

First description of the pupa and male of the Neotropical predatory midge *Pellucidomyia oliveirai* (Lane) (Diptera: Ceratopogonidae)

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Abstract – The pupa and reared adult male of the Neotropical predatory midge *Pellucidomyia oliveirai* (Lane) are described, photographed and illustrated for the first time. The genus *Pellucidomyia* Macfie is reported for the first time from Argentina, and the adult female is redescribed and photographed. A key is provided for the three known species of pupae of *Pellucidomyia*. Details of the bionomics of all the species of *Pellucidomyia* are discussed and their distributions plotted on a world map.

Key words: *Pellucidomyia* / Heteromyiini / pupa / adult / Neotropical

Introduction

The biting midges of the family Ceratopogonidae are a large, relatively well studied group of Culicomorpha. Many new species of Ceratopogonidae are being described annually, and 6267 extant species included in 111 genera (Borkent, 2016) are currently known. However, Borkent and Spinelli (2007) estimated that approximately 15000 species of biting midges likely inhabit the World.

The predatory genus *Pellucidomyia* Macfie (tribe Heteromyiini; subfamily Ceratopogoninae) is mostly known from the southern hemisphere. The immature stages live in aquatic habitats, such as ponds, various types of wetlands, and the margins of streams and lakes. This genus includes only nine species (Borkent, 2016) in the Nearctic, Neotropical, Afrotropical and Australian regions. Four of these species inhabit the Neotropical region: *P. oliveirai* (Lane) from Mato Grosso and Minas Gerais states, Brazil; *P. blantoni* (Lane) from Panama, *P. lanei* Wirth and Ratanaworabhan from Colombia and Jamaica, and *P. wirthi* (Lane), which also inhabits the Nearctic region in southern Texas, USA and Mexico south to Colombia. At present, pupae are only known of two species, *P. geari* (de Meillon and Wirth) from South Africa, and *P. leei* Wirth from Australia, and larvae are only known of *P. leei*.

In this paper, we provide the first descriptions of the pupa and adult male of *P. oliveirai* from specimens recently collected in Corrientes Province, Argentina.

Material and methods

Four pupae of *P. oliveirai* were collected during autumn 2012 with a metallic sieve placed in a white tray to extract specimens from a large pond with macrophytes from the Estación Biológica Corrientes (EBCo), Corrientes Province, Argentina. Pupae were collected with a pipette, transported to the laboratory, placed in individual vials with water, and observations were made daily until adult emergence. Adults were kept alive for 24–48 h to allow sclerotization and pigmentation of their exoskeletons, and they were preserved in 70–75% ethanol.

Specimens were slide-mounted in Canada balsam following the techniques described by Borkent and Spinelli (2007). Measurements of pupae were obtained with a micrometre in an eyepiece of a Nikon Eclipse E200 compound microscope, and illustrations were prepared with the aid of an attached camera lucida. Photographs were taken with a digital camera, Micrometrics SE Premium attached to the compound microscope. The terminology for morphological structures of pupae follows Borkent (2014), whereas terms for adults follow Borkent et al. (2009). The map was traced from Google Earth and

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kept in KLM format, and the format was converted to figures through a GPS Visualizer site. All specimens are deposited in the collection of the División Entomología, Museo de La Plata, Argentina (MLPA).

Results

Pellucidomyia oliveirai (Lane) (Figures 1–30)

Macfiehelea oliveirai Lane, 1946: 209 (female, Brazil).

Pellucidomyia oliveirai: Wirth, 1960: 3 (combination); Borkent and Wirth, 1997: 114 (in World catalog); Borkent and Spinelli, 2000: 57 (in New World catalogue south of the USA); Borkent and Spinelli, 2007: 89 (in Neotropical catalog); Borkent, 2016: 146 (in online World catalog).

Specimens examined: Argentina, Corrientes prov., Estación Biológica Corrientes (EBCo), 27°32'50.5"S, 58°40'49.5"W, elevation 53 m., 30-III-2012, Díaz-Marino col., 1 male with pupal exuvium, 2 females with pupal exuviae, 1 male pupal exuvium.

Diagnosis: *Male adult:* The only species of *Pellucidomyia* with femora and tibiae dark brown except basal 1/2 of hind femur slightly paler; base of midtibia and proximal 3/4 of hind tibia with pale band; and parameres fused with a bulbous apex. *Female adult:* the only species of *Pellucidomyia* with femora and tibiae dark brown except bases of tibiae with a narrow pale band (best developed on hind leg). Pupa: the only species of *Pellucidomyia* with setae of cephalothorax and abdomen branched and tergite 1 without sensillum D-9-I.

Female pupa (Figs. 1–7 and 21–23). Exuviae brown. Antennal flagellum (Fig. 1) adpressed against lateral margin of midleg, wing. Ecdysial tear around base of antenna, with narrow connection between frons and base of antenna. Total length 2.65–2.73 (2.69, $n = 2$) mm.

