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BIOLOGY AND TAXONOMY OF NORTH AMERICAN BEETLES OF THE SUBFAMILY GEOTRUPINAE, WITH REVISIONS OF THE GENERA BOLBOCEROSOMA, EUCANTHUS, GEOTRUPES, AND PELTOTRUPES (SCARABAEIDAE)

By Henry F. Howden [1]

Introduction

A number of entomologists have been interested in the biology and taxonomy of the beetles in the subfamily Geotrupinae, family Scarabaeidae. While the adults have been collected and their habits recorded, little has been published on the biology of the larvae of these elusive beetles.

Revisions of the genera *Eucanthus*, *Bolbocerosoma*, *Geotrupes*, and *Peltotrupes* are included, with descriptions of seven new species and subspecies. Also, two previously unrecognized subspecies of *Geotrupes* are described.

The key to the tribes and genera of North American Geotrupinae is on page 161, and in the review of the subfamily the genera and species are treated in the following order:

Bolbocerosoma Schaeffer
B. farctum (Fabricius)
B. confusum Brown
B. tumefactum (Palisot de Beauvois)
B. bruneri Dawson and McColloch
B. hamatum Brown
B. lepidissimum Brown
B. biplagiatum Dawson and McColloch
B. pusillum Dawson and McColloch
B. pusillum townesi, new subspecies
B. quadricornum Robinson
B. ritcheri, new species
B. cartwrighti, new species
B. elongatum, new species

[1] Department of Zoology and Entomology, University of Tennessee, Knoxville, Tenn., formerly of North Carolina State College, Raleigh, N. C.

Bradycinetulus Cockerell
B. fossatus (Haldeman)
B. ferrugineus (Palisot de Beauvois)
B. rex Cartwright
Bolborhombus Cartwright
B. carinatus (Schaeffer)
B. angulus (Robinson)
B. parvulus Cartwright
Bolbocerastes Cartwright
B. regalis Cartwright
B. imperialis Cartwright
B. imperialis kansanus Cartwright
B. serratus (LeConte)
B. peninsularis (Schaeffer)
Bolbelasmus Boucomont
B. arcuatus (Bates)
B. minor (Linell)
B. hornii (Rivers)
Eucanthus Westwood
E. lazarus (Fabricius)
E. lazarus subtropicus, new subspecies
E. alutaceus Cartwright
E. greeni Robinson
Bolboceras Kirby
B. obesus (LeConte)
B. falli (Wallis)
B. thoracicornis (Wallis)
B. cornigerus Melsheimer
B. liebecki (Wallis)
B. filicornis (Say)
B. floridensis (Wallis)
B. simi (Wallis)
B. darlingtoni (Wallis)
B. alabamensis (Wallis)
Geotrupes Latreille
G. opacus Haldeman
G. ulkei Blanchard
G. blackburnii (Fabricius)
G. blackburnii excrementi Say
G. egeriei Germar
G. hornii Blanchard
G. balyi Jekel
G. stercorarius (Linnaeus)
G. splendidus (Fabricius)
G. splendidus miarophagus Say
G. semiopacus Jekel
Peltotrupes Blanchard
P. profundus Howden
P. profundus dubius, new subspecies
P. youngi, new species
Mycotrupes LeConte
M. retusus LeConte
M. lethroides Westwood
M. gaigei Olson and Hubbell
M. cartwrighti Olson and Hubbell
M. pedester Howden

In the discussion, an attempt is made to compare the habits of North American Geotrupinae with the habits of Geotrupinae from other continents, particularly Europe. The feasibility of using food and burrowing habits as aids in taxonomic and phylogenetic investigations are discussed, and one case is pointed out where they could be applied.

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REVIEW OF LITERATURE

Latreille (1796) was the first to propose the genus *Geotrupes* in the Scarabaeidae, not placing, at that time, any species in the genus. Two years later Fabricius (1798) again proposed the name *Geotrupes* with 65 included species, but used the name with an entirely different connotation than did Latreille. Latreille (1802, 1804) repudiated the Fabrician application of the name and listed some species that he believed should be included in the genus, and it has been his concept, and not that of Fabricius, that has been followed by subsequent authors.

Recently, Potts (1948, 1951) has raised the question of the validity of the acceptance of *G. stercorarius* Linné as type of the genus, for it was not included in the Fabrician list of species in 1798. I believe, however, as did Latreille (1802), that the *Geotrupes* of Fabricius was not intended to be that of Latreille and is therefore a primary homonym, invalidating the Fabrician list for genotype selection in this case and leaving *G. stercorarius* Linné as type of the genus.

This problem has been more fully discussed by Townes and Howden (1952) and has been referred to the International Commission of Zoological Nomenclature. It is still under consideration by the Commission.

The erection of the subfamily (or family) Geotrupinae was credited to Latreille (1804). Following Latreille there were a number of more or less comprehensive taxonomic works on the subfamily which included the tribes Bolboceratini, Geotrupini, and Lethrini. Little of this work, however, dealt even sparingly with North American forms. The first comprehensive paper on North and Central American species was a monograph by Jekel (1865) that dealt solely with the tribe Geotrupini. This paper incited considerable interest and Horn (1868, pp. 313–322) published what is essentially a supplement to this work, commenting on synonymy and pointing out varieties within some of the species. He followed this in 1870 (pp. 48–50) with a key to the other North American genera, exclusive of *Geotrupes*, for which he subsequently published a key (1880, pp. 144–145). The information on the Central American Geotrupinae was assembled by Bates (1887), and one year later Blanchard (1888) published the most recent comprehensive work on the North American species in the genus *Geotrupes*. Bradley (1944) published a key to the species of *Geotrupes* as given by Blanchard, but without any consideration of synonymy or undescribed species.

The information that had been rapidly accumulating before 1900 was finally brought together and greatly augmented by a series of extensive papers, worldwide in scope, by Boucomont. In 1902, in Wytsman's "Genera Insectorum," he set forth the genera and listed

the described species under each. This was followed by a paper by Schaeffer (1906) in which was published a revision of the North American genera and species in the tribe Bolboceratini. In the same year Boucomont (1906) published his "Catalogue Provisoire des Geotrupidae." Then, in 1911, Boucomont published a revision of the genera of the Geotrupinae, dealing in large part with the Bolboceratini, in which he discussed Schaeffer's paper and proposed a number of new genera and subgenera. Perhaps the most useful part of Boucomont's work was his catalog of the literature of the subfamily published in 1912 in Schenkling's "Coleopterorum Catalogus." He subsequently published a number of other papers, none of which dealt with the American fauna.

Following this flurry of papers there have been only a few revisions of North American genera. Descriptions and keys to the species of *Bolbocerosoma* were published by Dawson and McColloch (1924) and later revised by Brown (1928, 1929). The genus *Bolboceras* (formerly *Odontaeus*) was very carefully worked up by Wallis (1928, 1929). Blatchley (1910, 1928) published keys to local species of Geotrupinae in Indiana and Florida. These were the major contributions to the taxonomy of the adult Geotrupinae until the present. O. L. Cartwright has completed (1953) a revision of the genera *Bradycinetulus*, *Bolbelasmus*, *Bolbocerastes*, and *Bolborhombus* in North America, and Olson, Hubbell, and Howden (1954) have discussed the genus *Mycotrupes*.

Information about the biology of the immature stages has accumulated very slowly and almost all of the investigations have been by Europeans. The earliest known biological observation was by Johann L. Frisch in 1736. He not only discussed the biology, supposedly of *Geotrupes stercorarius* Linné, but also crudely pictured the larva.

Following this early work by Frisch, there were only a few scattered notes on the biology for a number of years. Mulsant (1842) briefly mentioned the biology and the odd larva of *Geotrupes*, but the first fairly accurate drawings of the larva of any species of *Geotrupes* were done by Schiødte (1874). Unfortunately, the least accurate of his drawings, the epipharynx of *Geotrupes stercorarius* Linné, was the only one that has been reproduced on later occasions. In 1880, Rupertsberger made a valuable contribution with a bibliography on the biological work done up to that time on European Coleoptera. He followed this with a supplement in 1894. In 1905 Kolbe discussed the biology of some of the species of Geotrupinae, and in 1929 he published a paper on the distribution of species of *Geotrupes* and the evolution of their antennae. Spaney (1910) published an excellent account of adult and larval biology, with drawings of larvae and pupae

of three species of European *Geotrupes* and of *Typhoeus typhoeus*. Several other excellent papers appeared, at almost the same time, by Fabre (1918), Sano (1915–1916), Main (1917, 1918), and Schjelderup-Ebbe (1925). Main's observations were the most comprehensive of the biological studies done in Europe. Recently, von Lengerken (1952) published on the biologies of several species of Geotrupinae. While most of the work was done on the Geotrupini, the tribe Lethrini received some early attention. Emich (1884) discussed the metamorphosis of *Lethrus apterus*, and other works on single species of *Lethrus* were done by Shipley (1887), Schreiner (1906), and Reymond (1933). Fabre (1912, 1919, 1922) discussed the habits mainly of the adults of *Bolbelasmus* and *Typhoeus* (under the name *Minotaurus*). The biology of the single European species of *Odontaeus* (now *Bolboceras*) has been discussed by Bedel (1911), Arens (1922), and Muller (1948). The information on larval morphology of the British Geotrupinae has been ably compiled and summarized by van Emden (1941) with descriptions and keys to all known larvae. He did not, however, include biological data.

Despite the amount of work on European species, very little has been written concerning the habits of American species. Sim (1930) made some careful studies of a number of species of *Bolboceras*, but was not fortunate enough to work out the biology of the immature stages. The first mention of the biology of the larva of a species of North American *Geotrupes* was a brief account by Loding (1935) of *Geotrupes ulkei*. This was followed by a very detailed and comprehensive paper by Ritcher (1947) in which were given descriptions and biological notes of the known larvae of North American Geotrupinae and keys to all known genera. It was in this paper that the larvae of the genera *Bolbocerosoma* and *Bolboceras* were accurately described for the first time.

Before the appearance of Ritcher's paper, a number of authors—Böving and Craighead (1930–1931), Paulian (1939), Hays (1929), and later Edwards (1949)—had stated the necessity of erecting the family Geotrupidae based in large part on the reduced third leg of the larva of *Geotrupes*. While the question of family rank will not be settled for some time, Ritcher added a number of new facts to be considered, which make the writer doubt the validity of family rank. The group is at present treated as a subfamily.

The most recent work that included some biology was a compilation of information by Arrow (1951). While this work contained a large amount of data, it was unfortunate that there was not more originality in the biological observations. All of the portions on biology of the Geotrupinae were either taken from other sources, many of them faulty, or were poorly based suppositions. It is unfortunate that so

many erroneous observations had to be preserved in an otherwise interesting book by a well known worker.

Besides the papers already mentioned there have been a few others that have added materially to our information on the Geotrupinae. Very interesting papers and notes on the physiology of *Geotrupes*, some dealing with their reaction to odors, have been published by Vaternahn (1924), Warnke (1931, 1934), Dethier (1947), and Brues (1946). Arrow (1904) discussed sonification in some of the genera. The morphology of the mouthparts of North American genera was discussed and illustrated by Hardenburg (1907), and the structure of the male genital tube of some European species was discussed by Sharp and Muir (1912). There have also been a number of papers on the parasites of adult and larval Geotrupinae by Chapman (1869–1870), Hall (1929), Wetzel (1935), Theodorides (1949, 1950a, 1950b, 1951), and van Emden (1950). The most interesting and unusual of these papers are those by Chapman (1869–1870). These and many other papers mentioned will be discussed in greater length in a more appropriate place.

METHODS AND MATERIALS

Horn (1868, p. 321) made the statement that he had never seen a good series of all the species of *Geotrupes* in any collection, and the situation to which this statement applied was still true in 1950. However, many of the collections had excellent series of some of the species, and through the generous loan of specimens from institutions and individuals mentioned previously I was able to examine large series of most of the species.

Almost all of the distributional data contained in this paper were taken from specimens personally examined, and all localities were checked in the U. S. Postal Guide or Rand McNally Atlas. Because of the large number of errors found in Brimley's "Insects of North Carolina" (1938, pp. 201–202), it was decided not to use records in any local state lists. Some little known or unusual records can be found in the following works: Beaulne (1942, p. 12), Brown (1940, p. 74), Cartwright (1934, pp. 239–240), Davis (1904), Easton (1909, p. 51), Frost (1920, p. 251), Gardiner (1879, p. 213), Gorham, Walker, and Simpson (1929, p. 15), Loding (1933, p. 147), Nicolay (1913, p. 125), Nylen (1929, p. 219), Snow (1904, p. 197), Townsend (1889, p. 233), and Wickham (1894, p. 197).

In addition to borrowed material, all of the type material that was available in the eastern United States was studied. In some instances where the type was not readily available, I was able to see paratypes. Dr. Tuxen, of the Zoologische Museum, Copenhagen, and Dr. van Emden, British Museum (Natural History), were extremely helpful in comparing material with some of the Fabrician types.

It should be mentioned here that the types of several of the species described in this paper, along with most of the larvae collected during the study, have been deposited in the collection of the U. S. National Museum.

In studying many of the specimens, it was necessary to extract the genitalia, particularly of the males. This was done by relaxing the specimens in a humidor for several days and then removing the genital caspule and genitalia under a dissecting microscope. The capsule and genitalia were then mounted on a card point on the pin beneath the specimen. When it was necessary to relax a specimen rapidly, it was placed in water just at the boiling point for three minutes, which was ordinarily enough time to completely relax it. Unfortunately, this method usually changed the hue of iridescent species.

In studying the genitalia a few were cleared in potassium hydroxide, but all drawings were made from genitalia that had not been cleared. The drawings were made using a binocular dissecting microscope with a net reticule at magnifications of 45× and 90×. In some of the larval illustrations a compound microscope was used to check and to fill in detailed structures. Larval dissections were done with a small blade-like probe, several insect pins, and a fine pair of dissecting scissors.

The problems encountered in the biological studies were numerous and sometimes exasperating. The adult Geotrupinae are quite secretive, spending much of their life in deep burrows. There have been a number of notes, written by Mohr (1943), Frost (1929), Park (1931), Young (1950), and others, on collecting the adults at dung, fungi, and decomposing animal and vegetable matter. At first, collecting was done by looking for the burrows near dung and fungi. However, this method was slow and much time was consumed digging out a few beetles. In sandy areas the time necessary for digging was greatly shortened by the use of a posthole digger. There the burrows were almost vertical, and, when marked with a straw thrust into them, they could be easily followed by digging beside the burrow with a posthole digger and using a trowel to follow the burrow. If it was a question of merely obtaining the specimen at the bottom of the burrow, it was excavated with the posthole digger and the dirt sifted through a quarter-inch mesh screen.

In many cases it was difficult to locate burrows, particularly when the ground was covered with litter. In order to obtain a sufficient number of adults to use in rearing cages, various methods of trapping were tried. Spector (1943) noted a number of *Geotrupes* attracted to chicken feathers. Elaborating on Spector's observation, I covered the bottoms of apple crates with fine screen wire. These were sunk into the ground, partially filled with soil, and a layer of chicken feathers and entrails placed on top of this. This method of trapping yielded

some specimens, but not in the numbers desired. Another technique employed gallon cans partially filled with dirt that were sunk into the gound and then baited with fungi and dung. While producing a number of specimens, these methods were still not satisfactory.

Young (1950) had mentioned the attractive power of molasses, and several types of molasseslike substances were tried. The most successful of these was found to be one part of triple malt extract to three parts of water with a little yeast added. This was a very good method for determining the species in an area. Also malt was the best attractant found for use in very xeric habitats in the summer. Other advantages were that the attractiveness lasted over a long period and once the beetle fell into the mixture it did not escape. However, although the malt traps were very successful, specimens captured were invariably drowned and the method is not recommended for obtaining live specimens. A screen to keep the beetles out of the malt was added but for some reason the trap then lost some of its effectiveness. Also, it is apparently necessary for the malt to ferment for a number of days before becoming fully effective and some other attractant was needed when the collector was only staying in an area overnight.

Shortly before the conclusion of this work, a number of adult *Geotrupes* were procured in an interesting manner. At Faison, N. C., some work was in progress on the control of the fall army worm. In August and September several applications of Endrin (Julius Hyman Compound 269) were made on corn at the rate of one-eighth pound of insecticide per acre. Three weeks following the last treatment, on Oct. 28, 1952, a large number of dead and dying *Geotrupes blackburnii* were noted in a small area of the corn field. On closer examination, some human dung was found between the rows of corn. In, under, and around the dung were many dead and dying dung-inhabiting insects (including about 40 *G. blackburnii*). The only apparent explanation for the death of the beetles appears to be the residual action of the insecticide. I have not been able to further pursue this seemingly productive method of collecting some of the dung- and ground-inhabiting Scarabaeidae.

Finally, a trap was devised that attracted numbers of *Geotrupes* and did not kill or injure them. It consisted of a can containing an attractant and a funnel top. The top was cut out of a gallon can and holes were punched in the bottom with a nail to permit drainage. Two holes were made 2 inches above the bottom for attaching a small vial of attractant. Then three holes, for wire hooks to hold a funnel, were punched around the top of the can. A piece of cardboard was cut out to form a shallow funnel with a central opening 1 inch in diameter and sides overlapping the can by 1 inch. The cardboard was

turned to form the funnel, stapled, and given several coats of brown outdoor paint on both sides. The finished funnel presented a smooth surface and lasted for well over a year. The funnel was held in place by the three wire hooks at the top of the can. The trap was complete when a small vial of attractant was fastened to the inside of the can by a piece of string passed through the holes in the side near the bottom. It was then sunk until its top was level with the surface of the ground. Water did not reach the attractant nor accumulate in the can and *Geotrupes* would survive for a week or more.

The greatest problem was to find suitable attractants. Warnke (1931) had shown that some chemical products of decomposition were attractive to *Geotrupes*. The chemicals mentioned by him, plus a number of others recorded as products of the decomposition of plant or animal matter, were tried. There was no attempt made to vary concentrations, as the major purpose was merely to find a material to attract *Geotrupes*. Three of the materials, isoamylamine, butyric acid, and propionic acid, proved very successful. The only objection to the use of chemicals was that anything coming in contact with them retained the odor for some time. The chemicals were tried at Raleigh, N. C., by using them in bait cans placed in a large circle 6 feet apart. Materials that did not prove attractive were discontinued after several months and others substituted. The data from these traps are summarized in tables 3 and 4 (pp. 241, 267). Some of the better materials were used at Faison and Southern Pines, N. C., with good results. Oddly enough, *Geotrupes egeriei* would come in numbers to malt, but was not attracted by any of the chemicals. A few species, especially in genera other than *Geotrupes*, were most readily taken in light traps.

The species collected by these traps and by observation were separated and placed in rearing cages constructed by sinking 12-inch boards 8 inches into the ground, making an enclosure about 2 or 3 feet wide by 6 feet long. The soil was disturbed as little as possible in the center of the cages, allowing the adults to burrow to any depth they wished. The beetles were kept supplied with decomposing leaves, cow dung, and fungi or rotting bananas. The enclosures were kept tightly covered with galvanized wire screen.

In sandy areas, where the species present burrowed to considerable depths, a different type of cage was used that was extremely simple to make. It was merely a tube of galvanized wire screen, 3 feet deep with a varying diameter which averaged about 1 foot. The sides of the tube were fastened together by pulling off a few strands of wire parallel to the cut edges, then pushing the protruding wires through the holes in the screen on the opposite edge and bending them over. A screen top and bottom were fastened on in the same way, making

a strong, light, cylindrical cage which was easily sunk to the desired depth by use of a posthole digger.

After the adult beetles had been in the cages for a month or more, a portion of each cage was carefully investigated. If larvae were found, they were removed along with the food material provisioned by the adult and placed in 2-ounce, metal, salve boxes in which they were easily observed and reared. Depth of the larval cell, instar, food, and other information were recorded. Larvae were preserved by placing them alive in hot water kept just under boiling, leaving them there for 3 minutes, and then dropping them into vials of 70 percent alcohol. Various larval preservatives that contain acetic acid, kerosene, and alcohol in varying proportions were not employed because such preservatives caused undesirable distension of the larvae.

Review of the subfamily Geotrupinae

ADULT CHARACTERISTICS

The North American representatives of the subfamily Geotrupinae can be separated from other Scarabaeidae by the following characteristics.

Antennae 11-segmented with 3-jointed club, mandibles not hidden by the clypeus, clypeus sharply delimited from the vertex, often with a tubercle or horn, anterior femora with a silky spot on anterior surface, pygidium largely hidden by the elytra, abdominal spiracles on the membrane between sclerites, male genital armature enclosed in a definite sclerotized genital capsule.

The genus *Pleocoma* appears very closely related to the Geotrupinae but has been omitted from the present work.

Key to North American tribes of the subfamily Geotrupinae

Antennal club large, about as long as the basal eight segments, rounded, convex on both sides . . . . . I. **Bolboceratini**

Antennal club small, about half as long as the basal eight segments, elongate, not convex on both sides . . . . . II. **Geotrupini**

I. Key to genera of North and Central American Bolboceratini

1. Eyes entirely divided by canthus; color sometimes variegated 2
   Eyes only partially divided by canthus; color uniform brown to black . . 4
2. Scutellum very elongate and narrow. (Central and South America). **Athyreus**
   Scutellum triangular 3
3. Color brownish orange varied with areas of black or dark brown; middle coxae narrowly separated by slender projection of mesosternal plate. **Bolbocerosoma**
   Color uniformly brown to black; middle coxae contiguous, not separated by projection of mesosternal plate . . . . . **Bolboceras** (formerly *Odontaeus*)

4. Margin on posterior edge of pronotum broadly interrupted medially. (Central America) . . . . . **Bolbelasmus** (formerly *Kolbeus*) **arcuatus** Bates
   Margin on posterior edge of pronotum complete 5
5. Elytron with five striae between suture and humeral umbone; humeral angle of elytron not broadly rounded, the margin almost always produced into a tubercle at the angle . . . . . **Eucanthus**
   Elytron with seven striae between suture and humeral umbone; humeral angle of elytron broadly rounded, the margin never produced into a tubercle at the angle 6
6. Middle coxae nearly contiguous, intercoxal process less than 0.3 mm. wide and linear between coxae . . . . . **Bolbelasmus**
   Middle coxae well separated, intercoxal process more than 0.3 mm. wide and never linear 7
7. Base of elytron margined; pronotum without postapical carina 8
   Base of elytron not margined; pronotum with a postapical carina extending almost to side margins . . . **Bolborhombus** (*Bolboceras* of authors in part)
8. Apex of tibia of middle and hind legs deeply emarginate on outer side, the angle adjacent to spurs appearing almost as a fixed spur; without prosternal spine . . . . . **Bradycinetulus**
   Apex of tibia of middle and hind legs obliquely truncate, prosternal spine behind anterior coxae transverse, doubly pointed and remote from acutely angled intercoxal piece . . . . . **Bolbocerastes**

II. Key to genera of North and Central American Geotrupini

1. Elytra fused, connate, their surfaces roughly granulate; flightless species. (Southeastern U. S.) . . . . . **Mycotrupes**
   Elytra free, if connate not roughly granulate 2
2. Eye canthus abruptly angulate anteriorly, clypeus V-shaped, with horn or raised longitudinal carina running its length; thorax anteriorly with horn in males, merely slight postmarginal protrusion in the females. (México.) **Ceratotrupes**
   Eye canthus broadly arcuate anteriorly, clypeus usually approximately U-shaped, with small median tubercle posteriorly, but no longitudinal carina; thorax anteriorly without horn or postmarginal protrusion in either sex . 3
3. Middle and hind tibiae each with a pronounced transverse apical carina; margin of elytron not widely flared. (North and Central America.) **Geotrupes**
   Middle and hind tibiae with only a trace of an external transverse apical carina; margin of elytron widely flared. (Florida) . . . . . **Peltotrupes**

LARVAL CHARACTERISTICS

The larvae of the North American Geotrupinae can be distinguished from the larvae of other North American Scarabaeidae by the following characteristics.

Antennae 3-segmented, the penultimate segment bearing one or more conical sense organs. Third segment greatly reduced in diameter. Inner and outer lobes of the maxillae entirely free. Teeth present on maxillary stridulatory area. Hypopharynx with oncyli. Terga of abdominal segments 3 to 7 with two dorsal annulets. Mesothoracic

and metathoracic legs often with stridulatory organs (*Bolboceras*, *Peltotrupes*, *Geotrupes*).

The genus *Pleocoma* was included in Ritcher's (1947, p. 5) key to Geotrupinae, as were the known European forms. *Pleocoma* has been omitted because of the present uncertainty over its inclusion in the subfamily Geotrupinae. For descriptions of the larvae in the genus *Pleocoma* and the European genera *Lethrus* and *Typhoeus* the reader is referred to Ritcher's (1947) excellent paper.

Key to the North American tribes and genera of known Geotrupinae larvae

1. Metathoracic legs greatly reduced; last abdominal segment obliquely flattened; body sharply bent with swollen abdomen (pl. 11, figs. 1, 2). (Geotrupini) . 2
   Metathoracic legs not reduced; last abdominal segment rounded posteriorly; body slightly bent without enlarged abdomen (pl. 12, figs. 1, 2; pl. 13, fig. 1). (Bolboceratini) 4
2. Third antennal segment less than one-sixth as long as second segment (pl. 7, fig. 6); abdomen greatly swollen . . . . . **Peltotrupes**
   Third antennal segment at least one-fourth as long as second segment; abdomen moderately swollen 3
3. Endoskeletal figure of ventral anal lobe below anal opening laterally expanded with sharp, fairly truncate angles . . . . . **Geotrupes**
   Endoskeletal figure of ventral anal lobe below anal opening lacking sharp angles, broadly rounded . . . . . **Mycotrupes**
4. Legs lack claws, 2-segmented; penultimate segment of antenna (pl. 6, fig. 3) bearing a single conical sense organ; lower anal lobe single (pl. 6, fig. 10). **Bolboceras**
   Legs with claws, 3- or 4-segmented; penultimate segment of antenna with two or more conical sense organs; lower anal lobes paired 5
5. Penultimate segment of antenna (pl. 6, fig. 2) with two conical sense organs; galea emarginate; legs 4-segmented . . . . . **Bolbocerosoma**
   Penultimate segment of antenna (pl. 6, fig. 1) with more than two (usually four) conical sense organs; galea not emarginate (pl. 6, fig. 6); legs 3-segmented. **Eucanthus**

(Larvae of the following genera are unknown: *Bolbelasmus*, *Bolborhombus*, *Bradycinetulus* and *Bolbocerastes*.)

Genus *Bolbocerosoma* Schaeffer

Bolbocerosoma Schaeffer, 1906, p. 254.—Boucomont, 1911, pp. 332–350.—Blatchley, 1910, p. 937; 1928, p. 29.—Dawson, 1922, p. 194.—Dawson and McColloch, 1924, pp. 9–15. Brown, 1928, pp. 192–195; 1929, p. 213.—Robinson, 1941, p. 132.—Ritcher, 1947, pp. 11–12.

GENOTYPE: *Scarabaeus farctus* Fabricius, designated by Schaeffer (1906).

GENERIC LIMITATIONS: Given by Schaeffer (1906, p. 254): "Eyes completely divided, intermediate intercoxal process between the

coxae with a tooth-like elevation, intermediate coxae very narrowly separated, nearly contiguous."

Other useful characteristics are: Yellow or red-brown color, dorsally with black markings, lateral pronotal carinae no wider than head, at least a few deep coarse median punctures on pronotum, elytral base not margined.

MALE GENITALIA: The genital capsule of the male is the most conspicuous part of the genital structures. The genitalia itself is rather simple, with symmetrical pointed parameres and a central spiculate aedeagus. Characteristics useful in differentiating various species were found mainly in the size and shape of the lateral lobes of genital capsule. The capsule readily separates the genus into the following species groups:

(A) Capsule large, heavily sclerotized, lateral lobes elongately (over twice as long as wide) triangular, narrowly separated at tip, lobate basally. **farctum, confusum**

(B) Capsule slightly smaller and less sclerotized, lateral lobes with bluntly angulate tips, widely separated, not lobate basally . . **tumefactum, bruneri**

(C) Capsule small with lateral lobes deflexed at tips to form hooks . **hamatum**

(D) Capsule small, moderately sclerotized, lateral lobes with tips blunt and broadly rounded. . . . . **All remaining species**

In the genus *Bolbocerosoma* intraspecific variation, particularly in males, is very evident, expressing itself in the size of the tubercle on the eye canthus, the tubercle at the midline of the clypeus, the horn of the vertex, and the development of the pronotal modification. Generally, the modifications of the head and pronotum of the males are well developed, only occasionally being very small, with the pronotal modification quite similar to those of the female. In the females variation is much less noticeable.

Descriptions have been based, whenever possible, on well-developed individuals. Variations in size, color pattern, and punctation occur and are noted for each species whenever variation is evident.

Known larvae in this genus may be distinguished from related genera by the following characteristics: Antennae 3-segmented, penultimate segment with two conical sense organs, galea emarginate, legs 4-segmented with pronounced claws, metathoracic legs not reduced, and abdomen not enlarged.

Key to the North and Central American species of Bolbocerosoma

1. Elytron with seven deep and strongly punctured striae between suture and humeral umbone 2
   Elytron with five deep and strongly punctured striae between suture and humeral umbone, the second and fifth striae feeble or obsolete 3
2. Pronotum never with a black median spot or stripe, distal black area of elytron confluent with the black sutural stripe. **bruneri** Dawson and McColloch

Pronotum with black median spot or stripe, black distal area of elytron usually well separated from the black sutural stripe.
tumefactum (Palisot de Beauvois)

3. Punctures of elytral striae and dorsal surface (besides some of the marginal punctures) bearing at least a few fine long erect yellow hairs 4
Punctures of elytral striae and dorsal surface (except in some cases the marginal punctures) without hairs 8
4. Elytron with a large distal black area which is confluent with posterior half of black sutural stripe . . . . . **pusillum** Dawson and McColloch
Elytron with black spot which is separated from both sutural stripe and lateral margin 5
5. Black spot of elytron almost twice as long as wide; black sutural stripe of elytron continuing around the posterior half of lateral margin; posterior of pronotum with black markings pronounced and extending beyond margined edge 6
Black spot of elytron almost circular; black sutural stripe of elytron not extending around lateral margin; posterior of pronotum with only a vague black line 7
6. Pronotum and elytra with many long hairs; portions of lateral margins of pronotum black; entire posterior pronotal margin black with median black toothlike mark . . . . . **cartwrighti,** new species
Pronotum and elytra with a few short hairs; lateral margins of pronotum without any trace of black; only lateral portions of posterior margin of pronotum black . . . . . **ritcheri,** new species
7. Body shape oval; vertex and pronotum densely, coarsely punctured; vague circular postmedian elytral spot confined to posterior half of elytron; lateral lobe of male genital capsule about 1.3 times as long as wide.
quadricornum Robinson
Body shape elongate; vertex and pronotum at most moderately coarsely punctured; vague circular postmedian elytral spot confined to posterior third of elytron; lateral lobe of male genital capsule about 1.8 times as long as wide . . . . . **elongatum,** new species
8. Elytron with slightly postmedian black spot which is separated by approximately its own width from both the black sutural stripe and the lateral margin. 9
Elytron with distal black area which is confluent with apical half of either sutural stripe, or with lateral margin, or with both 10
9. Elytral spot almost circular; black border at posterior of pronotum usually extended forward at the midline, making a spikelike pattern; pronotal declivity coarsely punctate only in apical half.
biplagiatum Dawson and McColloch
Elytral spot almost twice as long as wide; basal black border of pronotum not projecting forward at midline; pronotal declivity with at least the apical two-thirds coarsely punctate . . . . . **confusum** Brown
10. Lateral margin of elytron in front of distal black area with at least a faint black band extending forward to the humeral angle 11
Lateral margin of elytron in front of distal black area without any black markings (Arizona and México) . . . **pusillum townesi,** new subspecies
11. Vertex of head closely covered with coarse punctures; second elytral stria very feeble, but evident 12
Vertex of head sparsely covered with fine punctures; second elytral stria absent . . . . . **lepidissimum** Brown

12. Lateral lobes of genital capsule of male deflexed at apices to form hooks; in the female the distal black area of elytron is usually confluent only with sutural stripe and not with the black marginal stripe; general form often somewhat elongate (Georgia and Florida) . . . . . **hamatum** Brown
Lateral lobes of genital capsule of male elongate, not deflexed; in the female the distal black area is usually confluent with both sutural stripe and black marginal stripe; general form oval . . . . . **farctum** (Fabricius)

To my knowledge, only two larvae in this genus have been collected. One larva was described by Ritcher (1947, pp. 11, 12) and tentatively identified as *tumefactum*. The second, procured by Ritcher and myself, is the larva of *farctum*. The two larvae are so close morphologically that I doubt that there is a specific difference.

If the larvae do represent two species, they may be separated by the following characteristic of doubtful constancy.

Labrum broadly rounded . . . . . **tumefactum**
Labrum truncate (pl. 6, fig. 4) . . . . . **farctum**

Bolbocerosoma farctum (Fabricius)

Scarabaeus farctus Fabricius, 1775, p. 14, No. 43; 1781, p. 14, No. 53; 1787, p. 7, No. 56; 1792, p. 22, No. 65.—Herbst, 1789, p. 112, No. 80.—Panzer, 1794, p. 3, No. 8.
Geotrupes farctus (Fabricius) Fabricius, 1798, p. 21, No. 58.
Bolboceras farctus (Fabricius) Kirby, 1818, p. 460.—Klug, 1845, p. 51.
Bolbocerosoma farctum (Fabricius) Schaeffer, 1906, p. 254.—Boucomont, 1911, p. 341.—Dawson and McColloch, 1924, p. 10.—Blatchley, 1928, p. 29 (probably referable to *hamatum*).—Brown, 1928, p. 193.
Scarabaeus cephus Fabricius, 1775, p. 18, No. 64; 1781, p. 19, No. 78; 1787, p. 10, No. 85.—Herbst, 1789, p. 286, No. 177.—Olivier, 1789, genus 3, p. 68.—Palisot de Beauvois, 1805, p. 90, pl. 2b, fig. 5.—Klug, 1845, p. 51.

Length 9 to 13 mm., greatest width 7 to 8 mm.

Dorsum yellow-brown to red-brown, marked with black as follows in male: Eye, vertex, tip of horn, tip of clypeus and eye canthus, transverse pronotal carina, lateral limiting grooves, apical pronotal margin between lateral carinae, band on pronotal base extending laterally no farther than elytral margin, scutellum, sutural intervals, extreme base of elytron, elytral margins, and entire posterior half of elytron forward to subapical umbone. Black area may not extend to subapical umbone in some cases, nor completely suffuse entire posterior portion of elytron, leaving a blackish brown area adjacent to the black margin. Female marked as male; in a few cases the black area of the vague lateral limiting grooves absent. In both sexes ventral portion of head and thorax is yellow to red-brown, with abdomen blackish brown. Foretibia fringed with black. Vortex coarsely, sparsely punctured; punctures of clypeus irregular, dense, and sometimes confluent. Pronotum coarsely, irregularly punctate medially, posterior black area impunctate, lateral portion more finely, closely

punctate, more so anteriorly. Minute secondary punctures evenly distributed over pronotum. Declivity of pronotal modification coarsely punctured only in lower half. Scutellum usually with two or three coarse punctures and numerous minute secondary punctures. The second, fifth, and eighth elytral striae almost obsolete, indicated by a few punctures; second stria having 6 to 12 punctures. Punctures in elytral striae separated by about their own diameter; without setae. Epipleuron and elytral margin each bear a row of long setae. Foretibia usually armed with eight teeth on outer margin. Mesosternal prominence in front of middle coxae only slightly elevated, above metasternal plane. Hair of underside moderately long and dense.

Head of male having a tubercle formed by anterior margin of each eye canthus and one on the median anterior margin of clypeus. Horn in center of vertex pronounced, almost twice as long as tubercle of clypeus and usually slightly bifid at tip (except in worn specimens). Head of female lacking the tubercles on eye canthi and clypeus. Horn of vertex replaced by transverse carina in front of eyes. The carina higher in center with two vague elevations and ending in a small tubercle on each side (usually not noticeable in worn specimens). Pronotal modification of male with transverse carina feebly emarginate. Lateral limiting grooves shallow, lateral carinae small. In the female the transverse carina is slightly developed and evenly arcuate, highest at the midline. The lateral carinae and limiting grooves only barely indicated.

Genital capsule of male elongate, lateral lobes lobate basally, almost three times as long as wide, tipped with a number of long setae (pl. 3, fig. 3).

Variation is mainly evident in the black area of the elytra. Usually the black area covers at least half the area of each elytron, but in a few cases the area may be reduced to vague black spots barely confluent with the sutural and marginal stripes, and then only in anterior portions.

Bolbocerosoma farctum is a wide-ranging eastern species, nowhere common. Other than an occasional reference to its occurrence in local lists of species, nothing has been published on its biology.

In North Carolina the species has been collected in some areas of the mountains, the piedmont plateau, and two localities on the coastal plain. In the localities where I have collected specimens the immediate vicinity has been rather sandy. Specimens have been taken in February, April, May, June, July, August, September, and October, indicating a long period of adult activity. At Oxford, N. C., several light traps were run by the Tobacco Experiment Station for much of the summer, and between Aug. 2–13, 1951, 12 specimens of *farctum* were taken in the traps. After mid-August, no other specimens were

taken. This might indicate a long period of burrowing activity from February to October, but a relatively short time for above-ground activity, in which specimens would come to light. However, an occasional specimen may be taken at light on any warm summer night.

While the adults were fairly commonly collected at light at Oxford, I was never able to locate burrows in the neighboring pasture or woodland. Attempts to make the adults oviposit in cages were completely unsuccessful, and it was only by chance that any information concerning the larval habits was obtained.

In a small, rather open pine woods on the inner coastal plain at Faison, N. C., P. O. Ritcher and I located a colony of *Bolboceras* (formerly *Odontaeus*) *darlingtoni* (Wallis). While digging up this species, larval cells of *Geotrupes blackburnii* were found. Over a period of a month, in two areas about 20 feet apart, we did considerable digging for these species, disturbing a large amount of surface soil. In these areas most of the ground vegetation had been killed or pulled up. In one spot that had been disturbed a month previously, a fresh burrow was noted on Sept. 4, 1951, and dug up. The burrow, containing a female *farctum*, was almost vertical with a plug of yellow sand at its opening, which was at the center of a typical push-up. About 14 inches below the ground surface the female had the burrow packed with very finely divided, black surface humus mixed with sand. As this was the same material that *Bolboceras darlingtoni* (Wallis) had been noted to provision for its larva, a very careful examination of the material was made, but with no results.

A further examination of the entire area was made on September 4, but no additional burrows were discovered until September 11 when a fresh burrow was noted and marked with a stake. This burrow was not disturbed until Oct. 31, 1951, when it was carefully excavated.

The burrow itself was at the edge of an old dirt road that ran through the area (pl. 16, figs. 1, 2). Vegetation was rather sparse in the sandy soil, but the immediate area had not been disturbed by previous digging. Partial shade was afforded by a single loblolly pine, and there were a few clumps of *Andropogon*. Other than that the ground was bare. The entrance of the burrow was marked by the usual push-up, a mound of yellow sand 3 to 4 inches in diameter and about 2 inches high. When the burrow was excavated the rain had almost obliterated the push-up and burrow entrance.

The vertical burrow (diagrammed on pl. 10, fig. 3) was open 8 inches. It then was filled with sand that was slightly darker than the sand of the surrounding subsoil. This portion continued to a depth of 16 inches and was slightly sinuate, but generally vertical. At the 16-inch level all trace of the burrow was lost, but digging was continued. At 18 inches the burrow suddenly reappeared, this time

filled with very finely divided, black surface humus and sand. The burrow was no longer vertical, having veered to one side at an angle of approximately 40 degrees. Also, the subsoil had suddenly become considerably damper. The portion of the burrow packed with the black humus was slightly over 3 inches long, going to a depth of 22 inches. In its slightly tapered lower end was a fully grown third-stage larva. The larva appeared to be in an oval pupal cell, 17 by 10 mm. at its widest point, and within one-half inch of the lower end of the burrow. The position of the pupal cell can be noted in the diagram (pl. 10, fig. 3). Plate 13, figure 2, shows the larva as it was found in the burrow. Most of the black humus in the burrow, about 60 mm. of it, had been in large part consumed, being replaced by very small, scattered, dry, black fecal pellets. The food cell (pl. 13, fig. 2), even though largely consumed, had the same general appearance as the unconsumed humus noted in the burrow dug on Sept. 4, 1951. The larva was immediately preserved and is subsequently described. It is evident that the larva of *farctum*, as in other Geotrupinae, has a rapid development. The burrow was made between Sept. 4–11, 1951, and the full grown larva was found on October 31; this indicates a maximum period of development of slightly under two months.

On the same date, Oct. 31, two other fresh burrows were discovered. The first burrow, largely concealed by a covering of dead oak leaves, was in a rather shaded spot. The burrow yielded a single, newly emerged female at a depth of 14 inches. The excavation of the second burrow produced a slightly teneral male at a depth of 11 inches. Both specimens, apparently newly transformed, were making fresh burrows, but no evidence of any old burrows could be found.

Further careful search of the area and subsequent visits in 1951 and 1952 did not yield further specimens.

The following description of the larva of *Bolbocerosoma farctum* is based on one third-stage larva collected Oct. 31, 1951, at Faison, N. C., by H. Howden and P. O. Ritcher, from a burrow previously marked.

The larva differs from Ritcher's (1947, pp. 11, 12) description of *Bolbocerosoma* in the following respects: Maximum width of head capsule 3.4 mm. Antennae (pl. 6, fig. 2) and head capsule almost identical except for an additional exterior frontal seta on one side (making the number 2 or 3), and 4 to 6 anterior frontal setae. Labrum entire, truncate (pl. 6, fig. 4), width 2½ times greater than length. Mandibles, maxillae, hypopharynx, and glossa not varying in any particular from Ritcher's description. Tormae of epipharynx (pl. 6, fig. 4) not united mesally, each with a pternotorma, on the inside of which are found 3 to 5 sensilla. Otherwise epipharynx is similar.

Morphological characteristics of spiracles, body (pl. 13, fig. 1), and legs do not vary from Ritcher's description.

The single unassociated larva which Ritcher described was collected at Dover, Del., October–November 1941. Ritcher believed it was probably the larva of *Bolbocerosoma tumefactum* as it is the common species in that area. However, the larva upon which Ritcher based his description was compared with the Faison specimen of *B. farctum* and was found to be almost identical. The few differences noted, with the possible exception of the truncate labrum, could very easily be normal variation within a species. In *Bolboceras* (and perhaps *Eucanthus*) the known larvae show a number of interspecific differences, and I would suspect this to be true in *Bolbocerosoma*. Certainly, more information is needed concerning the larvae of this interesting group.

Specimens examined: 93 males, 89 females.

CONNECTICUT: 1 female. Bridgeport; (1) July.
DISTRICT OF COLUMBIA: 3 females. Rock Creek; (2) July, (1) August.
GEORGIA: 3 females. Atlanta, Thomasville (?), (2) September.
KENTUCKY: 1 male. Eden; (1) July.
LOUISIANA: 2 males, 2 females. Baton Rouge, Covington, Shreveport; (1) April, (2) March.
MARYLAND: 4 males, 7 females. Cabin John (Burning Tree Golf Links), Chevy Chase, Edgewood, Plum Point, Towson; (7) June, (1) July, (1) August, (1) September, (1) October.
MISSISSIPPI: 7 males, 3 females. Camp Shelby, Harrison County, Leakesville, Lucedale, Starkville; (1) April, (2) May, (1) June, (1) July, (1) September, (2) October.
NEW JERSEY: 20 males, 21 females. Merchantville, Newark, Rancocas; (2) June, (2) July, (24) August, (10) September, (1) October.
NEW YORK: 6 males, 6 females. Babylon, Cold Spring Harbor, Flushing, Southold, West Point; (2) August.
NORTH CAROLINA: 25 males, 14 females. Asheville, Faison, Hickory, Hillsboro, Julian, Monroe, Oxford, Raleigh; (1) February, (2) April, (6) May, (3) June, (4) July, (18) August, (2) September, (2) October.
OHIO: 1 female. No data.
PENNSYLVANIA: 3 males, 4 females. Delaware County, Frankford, Germantown, Glen Olden, Jeannette; (1) April, (2) July, (1) October.
SOUTH CAROLINA: 20 males, 9 females. Chesterfield, Clemson College, Greenville, Jocassee, Oconee County, Rocky Bottom, Table Rock, Tunnel Walhalla; (1) May, (1) June, (14) July, (13) August.
TENNESSEE: 3 males, 6 females. Clarksville, Deer Lodge; (7) July.
VIRGINIA: 2 males, 8 females. Falls Church, Fredericksburg, Herndon, Nelson County; (1) May, (1) June, (1) July, (8) August, (1) October.
WEST VIRGINIA: 1 female, White Sulphur Springs; (1) August.

Bolbocerosoma confusum Brown

Bolbocerosoma confusum Brown, 1928, p. 194. Type, male, Oklahoma (CC).

Length 10 to 12 mm., greatest width 7 to 8.5 mm.

Dorsum reddish brown, marked with black as follows in male: Vertex and at least part of the clypeus, eyes, eye canthi, apical pronotal margin between lateral carinae, all of pronotal declivity except at midline, lateral limiting grooves, band on pronotal base not extending forward at midline and extending laterally no farther than elytral margin, scutellum, sutural intervals, extreme base of elytron, usually apical half of elytral margin, and an oval spot. Oval spot slightly postmedian, parallel to the striae, extending from fourth to eighth elytral striae, almost twice as long as wide (figured by Brown). Spot is not confluent with any other black area, and is not vague in outline. Female marked as male. In both sexes ventral thoracic sclerites and legs except femora in part, blackish; abdomen brown or brownish yellow. Vertex coarsely, somewhat sparsely punctate; punctures of clypeus slightly irregular, dense, generally not confluent. Pronotum coarsely, moderately, irregularly punctate medially, punctures becoming fine, close laterally. Minute secondary punctures evenly distributed over pronotum. Lower half or two-thirds of declivity of pronotal modification coarsely punctured. Scutellum, usually with only minute secondary punctures. The second, fifth, and eighth elytral striae obsolete, indicated by a few punctures. Second stria indicated by 8 to 10 punctures, fifth and eighth striae slightly more pronounced. Punctures in striae moderate, usually separated by distance of about 1.5 times their diameter, without setae. Epipleuron with a few long and numerous short setae. Margin of elytron with only a very few long setae and a number of minute ones. Mesosternal prominence in front of middle coxae slightly elevated above plane of metasternum. Hair of underside long and moderately dense.

Head of male with tubercles on eye canthi and clypeus small. Horn in center of vertex moderate, slightly smaller than in *B. farctum* Fabricius, slightly bifid at tip (except in worn specimens). Head of female lacks tubercle, but has carina similar to females of *farctum*. Pronotal modification of male with transverse carina feebly emarginate. Lateral limiting grooves shallow to moderate, lateral carinae small. In the female the transverse carina less developed and evenly arcuate. The lateral carinae and limiting grooves only barely indicated.

Genital capsule of male somewhat elongate, lateral lobes approximately twice as long as wide, apical angle less prolonged than in *B. farctum*, tipped with a few long setae (figured by Brown).

Variation in elytral maculation is moderate; the oblong spot is fairly uniform, but the elytral margins may or may not be marked with black. *B. confusum* may be distinguished from other species having elytral spots by the absence of a median forward dentiform projection of the posterior pronotal black area and by the lack of any setae in the elytral punctures, except for a few seta-bearing punctures at the margin and on the epipleuron.

Biologically, little is known about this species. Brown (1928, p. 192) mentions collecting *B. confusum* in a mixed aggregation with *B. biplagiatum*. Occasional specimens have been collected at light, indicating at least some nocturnal activity. From the label data on specimens examined, the adults appear to be active during March, April, May, August, September, October, and November, with the fall months being the period of greatest activity.

Specimens examined: 27 males, 22 females.

ARKANSAS: 10 males, 6 females. Fayetteville, Hope, Imboden, Washington County: (2) August, (1) September, (4) October, (2) November.
ILLINOIS: 2 males, 1 female. Olney.
IOWA: 1 male. Ames. Paratype, from literature.
LOUISIANA: 2 males, 2 females. Camp Claiborne, Lafayette, Opelousas; (1) October.
MISSOURI: 2 males, 2 females. Columbia, Scott County, Springfield; (1) May, (3) November.
OKLAHOMA: 4 males, 4 females. Payne County, Stillwater; (1) May, (1) September, (4) October.
TEXAS: 6 males, 7 females. Brazos County, College Station, Dallas County, Rockwall; (2) March, (1) April, (1) May, (1) September, (2) November.

Bolbocerosoma tumefactum (Palisot de Beauvois)

Scarabaeus tumefactus Palisot de Beauvois, 1805, p. 91, pl. 2, fig. 6.
Bolboceras tumefactus (Palisot de Beauvois) Klug, 1845, p. 50.
Bolbocerosoma tumefactum (Palisot de Beauvois) Schaeffer, 1906, p. 254.—Dawson and McColloch, 1924, p. 13.—Brown, 1928, p. 193.—Ritcher, 1947, pp. 11–12.

Length 8 to 11 mm., greatest width 5.5 to 8 mm.

Dorsum orange-brown to red-brown, marked with black as follows in male: Eye, eye canthus, vertex, tubercles, horn, usually most of clypeus, tips of carinae of pronotal modification, basal portion of lateral limiting grooves, apical pronotal margin between lateral carinae, median spot behind pronotal modification, narrow band widest medially, extending laterally no farther than elytral margin, scutellum, extreme base of elytra, elytral margin, sutural intervals, and postmedian spot normally confluent only with elytral margin. Postmedian spot in a few instances touching black sutural interval in

posterior third. In females, the only black pronotal markings may be medial pronotal spot behind the transverse carina, or in some cases the spot is produced into a broad band running the length of the pronotum; otherwise markings are similar to male. Ventral portions of thorax and abdomen brownish yellow. Tibia reddish brown to black. Vertex and clypeus densely, coarsely, irregularly punctured, least in posterior portion of vertex, more so on clypeus. Pronotum coarsely, irregularly punctate medially, lateral portions more finely, closely punctured, more so anteriorly. Minute secondary punctures evenly distributed over pronotum. Declivity of pronotal modification coarsely punctured mainly in lower half, but with a few punctures scattered over entire face in some cases. Scutellum with vague, median indentation running its length and with minute secondary punctures. All elytral striae well developed except basal portion of eighth. Poorly delimited punctures usually separated by slightly less than own diameter, closer together than in *farctum*. Elytron without setae, except epipleuron and elytral margin each bearing a row of long setae. Foretibia armed with seven or eight teeth on outer margin. Mesosternal prominence in front of middle coxae well developed, only slightly concave on anterior face, elevated above mesosternal plane.

Head of males with tubercles moderate, horn well developed, not generally bifid at tip. In male, pronotal modification well developed; pronounced transverse carina moderately emarginate, scarcely wider than upper portion of lateral limiting groove, much narrower than in *B. bruneri*. Lateral carinae and limiting grooves well developed. In female transverse carina small and evenly arcuate, lateral carinae and limiting grooves obsolete.

Genital capsule of male (pl. 3, fig. 1) moderately elongate, not lobate basally, tip of lateral lobe rounded, not prolonged as in *B. farctum*, similar to *B. bruneri*.

One of the most variable species of *Bolbocerosoma* in extent of the black markings, it is still easily distinguished by the median black pronotal spot or stripe, the well developed elytral striae, and usually by the postmedian black spot confluent with elytral margin, but not with sutural interval.

Bolbocerosoma tumefactum, the most common northeastern species, is particularly abundant in some areas of New Jersey, Maryland, and Pennsylvania, where on occasion it has been found burrowing in golf courses to such an extent that it was considered a pest.

The species is active from May until October, with the majority of specimens being collected in July and August. A few specimens were collected at light, indicating some nocturnal surface activity. Sim (1930, pp. 139–147) mentioned collecting many specimens near

Rancocas, N. J. They were commonly taken at the golf course and along old sandy roadways which were not too well shaded. This was the same type of habitat where Sim also found *Bolboceras* and *Eucanthus*. Between Aug. 21 and Oct. 3, 1927, in this locality, Sim was able to collect 75 specimens of *tumefactum*.

In North Carolina, South Carolina, and Georgia, *tumefactum* appears to be limited to the mountains and upper piedmont regions, while in more northern states it can be found on the sandy coastal plain.

Nothing is known of the larval food or habits.

Ritcher (1947, pp. 11, 12) described a single larva of *Bolbocerosoma tumefactum* collected near Dover, Del. I have already expressed doubt over the specific value of the vague differences between this larva and that of *farctum*. However, the broadly rounded labrum may be a consistent difference. Additional larvae are needed to decide the limitations of intraspecific variation.

Specimens examined: 96 males, 111 females.

CONNECTICUT: 2 males, 2 females. East Norwalk, Hamden, Hartford; (2) June, (2) July.

DELAWARE: 1 male. No data.

DISTRICT OF COLUMBIA: 1 male, 2 females. Rock Creek; (2) June.

GEORGIA: 2 females. Blue Mountain (Towns County); (1) August.

MARYLAND: 19 males, 23 females. Bryantown, Cabin John (Burning Tree Golf Links), College Park, Glen Echo, Mountain Lake Park, Sandy Springs, T. B. Junction; (8) May, (28) June, (2) July, (1) September, (1) October.

MASSACHUSETTS: 3 females. Amherst; (3) June.

NEW HAMPSHIRE: 1 female. Lyme; (1) June.

NEW JERSEY: 9 males, 15 females. Alpine, Hewitt, Hopatcong, Newark, Passaic, Paterson, Ramsey, Rancocas, Westwood; (2) June, (3) July, (10) August, (5) September.

NEW YORK: 5 males, 2 females. Babylon, Cold Spring Harbor, Farmingdale, Flushing, New York City, Pelham; (3) June, (3) July, (1) August.

