

*This contribution is published  
to honor Prof. Vladimir Chikatunov,  
a scientist, a colleague and a friend,  
on the occasion of his 80<sup>th</sup> birthday.*

## **Profile of a species: *Attagenus rufiventris* Pic (Coleoptera: Dermestidae)**

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### **ABSTRACT**

A complete description of *Attagenus rufiventris* Pic, 1927 is provided for the first time. The habitus, antennae and ventrites are illustrated. Females are marginally, but significantly, larger than males; both sexes are slightly over 4 mm long. Variation in the colour pattern is quantified and found to be little in both males and females. Both sexes are dissected, measured, and images of the male genitalia are presented for the first time. The aedeagus is short at less than 13 % of the body length. The identification of *A. rufiventris* compared with other South African *Attagenus* species is discussed. The article elaborates on the importance of detailed description and clear presentation of the male genitalia. Morphometric analysis takes intraspecific variation into account, which is often largely overlooked when describing new species. Such analysis is also vital for recognition of cryptic species.

**KEYWORDS:** Afrotropical, Dermestidae, aedeagus, morphology, morphometrics, taxonomy, variation.

### **INTRODUCTION**

The hide, larder and carpet beetles, Dermestidae Latreille, 1804, is a moderately large and relatively understudied family of mostly small beetles containing over 1600 species (Háva 2020). *Attagenus* Latreille, 1802, is one of most speciose genera with over 220 species (Háva 2020). The genus is currently split into two subgenera *Aethriostoma* Motschulsky, 1858 and *Attagenus* s. str. Latreille, 1802. The current study focuses on species in the latter subgenus, and hereafter any mention of *Attagenus* refers to *Attagenus* s. str. Little is known about many species of Dermestidae, particularly distribution and intraspecific variation. While published descriptions do exist, most species suffer a distinct lack of morphometric data. Without measurements and statistical comparisons, it is impossible to confidently assess taxonomic placement and compare species statistically. Statistical analysis is a useful tool in distinguishing between species (Holloway *et al.* 2020, in press; Holloway & Bakaloudis 2020) and recognition of new ones (Holloway 2020, in press).

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It has been argued that it is important to dissect dermestids to measure not only external characters, but also internal elements such as the aedeagus (Beal 1998; Kadej *et al.* 2007; Kadej & Háva 2011). In particular, Kadej *et al.* (2007) examined many species within the difficult *Anthrenus pimpinellae* Fabricius, 1775 complex, acknowledging the importance of intraspecific variation. Curiously, hardly any studies since then have considered intraspecific variation, despite this point being raised repeatedly as a big problem (Beal 1998). Exceptions where measuring long series of specimens was integral to the design of research include Holloway and Bakaloudis (2020) and Holloway *et al.* (in press, a). Holloway and Bakaloudis (2020) showed that there is not much intraspecific variation in many phenotypic characters in *A. pimpinellae pimpinellae* or *A. amandae* Holloway, 2019. Holloway *et al.* (in press, a) demonstrated that *A. p. isabellinus* Küster, 1848 had been assigned to the wrong species for over 170 years and, in fact, was conspecific to *A. dorsatus* Mulsant & Rey, 1868, synonymizing the latter under *A. isabellinus*. Dissecting and measuring pools of preserved specimens also reveals cryptic species (Holloway 2019, 2020, in press). As a result of this endeavour, there now exist a small number of species that have been thoroughly measured and catalogued, against which other species can be compared.

*Attagenus rufiventris* Pic, 1927 is an African species of Dermestidae about which we know very little other than a basic description based on female specimens from South Africa (Pic 1927; Kalík 1955 cited in Kalík & Háva, 2005). There are no morphometric data currently available for the species, nor any information on its ecology or conservation status. Among entomologists today, there is great emphasis on using male genitalia to back up more easily observed field characters. Dissecting the genitalia is also very important for recognition of cryptic species (e.g. Kadej *et al.* 2007; Kadej & Háva 2011; Holloway 2019; Holloway 2020, in press). For a variety of reasons then, it means that published descriptions which include morphometric description and analysis with clear images of the genitalia are desirable. Currently, there is nothing published to this extent for *A. rufiventris*.

