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A brachypterous *Bryophaenocladius* (Diptera: Chironomidae: Orthocladiinae) with hypopygium inversum from Heggie's Rock, Georgia, U.S.A.

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Abstract

The adult male and female, pupa and larva of a new species, *Bryophaenocladius chrissichuckorum*, are described from Heggie's Rock, Georgia, U.S.A. Males and females of the species are brachypterous; males have a hypopygium inversum. Pupae differ from other described *Bryophaenocladius* by the presence of three pairs of small setae on the prefrons. Larvae have a mentum with 2 broad median teeth and AR of about 0.99, but are not realistically separable from many other *Bryophaenocladius* species. The immature stages inhabit shallow ephemeral pools.

Key words: Diptera, Chironomidae, *Bryophaenocladius*, new species, brachypterous, Nearctic, Heggie's Rock

Introduction

The orthoclad genus *Bryophaenocladius* is a species rich taxon, with over 100 species described from all continents except Antarctica; no species are described from Australia but Cranston (1996) noted the occurrence of larvae in terrestrial samples from orchards in western Australia. Fifteen described species are known from the Nearctic; Wang *et al*. (2004) provided a key to adult males for 13 of those species. Some of the difficulties concerning the systematics of the genus were discussed in Wang *et al*. (2006) and Du *et al*. (2011).

Larvae are found in a variety of habitats ranging from completely terrestrial to aquatic, with relatively few species definitely aquatic.

This paper reports the existence of the first known brachypterous *Bryophaenocladius* and the first with a hypopygium inversum (twisted 180˚ from the normal position), and describes the adult male and female, the pupa and the larva of the species.

Material and methods

Unless indicated otherwise, all measurements are in µm, and consist of the minimum, maximum and mean (if 4 or more specimens were measured); the number of specimens (n) measured/counted is given in parentheses if different from the number cited at the beginning of the description. Because the wing veins are obsolete, "R complex" is used for the combined R veins which bear setae. Wing length was measured from the most proximal seta of the brachiolum to the apex of the wing; larval head length was measured from the base of the antenna to the postocciput; other measurements follow Epler (1988). Abbreviations used: Pex—pupal exuviae; Lex—larval exuviae; other abbreviations and terms follow standard chironomid taxonomy (Sæther 1980).

The holotype and several paratypes are deposited in the William L. Peters Museum Collection of Aquatic Insects (part of the Florida State Collection of Arthropods) at Florida A & M University, Tallahassee, Florida, U.S.A.; some paratypes are also deposited in the University Museum of Bergen, Bergen, Norway; the Zoologische Staatssammlung, München, Germany and the author's collection.

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Taxonomy

Bryophaenocladius chrissichuckorum sp. nov.

Diagnosis. Adults are distinguished by antennae with 5–6 flagellomeres (male and female); male AR around 0.53; maxillary palp with 4 or fewer palpomeres; brachypterous wings with obsolete veins; obsolete scutellum; male hypopygium without anal point, with minutely spinous virga, small digitiform inferior volsella; megaseta placed subapicoventrally on gonostylus; mated males with a hypopygium inversum. Pupae differ from other described *Bryophaenocladius* by the presence of three pairs of small setae on the prefrons. Larvae have a mentum with 2 broad median teeth and AR of about 0.99, but are not realistically separable from many other *Bryophaenocladius* species.

Description. Adult male (n = 8).

Coloration. Black, with tibiae and tarsi gray (Fig. 25).

General dimensions. Thorax 0.69–0.78, 0.74 mm; abdomen 1.73–2.44, 2.08 mm; total 2.46–3.22, 2.82 mm; wing 285–350, 313 µm long, 125–150, 138 µm wide (7).

Head (Fig. 3). Eyes well separated, without dorsomesal extension. Temporal setae 8–16, 12; clypeal setae 3–7, 5; cibarial sensilla 7–16, 12 (5). Tentorium 130–158, 144 µm long (5), 13–20, 17 µm wide (5); stipes 95–128, 109 µm long 6), 35–55, 47 µm wide (6) (Fig. 4). Antenna (Fig. 2) usually with 5 or 6 antennomeres; ultimate flagellomere 80–108, 99 µm long (6), without strong subapical seta. AR 0.34–0.86, 0.53 (6) (see Remarks). Maxillary palp with 4 palpomeres; lengths (in µm) of palpomeres 1–4: 33–45, 37; 35–53, 44; 80–88, 83 (7); 53–68, 60 (7). Palpomere 3 (Fig. 5) with sensillum coeloconicum with about 12 sensilla clavata.

Thorax (Fig. 1). Setae: antepronotals 4–7, 5; acrostichals 12–24, 17; dorsocentrals 7–13, 9; scutellars 3–7, 5; prealars 2–8, 4. Scutellum obsolete.

Wing (Fig. 6). Wing reduced, moderately punctate, veins scarcely visible, anal lobe/squamal area reflexed under wing. Brachiolum with 1–2, 2 setae; R complex with 1–8, 4 setae. Pleural wing process enlarged, rounded, heavily microtrichiose, with 1–3 setae. Haltere reduced to a cordate lobe.

