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BIOLOGICAL INVESTIGATIONS ON A NEW SPECIES
OF CERATOZETES AND OF PERGALUMNA
(ACARINA : CRYPTOSTIGMATA)

BY

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The two species described here were collected in south Louisiana. *Ceratozetes jeweli* (collected in June, 1964) came from leaf litter on the Louisiana State University campus in Baton Rouge, Louisiana. *Pergalumna omniphagous* (collected in October, 1964) came from a combination of moss (Family-Tortulaceae) and fern (Family-Polypodiaceae) found growing matlike on the side of a tree in Lake Villars, Ascension Parish. The specimens were extracted by means of a standard Tullgren funnel. The holotype and four paratypes, in alcohol, have been deposited in the U. S. National Museum. The methods of preparation and observation were those of Balogh (1959).

**Pergalumna omniphagous** n. sp.

Figures 1-5.

1. **Description.**

A. Adult (Fig. 1, 3 & 5). — The average size is 0.58 mm in length and 0.39 mm in width. The color is dark brown. Alar proese area is slightly T-shaped becoming bulbous at end near margin of body; porose area \(A_1\) round and large; \(A_2\) and \(A_3\) oval in shape with \(A_3\) being smaller than that of \(A_3\). Interlamellar setae prominent with anterior half covered with small setules; rostral setae shorter than the lamellar or interlamellar setae, the latter two of near equal length; pseudostigmatic organ nearly of uniform shape with slight swelling at its tip. The cuticle is very smooth and shiny. A raised process originating near bothridium covers the dorsal half of the S line (Fig. 3). The spermatophore stalk of this species is unusually short, being no longer than the diameter of the ball of semen. It is also unusual in that

there are three supporting arms (Fig. 5) instead of the usual flanged single finger of oribatid spermatophores.

B. Tritonymph (Fig. 2). — Propodosomal shield averages 0.14 × 0.22 mm at its longest and widest points. Interlamellar setae slightly less than twice as long as lamellar setae; rostral setae approximately two-thirds the length of interlamellar setae; pseudostigmatic organ tapered slightly with its upper half covered with small hairs. A faint lamella is present on the propodosomal shield. The cuticle on propodosoma is curved ventrally giving an appearance of a suture when viewed dorsally. Notogaster overhangs propodosoma. The dorsum of hysterosoma is smooth and glabrous with one prominent setae (c₃) on anterior margin. Exostigmatic setae covered with fine setules and as long as c₃. No pygidial plate is present.

C. Larva (Fig. 4). — Larval propodosomal shield averages 0.11 × 0.13 mm at its longest and widest points. Rostral and interlamellar setae are of approximate equal length; lamellar setae minute and approximately half as long as interlamellar setae. The upper half of pseudostigmatic organ is wide and covered with small setules, while the lower half is thin and smooth. The pygidial plate is very large, almost reaching propodosomal shield. The dorsum of the hysterosoma is glabrous.
II. Biology.

A. Life Cycle. — The method used in culturing *Pergalumna omniphagous* was that of Wording and Cook (1962). Observations on the developmental stages of this species were made from October, 1964 to June, 1965. All cultures were kept continuously at an approximate temperature of 25°C. and about 90-95% relative humidity. The food consisted of what appeared to be an optimal diet for the particular species being studied. Each timed culture contained a minimum of five to a maximum of twenty individuals. The number of individuals present in a single culture tube appeared to have no effect on the average length of the life cycle.

