**New insight into the pupal characters of *Gabrius* STEPHENS, 1829
(Coleoptera: Staphylinidae: Staphylinini)**

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ABSTRACT. The pupa of *Gabrius appendiculatus* SHARP, 1910 is described and illustrated for the first time. A key to the known pupae of four *Gabrius* species applying newly defined morphological characters is provided.

KEY WORDS: rove beetles, morphology, immature stages, key.

INTRODUCTION

The literature data of immature stages of the genus *Gabrius* STEPHENS, 1829 is scarce and incomplete. The lack of such information is due mainly to the difficulty in finding immature forms in the field and determining them properly. Of the 337 members of *Gabrius* known in the world, some morphological characters of the eggs, larvae and/or pupae of only seven species have been published (POTOTSKAYA 1967, KASULE 1970, HINTON 1981, HERMAN 2001, STANIEC & PIETRYKOWSKA-TUDRUJ 2007, PIETRYKOWSKA-TUDRUJ & STANIEC 2007, 2010, 2011). Of these, data of pupae are given for three species: *G. astatus* (ERICHSON, 1840), *G. osseticus* (KOLENATI, 1846) and *G. splendidulus* (GRAVENHORST, 1802). These have been described by PIETRYKOWSKA-TUDRUJ & STANIEC (2007, 2010, 2011) sufficiently well to be a source for diagnostic and/or phylogenetic analysis. The present study on *G. appendiculatus* SHARP, 1910 is a continuation of extensive research into the pupal morphology of *Gabrius* species, and indeed of the

subtribe Staphylinini, to which this genus belongs.

G. appendiculatus is distributed in Europe, Asia (Iran, Turkey, Russia) and North America. Adults of this species occupy wet habitats, wetlands (marshes, swamps and bogs), and various water bodies such as lakes, ponds, brooks and rivers, as well as swampy meadows. The beetles usually occur under leaf or grass litter on muddy and clayey soil, in flood debris and *Sphagnum* (SMETANA 1995, WEBSTER et al. 2012). In North America this hygrophilous species also inhabits agricultural areas, e.g. soybean fields (SMETANA 1989, BRUNKE & MARSHALL 2011).

The purpose of this paper is to describe and illustrate the hitherto unknown pupal morphology of *G. appendiculatus*. A key to the known pupae of four *Gabrius* species applying newly defined morphological characters is presented.

MATERIALS AND METHODS

Pupae of *G. appendiculatus* were obtained by rearing 25 adults under laboratory conditions (t. 22±2°C). Adults were collected on 12 April 2013, on the shoreline of temporary floodplain pools of the River Wieprz in the vicinity of Milejów (Lublin Upland, SE Poland). Mature beetles and larvae of various instars were fed with springtails and freshly killed domestic crickets. Reared pupae were killed with boiling water and preserved in ethanol (75%). Habitus, structures of atrophied spiracles and terminal abdominal segment were illustrated from photos using a digital camera attached to an Olympus® BX61 compound microscope and edited with CorelDRAW Graphics Suite X6. For more detailed studies of other pupal structures, an SEM (VEGA3 TESCAN) was used. For the SEM work, pupal specimens taken from alcohol were briefly dried and placed directly in the SEM chamber for observation.

Habitus illustrations were made from living specimens. All measurements are given in millimetres; the averages are given in parentheses according to the range observed. The terminology of some morphological structures and abbreviations of cuticular structures follows PIETRYKOWSKA-TUDRUJ & STANIEC (2010); other terms have been newly coined. The material examined for morphological descriptions (including measurements) consisted of 12 pupae (6 males and 6 females). The voucher specimens are deposited at the Department of Zoology MCSU.

RESULTS

Generic diagnosis of *Gabrius* pupa

The diagnostic characters of the genus *Gabrius* proposed by PIETRYKOWSKA-TUDRUJ & STANIEC (2010, 2011) have been modified and supplemented as follows: body colour from yellow just after pupation to dark beige, moderately sclerotized and stocky; anterior margin of pronotum with 7-12 long setiform projections, these laterally curved; fore, mid and hind tibiae with protuberances; abdominal segments VII-VIII each bearing a pair of long setiform projections on the sides; all setiform projections on the body and prolongations on terminal segment IX with cuticular microprocesses; abdomen gradually widening to segment IV and then tapering towards terminal segment IX.

Figs 1-2. *Gabrius appendiculatus*, pupa. 1, Ventral aspect; 2, lateral aspect with microstructure (A-C) and protuberances (D-F). Abbreviations: I-IX, abdominal segments; An, antenna; As, atrophied spiracle; Fs, functional spiracle; Ft, fore tarsus; Ht, hind tarsus; Md, mandible; Mp, maxillary palp, Mt, mid tarsus; Sp, setiform projection; Tp, terminal prolongation; Vp, ventral prolongation.

