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MATING BEHAVIOR OF NEMOBIINE CRICKETS— *HYGRONEMOBIUS, NEMOBIUS,* AND *PTERONEMOBIUS* (ORTHOPTERA: GRYLLIDAE)[1]

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ABSTRACT

Pteronemobius females mount and briefly couple genitalia with males that have not yet formed spermatophores. This preliminary mounting, previously unreported for *Pteronemobius* and unique among Gryllidae, is prerequisite for spermatophore production in each mating sequence. The female mounts and couples genitalia with the male a second time and receives the spermatophore. The two remain coupled for an extended period while the female feeds on specialized tibial spurs of the male. This sequence is basically the same for 10 species in 3 subgenera as follows: (*Allonemobius*) *ambitiosus* species complex 3 spp., *fasciatus, sparsalsus*; (*Neonemobius*) *cubensis,* nr. *mormonius* Florida, nr. *mormonius* So. California; (*Eunemobius carolinus, melodius.* The mating pattern of *Pteronemobius* is interpreted as derivative from one like *Nemobius sylvestris* where males form and pass a small spermatophore prior to a much larger one. After each spermatophore is passed the female often feeds on a glandular area at the base of the male's tegmen. Mating in *Hygronemobius alleni* is no more complex than in most other gryllids: courtship is brief, a full-sized spermatophore is passed during the first mounting, and behavior after spermatophore tube insertion involves no mouthing of special glandular areas and no continued coupling.

In most crickets the female mounts the male prior to copulation. A spermatophore that is formed before this mounting is generally visible at the end of the male's abdomen. The tubular process of the spermatophore is inserted into the female but the spermatophore itself remains external. Internal pressures, developed by diffusion of fluid across a semi-permeable membrane within the spermatophore, force sperm through the tube into the female (Khalifa 1949).

In some species, the female feeds at a specialized glandular area of the male following receipt of the spermatophore. The most elaborate of such areas are the metanotal glands, found in all species of Oecanthinae, some Eneopterinae and a few Gryllinae (Walker and Gurney 1967). Only members of the nemobiine genus *Pteronemobius* have a special glandular spur on the male's hind tibia (Fulton 1931), while a closely related European genus, *Nemobius,* has an apparently glandular area at the base of the right tegmen. Alexander and Otte (1967) discussed mating in *Pteronemobius* and *Nemobius* by comparing Fulton's (1931) and Gabbutt's (1954) observations with their own observations of *N. sylvestris* and *P. allardi.* Descriptions of mating of *N. sylvestris* by Richards (1952) and Gabbutt (1954) appeared the most detailed and complete but because of their complexity were difficult for Alexander and Otte (1967) to relate to mating in *Pteronemobius.* The present study reveals undetected complexity in *Pteronemobius* that simplifies this comparison. *Hygronemobius alleni,* the sole United States representative and type of this large Neotropical genus was

[1]Florida Agricultural Experiment Station Journal series no. 3653.

TABLE 1. LOCALITY, NUMBER OF OBSERVATIONS, AND LIGHTING FOR STUDY OF MATING IN 11 SPECIES OF NEMOBIINAE.

Species	Locality	Number of Matings Observed	Light** Conditions
*Pteronemobius (Allonemobius)**			
nr. *ambitiosus* 531 B	North-Central Fla.	20†	On
nr. *ambitiosus* 531 D			
nr. *ambitiosus* 528			
fasciatus	Gainesville, Fla.	2	On
sparsalsus	Cedar Key, Fla.	3	Off
Pteronemobius (Neonemobius)			
cubensis	Florida	3	Off
nr. *mormonius* 535	North & West Fla.	2	On-Off
nr. *mormonius* 527	Riverside Co., Cal.	4	On-Off
Pteronemobius (Eunemobius)			
carolinus	Gainesville, Fla.	2	On-Off
melodius	Gainesville, Fla.	2	On-Off
Hygronemobius			
alleni	Flamingo, Fla.	13	On-Off

*Vickery and Johnstone (in press) have proposed that the subgenera *Allonemobius*, *Neonemobius* and *Eunemobius* be given generic status.
**On=flourescent lighting (90 ft-c) ; Off=Westinghouse red bulb (<.5 ft-c)
†All *ambitiosus* combined

studied for comparison with *Nemobius* and *Pteronemobious* because it lacked external glandular areas like most other Nemobiinae.

METHODS

Representatives of all North American genera and subgenera of Nemobiinae were available for study (see Table 1 for list of species) and comparison with published accounts of mating in *Nemobius sylvestris* from Europe.

Specimens used in mating were reared by isolating single field collected females in wide mouth gallon jars containing about 2 inches of sand, a small cap of crushed dog food and a water vial. Water was added to the sand near the wick of the water vial to provide humidity and a site for oviposition. Penultimate and antepenultimate female nymphs were transferred to holding jars and reared to virgin adults. Calling songs of sibling males were recorded to verify the song type of each group of females. These males plus recorded field collected males, were mated with the reared virgin females.

Matings were observed of pairs confined in the following types of cages: (1) clear plastic or screen cylinders (4×4 inches) placed on moist sand, (2) wide mouth gallon jars containing about 2 inches of sand, (3) 4 inch^2 screen covered cages. The plastic or screen cylinders were used for still and motion picture photography and sound recording since once courtship began, the cylinders could be removed without disturbing the crickets.

Females walked about new containers, generally unresponsive to males immediately following transfer, whereas males began courting almost as soon as they were transferred and contacted a female. For this reason females were allowed 2 or more hr to acclimate to their new surroundings. When mating was to take place on sand, males were restricted beneath overturned 1 inch diam plastic vials in the same container with the female for the acclimation period, or they were released directly into containers with acclimated females. All observations were made in a carpeted room, lined with acoustic tile, and at 25°±2°C. Mating behavior studied under bright (90 ft-c) and very dim red light (7.5 ft-c) (Table 1) was similar, with the exception that occasionally movements the author made while observing, disturbed the crickets when the lights were on. The individuals observed or specimens from the same laboratory colonies are deposited in the Florida State Collection of Arthropods, Division of Plant Industry, Gainesville. Identifications were made by Dr. Thomas J. Walker, University of Florida.

Mating of *Hygronemobius alleni* (Fig. 1)

The following is a composite description of mating of *Hygronemobius alleni* from 4 complete mating sequences (including an analysis of 2 filmed sequences) using specimens from the original field collections of adults and nymphs and from 5 complete and 4 incomplete sequences using 6 pairs of second generation laboratory reared siblings.

When a male was allowed to move freely about the container (by removing the retaining vial) he would generally contact or be contacted by the female within 3 min. At this time most males produced a short burst of song, fenced antennae with the female, and assumed a characteristic courting position, directly behind or slightly off to one side of the female. The male's song began at the first fencing of antennae and lasted for 10

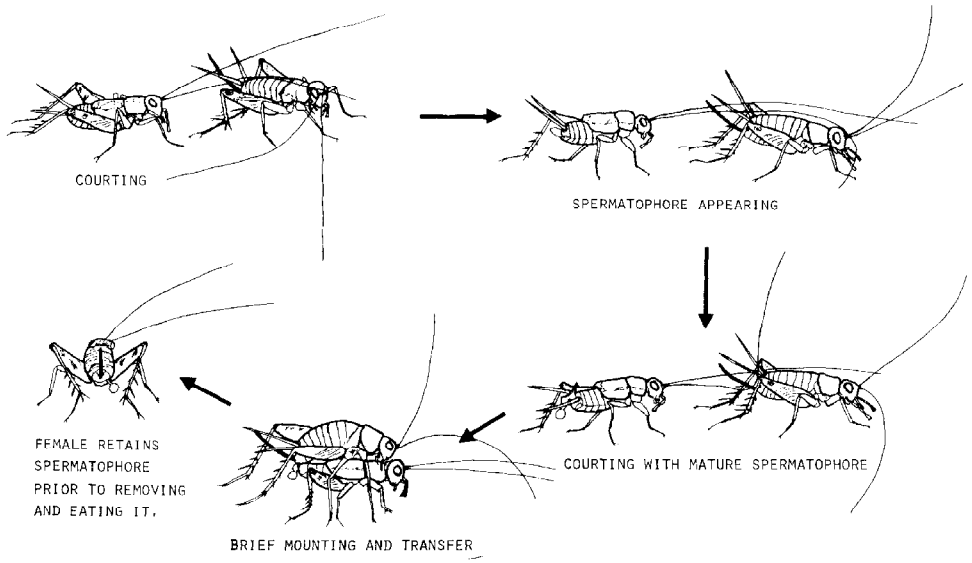

Fig. 1. Sequence of events in mating of *Hygronemobius alleni.*

sec or less. A female contacted by a male's antennae would stop, turn, and often advance toward the male as he stridulated and antennated her briefly. The male then moved behind the female and she ceased moving as he antennated her.

If the female moved from antennal range of the male, he pursued her. In one case after a 10 min chase, a male briefly walked up on a female. This male had repeatedly darted toward the female, but each time she would turn to one side and he would back off and resume antennating her.

Antennation of the female continued throughout the mating sequence and appeared to be the primary means of communication. The male lashed his antennae over the entire length of the female, particularly contacting her metathoracic legs, upturned cerci, and ovipositor. Each lash was a series of short up and down strikes of the antennae too rapid to count. Between lashings both antennae were held motionless, remaining bowed downward when contacting the female's ovipositor, cerci, or metathoracic legs, or held outward when over or lightly contacting her tegmina, thorax, head, and antennae.

The male would position himself directly behind or just to one side and antennate with an alternating left-right emphasis, giving an illusion of sweeping the antennae across the female's cerci. The ovipositor and inner margins of the cerci were frequently struck but most contact was made against the terminal portions and outer margins of the cerci, and the metathoracic legs. During a mating sequence the antennation rate (lashing episodes per min) increased (Fig. 2). The female responded to the

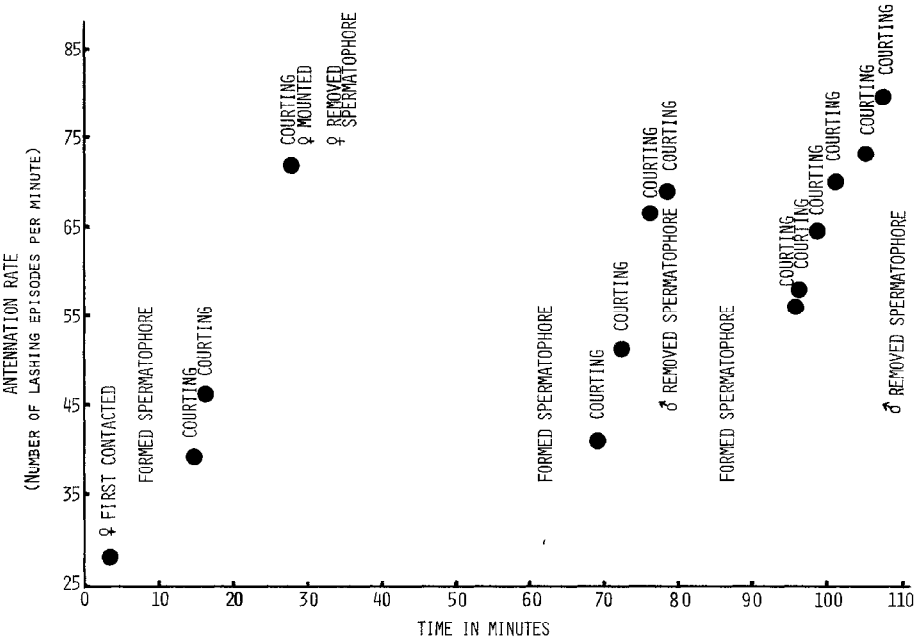

Fig. 2. Changes in antennation rate during courtship of *Hygronemobius alleni*. In the case illustrated the male completed transfer of the first spermatophore but failed with the following two.

male's antennation with a concurrent upward movement of her ovipositor and occasional rearward antennation to the male.

The spermatophore appeared 5.0, 6.0, 6.0, and 9.5 min (4 fastest sequences) after first antennal contact with the female. Holding the abdomen high, and with 5-10 pumping motions the opaque, white, pearshaped spermatophore appeared at its tip. The spermatophore was held at the distal end of the genitalia, and moved up and down as the genitalia became fully extruded. After 2 to 3 min, the spermatophore began to clear marginally, appearing as a tiny glasslike bead with a white center one-third of the total diameter. In one instance, courtship contact was loosely maintained 90 min before the spermatophore appeared, and courting continued 48 more min before the spermatophore was transferred. In situations where females appeared unresponsive and were actively walking around the cage, males occasionally removed and ate their spermatophores 15 to 30 min after formation.

The male appeared to initiate mounting 14 to 24 ($\bar{x}=18.5$, $n=6$) min after spermatophore formation by pushing forward and producing 5 to 10 soft chirps while antennating the female. In one case a male walked up to a female and palpated her cerci. She repelled him for about 3 min by slowly extending her legs backward. The male then turned around, and rocked and vibrated while stridulating in front of the female and shuffling backwards to her. When a female began to mount, the male would lower his wings. When she was directly above him he would suddenly thrust the terminal portion of his abdomen upward and transfer the spermatophore to the female. In one filmed sequence, after making an advance, a male quickly turned around in 0.11 sec (2 frames max at 18 frames/sec). Immediately the female ran up on him and coupled genitalia for 1.00 sec (18 frames) to receive the spermatophore. For most matings, the genitalia appeared to be coupled, the spermatophore transferred, and genitalia uncoupled in even less time than a second. Males bobbed their abdomens upward tapping as many as 20 times against the venter of the female before and occasionally after transfer of the spermatophore. This upward bobbing brought the male cerci into contact with the female venter and may have functioned in pair alignment. It is difficult to understand how the spermatophore tube could have been inserted into the female properly, although similar speed has been noted for *Cyrtoxipha* (Alexander and Otte 1967).

Most females (6 of 8) dismounted immediately after receipt of the spermatophore and remained motionless, as did the males, for 1 to 2 min.

Those females that did not dismount immediately remained motionless, standing upon the male. In one case, the female stood on the male for 8.5 sec. Dismounting females ran forward over the male's head or backed down the male's back. Having retained the spermatophore for 3.2 to 15.0 min ($\bar{x}=8.0$, $n=9$), females lowered their abdomens and backed up, wiping the spermatophore off against the sand. Reaching beneath themselves, females then grasped the spermatophore with their mouth parts, and spent 3.5 to 15 min ($\bar{x}=8.9$, $n=8$) consuming it. During this time the male relocated and resumed antennation of the female, frequently producing a series of 10 to 20 short chirps at 1 sec intervals usually while the female was eating the spermatophore. No other post copulatory behavior was

noted. Continued antennation by the male generally led to the beginning of another courtship sequence.

The male of 1 pair produced and transferred a sequence of 3 spermatophores with intervals of 24 and 76 min. During the hour after the third spermatophore, the male slowed and then ceased antennation of the female and walked away. Another pair coupled twice unsuccessfully, losing the first 2 spermatophores which were produced 36 min apart. A third spermatophore produced 26 min later was carried 29 min by the courting male before being removed and eaten by him. Following this, the male and female walked about the enclosure for more than 1 hr but no further courting occurred. These 2 instances suggest that a male may be able to produce only 3 spermatophores during a courtship and mating sequence.

