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Comparative morphology of the development stages of *Poophagus hopffgarteni* TOURNIER, 1873 and *P. sisymbrii* (FABRICIUS, 1776), with comments on their biology (Coleoptera: Curculionidae)

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ABSTRACT. First detailed descriptions of the larvae and pupae of *Poophagus hopffgarteni* TOURN. and *P. sisymbrii* (FABR.) are given. The diagnostic characters of the preimaginal stages of the genus *Poophagus* and both examined species are listed. Remarks on the ecology, biology and distribution of the mentioned species are given.

Key words: entomology, morphology, Coleoptera, Curculionidae, *Poophagus hopffgarteni*, *P. sisymbrii*, larva, pupa, distribution, environmental protection.

INTRODUCTION

Genus *Poophagus* SCHOENH. is represented by four species, of which three were found in Europe and two: *Poophagus hopffgarteni* and *P. sisymbrii* (Figs 1a, 1b) were recorded in Poland so far (SMRECZYNSKI 1974, WANAT & MOKRZYCKI 2005). Characteristic features of the mentioned genus include e.g.: middle size of the body (length: 2.3 - 3.5 mm); long, cylindrical, rostrum; long (or even very long) limbs and body covered by waterproof scale-like setae (FREUDE et al. 1983). *P. hopffgarteni* is a palearctic species, in Europe distributed in: Austria, Croatia, Czech Republic, Germany, Hungary, Poland, Slovakia and Ukraine. In Poland its occurrence is strictly connected with Bug River Valley and Narew River Valley (East Poland) (JELÍNEK 1993, PODLUSSÁNY 1996, BEHNE 1998, LEGALOV & OPANASENKO 2000, WANAT & GOSIK 2003). However *P. sisymbrii* is distributed in the Holarctic, in Europe recorded from many localities (ALONSO-ZARAZAGA 2005). *P. hopffgarteni* is known as a stenotopic and monophagous species, connected

with great yellowcress (*Rorippa amphibia* (L.) BESS.). It occurs exclusively on shores of lakes and river-beds. In whole distribution range it is an extremely rare and endangered weevil (WINKELMANN 1991). *P. sisymbrii* is a eurytopic and oligophagous species connected with *Nasturtium officinale* R. BR. and *Rorippa* SCOP. species growing on: the aquatic, hygrophilous and meadow plant associations. On some known localities both species occur together (KOCH 1992, WANAT & GOSIK 2003). The life-cycle of the mentioned weevils is relatively completely described. According to DIECKMANN (1972) there are no important differences between bionomics of *P. hopffgarteni* and *P. sisymbrii*. The imagines were collected from the beginning of May until the middle of September. The larvae and pupae were collected from inside of the stems, in a period from the end of May to September. Usually, more than one specimen was found inside single plant. Immature stages of *P. hopffgarteni* inhabit the thin (protruding over the water surface) parts of stems, close to the flowers. In the case of *P. sisymbrii* larvae and pupae were collected from submerged, old parts of stems, near the roots. The adults of the mentioned weevils overwinter in plant remains, on the banks of water bodies (HOFFMANN 1954, BURAKOWSKI et al. 1997).

The morphology of developmental stages of the mentioned genus is still very poorly known. Only SCHERF (1964) provided the superficial (unillustrated) description of the *Poophagus* larvae. Both mentioned species are very similar to each other and they often inhabit together the same biotopes. The detailed, illustrated description of immature stages of *P. hopffgarteni* and *P. sisymbrii* is necessary, especially because the first one belongs to the most uncommon and endangered water beetles.

MATERIAL AND METHODS

The examined material contained:

Poophagus hopffgarteni: L₃ – 11 specimens, pupa – 9 specimens;

P. sisymbrii: L₃ – 47 specimens, pupa – 18 specimens.

(The number of collected specimens of immature stages of *P. hopffgarteni* was reduced to indispensable minimum because of the species scarcity).

The observation on biology and study material was obtained during seasons 2003-2006 from the Bug River Valley in: Gołębie (UTM nets: KS91), Ślipcze (GB02), Gródek (GB03) near Hrubieszów; Magazyn (FC80), Wołczyn (FC80) near Włodawa; Niemirów (FC49), Zajęczniki (FD10) near Mielnik (CE Poland).

