Walter, D. E., and H. Proctor. 2013. Mites: Ecology, Evolution & Behaviour. Second edition. Springer Netherlands. doi:10.1007/978-94-007-7164-2.

Zieger, S. L., S. Ammerschubert, A. Polle, and S. Scheu. 2017. Root-derived carbon and nitrogen from beech and ash trees differentially fuel soil animal food webs of deciduous forests. PLOS ONE **12**:1–14. doi:10.1371/journal.pone.0189502.

Larger insect collection specimens are not more likely to show evidence of apparent feeding damage by dermestids (Coleoptera: Dermestidae)

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Abstract

Dermestids can not only cause damage to museum insect specimens but if left unchecked can ruin museum collections. This study aimed to determine whether larger insect specimens are more likely to show evidence of apparent feeding damage by dermestids than smaller specimens. We examined 366 specimens of various taxa in the Kenelm W. Philip collection, currently housed in the University of Alaska Museum Insect Collection. We measured the size of each specimen and examined each specimen for evidence of dermestid feeding under magnification. The median specimen sizes of the damaged and undamaged groups were compared using a Mann-Whitney *U*-test. We could not reject the null hypothesis ($p = 0.0878$) that all sizes of specimens are equally likely to show apparent feeding damage.

Introduction

Many different fields of research regularly use museums specimens for a variety of topics from ecology to phylogenetics (Suarez and Tsutsui, 2004; Andersen and Mills, 2012). Because of this, it is important to ensure the long-term preservation and protection of these specimens. Dermestidae are a family of beetles (Coleoptera) that feed on protein-rich, dry animal and plant material. In nature, dermestids provide a key ecosystem function as decomposers, but they are commonly considered pests in museums because they feed on specimens and can be difficult to control (Burges, 1959; Gilberg and Brokerhof, 1991). Many studies have looked at effective ways to protect specimens from this damage (Zaitseva, 1987; Su and Scheffrahn, 1990). But much remains to learned about the behavior of dermestids that feed on museum specimens. The purpose of this study was to determine if dermestids show a size preference in their choice of specimens. However, because live dermestids were not used and we had to assume dermestids were the causitive agents of the observed damage, we tested the null hypothesis that the median sizes of apparent feeding-damaged and undamaged specimens would not be significantly different (with no specification of the causitive agent of the damage).

Methods

One drawer of specimens in the Kenelm W. Philip collection, currently held at the University of Alaska Museum Insect Collection, that had obvious signs of dermestid damaged specimens was used (Figure 1). This drawer had exuvia of dermestid larvae, feeding detritus, and obvious holes chewed in specimens, and contained 366 dried, pinned insect specimens of various sizes and insect taxa (misc. orders, specimens thought to have been collected by W. C. Frohne or at least part of Frohne's collection). Size mea-

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surements of each were taken from the front of the head (not including mandibles, palps, or antennae) to the end of the abdomen (not including cerci, ovipositor, etc.) using digital calipers in millimeters to the nearest one-tenth of a millimeter for specimens over 3 mm and using an ocular micrometer to the nearest tenth of a millimeter using a Leica M165C stereomicroscope for specimens under 3 mm. Specimens were examined under magnification using this Leica microscope for direct evidence of chew marks or holes left by dermestids (e.g., Figure 2).

If a specimen was missing its head or abdomen the size measurement was estimated to account for the lost body part. Specimens with broken body parts but no evidence of dermestid feeding were considered not feeding damaged (specimens can become broken from a variety of non-dermestid causes). Each measurement was assigned to one of two groups: specimen feeding damaged or specimen not feeding damaged. The smallest specimens might get eaten entirely, leaving very little evidence, and thus be unavailable for measuring—possibly biasing the results towards an overabundance of specimens too large to eat entirely. The drawer had 12 pins with labels but missing specimens, ten of which were pointed specimens. To account for these potentially feeding damaged and small, but missing specimens, we added 12 randomly generated size values between 1 mm and 5 mm to the damaged data (generated using the `R` (R Core Team, 2017) command `runif(12, min=1, max=5)`). These added values constitute the last 12 values of damaged specimens in the data. The data are archived at FigShare doi: doi:10.6084/m9.figshare.5930686.

Figure 1: One drawer of the Kenelm W. Philip collection of miscellaneous taxa from various regions including the Philippines, California, Missouri, Ethiopia, and Alaska.

Figure 2: A small parasitoid wasp specimen with a hole presumably chewed by dermestids (arrow). The numbers on the scale bar mark half mm increments.

Results

There were 182 undamaged specimens and 184 feeding damaged specimens. The mean size of the undamaged specimens was 11.83 mm (9.22 mm SD) and the median was 10.47 mm (Figure 3). The mean size of the feeding damaged specimens was 13.97 mm (9.28 mm SD) and the median was 11.32 mm. The Mann-Whitney U-test showed these medians to be significantly different ($W = 14160$, $p = 0.0107$). However, when this test was re-run with the 12 added damaged values to account for small specimens presumably eaten entirely the medians were not significantly different ($W = 16024$, $p = 0.0878$).