Mating of *Nemobius sylvestris*

The following summary is taken primarily from Richards (1952, 1953) and supplemented with data from Gabbutt (1954), who apparently observed a larger number of matings. Richards wrote a description of mating as if it were a single observation, but it was likely a composite of several observations owing to the detail included.

Stridulation occurs with the first contact of a female and is accompanied by antennating and body jerking. With a "peculiar trembling gait" the male walks to relocate the female, but courts with his back toward her, yet she is not allowed to mount for 30-45 min. Gabbutt (1954) records 20 to 35 min elapsed before the female first mounts.

Just prior to the female mounting the male, the male's stridulation becomes uneven amidst violent body jerking. The female mounts the male over his lowered cerci and elytra as he pushes backwards beneath her "raising his abdomen," elevating the genital organ to the female's subgenital plate, where the spermatophore and its "fine, stalk-like tube" are transferred "instantaneously" to the female. The pair separate "at once and for a minute or so both stand motionless . . ." The male jerks backward again and the female mounts and "appears to feed on something from the male's elytra." Gabbutt described this as a resumption of male body motions and a time when the females may or may not mount and "feed" on the male's right tegmen, the whole period lasting 10 to 15 min with "feeding" occurring in only 6 of 19 cases observed. Richards' term "feeding" may better be termed mouthing since the female's labial palpae, not the mandibles are worked with a "sweeping motion" over this area. Gabbutt describes the pair separating, followed by the male pursuing the female for "as long as 15 min", followed by 5 to 15 min remaining motionless and without stridulation before a spermatophore was produced. Richards relates that this second spermatophore is "twice the size of the previous one" but Gabbutt's measurements of 0.946 mm ($\sigma_{28} = 0.016$) compared to the first 0.303 mm ($\sigma_{11} = 0.0025$) make it fully 3 times the diameter of the first.

The first spermatophore is retained by the female for 30 to 60 min before it is removed (Gabbutt). Richards notes the first spermatophore is "loosened" with the aid of spines of the female's hind tarsus before she backs over the substrate and finally rubs it off and eats it. The second spermatophore slowly "becomes translucent" around a white central core.

The male begins rapid antennation and steady stridulation while seeking the female. As before, the male courts facing away from the female, culminating in a second mating 60 to 70 min after the first. Occasionally the first and second spermatophores are carried together by a female.

Gabbutt noted "feeding movements" [mouthing] in 19 of 52 cases following transfer of the second spermatophore.

Richards doubts the receipt of the 2 spermatophores by the same female under natural conditions and even suggests "that after mating [passing the first spermatophore] the male pursues the female as if to chase her away; and, as an hour or more elapses between the 2 matings, it is more than likely that another female would normally receive the second spermatophore." However, Richards observed that when males produced a small spermatophore but were unable to mate, they would "eject" it and "devour it" and *not* produce the larger (second) spermatophore. This suggested to Richards that a preliminary sequence of events was necessary to the transfer of the larger spermatophore.

Mating in *Pteronemobius*

The genus *Pteronemobius* is unique in that males possess a proximal internal spine on each hind tibiae which is mouthed and *fed upon* by the female during a comparatively extended copulation (Fig. 2). Hebard (1913b) and Davenport (1960) recognized 3 subgenera of *Pteronemobius* for America north of Mexico. The subgenera *Allonemobius* and *Neonemobius* have unequal disto-ventral spurs on the hind caudal tibiae, the ventral margin of the ovipositor apex unarmed, and male karyotypes of 7 and 9 autosomes plus XO respectively, whereas in *Eunemobius* the spurs are equal in length, the ventral margin of the ovipositor apex is armed with minute serrulations, and the male karyotype is 3 autosomes plus XO.

Allonemobius and *Neonemobius* proved to be so similar that they are discussed here together and in contrast with *Eunemobius* from which they differ in several respects.

The Subgenera *Allonemobius* and *Neonemobius*

The following description is based primarily on observations of more than 20 mating sequences of *P.* (*Allonemobius*) *ambitiosus* (species complex), plus at least 2 complete and several incomplete sequences of the 5 other species listed in Table 1 under *Allonemobius* and *Neonemobius*.

Males respond to the first antennal contact with the female and frequently stridulate briefly while facing and antennating her. Courtship is similar throughout the mating sequences studied and is characterized by a pattern or rhythm of antennation (short bursts of rapid antennal lashing) by the male which alone appears sufficient preparation for receipt of the spermatophore by the female. The male positions himself before or just off to one side of the female and antennates her outstretched antennae. The pattern of chirps during courtship follows the pattern of antennation and is usually accompanied by a slow forward list of the body and a shift in stance without moving the legs.

Courtship songs are a series of quiet chirps. Often more widely spaced pulses begin each chirp followed by a speed up toward the end, giving the impression of an increase in pitch and intensity. One *ambitiosus* 531B

male which did not stridulate (tegmina appeared normal but physically stuck together), a male *sparsalsus*, and a male *cubensis* which stridulated very little, completed mating sequences (2 successively for the "mute" *ambitiosus* 531B) with their respective females, as rapidly and as completely as those males which stridulated more during courtship.

After contacting a female, most males did not court or courted very little prior to suddenly turning around in front of her. The following backing sequence is similar for all *Allonemobius* and *Neonemobius* studied. The male trills continuously and appears to vibrate and sway back and forth in front of the female. With the first contact by the female's palpi or antennae the trilling softens in intensity, the wings are lowered some and the male begins backing beneath the female. With this lowering of the male's tegmina, a series of grating clicks and squeaks often accompanies the final wing closure. The male backs part way under the female, but simultaneously the female often walks up on the male's back. The mounting involves both sexes actively positioning themselves with respect to each other. If no contact is made by the female, the trilling increases in intensity, but the male eventually turns around and resumes courting.

Frequently the male's claspers can be seen just prior to this mounting. The claspers are apparently inserted into the female genital opening as the 2 couple together in a manner difficult to observe in detail. The pair jump and vibrate together for 1/2 to 2 sec with their genitalia firmly attached. The male is probably responsible for the jumping since he has more contact with the substrate. The pair separate in an almost violent explosion with the female bouncing upward and forward off the male's back. If the female does not mount the male in a way such that the genitalia couple, or the pair is disturbed during this phase, this process is repeated. In several instances this first mounting was repeated until the pair maintained a firm attachment of their genitalia and "jumped" together briefly without separation. This first mounting and coupling (first in a series of 2) is very brief yet it is a prerequisite for spermatophore formation and transfer. There was no instance of spermatophore formation without the male first being mounted by the female. This first mounting was repeated prior to the production of each subsequent spermatophore in all repeat matings ($n>15$).

The male resumes courting the female following the first mounting and approximately 5 to 10 min later he forms a spermatophore. Raising his abdomen high and with a great deal of abdominal pumping, the pear-shaped spermatophore is first extruded straight backward. With additional pumping and pulsing of the abdomen, the spermatophore (carried at the proximal portion of the male's genitalia) extends downward as the genitalia are fully protruded. This extrusion of the spermatophore may or may not be accompanied by the courtship type song. Courtship continues as the male faces the female's head or side and antennates her on her outstretched antennae. Within 1 or 2 min the spermatophore becomes round and in 5 to 10 min the outer two-thirds clears.

If the female leaves the vicinity, especially after the spermatophore has been formed, the male produces a trill which appears louder than either the calling or courtship song. Generally this loud "courtship interruption" song (Alexander 1962) arrests or attracts the female, enabling the

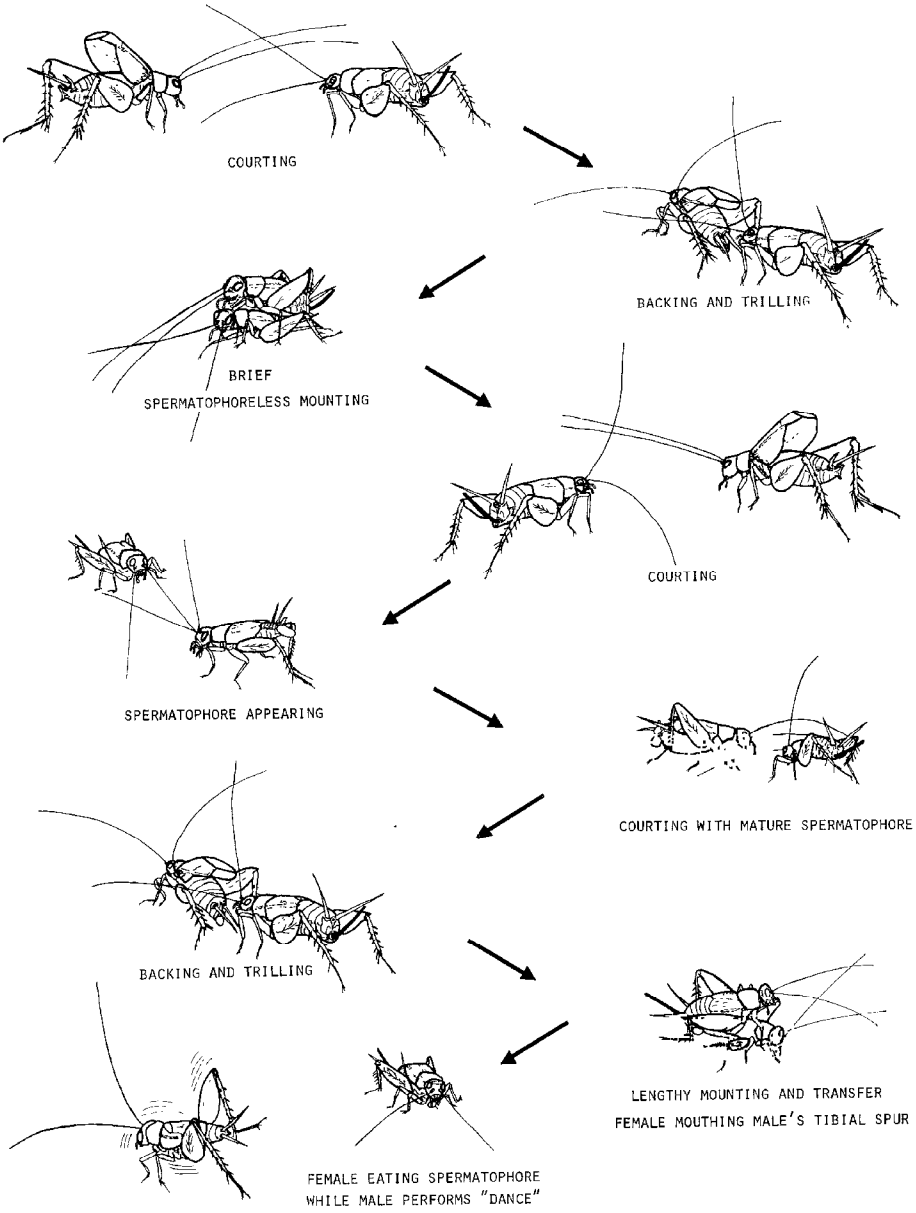

Fig. 3. Mating sequence in *Pteronemobius* subgenera *Allonemobius* and *Neonemobius*. Mating sequence in subgenus *Eunemobius* differs only slightly (see text) from the basic pattern shown here.

male to resume courting. If the female cannot be located, the male eventually removes the spermatophore with his hind tibia and eats it. After approximately 20 to 40 min of courting with the spermatophore (by this time it has darkened somewhat), the male turns around and trills continu-

Fig. 4-5. Specialized tibial spur of *Pteronemobius* nr. *ambitiosus* 531D. Fig. 4—Spur of virgin male with unmodified spur in background (200X). Fig. 5—Tip of spur which has apparently been opened by the female's mandibles during mating releasing the exudate (1200X). (Scanning electron micrographs made at Insect Attractants, Behavior and Basic Biology Research Laboratory, USDA, Gainesville, Fla. Courtesy P.S. Callahan, T. Carlysle and T. J. Walker).

ously, vibrating and swaying back and forth in front of the female much the same as before. The female mounts as the male pushes under and upward with his abdomen, finally engaging the female's genitalia. A pair usually remains coupled for 20 to 30 min. Shortly after coupling (0 to 5 min) the male brings 1 or both metathoracic legs forward and close beside his body. Now in an unnatural appearing posture, the internal proximal area of the tibia is in a position to be mouthed by the mounted female. Mr. Alberto Broce (1969 personal communication) examined the internal proximal tibial spurs of virgin and laboratory-mated males. In every instance where females mouthed the tibial region, the outer most portion of this spur was absent, whereas, the spines of unmated (virgin) males remained entire. Evidence of active chewing damage to a spur and the resulting exudation of a glandular substance, apparently fed upon by the female, is illustrated in Fig. 4-5. Field collected males of *P. ambitiosus* (species complex) have more than 80% of their glandular tibial spurs damaged to this degree apparently as a direct result of females chewing and feeding on them during mating.

Mouthing of the spur area continues the entire time the female is mounted. She may mouth the pronotum-head area briefly in switching across to the opposite tibial spur, which may not have been brought forward yet. The pair disengages genitalia usually after the female walks off to one side. Occasionally the pair may remain motionless for a few min coupled in an end to end position prior to separation and female retention of the spermatophore. This end to end position appeared more often in the subgenus *Eunemobius* discussed below.

Upon separation, the male frequently jumps and jerks in sudden bursts. This "dance" was absent from the *sparsalsus* and *cubensis* mating sequences and in some of the mating sequences of the other *Pteronemobius* (*Allonemobius-Neonemobius*) species.

Following the dance, the male produces a long trill (similar to "courtship interruption"), a short series of chirps, or no sounds at all. Five to 10 min after uncoupling, the female removes the spermatophore by wiping it against the sand while backing up, and kicks at it with her hind legs. The female then searches the sand, recovers the spermatophore, and eats it. Some sort of male stridulation (calling, courting, or even "courtship interruption") is usually produced while the female eats the spermatophore. As soon as the female contacts the male (antennation) he begins to court. This marks the beginning of another mating sequence enacted exactly as before (including a spermatophoreless first mounting).

The Subgenus *Eunemobius*

The mating behavior of the 2 available species of *Eunemobius* (*melodius* and *carolinus*) is based on 2 complete and 2 incomplete sequences from each species. *Eunemobius* differed from the *Allonemobius-Neonemobius* studied in the following 7 ways. (1) The male stands in front of and faces away from the female during most all courtship phases. Antennation by the female apparently keeps the male stationary in 1 place. The male does occasionally antennate the female but usually during an initial encounter, when she is being pursued after leaving the male's vicinity, or occasionally when the male walks around the female during early stages of courtship. (2) Males appear to "'dance" (jerking and swaying) in front of the female for a longer period prior to the first mounting. (3) During the first mounting, pairs coupled and jumped together violently at first, remaining mounted and connected considerably longer (20 sec for *carolinus* [n=1] and 14 sec for *melodius* [n=1]). The pair of *melodius* remained connected end to end for an additional 12 sec. (4) The spermatophore does not hang downward, but rather is tucked up against the venter of the male's abdomen during courtship. The abdomen is held low ($<30°$) with the legs extending nearly straight backward compared with the abdomen held high ($>30°$) and the legs bent at right angles in *Allonemobius* and *Neonemobius*. (5) The male stridulates almost continuously during courtship. (6) The male's metathoracic legs are held wide out to the side during the second mounting. (7) The second mounting (spermatophore transfer) in a single *P. melodius* mating involved 10 min of spur feeding followed by rotation to an end to end position held for 20 min; resumption of spur feeding for 25 more min followed rotation to end to end for at least 5 min prior to breaking genital contact. In a single *P. carolinus* mating the female began to rotate off the male after feeding on his spur for 33 sec, and eventually ended up making 3 1/4 complete 360° rotations to the left without ever uncoupling genitalia with the male! Both of these instances may represent atypical matings, yet are mentioned here because they contrast with the observations of *Allonemobius* and *Neonemobius*.