Legs (Fig. 9). Lengths and ratios in Table 1. Fore tibial spur (Fig. 7) simple, sinuate, sometimes with minute spinulae near base; 45–68, 62 µm long. Mid and hind tibial spurs simple, straight; mid tibial spurs 43–53, 52 and 23–30, 27 µm long (7); hind tibial spurs 50–65, 56 and 18–33, 27 µm long. Pseudospurs on first and second tarsomeres of mid and hind legs: pseudospur mid ta_1 13–23, 18 µm long, pseudospur mid ta_2 13–20, 17 µm long; pseudospur hind ta_1 15–23, 18 µm long (7), pseudospur hind ta_2 13–19, 15 µm long (7). Hind tibial comb (Fig. 8) with 7–12, 9 spines. Sensilla chaetica absent. Tarsal claws simple.

TABLE 1. *Bryophaenocladius chrissichuckorum* **sp. nov.**, leg measurements and ratios.

male (n = 8)	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV
p_1	650–790, 702	620–750, 708	270–305, 296 (7)	150–170, 160 (7)	120–140, 134 (7)	95–110, 102 (7)	95–105, 101 (7)	0.40–0.44, 0.42 (7)	3.25–3.65, 3.45 (7)	4.49–5.07, 4.79 (7)
p_2	660–810, 753	660–790, 753	200–220, 215	95–120, 106	90–100, 96	70–75, 71	80–90, 88	0.28–0.30, 0.29	4.22–5.18, 4.77	6.60–7.27, 7.00
p_3	710–870, 811 (7)	780–890, 843	280–320, 308	130–160, 140	140–160, 154	80–95, 87	70–95, 88	0.35–0.39, 0.37	3.98–4.34, 4.18	5.03–5.68, 5.36
female (n = 5)										
p_1	460–570, 510	470–550, 508	190–230, 210	105–130, 117	90–105, 102	70–80, 76	80–95, 89	0.40–0.43, 0.41	3.05–3.36, 3.20	4.70–4.95, 4.85
p_2	550–650, 605	525–600, 563	160–190, 176	80–100, 88	70–80, 76	50–60, 57	80–85, 81	0.30–0.32, 0.31	4.05–5.05, 4.46	6.47–6.75, 6.64
p_3	600–720, 661	580–690, 653	230–260, 252	115–130, 122	110–130, 124	65–80, 74	65–90, 82	0.38–0.40, 0.39	3.79–3.97, 3.90	5.02–5.42, 5.21

Hypopygium (Fig. 10). Mated males with a hypopygium inversum, with torsion at abdominal tergites 6 and 7 (Fig. 25). Gonocoxite 330–390, 373 µm long; gonostylus 168–180, 174 µm long. Transverse sternapodeme 130–168, 154 µm wide (7); phallapodeme 148–170, 161 µm long (7). Laterosternite IX with 8–16, 13 setae; tergite X with 18–35, 24 setae. Megaseta placed subapicoventrally on gonostylus (Fig. 11), 8–13, 12 µm long.

Adult female (n = 5).

Coloration. As in male.

General dimensions. Thorax 0.64–0.81, 0.71 mm; abdomen 1.68–2.80, 2.25 mm; total 2.32–3.61, 2.96 mm; wing 265–315 µm long, 105–140 µm wide (3).

Head. Eyes well separated. Temporal setae 5–11, 9; clypeal setae 3–7, 6: cibarial sensilla 9–14, 12. Tentorium 125–173, 143 µm long (4), 15–18, 17 µm wide. Stipes weakly developed, 88–100 µm long (3), 33–35 µm wide (3). Antennae with 5–6 flagellomeres, ultimate flagellomere 60–88, 76 µm long. AR 0.38–0.55, 0.46. Maxillary palp with 4 palpomeres (one specimen with palpomeres 3 and 4 fused; see Remarks); lengths (in µm) of palpomeres 1–4: 33 (3); 35–38 (3); 63–65 (2); 48–65 (2). Palpomere 3 with sensillum coeloconicum with about 12 sensilla clavata.

Thorax. Acrostichal setae in numerous rows. Setae: antepronotals 3–6, 4; acrostichals 18–25, 22; dorsocentrals 6–13, 9; scutellars 3–6, 4; prealars 2–3, 3. Scutellum obsolete.

Wing. As in male. Brachiolum with 1–3, 2 setae; R complex with 2–8, 5 setae.

Legs. Lengths and ratios in Table 1. Fore tibial spur simple, sinuate, sometimes with minute spinulae near base; 40–50, 45 µm long. Mid and hind tibial spurs simple, straight; mid tibial spurs 33–43, 38 and 18–23, 20 µm long; hind tibial spurs 40–45, 41 and 2 12–18, 16 µm long. Pseudospurs absent. Hind tibial comb with 7–10, 8 spines. Sensilla chaetica absent. Tarsal claws simple.

Genitalia (Fig. 12). Sternite VIII with 15–27, 20 long setae; gonocoxite IX with 13–23, 16 long setae; tergite IX (Fig. 14) with 22–30, 25 long setae. Notum 190–215, 201 µm long from base to bifurcation. Seminal capsules and neck sclerotized, 130–185, 164 µm (4) long. Apodeme lobe as in Fig 13. Cercus 98–105, 101 µm long, with 27–36, 30 long setae.

Pupa (n = 10).