Up to the present, species belonging to the family Galumnidae have been reared or cultured by Krull (1939), Stunkard (1944), Sengbusch (1954), and Wording (1965). Sengbusch was the first to culture galumnid mites. In the course of his study he cultured *Galumna nervosa* (Berlese, 1914) *G. longipluma* (Berlese, 1914) and *G. climatus ithacensis* Jacot 1935. The total average life cycle for egg
deposition to adult emergence was 87.2 days for *G. elimatus ithacensis*, 47.1 days for *G. nervosus*, and 60.9 days for *G. longipluma*. Woodring (1965) found the average life cycle from egg deposition to adult emergence of *G. confusa* Woodring, 1965 to be approximately 58 days; which is a much shorter time than that determined by Sengbusch (1954). *G. elimatus* sensu Jacot (1935) is synonymous with *G. confusa* Woodring (1965), and is not *G. elimatus* Koch, (1841). This difference is undoubtedly due to a difference in culturing methods. In this study, the authors found the total average life cycle time from egg deposition to adult emergence of *Pergalumna omniphagous* to be 42 days. The survival percentages for the various immature stages were virtually 100% which differed greatly from the survival percentages of 30-50% for other galumnids cultured by Sengbusch (1954) and Woodring (1965). There was very little variation in the developmental time of *P. omniphagous* at 25°C. The shortest time required for a freshly emerged female to oviposit in the presence of a male was 18 days with the longest being 21 days. Oviposition usually occurred in a secluded, protective spot. As with many other oribatids, the primary choice for oviposition in all cultures was in old exuviae. In the case of the moss-containing culture, oviposition frequently occurred in the axil of a leaf. A few eggs would be found in such places as shallow holes in the culture substrate and food piles. The percentage of eggs laid in the open was very low. There was considerable variation in the number of eggs deposited at one time the species. The number varied between one and six. Sengbusch (1954) states that oviposition in species of *Galumna* may occur in nature from spring to fall, and that in the fall it is probably correlated with temperature. The authors feel that *P. omniphagous* oviposition in the laboratory is not entirely correlated with temperature. In culturing *P. omniphagous* from December to May, egg production was slow with an average of one egg per oviposition; however, in the early part of May there was a sudden spurt in egg production with four eggs being common for a single oviposition.

**Table I.**

Length of Time in Days at 25°C. of the Developmental Stages of *Pergalumna omniphagous*.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Shortest</th>
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<th>Longest</th>
<th>No. Observed</th>
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<td>Tritopers</td>
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Spermatophore deposition would consistently occur on any clean spot on the substrate. Resembling water droplets, the spermatophores were large and possessed extremely short stalks (Fig. 3).

In the moss-containing cultures, molting nearly always occurred in the axil of a leaf. As the amount of moss present in the culture was always small, it was not uncommon to see as many as three individuals molting on one leaf. In the cultures devoid of moss, molting occurred on the open substrate, since there was no secluded or protective spot available.

Adult longevity was not determined due to the remarkable fact that all of the cultured adults are still living, the oldest being 210 days old.

B. Nutrition. — No feeding problem was encountered in culturing *P. omniphagous*. The food consisted primarily of ground, dried mushroom and the resultant fungal growth. The majority of the culture tubes used for timing life cycles also contained small amounts of moss taken from the species' habitat; however, deletion of moss from this species' diet did not appear to have any detrimental effects. The specimens in culture tubes devoid of moss had comparable life cycles times and survival percentages as those with moss in the culture tube.

This species proved to be an excellent fungivore. As few as five specimens (any stage) in a single culture tube would keep fungal growth down to a minimum as long as food was not excessive. This is the suspected reason why the number of individuals present in a single culture tube had no effect on the developmental time. This is in accordance with Woodring (1965), who suspected that uncontrolled fungal growth would impede the movements and feeding of some mite species in culture and consequently produce unreal life cycles.

The natural foods of most oribatid species are generally assumed to consist primarily of higher plant organic matter and living or dead lower plant such as algae, lichens, fungi, or moss. The question as to whether or not oribatids will eat living or dead animal tissue appears to depend on the species. Krull (1939) and Freeman (1952) noted that oribatids will eat tapeworm eggs. Riha (1951) claimed that *Hypochthonius rufulus* and *Belba pulverulenta* will become carrion feeders under starvation conditions. Graves (1960) observed large, black galumnids feeding upon dead collembola and living *Fannia*-like species of fly larva. The galumnids reportedly tore open the body of a fly larva and fed upon its body fluids while it was still alive and squirming. Hammer (1965) reported that various oribatids will feed on dead insects. Until the present, Graves' account was the only reported incident of an oribatid feeding on an active, live animal. In the process of observing the life history of *P. omniphagous*, nematode infested moss was accidentally placed into one culture. Unexpectedly the mites (all stages except larvae) were observed feeding on live nematodes. The nematodes were rather large saprophytic forms which afforded good observations of the feeding process. A mite would pick up a squirming worm at one end or middle of its body and slowly ingest it. In the case of immature stages, with a lightly sclero-
tized cuticle, the heavy, strong, chewing chelicerae and endites could be observed in the process of grinding up the nematode. The mite would continue to eat until the worm had been completely eaten. Gentle probing of the mite's hysterosoma with a minute probe would cause the mite to move, but it would seldom release the nematode from its grasp. On one occasion two tritonymphs grasped opposite ends of a nematode at the same time and a miniature tug-of-war resulted, which continued until one of the tritonymphs dropped the worm. An attempt was made to determine the average time required for a particular developmental stage of *P. omniphagous* to eat a nematode. The adult required 75 seconds; the tritonymph required 40 seconds; and the protonymph required an unexpected 20 minutes.

