LEKKING BEHAVIOR OF THE BLACK SOLDIER FLY (DIPTERA: STRATIOMYIDAE)

JEFFERY K. TOMBERLIN AND D. CRAIG SHEPPARD
Department of Entomology, University of Georgia

The black soldier fly, *Hermetia illucens* (L.), (Diptera: Stratiomyidae), is a large (13 to 20 mm), wasp-like fly (May 1961). It has three generations per year in the southeastern United States and can be collected from late spring through early fall (Sheppard et al. 1994). Breeding occurs all year in the tropics. Larvae occur in assorted decomposing materials, such as fruits, animals, and manure (James 1935).

The black soldier fly is interesting because its presence can be used to solve many of the problems associated with large manure accumulations at confined animal feeding operations (CAFO). Problems, such as pest insects, water pollution and odors, are a product of excess nutrients (manure) at the CAFO. Soldier fly larvae concentrate excess manure nutrients into valuable feedstuff and other products (ca. $200 per ton), which can be economically transported (unlike manure at ca. $10-20 per ton). This would relieve local nutrient overload (Sheppard & Newton 2000)

House fly, *Musca domestica* L., control due to manure being colonized by the black soldier fly has been reported by Furman et al. (1959), Tingle et al. (1975), Sheppard (1983), and Axtell and Arends (1990). Additionally, Tingle et al. (1975) documented that black soldier fly larvae reduce waste within poultry facilities. Sheppard (1983) followed up their work and determined that the black soldier fly can reduce manure accumulation by 42-56%. Concentrations of nitrogen, and other nutrients are also significantly lower in this reduced manure, thus further reducing the potential for pollution.

Soldier fly prepupae can be easily self-harvested by directing their search for pupation sites into collection bins (Sheppard et al. 1994). Approximately 58 tons of prepupae can be collected in five months from the manure of a single layer facility, housing approximately 100,000 hens (Sheppard et al. 1994). The prepupae can be used as feed (42% protein, 35% fat) for a variety of livestock (Newton et al. 1977; Sheppard et al. 1994). This feedstuff, when dried, has an estimated value comparable to soybean or meat and bone meal. If used live, as specialty feed, or marketed to exploit its other unique qualities (essential fatty acids and chitin), the value of the product may be higher (Sheppard et al. 1994).

This manure management system depends on a robust soldier fly population for dependable inoculation of the manure with larvae. Presently, little is known about the biology of *H. illucens*.

Tingle et al. (1975) described the black soldier fly mating behavior. Males were attracted to "calling" females in the same "resting" area and mating occurred on the ground with the male and female facing opposite directions. However, Copello (1926) noted that mating occurred during flight. We provide a description of the mating, which differs from that provided by Tingle et al. (1975), and lekking behaviors of the black soldier fly, which may be important to maintaining this natural waste management system.

The study site was a poultry farm (three California style open-sided layer houses side-by-side) located in Bacon County, in the coastal plain region of Georgia. Observations were made during the mid-day (1100-1400 h) on 21 and 30 July 1998. Various weeds and grasses grew around the poultry facilities with a hardwood forest located approximately 100 m to the north. The forest edge was covered with a mixture of kudzu, *Pueraria lobata* (Wild), and morning glory, *Ipomoea* species. A pond, approximately 15 m in diameter, was located on the eastern side of the forest.

Large numbers of soldier flies were observed at two sites: within the chicken houses (a known larval habitat) and along the edge of the woods, especially a 10 to 15 m stretch of kudzu and morning glory facing the poultry facilities. We used an aerial net to sample these areas. We judged that there were several hundred soldier flies present during our collection periods. Adults collected from the forest edge were 91.9% (n = 109) male, while those collected from the poultry facilities were primarily female (91.3%, n = 123) apparently seeking oviposition sites. Furman et al. (1959) and Sheppard et al. (1994) suggest that adults live in a wild environment and that those observed in livestock facilities are newly emerged or ovipositing females.