Figs 3-4. *Gabrius appendiculatus*, pupa. 3, Dorsal aspect with functional spiracles (A) and atrophied spiracles (B, C); 4, terminal sternite of female with ventral prolongations (A-C1) and terminal prolongations (D). Abbreviations: I-IX, abdominal segments; As, atrophied spiracle; Fs, functional spiracle; Gt, gonotheca; Sp, setiform projection; Tp, terminal prolongation; Vp, ventral prolongation.

Morphological description of the pupa of *G. appendiculatus*

Colour yellow just after pupation. Body length (without abdominal process): 1.45-1.94 mm (mean 1.6 mm); body width in the widest place (between hind knees): 0.61-0.70 mm (mean 0.65 mm); head width (between eyes): 0.32-0.36 mm (mean 0.34 mm); head length: 0.47-0.55 mm (0.50 mm); pronotum width: 0.40-0.45 mm (mean 0.42 mm); pronotum length: 0.44-0.52 mm (0.47 mm), 1.1 times as long as wide at the base. Colour light yellow just after pupation. Head directed ventrally towards thorax, about 1.5 times as long as wide (Figs 1, 2). Labrum 1.6 times as wide as long. Mandibles crossed at their apices. Antennae curved, long with small, well-rounded protuberances (Fig. 2E), protruding slightly beyond half the length of the shortened elytra. Anterior margin of pronotum with 9-11 curved

Figs 5-7. *Gabrius appendiculatus*, pupa, setiform projections with cuticular processes. 5, 5A, B, Setiform projection on pronotum; 6, 6A, B, setiform projection on abdominal segment VII; 7, 7A, setiform projection on abdominal segment VIII. Abbreviations: Sp, setiform projection.

projections (looking from ventral side 5/5 – 8 exx, 5/6 – 2 exx, 5/4, 4/5 projections on sides in the individuals examined) (Figs 1, 5, 5A, B). Surface of pronotum uneven with shallow depressions, a few tiny protuberances and microstructure (Figs 2A, D). Wings extending to ventral side, slightly protruding beyond posterior margin of 2nd (morphologically 3rd)

clearly visible (from the side) abdominal sternite, elytra with microstructure (Figs 1, 2, 2B). Tibiae and tarsi directed obliquely to the middle of the body. All tibiae with poorly visible outlines of protuberances; fore, mid and hind tibiae with 6, 10 and 7-8 protuberances respectively (Figs 2, 2F). Tarsi of all legs relatively short, fore tarsi not reaching level of apices of mandibles, mid tarsi not reaching level of apices of maxillary palps, hind tarsi reaching anterior margin of 4th (morphologically 6th) well-visible (from ventral side) sternite (Fig. 1). Abdomen moderately and gradually widening to segment IV and then tapering to the terminal segment of the body (Figs 1, 3). Abdominal tergite I twice as long as tergite II. Surface of abdominal segments with microstructure as in Fig. 2C. Abdominal segments VII and VIII each bearing on sides a pair of curved, setiform projections, longer than segments (Figs 1, 3, 6, 6A, B, 7, 7A). Projections on segment VII longer than those on VIII. All setiform projections with tiny processes occurring throughout their length. Terminal sternite with well-marked sexual dimorphism. Female pupa with double gonotheca (Gt) and two well-developed ventral, outward curving prolongations [in some specimens prolongations doubly curved: inward at half-length and outward apically (Figs 4 C, C1)], covered by numerous cuticular processes (Figs 4, 4A, B); male pupa with single gonotheca (as in Fig. 20, PIETRYKOWSKA-TUDRUJ & STANIEC 2010); terminal prolongation of both pupae relatively long with numerous cuticular processes on posterior part (Figs 4, 4D). Abdominal tergites I-IV with functional spiracles (Figs 3, 3A), tergites V-VIII with atrophied spiracles (Figs 3, 3B, C).

CONCLUSION

Excluding the generic characters for known pupae of *Gabrius*, others shared by them are: labrum about 1.6-1.7 times as wide (at the base) as long; mandibles crossed at their apices; wings extending to ventral side beyond posterior margin of 3rd abdominal sternite; abdominal tergite I about twice as long as 2nd; functional spiracles on abdominal tergites I-IV and atrophied spiracles on V-VIII present; 1st pair of functional spiracles situated more laterally than the rest; microstructure on abdominal segments present.

The characters for differentiating the known pupae within *Gabrius* relate mainly to body measurements, length of antennae, fore, mid and hind legs, and the shape and length of the abdominal prolongation. Pupae of *G. appendiculatus* clearly differ from other known pupae of *Gabrius* in their smaller body size, shorter legs and moderately long antenna protruding slightly beyond half the length of the elytra (see Table).