A preliminary attempt was made to determine the number of nematodes a small colony of *P. omniphagous* would eat in 24 hours. Thirty of the saprophytic nematodes were hand counted and placed in a colony containing three adults, one tritonymph, one deutonymph, and two protonymphs. For a control, 30 nematodes were placed in an empty culture tube. Twenty-four hours later, the culture tube containing the mites was devoid of worms while at least 30 remained active the in control tube (some worm reproduction occurred).

An attempt was also made to determine if *P. omniphagous* would eat nonsaprophytic nematodes. For this purpose, a plant parasitic form (*Tylenchorhynchus martini*) on sugar cane was obtained and placed in a colony. As with the saprophytic nematodes, all developmental stages of *P. omniphagous* (except larvae) readily ate them. It was not uncommon for a tritonymph or adult to eat two of the worms within a five minute period. The mite appeared to have a preference for the nematodes, almost always eating one when given the opportunity, even though abundant mushroom was present.

At the present, *P. omniphagous* is the only oribatid mite known to eat live nematodes. It is possible that there are other nematophagous oribatid species and that oribatids play an essential part in the biological control of nematodes. Further work on this subject is contemplated. It is interesting to note that the population density of this species of oribatid mite would not be dependent upon the population density of nematodes, as would strictly predaceous mite populations be dependent upon prey populations.

A single positive incident of an adult *P. omniphagous* eating a spermatophore was observed, but it is believed to be a fairly common occurrence. Whether these mites eat fresh or only old spermataphore is not known.

**Ceratozotes jeweli** n. sp.

I. *Description.*

A. Adult (Fig. 6 & 7). — The average size is 0.51 mm in length and 0.20 mm in width. Color is reddish-brown. The dorsum of hysterosoma is shiny. Lamel-
lar cusp is broadest at base with its tip being squared off; entire cusp is about one-third the length of lamellar setae. No translamella is present. The lamellar setae and interlamellar setae are covered with stiff short setules; interlamellar setae only slightly shorter than lamellar setae; outer margins of rostral setae are rough while inner margins are smooth. Pseudostigmatic organ has slight swelling at its tip; tip is covered with setules while stalk is smooth except for distal half of inner margin. Exostigmatic setae two-thirds the length of inter-
lamellar setae and covered with setules. Tutorium narrow with serrated upper edge and without a drawn-out point at tip. Rostral setae arise from a process. Tectopedia I extremely large, completely covering coxal opening I when viewed laterally. Tectopedia II only partially covers coxal opening. Cuspis extending to tectopedia II. Conspicuous arrow-shaped supporting apodeme reaches from coxal III opening to notogastral suture. Notogastor glabrous but with full complement of setal sockets. Alar porose area squarrish and larger than other porose areas. $A_1$ twice the size of either $A_2$ or $A_3$. Anterior notogastor with a distinct overhang.

B. Tritonymph (Fig. 9). — Propodosomal shield is $0.12 \times 0.11$ mm at its longest and widest points. Rostral and lamellar setae of near equal length; interlamellar setae twice as long as lamellar setae. Pseudostigmatic organ has a slight swelling at its tip; upper half of pseudostigmatic organ is covered with setules. Indications of lamella present on propodosomal shield. A pair of U-shaped clear areas indents the posterior margin of propodosomal shield. Pygidial plate large and bearing four pairs of setae. The hysterosomal setae not on the pygidial plate each arise from a small lightly sclerotized oval-shaped plate. A row of chitinous "buttons" in adanal position occur on venter.

C. Larva (Fig. 8). — Propodosomal shield averages $0.07$ mm $\times 0.08$ mm at longest and widest points. Rostral, lamellar, and interlamellar setae of near equal length. Head of pseudostigmatic organ is very broad and prominent.

