

LARVAL MORPHOLOGY OF *YOLA* GOZIS, 1886 (COLEOPTERA: DYTISCIDAE: BIDESSINI) AND COMPARISON WITH OTHER GENERA OF THE TRIBE BIDESSINI

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ABSTRACT

The second and third instars of *Yola wraniki* Wewalka, 2004 are described and illustrated for the first time, with detailed morphometric and chaetotaxic analyses of the cephalic capsule, head appendages, legs, last abdominal segment, and urogomphi. The mature larva of *Yola* Gozis, 1886 can be distinguished from those of the other known Bidessini genera by the following combination of morphometric and chaetotaxic characters: ratio length of metathoracic leg/head width greater than 2.85; ratio length of urogomphus/head width greater than 2.70; absence of a ventroapical spinula on third antennomere; secondary temporal spine-like setae on parietale; natatory setae on tibia; secondary posteroventral setae on tarsus and secondary setae on urogomphus; presence of pore PAK and secondary dorsal setae on protarsus; and mandibular pore MNa located in a clearly distal position with respect to pore MNb. A key for the identification of the third instars of the genera of Bidessini known in detail is provided.

Key Words: diving beetle, Hydroporinae, *Yola wraniki*, morphometry, chaetotaxy, key

The Bidessini (Dytiscidae) are a speciose group of small diving beetles consisting of 45 genera and some 676 species (Nilsson 2015). In spite of its great diversity, the larval morphology of members of this tribe remains poorly known (Michat and Alarie 2006; Michat and Torres 2013 and references therein), with larvae of most genera unknown to science.

The present study focuses on the larvae of *Yola* Gozis, 1886, a genus of 47 species occurring in the Afrotropical, Oriental, and Palearctic regions (Biström 1983; Bilton 2015; Nilsson 2015). Larval morphology of *Yola* is practically unknown, except for a very succinct description of the larva of *Yola bicarinata* (Latreille, 1804) by Bertrand (1935, 1972), which refers to general morphological features and does not consider chaetotaxy.

Larvae of the Bidessini are very homogeneous morphologically. Therefore, morphometric and chaetotaxic analyses allow the exploration of additional characters potentially useful for diagnosis of genera and species. In this contribution, we pro-

vide, for the first time, a detailed description of the second and third instars of a species of *Yola* (*Yola wraniki* Wewalka, 2004) in the context of modern descriptions of larvae of this tribe, which incorporate detailed morphometric and chaetotaxic analyses (e.g., Michat and Alarie 2006, 2008; Michat and Torres 2006, 2013; Alarie *et al.* 2007; Michat *et al.* 2010, 2011, 2012). We also compare the larval features of *Yola* with those of other Bidessini genera for which the larvae have been described and present a preliminary key to separate the larvae of Bidessini genera which are known in detail.

MATERIAL AND METHODS

The description provided in this paper is based on two instar II and four instar III specimens collected at the following locality: Yemen, Socotra Island, Al Haghier Mts., Wadi Madar, 1,180–1,230 m, 12/14.XI.2010, 12°33.2'N 54°0.4'E. The larvae were cleared in lactic acid, dissected, and mounted on

glass slides in polyvinyl-lacto-glycerol. Microscopic examination at magnifications up to 1,000X and drawings were made using an Olympus CX31 compound microscope equipped with a camera lucida. Drawings were scanned and digitally inked using a Genius PenSketch tablet. The material is held in the larval collection of Y. Alarie (Laurentian University, Sudbury, ON, Canada) and in the collection of the National Museum (Natural History), Praha, Czech Republic.

The methods and terms used herein follow those employed in previous papers dealing with the larval morphology and chaetotaxy of Bidessini species. The reader is referred to Michat and Alarie (2006, 2008) and Michat and Torres (2006) for a complete list and additional explanations of the terms used in the present study. Whereas represented by instars II and III only, primary sensilla of *Y. wraniki* were tentatively identified by comparison with the Bidessini ground plan wherever possible (e.g., head appendages and legs) (Alarie and Harper 1990; Alarie *et al.* 1990; Alarie 1991; Alarie and Michat 2007). In these cases, homologies were recognized using the criterion of similarity of position (Wiley 1981). Secondary sensilla were also tentatively identified by comparison with