Head: Dorsal apotome missing. Mandible well developed, lacinia absent; palpus stout, extending to posterolateral margin of labium; labium separated medially by labrum. Apex of antennal flagellum extending posteriorly to midlength portion of midleg (lateral portion of mesosternum). Sensilla: dorsolateral cephalic sclerite sensilla DL-1-H stout, short seta, DL-2-H campaniform sensillum (Figs. 2 and 21); clypeal/labral: CL-1-H, CL-2-H branched, long, moderately thick setae (Fig. 4); CL-1-H longer than CL-2-H; oculars O-1-H and O-3-H, long thin setae, O-3-H longer than O-1-H; O-2-H campaniform sensillum (Fig. 4). Cephalothorax rectangular, surface smooth, length 1.17–1.20 (1.18, $n = 2$) mm, width 0.85–0.87 (0.86, $n = 2$) mm.

Thorax: Prothoracic extension wide, well developed, narrow dorsolaterally; respiratory organ (Figs. 1–3 and 21) brown, funnel-shaped, moderately elongate, straight, with 40–50 apical pores, arranged in single circular row; surface smooth; ROL 0.24 ($n = 2$) mm, ROW 0.05 ($n = 2$) mm, without pedicel. Sensilla as follows: 3 anteromedials AM-1-T, AM-2-T branched, long setae, AM-1-T longer than AM-2-T, AM-3-T campaniform sensillum (Figs. 2–3 and 21); anterolateral AL-1-T long,

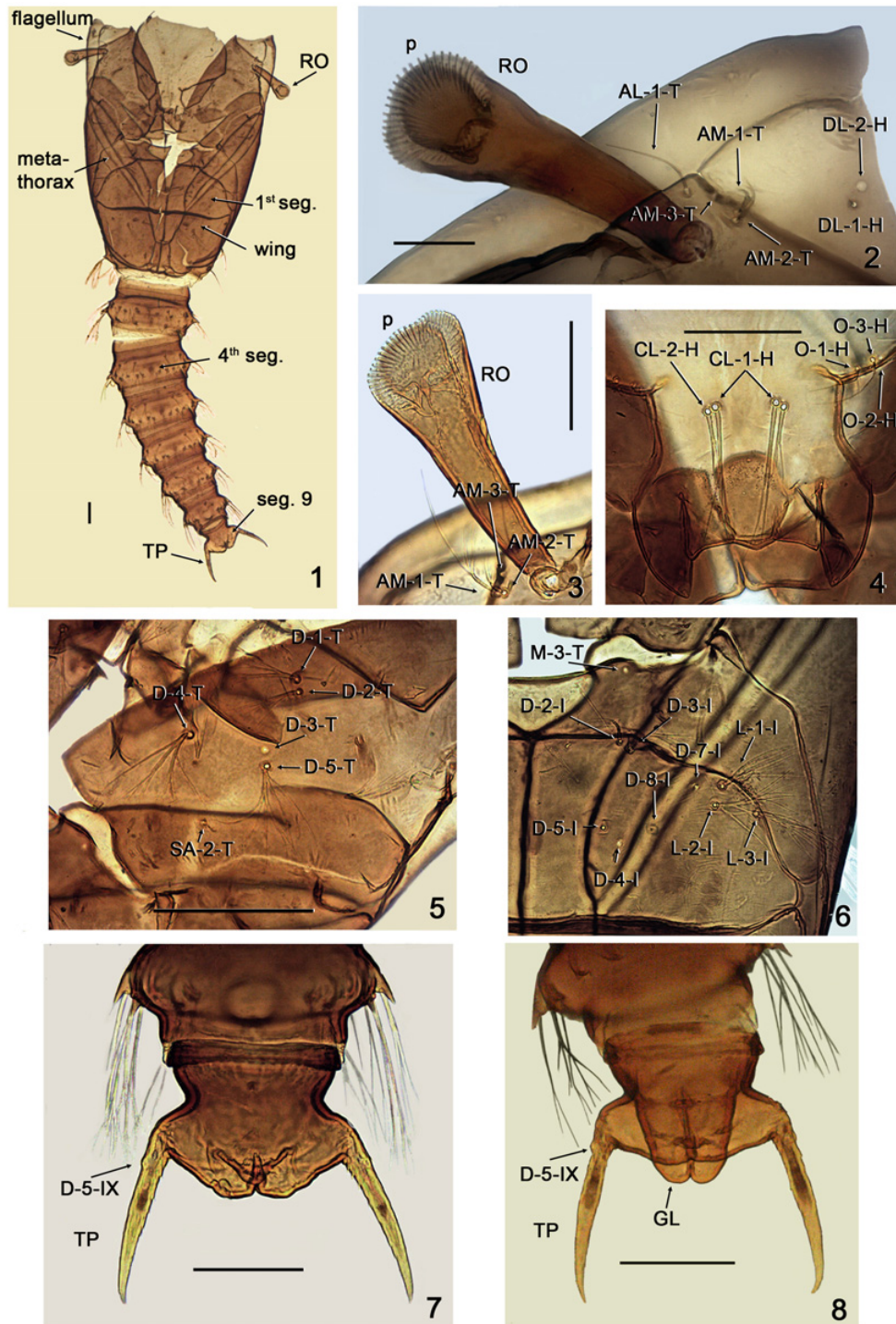
thin seta (Figs. 2 and 21); 5 dorsal setae (Fig. 5) D-1-T, D-2-T, D-4-T, D-5-T branched, long, hyaline setae, D-3-T campaniform sensillum; D-1-T, D-2-T on single tubercle, D-3-T posterior to D-4-T; supraalar SA-2-T campaniform sensillum (Fig. 5); metathoracic M-3-T campaniform sensillum, near anterior margin of metathorax (Fig. 6). **Abdomen:** Abdominal segments smooth with branched setae, tergite of segments 1–7 with medial brown spot, segment 8 with pale spot, segment 9 without spot. Sensilla: tergite 1 (Fig. 6) with 7 setae, 2 campaniform sensilla, as follows: two anterior setae, D-2-I, D-3-I long, branched, stout setae, D-4-I, D-7-I campaniform sensilla, D-5-I, D-8-I branched setae, L-1-I, L-2-I, L-3-I branched, stout setae, each on single tubercle; segment 2 similar to 1 except for D-9-I which is a long, thin seta; segment 4 with sensillar pattern (Figs. 1 and 23) as follows: D-2-IV, D-3-IV, D-5-IV, D-8-IV branched setae, D-4-IV, D-7-IV campaniform sensilla, D-9-IV long, thin seta on small tubercle, D-8-IV, D-9-IV on separated but closely approximated tubercles; L-1-IV, L-2-IV, L-3-IV, L-4-IV long, stout setae, branched, L-1-IV longer than other three setae, each located on stout triangular tubercle, V-5-IV, V-6-IV, V-7-IV branched setae, V-5-IV, V-6-IV each on stout prominent tubercles, V-7-IV on rounded tubercle; V-6-IV, V-7-IV closely approximated. Segment 9 (Figs. 1 and 7): ventral surface with few wrinkles on anterior margin, length 0.26–0.27 (0.265, $n = 2$) mm, width 0.16 ($n = 2$) mm; terminal processes (Figs. 1 and 7) greatly elongate, very slender, spiculate, tip pointed, D-5-IX, D-6-IX campaniform sensilla present; length 0.16 ($n = 2$) mm.

