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PREY ATTRACTION AS A POSSIBLE FUNCTION OF BIOLUMINESCENCE IN THE LARVAE OF *PYREARINUS TERMITILLUMINANS* (COLEOPTERA: ELATERIDAE)

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ABSTRACT

Elaterid beetle larvae. Pyrearinus termitilluminans *(sp.n., Costa, 1982.) live in termite mounds in central Brazil. Each larva produces light in the segment immediately behind its head. Larvae were observed to luminesce only during the first weeks of the rainy season, the same times as the ant and termite alate flights. Alates, apparently attracted to* P. termitilluminans *larval lights, serve as an important food source for the larvae. The prey-catching and food-storing behavior and the phenomenon of bioluminescence are apparently an evolutionary response by* P. termitilluminans *larvae to a short, rich pulse of food. Prey attraction as a probable cause for luminescence has been suggested only twice before.*

Over twenty functions of bioluminescence have been advanced (Buck, 1978). Prey attraction has been suggested as a probable cause for luminescence in only two cases, benthic fishes (refs. in Buck, 1978) and fungus gnats (refs. in Lloyd, 1978; Sivinski, in press). This study reports an additional example of prey attraction in a Neotropical elaterid beetle larva, *Pyrearinus termitilluminans.*

As early as 1850 travelers to central Brazil have reported termite mounds with "pale glows of phosphorescent light, like coals in the ashes" (Smith, 1879; Castelnau in Branner, 1909). Various explanations were offered for these mysterious lights, from fungus and bacteria to the termite mounds themselves (Knab, 1909; Neiva & Penna, 1916; Branner, 1909). Harvey (1952), in his comprehensive review of bioluminescence suggested that the lights might emanate from an insect living in or collecting on the termite hills, singling out glowworms, fireflies and dipterous larvae as possible candidates. I recently found that these lights were produced by the larvae of an undescribed species of *Pyrearinus.* Costa (1982) named the new species *termitilluminans.*

The author recently found in Mathews (1977: 51) reference to a similar form of bioluminescence from unidentified Elaterid larvae living in the gallery forest mounds of *Cornitermes bequaerti.* An explanation similar to the one advanced in this paper was offered by Mathews.

METHODS AND RESULTS

In 1980 and 1981, in Emas National Park in the western region of Goiás State, Brazil, the phenomenon of bioluminescent termite mounds was observed. The vegetation in this area is open-formation cerrado. The climate is highly seasonal with a pronounced dry and wet season. Termite mounds in the Park can reach densities of over 300 per hectare, with the larger mounds, built by *Cornitermes cumulans* (mean height = 77.7 cms.; SD = 28.3; N = 35), occurring up to 75 per hectare. Bioluminescent *Pyrearinus* larvae are found in these *Cornitermes* mounds.

Pyrearinus (Costa, 1975) larvae in general are similar to those of all Pyrophorini, differing mainly in the way they luminesce (Costa, 1978). However, *P. termitilluminans* larvae are very different than other *Pyrearinus* larvae so far examined (Costa, pers. comm.). Larvae obtained from two termite mounds have an average length of 17.9 mm (S.D. = 5.0; N = 180) and ranged

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from 6-29 mm. Light is visible only in the segment immediately behind the head (prothorax), except for a very faint glow from the tips of the expanded tenth abdominal segment, which serves as a pseudopod. This light is produced continuously, for many minutes at a time but is extinguished when the larva enters a tunnel. During 1980 and 1981 luminescence by *P. termitilluminans* larvae began in late September, concurrent with the start of the rains, an observation confirmed by Lustosa (in Branner, 1910) and longtime residents of the area. Forty mounds surveyed over four nights before the first rain of 1981 averaged 16.0 luminescing *Pyrearinus* larvae per mound (S.D. = 6.0). In contrast, after the first rain, 90 mounds surveyed over 11 days averaged 179.6 larvae (S.D. = 61.8). This very large number of luminescing larvae is not observed before or later than a few weeks after, the advent of the rains. When it does not rain during the day, the larvae will not usually be luminescent at night. More luminescence is apparent soon after dark than later in the night. Early in the evening, on a night after a heavy diurnal shower, the horizon is aglow with more than 200 yellow-blue lights per termitarium. The thousands of termitaria in view transform the landscape into something akin to an aerial nighttime view of a city.

Also associated with the onset of the rains are the ant and termite alate flights. Over fifty species of termites and ants have been collected from Emas Park, and the alate flights of probably all of them are triggered by the first rains. At times the air is thick with fluttering alates and at night a light attracts them by the thousands. *P. termitilluminans* larvae have well developed mandibles, are highly predaceous, and feed on these abundant alates. The larvae live in tunnels in the hard soil shell of *Cornitermes* mounds and when 'hunting', extend the front part of their bodies out of the tunnel mouth and lay them against the outer surface of the termitaria. They are braced inside the gallery by two well-developed 'pseudopods' and can pull into the hole very rapidly when disturbed.

From the extended position the larva exposes the full surface of its luminescent segment and when attacking an alate strikes downward, pulling back into the hole at the same time. If it has succeeded in catching something, the larva drags it into the tunnel, pauses a few seconds, and then extends itself out of the tunnel mouth again. I have fed nine termite alates to one larva in less than a minute in this fashion. My impression was that the larval light increases in intensity after the larva has made a capture and comes to the mouth of its tunnel again.

