Larval morphology of *Aphodius sus* (Herbst) and *A. variicolor* Koshantschikov (Coleoptera: Scarabaeidae: Aphodiinae)

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Abstract

Morphological descriptions and illustrations are presented for third-instar larvae of two species of the scarab beetle genus *Aphodius* Illiger: *Aphodius* (*Heptaulacus*) *sus* (Herbst) and *A. (Chilothorax) variicolor* Koshantschikov. These descriptions are based on material collected in European Russia. Larvae were collected from the soil with no association to dung although the adults of the same species normally occur in horse dung. Characters of the larvae are compared with those of described larvae of other species.

Key words: scarab beetles, larvae, southern Russia

Introduction

The larval morphology of the mega-diverse scarab beetle genus *Aphodius* Illiger (sensu lato) is poorly known. The larvae for only one third of western European species have been described, even though these species are the taxonomically well known. Even so, most of these descriptions are incomplete (Krell 1997). Regarding the world fauna, immature stages for less than 5% of the species are known. Due to the scarcity of data, larval characters have not been considered in the proposed classifications of the genus and the tribe Aphodiini. This paper is aimed at filling this gap by describing two *Aphodius* species larvae with food preferences different from the adult.

The majority of *Aphodius* species with fully-known life histories are obligate coprophages as both imago and larvae. Larvae of some species, however, live in soil and feed on humus or plant roots. Third-instar larvae of two such species are described and illustrated herein. These larvae were collected in two different biotopes in the Astrakhan Province (south of the European part of Russia). Methods of larvae preparation and character terminology follow Frolov (2000). Dissected sclerites of *A. sus* larvae were, for comparative purposes, stained with chlorazol black and thus appear darker in the illustrations. Staining however did not reveal any additional details when compared to the non-stained specimens. All examined material is deposited at the Zoological Institute RAS, Sankt-Petersburg (ZIN).

Larval descriptions

*Aphodius* (*Heptaulacus*) *sus* (Herbst, 1783)
Figs. 1–15, 20, 21, 31, 33, 35, 37, 39

*Aphodius sus* (Fig. 2) is widely distributed in the south of European part of Russia up to Smolensk, Tula, Saransk, U'lyanovsk and Ufa in the north (Kabakov & Frolov 1996). In Dosang environs, it is a common species with adults occurring in large numbers in horse dung in the fall.
FIGURES 1–7. Aphodius sus. Fig 1. Larva in lateral view. Fig. 2. Imago in dorsal view. Fig 3. Head of larva. Figs 4–7 Mandibles of larva (4, 5—in dorsal view, 6, 7—in ventral view; 4, 7—left, 5, 6 —right).
FIGURES 24–30. *Aphodius variicolor*. Fig. 24. Larva in lateral view. Fig. 25. Imago in dorsal view. Fig. 26. Head of larva. Figs 27–30. Mandibles of larva (27, 28— in dorsal view, 29, 30— in ventral view; 27, 30—left, 28, 29—right).
Material examined. Forty-six third-instar larvae were collected on 16.V.2007 in grass roots at the depth of 10–15 cm in riverine secondary forest near Dosang village. All larvae were about the same size and similar
exteriorly. Twenty living larvae were taken to the ZIN laboratory and in a month eight adults were obtained.

**Third-instar larval description.** Larva of typical C-shape form (Fig. 1). Head width: 1.16±0.04 mm, length (without labrum): 1.01±0.05 mm. Head surface shiny, yellowish-brown with unclear pattern of small, brown spots on pleural sclerites near frontal sutures (Fig. 3). Medial part of pleural sclerites and base of frons a bit darker than remaining part of the head capsule. Frontal sutures are visible as very fine, darker lines.

Epicranial suture approximately 2 times shorter than frons height. Each pleural sclerite with 5 long setae: 3 near palpifer, 1 in the center, and 1 near epicranial suture. A number of shorter setae located on pleural sclerite without an obvious definite pattern. Frons with 5 pairs of setae: 2 short in the center of frons, 1 short mediadly, and 2 long laterally.

Clypeus trapezoidal, yellowish-brown, with 2 pairs of long setae and 1 pair of short setae laterally. Basal part of clypeus (3/4 length of clypeus) is darker than apical quarter. Surface of clypeus without prominent tubercles.

Labrum trilobed, with 2 pairs of long setae on dorsal surface, and 24 short to relatively long setae on the distal margin. Ventral side of labrum with 1 pair of short setae basally (Fig. 33).

Mandibles triangular, asymmetrical. Left mandible slightly longer than right mandible, scissorial part of left mandible wider than in right mandible (Figs. 4–7). Base of mandibles light brown, scissorial and molar part almost black.

Maxillae symmetrical with respect to each other (Fig. 31). Cardo with 4 short setae: 2 on ventral side and 2 on lateral margin near base of stipes. Ventral side of stipes with long proximal and short distal setae, dorsal side with a row of 7–9 stridulatory teeth and 2 short setae near base of palpifer. Palpifer without stridulatory teeth, with 1 short seta ventrally. Maxillary palpus with 4 palpomeres; 1st and 4th palpomeres with 1 seta each, 3rd with 2 setae. Ventral side of galea with longitudinal row of 6 short setae. Dorsal side and apex of galea with 5 relatively long setae. Dorsal side of lacinia with 5 long and thick setae and 1 short setae, ventral side with 1 long and thick seta apically and 1 short seta basally. Apex of lacinia tridentate.