Male pupa (Figs. 8 and 22). Similar to female with the usual sexual differences. Total length 2.64 mm. Exuvium brown. Respiratory organ, ROL 0.210–0.225 (0.217, $n = 2$) mm, ROW 0.042–0.045 (0.043, $n = 2$) mm; without pedicel. Cephalothorax length 1.14 mm, width 0.84 mm; metathoracic M-3-T and tergite 1 as in Fig. 22. Segment 9 (Fig. 8) apically truncate, genital lobe extending posteriorly well beyond posterior margin of segment, length 0.20–0.24 (0.22, $n = 2$) mm, width 0.11–0.12 (0.115, $n = 2$) mm; terminal processes (Fig. 8) widely spaced, greatly elongate, very slender, tip pointed, D-5-IX and D-6-IX present.

Male adult (Figs. 9–13 and 24–26).

Head (Fig. 9): Brown. Eyes broadly separated. Antennal pedicel dark brown, flagellomeres brown except bases of 2–11 yellowish brown; flagellomeres 1–10 vasiiform, 11–13 elongate; antennal ratio 0.77. Clypeus with two pairs of setae. Palpus (Fig. 10) short; segment 3 without pit; palpal ratio 1.75. Mandible with two very small, apical teeth.

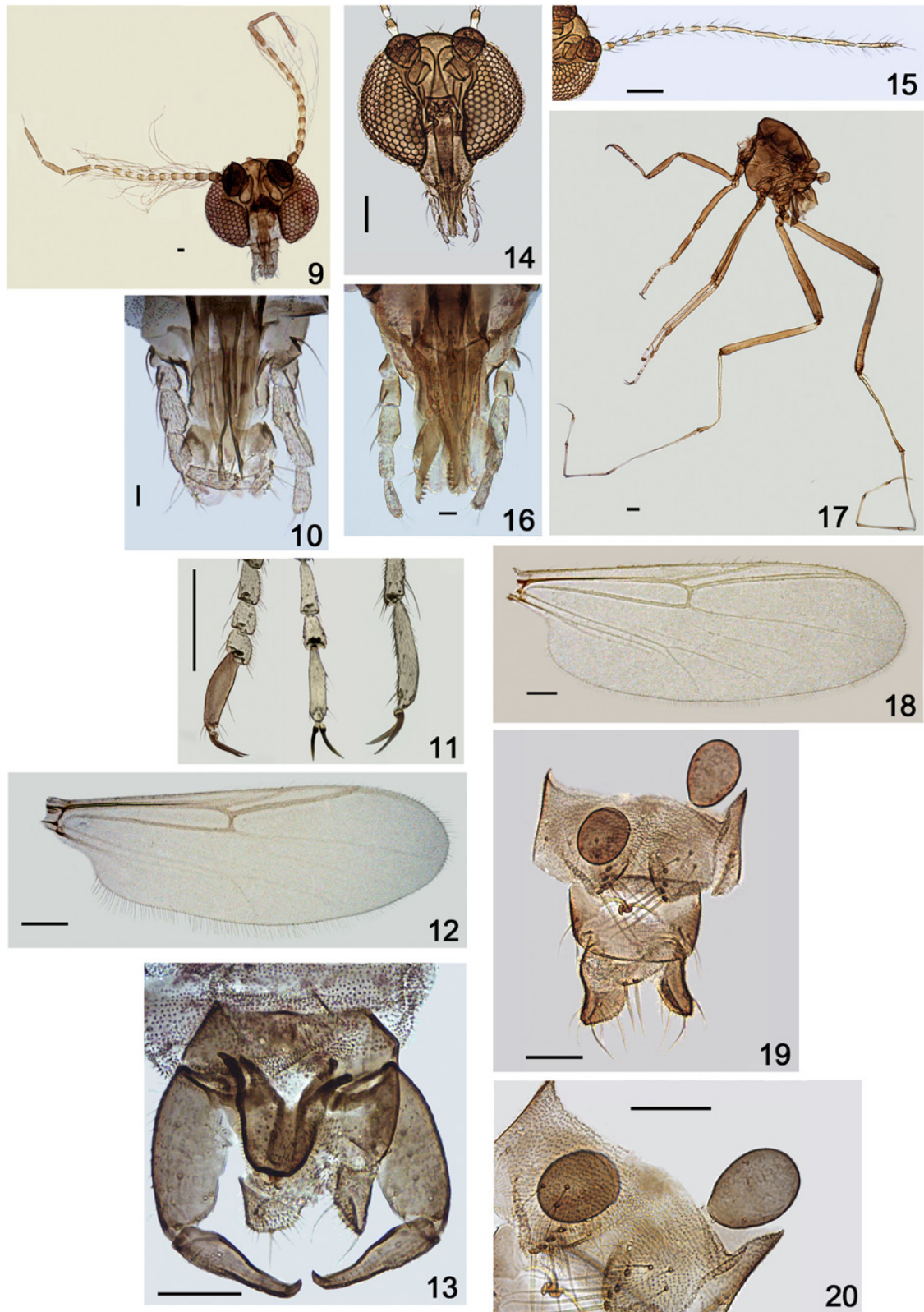