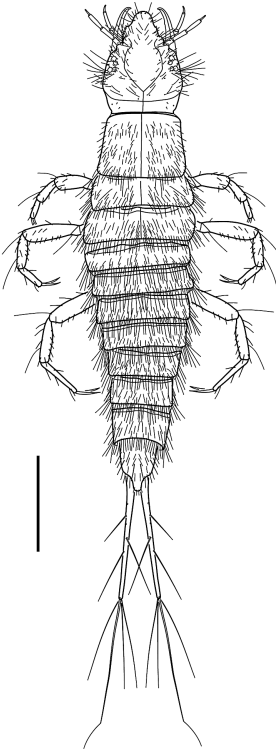


Fig. 1. *Yola wraniki*, instar III. Habitus, dorsal aspect. Scale bar = 0.60 mm.

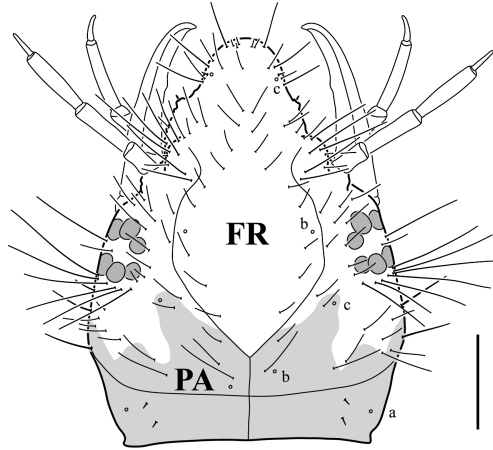


Fig. 2. *Yola wraniki*, instar III. Head, dorsal aspect, showing color pattern on cephalic capsule. Lowercase letters indicate primary pores. FR = frontoclypeus; PA = parietale. Scale bar = 0.15 mm.

the primary sensilla of species of Bidessini (see references above).

RESULTS

Diagnosis. Larvae of *Yola* can be distinguished from those of other Bidessini genera by the following combination of characters: HL = 0.62–0.66 mm (instar III); pore PAk present; lateroventral margin of PA lacking secondary spine-like setae (Fig. 2); A3 lacking a ventroapical spinula (Fig. 4); pore MNa inserted clearly distally to pore MNb (Fig. 5); ratio L3/HW > 2.85 (instar III); tibia lacking natatory setae (Figs. 10–11); secondary setae on dorsal margin of protarsus present (Fig. 10); secondary setae on posteroventral margin of tarsus absent (Fig. 11); ratio U/HW > 2.70 (instar III); U lacking secondary setae (Fig. 12).

Description of Instar III. Head capsule pale yellow except posterodorsal area light brown (Fig. 2); in some specimens, light brown area projecting forward a short distance contiguously with ecdysial line; head appendages pale yellow except mandible light brown; thoracic and abdominal sclerites light brown except anterior half of segment VIII pale yellow; membranous parts creamy white; legs pale yellow; urogomphus light brown.

Body (Fig. 1) subcylindrical, narrowing towards abdominal apex. Measurements and ratios that characterize the body shape are shown in Table 1.

Head capsule (Fig. 2) longer than broad; posterior third with reticulation, more evident ventrally; maximum width posterior to stemmata, lacking neck constriction; occipital suture present; ecdysial line well-marked but anteriorly diffuse, coronal line

Table 1. Measurements and ratios for the second and third instars of *Yola wraniki*. A = antenna; A1–A4 = antennomeres 1–4; A3' = apical lateroventral process of A3; CL = claw; CO = coxa; COL = coronal line length; FE = femur; FRL = frontoclypeal length; HL = head length; HW = head width; LAS = length of last abdominal segment; LP = labial palpus; LP1–LP2 = labial palpomeres 1–2; L1–L3 = legs 1–3; MNL = mandibular length; MNW = mandibular width; MP = maxillary palpus; MP1–MP3 = maxillary palpomeres 1–3; MW = maximum body width; OCW = occipital foramen width; TA = tarsus; TI = tibia; TL = total body length (excluding urogomphi); U = urogomphal length; U1–U2 = urogomphomeres 1–2.