Legs are about the same size, anterior legs slightly shorter than others (Fig. 37).

Anal sternite with 30–40 relatively long, strongly sclerotized spinules flattened and strongly widened apically (Fig. 20). The spinules are not arranged in rows or, in some specimens, medial spinules appear to be arranged in 2 or even 4 irregular longitudinal rows of 6–7 spinules each (Figs. 8–15). Lower anal lobe sinuate in the middle (Fig. 21).

Lateral bulges of abdominal segments with 2 setae. Each fold of abdominal tergites with transverse row of short, thick setae.

**Diagnosis.** The larvae of *A. sus* can be separated from the majority of other described larvae by the combination of characters of the maxilla, anal sternite, abdominal segment chaetotaxy, and head coloration. In the Krell’s (1997) key to Central European *Aphodius* larvae, the larvae of *A. sus* goes to the couplet with *A. lividus* (Olivier), but the characters provided are not enough to distinguish these two species. They probably differ in thorax and abdomen chaetotaxy or shape of galea apex but, due to lack of *A. lividus* larvae, I cannot examine these characters.

*Aphodius (Chilothorax) variicolor* Koshantschikov, 1894

Figs. 16–19, 22–30, 32, 34, 36, 38, 40, 41

This rarely collected species was known from a few localities in western Kazakhstan (Frolov 2002) and was recently recorded from Russia (Akhmetova & Frolov 2008).

**Material examined.** More than 50 third-instar larvae were collected from fixed sands in the Dosang environs. Larvae were collected in roots of cheat grass (*Anisantha tectorum* (= *Bromus tectorum*) (Fig. 41) on 14.IV.2007 (10 specimens) and 4.IV.2008 (majority of specimens). All larvae were about the same size and similar externally. Twenty living larvae collected in 2008 were taken to the ZIN laboratory and in five weeks six adults were obtained.
FIGURE 41. Habitat of *Aphodius variicolor* larvae in Dosang environs (Astrakhan Province, Russia).
Third-instar larval description. Larva of typical C-shape form (Fig. 24). Head width: 1.39±0.04 mm, length (without labrum): 1.21±0.04 mm. Head surface shiny, brown with unclear pattern of small brown spots on pleural sclerites (Fig. 26). Medial part of pleural sclerites and base of frons a bit darker than remaining part of the head capsule. Frontal sutures are visible as very fine, darker lines.

Epicranial suture approximately 2.5 times shorter than frons height. Each pleural sclerite with 4 long setae: 3 near palpifer, 1 near epicranial suture. Two pairs of shorter setae are in the middle of each pleural sclerite. A number of shorter setae located on pleural sclerite without apparent definite pattern. Frons with 5 pairs of setae: 2 short setae in the center of frons, 1 short seta medially and 2 long setae laterally.

Clypeus trapezoidal, yellowish-brown, with 2 pairs of long setae and 1 pair of short setae laterally. Basal part of clypeus (4/5 length of clypeus) is darker than apical fifth. Surface of clypeus without prominent tubercles.

Labrum trilobed, with 2 pairs of long setae on dorsal surface, and 24 short to relatively long setae on the distal margin. Ventral side of labrum with a pair of short setae basally (Fig. 34).

Mandibles triangular, asymmetrical. Left mandible slightly longer than right mandible, its scissorial part wider than in right mandible (Figs. 27–30). Base of mandible light brown, scissorial and molar part almost black.

Maxillae symmetrical (Fig. 32). Cardo with 4 short setae: 2 on ventral side and 2 on lateral margin near base of stipes. Ventral side of stipes with long proximal and short distal setae, dorsal side with a row of 10–12 stridulatory teeth and 2 short setae near base of palpifer. Palpifer without stridulatory teeth, with one short setae ventrally. Maxillary palpus with 4 palpomeres; 1st and 4th palpomeres with 1 seta each, 3rd with 2 setae. Ventral side of galea with longitudinal row of 6 short setae. Dorsal side and apex of galea with 6 longer setae. Dorsal side of lacinia with 5 long and thick setae, ventral side with 1 long and thick seta apically and 1 short seta basally. Apex of lacinia tridentate.

Legs are about the same size, anterior legs slightly shorter than others (Fig. 38).

Anal sternite with 48–58 relatively long, strongly sclerotized spinules flattened and abruptly rounded apically (Fig. 22). The spinules are not arranged in rows, in some specimens they are indistinctly divided into 2 groups by a narrow smooth area (Figs. 16–19). Lower anal lobe sinuate in the middle (Fig. 23).

Lateral bulges of abdominal segments with 2 to 3 setae (normally there are probably 3 setae of which one can be abraded). Folds of abdominal tergites with short, thick setae not arranged in transverse row or arranged in a few irregular rows.