Discussion

The significance of a *Pteronemobius* female mounting the male,

coupling briefly, and dismounting prerequisite to his producing a spermatophore is suggested through comparison with mating behavior in *Nemobius sylvestris* and *Hygronemobius alleni*. Nemobiine crickets that possess external glandular areas mouthed during mating (*N. sylvestris* and *Pteronemobius*) appear unique among gryllids in both the types of glandular structure and the length and complexity of the mating sequence. The mating system of these crickets appears derivative from the quick and simple mating systems represented by glandless *H. alleni* and presumably most other Nemobiinae.

Evolution toward fewer spermatophores with more safeguards that the female will be fully inseminated may explain the origin of glandular areas in *Nemobius* and *Pteronemobius*. The first mounting in *Pteronemobius* appears homologous to that in *Nemobius*, both being necessary for production of a large spermatophore. In *Nemobius* the spermatophore passed during the second mounting is 3 times the diameter and therefore 27 times the volume of the first. In *Pteronemobius* only the second mounting involves passage of a spermatophore. Female *Nemobius* do not always mouth the glandular areas at the base of the male's tegmina during each mount yet in *Pteronemobius* the glandular tibial spine is chewed upon extensively, but only during the second mount.

The extended coupling and spur feeding in *Pteronemobius* may function in allowing sufficient time for complete emptying of each spermatophore and keeping the female in the male's vicinity for another courtship sequence. Yet in *Oecanthus* (feeding on metanotal glands) and *Nemobius* (mouthing at the base of the right tegmen) females receive spermatophores during a brief coupling and then proceed to feed or mouth the glandular areas at length without the engagement of the genitalia. The 30 sec coupling *Acheta* and *Gryllus* was described by Alexander and Otte (1967) as necessary to complete the threading of the spermatophore into the female. This may instead be analagous to a post copulatory (i.e., post spermatophore tube insertion) act, holding the female as the spermatophore begins to empty. In *Oecanthus* and *Nemobius*, metanotal glands and glandular tegmina respectively serve this post copulatory function. *Pteronemobius* most certainly does not require 20 to 30 min to complete a threading process that is accomplished by *Nemobius* and *Hygronemobius* in a few seconds. Perhaps examination of the female spermatheca in both *Gryllus* and *Pteronemobius* will distinguish a copulatory act (coupling genitalia with spermatophore tube insertion) from a post copulatory-like adaptation (genitalia remaining engaged) that promotes full insemination. The 10 species of *Pteronemobius* studied here and *Nemobius sylvestris* show other similarities. Males of *Pteronemobius* subgenus *Eunemobius* court with their tails toward the female's head as in *N. sylvestris*. Actions of males searching for females that have left during a courtship sequence are amazingly similar. I believe Richards (1952) misinterpreted the actions of a *N. sylvestris* male when he wrote " . . . after mating [first mount] the male pursues the female as if to chase her away. . . .", because similar actions were performed by *Pteronemobius* males following disturbances (by the observer) of the females they were courting. The males chirped loudly and followed the females around the cage apparently in an effort to re-establish contact. When contact was re-established the males resumed quiet courtship tones.

Comparing *Pteronemobius* with *Nemobius sylvestris* leads to a highly probable interpretation of the evolution of the first mounting (without a spermatophore) in *Pteronemobius*. In the *Pteronemobius* matings I have observed, spermatophore production was always preceeded by the female mounting the male and their coupling genitalia briefly. The sequential nature of *Nemobius* mating (small spermatophore passed before the larger one is formed) suggests that the first may be of little or no value in inseminating the female and resembles a logical precurser of the *Pteronemobius* system. Using *Nemobius sylvestris* and *Hygronemobius alleni* to explain the origin of the spermatophoreless mount in *Pteronemobius* may be presumptuous in the absence of knowledge of mating in any other nemobiine genus. The possibility that a similar spermatophoreless mount occurs in *N. sylvestris* is supported by Richards' (1952) statement that the female ". . . makes several attempts to mount. . ." the male 30 to 45 min prior to passage of the first spermatophore. Could a brief spermatophoreless first mount have been overlooked in *N. sylvestris* as it apparently was for *Pteronemobius* by Fulton (1931) and Alexander and Otte (1967)?

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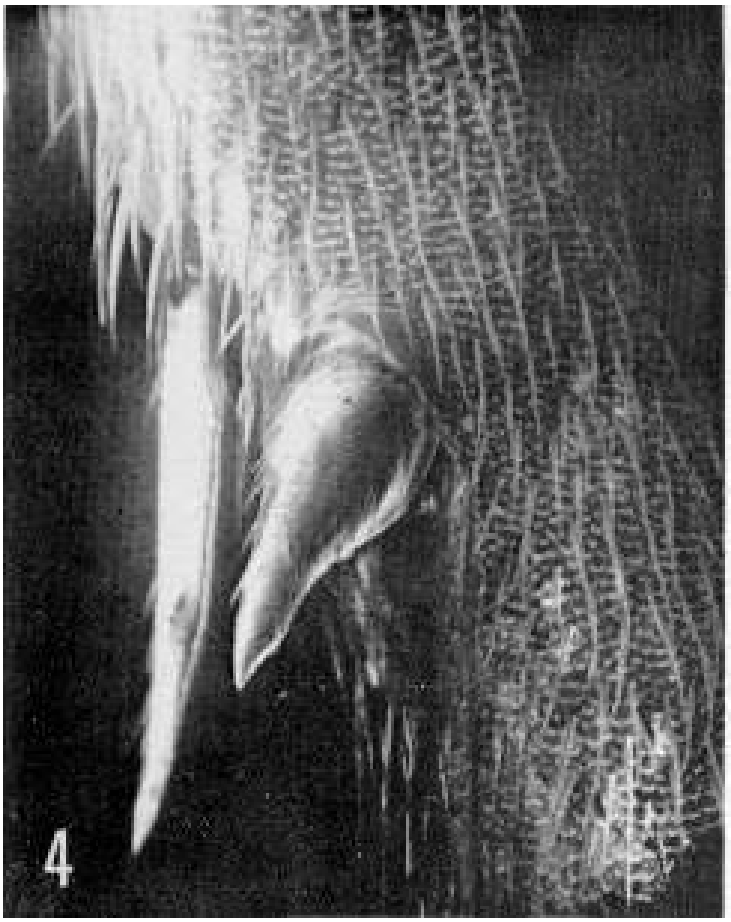
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MICROFAUNAL POPULATIONS ON GLADIOLUS CORMS[1]

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ABSTRACT

The most common microfauna on field grown gladiolus in Florida included 3 species of mites, *Lasioseius subterraneous* Chant, *Rhizoglyphus robini* (Claparede), and *Histiostoma feroniarum* (Du four), an enchytraeid worm, and nematodes. These organisms appeared to be predators, saprophytes, or scavengers and fed on diseased and decayed plant tissue. Populations developed apparently in response to either disease increase or to precipitation. Disease symptoms increased with increased precipitation. Infestations appeared from sources outside the soil since attack was initiated from above ground in the neck region of the host before proceeding to the corm. Corms grown in a greenhouse in sterile soil became infested with the same species as field grown plants.

Flower crops that begin as underground rhizomes, bulbs, or corms provide an ideal microcosm below the soil for many organisms. Subterranean environments possess a high relative humidity and have minimal temperature fluctuation, while stored food material within the plant serves as an abundant and nutritious energy supply. Many soil inhabiting worms, nematodes, mites, and insects frequent this microcosm and feed upon the plants, fungi, or dead tissues. Many species of fungi and bacteria are resident flora and some attack roots and stems to bring about disease and decay. *Gladiolus grandiflorus* corms grow in such a microcosm, and populations of pests and pathogens attacking the crop are often cause for concern.

Conditions conducive to pest population development on gladiolus corms are often ill-defined or unknown. At certain times 1 or more species becomes abundant and causes corm damage. Kelsheimer (1955) reported excessive damage by nematode populations. During warm weather *Fusarium oxysporum* f. sp. *gladioli* (Massey) may become a problem, while in cooler weather *Botrytis gladiolorum* Timmermans, *Stromatinia gladioli* (Drayt), or *Stemphylium* sp. may be the major disease concern (Magie et al. 1966). *Pseudomonas marginata* (McCull) and *Curvularia* sp. are more abundant in warm wet weather (Magie et al. 1966).

Pathogen infested planting stock provides excellent medium for species of saprophytic and scavenger organisms. Several species of saprophytic mites are commonly found in association with bulbous crops and have been suspect as primary vectors of disease organisms, as primary pests of the plant itself, or as secondary saprophytes feeding on diseased tissue.

A case for saprophytic mites being primary pests of plants was given by McDaniel (1931) who stated that *Rhizoglyphus hyacinthi* (Banks) preferred solid, healthy gladiolus corms and avoided wet, decayed corms. These mites fed and "inoculated" healthy corms with bacteria inducing rot. Bald and Jefferson (1952) incriminated *R. rhizophagus* Banks as a serious primary pest of gladiolus and Jefferson et al. (1956) suggested that *R. solani* Oudemans might be a primary pest of gladiolus. Forsberg (1959,

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1965) associated *R. echinopus* (Fumouze and Robin) with bacterial scab and stated that the scab causing organism, *Pseudomonas marginata* (McCull), was transmitted by the mite. Control of mites reduced the incidence of scab but led to high incidence of Stromatinia rot, a more serious threat to commercial gladiolus production.

Young (1954) indicated that scab did not reduce the flower productiveness of gladiolus corms but did reduce market sale value of corms. Florida growers harvest and store corms and cormels, and the sale of corms is minimal. Consequently in Florida scab is not considered as great a threat as in areas where corms are grown for sale and not for flower production. Although Kelsheimer (1956) did not list the bulb mite complex as pests of gladiolus corms, recent attention has been given this problem on recropped lands where pathogens and mites are present (Engelhard 1967, Engelhard and Overman 1968).

Corms are universally contaminated with disease organisms as a result of repeated plantings of cormels to obtain flower producing size corms. It is almost certain that no stock is pathogen free (Roistacher et al. 1957, Engelhard and Overman 1968). In spite of planting stock being pathogen contaminated, Engelhard (1969) believes that *Rhizoglyphus* mites are important vectors that transmit scab organisms in Florida. Woodring (1963) is of the opinion that this group of mites are saprophytic scavengers and feed only on rotting tissue, bacteria or fungi. Transmission of pathogenic organisms would thus be secondary as would be their status as pests.

Examination of corms grown in Florida's sandy soils showed that infected or diseased corms in any state of decay were often infested with mites. However, corms without disease symptoms were not mite infested. The experiment reported herein was conducted in the fall, 1969, in an attempt 1) to establish the identity of mite populations on gladiolus corms; 2) to clarify the role of pathogens and arthropods in the soil microfaunal complex; 3) to gain insight into environmental parameters influencing population development; and 4) to determine which arthropods are primary and secondary pests of corms and whether they are of sufficient importance to warrant special concern in the development of control procedures.

Materials and Methods

One hundred 2-inch diam. (Jumbo) 'Valeria' corms were examined and found free of arthropods, before planting in plots of 10 corms each in Leon fine sand under field conditions and in sterilized flats of sand in a greenhouse. Beginning 4 weeks after planting, 1 corm was removed weekly from each plot for 10 weeks and examined under low power magnification. Specimens were mounted on glass slides and identification was made or confirmed under higher magnification (100 X). In some cases identification was provided by the Bureau of Entomology, Division of Plant Industry and Consumer Services. Presence of 10 or more individuals of different stadia of the same species constituted a population. Actual numbers were recorded when fewer than 10 individuals were present. Pathogens were identified by symptoms. Weather records, ambient tempera-

tures, and rainfall, were kept throughout the growing period on a hygrothermograph maintained by the U. S. Weather Bureau on the farm.

Results and Discussion

The organisms recovered from corms during the study, their location and role, and frequency of occurrence are listed in Table 1. Only *Rhopalosiphum rufiabdominalis* (Sasaki), an aphid, fed directly on the corm. All other organisms appeared to be scavenging on rotting tissue, feeding on the disease organisms, or preying on 1 or more of the scavenger/saprophytic species.

TABLE 1. Organisms recovered from 'Valeria' gladiolus grown in Leon sand in Florida.

Organism	Taxonomic affiliation	Site on host	Role	Frequency of occurrence
Enchytraeidae	Annelida	neck, corm	Scavenger	>50
Histiostoma feroniarum	Acarina Anoetidae	neck, corm	Saprophyte	>50
Lasioseius subterraneus	Acarina Ascaidae	neck, corm	Predator	>50
Nematodes	Cephalobus	corm	Scavenger	>50
Parasitidae	Acarina	neck, corm	Predator (?)	10
Poduridae	Collembola	neck, corm	Scavenger (?)	50
Rhizoglyphus robini	Acarina Acaridae	neck, corm	Saprophyte Scavenger	>50
Rhodacarus sp.	Rhodacaridae	corm	Predator	2
Rhopalosiphum rufiabdominalis	Aphidae	corm	Primary feeder	4
Scatopse fuscipes	Diptera	corm	Scavenger	1
Staphylinidae	Coleoptera	corm	(?)	10

Fig. 1 and 2 show maximum, average, and minimum ambient temperatures and precipitation for each week during the sampling period. One inch or more rainfall occurred during weeks 1, 4, 6, and 8 of the sampling period. Ambient temperatures fell to or below freezing on 2 occasions, but minimal temperatures were usually several degrees above freezing.

The greatest number of plants was infested with an annelid worm of the family Enchytraeidae (Table 2). These worms were small, not more than 2 cm long, pearly white to opaque, and were feeding on rotting tissue either in the neck region at the soil line or on corms. According to W. J. Harman (personal communication) members of this family of Annelida are associated with plant diseases caused by other organisms. Enchytraeids are apparently scavengers on bulb or root crops and are inhabitants of leaf litter and soil where decayed tissue is present. Their scavenging activities may aid in cleaning up necrotic plant tissue on gladiolus. This worm has not heretofore been reported on gladiolus corms in Florida.

TABLE 2. FREQUENCY OF ORGANISMS ON 'VALERIA' GLADIOLUS CORMS.

Organism	Plants affected (n=100) Field No. or %	Greenhouse No. or %	Week of highest incidence for field grown corms
Enchytraeidae	70	52	4
Stromatinia	67	70	6
Pseudomonas marginata	59	45	8
Mites (species listed below)	48	27	7,9
Lasioseius subterraneous	33	12	9
Rhizoglyphus robini	13	7	4,7
Histiostoma feroniarum	2	8	6
Nematodes (Saprophytic)	39	21	3,6
Stromatinia +			
a) Enchytraeidae	45	37	6
b) Nematodes	34	14	9
c) Mites	29	17	6
Pseudomonas +			
a) Saprophytic mites	14	12	9,10

Neck rot (*Stromatinia*) and scab symptoms occurred on more than half the plants, with the next largest numbers of plants infested by mites and nematodes (Table 2). Field grown plants showed a higher incidence of all organisms (except Stromatinia) than plants grown under greenhouse conditions. The greatest incidence of all organisms occurred during weeks with 1 inch or more rainfall or during the week following rainfall. This was particularly true of diseases which have long been associated with wet weather. Mite infestation (*Rhizoglyphus*) was more widespread 4 to 7 days following heavy rainfall. Highest infestations of worms and pathogens were found during weeks of high rainfall; however, mite infestations showed a lag and appeared higher the following week.

