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A morphological examination of *Trogoderma angustum* (Coleoptera Dermestidae)

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Abstract

Despite being a widespread and common species in several parts of the world, *Trogoderma angustum* (Solier) (Coleoptera Dermestidae) has never been subjected to a thorough morphological examination. Dissection and clear images of body components is vital for subsequent taxonomic studies. Some morphological components have been displayed elsewhere, such as habitus and antennal structure, but clear images of the aedeagus and sternite IX have not been produced. In addition to images of external and internal features, a morphometric analysis of body dimensions is carried out. Body length varies from approximately 2.2 mm to 3.9 mm and there is little overlap in body length between males and females, with males being smaller than females. The effect of aggressive cleansing agents, such as pepsin in HCl and KOH, on delicate components of the aedeagus is discussed.

Key words: Megatominae, paramere, genitalia, aedeagus, sternite IX, *Anthrenus*.

Introduction

The Dermestidae contain over 1800 named species and the rate at which new species are discovered and named is high (Háva, 2022). Little is known about most species, no matter how common, beyond the name assigned. The exceptions to this are some species of economic and cultural concern. Some Dermestidae are pest of stored commodities (e.g., *Dermestes maculatus* De Geer 1774 and *Trogoderma granarium* Everts 1898) or museums and historic properties (e.g., *Anthrenus verbasci* L. 1767 and *Attagenus smirnovi* Zhantiev 1973). *Trogoderma angustum* (Solier in Gay 1849) falls into the latter category as a pest of museums and historic houses. It is thought to have origins in South America (Phillipp, 1968; Halstead, 1975), but it is now a well-known species having been introduced to many parts of the world (Háva, 2022). The larvae are exceptionally polyphagous and able to develop on plant, grain, and animal-based products (Kemper and Döhring, 1963). Despite being well-known, no detailed morphological examination has been carried out. Sound taxonomic research is predicated on a thorough knowledge of known species. Good knowledge of existing species makes the job of recognizing new species much easier. For some families, very common or widespread species are often not well-described, perhaps because they are so frequently encountered, and perhaps also considered easy to recognize.

Here we examine *T. angustum* to offer an accurate morphological description of the species and, in particular, to present clear images of internal and external features.

Materials and methods

The study insects were derived from a number of specimens found in the Natural History Museum, Vienna and cultured at The University of Reading, UK. The culture was maintained on rolled oats and yeast at 23 °C. Emerging adults were kept in 70% ethanol prior to dissection. The abdomen was detached using entomological pins and the tergites were peeled away from the ventrites to facilitate removal of the genitalia. Only male genitalia, including the aedeagus and sternite IX, were examined. Dissection was carried out under a Brunel BMSL zoom stereo LED microscope. Images were taken using a Canon EOS 2000D and fed through Helicon Focus 8-Pro focus stacking software to produce sharply focused images. Habitus images were captured at 20× (female) and 30× (male). Images of the antennae and the genitalia were captured at 200× magnification through a Brunel SP28, also using the Canon EOS 2000D. Measurements were made using DsCap.Ink software. The following measurements were taken:

Body length (BL): linear distance from anterior margin of pronotum to tip of elytra.

Body width (BW): linear transverse distance from midpoint of outer margins of elytra (values were obtained for each elytron separately and then summed).

Paramere length (PL): linear length of one paramere from apical tip to base.

Statistical analysis was carried out using Minitab version 21.

Results

Sixty-one *T. angustum* individuals (31 ♂, 30 ♀) were dissected. Figure 1 shows male and female habitus. The tegument of both sexes is dark brown to black, and the elytra carry three orange-brown fasciae: sub-basal, post-medial and apical. The body is entirely covered in white hairs and scales. On the elytra between the orange fasciae, the dark sections are coated in short, white hairs. On the orange patches the hairs are bright white and broader adopting a scale-like appearance tapering to a sharp point. The head and prothorax are also covered in white scales, but these are not as broad as the scales on the orange elytral fasciae. The scales and hairs can be rubbed off easily as illustrated in figure 1B. The outer margins of the elytra are sigmoid,

