A Method of Sexing *Trogoderma* (Coleoptera: Dermestidae) Pupae[1]

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ABSTRACT

Two characters (antennal configuration and the last abdominal segment) were found to be reliable guides in sexing pupae of *Trogoderma* spp. Pupae were exposed by gently pressing the center of the ventral side with a small brush; then, with a large insect pin, the head region of the last larval skin was lifted and pulled back, thus exposing the exarate-type pupae. As in adults, the exposed antennal structures are distinctly different among species, and between male and female pupae of each species. The last abdominal segment serves as an accurate and rapid key for sexing pupae, because in the male pupae the last segment is round, while females have a distinct pair of processes on the last abdominal segment. The handling of pupae had no deleterious effects on the reproductive capabilities of the adults.

In our studies of the life histories and bionomics of *Trogoderma* spp., it was found desirable to have an accurate, rapid method of sexing pupae. Lindgren et al. (1955) and Burges (1957) commented that female pupae of the khapra beetle, *T. granarium* Everts were larger than male pupae. Hadaway (1956) measured pupae of *T. granarium* and *T. inclusum* LeConte (cited as *T. versicolor* (Creutz)) and found the females larger than the males. Loschiavo (1960) noted this to be true among pupae of *T. parabile* Beal, and we have observed that female pupae of this species are usually larger than males (Fig. 1). However, size alone cannot be relied upon for sexing *Trogoderma* pupae, because size varies with quality of food, crowding, and environmental conditions. In our observations of *T. glabrum* (Herbst), *T. grassmani* Beal, *T. inclusum*, *T. parabile*, *T. simplex* Jayne, and *T. sternale* Jayne we found that size overlaps between the sexes, although female pupae of all these species generally are larger than the males.

This paper presents 2 pupal characters (antennal configuration and the last abdominal segment) that can be used to differentiate between the sexes of *Trogoderma* spp. The effects of pupal disturbances on the reproductive capabilities of the adults also were studied. Pupae used in these experiments were collected from stock cultures reared under appropriate conditions for each species. The experiments were conducted under a constant room temperature of 80± 2°F and 55±5% RH.

ANTENNAL CHARACTERS.—From cultures of each of 6 species of *Trogoderma*, pupae were collected for sexing by antennal characters. Sexing was accomplished under a binocular microscope by gently pressing in the center of the ventral side of the pupae with a small brush; then with a large insect pin, the head region of the last larval skin was lifted and pulled back, exposing the exarate-type pupae. Fifty ♂ and 50 ♀ were sexed and held for extensive examinations.

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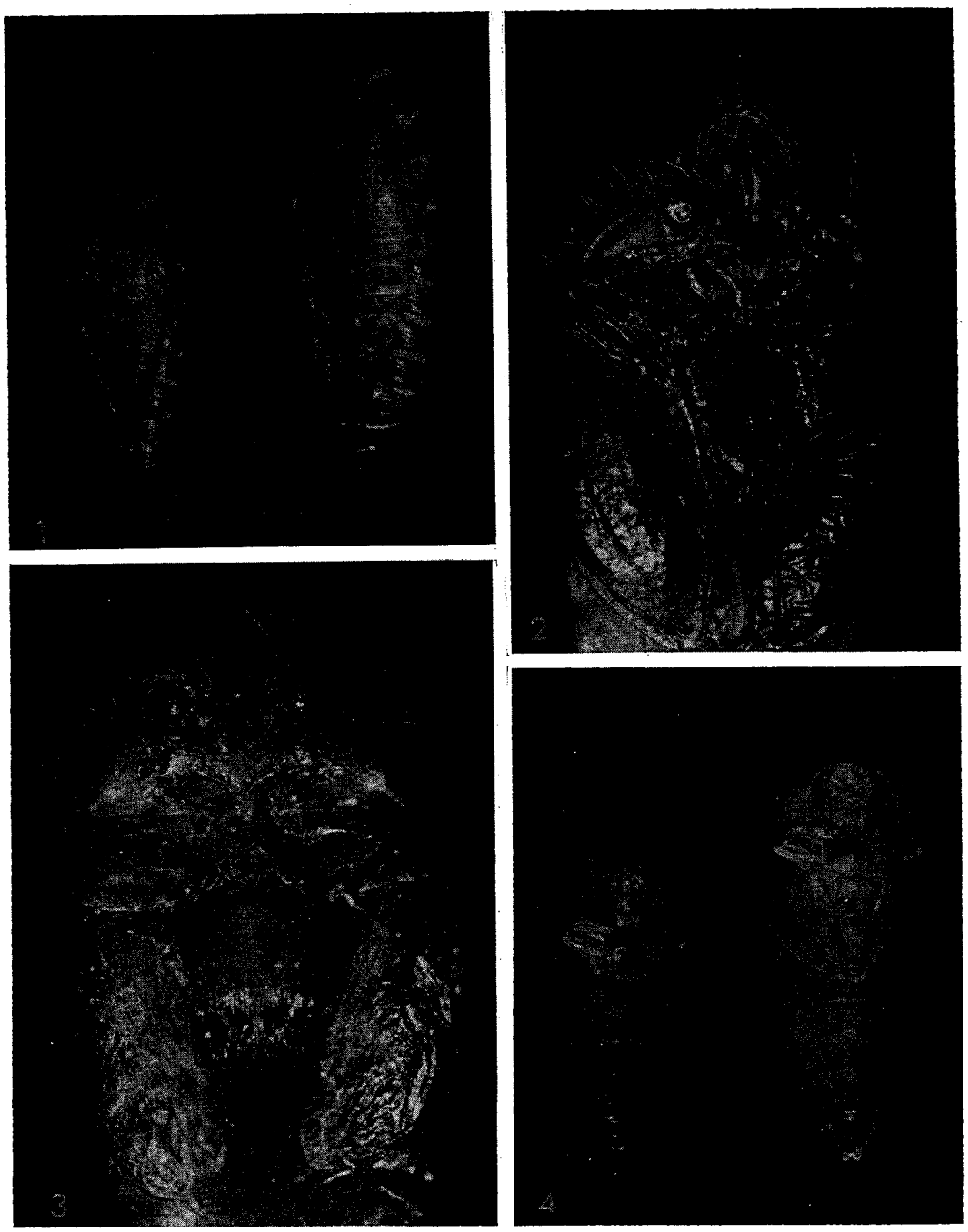

