LABORATORY OBSERVATIONS ON THE LIFE CYCLE OF
PHELISTER PANAMENSIS LeCONTE (COLEOPTERA: HISTERIDAE) INCLUDING SCANNING ELECTRON MICROSCOPY OF THE LIFE STAGES

James W. Summerlin, Shirlee M. Meola, G. Truman Fincher, and James P. Roth
Agricultural Research Service, U.S. Department of Agriculture
Food Animal Protection Research Laboratory
Route 5, Box 810, College Station, TX 77840

ABSTRACT

The biology of the predatory histerid beetle Phelister panamensis LeConte was studied in the laboratory. Throughout the study, the life stages were maintained with constant light at 25-28°C and 40-60% relative humidity. Female beetles deposited single eggs 2-7 mm deep in soil beneath deposits of cattle manure. Embryogenesis was completed in approximately 2.4 d after oviposition. The two larval instars required about 3 and 4.2 d to complete development, while the pupal stage duration averaged 9.2 d. Development from egg to adult averaged 19 d. This is the first study of the life stages of a histerid beetle using scanning electron microscopy in order to more clearly visualize minute external structures.

Key Words: Biology, histerid beetle, Phelister panamensis, horn fly, biological control, Haematobia irritans, Diptera, Muscidae, Coleoptera, Histeridae.

J. Agric. Entomol. 8(3): 189-197 (July 1991)

Native and exotic species of Histeridae that inhabit cattle dung are being studied to evaluate their role as natural enemies of the horn fly, Haematobia irritans (L.). The horn fly is an important pest of cattle that costs the livestock industry in the United States more than $780 million annually (Drummond et al. 1981). Cattle irritated by these biting flies suffer loss of blood and weight, a decline in general health and vigor, and an increase in their susceptibility to cattle diseases. Control procedures currently depend on the use of insecticides. However, the horn fly has become resistant to many of the insecticides used for its control (Sparks et al. 1985). Therefore, alternate methods of control are being sought to reduce dependence on chemical insecticides to control this important pest. One approach to achieving this goal is to maximize use of biological methods in integrated pest management programs. The manipulation of native species of histerids and introduction of exotic species may suppress horn fly populations. Phelister panamensis LeConte, a species native to Texas (Summerlin 1980, Blume 1985), is under investigation to determine its potential as a biological control agent. Since its biology has not previously been studied, we report here the results of investigations on the life cycle of P. panamensis.

1 Received for publication 27 August 1990; accepted 22 February 1991.
2 Current address: Dept. of Entomology, Texas A&M University, College Station, Texas 77841.
3 Corresponding author.
MATERIALS AND METHODS

*Phelister panamensis* was colonized in September 1988 from 44 adults collected in Kleberg County, Texas. The beetles were taken from cattle droppings less than 24-h old. Adults were confined in plastic cages (8.5 cm by 25 cm diam) filled to a depth of ca. 1 cm with sandy soil. The cages were maintained in growth chambers with constant light at 25-28°C and 40-60% RH. The cages were fitted with plastic lids with a cotton muslin insert to provide ventilation. Fresh cow dung (100 g) was placed on the soil surface in each cage and stable fly, *Stomoxys calcitrans* (L.), eggs (ca. 1000) were added on top of the dung daily as food for the adult beetles and developing beetle larvae. The stable fly eggs were suspended in water and placed on the manure with a rubber bulb and pipette. Fresh dung was added every 5-7 d when aged and dried dung became unsuitable for maturing fly larvae. The cages were cleaned ca. every 4 wk. Beetles and dung were removed from the cages and held in separate containers. The soil was carefully sifted 3-4 times to recover *Phelister* eggs and larvae, and the manure was broken apart and meticulously inspected for adults and larvae. Containers holding the sifted soil and the inspected dung were flooded with tap water. Undetected adults and dislodged pupae floated to the surface and were recovered. No eggs and few larvae were recovered in this manner. Adult *P. panamensis* were then set up in similar cages with soil, dung, and fly eggs as above. Histerid eggs and/or larvae recovered during the cleaning process were transferred to similar rearing cages.