Table. Some diagnostic characters of pupae of four *Gabrius* species (A1 – not reaching half-length of elytra; A2 – protruding slightly beyond half-length of elytra; A3 – reaching about three-fifths of elytra length; Ft1 – not reaching level of apices of mandibles; Ft2 – reaching level of apices of mandibles; Ft3 – protruding beyond level of apices of mandibles; Ht1 – reaching anterior margin of 4th (morphologically 6th) well-visible (from ventral side) sternite; Ht2 – reaching almost one third the length of 4th (morphologically 6th) well-visible (from ventral side) sternite; Ht3 – reaching at least half-length of 4th (morphologically 6th) well-visible (from ventral side) sternite; Mt1 – not reaching level of apices of maxillary palps; Mt2 – protruding beyond level of apices of maxillary palps; Mt3 – reaching posterior margin of 1st (morphologically 3rd) well-visible (from ventral side) sternite; Vp1 – protruding slightly beyond posterior margin of last abdominal segment; Vp2 – protruding distinctly beyond posterior margin of last abdominal segment; Ltwr – length/width ratio; Sp – setiform projections; ? – no data; * newly defined pupal character.

Character	Species		
	<i>G. appendiculatus</i>	<i>G. astutus</i>	<i>G. splendidulus</i>
Cocoon	absent	absent	present or absent
Body length	1.45-1.94 (1.6)	3.52-3.80 (3.66)	2.58-2.86 (2.74)
Body width	0.61-0.70 (0.65)	1.60-1.74 (1.68)	1.10-1.24 (1.18)
Head			
Width	0.32-0.36 (0.34)	0.82-0.88 (0.85)	0.58-0.66 (0.63)
Ltwr	1.5	1.7	1.7
Number of Sp on pronotum	9-11 (5/4, 4/5, 5/5-8 exx, 5/6-2 exx)	10-11 (5/5-6 exx, 5/6-2 exx, 6/5)	7-9 (3/4, 4/3, 4/4-3 exx, 4/5)
Antennae, length	A2	A3	A1
Antennae, protuberances	present	present	present
Leg			
Number of protuberances on tibiae (fore/mid/hind)	6/10/7-8	?/4/3	7/12/5
Fore tarsi, length*	Ft1	Ft3	Ft2
Mid tarsi, length*	Mt1	Mt3	Mt2

Table. Continued.

Character	Species		
	<i>G. appendiculatus</i>	<i>G. astutus</i>	<i>G. splendidulus</i>
Leg			
Hind tarsi, length*	Ht1	Ht3	Ht2
Abdomen			
Length of Sp to segment VII	longer	longer	shorter
Sp on segments VIII	longer	longer	equal
Ventral prolongation, shape*	curved outside	straight	curved inside
Ventral prolongation, length*	Vp2	Vp1	Vp1
References	Present study	PIETRYKOWSKA-TUDRUJ & STANIEC (2010)	PIETRYKOWSKA-TUDRUJ & STANIEC (2011)
			PIETRYKOWSKA-TUDRUJ & STANIEC (2007)

Key to known pupae of four *Gabrius* species

The newly defined morphological characters such as the length of fore, mid and hind tibia, and length of the ventral prolongation on the terminal segment, combined with the features described earlier, allow the known pupae of the genus *Gabrius* to be distinguished.

1. Pupal cocoon present. *Gabrius splendidulus* (GRAVENHORST, 1802).
– Pupal cocoon absent. 2.
2. Mid tarsi protruding beyond level of apices of maxillary palps, hind tarsi protruding beyond anterior margin of 4th (morphologically 6th) well-visible (from ventral side) sternite, body length 2.58-4.00 mm. 3.
– Mid tarsi not reaching level of apices of maxillary palps, hind tarsi reaching as far as anterior margin of 4th (morphologically 6th) well-visible (from ventral side) sternite (Fig. 1), body length 1.45-1.94 mm. *G. appendiculatus* SHARP, 1910.
3. Mid tarsi reaching posterior margin of 1st (morphologically 3rd) well-visible (from ventral side) sternite, fore tarsi protruding beyond level of apices of mandibles, in female ventral prolongation short (protruding slightly beyond posterior margin of last abdominal segment), body length 3.52-4.00 mm. 4.
– Mid tarsi ending before posterior margin of 1st (morphologically 3rd) well-visible (from ventral side) sternite; fore tarsi reaching level of apices of mandibles, in female ventral prolongation long (distinctly protruding beyond posterior margin of last abdominal segment); body length 2.58-2.86 mm. *G. splendidulus* (GRAVENHORST, 1802).
4. Antenna not reaching half-length of elytra, hind tarsi not reaching half-length of 4th (morphologically 6th) well-visible (from ventral side) sternite, body length 3.74-4.00 mm. *G. osseticus* (KOLENATI, 1846).
– Antenna protruding beyond half-length of elytra; hind tarsi reaching at least half-length of 4th (morphologically 6th) well-visible (from ventral side) sternite, body length 3.52-3.80 mm. *G. astutus* (ERICHSON, 1840).

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