

## BIOLOGICAL OBSERVATIONS ON *ZOROTYPUS HUBBARDI* CAUDELL (ZORAPTERA)<sup>1</sup>

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**ABSTRACT:** The nymphal period for *Zorotypus hubbardi* Caudell (Insecta: Zoraptera) was found to be 30 to 50 days; the adult lifespan was 30 to 40 days. Observations on food, reproduction, social interaction and caste determinations are made. A culture method is described.

Zorapterans are small termite-like insects which were first recognized as an order in 1913. The approximate twenty species found in the world are in a monotypic genus and have two distinct castes. The common caste is apterous, cream-colored and eyeless. The other caste is darkly pigmented, has compound eyes and ocelli, and is alate and capable of shedding the wings.

The Nearctic *Zorotypus hubbardi* Caudell is usually found in old termite galleries (though not true inquilines), lumber mill sawdust piles and under dead tree bark. Few observations on the biology of *Z. hubbardi* have been made. Most papers deal with records which have extended the known range (Gurney 1959; Riegel 1963, Shetlar 1967).

*Z. hubbardi*'s known range seems to include the territory south of a line running from southern Pennsylvania across to lower Iowa and south through mid-Texas. Riegel (1963) suggested that dispersal northward was made by mated alate females borne on the wind. The limiting factor of northern extension seems to be severe winters. He also stated that most northern colonies exist in fermenting sawdust piles which maintain warm internal temperatures through decomposition over winter. Thus, after a few years a colony would be doomed to failure unless a new site was found. Mingot and Sillings (1969) suggested that *Z. hubbardi* could naturally withstand colder climates. Zorapterans have often been found with termites, enicocephalid bugs as well as collembolans and mites (Gurney 1938).

No investigator has been able to rear and observe zorapterans over a long period of time. During this study a culture method was developed using modified techniques derived from the attempts of Gurney (1938). With this successful rearing technique, studies were undertaken to determine the essentials of the zorapteran life cycle and caste system.

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## MATERIALS AND METHODS

On January 24, 1967, a colony of *Z. hubbardi* was discovered in a rotten log in Oliver's Woods Wildlife Preserve, The University of Oklahoma, Norman, Oklahoma. About 100 specimens were preserved and an additional 20 to 25 specimens were collected alive. Another large colony was discovered in an old log in the Preserve on March 11. About 100 individuals were placed in culture. On August 28, three colonies were discovered in Northeast Oklahoma City, two in old termite galleries and one under loose bark. Individuals were again taken alive and cultured. Finally, a colony was discovered in Huntsville State Park, Texas on November 26, 1967 from which live specimens were taken for culture.

Gurney (1938) was able to keep individuals in a culture for approximately five and a half months. His rearing chambers consisted of two glass jars about four inches high by two inches in diameter, lined with thin strips of decaying wood, and loosely filled with decaying sawdust. Reigel (1963) observed that *Z. hubbardi* apparently ate molds and dry yeast.

An initial culture was started by placing wood chips from the log of a wild colony in a 4-inch finger bowl and sprinkling dried yeast over the top. This culture soon had eggs and new nymphs. Other stock cultures were then established in a similar manner. The finger bowls were covered with glass plates to reduce moisture loss. Water was sprinkled, by hand, over the wood in the bowls every three to four days or earlier if the culture appeared to be drying. Individuals or small groups of individuals were maintained on wood chips in 76 x 15mm glass petri dishes. All the cultures were sprinkled every five to six days with active dry yeast. The cultures were not maintained under constant day/night cycles, or under constant temperature.

Test chambers for the studies of social behavior and the life cycle were made of petri dishes supplied with filter paper and yeast. Another chamber was constructed by pouring plaster of Paris into a three-inch finger bowl to a depth of 20mm. Holes, 15 mm in diameter, were drilled in the plaster and each hole was covered with 22mm x 22mm cover glass. The plaster was kept moist and the holes were supplied with yeast.

To study the behavior and molting times, the zorapterans were marked with India ink, magic marker<sup>R</sup>, enamel, and vital dyes such as fast green, methylene blue and neutral red.

The length of the nymphal period was calculated by setting up a chamber with 10 adults which were counted every other day. By using rather smooth pieces of wood in the chamber, eggs could be counted and date of detection noted. By keeping the adult population at 10 and replacing lost individuals from another culture, dates that the population exceeded 10 were noted and the extra adults were removed. Using the date of laid eggs, hatching and

appearance of extra adults, a crude measure of the nymphal period was made.

Observations of living material were made with the aid of a 16x magnifying glass and a B&L dissecting microscope fitted with 15x oculars and 6.5x, 0.7x, 1x, and 3x objectives. Observations were best made after a period of total darkness followed by low illumination from a 50 watt incandescent bulb approximately ten feet away from the cultures.