| Measure | Instar II (n = 2) | Instar III (n = 3) | Measure | Instar II (n = 2) | Instar III (n = 3) |
|----------|-------------------|--------------------|------------|-------------------|--------------------|
| TL (mm) | 1.70–2.20 | 3.20–3.70 | MP2/MP1 | 1.25–1.31 | 0.88–1.00 |
| MW (mm) | 0.35–0.45 | 0.60–0.70 | MP2/MP3 | 3.33–3.50 | 2.56–3.13 |
| HL (mm) | 0.47 | 0.62–0.66 | MP/LP | 1.30–1.40 | 1.39–1.49 |
| HW (mm) | 0.34 | 0.46–0.48 | LP2/LP1 | 1.50–1.54 | 1.16–1.29 |
| FRL (mm) | 0.37 | 0.49–0.51 | L3 (mm) | 1.07–1.10 | 1.42–1.49 |
| OCW (mm) | 0.24–0.25 | 0.33–0.37 | L3/L1 | 1.37–1.39 | 1.42–1.47 |
| HL/HW | 1.36–1.38 | 1.30–1.41 | L3/L2 | 1.18–1.19 | 1.19–1.22 |
| HW/OCW | 1.38–1.42 | 1.31–1.40 | L3/HW | 3.17–3.21 | 2.97–3.20 |
| COL/HL | 0.21 | 0.21–0.22 | L3 (CO/FE) | 0.98–1.04 | 0.95–0.97 |
| FRL/HL | 0.79 | 0.78–0.79 | L3 (TI/FE) | 0.71–0.74 | 0.69–0.72 |
| A/HW | 0.69–0.70 | 0.64–0.67 | L3 (TA/FE) | 0.76–0.77 | 0.68–0.70 |
| A3/A1 | 2.25–2.71 | 1.83–2.20 | L3 (CL/TA) | 0.56–0.58 | 0.45–0.48 |
| A3/A2 | 1.38–1.46 | 1.10–1.16 | LAS (mm) | 0.21–0.22 | 0.31–0.32 |
| A4/A3 | 0.42–0.50 | 0.41 | LAS/HW | 0.61–0.65 | 0.64–0.69 |
| A3'/A4 | 0.67–0.75 | 0.78–0.89 | U (mm) | 1.08–1.10 | 1.31–1.34 |
| MNL/MNW | 3.83 | 3.47–3.94 | U/LAS | 4.98–5.29 | 4.17–4.31 |
| MNL/HL | 0.49 | 0.46–0.47 | U/HW | 3.22 | 2.72–2.90 |
| A/MP | 1.12 | 1.09 | U1/U2 | 0.92–1.06 | 0.99–1.05 |

short; occipital foramen broadly emarginate ventrally; posterior tentorial pits visible ventrally; FR elongate, lateral margins sinuate; nasale moderately elongate, subtriangular, rounded apically, markedly sinuate laterally, with 1 small branch at each side; ventrolateral margin with several robust spinulae, ventrodiscal surface with 2 patches of small, slender spinulae; 6 dorsolateral stemmata at each side forming a circle. Antenna elongate (Figs. 3–4), composed of 4 antennomeres, shorter than HW; A1 and A4 shortest, subequal, A2 and A3 longest, subequal; A3 lacking a ventroapical spinula; A3' relatively elongate. Mandible prominent, broad basally, distal half projected inwards and upwards, apex sharp (Fig. 5); mandibular channel present. Maxilla (Figs. 6–7) with cardo fused to stipes; stipes short, broad; galea absent; MP elongate, slightly shorter than antenna, composed of three palpomeres, MP3 shortest, MP1 and MP2 longest, subequal. Labium (Figs. 8–9) with prementum small, subtrapezoidal, about as long as broad, anterior margin not or barely indented medially, lateral margins curved, lacking spinulae; LP elongate, composed of 2 palpomeres; LP2 slightly longer than LP1.