The preimaginal stages were collected from the stems of great yellowcress growing on scant, shallow meadow water reservoirs. The larvae and the pupae of *P. hopffgarteni* were collected only from protruding over water surface, and from the plants on which the copulation has been observed. Equity of this method is confirmed by the fact that on this parts of stems, I have never found pupae or teneral imagines of *P. sisymbrii*. In order to determine, some pupae were kept alive until metamorphosis. The immature stages of *P. sisymbrii* were collected in localities where *P. hopffgarteni* was not present. The preimaginal stages were preserved in a 1:1 solution of glycerine and alcohol. Punctured larvae and pupae were rinsed in distilled water and cleared in chloralphenol and finally placed in Berlesy's liquid to prepare microscopic slides. The drawings were

made using camera lucida. The terminologies used in the morphological description of larvae and pupae follow SCHERF (1964) and MAY (1994).

RESULTS

1. Morphological description

Results of morphological description of larvae and pupae of both *Poophagus* specie are given in Table 1. Parts with important morphological differences between the mentioned species are **bold marked**.

2. Remarks on the ecology and biology

The beginning of the activity of both species is connected with the increase of temperature and insolation. The first active specimens were recorded in the end of March and the copulation was observed in the first decade of May. The different larval stages were collected until the beginning of August. In my observations, adults stay in the place of their metamorphosis from 2 to 3 weeks. The results of my study demonstrate the difference in the duration of development period between *P. hopffgarteni* and *P. sisymbrii*. The first pupae of *P. hopffgarteni* were observed in the begging of June, whereas at the same period of time only larvae of *P. sisymbrii* were detected. The first pupae of *P. sisymbrii* were collected three weeks later. On the contrary to *P. sisymbrii*, the development of *P. hopffgarteni* took place inside the stems, emergency over the surface of the water. Apparently, the development of *P. hopffgarteni* correlated with the air temperature. The air temperature was markedly higher than the water temperature at that period of time. The results of my study indicate that the difference between the temperature of water and air takes crucial role in the development rate of both species - preimaginal stages of *P. hopffgarteni*, living above water and in higher temperatures develop more quickly than *P. sisymbrii* living under water. During the study no predators or parasites of *P. hopffgarteni* were detected, whereas many larvae and pupae of *P. sisymbrii* were seen attacked by larvae of undetermined *Staphylinidae*.

The majority of adults of *P. hopffgarteni* were observed on the surface of leaves of great yellowcress. The plant was growing in the shallow meadow water reservoirs with dominant *Magnocaricion* rushes or in the undergrowth of alder forest (*Ribeso nigri-Alnetum*). A few individuals were found in the undergrowth of melting floodplain forest (*Alno-Ulmion*). Those observations could explain distinctly demanding ecosystem preferences of both species. Most probably, abiotic factors like environmental pollution could be regarded as pivotal agents in the weevil distribution. The occurrence of *P. hopffgarteni* is directly connected with undisturbed ecosystems. The centre of distribution of *P. hopffgarteni* is localized in the middle of Europe. However, its distribution in Poland is connected only with rivers in the east part of the country. It indicates that Bug River Valley is active, ecological corridor that plays important role in the migration of weevil species in the North-Eastern Europe.

Table 1. Morphological description of larvae and pupae of *P. hopffgarteni* and *P. sisymbrii*.

