Anthrenus flavipes LeConte, 1854 (Coleoptera; Dermestidae); a destructive pest of natural history specimens

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Abstract

An important component of integrated pest management is vigilance. There is always the scope for pest species from other parts of the world to become established outside of their natural range. Here we report on a damaging infestation of natural history specimens by the Dermestid beetle *Anthrenus flavipes* LeConte 1854. The beetles caused considerable damage to caprid horn in the collection of stuffed vertebrate specimens held in the Aristotle University of Thessaloniki, Greece. Identification features of *A. flavipes* are described and comparisons with other pest *Anthrenus* species made.

Keywords: *Anthrenus*, *verbasci*, *sarnicus*, *fuscus*, *museorum*, IPM, pest management, carpet beetle, taxidermy, horn

Introduction

Managing the threat from pest species of natural history collections is a continual occupation. The management of this threat in modern museums has developed into something of an art in the form of integrated pest management (Pinniger, 2015; Querner, 2015). Integrated pest management involves much more than simply destroying the pest insects that happen to be found. Attention is paid to the security of the buildings and cabinets in which the specimens are housed, temperature and relative humidity, pest numbers are continually monitored to intercept outbreaks quickly, and insect populations are controlled. Part of this process is the identification of pest species existing at low, background population levels, and responsible for any outbreaks. Appropriate management procedures are dependent on correct identification. All insect species exhibit different life histories and require different conditions to complete their life cycles. Consequently, misidentification could result in inappropriate management methods being deployed, perhaps even spending time, money, and resources dealing with a problem that does not really exist.

In the UK, the principle *Anthrenus* pests are *Anthrenus verbasci* Linnaeus 1767 and *A. sarnicus* Mroczkowski, 1963. *A. fuscus* Olivier, 1789 sometimes occurs in buildings, *A. museorum* Linnaeus, 1761 almost never does, but neither are generally serious pests in natural history museums. Holloway and Pinniger (2020) illustrate these species and how to distinguish between them. At

more southerly, warmer latitudes, different *Anthrenus* species enter museums and can cause problems, such as *A. coloratus* Reitter, 1881 in Iran (Shahrabi *et al.*, 2018), Italy (Nardi and Háva, 2019), and Russia (Kovalenko, 2019), and *A. flavipes* Leconte, 1854 in India (Kumar *et al.*, 2013). Here we report on an infestation of *A. flavipes* in caprid horn held in the Aristotle University of Thessaloniki, Greece.

Natural History Collection Aristotle University of Thessaloniki, Greece

An extensive collection of stuffed animals is housed at the School of Forestry and Natural Environment in the Aristotle University of Thessaloniki, Greece. The building housing the collection (Figure 1) was opened in 1992 and the collection hall covers approximately 500m^2. The building sits amongst other university buildings within a forest-botanic garden. Prior to 1992, the specimens were scattered throughout the old university buildings, but in their current cabinets. Many of the specimens date from 1935-1950, although the caprids were added to the collection 2002-2005. The collection consists almost exclusively of vertebrates principally mammals (20 species) (Figure 2) and birds (236 species) (Figure 3), but also a small number of reptiles. As well as undergraduate students at the university, between 1200 and 1500 school children from the surrounding area visit the collection each year. All specimens have been very well prepared and presented, including some beautiful dioramas illustrating the avifauna and mammals associated with different habitats in Greece (Figure 4).

During a visit to the collection in May 2019, a heavy infestation of carpet beetles was noted in cases containing the skulls of different species of caprid (Figure 5). The pest species was subsequently identified as *A. flavipes*. The beetles had caused a great deal of damage (Figure 5). The larvae were concentrated in the younger keratin layers close to the bone whilst the tougher, outer horn was largely undamaged. The infestation must have been present for at least two years since

***Figure 1**. Natural history collection, Aristotle University of Thessaloniki.*

***Figure 2**. Cases containing stuffed mammals in the natural history collection, Aristotle University of Thessaloniki*

***Figure 3**. A case containing stuffed birds in the natural history collection, Aristotle University of Thessaloniki.*

***Figure 4**. A diorama illustrating typical avifauna in Greek wetlands, Aristotle University of Thessaloniki.*

Figure 5. *Damage to horny material on wild goat (Capra aegagrus) skulls by* Anthrenus flavipes, *Aristotle University of Thessaloniki. Many larval exuviae and adult insects, along with dust from feeding activity, can be seen around the specimens.*

Figure 6. *Wooden casing used to house natural history specimens, Aristotle University of Thessaloniki.*

many live larvae at different stages were present along with dead adults and the life cycle takes one year to complete in India (Kumar *et al.*, 2013). It is not clear how the carpet beetles got into the caprid case. Although the case is never opened, it is unlikely that the caprids were introduced into the cabinet in an infested condition since they were brought into the collection at least 15 years ago. *Anthrenus* species are found on the wooded university campus, but mostly *A. verbasci* and *A. isabellinus* Küster 1848 (Holloway *et al.*, 2020). Whilst *A. verbasci* is a serious museum pest, *A. isabellinus* is not.