Three species of mites were commonly found on the plants (Table 2). *Lasioseius subterraneous* Chant (Ascaidae) appeared most common on both field grown and greenhouse grown plants. *Lasioseius* preyed upon other mites but was found on corms in the absence of any observed prey species. *Rhizoglyphus robini* (Claparede) (Acaridae) occurred most often on field grown plants but *Histiostoma feroniarum* (Dufour) (Anoetidae) occurred most often on greenhouse grown plants. Numbers of infested corms are shown in Table 2. The presence of *Lasioseius* on many plants, both infested and free of prey mites, suggests it is a soil dweller and extremely mobile in searching for prey. This species might be able to feed on fungus as an alternate host but the relationship is not firmly established. A second mesostigmatid mite, an unidentified species of Parasitidae, occurred infrequently and in low numbers on some plants. *Rhizoglyphus* mites were found feeding on decaying tissues on corms and in neck areas. *Histiostoma* appeared in association with moist lesions on corms but rarely on necrotic areas of the neck.

TABLE 3. INDIVIDUAL OCCURRENCE OF PESTS ON 'VALERIA' CORM FOR 2 SAMPLING PERIODS

	No. of plants affected (n = 20)			
	Week 5		Week 10	
Organism	Field	Greenhouse	Field	Greenhouse
Stromatinia nect rot	2	3	7	4
Pseudomonas scab	2	4	3	3
Mites	0	0	0	0
Worms	0	0	0	0
Nematodes	0	0	0	0

Table 2 also shows the incidence of visible pathogen symptoms associated with pest species and Table 3 shows the occurrence of one without the other. Worms were most abundant and appeared most often associated with neck rot; nematodes (*Cephalobus*) were next largest in numbers, and then mites collectively. Scab and mites were associated on less than 25% of corms but almost as often on greenhouse plants as on field plants.

Of the 20 corms examined at the 5 and 10 week interval (Table 3) none were found to have mites, worms, or nematodes without also showing symptoms of fungus or scab. The converse was not true since a low number of corms were diseased but did not have associated pests. This suggests that corms develop pathogenic symptoms (lesions, rot), then become attractive to the saprophytic organisms. Worms were always found feeding in decayed tissue; mites were sometimes found crawling about on corms, but populations (10 or more individuals) were always associated with necrotic tissue or scab lesions (Table 5).

TABLE 4. LOCATION OP PESTS ON THE HOST AND THE NUMBER OF CORMS AFFECTED (n = 20)

	Mites										Worms									
Location	Week Number										Week Number									
on Plant	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Neck	1	0	3	6	7	4	3	1	0	1	6	12	8	14	13	14	8	9	3	2
Corm (Top)	0	0	0	1	1	3	8	5	8	6	0	0	9	11	8	5	5	5	3	5
Corm (Bottom)	0	0	1	1	0	2	0	3	3	4	0	0	5	5	0	3	0	4	2	2

Table 4 shows the location of the pest on the plant and the number of plants affected per week for the combined growing period. Worms were found the first week and in greater numbers in the neck region. After 3 weeks worms were recovered from the top and bottom portions of the

TABLE 5. NUMBER AND LOCATION OF POPULATION* OF PESTS ON GLADIOLUS CORMS AND WEEKS OF OCCURRENCE.

Location	Mites		Worms	
on plant	No.	Week	No.	Week
Neck	1	6	6	3,4,5,7,8,10
Corm (Top)	4	4,6,9,10	4	4,5,8,10
Corm (Bottom)	3	4,6,10	1	6

*Population = 10 or more individuals of a species.

corms. Mites occurred first on the neck regions but later became more frequent on corm tops. The least mite infestation occurred on the bottom of the corm.

Distribution data of Table 4 indicate the infestation of worms and mites began in the neck region near the surface of the ground and proceeded downward, probably in response to moisture levels and disease development. During cooler, drier weather more pests were found on the upper and lower portions of the corm. These data suggest that mites and worms are invading fields from an outside source and beginning their feeding on the upper regions of the plant or migrate from the soil to the neck region to initiate feeding on the diseased tissue.

Distributions of populations of 10 or more individuals on gladiolus plants are given in Table 5 along with the week of occurrence. In only 1 week did a population of mites occur in the neck region; populations appeared most often on the corm top or bottom. This is in contrast to the worm populations which developed most often on the neck and corm top.

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DESCRIPTION OF *EREYNETES* (*ANEREYNETES COENOBITUS* N. SP. (ACARINA: EREYNETIDAE) ASSOCIATED WITH THE HERMIT CRAB[1]

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ABSTRACT

Ereynetes (*Anereynetes*) *coenobitus* n. sp. is described and illustrated. The species is associated with the land hermit crab, *Coenobita clypeatus* (Herbst), from Puerto Rico.

The present paper describes a new species of *Ereynetes* (*Anereynetes*) collected from the land hermit crab, *Coenobita clypeatus* (Herbst), from Puerto Rico, the first record of an Ereynetinae from this geographic area. *Ereynetes* mites are generally free living or associated with insects, and the species described below is the first record of an *Ereynetes* associated with a crustacean. However, members of the small Ereynetine genus, *Riccaroella,* are associated with snails.

Thirty species (9 from North America, 21 from Europe) have been listed in the genus *Ereynetes* Berlese (subfamily Ereynetinae). The genus may be briefly characterized as follows: integument finely striate-punctate; an anterior and a posterior pair of barbed sensory setae present; palpi simple, 5-segmented; subcuticular propodosomal plate usually present; dorsolateral propodosoma with lenslike or pigmented eyes in integument, or eyes absent; legs I to III 6-segmented, legs IV 7-segmented. Males with a sclerotized aedeagus and 3 pairs of small, barbed setae in a genital vestibule. *Ereynetes* has been divided into 5 subgenera (Fain, 1964) as follows: *Ereynetes*—1 or 2 dorsal plates, lenslike eyes present; *Opsereynetes*—1 dorsal plate; pigmented eyes present; *Anereynetes*—1 or 2 dorsal plates, eyes absent; *Gymnereynetes*—dorsal plate absent or vestigial, eyes absent; and *Huntereynetes*—a single large propodosomal plate extending over the anterior part of the opisthosoma, ventral adanal setae (CN) vestigial or absent.

In the following description, dorsal setal nomenclature follows Hunter and Cross (1968).

Ereynetes (*Anereynetes*) *coenobitus* new species
Fig. 1-10

This species is unique in the following characters: dorsal setae CF equal in length to anterior sensory setae (CB); setae CI longer than posterior sensory setae (CK); cheliceral stylets long, equal to, or longer than, fixed digit.

FEMALE. Holotype. Widest at level of dorsal setae CF. *Dorsum.* Sub-

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[1]University of Georgia College of Agriculture Experiment Stations, Journal Series Paper No. 927, College Station, Athens.

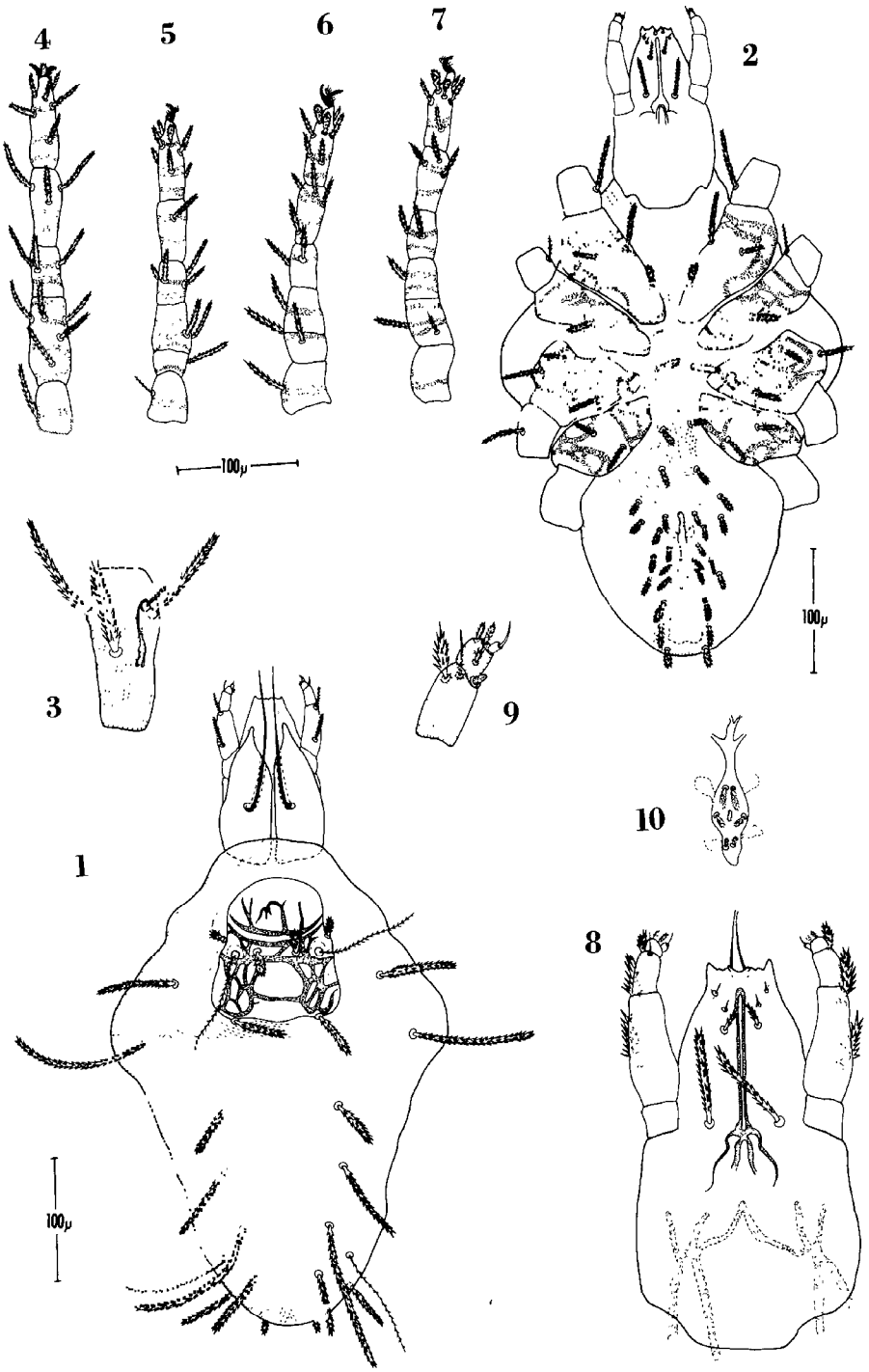

Fig. 1-10, *Ereynetes* (*Anerynetes*) *coenobitus* n. sp. Female: 1. dorsum; 2. venter; 3. tibia I; 4-7. legs I to IV respectively; 8. gnathosoma (venter); 9. tarsus, tibia, and genu of palpus (ventral view). Male: 10. genital area.

cuticular propodosomal plate of a general rectangular shape, not extending posterior of setae CE; pattern of plate as illustrated (Fig. 1). Eyes absent. Body striations as shown. Setae CC slightly longer than setae CA and arising in line with base of anterior sensory setae (CB); setae CF equal to or slightly longer than CB; setae CI longer than posterior sensory setae (CK); except for sensory setae, dorsal setae thick and heavily barbed, relative lengths and thickness as shown; dorsal chaetotaxy 2-4-4-2-2-2-4-2, setae CN arising ventrally in mounted specimens. *Venter* (Fig. 2). Setae thick and strongly barbed; coxal chaetotaxy 3-1-3-2; coxal setae and intercoxal setae of varying lengths, as illustrated; coxae I and II separated from coxae III and IV by narrow strip of integument. Integumental striations forming V-shape pattern between anterior part of coxae I, posteriorad striations are longitudinal between coxae; striation pattern over remainder of venter as shown. Ten pairs (5 lateral, 5 medial) of genital setae; lateral setae approximately same length as medial setae; 2 pairs of genital suckers present. *Legs.* Ereynetal organ of tibia I not bulbous, enlarged portion approximately same width throughout, walls thickened (Fig. 3). Duplex setae consisting of thickened, barbed, normal leg seta (seta ae) and much shorter, sparsely pectinate second seta (seta x) about one-third length of seta ae. Seta on trochanter II minutely pectinate, other leg setae strongly barbed (Fig. 4-7). *Gnathosoma.* Venter (Fig. 8) bearing 2 pairs of thickened barbed setae, posterior pair 3 to 4 times length of anterior pair, and 2 pair of minute, nude setae at anterior tip of gnathosoma. Peritremes visible internally. Palpal femur bearing 2 barbed setae dorsally; chaetotaxy and setal type for genu, tibia, and tarsus as in Fig. 9. Chelicera consisting of long needlelike piercing (ventral) digit equal to or longer in length than bulbous, fixed (dorsal) digit (Fig. 1).

MALE: General characteristics of dorsum, legs, and gnathosoma as in female. Venter as in female except for male vestibular genital area which bears 3 pairs of vestibular genital setae of unequal lengths (Fig. 10), vestibular setae distinctly smaller than medial genital setae.

IMMATURE STAGES. Not available for description.

Type series consisting of 7 females and 5 males from land hermit crabs, *Coenobita clypeatus,* collected in Puerto Rico, February 1968, and maintained in a terrarium at the University of Missouri, Columbia, Missouri, USA. Mites were collected from these crabs in August 1969 by S. L. Poe. Type deposition as follows: holotype, 4 females and 3 male paratypes in the Acarology Collection, Department of Entomology, University of Georgia, Athens; 1 paratype of each sex in collection of junior author; 1 paratype of each sex, United States National Museum, Washington, D. C.

BIOLOGY

Ereynetes (Anereynetes) coenobitus n. sp. was found associated with the land hermit crab, *Coenobita clypeatus,* in a terrarium maintained at the University of Missouri, Columbia, Missouri. The crabs were originally collected from Puerto Rico in February 1968. Three crabs (2 approximately 2" long and a third about 3" long) occupied the terrarium. Several sizes of snail shells were strewn on the sand in the terrarium and

each crab occupied one of these shells. Mites were found only inside inhabited shells, suggesting a relationship with the crab and not with snail shells. Mites moved freely on the crabs and from crab to shell but not onto the sand. The mites ran freely over the rostrum, carapace, eyes, bases of the antennae, and the proximal segments of the walking legs when the crabs were motionless and extended from the shell; however, when the crabs began to move, mite activity diminished. Mites were not observed to move distad of the third leg segment. When the crabs were handled (i.e. placed on, or removed from, the stage of a dissecting microscope), the mites rapidly disappeared into the hidden recesses of the shell. This was particularly noticeable when the crabs were examined in bright light.

Body color of the mites ranged from pale pink to light beige or white depending on the sex and stage of maturity; juveniles generally were lighter in color. Because of their pale color, motionless mites were often mistaken for sand particles which were also common on the crabs.