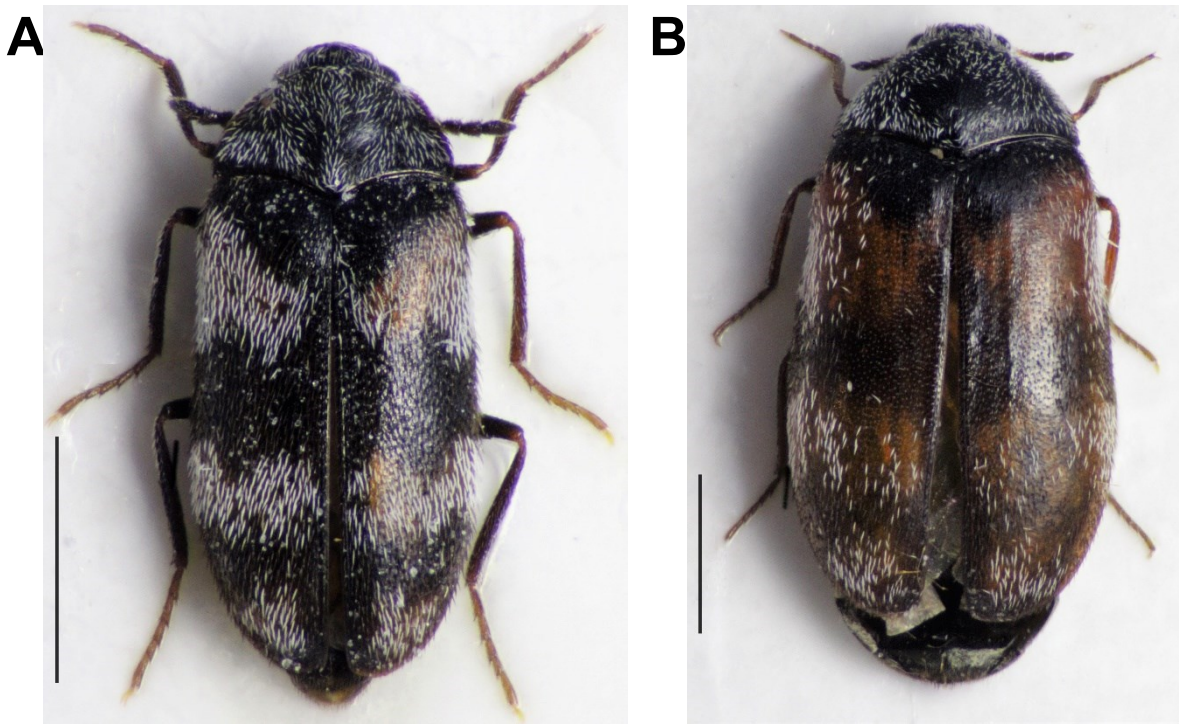

Figure 1. Habitus *T. angustum*, dorsal aspect, (**A**): male, (**B**): female. Scale bar = 1 mm.