Oviposition sites were determined for *P. panamensis* by making daily observations to determine ovipositional activity as previously reported for *Hister coenosus* Erichson and *Hister incertus* Marseul (Summerlin et al. 1981). Eggs were removed from the soil with a small moist brush, measured, and individually isolated in small petri dishes (50 mm by 7 mm deep) containing a moist filter paper disk. This holding method allowed observation of the egg and protected it from desiccation. Specimens at all life stages were placed in these filter paper-lined dishes for measurement. Measurements of the length at the widest portion of the egg were made with a binocular microscope with an eyepiece micrometer. Eggs were inspected several times daily for hatching. Measurements of newly hatched larvae were made as described with the width being determined at the widest portion of the head capsule. Larvae were provided 50-100 stable fly eggs twice weekly as a food source. Measurements were made periodically of the length and width at each larval stage. The larvae were placed in the damp paper-lined petri dishes and observed hourly to determine molt. Measurements were made on newly molted larvae at each stage. The length and width of the pupae were made at the molt, with width measurements taken at the widest portion of the abdomen. Observations were made daily from oviposition to adult eclosion. New adults were transferred to separate cages and held under similar conditions; each generation was kept separate. Voucher specimens were retained in our laboratory collection. The duration of egg incubation, larval instars, initiation of pupal cell formation, pupation and adult development were recorded. The specimens were prepared for electron microscopy by fixation in 4% gluteraldehyde in 0.1 M phosphate buffer pH 7.4, dehydration in ethanol and critical point drying. After mounting on stubs, the specimens were coated with gold in a sputter device and subsequently viewed with a Cambridge 200 microscope at 10 KV. Due to their fragility under vacuum used for gold sputtering and SEM viewing, eggs were also prepared by freeze drying in liquid nitrogen rather than critical point drying.
RESULTS AND DISCUSSION

Adults of *P. panamensis* are black, oval beetles varying from 2.8-3.6 mm in body length and from 1.6-1.8 mm in width. Males and females are morphologically indistinguishable. Elytra are striate with four complete dorsal striae with apical 5th and sutural striae extending to ca. mid-elytra (Fig. 1A). The protibia of the adult contains an apical spine, a row of six denticles along the outer or lateral surface of the tibia, and two rows of spinules; one extending along the mid-dorsal region of the tibia, the other along the inner or medial surface (Fig. 1B).

Males and females mated in or under the manure to which they were attracted. The females lay single eggs at various angles in the soil 2-7 mm beneath the manure. In most instances, eggs were deposited ca. 2 mm deep. Eggs were white, glistening, and bluntly rounded at both ends. Viewed with a dissecting microscope, the eggs appeared to have a smooth chorion (Fig. 2A); when viewed with SEM (Fig. 2B), the chorion appeared to have a pattern. This apparent pattern was an artifact that occurs during preparation of the egg for scanning electron microscopy due to shrinkage of an extrachorionic membrane (Fig. 2C). The non-patterned chorion (Ch) was visible between the torn edges (arrow) of the extrachorionic membrane (EM) (Fig. 2C). Newly deposited eggs averaged 0.43 by 1.20 mm in width and length, respectively (Table 1). The incubation period for the eggs averaged 2.4 d at soil temperatures of 25-28°C.