## RESULTS AND DISCUSSION

### A. Life Cycle

Great difficulties were encountered in finding out the number of instars. Isolation of individuals into separate chambers, with wood or in plaster cells, always resulted in the death of the individual in a few days. Also, the exuvia seem to be eaten or are extremely fragile because no exuvia were found.

Marking by using enamel resulted in death or the enamel would not adhere to the cuticle. Marking with India ink or Magic Marker<sup>R</sup> met with similar results. With vital dyes the zorapterans would either eat the dye or the dye was absorbed into the tissues below the cuticle.

The length of the nymphal period was calculated to be from 30 to 50 days. It was found that the average number of days taken from hatching egg to adult was 44 days with a range of 27 to 51 days.

Adult lifespan was found to be about 30 to 40 days. One adult was found to have lived 68 days and Gurney (1938) cites that he kept adults for 75 days. However, it is unclear whether Gurney was observing the same adults.

### B. Food

Zorapterans have been noted to feed on various fungal hyphae and spores, as well as animal materials (Gurney, 1938; Riegel, 1963). In this study, only freshly collected specimens were seen to have contained any fungal hyphae even though the culture chambers often had molds and fungal masses present. The principal plant food taken by the captive zorapterans was yeast. This was determined by dying the yeast with neutral red and observing the yeast particles in the gut. It may be that the molds and fungi present were unsuitable.

One of the culture chambers contained a population of entomobryid collembolans which, from time to time, were quite abundant. Adult zorapterans taken from this culture and dissected often had fragments of legs and cuticle in the gut. Twice, a last instar nymph and an adult *Z. hubbardi* was seen to attack a living mite, roll it over, or pick it up by its mandibles. These attempts did not cause the death of the mite, which merely withdrew its head and legs. The mite was soon dropped and left. Similar attacks on

mites were observed by Gurney (1938). Encounters with the collembolans were quite different. When the zorapteran touched the collembolan with its antennae, the collembolan would jump or run rapidly away. The zorapteran would then undergo random searching movements, stop and wave its antennae, or rapidly run in the opposite direction. No zorapteran was actually seen to capture a live collembolan.

Freshly killed collembolans, mites, termites, and a small piece of beef were placed in a culture containing zorapterans of different ages. Within one to two days the arthropod remains disappeared except for pieces of cuticle, especially head capsules and leg fragments. The beef was untouched and soon developed mold. Observations by Gurney (1938) and Riegel (1963) that zorapterans eat the remains of their own species was confirmed in this study. Freshly killed specimens were placed in a culture and they usually disappeared in a day.

Zorapterans were often observed carrying insect remains, but upon occasion were seen carrying pieces of wood or sand grains. They never seemed to do anything with these objects, but usually dropped them within a short time.

Dissection of fresh specimens in saline never revealed protozoans, but bacteria were abundant. Examination of fecal material revealed no sporezoans.

### C. Reproduction

Gurney (1938) was fortunate enough to see an apterous adult climb upon the dorsal surface of another facing in the same direction. After the genitalia were united, the dorsal individual climbed forward dragging its mate behind.

Couples in copula were seen only four times. Twice, mere movements of the culture caused the joined pair to separate and in another observation, the

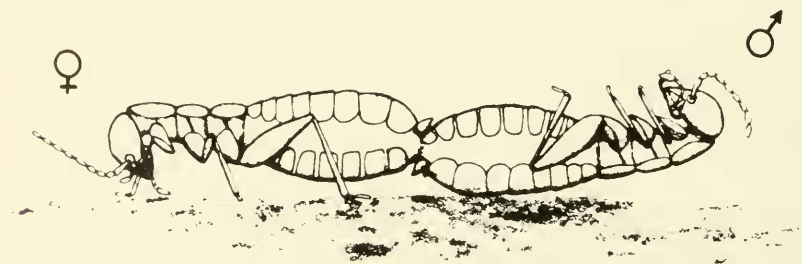


Figure 1. Copulation of *Zorotypus hubbardi* Caudell.

pair remained together for about two minutes. From the last copulation one of the individuals was captured immediately after separation. The female was found to be the forward upright specimen and the male was the posterior upside down specimen (Fig. 1).

This may explain the function of the median dorsal hook located along the posterior margin of the eighth abdominal tergite of the male as described by Crampton (1920). The hook should be looked at histologically to see if a gland might be present which releases a pheromone. Under high power magnification, no pore could be found nor could a gland be seen without staining.

Fecundity was estimated by setting up a chamber with five females and five males. Twenty-seven eggs were collected in forty-eight days, at which time the last female died. This means that an apterous female may produce five to seven eggs in her lifetime and it may take her about ten days to produce an egg. It would be most interesting to check the fecundity of alate females to see if they have a higher rate, since these are thought to establish new colonies (Riegel, 1963).

#### D. Social Organization

This study confirms the speculation by previous workers (Gurney, 1938, Delamare-Deboutteville, 1948) that *Zorotypus* is gregarious rather than actually social. The most common encounter of zorapterans seems to be antenna lashing and immediate avoidance. In a test of colony recognition, individuals from cultures collected from different wild populations were transferred to various chambers. No difference in behavior of either introduced or local individuals was noted.

