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MORPHOLOGY OF DEVELOPMENTAL STAGES OF *PHILONTHUS FUMARIUS* (GRAVENHORST, 1806) (COLEOPTERA, STAPHYLINIDAE) WITH NOTES ON BIOLOGY

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The mature larva (L3) and pupa of *Philonthus fumarius* (GRAVENHORST, 1806) are described for the first time, with illustrations of structural features provided. The poorly known morphology of the egg is supplemented. Some diagnostic characters of egg, larva and pupa of the known *Philonthus* species, including *P. fumarius*, are listed. Some data on its distribution, environmental requirements and biology under laboratory conditions are also provided.

Key words: Egg, larva, pupa, adult, stenotopic species, *Philonthus*

INTRODUCTION

The genus *Philonthus* STEPHENS, 1829 represents one of the largest genera of Staphylinidae, with about 1260 (19 doubtful) described species, of which roughly 70 species have been recorded from Central Europe and almost 60 species from Poland (BURAKOWSKI *et al*. 1980, HERMAN 2001, KOCH 1989, LUCHT 1987). Within this genus, only few data about the morphology of eggs of 27 species, larvae of over 30 species and pupae of 24 species have been reported (BOLLER 1983, BYRNE 1993, CERRUTI 1941, HINTON 1981, HU & FRANK 1995, KASULE 1970, KRANEBITTER & SCHATZ 2002, MOORE 1977, PAULIAN 1941, PIETRYKOWSKA-TUDRUJ & STANIEC 2006, POTOTSKAYA 1967, SMETANA 1958, 1962, STANIEC 1999, 2001–2004*a*, STANIEC & KITOWSKI 2004, STANIEC & PIETRYKOWSKA 2005, SZUJECKI 1965, TAWFIK *et al*. 1976*a*, *b*, *c*, TOPP 1978, STANIEC & PIETRYKOWSKA-TUDRUJ 2007*a*,*b,* 2008). Because many descriptions are incomplete and poorly illustrated, correct identification of the preimaginal stages of individual species, especially of closely related taxa, is still highly problematic. Consequently, these descriptions require supplements or redescriptions.

With reference to immature stages of *Philonthus fumarius*, only HINTON (1981) in a key of eggs of Staphylinidae species provided a brief and superficial description of the egg stage. The objectives of this study are to describe the third larval instar and pupal stages, to supplement the existing description of the egg stage, In addition, biology of *Ph. fumarius* under laboratory conditions is presented. Morphological characters of the egg, larval and pupal stages of known *Philonthus* species is summarized and reviewed.

MATERIALS AND METHODS

Immature stages (egg, third larval instar, pupa) for the morphological study and biology of *Ph. fumarius* were obtained by rearing 14 specimens of adults (of them 7 ♀♀) that were collected near Łęczna (SE Poland; square of UTM: FB37) in Nadwieprzański Landscape Park on 5 May 2005. The study area was the waters edge surrounded by the alder forest situated in the Wieprz river valley. Beetles were collected by sifting wet leaf litter in the ecotone zone at the waters edge and surrounding forest. Reproductive activity and mortality were studied in the laboratory. Of this sample, 5 male-female pairs were reared separately. The adults were kept in a plastic containers (10 cm diameter × 7 cm high) filled with soil. After oviposition, 40 freshly laid eggs were placed separately in Petri dishes, filled with moist soil (about 1/3 height of petri dish). The insects were reared from egg to pupa. Insects were not successfully reared to the adult stage. Rearing was conducted beginning 7 May 2005 at 20±3°C. Adults and various larval instars were fed with ant larvae. Some reared immature stages were used to describe their morphology. These specimens were preserved in a 1:1 solution of glycerine and alcohol. For microscopic slides the punctured larvae were rinsed in distilled water, cleared in chloralphenol and placed in Berlese's fluid. The drawings of morphological details were made by using a camera lucida. The total illustrations of larvae, pupa and adult were made from photographs.

Material examined: a) 11 eggs, 6 L_3, 8 pupae (all reared from adults) were used in morphological descriptions; b) 14 adults (of them 7♀♀), 40 eggs, 18 L_1, 17 L_2, 10 L_3, 5 prepupa, 5 pupa were used to the study life history in the lab.

RESULTS

Description of the developmental stages

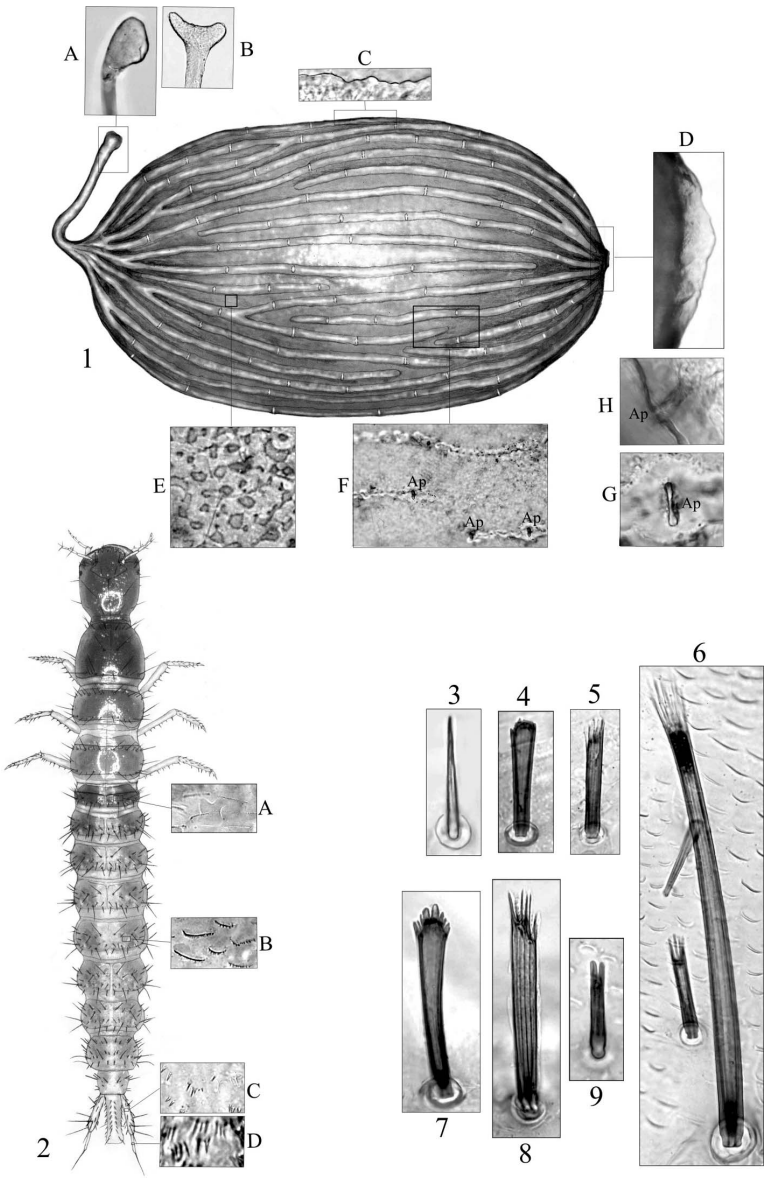
Egg (Figs 1A-H) – Length: 1.37–1.54 mm (mean 1.41 mm), width: 0.77–0.98 (mean 0.88). Macroscopic aspect (Fig. 1): colour white, shape oval; with clearly visible 35–40 longitudinal ridges, some of them shortened, most of them branched; openings of aeropyles clearly visible, aeropyles arranged on all ridges of 3–6 aeropyles each; posterior projection present, with widened ending (Figs 1A, B); egg 3.5–5 times as long as posterior projection. Microscopic aspect: microstructure and anterior pole as in Figs 1C-F; aeropyles openings tighten (Figs 1F–H).

Insects were reared beginning 6 May 2005. Eggs were observed in the laboratory from 8 May to 20 June 2005. Eggs habitat is slimy waters edge in decaying plant matter in alder forests.