NORTH CAROLINA: 15 males, 19 females. Balsam, Black Mountains, Blowing Rock, Cranberry, Marion, Raleigh, Sunburst, Waynesville; (9) June, (8) July, (11) August, (3) September.

OHIO: 2 males. Holmes County, Springfield (Muskingum County); (1) June, (1) September.

PENNSYLVANIA: 25 males, 20 females. Allegheny County, Angora, Aspinwall, Broomall, Chester County, Clarkes Valley, Delaware County, Downington (=Downingtown?), Germantown, Green Lane, Harrisburg, Jeannette, Lebanon County, Lehigh Gap, Nicktown, Philadelphia, Pittsburgh, Somerset County, Springfield, Swarthmore, Water Gap, "Westtown Sch.," Windgap; (1) May, (7) June, (13) July, (5) August, (1) September.

SOUTH CAROLINA: 5 males, 6 females. Kings Creek (Oconee County), Oconee County, River Falls, Rocky Bottom, Sassafras Mountain, Tunnel Walhalla; (2) June, (4) July, (3) August, (2) September.

VIRGINIA: 7 males, 9 females. Cobham, Falls Church, Glen Lyn, Middletown, Mountain Lake Biological Station (Giles County), Nelson County, Warrenton; (1) May, (2) June, (5) July, (5) August, (1) September.

WEST VIRGINIA: 5 males, 7 females. Beckley, Lewisburg, White Sulphur Springs; (9) July, (2) August.

Bolbocerosoma bruneri Dawson and McColloch

Bolbocersoma bruneri Dawson and McColloch, 1924, p. 14 (type, male, Nebraska (UnNeb)).—Dawson, 1922, p. 194.—Brown, 1928, pp. 192–193.
Bolbocerosoma farctum Blatchley (not Fabricius), 1910, p. 937.

Length 8.5 to 14.5 mm., greatest width 6.5 to 9.5 mm.

Dorsum yellow to reddish brown, marked with black as follows in male: Eyes, vertex of canthus, tubercles, horn, part of clypeus, tips of tubercles of pronotal modification, lateral limiting grooves, apical pronotal margin between lateral carinae, band on pronotal base extending laterally no farther than elytral margin, scutellum, extreme base of elytra, sutural stripe, margin of elytra below humeri extending in a few cases to apex and large posterior spot confluent with sutural stripe. Posterior spot usually not confluent with elytral margin except at apex. Female marked as male except the only black on pronotal modification is trace along transverse carina. In both sexes ventral surface reddish brown, slightly darker on abdomen. Tibia edged with dark brown. Vertex and clypeus coarsely and densely punctured. Pronotum coarsely, irregularly punctate medially, more so than in either *farctum* or *tumefactum*. Lateral portion of pronotum more finely, closely punctate, more so anteriorly. Minute secondary punctures evenly, rather densely distributed over pronotum. Declivity of pronotal modification coarsely punctured only in lower half. Scutellum with numerous secondary punctures. All elytral striae well developed, except basal portion of eighth. Punctures in elytral striae separated by about one-half their diameter, without setae. Epipleuron and elytral margin each bear a row of long setae. Foretibia usually armed with eight teeth on outer margin, sometimes with seven or nine. Mesosternal prominence in front of middle coxae well developed, concave on anterior face and elevated above metasternal plane. Hair of underside long, not dense.

Head of male with pronounced tubercles and horn, not bifid at tip. In male, pronotal modification well developed. Pronounced transverse carina widely emarginate, more so than in *tumefactum*. Lateral limiting grooves deep, lateral carinae moderate. In female, transverse carinae small, evenly arcuate. Lateral limiting grooves and lateral carina obsolete.

Genital capsule of male (figured by Brown) moderately elongate, not lobate basally, tip of lateral lobe rounded, not prolonged as in *B. farctum*. Similar to *B. tumefactum*.

Variation of pattern is quite pronounced, clypeus either entirely black or brown. One-third to one-half of the posterior portion of elytra is black, and elytral margin may be entirely black or brown.

Despite variation the species is easily recognized by the well developed striae and the lack of the median pronotal spot or band present in *tumefactum*.

Bolbocerosoma bruneri is the common midwestern species of *Bolbocerosoma*, apparently taking the place of the closely related common northeastern species *tumefactum*.

The habits of the species appear in general to be similar to other species in the genus. Brown (1927, p. 27) found them making burrows 4 to 18 inches deep in pastures and old roads where the soil was rather sandy. His observations were made in Payne County, Okla., where that species was rather uncommon, being collected only in June and October.

Later, Brown (1928, p. 192) mentions that the species is nocturnal and colonial, often being found in an aggregation containing several species of *Bolbocerosoma*, and sometimes other Geotrupinae.

In other localities, particularly in Illinois and Iowa, the species is active from April until November, being most often collected in June, July, and August. A number of the specimens examined were collected at light, but this fact adds little to the biological knowledge of the species.

To my knowledge, no accurate observations of an adult *Bolbocerosoma* feeding have been made. Mohr (1930, p. 265) seems to infer (in my opinion, incorrectly) that *bruneri* feeds on dung. He conducted a study of the morphology of the forelegs and mouthparts, and, because of their structure rather than on biological observation, included *B. bruneri* with the dung feeders.

Little else is known about the habits of this species; the larva has never been described.

Specimens examined: 145 males, 130 females.

CANADA

MANITOBA: 1 male. Woburn.

UNITED STATES

ARKANSAS: 4 females. Imboden.

ILLINOIS: 37 males, 29 females. Algonquin, Carthage, Chicago, Cook County, De Kalb County, Homer, Kankakee, Lacon, Lake Forest, Ogle County, Olive Branch, Olney, Pittsfield, Putnam County, Quincy, Rogers Park, Springfield, Urbana, West Northfield, Willow Springs; (1) April, (2) May, (6) June, (2) July, (5) August, (4) September, (2) October, (1) November.

INDIANA: 4 males, 4 females. Bedford, Beverly Shores, Knox County, Michigan City, Vincennes; (1) May, (4) June, (3) July.

IOWA: 35 males, 35 females. Ames, Cedar Rapids, Cherokee, Clear Lake, Clermont, "Counties #3, #87, #89, #94," Crawford County, Dallas County, Davis County, Delaware County, Elma, Iowa City, Moulton, Mount Pleasant, Randolph, Union County; (3) May, (11) June, (15) July, (9) August, (4) September, (8) October.

KANSAS: 17 males, 9 females. Atchison County, Douglas County, Fort Leavenworth, Johnson County, Lawrence, Manhattan, Onaga, Wallace County, west Kansas; (2) June, (3) July, (2) August (3) September,
KENTUCKY: 8 males, 11 females. Lexington, Louisville, Nicholasville, Paris, Princetown, Sadieville; (3) May, (1) June, (3) July, (3) August, (5) September, (2) October.
MICHIGAN: 2 males, 4 females. Detroit, Livingston County, Macatawa Beach; (1) May, (1) July.
MINNESOTA: 5 males, 3 females. Fort Snelling, Minneapolis, Red Wing, St. Paul; (1) June, (1) July.
MISSOURI: 12 males, 8 females. Affton, Columbia, Kirkwood, New Hartford, St. Louis, Springfield, Willard; (2) May, (4) June, (4) July, (2) August, (2) October.
NEBRASKA: 2 males, 4 females. Bennet, Lincoln, Malcolm, Norfolk; (2) June, (1) September.
NEW MEXICO: 1 male. No data.
OHIO: 4 males, 2 females. Columbus, Pickaway County; (1) June.
OKLAHOMA: 1 male. Wichita National Forest; (1) June.
SOUTH DAKOTA: 5 males, 3 females. Elk Point, Interia (Stanley County), Volga; (1) June, (1) August.
TEXAS: 2 males, 3 females. Fedor.
WISCONSIN: 8 males, 10 females. Gays Mills, Madison, Milwaukee, Neillsville, Oshkosh, Racine; (1) April, (2) May, (9) June, (1) July, (1) August, (2) September, (1) October.
WYOMING: 1 male, 1 female. Bridger Basin.

Bolbocerosoma hamatum Brown

Bolbocerosoma hamatum Brown, 1929, p. 213. Type, male, Georgia (CU).

Length 10 to 11 mm.; greatest width 7 to 8 mm.

Dorsum reddish brown, male marked with black as follows: Vertex, eye canthi, margin of clypeus, tubercles and limiting concavities of pronotal carina, entire anterior margin of pronotum, broad band on pronotal base between the elytral humeri, scutellum, extreme base of elytra except the humeri, sutural intervals, and about two-thirds of each elytron with an area extending from humerus and sutural interval at basal fourth to apex, not including the apical umbone; ventral surfaces light orange-yellow; outer margin of tibia blackish brown. Female with markings similar to male, except on the elytron where the large posterior black elytral markings are only vaguely confluent with black elytral margin; a thin brownish red band running just above elytral margin nearly to apex. Vertex coarsely, sparsely punctured, punctures of clypeus irregular, dense, sometimes confluent. Pronotum rather heavily, coarsely, irregularly punctured medially, posterior black area lacking punctures except at anterior edge, lateral portions of pronotum with punctures becoming finer, dense and feebly impressed, more so anteriorly. Minute secondary punctures evenly distributed over pronotum. Declivity of pronotal modification coarsely, indistinctly, and sparsely punctured only in lower half.

Scutellum with small coarse punctures present, but vague. Second elytral stria obsolete, represented basally by four or five fine and very feeble punctures. Fifth and eighth striae obsolete, represented by a vague row of fine punctures; the five well-developed striae between suture and humeral umbone deep and coarsely punctured, dorsally without hairs. Punctures separated by slightly more than their diameter. Epipleuron and elytral margin each bear a row of setae. Foretibia usually armed with eight or nine teeth on outer margin. Mesosternal prominence in front of middle coxae acute, not elevated above the plane of the metasternum. Hair of underside not dense.

Head of both sexes similar to that of *Bolbocerosoma farctum* Fabricius. The transverse carina of female with only a trace of the small lateral tubercle. Pronotal modification of male poorly developed; the carina somewhat emarginate medially, the tubercle at each end very small and vague. Pronotal disk of holotype with a broad, rather feeble, but distinct depression on each side midway between the pronotal modification and humeral umbone of elytron. This depression is lacking in some of the other specimens examined. In the female the carina is evenly arcuate, with lateral carinae obsolete, barely indicated by slight swellings.

Genital capsule of male short, lateral lobes no longer than wide. The distinctive characteristic of the species is the lateral lobes of the genitalia which are deflexed at their apices to form hooks. (Figured by Brown.)

Variation was slight in the few specimens examined. The pronotal depressions do not appear too consistent, but the pattern seems fairly constant, with the large black area of the elytron usually separated in the females from the black elytral margin except at the apex.

B. hamatum was probably the species mentioned in Blatchley (1928, p. 29) as *farctum:* Collected at "Gainesville, one, July 30, flying over grass of wet prairie; one, Aug. 3, beneath loose bark of pine (Doz.)" (Dozier, 1920). From the data on the few specimens examined, the adults appear to be active for a large part of the year.

Specimens examined: 5 males, 6 females.

FLORIDA: 1 male, no date (Robinson). 1 female, no date (MCZ). 1 male, 2 females, Gainesville, Apr. 6 and Oct. 5, 1935, Young (UnMich). 1 female, Kissimmee (Cartwright). 1 male, Lakeland, Sept. 11, 1919 (Robinson). 1 female, St. Augustine, Liebeck Collection (Fall at MCZ). 1 male, Steinhatchee River, April (AMNH).

GEORGIA: 1 male (holotype 1578), Billy's Island, Okefenokee Swamp (CU). 1 female, Chickamauga, June 26, 1898, Viereck (USNM).

***Bolbocerosoma lepidissimum* Brown**

Bolbocerosoma lepidissimum Brown, 1928, p. 193. Type, male, Oklahoma (CC).

Length 8.5 to 11 mm., greatest width 6 to 7.5 mm.

Dorsum pale brownish yellow to light reddish brown, marked with brown to black as follows in male: Eye, vertex, tip of horn, tips of clypeus and eye canthus, lateral portions of transverse pronotal carina, lower half to two-thirds of lateral limiting groove, narrow line on apical pronotal margin, between lateral carinae, band on pronotal base extending laterally no farther than elytral margin, scutellum, sutural intervals, extreme base of elytron except humerus, elytral margins and posterior half to two-thirds of elytron from sutural interval to elytral margin but not including the subapical umbone. Small spot at apex of elytron usually not blackish. Punctures in elytral striae often noticeably blackish in color. Female similarly marked. In both sexes ventral portion of head and thorax yellow to reddish yellow, abdomen brownish yellow to brown. Outer margin of at least foretibia edged with black. Vertex of male finely, sparsely punctured; punctures of clypeus rather coarse and close, but not well defined. Coarse medial punctures of pronotum very sparse, becoming slightly smaller and more dense laterally; posterior black area impunctate. Minute, indistinct secondary punctures evenly distributed over pronotum. Declivity of pronotal modification sparsely, coarsely punctured only in lower third or half. Scutellum with minute secondary punctures. Punctures of female (from Brown): Head densely, rather coarsely punctate; a space on the vertex smoother; pronotum at middle very sparsely, irregularly punctate; the punctation of the sides finer and dense; the declivity with moderately close, coarse punctures on apical half, the basal half very finely punctate. Second elytral striae entirely lacking, fifth and eighth striae not impressed, represented by only a few small punctures. Pronounced punctures in elytral striae separated by slightly more than their diameter, without setae. Epipleuron and elytral margin each bear a row of long setae. Foretibia armed with eight teeth on outer margin. Mesosternal prominence in front of middle coxae acute, elevated slightly above metasternum. Hair of underside fairly long and moderately dense.

In male, the tubercles of clypeus and eye canthi similar to those of *B. farctum*, slightly thinner dorsoventrally. Horn in center of vertex pronounced, noticeably smaller in width than *B. farctum*, usually slightly bifid at tip (when not worn). Female lacking horn and tubercles, but with carina similar to female of *B. farctum*. Pronotal modification of male with transverse carina feebly emarginate. Lateral limiting grooves very shallow, lateral carina only vaguely indicated. Brown states that the pronotal modification of female is

of usual type, not strongly developed, the limiting concavities and tubercles obsolete.

Genital capsule of male (figured by Brown) blunt, lateral lobe 1.5 times as long as wide, tipped with a number of very long setae, a few being almost as long as the capsule.

Variation of color was quite pronounced in the few specimens examined, one specimen with light yellowish tan markings, and another with the markings almost black. Generally all of the specimens have a faded appearance.

The complete lack of second elytral stria, the sparse punctures, the male genitalia, and usually the color will distinguish this species.

Brown (1928, p. 192) mentions finding *lepidissimum* with *bruneri* and *biplagiatum*, presumably with the same nocturnal and burrowing habits as the other species. Nocturnal activity is also indicated by one of the few specimens examined bearing the label "at light." Specimens, to date, have only been collected in June and July but probably have a longer period of adult activity.

Specimens examined: 3 males, 1 female.

ARKANSAS: 1 male, Washington County, July 18, 1928 (INHS).
ILLINOIS: 1 male, Anna, June 27, 1909, at light (Howden).
LOUISIANA: 1 male, Vernon Park (AMNH).
OKLAHOMA: (Type and allotype, from literature, Payne County, October, Brown (CC).)
TEXAS: 1 female, Marathon (Brewster County) (Robinson).

Bolbocerosoma biplagiatum Dawson and McColloch

Bolbocerosoma biplagiatum Dawson and McColloch, 1924, p. 12 (type, male, Nebraska (UnNeb)).—Dawson, 1922, p. 194.—Brown, 1928, p. 193.

Length 8.5 to 13.5 mm., greatest width 6.5 to 9 mm.

Dorsum orange-brown to red-brown, marked with black as follows in male: Vertex, most of clypeus, eyes, eye canthi, apical pronotal margin between lateral carinae, lateral limiting grooves, lateral portions of transverse carina, lateral portions of pronotal declivity, band on pronotal base extending sharply forward at midline (dentiform point), and extending laterally no farther than elytral margin, scutellum, extreme base of elytra, sutural intervals, and a small almost circular postmedian spot. This spot is usually scarcely longer than wide and is separated from both the sutural interval and elytral margin by about its own width. Female marked as male except the black of the lateral limiting grooves may be lacking. In both sexes the ventral portions of thorax and abdomen dull yellowish brown, some of thoracic sternites may be black; femora dark brown to black. Vertex coarsely, sparsely punctate, less so in females; punctures of clypeus slightly irregular, dense, generally not confluent. Pronotum

coarsely, moderately, irregularly punctate medially, punctures becoming fine, close laterally. Minute secondary punctures evenly distributed over pronotum. Lower half of pronotal declivity of male coarsely, sparsely punctured, more heavily and completely punctate in female. Scutellum usually with only minute secondary punctures. The second, fifth, and eighth elytral striae obsolete, indicated by a shallow indentation or a few punctures or both. Second stria indicated by four to eight punctures, fifth and eighth striae slightly more pronounced. Punctures in striae moderate, usually separated by slightly more than their own diameter; without setae. Elytral margin and epipleuron each with a row of moderately long setae and numerous short setae. Metasternal prominence in front of middle coxae small and only slightly elevated above plane of mesosternum. Hair of underside long and moderately dense.

Head of male with tubercles on eye canthi and clypeus moderate to well developed. Horn of vertex long, not bifid at tip. Head of female lacks tubercles and horn, but has carina similar to females of *B. farctum*. Pronotal modification of male moderately to strongly emarginate. Lateral limiting grooves and carinae moderate. In female the transverse carina is less developed and evenly arcuate. The lateral carinae and limiting grooves only barely indicated.

Genital capsule of male short and blunt, about 1.5 times as long as wide, tipped with long setae. Genital capsule is very different from that of *B. confusum*, which is much more elongate.

Variation in the specimens examined is slight. The species can be easily distinguished by the almost circular postmedian elytral spot, the median dentiform point of the black border of posterior pronotal margin, the male genital capsule, and pronounced horn and tubercles of well developed individuals.

B. biplagiatum was mentioned by Brown (1927, p. 27) as occurring with other species in pastures and old sandy roads. He reiterates later (1928, p. 192) that the species is colonial, occurring in mixed colonies with other species.

Adults have been collected occasionally at light and are active from May until October. At no time are they common, but appear to be more numerous in the fall.

Specimens examined: 25 males, 26 females.

KANSAS: 14 males, 14 females. Clark County, Douglas County, Larned, Medora, Norton County, Rush County; (2) May, (2) June, (1) July, (2) August.

NEBRASKA: 1 female. Cambridge; (1) August.

OKLAHOMA: 10 males, 8 females. Payne County, Noble County; (1) May, (1) June, (6) September, (10) October.

TEXAS: 1 male, 3 females. Dallas.

WISCONSIN [Paratype, male, from literature, Trout Lake (Vilas County).]

Bolbocerosoma pusillum Dawson and McColloch

Bolbocerosoma pusillum Dawson and McColloch, 1924, p. 11 (type, male, Kansas (KanStU)).—Dawson, 1922, p. 194.—Brown, 1928, p. 193.

Length 6 to 10 mm., greatest width 4 to 7 mm.

Dorsum reddish brown marked with black as follows in male: Vertex, most of clypeus, eyes, eye canthi, apical pronotal margin between lateral carina, lateral limiting grooves and inner portions of adjacent tubercles of transverse and lateral carinae, band on pronotal base very narrow at midline and extending no farther than elytral margin, scutellum, extreme base of elytra, sutural intervals, and entire apical two-fifths of elytra extending from sutural interval to margin. The black area barely reaches margin, and then usually only in apical fourth. Females marked as male except at pronotal modification where there is only a trace of black along the transverse carina and in lateral limiting grooves. Ventral surface of both sexes reddish brown. Tibia of males edged with trace of black, females with tibia usually entirely brown. Vertex coarsely, moderately punctured, usually more so in female, punctures of clypeus generally regular and dense. Pronotum coarsely, irregularly punctate, lateral portions more finely, closely punctured, more so anteriorly. Minute secondary punctures evenly distributed over pronotum. Declivity of pronotal modification in male coarsely punctured only in lower half, female in some cases with some punctures over entire declivity. Scutellum usually with faint groove running its length, with moderate number of secondary punctures. Second elytral stria obsolete, represented by shallow groove or two or three minute punctures. Fifth and eighth striae indicated by a line of small punctures. Punctures in striae usually not well delimited, generally separated by about their own diameter. Many of elytral punctures and other scattered punctures of elytra and pronotum bearing long erect yellow hairs. Long setae also present on epipleura and elytral margins. Foretibia usually armed with seven teeth on outer margin, but sometimes with eight, rarely six. Mesosternal prominence only slightly developed in front of middle coxae, not elevated above plane of metasternum. Hair of underside long and moderately sparse.

Head of male with tubercles of eye canthi and clypeus pronounced, sharply upturned. Horn in center of vertex long, somewhat conical, tip not bifid. Head of female with suggestion of a tubercle on eye canthus, but none on clypeus. Horn of vertex replaced by a transverse carina which has four small but noticeable tubercles, one at each end of the carina and two slightly more than halfway toward the median line. Pronotal modification of male with the pronounced transverse carina deeply emarginate. Lateral limiting grooves deep, lateral carinae large and elongate. In the female the transverse

carina is slightly developed, evenly arcuate. Lateral limiting grooves and lateral carinae barely indicated.

Genital capsule of male blunt (pl. 3, fig. 6), lateral lobe about 1.3 times as long as wide, tipped with a dozen or so long setae.

A moderate amount of variation is present in the extent of the subapical black spot, but it is always confluent with sutural interval, and this coupled with the long erect yellow setae will distinguish the species. The number of setae on the pronotum and elytra vary considerably and sometimes are overlooked on hasty examination.

Nothing has been published on the biology of *pusillum*. Specimens examined were collected from April through November, except during August, indicating a long period of adult activity.

Specimens examined: 25 males, 25 females.

COLORADO: Paratype (from literature), 1 female. No data.
ILLINOIS: 1 male. Chicago (?).
KANSAS: 6 males, 3 females. Manhattan, Onaga, Riley County, Wallace; (2) June, (1) July.
OKLAHOMA: 1 male. Wichita National Forest.
TEXAS: 17 males, 22 females. Abilene, Amarillo, Brownsville, Comfort, Coryell County, Dallas County, Fedor, Liberty Hill, New Braunfels, Val Verde County, Wichita Falls; (2) April, (5) May, (3) June, (1) July, (1) September, (1) November.

***Bolbocerosoma pusillum townesi*, new subspecies**

HOLOTYPE: Male, length 10.5 mm., greatest width 7.2 mm.

Dorsum reddish brown marked with black as follows: Vertex, most of clypeus, eyes, eye canthi, apical pronotal margin between lateral carinae, lateral limiting grooves and inner portions of adjacent tubercles of transverse and lateral carinae, band on pronotal base very narrow at midline, broader laterally and extending no farther than elytral margin, scutellum, extreme base of elytra, sutural intervals, and entire apical two-fifths of elytra extending from sutural interval almost to margin. The black area barely reaches margin of elytra and then only in apical fourth. Ventral surface brownish black. Tibiae brownish black. Vertex coarsely, moderately punctured, punctures of clypeus generally regular and dense. Pronotum coarsely, irregularly punctate, slightly less so than in majority of specimens of *B. pusillum* examined, lateral portions more finely, closely punctured, more so anteriorly. Minute secondary punctures evenly distributed over pronotum. Declivity of pronotal modification coarsely punctured only in lower two-thirds. Scutellum with shallow groove running its length, with moderate number of secondary punctures. Second elytral stria entirely lacking. Fifth and eighth striae indicated only by a line of very small punctures. Punctures in striae not sharply delimited, generally separated by slightly less than their own diameter,

and entirely without setae. Epipleuron and elytral margin each bear a row of long setae. Along elytral margin and extending inward no more than 0.5 mm. are a number of small setae; otherwise, elytra and entire dorsal surface of thorax are bare. Mesosternal prominence only slightly developed in front of middle coxae, not elevated above plane of metasternum. Hair of underside moderately long and sparse.

Head with tubercles of eye canthi and clypeus pronounced, sharply upturned. Horn in center of vertex long, scarcely wider near base than at tip, which is not bifid. Pronotal modification with pronounced transverse carina deeply emarginate. Lateral limiting grooves deep, lateral carinae large and elongate.

Genital capsule blunt, lateral lobe about 1.3 times as long as wide. Almost identical to that of *B. pusillum* except that the setae at the tips of the lateral lobes are fewer and shorter than those of *B. pusillum*.

ALLOTYPE: female, length 8.5 mm., greatest width 6.1 mm.

Markings similar to holotype except at pronotal modification where there is only a trace of black along the transverse carina and in the lateral limiting grooves. Tibiae brown edged with trace of black. Coarse punctures of pronotum irregular and more numerous than holotype, secondary punctures also more pronounced. Elytral striae and punctures not showing significant variation. Foretibia armed with seven teeth on outer margin.

Head of allotype with suggestion of tubercle on eye canthus, but none on clypeus. Horn of vertex replaced by a transverse carina which has four small but noticeable tubercles, one at each end of the carina and two slightly more than halfway toward the median line. Pronotal modification with the transverse carina slightly developed, evenly arcuate. Lateral limiting grooves and lateral carinae barely indicated.

Holotype, male, St. Johns, Apache County, Ariz., May 28, 1931, (from Barr collection) (USNM 61680). Allotype, female, Brewster County, Tex., August 24, Greene (USNM 61680). Paratypes, male, Clovis, N. Mex., Wickham, August (also paratype of *pusillum* Dawson and McColloch); female, Mesa de la Eucnotada(?), 7,000 ft., Sierra del Carmen, Coahuila, México, July 28, 1938, Baker; female, Valle de Olivos, Chihuahua, México, 5,500 ft., July 20, 1947, D. Rockefeller Expedition, Cazier; female, 5 miles east of Marathon, Brewster County, Tex., 4,100 ft., Sept. 27, 1950, Gertsch and Cazier. Paratypes in the collections of the American Museum of Natural History, O. L. Cartwright, and the writer.

Variation in the six specimens at hand is very slight. Size ranges from 8.5 to 11 mm. in length, 6 to 7.2 mm. in greatest width. Pattern is quite constant. Tibiae of the males are black, those of the females

brown. The punctures of the head and thorax are more pronounced in the females than in the males. The obsolete second striae on some of the specimens are represented by two or three very small punctures. Teeth on outer margin of foretibia are either seven or eight in number. Other differences are slight.

This subspecies has almost the identical markings of *pusillum* but can be separated from it by the lack of the long erect yellow hairs on the dorsal surfaces of pronotum and elytra. It may be separated from other species by the blunt genital capsule of the male and by the distal black area which is confluent with the sutural stripe, but which laterally and anteriorly does not extend to the elytral margin.

No biological information other than that contained on the labels is available for this subspecies.

Bolbocerosoma quadricornum Robinson

Bolbocerosoma quadricornum Robinson 1941, p. 132. Type, male, New Braunfels, Comal County, Tex., August, Schaeffer (Robinson).

Length 8.8 to 9 mm., greatest width 6.2 to 6.4 mm.

Dorsum reddish brown marked with black as follows in holotype (male): Vertex, tip of horn, and tubercles, apical pronotal margin between lateral carinae, lateral limiting grooves, and inner portions and tips of adjacent tubercles of transverse and lateral carinae, band on pronotal base very narrow at midline and extending no farther than elytral margin, edges of scutellum, sutural intervals, and a postmedian spot with its forward edge beginning halfway between the base and apex of the elytron and from the fourth stria almost to the margin. Foretibia edged with black. Ventral surface dark orange to almost black. Vertex coarsely, heavily punctured with the punctures of the clypeus regular and dense. Pronotum coarsely, heavily, irregularly punctate, punctures becoming smaller and very dense laterally. Minute secondary punctures scattered evenly over entire pronotum. The declivity of pronotal modification coarsely punctured only on lower (apical) half. Scutellum with a few irregularly placed coarse punctures and numerous fine secondary punctures. Second elytral stria obsolete, represented by only two or three shallow punctures. Fifth and eighth striae indicated by only a few small punctures. Punctures in elytral striae moderately pronounced, usually separated by slightly more than their own diameter. A few of the elytral punctures and other punctures of the elytra and pronotum bearing long erect yellow hairs which are very sparse. Long setae also present on epipleura and elytral margin. Foretibia armed with eight teeth on outer margin. Mesosternal prongs only slightly developed in front of middle coxae, not elevated above plane of metasternum. Hair of underside long and sparse.

Head of holotype with tubercles of eye canthi and clypeus pronounced, sharply upturned; horn in center of vertex long, somewhat conical, tip not bifid. Pronotal modification with the pronounced transverse carina deeply emarginate, lateral limiting grooves deep, lateral carinae large and elongate.

The female of this species is not known.

Genital capsule of male blunt, almost identical to *pusillum*, lateral lobe about 1.3 times as long as wide, tipped with a few long setae.

Variation in this species appears slight in the two specimens seen. Markings are almost identical, but in one specimen the postmedian spot in the elytron begins at the third stria. The carinae of the head and pronotum are slightly less pronounced than in the type.

The species can be distinguished from other species—particularly from *pusillum* to which it is closely allied—by the pronotum heavily punctured, by the rather vague circular elytral spot, separated from the sutural stripe, and by the scutellum with only a black margin, not entirely black as in other species. The presence of long erect hairs on the elytra and pronotum and the shape of the lateral lobes of the genital capsule show extremely close relationship with *pusillum*.

Specimens examined: 2 males.

TEXAS: 2 males. New Braunfels (Comal County), (1) type, August, Schaeffer (Robinson); Comal County (1) (AMNH).

Bolbocerosoma ritcheri, new species

HOLOTYPE: Male, length 8.5 mm., greatest width 6.1 mm.

Dorsum yellow-brown to light red-brown, marked with black as follows: Eyes, eye canthi, tubercles, vertex, horn, clypeus except tubercle, apical pronotal margin between lateral carinae, tips of lateral carinae, lateral portions of transverse carina almost to midline, spot on either side of base of pronotum between outer edge of scutellum and elytral margins, scutellum, extreme base of elytra to humeri and completely around elytral margins, sutural intervals, elytral punctures, and postmedian oblong spot extending from third to ninth striae. The elytral spot is quite similar to that of *B. confusum*. Ventral thoracic sclerites dark brown to black, ventral portions of head and abdomen yellow-brown. Tibia fringed with dark brown, almost no black. Vertex coarsely, moderately, fairly evenly punctured, punctures becoming coarser and slightly more numerous on the clypeus. Pronotum coarsely, irregularly punctate medially, lateral portion more finely, closely punctate, more so anteriorly. Minute secondary punctures evenly distributed over pronotum. Lower half of pronotal declivity heavily punctate. Scutellum is unusual in having on it 10 or more coarse, irregularly placed punctures with no or few minute secondary punctures. Second elytral striae absent, fifth obsolete,

represented by 3 to 12 very small punctures, eighth stria represented by a line of 8 to 15 small punctures. A number of punctures on prothorax, scutellum, and elytra bear small erect yellow setae similar to, but about one-third as long as those of *B. pusillum*. The setae are irregularly placed and easily overlooked. They are slightly longer and more dense on elytral margin and epipleuron. The elytral punctures are sharp, well defined, and rather irregularly spaced, being separated by slightly more than their diameter in many places, but in some cases, in the same stria, they may be almost confluent. Foretibia armed with eight teeth on outer margin. Mesosternal prominence in front of middle coxae small, rounded at tip, only slightly elevated above metasternal plane. Hair of underside moderately long and sparse.

Head with tubercles moderate, those of eye canthi sharply upturned. Horn of vertex rather short when viewed from posterior, broadly conical, tip rather pointed, not bifid. Pronotal modification of male with rather narrow, feebly emarginate transverse carina; lateral carinae, and limiting grooves moderate.

Genital capsule of male with lateral lobes blunt, very similar to *B. pusillum*, 1.3 times as long as wide and tipped with 10 long setae (pl. 3, fig. 2).

Allotype: Female, length 9.5 mm., greatest width 6.8 mm.

Marked as the holotype except that the transverse carina of the pronotum is black for its entire length, while the black is lacking on the other portions of the pronotal modification. Also, the elytral spot extends almost to the second stria, making the spot somewhat wider than in the male. Vertex, clypeus, and pronotum heavily punctured. The pronotal declivity is heavily punctured over its entire surface.

Head without tubercles or horn, but with a pronounced transverse carina similar to that of females of *B. farctum*. Pronotal modification with a small, evenly arcuate transverse carina, obsolete lateral carinae and limiting grooves.

Holotype, male, Brownsville, Tex., Sept. 8, 1947, Alexander (USNM 61681). Allotype, female, Brownsville, Tex., July 23, Barber (USNM 61681). Paratype, male, Brownsville, Tex., Sept. 8, 1947, Alexander (Howden).

The three specimens examined vary in length from 7.7 to 9.5 mm., and in width from 5.5 to 6.8 mm. Also, variation is evident in the divided spots on the posterior pronotal margin. In the type the spots are well separated, but in the other male the spots are joined at midline at their forward margin, leaving a small brown spot at the pronotal margin. The elytral spots are quite constant, slightly larger in the female than in the males.

This species can be separated from other *Bolbocerosoma* by the following characteristics: Sparse short erect yellow hairs scattered over pronotum and elytra, elytral margins black for their entire length, elongate postmedian elytral spot well separated from both black sutural stripe and margin, and punctures of elytral striae very deep, sharply delimited, with their edges rimmed with black.

It gives me a great deal of pleasure to name this colorful species in honor of Dr. P. O. Ritcher, who has given me invaluable aid, both in the field and in the numerous problems encountered in the preparation of this paper.

***Bolbocerosoma cartwrighti*, new species**

HOLOTYPE: Male, length 7.5 mm., greatest width 4.6 mm.

Dorsum red-brown marked with black as follows: Eyes, eye canthi, tubercles, vertex, horn, most of clypeus, apical pronotal margin between lateral carinae, inner portions of lateral carinae, lateral portions of transverse carina, lower portion of lateral limiting grooves, lateral margins of the pronotum, band on pronotal base extending sharply forward at midline (dentiform point) and extending laterally no farther than elytral margin, scutellum, extreme base of elytra almost to humeri, posterior half to two-thirds of elytral margin, sutural intervals and postmedian oblong spot extending from third to ninth striae. The elytral spot is quite similar to that of *B. confusum*. Entire undersurface and legs very dark brown to black. Vertex coarsely, somewhat sparsely punctured, punctures becoming coarser and more numerous on the clypeus. Pronotum heavily, coarsely punctate medially, lateral portion more finely, closely punctate, more so anteriorly. Minute secondary punctures evenly distributed over pronotum. Lower two-thirds of pronotal declivity coarsely punctured. Scutellum is unusual by having 15 to 20 coarse, irregularly placed punctures and a few minute secondary punctures. Second elytral stria obsolete, represented by a vague depression without punctures, fifth and eighth striae represented by a few small punctures. Numerous long erect yellow setae are present near most of the coarse punctures on the prothorax, scutellum, elytra, elytral margins, and epipleura. Elytral punctures are well defined and usually separated by slightly more than their own diameter, but this varies. There is an accessory row of moderately coarse, seta-bearing punctures running the length of the elytra next to the suture. In no other species was this noticeable row of accessory punctures present. A few similar punctures are present in a few specimens of *B. pusillum*, but a uniform row was not noted in any of the specimens examined. Foretibia armed with seven teeth. Mesosternal prominence in front of middle coxae small, barely elevated above metasternal plane. Hair of underside long and moderately sparse.

Head with tubercles moderate, those of eye canthi upturned, horn of vertex not long, rather slenderly conical when viewed from posterior, tip not bifid. Pronotal modification of holotype with moderately developed transverse carina broadly, shallowly emarginate; lateral limiting grooves small; lateral carinae well developed, rather elongate.

Genital capsule (pl. 3, fig. 4) with blunt lateral lobes, similar to *B. pusillum*. Lateral lobes 1.2 times as long as wide and tipped with a few long setae.

Allotype: Female, length 9.2 mm., greatest width 6.5 mm.

Markings similar to holotype except that the unusual lateral black band on the pronotum is much more pronounced; also the transverse carina, lateral carinae, and lateral limiting grooves are black. Vertex, clypeus, and pronotum more heavily punctured in allotype than in holotype. Pronotal modification with entire declivity heavily punctured. Foretibia armed with eight external teeth.

Head of allotype without tubercles or horn, but with small transverse carina, sharply delimited and evenly arcuate. Lateral limiting grooves and lateral carinae small, but noticeable.

Holotype, male, El Paso, Tex. (USNM 61682). Allotype, female, Texas (Howden).

Variation in the two specimens seen is mainly evident in the larger and more pronounced black areas on the pronotum of the female.

Bolbocerosoma cartwrighti can be easily distinguished by the blackish or black lateral portions of the pronotal margin which are not to be noted on any other species. In the male the area is only brownish black, but in the female the area is entirely black and extends from the anterior to posterior angles and inward over 1 mm.

Other distinguishing characteristics are: The accessory punctures along elytral suture, the large number of long erect yellow setae on dorsal surface, the median dentiform point formed by black band on posterior margin of pronotum, and the oblong postmedian elytral spots which are similar in shape to those of *B. confusum*.

This interesting species is named in honor of O. L. Cartwright, who has been of tremendous aid by furnishing many specimens, checking identifications, answering numerous questions, and checking the manuscript.

Bolbocerosoma elongatum, new species

Holotype: Male, length 10.5 mm., greatest width 6.5 mm.

Dorsum reddish orange marked with black as follows: Vertex, eyes, eye canthi, tubercles, margins of clypeus, apical pronotal margin between lateral carinae, tips of tubercles of lateral and transverse carinae, thin line on the extreme posterior margin of pronotum extending no farther than elytral margins, extreme base of elytra, scutellum, sutural intervals, posterior portion of adjacent intervals, and vague

circular postmedian spot. Spot is entirely in posterior third of elytra and is separated from lateral margin and vaguely separated at the third elytral interval from the expanded sutural stripe. The spot is separated by five or six striae from the lateral elytral margins, which are without black markings. Ventral surfaces yellowish brown. Outer margins of foretibia edged with brownish black. Vertex coarsely, sparsely punctured; punctures of clypeus generally regular and dense. Pronotum, coarsely, moderately, irregularly punctate; lateral portions more finely, closely punctured, more so anteriorly. Minute secondary punctures evenly distributed over pronotum. Declivity of pronotal modification with small coarse punctures only in lower half. Pronotum with numerous, very small secondary punctures. Secondary punctures on scutellum about twice the diameter of those on the pronotum. Second elytral striae entirely lacking. Fifth and eighth striae indicated only by a line of very small punctures. Punctures in striae not sharply delimited, generally scattered over the elytra are a few long erect yellow hairs. Epipleuron and elytral margin each bear a row of long setae. Sides of the elytra are almost parallel for approximately half their length, making this species in proportion appear more elongate than other species of *Bolbocerosoma*. Foretibia armed with eight teeth on outer margin. Mesosternal prominence poorly developed in front of middle coxae, only slightly elevated above plane of metasternum. Hair of underside long and moderately dense.

Head with tubercles of eye canthi and clypeus pronounced, sharply upturned. Horn in center of vertex long, slimly conical, not bifid at tip. Pronotal modification with pronounced transverse carina deeply emarginate. Lateral limiting grooves deep, lateral carinae large and elongate.

Genital capsule of male blunt, falling into the same general group as *pusillum*, *lepidissimum*, etc., but much more elongate. The lateral lobes of the capsule are about 1.8 times as long as wide (pl. 3, fig. 5).

Female is unknown.

Holotype, male, Chisos Mountains, Big Bend, Tex., July 8, 1946, Van Dyke Collection (CAS).

This species can be distinguished by its slightly elongate form, by the rather elongate blunt genital capsule of the male (pl. 3, fig. 5), by the scattered long erect yellow hairs on the elytra, by the thin vague black band on the posterior pronotal margin, and by the vague circular brownish black spot confined to the posterior third of the elytron and separated from the sutural stripe.

Additional material will probably indicate that the holotype is rather poorly marked, as the black circular spot may in other specimens be confluent with the sutural stripe.

Genus *Bradycinetulus* Cockerell

Bradycinetulus Cockerell, 1906, p. 242.—Cartwright, 1953, p. 101.
Bolboceras Kirby (in part), 1818, p. 459.
Amechanus Horn, 1870, p. 48.
Bradycinetus Horn, 1871, p. 334.
Bradycellus Schaeffer, 1906, p. 249.

GENOTYPE: *Bradycinetulus ferrugineus* (Palisot de Beauvois), designation by Cartwright (1953, p. 101).

GENERIC LIMITATIONS: Given by Horn (1870, p. 48; Cockerell merely gave *Bradycinetulus* as a new name for Horn's *Bradycinetus*) under the name *Amechanus:*

. . . the scutellum being broad, triangular with the sides rounded, and not depressed below the level of the elytra. The very narrow linear and depressed scutellum is seen only in *Athyreus* and *Stenaspidius* in the group Geotrupinae, while the form of the scutellum of our species is very similar to that seen in the *Geotrupes* or *Bolboceras*.

Additional characteristics given by Cartwright (1953, p. 101) are:

. . . the mandibles are evenly arcuate externally, the median prominence of the pronotum is developed into a pair of horns in the male, the scutellum is wider than long and distinctly punctate with fine to moderate punctures, and the posterior vertical face of the prosternal intercoxal piece is wide and flat with the ventral edge evenly arcuate or slightly angulate at middle. The three species placed here are all of large size, 17 to 21 mm. in length by 10 to 12 mm. in width.

Because of Cartwright's recent and very adequate revision of the genus, no comments on synonymy or adult morphology are needed here. A brief review of the pertinent literature is given, along with any available information on the biology of the species. For keys to the species and locality records the reader should consult Cartwright's revision. Also included in Cartwright's paper were distributional data that the present writer had accumulated.

Bradycinetulus fossatus (Haldeman)

Bolboceras fossatus Haldeman, 1853, p. 362 (type, Texas, LeConte collection at MCZ).—Boucomont, 1911, p. 241.
Amechanus fossatus (Haldeman) Horn, 1870, p. 48.
Bradycinetus fossatus (Haldeman) Schaeffer, 1906, p. 250.
Bradycinetulus fossator (Haldeman) Cockerell, 1906, p. 242.—Cartwright, 1953, p. 103.

The midwestern species *fossatus* appears to have habits similar to its eastern counterpart, *ferrugineus*. *Bradycinetulus fossatus* has been recorded from sandy localities from Nebraska to Texas. Specimens have been collected in every month from May through August, most commonly in June.

In Noble and Payne Counties, Okla., Brown (1927, p. 27) found it commonly from May to July in vertical burrows from 6 to 14 inches

in depth. Similarly, in the sandy areas of Kansas, Knaus (1926, p. 264) found occasional specimens in perpendicular, 8- to 12-inch burrows.

Two miles from Sylvia, Kans., Warren (1917, p. 413) made the following observations on *fossatus:*

> The first impression at sight of the burrow of this species is as though a carpenter had used a half inch auger and left the chips around the hole. . . . The use of a spade a number of times failing in results, a dry weed stalk was pushed down the pit and the sand dug away on one side within two inches of the stem or hole and the rest carefully removed with the fingers, when the beetle would be found at the bottom, sometimes both sexes being present, at other times either singly. The well would be perfectly straight and about 14 inches deep. The species is not scattered but usually restricted to small areas in apparent colonies. A strong light placed on the sand near the burrows yielded from three to five specimens per evening.

Bradycinetulus fossatus has been collected in Arkansas, Kansas, Nebraska, Oklahoma, and Texas.

Bradycinetulus ferrugineus (Palisot de Beauvois)

Scarabaeus ferrugineus Palisot de Beauvois, 1809, p. 90.
Athyreus ferrugineus (Palisot de Beauvois) Klug, 1845, p. 22.—Boucomont, 1902, p. 8.
Bolboceras ferrugineus (Palisot de Beauvois) Lacordaire, 1856, p. 143.—Boucomont, 1911, p. 241.
Amechanus ferrugineus (Palisot de Beauvois) Horn, 1870, p. 48.
Bradycinetus ferrugineus (Palisot de Beauvois) Horn, 1885, p. 89.—Schaeffer, 1906, p. 250.
Bradycinetulus ferrugineus (Palisot de Beauvois) Cockerell, 1906, p. 242.—Cartwright, 1953, p. 102.
Bolboceras lecontei Dejean, 1833, p. 149.

Bradycinetulus ferrugineus, the only East Coast representative of this genus, is found in the inland sandy areas from Florida to North Carolina. Because of its seeming rarity, there is a paucity of knowledge concerning the biology of this insect. The reason for this lack became evident after I spent many weekends over a period of three years attempting unsuccessfully to learn something of the biology of the immature stages of this species. The only data obtained from this work were the times and places where the larvae were *not* found. It is hoped that the present meager information may possibly be of some aid or stimulation to some investigator in the future.

For me, the most easily accessible area where *ferrugineus* was known to occur was in the sand hills around Southern Pines, N. C. There Manee (1908b, pp. 459–460) had recorded finding the beetle from June through August. He mentioned that when he found a pair at work the burrow was closed, and when they were burrowing singly the burrow was open. In his notes he stated that the beetles

went to a depth of from 4 to 9 inches (in one case) very rapidly. He further mentioned that he never saw two specimens of the same sex in the same burrow. Males occasionally were collected at light by Manee.

I agree with Manee that the beetles are strong diggers, occasionally come to light, and that they dig vertical burrows, but in other respects my observations differ considerably.

Originally, an attempt was made to locate the exact area in which Manee had made his notes. This failing, considerable time was spent trying to find an area having a large population of these beetles.

During the first summer only occasional burrows were found in August and September. These were usually located in the ruts of seldom-used, sandy roads. The beetles made vertical burrows 2 to 3 feet deep, marked by ropey push-ups of sand 3 to 4 inches in diameter (pl. 10, fig. 2). These burrows were traced by shoving long straws into their openings and then digging down beside the straws. Usually the depth necessitated making a rather large hole with a shovel or trowel. On one occasion it was rather embarrassing trying to explain to the curious owner the reason for the excavation in his road. The occasional need to rapidly remove a beetle from its burrow, plus the difficulty of digging out the beetles with a trowel or spade, led to the use of a posthole digger and a sifter. Due to the beetles' habits of digging a perfectly vertical burrow the digger could be centered over the entrance and the sand sifted as it was brought out. In this manner a beetle could be brought up from a depth of 3 or 4 feet in about 10 minutes. If one wanted to study the burrow, the hole was dug beside the burrow and a trowel was used to carefully expose the shaft of the burrow.

During the second summer, beside a small airport 2 miles north of Southern Pines on U. S. Highway 1, a moderate colony of *ferrugineus* was found. The land across the road from the airport had several seldom-used roads and open patches of bare sand. The area, which was near the top of a high sand ridge, was largely grassy with a few scattered turkey oaks and longleaf pines. It was in this area that both *ferrugineus* and *Eucanthus* (pl. 17, fig. 1) were found.

The burrows of *ferrugineus* were invariably in the open spots of bare sand or in the sandy roads. Burrows were marked and a number of adults were put in rearing cages in the same area. It was noticed that sometimes the entrance of a burrow was plugged with sand at its opening, sometimes it was not. Closer observation showed that usually it was the burrow of a male which had a plug of sand at its entrance. Often the burrow of the female was open 10 to 12 inches before a sand plug was encountered. At no time during the three years, in which time over 70 burrows were dug, were two specimens,

pairs or not, ever found in the same burrow. No beetle was ever found feeding or associated with any possible food.

Just before the conclusion of this work, beside the Carthage-Southern Pines airport on the Carthage road, a large number of *ferrugineus* were taken by digging in early September in the wasteland between the airport and the road. There was no sign of feeding or mating, mention being made of the area merely because of the number of *ferrugineus* found there.

Despite the lack of success in procuring any larvae, a few interesting facts were obtained during the three years. The adult beetles lived for almost a year. A number of burrows were marked in September and later dug during the winter. The quiescent adult beetles were found singly at the bottom of their vertical burrows in November and again in March. There they remained until early June, at which time fresh burrows were found. One interesting fact was noted—the older the beetle, the darker brown it was. Specimens taken in June in some instances were almost black. Later in July of 1951 only lightly colored males were found in fresh burrows.

Some of the fresh June burrows were marked and left undisturbed. By mid-July the cages containing adults collected the previous fall were dug up. One female, out of four that were active on June 28, was still alive in one cage, but there was no sign of any brood activity. In another cage, which was merely an enclosure with no bottom, none of the adults or fragments could be found. Every shovelful of sand under the cage was sifted to a depth of 7 feet with no results.

The burrows which were marked in June were then dug. In the latter part of July, three different holes were made following burrows to a depth of as much as 11 feet with no results.

The investigator finally had to conclude that the beetles either went to great depths or changed their burrowing habits and went sideways for a number of feet. The latter supposition would seem to be the probable one.

No fresh burrows were seen in July 1952. On Sept. 12, 1952, the colony at the Carthage airport was found and, out of 48 beetles collected, there were 8 males and 12 females that were fairly dark and 16 males and 12 females that were quite teneral, appearing to be freshly emerged. All of the burrows, as usual, were from 14 inches to 3½ feet deep, with an average depth of 28 inches.

If I were asked to hazard a guess as to the time that the larvae could be found, I would say that, according to the above information, the larvae of *ferrugineus* should occur during June, July, and perhaps August. The problem still remains to find them.

Specimens of *ferrugineus* have been collected in Florida, Georgia, Mississippi, North Carolina, and South Carolina.

***Bradycinetulus rex* Cartwright**

Bradycinetulus rex Cartwright, 1953, p. 103. Type, male, Sarita, Tex., collected on bare sand Nov. 30, 1911 (USNM).

Only three specimens of this species are known, the type and two male paratypes. All were collected in Texas, the two paratypes coming from Corpus Christi, June 28, 1942, and Kingsville.

Genus *Bolborhombus* Cartwright

Bolborhombus Cartwright, 1953, p. 116.

Genotype: *Bradycinetus carinatus* Schaeffer (*Bolboceras schaefferi* Boucomont), designated by Cartwright (1953, p. 117).

Generic Limitations: Given by Cartwright (1953, pp. 116–117):

Mandibles arcuate externally. Head, male and female, without median frontal horn. Pronotum serrate laterally; apex with a carina paralleling anterior margin, the interspace interrupted behind each eye by a distinct rather deep foveola; base margined. Scutellum triangular with base straight, sides arcuate. Elytra not margined at base; seven discal striae, the first two interrupted by the scutellum, the second sometimes indistinctly forked opposite the apex of scutellum. Two prosternal spines in tandem behind anterior coxae, the posterior more or less hastate. Metasternal plate rhomboid in shape, the posterior angle acute with adjacent edges cariniform, the lateral angles with adjacent edges rounded; the intercoxal lobe deeply concave with strong cariniform lateral edges.

For adult descriptions, keys, and locality records the reader should consult Cartwright's revision. None of the species in this genus have been collected in numbers and nothing has been written concerning their biology.

***Bolborhombus carinatus* (Schaeffer), new combination**

Bradycinetus carinatus Schaeffer, 1906, p. 251. Type, male, Palmerlee, Cochise County, Ariz. (USNM).
Bolboceras schaefferi Boucomont, 1911, p. 347.
Bolborhombus schaefferi (Boucomont) Cartwright, 1953, p. 119.

This species was originally described in the genus *Bradycinetus* by Schaeffer (1906, p. 251). The same year Cockerell (1906, p. 242) stated that the name *Bradycinetus* was preoccupied and changed it to *Bradycinetulus*. Then Boucomont (1911, p. 347) decided that *Bradycinetus* (or *Bradycinetulus*) was merely a synonym of *Bolboceras*. As the name *carinatus* had previously been used by Blackburn in 1904 to describe an Australian species of *Bolboceras*, Boucomont stated that *carinatus* Schaeffer was a homonym and proposed the name *schaefferi* to replace it.

Since then Cartwright (1953, p. 101) and I have concluded that Boucomont's application of the name *Bolboceras* was in error (*Bolboceras* being the correct name for the genus sometimes known as *Odontaeus* for reasons given in the section on *Bolboceras*). Because

of this, *carinatus* Schaeffer should not have been synonymized, and, as the Australian species *carinatus* Blackburn certainly cannot be referred to the present genus *Bolborhombus* established by Cartwright, the name *carinatus* Schaeffer is restored here.

The species *Bolborhombus carinatus* (Schaeffer) has been sparingly found in Arizona, New Mexico, Texas, and México from June through October with one record in December. The majority of specimens were collected during July and August, some of these bearing the label "light."

***Bolborhombus angulus* (Robinson)**

Bolboceras angulus Robinson, 1947, p. 170. Type, male, Dog Canyon, Brewster County, Tex. (Robinson).
Bolborhombus angulus (Robinson) Cartwright, 1953, p. 117.

Originally described from a unique specimen, three others have since been found. Three of the specimens, including the type, were collected in Brewster County, Tex., while the fourth specimen came from Miller Canyon, Huachuca Mountains, Ariz. All of them were collected in July.

***Bolborhombus parvulus* Cartwright**

Bolborhombus parvulus Cartwright, 1953, p. 118. Type, male, Triunfo, Baja California, México, Aug. 7, 1938, Michelbacher and Ross (CAS).

This species was described from four specimens, all from Baja California. They were collected at Triunfo, San Venancio, and Santa Rosa in August and October.

Genus *Bolbocerastes* Cartwright

Bolbocerastes Cartwright, 1953, p. 105.

GENOTYPE: *Bolbocerastes regalis* Cartwright, designated by Cartwright (1953, p. 105).

GENERIC LIMITATIONS: Given by Cartwright (1953, p. 105):

> This genus is closely allied to *Bradycinetulus* but differs in that the apex of the tibia of the middle and hind legs is obliquely truncate, the scutellum is smooth or minutely punctate, the mandibles are parallel, nearly straight sided and bent sharply inward anteriorly, the sides and anterior edges forming a rectangle, the median prominence of the pronotum is without horns, two elevated carinae are present on each side of the pronotum, the prosternal spine behind the anterior coxae is transverse, doubly pointed and remote from the acutely angled intercoxal piece, and the aedeagus of the male is of a characteristic form . . .