Thorax: Dark brown. Scutum without anterior tubercle, sparsely covered with stout setae; scutellum with six large setae. Legs dark brown, basal 1/2 of hind femur slightly paler; base of midtibia, basal 3/4 of hind tibia with pale band; tarsi pale except fore tarsomere 5 infuscated; hind tibial comb with three large setae, the outer two, stouter; prothoracic TR 2.67, mesothoracic TR 2.22, metathoracic TR 1.87; ventral palisade setae in one



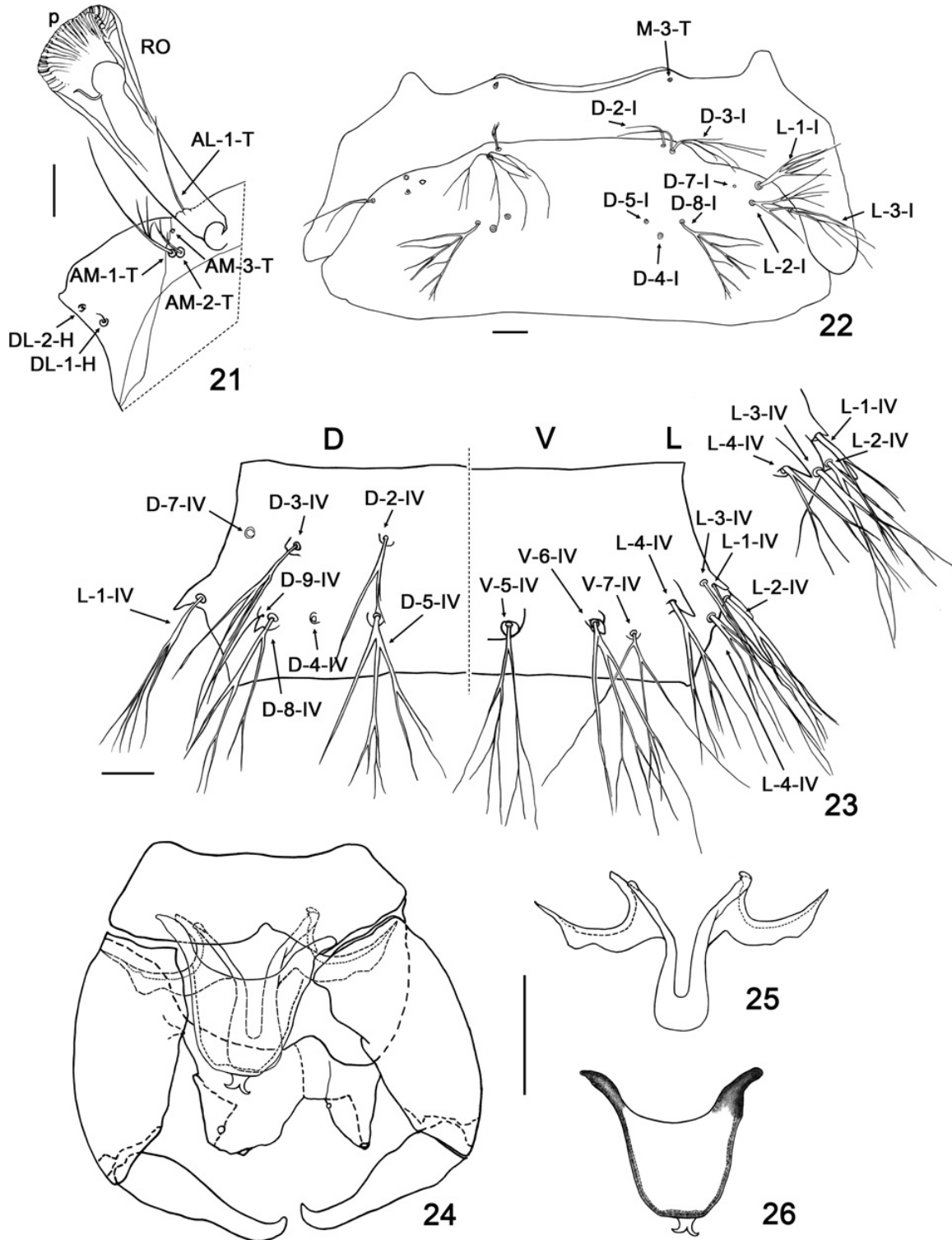
Figs. 1–8. *Pellucidomyia oliveirai* (Lane), pupa. 1–7. female pupa; 8. male pupa. 1. Entire pupa (dorsal view); 2. cephalothoracic sensilla (dorsal view, right side); 3. respiratory organ (right side); 4. clypeal/labral sensilla and ocular sensilla (ventral view); 5. dorsal sensilla (dorsal view); 6. metathorax and tergite 1 (dorsal view); and 7–8. segment 9 (ventral view). Abbreviations: AL-1-T, anterolateral sensillum; AM-1-T, AM-2-T, AM-3-T, anteromedial sensilla; CL-1-H, CL-2-H, clypeal/labral sensilla; D-1-T, D-2-T, D-3-T, D-4-T, D-5-T, dorsal sensilla; D-2-I, D-3-I, D-4-I, D-5-I, D-7-I, D-8-I, L-1-I, L-2-I, L-3-I, tergite 1 sensilla; DL-1-H, DL-2-H, dorsolateral cephalic sclerite sensilla; GL, genital lobe; M-3-T, metathoracic campaniform sensillum; O-1-H, O-2-H, O-3-H, ocular sensilla; p, pores; RO, respiratory organ; SA-2-T, supraalar campaniform sensillum; TP, terminal process. Scale bars: 0.05 mm.