	<i>P. hopffgarteni</i> (Figs a)	<i>P. sisymbrii</i> (Figs b)
Larva (L ₃) (Figs 2a, 2b)	Body length: 4.15 – 5.50 mm, (mean 5.10 mm); moderately slender, slightly curved, on cross-section rounded ; light yellow, pronotum grayish-yellow, setal numbers greatly reduced, setae on various length, on protuberance, light yellow. Cuticule minutely spiculate.	body length: 4.35 – 6.28 mm, (mean 5.40 mm); slender, slightly curved, oblate dorsa-ventrally , light yellow, pronotum grayish-yellow, setal numbers greatly reduced, setae on various length, on protuberance, light yellow. Cuticule minutely spiculate.
Head (Figs 3a, 3b)	Width: 0.68 mm. , light brown, oval, frontal suture distinct. Macro setae of head: 4 pairs of dorsal epicranial setae (des ₁ , des ₂ , des ₃ , des ₄), des₃ much shorter than other des , des ₃ located on frontal suture; 2 frontal setae (fs ₂); 4 lateral epicranial setae (les ₁ , les ₂); les₁ much shorter than les₂ . Front with 5 pairs of pores and 1 pair of setal sensillae.	Width: 0.77 mm. , light brown, oval, frontal suture distinct. Macro setae of head: 4 pairs of dorsal epicranial setae (des ₁ , des ₂ , des ₃ , des ₄); all macro setae of head equal length . des ₂ located on frontal suture; 2 frontal setae (fs ₁); 4 lateral epicranial setae (les ₁ , les ₂). Front with 5 pairs of pores and 1 pair of setal sensillae.
Antennae (Figs 4a, 4b)	Conical, long ; basal membranous area with 5 slender sensillae.	Conical, short and stocky ; basal membranous area with 5 short sensillae.
Clypeus and labrum (Figs 5a, 5b)	Clypeus (cl) 2.4 x as long as wide with 6 setal sensillae; labrum (lrm) about 3.5 x as long as wide with 2 setal sensillae medially and 6 labial setae (lrms); all lrms equal in length. The anterior margin of labrum simply .	Clypeus (cl) 3.2 x as long as wide with 6 setal sensillae; labrum (lrm) about 2.0 x as long as wide with 2 setal sensillae postero-medially and 6 labial setae (lrms); all lrms equal in length. The anterior margin of labrum sinuate .
Epipharynx (Figs 6a, 6b)	6 antero-median setae (ams), all equal in length, truncated. 6 antero-lateral setae (als), all equal in length, truncated. The (als) 2 x longer then (ams). 2 pairs of median setae (mes) short, sharp; torma (t) convergent, elongated .	6 antero-median setae (ams), all equal in length, truncated. 6 antero-lateral setae (als), all equal in long, truncated. The (als) 2 x longer then (ams). 2 pairs of median setae (mes) short, sharp; torma (t) convergent, short .
Maxilla (Figs 7a, 7b)	Consists of triangle cardo (cd), stipes (st), mala (ma) and maxillary palp (mp). Stipes and mala fused, stipes with 3 setae dorsally, 2 pores and 2 setal sensillae (ss). Mala with 2 setal sensillae dorsally, 2 setae ventro-apically (vms) and 7 truncate, simple, macro setae on adoral margin (dms). Maxillary palp 2-segmented; segment I is almost as long as segment II and distinctly wider than segment II, length ratio of segment I and II: 1 : 1.5. Segment II with 8 conical cuticular process apically. Segment I with 1 setal sensillae.	Consists of triangle cardo (cd), stipes (st), mala (ma) and maxillary palp (mp). Stipes and mala fused, stipes with 3 setae dorsally, 2 pores and 2 setal sensillae. Mala with 4 setal sensillae dorsally, 2 setae ventro-apically (vms) and 5 truncate, simple, macro setae on adoral margin (dms). Maxillary palp 2-segmented; segment I is almost as long as segment II and distinctly wider than segment II, length ratio of segment I and II: 1 : 1.5. Segment II with 8 conical cuticular process apically. Segment I with 1 setal sensillae.
Mandible (Fig 8)	Broad, bifid, teeth almost of equal height, slightly truncate, with 3 setal sensillae.	Broad, bifid, teeth almost of equal height, slightly truncate, with 3 setal sensillae.

Table 2. Comparison of the some known morphological characters of larvae and pupae of *P. hopffgarteni* and *P. sisymbrii*.

Features	<i>P. hopffgarteni</i>	<i>P. sisymbrii</i>
Larva (L₃)		
Body shape	on cross-section rounded	slightly oblate dorsa-ventrally
Head	width - 0.68 mm.; des ₃ much shorter than other des, les ₁ much shorter than les ₂ .	width - 0.77 mm.; all macro setae of head equal length.
Antennae	long; sensillae slender.	short and stocky; sensillae short
Clypeus and labrum	(cl) 2.4 x as long as wide; the anterior margin of labrum simply. Setal sensillae located medially.	(cl) 3.2 x as long as wide; the anterior margin of labrum sinuate. Setal sensillae located postero-medially
Epipharynx	torma (t) elongated.	torma (t) short.
Maxilla	2 (vms), 7 (dms).	4 (vms), 5 (dms).
Labium	(plb) small, (pslb) with 3 pairs, sharp, short macro setae. Segment I of (Lpa) wide, distinctly bigger than segment II. (la) with 4 short, sharp setae. Surface of cuticle on pslb with tooth-like cuticular processes.	(plb) wide, (pslb) with 1 pairs, sharp, simply macro setae. Segment I of (Lpa) some wider than segment II. (la) with 4 simply setae. Surface of cuticle on pslb smooth.
Pupa	length: 3.6 mm, width 2.1 mm. The tarsi of first pair reach the coxas of third pair. The tarsi of third pair protrude distinctly over the apex of the elytrons. The lateral margin of pronotum (in the middle parts) slightly rounded. Setae (ds ₂) located in the posterior part of pronotum.	length: 4.1 mm, width 2.0 mm. The tarsi of first pair protrude the coxas of second pair. The tarsi of third pair reach the apex of the elytrons. The lateral margin of pronotum (in the middle parts) parallel. Setae (ds ₂) located in the anterior part of pronotum.