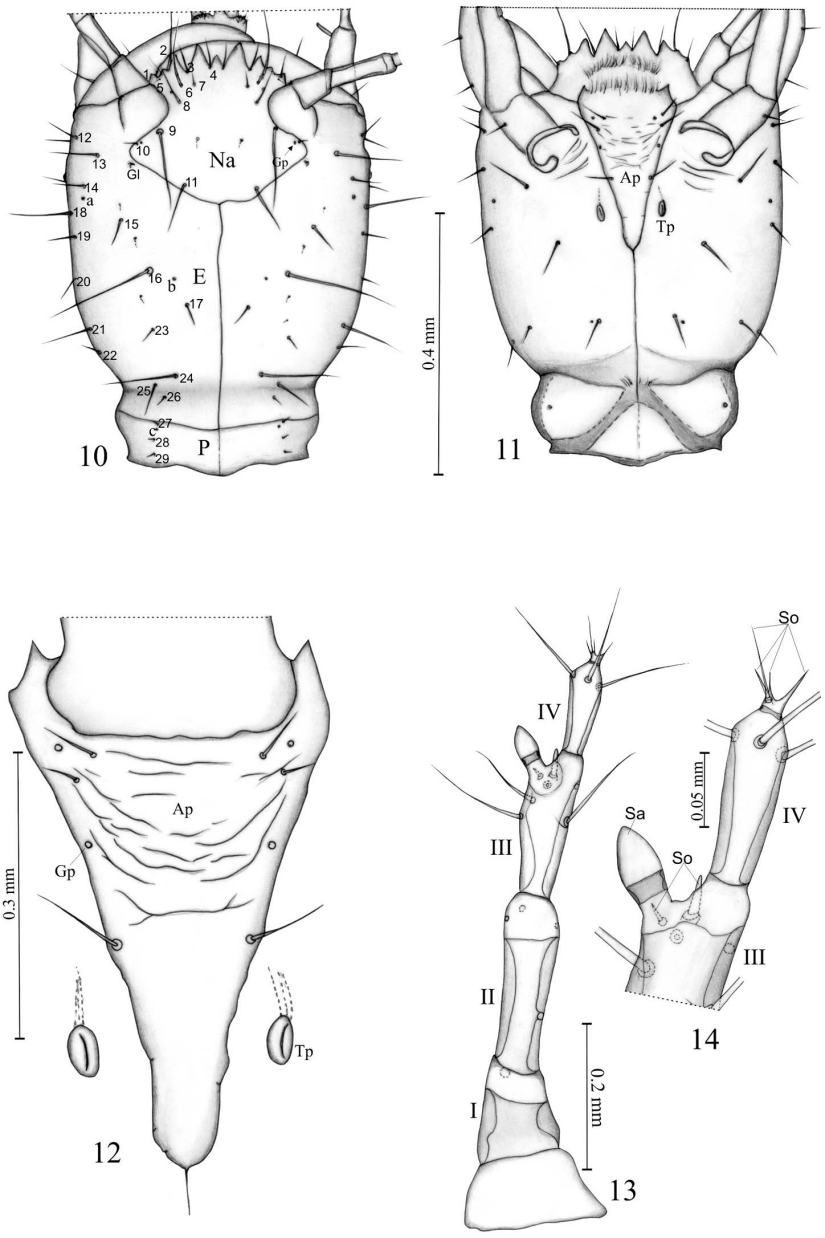
Third instar larva (Figs 2–32) – Body length (from anterior margin of nasale to the end of pygopod): 6.48–8.00 mm (mean 7.20 mm); head width (between stemmata): 0.98–1.02 mm (mean 0.99 mm); pronotum width: 1.06–1.12 mm (mean 1.09 mm). Colour: head, mandibles reddish-brown, thoracic tergites brownish-gray, first abdominal tergite light brown, remaining abdominal tergites, sternites, antennae, legs and body dirty white, setae black or brownish-black (Fig. 2).

All setae of head and thorax and abdominal sternite I, some setae on urogomphi, tergites I–IX and sternites II–IX simple (Fig. 3); remaining macro and microsetae situated on abdominal segments I–X rod-shaped and frayed or bifurcate apically (Figs 4–9). Body elongated, prothorax 1.1 times as wide as head and 1.3–1.4 times as long as mesothorax; metathorax (broadest segment of the body) slightly broader than pro- and mesothorax; abdomen slightly widened to segment III or IV and then gradually narrowed to terminal segment of body (Fig. 2).

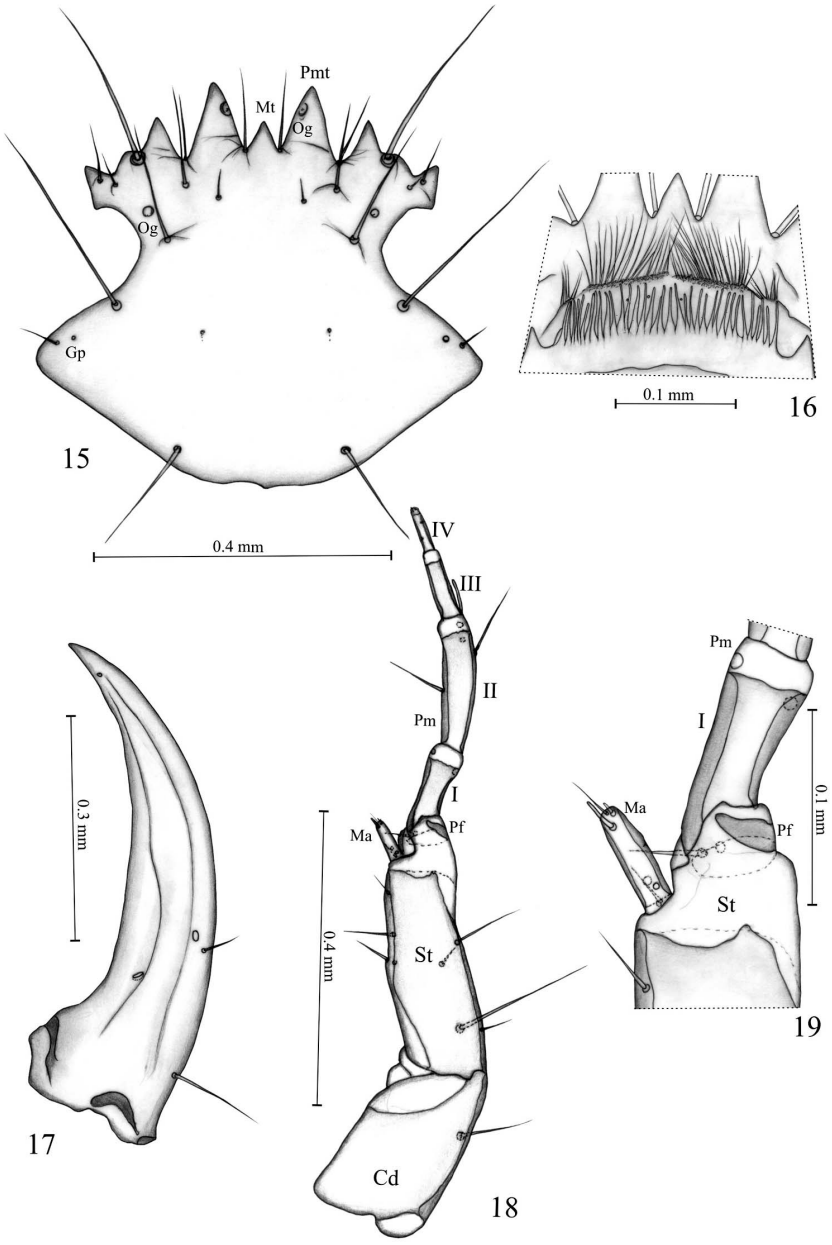
Head (Figs 10–21): 1.1–1.2 times as long as wide, lateral margins slightly rounded; epicranial suture bifurcate before half of head length (Fig. 10). Chaetotaxy of dorsal side of head with 58 setae:



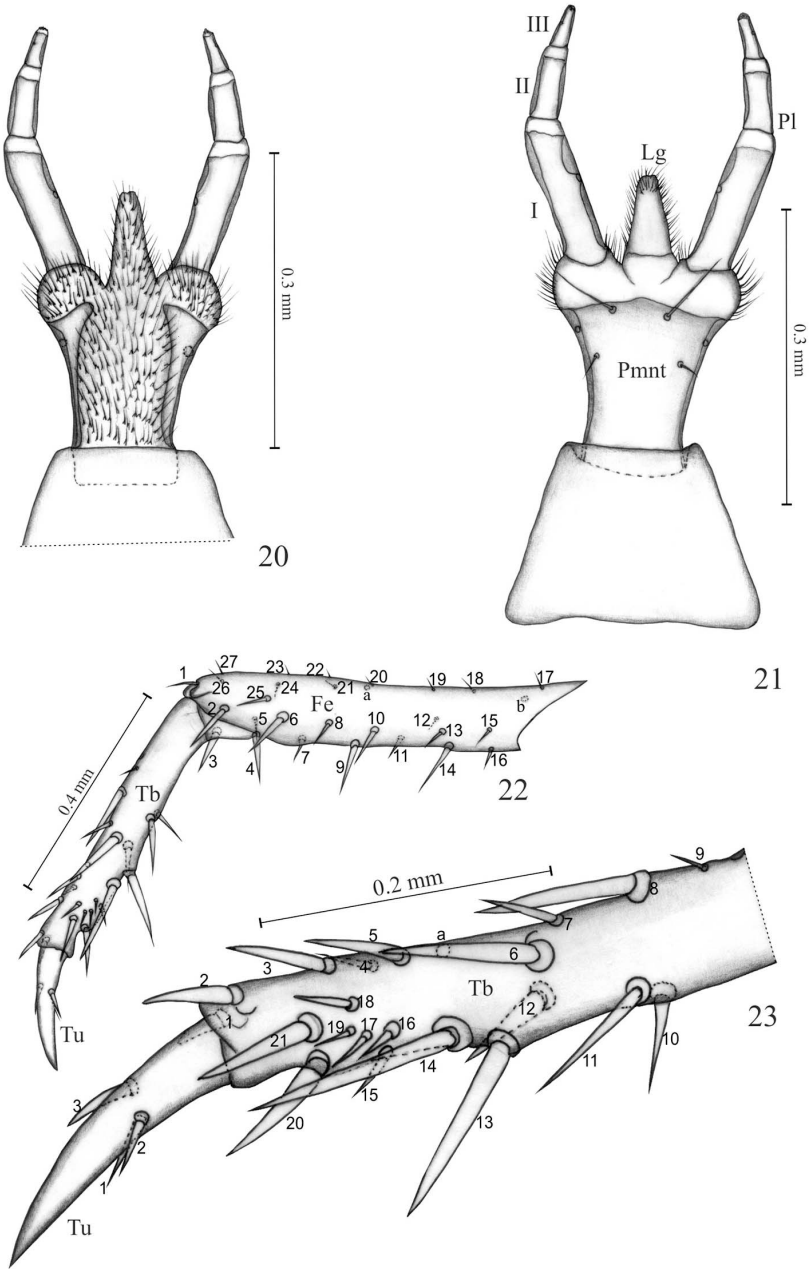
Figs 1–9. *Philonthus fumarius*. 1, 1A–H = Egg; 2, 2A–D, 3–9 = mature larva. 1 = General view; 1A, B = distal end of posterior projection; 1C = ridge microstructure; 1D = structure of anterior pole; 1E = surface microstructure between ridges; 1F = surface microstructure with ridges and aeropyles (Ap); 1G, H = aeropyles; 2 = general view; 2A–D microstructure of: first abdominal tergite (A), abdominal tergites II–IX (B), segment I (C) and II (D) of urogomphus; 3 = simple macro seta of pronotum; 4–8 = rod-shaped and frayed apically setae of abdominal tergite: I (4), II (5), IV (6), VI (7), VIII (8); 9 = bifurcate microseta of abdominal segment VII.



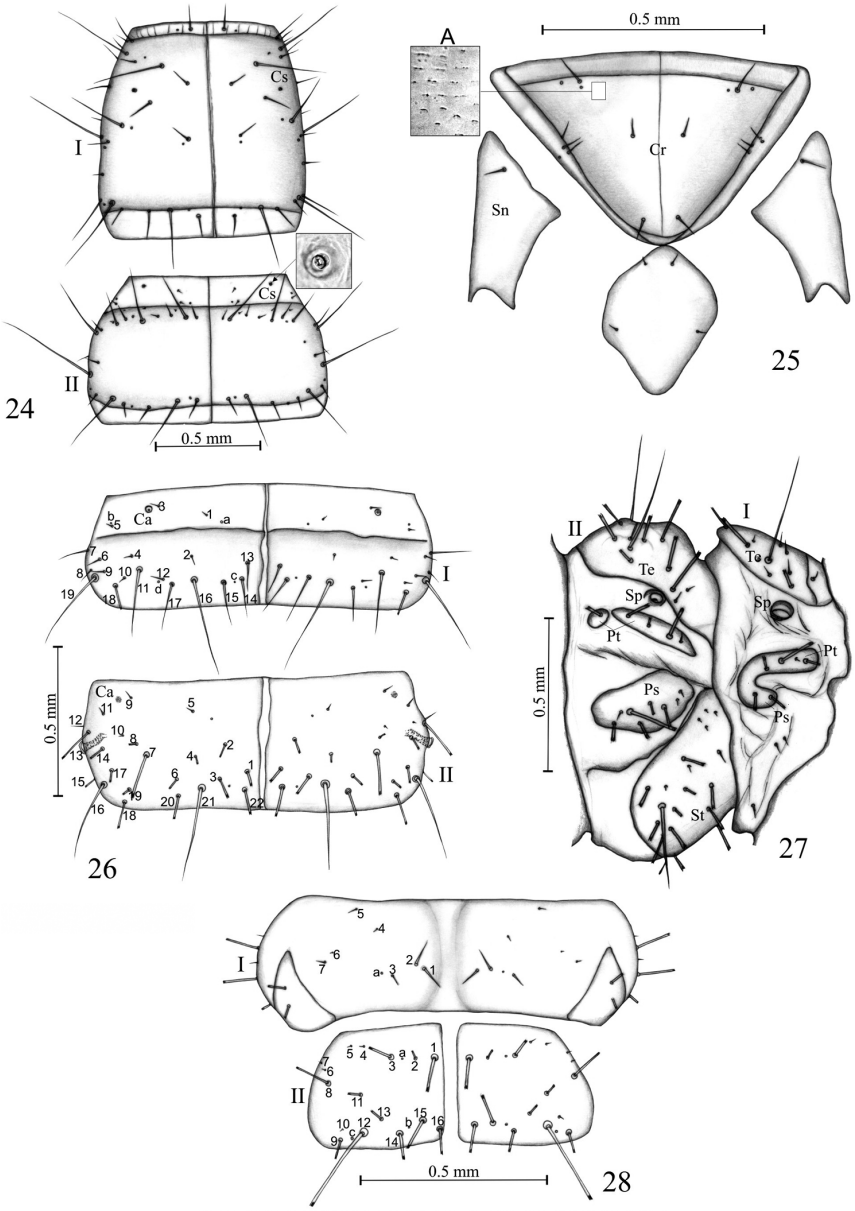
Figs 10–14. *Ph. fumarius,* head, mature larva. 10 = Head in dorsal aspect (a–c – pores, E – epicranial part, Gl – gland, Gp – glandular pit, Na – nasale, P – posterior part, 1, 2. – codes of setae); 11 = head in ventral aspect (Ap – apotome, Tp – tentorial pit); 12 = apotome (Ap) and tentorial pits (Tp) (Gp - glandular pit); 13 = right antenna in dorsal aspect (I-IV – antennal segments); 14 = apical part of right antenna in dorsal aspect (Sa – sensory appendage, So – solenidia, III and IV – antennal segments)



Figs 15–19. *Ph. fumarius*, head, mature larva. 15 = nasale in dorsal aspect (Mt – median tooth, Og – olfactory organ, Pmt – paramedian tooth); 16 = epipharynx; 17 = right mandible in dorsal aspect; 18 = right maxilla in dorsal aspect (Cd – cardo, Ma – mala, Pf – palpifer, Pm – maxillary palp, St – stipes, I–IV maxillary palp segments); 19 = anterior part of stipes in dorsal aspect (Ma – mala, Pf – palpifer, Pm – maxillary palp, St – stipes)



Figs 20–23. *Ph. fumarius*, mature larva. 20 = Hypopharynx; 21 = labium in ventral aspect (Lg – ligula, Pmnt – prementum, Pl – labial palp, I-III – segments of labial palp); 22 = fore femur (Fe) and tibia (Tb) with tarsungulus (Tu) in anterior aspect (a, b – codes of pores, 1, 2, … – codes of setae); 23 = anterior part of fore tibia with tarsungulus (a – code of pore, 1, 2, … – codes of setae)