Descriptions, keys, references, and distributions of the species are given by Cartwright.

All of the known North American species are quite similar in form. They have frequently been recorded coming to light, while an occa-

sional specimen examined by me bore the label "in burrow." Other than this, nothing has been recorded about the habits of these species.

Bolbocerastes regalis Cartwright

Bolbocerastes regalis Cartwright, 1953, p. 106. Type, male, "3206. Colo. R. bottom. Monument 204, Mex. Bd. line, Mar. 20–31, '94 U. S. N. M. Acc. No. 28133, Dr. E. A. Mearns." (USNM.) The above locality, according to Cartwright, is about 20 miles south of Yuma, Ariz.

This rather striking species was described by Cartwright from 97 specimens from Arizona, California, Nevada, and México. The species has been collected in every month from March through September, being more frequently seen in the spring.

Previously, the species had been confused with *serratus* (LeConte) and many records of *serratus* from California and Arizona probably refer to this species or to *imperialis* Cartwright.

Bolbocerastes imperialis Cartwright

Bolbocerastes imperialis Cartwright, 1953, p. 109. Type, male, Imperial County, Calif., on the experiment farm, June 1912, Bridwell (USNM).

This species, which is very similar to *Bolbocerastes serratus* (LeConte), was described from 212 specimens collected in Arizona, California, New Mexico, western Texas, and México. They were found in every month from May through November, but have been most commonly collected in the summer and fall.

Bolbocerastes imperialis kansanus Cartwright

Bolbocerastes imperialis kansanus Cartwright, 1953, p. 112. Type, male, Rush County, Kans. (CC).

Only seven specimens of this species are known. They were all collected in Rush and Ness Counties, Kans., during July and August.

Bolbocerastes serratus (LeConte)

Athyreus serratus LeConte, 1854, p. 80 (type, LeConte collection, MCZ).—Boucomont, 1902, p. 8.
Amechanus serratus (LeConte) Horn, 1870, p. 48.
Bradycinetus serratus (LeConte) Horn, 1894, p. 334.—Schaeffer, 1906, p. 251.
Bradycinetulus serratus (LeConte) Cockerell, 1906, p. 242.
Bolboceras serratus (LeConte) Boucomont, 1911, p. 341.
Bolbocerastes serratus (LeConte) Cartwright, 1953, p. 113.

This species ranges from Kansas through Oklahoma and Texas to México. It has been frequently taken in Texas from April through September. Specimens have been collected at light, but other than that nothing has been written concerning its habits.

Bolbocerastes peninsularis (Schaeffer)

Bradycinetus serratus var. *peninsularis* Schaeffer, 1906, p. 252. Type, male, Santa Rosa, Baja California, México (USNM).
Bolboceras serratus var. *peninsularis* (Schaeffer) Boucomont, 1912, p. 13.
Bolbocerastes peninsularis (Schaeffer) Cartwright, 1953, p. 116.

This rare species has been collected only in Baja California, México. Specimens were taken at Santa Rosa, San Felipe, La Paz, and San Ignacio from July to October.

Genus *Bolbelasmus* Boucomont

Bolbelasmus Boucomont, 1911, p. 335.—Cartwright, 1953, p. 97.
Kolbeus Boucomont, 1911, p. 335.—Chapin, 1946, p. 79.

GENOTYPE: *Scarabaeus gallicus* Mulsant, designated by Cartwright (1953, p. 97).

GENERIC LIMITATIONS: Given by Boucomont (1911, p. 335).

Clypeo subrotundato, inermi, tenui, carinula a fronte separato, tuberculo frontali subconico; antennarum clavae primo articulo cum circumscripta area denudata; posterni fovearum oris declivibus absque carinis; coxis intermediis subcontiguis, mesosterno inter illas tenuissimo seu lineari, a genere Bolbocerate tantum differt.

The genus *Kolbeus* was synonymized under *Bolbelasmus* by Cartwright (1953, p. 97) because he believed that there were insufficient morphological differences to warrant generic separation. While *Kolbeus arcuatus* Bates lacked the posterior marginal line on the pronotum, Cartwright found it otherwise essentially similar to the genus *Bolbelasmus*. For full particulars on distributional data, keys, descriptions, and synonymy the reader should consult Cartwright's revision (1953, p. 97).

Bobelasmus arcuatus (Bates)

Bolboceras arcuatus Bates, 1887, p. 111. Type, probably in British Museum.
Kolbeus arcuatus (Bates) Boucomont, 1911, p. 336.—Chapin, 1946, p. 79.
Bolbelasmus arcuatus (Bates) Cartwright, 1953, p. 98.

This species has been collected in México and Costa Rica from May through July. One specimen in the Carnegie Museum bears the label "Los Angeles, California," but I would prefer to see other specimens collected in the United States before considering *arcuatus* a North American species.

Bolbelasmus minor (Linell)

Bradycinetus minor Linell, 1895, p. 723. Type, female, San Diego, Tex. (USNM).
Bolboceras minor (Linell) Schaeffer, 1906, p. 253.
Kolbeus minor (Linell) Chapin, 1946, p. 79.
Bolbelasmus minor (Linell) Cartwright, 1953, p. 100.

This rare little species has been collected from May through June only in the southern tip of Texas from Duval County southward to Brownsville. Nothing is known of its habits.

Bolbelasmus hornii (Rivers)

Bradycinetus hornii Rivers, 1886, p. 61. Type, Sonora, Tuolumne County, Calif. (present location of type unknown).
Bolboceras hornii (Rivers) Schaeffer, 1906, p. 253.
Bradycinetulus hornii (Rivers) Cockerell, 1906, p. 242.
Kolbeus hornii (Rivers) Chapin, 1946, p. 79.
Bolbelasmus hornii (Rivers) Cartwright, 1953, p. 100.

I have examined specimens labeled "dug from burrow" and seen others with "at light" labels. Presumably this rather common California species has much the same burrowing habits as the species in closely related genera. Of the 130 specimens examined, 6 were collected in January, 6 in February, 7 in March, 38 in April, 61 in May, and 7 in June. To my knowledge, the immature stages of *hornii* have never been collected or described.

Genus *Eucanthus* Westwood

Eucanthus Westwood, 1848, p. 387; 1852, p. 26.—Schaeffer, 1906, p. 253 (as *Bolboceras* in part).—Manee, 1908b, p. 459.—Blatchley, 1910, p. 937 (as Bolboceras); 1928, p. 30.—Boucomont, 1911, p. 336.—Dawson, 1922, p. 195.—Cartwright, 1944, p. 30.—Ritcher, 1947, p. 10.—Robinson, 1948, p. 30.

GENOTYPE: *Scarabaeus lazarus* (=*meliboeus*) Fabricius, by monotype *in* Westwood (1848).

GENERIC LIMITATIONS: Given by Westwood (1848, p. 387): "Corpus minus depressum quam in reliquis; pronoto antice haud retuso. Tibiae anticae dentibus duobus apicalibus magnis aliisque minutus externus versus basin armato. Elytra punctato-striata; singulo striis 5 tantum inter humeros et suturam, punctis, profundis."

Other useful characteristics are: Coarse lateral punctures of pronotum with about half of their rims elevated, giving tuberculate appearance; transverse hornlike carinae, one on clypeus, one on vertex, present in both sexes; humeral angle of elytron not broadly rounded, usually with tubercle.

MALE GENITALIA: Both the genitalia and genital capsule are rather simple and poorly sclerotized with no usable characters noted. However, careful study of the genitalia may be helpful in some cases for setting specific limits.

In the genus sexual and size variation is very pronounced. In both sexes the size of horns (carinae) and tubercles may vary, and this size to some extent appears coupled with body size and degree of coarse punctation.

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Descriptions have been based where possible on specimens believed to be normally well developed.

LARVAE: Known larvae may be distinguished by the following characteristics: Body slightly bent without enlarged abdomen; legs 3-segmented with claws, metathoracic legs not reduced; paired ventral anal lobes; galea not emarginate; penultimate segment of antenna with more than two (usually four) conical sense organs.

The genus is represented by three species and one subspecies in North America, one known species in South America, and one in Australia.

Key to the North American species of Eucanthus

1. Surface of head, pronotum, and elytron smooth, not granulate, giving shining brown or black color 2
   Surface of head, pronotum, and elytron finely granulate, giving an oily dark brown color (Gulf Coast States) . . . . . **alutaceus** Cartwright
2. Pronotum noticeably explanate; transverse pronotal carina pronounced; tubercle at humeral angle present, usually quite pronounced (subspecies of *lazarus*) 3
   Pronotum only slightly explanate; transverse pronotal carina not pronounced; tubercle at humeral angles of elytra absent or vaguely indicated (Southwestern States) . . . . . **greeni** Robinson
3. Color brown to dark brown, antennal club large, at least slightly longer than eye (pl. 2, fig. 7); 2nd and 4th elytral intervals slightly wider than adjacent ones and usually with a medial row of very fine punctures (pl. 2, fig. 9); punctures of elytral striae shallow . . . . . **lazarus lazarus** (Fabricius)
   Color dark brown to black, antennal club small, slightly shorter than eye (pl. 2, fig. 6); 1st, 2nd, 3rd, and 4th elytral intervals approximately the same width and lacking any supplementary row of small punctures (pl. 2, fig. 8), strial punctures deep, those of third stria (and others) almost confluent (Florida, Alabama, north to North Carolina).
   lazarus subtropicus, new subspecies.

Key to the known larvae of North American species of Eucanthus

Glossa not constricted behind base of palpi, setae limited to lateral portions near the base of the palpi . . . . . **lazarus lazarus**

Glossa (pl. 6, fig. 6) constricted behind base of palpi, setae extending entirely across anterior . . . . . **lazarus subtropicus**

Eucanthus lazarus (Fabricius)

Scarabaeus lazarus Fabricius, 1775, p. 11; 1781, p. 11, No. 34; 1787, p. 5, No. 25; 1801, p. 23, No. 5.—Jablonsky, 1785, p. 276, No. 38.—Olivier, 1789, genus 3, p. 63.—Panzer, 1794, p. 2, No. 4.

Bolboceras lazarus (Fabricius) Castlenau, 1840, p. 105, No. 11.—Klug, 1845, pp. 51–52.—Horn, 1870, p. 49.—Schaeffer, 1906, p. 253.—Blatchley, 1910, p. 937.

Eucanthus lazarus (Fabricius) Westwood, 1852b, p. 26.—Manee, 1908b, p. 459.—Boucomont, 1911, p. 336.—Dawson, 1922, p. 195.—Blatchley, 1928, p. 30.—Ritcher, 1947, p. 10.

Scarabaeus meliboeus Fabricius, 1775, p. 20.

Eucanthus meliboeus (Fabricius) Westwood,1848, p. 387; 1852, p. 26.

Length 6.5 to 14 mm., greatest width 4 to 8 mm.

Color of dorsum shining orange-brown to dark red-brown, with eyes, tips of horn, edge of eye canthus, posterior edge of pronotum, and sutural intervals darker brown to black. Antennal club light yellowish brown in color. Ventral portions of thorax and abdomen the same or slightly darker in color than dorsally. Tibiae darker brown to black. In male, punctures of vertex moderately numerous and rather fine, punctures usually more numerous and pronounced in females. Punctures coarse and numerous on the eye canthi and on the base of the clypeal horn of both sexes. Anterior and lateral margins of pronotum heavily and coarsely punctured, as is a narrow band running from the transverse carina to the posterior pronotal margin. On either side of this is a transverse band of coarse punctures, parallel to the posterior pronotal margin, and midway between the margin and the transverse carina, extending almost to the pointed lateral carina. Very minute secondary punctures are scattered over the entire pronotum. Punctures in elytral striae shallow to moderate, separated by a distance usually greater than their own diameter. Elytral punctures without setae except those on the margins and epipleura, where a few of the punctures bear long reddish setae. Five well developed striae between sutural interval and umbone. The second and fourth intervals, which are wider than the adjacent ones, each have a row of minute punctures (pl. 2, fig. 9) (similar to the obsolete second and fifth striae in some *Bolbocerosoma*). Humerus of elytron bearing a small sharp tubercle at edge. Foremargin of eye canthus scarcely produced forward at outer angle and broadly rounded in both sexes. The lamellae of the antennal club noticeably longer than the eye (pl. 2, fig. 7). Male with pronounced clypeal horn, usually longer than wide, bifid at tip. Poorly developed transverse carina on vertex. Pronotal modification with well developed transverse carina, deep lateral limiting grooves and pointed lateral carinae, which are almost the height of the transverse carina. In the female the clypeal horn is small, short, and slightly bifid. The transverse carina of the vertex is better developed than in the male, longer than the clypeal horn, and somewhat bifid. The pronotal modifications of the female are similar to those of the male but smaller and less pronounced.

Genitalia and genital capsule of male poorly sclerotized, no useful constant characters noted.

The above description of the male was based mainly upon a specimen from Oxford, N. C.

Variation in this species is extreme, eastern specimens usually being smaller, with more pronounced punctures, and darker than western ones. However, a specimen in my collection from Alpine, Calif.,

is very similar to small eastern specimens collected in North Carolina; many examples of this sort were noted and made limitation of the species difficult. Individual colonies of *Eucanthus lazarus* appeared to exhibit remarkable uniformity, but considerably more material with exact data is needed to determine if the variation is intraspecific or interspecific.

I was unable to locate the Fabrician type of *lazarus*, which apparently has been lost. However, specimens were compared with the Fabrician specimens bearing the name *meliboeus* in the collection of the Hope Department, Oxford University Museum, by Dr. F. I. van Emden. The Fabrician specimen, a female in the Hope Collection, bears a label "Lee's Cabinet" and a label affixed by Dr. Taylor stating, "This may be the type, but I cannot be certain." In case other specimens of *meliboeus* were in Lee's collection and should be discovered, and in order to avoid possible confusion, the female specimen bearing the above-mentioned labels in the Hope Department, Oxford University Museum, is here designated as the type of *Eucanthus meliboeus*.

Several of my specimens were compared with the type by Dr. van Emden, and a female from Havana, Ill., was picked by him as very similar to the type, differing mainly by being slightly larger and lighter in color. The type, while being rather dark, has the large antennal club of the northern and midwestern *lazarus*. Because of Dr. van Emden's careful notes I am fairly certain that *meliboeus* Fabricius is identical with *lazarus* as described above.

While *Eucanthus lazarus* is the most common and wide-ranging species of the Bolboceratini, little has been published on its biology. Brown (1927, p. 27) mentioned that the species was often collected in the same pasture or old roads where he would find *Bolbocerosoma*. Wallis (1928, p. 112) mentioned that Sim found the species burrowing in the same areas, old roads and golf courses, where he took *Bolboceras*.

All available biological information was summarized and the larva of *Eucanthus* described for the first time by Ritcher (1947, pp. 10, 11). He stated that the larvae he described were collected in the soil of a vineyard near Fayetteville, Ark., by M. W. Sanderson in the summer of 1942. Unfortunately, there was no additional information.

Since Ritcher's work, nothing has been added to increase the information on the habits of *lazarus lazarus*. The species occurs rather sparingly in the mountain and piedmont regions of North Carolina, but in more northern and western states it is locally common and appears frequently in some of the collections from midwestern states.

The species has often been recorded as attracted to light. I collected a number of specimens in a light trap at Oxford, N. C., on Aug. 2, 1951, and again on August 10. A few specimens were found

at Raleigh, N. C., digging vertical burrows 6 to 10 inches deep in the hard clay soil of an old pasture during August. No data was obtained on adult or larval food and no larvae were collected.

The larva of *E. lazarus lazarus* has been described by Ritcher (1947, pp. 10, 11) from one third-stage larva and two third instar exuviae associated with the adults, all collected near Fayetteville, Ark.

Characteristics given by Ritcher (1947, p. 10) which may be useful in separating *lazarus lazarus* from the subsequent form are: "Frons on each side with a pair of posterior frontal setae, a single exterior frontal seta . . . Hypopharynx with 2 symmetrical bulbous oncyli covered with cilia."

The following additional structural characteristics may prove useful: Glossa not constricted behind the base of the palpi; glossal setae limited to the lateral portions near the base of the palpi.

Specimens examined: 265 males, 282 females.

CANADA

MANITOBA: 6 males, 4 females. Aweme; (4) July.

UNITED STATES

ALABAMA: 1 female. Elamville; (1) August.

ARIZONA: 7 males, 8 females. Cavecreek, Chiricahua Mountains, Cochise County, Dewey, Elgin, Flagstaff, Nogales, Paradise(?), Patagonia, Thatcher; (1) July, (3) August, (7) September, (1) October.

ARKANSAS: 13 males, 12 females. Benton County, Hope, Russellville, Springdale, Washington County; (1) April, (4) May, (1) June, (1) July, (4) August, (2) September.

CALIFORNIA: 1 male, 1 female. Alpine, St. Elmo(?); (1) June, (1) July.

COLORADO: 5 males, 7 females. Akron, Carr, Cheyenne Wells, Denver, Watkins (Adams County); (2) July, (3) August.

DISTRICT OF COLUMBIA: 3 males, 4 females. No data.

FLORIDA: 7 males, 8 females. Buena Vista, Captiva Island, Enterprise, Gunntown, Homestead, Indian River, Miami, Sanford, Winter Park; (1) January, (2) March, (2) April, (1) May, (1) November.

GEORGIA: 3 males, 7 females. Atlanta, Roswell, Tifton; (1) April, (1) May, (1) August.

ILLINOIS: 27 males, 33 females. Algonquin, Chicago, Cook County, Elizabethtown, Evanston, Havana, Hazel Crest (Cook County), Homer Park, Le Roy, Putnam County, Urbana; (2) January, (3) May, (11) June, (10) July, (1) August, (7) September, (2) October.

INDIANA: 1 male, 6 females. Hessville, Lafayette; (4) June.

IOWA: 42 males, 37 females. Ames, Denison (Crawford County), Elma, Herrold (?), Lineville, Polk City, Shenandoah, Storm Lake; (1) March, (1) May (64) June, (6) July, (6) August.

KANSAS: 15 males, 15 females. Atchison, Douglas County, Goodland, Larned, Lawrence, Reno County, Sedgwick County, Thomas County; (2) May, (1) June, (1) July, (1) September.

KENTUCKY: 4 males, 5 females. Natural Bridge State Park, Sanborn(?), Sandgap; (1) April, (1) June.

LOUISIANA: 1 female. (1) March.

MASSACHUSETTS: 1 female. Chicopee.
MARYLAND: 1 male, 3 females. Chesapeake Beach, College Park; (1) June, (1) July.
MICHIGAN: 3 males, 1 female. Albion, Allegan, East Lansing, Olivet; (1) June, (1) July, (1) August.
MINNESOTA: 2 males, 6 females. Fairfax, Granite Falls, Rapidan, St. Paul; (1) June, (1) July, (1) August.
MISSISSIPPI: 1 female. Crystal Springs, (1) April.
MISSOURI: 3 males, 4 females. Columbia, Pevely (Jefferson County), St. Charles; (2) May, (2) June, (1) August.
MONTANA: 1 male, 1 female. Poplar; (2) July.
NEBRASKA: 15 males, 14 females. Bennet, Brownville, Dodge County, Friend, Imperial, Malcolm, Mitchell, Niobrara, North Platte, Ponca, West Point; (5) April, (3) June, (15) July, (1) August.
NEW JERSEY: 5 males, 9 females. Atsion, Burlington, Chester, Newark, Newfoundland, Ocean City, *Old Dominion* boat off New Jersey, Riverton, Surf City, Woodbury; (5) June, (2) July, (2) August, (1) September.
NEW MEXICO: 4 males, 1 female. Embudo, Jemez Springs, Mesilla; (1) May, (1) July, (1) September.
NEW YORK: 1 male, 3 females. Greene County, Wading River (L. I.).
NORTH CAROLINA: 23 males, 15 females. Chimney Rock, Edenton, Franklin, Hendersonville, Laurel Hill, Marion, Base of Mount Pisgah, New River (Onslow County), Oxford, Raleigh, Rocky Mount, Smokemont (Swain County), Winston-Salem; (2) April, (5) May, (1) June, (10) July, (15) August, (1) September, (1) November.
OKLAHOMA: 4 males, 4 females. Norman, Sulphur, Wichita National Forest, Woodward; (1) May, (4) June, (1) September.
PENNSYLVANIA: 13 males, 9 females. Allegheny County, Easton, Jeannette, Pipers Gap, Pittsburgh; (5) May, (6) July, (6) August.
SOUTH CAROLINA: 5 males, 4 females. Clemson College, Sassafras Mountain; (1) May, (1) June, (2) July, (2) September.
SOUTH DAKOTA: 1 male, 1 female. Blunt, Volga; (1) July.
TENNESSEE: 1 male, 1 female. Manchester; (1) June.
TEXAS: 35 males, 41 females. Abilene, Alpine, Austin, Dallas County, Fedor, Fort Davis, Hallettsville, Kingsville, Lee County, Sarita, Wills Point; (7) April, (8) May, (3) June, (19) September, (5) October, (1) December.
VIRGINIA: 4 males, 3 females. Bedford Springs, Falls Church, Haywood; (1) March, (1) June, (1) September.
WEST VIRGINIA: 1 female. Talcott; (1) July.
WISCONSIN: 10 males, 10 females. Dane County, Dodgeville, Lancaster, Madison, Port Edwards, Ripon, Winnebago County, Griffith State Nursery (Wood County); (7) June, (6) July, (2) August, (2) September

***Eucanthus lazarus subtropicus*, new subspecies**

HOLOTYPE: Male, length 8.5 mm., greatest width 5.3 mm.

Color shining dark brownish black, darker sutural markings not evident. Antennal club reddish brown. Ventral portions of thorax and abdomen dark red-brown to black. Tibiae almost entirely black. Coarse punctures of vertex almost absent, entirely so medially. Punctures coarse and close on the inner part of the eye canthi (pl. 2, fig. 6) and the base of the clypeal horn. Anterior margin of pronotum

with a few coarse punctures, heavily punctate laterally. Coarse punctures are present in a narrow median band running from the transverse carina of pronotum to the posterior margin. Another band of punctures is present at the posterior of the lateral limiting grooves. A second one runs halfway between and parallel to the first band and the posterior margin of pronotum, extending almost to lateral carina. This second band of punctures is in a wide groove, only vaguely indicated in most specimens of *E. lazarus lazarus*. Minute secondary punctures are extremly small and vague, rather sparsely but evenly scattered over pronotum. Punctures in elytral striae deep, sharply delimited, generally separated by less than their own diameter (pl. 2, fig. 8). Elytral punctures without setae except those on the margins of the elytra and epipleura, where some of the punctures bear long yellowish red setae. Five well developed striae between sutural interval and umbone. All of the intervals between these five striae (pl. 2, fig. 8) with no noticeable difference in their widths. Rows of punctures noted in *E. lazarus lazarus* in the wider second and fourth intervals are entirely absent in *E. lazarus subtropicus*. Humerus of elytron bearing a small sharp tubercle at edge. Foremargin of eye canthus noticeably produced forward at outer angle, where it is sharply rounded (pl. 2, fig. 6). The lamellae of the antennal club no longer than eye (pl. 2, fig. 6), noticeably smaller than in *E. lazarus lazarus*. Also, eye size is slightly smaller than in the usual *E. lazarus lazarus*. Holotype with clypeal horn about as long as wide, bifid at tip. Poorly developed transverse carina on vertex. Pronotal modification poorly developed, carinae small with lateral limiting grooves shallow.

Allotype: Female, length 9.3 mm., greatest width 5.8 mm. Differs from the male holotype mainly in the following respects. Clypeal horn reduced, smaller than the one on the vertex which is larger than on males. Other than the differences in the horns and a slight difference in size, the female is similar to the male. Shape of eye canthus, antennal size, pronotal modifications, and elytral striae are all similar.

Holotype, male, Emory University Field Station, Newton, Baker County, Ga., light, Aug. 12, 1952. (USNM 61683). Allotype, female, Tarpon Springs, Fla., Mar. 20, 1951, H. and A. Howden (USNM 61683). Paratypes: 95 males, 106 females. *Alabama:* Florala; Grand Bay, Aug. 16, Loding; Pineapple, Aug. 25, 1933; Salt Mountain, 6 mi. south Jackson, Clarke County, May 14–16, 1935, Archer; Selma, October 1880, "W. H. I." *Florida:* No data (USNM 1072J); Archbold Biological Station, Lake Placid, April 1947, Needham; Crescent City, June 1938, Brues; Daytona Beach, July 15, 1945, Robinson; Dunnellon, Marion County, Aug. 3, 1938, Hubbell, Friauf; Fort Lauderdale, Apr. 10–25, Mar. 9, 26, May 22,

June 1, 1928, Bates; Gainesville, Alachua County, Sept. 26–Oct. 2, 1914; July 7, 1927, Rogers; Mar. 26, 1922, Mar. 22, 1923, Apr. 7, 8, 1923, Apr. 23, 1925, May 20, 1916, May 1946, Sept. 7, 1945, Oct. 5, 1925, Oct. 5, 1929, Oct. 20, 1934, Nov. 15, 1935, Bigelow, Alexander-Walker, Hubbell, Young; Greenville, Madison County, Sept. 2–6, 1932, Gloyd; Hillsborough County, Little Manatee River and U. S. Highway 41, Aug. 15, 1938, Hubbell, Friauf; Jacksonville, Aug. 9, 1898, Bowditch; La Belle, July 16, 1939, Oman; Liberty County, T. 2 N., R. 7 W., Apr. 24, 1924, Hubbell; Miami, Feb. 25, 1934, Aug. 12, 1934, Young; Monticello, Jefferson County, July 21, 1933, Walker; Orlando, van Dauber; Port Sewall, Dec. 11, 1938 (AMNH 36406), Watson, Sanford; Sanford, June 1, 28, 29, July 1, 29, 1929, Gehring; Tarpon Springs, Mar. 20, 21, 1950, H. and A. Howden; Welaka, Putnam County, Oct. 12, 1939, Friauf; Winter Park, Jan. 29, 1929, Feb. 15, 1928, Gehring. *Georgia:* No data; Americus, Aug. 1, 1950, Cartwright; Bainbridge, Sept. 17–Oct. 19, 1910, Bradley; Cordele, Aug. 1, 1950, Cartwright; Emory University Field Station, Newton, Baker County (all specimens from this locality were procured through the help of S. Breeland), June 27, 28, July 1–2, July 31–Aug. 1, Sept. 28–October 1, 1951, July 13, 17, 25, Aug. 13, 18, 20, 21, 28, 1952, light trap; Macon, Bibb County, June 8, 1923, Walker; Rabun County, June 25, 1927, July 10, 1928 (AMNH 30831), Richards; Sparks, Cook County, June 11, 1923, Walker. *Mississippi:* Camp Shelby, near Hattiesburg, Apr. 25, Aug. 10, 18, 26, 30, Sept. 21, 1944, Michener; Lucedale, Apr. 22, May 27, 1932, June 20, 1931, June 20, 1932, Aug. 22, 1931, Oct. 7, 1930, Dietrich; *North Carolina:* Rocky Mount, Aug. 1, 1951, Ritcher; Southern Pines, June 1907, May 12, June 19, 1909, Manee; Mar. 20, May 3, 16, June 14, 21, 1952, July 24, 1951, Aug. 18, 1951 (with Ritcher), May 17, 20, 1953, Sept. 5, 1952, Nov. 9, 1951, H. and A. Howden. *South Carolina:* No data; Aiken; CCC Camp F2, Oconee County, Aug. 12, 1936, Cartwright; Clemson College, Apr. 29, 1935, May 3, 1938, May 18, 1948, May 30, 1934, June 24, 1934, Aug. 1, 1950, Sept. 16, 1934, Cartwright, Dunavan; Edisto Exp. Sta., Blackville, June 8, 1938, Cartwright; Florence, July 14, 1930, Cartwright; Jocassee, July 17, 1932, Cartwright; Rocky Bottom, June 3, 1932, Cartwright; Walhalla, July 2, 1934, July 20, 1936; White Pond, Sept. 6, 7, 1951, Ritcher and H. Howden; Windsor, May 8, 1948, Cartwright. *Tennessee:* Deer Lodge, July 15–30, 1939, Benesh.

Paratypes are in the collections of American Museum of Natural History, British Museum (Natural History), California Academy of Sciences, Canada Department of Agriculture, Carnegie Museum, Cornell University, Illinois Natural History Survey, Iowa State College, Museum of Comparative Zoology, North Carolina State Col-

lege, Ohio State University, Oregon State College, U. S. National Museum, University of Arizona, University of Kansas, University of Michigan, and in the private collections of O. L. Cartwright, B. K. Dozier, C. A. Frost, A. Martinez, G. H. Nelson, M. Robinson, and the writer.

Variation in specimens of the type series is moderate. Length varies from 6.5 to 10 mm., width from 4.3 to 6 mm. Color ranges from an even reddish brown to black. The area of intergradation with *lazarus lazarus* is not too clear, but in general specimens from areas not bordering the Gulf of Mexico are intermediate in many of their characteristics. Specimens from localities bordering the East Coast tend more toward *lazarus lazarus*. Surprisingly, some specimens from Miami, Fla., exhibit many of the characters of *lazarus lazarus*. *E. lazarus subtropicus* appears to be more a Gulf and inland sandhill form, ranging northward in inland sandy areas to Southern Pines, N. C. Occasional northern specimens appear to exhibit most of the characters of *subtropicus*.

Generally, specimens of *subtropicus* can be easily distinguished by the very small antennal club, shape of eye canthus (pl. 2, fig. 6), evenly spaced elytral intervals between sutural interval and umbone, short clypeal horn in the male, blackish color, few punctures on vertex of head, and deep punctures of elytral striae. Some of these characters can occasionally be found either singly or in some combination in specimens of *lazarus lazarus* scattered throughout the country, particularly on the East Coast. However, further study may prove *subtropicus* to be a distinct species, for in a few cases both *lazarus* and *subtropicus* have been recorded from the same locality, while the specimens themselves show little intergradation. I have never collected both forms or seen them from any one small area—a colony seeming to represent only one subspecies and never both. If it were not for the fact that occasionally a few characteristics of *subtropicus* appear in the varied population of *lazarus lazarus*, I would consider it a separate species.

Eucanthus lazarus subtropicus is generally found in sandy, rather open habitats. Adults were collected in their burrow in every month of the year, but were less frequently found in June than in other months. Specimens were often attracted to light, but were never collected by baits or chemical attractants. No adults were ever seen to feed nor were they collected near any material they seemingly might use for food.

Most of my observations on this subspecies were made at Southern Pines, N. C. It was here that Manee's (1908b, p. 459) observations on *Eucanthus* were made. He mentioned that they (presumably *subtropicus*) dug verticle burrows in the sand and he included a

diagram of the push-up and burrow containing the adults. However, the larvae eluded him.

Two miles north of Southern Pines I found *subtropicus* in moderate numbers burrowing in an old sandy road (pl. 17, fig. 1). The road ran along near the top of a high sand ridge which was largely covered with grasses and weeds. The *Eucanthus* did not utilize the shade afforded by the few scattered turkey oaks and longleaf pines present in the area, but burrowed in the exposed bare sandy areas. Here the burrows could be easily located by the characteristic push-ups of "ropey" piles of sand almost 1 inch high and about 2 inches in diameter.

This locality at Southern Pines was visited rather frequently during 1951 and 1952. In July 1952 pairs of *Eucanthus* were found in 3 of 12 burrows dug. The vertical burrows averaged about 20 inches deep, the deepest one measured being 30 inches. On July 24, 1951, three burrows, separated by only a few inches, were excavated by using a posthole digger and sifting the sand as it was brought to the surface. A female was sifted out of the sand, brought up from a depth of 20 inches. In the sand from a depth of 24 inches, a larva was found during the sifting. Because of the manner in which it was collected little could be ascertained concerning the food of the larva or the type of cell that it occupied. A quantity of black humus, similar to that used by *Bolbocerosoma* and *Bolboceras*, was present in the sand brought up. Some of this material was placed in a metal salve box with the live larva for several days, but it could not be determined whether the larva used the humus for food. The larva, a third instar, was preserved on July 29.

After the discovery of the larva on July 24, a number of other burrows were dug the same day, but with rather unsatisfactory results. One burrow, 22 inches deep, yielded a very callow female, but no cell or food material was found. Further digging produced only adults.

During August 1951 considerable adult activity was noted, but no additional larvae were found. Two burrows dug at Southern Pines on August 18 were shallow, being only 12 and 14 inches deep. Numerous other fresh burrows were seen the same day. During the remainder of August and in early September all the burrows dug were shallow. After Sept. 8 a number of these burrows were marked with stakes and left undisturbed.

When the area was next visited, on Nov. 9, 1951, there was no sign of fresh surface activity. Two of the marked burrows were carefully investigated. The burrows, 12 and 14 inches deep, each contained a pair of *subtropicus*, the male slightly above the female in the burrow. The burrow formed a perfectly straight vertical tube ending without any indication of a food supply.

In April 1952 a marked burrow yielded a pair in a 15-inch burrow without any sign of brood activity. In early May two burrows yielded solitary females, but nothing else. On May 16 there were signs of surface activity and a female was collected at light. One burrow, 15 inches deep, yielded a pair of *subtropicus*, but again there was no indication that they were provisioning a cell.

On June 8 fresh burrows were in evidence, but were not as numerous as they had been previously. On June 14 one 18-inch burrow yielded a solitary female, while investigation of a 20-inch burrow produced a pair at the end of a vertical shaft. On the same day one of the burrows that had been marked all winter was examined. After digging to a depth of 30 inches a very callow male was found. Again no definite brood cell could be found in the loose sand, but a quantity of the black humus was nearby.

The following week, on June 21, a burrow was examined that had been newly made four weeks previously. A solitary female was found at a depth of 14 inches. The burrow extended beyond, and digging was continued to a depth of 22 inches, at which point a large, third-stage larva was found. A quantity of poorly compacted, fine, black humus mixed with sand and containing some fungus mycelia was within 1 inch of the spot where the larva was found. While it was not possible to definitely conclude that this was the material used for food, it seemed likely that it was so used. The larva of the closely related *Bolboceras darlingtoni* (Wallis) left the compacted food mass of humus and formed a pupal cell in the sand one-half to 1 inch from the food material. The larval *Eucanthus* may have moved from its food supply to pupate. The burrow push-ups of *Eucanthus* are almost identical to that depicted for *darlingtoni* (pl. 10, fig. 1) and it seemed probable that the larval habits were similar.

Further digging during June and July 1952 yielded only adults, and no further information was obtained concerning the larval habits.

The adults of *subtropicus* apparently have a long period of adult activity and a moderately long period of oviposition. This conclusion tends to be supported by the third-stage larvae being collected in June and July and callow adults being found in mid-June and late July.

Two larvae of *Eucanthus lazarus subtropicus* collected bear the following data: One third-stage larva found at a depth of 24 inches at Southern Pines, N. C., on July 24, 1951, by H. Howden and Ritcher; one third-stage larva found at a depth of 22 inches with female at Southern Pines, N. C., on June 21, 1951, by H. and A. Howden.

Adult specimens from Southern Pines differ considerably from western (Arkansas) *Eucanthus*, exhibiting the characteristics of *sub-*

tropicus. Several differences are also quite evident between the larvae from the two localities. Not enough larvae have been found to establish any limits of variation and it is possible that the larvae are generally as variable as the adult.

The Southern Pines larvae of *subtropicus* differ from the larvae of *lazarus* described by Ritcher in the following respects: Maximum width of head capsule 2.0 mm., frons on each side with two or three posterior frontal setae. Otherwise, head capsule and antenna (pl. 6, fig. 1) appear similar.

Mandibles similar to the Arkansas specimens but with the anterior portion of the scissorial area produced into a tooth, which may have been worn away in the Arkansas specimens. Maxillary stridulating area with a patch of 12 to 18 small, sharp, conical teeth on each side. Hypopharynx with two slightly asymmetrical oncyli covered with fine setae. Glossa with small setae extending entirely across anterior portion (pl. 6, fig. 6). These setae appear to be lacking in the Arkansas specimens (Ritcher, 1947, p. 25, fig. 30). Haptolachus with apparently two sensilla on each side, mesally with a dense, well defined phoba (pl. 6, fig. 6), which differs somewhat in outline from the Arkansas specimens.

Body (pl. 12, fig. 2) not humped or conspicuously swollen. Segments as described by Ritcher. Anal opening (pl. 6, fig. 7) more Y-shaped than V-shaped. Otherwise structures appear similar.

The most noticeable difference between these larvae and other ones described by Ritcher are in the shape of the glossa and in the fact that the setae extend completely across anterior portion of the glossa in *subtropicus*.

Eucanthus alutaceus Cartwright

Eucanthus lazarus var. *alutaceus* Cartwright, 1944, p. 30. Type, male, Mississippi (USNM).

Length 11 to 14 mm., greatest width 6.5 to 7.5 mm.

Color of dorsum oily dark red-brown; head, thorax, and sutural intervals slightly darker than elytra. The oily appearance is due to the fine alutaceus appearance of the dorsum. Color of antennal club reddish brown. Ventral portions of thorax and abdomen the same or slightly darker in color than dorsally. Tibia darker brown to black. Punctures of vertex very few and sparse in both sexes. Coarse punctures of clypeus, eye canthi, and pronotum identical to those of *E. lazarus lazarus*. Secondary punctures of pronotum very fine, much less noticeable than in most specimens of *lazarus lazarus*. Punctures of elytral striae moderate, separated by a distance usually slightly more than their diameter. Elytral punctures without setae except those on the margins of the elytra and epipleura, where a few of the punctures bear long reddish setae. Width of elytral striae similar to

lazarus lazarus, second and fourth intervals slightly wider than others, and usually with a line of fine punctures. Humerus of elytron bearing a small sharp tubercle at edge. Foremargin of eye canthus scarcely produced forward at outer angle, slightly more sharply rounded than in typical *lazarus*. The lamellae of the antennal club noticeably longer than the eye (as in *lazarus lazarus*). Male with very pronounced clypeal horn, almost twice as long as wide. Clypeal horn of female small and thin, slightly bifid. Horn of vertex more pronounced, noticeably bifid. Pronotal modifications of male identical to well developed males of *lazarus lazarus*, females similar to females of *lazarus lazarus*.

No useful characteristics were noted in male genitalia or genital capsule.

Variation in size, color, or other noticeable characters is very slight. Cartwright described this species as a variety of *lazarus*, but none of the specimens known have been collected in areas with *lazarus lazarus*. Specimens of *alutaceus* occur along the Gulf of Mexico, within the range of *subtropicus*. As it is very distinct from *subtropicus* it is my opinion that it is a separate species. It is easily distinguished by its dorsal alutaceus appearance.

Most of the known specimens were collected at light and there is no information available concerning either the adult or larval biology.

Specimens examined: 14 males, 9 females.

ALABAMA: 1 male (paratype), Grand Bay, August 1906, Loding (Cartwright).
FLORIDA: 1 female, Gainesville, Feb. 13, 1935 (UnMich).
GEORGIA: 12 males, 8 females. Emory University Field Station, Baker County, Sept. 28 to Oct. 1, 1951, Dec. 29 to Jan. 3, Jan. 17, 18, 21, 22, Aug. 12, 19, 20, Sept. 9, 1952, light trap (Howden). Thomasville, paratype, Apr. 1, 1939, Thames (Cartwright).
MISSISSIPPI: 1 male (paratype), Lucedale, Apr. 7, 1932, Dietrich (Cartwright).

Eucanthus greeni Robinson

Eucanthus greeni Robinson, 1948, pp. 30–31. Type, male, New Mexico (Robinson).

Some of the following discussion has been taken from Robinson's original description and has been added to and rewritten merely for the sake of uniformity.

Length 8.3 to 11 mm., greatest width 4.9 to 6.8 mm.

Color of dorsum shining reddish brown with eyes, tips of horn, edge of eye canthus, anterior and posterior edges of pronotum, and sutural intervals darker brown to black. Antennal club light reddish brown in color. Ventral portions of thorax and abdomen the same or slightly darker in color than dorsally. Tibia dark brown to black. In male, coarse punctures of vertex absent, which is also usually true in the female. Moderately coarse pronotal punctures are present on

the anterior margin, on the slightly explanate side margins, on the area behind the tubercles, and on a thin median strip from the carina to the basal margin. The punctures near the lateral margins have about half the rim elevated as in the other species, giving them a tuberculate appearance. Very minute secondary punctures are scattered over the entire pronotum. Crenate punctures of elytral striae shallow, usually separated by about twice their diameter. Elytral punctures without setae except those on the margins and epipleura, where a few of the punctures bear long reddish setae. Five well developed striae between sutural interval and umbone. The second and fourth intervals, which are slightly wider than the adjacent ones, each sometimes having a row of very small punctures. Side margins of pronotum less explanate than in the other species of *Eucanthus*. Humerus of elytron with tubercle at edge lacking or only vaguely indicated. Foremargin of eye canthus (gena) at right angle to side, with angle evenly rounded. The lamellae of the antennal club noticeably longer than the eye (similar to *lazarus lazarus*). Male with pronounced clypeal horn, noticeably longer than wide, bifid at tip. Poorly developed transverse carina on vertex. Pronotal modification with transverse carina only barely indicated, lateral limiting grooves shallow, but lateral pointed carinae well developed. In the female the transverse carina of the vertex is a bifurcate tubercle of equal height with the clypeal horn or sometimes even higher. The pronotal carinae are less developed than in the males and the coarse pronotal punctures are larger and denser.

Robinson differentiates the species from *lazarus lazarus* by the following characters: Eye canthus (gena) more angular, lateral margins of the thorax less explanate, sinuation of hind angle less pronounced, coarse punctures of pronotum slightly less pronounced than those of other species, small punctures of elytral striae, transverse pronotal grooves absent or barely indicated and transverse carina poorly defined. It might be added that the tubercle of the elytral humerus absent or barely indicated appears to be an additional character not mentioned by Robinson. Many of the characters mentioned above intergrade with *lazarus lazarus*; some specimens from Manitoba, Canada, and Thomas County, Nebr., show most of the characterists given for *greeni*. Upon further study *greeni* may prove to have subspecific rather than specific rank.

Specimens examined: 6 males, 9 females (1 male, New Mexico or Arizona (CAS)).

UNITED STATES

ARIZONA: 1 male, Granito Mountain, Yavapai County, Sept. 19, 1929, Kusche (CAS).

NEW MEXICO: 2 females (paratypes), Jemez Mountains, July 24, Aug. 1, Woodgate (CAS). 1 male, Santa Fe, August (CAS).
UTAH: 1 female, Moab, Grand County, Aug. 18, 1929, Gloyd (UnMich).

MÉXICO

CHIHUAHUA: 3 males, 6 females. Samalayuca, Aug. 7, 1950, Smith (AMNH).

Genus *Bolboceras* Kirby

Bolboceras Kirby, 1818, p. 459.—Stephens, 1828, p. 178.—Curtis, 1829, description opposite pl. 259.—Melsheimer, 1845, p. 138.—Cartwright, 1953, p. 101.
Odontaeus Megerle, *in* Dejean, 1821, p. 56, nomen nudum and therefore not valid.
Odantaeus Klug, 1845, p. 37.—Westwood, 1852a, p. 11.—Lacordaire, 1856, p. 144.—Horn, 1870, p. 42.—Blatchley, 1910, p. 938; 1928, p. 29.—Dawson, 1922, p. 193.—Wallis, 1928, pp. 119–128, 151–156, 168–176; 1929, pp. 239–241.
Scarabaeus Fabricius, 1775, p. 11.—Olivier, 1789, p. 63.—Marsham, 1802, p. 8.
Geotrupes Latreille, 1804, p. 145.

GENOTYPE: *Bolboceras mobilicornis* Fabricius, designated by Curtis (1829, page opposite pl. 259).

GENERIC LIMITATIONS: Given by Kirby (1818, p. 459):

Labrum transversum.

Labium bipartitum; laciniis oblongo-quadratis.

Mandibulae corneae, supra concava, altera apice bidentata; dente interiori longiori acuto.

Maxillae apice bilobae; lobis ciliatis; interiori minuto, exteriori subcuneiformi; angulo apicis intus producto acutissimo.

Palpi filiformes.

Mentum subquadratum, integrum.

Antennae undecim-articulatae; articulo primo sublcavato extus minutissimo, secundo cylindrico, proximis sex transversis, ultimis tribus clavam maximan compressam suborbiculatam, pilosam, articulo intermedio saepius penitus tecto et abdito, formantibus.

For a detailed account of additional generic characteristics, consult Wallis (1928, pp. 124–126).

Cartwright (1953) has stated that if one accepts the designation by Curtis (1829, page opposite pl. 259) of *mobilicornis* Fabricius (*armiger* Scopoli) as the type of the genus *Bolboceras*, then *Odontaeus* should be placed in synonymy. As no alternative to this has been found, the name *Bolboceras*, as it is used here, includes all the North American species formerly placed in the genus *Odontaeus* by Wallis (1928, 1929).

Since the species in the genus were carefully described by Wallis (1928, 1929), it is unnecessary to redescribe them here. A few notes on adult morphology have been added, but for keys to the species and descriptions of the adults the reader is referred to the previously mentioned papers by Wallis. In the present discussion, only the known biology and larval morphology of the species are considered.

While the species of *Bolboceras* are, as adults, remarkably alike, the known larvae (three species) are remarkably unlike. The larva of

Bolboceras simi (Wallis) was carefully described by Ritcher (1947, pp. 13, 14). The larvae of *Bolboceras darlingtoni* and *liebecki* are subsequently briefly described for the first time by listing only the structures which differ from Ritcher's description of *B. simi*.

Generic larval characteristics exhibited are: Antennae (pl. 6, fig. 3) with one conical sense organ on penultimate segment; first segment longer than second, which is longer than the third; body not humped (pl. 12, fig. 1); anal opening transverse (pl. 6, fig. 10) with lower anal lobe unpaired; prothoracic legs smaller than others, which are similar in size. Legs 2-segmented, lacking claws.

Members of this genus are found largely in the eastern United States and in southeastern Canada, with the exceptions of one species occurring in the western United States and one in Europe.

Biological information on the genus is rather sparse, almost all of the information previously available having been accumulated by Sim (1930). In addition to this published work, Wallis (1928) quotes a number of statements on biology made by Sim in personal correspondence.

Key to the known larvae of the North American species of Bolboceras

1. Anterior frontal setae absent; glossa not emarginate; hypopharynx symmetrical, pternotorma absent . . . . . **simi**
   Anterior frontal setae present; glossa vaguely emarginate; hypopharynx (pl. 6, figs. 8, 11) somewhat asymmetrical, epipharyngeal pternotorma indicated . 2
2. Epipharynx (pl. 6, fig. 12) with a small posterior epitorma; small pternotorma elongate. . . . . **liebecki**
   Epipharynx (pl. 6, fig. 9) with a large posterior epitorma; small pternotorma bulblike . . . . . **darlingtoni**

***Bolboceras obesus* (LeConte)**

Odontaeus obesus LeConte, 1859, pp. 282–283 (type, male, LeConte collection, MCZ).—Horn, 1870, p. 47.—Wallis, 1928, p. 127.

Bolboceras obesus (LeConte) is the only species of this genus occurring in the western United States where, from the number of specimens examined, in many places it seems to be rather common.

Specimens have been collected in almost every month of the year, but adult activity appeared from the data to approach its peak in spring and early summer. While the adult habits appeared similar to the eastern species, little biological information has been amassed. Adults have been occasionally noted coming to light. Linsley and Michener (1943, p. 79) made the following observations on *obesus* in the vicinity of Mount Lassen, Calif.: "Several hundred pupae and a few larvae of this species were excavated from the sandy soil of an old road bed in the midst of a manzanita chute on June 16 [1941]. One adult female was found at this time. The pupal cells averaged 8×7 ×15 mm., and were found at a depth of from 3 to 6 inches below the

surface." No mention was made of larval food, nor was there any description of the larvae or pupae.

Rivers (1886, pp. 69–70) gave an extremely vague description of a larva referred to as *Odontaeus obesus*. He stated that the larva was chestnut in color with tufts of setae around each spiracle and had prominent legs. He found the larva feeding on the rootlets of *Umbellularia californica* Nuttall. The above characteristics from his vague description differ in most respects from the described characters of the larvae of other species. That fact, coupled with the statement "feeding on rootlets," which would seem to be a radical departure from the known larval habits of any *Bolboceras*, makes me feel fairly certain that Rivers was mistaken in his identification of the larva before him.

Careful and accurate descriptions of the biology and of the larva are still needed.

Specimens examined: 67 males, 82 females.

CANADA

BRITISH COLUMBIA: 12 males, 16 females. Agassiz, Creston, courtenay, Duncan, Salmon Arm, Victoria; (2) April, (4) May, (6) June, (2) July, (3) August, (1) September.

UNITED STATES

ARIZONA: 1 male, 2 females. McNary, White Mountains (Gila County); (1) August, (1) September.

CALIFORNIA: 29 males, 34 females. Berkeley, Brownsville, Dutch Flat (Placer County), Kaweah, Lassen National Park, Lelands [Stanford?] University, Nevada County, Piedmont (Oakland), Pollock Pines (El Dorado County), Sequoia National Park, Smith River (Del Norte County), Tulare County; (1) February, (1) March, (5) April, (16) May, (27) June, (1) August.

COLORADO: Included by Wallis.

IDAHO: 1 male, 5 females. Moscow, Sandpoint; (1) April, (1) June, (1) August.

NEVADA: 1 male, 1 female. Carson City; (1) June.

NEW MEXICO: 3 males, 3 females. "Mescalero Apache Indian Reservation, Rio Grand (near Taos)," Tajique; (2) June, (1) July, (2) August.

OREGON: 14 males, 13 females. Corvallis, Dilley, Klamath, La Grande, Medford, Portland, Wallowa Lake; (2) April, (6) May, (2) June, (2) July, (1) August.

UTAH: 1 male, 1 female. Salt Lake City, Warner Ranger Station (La Sal Mountains); (1) June.

WASHINGTON: 5 males, 6 females. Pullman, Seattle, Tenino; (9) May, (1) July.

WYOMING: 1 female. Cheyenne; (1) June.

Bolboceras falli (Wallis)

Odontaeus falli Wallis, 1928, p. 151. Type, male, Foxwarren, Manitoba, June 14, 1927, Wallis (Wallis).

Bolboceras falli is a northern species, closely related to *obesus* (LeConte). It is found during June, July, and August.

The only biological observations were made by Wallis (1929, pp. 123–124), and following are excerpts from his discussion:

. . . *falli* inhabits somewhat richer land than those [species] taken by Mr. Sim. Mr. Criddle finds them near his home at Aweme, Manitoba, along a road through the aspen poplars, where the soil is a rich dark sandy loam. They appear never to occur on the more sandy uplands a few yards away or on the bare sand which, too, is quite close * * * burrows seem never to be more than a few inches deep.

Falli occasionally comes to light at Winnipeg, or rather flies around light, rarely if ever coming directly to it, but circling it and falling to the ground some feet away. On one occasion when sugaring for moths in a rich wood, I noticed a small area of the leaf humus undulating in a most vigorous and extraordinary manner. On rolling the pieces of mould off like a blanket a seething mass of *Odontaeus* was found beneath, rolling, crawling, clinging . . . . They . . . appeared to have gathered for mating purposes, as many of the males had the genitalia partly exposed.

No other new facts on the biology of *B. falli* have been mentioned since Wallis' interesting account.

Specimens examined: 27 males, 22 females.

CANADA

MANITOBA: 11 males, 13 females. Aweme, Foxwarren, Shell River, Winnipeg; (2) June, (18) July, (3) August.
ONTARIO: 2 males. Ottawa.
QUEBEC: Quinze Lake, listed by Wallis.
SASKATCHEWAN: Regina, listed by Wallis.

UNITED STATES

MICHIGAN: 11 males, 9 females. Cheboygan County, Douglas Lake, "Hrn. Mt. [=Huron Mountain?] Club," Houghton County, Marquette, Onota (Alger County); (4) June, (12) July, (4) August.
SOUTH DAKOTA: 1 male. Volga.
WISCONSIN: 2 males. Vilas County, Wisconsin Trout Lake Nursery; (1) July.

Bolboceras thoracicornis (Wallis)

Odontaeus thoracicornis Wallis, 1928, p. 153. Type, male, Cincinnati, Ohio, Dury (Wallis).
Odontaeus cornigerus Blatchley (not Melsheimer), 1910, p. 938.

Only one note was found concerning the biology of this species and this was by Blatchley (1910, p. 938) under the name *cornigerus*. His statement was: "One male from Vigo County, Sept. 28. Taken from beneath a partly burned log in upland, sandy woods."

From the information accumulated by dates of capture, the species seems to be adult in the fall, winter, and spring.

Specimens examined: 18 males, 7 females.

ARKANSAS: 1 male. Camp Chaffee; (1) June.
GEORGIA: 2 males. Atlanta, Clarke County; (1) March, (1) May.

ILLINOIS: 5 males, 3 females. Putnam County, Urbana; (1) May, (3) June (1) October.
INDIANA: 1 female. Hessville; (1) June.
IOWA: 4 males. Ames, Burlington; (2) March, (1) November.
KENTUCKY: 1 male, paratype. No data.
MICHIGAN: 1 male. No data.
MISSISSIPPI: 1 male. Lucedale; (1) September.
NORTH CAROLINA: 1 male. Raleigh; (1) May.
OHIO (Type, Cincinnati; from literature.)
OKLAHOMA: Listed by Wallis.
PENNSYLVANIA: 1 male. Allegheny County; (1) October.
SOUTH CAROLINA: 1 male, 1 female. Clemson College; (2) November.
TENNESSEE: Listed by Wallis.
VIRGINIA: 2 females. No data.
TEXAS: Listed by Wallis.

Bolboceras cornigerus Melsheimer

Bolboceras cornigerus Melsheimer, 1845, p. 138. Type, male, Melsheimer collection (MCZ).
Odontaeus cornigerus (Melsheimer) Horn, 1870, p. 47.—Wallis, 1928, p. 172.

Nothing is known about the biology of this species, for while it has a wide range it appears to be very uncommon. During the course of his work Wallis (1928, p. 173) saw only 10 specimens and I have seen only 19, many of them the same specimens seen by Wallis.