CONCLUSIONS

Diagnosis of the larva of the genus *Poophagus*: (1) setal number greatly reduced, (2) head with frontal suture distinct, (3) antennae conical, with 5 sensillae, (4) ocelli present, (5) head with setae des₃, (6) labrum with 6 macro setae, (7) labial palp two-segmented, (8) mandibles bifid, teeth slightly truncate, (9) ligula concave, (10) spiracles bicameral, (11) each pedal area with some setae on irregular length, (12) anus ventral.

The characters given by SCHERF (1964) are not sufficient to distinguishing the larvae *P. hopffgarteni* and larvae *P. sisymbrii*. However, distinguishing preimaginal stages of both species is possible not only on the base of differences in their ecology but also in morphology. This applies to both larvae and pupae (Tab. 2).

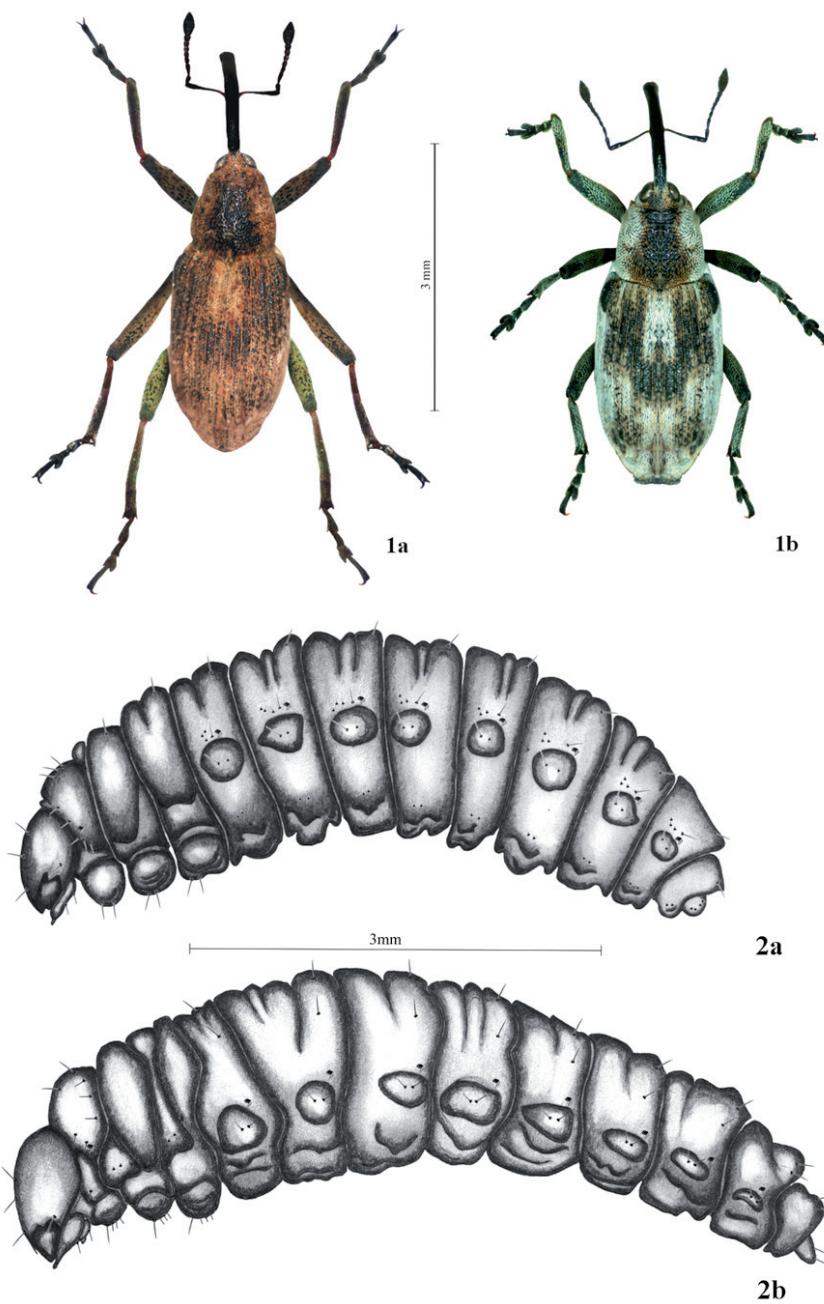
Poophagus sisymbrii is a common, eurytopic species, resistant to environmental pollution. On the contrary, *P. hopffgarteni* is a rarity, susceptible to environment degradation. It is connected with undegraded old river-beds. Consideration of this facts shows that *P. hopffgarteni* fulfills the criterions of the Red List of Threatened Animals.