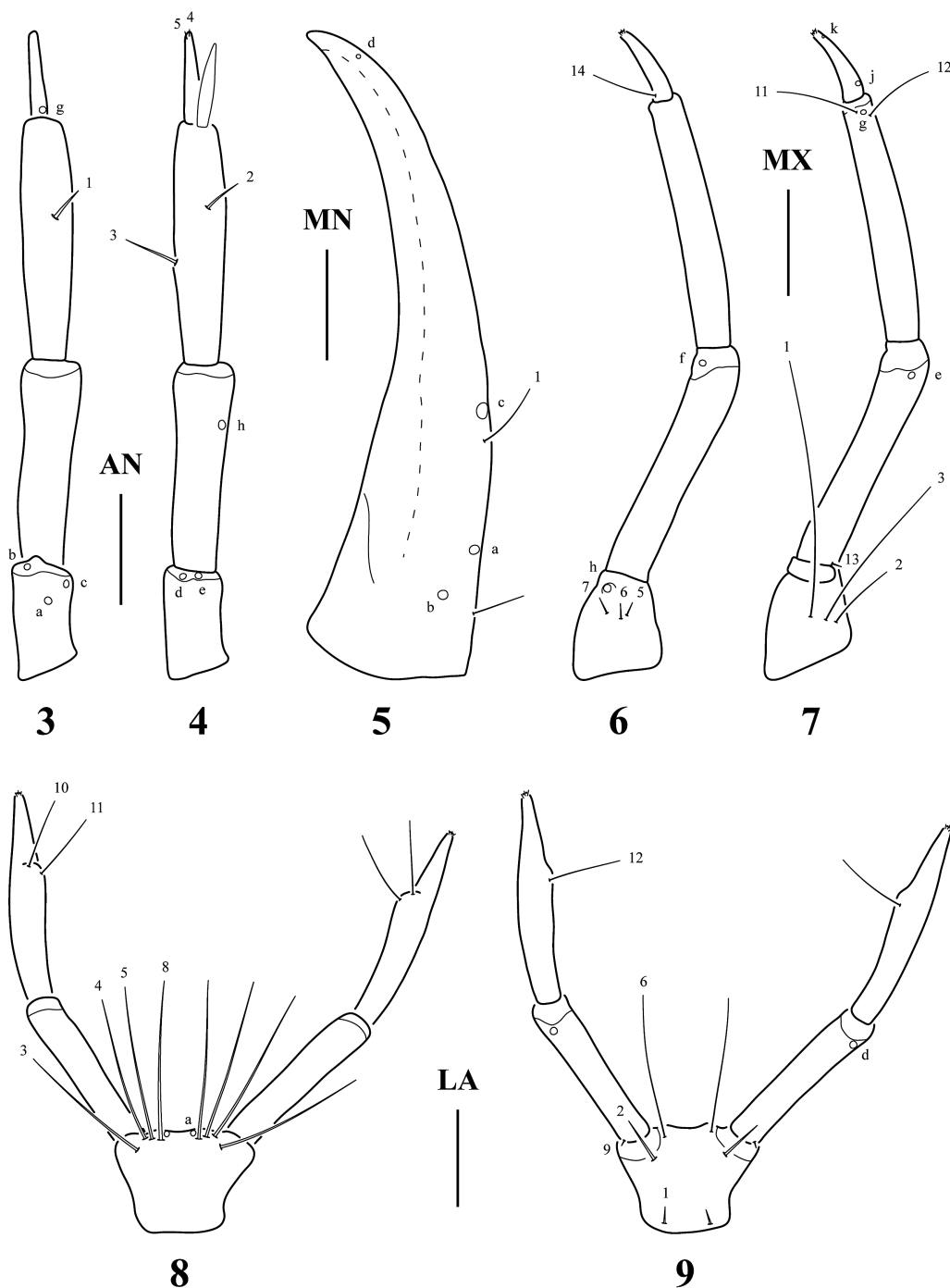
Thoracic terga convex, pronotum slightly shorter than meso- and metanota combined, meso- and metanota subequal; protergite subrectangular to subovate, more developed than meso- and metatergites; meso- and metatergites transverse, with anterotransverse carina; sagittal line well-visible

on 3 tergites; sterna membranous; spiracles present on mesothorax.