Coloration. Exuviae pale brown.

General dimensions. Cephalothorax 0.66–1.10, 0.87 mm (6); wing sheath 670–945, 832 µm; abdomen 2.48–3.26, 2.88 mm; anal lobe 300–470, 364 µm (9); total length 3.38–4.00, 3.67 mm (6).

Cephalothorax (Fig. 15). With moderate rugosity anterodorsally; remainder, including wing sheath, relatively smooth. Head as in Figs. 16 and 17; with 3 pairs of very small setae on prefrons. Thoracic horn absent. Antepronotum with 2 stout setae, upper longer, 23–45, 35 µm (9) than lower, 23–33, 27 µm (8). Precorneal setae with anterior seta longer, 28–40, 34 µm (7), than subequal posterior 2 setae, 23–33, 25 µm (7). With 3 dorsocentral setae, arranged in ascending row or in triangle, 20–33, 28 µm (6). Distance from Dc_1 to Dc_2 15–30, 23 (7) µm; from Dc_2–Dc_3 18–36, 25 (7) µm.

Abdomen. Tergites (Fig. 18) and sternites mostly covered with strong shagreen spinules, reduced on T I and S I. T I and VIII with 1 small lateral seta, T II–VII with 3 small lateral setae. T I–VII with 2 pairs D setae, T VIII with 1 pair. S I and VIII with 1 pair V setae, S II–VII with 3 pairs V setae. Anal lobe (Fig. 19) without setal fringe or macrosetae; with 3 pairs very small (~18 µm) dorsal setae.

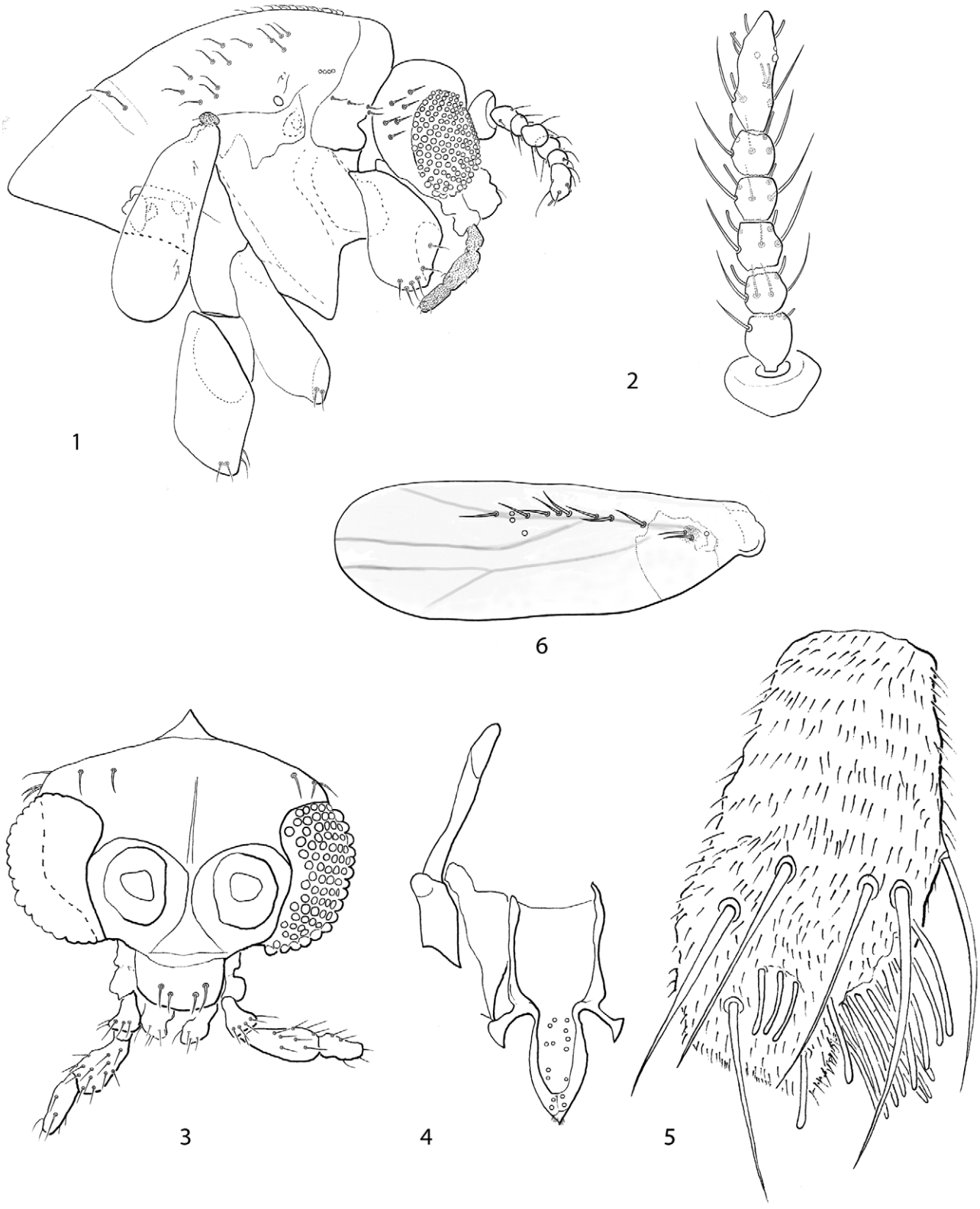
Fourth instar larva (n = 10).