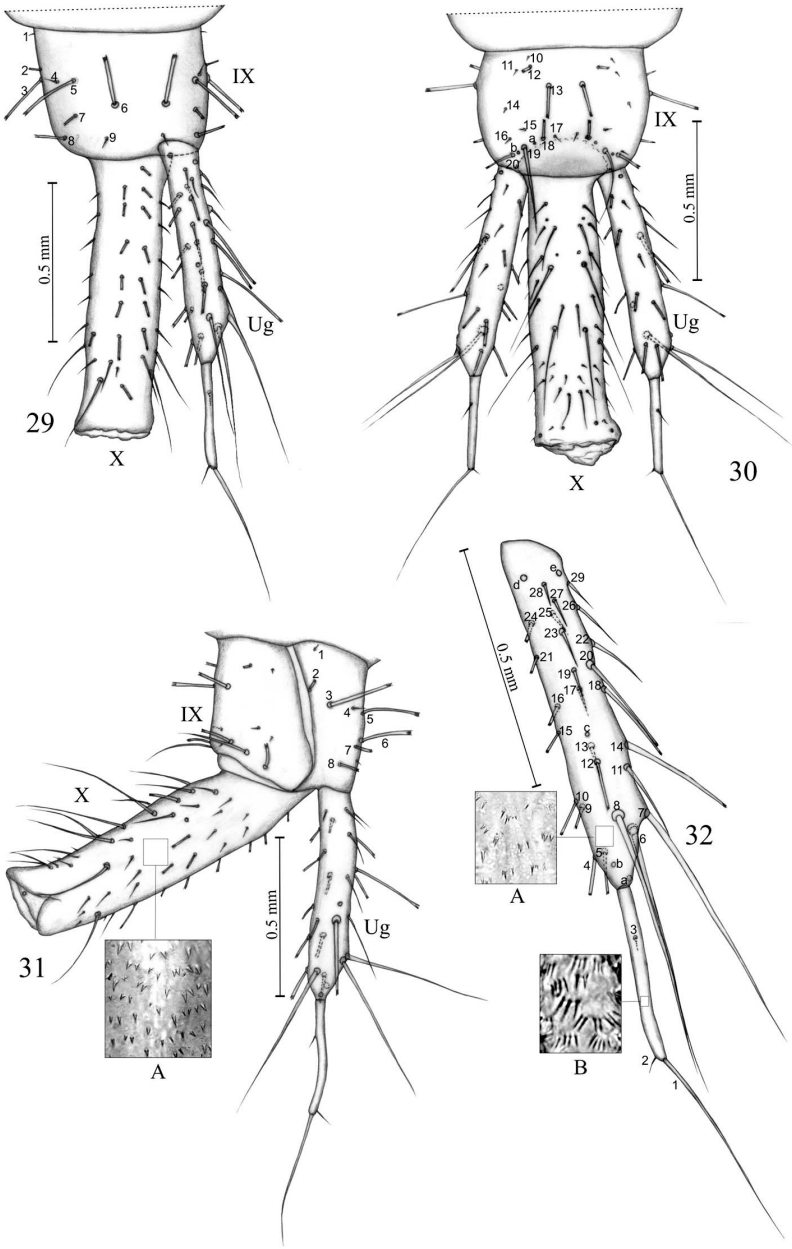
Figs 24–28. *Ph. fumarius*, mature larva. 24 = pronotum (I) and mesonotum (II) (Cs – coeloconic sensillum); 25 = prothorax in ventral aspect (Cr – cervicosternum with microstructure [A], Sn – sternite); 26 = abdominal tergite I and II (a, b, c – pores, 1, 2… – codes of setae, Ca – coeloconic sensilla); 27 = abdominal segments I and II in lateral aspect (Ps – parasternite, Pt – paratergite, Sp – spiracle, St – sternite Te – tergite); 28 = abdominal sternite I and II (1, 2… – codes of setae, a, b, c – codes of pores)

nasale part (Na) – 22 setae (codes: 1–11), a pair of gland pits (Gp) and 4 pores; epicranial (E) part – 30 setae (codes: 12–26), a pair of glands (Gl), 4 pores (codes: a, b) and a few indeterminate sensillae; posterior (P) part with 6 micro setae (codes: 27–29) and 2 pores (code: c). Ventral side of head with 14 macro setae, 6 pores and a pair of clearly visible tentorial pits (Tp) (Fig. 11). Each side of head with 4 stemmata in the cluster. Apotome (Ap) (Figs 11, 12) in broad outline triangular, distinctly extending beyond tentorial pits (Tp); with 6 setae, 2 pores and a pair of glandular pits (Gp).

Antenna (Figs 13, 14) 4-segmented, length ratio of segments I-IV 1.2 : 1.9 : 1.6 : 1 respectively; segment I almost 1.4 times as long as wide, with one pore ventro-apically; segment II 3.5 times as long as wide, with 4 pores (2 latero-dorsally, 1 latero-ventrally, 1 ventro-apically); segment III 3 times as long as wide at maximum width widest place, with 3 macro setae (1 growing on the outer margin, 2 on the inner margin), 2 sensory appendages (Sa) (one club-shaped and second tiny), 2 solenidia (So) and 1 pore ventrally; segment IV 3.4 times as long as wide, about 2.2 times as long as sensory appendages, with 3 macro setae and 4 solenidia (So) apically. Nasale (Na) (Figs 10, 15) with 22 setae, 2 pairs of olfactory organs (Og) anteriorly and 2 glandular pits (Gp) postero-laterally. Anterior margin of nasale (Fig. 15) with 9 teeth divided into 3 distinct clusters (one middle and two lateral), each cluster with 3 teeth, paramedian teeth (Pmt) about 2.3 times as long as median tooth (Mt). Epipharynx (Fig. 16) with 4 bunches of straight, long hairs anteriorly and about 35 long cuticular processes posteriorly. Mandible (Fig. 17) slender with 2 setae on outer margin and 2 pores dorsally. Maxilla (Figs 18, 19): length ratio of cardo (Cd) and stipes (St) 1:1.5; cardo 1.6 times as long as wide, bearing 1 seta ventro-laterally; stipes 3.1 times as long as wide with 8 setae (2 on outer margin, 2 ventrally, 3 on or near inner margin, 1 ventro-apically) and 2 pores (1 closely near inner margin, 1 ventro-apically). Mala (Ma) (Fig. 19) finger-shape, with 1 clearly visible seta ventro-basally, 2 pores, 2 micro sensory appendages and 1 micro seta apically; 3.4 times as long as wide; length ratio of mala and segment I of maxillary palp 1:2. Maxillary palp (Pm) 4-segmented; length ratio of segments I-IV: 1.9:2.4:1.6:1 respectively; segment I 2.7 times as long as wide, with 2 pores; segment II 4 times as long as wide, with 2 setae and 2 pores; segment III 3.5 times as long as wide, with 1 digitiform sensory appendage basally on outer margin; segment IV 3.2 times as long as wide, with 2 pores and a few micro sensory appendages on apex. Hypopharynx membranous and thickly pubescent (Fig. 20). Labium (Fig. 21): ventral side of prementum (Pmnt) sclerotized, with 4 setae (2 macro, 2 micro setae) and 2 pores laterally. Ligula (Lg) conical, about 1.7–1.8 times as long as wide at base; at least slightly wider than segment I of labial palp at base; length ratio of ligula and segment I of labial palp 1:1.7. Labial palps (Pl) 3-segmented; length ratio of segments I-III 3.4:1.6:1 respectively; segment I with 1 pore laterally; segment III with 1 pore laterally and a few micro sensory appendages apically.

Foreleg (Figs 22, 23): femur (Fe) with 27 setae (16 spine-shaped of different length, 11 micro setae) and 2 pores (a, b); tibia (Tb) with 21 spine-shaped setae of different length and one pore (a), tibial comb present, consisting of 4 setae (codes: 15–19); tarsungulus (Tu) with 3 spine-shaped setae. Length ratio of profemur, protibia and protarsungulus 3.3:2.4:1 respectively. Thorax (Figs 2, 24, 25): pro-, meso-, and metanotum with mid-longitudinal ecdysial line. Pronotum (Fig. 24) with 46 setae, several pores and a pair of coeloconic sensillum (Cs) probably; meso- (Fig. 24) and metanotum with similar chaetotaxy, each with 36 (18 x 2) macro setae, 12 micro setae, several pores and a pair of coeloconic sensillum (Cs) probably anteriorly. Cervicosternum (Cr) (Fig. 25) triangular with 6 setae and 4 pores. Prosternal area with 2 sternites (Sn), each with one seta; surface between sternites with 4 micro setae, and between cervicosternum (Cr) and sternites (Sn) with 6 setae and 2 pores.