All specimens are housed in wooden cases that consist of a box to raise the specimen(s) from ground level, a four-sided frame on top of the box with glass sides, and a heavy-duty piece of glass laid on top to close the top of the frame off (Figure 6). The specimens are inspected periodically by undergraduate students of Forestry and Natural Environment, but the specimens are never removed from the cabinets. Once a year, a routine inspection of the specimens is carried out. Pest insects are controlled using camphor and carbamate (Baygon). In addition, thermal pest management is sometimes carried out. Other than these annual treatments, no continual IPM activities are performed.

Identification of *Anthrenus flavipes*

Holloway and Pinniger (2020) described how to identify the species of *Anthrenus* likely to be found in museums in the UK. The common species encountered are *A. verbasci* and *A. sarnicus*. *A. fuscus* is occasionally found inside buildings. Despite the name, *A. museorum* is virtually never found indoors, at least in the UK.

Both *A. fuscus* and *A. museorum* are chocolate brown dorsally with some golden coloured scales (Holloway and Foster, 2018; Holloway and Pinniger, 2020). *A. sarnicus* has a greyish coloration and is, again, distinctive. *A. flavipes* has the same-coloured scales as many examples of the highly variable *A. verbasci*, but the dorsal colour patterns of the two species are different. Figure 7 shows examples of *A. flavipes* and *A. verbasci*. Both species possess black, white and orange scales (although note that some *A. verbasci* have largely only white/pale grey and black scales, whilst other examples might display black, white and yellow scales. See Holloway and Pinniger (2020) for colour pattern range). However, *A. flavipes* has a striking and quite beautiful colour pattern (Figures 7 and 8). The orange scales of *A. flavipes* are intensely coloured, whilst the white scales are dazzling, almost silver white, and arranged in well-defined spots along both elytra. The dorsal colour pattern of *A. verbasci* is highly variable (Holloway and Pinniger, 2020). There is very little colour pattern variation in *A. flavipes*, in particular all individuals retain the very obvious white spots on the dorsal side.

The scales on the ventral side of *A. flavipes* are bright, silvery white with golden scales along the legs (Figure 8). The scales on the ventral side of *A. verbasci* are greyer including the scales on the legs (Figure 8).

With access to a stereomicroscope, the shapes of the scales on the dorsal surface can be examined. There is considerable difference between the shapes of the scales of *A. flavipes* and *A. verbasci*. *A. flavipes* has broad, overlapping, leaf-shaped scales (Figure 9), whilst *A. verbasci* has narrow, lozenge-shaped scales (Figure 10).

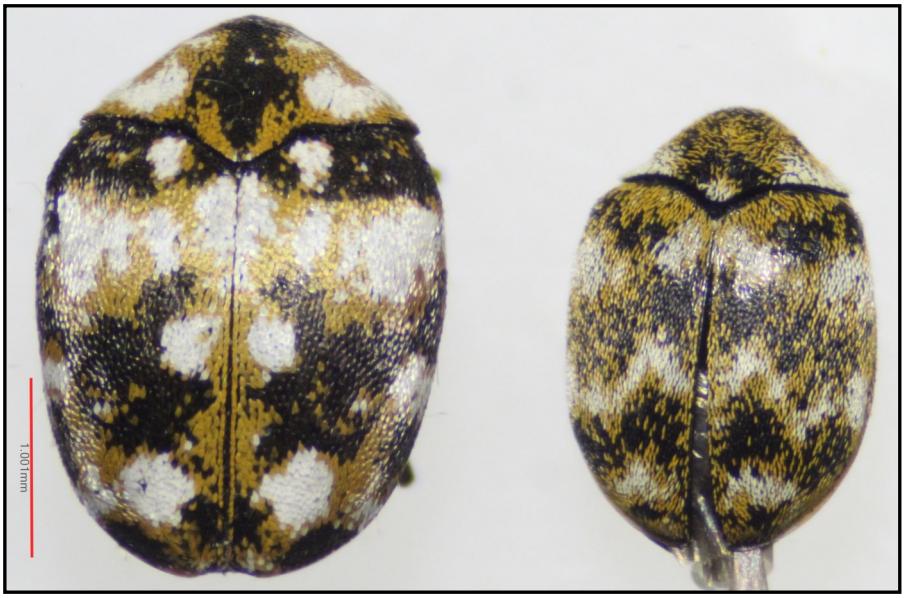

Figure 7. *Dorsal surfaces of* Anthrenus flavipes *(left) and* Anthrenus verbasci *(right). Scale = 1mm.*