The aim of the current study is to describe both male and female *A. rufiventris* and to deliver a morphometric examination, including male genitalia.

## MATERIALS AND METHODS

### *Specimens examined*

The material was obtained from a culture of *A. rufiventris* maintained at the University of Reading, UK. The beetles originated from South Africa. From this culture, 55 specimens (♂ n=23, ♀ n=32) were examined. The insects were killed by freezing and stored in 2% acetic acid prior to dissection. Dissection protocol followed Holloway and Bakaloudis (2020), but is repeated here for convenience. Dissection was carried out under a Brunel BMSL zoom stereo LED microscope. Images of the male and female habitus, both upper- and underside, were captured at 10× magnification using a Canon EOS 1300D camera mounted on the BMSL microscope. Dissection of males involved detaching the abdomen using two ento-

mological pins. The soft tergites were then peeled off the harder ventrites to expose the genitalia. The aedeagus was detached from the ring sclerite. In addition to the aedeagus, sternite IX was also detached from the ring sclerite and the aedeagus. Images of aedeagi and sternite IX were captured at 100× magnification using the EOS camera mounted on a Brunel monocular SP28 microscope. After dissection, all body parts were mounted on card. The antennae were teased out and images were taken at 100× magnification through the SP28 microscope. All images were fed through Helicon Focus Pro version 6.8.0 focus-stacking software. Morphometric measurements were made using DsCap.Ink Software version 3.90.

### *Measurements*

Body length (BL): the distance from the anterior margin of pronotum to the apex of the elytra.

Body width (BW): the distance across each elytron from the mid-point of the outer margin to the centre (values for each elytron summed).

Antennal club length (AL): the length of the last three antennomeres.

Paramere length (PL): the distance from the anterior end of the parameres to the apex of the parameres.

Sternite IX length (SL): the distance from posterior tip to the middle of the anterior margin.

All measurements are done in millimetres.