The larger crab appeared to have the largest mite population (about 30 individuals). The rapidity of movement by the mite and the seclusion offered by the crab and shell made accurate counts impossible.

No mites were observed feeding; however, on one occasion several mites were found clustered on a crab near a moist area at the junction of the gill filament and maxilliped and appeared to have their mouth parts immersed in the collected fluid.

Literature Cited

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Hunter, P. E., and E. A. Cross. 1968. Key to North American Ereynetinae and description of a new species (Acarina: Ereynetidae). J. Georgia Entomol. Soc. 3:154-158.

PARASITISM OF ARMORED SCALE INSECTS IN COMMERCIAL FLORIDA CITRUS GROVES[1]

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ABSTRACT

A 27 grove survey, 1960 to 1970, of armored scale insects on the leaves of Florida citrus trees has shown the predominant species in descending order of abundance to be Glover scale, *Lepidosaphes gloveri* (Packard); chaff scale, *Parlatoria pergandei* (Comstock); purple scale, *Lepidosaphes beckii* (Newman); yellow scale, *Aonidiella citrina* (Coquillet); and Florida red scale, *Chrysomphalus ficus* (Ashmead). These species have occurred at noneconomic levels since 1964. Data indicate that parasitic hymenoptera, a parasitic fungus, and unknown mortality factors are probably responsible for these noneconomic populations.

Within the past 25 years, presumably endemic hymenopterous and fungal parasites of armored scale insects in Florida citrus groves have been reported and evaluated by a number of workers (Mathis 1947, Griffiths and Thompson 1947, Griffiths and Stearns 1947, Fisher et al. 1949, Griffiths and Fisher 1949, Fisher 1950, Fisher and Griffiths 1950, Griffiths 1951, Muma 1955 and 1959, Muma and Clancy 1961A). Although most parasites reportedly exerted some control pressure and several proved to be potentially effective, none were highly effective under the cultural practices then utilized for commercial Florida citrus production.

The enigmatically introduced parasite, *Aphytis lepidosaphes* Compere, was first recorded attacking purple scale, *Lepidosaphes beckii* (Newman), by Muma and Clancy (1959). The parasite spread rapidly throughout peninsular Florida (Clancy and Muma 1959) and by the summer of 1960 had attained effective control of the scale (Simanton 1960, Muma and Clancy 1961). This startling success prompted the introduction of *Aphytis holoxanthus* DeBach, in the fall of 1960, for the control of Florida red scale, *Chrysomphalus ficus* (Ashmead) (Clancy et al. 1963). The rapid spread of this parasite and the dramatic reduction of Florida red scale infestations have been recorded by Clancy et al. (1963), Muma and Selhime (1966), and Selhime et al. (1969).

In the fall of 1960, a survey was set up to monitor the establishment and population development of these 2 introduced parasites in purple and Florida red scale infestations on Florida citrus. Chaff scale, *Parlatoria pergandei* (Comstock), Glover scale, *Lepidosaphes gloveri* (Packard), and yellow scale, *Aonidiella citrina* (Coq.), were also included in the survey to make it comprehensive. The scope of and methods used in this survey were outlined by Muma and Clancy (1961) who also presented comparative data on purple scale and Florida red scale obtained during the first year of operation. Some survey data on the several scale insects and parasites were also cited by Muma and Selhime (1966), Selhime et al. (1969), and Muma (1969). However, no report on the total results has been made; such is the purpose of the present paper.

[1]Florida Agricultural Experiment Stations Journal Series No. 3873.

METHODS

Muma and Clancy (1961) outlined the original scope of and methods utilized in the survey but presented no details. These are presented here along with procedural changes that have been necessitated either by changes in citrus cultural practices or by the opportunity to obtain additional data.

Of the 27 groves selected originally, 9 were unsprayed, 9 were sprayed with the usually recommended scalicides, miticides, fungicides, and nutritional elements, and 9 were sprayed or dusted with sulfur in addition to the recommended chemicals. Since initiation of the survey, the development of adequate biological control of important armored scale insects has caused some growers to abandon regular scalicide applications while others have maintained scale control treatments as a preventative measure. The regular use of sulfur has been abandoned; it is now used sporadically as needed. Also, following the major freeze of 1962-63 many groves were pruned back and spray programs were either altered or completely changed. As a result, only 2 categories of survey groves can now be maintained, those that are essentially unsprayed, and those that are more or less regularly sprayed.

These groves are presently distributed from Marion County in the north to Highlands County in the south: 1 in Marion County, 2 in Orange County, and 6 in Lake County are considered northern; 9 in Polk County are considered central, 3 in DeSoto County, 1 in Hardee County, and 5 in Highlands County are considered southern. Some are not the groves originally selected because changes in spray programs, ownership, and removal of groves have forced several reevaluations and new site selections.

Each of the groves was sampled 4 times a year: in the spring (March, April, or May), in the summer (June, July, or August), in the fall (September, October, or November), and in the winter (December, January, or February). Samples were comprised of 25 randomly selected leaves from the basal part of the last or next to last flush of growth from each of 4 adjacent sample trees in each grove. These 100-leaf samples were examined in the laboratory under a dissecting microscope and percentage infested leaves; number of living, healthy, adult female scales; number of females infested with living hymenopterous parasites; number of females with recognizable chytrid (parasitic fungus) infection; number of dead females showing evidence of hymenopterous parasitism; and number of females dead from unknown causes were recorded.

These data were summarized, tabulated, and graphed for examination. The magnitude of intergrove variation was great, so all data were reduced to total, annual, geographical, seasonal, and treatment means for evaluation.

The survey results over 10 years, from the fall of 1960 through the fall of 1969, are presented in several ways. Mean populations per grove of living, parasitized, and dead adult female scale insects in each surveyed citrus area are listed in Table 1. Mean populations during each season of the year in sprayed and unsprayed groves are listed in Table 2. Responses of scale insect mortality factors under sprayed and unsprayed conditions to a major freeze (1962-63) are expressed in percent mortalities in Table 3. Differences in means and percentages among the tables are caused by

differences in the number of counts or seasons per year or study period owing to the freeze and survey beginning and ending dates. Population fluctuations of living adult female scale insects and hymenopterous parasites in sprayed and unsprayed groves before and after the freeze are represented by graphic trend lines in Fig. 1, 2, 3, 4, and 5.

Since each scale insect responded differently to the various conditions and factors that were in operation during the survey, results with each species are presented separately.

RESULTS

GLOVER SCALE, *Lepidosaphes gloveri* (PACKARD): During the past 10 years, this insect was the most abundant armored scale on Florida citrus leaves and was more abundant in the southern area than in the central or northern areas (Table 1). Although more individuals died from unknown causes in the south, hymenopterous parasites were slightly more abundant in the northern area. Disease incidence exhibited no geographic trend. Scale abundance was reflected in percent infested leaves.

Scale population peaks occurred in the spring, and populations were lowest in the fall during peak parasitism in both sprayed and unsprayed groves (Table 2). Greatest disease incidence occurred during both the summer and winter in unsprayed groves but only during the summer in sprayed groves. In general, populations of both scales and biotic agents

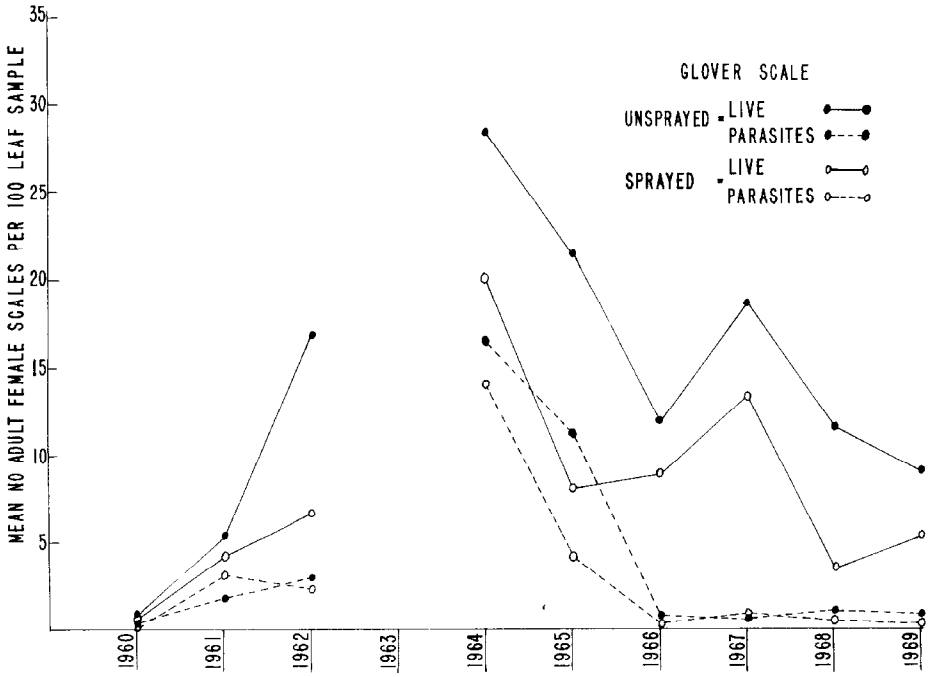

Fig. 1. Glover scale: annual mean adult female populations and parasitism incidence in sprayed and unsprayed groves from the fall of 1960 to the fall of 1969.

TABLE 1. GEOGRAPHIC COMPARISON OF MEAN INFESTATION PER CITRUS GROVE OF COMMON ARMORED SCALE INSECTS, FALL 1960-FALL 1969.

Geographic Areas and Condition of Scale Insects	Mean ♀s per Grove from Fall 1960 to Fall 1969*				
	Glover	Chaff	Purple	Yellow	Florida Red
Northern Groves (9)					
Dead (Unknown Causes)	56.8	80.6	57.0	29.0	17.7
Dead (Hymenopterous Parasites)	13.6	34.0	31.6	7.7	6.7
Living Healthy	29.4	39.0	26.7	11.9	3.8
Living Parasitized	4.3	13.3	6.9	0.7	1.1
Dead (Diseased)	5.0	0.7	5.2	0.2	0.1
% Infested Leaves	8.9	9.1	9.3	7.2	3.0
Central Groves (9)					
Dead (Unknown Causes)	71.0	49.6	30.9	24.0	9.0
Dead (Hymenopterous Parasites)	7.8	17.8	28.1	8.0	2.1
Living Healthy	40.0	26.3	11.6	12.3	1.7
Living Parasitized	1.5	3.9	4.5	0.8	0.3
Dead (Diseased)	4.1	0.7	3.3	0.2	0.1
% Infested Leaves	10.8	6.5	8.0	6.4	1.6
Southern Groves (9)					
Dead (Unknown Causes)	104.1	41.8	43.1	16.4	13.3
Dead (Hymenopterous Parasites)	6.7	9.6	29.1	5.5	3.5
Living Healthy	46.7	17.9	13.7	6.4	2.7
Living Parasitized	1.5	2.8	5.6	0.5	0.8
Dead (Diseased)	5.5	0.3	2.8	0.1	0.2
% Infested Leaves	11.3	5.5	8.8	5.3	2.3

*Mean number of adult female scales per 100 leaf sample for survey period.

were higher in unsprayed groves than in sprayed groves and were reflected in an increased amount of dead scale.

Scale mortality from unknown causes decreased after the 1962-63 freeze and insect parasitism and disease incidence increased (Table 3). Peak of disease incidence occurred later, however, in sprayed groves. Scale and hymenopterous parasite populations increased in both unsprayed and sprayed groves after the freeze. Under both conditions, increased parasitism remained high for 2 years before decreasing to prefreeze levels (Fig. 1).

CHAFF SCALE, *Parlatoria pergandei* (COMSTOCK): This scale insect was the second most abundant armored scale on Florida citrus leaves during the past 10 years and was more abundant in the northern area than in the central or southern areas (Table 1). More individuals died from unknown causes in the north. Hymenopterous parasites were also more abundant in the north but disease incidence exhibited no clear cut geographic trend. Scale abundance also was not reflected in percent infested leaves.

Scale population peaks occurred in the spring during lowest insect

TABLE 2. SEASONAL COMPARISON OF MEAN INFESTATIONS PER CITRUS GROVE OF COMMON ARMORED SCALE INSECTS AND OF FACTORS CAUSING MORTALITY, FALL 1960-FALL 1969.

Scale Insect	♀ Population Condition	Mean ♀s per Grove per Season (1960-1969)*							
		Unsprayed (9 Groves)				Sprayed (18 Groves)			
		Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer
Glover Scale	Living	7.5	13.3	20.2	17.1	6.1	9.1	12.9	9.7
L. gloveri (Pack.)	Parasitized	4.4	3.8	4.4	5.1	3.3	2.6	2.2	3.9
	Diseased	1.3	2.4	1.3	2.1	0.8	1.2	1.1	2.2
	Dead	32.0	29.4	21.5	34.1	19.9	17.5	11.1	28.8
	% Infested Leaves	14.6	16.4	15.9	16.3	9.3	10.1	10.2	12.3
Chaff Scale	Living	7.1	11.2	12.6	11.3	6.6	4.9	7.7	9.1
P. pergandei (Comst.)	Parasitized	12.2	9.9	7.4	10.7	7.8	5.9	5.4	8.1
	Diseased	0.2	0.1	0.0	0.7	0.2	0.03	0.1	0.2
	Dead	19.6	21.2	18.5	23.1	14.6	15.2	11.2	19.2
	% Infested Leaves	10.9	11.6	11.1	10.4	6.7	6.5	7.1	7.3
Purple Scale	Living	4.0	5.5	6.0	3.8	2.8	3.9	9.6	5.5
L. beckii (Newm.)	Parasitized	11.7	12.2	15.1	14.3	6.9	7.7	11.0	10.8
	Diseased	1.0	1.1	0.9	1.5	0.5	0.7	0.8	2.6
	Dead	12.6	12.5	13.0	15.1	9.9	10.3	13.1	18.0
	% Infested Leaves	10.9	11.9	14.3	11.9	7.6	9.2	11.0	9.8
Yellow Scale	Living	2.8	2.1	4.5	8.0	1.7	2.0	3.0	2.9
A. citrina (Coq.)	Parasitized	3.0	2.5	2.8	3.8	1.3	2.1	1.8	2.4
	Diseased	0.04	0.0	0.0	0.2	0.04	0.1	0.0	0.05
	Dead	9.1	11.0	6.7	9.0	5.0	6.9	4.8	6.4
	% Infested Leaves	8.1	9.7	9.2	10.1	5.3	6.7	7.1	7.3
Florida Red Scale	Living	0.4	0.5	0.4	0.6	0.8	0.6	1.1	1.5
C. ficus (Ashm.)	Parasitized	3.3	1.6	0.8	1.4	1.7	1.3	0.8	1.0
	Diseased	0.02	0.03	0.0	0.01	0.02	0.1	0.1	0.03
	Dead	5.1	5.3	3.5	4.3	3.3	3.2	3.1	4.8
	% Infested Leaves	3.7	3.6	2.4	2.7	2.5	2.2	2.3	2.9

*Mean number of adult female scales per 100 leaf sample for each season.