row on tarsomere 1, tarsomere 4 of fore, midlegs subcylindrical, tarsomere 5 of foreleg swollen, claws equal-sized (Fig. 11), longest on foreleg, with bifid tips.

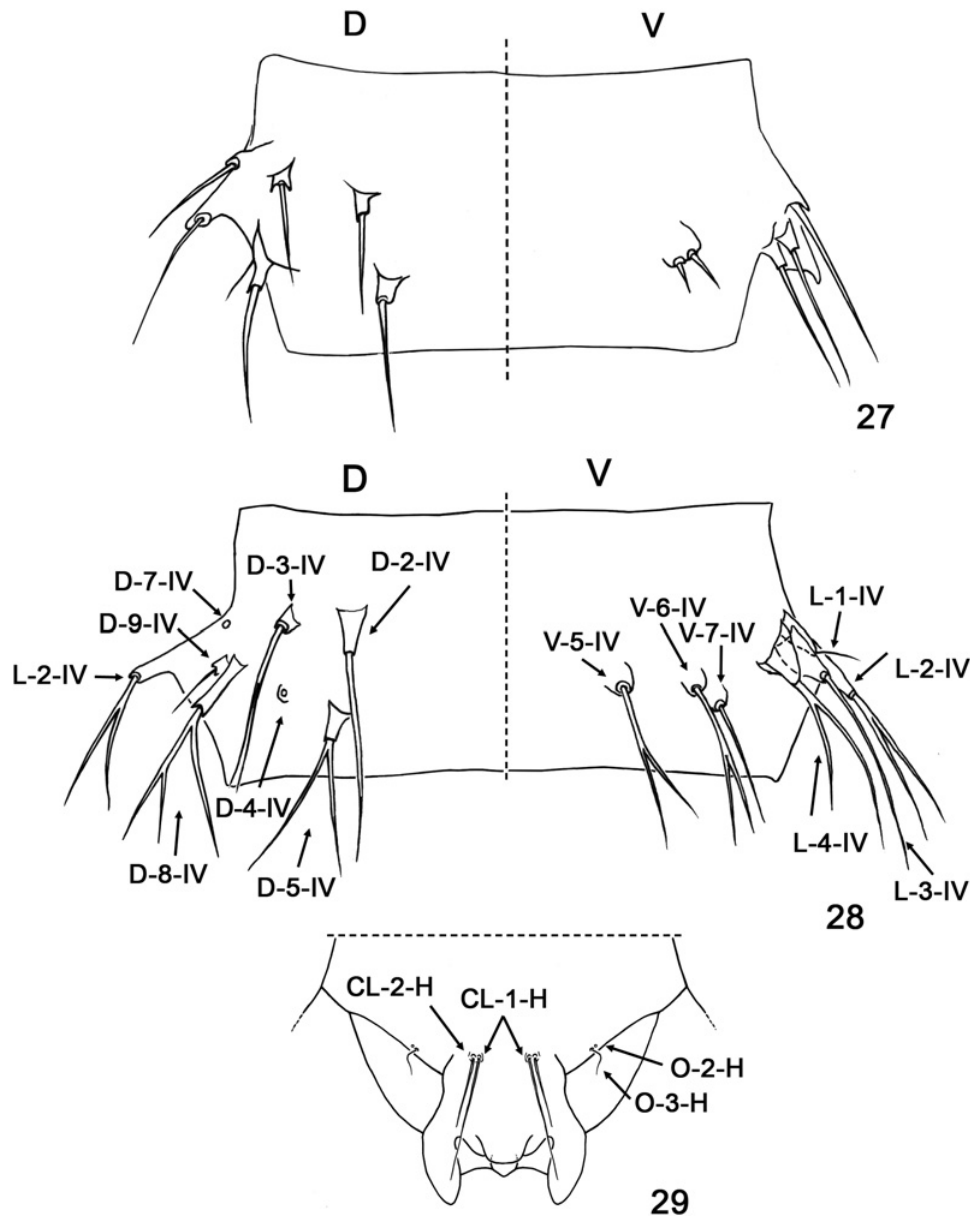
Wing (Fig. 12) with anterior veins brown, posterior veins lighter brown; wing length 0.98 mm, breadth 0.34 mm; costal ratio 0.78. Halter dark brown.