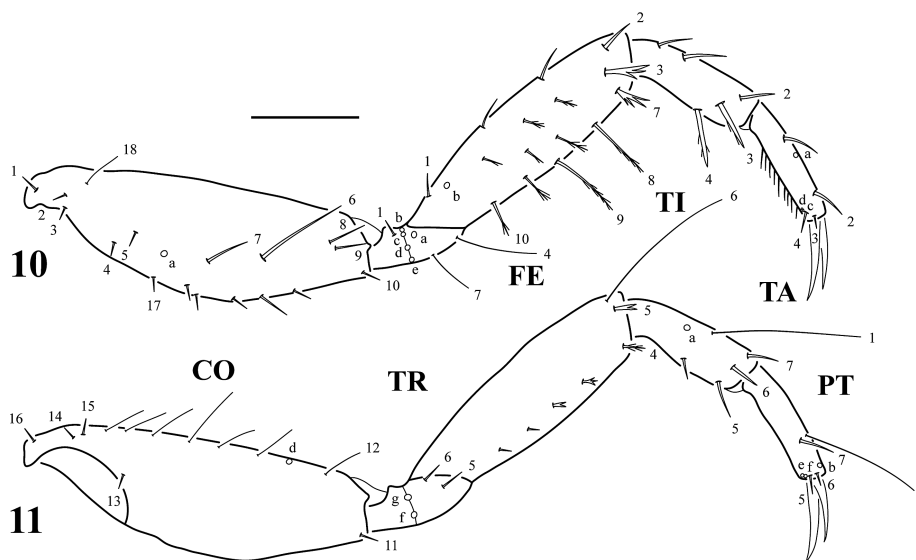
Legs (Figs. 10–11) long, composed of 6 articles (*sensu* Lawrence 1991), L1 shortest, L3 longest; CO robust, elongate, TR divided into 2 parts by an annulus, FE, TI, and TA slender, subcylindrical, PT with 2 long, slender, slightly curved claws; posterior claw shorter than anterior claw on L1 and L2, posterior claw longer than anterior claw on L3; most of surface of FE, TI, and TA covered with minute slender spinulae in transverse rows; ventral surface of TA and to a lesser extent pro- and meso-TI with elongate spinulae.

Abdomen 8-segmented; segments I–VI sclerotized dorsally, membranous ventrally; tergites I–VI narrow, transverse; segments VII–VIII completely sclerotized, ring-like; all sclerites lacking sagittal line, with anterotransverse carina, covered with minute spinulae in transverse rows; spiracles present lateroventrally on segments I–VII; segment VIII (Fig. 12) longest and narrowest, projected backwards into short subconical siphon. Urogomphus (Fig. 12) very long, composed of 2 urogomphomeres; U1 long, much longer than segment VIII, covered with minute spinulae except apically; U2 narrow, setiform, subequal in length to U1.

Chaetotaxy (Figs. 1–12) as follows: Head capsule with numerous secondary setae; lateroventral margin of PA lacking secondary spine-like setae; anteroventral margin of nasale with a half circle of 47–49 lamellae clypeales of different lengths,



Figs. 3–9. *Yola wraniki*, instar III. **3)** Right antenna, dorsal aspect; **4)** Left antenna, ventral aspect; **5)** Right mandible, dorsal aspect; **6)** Right maxilla, dorsal aspect; **7)** Left maxilla, ventral aspect; **8)** Labium, dorsal aspect; **9)** Labium, ventral aspect. Numbers and lowercase letters indicate primary setae and pores, respectively. AN = antenna; LA = labium; MN = mandible; MX = maxilla. Scale bars = 0.05 mm.



Figs. 10–11. *Yola wraniki*, instar III. **10)** Left prothoracic leg, anterior aspect; **11)** Right prothoracic leg, posterior aspect. Pretarsal setae PT1 and PT2 not represented. Numbers and lowercase letters indicate primary setae and pores, respectively. CO = coxa; FE = femur; PT = pretarsus; TA = tarsus; TI = tibia; TR = trochanter. Scale bar = 0.10 mm.

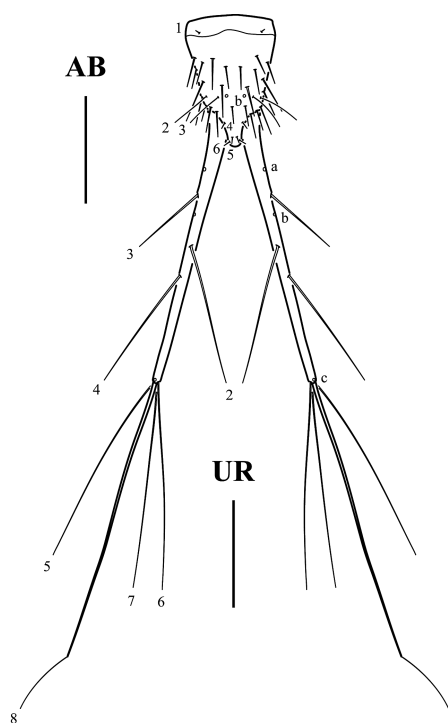


Fig. 12. *Yola wraniki*, instar III. Abdominal segment VIII and urogomphi, dorsal aspect. Numbers and lowercase letters indicate primary setae and pores, respectively. AB = abdominal segment VIII; UR = urogomphus. Scale bar = 0.25 mm.