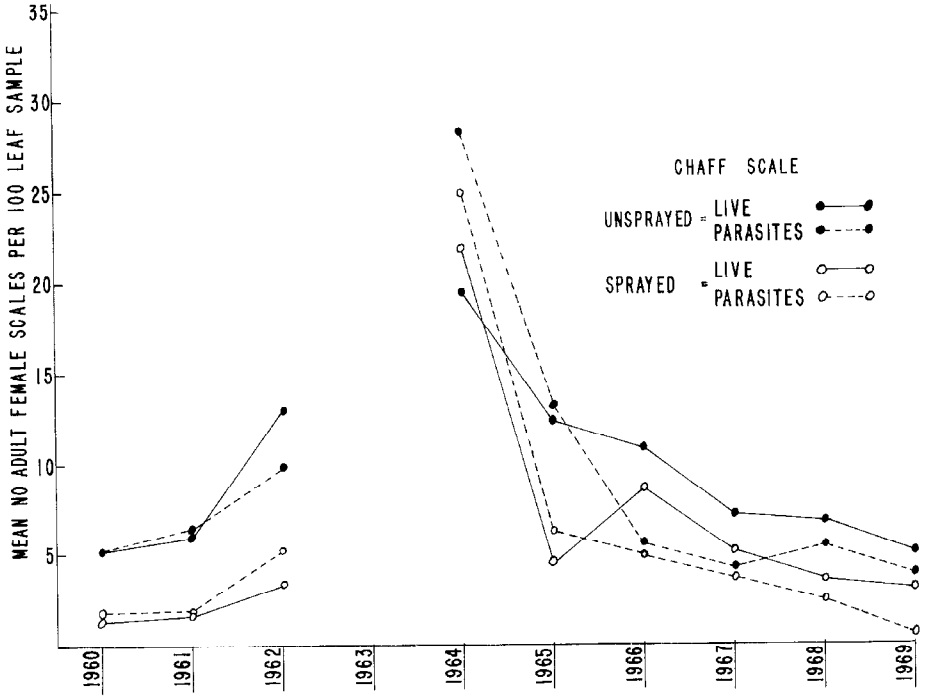

Fig. 2. Chaff scale: annual mean adult female populations and parasitism incidence in sprayed and unsprayed groves from the fall of 1960 to the fall of 1969.

parasitism, and populations were lowest in the fall during peak insect parasitism in unsprayed groves (Table 2). In sprayed groves, population peaks occurred in the summer, and populations were lowest in the winter but were not distinctly related to insect parasitism. Disease incidence exhibited no seasonal trends related to scale populations but was highest in the summer in unsprayed groves, and in the summer and fall in sprayed groves. In general, scale and biotic agent populations were higher in unsprayed groves than in sprayed groves and were reflected in an increased amount of dead scale.

Mortality from unknown causes decreased and insect parasitism increased after the 1962-63 freeze (Table 3). Disease incidence was fractional and not affected by the freeze. Scale populations increased after the freeze in both sprayed and unsprayed groves. Under both conditions, the increased parasitism remained high for only a year before decreasing to prefreeze levels (Fig. 2).

PURPLE SCALE, *Lepidosaphes beckii* (NEWMAN): Purple scale populations on Florida citrus leaves exhibited no geographic trend of abundance during the past 10 years (Table 1). Mortality from unknown causes and hymenopterous parasites also exhibited no clear cut geographic trend; disease incidence was highest in the north. Percent infested leaves was variable among the areas.

Scale population peaks occurred in the spring, and populations were lowest in the fall in both sprayed and unsprayed groves (Table 2). Insect

TABLE 3. MEAN PERCENT MORTALITY OF COMMON CITRUS SCALE INSECTS BEFORE AND AFTER 1962-63 FREEZE IN UNSPRAYED AND SPRAYED GROVES.

Scale Insect	Mortality Factors	Mean Percent Mortality* Unsprayed (9 Groves) 1960–62	1964–66	1967–69	Sprayed (18 Groves) 1960–62	1964–66	1967–69
Glover	Unknown	89.3	73.2	93.4	82.4	79.6	87.9
Scale	Insect Parasites	9.7	19.6	2.8	15.2	15.7	3.9
L. gloveri (Pack.)	Parasitic Fungus	1.0	7.1	3.8	2.3	4.7	8.1
Chaff	Unknown	67.1	64.4	77.4	72.0	65.9	79.1
Scale	Insect Parasites	32.7	34.4	22.1	27.6	33.6	20.4
P. pergandei (Comst.)	Parasitic Fungus	0.2	1.2	0.5	0.5	0.5	0.4
Purple	Unknown	58.4	45.4	43.1	62.3	49.4	45.4
Scale	Insect Parasites	41.0	50.0	51.2	33.9	44.7	47.2
L. beckii (Newm.)	Parasitic Fungus	0.5	4.6	5.7	3.8	5.8	7.3
Florida Red	Unknown	71.5	62.1	84.8	73.9	58.9	88.7
Scale	Insect Parasites	28.4	37.4	13.3	25.3	39.3	8.8
C. ficus (Ashm.)	Parasitic Fungus	0.1	0.4	1.9	0.8	1.8	2.5
Yellow	Unknown	86.4	74.6	74.5	78.7	74.7	75.0
Scale	Insect Parasites	13.6	25.0	25.1	21.3	25.3	24.1
A. citrina (Coq.)	Parasitic Fungus	0.0	0.3	0.6	0.0	0.1	0.9

*Mortality of adult female scales on 100 leaf samples collected 4 times per year.

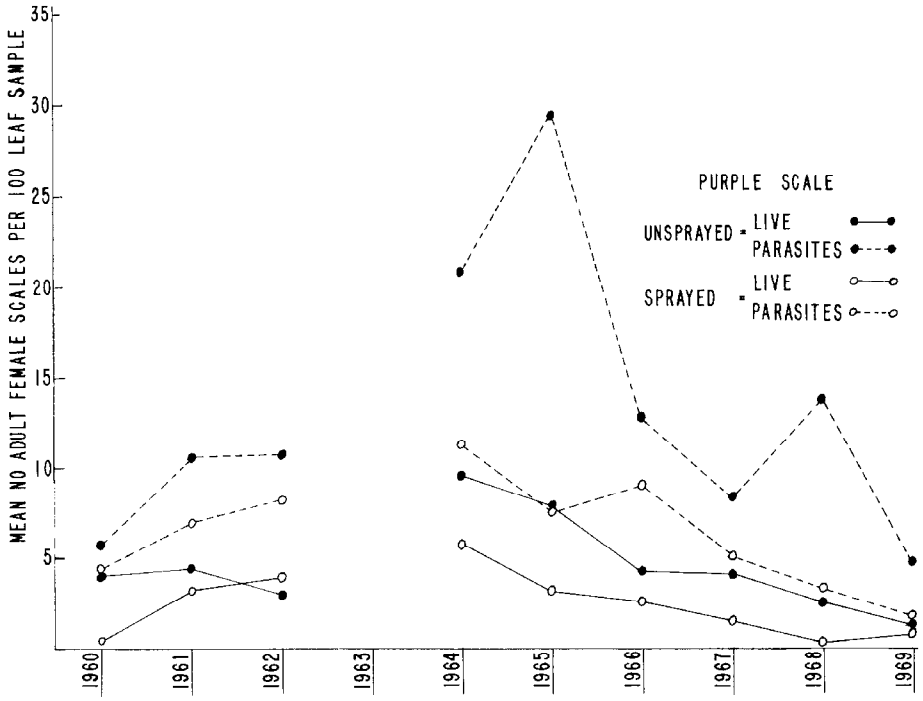

Fig. 3. Purple scale: annual mean adult female populations and parasitism incidence in sprayed and unsprayed groves from the fall of 1960 to the fall of 1969.

parasitism was greatest during peak scale populations in the spring but disease incidence was higher during the summer months. In general, populations of scales and biotic agents were higher in unsprayed than in sprayed groves and were reflected in an increased amount of dead scale.

No reduction in mortality from unknown causes occurred after the 1962-63 freeze (Table 3). However, a slight post-freeze increase occurred in both insect parasitism and disease incidence. Slightly increased post-freeze scale populations were associated with increased insect parasitism (Fig. 3).

YELLOW SCALE, *Aonidiella citrina* (COQUILLET): Yellow scale populations on Florida citrus leaves exhibited a north to south geographic trend of abundance during the past 10 years (Table 1). Although parasites and disease incidence exhibited no geographic trend, mortality from unknown causes was highest in the north. Percent infested leaves reflected scale abundance.

A distinct scale population peak occurred in the summer, with lowest populations in the winter in unsprayed groves; a peak occurred in the spring, with lowest populations in the fall in sprayed groves (Table 2). Insect parasitism was related to scale populations in unsprayed groves but showed no distinct seasonal trend in relation to scale populations in sprayed groves. Disease incidence was fractional and exhibited no seasonal trend. In general, scale and populations of scales and biotic agents

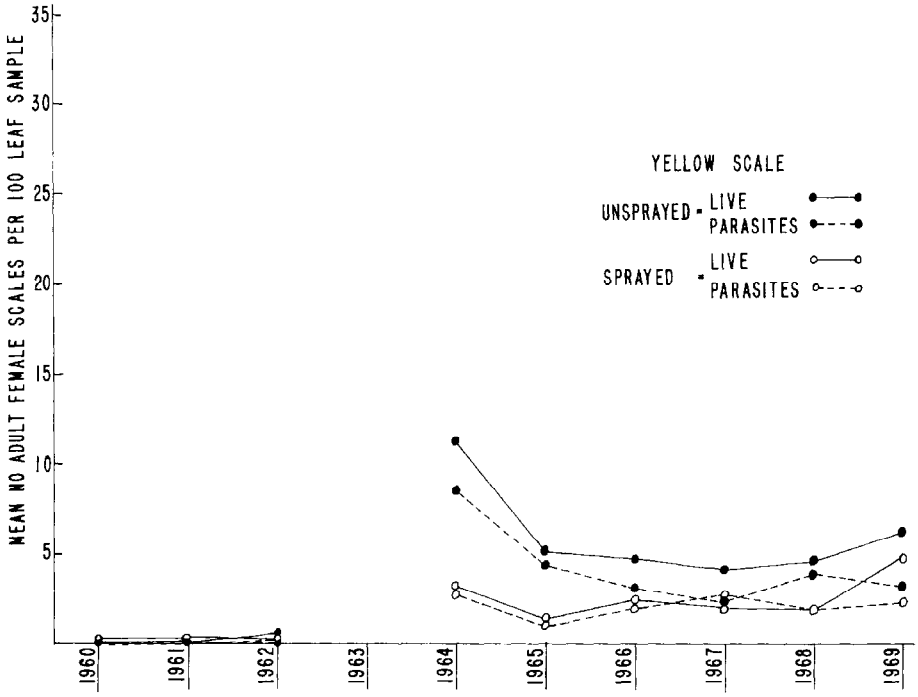

Fig. 4. Yellow scale: annual mean adult female populations and parasitism incidence in sprayed and unsprayed groves from the fall of 1960 to the fall of 1969.

were higher in unsprayed than sprayed groves and were reflected in an increased amount of dead scale.

The unknown mortality factor was reduced following the freeze of 1962-63, and both insect parasitism and disease incidence increased slightly (Table 3). Disease incidence was, however, fractional in percentage. A distinct increase in post-freeze scale infestations was associated with an increase in insect parasitism in unsprayed groves; infestations in sprayed groves responded similarly but at much lower levels. Scale and factor populations tended to be higher in unsprayed than in sprayed groves (Fig. 4).

FLORIDA RED SCALE, *Chrysomphalus ficus* (ASHMEAD): No geographic trends in Florida red scale populations or mortality factors were evident during the past 10 years (Table 1).

Scale population peaks occurred during the summer; but populations were lowest in the spring in unsprayed groves and lowest in the winter in sprayed groves (Table 2). Insect parasitism was distinctly higher in the fall and lower in the spring. Disease incidence was fractional and exhibited no trend. In general, scale populations were higher in sprayed groves and insect parasite populations higher in unsprayed groves.

A distinct decrease in mortality from unknown causes followed the 1962-63 freeze (Table 3). Insect parasitism, on the other hand, increased during the immediate post-freeze years. Disease incidence was fractional but has increased steadily since the freeze. Scale infestations and mortality factors have all been at trace levels since the freeze (Fig. 5).

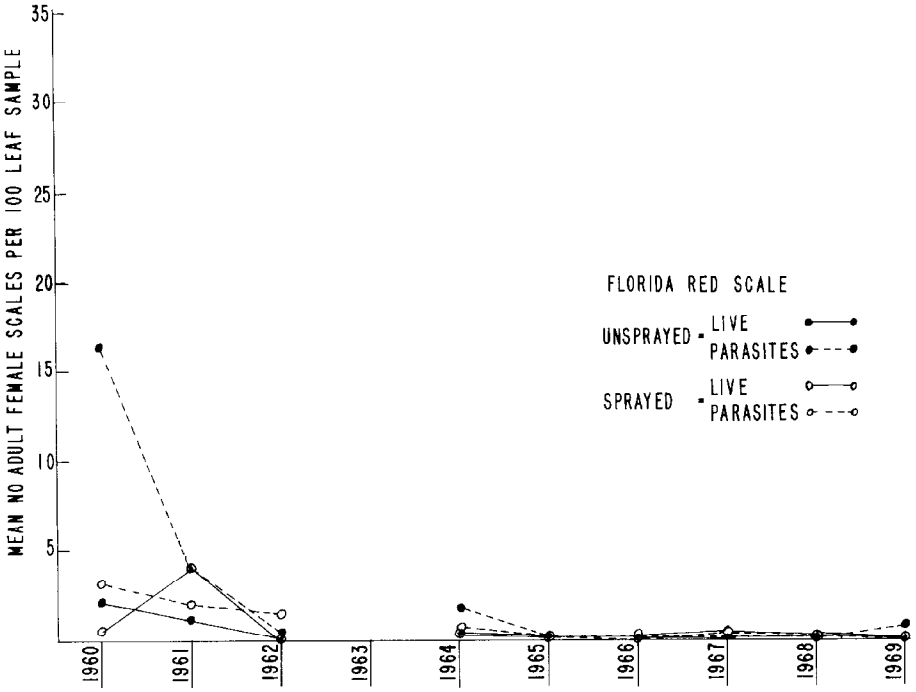

Fig. 5. Florida red scale: annual mean adult female populations and parasitism incidence in sprayed and unsprayed groves from the fall of 1960 to the fall of 1969.

Discussion and Conclusions

Perhaps the most important information obtained from this 10 year armored scale insect survey is that related to the actual and relative abundance of the 5 included species. Not one of the species has consistently occurred at a population level which would be considered economically important. Although measurable increases in infestations of 3 species occurred following the 1962-63 freeze, economically important infestations have not been recorded from the survey groves since 1964. Prior to 1958 and 1960, purple and Florida red scale, respectively, were the most and second most abundant and economically important armored scale insects attacking Florida citrus. During the past 10 years, these 2 species, now adequately controlled by introduced insect parasites of the genus *Aphytis* Howard, have been superseded by Glover and chaff scale, respectively. Furthermore, a previously localized species, yellow scale, has achieved an abundance greater than that of the previously important Florida red scale.

Since all of the included armored scale insects are and have been, for the past 10 years, at population levels rarely requiring chemical control measures, they must be considered to be under adequate biological or natural control. It is also evident that such controls are not seriously affected by low temperatures, at least those of a magnitude experienced during the severe freeze of 1962-63, or by spray chemicals such as those currently used on Florida citrus.