Figs. 9–20. *Pellucidomyia oliveirai* (Lane), adult. 9–13. male; 14–20. female. 9, 14. Head; 10, 16. palpus and manible; 11. claws of fore, mid and hind legs; 12, 18. wing; 13. genitalia; 15. flagellum; 17. thorax; 19. tip of abdomen; and 20. spermathecae. Scale bars: 0.05 mm.



Figs. 21–26. *Pellucidomyia oliveirai* (Lane), pupa, adult male. 21, 23. female pupa, 22. male pupa; 24–26. male adult. 21. Cephalothoracic sensilla (dorsal view) and respiratory organ (right side); 22. metathorax and tergite 1 (dorsal view); 23. segment 4; 24. genitalia; 25. parameres; and 26. aedeagus. Scale bars: 0.05 mm. Abbreviations: AL-1-T, anterolateral sensillum; AM-1-T, AM-2-T, AM-3-T, anteromedial sensilla; D-2-I, D-3-I, D-4-I, D-5-I, D-7-I, D-8-I, L-1-I, L-2-I, L-3-I, tergite 1, chaetotaxy; DL-1-H, DL-2-H, dorsolateral cephalic sclerite sensilla; D-2-IV, D-3-IV, D-4-IV, D-5-IV, D-7-IV, D-8-IV, D-9-IV, L-1-IV, L-2-IV, L-3-IV, L-4-IV, V-5-IV, V-6-IV, V-7-IV, segment 4, chaetotaxy; RO, respiratory organ.



Figs. 27–29. *Pellucidomyia geari* (de Meillon and Wirth), male pupa (modified from de Meillon and Wirth, 1981) and 28–29. *Pellucidomyia leei* Wirth, female pupa (from Borkent, 2014). 27–28. Segment 4, chaetotaxy; and clypeal/labral sensilla and ocular sensilla (ventral view). Abbreviations: D-2-IV, D-3-IV, D-4-IV, D-5-IV, D-7-IV, D-8-IV, D-9-IV, L-1-IV, L-2-IV, L-3-IV, L-4-IV, V-5-IV, V-6-IV, V-7-IV, segment 4, chaetotaxy; O-2-H, O-3-H, ocular sensilla. Scale bars: 0.05 mm.

Abdomen: Brown. Genitalia (Figs. 13 and 24–26) brown. Tergite 9 broad, tapering gradually distally, distal margin extending to midlength of gonocoxite, posterior margin with medial notch; cercus elongate. Sternite 9 0.2 length of greatest width, posterior margin with narrow shallow excavation. Gonocoxite $2.25 \times$ longer than broad, with small mesobasal pointed tubercle; gonostylus stout, $0.8 \times$ length of gonocoxite, distal 1/3 tapered with recurved pointed tip. Parameres (Fig. 25) separate basally and proximal 2/3 of distal portion, apical 1/3 broadly fused, basal arms articulated with stout arcuate gonocoxal apodemes, apex bulbous. Aedeagus (Fig. 26)

tapering gradually distally, apex rounded with short appendage that is bifurcate, each half greatly divergent; basal arch concave, extending 0.45 of total aedeagus length, basal arms heavily sclerotized.

Female adult (Figs. 14–20).

Head (Fig. 14): Dark brown. Antennal flagellum (Fig. 15) with flagellomeres brown, bases yellowish; flagellomeres 9–13 elongate; antennal ratio 1.52. Clypeus with three pairs of setae. Palpus (Fig. 16) brown, short; segment 3 shorter than 4 + 5 combined, with three mesal capitate sensilla; palpal ratio 1.89–1.90 (1.89, $n = 2$). Mandible (Fig. 16) well developed with 10–11 large teeth.