directed downwards; AN, MX, and LA lacking secondary setae; MN with 1 hair-like secondary seta on basoexternal margin; [we were unable to find pores MXi and LAb, but we could not establish if they are really absent]; thoracic and abdominal sclerites I–VIII with numerous secondary setae mainly on posterior half; secondary leg setation detailed in Table 2 and Figs. 10–11; U lacking secondary setae; UR8 inserted apically on U2; primary chaetotaxy similar to that of generalized Bidessini larvae (Alarie and Harper 1990; Alarie *et al.* 1990; Alarie 1991; Alarie and Michat 2007); primary setae on cephalic capsule most likely present, although difficult to evaluate due to presence of secondary setae.

Description of Instar II. As instar III except as follows: Color somewhat lighter in general. Measurements and ratios that characterize the body shape are shown in Table 1. Antennomere 3 longest. Maxilla with MP2 longest. Labium with LP2 longer than LP1. Thoracic spiracles absent. Abdominal spiracles absent on segments I–VII. Secondary setae on cephalic capsule and thoracic and abdominal tergites less numerous; anteroventral margin of nasale with 23–25 lamellae clypeales; secondary leg setation detailed in Table 2; UR8 inserted subapically on U2.

Habitat Notes. *Yola wraniki* is a species endemic to Socotra Island lying in the Arabian Sea. The species is rather widespread in pools with gravely or muddy bottom in wadis (ephemeral streams) originating from the Hagher Mountains. The altitude

Table 2. Number and position of secondary setae on the legs of the second and third instars of *Yola wraniki*. Numbers between slash marks refer to pro-, meso-, and metathoracic legs, respectively. A = anterior; D = dorsal; P = posterior; Pr = proximal; V = ventral; Total = total number of secondary setae on the segment (excluding primary setae).

| Segment | Position | Instar II (<i>n</i> = 2) | Instar III (<i>n</i> = 3) |
|------------|----------|---------------------------|----------------------------|
| Coxa | PD | 3 / 3–4 / 2–3 | 7–9 / 6–10 / 4–5 |
| | V | 0 / 1–3 / 1 | 5–6 / 4–7 / 6–7 |
| | Total | 3 / 4–7 / 3–4 | 12–14 / 10–17 / 10–12 |
| Trochanter | Pr | 0 / 1 / 1 | 0 / 1 / 1–2 |
| | Total | 0 / 1 / 1 | 0 / 1 / 1–2 |
| Femur | A | 1–2 / 1 / 1–2 | 4–5 / 3–5 / 6 |
| | AD | 2 / 2 / 2 | 2 / 2 / 2–3 |
| | AV | 1 / 1 / 1 | 1 / 1 / 1–2 |
| | PV | 1–2 / 3 / 3–4 | 3–4 / 5–7 / 6–7 |
| | Total | 6 / 7 / 7–9 | 10–12 / 12–15 / 15–17 |
| Tibia | A | 0 / 1 / 1 | 0 / 2 / 2–3 |
| | AD | 0 / 1 / 1 | 1 / 1–2 / 2 |
| | AV | 0 / 1 / 1 | 0 / 1 / 1 |
| | PD | 1 / 1 / 1 | 1 / 1–2 / 1 |
| | PV | 0 / 1 / 1 | 1 / 2–4 / 3 |
| | Total | 1 / 5 / 5 | 3 / 8–10 / 9–10 |
| Tarsus | AV | 0 / 1 / 2 | 0 / 2 / 3 |
| | PD | 1 / 1 / 1 | 1 / 1–2 / 1–2 |
| | Total | 1 / 2 / 3 | 1 / 3–4 / 4–5 |

ranges between 140 and 1,250 m. However, the larvae were found only in a single spring pool in the mountain shrubland with dominant *Cephalocroton socotranus* Balf. f. (Euphorbiaceae). The pool was unshaded, partly covered with *Chara* L. (Characeae) algae, among which *Yola* larvae and adults were collected. In that locality, *Y. wraniki* was associated with adults of *Copelatus pulchellus* (Klug, 1834) and *Hyphydrus dioscoridis* Hájek and Reiter, 2014 (Hájek and Reiter 2014).