The species is apparently a summer form, having been collected from June to August. Because of the rarity of the species, complete data on the labels and the location of collections housing the specimens are given below.

Specimens examined: 8 males, 11 females (1 male, no data).

GEORGIA: 1 female, Clayton, 2,000–3,000 ft., July, 1910, Davis (AMNH).
MASSACHUSETTS: 1 male, Tyngsboro (Blanchard, at MCZ).
MARYLAND: Listed by Wallis.
MISSOURI: 1 female, no data (Ulke at CM).
NEW JERSEY: 1 male, Paterson, October 27 (AMNH).
NEW YORK: 1 female, Fort Montgomery, July 16, 1920, Schott (Robinson).
NORTH CAROLINA: 1 male, 1 female, Black Mountains, June 20, 1937, in burrows, Cartwright (Cartwright). 1 female, Raleigh, June 20, 1939, Wray (NCSM).
PENNSYLVANIA: 1 female, Allegheny County, June 17, 1888, Klages (CU). 1 male, Guys Mills, July 12, 1937, Casselbury (Robinson). 1 male, Pittsburgh, July 15 (Howden). 1 female, Sumneytown, Aug. 1, 1939, Peters (Robinson).
TENNESSEE: 1 female, no data (Howden). 1 male, north Tennessee, summer 1921, Gill (CU).
VERMONT: 1 female, Bennington County (AMNH).
VIRGINIA: 1 male, 1 female, no data (INHS). 1 female, Nelson County, July 13, 1910. Robinson (AMNH).

***Bolboceras liebecki* (Wallis)**

Odontaeus liebecki Wallis, 1928, p. 173. Type, male, Cornwall, Conn., May 30, 1921, taken under wash-up by Chamberlain (Wallis).

Bolboceras liebecki (Wallis) is a rather common, wide-ranging species found in most of the Northeastern States, and in the mountainous portions of the Southern States. Sim (1930, p. 145) stated that:

> This species is more distinctly characteristic of higher elevations. Unlike the preceding beetle [*simi*] which frequently works in open sunny places, *liebecki* is most likely to be found burrowing on the upper levels of well-shaded hills and mountains. While the beetles, of course, frequently have their homes under the leaf carpet of the forest floor, their diggings are much more easily found along some old wood road in which the little used wheel tracks are bare. For N. J. records I mention the Jersey Jump Mountains, August 17, 1929, and Arney's Mount, August 30, 1927.

Robinson (1938, p. 103) found specimens in a somewhat similar locality under leaves near West Chester, Pa.

I have found *liebecki* in this same type of habitat in North Carolina. At the Mills River recreation area in the Pisgah National Forest two males and a female were dug from shallow burrows, 1 or 2 inches deep, on Aug. 16, 1951. The beetles were found in a small, partially shaded clearing formed by an old road and parking spot at the top of a ridge. There were some sand and numerous pebbles, but for the most part just below the surface there were well-packed clay and stones. In the same area, in mid-August, several other specimens of *liebecki* were taken in sunken cans containing fermenting malt. This would seem to indicate that the adults may feed on decaying plant material (probably with food habits similar to those given for *darlingtoni*).

While all previous records of *liebecki* in North Carolina have been from the mountains, I was extremely fortunate in finding a few specimens on a well-wooded hillside 5 miles northwest of Raleigh. The first specimen, a female tentatively identified as *liebecki*, was taken in a trap baited with ethyl sulfide. As this material did not attract other specimens over a period of several months, its attractiveness, if any, was slight.

In the same area, I had a rearing cage, 6 feet long by 3 feet wide, containing *Geotrupes splendidus splendidus* (Fabricius) in the spring and early summer of 1951. At various times an assortment of fungi and rotten bananas were put in the cage to feed the adult *splendidus*, along with a large quantity of dead leaves, humus, and some cow dung to be used as larval food. Through natural decay, the activities of the beetles, and the subsequent digging of the author the top 2 or 3 inches of soil became well mixed with finely divided humus.

By August 1951 all of the *splendidus* had been removed and the screen top was left partially off of the cage. In April 1952 the cage

was again placed in use, this time for *Geotrupes hornii*. After the specimens were put in the cage a quantity of dead leaves and cow dung was added and the screen top was securely fastened. During the time that the cage had not been in use the soil (red clay) had become firmly compacted and, except for a rich layer of finely divided surface humus, had approximately the same profile as the neighboring undisturbed ground.

On June 19, 1952, I was digging in the cage for the *hornii* when an unarmed male *liebecki* was unearthed at a depth of 6 inches. The specimen was in a straight vertical burrow that continued downward into the subsoil, which began at a depth of 6 or 7 inches. The burrow was followed downward with difficulty. The rather dry, compact, red clay soil had to be chipped away, after a time bending the tip of one trowel so badly that a second one had to be used. Sim previously had also noted the propensity of *liebecki* to dig in firmly compacted soils in New Jersey. Wallis (1928, p. 123) quotes from correspondence with Sim as follows:

> Now in the *liebecki* localities the soil is pretty purely clay with numerous pebbles and rock fragments . . . [at] Jenny Jump Mountains in North Jersey the stones are so numerous that a burrow may be very irregular in its downward course. Too, the clay is more firm and difficult to dig [through]. So as I recall them the beetles were found from one inch to six or eight inches down.

While the Raleigh clay lacked the numerous pebbles, it was certainly difficult to dig through.

The *liebecki* burrow continued without turns to a depth of 11 inches. There it turned slightly and, behind a half-inch plug of red clay, it was packed with a mixture of some sand grains and rich, very fine surface humus. In the center of the cell of humus was a second-stage larva, about 12 inches below ground level. The larva, with its cell, was placed alive in a metal salve box. At least one other *Bolboceras* burrow was noted in the cage, but digging was temporarily postponed because of the difficulties that the excavation of the burrow entailed.

The larva in the salve box increased rather rapidly in size, sifting through the sand for the humus. Often a grain of sand, coated with humus, was grasped and rotated between the mandibles and maxillae, and then discarded minus its coating. On June 26, 1952, the larva was noted to be a third instar. On June 28, 1952, the larva died, probably killed by unaccustomed high temperatures (over 90° F. in the room in which the salve box was kept). The larva was immediately preserved and the remaining unconsumed portion of its food supply carefully saved.

Later, this material was taken to the North Carolina Department of Agriculture Soil Testing Laboratory. There, through the kindness of Dr. J. W. Fitts, both the food cell and the surrounding red clay were analyzed for the amount of readily oxidizable organic matter contained. A modified Walkley Black procedure was used (the major chemical components being sulphuric acid and sodium dichromate). This method oxidizes about 90 percent (by weight of soil) of the organic matter. The surrounding red clay contained 0.64 percent organic matter, while the larval food cell contained 7.60 percent. This, according to Dr. Fitts, was very high, the usual surface soil in the immediate area containing only 1 to 1.5 percent oxidizable humus. From this it would appear that, if the adult beetle did not concentrate the surface humus, it at least burrowed in spots with an extremely high surface concentration.

On July 1, 1952, the cage northwest of Raleigh was revisited. On this occasion a quantity of water was taken along and the ground in the cage kept thoroughly soaked. This made the digging of the one located *Bolboceras* burrow considerably easier. At a depth of 7 to 8 inches a female *liebecki* was taken in the burrow. Seven inches farther, at a depth of 14 inches, a fully grown third-stage larva was taken at the bottom of the burrow, which for 1½ inches was packed with humus and sand. Above this was a plug of red clay. The burrow was a single tube, much like that diagrammed for *Bolboceras darlingtoni* (Wallis) (pl. 10, fig. 1). The larva, slightly injured by the trowel, was immediately preserved. No other adults or larvae of *liebecki* were taken in the cage.

It was interesting and fortunate for purposes of identification that both adults remained in the burrows containing the larval cells. Whether the presence of the adults in the burrows indicated any brood care was not ascertained. This and many other questions concerning the life history of *liebecki* still are unanswered.

The subsequent description of the larva of *Bolboceras liebecki* was based on the following material: One second-stage larva collected at Raleigh, N. C., on June 19, 1952, by H. Howden, reared to third instar; and one third-stage larva collected at Raleigh, N. C., July 1, 1952, by H. and A. Howden.

Larvae of *liebecki* differed from Ritcher's (1947, p. 13) description of *simi* in the following respects: Maximum width of head capsule 2.2 to 2.5 mm.; frons on each side with 2 or 3 posterior frontal setae, 2 setae in each anterior angle, 1 or 2 exterior frontal setae and 4 or 5 anterior frontal setae; labrum, antennae (pl. 6, fig. 3), and mandibles similar to *simi;* maxilla differing only by having 4 or 5 setae, absent in *simi,* on the base of the galea; hypopharynx slightly asymmetrical with oncyli separated by triangular structure (pl. 6, fig. 11); glossa emar-

ginate; tormae of epipharynx (pl. 6, fig. 12) united medially, asymmetrical, with a small posterior and anterior epitorma; pternotormae small; slightly spiculate pedium with semicircle of phobae.

Structure of body, anal lobes, and legs differ in no respects from Ritcher's description of *simi*.

Specimens examined: 74 males, 67 females.

CANADA

ONTARIO; Listed by Wallis.
QUEBEC; 3 males, 2 females. Knowlton, Lake Memphremagog; (3) June, (2) July.

UNITED STATES

CONNECTICUT; 1 female. Cornwall; (1) May.
DELAWARE; Listed by Wallis.
ILLINOIS; 1 male, 1 female. No data.
INDIANA; Listed by Wallis.
MAINE; 3 males, 11 females. Bethel, Brunswick, Christmas Cove, Paris; (8) June, (4) July.
MARYLAND; 4 males, 1 female. College Park, Relay; (1) May, (1) June.
MASSACHUSETTS; 10 males, 10 females. Billerica, Cotting(?), Dorchester, Humarock, Malden, Marion, Natick, Pembroke, Petersham, Springfield, Tyngsboro, Wellesley, Woburn; (1) April, (4) June, (5) July, (1) August.
MICHIGAN; 1 male, 1 female. Macatawa Beach, Pentwater; (1) June, (1) July.
MISSOURI; Listed by Wallis.
NEW HAMPSHIRE; 7 males, 5 females. Durham, Franconia, Hampton, Manchester, Rumney, Tamworth, Three Mile Island; (1) May, (2) June, (1) July, (1) August, (1) September.
NEW JERSEY; 2 males. Burlington County, Ramsey; (1) June, (1) August.
NEW YORK; 6 males, 7 females. Bemus Point, Buffalo, Fair Haven, Hancock, Ithaca, Leon, Pike, West Farms; (1) May, (1) June, (1) July.
NORTH CAROLINA; 12 males, 16 females. Black Mountains, Highlands, Mills River, Pisgah Forest, Raleigh, Sunburst; (8) June, (8) July, (8) August.
PENNSYLVANIA; 20 males, 7 females. Allegheny County, Bucks County, Delaware County, Downingtown, Glen Olden, Indian Creek, Jeannette, Mont Alto, Pittsburgh, Sharpsville, Westtown; (8) June, (8) July, (1) August, (1) September.
SOUTH CAROLINA; 1 male, 3 females. Sassafras Mountain; (2) July, (2) September.
TENNESSEE; 1 male. Green Brier; (1) June.
VERMONT; 2 males, 2 females. Stowe; (3) June, (1) July.
VIRGINIA; Listed by Wallis.
WISCONSIN; 1 male. No data.

***Bolboceras filicornis* (Say)**

Geotrupes filicornis Say, 1823, p. 211. Type lost.
Odontaeus filicornis (Say) Horn, 1870, p. 47.—Wallis, 1928, p. 168. Neoholotype, male, Medora, Kans., July 14, 1923, W. Knaus (Wallis).

Because of the confusion in the use of the name *filicornis* until Wallis' work, some of the references using the name "*filicornis*" have

been referred to different species and others have been omitted due to the difficulty of assigning them to a species.

It was also difficult, owing to the nomenclatorial confusion, to guess whether some of the early biological notes referred to this species or some other. However, the two references cited below appear pertinent for this species. Knaus (1927, p. 126) mentioned that at Medora, Kans., a few specimens of *filicornis* were collected at light in early July; they were not collected otherwise. Later, he stated (1928, p. 98) that he had taken only two specimens at light that season and had never seen them in burrows in the area. Other references by Knaus (and others) add nothing to this information.

Specimens examined: 19 males, 15 females.

ARKANSAS; 1 male, 1 female. Hope; (1) June.
ILLINOIS; 1 male, 1 female. St. Clair County.
INDIANA; 3 males, 2 females. Hessville, Pine; (1) May, (1) June, (3) July.
KANSAS; 2 females. Medora; (1) May, (1) June.
MICHIGAN; 1 male. Douglas Lake; (1) June.
MINNESOTA; Listed by Wallis.
MISSISSIPPI; 4 males. Camp Shelby; (2) September, (1) October, (1) December.
NEBRASKA; 2 males, 2 females. Antioch (Sheridan County), Halsey, Meadville; (4) July.
NORTH DAKOTA; 1 male. Sully's Hill National Park; (1) July.
OHIO; 1 male. Ashtabula (Whitman Beach); (1) June.
SOUTH DAKOTA; 2 males. Brookings; (2) August.
WISCONSIN; 3 males, 7 females. Douglas County (Gordon State Nursery); (1) May, (2) June, (4) July, (3) August.

Bolboceras floridensis (Wallis)

Odontaeus floridensis Wallis, 1928, p. 155. Type, male, Lake Worth, Fla., collection of Mrs. A. T. Slosson (AMNH).

(?) *Odontaeus filicornis* Blatchley (not Say), 1928, p. 29. (Probably referable to *floridensis*.)

The type of this species, the only male available to Wallis, was unarmed. However, Wallis (1928, p. 156) states that "horned specimens are almost certain to occur and if so, judging from the shape of the male genitalia, the horns will probably be movable." This assumption has proven well founded, as I have examined several well-armed males, all with the "movable" horn.

Almost nothing is known about this seemingly rare species. I collected two specimens; one, a well-armed male, was taken at light, and the second, a female, was collected in a can of fermenting malt. From the collecting dates on the specimens seen, I would assume that

this is a winter species, perhaps comparable to *darlingtoni* in habits, but further information is badly needed.

Specimens examined: 4 males, 2 females.

FLORIDA: 1 male, Gainesville (Cartwright). 1 female, Interlachen, Nov. 18, 1951, H. Howden (Howden). 1 female, Lake Placid, Archbold Biological Station, Feb. 5, 1943 (AMNH). 1 male, Miami, Feb. 25, 1934 (Robinson). 1 male, St. Augustine, Mar. 4, 1940, Van Dyke Collection (CAS). 1 male, Tarpon Springs, Mar. 20, 1950, light, H. and A. Howden (Howden).

***Bolboceras simi* (Wallis)**

Odontaeus simi Wallis, 1928, p. 170. Type, male, Merchantville, N. J., July 27, 1926, Sim (Wallis).
Odontaeus filicornis Blatchley (not Say), 1910, p. 938.

The following excerpt from Sim (1930, p. 145) presents all the biological information available on the species:

> The type locality for the present species is the golf course at Merchantville, N. J. This seems to be a characteristic habitat. Throughout July and August the little beetles give evidence of their presence on green and fairway by pushing up small but conspicuous piles of sand . . . *Simi* has been found, also, associated with *darlingtoni* at Rancocas Park, in a pine-oak bush lot near Riverside and associated with *liebecki* on Arney's Mount.

Wallis (1928, p. 122) mentioned, quoting from correspondence with Sim, that the species was found in the open and was not present in fall, winter, or spring. Sim concluded that the beetles' actions were apparently the same as *darlingtoni* in burrowing habits and biology.

Sim collected two third-stage larvae with associated adults in September 1927 at Riverside, N. J. One larva pupated on Nov. 10, 1927. Subsequently, the larva was carefully described by Ritcher (1947, p. 13). Included here for purpose of identification are a few of the characteristics of *simi* mentioned by Ritcher.

Anterior frontal setae absent. Hypopharynx symmetrical; glossa not emarginate. Tormae of epipharynx united mesally; almost symmetrical, having a large posterior epitorma and a smaller anterior one. Pternotorma absent. Pedium surrounded by a fairly uniform arc of phobae and covered with spicules.

Specimens examined: 27 males, 19 females.

CONNECTICUT: Listed by Wallis.
INDIANA: 1 female. Hessville.
MASSACHUSETTS: 2 males, 1 female. Sherborn, Tyngsboro; (1) June.
MICHIGAN: 1 female. Paw Paw Lake; (1) July.
MINNESOTA: 1 male. Erskine; (1) August.
NEW HAMPSHIRE: 1 female. Manchester.
NEW JERSEY: 23 males, 14 females. Burlington County, Merchantville, Pine Valley, Riverton, Vineland (Maurice River); (5) June, (26) July, (3) August.
NEW YORK: 1 male. Southampton.
PENNSYLVANIA: 1 female. Allegheny; (1) August.

***Bolboceras darlingtoni* (Wallis)**

Odontaeus darlingtoni Wallis, 1928, p. 175. Type, male, Rancocas Park, N. J., Oct. 27, 1926, Sim (Wallis).

Bolboceras darlingtoni (Wallis) has been recorded as frequenting sandy areas in the pine and deciduous forests of the East Coast States from Georgia northward to Massachusetts. It was usually found on the coastal plain, but occasional specimens have been collected in mountainous areas. To cite an example of this odd distribution, several specimens of *darlingtoni* were taken along with a number of *liebecki* in the mountains at the Mills River recreation area in the Pisgah National Forest, N. C. The burrows of both species were found 2 to 4 inches deep in an old dirt road at the top of a small hill where the soil consisted of packed clay with numerous small rocks.

In sandy areas *darlingtoni* makes an almost vertical burrow from 8 to 18 inches deep. Sim (*in* Wallis, 1928, p. 123) mentioned finding the species working in pairs, but I rarely found a pair in the same burrow.

In North Carolina, adults were active in fall, winter, and spring. Specimens were occasionally found coming to light on warm nights in October, November, December, and January. Most of the fresh burrowing activity was noted in April, May, and June, and again in October.

On Oct. 18, 1952, in a sandy pine woods near Raleigh, N. C., I found two male and four female beetles in shallow burrows under what appeared to be "atypical puff balls." The beetles were feeding on decaying pieces of these puff balls which gave off an odor similar to fermenting apple cider. Several of them were later identified by Dr. A. Kelman, North Carolina State College, and Dr. Couch, University of North Carolina, as *Rhizopogon nigrescens* Coker and Couch (Hymenogastraceae, Gastromycetes). Previously, Sim (1930, p. 144) had noted that *darlingtoni* fed on *Rhizopogon pachyphloes* Zeller and Dodge. The *Rhizopogon* mentioned by Sim was entirely subterranean, the beetles burrowing down to it. Bedel (1911, p. 99) stated that he believes that the adult European *Bolboceras "armiger"* Scopoli had feeding habits similar to those of *Bolbelasmus gallicus* Mulsant, which has been recorded as feeding on a species of *Rhizopogon* and other types of fungi. No further references to the adult food habits were seen. Adults of several species were occasionally attracted to fermenting malt, which might indicate more generalized feeding habits than have been indicated by the data available.

While Sim (1930, pp. 139–147) recorded his observations about the habits of the adults, the larval biology of *darlingtoni* eluded him.

Dr. P. O. Ritcher and I were able to work out, at least partially, the biology and life history of these elusive beetles.

On Apr. 19, 1951, in the center of a burned-over area in a sandy pine, deciduous woods at Faison, N. C., two small push-ups of yellow sand were noted. One of these yielded a well-armed male at a depth of 5 inches. Under the second push-up a pair of *darlingtoni* was found in a small cell at a depth of 11 inches. A few inches away, apparently not connected to either of the two burrows containing adults, another small cavity was found at a depth of 11½ inches. In the cavity was a single elliptical egg, 2.4 mm. long by 1.5 mm. wide. Just above the cavity containing the egg (pl. 14, fig. 1) was the food supply. This consisted of very finely divided surface humus mixed with sand packed into the slightly sinuate burrow.

Through the kindness of Dr. J. W. Fitts, Soil Testing Laboratory, North Carolina Department of Agriculture, a portion of this black humus used for larval food by *darlingtoni* was analyzed. The analysis was made using a modified Walkley Black procedure to show the amount of readily oxidizable organic matter that the material contained. The larval food cell was found to have 3.44 percent organic matter compared to 0.16 percent found in the surrounding subsoil. Normally, the surface soil in the area contained only about 1 percent readily oxidizable organic matter. It would appear that, if the adult beetles actually did not concentrate the humus in the burrows, they at least chose areas that have a very high surface concentration of organic matter in which to burrow.

The egg collected at Faison was carefully transferred to a metal salve box along with the food material provided and was taken into the laboratory. Eleven days later, on Apr. 30, 1951, the larva emerged from the egg and the following day began feeding on the humus. Growth was quite rapid, the larva becoming a second instar on May 18 and a third instar on June 14. Several days after this the larva was preserved.

On June 19, 1951, the same area in the Faison woods where the egg had been collected was revisited. A fresh burrow was noted only a foot away from the previous excavation. The burrow yielded a single female *darlingtoni* and nothing else. No other activity was indicated by the surface push-ups, but the area of excavation was extended. At a depth of 10 inches in a rather winding burrow five-sixteenths of an inch in diameter, packed with the finely divided black humus, a third-stage larva was found.

Further digging yielded seven additional larvae in the same type of slightly sinuous burrows packed with surface humus. The food cell varied from 6.5 to 8 mm. in diameter and from 2 to 3 inches in length. The larvae were found at depths of 8¼, 8½, 9, 9¼, 10½, 11½, and 12 inches. All the larvae were third-stage. Two specimens had moved below the food material in the burrow and made a pupal

cell one-half to 1 inch to the side and below the burrow. One of the specimens in the cells, a prepupa, pupated on June 25. The position of the pupal cell in relation to the burrow is diagrammed in plate 10, figure 1.

Further excavation on June 26, 1951, yielded a male *darlingtoni* in an old burrow 7 inches deep, and a male pupa in a cell 12 inches deep, 1 inch from the humus-packed burrow. A second pupa was taken in a cell one-half inch from the burrow at a depth of 10½ inches. No additional specimens were found then or on later visits.

The life cycle of *Bolboceras darlingtoni,* in North Carolina, can be sketchily summarized as follows: Egg laying occurred in mid-April with the incubation period lasting approximately 11 or 12 days. The first instar (one example) occurred in early May, remaining as a first instar for 18 days. From May 18 to June 14, a period of 30 days, the larva was in second-stage. The exact length of time spent as a third instar was not obtained, but appeared to be from 2 to 3 weeks, with a prepupal stage of about 3 or 4 days. Length of pupation in one case was 24 days, the adult appearing on July 14 and taking a week or more to loose its callow appearance. At Raleigh, some adult feeding on *Rhizopogon nigrescens* Coker and Couch was noted in October. *B. darlingtoni* overwinters in the adult stage and becomes active on warm winter evenings. The period of oviposition was in the spring.

The time of mating was not ascertained, nor could it be definitely decided whether the burrows containing the larvae were single tubes or whether they were branched. If asked to hazard a guess on the latter, I would say that the burrows were branched, basing the guess on the following observation: On the surface of the 6 square feet dug up, there were only 4 push-ups, while there were 11 larvae found in the burrows under these push-ups.

Description of the immature stages of *Bolboceras darlingtoni* is based on the following material, all of which was collected at Faison, N. C., by P. O. Ritcher and H. Howden: One egg collected Apr. 19, 1951, reared to third instar; nine third-stage larvae collected June19, 1951; three being allowed to pupate, one emerging as adult male Aug. 26, 1951, before other pupae were preserved; two pupae collected June 26, 1951.

Third-stage larvae of *darlingtoni* differed from Ritcher's (1947, p. 13) description of *simi* in the following respects: Maximum width of head capsule 2.1 to 2.4mm. Frons on each side with 2 or 3 posterior frontal setae, 2 setae in each anterior angle, 3 exterior frontal setae, and 1 or 2 anterior frontal setae. Antennae similar to those of *simi* and *liebecki* (pl. 6, fig. 3), as are the mandibles and maxillae. Hypopharynx (pl. 6, fig. 8) slightly asymmetrical, with oncyli rather widely

separated anteriorly. Glossa slightly emarginate. Tormae of epipharynx (pl. 6, fig. 9) united mesally, with a large posterior epitorma and a very small, asymmetrically placed anterior epitorma. Tormae on each side forming a bulblike suggestion of a pternotorma. Pedium anteriorly with structure appearing to be an unattached, circular portion of the epitorma, and surrounded with irregularly placed phobae (pl. 6, fig. 9). Pedium generally finely spiculate.

Structure of body (pl. 12, fig. 1), anal lobes (pl. 6, fig. 10), and legs differed in no respect from Ritcher's description of *simi*.

Egg oval (pl. 14, fig. 1), yellowish white, 2.4 mm. in length, 1.5 mm. in greatest width.

First-stage larva with greatest width of head capsule about 1.5 mm. Body shape same as third instar.

Head capsule of second-stage larva about 1.9 mm.; skin was lost.

Specimens examined: 31 males, 35 females.

DISTRICT OF COLUMBIA: Listed by Wallis.
GEORGIA: 4 males, 1 female. Atlanta; (2) January, (2) March, (1) November.
MARYLAND: 1 female. College Park; (1) October.
MASSACHUSETTS: 1 female. Tyngsboro; (1) October.
MISSISSIPPI: 1 female. Lucedale; (1) December.
NEW JERSEY: 11 males, 18 females. Rancocas Park; (14) February, (2) March, (1) April, (4) September, (3) October, (2) November.
NEW YORK: Listed by Wallis.
NORTH CAROLINA: 11 males, 11 females. Faison, Mills River, Newton Grove, Raleigh, Southern Pines, Tarboro, Winston-Salem; (1) January, (7) April, (4) May, (2) June, (1) July, (2) August, (1) October, (3) November, (1) December.
SOUTH CAROLINA: 5 males, 2 females. Clemson College, Florence, Windsor; (2) January, (1) April, (4) November.
VIRGINIA: Listed by Wallis.

Bolboceras alabamensis (Wallis)

Odontaeus alabamensis Wallis, pp. 239–241. Type, male, Grand Bay, Ala., March 1908, Loding (Wallis).

So few specimens of this species have been collected that little has been noted concerning its habits. Specimens in my collection from the Emory University Field Station were all taken in light traps.

Further study of other specimens might indicate a complex of forms rather than a single species. I found some differences in male genitalia, but additional specimens are needed to satisfactorily establish the variation within the species and to ascertain its habits.

Specimens examined: 4 males, 5 females (1 female, no data, ANSP).

GEORGIA: 4 males, 4 females: 2 males, 3 females, Emory University Field Station, Baker County, Aug. 17–20, 31, Sept. 3, 1951, Jan. 3–4, 1952, Jan. 4–5, 1951, Feb. 1–6, 1952, light trap (Howden). 1 male, Thomasville, Apr. 6–10, 1940, Field (CNHM). 1 male, 1 female, Thomasville, Mar. 31, 1940, Thames (Cartwright).

Genus *Geotrupes* Latreille

Geotrupes Latreille, 1796, p. 6; 1802, pp. 142–144; 1804, pp. 142–147; 1806, pp. 91–95; 1810, p. 428; 1829, pp. 542–546.—Kirby, 1818, p. 461.—Mulsant, 1842, pp. 353–367.—Jekel, 1865, pp. 513–618.—Horn, 1868, pp. 313–322, 1880, pp. 139–154.—LeConte and Horn, 1883, p. 243.—Blanchard, 1888, pp. 103–110.—Boucomont, 1902, pp. 1–10; 1906, pp. 1–44; 1911, pp. 344–345; 1912, pp. 19–33.—Dawson, 1922, pp. 195–197.—Blatchley, 1910, pp. 938–939; 1928, pp. 44–45.—Bradley, 1944, p. 112.—Ritcher, 1947, pp. 1–27.—Potts, 1948, pp. 23–26; 1951, pp. 49–51.—Townes and Howden, 1952, pp. 207–209.

Geotrupes Fabricius (not Latreille), 1798, pp. 1–7.—Walckenaer, 1802, p. 1.

Scarabaeus Linné, 1758, pp. 345–354.—Fabricius, 1775, p. 17; 1798, pp. 23–34.—Olivier, 1789, pp. 55–69.—Marsham, 1802, p. 8.

GENOTYPE: *Scarabaeus stercorarius* Linné designated by Latreille (1810, p. 428) (see opinion 11 of the International Commission of Zoological Nomenclature). If this designation is not acceptable to some investigators, then Curtis' designation (1829, page opposite pl. 266) of *stercorarius* Linné should be. There has been some doubt concerning the application of the name *Geotrupes*, but I believe the above usage is correct. For a full discussion of the problems involved, consult Potts (1951) and Townes and Howden (1952).

GENERIC LIMITATIONS: Given by Latreille (1796, p. 6):

Antennes de onze articles. Lèvre superieure avancée. Mandibules fortes. Lèvre inférieure a deux divisions alongées.

C. H. chaperon rhomboidal. Écusson. Jambes antérieures dentelées.

Other useful characteristics, besides the 11-segmented antennae, are general oval body shape, antennal club 3-segmented, small, not convex on both sides, eyes divided by canthus, color dark iridescent blue or green to dark brown or black, front femur with conspicuous hairy spot on anterior internal surface, elytra usually striate, thorax similar in both sexes, mid- and hind tibiae with apical transverse carina complete.

In addition to the characters mentioned above, many males of the species of *Geotrupes* exhibit striking external modifications. These sexual differences have caused a number of investigators to propose subgeneric groupings for the various species. Many of these groupings appear justified but others contain a rather unrelated mixture of structurally different species.

It is in this category of unrelated species that many of the North American species seem to fall. The subgenera *Cnemotrupes* Jekel (type *Geotrupes blackburnii* Fabricius) and *Onychotrupes* Jekel (type *Geotrupes splendidus* Fabricius) are separated only on the basis of an enlarged middle tarsal claw in the males of the latter. In other morphological respects *Geotrupes splendidus* is closely related to *G. blackburnii*, while *G. ulkei* Blanchard and *G. egeriei* Germar, both in

TABLE 1.—*Some differences between the North American species of* Geotrupes

Species	*Color*	*Striae and punctures*	*Sutural striae complete to elytral base*	*Foretibial modifications of male*	*Posterior pronotal margin*	*Tarsal claws of male*
hornii	Black	Strong str., moderate punct.	Complete	Carina beneath extreme antepenultimate tooth	Complete	Not modified.
balyi	Black with purple, blue, or green iridescence.	Strong str., moderate punct.	Complete	No modification	Complete	Not modified.
stercorarius	Black dorsally, purple ventrally.	Strong str., vague punct.	Complete	Deflexed antepenultimate tooth.	Complete	Not modified.
opacus	Alutaceous black	Obsolete str., strong punct.	Incomplete	A.e.t.* produced forward.	Complete	Not modified.
semiopacus	Greenish or purplish black.	Strong str., no punct.	Incomplete	A.e.t. produced forward.	Incomplete medially.	Enlarged middle claw.
splendidus splendidus	Brilliant green	Strong str., strong punct.	Incomplete	A.e.t. produced forward.	Complete	Enlarged middle claw.
s. miarophagus	Coppery green to purplish black.	Strong str., strong punct.	Incomplete	Identical to *s. splendidus*.	Complete	Enlarged middle claw.
blackburnii blackburnii and *b. excrementi*.	Black	Strong str., moderate punct.	Incomplete	A.e.t. produced forward.	Complete	Not modified.
ulkei	Dark brown	Obsolete str., strong punct.	Incomplete	A.e.t. produced forward.	Incomplete laterally.	Not modified.
egeriei	Black with traces of blue or green.	Strong str., strong punct.	Incomplete	A.e.t. produced forward.	Complete	Not modified.

*Anterior external tooth.

TABLE 2.—*Summary of biological information on North American* Geotrupes

Species	*Oviposition time*	*Length of immature development*	*Time of adult emergence*	*Usual adult food*	*Usual larval food*	*Avg. depth of burrow*	*No. cells per burrow*
opacus	(?)	(?)	Fall?	Dung	Dung?	(?)	(?).
ulkei	Spring	1 summer?	Fall	Fungi	Dead leaves	2 or 3 in	1 or 2.
blackburnii blackburnii, b. excrementi.	Winter, early spring	1 summer	Sept.–Oct.	Dung	Cow dung, some leaves.	4 to 7 in	1.
egeriei	Aug. to Nov.	2 summers?	Late summer	Fungi, dung	Old cow dung	9 to 30 in	1 or more?
hornii	Early summer	2 summers	Late summer	Fungi	Old cow dung	15 to 24 in	3 or 4.
balyi	(?)	(?)	Late summer?	Fungi	(?)	(?)	(?).
stercorarius	Spring	2 summers	Fall	Dung	Cow or horse dung	2 to 10 in	4 or more.
splendidus splendidus	Spring	1 summer	Sept.–Oct.	Fungi	Dead leaves	5 to 8 in	1.
s. miarophagus (one case).	Spring	1 summer	Sept.–Oct.	(?)	Dead grass	(?)	Several.
semiopacus	(?)	(?)	Fall?	Fungi	(?)	(?)	(?).

the same subgenus with *blackburnii*, are radically different, particularly in body shape and size. These differences become even more striking when one includes the larval morphology in the comparisons. While it is very difficult to separate the larva of *G. splendidus* from that of *blackburnii*, the separation of *ulkei* is slightly more apparent and the larva of *egeriei* is quite different from any of the above-mentioned species.

However, the larvae of several of the species remain to be discovered and any changes in the subgeneric concepts of *Geotrupes* should be delayed until the unknown larvae can be procured and studied. The present subgeneric groupings as delimited by Jekel (1865) are *Geotrupes*: *stercorarius* (Linné); *Anoplotrupes*: *balyi* Jekel, *hornii* Blanchard; *Cnemotrupes*: *blackburnii* (Fabricius), *blackburnii excrementi* Say, *egeriei* Germar, *opacus* Haldeman, *ulkei* Blanchard; *Onychotrupes*: *semiopacus* Jekel, *splendidus* (Fabricius), *splendidus miarophagus* Say.

The ten native species and subspecies of North American *Geotrupes* are quite diversified and the affinities of our species with European or Asiatic species are not clear. *Geotrupes balyi* and *hornii* appear rather closely related to some of the European species. *G. stercorarius* (Linné), native of Europe and Asia, has recently become established in Canada (Brown, 1940, p. 74). The other species are quite divergent, with little resemblance to foreign species. *G. occidentalis* Horn is synonymous to *laevistriatus* Motschulsky, a Japanese species which has evidentally not become established in this country.

The North American species of the genus are quite variable (table 1) in size, shape, and often in color, and because of this variation considerable confusion has resulted in their nomenclature. Jekel (1865), in his lengthy monograph, named from single specimens a number of North American species, later synonymized by Horn (1868). Because of my inability to examine Jekel's types, the present synonymy may not be correct. However, I was able to personally examine the types of LeConte, Horn, and Blanchard, and had specimens compared with the Fabrician types, so the usage of the majority of names should be reasonably accurate.

The range of the genus *Geotrupes* in North America is limited to the states east of the Rocky Mountains, from southern Canada to México.

Adult and brood habits of the species vary greatly and will be discussed for each species after the adult description.

Key to the North American species of Geotrupes

1. Elytra with strongly impressed striae 3
   Elytra with striae vaguely impressed or obsolete 2
2. Color dull black, dorsal surface finely granulate (Indiana, Illinois, Kansas,

Missouri, Texas, Oklahoma) . . . . . **opacus** Haldeman

Color shining dark brown, dorsal surface not finely granulate (Virginia, North Carolina, and Alabama) . . . . . **ulkei** Blanchard

3. Anterior tooth of foretibia of males never expanded and produced inwardly; females (and males) with longitudinal row of setigerous punctures next to longitudinal carina on flattened dorsal surface of front tibia interrupted by a strong curved carina extending onto the penultimate tooth on outer margin (pl. 2, fig. 14) 4

Anterior tooth of foretibia of males expanded and produced inwardly; females (and usually males) with longitudinal row of setigerous punctures next to the longitudinal carina on flattened dorsal surface of front tibia not interrupted by a strong curved carina extending onto the penultimate tooth (pl. 2, figs. 12, 13); a weak carina sometimes present in males of *egeriei*. . 6

4. Femora without pronounced iridescent bluish or purple color; hind femur of male without posterior carina produced into a tubercle near the coxa; size generally 15 mm. or smaller. 5

Femora with pronounced iridescent bluish or purple color; hind femur of male with posterior carina produced into a tubercle near the coxa; size generally 20 mm. or over (Canadian Maritime Provinces) . . **stercorarius** (Linné)

5. Pronotum and elytra completely black without any trace of iridescent blue or purple; males with anterior femur bearing a tooth at base of forward margin, female without tooth (southeastern Canada to Georgia, generally east of the Mississippi River) . . . . . **hornii** Blanchard

Pronotum and elytra not completely black, with at least some trace of iridescent blue or purple; males without anterior femur bearing a tooth at base of forward margin, not externally different from female (southeastern Canada to Georgia, generally east of Mississippi River) . . . **balyi** Jekel

6. Longitudinal carina on flattened dorsal surface of front tibia not curving towards penultimate tooth of outer margin, generally close to inner margin throughout its length (pl. 2, fig. 13); punctures of elytral striae shallow, usually not having a more pronounced iridescent color than surrounding surfaces 7

Longitudinal carina on flattened dorsal surface of front tibia curving slightly toward or extending to outer margin when opposite penultimate tooth, approximately median in position, particularly apically (pl. 2, fig. 13); punctures of elytral striae deep, usually having a more pronounced iridescent color than surrounding surfaces (southeastern Canada to Florida).

egeriei Haldeman

7. Posterior ventral longitudinal setigerous carina on hind femur not extending two-thirds the length of the femur; elytral striae rough, with at least a trace of punctures 8

Posterior ventral longitudinal setigerous carina on hind femur extending more than two-thirds the length of the femur; elytral striae smooth, lacking any trace of punctures (southeastern Canada to North Carolina).

semiopacus Jekel

8. Row of longitudinal setigerous punctures which is contiguous basally with the longitudinal carina of the foretibia, apically separated from the carina, forming a smooth area usually several millimeters in length between the carina and the punctures (pl. 2, fig. 13); color dorsally usually black or dark bronzy brown; middle tarsus of male similar to that of female, not thickened. Subspecies of *blackburnii* (Fabricius) 10

Row of longitudinal setigerous punctures which is basally contiguous with the longitudinal carina of the foretibia apically contiguous or only slightly

separated from the carina, not forming a smooth area between the carina and the punctures; color dorsally usually green, bronze, or purple; middle tarsus of male not similar to that of female, thickened (southeastern Canada to Florida). Subspecies of *splendidus* (Fabricius). 9

9. Color bright green, size moderate (generally east of Appalachian Mountains). **splendidus splendidus** (Fabricius)

Color coppery green to purplish black, size large (generally west of the Appalachian Mountains) . . . . . **splendidus miarophagus** Say

10. Base of left dorsal paramere of male genitalia not extending posteriorly beyond base of right dorsal paramere (pl. 4, figs. 4, 5); unevenly spaced teeth on underside of foretibia of male largest apically, becoming evenly smaller basally (pl. 2, fig. 10); punctures in elytral striae usually moderately pronounced (Massachusetts and eastern Ohio south to Florida east of the Appalachian Mountains) . . . . . **blackburnii blackburnii** Fabricius

Base of left dorsal paramere of male genitalia extending posteriorly beyond base of right dorsal paramere (pl. 4, fig. 6); unevenly spaced teeth on underside of foretibia of male largest in the center, becoming smaller both apically and basally (pl. 2, fig. 11); punctures in elytral striae usually only vaguely defined (Iowa, Indiana south to Texas, generally west of the Appalachian Mountains) . . . . . **blackburnii excrementi** Say

Key to the known larvae of the North American species of Geotrupes

1. Sclerotized lines of the endoskeletal figure of the ventral anal lobe almost meeting, forming a triangular area, and below this continuing on to fuse with the sclerotized line defining the ventral edge of the anal lobe (pl. 7, figs. 15, 17) 2

Sclerotized lines of the endoskeletal figure of the ventral anal lobe meeting and forming a triangular area, without the narrow continuation to the ventral edge of the anal lobe . . . . . **stercorarius** (Linné)

2. Tip of tibiotarsus of each leg with tubercle bearing a minute brownish claw . 3

Tip of tibiotarsus of each leg usually with a small tubercle (pl. 7, figs. 10, 16), but in all cases the minute brownish claw is lacking 5

3. Epipharynx bearing, anterior to the pedium, an irregular transverse row of 10 to 12 very stubby setae (pl. 8, fig. 1); posterior epitorma of epipharynx slightly longer than anterior epitorma (pl. 8, fig. 1). **splendidus splendidus** (Fabricius)

Epipharynx bearing, anterior to the pedium, an irregular transverse row of 5 to 7 setae, not differing greatly in length from the setae on the chaetoparia; anterior epitorma of epipharynx slightly longer than posterior epitorma . . 4

4. Setae in front of the hypopharyngeal oncyli and behind the anterior transverse row of sensilla with their origins much nearer in position to the midline than are the outermost sensilla (pl. 8, fig. 2). **blackburnii blackburnii** (Fabricius)

Setae in front of the hypopharyngeal oncyli and behind the anterior transverse row of sensilla with their origins about the same distance from the midline as the outer sensilla (pl. 8, fig. 5) . . . . . **blackburnii excrementi** Say

5. Maxilla with inner surface of galea (pl. 7, fig. 1) bearing only 6 or 7 setae; epipharynx with row of fine setae extending from tip of posterior dexiopternotorma to tip of posterior epitorma . . . . . **ulkei** Blanchard

Maxilla with inner surface of galea bearing 9 or more setae; epipharynx lacking a continuous row of setae from the tip of the posterior dexiopternotorma to tip of posterior epitorma. 6

6. Dorsal annulets of abdominal segments 6 to 8 with a transverse patch of setae; 7 or 8 stridulatory teeth on the fused trochanter-femur and 1 tooth on the tibiotarsus of the reduced metathoracic legs; epipharynx in front of phoba with a single sensilla well isolated from either setae or row of sensilla at the base of the phoba (pl. 8, fig. 4) . . . . . **egerici** Haldeman

Dorsal annulets of abdominal segments 6 to 8 lacking a transverse patch of setae; 9 to 11 stridulatory teeth on the fused trochanter-femur and 5 to 8 small teeth on the tibiotarsus of the reduced metathoracic legs; epipharynx in front of phoba without a single sensilla isolated from the row of sensilla at the base of the phoba (pl. 8, fig. 7) . . . . . **hornii** Blanchard

(The larvae of *G. opacus, semiopacus, splendidus miarophagus,* and *balyi* are not known to the writer.)

Geotrupes opacus Haldeman

Geotrupes opacus Haldeman, 1853, p. 362 (type, LeConte collection, MCZ).—Jekel, 1865, pp. 533–594.—Horn, 1868, p. 318.—Blanchard, 1888, p. 110.—Blatchley, 1910, p. 939.—Dawson, 1922, p. 196.—Bradley, 1944, p. 112.
Geotrupes haldemani Jekel, 1865, p. 593.—Horn, 1868, p. 318.
Geotrupes chevrolati Jekel, 1865, p. 593.—Horn, 1868, p. 318.

Length 11 to 17.5 mm., greatest width 7 to 11 mm.

Color of dorsum dull brown to black, sometimes with traces of blue or green along margins of pronotum, elytra, and in some coarse punctures. Dull coloration is due to finely alutaceous surface of dorsum. Ventral surface black, sometimes with traces of bluish iridescence. Legs black. Antenna and antennal club usually piceous. Clypeus, eye canthus, and vertex rather finely densely punctured except on the tip of the rather pronounced clypeal tubercle. The tubercles near the eyes vaguely indicated. A distinctly indented narrow line runs from the middle of the vertex forward to the clypeus, where it bifurcates and runs along the posterior edge of the clypeus almost to the outer margins. Clypeus margined, varying greatly in shape, generally evenly rounded, but sometimes sharply arcuate either anteriorly or laterally. No other structural differences appear constantly correlated with these variations. The margined eye canthi are also rather variable in shape, but usually evenly arcuate and form a moderately obtuse angle with the clypeal edge. Pronotum completely margined, quite convex, but with considerable variation in the curvature of the lateral margins. Coarse punctures scattered over most of pronotum, most pronounced laterally. A line of coarse punctures may be present along the pronotal midline, and a small circular punctate depression is usually present laterally. Minute secondary punctures are sometimes present, scattered over entire pronotum. Scutellum usually coarsely punctured, roughly triangular with sides arcuate. Elytral striae obsolete, usually indicated only by somewhat irregular rows of coarse punctures. Elytral margin narrow, slightly wider anteriorly.

Foretibia of male with the anteriormost of the 6 or 7 teeth of the outer margin expanded forward and bifurcate. In both sexes there are small teeth on a ridge on the inner flattened surface of the foretibia. Dorsally there is a raised dorsal longitudinal carina extending along the inner edge, with a small sharp extension inward, almost onto the base of the penultimate tooth. Closely adjacent row of setae only interrupted by the small inward carinal extension. External face of tibia of mesothoracic leg with three complete transverse carinae, tibia of metathoracic leg with three, sometimes four, complete transverse carinae, with two or three partial carinae. Posterior edge of hind femur of male produced into a tubercle near coxa, which also protrudes slightly posteriorly. Tarsal claws similar in both sexes.

Genital capsule and genitalia of male well developed (pl. 5, fig. 2), rather similar to that of *egeriei*, but generally less elongate.

Variation within the species is considerable, but apparently is not due to population differences. Size and shape of clypeus and pronotum are extremely variable.

This species can be easily distinguished by its finely alutaceous dorsal surface, imparting a dull appearance to its brown or black color. Also, the lack of striae, fine dense clypeal punctures, piceous antennal club, and structure of male genitalia (pl. 5, fig. 2) will delimit the species.

Geotrupes opacus Haldeman has been collected in moderate numbers in sandy localities from South Dakota southward to Texas and from Ohio westward to Colorado.

Brown (1927, p. 28) mentioned that *opacus* could be collected from August to May in sandy localities in Payne County, Okla. Knaus (1916, p. 81) recorded taking three specimens on May 7 in the sand hills near Medora, Kans. One of the longer accounts of the species was published by Jones (1886, p. 80), in which he mentions finding in November a number of specimens under some fresh dung along the roadside between Manhattan and Salina, Kans. He observed that, "I have almost always taken it where I have found no other scavengers at work, except *Aphodius*, and a few *Staphylinus* perhaps, and I have always taken it either very early in spring or late in the fall. Generally, I have taken it on low bottom land, or on sand bars in the river, where cattle are wont to drink . . . ."

There are a few other desultory notes concerning the adults, but nothing has been published on the life history of the species.

Specimens examined: 128 males, 111 females.

ARKANSAS: 18 males, 12 females. Hope, Imboden, Marion County; (2) September, (6) November.
COLORADO: 1 female. No data.

ILLINOIS: 10 males, 10 females. Mason City, north Illinois, Topeka; (13) October.
INDIANA: 4 males, 4 females. Michigan City, Miller, Mineral Springs, Ogden Dunes (on Lake Michigan), Pine; (2) April, (2) May, (2) September (1) October.
IOWA: 2 males, 3 females. Columbus Junction, Sergeant Bluff; (2) September.
KANSAS: 20 males, 22 females. Douglas County, Lawrence, Medora, Mount Hope, Roybury (Reno County), Salina, Topeka, Wichita; (1) April, (3) May, (2) June, (15) September, (1) October, (2) November.
LOUISIANA: 7 males, 3 females. Leesville, Natchitoches; (8) September, (1) October.
MICHIGAN: 4 males, 3 females. George Reserve (Livingston County), Portage Lake (Washtenaw County); (1) May, (1) September, (4) October.
MISSOURI: 8 males, 5 females. Columbia, Galloway, Kimmswick (Jefferson County), Malden, New Hartford, St. Louis; (1) March, (1) April, (1) September, (5) October, (1) November.
NEBRASKA: 5 males, 8 females. Bennet, Frenchman River, Hyannis (Grant County), Malcolm, Sand Hills Nebraska National Forest (Thomas County); (1) April, (1) June, (1) July, (4) October.
OHIO: 2 males, 2 females. Williams County; (4) September.
OKLAHOMA: 7 males, 5 females. Caddo County, Cleveland County, Fort Sill Military Reservation, Noble, Payne County, Tulsa; (1) March, (3) April, (2) September, (3) October, (1) December.
SOUTH DAKOTA: 5 males, 2 females. Martin; (1) August, (6) September.
TEXAS: 36 males, 29 females. Abilene, Austin, Brazos County, Comfort, Dallas, Dallas County, Harris County, Kingsville, Mount Hope, Tyler; (1) March, (1) May, (1) June, (1) November.
WISCONSIN: 2 females. No data.

Geotrupes ulkei Blanchard

Geotrupes ulkei Blanchard, 1888, pp. 106–107 (lectotype, here designated, male, Virginia, labeled as type, Ulke collection in CM).—Loding, 1935, p. 108.—Bradley, 1944, p. 112.—Ritcher, 1947, p. 8.

Length 10 to 12 mm., greatest width 7 to 8 mm.

Color of dorsum dark brown with margins of thorax and elytra tinged with blue or purple. Ventral surface and legs brown to black. Antenna and antennal club dark brown, differing little in color from rest of ventral surface. Clypeus coarsely, deeply punctured; vertex and eye canthus with scattered coarse punctures. The three tubercles on the head extremely indistinct. An indistinct indented line runs from the middle of the vertex forward to the clypeus, where it becomes sharply delimited, bifurcates running along the posterior margin of the clypeus. Clypeus margined, more arcuate laterally. Poorly margined eye canthus forms a moderately obtuse angle with the clypeal edge, sides of eye canthi arcuate anteriorly, slightly so posteriorly, almost parallel. Pronotum moderately convex, margined anteriorly and laterally. The posterior margin broadly broken laterally. Poorly defined coarse punctures scattered unevenly over pronotum, slightly more pronounced laterally and in slightly indented median

line. Lateral portions of pronotum near margin with a vaguely defined indentation medially. Minute secondary punctures not apparent. Scutellum small, triangular with sides slightly arcuate. Elytra connate, metathoracic wings absent (this fact being called to my attention by Dr. T. H. Hubbell), elytral striae obsolete, indicated by rows of coarse punctures usually separated dorsally by a distance two to three times their own diameter. Elytral margin narrow, approximately the same width throughout.

Foretibia of male with anteriormost of the usually eight external teeth expanded inward and forward, somewhat bifid. The tip of the inward expansion, the tip of the normal portion of the tooth, and the tip of the penultimate tooth forming an almost straight row of tubercles. No other pronounced sexual modifications noticeable in male. Tarsal claws similar in both sexes as are hind femora. In both sexes there is a dorsal longitudinal raised carina extending along the inner edge of the foretibia, similar to the carina in *blackburnii*. A row of deeply indented setae is adjacent to the base of carina. Near the midline of the dorsal surface of the foretibia is a vague raised carina parallel to the carina on the inner edge, seemingly enclosing the previously mentioned row of setae in a wide shallow groove with small cross ridges separating each seta. External face of tibia of meso- and metathoracic legs each with three complete transverse carinae and from two to five vaguely indicated partial carinae.

Genitalia and genital capsule of male well developed, the elongate, rather linear dorsal parameres being quite distinctive (pl. 4, fig. 3).

The specimens examined showed little variation, except in size of the coarse dorsal punctures and curvature of the elytra. No constant geographical variation was noted.

The species can be readily distinguished by its small size, connate elytra, obsolete elytral striae, male genitalia, clypeus more arcuate laterally, and the dark shining brown color with traces of blue or purple on the thoracic and elytral margins. Also the dark brown antennal club seems characteristic.

Geotrupes ulkei Blanchard, while being one of the least frequently collected of the North American *Geotrupes*, was one of the first species to have its larval biology discovered.

The rarity of the species seems to be due in part to the restricted habitat of this insect and its general secretiveness. The type specimens were collected at fungi by Ulke. Subsequently, specimens have been collected in cans of fermenting malt or molasses and in their burrows.

All of the available information on the biology of the species has been published by Loding (1935, p. 108). His information was obtained from a colony of these beetles at Monte Sano, Madison

County, Ala., where in June 1934 he made the following observations (1935, p. 108):

. . . in burrows in the ground, in diameter the size of a lead pencil and about an inch and one-half deep, with some leaf frass at the bottom. . . . [found] 14 specimens all similarly located under leaves on level ground at the side of mountain paths, never more than one specimen in a hole one and a half to 2 inches deep with leaf frass at the bottom, [but] no larvae. In July Dr. Jones again visited the mountain and this time besides several beetles also found three larvae, 2 in one hole and one in another. The food seems to be decomposing leaves.

From the above information it would appear that the formation of the brood cells (and also the time of egg laying) was in June with rapid larval development in late June and July. The larvae collected by Dr. Jones in July and later described by Ritcher (1947, p. 8) and seen by the present writer appear to be small third instars. Adults which have been collected in September and October would seem to represent the newly emerged brood.

The third-stage larva of *Geotrupes ulkei* was described by Ritcher (1947, p. 8) and a caudal view of the last abdominal segment was given (p. 27).

One interesting feature of the third-stage larva is the small size of the head capsule, the maximum width mentioned by Ritcher being 2.45 to 2.52 mm.

In addition to the characters given by Ritcher, the following structures might be mentioned: Galea (pl. 7, fig. 1) of the maxilla with only 6 or 7 setae on its inner surface (other known species have 9 or more setae); epipharynx with a pronounced row of short stubby bristles running from the posterior tip of the dexiopternotorma to the tip of the posterior epitorma, and tips of all the legs with a tubercle, but lacking the small brownish claw.

Specimens examined: 16 males, 28 females.

ALABAMA: 13 males, 19 females. Monte Sano (Madison County); (30) June, (2) July.

NORTH CAROLINA: 5 females. No data.

VIRGINIA: 3 males, 4 females. Bald Knob, Fisher's Gap (Shenandoah National Park, Page County), Hillsboro, Mountain Lake Biological Station (Giles County), Salt Pond Mountain (Giles County); (2) July, (2) August, (1) September.