Certain specific data also require some discussion. Glover's scale is un-

questionably controlled to some extent by the parasitic wasp, *Prospaltella elongata* Dozier, and the parasitic fungus, *Myiophagus ukrainicus* (Wise) Thaxter, but an unknown factor may well be critical to the control of this scale. This is indicated by the fact that insect parasitism increased during the post-freeze years but has since decreased below prefreeze levels. Furthermore, fungus parasitism increased during the post-freeze years and is still well above prefreeze levels. On the other hand, Glover scale populations have fluctuated strikingly during the post-freeze years indicating that some unknown control factor either has not recovered from the freeze or operates independently of weather factors. Chaff scale seems to be controlled exclusively by natural factors and these appear to be primarily the parasitic wasps, *Prospaltella fasciata* Mal. and *Aphytis hispanicus* (Mercet). The incidence of *M. ukrainicus* in chaff scale is very low. Furthermore, populations of the parasitic wasps produced extremely high rates of parasitism during the immediate post-freeze year 1964, and by 1965 the scale populations were again reduced to prefreeze levels. Purple scale continues to be well controlled by the parasitic wasp, *A. lepidosaphes,* 12 years after its enigmatic introduction. Neither commonly used spray chemicals nor the 1962-63 freeze seemed to seriously affect this biological control. Striking increases in parasitism rates accompanied the slight post-freeze scale population increases but by 1966 purple scale populations were again reduced to or below prefreeze levels. Since yellow scale increased in abundance and attained statewide distribution on Florida citrus during this survey period, it is believed that scale-parasite relationships have been obscured by the development of new infestations and the lag in grove-to-grove extensions of parasite distributions. Despite this complication, it appears that yellow scale infestations are maintained at noneconomic levels by the parasitic wasps, *Aphytis chrysomphali* (Mercet) and *Comperiella bifasciata* Howard possibly assisted by *A. holoxanthus* as stated by Muma and Selhime (1966). It should be noted, however, that yellow scale infestations have remained above prefreeze levels for the past 6 years; and it is possible that stable scale-parasite relationships have not as yet been attained. Florida red scale has been successfully controlled by the introduced parasitic wasp, *A. holoxanthus,* during the survey period. Neither commonly used spray chemicals nor the 1962-63 freeze seemed to seriously affect this biological control.

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THE DIPLOPOD GENUS *POLYZONIUM* IN NORTH AMERICA

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ABSTRACT

The genotype, *P. germanicum* Brandt, of Europe, is redescribed and illustrated as are the American *bivirgatum* (Wood), *rosalbum* (Cope), *bikermani* and *mutabile* Causey. *P. cryptocephalum* (McNeill) is reduced to a synonym of *rosalbum* (Cope). Four new species are described, illustrated, and included in a key of all American species.

Polyzonium is one of very few milliped genera with species in both North America and Europe. Originally described from the latter, fewer species are known from there than the 8 here credited to the North American fauna. No species is common to both continents.

Our first species, *P. bivirgatum*, was named in 1864, followed by *rosalbum* in 1870, *cryptocephalum* in 1887, with no additions until *bikermani* and *mutabile* were described in 1951. Unfortunately, the 3 early descriptions were based on essentially generic characters; the specific ones, referring to size, number of segments, and color, are variable throughout the genus, with the latter of doubtful value except when described from mature live animals. Two of the earliest species were illustrated, but only family or generic characters are to be found in the figures.

Among the millipeds of this country described by the earliest writers on the group, few species remain today as poorly known as these first 3. Specimens of this genus are widely distributed in North America and quite frequently are found by collectors. They have not been difficult to classify as *Polyzonium*, but assignment to species appears to have been on a highly empirical basis. In most cases, available names have been used with little discrimination, rather than applying them after associating the specimens with types, type locality, or published structural features. Actually there was little alternative to this method of providing names, because of the disparity of published specific characters, an adequate type specimen of only 1 species remained available, and most specimens came from areas too far from the type localities of the 3 species for much confidence to be placed in geographically selected binomials.

With the exactness of previous identifications in question, additional complications are presented by the finding of new species in areas where older ones have been reported. In the present study, no published locality records have been relied upon except the original type and paratype localities.

With the excellent collection sent by Richard L. Hoffman, specimens contributed or lent by Nell B. Causey, and those already in my collection, it has been possible for the first time to make a comprehensive study of the

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[1]Contribution No. 191, Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture and Consumer Services.

[2]Research Associate, Florida State Collection of Arthropods, Division of Plant Industry, Florida Department of Agriculture and Consumer Services.

previously known species and, by direct comparisons, to establish new ones. Besides the peculiarities of the gonopods, other structural specific characters have been found that have been of material worth in evaluating the species. The extensive ranges of the 2 oldest species now have been roughly determined; greatly reduced ranges are indicated for the 2 species described in 1951, but much more collecting will be required to establish the distribution of the other 4 species, which now appear to be decidedly localized. The present range of the genus extends from southern Canada through the eastern United States as far south as South Carolina, Georgia, and Alabama, and westward to include Arkansas, Illinois, and Minnesota. Two species of the closely related *Hypozonium* have been found in California and Washington, suggesting that other species of this genus or of *Polyzonium* may occur in the intervening states.

Holotype and neotype specimens, most paratypes, and other specimens of older species have been deposited in the U. S. National Musum. At least one paratype specimen and available representatives of the other known species have been deposited in the Florida State Collection of Arthropods in Gainesville.

Polyzonium Brandt

Polyzonium Brandt 1834, p. 178.
Octoglena Wood 1864, p. 186; apparently Cook 1900, p. 516.
Petaserpes Cope 1870, p. 65; Bollman 1893, p. 117.
Hexaglena McNeill 1887, p. 328; Bollman 1893, p. 117.
Genotype: *Polyzonium germanicum* Brandt, by monotypy.

Examination of specimens of this European species, on which the following notes and figures are based, has failed to produce sufficient characters for the generic separation of the American species, and continuance of them under this genus seems required.

Three ♂ and 8 ♀ are labeled "*Polyzonium germanicum*, Austria, coll. Latzel ex Mus. Berol.", in O. F. Cook's writing. It is assumed that these specimens were correctly identified.

Description: Largest ♂ 13 mm long, 2 mm wide, 44 segments. Head short, its sides straight, meeting in a 65-70° angle in front; ocelli 3-3, the rows not strongly divergent behind, separated in front by 1- 1 1/2 times diameter of an ocellus; antennae long and slender, projecting beyond sides of midbody when held laterally. Pores on sides of segment 5 rather low, succeeding ones a little higher; interzonal stria only a little curved backward behind first pore. Posterior end of body shown in Fig. 1.

Anterior gonopod and part of sternum shown in Fig. 2, in which the seminal joint appears to be biramous, but later examinations convince me that the basal hispid lobe actually is at the apex of joint 5, a dotted line in the figure approximates the end of that joint. Coxae of legs 1 and 2 not raised into lobes; sterna not elevated; terminal claws long, slender, and slightly curved (Fig. 3); claws of succeeding legs considerably smaller. Third legs slightly heavier than those on either side. Pouch pits of coxae in front of gonopods quite large, transversely oval, those at midbody smaller and almost circular. Sterna of legs 3 to 8 narrow, only about half as wide as length of a coxal joint; sterna behind gonopods narrow with coxae almost touching.

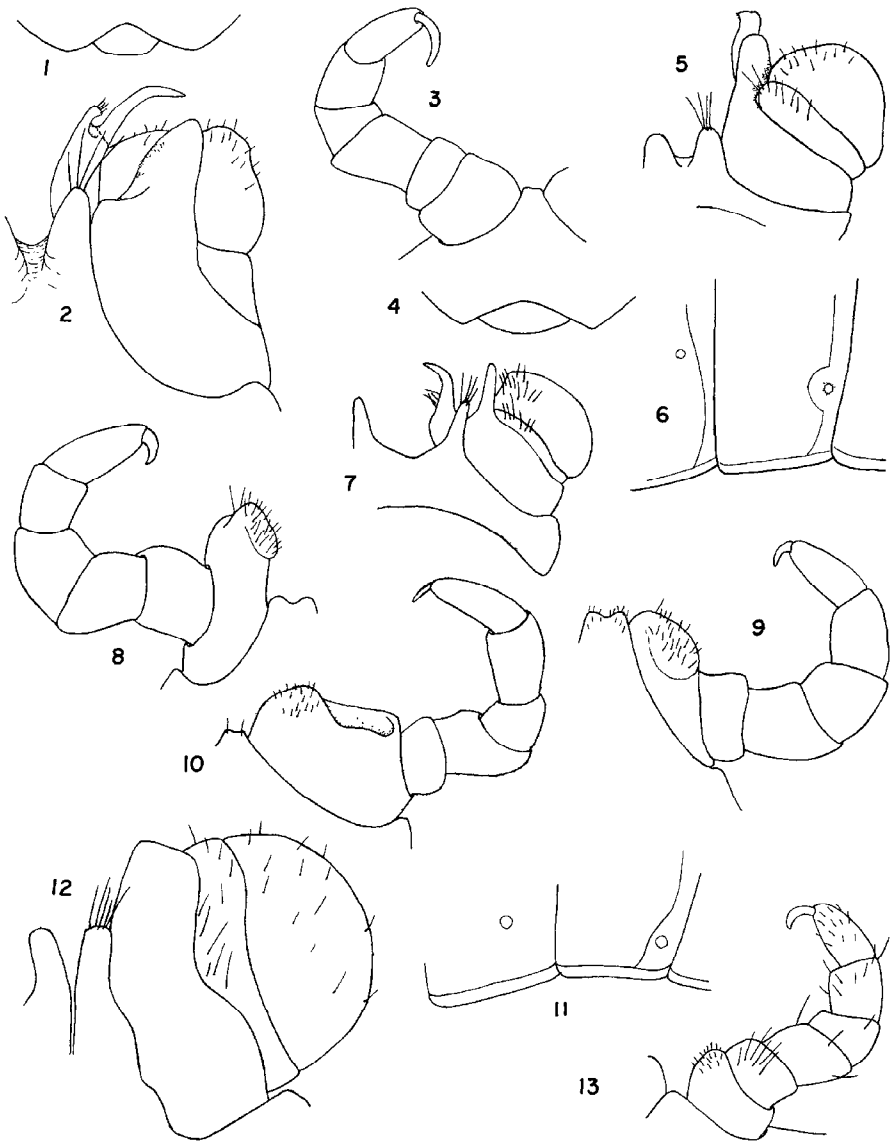

Fig. 1-3, *Polyzonium germanicum* Brandt: 1. Posterior end of body (dorsal view); 2. Right anterior gonopod and part of sternum (anterior view); 3. First leg and sternum of male (posterior view).

Fig. 4-5, *Polyzonium bikermani* Causey: 4. Posterior end of body (dorsal view); 5. Right anterior gonopod and part of sternum (anterior view).

Fig. 6-10, *Polyzonium bivirgatum* (Wood): 6. Segments 5 and 6 (lateral view); 7. Right anterior gonopod and part of sternum (anterior view); 8. Leg 1 and sternum (posterior view); 9. Leg 2 and sternum (posterior view); 10. Leg 3 and sternum, smaller scale (anterior view).

Fig. 11-13, *Polyzonium borealis* new species: 11. Segments 5 and 6 (lateral view); 12. Right anterior gonopod and part of sternum (anterior view); 13. Leg 1 and sternum (anterior view).

KEY TO THE NORTH AMERICAN SPECIES OF *Polyzonium*

1. Very small species (to 7 mm long) with anterior gonopods simple, all 6 joints exposed in front, the coxal joints without apical lobes ..... *gracilipes* new species
1.′ Slightly to much larger species (to 20 mm long); anterior gonopods more complicated; coxae enlarged, each with a distal lobe; at least joints 4 and 5 hidden from in front 2
2. Anterior gonopods with high, slender, subrectangular sternal lobes nearly in contact along the inner basal half ..... *borealis* new species
2.′ Anterior gonopods with sternal lobes subconical, usually well separated, not in contact along their inner sides 3
3. Sternum of anterior gonopods short, very broad, its outer limits suddenly and extensively raised; sternal lobes relatively small and contiguous at base; sterna behind third legs all narrow ..... *quadricauda* new species
3.′ Sterna higher in relation to width, their outer limits not as suddenly or extensively raised; sternal lobes larger and more separated at base; sterna of legs 4 to 8 wide 4
4. Head long and narrow, sides meeting in an angle of about 50°; anterior gonopods with sternal lobes slender and widely separated ..... *bivirgatum* (Wood)
4.′ Head shorter and broader, sides meeting in an angle of 60-72°; sternal lobes of anterior gonopods not slender and widely separated 5
5. Anterior gonopods with sternum essentially transverse in relation to its height and very short at middle ..... *bikermani* Causey
5.′ Anterior gonopods with sternum distinctly higher in relation to its width, median length greater 6
6. Sternum of anterior gonopods relatively small, outer limits not elevated ..... *divaricatum* new species
6.′ Sternum of anterior gonopods distinctly larger, its outer limits more or less elevated 7
7. Anterior gonopods with sternal lobes widely separated, seminal joints moderately slender and acute at tip ..... *rosalbum* (Cope)
7.′ Anterior gonopods with sternal lobes divergent but contiguous at base; seminal joints stout and obliquely truncate at tip ..... *mutabile* Causey

Polyzonium bikermani Causey 1951

Male and female paratypes collected on Rt. 1, SW of Prairie Grove, Washington Co., Arkansas, 20 October 1855, by Maxine Hite, and lent to me by Dr. Nell B. Causey. The species has been found in Benton and Carrol Counties as well.

Description: Male 10 mm long, 1.8 mm wide, 46 segments. Head short and broad, sides straight, meeting in an angle of 70-72°. Both specimens have ocelli 3-3, anterior pair separated by at least the diameter of an ocellus, posterior pair a little over twice as widely separated. Antennae quite thick, reaching laterally no farther than sides of midbody. Segment 5 with pores low on sides, opening from a large pad, rounded behind; pores thereafter noticeably higher. Posterior end of body shown in Fig. 4, the last segment without distinct lateral angles.

Anterior gonopods shown in Fig. 5, lobe of coxa partly held behind joints 2 and 3, lobe twisted one-eighth from transverse, its outer edge caudad of the inner one; seminal joint truncate-emarginate at apex, as also shown in Causey's illustration; sternum very short but broad, its outer limits not enlarged or raised.

First and second ♂ legs small and crassate; claws widened, curved, and rounded at tip; coxae of both legs raised high above sterna, longer than thick in vertical view, and with mesal faces flat or very slightly concave; sterna between them quite narrow and slightly depressed at middle. Third legs larger, a little more thickened than those either side; claws slender, acute; coxal pouch pits large and transversely oval from third legs caudad; sterna of legs 3 to 8 about as wide as length of a coxal joint; sternum behind gonopods about half as wide, succeeding ones suddenly narrowing, the coxae almost touching at base.

Polyzonium bivirgatum (Wood)

Octoglena bivirgata Wood 1864, p. 186; Cook and Loomis 1928, p. 18.
TYPE LOCALITY: "Mountains of Georgia." Probably near the NW corner of the state.

