Ecological Notes on Lamprophorus tenebrosus (Walker) (Coleoptera: Lampyridae), an Enemy of the Giant African Snail[1]

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The Indian glow-worm, *Lamprophorus tenebrosus* (Walker), is a voracious feeder on the African or Kalutara Snail, *Achatina fulica* Bowdich, in Ceylon and there is considerable interest in the possible use of this predator in combating the snail in other countries where it has become established. During 1954 and 1955 several hundred larvae were collected in Ceylon and shipped to Hawaii, Indonesia, and Guam, and arrangements have been made for the shipment of larvae to the Philippines. Considerable difficulty was experienced during the first attempts to collect larvae at night during June, 1954, but after investigating the habits of the larvae sufficient information was obtained so that eventually hundreds of larvae were taken during the daytime with comparative ease. This paper presents some of the pertinent ecological information known about *L. tenebrosus* and a discussion of the probable economic importance of this predacious beetle in Ceylon.

DISTRIBUTION OF L. TENEBROSUS

L. tenebrosus has been collected in India at Balugaon in Orissa, Madras, Pondicherry, Madura, and Dharwar near Bombay (Paiva, 1919) and in a number of localities in Ceylon. The information available indicates that the species is better known and probably more abundant in the hill country around Kandy and Peradeniya in Ceylon than elsewhere in Ceylon or in India.

GENERAL BIOLOGY

Female adults of *L. tenebrosus* are larviform, creamy yellow in appearance, and about 2½ inches in length, while the winged brownish males are approximately 1 inch in length. Adult males were collected at night in our residence in Kandy each month from June, 1954, through March, 1955, but only one female was observed during the same period. It was found on September 4,

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1954, in a chamber in the soil with about 40 eggs. Green (1912) and Gravely (1915) reported seeing females in the Kandy-Peradeniya area during the rainy season, around November to January, but it is likely that females also occur during the greater part of the year. Both Green and Gravely stated that virgin females attract the males to them at night by emitting light. Furthermore, Green observed males attracted to females of other species, including *Dioptoma* sp. On the night of July 26, 1954, a male *L. tenebrosus* and a larviform female of a smaller unidentified species were taken together, both emitting light at the time, but they were probably not *in coitu*.

After mating the female excavates a chamber in the soil in which she lays her eggs and broods over them until they hatch and she dies (Hutson and Austin, 1924). From 12 insectary-reared females they obtained between 30 and 101 eggs, an average of 66 eggs per female. They concluded that the normal length of life of the female was 2 to 3 months and that of the male about 2 weeks. The adults appeared to ingest water but did not feed on snails.

The eggs are spherical, yellowish to brownish in appearance, and about ⅛ inch in diameter when laid but increase to about ⅙ inch in diameter before hatching (Hutson and Austin). These authors found the incubation period to be about 7 weeks in the insectary.

The larvae during the earlier instars are shining black in appearance, while the larger larvae, although also basically shining black, have conspicuous creamy yellow to brownish lateral margins along the thoracic and abdominal segments. Full grown larvae may become 3 inches in length and are quite robust and conspicuous. Situated at the posterior end of the abdomen is an eversible organ with many finger-like processes which is reputed to be used as a "cleaning apparatus." Paiva described the procedure followed in cleaning the body with this organ. Larvae immersed in water extend the organ and possibly it has a respiratory function, for larvae immersed in water remained alive for more than 3 hours. The litter and soil in which the larvae live frequently become drenched during the monsoon rains, therefore, the ability to survive for hours immersed in water may be important to the species. Larvae are only active at night and are usually only seen during the rainy season when snails are active. Since larvae of various sizes were found from June, 1954, to March, 1955, and male adults were also collected each month throughout the same period, breeding and development probably occur throughout the year in the Kandy-Peradeniya area. However, in localities where there is a prolonged dry season both *A. fulica* and *L. tenebrosus* remain inactive during drought. Under insectary conditions Hutson and Austin found the larval period to be about 8 to 9 months.

Pupation occurs within chambers in the soil excavated by the larvae. The pupae are yellowish in color. Hutson and Austin found that the male pupae required from 16 to 23 days and the female only 7 to 10 days to complete their development and the adults to emerge.