***Geotrupes blackburnii blackburnii* (Fabricius)**

Scarabaeus blackburnii Fabricius, 1781, p. 20, No. 85. Lectotype, here designated, male; lectotype label placed on specimen by S. L. Tuxen (Fabrician collection at Kiel).

Geotrupes blackburnii (Fabricius) Castelnau, 1840, p. 100.—Jekel, 1865, p. 529.—Horn, 1868, p. 317.—Blanchard, 1888, p. 106.—Blatchley, 1928, p. 44.—Bradley, 1944, p. 112.

Geotrupes conicollis Jekel, 1865, p. 591.—Horn, 1868, p. 317.

Geotrupes jekellii Horn, 1868, p. 317.

Length 10 to 18 mm., greatest width 6.5 to 11 mm.

Color of dorsum dark shining coppery black to black. Occasional specimens dark brown. Ventral surface and legs black. Antenna, except basal segment which is black, dark reddish brown to black, club reddish brown. Eye canthus, clypeus, and anterior portion of vertex coarsely, densely punctured. The three tubercles on the head, one near the median basal margin of the clypeus and one beside each eye, lack punctures. A distinctly indented narrow line runs from the middle of the vertex forward to the clypeus, where it bifurcates and runs along the posterior edge of the clypeus, finally reaching the outer margins at the juncture of the clypeus with the eye canthi. Clypeus margined, more arcuate anteriorly. Poorly margined eye canthi form a very obtuse angle with clypeal edge; sides of eye canthi slightly arcuate, almost parallel. Pronotum completely margined, quite convex laterally, coarsely punctured laterally and usually along midline but both number and size of the punctures are variable, as are the clusters of punctures which usually form a median circular depression on each side. Minute secondary punctures lacking or barely visible near the posterior angles. In many specimens of both sexes the posterior half of the pronotal midline is indented, in others the indentation is completely lacking. Scutellum generally triangular with gradually arcuate sides. Elytra with well developed striae. Punctures in striae moderately developed basally, usually becoming vaguely delimited and uneven beyond top of scutellum. Elytral margin narrow, slightly wider anteriorly.

The foretibia of the male differs in two major respects from that of the female. The anteriormost of the seven or eight teeth of the outer margin is expanded forward in the male and somewhat bifurcate at the tip. Also on the inner flattened surface of the foretibia of the males there is an uneven row of 4 to 7 (usually 5) conical teeth. These teeth gradually become larger distally, the apical one being longest (pl. 2, fig. 10). In both sexes there is a dorsal longitudinal raised carina extending along the inner edge of the foretibia. This carina basally has a row of setae parallel and closely adjacent to it. Distally, opposite the penultimate tooth on the outer margin, the row of setae separates from the carina, leaving a smooth area enclosed by carina and setae. These reunite at the base of the distal tooth (pl. 2, fig. 13). External face of tibia of meso- and metathoracic legs each with three complete transverse carinae and two partial ones. Posterior edge of hind femur of male produced into a tubercle near coxa. Tarsal claws similar in both sexes.

Genitalia and genital capsule of male well developed, the dorsal parameres quite distinctive (pl. 4, figs. 4, 5). The most readily discernible characteristic is the basal portion of the right paramere

which is rather elongate, curved toward the midline, and extended beyond the basal tip of the wide left paramere

Variation within the species is considerable. Size, punctures, degree of sexual modification in the males and, to some degree, color show wide differences, even in specimens from the same colony.

The description of the male has been largely made from a homotype from Raleigh, N. C., compared with the Fabrician specimens for me by S. L. Tuxen of the Copenhagen Zoological Museum.

The species may be distinguished by the male genitalia (pl. 4, figs. 4, 5), the shape of the longitudinal carina of the foretibia (pl. 2, fig. 10), the conical teeth on the underside of the foretibia of the males, poorly punctured elytral striae, and shining black color, sometimes with a coppery cast.

Geotrupes blackburnii blackburnii was by far the most common species of *Geotrupes* taken by me in North Carolina. During the fall, winter, and early spring specimens were numerous under cow dung. Addiction to cow dung was not very noticeable however, as specimens were frequently taken at carrion, almost any type of dung, chicken feathers, and decaying fungi. On one occasion several specimens were taken on the bare ground under a willow tree badly infested with aphids, but whether they were attracted by the "honey dew" or not cannot be stated.

One of the easiest and best methods for collecting the adults, as it eliminated digging, was by the use of chemical attractants and fermenting malt. Not only were many adults collected by the use of attractants, but the time and amount of above-ground activity of the adult beetles could easily be traced through their use. These data, with the chemicals that proved useful, are given in table 3.

The greatest feeding activity was in the fall just after the emergence of the adults. The time of mating was not definitely ascertained, but as several pairs were taken in burrows 4 to 8 inches deep under cow dung in October, copulation may have occurred then. The adults were not only active during the spring and fall, but several times were also seen flying in the late afternoons or early evenings of warm winter days. Quite frequently specimens were taken at lights on warm nights, particularly during the winter. About 9 p. m. on Jan. 6, 1953, I found several male *blackburnii* at brightly lighted store windows.

Because of an ample supply of adults, rearing was attempted in several ways. Specimens were put in gallon cans partially filled with dirt and supplied with fresh cow dung. Others were put in an apple box filled with dirt and covered with a wire screen. Outdoors, in a shaded spot, an enclosure 3 feet wide by 8 feet long was made and covered with a wire screen. About 50 males and 50 females were put

in this cage, along with cow dung, fungi, carrion, and dead leaves. In this case the conditions approximated those in a moderately wooded area, and the beetles could, because of the absence of a bottom to the cage, burrow to any desired depth.

All rearing cages were kept in partial shade, for seldom was any species of *Geotrupes* collected in an open field. If there was a single tree in a field the beetles always took advantage of its shade.

After several months it was apparent that rearing was best undertaken in the large enclosure. The smaller the container the more difficult it was to induce the beetles to do anything. In addition, moisture and mites both became problems. Several of the beetles in the gallon cans laid eggs in wads of dung, but few of the eggs hatched. Gamassid mites appeared to be the cause of this failure, for when the mites clustered on an egg it never hatched. Fortunately, this problem was relatively minor in the outdoor enclosure, where much of the life history data was obtained.

There was one question that often could not be answered. Was the developmental rate of the immature stages either accelerated or retarded when they were brought indoors, where temperatures were usually higher and certainly fluctuated more rapidly than temperatures 6 or more inches underground? Early in the course of the work it was proved satisfactorily that larval development could be accelerated. One of the female *blackburnii* confined in a gallon can indoors oviposited about March 18. On March 27 the egg hatched. The larva became a second instar on April 16, a third instar on April 30, and a pupa on June 24. Subsequently it was found that in this case the development of the early stages was not particularly rapid, but that the time of development of the third instar to pupa was greatly shortened.

It was later found that acceleration of larval development was possible only under certain circumstances. If the female beetle was brought indoors and it oviposited, and development occurred from the start at a warm temperature, then it was possible to produce more rapid growth than was normal. However, if the egg was laid in a natural habitat and remained there for even a few days, its subsequent development could not be greatly affected even by much higher temperatures. This conclusion was reached by doing a small amount of digging in the cage of *blackburnii* at different times. On each occasion 10 or 15 larvae were collected and kept alive in salve boxes. These then could be compared with larvae subsequently collected from the cage to see if there was any great difference in growth between them. There was not.

It can be argued that conditions in the cage were not natural, the light being dimmed by the screen, the soil frequently dug up,

many beetles in a small enclosure, etc. Fortunately, a large natural colony of *blackburnii* was discovered at Faison, N. C., and digging there over the summer showed the development of the larvae in the cage closely approximated that found in the Faison woods (pl. 16, fig. 1).

One *blackburnii* larva was found in a pasture at Mills River, N. C., and the time of its pupation and emergence was the same as many of the larvae taken from Faison.

Before discussing the length of the various stages of development, the burrow and larval food should be mentioned. On the average the burrows of *Geotrupes blackburnii* were the shallowest of any of the species of *Geotrupes* studied. The vertical feeding burrows, which were 4 to 8 inches deep, were often deeper than the burrows having the larval cell at the bottom.

TABLE 3.—*Bait used in traps and number of* Geotrupes blackburnii blackburnii *Fabricius collected at Raleigh, N. C.*

(First column under month refers to first two weeks, second column to last two weeks)

Chemical	*Jan.*		*Feb.*		*Mar.*		*Apr.*		*May*		*June*		*July*		*Aug.*		*Sept.*		*Oct.*		*Nov.*		*Dec.*		*Total*
Propionic acid	6	3	2	6	2	2	0	0	0	0	0	0	0	0	0	0	0	2	2	3	6	11	26	7	78
n-Butyric acid	7	7	1	3	0	9	3	0	0	0	0	0	0	0	0	0	0	0	13	3	2	1	3		52
Oleic acid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isoamylamine	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Valeric acid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
n-Amyl mercaptan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0		2
Pelargonic acid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethyl mercaptan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	13	10	3	9	2	11	4	0	0	0	0	0	0	0	0	0	0	2	2	18	9	13	27	10	133

The brood burrows found at Faison, where the soil was a sandy loam, were from 3¼ to 6½ inches deep, with an average depth of 4 inches. The one burrow found at Mills River went to a depth of 5 inches into the hard red clay. In the enclosure at Raleigh, where the soil was not well packed, the burrows were slightly deeper, from 4½ to 9 inches, with an average depth of 6 to 7 inches. All the measurements given refer to the vertical distance between the point where the larva was found and the ground surface.

In the matter of larval food, *blackburnii* seemed to show a greater plasticity than did other species. The larval cell at Mills River and all of those at Raleigh were composed of fairly old cow dung, while those at Faison, while they may have contained some dung, also had bits of leaves and grass making up part of the wad. At the time the colony was found the larvae had largely eaten out the center of the wad, which may have been composed of dung. If this were true, it was not cow dung, as no cow had been in the woods for a number of years.

The burrow containing the single brood cell consisted of a short vertical shaft which took a sharp turn, at which point the food cell began. Often a plug of dung or soil was found near the opening of the burrow and in addition there was some soil covering the end of the brood cell. The brood cells were from 2½ to 3½ inches long with a diameter of from three-quarters of an inch to 1 inch. One-half inch from the terminal end was a cavity in which the female layed a single elongately oval egg (pl. 14, fig. 2). Plate 10, figure 6 is a diagram of a typical brood burrow. In no instances were two brood cells found originating from one burrow. When all the food of the cell was consumed, the larva plastered the sides of the cell with its feces, which became hard and made a compact cell about 2 inches long. Ten of these cells were measured just at the time of pupation (pl. 15, fig. 2). The inside length varied from 19 to 28 mm., the greatest inside width from 11 to 14 mm. The outside dimensions were more variable, ranging in length from 29 to 45 mm., and in width from 16 to 20 mm.

The complete life cycle of *blackburnii* takes one year in North Carolina. While exact dates are not mentioned below, as they can easily vary from place to place and from one year to the next, "early" refers to the first 10 days in the month, "mid" to the next 10 days, and "late" to the remaining days in the month. The dates and data given below were accumulated from notes made on 100 larvae.

In mid-September newly emerged adults began appearing. Feeding and perhaps mating occurred in the fall and winter with oviposition occurring from mid-January through early May. Incubation normally lasted at least 10 days, apparently taking considerably longer when the eggs were laid in January and February. First-stage larvae were found from late March until mid-May, the stadium usually lasting between 20 and 30 days. The second stadium took about 20 days. The first third-stage larvae appeared in late April. By the end of May all larvae collected were third instar. Early growth of the third-stage larvae was rapid. In 15 or 20 days the larvae had entirely consumed their available food supply, and then remained quiescent until September.

After the larva had become quiescent, if more food was added it would resume feeding but with no visible increase in size. The quiescent period lasted most of June, July, and August. In early September pupation occurred. On Sept. 4, 1951, several prepupae were found at Faison and pupae were taken on September 11. On Sept. 12, 1951, the remaining portion of the enclosure at Raleigh was dug. In it were found 1 third instar, 4 prepupae, and 19 pupae. The prepupal stage lasted from 4 to 9 days, with the pupal stage lasting from 15 to 20 days. It required 3 to 4 days for the adults

to become fully pigmented and hardened. About the fifth day after metamorphosis the adults became active, emerging from their cells in late September and early October.

The adults fed and overwintered in their feeding burrows. The following spring the females dug and provisioned the brood cells, unaided by the males.

Description of the larva of *Geotrupes blackburnii blackburnii* is based on the following material: 20 third instar exuviae with adults, 10 third-stage larvae, and 2 second-stage larvae, all collected during the summer of 1951 at Faison, N. C., by P. O. Ritcher and H. Howden; 23 pupae with third instar exuviae, 24 third-stage, 5 second-stage, 4 first-stage larvae, and 5 eggs, all from adults in cage at Raleigh, N. C., by H. Howden; third instar exuvia with adult collected at Mills River, N. C., by H. Howden.

The larvae of the eastern subspecies of *blackburnii* appear to differ only slightly from Ritcher's description (1947, pp. 6–7) of the larvae of *G. blackburnii,* which I have referred to the western subspecies, *G. blackburnii excrementi.* The only structures not consistent with Ritcher's excellent description were noted in the hypopharynx and glossa (pl. 8, fig. 2). The asymmetrical oncyli differed slightly in shape from the western subspecies *excrementi.* Also, the setae in front of the hypopharyngeal oncyli and behind the transverse row of sensilla have their origin much nearer to the midline than do the outermost sensilla. Other than that, there were no consistent differences noted. Maximum width of head capsule was 3.9 to 4.5 mm.

The egg of *G. blackburnii blackburnii* (pl. 14, fig. 2) is yellowish white, generally oval with one end larger than the other. The egg increases gradually in size until a maximum size of 3.8 to 4.0 mm. in length and 2.3 to 2.5 mm. in width is reached a day or so before hatching.

First instar maximum width of head capsule is 2.4 to 2.6 mm. Structurally, larva differs very little from third instar. The respiratory plates of the first instar are very small and circular, while in the second- and third-stage larvae they are large and crescent-shaped. Also, the antennal segments of the first instar vary slightly in length and the mandibular teeth are more pronounced than in later stages. Posterior portion of abdomen not swollen as in second and third instar.

Second instar maximum width of head capsule is 3.4 to 3.7 mm. Structurally it is very similar in all respects to third instar.

Specimens examined: 259 males, 237 females.

CONNECTICUT: 2 males, 1 female. Hartford, Pomfret, Yalesville; (1) April, (1) October.

GEORGIA: 18 males, 13 females. Armuchee, Atlanta, Clarkston, Head River, Morgan, Newton, Panthersville, Rome, Satolah, Savannah, Spring Creek (Decatur County), Stone Mountain, Summerville, Thomasville; (1) January,

(1) February, (5) March, (5) April, (1) May, (3) October, (14) November. [Intergrade: 7 males, 2 females. Atlanta, Rockmart; (1) October, (8) November.]

FLORIDA: 9 males, 8 females. Alachua County, Gainesville, Jacksonville, Lake City, Levy County, Newmans Lake (Alachua County), Ocala; (4) March, (4) October, (2) November, (6) December.

MARYLAND: 9 males, 16 females. Baltimore, Charles County, College Park, Edgewood, Ivory, Riverdale, Takoma Park; (4) April, (4) May, (1) July, (1) September, (2) October, (1) November.

MASSACHUSETTS: 10 males, 3 females. Milton, Sherborn, Springfield.

NEW HAMPSHIRE: 1 male. No data.

NEW JERSEY: 21 males, 16 females. Almonessung, Elizabeth, Manahawken, Manchester, Rancocas Park, Riverton, Snake Hill, Westville; (3) April, (1) May, (1) June, (1) August, (13) October, (1) December.

NEW YORK: 4 males, 5 females. Astoria, Brooklyn, Long Island, New York, Shelter Island; (4) July.

NORTH CAROLINA: 108 males, 102 females. Apex, Aquone, Asheville, Beaufort, Black Mountains, Boone, Burgaw, Cataloochee, Climax, Creedmoor, Davidson, Durham, Edenton, Elizabeth City, Faison, Lake Raleigh (Wake County), Lake Waccamaw, Lexington, Marion, Mills River, Plymouth, Raleigh, Southern Pines, Sunburst, Tryon, Whiteville, Wilmington, Victoria; (6) January, (6) February, (12) March, (6) April, (8) May, (62) October, (92) November, (3) December.

OHIO: 12 males, 11 females. Athens, Columbus, Delaware County, Hocking County; (2) April, (1) June, (2) September, (17) October. [Possible intergrade? 1 male. Worthington; (1) September.]

PENNSYLVANIA: 32 males, 30 females. Allegheny County, Castle Rock, Darby, Forrest County, Jeannette, Harrisburg, Morton, Philadelphia, Wilmerding; (1) March, (10) April, (3) May, (5) June, (1) July, (2) August, (2) September, (22) October, (4) November, (1) December.

RHODE ISLAND: 1 male, 1 female. No data.

SOUTH CAROLINA: 20 males, 21 females. Charleston, Clemson College, Florence, Kingstree, Marion County, Meredith, Mountain Rest, Oconee, Rocky Bottom, Summerville, Sumter County, White Pond, Windsor; (1) February, (9) October, (10) November, (8) December.

TENNESSEE: 1 male, 2 females. Deer Lodge; (3) May. [Western? 1 male, 1 female. Madison; (2) April.]

VIRGINIA: 6 males, 3 females. Falls Church, Fredericksburg, Newport News, Richmond; (1) May, (1) August, (2) October.

VERMONT: 1 female. No data.

WEST VIRGINIA [Intergrade: 5 males, 4 females. Fairmont; (9) April.]

Geotrupes blackburnii excrementi Say, new combination

Geotrupes excrementi Say, 1823, p. 210 (type lost).—Melsheimer, 1845, p. 139.—Jekel, 1865, p. 532.

Geotrupes blackburnii (Fabricius) Blatchley, 1910, p. 939.—Ritcher, 1947, pp. 6–7.

Length 12 to 19 mm., greatest width 7 to 11 mm.

Color of dorsum dark shining coppery black to black. Occasional specimens may have the elytral margin tinged with green; others in a few instances may be entirely dark brown in color. Antenna with first segment black, others dark reddish brown to black, with club reddish

brown. Structure and angle of clypeus, eye canthus, tubercles, and vertex very similar to *blackburnii*. No constant differences were noted. In general there appear to be a few more punctures near the clypeal base in *excrementi* than in *blackburnii*. Pronotum completely margined, but usually not as convex as in specimens of *blackburnii*. Coarse punctures either confined to sides or scattered unevenly over entire pronotum, most numerous laterally and along midline. A cluster of punctures usually forms a median circular depression on each side of the pronotum. Minute secondary punctures almost always evident laterally and in many cases scattered over the entire pronotum. The posterior half of the pronotal midline may or may not be indented. Scutellum and elytra like those of *blackburnii*, except that in *excrementi* the elytra are usually less convex and have slightly more pronounced strial punctures.

Foretibia of male differing from the female by having an expanded apical tooth and a row of conical teeth on the undersurface, both of which are lacking in the female. The conical teeth on the undersurface of the tibia of the males are highest medially, becoming smaller both basally and distally (pl. 2, fig. 11). In other respects the legs are similar in structure to *blackburnii*.

Genitalia and genital capsule of male are well developed, the parameres of the male genitalia being quite distinctive (pl. 4, fig. 6). The most readily discernible characteristic is the basal portion of the right paramere, which is moderately elongate, but shorter and thicker than in *blackburnii*. In none of the examples studied did it extend beyond the basal tip of the widened left paramere. The left paramere is more elongate than it is in specimens of *blackburnii*, and in many examples, particularly from the southwestern portion of the range, the inner portion of the paramere has many small spines.

NEOTYPE: Male, Columbia, Mo., Apr. 2, 1935, Start (USNM).

As Say listed two places in Missouri and the State of Pennsylvania as localities, I have picked Missouri as the type locality.

Variation is the same as that given for *blackburnii*. The subspecies *excrementi* is rather difficult to separate from *blackburnii* by external characteristics. Females are almost impossible to differentiate, but in general the presence of numerous, fairly distinct secondary punctures on the lateral portions of the prothorax will separate female *excrementi* from *blackburnii*. The males may be easily separated on genital characteristics (pl. 4, fig. 6) and by the conical teeth on the inner flattened surface of the foretibia which are longest in the middle in *excrementi*, while in the males of *blackburnii* the distal tooth is longest (p. 2, fig. 11).

To my knowledge, this subspecies has never been differentiated before. It is very probable that Say's description of *excrementi*,

which fits *blackburnii* equally well, was actually made from a specimen of this western subspecies, and as Say's name *excrementi* is available it has been used.

It might be mentioned here that the more northern specimens of *excrementi*, which Say probably had, have fewer pronounced secondary punctures than the southern specimens from Louisiana and Texas, but the male genitalia shows little difference.

Intergradation with *blackburnii* appears rather limited (actual intergrades seen were from only a few localities), but additional data will probably show intergradation occurring in a general line from central Ohio southward, west of the Appalachian Mountains to Rockmart, Ga. Specimens believed to be intergrades have been listed under *blackburnii*. The range of *excrementi* extends generally along the Mississippi River basin. Before assigning the name *excrementi* to this subspecies, I called it the "western subspecies" of *blackburnii* and had identified numerous specimens in that manner.

Since *excrementi* has not previously been recognized as distinct from *blackburnii blackburnii*, the biological information published on *blackburnii* from areas west of the Appalachian Mountains should be referred to the subspecies *excrementi*.

The following account, the best one available on this subspecies, is quoted from Ritcher's paper (1947, p. 7), which is mainly concerned with the larval morphology.

> It is fairly common at Lexington, Kentucky, especially in the early spring when it can be collected in numbers from soil beneath fresh cow dung. In March, 1943, the writer dug over 20 adults from burrows beneath one pile of cat dung. The species is also attracted to lights . . . . Adults construct winding vertical burrows in the soil and pack the lower end of each with an elongate wad of dung in which a single larva develops. Winter is passed in the adult stage.

A number of the adult beetles collected by Ritcher at Lexington, Ky., were later personally examined and identified as *excrementi*. Brown noted (1927, p. 28) that *blackburnii* (again subspecies *excrementi*) in Payne and Pawnee Counties, Okla., were common in the woods, hibernating as adults in their burrows. Mohr (1943, p. 296), in his work in Illinois on the succession of forms in cattle droppings, described *blackburnii* (*excrementi*) as an "irregular influent" of fairly fresh droppings.

The larva of *Geotrupes blackburnii excrementi* was originally well described by Ritcher (1947, pp. 6–7).

Only a few of the larvae of *G. blackburnii excrementi* were personally examined, but these seemed to differ slightly from the eastern *blackburnii blackburnii*. The differences were evident only on the hypopharynx and glossa (pl. 8, fig. 5). The asymmetrical oncyli were slightly different in shape from those of the eastern specimens. Also

the setae between the hypopharyngeal oncyli and the transverse row of sensilla did not have their origins any nearer to the midline than the outermost sensilla.

Maximum width of head capsule 3.9 to 4.6 mm.

Specimens examined: 173 males, 165 females.

ALABAMA: 11 males, 12 females. Blount Springs, Kushla (?), Lauderdale County, Mobile, Tuscaloosa County; (1) May, (1) June, (1) August, (1) October, (17) November, (1) December.

ARKANSAS: 8 males, 14 females. Fayetteville, Hope, Imboden, Lawrence, Ozark, Washington County; (1) January, (5) April, (7) September, (4) November.

ILLINOIS: 29 males, 21 females. Alton, Blandinsville, Carbondale, Dubois, Golconda, Homer, Martinsville, Muncie, Putnam County, St. Joseph, Topeka, Urbana, White Heath; (1) February, (2) March, (13) April, (3) May, (1) June, (23) October.

INDIANA: 3 males, 4 females. La Porte, Michigan City, Osborn, Terre Haute; (1) April, (1) July, (2) October.

IOWA: 2 males, 1 female. Ames, "County #89," Mount Pleasant; (3) April.

KANSAS: 7 males, 7 females. Douglas County, Elk City, Johnson County, Muncie; (2) April, (1) May, (1) June, (7) September.

KENTUCKY: 15 males, 13 females. Clay's Ferry (?), Frankfort, Fulton, Lexington, near Mammoth Cave, Russellville [east of Lexington areas of intergradation]; (1) January, (1) March, (2) April, (4) May, (2) June, (1) July, (1) August, (1) September, (5) October, (5) November.

LOUISIANA: 9 males, 8 females. Leesville, Mandeville, Pilare (?), Shreveport, Vowells Mill; (1) February, (3) March, (2) April, (5) December.

MICHIGAN: 1 female. Whitefish Point (Chippewa County); (1) July.

MISSISSIPPI: 16 males, 12 females. Cleveland, Hattiesburg, Vicksburg; (1) February, (4) March, (2) April, (1) June, (10) November.

MISSOURI: 17 males, 35 females. Carthage, Columbia, Fulton, Jefferson County, Louisiana, New Hartford, St. Louis, Willard, Williamsville; (2) March, (15) April, (3) May, (1) July, (2) September, (18) October, (1) December.

OKLAHOMA: 13 males, 10 females. Caddo County, McClain (?), Norman, Panama, Payne County, Sapulpa, Sequoyah County, Sulphur, Tulsa; (7) April, (1) May, (7) October, (6) November, (2) December.

TEXAS: 40 males, 27 females. Anderson County, Cherokee County, Dallas County, Houston; (7) January, (5) April.

WEST VIRGINIA: 2 males. Huntington; (2) August.

WISCONSIN: 1 male. No data.

Geotrupes egeriei Germar

Geotrupes egeriei Germar, 1824, p. 114.—Jekel, 1865, pp. 532, 593.—Horn, 1868, p. 318.—Blanchard, 1888, p. 106.—Blatchley, 1928, p. 44.—Bradley, 1944, p. 112.

Geotrupes lecontei Jekel, 1865, p. 592.—Horn, 1868, p. 318.

Length 11.5 to 20 mm., greatest width 7.5 to 13.5 mm.

Color of dorsum shining black tinged with traces of iridescent blue or green which is most pronounced in striae, on thoracic and

elytral margins, and on the head. Ventral surface strongly iridescent bluish black with numerous long reddish setae. Antenna dark brown with club light reddish brown. Legs black with traces of bluish iridescence. Eye canthus, clypeus, and most of vertex coarsely, densely punctured. The three tubercles on the head evident, the posterior clypeal horn being quite pronounced. Posterior edge of clypeus indicated by a distinctly indented line, which usually becomes obsolete laterally. Clypeus margined, generally evenly arcuate, but in some cases extended and sharply arcuate anteriorly. Eye canthus margined, forming a very obtuse angle with clypeus. Canthus arcuate, usually slightly more so posteriorly. Pronotum completely margined, convex, more so laterally. Deeply, coarsely punctured laterally, sometimes with punctures anteriorly and along vaguely indented midline. A very shallowly indented cluster of punctures usually present laterally. Extremely fine secondary punctures sometimes closely scattered over pronotum. Scutellum large, sides moderately arcuate. Convex elytra with striae well developed. Pronounced, irregularly shaped elytral punctures usually separated by about their own diameter, sometimes almost confluent. Elytral margin very narrow, not widened anteriorly.

The foretibia of the male differs in two major respects from that of the female. The anteriormost of the six or seven teeth of the outer margin is expanded forward and slightly inward in the male and is bifurcate. Also, there is on the inner flattened surface of the foretibia of the male an uneven row of about three to five conical teeth which are quite variable in size and number. In both sexes there is a dorsal longitudinal raised carina extending along the inner edge of the foretibia. This carina differs from those of *blackburnii*, *splendidus*, *semiopacus*, and *ulkei* by bending slightly inward opposite the penultimate tooth (pl. 2, fig. 12). A row of setae closely approximates the carina throughout its length. On the external face of the tibia of meso- and metathoracic legs there are three complete transverse carinae and one or two partial ones. Posterior edge of hind femur of male produced into a tubercle near coxa. Tarsal claws similar in both sexes.

Genital capsule and genitalia of male well developed and distinctive (pl. 5, fig. 1). The left dorsal paramere is somewhat triangular in outline, widest at base and sinuate near the tip.

The size and shape of clypeus and density of the punctures vary greatly in this species. Color is fairly constant. Specimens north of Maryland tended to be slightly smaller, more elongate, and yellowish green, but none of these differences could definitely be correlated with range.

The species can be distinguished by its oval, very convex form, pronounced punctures in elytral striae, external carina on foretibia curved inward opposite penultimate tooth (pl. 2, fig. 12), black color with traces of blue or green iridescence along elytral striae, margins, and on head, and by the shape of male genitalia (pl. 5, fig. 1).

Geotrupes egeriei, ranging east of the Mississippi River from New Hampshire southward to Florida, appeared to me to be a rather common but elusive species. In three years of intermittent collecting at Southern Pines, N. C., I did not see a single specimen of *egeriei* in this locality except for specimens that were taken in cans of fermenting malt. In dry areas such as Southern Pines, the beetles were seldom taken in any other manner. Occasionally a few specimens came to butyric acid, but malt was by far the best attractant.

In the mountains near Mills River, N. C., specimens were taken in late July, August, and September feeding on the fungi *Clitocybe gigantea* (Fries) Quelet and *Russula emetica* (Fries) Kummer (determined by Dr. H. Fink, North Carolina Experiment Station at Mills River). In the drier nonmountainous localities specimens were seldom taken at fungi. On one occasion in October several specimens were found under rotten watermelon at Faison, N. C. Manee's note (1908a, p. 288) about collecting *balyi* under rotten watermelon at Southern Pines should be referred to *egeriei*, as Manee's specimens (seen by the writer) were incorrectly identified. In addition to finding specimens around decomposing vegetable matter, dung, and fungi, they were occasionally found attracted to light.

A number of adults were taken in burrows under cow dung at Mills River, N. C., and at Interlachen, Fla. The beetles taken at fungi had constructed burrows only 5 or 6 inches deep, but the burrows under dung were noticeably deeper. In the mountains, one burrow went 18 inches into the hard red clay, and at Interlachen, in the loose sand, several of the burrows reached a depth of 3 feet. The burrows, whether in sand or clay, were typically vertical with a small push-up around the opening. Often the burrows were open; at other times a small plug of dirt was found near the entrance.

It was noticed that there was a long period of adult activity, specimens being taken in every month from April to November. The greatest numbers, which seemed to include newly emerged specimens, were seen in August and September. Several deep burrows under old cow dung at Mills River yielded pairs of *egeriei* in July, but there was no indication of either mating or nidification. The burrows typically were under rather old, dried pieces of cow dung. This was different from *Geotrupes blackburnii*, which typically was found under fresh droppings.

At Mills River on July 30, 1951, a burrow was found under an old dried piece of cow dung at the edge of the woods in a well-shaded spot. The ground was extremely hard and rocky, making digging difficult. At a depth of 7½ inches the burrow, which had been open its entire length, took a sharp bend. There, a female *egeriei* was discovered still packing a larval cell with dung. The cell, about 2½ inches long and containing an oval yellowish white egg similar to that pictured for *blackburnii* (pl. 14, fig. 2), was carefully removed, placed in a metal salve box, and taken indoors. The first instar emerged on August 7; by August 18 the larva was second instar, and by September 10 was a third instar. The larva was preserved on September 24. The rapid growth of the larva, while not too unusual for the genus, probably was considerably accelerated by warm room temperatures and should not be considered typical. Under more normal conditions it would seem likely that the larva would have overwintered as a second or early third instar. However, this cannot be substantiated at present.

It should also be mentioned here that other larval cells might have been present at a greater depth, but as there was no indication that this was the case, digging was discontinued. Usually it was always deemed advisable to dig 6 to 12 inches below the visible end of a burrow, as multiple larval cells had sometimes been found at the end of a burrow (this being particularly true of European species).

At Interlachen, Fla., on Nov. 17, 1951, a pair of *egeriei* was taken in a burrow at a depth of 40 inches. The beetles had a small wad of cow dung, about 1 inch in length, packed in the end of the burrow, but no egg was found. A second burrow was noted and upon excavation yielded, at a depth of 20 inches, a female *egeriei* with a completed larval cell of old cow dung about 2½ inches long by 1 inch wide. An egg was found in a small cavity one-half inch from the terminal end of the wad. The egg, with the food supply, was placed in a metal salve box. On this occasion digging was continued to a depth of 3 feet and the hole was considerably enlarged, but no other cells were found, nor was a male present. (The males of European species of *Geotrupes* have often been credited with aiding the females in provisioning the larval cells, but I did not note any similar case of cooperation in North American species.)

The egg was brought indoors, at Raleigh, and it increased from 4.2 to 4.7 mm. in length and from 2.3 to 3.2 mm. in width before hatching occurred on Dec. 2, 1951. As the larva was indoors and not subject to the winter temperatures, development was rapid. The larva became a small third instar by mid-February at which time it died.

From the sketchy information available, it appears that *Geotrupes egeriei* has a 2-year life cycle at least in the North Carolina mountains.

The adults are present much of the year, being most numerous in the fall. Nidification occurs from the end of July (in the mountains) through November (in Florida) depending on the locality. It would seem that the egg or larva overwinters, emerging as an adult in the following summer in July and August. At that time the freshly emerged adults were found at Mills River, N. C., feeding on fungi. In the mountains and in northern states the newly emerged adults probably overwinter and begin egg laying in July of the next year. In the case of the Interlachen, Fla., specimens, they could possibly have either a 1-year or 2-year cycle, as activity certainly was not greatly impaired by any cold weather.

Description of larva of *Geotrupes egeriei* was based on the following material: One third-stage larva and second instar exuvia reared from egg collected with female at Mills River, N. C., July 30, 1951, H. Howden; one third-stage larva reared from egg collected with female at Interlachen, Fla., Nov. 17, 1951, H. Howden and B. Dozier.

Maximum width of head capsule 4.0 to 4.2 mm. Frons (pl. 7, fig. 8) on each side with 1 or 2 posterior frontal setae, 3 or 4 setae on each anterior angle, 1 or 2 exterior frontal setae, and 2 or 3 anterior frontal setae. Antenna 3-segmented, the last segment reduced in diameter and about three-fifths as long as the second segment (pl. 7, fig. 5) which distally bears a small conical sense organ. Mandibles (pl. 7, figs. 11, 12) similar to those of *blackburnii*. Maxilla (pl. 8, fig. 6) with stridulating area bearing a row of 5 to 7 small conical teeth on the stipes and 2 or 3 teeth on the posterior margin of the palpifer. Hypopharynx (pl. 8, fig. 6) with two asymmetrical oncyli. In front of the hypopharyngeal oncyli, on each side, is a row of 12 to 14 small sensilla almost united medially, bending anteriorly with a short line of 3 or 4 sensilla on each side. These two parallel forward extensions of sensilla have several small setae irregularly placed between them. Glossa slightly emarginate. Epipharynx (pl. 8, fig. 4) with thin tormae united mesally. Anterior and posterior epitormae present, their tips obscured by fine dense setae. Setae at tip of posterior epitormae rather V-shaped in outline. Phobae surrounding the pedium, which is mostly spiculate. Medially along the anterior edge of the phobae is a row of from 3 to 6 sensilla, and anteriorly, well separated from either the phobae or the irregular row of 9 to 12 setae, is a single isolated sensillum, slightly left of the midline.

Body shape (pl. 11, fig. 2) similar to that of *blackburnii*, as is the setal pattern. Dorsal annulets of abdominal segments 6 to 8 inclusive each with a transverse patch of long setae, as in *blackburnii*. Anal lobes (pl. 7, fig. 17) with endoskeletal figure slightly different from *blackburnii*. Stridulating organs on the reduced metathoracic legs consisting of a row of 7 or 8 teeth on the inner surface of the fused

trochanter-femur and a single small tooth on the tibiotarsus. Tips of all legs (pl. 7, fig. 16) with a circle of setae around a small tubercle which lacks the small brownish claw present in *blackburnii*.

When first collected, one egg measured 4.2 by 2.3 mm., and was oval and slightly wider at one end. Five days later the egg measured 4.6 by 2.7 mm., and in another five days it measured 4.7 by 3.1 mm. It finally attained the size of 4.7 by 3.2 mm. three days before hatching, which occurred on the 15th day.

Maximum width of head capsule of live first-stage larva about 3.1 mm. Exuvia not recovered.

Maximum width of head capsule of live second-stage larva about 3.7 mm. Exuvia recovered but no significant differences were noted between it and the third-stage larva.

Specimens examined: 183 males, 127 females.

ALABAMA: 4 males, 4 females. Augustine (Perry County), Mobile, Monroeville, Monte Sano, The Pocasins (Pike County); (1) July, (5) August, (1) November.

DISTRICT OF COLUMBIA: 1 male. (1) July.

FLORIDA: 49 males, 47 females. Gainesville, Interlachen, Jacksonville, Lakeland, Lutz, Miami, Monticello (Jefferson County), New Smyrna, Ocala, Putnam County, Sanford, Steinhatchee, Valparaiso; (5) January, (10) March, (3) April, (3) June, (1) July, (5) August, (7) September, (2) October, (11) November, (1) December.

GEORGIA: 4 males, 3 females. Head River, Midway (Bryan County), Roberta, Robertstown, Vidalia; (1) May, (1) June, (2) August, (2) September.

ILLINOIS: 1 male, 1 female. Maywood, northern Illinois.

LOUISIANA: 1 female. No data.

MARYLAND: 2 males, 1 female. Beltsville, College Park; (1) April, (1) May, (1) September.

MASSACHUSETTS: 19 males, 12 females. Chicopee, Counb (?), Dover, Duxbury, Framingham, Lowell, Nantucket, Norfolk, Sherborn, South Hadley, Springfield, Tyngsboro, Wayland, Wellesley; (4) April, (1) July, (7) August, (5) September, (3) October.

MICHIGAN: 2 females. Bloomfield (Oakland County), George Reserve (Livingston County); (1) July, (1) August.

MISSISSIPPI: 8 males, 6 females. Camp Shelby, Iuka, Lakesville [Leakesville?], Leakesville, Lucedale, New Augusta; (2) July, (7) September, (5) October.

NEW HAMPSHIRE: 4 males. Exeter; (1) September.

NEW JERSEY: 19 males, 17 females. Browns Mills, Burlington County, Cape May County, Marlton, Ocean View, Palmyra, Point Pleasant, Ramsey, Riverton, Sea Girt, Westwood; (1) May, (2) June, (1) July, (19) August, (2) September, (9) October, (1) November, (1) December.

NEW YORK: 1 male, 3 females. Farmingdale, Montauk; (2) August.

NORTH CAROLINA: 47 males, 13 females. Dunn, Faison, Julian, Mills River, Newton Grove, Oxford, Pine Bluff, Raleigh, Southern Pines, Swannanoa, Tarboro; (8) May, (7) June, (26) July, (7) August, (4) September, (6) October, (1) November.

PENNSYLVANIA: 5 males. Glenolden, Jeannette; (1) July, (1) August, (1) October.

RHODE ISLAND: 1 male, 1 female. Berkeley, Warwick; (1) April, (1) July.

SOUTH CAROLINA: 17 males, 12 females. Clemson College, Columbia, Florence, Govan, Hampton, Jocassee, Longcreek, Meredith, Orangeburg, Palmetto, Rocky Bottom, Sassafras Mountain, Tunnel Walhalla, Williamsburg County; (6) June, (13) July, (6) August, (3) September, (3) October.
TENNESSEE: 1 female. Sparta; (1) August.
VIRGINIA: 1 male, 3 females. Nelson County, Norfolk, Petersburg (Camp Lee); (1) April, (2) August, (1) September.

Geotrupes hornii Blanchard

Geotrupes hornii Blanchard, 1888, pp. 107, 108 (lectotype, male, bearing label "Tewks. (Mass), 4/28," in Blanchard collection, MCZ).—Boucomont, 1911, p. 344.—Bradley, 1944, p. 112.
(?) *Geotrupes miarophagus* Say, *in* Melsheimer, 1846, p. 139.

Length 12 to 18 mm., greatest width 7 to 11 mm.

Color of dorsum and ventral surface black without any trace of other colors. Antennal club rather dull yellow-brown, slightly lighter than remaining segments. Eye canthus, clypeus, and most of vertex coarsely, densely, and sometimes confluently punctured. Three tubercles of head poorly defined, but with indented line at base of clypeus rather pronounced. Clypeus poorly margined, varying considerably in shape, usually rather evenly arcuate or slightly more so anteriorly. Anterior portion of eye canthus poorly margined, sometimes forming an almost straight line with the clypeus or at most forming a very obtuse angle. Sides of canthi slightly arcuate. Pronotum completely margined, rather convex. Posterior margin may be only slightly margined laterally. Coarse punctures scattered irregularly over pronotum, dense laterally. Median lateral indentation very poorly indicated. At least posterior half of pronotal midline slightly indented. Scutellum generally triangular with median line usually slightly indented, sides arcuate, more so anteriorly. Elytra with well developed striae containing coarse, very irregular punctures. Sutural stria extends around scutellum to elytral base. Second stria does not reach the elytral base. Elytral margin narrow, slightly widened anteriorly.

Foretibia of male differing from that of female by having the antepenultimate external tooth deflexed slightly downward and thickened ventrally. Otherwise the foretibiae are similar, with six or seven external teeth and a longitudinal raised carina extending along the inner edge of the dorsal surface. This carina, similar to that of *balyi* (pl. 2, fig. 14), has an extension onto the penultimate tooth. The row of setae at the base of the longitudinal carina has each seta separated by a small transverse carina. Male specimens also have a small raised carina near the anterior base of the front femur; hind femora are unarmed. External faces of tibiae of meso- and metathoracic legs have three complete carinae and one or two partial carinae. Tarsal claws similar in both sexes.

Genital capsule and genitalia of male well developed, the parameres almost concealed by the phallobase (pl. 3, figs. 8, 9), which gives the genitalia a symmetrical appearance. The parameres are tipped with numerous short setae.

Size variation is considerable, specimens from the Appalachian Mountains being generally smaller than ones taken from the piedmont or coastal plain areas of the East Coast. Several large, elongate, heavily punctured specimens collected in Newfoundland appeared to differ slightly from mainland specimens, but additional specimens and further study are needed to fully determine and correlate structural differences with geographical ones.

The species can be distinguished by its entirely black dorsal and ventral color, the sutural stria extending around the scutellum to elytral base, second stria not reaching elytral base, irregularly punctate elytral striae, coarsely rather densely punctured pronotum, shape of the carina of the foretibia, the small carina on the anterior base of the front femur of the males, and the numerous setae on the tips of the parameres almost hidden by the phallobase (pl. 3, figs. 8, 9).

Geotrupes miarophagus Say as described by Melsheimer (1846, p. 139) appears to be synonymous with *G. hornii* Blanchard, if the description was based upon specimens in the Melsheimer collection now housed in the Museum of Comparative Zoology at Cambridge. There are only two specimens labeled *miarophagus* in this collection; the first specimen bears the label "U. S. Melsheimer" with a separate red-margined label "*splendidus* var. *miarophagus* Melsh." This specimen is a large female *hornii* Blanchard (as we now know it). The second specimen, labeled simply "*miarophagus*," is a female *blackburnii* (Fabricius).

Following his description of *Geotrupes hornii*, Blanchard (1888, p. 109) wrote that Ulke, in correspondence, mentioned that *hornii* sometimes came to light while *balyi* did not. While at Hendersonville, N. C., where both species occurred, I noted *hornii* was attracted on several occasions to lights while *balyi* was not. This difference in attraction to light was interesting, for in other respects these two species seemed to have very similar habits, often being collected in adjacent burrows under the same fungi. Frost (1929, p. 111) in Massachusetts stated that *hornii*

> . . . is one of the common species of the genus in this locality occurring, according to my series, from August 8 to September 30. It can be easily distinguished from the other species by its pure black color with nonmetallic reflections. I have found it frequently under a fungus having an acrid milky juice (*Lactarius*, perhaps *piperatus*) and it often bores from the top down through the stem and into the ground to a depth of 5 or 6 inches; I have never noticed this particular mode of attack by *G. balyi* Jek. which at times frequents the same species of fungi.

Although the writer, with P. O. Ritcher, has taken a number of *hornii* at Mills River, N. C., on the fungi *Clitocybe gigantea* (Fries) Quelet and *Russula emetica* (Fries) Kummer, they were not noted boring down through the fungi in the manner described by Frost.

While *hornii* has been found fairly commonly in the northeastern United States, it is generally restricted to the mountains of western North Carolina. An occasional specimen was taken at Raleigh and a single pair was found under fungi at Faison, which is situated in the center of the North Carolina coastal plain.

From July through September adults of *hornii* were taken in shallow, sinuous burrows under fungi and human feces. During that time they were also taken in traps of fermenting malt and propionic or butyric acid. However, I was puzzled to find an occasional adult in April and May which was never near any fungi or other source of food. A possible explanation for this apparent change in habits will be discussed later.

In the fall of 1951, 16 specimens of *hornii* from Mills River were placed with a quantity of fungi and cow dung in a rearing cage at Raleigh. The cage, 5 feet long by 3 feet wide and composed of boards sunk into the ground and covered with a wire screen, was situated on a well drained hillside in a rather open deciduous forest. The particular area was chosen as the conditions there appeared to approximate rather closely those found at Mills River.

The cage was opened for the first time on Oct. 22, 1951. Numerous burrows were found where the fungi had been placed. Some of these burrows were dug up and in every case, at a depth of 8 to 10 inches, a single adult was found at the bottom of its vertical hole with a small wad of decomposing fungi. None of the burrows contained any dung. Again, on Apr. 7, 1952, the cage was partially dug up. The adults were still alive, but there was no activity, and no food in evidence at the bottom of the burrows. Fresh cow dung was added and the screen wire replaced.

In late April and May a few adults were collected in fresh burrows at Raleigh and Mills River, but there was no sign of adult feeding or any indication of any provisioning for larvae. The cage at Raleigh was examined again on June 19, 1952, and, as several of the adults were noted making fresh burrows, the cage was not disturbed.

Finally, on July 1, 1952, a portion of the cage was dug up, even though some of the adults were still active. Digging was extremely difficult in the packed red clay, which at the time was quite dry. The two burrows, which were carefully investigated, were open for 12 and 13 inches, then suddenly came to an end. The clay at the end of the burrow, while having the same consistency and hardness as the

surrounding soil, was slightly darker in color. As it seemed that the burrow might possibly have been filled in, digging was continued. At a depth of 17 inches, slightly to one side, a cell parallel to the surface of the ground was found. It was almost 4 inches long and coated on the outside with a few dead leaves, but on the inside it was composed entirely of old cow dung. Near the terminal end of the cell a small second instar was found.

Further digging produced a second cell at a depth of 18 inches, apparently coming from a branch of the burrow which led to the first cell. Two other cells were found, 19 and 24 inches deep, both seemingly attached to the same burrow as the others. A fifth cell containing a dead larva was found near the others. As all the cells contained second-stage larvae, further investigation was postponed. A number of the adult beetles, six females and one male, were still alive and they were removed from the cage.

No further digging was undertaken until Aug. 4, 1952. Then, before attempting to follow any of the burrows, 5 gallons of water was poured into the cage and allowed to settle. This procedure greatly facilitated digging.

Seven larvae, all small third-stage, were found on this occasion. Four cells were grouped at the end of one burrow; two cells were at the end of another, and one burrow apparently had only a single cell at its end. The depth of the cells ranged from 16 to 20 inches. A diagram of the burrow and cell arrangement is given in plate 10, figure 5. All of the cells were composed of old cow dung, some coated with a thin layer of dead leaves, some without the layer. The larvae overwintered as third instar, some being kept alive through January 1953.

Pupation probably occurs in early summer with adult emergence in July and August. It would seem from the data obtained that the general biology of *hornii* is quite similar to that of *G. stercorarius* described by Sano (1915–1916, pp. 25–28).

The life cycle of *Geotrupes hornii* apparently takes two years. Freshly emerged adults feed on fungi from July until October, overwintering in their feeding burrows. Adult activity begins again in April and May. Then, instead of feeding on fungi, the beetles burrow under old dung, with which they provision the larval cells. Oviposition appears to take place in May and June with the larvae becoming third instars by fall. The second winter is passed as a larva, with pupation assumed to occur in early summer. The adults emerge in July and August and begin feeding on fungi.

Description of *Geotrupes hornii* larva is based on the following material reared at Raleigh, N. C., from adults collected at Mills River,

N. C.: Three second-stage, one third-stage larvae collected from cage on July 1, 1952; two second-stage larvae collected from cage Aug. 4, 1952; and five third-stage larvae collected in August and preserved on Sept. 15, 1952

Third-stage larvae of *G. hornii* differ from Ritcher's description (1947, pp. 6–7) of *G. blackburnii excrementi* in the following respects.

Maximum width of head capsule 4.0 to 4.5 mm. Frons on each side with 1 posterior frontal seta, 2 or 3 setae in each anterior angle, 1 exterior frontal seta and 1 or 2 anterior frontal setae. Antenna fairly long, the length of the second segment equal to or slightly longer than that of the first segment. Third segment greatly reduced in diameter (pl. 7, fig. 7), only half as long as the second segment. Mandibles and maxillae not differing in any respect from Ritcher's description, except that the 2 or 3 stridulatory teeth on the posterior margin of the palpifer of *blackburnii* are usually lacking in *hornii*. Hypopharynx (pl. 8, fig. 8) with 2 asymmetrical oncyli which are generally narrower than that of *blackburnii*. Before the hypopharynx is a row of 20 or more sensilla on each side united medially. At the midline, anteriorly, is a clump of 6 or 7 sensilla and, posteriorly, 2 setae. Glossa slightly emarginate. Epipharynx (pl. 8, fig. 7) with tormae united mesally, very similar to *blackburnii*. Anterior and posterior epitormae of equal length. Anterior to the pedium is a row of 7 or 8 setae. In *blackburnii* there are about 6 setae in the same area, in an uneven row.

Body less swollen posteriorly than *blackburnii* but otherwise quite similar. Endoskeletal figure (pl. 7, fig. 15) of anal segment not as constricted as that of *blackburnii*, quite similar to that figured for *ulkei* by Ritcher (1947, p. 27, fig. 44). Dorsal annulets of abdominal segments 7 and 8 lacking the transverse patch of long setae present in *blackburnii*, otherwise setal patterns are quite similar.

Legs 3-segmented, prothoracic and mesothoracic legs rather long, metathoracic legs reduced in size. Nine to 11 stridulatory teeth on the inner surface of the fused trochanter-femur of metathoracic legs and 5 to 8 small teeth on the inner surface of the tibiotarsus. Tips of all legs with a circle of setae around a small tubercle (pl. 7, fig. 10) which lacks the small brownish claw present in *blackburnii*.

Second instar maximum width of head capsule 3.2 to 3.5 mm. No other morphological difference noted to distinguish second instar from the third-stage larva.

Specimens examined: 114 males, 131 females, 22 not sexed.

CANADA

NO EXACT LOCALITY: 1 specimen. No data.

NEWFOUNDLAND: 1 male, 3 females. Nicholasville, Romaine Brook; (1) July.

UNITED STATES

CONNECTICUT: 1 male. No data.
DISTRICT OF COLUMBIA: 4 males, 3 females. (1) June.
GEORGIA: 1 female. Clayton; (1) July.
ILLINOIS: 3 males, 2 females. Cook County, Schiller Park, Urbana; (1) April, (1) October.
INDIANA: 1 male. Brown County. (1) July.
IOWA: 1 male, 1 female. Forest City; (2) August.
MAINE: 3 males, 2 females. Katahdin, Monmouth, Paris; (1) July, (1) August, (1) September.
MARYLAND: 1 male, 7 females. College Park, Easton, Glen Echo; (3) July, (1) August, (1) October.
MASSACHUSETTS: 18 males, 21 females. Dorchester, Duxbury, Framingham, Natick, Nantucket, Sherborn, Tewksbury, Tyngsboro, Wilbraham, Wilmington; (1) April, (1) June, (5) July, (5) August, (19) September.
MICHIGAN: 7 males, 6 females. Beaver Island (?), Cheboygan County, Douglas Lake, George Reserve (Livingston County), Naubinway, Pentwater; (4) July, (5) August, (1) September, (2) October.
MISSISSIPPI: (?) 1 female. No data.
NEW HAMPSHIRE: 3 males, 2 females. Belknap County, Exeter, Franconia, Mount Washington; (1) September.
NEW JERSEY: 22 males, 24 females. Burlington, Frieses Mill (?), Lakehurst, Marlton, Maurice River (Vineland), Merchantville, Millville, Mount Laurel (?), Ocean City, Palmyra, Phillipsburg, Rancocas, Riverton, Sea Girt, Shark River, Warren Grove (?), Westville; (2) March, (1) June, (3) July, (28) August, (6) September, (3) October.
NEW YORK: 4 males, 4 females. Ithaca, Jamaica, Long Island, New Windsor, West Point; (1) April, (1) July, (1) August, (1) September.
NORTH CAROLINA: 15 males, 21 females. Black Mountain, Cullasaja River (Macon County), Faison, Hamrick, Highlands, Linville, Mills River, North Wilkesboro, Raleigh; (1) April, (1) May, (1) June, (7) July, (15) August, (1) September, (2) October.
OHIO: 1 male. Ashtabula County; (1) June.
PENNSYLVANIA: 14 males, 10 females. Allegheny County, Forest Park, Germantown, Jeannette, Lancaster County, Mount Alto, Pittsburgh, Poe Paddy (?), Windgap; (13) July, (4) August, (3) September.
SOUTH CAROLINA: 9 males, 20 females. Cashiers Valley Road (Oconee County), Clemson College, Greenville, Mountain Rest, Oconee County, Rocky Bottom, Sassafras Mountain, Table Rock; (1) June, (17) July, (5) August, (2) September, (4) October.
TENNESSEE: 1 male. Deer Lodge; (1) March.
VIRGINIA: 21 specimens. Great Falls, Nelson County, Rosslyn; (21) August.
WEST VIRGINIA: 2 males. White Sulphur; (2) July.
WISCONSIN: 3 males, 4 females. Wood County; (3) July.