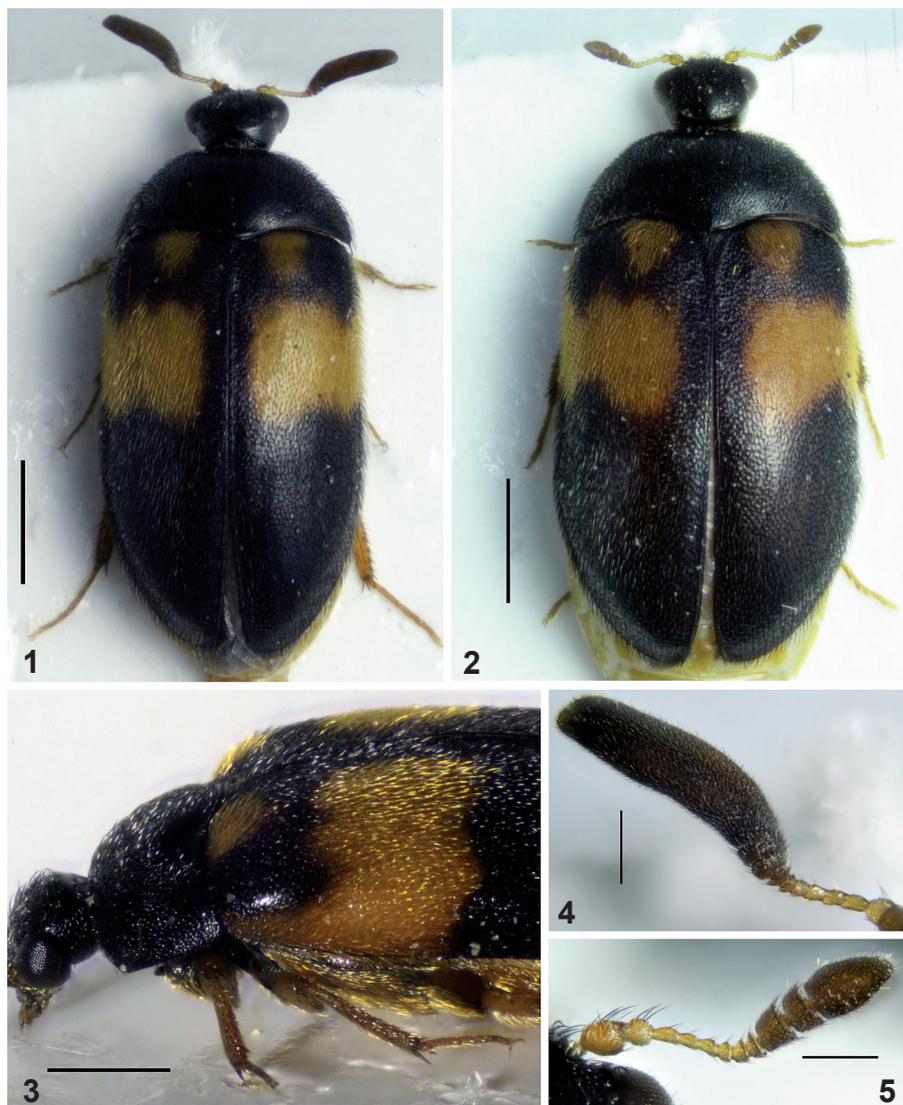
### *Statistical analysis*

Statistical analysis was carried out using Minitab (version 19). All data conformed to normality and homoscedasticity. Means (bold values) and values encompassing 95 % of expected values above and below the mean are presented. Coefficient of variation (CV) values (standard deviation/mean\*100 %) are also included as an indication of a standardised measure of variability of each character.

## RESULTS

**Description:** Whole body covered in hairs matching the underlying cuticle colour. Cuticle mainly black dorsally with four patches of orange colour on elytra: smaller circular patch of orange close to basal margin of each elytron, and second larger patch spreading from outer margin of each elytron almost to elytral suture. Sexual dimorphism evident in colour pattern: in males, posterior orange elytral patch broadly rectangular (Fig. 1), and in females, this patch thinner laterally and widens towards elytral suture (Fig. 2). Orange coloration extends from posterior patch along elytral margin to elytral shoulder (Fig. 3). Posterior margin of pronotum broad, narrowing anteriorly. Anterior edge of pronotum uniformly rounded when viewed from above, with small concave section medially to accommodate back of head. Posterior margin of the pronotum sinuate with small, sub-marginal, unpunctured medial ridge above scutellum, more obvious in males than females. Dorsum of pronotum and top of head covered with semi-erect, black hairs swept

back towards posterior. Scutellum black and triangular. Cuticle on ventral surface orange apart from black prosternum and mesonotum. Ventral surface hirsute. Legs unicoloured with orange hairs. Tibiae with pale hairs interspersed with slightly darker spines. Tarsi 5:5:5, hairy and simple. Head small with large eyes covered



**Figs 1–5:** (1–3) Habitus of *Attagenus rufiventris*: (1, 2) dorsal view of male (1) and female (2); (3) lateral view of male, showing extension of orange coloration along outer margin to base of elytron; (4, 5) antenna of male (4) and female (5). Scale bars: 1 mm in Figs 1–3, 200  $\mu$ m in Figs 4, 5.