Even though actual social behavior was not observed, aggregation seems to have an effect on individual survival as isolated individuals soon die. An observation made several times while collecting specimens was the presence of a characteristic odor. This odor was noted each time specimens were sucked into an aspirator. The odor was slightly sweet and aromatic, reminiscent of odors produced by some of the aquatic Coleoptera. This odor may be an alarm odor, defensive, or aggregation odor.

#### E. Determination of the Alate Caste

The mechanism of determination of alate individuals was not found in this study, but the following observations are included.

Since winged males have been found, determination of winged individuals by sex linkage does not seem plausible. However, with the majority of alates being female, the determination may be sex-influenced or sex-related.

Individuals collected by Riegel (1963) had slightly pigmented eyes, but

were adult wingless females. A series of individuals with even more striking alate-apterous qualities were found in this study. Four adult females had caudo-lateral extensions of varying length arising from the meso- and meta-thoracic nota (Fig. 2). These same females had pigments corresponding to the position of the eyes, but no cuticular structures such as cornea were seen.

Crowding does not seem to have an effect on production of winged individuals. Laboratory colonies ranged from ten to fifty individuals but no differences in numbers of alates were found.

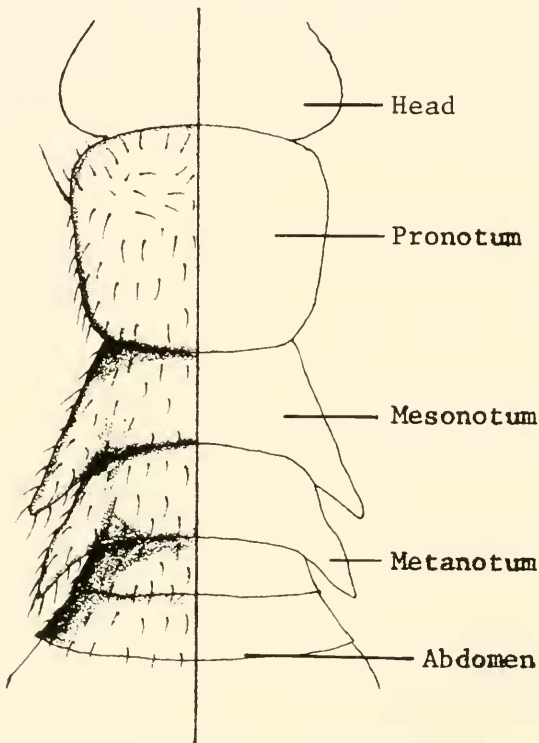


Figure 2. Dorsal aspect of apterous *Zorotypus hubbardi* Caudell showing mesonotal and metanotal lateral projections.

## SUMMARY

An easy method for culturing zorapterans using wood chips and dried yeast was developed and used to study the biology of *Z. hubbardi*.

The zorapterans were active scavengers eating disabled or dead arthropods, yeasts and molds. The nymphal period was about 40 days and the adults lived 30 to 40 days. Copulation occurred with the female upright and the male dragged on its dorsum behind the female. Females may lay 5 to 7 eggs.

No social organization was observed though isolated individuals usually died within a short period of time. Encounters among individuals generally resulted in avoidance behavior or a short period of antennal palpating.

Alate determination was still not elucidated but intermediate individuals with eye pigments and lateral thoracic projections were observed.

## LITERATURE CITED

- Crampton, G.C. 1920. Some anatomical details of the remarkable winged Zorapteran, *Zorotypus hubbardi* Caudell, with notes on its relationships. Proc. Ent. Soc. Washington. 22: 92-106.
- Delamare-Deboutteville, C.D. 1948. Observations sur l'écologie et l'éthologie des Zoraptères. La question de leur vie sociale et de leur prétendus rapports avec les Termites. Rev. Ent. (Rio de Janeiro). 19 (1/2): 347-352.
- Gurney, A.B. 1938. A synopsis of the order Zoraptera, with notes on the biology of *Z. hubbardi* Caudell. Proc. Ent. Soc. Washington.
- \_\_\_\_\_. 1959. New distribution records for *Zorotypus hubbardi* Caudell (Zoraptera). Proc. Ent. Soc. Washington. 61(4): 183.
- Mignot, E.C. & J.O. Sillings. 1969. Winter occurrence of *Zorotypus hubbardi* (Zoraptera) in Tippecanoe County, Indiana. Michigan Ent. 2 (3/4): 73-73.
- Riegel, G.T. 1963. The distribution of *Z. hubbardi* (Zoraptera). Ann. Ent. Soc. Amer. 56(6): 744-747.
- Shetlar, D.J. 1967 (1969). New distribution records of Zoraptera (Insecta) in Oklahoma. Proc. Okla. Acad. Sci. 48: 104-105.