

A STUDY OF THE LIFE HISTORY OF THE FORKED FUNGUS BEETLE, *BOLITOTHERUS CORNUTUS* (PANZER)

(COLEOPTERA: TENEBRIONIDAE)¹

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The forked fungus beetle, *Bolitotherus cornutus* (Panzer), is a common inhabitant of polyporoid fungi in forested areas, especially beech-maple, east of the Mississippi River. Although descriptions and brief life history notes concerning *B. cornutus* (also known as *B. bifurcus*) have appeared in the literature, no extended study of its development and habits has been published.

This study was made by rearing the beetle in the laboratory and observing it in the field. Although some observations were made in Hocking County, Ohio, from February through May, 1954, the majority of the laboratory and field work was conducted in the vicinity of the University of Michigan Biological Station, Cheboygan County, Michigan, during the summers of 1953 and 1954. Overwintering material was obtained from that area.

METHODS

Food for laboratory cultures of larvae was prepared by grinding dried, apparently uninfested conks of *Fomes applanatus* (Pers.) Gill. to the consistency of fine sawdust with a micro-pulverizer. This material was autoclaved to reduce mold, and stored in plastic bags.

For larval development studies, a one-third inch layer of the ground fungus was placed on several layers of wet paper toweling in a stentor dish, and covered with a single layer of damp toweling. One freshly laid egg, removed from the host fungus, was placed on this toweling and the larva, on hatching, burrowed through it into the fungus material. The labeled and covered stentor dishes were kept on a darkened shelf. The fungus material in these dishes was changed daily and the removed material was inspected for cast larval skins.

Adults collected in copulation were isolated in pairs and daily records were kept of the oviposition of the female of each pair. The mated pairs were isolated in fingerbowls containing wet paper toweling and a small specimen of *F. applanatus* showing no previous oviposition. These fungi were freshly collected from a beech-maple area, William's Corners, Cheboygan Co., Michigan. The bowls were labeled, stacked together, and placed on a darkened shelf in the laboratory.

In a beech-maple area, regular collections of infested fungi were made from stumps of trees cut five or six years prior to the collecting season. Some of these specimens were broken apart and examined; others were kept in screen cages for observation purposes.

Daily observations were made on the laboratory material, especially between 4:00 P.M. and 10:00 P.M. Two or three times a week, the nocturnal activities of the beetle were observed in both laboratory and field between 11:00 P.M. and 4:00 A.M.

DESCRIPTION OF STAGES

The eggs of the forked fungus beetle were first described by Weiss and West (1920) as follows:

¹From a thesis presented in partial fulfillment of the requirements for the degree Master of Science, The Ohio State University, 1955.

"The blisters or egg capsules were composed of dark excrement-like material, each being oval or sub-oval in outline, about 3.5 mm. long, 2.5 mm. wide, and from 1 to 1.5 mm. high in the center, sloping toward the edges. The average thickness of the wall of a capsule was about 0.5 mm. . . . The translucent eggs were cylindrical with broadly rounded ends and varied in length from 1.7 mm. to 2 mm., and in width from 0.8 mm. to 1 mm. The outer covering of each egg was whitish and marked with slightly raised dots."