*Phelister panamensis* larval development consisted of only two stages. Newly hatched larvae were essentially white and non-pigmented, but the head capsule became fully pigmented (dark brown) within 6 h (Fig. 3A). The pronotum of first instar larvae has a rectangular shape while that of the second instar is crescent shaped at the posterior margin. First instars at eclosion averaged 2.2 mm in length, and the head capsules were a uniform 0.29 mm wide (Table 1). The urogomphi of the larval stages are segmented, tubular-shaped structures (Figs. 3A, 4B). The duration of the first instar averaged 3 d. After molting to the second instar (Fig. 3B), the head capsule measured 0.57 mm. The initial lengths of the second instar ranged from 4.1-5.7 mm, increasing to ca. 6.3 mm prior to pupation. After 3-7 d, the maturing second instar entered the prepupal stage as evidenced by a color change from pale yellow to white. The prepupal stage ranged from 3-6 d. A pupal chamber was constructed with either soil or manure particles, or sometimes a mixture of both. When prepupae were confined in petri dishes on moist filter paper disks, they shredded the paper with their mandibles and formed chambers around themselves with the masticated paper. Pupation occurred within the chamber. Just prior to pupal eclosion, the head and thorax of the prepupa became reflexed over the ventral surface of the abdomen (Fig. 3C). And the prepupa then became quiescent within the pupal chamber. Newly formed pupae were white and the head was depressed beneath the pronotum. The pupal abdomen was conical and the last segment had horn-shaped (corniform) appendages (Figs. 4A, 4C). The length of the pupal period was variable, lasting an average of 5.3 d (Table 1). As mature pupae shed their skins within the pupal chamber, the newly formed adult beetles were only slightly pigmented (yellow/orange) and soft. They became fully pigmented (black) and hardened within 3-4 d and emerged from the pupal chamber after another 3-4 d by gnawing through the chamber wall. Developmental time from oviposition to adult averaged 19 d.
Fig. 1. A. Dorsal view of adult *P. panamensis*. Note striations on elytra and distinctive protibia (arrow). B. Higher magnification of the protibia reveals the distinctive denticles along outer margin and a row of spinulae on the median and inner surface of the tibia. The clawed tarsus is folded onto the upper surface of the tibia.
Fig. 2. A. Lateral view of *P. panamensis* egg viewed with a dissecting microscope. B. Lateral view of *P. panamensis* egg viewed with SEM. C. Higher magnification with SEM to show the smooth non-patterned chorion (Ch) and the thin, fibrous extrachorionic membrane (EM) that has retracted (arrow) from a portion of the chorion.
Table 1. Measurements and developmental times of different stages of *Phelister panamensis* reared in the laboratory at 25-28°C.*

<table>
<thead>
<tr>
<th>Stage</th>
<th>Length (mm)</th>
<th>Width (mm)†</th>
<th>Development time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean ± SD</td>
<td>Range</td>
</tr>
<tr>
<td>Egg</td>
<td>1.1 - 1.3</td>
<td>1.2 ± 0.08</td>
<td>-</td>
</tr>
<tr>
<td>1st instar</td>
<td>1.4 - 4.1</td>
<td>2.2 ± 0.73</td>
<td>-</td>
</tr>
<tr>
<td>2nd instar</td>
<td>4.1 - 5.7</td>
<td>4.6 ± 0.60</td>
<td>-</td>
</tr>
<tr>
<td>Prepupa</td>
<td>5.7 - 7.1</td>
<td>6.3 ± 0.70</td>
<td>-</td>
</tr>
<tr>
<td>Pupa</td>
<td>2.3 - 3.3</td>
<td>2.8 ± 0.30</td>
<td>1.4 - 1.8</td>
</tr>
<tr>
<td>Adult</td>
<td>2.8 - 3.6</td>
<td>3.2 ± 0.20</td>
<td>1.6 - 1.8</td>
</tr>
</tbody>
</table>

* Data represent observations of 21 individuals from oviposition to adult.
† Measurements of width were of the widest portions of the egg and adult abdomen; measurements of larvae were of the width of the head capsule; measurements of pupae were of the widest portions of the abdomen.
‡ No variation existed in width within accuracy of measurement.
Fig. 3. Larval stages of *P. panamensis*. Dorsal view of first (A) and second (B) instar larvae. The pronotum of the first instar is rectangular while that of the second instar is crescent-shaped at the posterior margin (B, arrow). The urogomphi (U) of the larval stage are segmented, rod-shaped organs. C. Lateral view of prepupa showing reflexed posture of larva prior to pupation. The urogomphi are reflected upon the abdominal segments (arrow).
Fig. 4. A. Ventral view of mature pupa with well developed mouthparts, antennae, wings, legs, and genital region. B. The segmented, rod-shaped urogomphi of the larval stage. C. Corniform (crescent-shaped) urogomphi of the pupa. Note the nodular structures on the tips of the pupal wings.
Of the five native and three exotic species of Histeridae we have investigated, *Phelister panamensis* is the smallest of these species and it has the shortest life cycle. The occurrence of adults of this species in cattle dung less than 24 h old and its short egg and larval stages could mean that both *P. panamensis* adults and larvae have an opportunity to prey on the immature stages of the horn fly.

ACKNOWLEDGMENT

We are especially grateful to Rupert L. Wenzel, Curator Emeritus, Insects, Field Museum of Natural History, Chicago, Illinois, for identifying the beetle species studied, and Lynn Carroll, Entomology Department, Texas A&M University, College Station, Texas, for advice on preparation of the larval specimens for scanning electron microscopy.

REFERENCES CITED