Abdomen (Figs 2, 26–32): segments I–VIII each with tergite (Te) and sternite (St) divided into two parts to segments VII by membranous area, a pair of paratergites (Pt) and a pair of parasternites (Ps) laterally (Fig. 27); on segment I paratergites and parasternites fused; on segments II-VIII paratergites divided into two parts: greater anteriorly and tiny posteriorly (Fig. 27). Segment I: tergites with 38 setae (18 macro, 20 micro setae), 8 pores and a pairs of campaniform sensillum (Ca)



Figs 29–32. *Ph. fumarius*, mature larva. 29 = Abdominal segment IX and X in dorsal aspect (Ug – urogomphus, 1, 2… – codes of setae); 30 = abdominal segment IX and X in ventral aspect (Ug – urogomphus, 1, 2… – codes of setae); 31 = abdominal segment IX and X in lateral aspect (Ug – urogomphus, A – microstructure of abdominal segment X); 32 = urogomphus (I, II – segments, 1, 2… – codes of setae, A, B – microstructure of segment I and II)

Table 1. Morphological characters of the known eggs of species of *Philonthus*. (0 – posterior projection or/and longitudinal ridges absent; brn. – at least some of longitudinal ridges branched; s – aeropyles scattered; Nr/Na – number of rows of aeropyles/number aeropyles in row; N - number of all aeropyles; Abr. – aeropyles between longitudinal ridges; Aor. - aeropyles on longitudinal ridges; ? – no data).

Species	Length; width [mm]	Number of longitudinal ridges	Length ratio egg to posterior projection	Aeropyles Nr/Na or N; Abr. or Aor.	Figure; Author(s)
Philonthus alpinus EPP.	1.00–1.20; 0.60–1.67	0	1.1–3.1:1	s	Fig. 10; STANIEC & PIETRYKOWSKA-TUDRUJ (2007*b*)
Ph. atratus (GRAV.)	1.54–1.89; 0.84–1.10	many (brn.)	1.0–2.7:1	?	Fig. 11; STANIEC & PIETRYKOWSKA-TUDRUJ (2007*b*)
Ph. carbonarius (GRAV.)	1.00; ?	many (brn.)	1:1	? Abr.	Fig. 246G; HINTON (1981)
Ph. cognatus STEPH.	1.9–2.2; 1.2–1.3	28 (brn.)	0	4/9–10; Abr.	Fig. 250C; SZUJECKI (1965), HINTON (1981)
Ph. concinnus (GRAV.)	1.00; ?	0	1:1.0–1.1	s	Fig. 246B; HINTON (1981)
Ph. corvinus ER.	1.08–1.22; 0.64–0.74	11–13	1:1–1.3	8–9/10–11; Abr.	Fig. 12; STANIEC & PIETRYKOWSKA-TUDRUJ (2007*b*)
Ph. cruentatus (GMEL.)	1.40; ?	8	1.5–2:1	8/15–22; Aor.	Fig. 249F; HINTON (1981)
Ph. decorus (GRAV.)	2.80; ?	many (brn.)	0	s; 110–150	Fig. 250B; HINTON (1981)
Ph. flavolimbatus ER.	0.79–0.88; 0.39–0.50	7–8	?	7–8/16–21; Aor.	Fig. 1B; HU & FRANK (1995)
Ph. fumarius (GRAV.)	1.37–1.54; 0.77–0.98	35–40 (brn.)	3.5–5:1	?/3–6; Aor.	Fig. 1; present study
Ph. hepaticus ER.	0.79–0.88; 0.39–0.50	0	0	?	Fig. 1E; HU & FRANK (1995)
Ph. intermedius LAC.	2.40; ?	?	0	?/12–14; Abr.	Fig. 250D; HINTON (1981)
Ph. lepidus (GRAV.)	1.22–1.43; 0.63–0.91	22–24 (brn.)	1.0–1.8:1	?/5–7; Abr.	Fig. 13; STANIEC & PIETRYKOWSKA-TUDRUJ (2007*b*)
Ph. longicornis STEPH	1.07–1.20; 0.52–0.57	7–8	?	7–8/? Aor.	Fig. 1A; HU & FRANK (1995)

Table 1 (continued)

Ph. marginatus O. F. MÜLLER	1.80; ?	0	3–4:1	s	Fig. 246C; HINTON (1981)
Ph. micans (GRAV.)	1.05–1.19; 0.59–0.76	40–45 (brn.)	2.4–4.3:1	6/8–11; Abr.	Fig. 14; STANIEC & PIETRYKOWSKA-TUDRUJ (2007*b*)
Ph. nigrita (GRAV.)	1.1–1.3; 0.66–0.82	35–40 (brn.)	0	many/many Aor.	Fig.1; S*taniec* & PIETRYKOWSKA-TUDRUJ (2008)
Ph. punctus (GRAV.)	1.51–1.75; 0.87–0.95	many (brn.)	3:1	6/16 or 19; ?	Fig. 1; PIETRYKOWSKA-TUDRUJ & STANIEC (2006)
Ph. quisquiliarius (GYLL.)	1.00; ?	many (brn.)	7–8:1	30–50 Abr.	Fig. 249E; HINTON (1981)
Ph. rubripennis STEPH.	0.98–1.10; 0.49–0.64	25–30 (brn.)	3:1	7/9–10; Abr.	Fig. 1; STANIEC & PIETRYKOWSKA-TUDRUJ (2007*a*)
Ph. rufipes (STEPH.)	1.40; ?	many (brn.)	5–6:1	200–300 Abr.	Fig. 249C; HINTON (1981)
Ph. sanamus TOTT.	1.47; 0.89	10	1:1.5–2.0	8/13–18	Fig. 1a; BYRNE (1993)
Ph. sanguinolentus (GRAV.)	1.50; ?	many (brn.)	1.5–2:1	s; 250–350	Fig. 249D; HINTON (1981)
Ph. sericans (GRAV.)	0.79–0.91; 0.38–0.50	many (brn.)	0	s; Abr.	Fig. 1D; HU & FRANK (1995)
Ph. splendens (FABR.)	2.5; ?	many	0	Abr.	Fig. 250E; HINTON (1981)
Ph. tenuicornis MULS & REY	3.0; ?	?	4.0–3.5:1	? Abr.	Fig. 249H; HINTON (1981)
Ph. varians (PAYK.)	1.1; ?	many (brn.)	0	?	Fig. 250A; HINTON (1981)
Ph. ventralis (GRAV.)	1.04–1.21; 0.48–0.59	4–5	0	s; Abr.	Fig. 1C; HU & FRANK (1995)

Table 2. Morphological characters of the known larvae of species of *Philonthus*. (1a – without serration on inner margin; 1b – with serrations on inner margin; 2a – segment I shorter than pygopod; 2b – segment I equal in length or longer than pygopod; 3a – not extending beyond tentorial pits; 3b – usually narrow and distinctly extending beyond tentorial pits; 3c – slightly extending beyond tentorial pits; 4a – less than 2.4 times as long as median tooth; 4b – 2.5-3 times as long as median tooth; 4c – more than 3 times as long as median tooth; 5a – well developed, with numerous setae; 5b – represented by only from 2 to a few setae; 5c – no trace of comb; (x) - the number(s) of figure(s); Pmt – paramedian tooth; * - the character is not clear because of too small figure).

	1. Mandibles	2. Urogomphi	3. Apotome	4. Length of Pmt of anterior margin of nasale	5. Comb of small setae on fore tibia (L_{2-3})	6. Body length (L_3)	7. Head width (L_3)	References
Philonthus aerosus KIESW.	a (1, 2)	b (14)	b (8)	a or b* (3)	a (12)	–	1.18–1.40	KRANEBITTER & SCHATZ (2002)
Ph. albipes (GRAV.)	–	–	a (63)	a (61)	–	–	–	BOLLER (1983); KASULE (1970)
Ph. carbonarius (= *varius*) (Grav.)	a	–	–	b	–	8.50–9.50	0.86–0.93	POTOTSKAYA (1967)
Ph. cognatus (= *fuscipennis*) STEPH.	–	–	–		b	14.50	1.30	SZUJECKI (1965)
Ph. debilis (GRAV.)	–	–	–	a	–	–	–	POTOTSKAYA (1967)
Ph. decorus (GRAV.)	a	–	b (73)	a	a (74)	–	–	KASULE (1970)
Ph. caucasicus (= *dimidiatus*) NORDM.		a		a	–	–	–	POTOTSKAYA (1967)
Ph. diversiceps BERNH.	a	a (4D)	–	a (4B)	c (4A)	–	9.50	POTOTSKAYA (1966)
Ph. fumarius (GRAV.)	a (17)	a (29, 30)	b (11, 12)	a (15)	b (22, 23)	6.48–8.00	0.98–1.02	present study
Ph. laminatus (CREUTZ.)		b						POTOTSKAYA (1967)
Ph. marginatus O. F. MÜLL.	a	a	b (77)	c (81)	c			KASULE (1970); BOLLER (1983)