Geotrupes balyi Jekel

Geotrupes balyi Jekel, 1865, p. 617 (type, J. Baly, Canada, in Jekel collection).—Horn, 1868, p. 319.—Blanchard, 1888, p. 108.—Boucomont, 1911, p. 344.—Bradley, 1944, p. 112.
Geotrupes similis Jekel, 1865, p. 617.—Horn, 1868, p. 319.
(?) *Geotrupes starkii* Jekel, 1865, p. 609.—Horn, 1868, p. 319.

Length 10 to 16 mm., greatest width 6 to 10 mm.

Color of dorsum black suffused with vague purple, blue, or green iridescence which is obscure at times but noticeable along elytral margins and in lateral striae. Ventral surfaces black. Antennal club light reddish brown with middle lamella not emarginate. Eye canthus, vertex, and clypeus, except for small median area just before tubercle, coarsely, densely, irregularly punctate. Three tubercles on head very vague, as is the indented line at the clypeal base. Clypeus margined, slightly more arcuate anteriorly. Eye canthi vaguely margined, rather sharply bent anteriorly, sides almost parallel; angle with clypeus very obtuse. Pronotum completely margined, moderately convex, with numerous coarse punctures most numerous laterally and along indented posterior portion of midline. Vague median circular depression usually present on the sides of the pronotum. Minute secondary punctures almost always lacking. Scutellum triangular with a longitudinal median depression and sides rather evenly arcuate. Elytra with well developed striae having numerous irregularly spaced and shaped punctures. The sutural stria extends around the scutellum reaching the elytral base. The second stria does not quite reach the elytral base. Elytral margin narrow, wider anteriorly.

There is no distinguishing external sexual modification between male and female. Foretibiae, which are identical in both sexes, have the dorsal longitudinal raised carina extending along the inner edge of the outer flattened surface. The carina has a pronounced extension onto the penultimate external tooth (pl. 2, fig. 14) and a row of adjacent setae basally, which are separated by small transverse carinae. External face of tibia of meso- and metathoracic legs each with two complete transverse carinae and two or three partial carinae. Tarsal claws similar in both sexes.

Genital capsule and genitalia of male well developed with the parameres almost hidden by the large phallobase. Both parameres lacking long setae at tips (pl. 3, figs. 10, 11).

Variation in size, punctures, and color is moderate. There is no evident external difference between male and female specimens; however, female specimens appear to be generally slightly larger than males.

The species may be distinguished by the lack of external sexual differences, dorsal black color slightly suffused with purple, blue, or green iridescence, sutural stria extending around scutellum to elytral base, second stria not reaching base, only two complete external transverse carinae on tibiae of meso- and metathoracic legs, tips of parameres of male genitalia lacking long setae.

Geotrupes balyi Jekel has often been recorded from the wooded Northeastern States and also has been frequently found during July and August in the mountains of North Carolina, South Carolina, and Tennessee.

During August and September I collected a number of specimens at Mills River, N. C. The beetles in most cases had made burrows 2 to 5 inches deep at the base of several species of fungi. Into these burrows they had taken small bits of the fungi on which they were feeding. Dr. Harry Fink, North Carolina Experiment Station at Mills River, later identified the fungi as *Clitocybe gigantea* (Fries) Quelet and *Russula emetica* (Fries) Kummer.

The beetles were taken in wooded areas and not in open pasture land. None were noted at cow dung, but several specimens were taken at what may have been human feces. Other specimens were collected in traps baited with butyric acid or fermenting malt.

Numerous specimens of *Geotrupes balyi* bore the label "fungi." Moennich (1939, p. 156) states that *balyi* was collected at Midvale, N. J., on the fungus *Lactarius piperatus* (Fries) Quelet. Another reference to *balyi*, by Manee (1908a, p. 288), states that specimens from Southern Pines, N. C., were collected not only at animal droppings but on decaying fruit, watermelon, etc. This reference caused me some doubts, as specimens from Southern Pines would not only be considerably out of their range for the species in North Carolina, but the reference to animal droppings itself was unusual. Later, I noted than a number of Manee's Southern Pines specimens in the North Carolina Department of Agriculture collection were identified as *balyi* when, in actuality, they were *egeriei*. It would seem that Manee's note (1908a, p. 288) should be referred to *egeriei*, which is a common species at Southern Pines. Other references to *balyi* are scattered and usually merely mention its capture.

Nothing has been written, to my knowledge, about the larval biology of this species.

Specimens examined: 401.

CANADA

QUEBEC: 5 specimens. Fort Coulonge, Isle of Orleans, Val Morin; (2) June, (3) August.

UNITED STATES

CONNECTICUT: 21 specimens. Cornwall, Eastford, Stamford, Union (Tolland County); (3) July, (13) August (2) October.
DISTRICT OF COLUMBIA: 1 specimen. No data.
GEORGIA: 1 specimen. Tray Mountain; (1) September.
ILLINOIS: 3 specimens. Algonquin.
IOWA: 4 specimens. Forest City; (1) August.
KENTUCKY: 5 specimens. Near Mammoth Cave; (5) April.

MAINE: 13 specimens. Bethel, Isle au Haut, Katahdin, Lincoln County, Monhegan, Monmouth, Paris, Southport; (1) July, (6) August, (3) September, (1) October.

MARYLAND: 3 specimens. Lakeland; (1) August.

MASSACHUSETTS: 47 specimens. Ashland, Chatham, Concord, Cummington, Framingham, Houghton (?), Lenox, Marion, Melrose Highlands, Milton, Monterey, Montgomery (?), Natick, Norfolk County, Sherborn, Springfield, Tyngsboro, Wakefield, Westfield; (1) March, (2) June, (3) July, (13) August, (8) September, (1) October.

MICHIGAN: 37 specimens. Alger County, Charlevoix County, Cheboygan, Crawford Lake, Douglas Lake, East Lansing, Emmet County, "Hrn. Mt." [=Huron Mountain?] Club, Isle Royale (?), Lake County, Makinac County, Naubinway, Oakland County, South Fox Island, Leelanau County; (2) June, (8) July, (10) August, (2) September, (9) October.

NEW HAMPSHIRE: 13 specimens. Belknap County, Chocoura, Farmington, Lyme, Mont Vernon, Percy, Pittsburg, Rumney; (2) May, (3) July, (4) September.

NEW JERSEY: 12 specimens. Bear Swamp, Carmel, Cecil, Greenwood Lake, Hopatcong, Lakehurst, Marlton, Rancocas Park, Split Rock Lake, Stanhope; (1) April, (1) July, (2) August, (6) September.

NEW YORK: 58 specimens. Allegheny State Park, Bear Mountain, Catskill Mountains, Debruce, Delmar, Duane, Fallsburgh, Ithaca, Locke, McLean Bogs (Tompkins County), Montauk, Mount McIntyre (summit), New York City and vicinity, Perrysburg, Scarsdale, Tupper Lake, Washington County, West Point; (3) May, (2) June, (13) July, (20) August, (12) September, (1) October.

NORTH CAROLINA: 51 specimens. Balsam, Black Mountain, Chimney Rock, Crestmont, Deep Gap, Gray Beard Mountain, Highlands, Mills River, Mount Mitchell (5,000–6,700 ft.), Newfound Gap, Pisgah Forest, Satulah Mountain, Sunburst, Whiteside Mountain; (3) June, (11) July, (7) August, (12) September, (3) October.

OHIO: 2 specimens. Jefferson, Sandusky; (1) August, (1) September.

PENNSYLVANIA: 64 specimens. Allegheny, Bellasylva (?), Bonadense (?), Brandtsville (?), Clarks Valley, Coudersport, Dauphin County, Doubling Gap, Forest County, Germantown, Indian Creek, Jeannette, Jefferson County, Lancaster County, Lehigh Gap, Ligonia, Maysville, Mont Alto, Mount Pocono, Pen Mar, Pike County, Pittsburgh, Pocono Mountains, Pocono Pines, Seven Mountains (Centre County), Warren County, Windgap; (2) April, (2) May, (3) June, (14) July, (15) August, (15) September, (3) October.

RHODE ISLAND: 5 specimens. Watch Hill; (4) July, (1) August.

SOUTH CAROLINA: 18 specimens. Cashiers Valley Road, Clemson College, Greenville, Greenwood, Jocassee, Mountain Rest, Oconee County, Rocky Bottom, Sassafras Mountain; (2) July, (12) August, (3) September, (1) October.

TENNESSEE: 1 specimen. Deer Lodge; (1) June.

VERMONT: 1 specimen. Salisbury; (1) July.

VIRGINIA: 19 specimens. Basye, Giles County, Jones Creek (Lee County), Mountain Lake, Nelson County, Pennington Gap; (1) July, (2) August, (2) September.

WEST VIRGINIA: 2 specimens. White Sulphur Springs; (1) July.

WISCONSIN: 15 specimens. Bayfield, Eagle River, Spread Eagle, Stanley, Washington County; (5) July, (2) August.

***Geotrupes stercorarius* (Linnaeus)**

Scarabaeus stercorarius Linné, 1758, p. 349.—Gorham, Walker, and Simpson, 1929, p. 15.—Brown, 1940, p. 74. (For complete synonymy see Boucomont, 1912, pp. 24, 25. Only references pertaining to North American specimens are given here.)

The following description is intended only to separate the introduced *stercorarius* from North American species and is based entirely on New Brunswick specimens furnished me by W. J. Brown, Canadian Department of Agriculture, Division of Insect Identification.

Length 20 to 26 mm., greatest width 11 mm. to 16 mm.

Color of dorsum black with traces of bluish iridescence in striae and along thoracic and elytral margins in some specimens. Ventrally black with strong blue or purple iridescence on thorax, abdomen, and femora. Basal segment of antenna dark brownish black; other segments, including the club, dark reddish brown. The middle lamella of the antennal club is very strongly emarginate on one side. Eye canthus, clypeus, and vertex densely rather finely irregularly punctured. The three tubercles of the head moderately developed, indented line present at base of clypeus extending for a short distance on the vertex at median line. Clypeus margined, sharply arcuate anteriorly. A slight obtuse angle is formed between edge of clypeus and margined eye canthus. Pronotum completely margined, only moderately convex, with a few coarse rather vague punctures present laterally. The median lateral circular indentations are present but shallow. Posterior half of pronotal midline may be slightly indented, but usually lacks coarse punctures. Minute secondary punctures lacking. Scutellum triangular, sides slightly arcuate. Elytra with well developed striae which are vaguely and shallowly punctate. The sutural stria extends completely around the scutellum to elytral base (this also occurs in *balyi* and *hornii*), and the second stria does not quite reach the base. Elytral margin is narrow, slightly wider anteriorly.

The anterior-external tooth of the foretibia of the male is slightly smaller than that of the female. In the male there is a longitudinal carina ending in a tubercle on the ventral flattened surface of the foretibia extending a distance roughly equal to that between the fourth to sixth external teeth. In both sexes there is a dorsal longitudinal raised carina extending along the inner edge of the foretibia. There is an irregular lateral extension of this carina onto the penultimate external tooth somewhat similar to the carinal extension of *balyi* (pl. 2, fig. 14). A row of setae is closely adjacent to the base of the carina, briefly interrupted by the carinal extension into the penultimate external tooth. External face of tibia of meso- and metathoracic legs with three transverse carinae, the upper one small.

One or two incomplete carinae are also present. Tarsal claws similar in both sexes.

Genital capsule and genitalia of male large, most of the elaborately sinuate parameres enclosed dorsally and ventrally by the phallobase (pl. 4, fig. 2), which is somewhat similar in structure to that of *balyi* and *hornii*.

Variation in the specimens examined was not great. Size and number and density of the coarse head and pronotal punctures showed the greatest differences, but the species appears quite uniform. No consistent differences were noted between New Brunswick and European specimens.

This species can be distinguished from other North American species by its generally large size, poorly punctured elytral striae, the sutural stria continued around the scutellum to the elytral base with the second stria not extending to elytral base (differing from other North American species except for *balyi* and *hornii*), the second segment of the antennal club strongly emarginate, the structure of the male genitalia (pl. 4, fig. 2), and the bright purple or blue iridescence of the ventral surface.

While the biology of *Geotrupes stercorarius* has not been studied in North America, there have been numerous observations made on its life history in Europe where it is widely distributed, ranging from Great Britain (Curtis, 1829, page opposite plate 266) to Russia (Lebedeva, 1906, p. 436). However, due to nomenclatorial confusion, any references to this species must be used with caution, as is pointed out by Main (1917, p. 18):

> . . . it is by no means certain that the beetle we now call *G. stercorarius* is the species referred to by Fabre or other earlier writers by that name. Hence, apparent discrepancies in the records of various authors about an insect may be due to the fact that different species are being referred to under the same name. As a case in point, Fabre gives the autumn as the time of oviposition of *G. stercorarius*, while the insect which now goes by this name lays its eggs in the spring, and it is our [British] *G. spiniger*, whose name he does not mention, which lays its eggs in the autumn. . . .
>
> It might also be put on record that the interesting account of the parasitism of *Aphodius porcus*, related by Dr. Chapman in the "E. M. M.," 1869, pp. 273–276, should be referred to *G. spiniger* Marsh, as the host, and not *G. stercorarius* L., the names having certainly been transposed since the date of the published account.

Several good, fairly recent papers dealing entirely or in part with the biology of *Geotrupes stercorarius* are Spaney (1910, pp. 625–634), Sano (1915–1916, pp. 25–28), Main (1917, pp. 18–22), and Schjelderup-Ebbe (1925, pp. 97–98). Some of the information set forth in these papers is briefly summarized here.

Geotrupes stercorarius has been noted as using horse or cow dung for larval and adult food. Egg laying occurs in the spring and early

summer. Incubation lasts about 14 to 16 days with the resulting larva growing rather rapidly until fall. Then, as an early third instar, it overwinters, does a small amount of feeding in the spring, and finally pupates in July. The adults emerge from their pupal cells in September, overwinter, and begin egg laying the following spring, completing a 2-year life cycle.

Sano mentioned that the emerging beetles do not necessarily come to the surface by way of the old burrows, but dig new ones. Main (1917, pp. 18–22) brought out several interesting facts. In many cases he found the male aiding the female in making burrows and provisioning the larval cells. The male pushed the excavated dirt from the burrow, rotating the body 90°, and then heaved the small plug of earth upward. This was followed by another turn, another heave, and so on. When the burrow reached the desired depth, the male brought the dung down the burrow to the female, and she in turn packed the larval cell. Main observed that if the male did not return with alacrity (p. 20) "the female then calls him using the stridulatory apparatus situated on the base of the abdomen and the posterior coxae. It is quite audible to an observer. If he still lags she comes up after him and gives him a good dressing down, clawing him vigorously, and he then once more resumes his task." Main mentioned however, that the female may do all of the work unaided. He also stated that three, four, or five brood chambers may be made branching off a single burrow. A diagram of the burrow of *Geotrupes stercorarius* with its brood cells can be found in the paper by Spaney (1910, fig 3).

The larva of this introduced species, *Geotrupes stercorarius* Linné, has not been collected in this country to my knowledge. However, it has been described in European literature a number of times. The original description was by Frisch (1736, pp. 13–15), but the only larval character brought out by him was the reduced metathoracic leg. Later, Schiødte (1874, table 16, pl. 61, figs 1–18; table 19, pl. 64, fig. 13) described the larva more fully, but unfortunately treated some of the structures more artistically than accurately. Schiødte's fanciful drawing of the epipharynx was later perpetuated by Hayes (1929, p. 25, pl. 6, fig. 58). The most adequate descriptions and best illustrations can be found in Spaney (1910, p. 632), Sano (1915–1916, pp. 25–28), Main (1917, pp. 18–22), and van Emden (1941, p. 121).

The larva can easily be separated from the other known North American *Geotrupes* larvae by the following characteristics given by van Emden (1941, p. 121): Greatest width of head capsule of third instar "5.9 to 6.8 mm," and

Sclerotized line of the endoskeletal figure of ventral anal lobe meeting that of the other side and forming with it a subtriangular area, but not extending beyond it towards the sclerotized line that defines the ventral edge of the lobe. Sub-

triangular part of endoskeletal figure slightly wider than long, the angles broadly truncate and rounded, the sclerotized band dilated at middle of dorsal side and broader at that point than at lateral angles, stalk narrow above, more gradually widening to dorsal angles of subtriangular part.

Specimens examined: 20.

CANADA

NEW BRUNSWICK: 3 males, 1 female, Tabusintac, June 22, 24, 27, 1939, Brown (Howden). 4 specimens, Tabusintac, June 20, 22, 24, 1939, Brown (Frost). 4 specimens, Tabusintac, Apr. 27, 1939, Brown (MCZ). 1 male, 1 female, Tabusintac, May 24, 1939, Brown (CU). 5 specimens, Tabusintac, June 24, 1939, Brown (Robinson). 1 specimen, Fredericton, Aug. 1, 1928, Gorham (Robinson).

Brown (1940, and in correspondence) lists the following additional Canadian localities.

NEW BRUNSWICK: Bathurst, Scotch Lake, Shediac.
PRINCE EDWARD ISLAND: Alma, Bedford, Kinkora.
QUEBEC: St. Hilaire.

***Geotrupes splendidus splendidus* (Fabricius)**

Scarabaeus splendidus Fabricius, 1775, p. 18, No. 63. Lectotype, male, here designated. Lectotype label placed on the specimen by S. L. Tuxen (Fabrician collection at Kiel).

Geotrupes splendidus (Fabricius) Say, 1823, p. 210.—Melsheimer, 1846, p. 139.—Jekel, 1865, p. 529.—Horn, 1868, p. 316.—Blanchard, 1888, p. 106.—Blatchley, 1928, p. 45.—Bradley, 1944, p. 112.

Geotrupes blackburni Palisot de Beauvois (not Fabricius), 1805, p. 75.—Jekel, 1865, p. 530.

Geotrupes starki Jekel, 1865, p. 609.—Boucomont, 1912, p. 28.

Length 13 to 18 mm., greatest width 7.5 to 11 mm.

Color of dorsum usually bright shining green. Occasional specimens may be entirely light blue, others rarely entirely purple black. Ventrally specimens are generally black with slight bluish iridescence, particularly on the femora. Antenna dark reddish brown with antennal club light reddish brown. Eye canthus, clypeus, and anterior two-thirds of vertex coarsely, closely punctured. The tips of the three tubercles on the head, one medially near the basal margin of the clypeus and one beside each eye, lack punctures. A distinctly indented narrow line runs from the middle of the vertex forward to the posterior edge of the clypeus, where it bifurcates and runs along the posterior margin of the clypeus, finally reaching the outer margin at the juncture of the clypeus with the eye canthus. Clypeus margined, almost semicircular. Poorly margined eye canthus forms a very obtuse angle with clypeal edge, with sides of eye canthi slightly arcuate, almost parallel. Pronotum completely margined, moderately convex with the lateral edges evenly arcuate. Width of anterior half

of pronotum noticeably less than posterior half, coarsely punctured unevenly over entire pronotum; punctures more numerous laterally and along vaguely indented midline, where they form a narrow line. An uneven indentation, heavily punctured, may be present medially on each side of the pronotum. Minute secondary punctures may be evident over entire pronotum or visible only laterally. Scutellum triangular with sides only slightly arcuate. Elytra with striae well developed, strial punctures irregular in outline and shallow, rather evenly placed in the striae. Elytral margin narrow, slightly wider anteriorly.

Foretibia of the male with apical tooth inwardly expanded, slightly bifid; the mesotarsal claw is greatly enlarged and the hind femur has a small posterior tooth in the males, modifications which are not present in the females. In both sexes there is a dorsal longitudinal uninterrupted carina extending along the inner edge of the foretibia similar to carina of *blackburnii;* a row of setae is contiguous with the carina throughout its length. External face of tibia of meso- and metathoracic legs each with three complete transverse carinae and two partial ones.

Genitalia and genital capsule of male well developed, the shape of dorsal parameres readily separating the species (pl. 4, fig. 1).

The species may be most easily distinguished by the well developed strial punctures, the male genitalia (pl. 4, fig. 1), the shape of the carina and the closely adjacent row of setae on the foretibia, the enlarged tarsal claw of the mesothoracic leg of the males, and usually the shining green color.

Variation, particularly in color, within the species is considerable, with punctures and size varying to a noticeable extent. The description was based on Raleigh, N. C., specimens compared with the Fabrician type for me by S. L. Tuxen. Size limits given in the description refer to southern specimens only, as does the description of color. Specimens collected from North Carolina southward generally are quite uniform in size and color. The constancy diminishes northward and westward. Specimens collected west of the Appalachian Mountains usually show sufficient constant size and color differences to warrant subspecific rank, which they are subsequently given. However, as areas of intergradation are large with clear subspecific separation not always possible, no attempt at separation has been made in the species locality list, both subspecies being listed together.

Although *Geotrupes splendidus splendidus* is one of the most common and most widely distributed species in the genus, there have been relatively few notes published on its biology. The feeding habits, particularly of the newly emerged adults in the fall, appeared to be amazingly varied. While fungi were noted to be the preferred food,

beetles were attracted to horse and cow dung, human feces, dead animals, chicken feathers and entrails, fermenting malt, isoamylamine, and butyric and propionic acids. By the use of the last three and other chemicals in traps, adult activity could be easily plotted. The relative abundance and time of surface activity of *splendidus* as it was indicated by the use of chemical baits is shown in table 4.

Spector (1943, p. 229) had previously noted the attraction of *splendidus* to chicken heads and feathers, while Moennich (1939, p. 156) mentioned finding a specimen of *splendidus* at Midvale, N. J., feeding on the fungus *Clavaria aurea* Fries. In North Carolina, *splendidus* did not seem to be limited to one or two species of fungi but merely utilized what was at hand.

Despite the omnivorous habits of the adults, fungi were definitely preferred. In September, the freshly emerged males made burrows 4 to 6 inches deep under partially decayed fungi. They then took portions of the fungi into the burrows, fed, and apparently awaited the approach of a female. From observation, it seemed to me that the female entered the burrows after the males. The males, when considered as a group, emerged a week or so before the females and made their burrows. When the females appeared, single males could be found in a few of the burrows, but never single females.

TABLE 4.—*Bait used in traps and number of* Geotrupes splendidus splendidus *Fabricius collected at Raleigh, N. C.*

(First column under month refers to first two weeks, second column to last two weeks)

Chemicals	*Jan.*		*Feb.*		*Mar.*		*Apr.*		*May*		*June*		*July*		*Aug.*		*Sept.*		*Oct.*		*Nov.*		*Dec.*		*Total*
Propionic acid	1	0	1	0	2	1	1	8	3	0	0	0	0	0	0	0	0	0	5	3	2	8	0		35
n-Butyric acid	2	0	0	1	0	3	30	4	4	1	0	0	0	0	0	0	1	0	21	4	1	9	0		81
Oleic acid	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1
Isoamylamine	0	0	0	0	0	0	0	4	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0		11
Valeric acid	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		6
n-Amyl mercaptan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0		5
Pelargonic acid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0		5
Ethyl mercaptan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		1
Total	3	0	1	1	2	4	31	23	11	3	1	0	0	0	0	0	1	0	36	8	3	17	0		145

Sex ratio: 66 males, 79 females.

In an attempt to learn more about the habits of the adults during the fall, several gallon-cans were filled with dirt, sunk into the ground, and fungi placed on top. When the burrows were noted in the dirt the cans were pulled out, rapidly inverted, and dumped out. In this way several pairs of *splendidus* were observed in copulation. The male genitalia, when in the process of retraction, was rotated a full 360° to the right. At no time was the genital capsule seen, apparently never being extruded. On Oct. 23, 1950, a pair of *splendidus* left for

several hours in a salve box were found in copulation. The 360° rotation of the male genitalia during retraction was again noted.

In order to ascertain the stage of development of the female ovaries at the time of mating, several females were subjected to histological examination. Only vague suggestions of one or two partially formed eggs were seen in the specimens examined.

During September and October at Raleigh, a number of *splendidus* were kept alive and placed, along with a quantity of cow dung, in a 3-by-6-foot enclosure which was covered with screen wire. On Apr. 17, 1951, the cage was dug up. In most cases the adults were found inactive at the bottom of shallow burrows. In two instances the burrows turned sharply at a depth of about 6 inches and were then packed with an elongate wad of dung. In each dung wad, within one-half inch of the terminal end, was a small cavity about one-fourth inch in diameter containing an elongately oval, yellowish white egg. The eggs, with their accompanying wads of dung, were placed in salve boxes and taken indoors. One egg failed to hatch, probably due to injury by mites. The other egg hatched on April 29. The larva grew rather rapidly, becoming a second instar in May 10, and then died, for no apparent reason, on May 17, 1951.

Because of the rather poor results obtained, it was decided to move the adults to a new enclosure in an area where many *splendidus* had been collected. The area chosen, about 5 miles north of Raleigh, was on a well-wooded, southward-facing hillside. The deciduous trees, predominantly oaks, were by far the largest components of the woods and beneath them was a thick layer of dead leaves.

The adult beetles were placed in a new enclosure, the same size as the old one, along with a quantity of the ground litter, dead leaves, and some fresh cow dung.

The cage was left undisturbed for over a month; then, a portion of the cage was dug up on June 27, 1951, with gratifying results. Each burrow yielded a cell containing an egg or larva. The burrows typically went to a depth of from 3¾ to 6½ inches, where they took a sharp, almost right-angled turn. Half an inch beyond this turn the packed food cell began. These wads, 2 to 3 inches long and slightly under 1 inch in diameter, were composed, surprisingly, of tightly packed pieces of dead leaves in concentric layers. There was no dung or other material used, merely small bits of dead leaves (largely oak) which were so tightly packed into a firm mass that it retained its shape when removed from the burrow. Seemingly none of the burrows led to more than one cell, but because of the difficulty of digging in the hard red clay, and because of the beetles' habits of partially refilling the burrows, the statement cannot be made with certainty. Plate 10, figure 7 is a diagram of what is believed to be a typical burrow and cell.

Five of the cells found on June 27 contained eggs, three cells contained first instars, two cells contained second instars, and one cell contained a small third instar. Several of the larvae were preserved; others were kept alive in salve boxes.

The remainder of the cage was dug up on Aug. 8, 1951. At this time all of the cells found (a total of 14) contained third-stage larvae. These were at depths ranging from 4½ to 7 inches. Again all of the cells were composed of bits of leaves. Cow dung, while available, was not used in a single instance.

Previously, on Apr. 23, 1951, several hundred yards from the cage a burrow was found which yielded a tightly packed wad of leaves at a depth of 3½ inches. An egg contained in the wad was reared, became a third instar on July 5, and a pupa on September 6. The adult which emerged on September 20 proved to be a specimen of *splendidus*.

A second burrow, containing a second instar in a tightly packed cell of leaves, was found in the same area on May 7, 1951. This larva, which also proved to be *splendidus*, became a third instar on May 26, a pupa on August 20, and an adult on August 28.

From information gained from reared larvae, both from the cage and from unknowns, the life history of *splendidus* in North Carolina can be summarized as follows:

Newly emerged adults feed largely on fungi during September and October. Mating occurs at this time in burrows probably made by the males. The adults pass the winter in these burrows, emerging in April. Oviposition lasts from April through June. In late June all stages of the larvae can be found, but, because of the rapid development of the early stages (11 to 17 days for the first instar, and 15 to 25 days for the second), by August all of the larvae are third instar. Pupation occurs from late August until mid-September. The newly transformed adults begin to emerge in early September, completing a life cycle of one year.

Description of the immature stages of *Geotrupes splendidus* was based on the following material collected at Raleigh, N. C.: One egg, Apr. 21, 1951, H. Howden; two first-stage larvae, June 27, 1951, H. Howden; two second-stage larvae, June 29, 1951, H. Howden; 11 third-stage larvae in cage, Aug. 8, 1951, H. Howden and P. O. Ritcher; one prepupa, Sept. 12, 1951, H. Howden and P. O. Ritcher; 7 third-stage larval skins associated with pupae and adults reared from larvae.

Third-stage larvae of *Geotrupes splendidus* differ from Ritcher's (1947, pp. 6, 7) description of *G. blackburnii* (*excrementi*) in the following respects.

Maximum width of head capsule 4.0 to 4.5 mm. Frons (pl. 7, fig. 9) on each side usually with 1 posterior frontal seta, 2 setae in each

anterior angle, 1 exterior frontal seta and 1 anterior frontal seta. First two antennal segments approximately equal in length, third segment greatly reduced in diameter (pl. 7, fig. 2) and slightly over half the length of the second segment. Mandibles (pl. 7, figs. 13, 14) and maxillae (pl. 8, fig. 3) similar to those of *blackburnii* except for the maxillary stridulating area which consists of a row of 8 to 10 conical teeth on each stipes and a short row of 3 teeth along the posterior margin of the palpifer. Hypopharynx (pl. 8, fig. 3) with asymmetrical oncyli differing in shape from those of *blackburnii* (pl. 8, fig. 2) and *excrementi* (pl. 8, fig. 5). Before the hypopharynx is a row of about 10 sensillae on each side, separated medially by several setae. The setae are part of a small group of 7 or 8 median setae just anterior to the row of sensillae (pl. 8, fig. 3). Glossa emarginate. Epipharynx (pl. 8, fig. 1) quite similar to that of *blackburnii*. Torma united mesally, posterior epitorma slightly larger than anterior epitorma. Anterior to the pedium are about 12 very irregularly placed stubby setae (much shorter than the irregular row of 6 setae in *blackburnii* or the even row of 7 or 8 setae in *hornii*).

Body shape and setal arrangement similar to *blackburnii*. All legs with tuberculate tips bearing small brown claws identical to those of *blackburnii*, as are the position and number of stridulatory teeth on metathoracic legs. Endoskeletal figure of last abdominal segment ventrad of triangular area not quite as constricted as that of *blackburnii*, but very similar otherwise.

Egg yellowish white, oval, largest near one end, 4.5 mm. in length, 2.4 mm. at greatest width.

First instar, greatest width of head capsule 2.5 mm. Setal patterns of head and abdomen and leg structures similar to that described for third instar. Mandibles more elongate, endoskeletal structure of anal lobes rather indistinct, apparently quite similar to that of third instar. Spiracular plates, large and crescent-shaped in later stage, are small and circular in the first instar.

Second instar, maximum width of head capsule 3.1 to 3.3 mm., otherwise structurally similar to third instar.

Specimens examined: 562 males, 433 females.

CANADA

ONTARIO: 2 females. Toronto; (2) June.
QUEBEC: 2 females. Nominingue.

UNITED STATES

ALABAMA: 2 males, 1 female. Blount Springs, "Felix (Perry County)," Tuscaloosa County; (2) August.
ARIZONA: 1 female. Snowflake [? doubtful record].
ARKANSAS: 1 male. Osceola; (1) August.

DISTRICT OF COLUMBIA: 3 males.

CONNECTICUT: 7 males, 9 females. Cornwall, Marlboro, Pomfret, Ridgefield; (4) June, (1) August, (1) September.

FLORIDA: 1 female. Orlando (?).

GEORGIA: 4 males, 7 females. Athens, Atlanta, Clarke County, Margret, Neil Gap, Rabun Bald Mountain, Satolah; (1) February, (2) March, (1) April, (2) May, (2) June, (1) September, (1) December.

ILLINOIS: 38 males, 35 females. Algonquin, Beverly Hills, Champaign, Chicago, Cook County, Dubois, Edgebrook (?), Elgin, Grand Detour, Heyworth, Homer, Martinsville, north Illinois, Ogle County, Oregon, Palos Park, Peoria, Pittsfield, Princeton, Putnam County, Schiller Park, Urbana, White Heath, Willow Springs; (5) April, (16) May, (23) June, (8) July, (7) August, (4) September, (8) October.

INDIANA: 18 males, 11 females. Beverly Shores, Bloomington, Bluffton, Clarke, Hanover, Hessville, Monroe County; (3) May, (1) June, (4) July, (5) August, (15) September.

IOWA: 30 males, 19 females. Ames, "County 88," Davis County, East Gilbert, Forest City, Iowa City, McGregor, Moulton; (7) April, (17) May, (9) June, (6) August, (1) September, (3) October.

KANSAS: 28 males, 22 females. Argentine, Clay County, Douglas County, Franklin County, Lawrence, Muncie, Onaga, Osage City, Wichita; (1) March, (7) April, (5) May, (6) June, (3) August, (16) September.

KENTUCKY: 1 female. (University of Kentucky collection, No. 5602.)

MAINE: 3 males, 5 females. Bethel, Cape Rosier, Christmas Cove, Greenwood, Monmouth, Paris; (1) June, (1) July, (3) August, (1) September.

MARYLAND: 5 males, 2 females. College Park, Takoma Park; (1) May, (1) July, (1) August.

MASSACHUSETTS: 18 males, 17 females. Berkshire County, Concord, Framingham, Lenox, Montgomery (?), Mount Tom, Princeton, South Hadley, Springfield, Tyngsboro, Wakefield, Watatick [?]; (3) May, (3) July, (10) August, (9) September, (2) October.

MICHIGAN: 97 males, 63 females. Ann Arbor, Grosse Pointe, Cheboygan County, Commerce, Detroit, George Reserve (Livingston County), Galesburg, Huron County, Olivet, Portage Lake (Livingston County), Washtenaw County; (2) April, (2) May, (6) June, (17) July, (115) August, (5) September, (2) October.

MINNESOTA: 4 males. Duluth, Le Sueur County, Olmsted County; (2) August.

MISSISSIPPI: 1 male, 4 females. Iuka, Lucedale, Meridian, New Augusta; (1) June, (3) July, (1) August.

MISSOURI: 14 males, 16 females. Allenton, Clarksville, Columbia, Fulton, Kansas City, St. Louis, St. Marys; (3) April, (2) May, (3) June, (3) September, (9) October, (3) November.

NEBRASKA: 2 males, 3 females. Bennet, Niobrara, Omaha; (1) August, (1) September, (2) October.

NEW HAMPSHIRE: 12 males, 7 females. Antrim, Barnstead, Belknap County, Chocorua, Durham, Exeter, Farmington, Rumney, Shelburne, West Milton; (1) April, (1) May, (3) June, (5) August, (4) September.

NEW JERSEY: 13 males, 8 females. Burlington County, Chester, Dumont, Eagle Rock (Essex County), Fort Lee, Golden's Bridge (?), Lake Lackawanna (Stanhope), Montclair, Paterson, Phillipsburg, Ramsey, Riverton, Terrace Pond, Westville; (2) May, (1) June, (2) July, (6) August, (5) September, (1) October.

NEW YORK: 27 males, 27 females. Astoria, Bemus Point, Black Brook (Clinton County), Delmar, Flushing, Ithaca, New Lebanon, Plattsburg, South Fallsburg, Washington County, West Point; (6) June, (43) August.

NORTH CAROLINA: 61 males, 49 females. Andrews, Asheville, Balsam, Beaver Creek (Mill Hill), Black Mountain, Blue Ridge Parkway (Deep Gap), Bryson City (2,000 ft.), Cabarrus County, Carthage, Chapel Hill, Chimney Rock, Cullasaja Falls, Davidson, Delhaven, Haywood County, Hendersonville, Highlands, Hickory, Lake Lure, Lake Toxaway, Macon County, Marion, Mills River, Old Fort, Pisgah Forest, Raleigh, Whiteside Mountain; (2) January, (19) April, (15) May, (19) June, (2) July, (8) August, (9) September, (19) October, (7) November.

OHIO: 13 males, 14 females. Beamsville (Darke County), Clear Fork (Ashland County), Clermont County, Cleveland, Conneaut, Delaware County, Eaton, Geneva, Hocking County, Jefferson, Lima, Locust Creek (Adams County), Mercer County, Oxford, Preble County, Worthington; (1) April, (1) May, (3) June, (4) July, (3) August, (13) September, (2) October.

OKLAHOMA: 2 males. Alva (Oklahoma Territory), Payne County; (1) October.

PENNSYLVANIA: 43 males, 32 females. Allegheny County, Broomall, Castle Rock, Dauphin County, Delaware County, Downington [=Downingtown?], Forest County, Jeannette, Jefferson County, Mont Alto, Ohiopyle, Pittsburgh, Pocono Mountains, Pocono Pines, Rockville, Sumneytown, West View, Wilmerding, Windgap; (1) March, (2) April, (8) June, (24) July, (16) August, (7) September, (5) October, (2) November.

RHODE ISLAND: 1 male. Westerly; (1) September.

SOUTH CAROLINA: 99 males, 61 females. Cashiers Valley Road (Oconee County), Clemson College, Columbia, Greenville, Greenwood, Hardeeville, Kings Mountain, Mountain Rest, Oconee County, Rocky Bottom, Sassafras Mountain (3,500 ft.), Table Rock, Tunnel Walhalla; (1) February, (1) April, (1) May, (7) July, (11) August, (128) September, (7) October, (3) December.

TENNESSEE: 6 males, 6 females. Deer Lodge, Gatlinburg, Grassy Cove (Cumberland County); (1) May, (10) June, (1) September.

VIRGINIA: 5 males, 6 females. Basye, Falls Church, Harpers Ferry, Jones Creek (Lee County), Mountain Lake, Mount Vernon, Nelson, Suffolk; (1) June, (3) August, (3) September.

WISCONSIN: 5 males, 2 females. Dane County, Grant County, Kilbourn (?), Lac Vieux Desert, Madison, Wood County; (1) May, (1) June, (4) August.

Geotrupes splendidus miarophagus Say, new combination

Geotrupes miarophagus Say, 1823, p. 210 (type lost).—Jekel, 1865, p. 611.—Horn, 1868, p. 316.

Geotrupes gilnicki Jekel, 1865, p. 608.—Boucomont, 1912, p. 28.

Geotrupes mixtus Horn, 1868, p. 316.

Geotrupes splendidus (Fabricius) Blatchley, 1910, p. 939.—Dawson 1922, p. 197.

Length 15 to 20 mm., greatest width 9.5 to 12.5 mm.

Color of dorsum yellowish green with varying amounts of golden or reddish iridescence. Many specimens are very dark, some blackish with traces of reddish or purple color in the striae. Ventrally specimens are black with traces of green or purple iridescence on the legs.

Structurally many specimens cannot be separated from the eastern *splendidus*. However, in the majority of specimens the pronotum

laterally is more convex and not as narrowed anteriorly as in many eastern *splendidus*. Other structures, such as carinae on legs, striae, and male genitalia, do not exhibit even moderately constant differences from *splendidus*.

NEOTYPE: Male (purplish black), Columbia, Mo., Apr. 24, 1935, Starr (USNM). No type locality given by Say.

This subspecies can be differentiated by the yellowish color of the dorsum, which is quite different from the deep "grass" green of the southeastern *splendidus*. In general the larger size and more rounded and slightly wider anterior portion of the pronotum will also distinguish *miarophagus*.

Say's description of *miarophagus* is woefully inadequate, and does not fit the usual western forms. A number of the western specimens examined were very dark (which is extremely rare in eastern specimens and it seems probable that Say merely described the less usual color phase of the western form).

Geotrupes gilnicki Jekel appears to be a fair description of the western subspecies, but is recorded (questionably perhaps) from Haiti.

The type of *Geotrupes mixtus* Horn is a large purple black male in the LeConte collection and again appears to be one of the unusual dark forms of *splendidus*. A very occasional large specimen, identical to Horn's *mixtus*, is found in the uniform southern population. I am unable to detect definite structural differences (other than size) between these unusual specimens and the usual southern *splendidus*, and for the present can consider it only a variety. Future investigation may prove this belief erroneous.

There has been a moderate amount of information published on the biology of *miarophagus*, here considered the western subspecies of *Geotrupes splendidus*. The references all use the name *splendidus*, but have, because of the locality in which the work was done, been referred to *miarophagus* by the present writer.

Brown (1927, p. 28) found the species commonly from April to June and from September to October in moist woods in Payne County, Okla. Mohr (1943, p. 278) mentions finding the adults at 2- or 3-day-old dung, while Park (1931, p. 200) lists finding "*splendidus*" at the fungus *Hydnum septentrionale* Fries on July 1, 1926. Blatchley (1896, p. 436) mentions finding specimens flying in March in Vigo County in Indiana. He states that he found a pair in copulation under a log in December, and follows this with the rather doubtful statement, "They usually mate in May."

R. W. Dawson, when at Lincoln, Nebr., published (1922, pp. 196–197) the following interesting account on the biology of *miarophagus:*

> During the month of June, 1905, while the writer was spading in his home garden he had occasion to remove a quantity of lawn clippings that had been

piled on a bare spot of ground several weeks previously. In turning up the soil that had been covered by the clippings a rather large and neatly formed pod of dead grass was discovered, and along with it a female *splendidus* [*miarophagus*]. Careful examination disclosed a branched tunnel with four additional food pods. One of the pods was preserved, and is before me at the present writing, the others were placed in a box of moist soil, from which the beetles emerged the following August. The food pods were all pear-shaped, and very uniform in size, measuring about two inches in length by one inch in their greatest diameter. The pods are interesting because of their relatively large size, and from being composed entirely of clean, fresh grass blades. A greater bulk of clean food seems to be required than is the case with the more concentrated material (droppings of animals) most frequently used by the beetles in this section of the family *Scarabaeidae*.

The above account indicates quite a difference in the habits of *miarophagus* from the eastern *splendidus*. North Carolina specimens of *splendidus* made a single "pod" of dead leaves at the bottoms of their burrows. In two instances caged specimens used cow dung to provision the larval cell. In addition to these food and burrow differences, there appears to have been some difference in the shape of the pod. The eastern beetles formed a mass best described as a stubby bent cigar-shape, 2½ to 3½ inches long, and of fairly uniform diameter, three-fourths of an inch to 1 inch wide.

It will be very interesting if future investigation further correlates these differences in biology between the two subspecies with the morphological differences already noted.

Geotrupes semiopacus Jekel

Geotrupes semiopacus Jekel, 1865, p. 612 (type, series in collection of H. Jekel, location unknown).—Horn, 1868, p. 316.—Blanchard, 1888, p. 106.—Blatchley, 1910, p. 939; 1928, p. 45.—Dawson, 1922, p. 196.—Bradley, 1944, p. 112.

Geotrupes blackburnii Melsheimer (not Fabricius), 1846, p. 139.

Geotrupes melsheimeri Jekel, 1865, p. 613.—Horn, 1868, p. 316.

Geotrupes ovalipennis Jekel, 1865, p. 614.—Boucomont, 1912, p. 28.

Length 12.5 to 19.5 mm., greatest width 8 to 11 mm.

Color of dorsum dull green to purple, faintly iridescent with underlying color of dark brown to black. Ventrally specimens are black with traces of bluish iridescence. Antennal club reddish brown, other segments dark reddish black. Eye canthus, clypeus, and small anterior portion of vertex coarsely, vaguely punctured. The three tubercles on the head only vaguely indicated. The Y-shaped sutural line on vertex and clypeal base entire, as in *blackburnii*, or only present medially. Clypeus margined, more arcuate anteriorly. Margined eye canthus forms a very obtuse angle with edge of clypeus. Sides of eye canthi gradually arcuate. Pronotum sometimes completely margined, usually with median portion of posterior margin obsolete.

Coarse punctures usually confined to lateral portions and along margins of the pronotum and sometimes in the vague median indentation. Minute secondary punctures usually not evident. Scutellum generally triangular, with sides slightly arcuate, more so anteriorly. Elytra with well developed striae, which, dorsally at least, lack punctures. Elytral margin narrow.

Foretibia of male with anteriormost of the seven external teeth expanded sharply inward and forward. Male also has tarsal claws of mesothoracic legs greatly enlarged, similar to *splendidus*. Hind femur of male without modifications, similar to female. Foretibia in both sexes with longitudinal raised carina, similar to *blackburnii*, running its entire length on the inner edge of the dorsal flattened surface. A row of setae is closely adjacent to the base of this carina throughout its length, being similar to the carina and setae of *splendidus*. External face of tibia of meso- and metathoracic legs each with three transverse carinae, the innermost sometimes poorly developed. Two partial carinae are usually present on the tibia of the metathoracic legs.

The genital capsule and elongate genitalia well developed, the dorsal parameres very distinctive (pl. 5, fig. 3).

Variation in size and color within the species is considerable. Otherwise the characteristics are rather constant, with no geographic or consistent population differences noted.

This species can most easily be distinguished by its dull green or purple color, without any coarse punctures in elytral striae. Other characteristics are the vague tubercles of the head, the carina of the foretibia similar to *blackburnii* but with the setae adjacent to the carina throughout its length rather than separated anteriorly (as it is in blackburnii), the enlarged tarsal claw of the mesothoracic leg of the male, and the distinctive genital armature of the male (pl. 5, fig. 3).

Geotrupes semiopacus Jekel occurs from southern Canada to the mountains of North Carolina and Tennessee. Predominantly a common northern species, it is active the entire summer from May until September.

Many of the specimens examined bore in addition to the locality label one reading "fungi." *G. semiopacus* has often been found in wooded areas frequenting the same general type of habitat as *balyi* or *hornii*.

Besides its habit of feeding on fungi, Spector (1943, p. 229) found *semiopacus* attracted to a heap of chicken heads and feathers placed under a flat rock. No other attractants were listed by Spector or other authors.

It is surprising that so little is known about the biology of this species, as there were a large number of adults represented in the various collections examined.

Specimens examined: 240 males, 220 females, 1 not sexed.

CANADA

MANITOBA: 1 male. Winnipeg; (1) August.

ONTARIO: 6 males, 1 female. Belleville, Lyn, Ottawa, Toronto; (1) June, (1) August, (4) September.

QUEBEC: 14 males, 4 females. Hemmingford, Joliette, Lake Nominingue (La Belle County), St. Césaire, Val Morin; (4) June, (2) July, (8) August.

UNITED STATES

CONNECTICUT: 7 males, 10 females. Cornwall, Marlboro (?); (3) June, (1) July, (4) August, (3) September.

DISTRICT OF COLUMBIA: 2 males. No data.

ILLINOIS: 36 males, 32 females. Algonquin, Beverly Hills, Bloomington, Bowmanville (Cook County), Chicago, Cook County, Edgebrook (?), Glen Ellyn, Havana, Normal, north Illinois, Palos Park, Peoria, Putnam County, Urbana, West Pullman (?), White Heath, Willow Springs; (1) May, (1) June, (1) July, (11) August, (9) September, (2) October.

INDIANA: 4 males, 1 female. Bloomington, Hessville, Wayne County; (3) August.

IOWA: 15 males, 22 females. Ames, "Counties #52, #88," Decorah, Forest City (Winnebago County), Mount Vernon; (1) April, (7) May, (9) June, (11) July, (5) August.

MAINE: 6 males, 7 females. Paris, Stoneham, Wallis; (2) June, (1) July, (7) August.

MARYLAND: 5 males, 7 females. Hagerstown, Montgomery County; (2) August, (1) September.

MASSACHUSETTS: 7 males, 6 females. Concord, Lenox, Springfield, Wilbraham; (2) September.

MICHIGAN: 2 males, 9 females. East Lansing, George Reserve (Livingston County), Macatawa Beach, Olivet, Paw Paw Lake, Port Huron; (5) May, (2) June, (2) August, (1) September, (1) October.

MINNESOTA: 8 males, 7 females. Fort Snelling, Le Sueur County, Minneapolis, Olmsted County, Winang (?); (1) June, (9) August.

MISSOURI: 1 male, 2 females. No data.

NEW HAMPSHIRE: 9 males, 9 females. Antrim, Barnstead, Franconia, Jaffrey, Lebanon, "Mt. Plst. Hse.," Rumney, White Mountains, Wilton; (2) June, (2) July, (5) August, (4) September.

NEW JERSEY: 6 males, 7 females. Hopatcong, Leonia, Phillipsburg, Somerville, Treasure Island; (3) May, (2) July, (3) August, (2) September.

NEW YORK: 27 males, 16 females. Buffalo, Cooks Falls, Greene County, Lancaster, Mount Vernon, New York City and vicinity, Onandaga County, Otto, Pike, Schroon River, Upper Saranac, West Hebron (?), West Point; (3) May, (1) June, (10) July, (14) September.

NORTH CAROLINA: 12 males, 19 females. Black Mountain, Great Smoky Mountains, Pisgah Forest, Sunburst; (2) May, (10) June, (3) July, (12) August, (2) September, (2) October.

OHIO: 5 males, 3 females. Cleveland, Columbiana County, Hudson, Nile (Scioto County), Oxford, Salineville, Summit County; (1) June, (1) July, (1) August, (2) September.

PENNSYLVANIA: 57 males, 45 females. Allegheny County, Aspinwall, Butler, Cumberland County, Delaware County, Dunbar, Easton, Elwood City, Forest County, Harrisburg, Indian Creek (?), Jeanette, Jefferson County, Langhorne, Lima, Mount Blaine (?), Philipsburg, Pittsburgh, Pocono Lake, Pocono Pines, Sumneytown, Washington, Westville; (2) May, (15) June, (19) July, (29) August, (7) September, (1) October.

TENNESSEE: 2 females. Elmwood, Mount Le Conte; (1) June.

TEXAS: 1 female. No data.

VERMONT: 1 specimen, Bennington County, East Burke; (1) August.

VIRGINIA: 1 male, 1 female. No data.

WEST VIRGINIA: 5 females. Cheat Mountain, White Sulphur Springs; (2) June.

WISCONSIN: 11 males, 4 females. Dane County, Gays Mills, Lone Rock, Madison, Worden (?) (Clark County); (1) May, (1) June, (2) July, (2) August.

Genus *Peltotrupes* Blanchard

Peltotrupes Blanchard, 1888, pp. 105, 109.—Boucomont, 1911, p. 345.—Bradley, 1944, p. 112.—Howden, 1952, p. 44.

GENOTYPE: *Geotrupes chalybaeus* LeConte, by monotype *in* Blanchard, (1888).

GENERIC LIMITATIONS: Given by Blanchard (1888, pp. 105, 109):

> Middle and hind tibia without external [transverse] apical ridge [carina].
>
> The anterior tibiae have on the upper surface the usual inner impressed line bearing a row of setae but the adjacent outer carina is quite absent . . . . in our other *Geotrupes* the middle and hind thighs [femora] are flattened posteriorly to receive the tibiae, and have the margins finely elevated each side while in *chalybaeus* [now *profundus*] they are convex behind with a single strong margin which is next to the upper side.

Other useful characteristics are: General body shape oval and rather flattened dorsoventrally, fine elytral striae, widely expanded elytral margins, complete margin around pronotum, and the modification of the foretibia in the males rectangularly inturned, strongly produced.

The unusual characters exhibited by *Peltotrupes* caused Blanchard (1888, p. 104) to state that it "is an obvious interruption in our series . . . . It seems equally out of place among any of the exotic subgenera mentioned by Jekel, and the proper course appears to be to establish a distinct genus for it."

I am inclined to agree with Blanchard and have elevated *Peltotrupes* to generic rank. It appears distinct from *Geotrupes* not only by many of its adult structural characteristics but also by many of its larval characteristics. Even biologically, *Peltotrupes* differs considerably in larval habits from the habits of other known Geotrupini.

Superficially, in general form *Peltotrupes* resembles some of the varieties of the European *Geotrupes vernalis*, particularly variety

fulgidus Motschulsky, which occurs in Turkey. However, the resemblance is only in size and general shape, there being no indication of close relationship with *vernalis* or other species. This conclusion was also reached by Boucomont (1911, p. 345), who compares *Peltotrupes* with the oriental subgenus *Thorectes*.

The genus *Peltotrupes* presents an interesting taxonomic problem, due in part to the following causes. The species range almost entirely across Florida from near Tampa northward to the vicinity of Lake City; however, their distribution is very spotty. Young (1950, p. 88) states that their "rarity seems to be due to the restricted habitat[s] of the species and to [their] occurrence in the winter and early spring months." The habitat is St. Lucie and other deep sands covered with scrub oaks and pine but without much ground cover. The members of the genus appear to be deep burrowing (Howden, 1952, p. 42), placing their larval cells at some depth in the sands. The necessary sand ridges are irregularly scattered over northern Florida, some of them isolated by swamps or lowlands. Furthermore, there are the short winter period of adult activity and the insects' very doubtful powers of flight—I spent some time trying unsuccessfully to induce beetles to fly. Because of these facts, I distinguish between several rather distinct, isolated populations.

The development of distinct populations of isolated colonial beetles was early noted in the related genus *Pleocoma*, in which the females are flightless. Linsley (1946, p. 61) states: "There is little doubt that the various forms of *Pleocoma* to which names have thus far been applied represent distinct populations, but the exact taxonomic status of the more closely related of these must await future interpretation on the basis of longer series of both sexes from many more geographical areas than are now represented in collections." This last statement is equally applicable to the populations of *Peltotrupes*.

Isolation of the various populations appears to have occurred in recent geological times, as the populations, while distinct, are very close structurally. The male genital armature is very complex but is also quite variable, and a method of separation of the populations by constant genitalic characteristics was not found.

Descriptions have been based on examples that I believe are typical of the different populations. Care must be taken with worn specimens which before collection have burrowed sufficiently to obliterate some of the better distinguishing characteristics.

Characteristics distinguishing the larvae from known larvae of *Geotrupes* (Howden, 1952, p. 48) are: Greatly shortened third antennal segment, presence of tuberculate bases of the setae on the end of the tibiotarsus, the shape of the anal lobes, and the greatly swollen

abdomen (pl. 2, fig. 1). The larvae have the metathoracic legs reduced, as does *Geotrupes*.

The range of the genus appears to be limited to the deep sand ridges of northern and central peninsular Florida (Young, 1950, p. 88).

Key to the species of Peltotrupes

1. Sutural stria by tip of scutellum definitely impressed, other striae evident; iridescent color largely purple (subspecies of *profundus*) 2
   Sutural stria by tip of scutellum not impressed, other striae generally obsolete; iridescent color largely green (4 miles west of Rodman, Fla.). **youngi**, new species
2. Median posterior edge of anterior pronotal margin lacking any trace of a tubercle (pl. 2, fig. 3b); elytron just behind and below humeral umbone sharply flared before the margin (pl. 2, fig. 4b) (west coast of Florida, Gainesville to Tampa) . . . . . **profundus** Howden
   Median posterior edge of anterior pronotal margin with V-shaped tubercle (pl. 2, fig. 3c); elytron just behind and below humeral umbone moderately flared before the margin (pl. 2, fig. 4c) (east coast of Florida, Welaka and St. Augustine) . . . . . **profundus dubius**, new subspecies

Only the larva of *Peltotrupes youngi* is known; it was described by the writer (Howden, 1952) under the name *Geotrupes* (*Peltotrupes*) *profundus*. Because of the very close relationship of the adults it is somewhat doubtful that consistent morphological differences will be exhibited by the larvae of the other species if they are discovered. Conversely, it is also possible that the larvae may be more easily separated than the adults, which is true in the case of some of the *Bolboceras*.