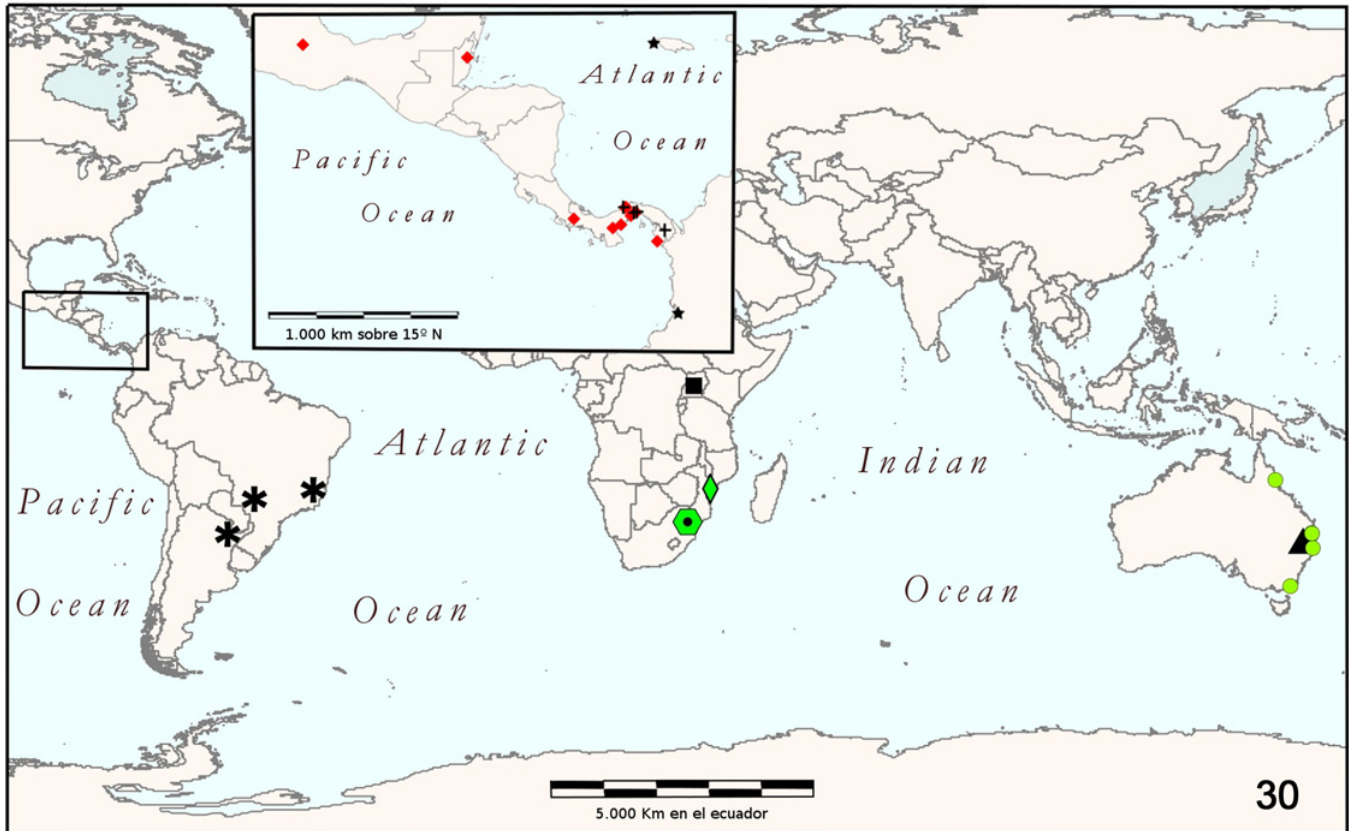


Fig. 30. World distribution map of species of *Pellucidomyia*: + *P. blantoni* (Lane); ▲ *P. dycei* Debenham; ◆ *P. geari* (de Meillon and Wirth); ★ *P. lanei* Wirth and Ratanaworabhan; ● *P. leei* Wirth; * *P. oliveirai* (Lane); ◆ *P. sambulena* (de Meillon); ■ *P. ugandae* Macfie; ◆ *P. wirthi* (Lane).

Thorax (Fig. 17): Dark brown. Scutellum with 8–10 large setae. Legs dark brown, bases of tibiae with narrow pale band, band more evident on hind leg; hind tibial comb with 4 spines, outer two longest; tarsomeres pale except foretarsomere 5, midtarsomere 1 infuscated, hind tarsomeres with bases, apices darker; prothoracic TR 2.86, mesothoracic TR 2.58, metathoracic TR 0.95; palisade setae in two rows on tarsomeres 1–2 of midleg, in one row on tarsomere 1 of hind leg; claws equal on fore, midleg, hind leg with single claw that is shorter than tarsomere 5. Wing (Fig. 18) membrane lightly infuscated, anterior veins brown, posterior veins lighter brown; wing length 1.46 mm ($n = 2$), breadth 0.50–0.52 (0.51, $n = 2$) mm; costal ratio 0.90–0.93 (0.92, $n = 2$). Halter dark brown.

Abdomen: Brown, pleurae darker brown. Genitalia as in Fig. 19. Sternite 8 with 3–4 pairs of stout setae. Two large, globose, slightly unequal spermathecae (Fig. 20) without necks, measuring 80–90 (85, $n = 2$) by 56–60 (58, $n = 2$) μm , and 68–78 (73, $n = 2$) by 50–52 (51, $n = 2$) μm ; and a small rudimentary 3rd spermatheca with recurved neck.

Distribution: Brazil (Mato Grosso and Minas Gerais states) and Argentina (Corrientes province) (Fig. 30).

