

- 1970a. Evolutionary morphology of the external insect genitalia. 2. Hymenoptera. *Ibid.* 63: 1-27.
 1970b. Biosystematics and morphology of Symphyta: II. Biology of gall-making nematine sawflies in the California Region. *Ibid.* 63: 36-51.
 1970c. Biology and structure of the dobsonfly *Neohermes californicus* (Walker) (Megaloptera: Corydalidae). *Pan-Pac. Entomol.* 46: 142-50.
 1970d. Biology and structure of some California bristletails and silverfish (Apterygota: Microcoryphia, Thysanura). *Ibid.* 46: 212-25.

Tuxen, S. L. [ed.] 1970. *Taxonomist's Glossary of Genitalia in Insects*. 2nd ed. Munksgaard, Copenhagen. 359 p.

Maturation of the Response of Male *Tenebrio molitor* to the Female Sex Pheromone^{1,2}

GEORGE M. HAPP

Department of Biology, New York University,
Bronx 10453

Several chemical signals coordinate the reproductive behavior of male and female yellow mealworm beetles, *Tenebrio molitor* L. (Valentine 1931, Tschinkel et al. 1967, Happ and Wheeler 1969, Happ 1969). Of these pheromones, the best characterized is an attractant which is produced by females and which acts only on males. Females release very little of this attractant immediately after imaginal ecdysis, but the rate of emission increases markedly in the first 5 days of adult life (Happ and Wheeler 1969). The present study was designed to investigate the complementary phenomenon by asking the question: Do males become more responsive to the female attractant as they become reproductively mature?

The sensitivity of males to female scent was determined by bioassay. For this procedure, groups of 10 ♂ were confined in a lucite chamber. When exposed to unscented air, males congregated near the air outflow of the chamber, but when the air was laden with female scent, males which were reproductively mature (2-4 weeks after ecdysis) rushed upwind and attempted to mount one another. The proportion of males responding served as a measure of the relative potency of different scents (see Happ and Wheeler 1969 for details). In the present study, the same chemical sample, namely an extract of female *Tenebrio* which elicited responses from 70% of mature (2-4 weeks) males in a bioassay chamber, was used for all tests. Immediately after the imaginal ecdysis, callow males were individually numbered and transferred to bioassay chambers. No tests were attempted on the day of imaginal ecdysis, since the beetles had been disturbed by the manipulation.

At 1 day of age, the males were unresponsive to the scent (Fig. 1), although they were immediately excited by a puff of tobacco smoke. On succeeding days, increased proportions of males responded to the extract of females. By the 5th day the male response appeared to stabilize at about 70% (Fig. 1), the level characteristic of mature beetles. Throughout the bioassays, daily checks of the standard extract were run on chambers of males 14-28 days old.

¹ Coleoptera: Tenebrionidae.

² Received for publication Apr. 23, 1970.

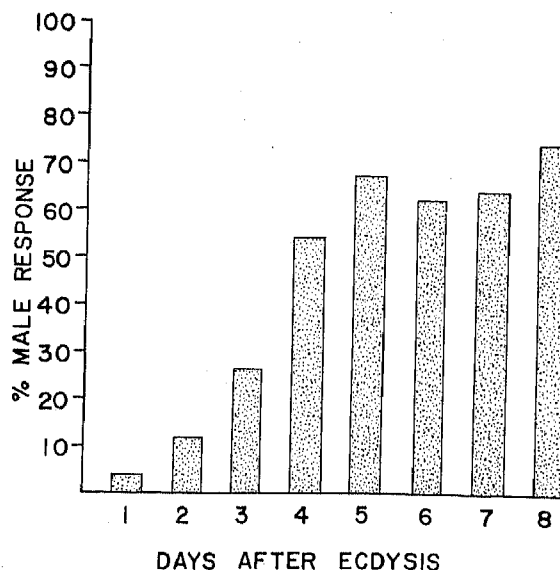


FIG. 1.—Responses of male *Tenebrio* at various periods after imaginal ecdysis to a standard extract of females. At least 100 ♂ of each age were tested.

The increasing sensitivity of the maturing male *Tenebrio* to female scent can be correlated with other aspects of the reproductive biology of this species. Since they emit little sex attractant, very young adult females are unattractive to males, but the pheromone emission increases with age and reaches a maximum at 4 or 5 days (Happ and Wheeler 1969). As shown by the present study, maturation of the male response parallels maturation of the emission of the pheromone by the female. Similar phenomena have been described in noctuid moths by Shorey et al. (1968). In *Tenebrio*, as in the noctuids, the maturation of the signal and response system is correlated with reproduction itself; in male or female *Tenebrio*, mating is first observed at 4 days after the imaginal ecdysis of males or females, and by 5 days most matings are accompanied by the transfer of a spermatophore.

ACKNOWLEDGMENT

This study was aided by grants from The Arts and Sciences Fund of New York University and from The NIH Institutional Grant to New York University.

REFERENCES CITED

- Happ, G. M. 1969. Multiple sex pheromones of the mealworm beetle, *Tenebrio molitor* L. *Nature* 222: 180-1.
 Happ, G. M., and J. W. Wheeler. 1969. Bioassay, preliminary purification, and effect of age, crowding, and mating on the release of sex pheromone by female *Tenebrio molitor*. *Ann. Entomol. Soc. Amer.* 62: 846-51.
 Shorey, H. H., K. L. Morin, and L. K. Gaston. 1968. Sex pheromones of noctuid moths. XV. Timing of development of pheromone-responsiveness and other indicators of reproductive age in males of eight species. *Ibid.* 61: 857-61.
 Tschinkel, W. C., C. Willson, and H. A. Bern. 1967. Sex pheromone of the mealworm beetle (*Tenebrio molitor*). *J. Exp. Zool.* 164: 81-85.
 Valentine, J. M. 1931. The olfactory sense of the adult mealworm beetle *Tenebrio molitor* (Linn.) *Ibid.* 58: 165-227.