Peltotrupes profundus Howden

Geotrupes chalybaeus LeConte, 1878, p. 402 (type, male, Florida, LeConte collection, MCZ).—Blanchard, 1888, pp. 103, 110.—Blatchley, 1928, p. 44.—Young, 1950, pp. 88–92 (in part).
Geotrupes profundus Howden, 1952, p. 41 (in part).

Length 15 to 23 mm., greatest width 9 to 14 mm.

Color of dorsum dark reddish brown to almost black, suffused with purplish iridescence, sometimes with bluish and slight traces of greenish iridescence. Iridescence is general but most pronounced on head, margins of pronotum and elytra, and along elytral striae. Ventral surfaces largely dark brown, thorax slightly darker than abdomen. Femora of meso- and metathoracic legs and epipleura dark brown with traces of iridescence. Head with broadly rounded clypeus forming a very obtuse angle with eye canthus (pl. 2, fig. 1b). Both clypeus and anterior portion of canthus are margined. Clypeus coarsely, densely, irregularly punctate except on posterior tubercle. Vertex of head with only a few coarse punctures between the eyes. Prothorax sharply and completely margined. Anterior angles obtusely and

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gradually rounded (pl. 2, fig. 2b). Inner edge of the anterior margin forming an almost straight line usually curved slightly forward near the midline. A double row of coarse punctures runs entirely across the pronotum just behind the anterior margin (pl. 2, fig. 3b). A few coarse, moderately deep punctures are unevenly scattered over the pronotum, being most numerous near the posterior angles. A deep, almost circular indentation with numerous coarse punctures is present on each side of the pronotum near the middle. Numerous fine secondary punctures usually evident over entire pronotum, becoming more pronounced near the posterior angles, sometimes giving the pronotum in that area a rough appearance.

Elytra with at least the first three or four striae shallowly indented; sutural stria deep and continuous, not vague anteriorly near scutellum. Fifth stria obsolete, indicated only by a regular row of punctures, the other striae barely indicated. Moderately coarse deep punctures are present in all striae, often being the only indication of obsolete striae. These punctures in many cases joined by deep grooves, while others are not, giving the striae an interrupted appearance. Elytral intervals are at least slightly convex in appearance, their highest point being midway between the adjoining striae. Elytral margin broadly expanded and somewhat explanate, more so anteriorly, posteriorly ending in a very small sutural spine. Angle between normal convexity of elytra and beginning of margin rather sharp in outline, approaching a right angle (pl. 2, fig. 4b). Much of ventral surface covered with numerous, long, reddish yellow setae. Median portions of the last three or four abdominal segments shiny, generally lacking setae except along posterior margins. Tibia with many long spinelike setae lining outer edges and carinae. In the male the apical tooth of the outer margin of the foretibia is greatly modified, elongate, bent rectangularly inwards, slightly recurved with inner edge sinuate. In addition, the foretibia has a row of 4 (sometimes 3 to 7) elongate conical teeth on inner surface. The hind femur of the male is also modified by having a small spine present near the posterior margin by the coxa. None of these modifications is present in the female.

Male genitalia and genital capsule large and heavily sclerotized. Capsule with dorsal and ventral plates fringed with a few short setae. Genitalia quite complex with two dorsal parameres and a bilobed ventral phallobase, which are rather variable in shape. The short right dorsal paramere is very complex, the posterior edge of the large bulbular basal portion usually forming a wide oblique irregular V (pl. 2, fig. 5b).

Variation in size, previously noted, is considerable. Differences between the two sexes is also considerable. The modifications of the foretibia and hindfemora in males have already been noted.

Dorsally, the iridescence is more pronounced. The ground color is more often brown than black, and the elytral striae are usually deeper in the males than in the females. There also appears to be a vague difference in the slope of the elytral apices, but this is small and quite variable.

Variation, other than in size and sexual characteristics, is not pronounced. The anterior angles of the pronotum show some variation, but are most often as depicted (pl. 2, fig. 2b). Depth of punctures and striae vary within and between the sexes, but the sutural stria is generally evident and unbroken throughout its length, beginning at the scutellum. Color, punctures, width of angles of elytral margin, and other characteristics are all quite constant within one sex.

This species can usually be distinguished by its dark brown color with the pronounced purplish iridescence, the double band of punctures completely (in most cases) across the pronotum just behind the straight inner edge of the anterior margin (pl. 2, fig. 3b), noticeable elytral striae (particularly the sutural one) with intervals usually convex, fifth stria represented by a straight regular row of punctures, moderately deep punctures in all striae, and the rather sharp angle between the line formed by a normal curve of elytron and the expanded margin when viewed from the posterior (pl. 2, fig. 4b).

The above description was largely made from a Gainesville, Fla., specimen carefully compared by the author with the fragments of LeConte's type, which included the head, thorax, one elytron, and one male foreleg. It is possible that the elytron (and some of the other fragments) could have come from a female specimen, as the rounded contour of the posterior portion of the elytron matched a number of females and was not quite like the male homotype selected.

Very few specimens have been taken in the vicinity of Tampa, the type locality. Gainesville specimens from which the description has been made may have constant characteristics differentiating them from the Tampa population. If these differences occur they have been overlooked because of the paucity of specimens from the type locality. From the specimens examined, I believe that the various populations, ranging along the west coast of Florida and inland to Orlando, Gainesville, and Lake City, represent a moderately uniform group. Future collecting from isolated sand ridges should provide much useful and needed information concerning these interesting beetles.

Until Young's (1950) paper almost nothing was known about these beetles. In his paper Young discusses the distribution and adult habits of the species (here considered two species and one subspecies). Most of the information that has been accumulated by Young and myself concerns the Interlachen, Fla., population herein described

as new. It seems reasonable to assume that the habits of all the species are similar, so the reader is referred to the subsequent discussion of the biology of the new species *youngi*.

A few other general notes have been published concerning the habits of *profundus* under the name *chalybaeus* LeConte. Leng (1887, p. 212) published a note that he received specimens from Orange County, Fla., collected Dec. 24, 1885, "late in the afternoon about a quantity of horse and mule manure on a sandy road running through high pine lands." Whether manure acted as an attractant is doubtful. Schaeffer (1913, p. 169) mentions that he noted "*G. chalybaeus*" attracted by stale urine. The only other early references to this beetle that I have seen were an occasional reference to its seeming rarity. Young and Hubbell have disproved this by collecting large numbers of *Peltotrupes* in traps containing fermenting molasses sunk in the ground.

Specimens examined: 66 males, 60 females.

FLORIDA: 66 males, 60 females. Croom (Hernando County), Enterprise, Gainesville, Gilchrist County, Hernando County, Kissimmee, Lake City, Orlando, Pensacola, Putnam County, Tampa, Tarpon Springs, Winter Park; (11) January, (57) February, (5) March, (1) April, (1) May, (1) November.

***Peltotrupes profundus dubius*, new subspecies**

HOLOTYPE: Male. Length 17.5 mm., greatest width 12 mm.

Color of dorsum very dark blackish brown to black, suffused with bluish iridescence. Tinged with green iridescence, most pronounced on head, margins of elytra, and along elytral striae. Ventral surfaces blackish, femora black with traces of purplish iridescence. Head with margined clypeus and canthus forming angles almost identical to those of *profundus*. Margin of eye canthus usually slightly less rounded (pl. 2, fig. 1c). Pronotum sharply and completely margined. Anterior angles obtusely and gradually rounded (pl. 2, fig. 2c). Sides of thorax more evenly arcuate than is usual in specimens of *profundus*. Inner edge of the anterior margin with a small but definite triangular tubercle projecting posteriorly at midline (pl. 2, fig. 3c), interrupting the line of punctures across the pronotum behind the margin (also present in *profundus*). Very few coarse punctures on lateral portions of pronotum. Middle of lateral portion of pronotum with only a vaguely indicated circular indentation. Fine secondary punctures visible only laterally on pronotum, more so posteriorly.

First few elytral striae rather pronounced, with deep punctures, appearing identical to *profundus*. Fifth stria appears as an irregular double row of punctures in many places. The angle formed between the expanded elytral margin and the normal convexity of the elytron

is slightly more obtuse than in *profundus* (pl. 2, fig. 4c). Setae of ventral portions similar, but appearing not quite as dense as on *profundus*. Tibiae and femora of holotype apparently similar to those of *profundus*, as are the genitalia and genital capsule. Angle at center of posterior portion of complex right dorsal paramere more V-shaped than in *profundus* (pl. 2, fig. 5c).

ALLOTYPE: Female. Length 18 mm., greatest width 12.5 mm.

Color of dorsum similar to that of holotype except that there is slightly more iridescent green suffusing the purple elytral margin near the apices. Except for the male modifications of the apical tooth of the foretibia and hind femur, which the female lacks, the allotype is very similar to the holotype. The lateral pronotal margin is slightly less evenly arcuate than in the holotype, but in other respects there is almost no difference.

Holotype, male, Welaka, Fla., Apr. 29, 1949, van Pelt (UnMich). Allotype, female, Welaka, Fla., Mar. 4, 1940, at light "(T–35)," Friauf (UnMich). Paratypes, 10 males, 2 females: 1 male, Florida; 3 males, Welaka, Fla., Apr. 29, 1949, van Pelt; 1 female, Welaka, Fla., Feb. 18–20, 1947, Moore; 6 males, 1 female, St. Augustine, Fla. Paratypes are in the collections of the University of Michigan, U. S. National Museum (USNM 61968), Carnegie Museum, and of the writer.

Variation in the few specimens at hand is moderate. Size ranges from 16 to 21 mm. in length and from 11 to 13.5 mm. in width. Sexual variation other than that mentioned for the tibia and femur is slight. The tubercle at the base of the foremargin of the pronotum is not clearly evident in a few of the specimens, particularly the females, and the anterior angle of the pronotum shows some variation, as does the amount of purple iridescence. Due to the variation of some of the characteristics, the small series, and its close similarity to *profundus*, I have attempted to point out the apparent differences without giving specific status to a population, which, with additional data and specimens, may prove distinct.

Distinguishing characteristics are the few thoracic punctures, the sharp triangular tubercle projecting posteriorly from the inner edge of the anterior margin of the pronotum, the purplish iridescence, and the usually evenly arcuate lateral pronotal margin which in *profundus* is usually distinctly bent near the middle.

In differentiating this form all characters should be considered, as no single character will consistently differentiate *dubius* from *profundus*.

The specimens from St. Augustine, Fla., are included here as paratypes because of their similarity to the Welaka specimens, but several differences in the populations can be noted. Two of these differences are the interrupted second elytral stria, which is broken at intervals

in the St. Augustine specimens, and the lateral margins of the pronotum, which are not as evenly arcuate as are the margins of the Welaka specimens.

The range of *dubius* probably extends along the northeastern coastal area of Florida.

So far, nothing has indicated that the habits of *dubius* vary in any way from those of the preceding species. The "at light" label on one specimen is interesting, but ordinarily light does not appear to be a good attractant.

Peltotrupes youngi, new species

Adult biology by Young (1950, pp. 88–92), as *chalybaeus* LeConte.

Description of larva by Howden (1952, pp. 41–48), as *profundus* Howden.

HOLOTYPE: Male. Length 17.5 mm., greatest width 12 mm.

Color of dorsum dark reddish brown to black, suffused with pronounced iridescent green, only occasional slight traces of blue or purple. Iridescence is general but most pronounced on head, margins of thorax and elytra, and along elytral striae. Ventral surfaces are very dark brown to black, thorax slightly darker than abdomen. Femora and epipleura blackish with traces of iridescence. Head with broadly rounded clypeus forming a rather sharp obtuse angle with eye canthus (pl. 2, fig. 1a). Both clypeus and anterior portion of canthus are margined. Clypeus coarsely, moderately, irregularly punctate, except on posterior tubercle. Vertex of head with a very few coarse punctures between the eyes. Pronotum sharply and completely margined. Anterior angle sharply rounded, slightly obtuse (pl. 2, fig. 2a). Posterior edge of the anterior margin slightly curved posteriorly. Double row of coarse punctures noted in *profundus* lacking at midline (pl. 2, fig. 3a). A few coarse, moderately deep punctures are unevenly scattered over lateral portions of pronotum, very slightly more numerous posteriorly. The deep, circular, coarsely punctured indentation noted on each side near the middle of the pronotum of *profundus* is almost obsolete. The fine secondary punctures (less pronounced than is usual in *profundus*) are generally evident only laterally.

Elytra with striae obsolete, first stria vaguely indented, but not in the basal millimeter, where the stria is indicated only by a few small punctures. All the other striae are indicated only by rows of shallow punctures. Punctures generally about half the depth of those of *profundus*. Very small punctures indicating fifth stria forming a slightly irregular row anteriorly. Some of the second to sixth elytral intervals in places slightly concave, with their highest points next to the punctures. Elytral margin expanded, explanate, anteriorly less so than in *profundus*. Angle between normal convexity of elytron

and beginning of margin much more obtuse than in *profundus* (pl. 2, fig. 4a). Much of ventral surface covered with long reddish setae. Median portions of the last three or four abdominal segments shiny, setae generally sparse medially. Tibia with many long spinelike setae lining outer edges and carinae. In the holotype the apical tooth of the outer margin of the foretibia is greatly modified, elongate, bent rectangularly inwards, slightly recurved with inner edge sinuate. In addition, the foretibia has a row of four elongate conical teeth on inner surface. The hind femur is also modified by having a small tubercle present near the posterior margin of the coxa.

Genitalia and genital capsule large and heavily sclerotized. Capsule with dorsal and ventral plates fringed with a few short setae. Genitalia quite complex, with two dorsal parameres and a bilobed ventral phallobase (pl. 3, fig. 7). The short complex right dorsal paramere with the posterior edge of bulbular basal portion usually forming a wide irregular V, slightly less oblique than in *profundus* (pl. 2, fig. 5a).

ALLOTYPE: Female. Length 19 mm., greatest width 13 mm. Color of dorsum black with bluish green iridescence lacking except along elytral margins, where it is most pronounced near the elytral apices. The allotype differs from the holotype in several other respects. In the allotype the punctures of the clypeus are pronounced and numerous, the fine secondary punctures of the pronotum are almost absent, the elytral striae are obsolete, and the rows of elytral punctures are slightly less pronounced than in the holotype. The hind femur of the allotype lacks the tubercle present in the male, and the foretibia has the unmodified apical tooth similar in shape to the penultimate tooth. Tarsal claws are identical in size and shape to those of the holotype, as are other major characteristics.

Holotype, male, Putnam County, Fla., T. 11 S., R. 25 E., 4 miles west of Rodman, Mar. 18, 1949, "#544 traps," Young (UnMich). Allotype, female, Interlachen, Putnam County, Fla., Apr. 3, 1951, malt trap, H. and A. Howden (Howden). Paratypes, 113 males, 261 females: 240 specimens, Putnam County, Fla., Sec. 17, T. 11 S., R. 25 E., 4 miles west of Rodman, Young, Feb. 27, 1949, Mar. 3, 8, 18, 26, 1949, and Apr. 6, 1949; 14 specimens, Interlachen, Fla., H. and A. Howden, Apr. 1, 2, 3, 1951. 120 specimens, 8 miles southeast of Interlachen, Fla., Howden and Dozier, Mar. 20, 21, 22, 1953, in malt and propionic acid traps.

Paratypes are deposited in the collections of the American Museum of Natural History, British Museum (Natural History), California Academy of Sciences, Canadian Department of Agriculture, Cornell University, Museum of Comparative Zoology, North Carolina State College, Oregon State College, U. S. National Museum (USNM 61969), and the University of Michigan, and in the personal collections of

O. L. Cartwright, B. K. Dozier, C. A. Frost, M. Robinson, F. N. Young, and the writer.

Variation in size is considerable, ranging from 16 to 22 mm. in length and from 10.5 to 14.5 mm. in width. Sexual differences have already been noted in color, depth of striae and punctures, and in the male modifications of the foretibia and hind femur. In the males the row of irregular teeth on the underside of the foretibia is composed of from 3 to 7 teeth which are usually somewhat longer than those of *profundus* or *dubius*. While there is general uniformity in the lack of a double line of punctures behind the median anterior pronotal margin, there is often a suggestion of a V-shaped tubercle, noted in *Peltotrupes profundus dubius*. This tubercle is never as pronounced as that of *dubius*, nor does a double row of punctures run on either side of it as is the case in *dubius*. The anterior pronotal angles exhibit such variation that their usefulness as a distinguishing characteristic is slight. Depth of striae and punctures also show some variation, but seldom approach the degree of development noted in *profundus* or *dubius*. The greenish iridescence is quite constant, but its extent is varied, being much more evident in the males. Other differences in morphological characteristics noted are slight.

The obsolete elytral striae indicated by the rows of small punctures, the very obtuse angle (pl. 2, fig. 4a) anteriorly between normal convexity of elytra and beginning of elytral margin, and the green iridescent color usually readily separate *youngi* from either *profundus* or *dubius*. Other differences are the sparse thoracic punctures, and the posteriorly curved inner edge of the anterior margin of the pronotum, which lacks the sharply defined tubercle of *dubius* (pl. 2, fig. 3a).

The known range of this species is very restricted, being confined to a small isolated sand ridge south of Interlachen, Fla., which was discovered and carefully described by Frank N. Young. This species has been named after Dr. Young in appreciation for his interest and the help that he has given me.

The biology of this species is better known than the other species of *Peltotrupes*, having been discussed by Young (1950) under the name *chalybaeus* and by Howden (1952) under the name *profundus*.

To my knowledge, nothing of importance since these papers has been added to the known facts of the habits of this interesting species.

The adults, which occur from January to April, are colonial and deep burrowing, and confine their surface activity to the hours of darkness. Adults are readily attracted to decaying fungi, malt, or molasses, and even banana peels and propionic acid. No evidence was seen of their feeding on dung, but it is quite possible.

The burrowing activities of the adults are amazing, both in the number of burrows in a restricted area (pl. 17, fig. 2) and in the depth,

which averages about 6 feet in the loose sand! At the opening of the burrow is a large push-up of sand (pl. 18, fig. 1) about 5 inches across and 2 or 3 inches high. At one side of this pile is the burrow entrance, plugged with sand and sloping away from the push-up. (This is radically different from the burrows of other known Geotrupini, which all have the burrow entrance opening under the center of the push-up.) After descending at an angle for 4 to 6 inches the burrow turns and descends vertically, usually becoming open shortly after the turn. Young (1950) believed this plug of sand near the surface perhaps serves to prevent undue moisture loss in the rather zeric habitat of the high sand ridge.

The broad burrow, after the initial bend, descends without further turning until it reaches a depth of from 4 to 9 feet, where it bends sharply at almost a right angle. An inch or so after this bend a large cavity 6 or 7 inches long with a maximum diameter of about 2 inches is found loosely filled with bits of surface litter. Plate 10, figure 4, shows a diagram of a typical burrow.

The rather loosely packed cell of surface litter, composed largely of live-oak leaves (*Quercus virginiana* Miller) and needles and male cones of the sand pine (*Pinus clausa* (Engelmann) Vasey), contains a single larva. The larval cells are apparently provisioned by the female with any litter near the opening of the burrow. In only two instances were more than one cell found at the end of a burrow. (Young did not mention nor did the writer find a pair of the beetles in any of the burrows.) Apparently the female digs the burrow, provisions a single cell after laying an egg near the terminal end, and then departs, repeating the entire process in a different place.

The egg hatches a week or so after oviposition, and early larval growth apparently is rather rapid, for many of the larvae are third-stage in April, three months after the earliest adult activity in January. The larvae then remain as third instar for a period of 6 to 8 months. Only third-stage larvae were found in the middle of November, so pupation must occur in late November, December, and perhaps January, when some of the adults begin emerging.

The larva of *youngi* has one very interesting adaptation to its sandy surroundings. The larva uses its own fecal matter to construct a tube around itself (pl. 18, fig. 2), thus keeping the loose litter and sand from caving in. The flattened anal lobes of the larva are kept applied to the edge of the tube, while the larva, by extending its head and thorax, pulls the litter to its shelter. As the larva grows the tube increases both in length and diameter, until finally, when all the food is consumed, the larva closes the ends, making a cell about 2 inches long by 1 inch in diameter. The tube itself is rather fragile, externally rough, showing the shape of the individual fecal pellets, and internally

smooth. Unfortunately, only large fragments of these tubes were found after digging up the cells. However, the larvae kept alive in salve boxes quickly constructed new ones.

The biology of *Peltotrupes youngi* is particularly interesting because of its numerous differences from the known biology of beetles in the closely related genus *Geotrupes*. The major differences are in the larval food and the loose manner it is placed in the cell, the use the larva makes of its own fecal material, and in the opening and depth of the burrows.

The larva, previously described (Howden, 1952), exhibits several interesting morphological peculiarities. The head capsule (pl. 9, fig. 3) is asymmetrical, similar to the North American *Geotrupes*, but the third (terminal) antennal segment (pl. 7, fig. 6), which is reduced to a mere cap on the second segment, is quite different. However, the mandibles (pl. 9, figs. 4, 6), maxillae, and hypopharynx (pl. 9, fig. 5) do not show any noteworthy departure from those of *Geotrupes*. The glossa is not emarginate in *youngi* as it is in most *Geotrupes*. The presence on the epipharynx (pl. 9, fig. 1) of 25 or more chaetae on each chaetoparia and the shape of the endoskeletal figure of the anal lobes (pl. 9, fig. 2) are both quite distinctive for *youngi*.

Metathoracic legs are reduced in the same way as in *Geotrupes*. All legs lack claws, but are terminated by several long stiff setae with tuberculate bases. One quite distinctive characteristic is the general body shape of *youngi* (pl. 11, fig. 1) with the head and thorax small in proportion to the tremendously swollen abdomen.

The egg of *Peltotrupes youngi* is yellowish white, almost oval, slightly longer at one end than the other. Length 4.6 to 4.7 mm., greatest width 3.0 to 3.5 mm.

Maximum width of larval head capsules: First instar 2.5 mm.; second instar 3.5 to 3.7 mm.; third instar 4.4 to 4.7 mm.

Genus *Mycotrupes* LeConte

Mycotrupes LeConte, 1866, pp. 381–382.—Horn, 1868, p. 314.—Blanchard, 1888, p. 109.—Bradley, 1944, p. 112.—Olson, Hubbell, and Howden, 1954, pp. 1–59.

GENOTYPE: *Geotrupes retusus* LeConte, by monotype, *in* LeConte, 1866.

GENERIC LIMITATIONS: Given by LeConte (1866, p. 381):

The elytra are broadly ovate, very convex, connate and destitute of striae; the clypeus is semicircular, with the lobes before the eyes large and rounded; the front in the male is armed with a short horn or acute tubercle, which in the female is reduced to a feeble elevation; the prothorax of the male is flattened and declivous before the middle, and longitudinally broadly excavated, thus producing a transverse somewhat lunate elevation about the middle; in the female a slight dorsal channel is seen, and a feebly impressed fovea each side, halfway between

the middle and lateral foveae. The apical tooth of the anterior tibia of the male is broadly emarginate at tip, and prolonged inwards into a slender acute process. The middle tarsi of male are slightly larger than those of female, but not thickened as in *G. splendidus* and its allies. The upper surface is opaque and very densely granulated; the second joint of the antennal club is normal that is, not received in the first.

This description will suffice to separate the species of *Mycotrupes* from other North American Geotrupinae. However, one important detail not mentioned above is the absence of the metathoracic wings. Dr. T. H. Hubbell has noted that all of the species of *Mycotrupes* have a groove by the posterior pronotal angles into which the elytral marginal humeral carinae fit, forming accessory articulation points. Dr. Hubbell has further pointed out in correspondence to me that this unusual modification is also present in *Geotrupes ulkei* Blanchard but has not been noted in other species.

The above information, along with extremely detailed generic and specific descriptions and an excellent key, is presented by Olson and Hubbell (1954, pt. 1). Part 2 of the same work consists of a very interesting discussion by Hubbell on the relationships and distribution of *Mycotrupes*, and part 3 consists of biological observations and a description of the larva of *Mycotrupes gaigei* by Howden.

A number of the characteristics of *Mycotrupes* such as the granulate dorsal surface, posterior edge of pronotum sinuate and unmargined, and the peculiar thoracic modification of the males are not to be noted in the supposedly related forms such as *Chelotrupes* Jekel and *Thorectes* Mulsant. This fact, coupled with the obvious dissimilarity between *Mycotrupes* and other North American *Geotrupes*, has led me to treat *Mycotrupes* as a distinct genus, following the conclusions expressed by Olson and Hubbell (*in* Olson, Hubbell, and Howden, 1954, pt. 1).

The speciation occurring in *Mycotrupes* appears to present almost the same problem as that already described for *Peltotrupes*. The various species are apterous, active from late fall to early spring, and are seemingly limited in their activity to inland deep sand ridges. The spotty distribution of these sand ridges, coupled with the poor dispersal powers of the beetles, has led to the development of a number of closely allied but rather distinct forms. Interestingly, one of the species appears to have a range almost identical to that of *Peltotrupes profundus*.

Since a revision of the genus *Mycotrupes* has just been completed by Olson and Hubbell (*in* Olson, Hubbell, and Howden, 1954), no detailed account of the adult morphology of the various species is given here. The few characteristics mentioned are those which,

coupled with distributional data, should be sufficient for identification.

The larva of *Mycotrupes gaigei* (the only species in which the larva is known) can be separated from any of the known larvae of *Geotrupes* by the shape of the endoskeletal figure, which lacks the sharp lateral expansions and abrupt angles found in the larvae of *Geotrupes*.

The discovery of the larva of *Mycotrupes* was made following the completion of the plates and descriptions for the present work. Since a discussion on biology and a larval description is given in the paper by Olson, Hubbell, and Howden (1954), only a brief account of my observations is included here.

All of the known species in the genus range in areas of deep sand from southern peninsular Florida northward to central South Carolina, and from the coast near Brunswick, Ga., westward to southwestern Georgia.

Mycotrupes retusus (LeConte)

Geotrupes retusus LeConte, 1866, pp. 381–382 (type, male, LeConte collection, MCZ).—Horn, 1868, p. 314.—Blanchard, 1888, p. 109.

Mycotrupes retusus (LeConte) Olson and Hubbell, *in* Olson, Hubbell, and Howden, 1954, pt. 1, pp. 28–33.

?*Geotrupes aeneus* Felsche, 1909, pp. 759–765.

This species, long incorrectly considered a synonym of *lethroides*, can be distinguished by the following characteristics: Clypeus rounded anteriorly and laterally; median pronotal tubercle often absent in both sexes, when present indicated in the male by a linear triangular callus confluent with the margin, and in the female by a small subtriangular expansion of the median anterior pronotal margin; dorsal circular granules generally evenly spaced; lack of elytral striae; and the inwardly produced hatchet-shaped tip of the extended left ventral portion of the phallobase of the male genitalia (pl. 5, figs. 5, 7).

Adults of *retusus* have been found active during the spring and fall months. They have been collected only in areas of deep sand where they have been noted feeding on fungi and dung.

In September 1951 P. O. Ritcher and I collected several specimens at White Pond, S. C., in burrows ranging from 17 to 36 inches deep. The weather had been dry and no surface activity was noted. The burrows were found by scraping away pine litter under thick stands of long-leaf pines, exposing the traces of the old push-ups marking the burrow entrance.

No signs of any food or larval cells were found. Several of the beetles were kept alive and later placed in a rearing cage at Raleigh, but, while both dung and fungi were supplied and the adults remained alive for almost a year, no larval cells were produced. At no time were males and females found in the same burrows.

The species seems to be restricted to central and southern South Carolina. I have examined specimens from Blaney, Columbia, Lexington, White Pond, and Windsor.

Mycotrupes lethroides (Westwood)

Geotrupes lethroides Westwood, 1837, pp. 256–257 (type, male, Westwood collection).—Boucomont, 1911, pp. 349–350.—Blatchley, 1928, p. 45.—Bradley, 1944, p. 112.—Olson and Hubbell, *in* Olson, Hubbell, and Howden, 1954, pt. 1, pp. 33–38.

Since I was unable personally to examine specimens of this species, the following descriptive information was summarized from information presented by Olson and Hubbell. Characteristics which distinguish the species are: Clypeus anteriorly rather truncate, sharply rounded laterally; dorsal granulations dense but not confluent, pronotal tubercle in male represented by a strong laterally compressed longitudinal ridge which is highest near its midpoint, tubercle in female large, tetrahedral or subconical in shape and confluent with anterior pronotal margin. Phallobase of male genitalia of the same general shape as that described for *retusus*.

Most of the specimens of *lethroides* are rather large. Dr. van Emden has stated in correspondence to me that Westwood's type, a male, is 20 mm. long with a strong, long, keel-shaped median tubercle present behind the foremargin of the pronotum.

The species, according to Olson and Hubbell, is found in Georgia near the Savannah River in the vicinity of Augusta.

Mycotrupes gaigei Olson and Hubbell

Mycotrupes gaigei Olson and Hubbell, *in* Olson, Hubbell, and Howden, 1954, pt. 1, pp. 15–19. Type, male, Columbia County, 3.9 miles north of Santa Fe River bridge at High Springs, Fla., Hubbell (UnMich).

Mycotrupes gaigei is a rather distinctive species, as there are several vaguely indicated striae on each elytron. In addition to this, the coarse granules of the elytra are often confluent and larger than in other species in the genus. Also serving to distinguish the species is the median tubercle about 0.5 mm. behind the anterior margin of the pronotum, the deep punctures lateral to and posterior to the ridge of the pronotal modification of the male, and the shape of the phallobase (pl. 5, fig. 6) of the male genitalia.

In late March 1953, through Dr. Hubbell's directions, B. K. Dozier and I were able to observe several aggregations of *gaigei* near High Springs and Archer, Fla. A large series of the adults was collected both by digging and by trapping, using malt and propionic acid.

Many of the specimens, particularly the males, appeared to be freshly emerged and there was much fresh burrowing activity. Some

of the push-ups were 5 or 6 inches in diameter, and as much as 4 inches high with the burrows descending to a depth of 6 or more feet.

An area which encompassed several old slumped burrows was excavated and it yielded three third-stage larvae in pupal cells. One cell was at a depth of 5½ feet, the others were at 6 and 6½ feet. From the position of the cells it seemed probable that they branched off a central burrow, but this could not be definitely ascertained.

One cell was found in which the larva had failed to develop. This cell was composed of tightly packed cow dung 2½ inches long and three fourths of an inch in diameter. Also a number of old cells were found, but it was impossible to tell if the food had been dung or surface litter.

Only the three third-stage larvae were found and no information on the other immature stages was obtained.

The range of the species is rather similar to that of *Peltotrupes profundus*, being the western part of central and northern peninsular Florida from Citrus to Columbia Counties.

Mycotrupes cartwrighti Olson and Hubbell

Mycotrupes cartwrighti Olson and Hubbell, *in* Olson, Hubbell and Howden, 1954, pt. 1, pp. 20–24. Type, male, Leon County, Fla., 6.5 miles east of Tallahassee, Hubbell (UnMich).

The species can usually be distinguished by its large size (15 to 20 mm. in length), the fairly uniform circular granulations of the elytra, elytral apices usually joining without forming a notch, the large elongate tubercle behind the median anterior pronotal margin in the male, the V-shaped tubercle connected to the margin in the female, and the slightly incurved ventral tip of the phallobase (pl. 5, fig. 5) of the male genitalia.

The habits of the adults probably do not differ greatly from *retusus* or *gaigei*. Several specimens examined were labeled "at dung" and one specimen was labeled "light."

The species ranges across northern Florida and southern Georgia in almost a straight line from Atlantic Beach, Fla., to Thomasville and Americus, Ga.

Mycotrupes pedester Howden

Mycotrupes pedester Howden, *in* Olson, Hubbell and Howden, 1954, pt. 1, pp. 24–28. Type, male, Punta Gorda, Charlotte County, Fla., Ramstadt (UnMich).

This species, which is closely allied to *cartwrighti*, can be distinguished by its normally small size (13 mm. to 16 mm. in length), by the fairly uniform and well separated granulations of the elytra, by the male genitalia (pl. 5, fig. 8), by the elytral apices which usually form a small notch where they meet, and by the sharply delimited posterior

edge of the anterior pronotal margin in the male, which usually lacks the tubercle present on the female at the midpoint of the pronotal margin.

The species has been found in southwestern peninsular Florida, ranging from Punta Gorda southward.

Discussion

In the preceding sections the similarities and dissimilarities of the morphology and biology of the North American Geotrupinae have been treated in some detail. It is the purpose of the following sections to discuss the Geotrupinae of the world with particular reference to biological differences.

PHYLOGENY AND DISTRIBUTION

Discussion of the phylogenetic position and rank of the group as a family or subfamily has been scrupulously avoided, as I feel that even now there is insufficient evidence upon which to base tentative assumptions. Certainly any such dogmatic statement as the following is premature: "Without exception the Scarabaeoidea have been proved capable of easy delineation into the identical groups, families, subfamilies, tribes, genera, and feeding complexes, no matter whether the larvae or adults were used for the comparisons" (Edwards, 1949, p. 92). Other investigators, while not expressing this attitude, have

TABLE 5.—*Geographic distribution of* Geotrupini

	Enoplotrupes	*Ceratophyus*	*Ceratotrupes*	*Typhoeus*	*Geotrupes*	*Thorectes*	*Mycotrupes*	*Peltotrupes*	*Total*
Europe	–	1	–	1	11	14	–	–	27
Russia	–	2	–	–	6	4	–	–	12
Eastern Asia, Japan	8	–	–	–	29	6	–	–	43
India, Burma, Malaysia	2	1	–	–	3	–	–	–	6
Australia	–	–	–	–	–	–	–	–	–
South Africa	–	–	–	–	–	–	–	–	–
North Africa, Near East	–	1	–	3	6	10	–	–	20
South America east of Andes	–	–	–	–	–	–	–	–	–
South America west of Andes	–	–	–	–	–	–	–	–	–
North America east of Rocky Mts.	–	–	–	–	9	–	5	3	17
North America west of Rocky Mts.	–	–	–	–	–	–	–	–	–
Central America	–	–	3	–	7	–	–	–	10
Total	10	5	3	4	71	34	5	3	135

written numerous papers debating the exact status and phylogenetic position of the "family" or "subfamily" Geotrupinae and its relation to other groups, particularly to the genus *Pleocoma*. For a full discussion of the problem the reader should consult the papers of Gerstaecker (1883), Smith (1888), Horn (1888a, 1888b, 1888c), Paulian (1941), Hayes and Chang (1947), and others on this argument.

Any discussion on the erection of a separate family, Geotrupidae, should be delayed until considerably more information has been accumulated. The arguments presented by Arrow (1904), Böving and Craighead (1930–1931), Paulian (1939), and Edwards (1949) for the establishment of a family were based only on very limited and carefully selected cases. One of these, the presence of 11-segmented antennae, not only is found in the Geotrupinae but also in other scarabaeids, such as *Pleocoma*. The rather distinctive genital capsule, not even considered by most workers, occurs not only in the Geotrupinae but in the Hybosorinae, Ochodaeinae, and Taurocerastinae. Arguments for establishing a separate family have been based on the reduced third leg found in the larvae of the genus *Geotrupes*. In this instance, what the investigators seem to have completely and conveniently overlooked was the fact that *Geotrupes*, *Peltotrupes*, and *Mycotrupes* are the only genera known that have the reduced metathoracic legs. *Typhoeus*, in the same tribe, does not have the reduced legs, nor do any of the known larvae in Lethrini or Bolboceratini. Our present knowledge still seems inadequate in these groups and no further comments will be made on phylogeny.

TABLE 6.—*Geographic distribution of* Lethrini

	Abrognathus	*Microlethrus*	*Lethrulus*	*Heteroplistolodus*	*Ceratodirus*	*Scelolethrus*	*Teratolethrus*	*Autolethrus*	*Lethrus*	*Goniolethrus*	*Total*
Europe	–	–	–	–	–	–	–	–	–	–	–
Russia	–	–	–	2	3	5	–	4	2	–	16
Eastern Asia, Japan	–	–	–	4	–	1	–	2	–	1	8
India, Burma, Malaysia	–	–	–	–	–	–	–	–	–	–	–
Australia	–	–	–	–	–	–	–	–	–	–	–
South Africa	–	–	–	–	–	–	–	–	–	–	–
North Africa, Near East	1	4	2	6	2	2	2	18	2	1	40
South America east of Andes	–	–	–	–	–	–	–	–	–	–	–
South America west of Andes	–	–	–	–	–	–	–	–	–	–	–
North America east of Rocky Mts	–	–	–	–	–	–	–	–	–	–	–
North America west of Rocky Mts	–	–	–	–	–	–	–	–	–	–	–
Central America	–	–	–	–	–	–	–	–	–	–	–
Total	1	4	2	12	5	8	2	24	4	2	64

Representatives of the subfamily Geotrupinae are worldwide in distribution (see tables 5–7), being found on all the continents with the exception, of course, of Antarctica. The habits of many of the genera are unknown, but all of them seemingly are strong burrowers, provisioning food for the nutrition of their larvae. Further investigation may prove the second part of this statement at least partially incorrect, for in the subfamily Geotrupinae there have been lumped three really diverse tribes, both in form and in habits.

These three tribes, the Lethrini, Geotrupini, and Bolboceratini, have little in common. The Lethrini are confined to eastern Europe, the Near East, and Asia, with the greatest speciation occurring in the Near East. The distribution of the major component of this tribe, the genus *Lethrus*, has been discussed by Semenov (1901, p. 251) and Reitter (1890, pp. 288–295). The Geotrupini are circumpolar in the Northern Hemisphere, absent in the Southern Hemisphere. The Bolboceratini are also circumpolar, but in this case they are largely

TABLE 7.—*Geographic distribution of* Bolboceratini

	Athyreus	*Stenaspidius*	*Bolbocerastes, Bolborhombus and 6 subgenera*	*Bolboceras*	*Bolbochromus*	*Bolbocerosoma*	*Eucanthus*	*Kolbeus*	*Bolbelasmus*	*Bolbotrypes*	*Elaphastomus*	*Eubolbitus*	*Total*
Europe	–	–	–	1	–	–	–	–	1	–	–	–	2
Russia	–	–	–	–	–	–	–	–	–	–	–	–	–
Eastern Asia, Japan	3	–	4	–	–	2	–	1	–	1	–	–	11
India, Burma, Malaysia	2	–	32	–	12	–	–	–	–	–	–	–	46
Australia	–	2	70	–	–	–	1	–	–	–	2	–	75
South Africa	6	–	40	–	–	–	–	–	–	–	–	–	46
North Africa, Near East	1	–	1	–	–	–	–	–	3	–	–	2	7
South America east of Andes	42	1	12	–	–	–	1	–	–	–	–	–	56
South America west of Andes	7	–	13	–	–	–	–	–	–	–	–	–	20
North America east of Rocky Mts	–	–	6	9	–	11	3	–	–	–	–	–	29
North America west of Rocky Mts	–	–	5	1	–	1	1	–	2	–	–	–	10
Central America	9	–	1	–	–	–	–	1	–	–	–	–	11
Total	70	3	184	11	12	14	6	2	6	1	2	2	313

restricted to the Southern Hemisphere with a few species occurring in the dry, hot regions of the Northern Hemisphere. Since the habits of these three groups are almost as diversified as their ranges, a brief account of the biological information accumulated on each of the tribes follows.

BIOLOGY OF THE LETHRINI

Living as they do in inaccessible areas, most of the Lethrini are poorly known. The one notable exception is the single European representative of the tribe, *Lethrus apterus* Laxman. One of the first works on its biology was by Emich (1884, pp. 184–188), in which he briefly discusses its metamorphosis. Perhaps the best paper on the development and habits of *Lethrus apterus* was by Schreiner (1906, pp. 197–208), in which he fully describes the peculiar habits and development of the "Rebenschneider" or vine-cutter.

Burrowing beetles usually confine their activities to the surface of the ground, but this is not true of *Lethrus*. The adults were found

by Schreiner climbing shrubs and trees, where they cut off the buds or leaves and then carried them down the tree into their burrow.

References to the peculiar habits of these beetles are scattered throughout the European literature because their promiscuous pruning occasionally is done on crops, causing some damage. Schreiner (1906, pp. 197–208) lists *Euphorbia*, *Artemisia*, *Plantago*, flax, turnip, wheat, buckwheat, young sunflowers, rape, hemp, dill, dahlias, narcissus, tulips, peonies, and shoots of fruit and forest trees among the plants pruned by *Lethrus apterus*. Other species seem to have similar habits. Reymond (1933, pp. 209–211) has discussed the adult habits of *Lethrus potanini*, which he found in one place pruning a species of *Ephedra*. The ravages of *Lethrus cephalotes* have been briefly mentioned by Shipley (1887, p. 335) and Schwarz (1891, p. 484).

According to the references cited above, adult activity, which is often diurnal, occurs in March, April, and May. Each cylindrical burrow made by the beetles is marked by a push-up and is about 15 to 30 cm. deep. Each burrow is occupied by a pair of beetles, the male doing most of the above-ground foraging, bringing the cut leaves to the burrow. According to Schreiner, *Lethrus apterus* packs the leaves into the cell after the egg is laid. The egg is not deposited in the cell, but is placed in a small cavity just beyond its termination. A diagram of the burrow and the shape and position of the 6 or 8 oval cells can be found in a recent booklet by von Lengerken (1952, opposite p. 45). The habit of placing the egg in a cavity beyond the food cell not only occurs in the genus *Lethrus* but has been accredited to *Typhoeus* (*Minotaurus*) by Fabre (1922, p. 93) and to *Bolboceras* by the present writer.

After the egg of *Lethrus* hatches, development was observed by Schreiner to be very rapid. The larva became third instar in 3 to 3½ weeks and emerged as an adult in another 3½ to 4 weeks. This rapid development seemed to me to be more typical of some of the Bolboceratini than it did of the Geotrupini.

The habit of using living leaves is almost unique. Dawson (1922, p. 196) noted a rather similar case in *Geotrupes splendidus miarophagus* using fresh cut grass to provision the larval cells, and I have found *G. splendidus* and *Peltotrupes youngi* using dead leaves for larval food. However, the habit of *Lethrus* of climbing vegetation to procure its larval food is not found in other groups. The oddly shaped asymmetrical mandibles that the males use for their pruning are likewise very characteristic.

BIOLOGY OF THE BOLBOCERATINI

The next tribe considered, the Bolboceratini, should perhaps precede the Lethrini on a phylogenetic basis, but when considered on a behavioristic basis its position is not important. The tribe varies

considerably both in morphology and habits from either the Lethrini or Geotrupini. Additional information on the group may show that its present grouping in the subfamily Geotrupinae is illogical, but its status has not been changed at present. Certainly, a heterogeneous mixture of genera are included in the tribe. Because of this, generalization on the habits of the group would be useless, for the biologies of only a few species are known.

Most of the members of the tribe are nocturnal, and moderately colonial, with burrows in rather restricted habitats. With the exception of several species of *Bolboceras* (formerly *Odontaeus*) and the European species of *Bolbelasmus*, which have been found to feed on certain subterranean fungi, none of the adults in this large tribe has ever been noted feeding, or doing much else for that matter except burrowing.

Fabre, who accumulated many obscure facts concerning the biology of the Geotrupinae, added considerably to our knowledge in his writings (1919, pp. 300–330) about *Bolbolasmus* (formerly *Bolbolceras*) *gallicus* (Mulsant). He found that the beetles dig directly down to and feed on underground trufflelike fungi, one species being *Hydnocystis arenaria* Tulasne. He later showed, by burying bits of fungi in a flower pot, that the *Bolbelasmus gallicus* are able to unerringly dig down to the food. Fabre also mentioned that when investigating the burrows, which are often found in sandy pine woods, the beetles were usually discovered with a bit of fungi on which they had been feeding. He did not mention finding the larva.

The only other European genus in the tribe contains one European representative and a number of North American species. The genus is *Bolboceras*, for a number of years known as *Odontaeus*, the European species being *Bolboceras mobilicornus* Fabricius (=*armiger* Scopoli of a number of authors).

There are several scattered references to the one European species, all using the name *Bolboceras armiger*. Notes on the habits of this species have been published by Lebedeva (1906, p. 436), Arens (1922, pp. 241–246), Bedel (1911, pp. 99–100), and Muller (1948, pp. 4–6, etc.). While the works of Arens and Muller on *armiger* were not available to me, the work of Bedel was. In it he mentions its nocturnal activity and compares its feeding habits to those of *Bolbelasmus gallicus*. He believed that *armiger* fed on subterranean fungi, such as some of the members of the genus *Rhizopogon*. He wrote nothing about the larval habits.

One very questionable observation on *armiger* was reported by Saunders (1936, p. 178). A nonentomological friend, after using worm killer on his lawn, found a number of dead *Bolboceras armiger* beside what he thought were worm holes. From this rather secondhand information, Saunders concluded that they did not burrow but used

worm holes instead! This reference should and would have been left in the obscurity it deserves had it not been the one reference to the genus used by the late G. J. Arrow (1951) in his book "Horned Beetles." In this book, Arrow's statements on biology do not seem to be based on any personal field experience. His section on *Bolboceras armiger* is one such case. He cited Saunder's reference, which stated that even though the beetles were found beside the worm holes, "the same burrow never produced both worm and beetle." After quoting this reference, which at least should have given rise to some doubts, Arrow said (1951, p. 48), "It is clear that this insect escapes the necessity of excavating its own burrow, for which the male is so unsuitably equipped, by adopting a ready-made one. Can there be some connection between the extravagant development attained by the horns and the abandonment of the labours for which, in related species, they are found useful accessories?" If Arrow had ever placed a live, well-armed, male *Bolboceras* on hard ground and observed its actions he would not have made the above statement but would have concluded that it was an excellent burrower.

The biologies of some of the North American representatives of the genus *Bolboceras* are better known. The adults of *Bolboceras darlingtoni* have been found feeding on species of *Rhizopogon* by Sim (1930, p. 144) and myself. Other *Bolboceras* were collected by using fermenting malt as an attractant, which would presumably indicate that they feed on some decomposing materials.

During the course of the present work a considerable amount of information was accumulated on *Bolboceras darlingtoni* and *liebecki*. Both species were found to provide for their larvae finely divided surface humus, which they packed into the bottom of their burrows. The former species deposits a single egg in a small cavity just beyond the packed humus (pl. 14, fig. 1). The larvae, after hatching, burrow through the humus, rapidly becoming third instars. Before pupation, the larvae leave the food, burrowing about an inch to one side where they make pupal cells (pl. 10, fig. 1), emerging as adults shortly thereafter. Development from egg to adult takes two to three months. Whenever larvae were found, an adult, either male or female, was found in the same burrow or in an adjoining one. What the relationship between the adult and larva was, if any, could not be ascertained. While there was a long period when adults of most species could be found, the times of surface activity varied—*darlingtoni, alabamensis,* and *floridensis* being active in the fall, winter, and spring, while the other species were found in the spring and summer.

The genus *Eucanthus,* which is largely confined to North America, has been found by the writer to have habits seemingly similar to those of *Bolboceras*. Pairs of adults were found in burrows during the winter,

and in the spring larvae and adults were taken from the same burrow. While the larval food appeared to be the finely divided surface humus, its use was not definitely established. In one way *Eucanthus* differed markedly from *Bolboceras*—the adults were never seen to feed, nor were they ever found near anything that could seemingly be used for food. None was taken by any chemical attractant or by fermenting malt, but specimens did come freely to light. In these last respects, the habits of *Eucanthus* were the same as those of *Bradycinetulus*, *Bolbocerastes*, and *Bolborhombus*. The species in all of these genera burrow strongly, but there is a dearth of information concerning their habits.

The biology of only one other genus (*Bolbocerosoma*) in the Bolboceratini is even partially known. One species, *farctum*, has had its biology partially described for the first time in this paper. From the small amount of information derived from the single larva, the food is similar to that used by *Bolboceras* and *Eucanthus*, i. e., finely divided surface humus packed into a burrow. The larva apparently pupates at one end of its food cell, and in this respect it differed from *Bolboceras darlingtoni*. Also, the larval burrow was deeper and less tortuous than that of *darlingtoni*. The burrow of *farctum* is diagrammed in plate 10, figure 3. The dimensions of a typical burrow of *Bolbocerosoma* are discussed at some length by Bryson (1939, p. 249). While the larval development was fully as rapid as in *Bolboceras* or *Eucanthus*, taking about two months, the adults were not found associated with the larva as they sometimes were in the cases of *Bolboceras* and *Eucanthus*.

From the above information concerning a few diverse genera in the Bolboceratini, one can only conclude that some of the adults may feed on decaying or fermenting vegetable matter. They are, as a group, strong burrowers, nocturnal in their activity, often coming to light. In the few cases where the larvae are known, finely divided black surface humus was provided by the adults for the larval food. Also, rapid larval development and a long period of adult activity may at present be considered a characteristic of the tribe.

BIOLOGY OF THE GEOTRUPINI

The members of the remaining tribe, the Geotrupini, have been subjected to more biological investigation than the other members of the subfamily. This is largely due to two causes; first, the tribe is well represented in the Northern Hemisphere, and, secondly, many of the species can be fairly easily reared in cages. Most of the work has been done in Europe, and, because of the rather voluminous literature and repetition of observations on many species, only the very briefest of summaries is given here. Much of this information can be found

summarized in works by Heymons and von Lengerken (1929, pp. 531–613) and von Lengerken (1939, 1952), who is now bringing some of his earlier publications up to date.

One of the European genera of Geotrupini, *Typhoeus*, has been the subject of much investigation, particularly one widely ranging species, *Typhoeus typhoeus* Linné, which early aroused the interest of Fabre, the famous French naturalist. Fabre (1922, Mattos translation, pp. 72–171) published an account of his investigations of these beetles using the name *Minotaurus*. Main (1917, p. 21) has said, "A good deal has been written about them [*Minotaurus*] by Fabre in which speculation however plays a large part. His votaries did not show him the insect actually engaged on much of their work, but his assiduity and devotion in recording in most delightful language his observations and speculations makes his works an inspiration to many besides his own countrymen." (Despite his occasional digressions into fantasy, Fabre was a very astute observer and subsequent workers have added little to his basic information on the biology of *Typhoeus*.)

From information contained in the works of Fabre (1922, Mattos translation, pp. 72–171), Carpenter (1928, p. 209), Ohaus (1909, pp. 105–111), Füessly (1794, p. 66), Main (1917, pp. 18–22; 1918, p. 90), and Arrow (1951, pp. 40–42), the habits of *Typhoeus* are briefly summarized as follows. In the early spring, adults, working in pairs, construct burrows 3 to 5 feet deep in shady, sandy localities. The male then provisions the burrow with pellets of rabbit, sheep, cow, or horse dung, which the female works into elongate pods of food for the future larva. The eggs are deposited singly in a small cell in the sand outside of the food, in a manner similar to *Lethrus*. Larval development, at first rapid, becomes slower, pupation not occurring until late in the summer and the imago emerging in the fall. Main (1918, p. 90) found that in England pupation occurred in the second summer. Six or eight larval cells are constructed, branching off of one burrow. This type of burrow with the larval cells branching off of it has also been recorded for many of the European *Geotrupes*. Except for the depth of the burrow, the oviposition of the egg outside of the food cell, and possible 2-year cycle, the habits of *Typhoeus typhoeus* differ only in minor ways from the European species of *Geotrupes*. However, the larva differs strikingly from that of *Geotrupes* by not having the metathoracic legs reduced in size.

It appears from the numerous works on European *Geotrupes* that the species all have similar habits and use either horse or cow dung to provision their larval cells. There are a number of excellent works to which the reader could profitably refer. The biology and larval morphology of *Geotrupes stercorarius* (Linné) have been briefly dis-

cussed by Blair (1934, p. 89), Frisch (1736, pp. 13–15), Korschefsky (1940, p. 45), Lebedeva (1906, p. 436), Perris (1876, p. 361), Sano (1915–1916, pp. 25–28), Schiødte (1874, pp. 227–376), and Schjelderup-Ebbe (1925, pp. 97–98). Kolbe (1929, p. 187) summarized the habits of the European subgenera of *Geotrupes* and treated briefly of several of the species. Ohaus (1909, pp. 105–111) discussed the habits of *Geotrupes stercorarius*, *vernalis*, *sylvaticus*, and (*T.*) *typhoeus*, while in the following year Spaney (1910, pp. 625–634) not only gave an excellent biological account of the same species but pictured the anal lobes of the larvae and the pupae of all the above species. Fabre (1918, Mattos translation, pp. 189, 234) gave, in his usual vivid and slightly fanciful style, a detailed discussion of the life history of *Geotrupes stercorarius* (believed by Main (1917) to be in actuality *Geotrupes spiniger*).

As the biologies of the European *Geotrupes* appear to be quite similar in the discussions of the works just mentioned, no attempt is made to give a detailed review of their life histories. Essentially all of the species fit into the following pattern. A burrow is made from 2 to 12 inches deep beneath cow or horse dung, often in the woods in a somewhat shaded spot. On numerous occasions the beetles have been noted working in pairs with the male bringing the dung to the female in the burrow. The female, in a side branch of the vertical burrow, makes a compact wad of dung 2 or 3 inches long and the width of the burrow. Near the terminal end she leaves a small cavity, sometimes lined with a thin coating of clay. Usually four to six food cells for the larvae are made branching off the main burrow, but the total number of burrows and food cells that a single female may construct is apparently unknown. Main (1917, pp. 18–22) did mention that the female does not need the assistance of the male as she is perfectly capable of doing all of the work.