Discussion

Borkent (2016) listed four species of *Pellucidomyia* in the Neotropical region: *P. oliveirai* (Lane), *P. blantoni* (Lane), *P. lanei* Wirth and Ratanaworabhan and *P. wirthi* (Lane), which also ranges north into the Nearctic region in Mexico and southern Texas; three species in the Afrotropical region: *P. geari* (de Meillon and Wirth), *P. sambulena* (de Meillon) and *P. ugandae* Macfie, and two species in the Australian region: *P. dycei* Debenham and *P. leei* Wirth (Fig. 30).

Species of *Pellucidomyia* primarily inhabit tropical regions. The absence of records in most of the Nearctic and Palearctic is likely legitimate considering the extensive general collecting carried out in both regions. Therefore, it is highly likely that *Pellucidomyia* is pan-tropical. The tropical areas of the Oriental region are less well known and it will be interesting to see whether the genus occurs there or not.

Elson-Harris and Kettle (1986) suggested that in pupae of *Pellucidomyia*, the branched setal arrangement and the apicolateral processes of segment 9 covered with sharp spicules may be a defense mechanism to ward off predators, and they probably use their elongate terminal

processes to thrust themselves forward against the substrate. Borkent (2014) determined that species of *Pellucidomyia* are the only pupae of Ceratopogonidae with the thorax and abdominal segment 2 markedly broader than segment 3. They are also unique in having an apically truncate segment 9 with very widely spaced, greatly elongate terminal processes, and a respiratory organ with the pores arranged in a nearly complete circle.

We compared the pupa of *P. oliveirai* with that of the Australian species *P. leei* described by Elson-Harris and Kettle (1986). Pupae of *P. leei* differ from those of *P. oliveirai* by the presence of only one ocular sensillum, by dorsal setae D-1-T and D-2-T being simple and D-5-T a campaniform sensillum; by the anterolaterals with one seta and one campaniform sensillum, by three anteromedials with two setae, one simple, another bifid and one campaniform sensillum; by segment 4 with D-2-IV, D-9-IV simple, D-5-IV and D-8-IV are bifid, D-7-IV a campaniform sensillum and D-4-IV absent. However, Borkent (2014) noted marked differences in the ocular setae, dorsal setae and chaetotaxy of segment 4 of *P. leei* as his illustrations depict oculars as two sensilla, D-5-T is a simple seta and D-4-IV is present. The only difference observed between *P. oliveirai* and the illustration of *P. leei* provided by Borkent (2014) is the presence of three oculars, two setae and one campaniform sensillum in *P. oliveirai*. The pupa of the Afrotropical species *P. geari*, was poorly described by de Meillon and Wirth (1981), and therefore, it is not possible to compare it in detail with *P. oliveirai*. However, it is worth noting that the pupa of *P. oliveirai* has long, pointed terminal processes and its male genital lobes extend considerably beyond the posterior margin of segment 9 as in *P. geari*.

Wirth (1960) provided a key to the adult females of the then five known species of *Pellucidomyia*, including *P. oliveirai*. Of the four species of *Pellucidomyia* known from the Neotropical region, only the male of *P. wirthi* was previously known. The male of *P. oliveirai* is easily distinguished from this species by its elongated parameres and the shape of the apex of fused parameres, which are a broadly rounded lobe in *P. wirthi*. The male of the Australian species, *P. leei* Wirth differs from that of *P. oliveirai* by the shape of the distal portion of the fused parameres, which is short and broad, with a slightly excavated distal margin. Finally, the male genitalia of the African species *P. geari* has a similar aedeagus to that of *P. oliveirai* but it can be distinguished from the latter species by its narrow parameres and the heavily sclerotized recurved tip of the gonostylus.

Key to pupae of *Pellucidomyia*

- (1) Abdominal segment 4 with simple setae (Fig. 27) *P. geari* (de Meillon and Wirth)
 - Abdominal segment 4 with bifurcating setae 2;

- (2) Abdominal segment 4 with setae D-3-IV, D-5-IV, D-8-IV, L-2-IV, L-4-IV, V-5-IV, V-6-IV bifurcating once; D-2-IV, L-3-IV elongate, simple; D-9-IV, L-1-IV short, thin simple; V-7-IV medium-sized, simple (Fig. 28); two ocular setae (Fig. 29) *P. leei* Wirth
 - Abdominal segment 4 with setae D-2-IV, D-3-IV, D-5-IV, D-8-IV, L-1-IV, L-2-IV, L-3-IV, L-4-IV, V-5-IV, V-6-IV, V-7-IV branched; D-9-IV elongate, thin simple (Fig. 23); three ocular setae (Fig. 4).....*P. oliveirai* (Lane).

Bionomics: Pupae were collected on March 30, 2012 from a large pond with abundant floating macrophytes, in water with a pH of 6–7, an ambient air temperature of 20 °C and 85% humidity. When pupae were removed from the aquatic mats and placed in water in white buckets without any vegetation, they moved actively. Pupae were collected with those of *Bezzia nobilis* (Winnertz). In the laboratory, at 18–21 °C, adult *P. oliveirai* emerged after five days of pupation. The pupae of other species of *Pellucidomyia* were collected in different habitats: *P. leei* in a rocky outcrop in the centre of a fast flowing stream section (Elson-Harris and Kettle, 1986) and, *P. geari* from along the margin of a water storage dam (de Meillon and Wirth, 1981).

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