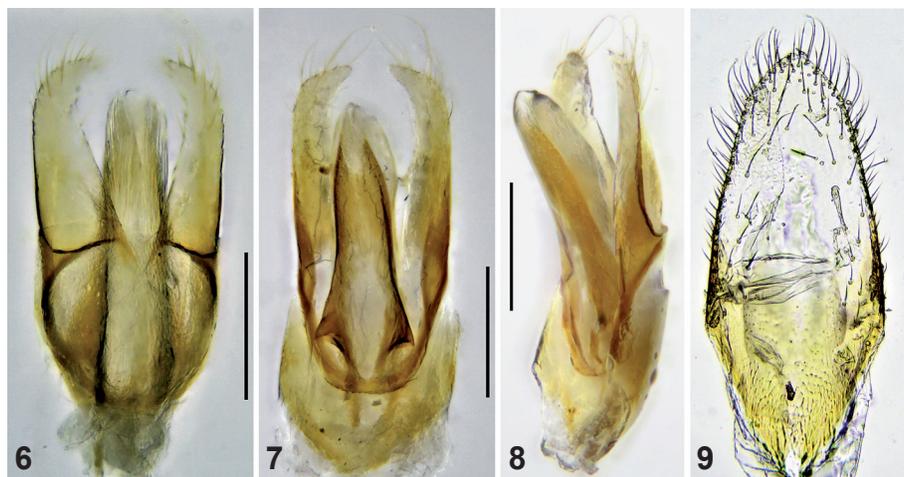
with short, erect pale setae, longer in eye centre than around margin (evident in Fig. 5). Single ocellus on vertex.

**Colour pattern variation.** The area (pixel count) of the posterior orange elytral spot was measured on males and females relative to the size (pixel count) of the elytra. The ratio in males is  $0.230 < \mathbf{0.267} < 0.304$ , CV 6.65 %. Females have a significantly smaller spot to elytra size ratio,  $0.216 < \mathbf{0.239} < 0.262$ , CV 4.6 % ( $t_{34}=32.92$ ,  $p < 0.001$ ).

**Habitus.** Body elliptical with parallel sides in males, elytra slightly expanded apically after midpoint in females. Male: BL  $3.74 < \mathbf{4.054} < 4.37$ , CV 3.77 %. Females are significantly larger: BL  $3.80 < \mathbf{4.192} < 4.58$  ( $t_{53}=2.99$ ,  $p=0.004$ ), CV 4.5 %. The body plan is assessed as BW/BL. A larger value denotes a wider individual. Females are broader than males (BW/BL: ♀ =  $0.522 < \mathbf{0.559} < 0.596$ , CV 3.2 %, ♂ =  $0.482 < \mathbf{0.513} < 0.544$ , CV 2.92 %,  $t_{53}=10.3$ ,  $p < 0.001$ ).

**Antenna** with 11 antennomeres. Antennomeres I–VII (male) and I–VIII (female) orange with lateral short pale hairs. Antennomeres I and II larger and more rounded than antennomeres III–VIII. Antennomeres VIII–X in males and VIII in females flattened into discs. In males, antennomeres VII–X dark brown, and antennomere XI forms dark brown, long, paddle-shaped club (Fig. 4). Male AL  $0.666 < \mathbf{0.749} < 0.831$ , CV 5.32 %. In females, antennomeres IX–XI form dark brown club (Fig. 5). Female AL  $0.331 < \mathbf{0.380} < 0.429$ , CV 6.33 %.

**Aedeagus.** PL  $0.471 < \mathbf{0.509} < 0.547$ , CV 3.54 %, (Figs 6, 7). Ratio PL/BL  $0.115 < \mathbf{0.126} < 0.137$ , CV 4.35 %. Parameres broad basally, curving strongly before apical tip to form a hook shape. Apical tips of parameres with long setae. Parameres come together as sharp V shape on ventral side (Fig. 7), but unite more gradually on dorsal side (Fig. 6). Median lobe broad, especially basally, gradually



**Figs 6–9:** (6–8) Aedeagus of *Attagenus rufiventris*, ventral (6) and dorsal (7) sides, and dorsolateral view (8); (9) sternite IX of *Attagenus rufiventris*. Scale bars, 200  $\mu\text{m}$ .

narrowing to complex tip that falls short of paramere tips. Tip of the median lobe is sharp dorsally (Fig. 6), but it sits on square ended horizontal plate that extends beyond sharp apex of median lobe. Tip of median lobe shown dorsolaterally in Fig. 8. Ridges running along dorsal surface of median lobe meet at tip (Fig. 7), after that ridges continue as a single edge, curving ventrally (vertically) to join horizontal plate.