Discussion

It was a long-held assumption of DSS that larger insect specimens are more likely to show feeding damage by dermestids. These results demonstrate this impression is most likely due to feeding damage being easier to see on larger specimens. Supporting this view are the results of a prior analysis of this question in which feeding damage was assessed without magnification. Those data strongly rejected the null hypothesis and indicated larger specimens were more likely to show feeding damage ($W = 4543.5$, $p < 0.00001$). However, when magnification was used to assess damage it was possible to see damage on the smaller specimens (eg., Figure 3) that had been previously missed without magnification. These results support a random-encounter model of dermestid feeding with no apparent choice or preference based on specimen size.

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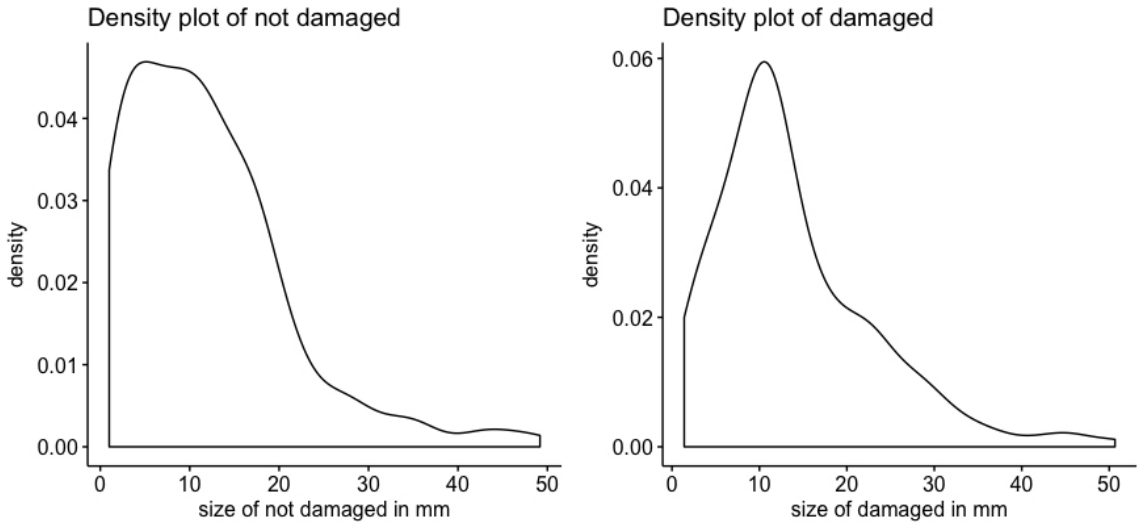

Figure 3: Density plots of not feeding damaged ($n = 182$) and feeding damaged ($n = 184$) specimens.

References

Andersen, J. C., and N. J. Mills. 2012. DNA extraction from museum specimens of parasitic Hymenoptera. PLoS ONE **7**:e45549. doi:10.1371/journal.pone.0045549.

Burges, H. D. 1959. Studies on the dermestid beetle *Trogoderma granarium* Everts: ecology in malt stores. Annals of Applied Biology **47**:445–462. doi:10.1111/j.1744-7348.1959.tb07278.x.

Gilberg, M., and A. Brokerhof. 1991. The control of insect pests in museum collections: the effects of low temperature on *Stegobium paniceum* (Linneaus), the drugstore beetle. Journal of the American Institute for Conservation **30**:197–201. doi:10.1179/019713691806066737.

R Core Team. 2017. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL `https://www.R-project.org/`.

Su, N.-Y., and R. H. Scheffrahn. 1990. Efficacy of sulfuryl fluoride against four beetle pests of museums (Coleoptera: Dermestidae, Anobiidae). Journal of Economic Entomology **83**:879–882. doi:10.1093/jee/83.3.879.

Suarez, A. V., and N. D. Tsutsui. 2004. The value of museum collections for research and society. BioScience **54**:66–74. doi:10.1641/0006-3568(2004)054[0066:TVOMCF]2.0.CO;2.

Zaitseva, G. A. 1987. Protection of museum textiles and leather against the dermestid beetle (Coleoptera, Dermestidae) by means of antifeedants. Studies in Conservation **32**:176–180. doi:10.1179/sic.1987.32.4.176.

DNA barcoding Alaskan willow rosette gall makers (Diptera: Cecidomyiidae: *Rabdophaga*)

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Introduction

Members of the *Rabdophaga rosaria* group form conspicuous rosette galls on a variety of willow (*Salix* spp.) hosts (Collet, 2002; Amendt, 2003) and have a holarctic distribution. Gall formation halts elongation of willow stems and alters the morphology and chemical makeup of host tissues (Gailite et al., 2005; Samsone et al., 2011). Ecologically, these flies are a keystone species for a community of insects associated with rose galls including multiple parasitoid, hyperparasitoid, and commensal species (Van Hezewijk and Roland, 2003; Collet, 2006; Skuhravá and Thuróczy, 2007). The larvae serve as food for chickadees and tits, which pick them out of galls in winter (Van Hezewijk and Roland, 2003; Nyman et al., 2011, Figure 1). The galls themselves are avoided by moose (Kenai National Wildlife Refuge staff, 1981; Ford et al., 1995; Rea, 2012) and snowshoe hares (Ford et al., 1995).

Figure 1: A black-capped chickadee dismantling a gall induced by *Rabdophaga strobiloides* in central Michigan, December 30, 2017 (`https://flic.kr/p/232e1Yn`). Image © J. D. Sommer. Used with permission.

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