Coloration. Head capsule light brown, body (in alcohol) gray.

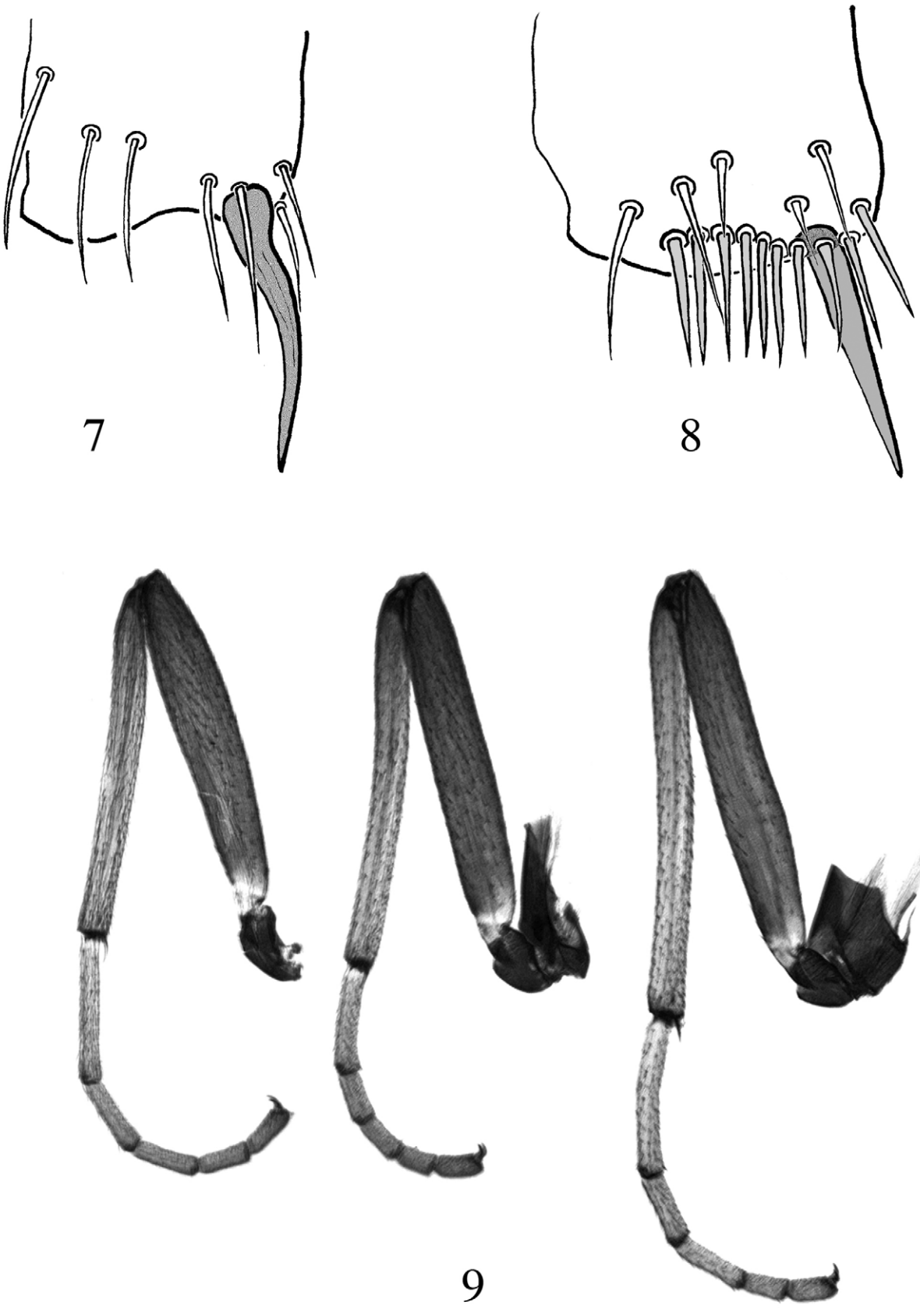
General dimensions. Small larvae, total length of 4th instar about 4–6 mm.

Head. Head capsule length 295–370, 338 (7) µm. Postmentum length 13–155, 139 µm. Antenna (Fig. 20) with 5 antennomeres, lengths (in µm, 1–5): 30–36, 33; 17–22, 20; 3; 3–4, 4; 2. AR 0.86–1.06, 0.99. 1st antennomere 19–23, 21 µm wide; antennal blade 26–34, 31 µm long (9), extending to 4th antennomere. Style 3–4 (2) µm long. Premandible (Fig. 21) 80–90, 83 µm long, with 1 apical tooth, one broad and one small inner tooth. Mandible (Fig. 22) 120–155, 144 µm long, with 3 inner teeth; seta subdentalis and seat interna absent. Mentum (Fig. 23) 100–125, 116 (9) µm wide, with 2 broad, well separated median teeth and 5 pairs of lateral teeth, last tooth reduced and set back posteriorly. Ventromental plates lobate, extending to or just past outer margin of mentum, 25–30, 29 µm wide (9).