Table 2 (continued)

	1. Mandibles	2. Urogomphi	3. Apotome	4. Length of Pmt of anterior margin of nasale	5. Comb of small setae on fore tibia (L_{2-3})	6. Body length (L_3)	7. Head width (L_3)	References
Ph. nigrita (GRAV.)	a (22)	a (40, 42, 44)	b (15)	a (20)	c (31, 32)	9.10–10.71	0.88–0.97	STANIEC & PIETRYKOWSKA-TUDRUJ (2008)
Ph. parvicornis (=*agilis*) (GRAV.)				a				POTOTSKAYA (1967)
Ph. politus (L.)			c			14.00–16.00	1.55–1.64	SMETANA (1958)
Ph. punctus (GRAV.)	a (19)	b (44, 46, 48)	b (11)	a (17)	b (26)	8.75–10.00	1.29–1.34	PIETRYKOWSKA-TUDRUJ & STANIEC (2006)
Ph. quisquiliarius (GYLL.)	b (35)	a	c	a	c			BOLLER (1983)
Ph. rectangulus SHARP		a		c (15)				BOLLER (1983)
Ph. rubripennis STEPH.	b (17, 18)	a (39)	c (26)	b (15)	b (30)	5.25–6.75	0.70–0.76	STANIEC & PIETRYKOWSKA-TUDRUJ (2007*a*)
Ph. sanguinolentus (GRAV.)		a		b				POTOTSKAYA (1967)
Ph. splendens (FABR.)			c (71)	b	a (72)			KASULE (1970)
Ph. succicola (=*chalceus*) THOMS.		b		a	b (75)			KASULE (1970)
Ph. tenuicornis (=*carbonarius*) MULS. & REY	a	b	b	c (1a)	a (76)	11.00–12.00	1.40	SMETANA (1962); BOLLER (1983)
Ph. umbratilis (GRAV.)	a		a	c (44)				BOLLER (1983)
Ph. varians PAYK.		a		a				POTOTSKAYA (1967)

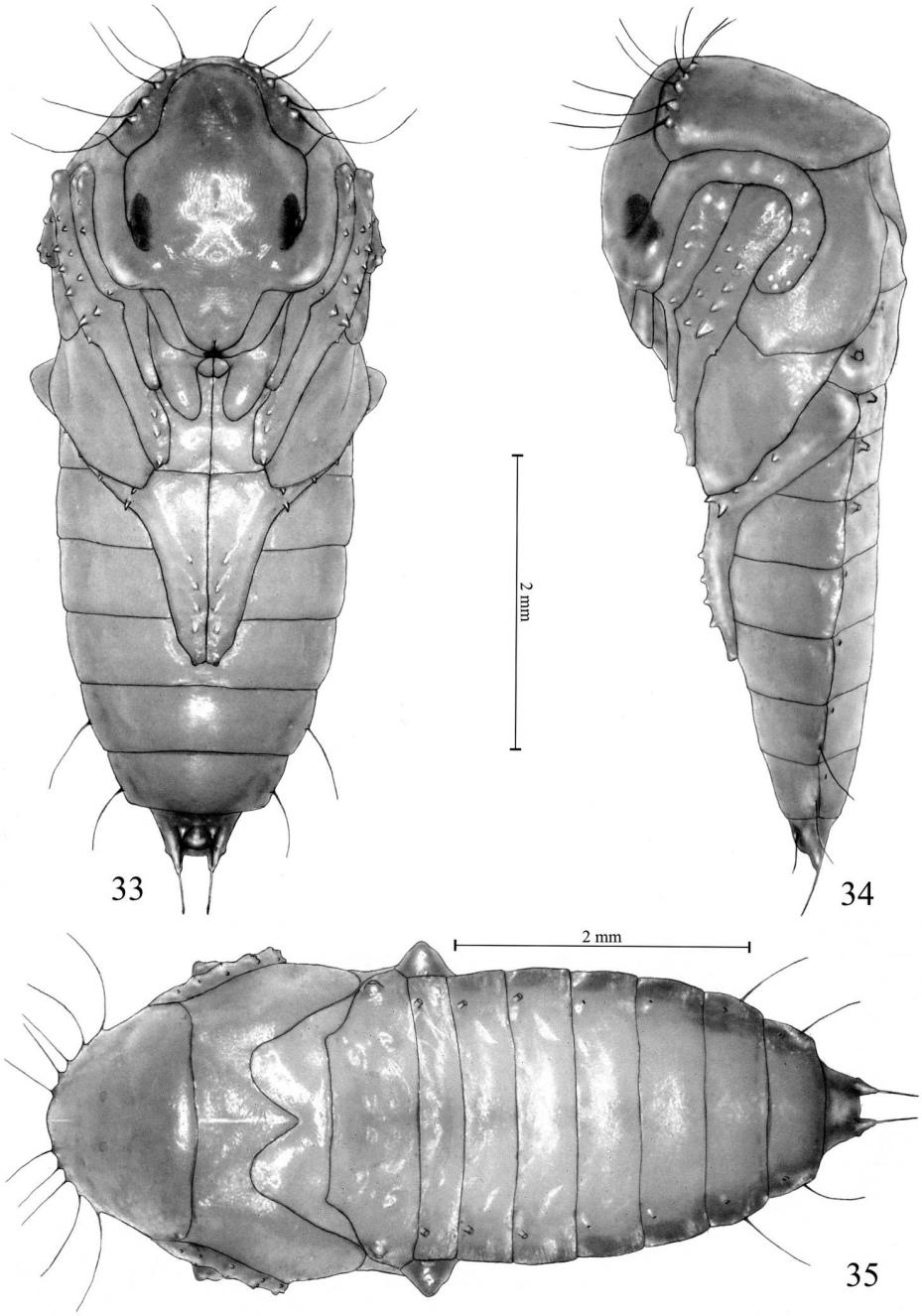
(Fig. 26); sternites with 14 simple setae and 2 pores (Fig. 28); fused paratergite and parasternite each with 6 simple setae (5 macro setae, 1 micro seta). Segment II–VIII: tergites with 43–45 setae (32 rod-shaped, frayed macro and 12 simple micro setae), 8 pores and a pair of campaniform sensillae (Ca); sternites with 32 setae (22 rod-shaped, frayed macro setae, 10 simple micro setae); paratergites and parasternites each with 5 setae (2 micro setae) and 7–8 setae (3–4 micro setae) respectively. Tergite and sternite of segment IX with 18 and 22 setae respectively (codes: 1–9 and 10–20) and 4 pores (codes: a, b) (Figs 29–31). Segment IX with a pair of two-segmented urogomphi (Figs 29–30); segment I with 26 setae (codes: 4–29) and 5 pores (codes: a-e) (Fig. 32); segment II with 3 setae (one long seta apically); length ratio of segments I and II of urogomphus and apical seta 2.1:1:1.2 respectively; microstructure of urogomphi as in Figs 32 A, B. Microstructure of tergites of segments I–IX as in Figs 2A, B. Segment X (pygopod): distinctly longer (1.3 times) than segment I and 1.2 times shorter than segment I and II of urogomphi; dorsal side with about 20 setae (Fig. 29), ventral side with about 35 setae (10–12 micro setae) and about 10 pores (Fig. 30); microstructure as in Fig. 31A. Abdominal segments I–VIII, each with a pair of spiracles (Sp) located between tergites and paratergites (Fig. 27).

Pupa (Figs 33–44) – Body length: 5.39–5.50 mm (mean 5.42 mm); maximum width (between hind knees): 1.99–2.25 mm (mean 2.10 mm); head width (between eyes): 0.98–1.05 mm (mean 1.00 mm). Colour ranges from almost white just after pupation to reddish brown with darker edges (a few days after pupation); setiform projections on pronotum and abdomen, light brown. Head 1.3 times as long as wide; wings distinctly protruding beyond posterior margin of the first clearly visible abdominal sternite (Fig. 33). Antennae reaching at least three fourths of length of the shortened elytra (Fig. 34). Pronotum about 1.1 times as wide as long; anterior margin with 9–11 setiform projections (looking from ventral side 4/6, 5/5, 5/4, 5/6, 5/5, 5/5, 5/5, 5/5 projections on sides in specimens examined). Each fore, middle and hind tibiae with 4–5, 10 and 5 clearly visible outlines of protuberances respectively. Hind tarsi protruding half of length of 4th clearly visible abdominal segment (Figs 33, 34). Abdomen widened from segment II to IV and then narrowed to the terminal segment IX (Fig. 35). Abdominal tergite I almost twice as long as tergite II. Segments VII–VIII, each bearing a pair of setiform projections on sides. Setiform projections on segments VII, VIII long, 1.2–1.4 as long as segments (Figs 33, 35). Terminal sternite with well-marked sexual dimorphism similar as in *Philonthus rubripennis* STEPHENS, 1832 (STANIEC & PIETRYKOWSKA-TUDRUJ [2007*b*]; Figs 54, 55). Microstructure of abdominal sternites (Fig. 36), functional (Fig. 37) and atrophied spiracles (Figs 38, 39) and structure of ventral and terminal prolongation (Figs 42–44) are as shown.