*Sternite IX* elliptical (Fig. 9), SL  $0.570 < 0.641 < 0.712$ , CV 5.29%. Transparent from apex to beyond middle of sternite. Setae regularly spaced around margin of posterior half of sternite increasing in length towards apical tip. Some setae scattered across surface of sternite, densest toward margins close to apex.

#### DISCUSSION

Based on available information, *Attagenus rufiventris* is easily differentiated from other South African *Attagenus* species by its elytral colour pattern. Thirty-five species of *Attagenus* are currently recorded from South Africa (Háva 2020). Several of them have reddish spots and bands across the dorsal surface. Only two species have no reddish markings on the apical halves of their elytra: *A. fasciatus* Thunberg, 1795 and *A. rufiventris* (Herrmann, 2020). *Attagenus fasciatus* has two large spots that meet at the elytral suture, whilst *A. rufiventris* has four orange spots, all in the basal half of the elytra, which is a unique pattern among South African *Attagenus* species.

This is the first time that the male of *A. rufiventris* has been described and both the aedeagus and sternite IX have been illustrated. Herrmann (2020) provides images of aedeagi of many *Attagenus* species. All of them are broad relative to their length, with hooked parameres like *A. rufiventris*. The complex structure of the apical tip of the median lobe does not appear to have been noted and described before. However, the published images suggest that this type of complexity is not limited to *A. rufiventris*. *Attagenus cinereus* (Herrmann & Kadej 2017), *A. mata-mata* (Kadej & Hava 2015), *A. pseudocapensis* and *A. fasciopuncatatus* (Herrmann *et al.* 2015) all have a similar flat plate-like structure attached to the ventral side of the median lobe. This plate could be an important structure on the aedeagus that requires description in more species.

The average body lengths of *A. rufiventris* presented here (male, 4.054 mm; female, 4.192 mm) correspond to the range provided by Herrmann (2020) (3.5–5.5 mm). There are no other aedeagi lengths to compare the values found here with, but the PL/BL value of just 0.126 suggests that the aedeagus is relatively small compared to some *Anthrenus* species (Holloway *et al.* in press, *a*).

It has been shown that sternite IX in males can be a useful feature for differentiation of *Anthrenus* species (Beal 1998; Kadej *et al.* 2007; Kadej & Háva 2011; Holloway 2019; Holloway *et al.* 2019, in press, *a, b*; Holloway & Bakaloudis 2019, 2020). There are fewer examples of *Attagenus* sternite IX available to inspect. However, Kadej and Háva (2015) illustrate and describe sternite IX of *A.*

*matamata* Kadej & Háva, 2015 as rhomboidal, whereas in *A. rufiventris* it has more rounded sides producing an oval shape. There are also differences in the distribution, density and length of hairs, as well as in the extent of the unpigmented area between the two species. In summary, *A. rufiventris* and *A. matamata* differ in many ways, which suggests that variation in sternite IX structure could be as valuable in diagnostics of *Attagenus* species as it is in *Anthrenus* species.

The first description of *A. rufiventris* by Pic (1927) was very concise and confined only to its basic appearance, which is not adequate for use as a diagnostic tool in taxonomic studies. Furthermore, Pic's description was based upon a single female specimen, which means that it cannot account for variation within the species nor sexual dimorphism. Kalík's (1955, cited in Kalík & Háva 2005) redescription of the species presents illustrations of female specimens. It is stated in Kalík and Háva (2005) that other material including males was studied by Kalík in 1980, 1989 and 1990, but again no illustration of the male genitalia nor morphometric analysis of the species was done. The paper states that antennal characters are the only difference. Results of the current study show that this is not the case as both elytral coloration and habitus proportions differ between sexes.