Hermetia illucens males present at the forest edge generally rested individually on the surface of morning glory and kudzu leaves. Male movement was observed when members of the same species were present within its vicinity (i.e., flying above the resting male or landing on the same leaf). Arrival of another male would prompt the resting male to close and grapple with the invader. This would result in the two vertically spiraling approximately 0.5 to 1.5 m above the resting male's leaf. Once within this elevation range, the two would part with one returning to the leaf and the other leaving the vicinity. Females were similarly greeted, however males would grasp passing females during this aerial encounter and descend *in copula*. No chasing or mating activities were observed at the layer house where ovipositing females predominated.

Similar behaviors have been observed for another stratiomyid species (Alcock 1990). *Hermetia comstocki* Williston males have been observed aggregating at agava trees and resting individually on the upper leaf surfaces. Resting males were observed repelling other approaching males. The "victor" of the engagement would return to the leaf while the "loser" would leave the vicinity. This scenario was defined as a territorial or lekking behavior (Alcock 1990). Additionally, these sites of high male density may serve as attractants to females ready for mating (Alcock 1990). Similar patterns of lekking behavior have been reported for hymenopteran species, and other dipterans (Toft 1989 & O'Neill 1983).

SUMMARY

We describe the lekking behavior of the black soldier fly. If this lekking behavior at specific habitats is needed for *H. illucens* mating to occur, the identification and conservation of these sites near CAFOs would be important. Without these sites, we hypothesize that mating may be reduced or not occur at all, resulting in a reduction in the soldier fly population and associated benefits. We would like to thank J. Ruberson and J. Greene for their helpful comments on this manuscript.

REFERENCES CITED

ALCOCK, J. 1990. A large male competitive advantage in a lekking fly, *Hermetia comstocki* Williston (Diptera: Stratiomyidae). Psyche 97: 267-279.

AXTELL, R. C. AND J. J. ARENDS. 1990. Ecology and management of arthropods pests of poultry. Annu. Rev. Entomol. 35: 101-126.

COPELLO, A. 1926. Biologia de *Hermetia illuscens* Latr. Rev. Soc. Ent. Argentina 1: 23-27.

FURMAN, D. P., R. D. YOUNG, AND E. P. CATTS. 1959. *Hermetia illucens* (Linnaeus) as a factor in the natural control of *Musca domestica* Linnaeus. J. Econ. Entomol. 52: 917-921.

JAMES, M. T. 1935. The genus *Hermetia* in the United States (Diptera: Stratiomyidae) Bull. Brooklyn Ent. Soc. 30: 165-170.

MAY, B. M. 1961. The occurrence in New Zealand and the life history of the soldier fly *Hermetia illucens* (L.) (Diptera: Stratiomyidae). N.Z. J. Sci. 4: 55-65.

NEWTON, G. L., C. V. BOORAM, R. W. BARKER, AND O. M. HALE. 1977. Dried *Hermetia illucens* larvae meal as a supplement for swine. J. Anim. Sci. 44: 395-399.

O'NEILL, K. M. 1983. Territoriality, body size, and spacing in males of the bee wolf *Philanthus basilaris* (Hymenoptera: Sphecidae). Behaviour 86: 295-321.

SHEPPARD, D. C. 1983. House fly and lesser fly control utilizing the black soldier fly in manure management systems for caged laying hens. Environ. Entomol. 12: 1439-1442.

SHEPPARD, D. C., AND G. L. NEWTON. 2000. Valuable byproducts of a manure management system using the black soldier fly—A literature review with some current results. Animal, Agricultural and Food Processing Wastes: Proceedings of the 8th International Symposium. James A. Moore ed. American Society of Agricultural Engineers, St. Joseph, Michigan. pp. 35-39.

SHEPPARD, D. C., G. L. NEWTON, S. A. THOMPSON, AND S. SAVAGE. 1994. A value added manure management system using the black soldier fly. Bio. Tech. 50: 275-279.

TINGLE, F. C., E. R. MITCHELL, AND W. W. COPELAND. 1975. The soldier fly, *Hermetia illucens* in poultry houses in north central Florida. J. Ga. Entomol. Soc. 10: 179-183.

TOFT, C. A. 1989. Population structure and mating system of a desert bee fly (*Lordotus pulchrissimus*; Diptera: Bombyliidae). I. Male demography and interactions. Oikos 54: 345-358.