FIG. 1.—Dorsal view of *T. parabile* pupae in last larval skin indicating differences in size of the male (left) and female.

FIG. 2.—Ventral view of a *T. parabile* male pupa removed from last larval skin, showing the characteristic elongated antennae of this species and the beginning of segmentation and sclerotization.

FIG. 3.—Ventral view of a *T. parabile* female pupa removed from the last larval skin showing the distinctly clubbed antennae of this species and the beginning of segmentation and sclerotization.

FIG. 4.—Ventral view of *T. parabile* pupae removed from the last larval skin. The round last abdominal segment of the male pupa (left) and the distinct processes on the last abdominal segment of the female pupae illustrate the characteristic sexual differences found in pupae of *Trogoderma* spp.

The antennal structure of the 6 species was noted, and distinct differences were observed among species and between the sexes of each species. Our observations agreed with Beal's (1954, 1956) descriptions. Although antennal characters are sometimes difficult to see in young pupae because the white antennae blend with the rest of the body, with practice an observer can readily discern sex of pupae from the antennal structure. In older pupae, these structures are clearly seen because of darkening and segmentation.

To verify further the use of antennal characters, 150 ♂ and 150 ♀ of *T. parabile* were sexed by their antennal structures (Fig. 2 and 3). The last larval skin was pulled back and replaced after exposing the antennae of the pupae. The sexed pupae were kept in separate containers. Results showed that 100% of the *T. parabile* pupae matured as sexed.

LAST ABDOMINAL SEGMENT.—After antennal characters were noted for pupae of each species, the last larval skin was completely removed. The procedure followed for removing this skin was similar to that for exposing the antennae. When the last larval skin was folded back, the brush was moved to the lower portion of the thorax. Then the last larval skin was removed by holding the exposed pupa firmly with the brush and gently pulling the skin posteriorly until it came free of the pupa. Naked pupae were sexed by examining the last abdominal segment. Distinct differences between the sexes of *Trogoderma* pupae are shown in Fig. 4, using *T. parabile* as an example. Use of these characters makes sex identification easier and more rapid than use of the antennal characters.

The last abdominal segment of male pupae is round, without any processes; the females have a distinct pair of processes that develop into the styli of the ovipositor. The styli were described by Tanner (1927) as being common to the family Dermestidae. After being sexed, the pupae were held in separate containers until maturity. Conclusive proof of sex was obtained by extracting the genitalia of each adult. Injury caused in removing the last larval skin from the pupae resulted in 6% mortality of *T. glabrum*, 3% of *T. inclusum* and *T. sternale*, and 2% mortality of *T. simplex*.