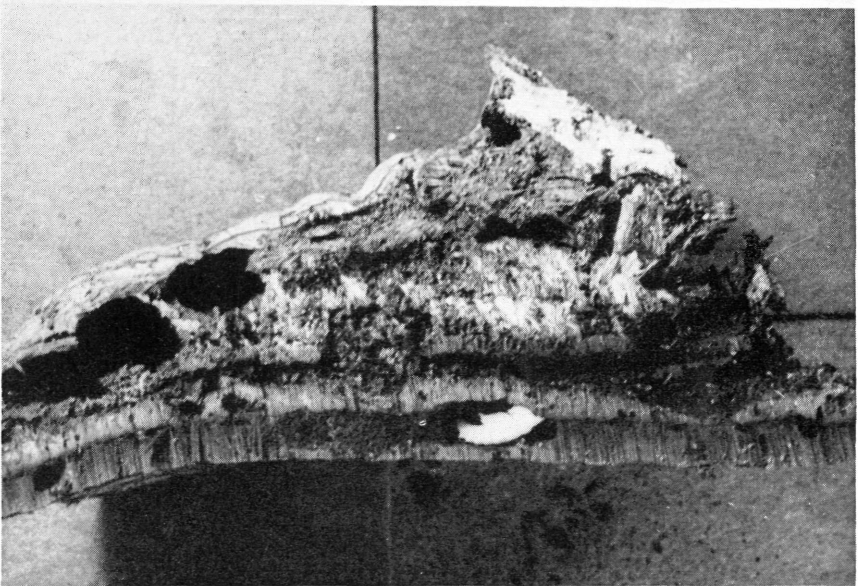
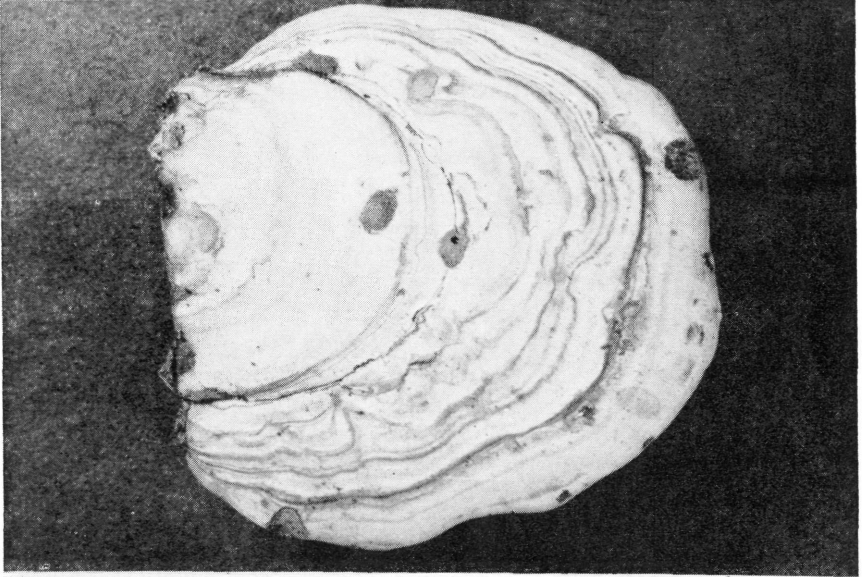


FIGURE 1. (above) A specimen of *Fomes applanatus* showing egg capsules of *Bolitotherus cornutus* (Panzer). A larval emergence hole is visible in the capsule in the center of the picture.

FIGURE 2. (below) Cross section through *F. applanatus*, showing chambers and tunnels occupied by *B. cornutus*.

Eggs collected in the Michigan area were as described by Weiss and West, but the average size of the capsule covering the egg varied from that of the original description. Egg capsules on the upper surface of the fungus were generally longer and wider (averaged 3.8 mm. in length, 2.7 mm. in width, and 1.5 mm. in