As *Attagenus* is one of the most speciose genera of Dermestidae, it is important for several reasons that species are properly described. An adequate description should not only include a comprehensive written description of morphology with quantitative measurements backed up by statistical tests, but it should be accompanied by clear images including those of the aedeagus and sternite IX. So far this has not been the case with *Attagenus* species. The number of described *Attagenus* species increased from 180 (Háva 2003) to over 220 (Háva 2020) in less than two decades. This rapid rate of discovery highlights the diversity of the genus. However, without adequate published descriptions it is impossible to compare species and to avoid confusion with their congeners, which in turn is important for biodiversity research (e.g. McNeely 2002). Gittleman and Pimm (1991) highlighted the fact that species can be lost if not properly recognised by taxonomists. Finally, adequate description—including ecological data from the field such as abundance and distribution—is vital for the discovery of cryptic species (Holloway 2020, in press). Misidentification can produce huge taxonomical issues; for example, see Fery and Rössner (2015) for *Aphodius* dung beetles. The value of proper description illustrated by photographs and not just simple line drawings should also be emphasised as the latter is not always easy to interpret when faced with actual specimens.

Our understanding of the current distribution of *A. rufiventris* is uncertain. The type specimens originated from north-eastern South Africa ('Transvaal'), but the species is also recorded in Uganda (Háva 2003) and Tanzania (Háva 2020). The existence of so hugely disjunct populations of a single species is quite unlikely (but not impossible, cf. Kolyada & Mostovski 2007). Pic (1951) noted a 'variety' of *A. rufiventris* from Tanzania called *A. r. conradsi* Pic, 1951. This variety was

later given a full species status and noted from Kenya and Tanzania (Háva 2006), although no image was provided to supplement the short description, and all specimens appear to reside in a private collection. No conclusions can be drawn without examination of further specimens from these localities.

The Dermestidae contain over 1600 species (Háva 2020), with a large proportion of these known from single, or just a very small number of, specimens. Very often (usually anecdotally), the issue of intraspecific variation is raised as an impediment to species differentiation (Beal 1998). More thorough descriptions of species including morphometric analyses as well as morphological comparisons are required. This approach, although time consuming, provides all the information required for species recognition (e.g. Holloway & Bakaloudis 2020) if doubt is raised (Háva & Herrmann 2019). Kadej *et al.* (2007) carried out limited morphometric analyses of the species within the Palaearctic *A. pimpinellae* complex. Thorough morphometric (and morphological) analyses have been carried out for *A. amandae* and *A. pimpinellae* (Holloway & Bakaloudis 2020; Holloway *et al.* in press, a), *A. isabellinus* (Holloway *et al.* in press, a), and now *A. rufiventris*. All these studies have demonstrated that several characters display little phenotypic variation, including colour pattern, the element that was argued to be highly variable (Beal 1998). The coefficient of variation for the colour pattern in males is only 6.6 %, whereas for females it is even less (4.6 %). Distribution of colour is difficult to measure accurately, so it is very likely that some degree of the variation described here can be attributed to experimental error, suggesting that the amount of natural variation could be very small. This should not come as a surprise really. It is likely that elytral colour patterns have an evolutionary function with an impact on fitness (Ottenheim *et al.* 1999) and are subject to natural selection. That being the case, it would be expected that colour pattern elements should display low levels of both genetic and phenotypic variation (Holloway *et al.* 1995). The most conserved character measured here (and in all *Anthrenus* species described so far) is BW/BL with a CV of about 3 % in *A. rufiventris* (less in some other species). It is acknowledged that some species, such as *A. isabellinus*, show a great deal of colour pattern variation. However, it is likely that most of this variation is a manifestation of phenotypic plasticity (Holloway *et al.* in press, a).

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