Diagnosis. The larvae of A. variicolor are most similar to those of A. distinctus (Müller), which is also a member of the subgenus Chilothorax Motschulsky (Frolov 1996). They can be separated from the later by larger number of anal sternite spinules (about 40 in A. distinctus) and tridentate apex of lacinia (as opposed to the bidentate lacinia in A. distinctus).

Discussion

Based on a comparision of the above description of Aphodius sus, and previously published descriptions by Ghilyarov (1964) and Martynov (1998), it is clear that the larvae examined are not conspecific. Ghilyarov (1964) presented a key to larvae of a few Aphodiini genera and considered the presence of 2 parallel rows of spine-like setae on the anal sternite as diagnostic for the genus Heptaulacus (here considered a subgenus of Aphodius as in Kabakov & Frolov (1996)). It is unclear whether Ghilyarov’s short diagnosis is based on a literature source or on some original data. Martynov (1998) gave a fairly detailed description of third-instar larvae as well as a description of the eggs. I cannot comment on the egg description due to lack of material, but description of third-instar larvae given by the author does not agree with my specimens in a number of characters, i. e. in the shape and pattern of anal sternite spinules and in the larval body size. Martynov wrote that larvae were reared in the laboratory from the eggs laid by the identified beetles, but eggs or larvae of some other species could accidentally be in the substrate. Martynov provided measurements of the larval head.
width 2.9 mm and length (without labrum) 2.7 mm. Larvae of such a large size should belong to a species with the adults some 2.5 times larger than those of *A. sus*. There is a sublinear relation between average size of larvae (determined from the size of a head as the only sclerotized segment) and adults in different *Aphodius* species (Frolov & Akhmetova 2005). According to the empirical formula provided in this publication, the larvae described here as *A. sus* should belong to a species with adults having average elytra width of 1.67 mm. This agrees with measurements taken from adult *A. sus* of the same population (average 1.82 mm, taken from 15 specimens). *Aphodius* larvae with the head width of ca. 3 mm can only belong to larger species like *A. fossor* (Linnaeus), *A. rufipes* (Linnaeus) or *A. bimaculatus* (Laxmann), which are found in the Ukraine. However, larvae of these species have different characters from those described by Martynov (1998).

Martynov (1998) also wrote that two weeks after parent beetles were placed in the cage, he found eggs and third-instar larvae. This supports the assumption that larvae of a different species were already present in the rearing substrate. I think that the eggs might have been laid by the beetles of *A. sus*, but development of third-instar larvae of that size in two weeks is highly unlikely.

It is a well-known fact that there is almost no correlation between morphological characters of imago and larva in Holometabola. Apart from expensive molecular diagnoses that have only recently been available, two methods are commonly used for identification of beetle larvae, including those of *Aphodius*: 1) larvae are reared from the eggs laid in laboratory by identified adults, and 2) adults are reared for identification from part of a series of larvae collected together and indistinguishable from each other by the morphological characters. The first method is preferable since it is theoretically not prone to error, valuable data about development terms, morphology of eggs and early instars of larvae can be obtained, and all reared larvae can be fixed for further examination. The drawbacks are that microhabitat and food preferences may differ for larvae and adults of the same species and that phenology of species is not always known. Thus, one needs to guess at these conditions when trying to breed beetles and rear larvae in a laboratory. Experience showed that these were the reasons my attempts in 2006–2007 to breed *A. sus* and *A. variicolor* and rear larvae on horse dung were adults are normally found failed.

One should also take precautions to prevent accidental introduction of adults, eggs or larvae of non-target species into the cage with the substrate (dung or soil). During flight period, *Aphodius* and other coprophilous beetles colonize fresh dung pads very rapidly, often in a few minutes. Therefore, dung collected in the field is likely to have beetles or eggs inside, often of a few species. It is virtually impossible to sift dung, and it is laborious and time consuming to pick the insects out manually. Experience has shown that a preliminary treatment is however necessary. This can be done by means of freezing the dung or depriving it of oxygen. Only after such a treatment can one be sure that the dung does not contain live insects.

The second method of the larva identification, used in the present study, is quite reliable provided that a reasonable series of larvae is collected. *Aphodius* larvae rarely occur singly. In most cases the substrate suitable for their development is highly ephemeral and widely dispersed (i.e. mammal dung or winter-annual crops in sand dunes). Every such microhabitat attracts a number of individual which also mate there. A female normally lays up to a few dozen eggs. Therefore, if larvae are found, it is often possible to collect a reasonable series sufficient for further rearing in the laboratory. Even in apparently large and uniform habitats larvae often occur in clustered large numbers. For example, larvae of *A. sus* described herein that were found in riverine forest in Dosang environs or larvae of *A. abdominalis* Bonelli occurring in grass roots in Carpathian alpine meadows (unpublished data). The second method can be reliably used if: 1) a reasonable series (preferably at least a few dozen) of exteriorly similar larvae are collected in the same place, 2) some of the randomly chosen specimens are preserved for detailed examination (which is difficult using live material) and confirmation they are conspecific, and 3) the remaining larvae transform to adults of one species. If these criteria are met, then it can be assumed the preserved larvae are conspecific with reared adults.
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Literature cited