II. Biology.

A. Life Cycle. — Up to the present, a species belonging to the family Ceratozetidae has been cultured only by Woodring and Cook (1962). They successfully cultured *Ceratozetes cisalpinus* and determined the average time from egg deposition to adult emergence to be 32 days. They found that the life cycle could be extended to 70 days by a minimum diet. The method used in culturing *C. jeweli* was the same as that used for *P. omniphagous*. Culturing and determining the average times of the developmental stages of *C. jeweli* proved to be very difficult. Being poor fungivors they did not respond well to isolation and would either die or have unreal life cycle times. A healthy culture (100 or more) was finally obtained by mixing *C. jeweli* with a healthy culture of good fungivor (*Oppia nova*). At this point, removal of the oppids had no effect on the culture, as there were enough individuals to keep the fungus cropped. To facilitate obtaining accurate and real life cycle times, groups of immature stages were placed in the *P. omniphagous* culture which was always free of excess fungi. Using this method, the survival percentages of all stages of *C. jeweli* were 90%. In an attempt to determine if fungi was the primary cause of producing death and unreal life cycle times, small groups of immature stage (usually two to six) were placed in a culture tube containing no other mites. Normal life cycle times of the immature stages (all stages) were obtained as long as the excess fungi
was removed daily by hand. Adult response to such treatment was totally different from that of the immature stages. Twelve young adults were placed in a culture tube which contained their normal food and no other mites. As with the immature stages, excess fungi was removed daily by hand. Within a week, eight were dead with two others showing symptoms of approaching death. Characteristically, the adults approaching death would lie on their backs and make feeble leg movements for approximately one day. A repeat of this experiment using young and old adults yielded similar results. At the present, the authors have no explanation for the cause of this high death rate among isolated adults.

The average length of time from egg deposition to adult emergence of this species was found to be 53 days. No one specimen consistently had the shortest or longest time for all stages.

### Table II

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Oviposition by this species nearly always occurred in old exuviae. A few eggs were found in food piles and on the bare substrate. The number of eggs deposited at one time by a female varied from one to four with an average number of two. As with *P. omniphagous*, an increase in oviposition occurred in the spring.

In a healthy colony containing a secondary substrate of fecal material and other organic matter, spermatophores resembling those of *C. cisalpinus*, were usually deposited on the sides of the culture tube. This is in accordance with Woodring and Cook (1962) who stated that *C. cisalpinus* males would only deposit spermatophores, on a clean dry surface and preferred a smooth surface.

In the old established colonies, molting usually occurred in a select spot which would result in a tremendous pile of cast nymphal skins. In the case of the immature stages, which were transferred to the *P. omniphagous* culture, molting usually occurred in the axil of a moss leaf.
B. Nutrition. — *C. jeweli* was cultured on a combination of ground, dried mushroom and chopped, cup lichen plus the resultant fungal growth. The majority of the feeding occurred on the mushroom with only slight feeding on the lichen. All developmental stages fed readily on the mushroom with the tritonymphs being the heaviest eaters. Many specimens were reared on mushroom alone and it is suspected that *C. jeweli* could have been cultured without the lichen. WOODRING and COOK (1962) stated that *C. cisalpinus* could be successfully cultured on either mushroom, lichen, or artificial diet, or any combination.

An attempt was made to determine if *C. jeweli* would eat living nematodes as *P. omniphagous* had done. On a single occasion, one adult was seen eating a live nematode; however, the authors believe this to have been a rarity. Further experimentation similar to that done with *P. omniphagous* yielded negative results.

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ABSTRACT.

All essential stages of *Ceratozetes jeweli* n. sp. and *Pergalumna omniphagous* n. sp. are described and illustrated. Both species were collected in south Louisiana. The time from egg deposition to adult emergence was 42 days for *P. omniphagous* and 53 days for *C. jeweli*. Observations on molting, egg production and spermatophore deposition are presented. Mushroom and ground, cup lichen plus the resultant fungal growth provided an adequate diet for *C. jeweli*; the same diet (minus lichen) was suitable for *P. omniphagous*. *P. omniphagous* ate saprophytic and parasitic nematodes. A review of the carnivorous habits of oribatids is presented.