After oviposition, the egg, which is large, oval, slightly wider at one end, and yellowish-white, swells to almost twice its regular size before hatching. Several hours after eclosion the larva starts feeding, and it increases rapidly in size until the third instar. The developmental time for each instar of the various European species has not been sufficiently studied to enable any generalized statements to be made. The larva, upon attaining maximum size or upon consuming all available food, remains quiescent for a period, coats the walls of its cell with a thick layer of its own feces, and then pupates. Two or three weeks after pupation ecdysis occurs, and after a few days the adult leaves the cell.

Any mention of the time of oviposition, hibernation, or emergence of the adults has been avoided until now, as it is there that the differences have been noted between the species. Main (1917, pp. 18–22)

noted that *spiniger* (the *stercorarius* of Fabre) oviposits in the fall and then dies, new adults emerging the next fall. The adults of *stercorarius* emerge in the fall and begin egg laying in the spring; nearly grown larvae overwinter, and the adults do not appear until fall of the second year. *Geotrupes mutator* was noted by Main ovipositing at the same time as *stercorarius*, but the larvae of *mutator* completed their development during the summer and the adults came out the same fall. Those species illustrate the three general patterns of development for the European *Geotrupes* insofar as they have been reported in the literature. A good summary of some of the biologies of the Geotrupinae was written by Paulian (1949, pp. 1013–1015). In this work Paulian has included a diagram of a typical burrow of the European species of *Geotrupes*.

Some variance has been noted due to climatic differences but, at present, records are not available that would make possible any comparisons of developmental rates for the same species in different climatic areas. I have tried to point out the close similarities between the habits of the various European *Geotrupes*, even though several are in different subgenera, which exhibit a number of morphological differences. When differences such as different dates of oviposition were found they often occurred between closely related species.

Compared with the uniform habits of the European species, the variation found in the habits of the American species was striking. Available detailed biological information has been given after the description of each species, and much of it is not repeated here. Clark (1895, p. 61) stated that North American *Geotrupes* were entirely dung or carrion feeders. If he had included fungi and decaying or fermenting vegetable matter in his statement, it could be considered generally correct in reference to the adults. In the European species, both the adults and larvae utilized the same substances for food, while this association was not always the case for American species. In the latter, the adults often were found feeding on one food, later using an entirely different material to provision their larval cell. *Geotrupes blackburnii* often uses dung for both the adult and larval food. *Geotrupes ulkei* and *splendidus* commonly feed as adults on fungi while the larvae develop on decaying leaves. *Geotrupes egeriei* and *hornii* are usually fungus feeders as adults, but provide their larvae with dung.

The larval food differences mentioned above are not as great as they might at first seem, if one takes into consideration an experiment conducted by Fabre (1922, pp. 219–224) many years ago. The astute French naturalist noted the similarity between old dung, which the European *Geotrupes* larvae used for food, and the rotting leaves of the forest floor. Taking some leaves, he rammed them tightly into a tube

along with an egg of *Geotrupes*. After hatching, the larva began feeding on the leaves without any hesitation, feeding on any part of the leaf it encountered, vein and all. All the specimens he treated in this way were reared to normal-sized adults. Fabre then elaborated upon this experiment by taking a dead-leaf-feeding *Cetonia* grub and rearing it successfully on cow dung. The implications in Fabre's work on adaptability of various insects to their food and even the fundamental similarity of the seemingly different materials have been neglected by subsequent investigators.

I found several cases that substantiated Fabre's findings. *Geotrupes splendidus* adults, when put in a cage containing only cow dung, constructed a few larval cells using the dung; when put in a cage containing both dung and dead leaves, they used only the dead leaves. The larvae feed indiscriminately on the food at hand. From this it seemed that not only did the larva develop on different foods, but the adult habits were not as inflexible as has formerly been believed.

This same flexibility of habit was noted to a lesser extent in *Geotrupes blackburnii*. The larval food provided by the adults in the rearing cages consisted of cow dung, even though leaves were in the cage. Larval cells of *blackburnii* found at Faison, N. C., seemed to be at least partially composed of dead leaves and grass, but, as much of the cells had already been consumed by the larvae when they were discovered, the major component of the cells, whether dung or leaves, could not be determined.

The above remarks on variability of food utilization should be kept in mind while reading the subsequent discussion on the habits of the American species of *Geotrupes*, as future investigation may indicate an even wider variation in food and other habits than is at present known. Considerable interspecific variation has been found in the time of oviposition, length of life cycle, and depth and type of burrow. While known larval morphology differs, several structural and developmental characteristics are common to all species. All of the eggs found, while differing slightly in size, are yellowish white, elongately oval, and wider near one end. Plate 14, figure 2, showing an egg of *Geotrupes blackburnii*, illustrates these characteristics. The eggs of the European species have been described as having the same general elongately oval shape. After hatching, initial larval development usually is quite rapid, taking perhaps a month for each of the first two stadia. In the species studied, the development of the third instar took much longer. The minimum time noted was about three months in the case of *blackburnii* and *splendidus*. The third-stage larvae of *hornii* overwinter, taking a much longer time to complete their development. Adult emergence from the larval cell occurs largely in the summer and fall.

While all of the data accumulated have been given after the taxonomic discussion of each species, a general summary of the available biological information can be found in table 2. In this table one of the most noticeable and constant of the interspecific differences shown is the variation in the burrow types. The burrows of *splendidus* are similar to those of *blackburnii*, but are slightly deeper and contain leaves instead of dung. The burrows of *egeriei* and *hornii* are considerably deeper than *blackburnii* and *splendidus* and both use old cow dung as larval food. However, *hornii* has a number of cells branching off a burrow, as has been noted for European species, while *egeriei* only had a single cell in the two cases found. An interesting subspecific difference in burrow habits may possibly exist between the eastern *splendidus* and the western *splendidus miarophagus*. I found the eastern subspecies making a single cell of dead leaves at the bottom of its burrow, while Dawson (1922, p. 196) recorded finding a burrow of *s. miarophagus* with several cells branching off the burrow, the pods being composed of fresh cut grass.

When considered in conjunction with adult and larval morphology, the burrow and food characteristics seem to have possible taxonomic importance, at least in a consideration of phylogeny and in generic and subgeneric groupings. On the basis of adult morphology I would consider that, of all the North American Geotrupini, *Geotrupes hornii* is the species most closely related to *Geotrupes stercorarius*. The same conclusion could be reached from a comparison of their burrows. The diagram of the burrow of *Geotrupes hornii* (pl. 10, fig. 5) closely approximates ones given for *stercorarius*. I believe, on the basis of adult and larval morphology and on the burrow characteristics, that the present subgeneric groupings of the North American Geotrupini are in need of some rearrangement, but hesitate to do so until something is learned about the larvae of *Geotrupes opacus*, *semiopacus*, and *balyi*.

In this paper I have elevated Blanchard's subgenus *Peltotrupes* to generic rank because of certain adult and larval characteristics which are not known to exist in any *Geotrupes*. Biological differences are in strong support of this generic separation.

The adults of *Peltotrupes* are active in the winter months, with oviposition occurring largely in January, February, and March.

The deepest burrow of any species of *Geotrupes* known to me did not approach 4 feet, even in the areas where *Peltotrupes* occurred. The burrows of *Peltotrupes* averaged 6 feet deep with one burrow reaching 9 feet. One great difference noted between *Peltotrupes* and the known *Geotrupes* was in the method of packing the larval cell. In *Geotrupes* the food material, whether it was dung or leaves, was tightly packed so that the cell retained its shape when removed from the ground. The cell of *Peltotrupes*, which was a conglomeration of

any surface litter near the burrow entrance, was so loosely packed that it would begin to crumble as the encompassing sand was dug away. The method of feces disposal of *Peltotrupes youngi*, which has been described in detail under that species, also seems to be different from any known *Geotrupes*. Certainly such biological differences should be considered to have some taxonomic value when found in conjunction with good morphological characters, both in the larvae and adults.

Only the immature stages of *gaigei* in the genus *Mycotrupes*, the last group of the North American Geotrupini to be discussed, are known. Information on the larval biology is scanty. The larval cells are found 5 or more feet deep, being composed of dung. Apparently several cells branch off one burrow, but this may not always be true. From the meager information at hand, the larval biology of *Mycotrupes* appears to be similar to that of the North American *Geotrupes*. The adults of all of the members of the genus are apterous with fused elytra, superficially resembling some of the Lethrini. They are found in isolated localities on some of the deep sand ridges in the southeastern United States, and are active in the fall, winter, and spring. Newly transformed adults appear during the early spring. They have been noted feeding on fungi burrowing under dung, and coming to fermenting malt or propionic acid placed in a sunken can. I found *Mycotrupes retusus* LeConte in September in 3-foot burrows under stands of pine, but no larval cells were found at that time. From the present available data the habits of all the species appear to be quite similar.

MISCELLANEOUS STUDIES

Apparent economic damage caused by any of the groups seemingly is slight, as there are few references to this aspect. The ravages of *Lethrus* through its habit of leaf cutting have already been mentioned. Thomas (1939, pp. 23–24) mentions a reference to a 10 percent loss of edible mushrooms, *Boletus edulis* Fries, in south Germany because of the activities of *Geotrupes stercorosus* Scriba. Wetzel (1935, pp. 188–191) implicates *Geotrupes sylvaticus* as an intermediate host of the fowl tapeworm, *Davainea proglottina*.

As a group, the Geotrupinae seem to be more beneficial to man than harmful, as they take a large amount of decaying material and dung underground rather rapidly, but just how much value this has remains an unanswered question.

Several desultory studies have been conducted on some of the Geotrupinae. Sharp and Muir (1912, p. 581) have discussed the morphology of the male genitalia of a few species, while Hardenburg (1907, pp. 548–602) and Mohr (1930, pp. 263–284) have compared

the mouthparts of some of the genera. Structures used in sonification have been mentioned by Arrow (1904, pp. 727–732), and the evolution of the antennae was considered by Warnke (1934, pp. 217–224).

The attractiveness of ammonia, indol, and skatol to several European species of *Geotrupes* was discussed by Warnke (1931, pp. 121–199), and this motivated the use of the chemicals listed in tables 3 and 4. Vaternahn (1924, pp. 20–27) previously had noted that certain chemicals would attract *Geotrupes*, and this fact was also noted by Dethier (1947, p. 285). However, all of these studies were very desultory and merely indicated the possibilities for further investigations.

Another line of investigation, the study of predators, parasites, and commensals of the Geotrupinae, has not been discussed here. I have observed both the adults and the larvae of the carabid *Scarites subterraneous* Haldeman feeding on the larvae of *Geotrupes blackburnii*. Also, several commensal organisms, Diptera and Collembola, have been taken in the larval cells. This material was given to J. Theodorides, who has already published several papers on the parasites and commensals of *Geotrupes* (1949, 1950a, 1950b, 1951, 1952) and is continuing his work. Van Emden (1950, p. 190), in his work on dipterous parasites of Coleoptera, expresses doubt that any of these parasites occur on the larvae of *Typhoeus*.

The most interesting case of parasitism on a species of Geotrupinae known to me was recorded by Chapman (1869–1870). He stated that he found as many as five or six pairs of *Geotrupes stercorarius* (actually the species we now call *spiniger*, according to Main, 1917, p. 19) burrowing under a piece of cow dung. He observed that they made a vertical burrow 6 to 12 inches deep, merely compacting the earth as they burrowed instead of bringing it to the surface. Six or eight cells branched off this burrow, the beetles making the upper cells first. Each cell, 4 or 5 inches long by 1 inch wide, contained a single egg measuring "$\frac{3}{16}$ inch in length," lying loosely in a cavity near its terminal end.

While making these observations, Chapman noticed an *Aphodius* (*A. porcus*) entering the egg cavity of the larval cell. The *Aphodius* then destroyed the egg, whether by eating it or not was not definitely ascertained. After destroying the *Geotrupes* egg, the *Aphodius* then laid its own eggs, using the food supply furnished by the *Geotrupes* to nourish its own larvae. Whether this is a normal occurrence has not been confirmed by subsequent investigators, but it does serve to show the unexpected complexities that may be encountered, and the need for more adequate biological information on the Geotrupinae and the insects associated with them.

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Explanation of Plates 1–10

Plate 1

Some adult Geotrupinae. Left row, top to bottom: *Mycotrupes cartwrighti* Olson and Hubbell; *Geotrupes splendidus miarophagus* Say; *Peltotrupes profundus* Howden; and *P. youngi*, new species. Right row, top to bottom: *Bolbocerosoma cartwrighti*, new species; *B. ritcheri*, new species; *B. pusillum townesi*, new subspecies; *Eucanthus lazarus subtropicus*, new subspecies; and *E. alutaceus* Cartwright.

Plate 2

1. Left eye canthus and lateral portion of clypeus of (a) *Peltotrupes youngi*, new species; (b) *P. profundus* Howden, (c) *P. profundus dubius*, new subspecies.
2. Left anterior angle of pronotum of (a) *P. youngi*, (b) *P. profundus*, (c) *P. profundus dubius.*
3. Anterior pronotal margin of (a) *P. youngi*, (b) *P. profundus*, (c) *P. profundus dubius.*
4. Outline cross section of anterior left elytral margin of (a) *P. youngi*, (b) *P. profundus*, (c) *P. profundus dubius.*
5. Posterior edge of left paramere of male genitalia of (a) *P. youngi*, (b) *P. profundus*, (c) *P. profundus dubius.*
6. Right eye canthus, eye, and antenna of *Eucanthus lazarus subtropicus*, new subspecies.
7. Right eye canthus, eye, and antenna of *E. lazarus lazarus* (Fabricius).
8. Diagram of first four striae of right elytron of *E. lazarus subtropicus.*
9. Diagram of first four striae of right elytron of *E. lazarus lazarus.*
10. Diagram of teeth on ventral surface of the left foretibia of male *Geotrupes blackburnii blackburnii* (Fabricius).
11. Diagram of teeth on ventral surface of the left foretibia of male *G. blackburnii excrementi* Say.
12. Diagram of dorsal surface of left foretibia of female *G. egeriei* Germar, showing longitudinal carina.
13. Diagram of dorsal surface of left foretibia of female *G. blackburnii blackburnii*, showing longitudinal carina.
14. Diagram of dorsal surface of left foretibia of female *G. balyi* Jekel, showing longitudinal carina.

Symbols: A, antenna; AT, anterior tooth; CL, clypeus; EC, eye canthus; LC, longitudinal carina; PT, penultimate tooth; S, elytral suture; SP, row of setigerous punctures; TC, transverse carina; 2E, second elytral interval; 4E, fourth elytral interval.

Plate 3

1. Right lobe of male genital capsule of *Bolbocerosoma tumefactum* (Palisot de Beauvois).
2. Right lobe of male genital capsule of *B. ritcheri*, new species.
3. Right lobe of male genital capsule of *B. farctum* (Fabricius). (Half the magnification of 1 and 2.)
4. Right lobe of male genital capsule of *B. cartwrighti*, new species.
5. Right lobe of male genital capsule of *B. elongatum*, new species.
6. Right lobe of male genital capsule of *B. pusillum* Dawson and McColloch. (Half the magnification of 4 and 5.)
7. Dorsal aspect of male genitalia of *Peltotrupes youngi*, new species.
8. Tip of male genitalia of *Geotrupes hornii* Blanchard.
9. Dorsal aspect of male genitalia of *G. hornii.*

10. Tip of male genitalia of *G. balyi* Jekel.
11. Dorsal aspect of male genitalia of *G. balyi.*

Symbols: LP, left paramere; PLL, phallobase; RP, right paramere.

PLATE 4

1. Dorsal aspect of male genitalia of *Geotrupes splendidus splendidus* (Fabricius).
2. Dorsal aspect of male genitalia of *G. stercorarius* (Linné).
3. Dorsal aspect of male genitalia of *G. ulkei* Blanchard.
4. Dorsal aspect of male genitalia of *G. blackburnii blackburnii* (Fabricius).
5. Same as 4, but another specimen.
6. Dorsal aspect of male genitalia of *G. blackburnii excrementi* Say.

Symbols: LP, left paramere; PLL, phallobase; RP, right paramere.

PLATE 5

1. Dorsal aspect of male genitalia of *Geotrupes egeriei* Germar.
2. Dorsal aspect of male genitalia of *G. opacus* Haldeman.
3. Dorsal aspect of male genitalia of *G. semiopacus* Jekel.
4. Ventral aspect of male genitalia of *Mycotrupes carlwrighti* Olson and Hubbell.
5. Dorsal aspect of male genitalia of *M. retusus* LeConte.
6. Ventral aspect of male genitalia of *M. gaigei* Olson and Hubbell.
7. Ventral aspect of male genitalia of *M. retusus.*
8. Ventral aspect of male genitalia of *M. pedester* Howden.

Symbols: LP, left paramere; PLL, phallobase; RP, right paramere.

PLATE 6

1. Left antenna of third instar of *Eucanthus lazarus subtropicus,* new subspecies.
2. Left antenna of third instar of *Bolbocerosoma farctum* (Fabricius).
3. Left antenna of third instar of *Bolboceras liebecki* (Wallis).
4. Epipharynx of third instar of *Bolbocerosoma farctum.*
5. Epipharynx of third instar of *Eucanthus lazarus subtropicus.*
6. Labium and hypopharynx of third instar of *E. lazarus subtropicus.*
7. Caudal view of last abdominal segment of third instar of *E. lazarus subtropicus.*
8. Labium and hypopharynx of third instar of *Bolboceras darlingtoni* (Wallis).
9. Epipharynx of third instar of *B. darlingtoni.*
10. Caudal view of last abdominal segment of third instar of *B. darlingtoni.*
11. Labium and hypopharynx of third instar of *B. liebecki.*
12. Epipharynx of third instar of *B. liebecki.*

Symbols: ASL, anal slit; DAL, dorsal anal lobe; DX, dexiotorma; GL, glossa; LT, laeotorma; O, oncylus; PH, phoba; SE, sensory organ.

PLATE 7

1. Left galea of third instar of *Geotrupes ulkei* Blanchard.
2. Last two antennal segments of third instar of *G. splendidus splendidus* (Fabricius).
3. Last two antennal segments of third instar of *G. ulkei.*
4. Last two antennal segments of third instar of *G. blackburnii blackburnii* (Fabricius).
5. Last two antennal segments of third instar of *Geotrupes egeriei* Germar.
6. Last two antennal segments of third instar of *Peltotrupes youngi,* new species.
7. Last two antennal segments of third instar of *G. hornii* Blanchard.
8. Head of third instar of *G. egeriei.*

9. Head of third instar of *G. splendidus splendidus* (Fabricius)
10. Tip of right mesothoracic leg of third instar of *G. hornii.*
11. Left mandible of third instar of *G. egeriei.*
12. Right mandible of third instar of *G. egeriei.*
13. Left mandible of third instar of *G. splendidus splendidus.*
14. Right mandible of third instar of *G. splendidus splendidus.*
15. Caudal view of last abdominal segment of third instar of *G. hornii.*
16. Tip of right mesothoracic leg of third instar of *G. egeriei.*
17. Caudal view of last abdominal segment of third instar of *G. egeriei.*

Symbols: A, antenna; AA, setae of anterior angle of frons; AF, anterior frontal setae; AS, antennal segment; BP, bifurcate process; EFS, exterior frontal seta; ESF, endoskeletal figure; L, labrum; MO, molar area, PFS, posterior frontal seta; SA, scissoral area; SE, sensory organ; TU, tubercle.

Plate 8

1. Epipharynx of third instar of *Geotrupes splendidus splendidus* (Fabricius).
2. Labium and hypopharynx of third instar of *G. blackburnii blackburnii* (Fabricius).
3. Maxilla, labium, and hypopharynx of third instar of *G. splendidus splendidus.*
4. Epipharynx of third instar of *G. egeriei* Germar.
5. Labium and hypopharynx of third instar of *G. blackburnii excrementi* Say.
6. Maxilla, labium, and hypopharynx of third instar of *G. egeriei.*
7. Epipharynx of third instar of *G. hornii* Blanchard.
8. Labium and hypopharynx of *G. hornii.*

Symbols: CPA, chaetoparia; DX, dexiotorma; ETA, anterior epitorma; ETP, posterior epitorma; GL, glossa; LT, laeotorma; MSA, maxillary stridulating area; O, oncylus; SEN, sensilla.

Plate 9

1. Epipharynx of third instar of *Peltotrupes youngi,* new species.
2. Caudal view of last abdominal segment of third instar of *P. youngi.*
3. Head of third instar of *P. youngi.*
4. Left mandible of third instar of *P. youngi.*
5. Maxillae, labium, and hypopharynx of third instar of *P. youngi.*
6. Right mandible of third instar of *P. youngi.*

Symbols: A, antenna; AN, anal lobe; BP, bifurcate process; CPA, chaetoparia; DX, dexiotorma; ETA, anterior epitorma; ETP, posterior epitorma; GL, glossa; L, labrum; LT, lacotorma; MO, molar region; MSA, maxillary stridulatory area; O, oncylus; PFS, posterior frontal setae; PH, phoba; SN, scissorial notch.

Plate 10

1. Diagram of brood burrows of *Bolboceras darlingtoni* (Wallis).
2. Diagram of burrow of *Bradycinetulus ferrugineus* (Palisot de Beauvois).
3. Diagram of brood burrow of *Bolboceras farctum* (Fabricius).
4. Diagram of brood burrow of *Peltotrupes youngi,* new species.
5. Diagram of brood burrow of *Geotrupes hornii* Blanchard.
6. Diagram of brood burrow of *G. blackburnii blackburnii* (Fabricius).
7. Diagram of brood burrow of *G. splendidus splendidus* (Fabricius).

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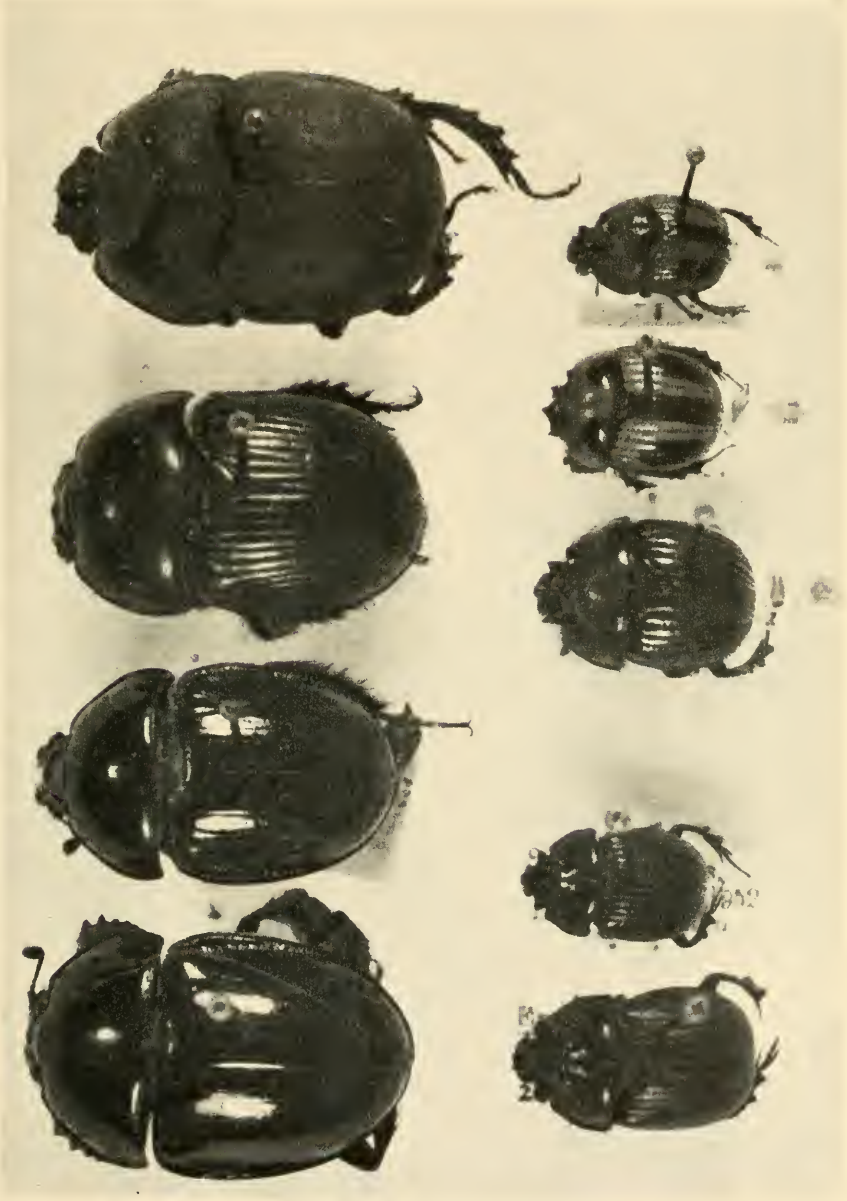

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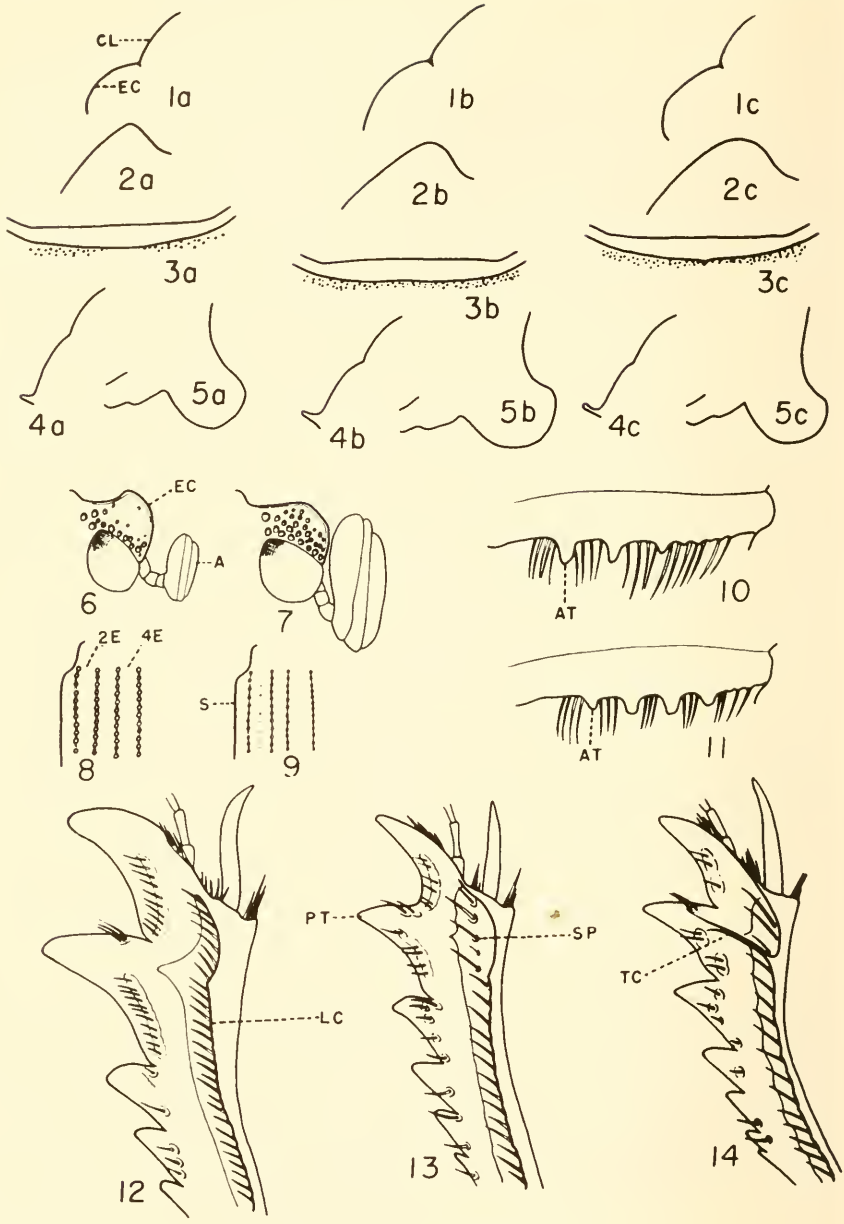

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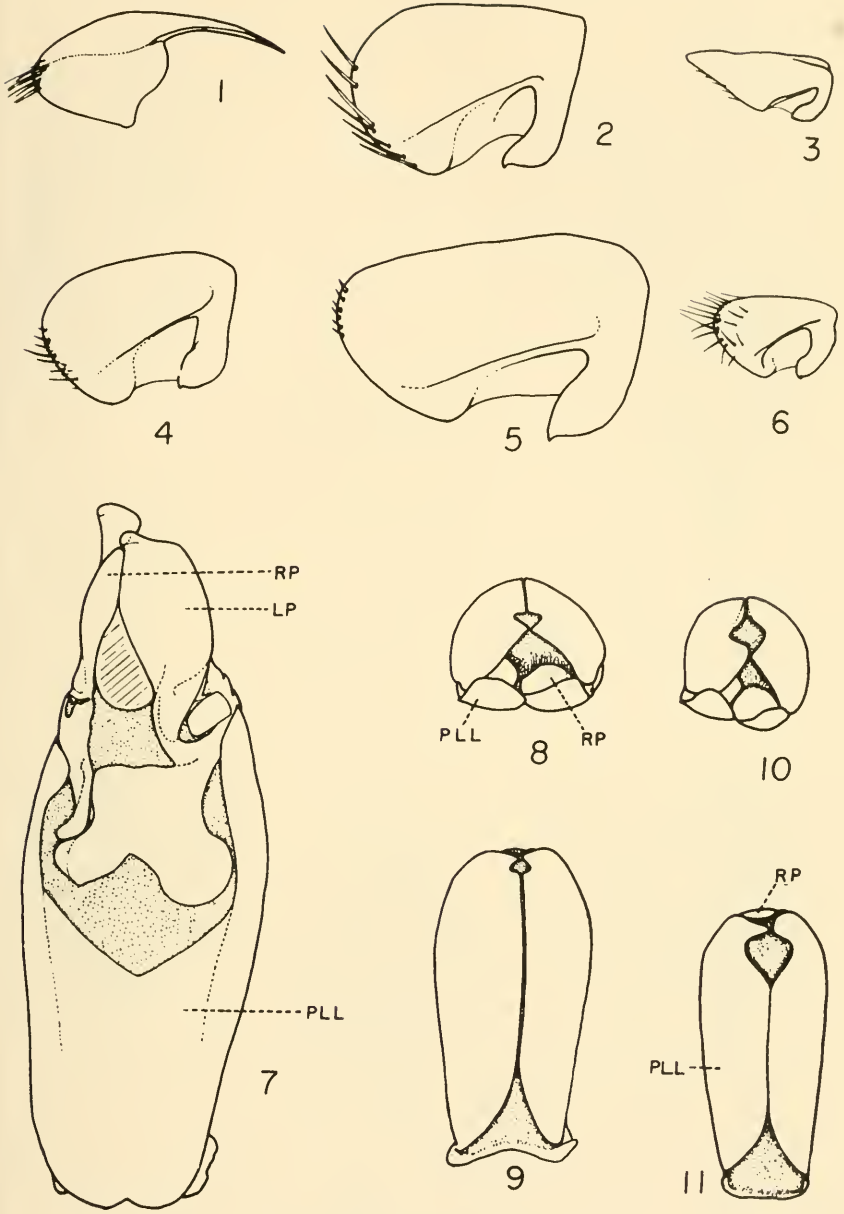

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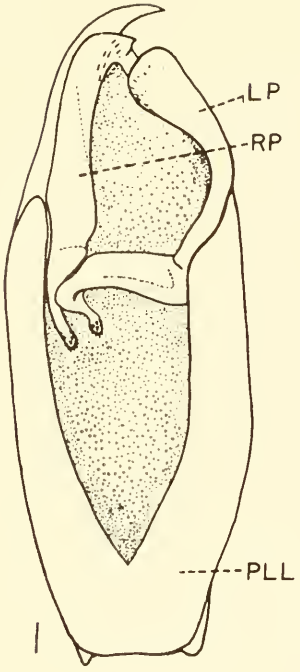

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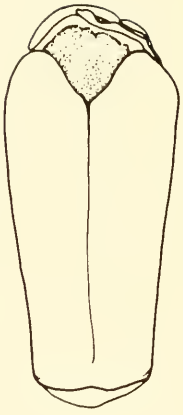

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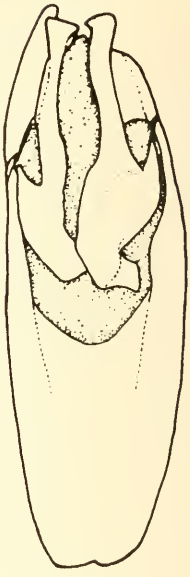

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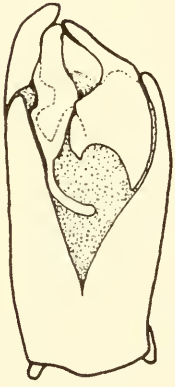

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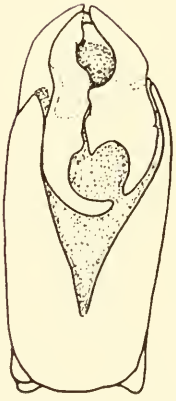

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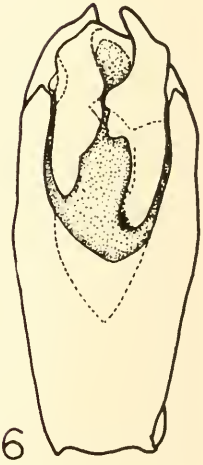

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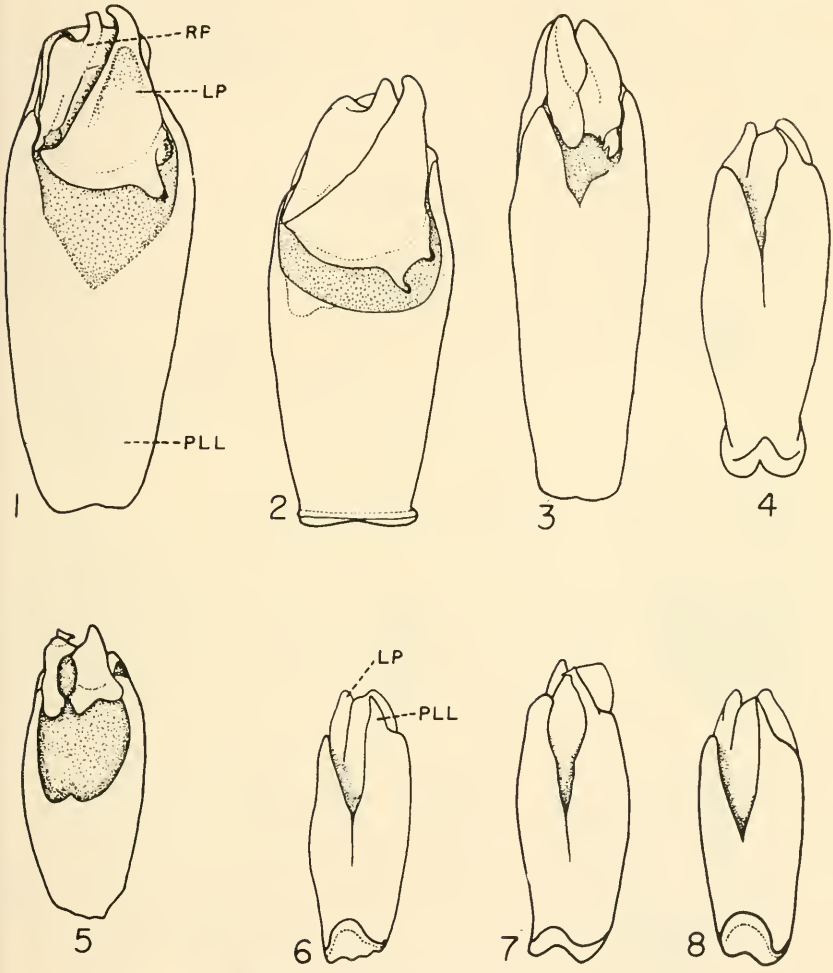

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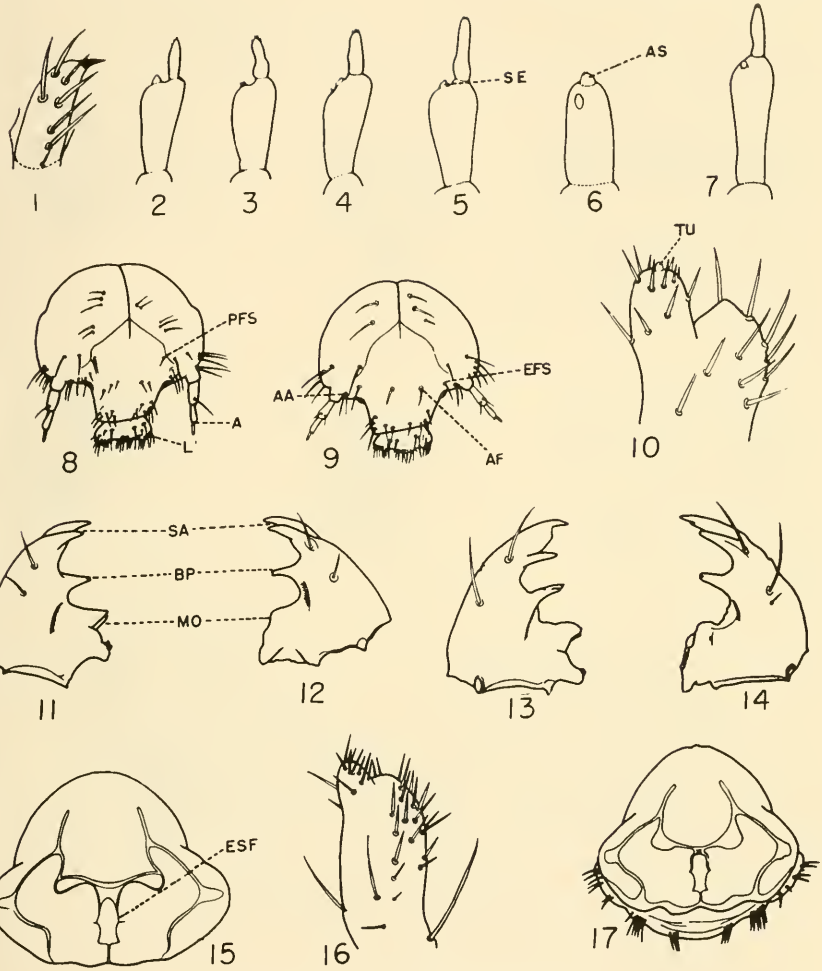
FOR EXPLANATION SEE PAGE 318



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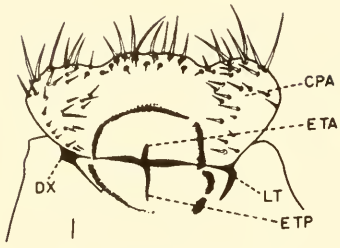
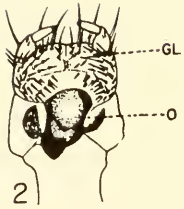
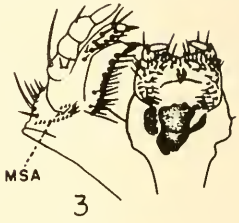
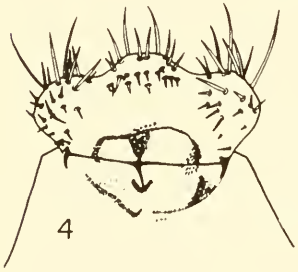
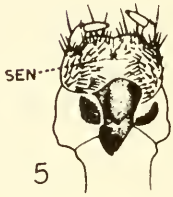
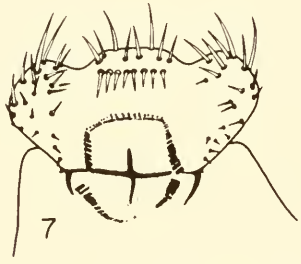




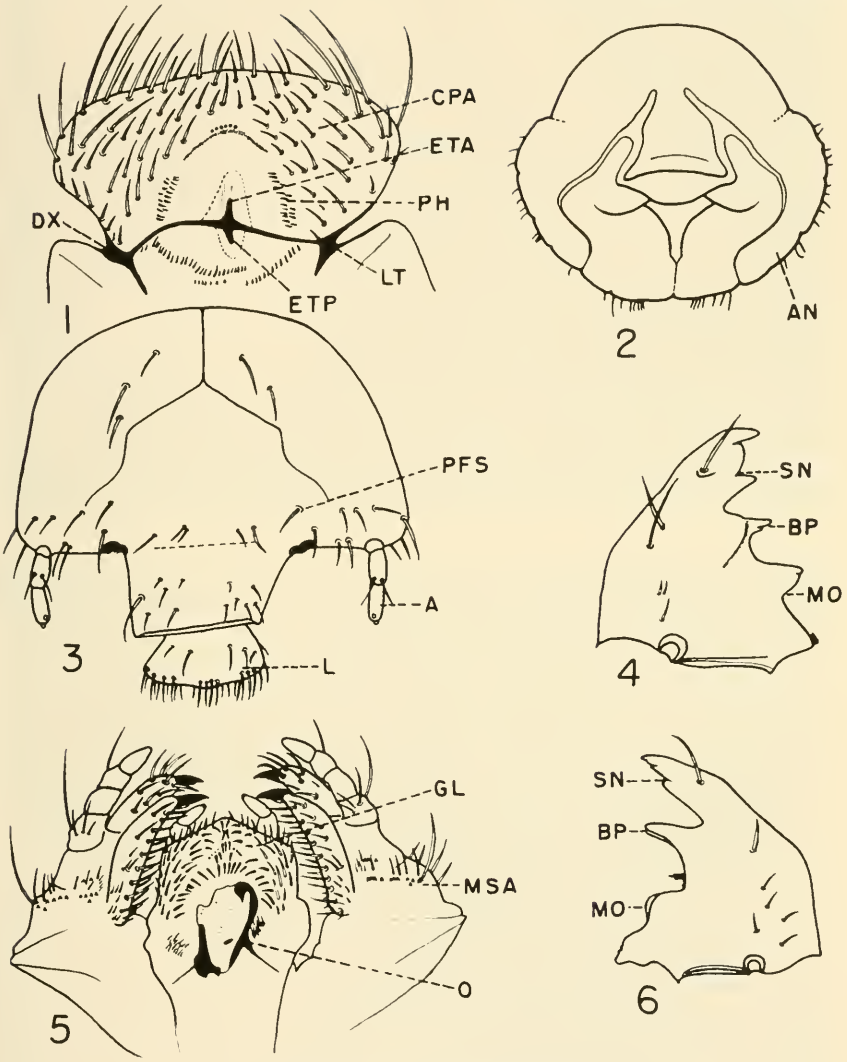




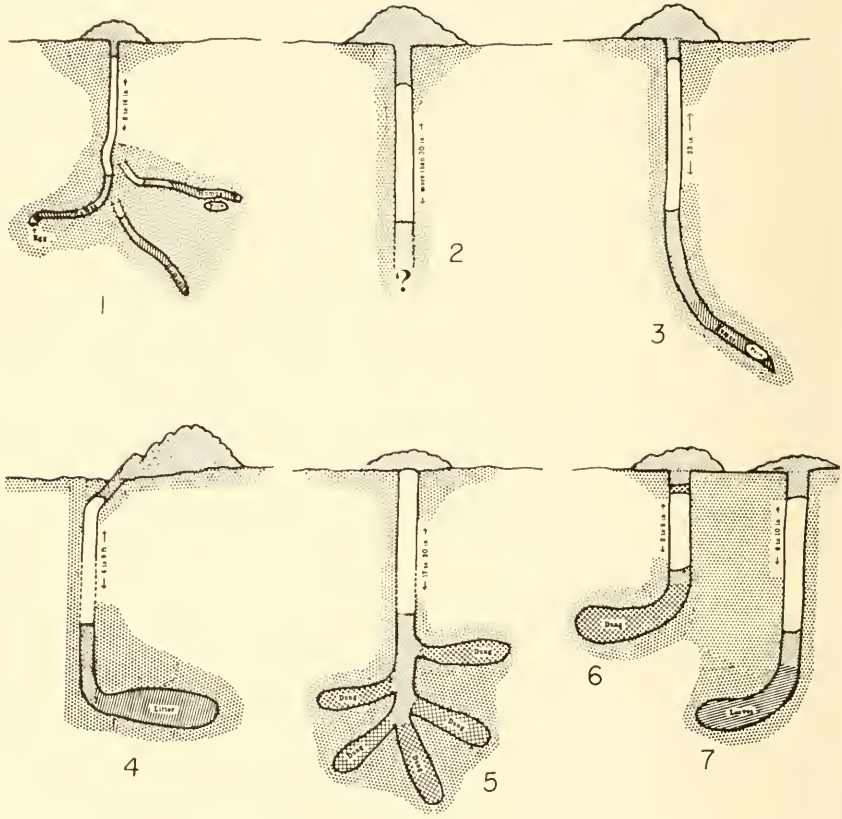




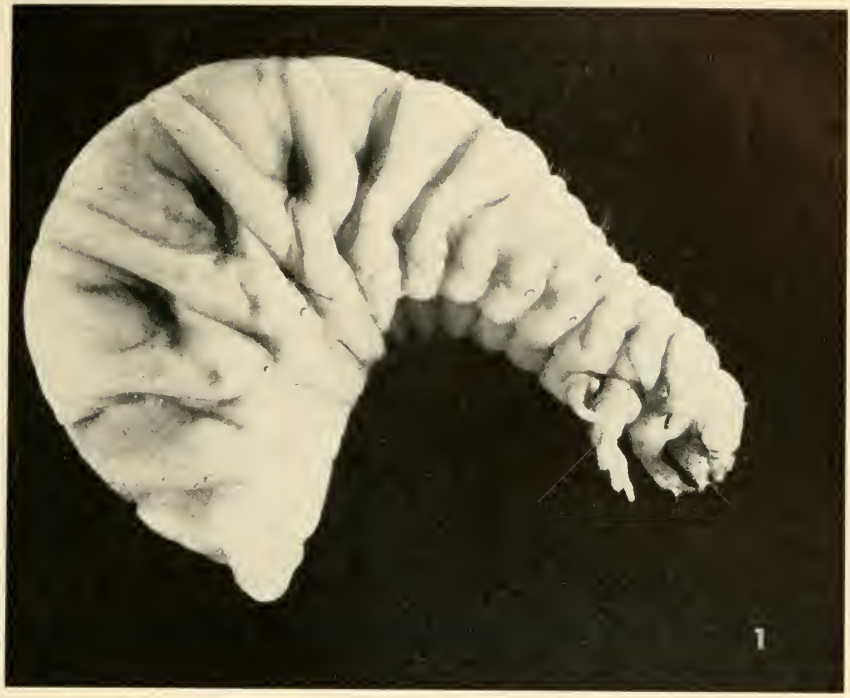
FOR EXPLANATION SEE PAGE 319



FOR EXPLANATION SEE PAGE 319



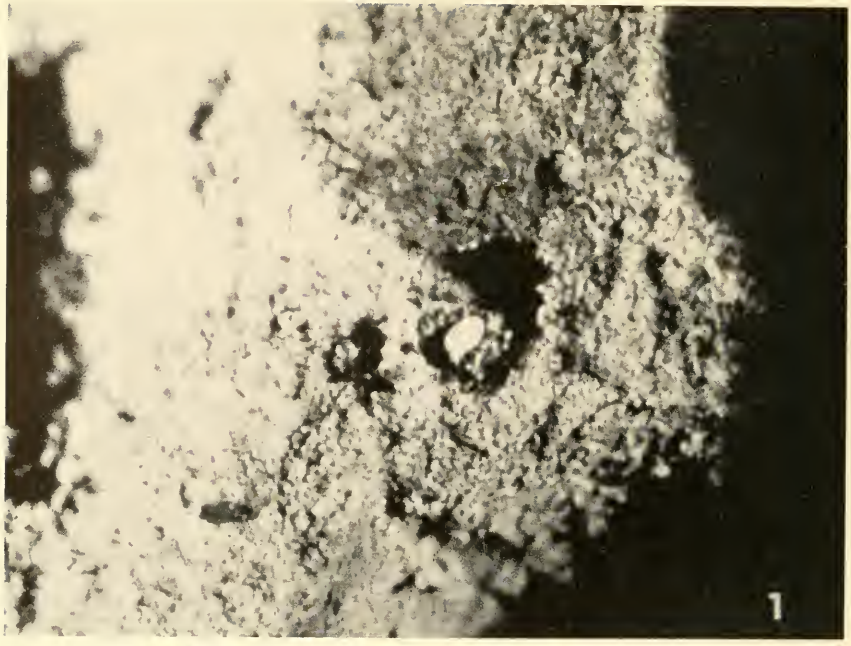
FOR EXPLANATION SEE PAGE 319



1. Third instar of *Peltotrupes youngi*, new species.
2. Third instar of *Geotrupes egeriei* Germar.

1. Third instar of *Bolboceras darlingtoni* (Wallis).
2 Third instar of *Eucanthus lazarus subtropicus*, new subspecies.

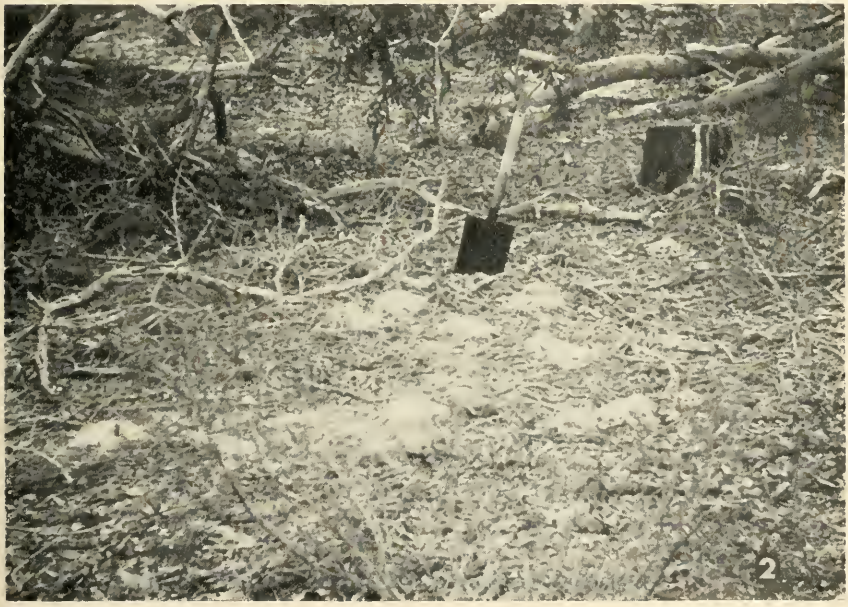
1. Third instar of *Bolbocerosoma farctum* (Fabricius).
2. Third instar of *B. farctum* in pupal cell, showing a portion of the cell (black) provisioned by the female.



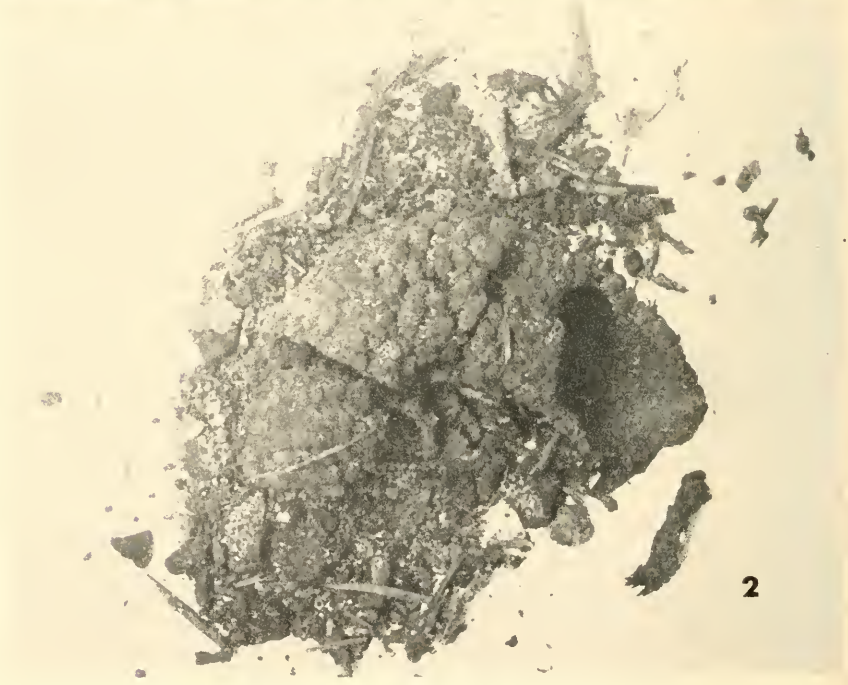
1. Egg of *Bolboceras darlingtoni* (Wallis) in cavity, made by the female just below the provisioned cell (dark gray).
2. Egg of *Geotrupes blackburnii blackburnii* (Fabricius) in cavity, at the terminal end of the dung wad provisioned by the female.

1. Pupa of *Bolboceras darlingtoni* (Wallis).
2. Pupa of *Geotrupes blackburnii blackburnii* (Fabricius) in cell.

1. Portion of the sandy woods at Faison, N. C., where *Geotrupes blackburnii blackburnii* (Fabricius), *G. egeriei* Germar, *G. hornii* Blanchard, *Bolbocerosoma farctum* (Fabricius), and *Bolboceras darlingtoni* (Wallis) were found.
2. Area in the Faison, N. C., woods where larvae of *Bolbocerosoma farctum* and *Bolboceras darlingtoni* were collected.



1. Old road at Southern Pines, N. C., where many burrows of *Eucanthus lazarus subtropicus*, new subspecies, were found. Five of these burrows are indicated by straws.
2. Push-ups marking the burrows of *Peltotrupes youngi*, new species. Four miles west of Rodman, Putnam County, Fla.



1. Push-up of *Peltotrupes youngi*, new species, surrounded by the typical surface litter which the female used to provision the larval cell.
2. Fecal tube constructed by the larva of *P. youngi*. This tube prevented the loose sand from caving in on the larva as the litter was eaten.