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Research Paper

# The exploitation of fresh remains by *Dermestes maculatus* De Geer (Coleoptera, Dermestidae) and their ability to cause a localised and prolonged increase in temperature above ambient

Alan Gunn

*School of Natural Sciences & Psychology, John Moores University, Liverpool, L3 3AF, UK*

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ABSTRACT

This article discusses the ability of adults of the coleopteran beetle *Dermestes maculatus* (De Geer) to colonise fresh remains. It also considers whether colonisation results in localised thermogenesis in a similar manner to that induced by blowfly larvae.

In the laboratory, adult *D. maculatus* instantly colonised fresh killed rats and mice. The adults entered the oral cavity within 1–2 h and the eyes and ears were among the first parts of the body consumed. Egg laying occurred on the torso and head within an hour of death and eggs hatched within 3–4 days. The larvae remained on the body whilst the adults (> 70%) rested in the surrounding wood chippings when not feeding or laying eggs. Larvae grew rapidly on the dead bodies and some were starting to pupate within 28 days.

The dermestids consumed the corpses predominantly from the head downwards and weight loss correlated with the number of larvae produced. In both rats and mice, colonisation of the abdominal region was associated with an increase in temperature. The maximum abdominal temperature and the length of time the temperature remained 1 °C or more above ambient correlated with the number of larvae produced. This rise in temperature would probably be sufficient to increase the rate of development of dermestid larvae and that of any other invertebrate or microbe in the region. In the absence of dermestids, the internal temperature rarely rose 1 °C above ambient.

Although there are previously published accounts of dermestid beetles consuming fresh corpses, they are reputed to favour older desiccated remains. This paper confirms that *D. maculatus* rapidly consumes and reproduces on fresh remains. The fact that dermestid beetles are seldom found on fresh remains under field conditions is therefore probably a result of inter-specific competition among decomposing insects rather than food preference. This information could be useful when determining the forensic significance of *D. maculatus* recovered from dead bodies.

## 1. Introduction

The family Dermestidae currently contains over 1000 species and includes many common household and stored product pests[1,2] but most of the dermestid beetles recovered from dead humans belong to just a few species of the genus *Dermestes*.[3,4] Members of the genus *Dermestes* are often referred to as skin beetles whilst their larvae are known as 'wooly bears' as a consequence of their numerous long setae. In France, it was found that in 81 cases in which dermestid beetles were recovered from dead bodies, *Dermestes frischii* (Kugelmann) and *Dermestes undulatus* (Brahm) accounted for the majority of infestations (42% and 35.8% respectively).[3] Similarly, in Turkey, *D. frischii* and *D. undulatus* are the most common dermestid beetles on pig carcasses.[5]

*Dermestes maculatus* (De Geer) is a cosmopolitan species that occurs in Europe, North and South America as well as Asia. In common with many dermestid beetle species, it requires a warm climate to complete its development. It takes an average of 27 days to reach adulthood at 30 °C and 74 days at 20 °C.[6] Consequently, it occurs usually within buildings and human dwellings in the UK and Northern Europe. It is well known as a pest of stored dry animal products and is common in both domestic and commercial settings. The frass and larval setae may cause allergic reactions.[7] *D. maculatus* are sometimes recovered from human remains and have occasionally been used as indicators of the post-mortem interval.[8] In countries with cool temperate climates *D. maculatus* are usually associated with bodies found indoors. For example, in Germany Schroeder et al.[9] describe a case in which the body of an adult man was skeletonised by dermestids within 5 months of him dying in his apartment. They assumed that this was subsequent to his

*E-mail address:* a.gunn@ljmu.ac.uk.

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body mummifying although as will be discussed later, colonisation may actually have begun a lot earlier. By contrast, in countries with hot climates such as South Africa and Brazil *D. maculatus* is also likely to colonise bodies exposed outside in the natural environment.[10,11]

Whilst not as commonly recorded on bodies as blowflies, dermestid beetles were found in 7.5% of 1093 cases investigated by French forensic entomology laboratories.[3] Drug residues are detectable in dermestids that have fed on remains containing them and therefore they may have potential in entomotoxicology.[12] Unfortunately, larval dermestids cannot provide the same level of accuracy for the determination of the minimum time since death as can the larvae of blowflies. This is because the larvae lack morphological indicators of instar number and, at least in some dermestids (e.g. *Trogoderma glabrum* Herbst), a reduction in food supply can result in 'regressive moults' in which the larvae become progressively smaller[13] whilst in others, such as *Dermestes lardarius* (L.), adverse conditions can result in extra instars and prolonged development times.[14] Consequently, it is impossible to determine a larva's instar or age from its size.

The aims of the present study were to assess whether *D. maculatus* would colonise fresh remains and whether their feeding induced localised thermogenesis.