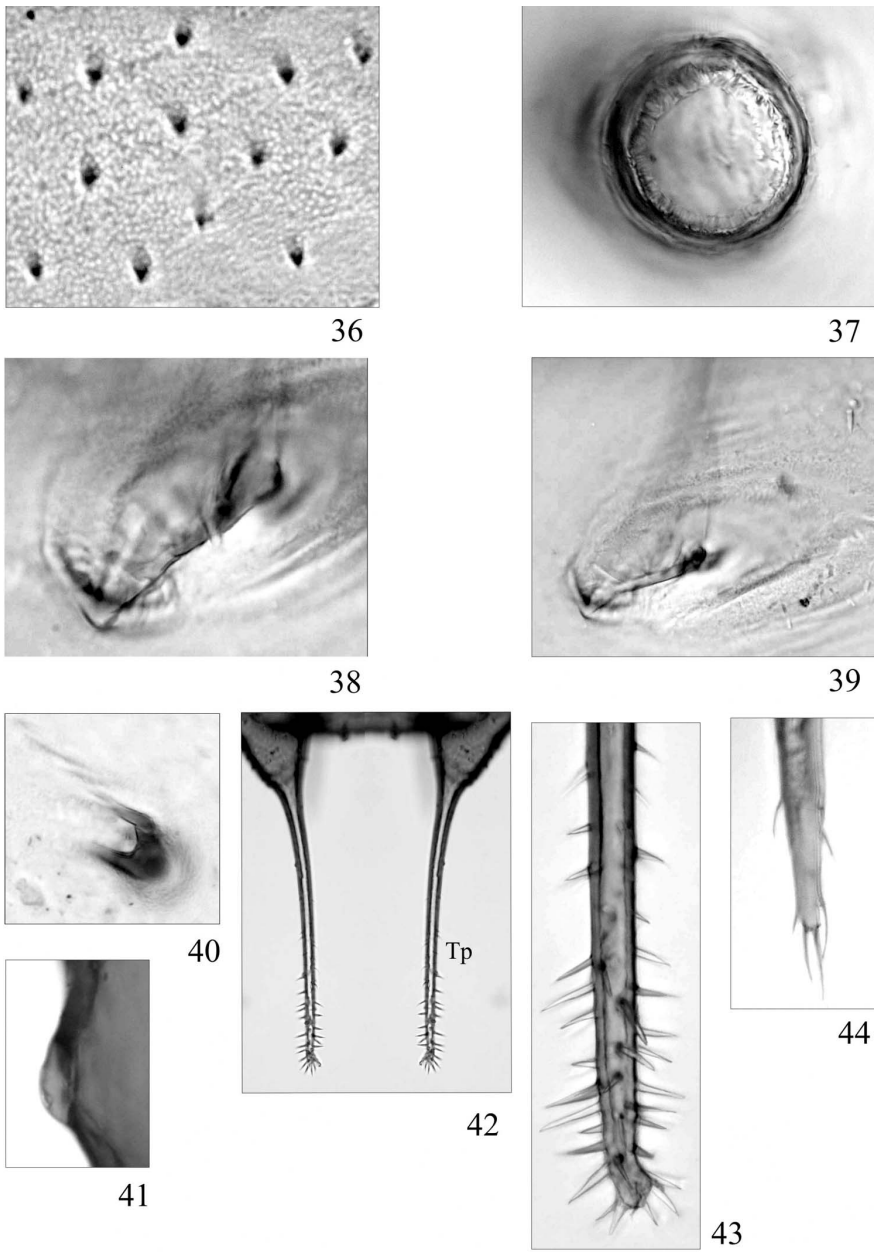
TAXONOMIC REMARKS

Diagnostic morphological characters of eggs, larvae and pupae of known species *of Philonthus* including *Ph. fumarius*, are presented in Table 1, 2 and 3 respectively, with references.

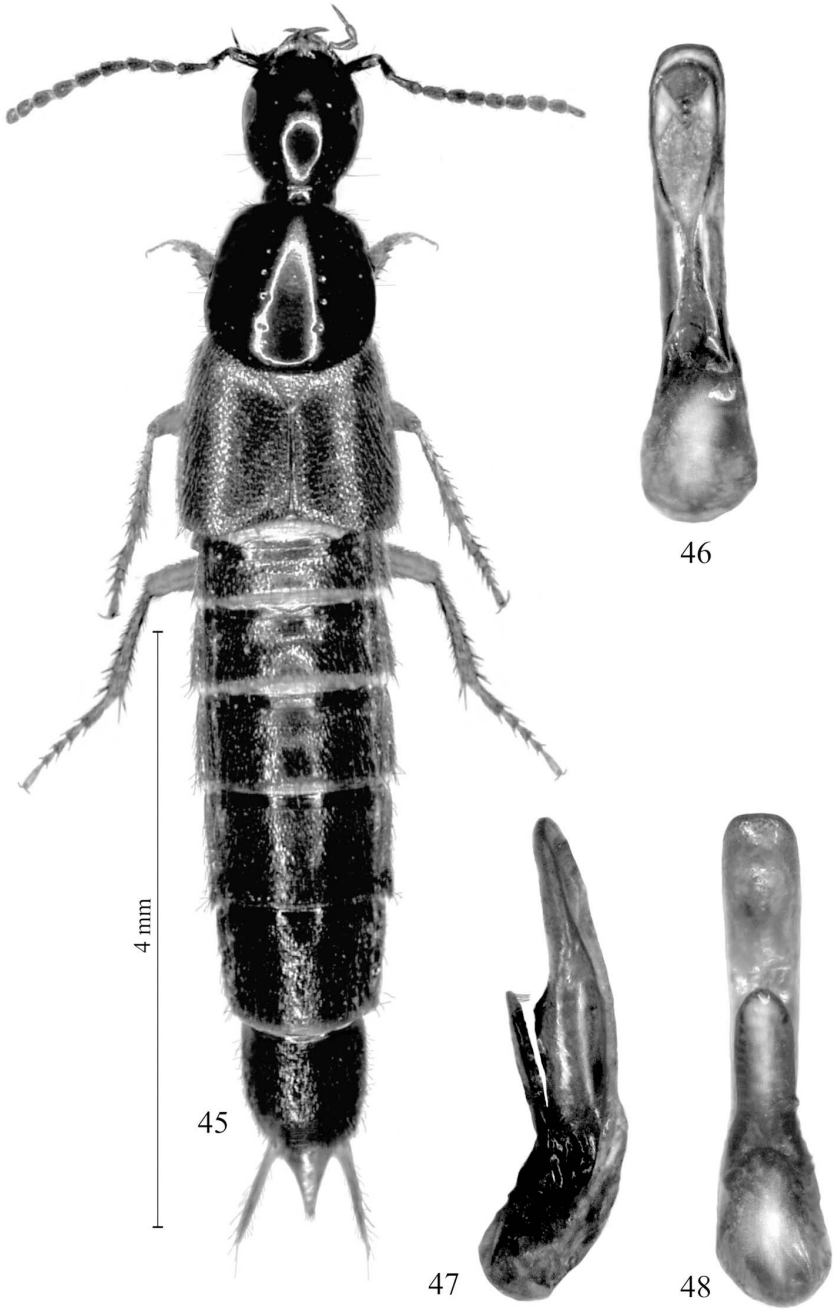
The egg of *Ph. fumarius*, is included into *Philonthus atratus* group of eggs (STANIEC & PIETRYKOWSKA-TUDRUJ [2007*b*], together with species having the most similar eggs – *Ph. corvinus* ER., *Ph. lepidus* (GRAV.), *Ph. micans* (GRAV.), *Ph. punctus* (GRAV.), and *Ph. rubripennis* STEPH. Characters which distinguish the egg of *Ph. fumarius* from eggs of species mentioned above are: the number of longitudinal ridges; length ratio of egg to posterior projection; moderately widened



Figs 33-35. *Ph. fumarius*, pupa. 33 = Ventral aspect; 34 = lateral aspect; 35 = dorsal aspect.