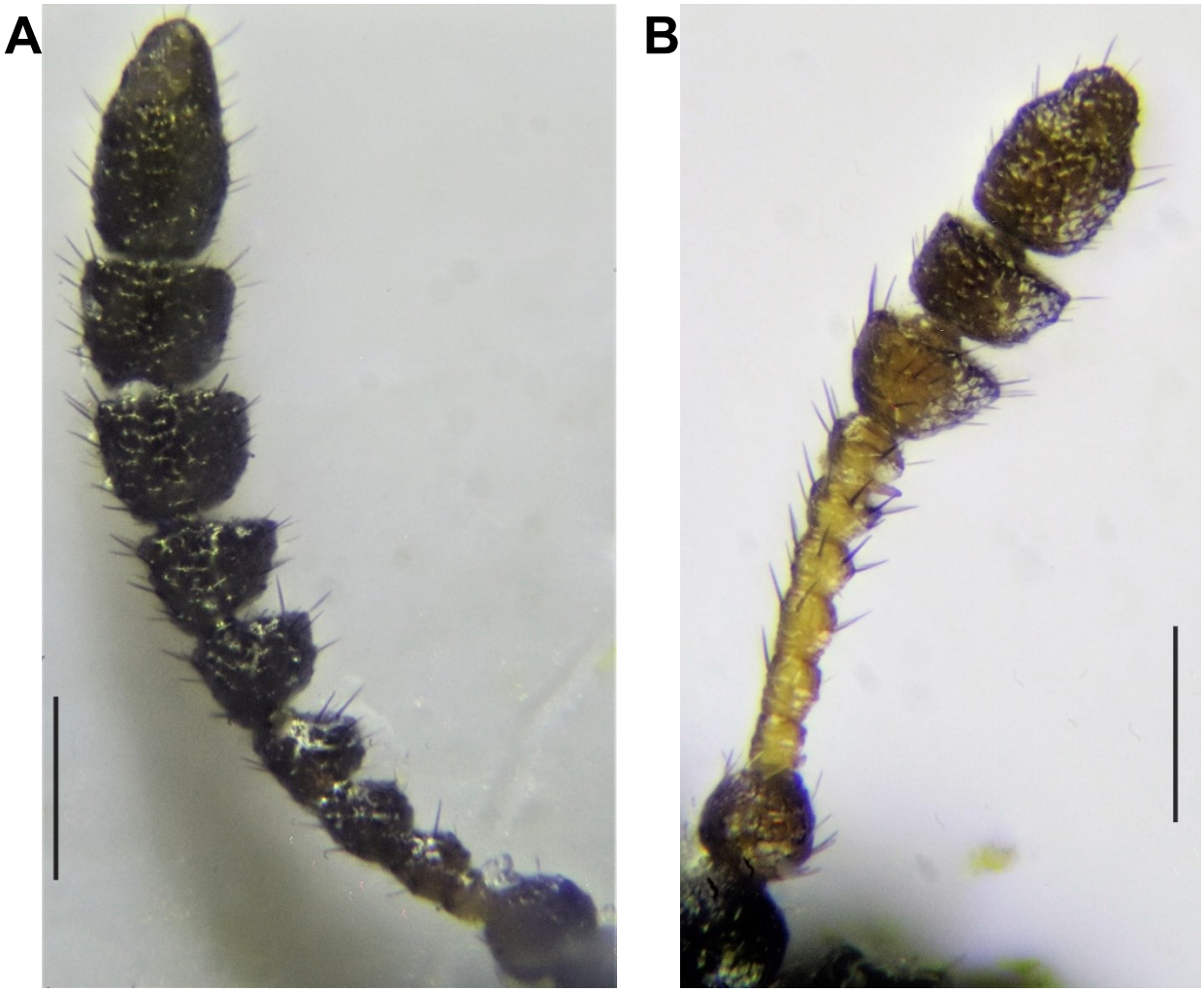

Figure 2. Antennae *T. angustum*, (**A**): male, (**B**): female. Scale bar = 100 µm.

narrowing from the small elytral humeri before widening half-way down the elytra and then sweeping inwards to the elytral apices. The female elytra widen considerably more than males in the apical half of the elytra so that females appear bulbous or tear-drop shaped.

All morphometric data were normally distributed and homoscedastic. Mean BL: ♂ = 2.5 ± 0.14 mm, ♀ = 3.45 ± 0.19 mm. There was a significant difference in BL between the sexes ($t_{59} = 21.58$, $p < 0.001$). 95% of male BL would be expected to range between 2.22 mm and 2.78 mm (in the current study minimum = 2.3 mm, maximum = 2.8 mm), while 95% of female BL would range between 3.05 mm and 3.84 mm (in the current study minimum = 3.0 mm, maximum 3.9 mm).

Mean BW/BL ♂ = 0.46 ± 0.02, ♀ = 0.51 ± 0.02. There was a significant difference between males and females in BW/BL ($t_{59} = 7.34$, $p < 0.001$).

Figure 2 shows the male and female 11-segmented antennae. Figure 2A shows an example of the mostly dark brown to black male antenna, although some of antennomere 2, antennomere 3 and part of antennomere 4 are yellowish. The male antenna gradually expands from the third antennomere to the terminal antennomere, but never forms a clear club. Female antennae (figure 2B) are yellow from the 3rd to the 8th antennomere with the brown 9th to the 11th antennomeres forming a well-defined club. Male antennae are longer than female antennae. The examples shown in figure 2 are 620 µm and 520 µm long, respectively. Given that male BL is shorter than females BL, male antennae are approximately 25% as long as male BL and female antennae are only approximately 15% of female BL.

Figure 3 shows the dorsal surface of the aedeagus and male sternite IX. The curved median lobe (figure 3A) is broad at the base narrowing to a tip that falls well short of the posterior ends of the parameres. The parameres consist of sclerotinized material in the basal 3/5. The inner margins of each paramere along this sclerotinized section carry many forward pointing hairs. The terminal 2/5 of the parameres are transparent, indicating that they are not sclerotinized and that this component of the paramere is soft and flexible. The surface of the transparent part of the parameres carry a few long hairs and also have a few evenly spaced hairs along the outer margin. At the paramere tips are several long, inward curved setae, and a series of shorter, crossed setae where the parameres curve inwards towards each other. The aedeagus is small measuring on average 304 ± 14 µm long, so the PL/BL = 0.12. Figure 3B shows an example of sternite IX. Sternite IX in this species is a thin, delicate structure. The anterior half is tinted brown indicating sclerotinization. The posterior half is entirely transparent with no rigidity at all. The posterior end of sternite IX carries a series of stout black spines. The sternite IX illustrated here was 350 µm long.

Figure 3. *T. angustum* (**A**): aedeagus (dorsal aspect), (**B**): male sternite IX. Scale bar = 100 µm.