ACKNOWLEDGEMENTS

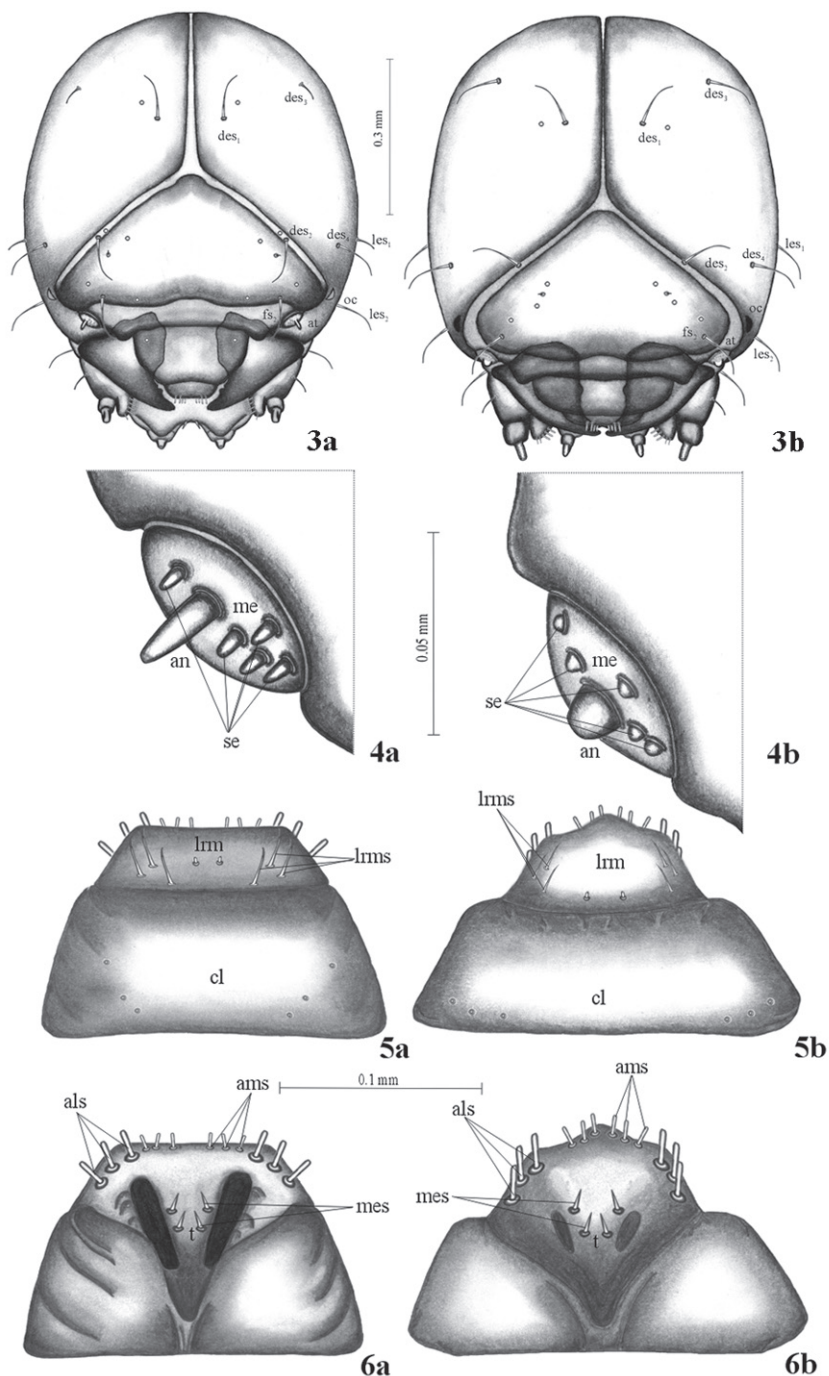
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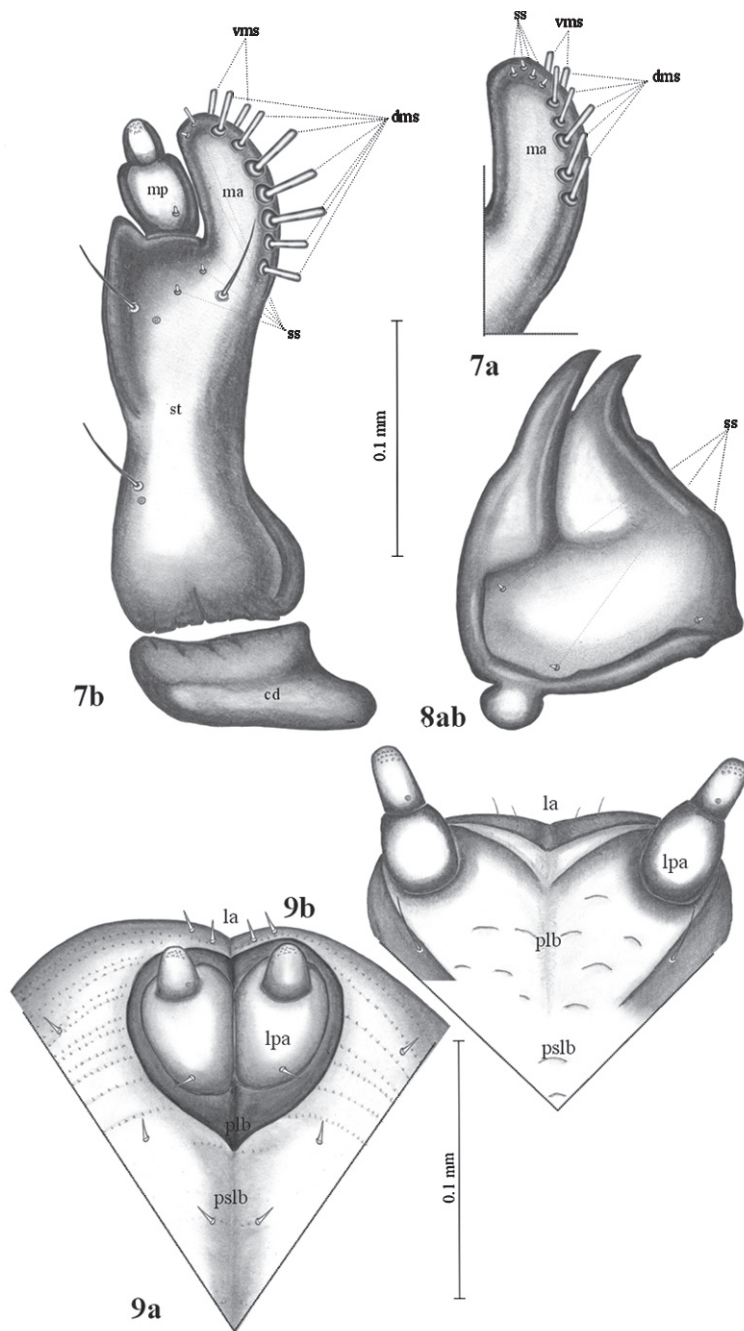
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