Differential stages of maturation in young pupae to young adults were observed in the last abdominal segment of specimens after the larval skin was removed. In young male pupae, the last abdominal segment is round, without any processes, but in older male pupae the aedeagus was observed protruding from the abdomen. The penis, lateral lobes, and the bridge (Beal 1954) were discernible under the binocular microscope because of their light, coppery color, indicating the beginning of sclerotization. In pupae approaching maturation the aedeagus was easily seen because of heavy sclerotization. In young male adults, from which the last larval skin was removed, the aedeagus protruded from the last abdominal segment. In young female pupae the styli were short and stocky, while in older female pupae the styli were slender and elongated. In young female adults, from which the last larval skin was removed, the ovipositor protruded from the last abdominal segment, with the styli distinctly evident at the tip.

EFFECTS OF DISTURBANCE.—Because of the amount of handling required in sexing *Trogoderma* pupae, an experiment with *T. parabile*, selected as an example, was initiated to determine possible deleterious effects on the reproductive capacity of adults maturing from the sexed pupae. Three replications of 50 pairs each were set up under each of the following conditions: (a) pupae undisturbed, (b) last larval skin pulled back to expose antennal characters, and (c) the last larval skin removed from pupae. The pupae were placed in separate containers until adults emerged. Undisturbed female and male pupae were initially separated by size, but the young adults were rechecked by using obvious antennal differences between the sexes (Beal 1954, 1956). Injury caused by handling resulted in mortality of 1% of pupae that had the antennae exposed, and 16% mortality of pupae that had the last larval skin removed.

Adults of each group, ranging from newly emerged to 3 days old, were placed in ½-pint jars for egg-laying. Lids equipped with 30-mesh brass strainer cloth were used on the jars. The jars were inverted over 100×15-mm plastic petri dishes containing pieces of 2½×2½-in. black paper on the bottom. A 90° fold was made at each of the 4 corners of the paper to facilitate handling. Most of the eggs were deposited on the paper, but a few were lost, having stuck to the strainer cloth. Some eggs were crushed by the adults. New petri dishes were substituted each day until all adults were dead. Although this method is not suitable for a biological study on number of eggs produced by the females, it is useful to compare the reproduction of each group, since the methods of handling are identical.

The larvae that hatched from the eggs were counted and data from the 3 replicates for each condition were pooled. The 150 ♀ in the undisturbed group produced 3962 larvae with a range of 1174–1659 larvae. The 149 ♀ from pupae that had the last larval skin pulled back to expose the antennae produced 5888 larvae with a range of 1335–2602 larvae. The 126 ♀ from pupae that were completely removed from the last larval skin produced 4262 larvae with a range of 1250–1627 larvae. Production of more larvae by the disturbed groups than the undisturbed group should not be attributed to disturbance, per se, but rather to the high variability in egg production by *T. parabile* adults (Loschiavo 1967).

Based on the results obtained, we conclude that *Trogoderma* spp. can be accurately sexed in the pupal stage by using either the antennal structure or the appearance of the last abdominal segment without any serious effects on the reproductive potential of the adults.

REFERENCES CITED

Beal, R. S., Jr. 1954. Biology and taxonomy of the Nearctic species of *Trogoderma* (Coleoptera: Dermestidae). Univ. California Pub. Entomol. 10 (2): 35–102.

1956. Synopsis of the economic species of *Trogoderma* occurring in the United States with description of a new species (Coleoptera: Dermestidae). Ann. Entomol. Soc. Amer. 49 (6): 559–66.

Burges, H. D. 1957. Studies on the dermestid beetle *Trogoderma granarium* Everts. I. Identification and duration of the development stages. Entomol. Monthly Mag. 93: 105–10.

Hadaway, A. B. 1956. The biology of the dermestid beetles, *Trogoderma granarium* Everts and *Trogoderma versicolor* (Creutz). Bull. Entomol Res. 46 (4): 781–96.

Lindgren, D. L., L. E. Vincent, and H. E. Krohne. 1955. The khapra beetle, *Trogoderma granarium* Everts. Hilgardia 24 (1) : 1–36.

Loschiavo, S. R. 1960. Life-history and behaviour of *Trogoderma parabile* Beal (Coleoptera: Dermestidae). Can. Entomol. 92 (8) : 611–8.

1967. Adult longevity and oviposition of *Trogoderma parabile* Beal (Coleoptera: Dermestidae) at different temperatures. J. Stored Prod. Res. 3 (4) : 273–82.

Tanner, V. M. 1927. A preliminary study of the genitalia of female Coleoptera. Trans. Amer. Entomol. Soc. 53: 5–50.

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