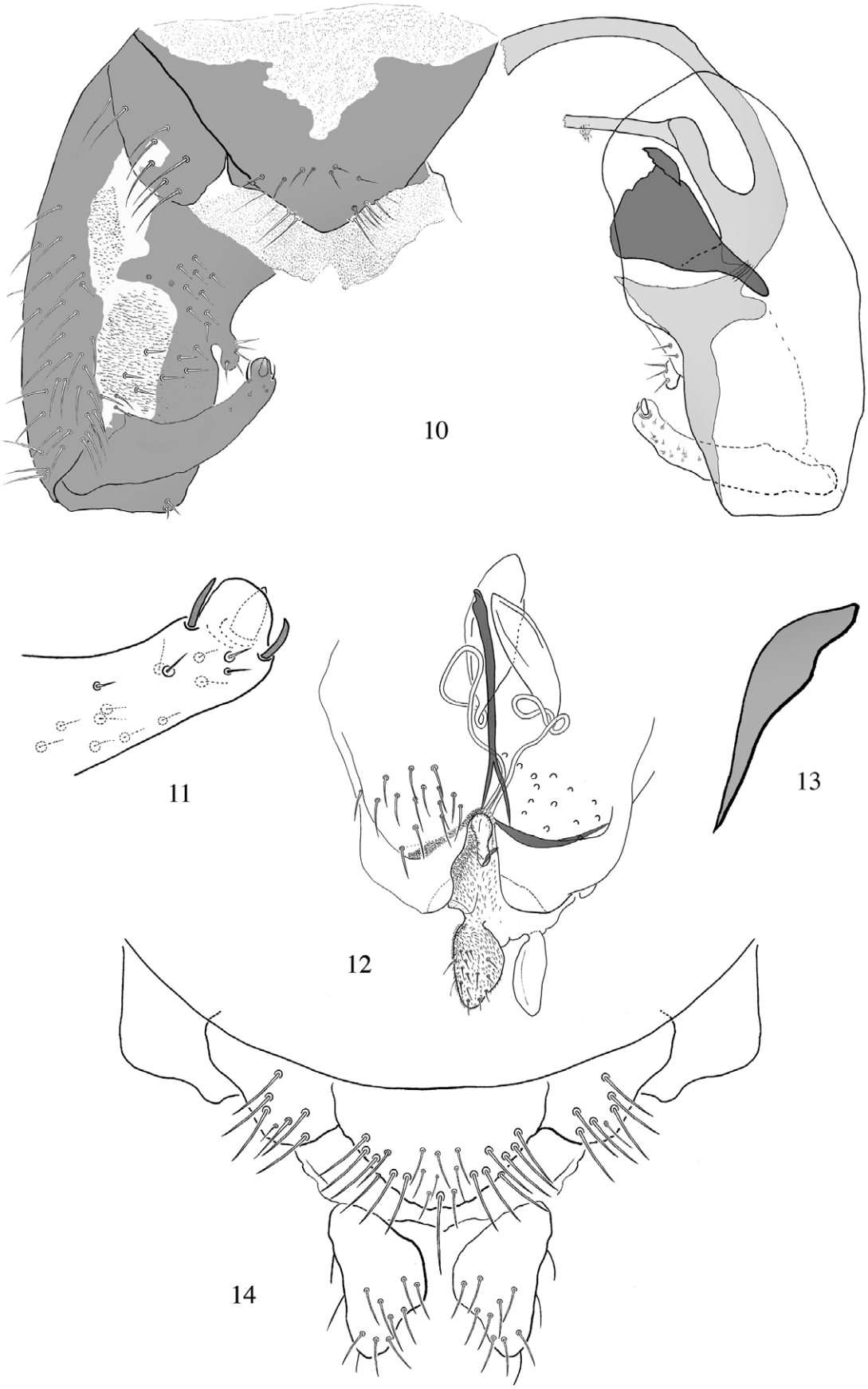
Body. Anterior parapods reduced, fused, with rows of small spinules. Procerci and anal setae absent. Posterior parapods each with about 10 simple claws.