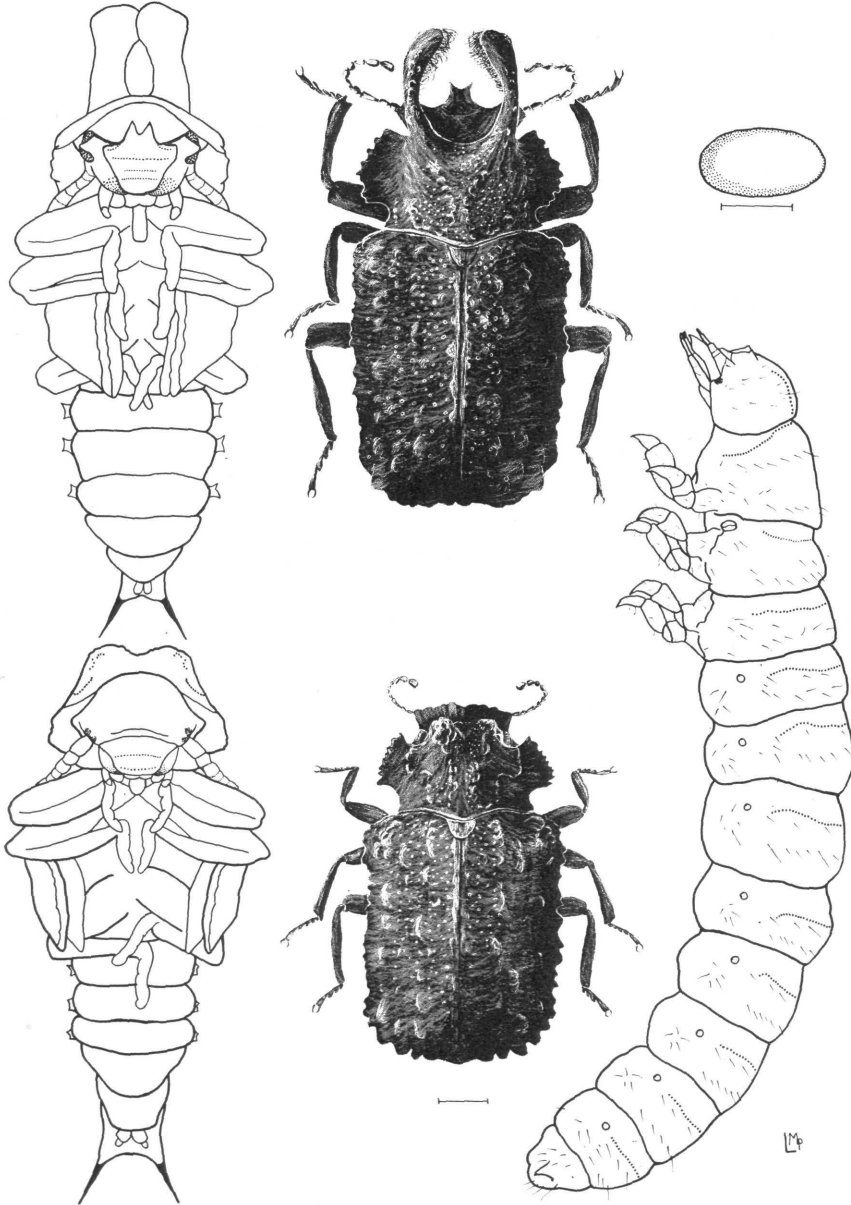


FIGURE 3. *Bolitotherus cornutus* (Panzer). Upper left: male pupa. Lower left: female pupa. Upper center: adult male. Lower center: adult female. Upper right: egg, capsule removed. Lower right: larva. Line indicates 1 mm.

height) and those deposited on the lower surface of the fungus were shorter, narrower and higher (averaged 3.4 mm. in length, 2.1 mm. in width, and 1.8 in height) (fig. 1 and 3).

The larvae were as described by Peterson (1953).

"Form cylindrical, slightly curved, segments distinct and mostly subequal in diameter; color dirty white except cephalic portion of head, mandibles and urogomphi; head prognathous, globular, possessing two, cone-shaped, sclerotized protuberances on frons caudomesad of mandibles; two, contiguous ocelli ventrolaterad of antennae, epipharynx with a single, conspicuous, sclerotized comb-like structure on right half of proximal area; transverse, fine, sclerotized, single lines occur on the cephalic portion of the dorsum of all segments except the prothorax and the ninth abdominal; short, pointed, caudoprojecting urogomphi present on ninth segment; colorless setae present on all areas; spiracles annular with pair on mesothorax oval and two or more times larger than others."