KEY TO THIRD INSTARS OF BIDESSINI GENERA

The following key was prepared to distinguish the Bidessini genera known in detail. However, as this tribe is very speciose and the larvae of many genera are unknown, the present key should be considered preliminary. The main purpose at this point is to recognize potentially useful characters to separate genera and to establish a template to which larvae described in the future can be incorporated.

1. Egg bursters present on frontoclypeus Instar I
- 1'. Egg bursters absent on frontoclypeus 2
2. Spiracles absent on mesothorax and abdominal segments I–VII Instar II
- 2'. Spiracles present on mesothorax and abdominal segments I–VII (Instar III) 3
3. Secondary setae on urogomphus present 4
- 3'. Secondary setae on urogomphus absent 6

4. Ratio L3/HW < 2.85; secondary posteroventral setae on tarsus absent; primary pore PAk absent *Amarodytes*
- 4'. Ratio L3/HW > 2.85; secondary posteroventral setae on tarsus present; primary pore PAk present 5
5. Head length < 0.50 mm; ventroapical spinula on antennomere III absent; natatory setae on tibia present; ratio U/HW > 2.70 *Brachyvatus*
- 5'. Head length > 0.70 mm; ventroapical spinula on antennomere III present; natatory setae on tibia absent; ratio U/HW < 2.70 *Allodessus* + *Limbodessus* (partim)
6. Ventroapical spinula on antennomere III absent 7
- 6'. Ventroapical spinula on antennomere III present 9
7. Secondary dorsal setae on protarsus absent *Anodocheilus*
- 7'. Secondary dorsal setae on protarsus present 8
8. Ratio U/HW > 2.70 *Yola*
- 8'. Ratio U/HW < 2.70 *Liodesuss*
9. Secondary posteroventral setae on tarsus absent 10
- 9'. Secondary posteroventral setae on tarsus present 11
10. HL > 0.70 mm *Hydroglyphus*

- 10'. HL < 0.70 mm.....*Glareadessus*
 11. Primary pore MNa contiguous to pore MNb
*Hypodessus*
 11'. Primary pore MNa distal to pore MNb.....
*Limbodessus* (*partim*)

DISCUSSION

Knowledge of Bidessini larvae is poor. In part because of this, and also to develop a system useful for phylogenetic analysis, a new descriptive template including a system of nomenclature for larval chaetotaxy was devised (Alarie *et al.* 1990; Alarie and Harper 1990; Alarie 1991; Alarie and Michat 2007). So far, such descriptive framework was particularly useful in studying 11 genera: *Glareadessus* Wewalka and Biström, 1998 (Alarie and Wewalka 2001), *Amarodytes* Régimbart, 1900 (Michat and Alarie 2006), *Anodocheilus* Babington, 1841 (Michat and Torres 2006), *Liodessus* Guignot, 1939 (Alarie *et al.* 2007), *Hypodessus* Guignot, 1939 (Michat and Alarie 2008), *Neobidessodes* Hendrich and Balke, 2009 and *Hydroglyphus* Motschulsky, 1853 (Michat *et al.* 2010), *Allodessus* Guignot, 1953 (Michat *et al.* 2011), *Limbodessus* Guignot, 1939 (Michat *et al.* 2012), *Brachyvatus* Zimmermann, 1919 (Michat and Torres 2013), and *Yola* (this paper). In the following, we summarize the characters potentially useful to separate larvae of *Yola* from those of other bidessine genera (Table 3). It should be noted, however, that in most cases the comparisons are based on single species and therefore these differences may change when more larvae are described.