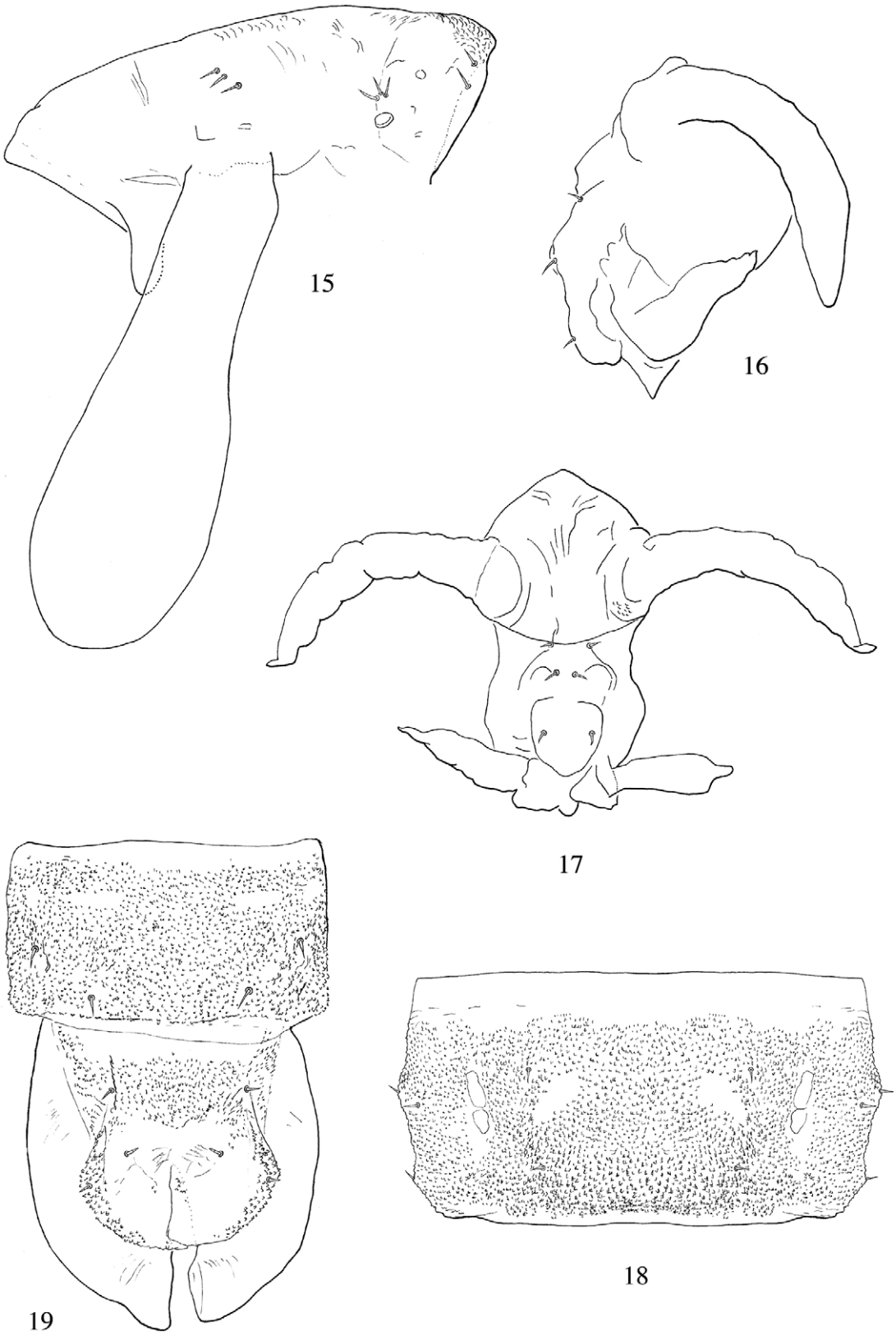
FIGURES 1–6. *Bryophaenocladius chrissichuckorum* **sp. nov.**, male. 1: head and thorax, lateral (holotype); 2: antenna; 3: frontal view of head; 4: tentorium, stipes and cibarial pump; 5: maxillary palpomere 3; 6: wing.



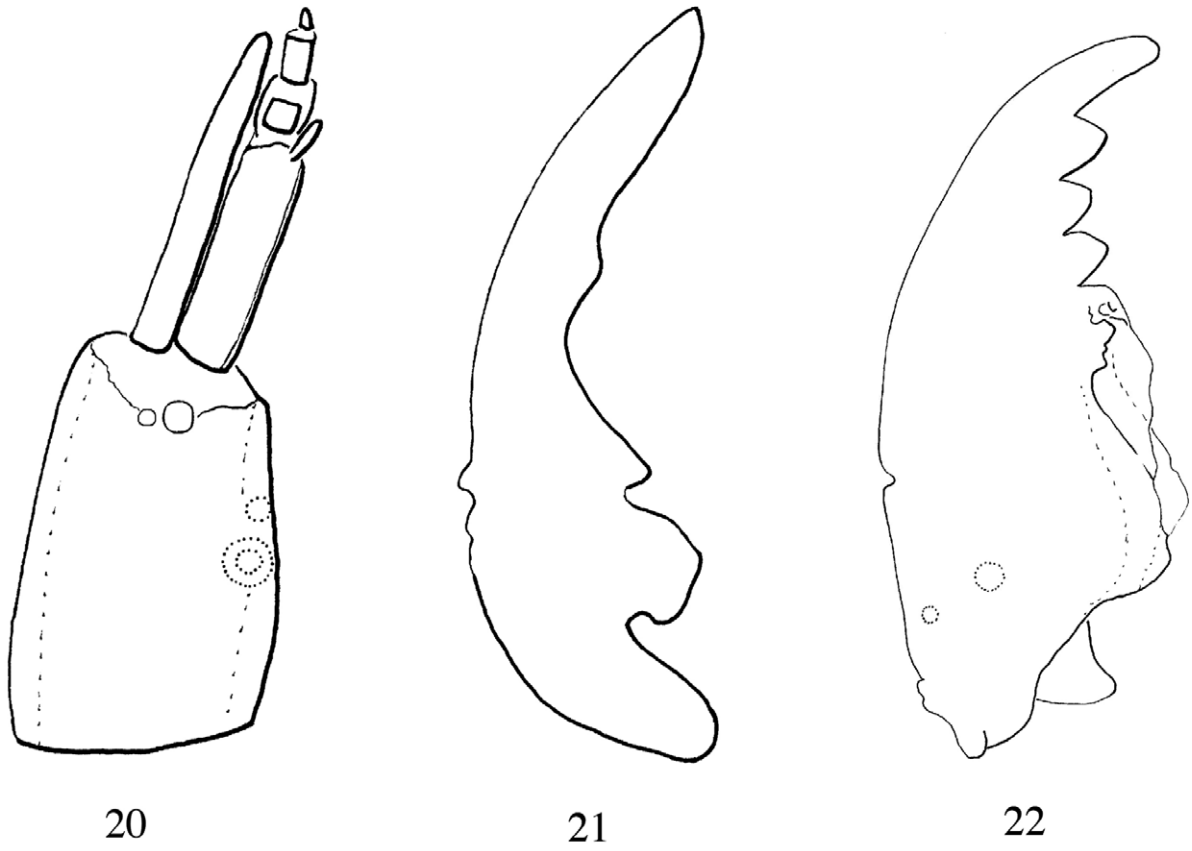
FIGURES 7–9. *Bryophaenocladius chrissichuckorum* **sp. nov.**, male. 7: fore tibia, apex; 8: hind tibia, apex; 9: legs, left to right: fore leg, mid leg, hind leg.