Male pupae had the two slightly curved horns on the thorax which are characteristic of the adult males. Pupae of the females had blunt tubercles on the prothorax which are present in the adult females. The first six abdominal segments of the pupae of both sexes each possessed two pairs of fleshy tubercles on the lateral margins, which ended in small spines. The last abdominal segment possessed a pair of spines. The average length of male pupae was 16.5 mm.; of female, 14.6 mm. (fig. 3).

The adults were as described by Triplehorn (1952).

"Elongate-rectangular, robust; black to reddish-brown, dull, lusterless. Head roughly sculptured, sides elevated; males with bifid horn on clypeus; female with two widely spaced small tubercles on clypeus; antennae 10-segmented, second segment small, third longer than 3 following segments combined, terminal segment globular; eyes deeply emarginate; pronotum roughly sculptured, twice as broad as long, lateral margins broadly flattened, serrate with variable number of rounded teeth; males with 2 slightly curved horns, broader at tip and clothed with yellow hairs beneath, projecting forward from disc of pronotum to well beyond head; females with blunt tubercles instead of horns. Elytra roughly sculptured, each with 4 rows of large irregular tubercles with smaller ones on intervals; abruptly deflected apically; epipleura entire. Ventral surface and legs dull black, lusterless, rugose; males with patch of yellow hairs on inner face of femora; prosternum blunt, horizontal, its apex prominent. Length 10-12 mm.; width 3.5-4 mm." (fig. 3).

SEASONAL HISTORY

B. cornutus was found wintering in both the larval and adult stages. Larvae collected in specimens of *Fomes applanatus* and *Ganoderma tsugae* in Hocking County, Ohio, in February of 1954, were in the third, fourth, and fifth instars. Larvae were also collected on subsequent field trips in March, April, and May. *Fomes applanatus* collected in Cheboygan County, Michigan, early in November, 1954, contained second and third instar larvae.

The adults wintered under the bark of trees, logs, and stumps supporting fungus growth, and also inside the fungi. Wintering adult beetles were collected in Hocking County, Ohio, in February and March of 1954, and in Cheboygan County, Michigan, in November, 1954.

The overwintering adults were apparently responsible for the spring brood of eggs, which, in northern Michigan, were laid from the middle of June until the first of July. Larvae from these eggs completed their development in the fall, and overwintered as adults.

The overwintering larvae completed their development during the early summer, and the resulting adults were responsible for the fall brood of eggs. In northern Michigan, these eggs were laid from the last of July until the middle of September, and the larvae continued to develop until weather conditions were no longer favorable (fig. 4).

Thus, in northern Michigan, there were two apparent egg-laying seasons; one in late spring, and one in early fall. Freshly laid eggs, collected on June 22 indi-

cated that the spring period of egg laying began shortly before this time. Females collected on this date continued to lay eggs in the laboratory until July 2. The following is the oviposition record of the female of a pair of copulating adults collected on June 22:

June 22.....	one egg
June 23.....	one egg
June 24.....	one egg
June 25.....	one egg
June 26.....	one egg
June 27.....	one egg
June 28.....	no egg
June 29.....	one egg
June 30.....	two eggs
July 1.....	one egg
July 2.....	no egg
July 3.....	one egg
July 4.....	one egg
Total	12 days 11 eggs

These eggs were laid on a specimen of fungus in the laboratory, always between the hours of 5:00 and 7:30 P.M. After July 4, no more freshly laid eggs were observed until July 26, when other females collected on July 19 began to deposit eggs. Freshly laid eggs were collected in the field from August 4 to September 12.

Oviposition records of individual females, and dissections of females collected, indicated that each female probably lays between 8 and 12 eggs.

These eggs were laid singly on the fungus host, mostly on the upper surface in crevices and folds, and along the outer margin. A few eggs were laid on the under or pore surface of the fungus where the new hymenium had not covered that of the previous year. No egg capsules were found on sporulating hymenium.