Figs 36–44. *Ph. fumarius*, pupa. 36 = Microstructure of abdominal sternite; 37 = functional spiracles of third pair; 38, 39 = atrophied spiracles of abdominal segment VI (38) and VII (39); 40 = lateral cuticular structure of first abdominal tergite; 41 = lateral margin of abdominal segment IX in female; 42, 43 = terminal prolongation (Tp); 44 = apical part of ventral abdominal prolongation in female.



Figs 45–48. *Ph. fumarius*, imago. 45 = Habitus; 46-48 = aedeagus in dorsal aspect (46), lateral aspect (47) and ventral aspect (48).

the end of posterior projection (similar as in *Ph. atratus*, *Ph. corvinus* and *Ph. lepidus*); aeropyles on longitudinal ridges in rows of 3–6 each, openings tighten; length (1.37–1.54 mm) (Table 1).

Based on the morphological characters provided in Table 2, *Ph. fumarius* larva is most similar in morphology and prefered habitats to larva of *Ph. punctus* (PIETRYKOWSKA-TUDRUJ & STANIEC, 2006). They can be distinguished by body length and head width (Table 2).

Diagnostic characters of pupae are presented in Table 3. *Ph. fumarius* pupa is very similar in morphology to the pupa of *Ph. nigrita* (GRAV.) (STANIEC & PIETRYKOWSKA-TUDRUJ 2008). The differences cover: the structure of the atrophied spiracles (Figs 38, 39 – *Ph. fumarius*; Figs 54, 55; STANIEC & PIETRYKOWSKA-TUDRUJ 2008 – *Ph. nigrita*), the measurements and habitats (*Ph. nigrita* occurs exclusively at high- and transitional moors, preferring the ecotone zones at the water bodies and surrounding peat bogs, where it usually inhabits the partly submerged peat (*Sphagnum*) layer (BURAKOWSKI *et al*. 1980, KOCH 1989).

REMARKS ON THE ECOLOGY AND BIOLOGY

Philonthus fumarius (adult habitus and aedeagus as in Figs 45–48) is known generally from north and Central Europe, Russia, Turkey and Kazakhstan. In Po-

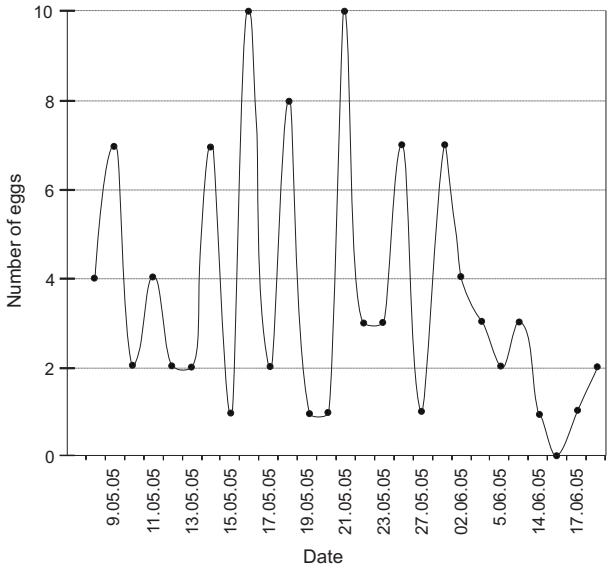


Fig. 49. Number of eggs laid per day by 5 females of *Ph. fumarius* at 20±2°C.

Table 3. Diagnosis of pupa. (s.p. – setiform projections; 3a – distinctly not reaching half of length of elytra; 3b – reaching or slightly protruding beyond half of length of elytra; 3c – reaching almost two thirds of length of elytra; 4a – reaching half of length of 4th (morphological 6th) segment; 4b – only protruding beyond anterior margin of 4th (morphological 6th) clearly visible abdominal segment, but not reaching half of length; 4c – protruding half of length of 4th (morphological 6th) segment; 4d – at least reaching posterior margin of 4th (morphological 6th) clearly visible abdominal segment; measurements in mm).

Species	1. Number of pairs of s.p. on abdomen	2. Number of s.p. on pronotum	3. Antennae length	4. Hind legs length	5. Body length	References
Philonthus albipes (Grav.)	6	8	b	a	3.4–3.5	STANIEC (2002)
Ph. cognatus Steph.	6	16	-	-	4.6–5.2	SZUJECKi (1965)
Ph. corvinus Er.	6	9–11	b	c	4.5–5.2	STANIEC (2003)
Ph. decorus (Grav.)	6	22–24	-	-	-	VERHOEFF (1918)
Ph. fumarius (Grav.)	2	9–11	c	c	5.4–5.5	present study
Ph. lepidus (Grav.)	6	8–13	c	a	3.4–4.6	STANIEC & KITOWSKI (2004)
Ph. longicornis Steph.	6	10	-	-	-	MANK (1923)
Ph. micans (Grav.)	6	10–11	c	a	3.8–4.1	STANIEC (2003)
Ph. nigrita (Grav.)	2	9–12	c	c	4.6–5.4	STANIEC (2001); STANIEC & PIETRYKOWSKA-TUDRUJ (2008)
Ph. punctus Grav.)	2	14–17	b	a	5.9–6.6	STANIEC (2003)
Ph. quisquiliarius Gyll.)	2	10	b	b	3.9–4.3	STANIEC (2001)
Ph. rectangulus Sharp	2	13–21	b	a	5.8–6.8	STANIEC (2004*a*)
Ph. rubripennis Steph.	6	10–12	c	a	3.6–4.2	STANIEC & PIETRYKOWSKA-TUDRUJ (2007*a*)
Ph. succicola THOMS.	6	18–20 or 22	a	d	7.0–8.5	STANIEC (2004*a*)
Ph. tenuicornis REY	6	16–20	b	b	6.8–7.6	STANIEC & PIETRYKOWSKA (2005)
Ph. umbratilis (GRAV.)	6	9–12	c	c	4.6–4.9	STANIEC & KITOWSKI (2004)
Ph. varians PAYK.	6	10–11	c	d	4.3–4.4	STANIEC (2002)

Table 4. Duration and mortality of immature stages of *Philonthus fumarius* at a temperature of 20±2ºC (N = number of specimens examined)

Stages	Duration (days)		Mortality (%)	N
	Range of duration	Mean		
Egg	5–10	7.6	55	40
L_1	3–5	3.6	5.5	18
L_2	5–7	5.6	41	17
L_3	8–14	10.8	50	10
Prepupa	2–3	2.8	0	5
Pupa	–	–	100	5

land, it is not a common staphylinid, known only from a few dispersed localities (BURAKOWSKI *et al*., 1980; HERMAN, 2001; LUCHT, 1987). It is defined as a stenotopic, hygrophilous, paludicolous and a phytodetriticolous species, inhabiting muddy and boggy shores of swamps and water bodies where it occurs in leaf litter, moss and decaying plants (BURAKOWSKI *et al*., 1980; KOCH, 1989).

During the rearing, conducted from 7 May 2005 oviposition was observed from the 8 May to the end of June (Fig. 49). Eggs were laid individually, distributed in soil filling a rearing container. During the reproductive period, a single female laid up from 0 to 3 eggs per day. The period of highest fecundity was observed from May to the beginning of June (Fig. 49), with maximum egg laying on 16 and 21 May. Five females in the laboratory (each paired with a male), totalled 105 eggs (each of these females laid: 15, 20, 22, 23, 25 eggs). The average number of eggs laid was 21 eggs per female. The embryonic development at a temperature of 20°C (±2) was about 8 days with the highest mortality of 55% (Table 4). In the laboratory, larvae appeared at the middle of May. Developmental time of various larval stages was 3 to 14 days (Table 4). The mortality rate of larval stages (L1–3) was recorded: 5.5%, 41% and 50%, respectively. All the larval instars distinctly avoid light. They were always observed on the bottom of rearing containers, under a layer of soil. Shortly before pupation the larvae were became less and less active. The prepupa and pupa stages are motionless. The prepupa stages lasted about 3 days (0% mortality). Unfortunately, the complete development (from egg to adult) of studied specimens could not be observed because all reared pupae died. The development from egg to pupa lasted from 23 to 26 days.

*

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