap5) short, reduced to lateral fragments. Posterior margin of post-sternal plate flattened, weakly undulated; aggenital plate concave in posterior margin, bearing developed anterior genital sclerite (ags), median genital sclerite (mgs) and posterior genital sclerite (pgs). Coxisternal setae 1b, 2a, 2b, 3a, 3c and 4c setiform, slightly barbed and pointed. Setae 1a thickened, smooth and blunt-ended; setae 3b, 4a and 4b smooth, thickened at basal half and pointed; pseudanal setae ps1 and ps3 subequal, barbed and pointed, about twice the length of setae ps2; setae ps2 setiform, smooth and adjacent setae ps1. Length of ventral setae: 1a 10 (10–11), 1b 29 (29–32), 2a 25 (24–27), 2b 27 (29–31), 3a 28 (27), 3b 19 (20–21), 3c 31 (34–36), 4a 19 (19–22), 4b 33 (35–37), 4c 40 (39–43), ps1 33 (30–34), ps2 16 (12–15), ps3 31 (29–32).

Legs (Figure 7). Leg I (Figure 7a): distinctly thicker and shorter than other legs; setae formulae: Tr 1-Fe 3-Ge 4-TiTa 16(4) (number of solenidia in parentheses); tibiotarsus with a robust claw; all setae on tarsus smooth except setae l” and pv”; tc” and ft” located apically and laterally, respectively, on a distinct pinnaculum; solenidia ω1 13 (12–15) and ω2 16 (15–18) baculiform, φ1 11 (10–11) finger-shaped, ρ2 13 (11–14) very slender and baculiform; all setae on genu, femur and trochanter smooth; setae d on femur short and spined, medially serrate. Leg II (Figure 7b): setae formulae: Tr 1-Fe 3-Ge 3-Ti 4(1)-Ta 6(1); empodium developed; seta u” smooth and indistinctly blunt-ended, tc” smooth and pointed, setae tc’, pv” and ρ2” on tarsus slightly barbed; ω 14 (13–15) elongate and baculiform; setae tv” and tv’ on tibia.

Figure 8. Micrograph of Archidispus hydrophilus sp. nov., phoretic female (a) dorsal general view; (b) ventral general view.
weakly barbed; \( \varphi 9 \) (7–9) weakly clavate; seta \( l'' \) on genu barbed; setae \( d \) on femur weakly blunt-ended; seta \( v' \) on trochanter moderately barbed and indistinctly blunt-ended. *Leg III* (Figure 7c): setae formulae: \( Tr \) 1-\( Fe \) 2-\( Ge \) 2-\( Ti \) 4(1)-\( Ta \) 6; empodium developed; \( u' \) shortest, smooth and indistinctly blunt; \( tc'' \) smooth and pointed; \( pv'' \) smooth and indistinctly blunt-ended; other tarsal setae moderately barbed; on tibia setae \( v' \) and \( v'' \) smooth; \( pv' \) smooth and pointed; on tibia seta \( d \) barbed and pointed, \( l' \) smooth and slightly blunt-ended; on tarsus \( v' \) barbed and pointed. *Leg IV* (Figure 7d): the longest leg; setae formulae: \( Tr \) 1-\( Fe \) 2-\( Ge \) 1-\( Ti \) 3(1)-\( Ta \) 6; proximal portion of tarsus elongated, tapering to apex; all setae blunt-ended, \( u' \) smooth, \( tc'' \) smooth, \( pl' \) smooth and rod-like; other tarsal setae barbed; on tibia all setae barbed and indistinctly blunt-ended, \( solenidion \ \varphi 6 \) (6–7) thin and uniform; on genu seta \( v' \) barbed and pointed; on femur setae \( d \) and \( v' \) barbed and weakly blunt-ended; on trochanter seta \( v' \) sparsely barbed and pointed.

3.2.1. Differential Diagnosis

This species is readily distinguishable from all other species of the genus due to the shape of seta \( 1a \) (thickened, blunt-ended and smooth) and presence of mgs; regardless, *A. hydrophilus* sp. nov. is most similar to *A. kazuyoshikurosai* Khaustov based on setae \( 3b, 4a \) and \( 4b \) being thickened in the basal half and thin in the distal half; however, it differs from the new species as all dorsal setae are moderately pointed (most dorsal setae are distinctly blunt-ended in *A. kazuyoshikurosai*), and setae \( 1a \) being short, spiniform and blunt-ended (setae \( 1a \) longer and beak-like in *A. kazuyoshikurosai*), setae \( pl'' \) on tarsus IV with blunt-tipped rod (pointed in *A. kazuyoshikurosai*).

3.2.2. Etymology

The species epithet ‘*hydrophilus*’ means water-loving and refers to the humid environment in which the hydrophilid host beetle of this species and most likely the species itself dwell.

4. Discussion

The host beetle genus *Coelostoma* shows the greatest diversity in the Afrotropical and Oriental regions, with a few species in the Palearctic and Australian realms [49–52]. Although many hydrophilid beetles are aquatic, some are semiaquatic, including *Coelostoma*, which resides in wet grasslands near riverbanks and ponds. Here, they live under wet rocks or among grass roots, where they feed on decomposing organic matter [51], which is also an ideal substrate for the growth of fungal mycelia—the likely food source for the phoretic *Allopygmephorus* and *Archidispus* mites. Many *Coelostoma* species are nocturnal: during the day, they usually hide under moss or the roots of plants growing next to the watercourse, and may be found feeding on wet and submerged surfaces, including those of wet rocks and artificial concrete surfaces, at night. Some species may be collected from mud or from underneath wet leaf litter; few species are only found in interstitial habitats under stones and among gravel at the sides of stony riverbeds [51].

*Allopygmephorus* is well-known from sodden and rotting vegetation matter or from the beetles that frequent these habitats, especially Hydrophilidae and Heteroceridae (Table 1). The genus is widespread, occurring in the Afrotropical, Indo-Malayan, Neotropical and Palearctic regions. Its discovery in the Australian realm is, thus, not surprising, although its presence on *C. fabricii*, the sole Australian representative of this large Afrotropical–Oriental beetle genus, suggests it may have arrived, together with its carrier, from the Oriental realm. However, this hypothesis makes the unconvincing assumption that *A. coelostomus* has a close host relationship with its carrier. Previous collections of *Allopygmephorus* suggest a low host specificity in the group, with mites riding on several families of beetles that presumably visit the same habitat (Table 1).

Scutacarid mites generally use their insect hosts for phoretic dispersal between ephemeral habitats; however, some can be inquilines of their hosts’ nests. It is hypothe-
sized that some species may play a sanitary role in their hosts’ nests [24]. Some genera show strong preferences towards special insect groups, while others are comparatively less host-specific [24]. *Archidispus* is a group of scutacarid mites with a strong preference for phoresy on carabid beetles [24]. Records from other beetle species are rare but do include a record of *A. bembidii* from *Coelostoma* hydrophilid beetles [9]. Similarly to *Allopygmephorus*, numerous species of *Archidispus* utilize several carrier species and it remains unknown if *A. hydrophilus* is specific to *C. fabricii* or is opportunistically phoretic on various semiaquatic beetles. Broader surveys are needed to provide more information and uncover more of Australia’s vast undescribed fauna of phoretic and other mites.

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