When the larvae were at the ends of their tunnels, the distance from the tunnel opening to the larva's head was 25 to 105 mm (mean = 51.2; S.D. = 23.3; N = 13). Tunnels averaged 3.6 mm in width (S.D. = 0.9; N = 10) and were cylindrical except for an outpocketing located from 9 to 21 mm in from the outside (mean = 14.8; S.D. = 4.4; N = 13) which was on the average 3.5 mm deep (S.D. = 1.1; N = 13). These outpocketings serve as storehouses, with 18 of 19 examined containing a total of 48 dead ant and termite alates. An average of 2.5 alates were found per storehouse, with a range of zero to eight. Alates were usually found intact with their wings still attached (72.9%) though on 14.6% of the occasions only wings were found and on 12.5% only the skeletal remains of eaten alates were present. Combinations of all three conditions of alates were found. The alates found represented at least three species of termites (*Velocitermes* sp., *Armitermes* sp. and an unknown genus) and one species of ant.

Larvae also seized and pulled soldiers and workers of the termite genus *Velocitermes* into their galleries, and seized, but could not hold ants of several sizes, larger ant alates, small moths and beetles — all offered between forceps. Apparently the larvae respond to tactile stimuli, preying on anything that enters their "strike range" that can be successfully retrieved. *P. termitilluminans* larvae are highly sensitive to vibrations, use their 'pseudopods' to brace inside the gallery, to avoid being removed and often expell a dark liquid from the mouth when disturbed. These actions probably all serve to reduce predation on the larvae.

Eight days after the first rain, 23 adult *P. termitilluminans* were found in galleries in *Cornitermes* mounds. Unlike the larval galleries, these adult galleries were sealed at the mouth with a plug of hard soil, averaging 2.3 mm thick (N = 4). In three cases, adults were found in the same gallery with a shed pupal skin; in two cases pupae were found; and in one case a prepupal form was found. On one occasion, at night, an adult beetle was found 'chewing' on the dirt plug blocking its tunnel, apparently creating an exit hole.

One night after the advent of the rains adult *P. termitilluminans* began landing on a termite mound, apparently attracted by the light from a headlamp. Eighteen fire beetles arrived in five minutes and after a half an hour there were more than 35 adult individuals. Twenty-four of these adults were collected and only two were found to be females (A. Newton and C. Costa, pers. comms.). Once on the termite mound, the adults began a slow, careful antennation of the uneven surface, entering some of the holes and depressions head first. In five cases a beetle entered a hole, backed out and then backed into the same hole, remaining there for several minutes. Adults largely ignored one another, although on one occasion, an adult entered a hole already occupied by another beetle, causing the original inhabitant to leave. Careful examination of the inside surface of the holes after beetles had left revealed no visible eggs, but it is possible that if a female were laying eggs, she could be depositing them within the soil shell of the termite mound.

The larval period of *Pyrearinus* and related elaterid genera is approximately two years in the laboratory (Costa, 1970, 1975; Dubois, 1886). When small, the larvae can be fed on Collembola, but when larger they consume termite workers and *Tenebrio* larvae (Costa, 1975). The pupal period for these beetles averages 24 days (Costa, 1975). Adults of *Pyrearinus* are plant feeders and can be kept alive on sugar water (Costa in Lloyd, 1978).

The hard soil shells of *Cornitermes* mounds, in which the *P. termitilluminans* live, average 18.5 cm in thickness (S.D. = 7.1; N = 40) and are generally unoccupied by termites or ants. The surface of the mound, however, is rich in arthropod life and could provide potential prey of all sizes for developing beetle larvae living in tunnels in the mound. Larval tunnels are often located within several centimeters of each other and there can be hundreds of larvae per mound. This large congregation of larval lights may attract alates, which would orient towards individual lights after landing on the mound.

DISCUSSION

The phenomenon of bioluminescence reported here is clearly an evolutionary response by *P. termitilluminans* larvae to a short, very rich pulse of food — the myriad social insects released during alate flights. The termite and ant alates tend to congregate on high spots in the landscape, and in open grassland, the highest spots are *Cornitermes* mounds, the location of the larvae. Sivinski (in press) has convincingly shown that insects can be attracted to a point-light source of less intensity than that produced by one *P. termitilluminans* (pers. comm.) and the positive phototropism of termite alates is well documented (Emerson, 1938). These beetle larvae will occasionally catch alates during the day, when a particularly heavy alate flight is in progress (observed only once). However, it is at night, when the larval light may greatly increase the chances of an alate approaching, that the beetle larvae are most active.

The presence of a storehouse in the larval gallery and the speed with which multiple alate-captures can be achieved all greatly increase the ability of a *P. termitilluminans* larva to exploit the short rich pulse of food. When ready to pupate the larva apparently seals the tunnel with an earthen plug which is removed when the adult is ready to emerge. Adult emergence may be triggered by the onset of the rains, which, by wetting the soil shell of the *Cornitermes* mound would make it easier for the adult to both emerge and oviposit. Adults may be attracted by the larval bioluminescence to termite mounds where breeding and oviposition can take place.

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