FIGURES 10–14. *Bryophaenocladius chrissichuckorum* **sp. nov.**, genital structures. 10: male hypopygium; 11: apex of gonostylus; 12: female genitalia, ventral; 13: apodeme lobe; 14: female apical tergites, dorsal.



FIGURES 15–19. *Bryophaenocladius chrissichuckorum* **sp. nov.**, pupa. 15: thorax, lateral; 16: head, lateral; 17: frontal apotome and prefrons; 18: tergite III; 19: tergite VIII and anal lobe.



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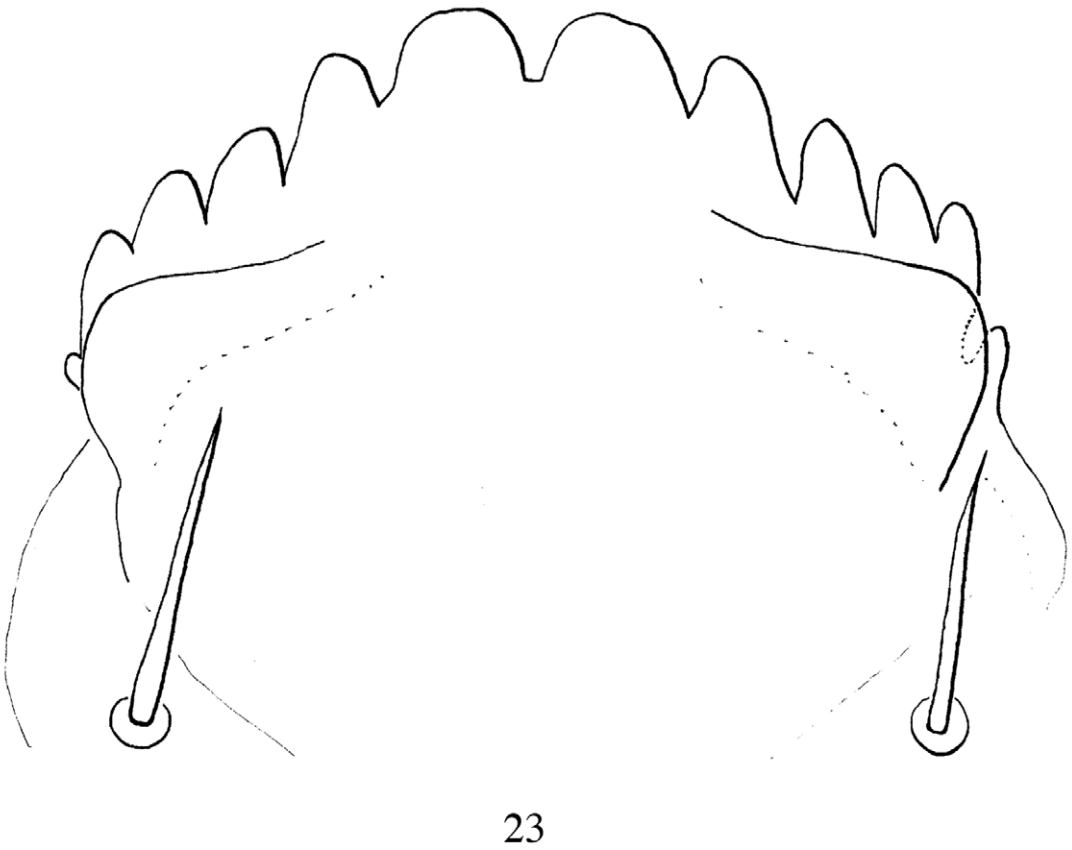

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FIGURES 20–23. *Bryophaenocladius chrissichuckorum* **sp. nov.**, larva. 20: antenna, 21: premandible, 22: mandible, 23: mentum.