Figure 8*. Ventral surfaces of* Anthrenus flavipes *(left) and* Anthrenus verbasci *(right)*

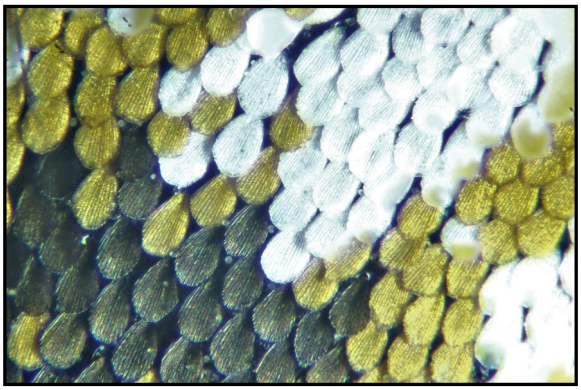

Figure 9. Anthrenus flavipes *elytral scales (x200 magnification).*

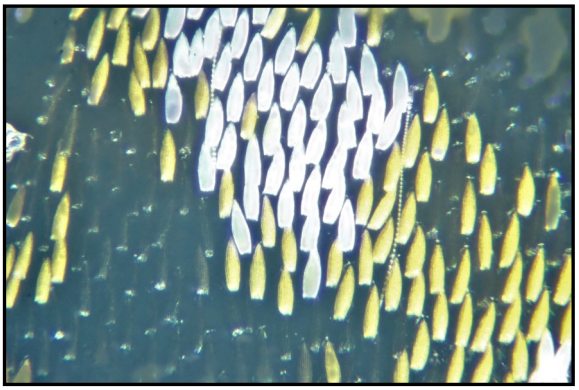

Figure 10. Anthrenus verbasci *elytral scales (x200 magnification).*

A. flavipes are 20% longer than *A. verbasci*. *A. flavipes* averages 3.11±0.05mm (mean ± standard error, n=30) versus 2.57±0.04mm (n=30) for *A. verbasci*; the difference is statistically significant ($F_{1,58}$=68, p<0.001). 95% of *A. verbasci* are under 2.8mm long, whilst 95% of *A. flavipes* are over 2.8mm long. There is limited scope for size overlap.

Discussion

This account highlights how enormously destructive *A. flavipes* can be to natural history collections when left unchecked. As with many other species of Dermestidae, *A. flavipes* feeds on proteinaceous material as a larva (Modarres Awal, 1997; Beal, 2003), such as wool, leather, horn and some stored products. Given the right conditions, it is easy to see how it could be a problem in natural history (and other) collections.

A. flavipes is a species typical of hotter conditions. *A. flavipes* is known from India (Kumar *et al*., 2013) and Iran (Ghahari and Háva, 2017). In Europe it has been recorded from Italy (Nardi and Háva, 2013) in the Mediterranean region and further north in the Czech Republic (Háva 2011). In fact, it has also been recorded in the UK (Peacock, 1993), but only as an occasional import. Háva (2020) states that *A. flavipes* is sufficiently widely distributed to be considered cosmopolitan. Since it is a pest of stored products, it has been recorded in many countries as an import, such as the UK (Peacock, 1993). In the UK, there is no evidence that conditions are suitable to maintain a self-sustaining breeding population and as a result the species has been removed from the British list (Holloway, 2020).

The distributions of pest species in museums have been tracked with great accuracy and we know when most species entered the country and what their progress across the country looks like (see, http://www.whatseatingyourcollection.com/). For Dermestidae under wild conditions this level of detail is not available. Our knowledge of distribution is coarse, at a scale of individual countries with data derived from museum specimens (Háva, 2020). As far as we are aware, the distributional change of only one *Anthrenus* sp. across Europe has been considered, *A. angustefasciatus* (Foster and Holloway, 2015). Foster and Holloway (2015) suggested that the spread of *A. angustefaciatus* north and west across Europe could have been mediated by climate change with the species reaching the UK. This being the case, it is entirely possible that other species found naturally in warmer parts of Europe, such as *A. flavipes*, could spread north under their own volition. Where *A. flavipes* manages to establish self-sustaining breeding populations, the capacity for the species to develop into a serious pest of natural history collections is greatly enhanced. As always, museum workers should remain vigilant to the possibility that new pest species could enter the system and *A. flavipes* could be a most unwelcome newcomer.

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