Habits and occurrence of larvae

Attempts made during early June, 1954, to collect *L. tenebrosus* by searching for the larvae at night in the Kandy-Peradeniya area resulted in the procurement of very few larvae and it was decided that if large numbers were to be obtained for shipment to Hawaii it would be necessary to find a more effective method of collecting. Subsequently, studies were made to determine where the larvae could be found during the daytime. Some of the findings relative to the habits and occurrence of the larvae which might facilitate collection are discussed below.

Locomotion

At night when there was sufficient moisture for the larvae and snails to be active, larvae were seen crawling around over the litter. In this way they come in contact with snails which are their food. Often 2 or more larvae were seen crawling along together and in many instances more than one larva was found during the daytime partially inside of a shell of *A. fulica*. Furthermore, larvae found in the litter did not occur at random but frequently in groups. All of these suggest a somewhat gregarious behavior. Only about 1 out of 5 larvae found at night with the aid of an electric lantern were emitting light which means that only a small part of the population is conspicuous because of the light emitted. Gravely also observed that male adults did not emit light themselves when approaching virgin females that were emitting light.

Feeding

Larvae locate their snail prey at night as described above but many larvae remain partially inside snail shells throughout the day, apparently continuing to feed until the individual is devoured, or the larva engorged, which may require several hours. Immediately following a rain, especially after many days of drought, many of the larvae become active and feed voraciously. On such occasions probably half the larvae found during the daytime were partially within shells, apparently feeding. It was common to find medium to large individuals of *A. fulica* with 3 to 4 *L. tenebrosus* larvae partially within them. Small to medium sized individuals seem to be preferred to the large individuals, for in one area where both *A. fulica* and *L. tenebrosus* were fairly abundant, large larvae were found feeding on small individuals and there were more empty small shells than large ones. However, several freshly killed large individuals were seen in the field with larvae feeding on them. In the insectary, also, large individuals were readily attacked and devoured.

Shelter

Except when larvae and adults are active at night, they, as well as the eggs and pupae, are concealed or sheltered in the litter or soil. Not only are the larvae inactive throughout the day, but some apparently remain inactive in concealment for weeks while others of the same population are actively

feeding. Furthermore, during extended periods of drought, snails are inactive and *L. tenebrosus* larvae are not to be found above ground. Shelter of a somewhat superficial nature among loose leaves in the litter was adequate when conditions were favorable for feeding at night, such as immediately following a substantial rain. At such times when the litter was moist, larvae were commonly found covered by a single leaf, but as the litter dried out the larvae receded into the deeper layers of the litter where it was moist and cool for longer periods. In exceptional cases, immediately following rains, as many as 6 larvae were found in 1 square foot of litter and 50 larvae within an area of 100 square feet, while nearby only a few larvae could be found by searching through the litter over an area of hundreds of square feet. After the litter had dried out, larvae were only found in the soil but here also occasionally several larvae were found within a few inches of each other. Larvae were found to a depth of 6 to 8 inches in the soil, especially in the vicinity of rocks or in the walls of trenches or holes. In the cacao plantations in Pallekelle where I collected the majority of the larvae in 1954 and 1955, catch basins about 18 inches wide, 24 inches deep, and several feet in length had been dug to conserve moisture. Many larvae were collected in the leaves that accumulated in these catch basins and also in the soil walls. *A. fulica* also commonly found shelter within these catch basins. Larval molt skins were often found in vacated chambers in the soil, which suggests that not only egg deposition and pupation occur in the soil chambers but also molting.

Moisture

Activity of the larvae is affected a good deal by moisture. In fact, no activity was observed during prolonged drought periods which occur over much of Ceylon, where there are distinct wet and dry seasons. The majority of the larvae were collected in cacao plantations in Pallekelle about 15 miles from Peradeniya, but it is considerably drier during the summer months in these cacao plantations than in Peradeniya and Kandy. Larval activity was observed and good collecting was had in these cacao plantations immediately following the scattered rains that fell in June and July, 1954, but searching for larvae was ineffective in the same areas between rains and especially during the more prolonged dry period during the latter part of the summer. During the northeast monsoon rains in the fall, although larvae could be found at all times in these plantations, activity and feeding on any one day were apparently less than immediately following the intermittent rains during the summer and the beginning of the monsoon rains in the fall. Collecting again became more difficult after the dry season set in about the end of February.