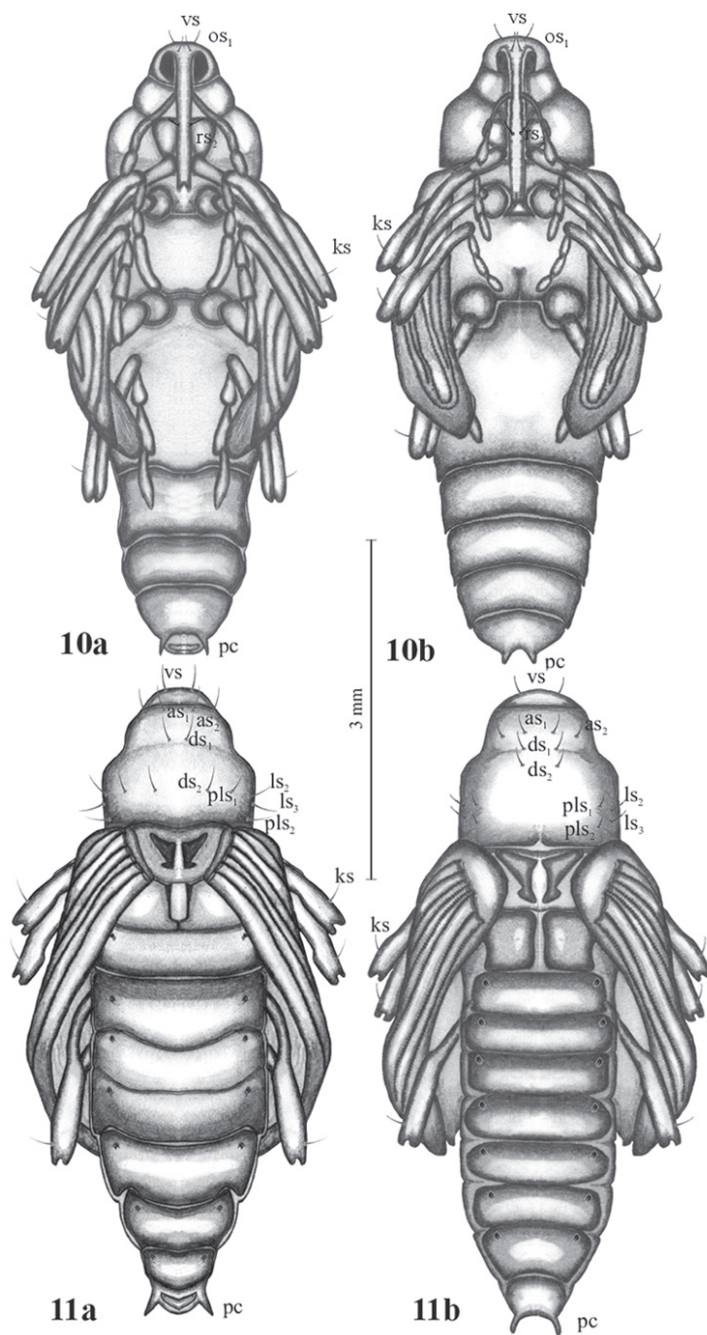
1. Imago (dorsal aspect); 2. Mature larva, habitus (lateral aspect): a. *Poophagus hopffgarteni*, b. *P. sisymbrii*