An egg was first deposited on its side on the fungus, and then covered by the excrement-like material composing the capsule. The female beetle deposited this material around the margin of the egg, and then smoothed it up and over the egg, using the soft, brushlike hairs on the tip of her abdomen. The capsular material was granular when first laid down, but these lumps were completely smoothed over. When first deposited, this capsule was dark, moist, black-brown, but dried to a lighter brown, similar to the color of the supporting fungus surface (fig. 1). The egg capsules on the upper surface of the fungus were noticeably lighter than those on the lower surface. This may be due to the more moist condition of the lower surface.

Eggs of the forked fungus beetle hatched in 11 to 26 days after they were laid, with an average pre-hatching period of 16 days. After hatching, the first instar larvae remained under the egg capsules for an average of 5 days before burrowing into the fungus. During this time, it appeared that the larvae fed on the capsular material, since the fungus beneath the capsule showed no signs of being eaten, and larvae removed from under these capsules had full intestinal tracts. In leaving the egg capsule, the first instar larva either burrowed directly into the fungus, leaving the capsule intact and full of frass, or, bored a small hole in the capsule, crawled out, and migrated over the surface of the fungus for a time before burrowing in. The site of burrowing was generally a crack or crevice in the fungus surface.

After entering the fungi, the larvae constructed tunnels inside the fungus body. These tunnels, unless they were extremely numerous, or unless the fungus had reached a late stage of decay, were not visible from the outside. The first instar larvae constructed small triangular chambers about 2 mm. below the surface. These chambers were approximately 2 mm. by 2 mm. by 3 mm. The first instar larval period lasted from 5 to 15 days with the average being 9.8 days. As the

larvae developed, the chambers were filled with frass and new and larger tunnels and chambers were built. These tunnels either wound down through the fungus or were developed entirely in the upper layer of the fruiting body. Crossing and intertwining of tunnels occurred frequently, but only one larva was present in any particular tunnel.

The average length of the second instar period, during the summer, was 11.3 days; of the third, 44.5 days; and of the fourth, 7 days. These records were made on larvae reared in individual stentor dishes on pulverized fungi in the laboratory during the summer of 1954. In addition to these four instars known to occur in the laboratory, field collections contained an apparent fifth instar. Four instars