Larvae of *Yola* can be easily distinguished from those of *Allodessus*, *Amarodytes*, *Brachyvatus*, and some species of *Limbodessus* by the absence of secondary setae on the urogomphi, which may suggest a closer relationship with *Anodocheilus*, *Glareadessus*, *Hydroglyphus*, *Hypodessus*, and *Liodessus*. Larvae of *Yola* stand out from any of these genera by the presence of very elongate urogomphi (ratio U/HW more than 2.70 compared to less than 2.70 in the other genera) (Table 3). It is also worth stressing that *Yola* larvae lack secondary temporal spine-like setae on the parietale, natatory setae on the tibia, and secondary posteroventral setae on the tarsus and bear the pore PAK on the parietale and secondary dorsal setae on the protarsus. Also, the mandibular pore MNa is located in a clearly distal position with respect to the pore MNb. This combination of chaetotaxic features combined with the absence of a ventroapical spinula on the third antennomere separates *Yola* from the rest of the studied genera except *Liodessus* (Table 3).

Descriptions of other bidessine genera can be found in the literature: *Neoclypeodytes* Young,

Table 3. Summary of characters useful to distinguish the third instar of *Yola* from those of other Bidessini genera. ALL = *Allodessus bistrigatus* (Clark, 1862); AMA = *Amarodytes dupontii* (Aubé, 1838); ANO = *Anodocheilus maculatus* Babington, 1841; BRA = *Brachyvatus acuminatus* (Steinheil, 1869); GLA = *Glareadessus stocki* Wewalka and Biström, 1998; HYD = *Hydroglyphus balkei* Hendrich, 1999; HYP = *Hypodessus cruciatus* (Régimbart, 1903); LIM = *Limbodessus* (five epigeic species); LIO = *Liodessus* (five species); YOL = *Yola wraniki*; + = present; – = absent.

| Character | ALL | AMA | ANO | BRA | GLA | HYD | HYP | LIM | LIO | YOL |
|---|----------------|--------------|--------------|--------------|--------|----------------|--------------|----------------|----------------|----------------|
| Head length (mm) | 0.79–0.81 | 0.74–0.77 | 0.49–0.50 | 0.47–0.49 | 0.63 | 0.78–0.80 | 0.71–0.73 | 0.56–0.84 | 0.46–0.62 | 0.62–0.66 |
| Pore PAK | + | – | + | + | ? | + | + | + | + | + |
| Secondary temporal spine-like setae on parietal | + | + | – | + | + | + | + | +/- | – | – |
| Ventroapical spinula on third antennomere | + | + | – | – | + | + | + | + | – | – |
| Pore MNa relative to pore MNb | clearly distal | ~ same level | ~ same level | ~ same level | ? | clearly distal | ~ same level | clearly distal | clearly distal | clearly distal |
| L3/HW ratio | > 2.85 | < 2.85 | < 2.85 | > 2.85 | ? | < 2.85 | > 2.85 | 2.63–3.07 | 2.70–2.98 | > 2.85 |
| Natatory setae on tibia | – | – | – | – | – | – | – | – | – | – |
| Secondary dorsal setae on protarsus | + | – | – | + | – | – | + | +/- | – | – |
| Secondary posteroventral setae on tarsus | + | – | – | + | – | – | + | + | – | – |
| U/HW ratio | < 2.70 | < 2.70 | < 2.70 | > 2.70 | < 2.70 | < 2.70 | < 2.70 | < 2.70 | < 2.70 | > 2.70 |
| Secondary setae on urogomphus | + | + | – | + | – | – | – | +/- | – | – |

1967 (Perkins 1980), *Uvarus* Guignot, 1939 (Matta 1983), and *Bidessus* Sharp, 1882 (Nilsson 1985). These descriptions did not include detailed morphometric and chaetotaxic analyses and therefore offer a more limited set of characters to compare them with recently described genera. Larvae of *Yola* can be distinguished from these three genera by having a greater U/HW ratio (more than 2.70 compared to less than 2.55 in *Neoclypeodytes*, *Uvarus* and *Bidessus*).

ACKNOWLEDGMENTS

M. C. Michat was supported by project PIP 112-201101-01087 from CONICET. Financial support was also provided by the Natural Sciences and Engineering Research Council of Canada in the form of a discovery research grant to Y. Alarie. The work of J. Hájek was partly supported by the Ministry of Culture of the Czech Republic (DKRVO 2015/14, National Museum, 0002327201).

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(Received 25 March 2015; accepted 9 June 2015. Publication date 18 September 2015.)