Discussion

T. angustum has a wide distribution and where found can be common. Despite this, much of the information presented here has not been published before. Accurate descriptions or presentations of species, including common species, are vital for taxonomic purposes. For example, the *Anthrenus pimpinellae* complex contains approximately 23 species distribution across the Palaearctic. Without an accurate description of *A. pimpinellae*, the confusion species would not have been discovered, and our understanding of distributions would still be flawed (Holloway *et al*., 2021). As with the genus *Anthrenus*, the genus *Trogoderma* contains many species (Háva, 2022). It is very likely that more *Trogoderma* species remain undiscovered, making good descriptions of the known species all the more significant.

Figure 1 shows dorsal views of male and female. Figure 1A in particular illustrates how bright white and sharply pointed scales coat the orange patches on the elytra rather than hairs as on the darker sections of the elytra. This is quite an obvious feature, but we are not aware that the scale like (rather than hair like) structure has been commented on in previous publications. We found that 95% of male BL would lie between approximately 2.2 mm and 2.8 mm, whilst females would range between about 3 mm and 3.9 mm, so very little overlap between the sexes in size. Herrmann (2022) suggests that the size ranges between 2.5 mm and 4 mm, so Herrmann's (2022) information and the current study concur reasonably well.

Herrmann (2022) shows good images of the male and female antenna. The image of the female antenna shows the clear club formed by the last three antennomeres, as also shown in figure 2B. Figure 2A illustrates a male antenna and shows that there is no clear club on male antennae, rather a gradual expansion in the width of the antennomeres from the 3rd to the terminal antennomere. To see this gradation clearly, orientation of the antennal segments is important, since the antennomeres are slightly flattened.

Differentiation among Dermestidae species usually involves dissection and inspection of the male genitalia, so good images of the genitalia are crucial. Herrmann (2022) illustrates a *T. angustum* aedeagus, but the image has low resolution making finer details impossible to distinguish. Herrmann and Háva (2017a; 2017b) describe a new species, *Trogoderma burgai* Herrmann et Hava 2017, and compare with the most obvious confusion species, *T. angustum*. The habitus and antennal images are good, allowing the species to be easily differentiated. The aedeagi of both species, however, have been badly damaged during the preparation process. The present study shows that the apical section parameres of *T. angustum* aedeagus is transparent and non-sclerotinized, and consequently most likely delicate. Herrmann and Háva (2017a) used pepsin in hydrochloric acid to 'make them [aedeagi] roughly free of protein tissues…'. This treatment might have also shrivelled the delicate apical sections of the parameres and all associated components, such as setae. In the current study, specimens were kept in 70% ethanol which has no adverse effects on soft body parts. The *T. angustum* aedeagus image shown by Herrmann and Háva (2017a) bears little resemblance to figure 3 shown in the current study. Although the aedeagus shown in figure 3A still has some extraneous soft tissue attached, all fine features on the structure can be seen clearly. Figure 3B shows an example of sternite IX. Sternite IX in *T. angustum* is very fragile and it would probably not survive the action of any cleansing agents. As far as we know, no image of *T. angustum* sternite IX has been previously published. *T. angustum* sits within the subfamily Megatominae along with *Anthrenus* spp.. Several studies have illustrated sternite IX from different *Anthrenus* (*sensu stricto*) species (e.g., Beal, 1998; Kadej *et al*., 2007; Holloway 2019; 2020; 2021; Holloway and Bakaloudis, 2020; Holloway *et al*., 2020; Holloway and Foster, 2022). *T. angustum* sternite IX differs from all studied *Anthrenus* species by having a very broad posterior lobe apically covered in spine like setae (*Anthrenus* have narrower posterior lobes carrying finer, mostly marginal, setae) and a single anterior horn (all *Anthrenus* studied have two anterior horns).

The aggressive action of pepsin and hydrochloric acid on aedeagal structure has been noted elsewhere (Hermand and Holloway, 2020). KOH is also frequently used to clean aedeagi and free them from soft tissue. KOH is a very aggressive chemical that attacks biological tissue and has the potential to have a detrimental effect on the aedeagal structure of small beetle species (Holloway and Foster, 2022). We would argue that chemical cleaning should be avoided wherever possible for fear of damaging delicate features. It does mean that connective tissue sometimes remains attached to the aedeagus and sternite IX, but much of this can be rendered invisible by using brighter transmitted light during image capture.

In conclusion, good images of various body components of *T. angustum* have been published here, in some cases for the first time despite the species being common in some parts of the world. The structure of the aedeagus contrasts with an aedeagus image in another study (Herrmann and Háva, 2017a; 2017b). It is concluded that aggressive preparatory agents, such as KOH, might not be appropriate for small internal features, or for structures carrying some delicate components.

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