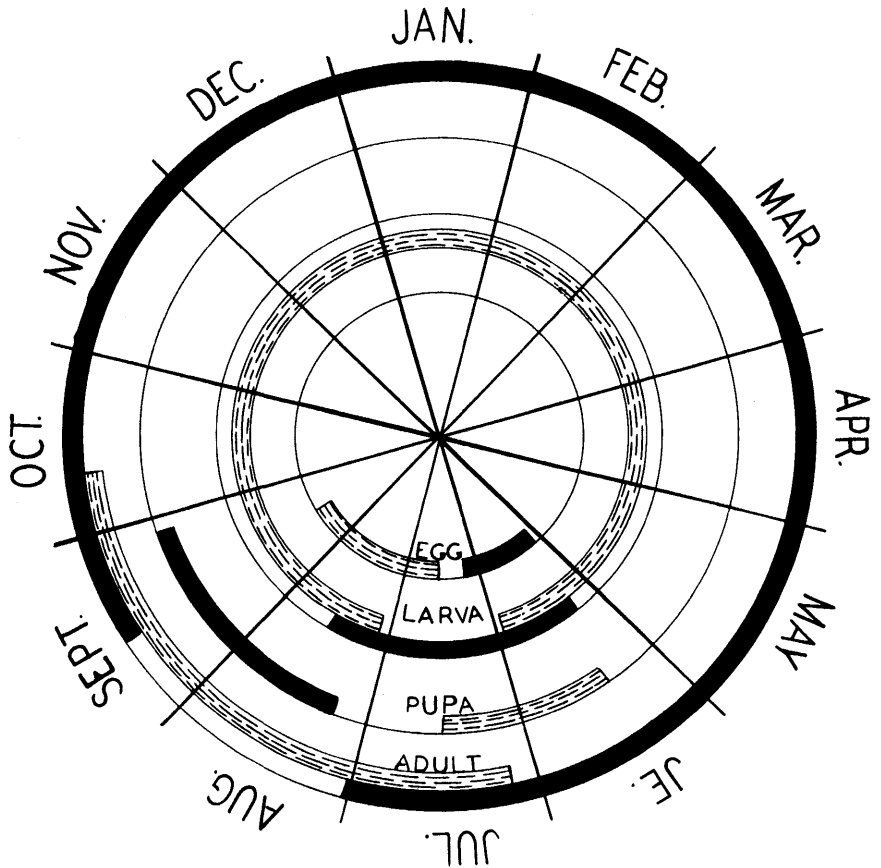


FIGURE 4. A diagram of the annual cycle of *B. cornutus* in northern Michigan. The solid black areas represent one brood, the broken line areas the other.

were present with head capsule measurements equivalent to those of the four instars in the laboratory cultures, but, in addition, fifth instar larvae with head capsules proportionately larger than the fourth instar, occurred in the field collections.

Cast larval skins of all these instars were found in the enlarged chambers in the fungus, but were not found in the connecting tunnels. These chambers were smooth sided and large enough for the larvae to twist about freely. Pupation

occurred in the last of the enlarged larval chambers. The pupae were very active and rotated clockwise and counter-clockwise by rapid thrashings of the abdomen. This movement inside the pupal chamber produced an audible rattling noise. The length of the pupal period during the summer was from 5 to 22 days with an average of 11.6 days.

The adults frequently occupied the pupal chambers for some time after emergence from the pupa. However, never more than one individual occupied each chamber. A larva was observed which had tunneled into the pupal chamber of another individual. The larva had eaten part of the pupa. Such cannibalism was also observed in laboratory cultures in which all the larvae removed from a single fungus were placed in one fingerbowl.

After emerging from the pupal stage, the adults darkened to full color within four days. This period was usually spent in the pupal chamber. The adults escaped from the fungus by chewing through it to the outside. Such emergence holes had a diameter ranging from 6 mm. to 9 mm. and occurred anywhere on the fungus.

TABLE 1

Occurrence of Bolitotherus cornutus (Panzer) in Polyporaceae collected in Cheboygan and Emmet Counties, Michigan, in the summer of 1954

Fungus	No. times Collected	Number containing		
		Egg Capsules	Larvae & Pupae	Adults
<i>Daedalea unicolor</i>	10	0	0	0
<i>Fomes applanatus</i>	63	50	50	49
<i>Fomes fomentarius</i>	5	0	0	1
<i>Fomes ignarius</i>	6	0	0	0
<i>Fomes pinicola</i>	4	0	1	1
<i>Ganoderma tsugae</i>	10	1	4	4
<i>Polyporus adustus</i>	14	0	0	0
<i>Polyporus betulinus</i>	23	0	0	0
<i>Polyporus cinnabarinus</i>	6	0	0	0
<i>Polyporus elegans</i>	3	0	0	0
<i>Polyporus perennis</i>	18	0	0	4
<i>Polyporus versicolor</i>	12	0	0	3

BEHAVIOR

B. cornutus is a nocturnal insect. During the day, the adults were found under the fungi, in old emergence and feeding holes, in the bottom of the fungi, and in crevices in the bark of the tree or log on which the fungi were attached. During the summer, the beetles became active around 8:00 P.M. and this activity continued until about 4:00 A.M. The beetles moved about the fungus a great deal during this time and during this period, feeding and copulation most frequently occurred.

When disturbed, the adult beetles responded with the death feint characteristic of many tenebrionids.