## 2. Methods

### 2.1. Beetles and rearing conditions

Culture conditions: The colonies of *D. maculatus* used in these experiments had been in laboratory culture for 48 months. The insects were maintained in clear plastic tanks (30 cm length × 19 cm width × 19 cm height) in an indoor insectary maintained at 23 ± 1 °C and a 12 h:12 h light: dark regime. There was a 2 cm layer of wood chippings at the base of the tanks and polystyrene packaging provided a medium into which the mature larvae could burrow when they were ready to pupate.

### 2.2. Colonisation of freshly dead rats and mice

Adult male rats (399.16–521.97 g) and female mice (19.56–24.06 g) were humanely euthanized using carbon dioxide and then weighed. There was no significant difference in the average weights of rats (ANOVA, $F_{2,11} = 0.756$, $P = 0.493$) and mice (ANOVA, $F_{1,10} = 0.091$, $P = 0.769$) used in the different treatment groups.

Each rat had a lead from a HOBO® U23-003 PRO V2 temperature data logger inserted via the rectum into the hindgut to record abdominal temperature. Owing to their smaller size, the abdominal temperatures of the mice were recorded using Elitech® RCA-4 Mini Temperature Data Loggers. The loggers recorded the temperature every 10 min. Separate data loggers recorded the ambient air temperature in the insectary.

The experiments took place within clear plastic tanks kept in the same insectary as the culture colonies. The dead rats were placed in 30 cm length × 19 cm width × 19 cm height tanks whilst the mice were placed in tanks measuring 20 cm length × 19 cm height × 19 cm width. Both types of tank had a 2 cm layer of wood chippings at the base and a cloth placed over the top to prevent escapes and other insects accessing the dead animals.

Adult, mixed sex, *D. maculatus* were added to the tanks 15 min before the dead animals were introduced. Either 50 (3 replicates) or 100 (6 replicates) adult beetles were added to the rat tanks and 20 (4 replicates) to each of the mouse tanks. Controls consisted of dead rats (5 replicates) and mice (8 replicates) without dermestid beetles set up in an identical manner at the same time as the experimental tanks.

The tanks were re-weighed after 6 h and then every 24 h for either 28 days (rats) or 24 days (mice). At the time of weighing, observations were made on the state of decay and the activities of the insects. The mice were observed for a shorter duration because by day 24 the dermestids had completely skeletonised their corpses. At the end of the observations, the numbers of insects in each tank were counted.

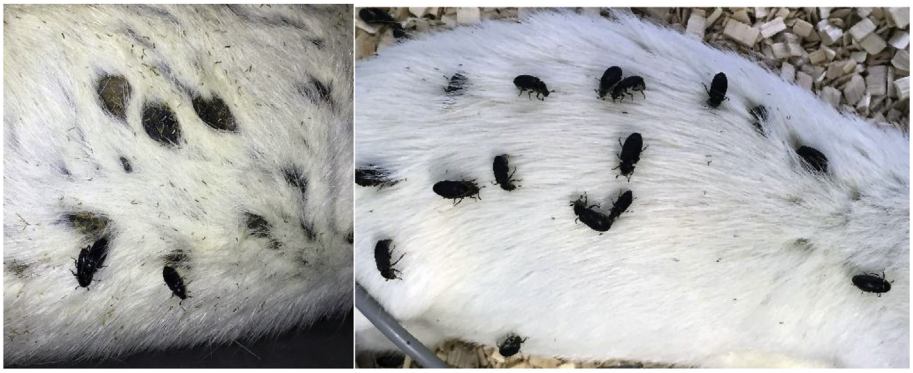
### 2.3. Statistical analysis

Descriptive statistics, ANOVA, and Spearman's Rank correlation analyses were performed using SPSS (version 24). Because the rats and mice were observed for different lengths of time, direct statistical comparisons between them are not appropriate.

## 3. Results

### 3.1. Colonisation of freshly-dead rats and mice

Adult beetles investigated the dead rats and mice almost immediately and began feeding within 5 min. The oral cavity and ear canals were invariably explored and the eyes were often consumed within 24–48 h. Feeding was usually communal with several insects feeding in close proximity to one another. The foot pads and ear lobes were also attacked within the first 48 h although it was common for just one ear lobe or foot pad to be extensively consumed whilst the other(s) were not touched until several days later. Although adult beetles fed around the anus, penis, and testicles in the rats and the anus and vagina in the mice, they consumed the bodies primarily from the head downwards. The first holes chewed into the body were always in the throat and upper thorax. The abdominal region was not exposed until after the body had deflated and the upper body was becoming skeletonised. The beetles chewed numerous slits into the skin rather than



a b

**Fig. 1.** (a) Post-mortem wounds in a dead rat caused by the feeding activity of *Dermestes maculatus*. Note the thin flecks of moist frass rather than long thin strands normally associated with dermestid beetles. (b) *D. maculatus* feeding and laying eggs on a rat that was dead for 24 h and entering the bloat stage of decomposition.