3. Mature larva, head (des – dorsal epicranial setae, fs – frontal seta, les – lateral, oc – ocellus, at – antenna); 4-6. Mature larva: 4 – antenna (an – antenna, me – membrane, se – sensillae); 5 – labrum (lrm) and clypeus (cl) (lrms – labial setae); 6 – epipharynx (ams – anteromedial setae, als – anteriolateral setae, t – tormae):
a. *Poophagus hopffgarteni*, b. *P. sisymbrii*



7-9. Mature larva: 7 – left maxilla, dorsal aspect (cd – cardo, st – stipes, ma – mala, mp – maxillary palp, dms – dorsally mala setae, vms – ventrally mala setae, ss – setal sensillae); 8 – left mandible (dorsal aspect) (ss – setal sensillae); 9 – labium, ventral aspect (plb – praelabium, pslb – postlabium, lpa – labial palp, la – ligula): a. *Poophagus hopffgarteni*, b. *P. sisymbrii*



10, 11. Pupa, habitus: 10 – ventral aspect (*vs* – vertical seta, *os* – orbital setae, *rs* – rostral setae, *ks* – knee setae, *pc* – pseudocerci); 11 – dorsal aspect (*as* – apical setae, *ls* – lateral setae, *ds* – discal setae, *pls* – posterolateral setae): a. *Poophagus hopffgarteni*, b. *P. sisymbrii*