A peculiar behavior pattern apparently connected with mating was observed in the beetles in the field and in laboratory cultures. Prior to mating, the male beetle clasped the female in such a manner that the ventral surface of his abdomen rested on the dorsal surface of her thorax, and the ventral surface of his thorax rested on the dorsal surface of her abdomen. When in this position, the male rubbed the ventral surface of his abdomen across the two prominent tubercles which projected from the female's thorax. This produced a distinct rasping sound audible at a distance of six to eight feet from the fungus. This noise making

was carried on for one or two minute periods interspersed by one or two minutes of quiet. At the end of one of these periods of rasping, the male reversed his position and copulated with the female. This noise making was carried on at different periods for several days before and after copulation, and during the egg laying period. However, the noise was usually produced at night. Pairs of beetles were frequently found in the position for noise making when no noise was being produced.

HOST RELATIONSHIPS

Larvae and adults of *B. cornutus* were observed feeding only on Polyporaceae. The most commonly infested fungus in northern Michigan was *Fomes applanatus* (table 1). The larvae burrowed inside the fungus and fed on the hymenial layers. Tunnels in these layers contained great quantities of excrement. The adults also fed internally in the fungus or on the exposed pore surface on the bottom of the fungus.

Examination of the excrement and gut contents of both larvae and adults showed broken fragments of fungus mycelium, broken and whole fungus spores, and great numbers of bacteria.

In the laboratory, larvae thrived equally well on autoclaved or unautoclaved pulverized fungi.

PARASITOID RELATIONSHIPS

Larvae of *B. cornutus* were attacked by a braconid, *Eubadizon orchesia* (Ashm.). The wasps' pupal cocoons, covered with light yellow silken threads, were frequently found in old larval tunnels in the fungi. A head capsule of a third instar *B. cornutus* larva was generally found at one end of each cocoon, indicating that the wasp probably completed its larval development during this phase of the host's development. The wasp cocoons averaged 6 mm. in length and 3 mm. in width.

Two female wasps, reared from collected material and released on a fungus covered with egg capsules of the beetle, ran about the surface of the fungus, moving their antennae over it rapidly and poking at it with their ovipositors. Whenever a small hole or crack was found in the fungus, the ovipositor was inserted in it. This was also true of the emergence holes in the tops of some of the egg capsules.

Fomes applanatus collected in the field frequently contained masses of white mycelium in the larval tunnels. Examination of these masses showed that each contained a dead *B. cornutus* larva with its body cavity filled with the mycelium.

SUMMARY

In the region of Cheboygan County, Michigan, the forked fungus beetle, *Bolitotherus cornutus* (Panzer), had one generation per year. The beetle overwintered both as adults and larvae; the adults under bark, the larvae in the fungus host, chiefly *Fomes applanatus*.

Overwintering adults laid eggs in mid June, the resulting larvae completing their development in early fall. The overwintering larvae became adults in mid summer and began ovipositing in late August. The larvae from these eggs developed until weather conditions retarded them.

The eggs were deposited singly on the upper and lower surfaces of the host fungus and were covered with an excrement-like capsule. Each female deposited between 8 and 12 eggs at a rate of 1 or 2 eggs per day.

The larvae bored into the host fungus and tunneled through it during development. Pupation occurred in an enlarged chamber in the larval tunnel.

The larval reared in the laboratory on pulverized *Fomes applanatus* underwent four instars before pupation. Measurements of head capsules of field collected larvae indicated that five instars may occur in nature.

The forked fungus beetle is nocturnal, feeding and mating chiefly at night. A peculiar noise making behavior occurred during the mating season.

A braconid wasp, *Eubadizon orchesiae* (Ashm.) was found in the pupal stage in old larval tunnels, with the head capsule of a third instar beetle larva at one end of its cocoon. *B. cornutus* larvae were also found dead in the center of a white mycelial mass in the larval tunnels.

ACKNOWLEDGMENTS

The author is indebted to the University of Michigan Biological Station, Cheboygan, Michigan, for the use of its facilities and to Dr. H. B. Hungerford for advise on this project during the summer of 1954. Appreciation is also expressed to Dr. R. H. Davidson for his help and advice, and to James S. Bowman for photography.

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