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FIGURES 24–28. *Bryophaenocladius chrissichuckorum* **sp. nov.** and its habitat. 24: Heggie's Rock, 17 March 2008 (reddish areas are shallow pools filled with *Diamorpha smallii*); 25: adult male (note hypopygium inversum); 26: "mating ball" of males surrounding female; 27: male and female in copula; 28: male copulating with female pupa (the pupa is on its dorsum). All photographs by Giff Beaton.

Etymology. the name *chrissichuckorum* is an anagram for Christiane ("Chrissie") Scott, and Charles ("Chuck") Scheihing; sister and cousin, respectively, of Susan Lautenbacher, who provided partial funding for this research. It is a noun in the genitive case.

Type material. Holotype male (undissected, but cleared, slide-mounted (Euparal) specimen): U.S.A., Georgia, Columbia County, Heggie's Rock Preserve (The Nature Conservancy), 33.543472˚N, 82.255768˚W, 8.xii.2010; leg. Giff Beaton, Malcolm Hodges. Paratypes: 4 males, 4 females, 1 female pupa, same data as holotype. Additional paratypes: 80 males, 48 females, 24 male pupae, 70 female pupae, 28 male Pex, 47 female Pex, 71 larvae and 45 Lex: U.S.A., Georgia, Columbia County, Heggie's Rock Preserve, 5.xii.1997, leg. J.D. Spooner.

Remarks. *Bryophaenocladius chrissichuckorum* adults display several character states that are often present in ground-dwelling flies - reduced antennae (in the male), strongly reduced wings, an obsolete scutellum, long legs and a hypopygium inversum. Antennae of males and females have 5–6 flagellomeres. In males the ultimate and penultimate antennomeres are sometimes partially fused; one specimen was examined with only 2 antennomeres; this resulted in an AR of 0.86; otherwise the AR range ran from 0.34 to 0.55. In females the basal 2 flagellomeres are sometimes fused, or the ultimate and penultimate antennomeres are sometimes partially fused. Maxillary palpomeres 3 and 4 may be fused. In a female with palpomeres 3 and 4 fused, the total length of the two was 0.95 µm. The scutellum is very reduced, indicated by a swollen saddle-like area, and appears similar, but more reduced, to that illustrated for brachypterous *Diamesa leona* Roback by Hansen & Cook (1976: Fig. 76). What I have interpreted as the pleural wing process, located on the thorax at the base of the wing, is well developed, bearing from one to three minuscule setae (Fig. 1).

Male pupal antennal sheaths are reduced in accordance with the shortened, female-like antennae, but wing sheaths of males and females are fully developed, despite the adult brachyptery. The prefrons bears 3 pairs of very small setae, unknown in other species of *Bryophaenocladius*. Larvae appear to be typical *Bryophaenocladius*.

Natural history. The following information is taken from notes supplied by Dr. John D. Spooner, Giff Beaton and Malcolm Hodges.

Bryophaenocladius chrissichuckorum is currently known only from several small ephemeral pools on Heggie's Rock. Heggie's Rock is an area protected by The Nature Conservancy, with an approximate area of 57 hectares. It is one of several outcrops of porphyritic granite associated with the Appling pluton, an oval formation about 11 km by 6 km entirely within Columbia County, Georgia, U.S.A. It is the only large outcropping of this formation that has not been quarried; note that the midge was observed at neighboring rocks outcrops in the past, but these have been developed or quarried and it is unknown whether they still exist there. The outcrop is a mosaic of lichen- and moss-covered rock and shallow-soil woodlands dominated by *Juniperus virginiana* L., *Pinus taeda* L., *Quercus nigra* L. and *Ulmus alata* Michx., with well developed shrub and herb layers dominated by *Forestiera ligustrina* (Michx.) Poir, *Andropogon virginicus* L. and *Danthonia spicata* (L.) P. Beauv. ex Roem. & Schult.

Several shallow pools of water, termed "dish gardens", are present on Heggie's Rock (Fig. 24); the pools are ephemeral and dry for long periods in the Summer and Fall. These pools are home to endangered plants such as pool sprite (*Amphianthus pusillus* Torrey) and the mat-forming quillwort (*Isoetes tegetiformans* Rury), which grows in only one pool at the site. Also found in the pools are elf orpine (*Diamorpha smallii* Britton) and Piedmont quillwort, *Isoetes piedmontana* (N. E. Pfeiffer) C. F. Reed. *Bryophaenocladius chrissichuckorum* larvae are detritus feeders on the pool bottoms where they form detritus tubes in which they live.

Adult *B. chrissichuckorum* emerge during a 6–8 week period from mid November to mid January; they emerge from different pools at different times. Since the pools are ephemeral, mating may be timed with rainfall events. Adults were found in pools with water and in pools that were mostly dried up, with little but damp soil remaining. Males tend to emerge before females. Emergence was observed on a cloudy day with the air temperature below 0˚ C, with adults moving swiftly over the rock and water surfaces. Males circle around pre-emergent females and may form a ball around a female (Fig. 26). Mating begins with the male on top; once the female is clasped with the male genitalia, the male twists around to face the opposite direction and the hypopygium inverts (Fig. 27). Post-copulatory males end up with the hypopygium permanently inverted (Fig. 25). Males will attempt copulation with pre-emergent female pupae (Fig. 28). Unmated males were often observed trying to mount other males.

Acknowledgements

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