Abundance and Economic Importance of L. tenebrosus

L. tenebrosus currently occurs in large numbers in certain areas where *A. fulica* is abundant in the hill country around Kandy and has been prevalent

in this general area for many years (Hutson and Austin). However, there are some localized areas in Pallekelle where *A. fulica* has been abundant for many years but *L. tenebrosus* was rare in these areas during 1954 and 1955. Furthermore, the observations made suggest that possibly *L. tenebrosus* is not adapted to such areas. The probable importance of *L. tenebrosus* if introduced into other countries to combat *A. fulica* is currently of considerable interest, therefore, it will be discussed in the light of the limited information available.

The highest population of *L. tenebrosus* encountered and the best collecting were in certain cacao plantations in the Pallekelle area where *A. fulica* was fairly abundant but not sufficiently abundant to warrant poisoning as was being done in many other parts of the plantation. The soil in these areas was a sandy loam, with higher fertility and moisture holding capacity than that of the poorer sites in the general area. In one of the sites on July 6, 1954, 97 larvae were collected from the litter (soil was not disturbed) in an area of approximately 4,000 square feet, which was at the rate of about 1,000 larvae per acre. Only a fraction of the larvae present were collected and larvae were collected again from this same area on several occasions during the summer and fall of 1954. There were 10 to 15 acres in each of two different sites of this type where more than 5,000 *L. tenebrosus* larvae were collected. There were many empty *A. fulica* shells in these areas and it seems likely that *L. tenebrosus* was an important factor influencing the abundance of *A. fulica.*

Within a few miles of the above areas where *L. tenebrosus* was abundant there were several places in cacao plantations where *A. fulica* was very abundant but *L. tenebrosus* rare. These areas were on outcroppings of limestone, with poor light sandy soils and low moisture holding capacity. During the dry season these areas were extremely dry; many of the cacao trees had died and others were stunted and making poor growth. It was recognized that the areas were sub-marginal for cacao, repeated replantings had failed, and there were only a few trees per acre that were productive. Each year for the preceding three years, an attempt had been made to convert many acres of cacao within these areas to pepper, but after each planting over 95 per cent of the pepper plants were destroyed by *A. fulica* even though an intensive poisoning program was carried out, sometimes as frequently as at 4 day intervals, during the season when there was enough moisture for snail activity. The foreman on the plantation stated that *A. fulica* had been continuously abundant in these particular areas for many years and that in spite of the recent intensive poisoning program snails were about as abundant in 1954 as 3 years before. Probably such areas are too dry or otherwise unsuited to *L. tenebrosus;* consequently, it has very little influence on the abundance of *A. fulica* in such areas.

In contrast to the above conditions encountered in Pallekelle, *A. fulica* and *L. tenebrosus* occur in small numbers throughout the nearby Peradeniya-Kandy area where there is a better distribution of the rainfall. In this area *A. fulica*

and *L. tenebrosus* are more or less continuously active throughout the year. Both species were more numerous in this area 30 to 40 years ago (Hutson and Austin) than now, but probably at the present time *L. tenebrosus* is more abundant in respect to *A. fulica* than it was when *A. fulica* was abundant, which suggests that this predator might be an important factor in the control of the snail in such areas.

SUMMARY

L. tenebrosus, a voracious feeder on the giant African Snail in Ceylon and parts of India, has recently been introduced into other countries to combat this snail.

Hutson and Austin studied the life history of *L. tenebrosus* in the insectary at Peradeniya, Ceylon, and found that the life cycle was completed in a little less than one year. However, because in the field both *A. fulica* and *L. tenebrosus* are inactive during prolonged dry periods, the life cycle may be longer than one year.

The best places found for collecting *L. tenebrosus* readily in numbers were certain cacao plantations in Pallekelle where *A. fulica* was also quite abundant. In these particular areas the soil was a sandy loam, relatively fertile and the trees were growing well and productive. In contrast, larvae were extremely scarce in nearby areas on poorer and drier sites, even though *A. fulica* was very abundant.

Although the larvae are only active at night when the litter is moist, they could be found more readily during the daytime than at night. When conditions are favorable for feeding at night, the larvae coil up in the litter during the day. Rains apparently stimulate larval activity and the greatest numbers were found immediately following rains after several days of dry weather. During extended dry periods the larvae enter into the soil and therefore are more difficult to find then than when present in the litter.

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