From present knowledge of *Polyzonium*, not much can be gleaned from Wood's original description, but his illustrations, inaccurate as they obviously are, show 2 characters that coincide with similar ones in most specimens here regarded as *bivirgatum*. These relate to the "beak", where its sides are seen to be emarginate in both dorsal and ventral aspects, and the beak forms an angle of about 50°. Chamberlin and Hoffman (1958) stated that the location of the type specimen of *bivirgatum* was "unknown, probably not in existence," but in a recent letter from Hoffman he mentioned having "examined the type of *Octoglena bivirgata* Wood in the Philadelphia collection" and that "the creature lacks the front end but otherwise appeared to be *Polyzonium*." Without the front end the species would be almost impossible to identify.

In the present collection from Alabama, Georgia, and South Carolina, only 1 species has been found that could possibly be *bivirgatum*, a description of which follows. As might be expected in a widespread population composed of essentially sedentary parts, considerable variation has developed from place to place in many of the specific characters, but nowhere do these appear to justify varietal recognition.

Localities: ALABAMA: ♀, The Gorge, 8 mi. SW of Pisgah, Jackson Co., 22 October 1962, Leslie Hubricht; 4 young, ravine near Skyway, 2.4 mi. N of Bankhead Firetower, N of Heflin, Cleburn Co., 23 October 1960, Leslie Hubricht; 3 young, 2 mi. SE of Collinsville, DeKalb Co., 25 May 1961, Leslie Hubricht. GEORGIA: ♂, ♀, ravine 4 mi. N. of Jasper, Pickens Co., 6 November 1960, Leslie Hubricht; ♀, 3.8 mi. SW of Dawson, Terrell Co., 8 April 1961, Leslie Hubricht; ♂, Cloudland Canyon State Park, Dade Co., 17 June 1962, R. H. Stevens. NORTH CAROLINA: 2♂, ♀, Linville Gorge, near Table Rock Mountain, Burke Co., 18 October 1969, L. S. Knight; many ♂, ♀, between Marshall and Hot Springs, Madison Co., 30 October 1929, O. F. Cook; ♀, vicinity of Hot Springs, Madison Co., 6 July 1968, R. L. Hoffman; ♂, 6 ♀, young, below Carver's Gap, 5,000 ft. elev., Roan Mountain, Mitchell Co., 23 September 1950, Leslie Hubricht. SOUTH CAROLINA: 4

♂, 16 ♀, ravine near Stevens Creek, E of Modoc, McCormick Co., 24 December 1951, Leslie Hubricht; ♀, Pickens Co., 14 November 1966, J. A. Payne. TENNESSEE: Many ♂, ♀, Newport, Cocke Co., 30 October 1929, O. F. Cook; 5 ♂, 7 ♀, Signal Mountain, Hamilton Co., 31 December 1957, R. L. Hoffman.

Diagnosis: The very narrow head with sides curving slightly inward; widely separated, slender coxal lobes of anterior gonopods; and details of anterior male legs, especially the second and third, are salient features distinguishing it from its nearest geographical relative, *P. rosalbum*.

Description: Strongly convex species of intermediate size; males with 37 to 58 segments, 7 to 14 mm long, 1.8 to 2.2 mm wide; females with 38 to 57 segments, 10 to 16 mm long, 2.2 to 2.5 mm wide.

Head very narrow; sides usually slightly emarginate, sometimes straight, meeting in a 45-52° angle; antennae not reaching outward as far as sides of midbody when laterally extended; ocelli 3-3, rarely 4-4, anterior ones separated by about the diameter of an ocellus, posterior ones at least 4 times as widely separated. Segment 5 with pores set quite low, usually in a distinct pad (Fig. 6), succeeding pores distinctly higher. Penultimate segment quite deeply and evenly emarginate behind; last segment broadly rounded at apex.

Anterior gonopod (Fig. 7) with slender, high sternal lobes widely separated; outer limits of sternum at most only slightly raised; coxal lobes slender, high, and usually a little curved; second joint larger than in most and readily seen. First and second legs shown in Fig. 8 and 9; coxae of latter raised and usually produced caudally at apex into lobes extending over basal portion of penes; claws small and somewhat blunt; sternum much raised between coxal lobes, emarginate and hispid at apex. Third legs (Fig. 10) with coxae unusually long and thick, a very large, transverse pouch pit occupying ventral face, inner subapical surface finely hispid. Succeeding sterna in front of gonopods wide; sterna behind gonopods with apex acute to narrowly rounded, coxae usually appearing almost in contact.

Polyzonium borealis new species

Five ♂, one the holotype; 3 ♀, 1 immature, in vial labeled "N shore Lake Superior, Mr. H. G. Hubbard, '96," probably Minnesota but possibly Ontario, Canada.

Diagnosis: Seen from in front the smoothly inflated joints 2 and 3 of the anterior gonopods, the hidden joints 4 to 6 joining others in an almost complete circle, and the adjacent lobes of the sternum are outstanding characters of this rather small species.

Description: ♂ with 36 to 41 segments, maximum length 9 mm, width 1.5 mm; ♀ with 36 to 45 segments, length to 10 mm, width to 1.6 mm. Head very short, lateral margins straight, meeting at an angle of 65°; ocelli 4-4, the anterior ones separated by a little less than the diameter of an ocellus, the posterior ones about 5 times as widely separated; antennae very long and slender, nearly equalling sides of body when held laterally. Pore pad of segment 5 (Fig. 11) low on side and only slightly bulging the interzonal stria; pores on succeeding segments higher. Penultimate segment rather

narrow behind, the angles less rounded than in *gracilipes*, intervening margin not as deeply concave.

Anterior gonopod and part of sternum shown in Fig. 12; each coxa with broad apical lobe, rounded-truncate at tip which approximates the highest part of second and third joints behind which the 3 distal joints are hidden but curve inward and forward; seminal joint short, curving a little laterad close to posterior face of coxal lobe, the joint concave along its inner side, apex directed almost laterad, thin but quite broadly truncated. First male legs (Fig. 13) narrowly separated by the sternum which is angular at apex; coxa little produced at mesal corner; claw distinctly spatulate in dorsal view. Coxae of second legs each slightly elevated into a low rounded prominence; claw as on leg 1, sternum rather narrow, nearly straight across apex which is not as high as coxae and has several erect setae. Sterna between legs 3 to 8 wider than those following gonopods where they are very narrow with coxae almost touching. Pouch pits of all coxae quite small, little broader than long.

Polyzonium divaricatum new species

Holotype ♂ from mixed woods NW of Higgins Lake, Roscommon Co., 1 September 1958; ♀ from swampy woods 0.4 mi. N of Levering, and another ♀ from upland maple woods 6 mi. S of Petoskey, Emmet Co., 31 August 1958; all collected in Michigan by Leslie Hubricht.

Diagnosis: The obliquely held coxal lobes of ♂ legs 1 and 2; relatively small stenum of anterior gonopods; very broad sterna of legs 3 to 8; and the separated coxae of other legs distinguish this species from *rosalbum*.

Description: Holotype ♂ 12 mm long, 2.3 mm wide, with 48 segments, the last 4 legless but gonopods fully formed; mature Levering ♀ 13 mm long, 2.5 mm wide, 48 segments. Head short and broad, side margins straight, meeting in a 70° angle, apex rather blunt; ocelli 4-4 in all specimens, front interocular space equal to width of an ocellus in ♂, considerably less in ♀ ♀; posterior space 5 or more times as wide (Fig. 14); antennae moderately long and slender, equalling sides of midbody when held laterally. Pores of segment 5 moderately low, the pads causing a slight projection of interzonal stria; succeeding pores at same level. Penultimate segment very narrow, posterior angles broadly subacute rather than rounded, intervening margin shallowly emarginate. Last segment evenly rounded behind, not in the least truncate.

Anterior gonopod (Fig. 15) with coxal lobe appearing subovoid; second joint short but distinct; seminal joint nearly straight to the strongly hooked, acute apex; sternum with rather small, well separated lobes. First 2 pairs of legs quite crassate (Fig. 16, 17), the coxae mesally elevated and oblique; sternum of second legs more distinctly bilobed than usual; sterna between legs 3 to 8 unusually wide, more than equal to length of a coxal joint; midbody sterna only a third to a fourth as wide, coxae distinctly separated; all coxae with large rounded pouch pits.

Polyzonium gracilipes new species

Three ♂ including holotype, 5 ♀, from Cloudland Canyon State Park, Dade Co., Georgia, 17 June 1962, H. R. Steeves; 2 females, ravine near

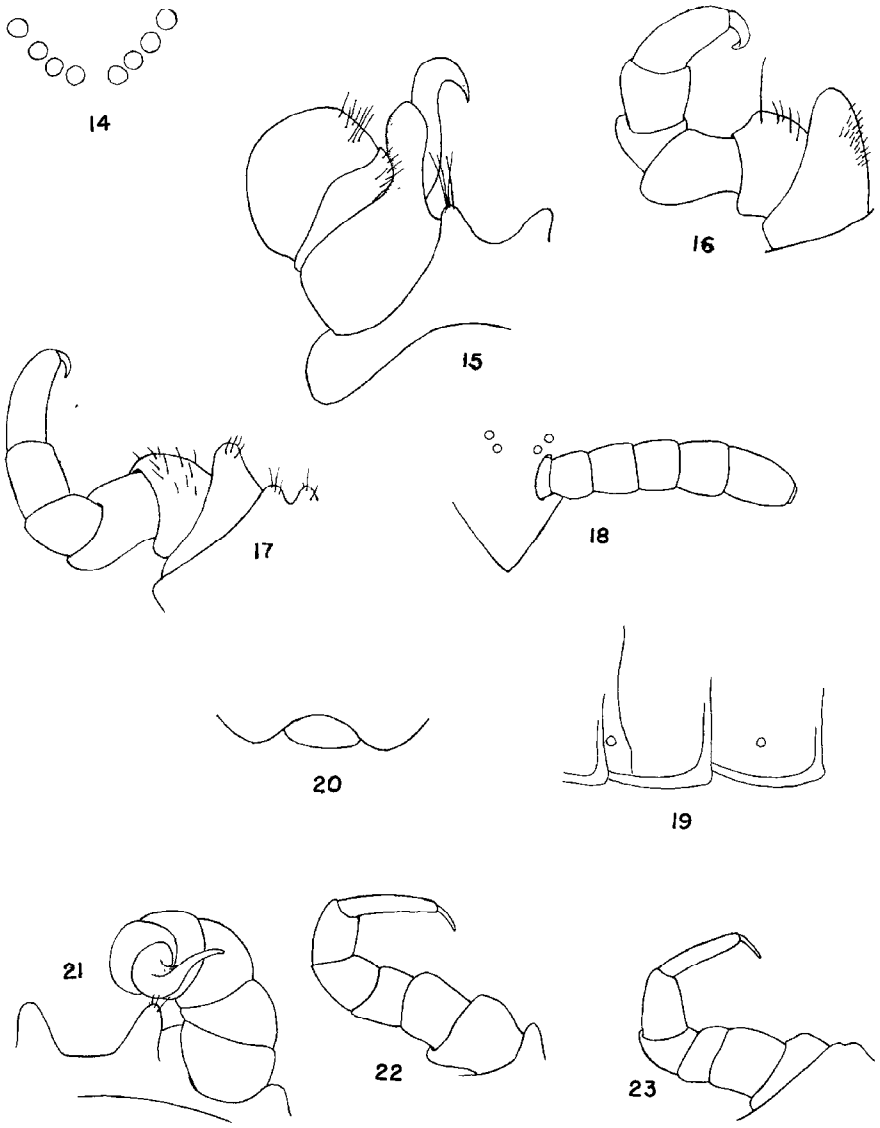

Fig. 14-17, *Polyzonium divaricatum* new species: 14. Ocelli; 15. Left anterior gonopod and part of sternum (anterior view); 16. Leg 1 (posterior view); 17. Leg 2 and part of sternum (posterior view).

Fig. 18-23, *Polyzonium gracilipes* new species: 18. Head (anterior view); 19. Segments 5 and 6 (lateral view); 20. Posterior end of body (dorsal view); 21. Right anterior gonopod and part of sternum (anterior view); 22. Leg 1 and sternum (posterior view); 23. Leg 2 and sternum (anterior view).

Skyway, 2.4 mi. N of Bankhead Firetower, N of Heflin, Cleburn Co., Alabama, 23 October 1960, Leslie Hubricht.

Diagnosis: Probably this is the smallest American species and it has a number of structural peculiarities: foremost are the simple anterior gonopods and slender outer joint of all legs, including the first 2 pair in the ♂.

Description: A small, relatively broad species; largest ♂ (holotype) with 31 segments, last 4 legless; other ♂ with 29 and 30 segments, last 3 legless; largest specimen, a ♀, with 31 segments, 3 legless, 7 mm long, 1.6 mm wide. Head (Fig. 18) short and broad, sides straight, meeting in a 70° angle; antennae unusually short and thick, not extending laterally beyond outer limits of segment 3; ocelli of all specimens 2-2, anterior ones separated by at least twice the diameter of an ocellus. Segment 5 with pores very low on sides, interzonal stria little bent behind them, other pores similarly low (Fig. 19). Penultimate segment narrow behind and deeply emarginate (Fig. 20), last segment small and rounded behind.

Anterior gonopods simple (Fig. 21), all joints visible from in front; coxae small and without distal lobes; seminal joint only slightly curved and with slender, acute tip. Sternum very short but broad with short, moderately separated lobes; outer limits raised. Male legs 1 and 2 (Fig. 22, 23) with unlobed coxae, sixth joints very slender with long, slender, acute claws; other legs with similar last joints and claws. First sternum narrow, a little raised; second sternum low and slightly wider; other sterna throughout body of both sexes narrow. Coxae in both sexes with large, broadly oval and transverse, pouch pits.

Polyzonium mutabile Causey 1951

After seeing a somewhat mutilated Illinois paratopotype ♂ from Dr. Causey, a partial description was prepared but was expanded much later after seeing additional paratopotype material from the Illinois Natural History Survey.

Description: All 5 ♂ seen had 3 legless posterior segments but otherwise appeared mature; all had ocelli 3-3; antennae stout and relatively short, when extended laterally seldom exceeding outer limits of segment 3; head shorter and broader than in any other species seen; in largest ♂ the straight sides meet in front at an angle of 82 to 83°. Pores of segment 5 set low and farther caudad in prozonite than in other species, each pore directly in the nearly straight but slightly elevated interzonal stria. In 1 ♂ not enough of the stria is exposed for the pore to be seen within it; succeeding pores higher and well behind the striae. Posterior corners of penultimate segment abruptly rounded but not angular, intervening border rather deeply and evenly emarginate. Last segment broadly but moderately rounded behind; corners rounded rather than angular.

Anterior gonopod and mutilated legs 1 and 2 of Causey ♂ shown in Fig. 24 to 26; legs 1 and 2 of Urbana males scarcely crassate with nearly straight claws little blunted at tips. Legs 1 to 8 gradually increasing in size with third legs not thicker than adjacent ones. Third sternum not over a third the length of either coxa; sterna thereafter widening to between eighth legs which about equal half the length of either coxa; sterna behind gonopods narrowly truncate at tip, separating the coxae slightly. Coxal pits all rather small, more circular than oval and subequal in size.

Dr. Causey originally reported this species from 6 other localities in Illinois.

Polyzonium quadricauda new species

Holotype ♂ male, Stony Brook State Park, Steuben Co., New York, 1 August 1957, R. L. Hoffman and W. B. Muchmore.

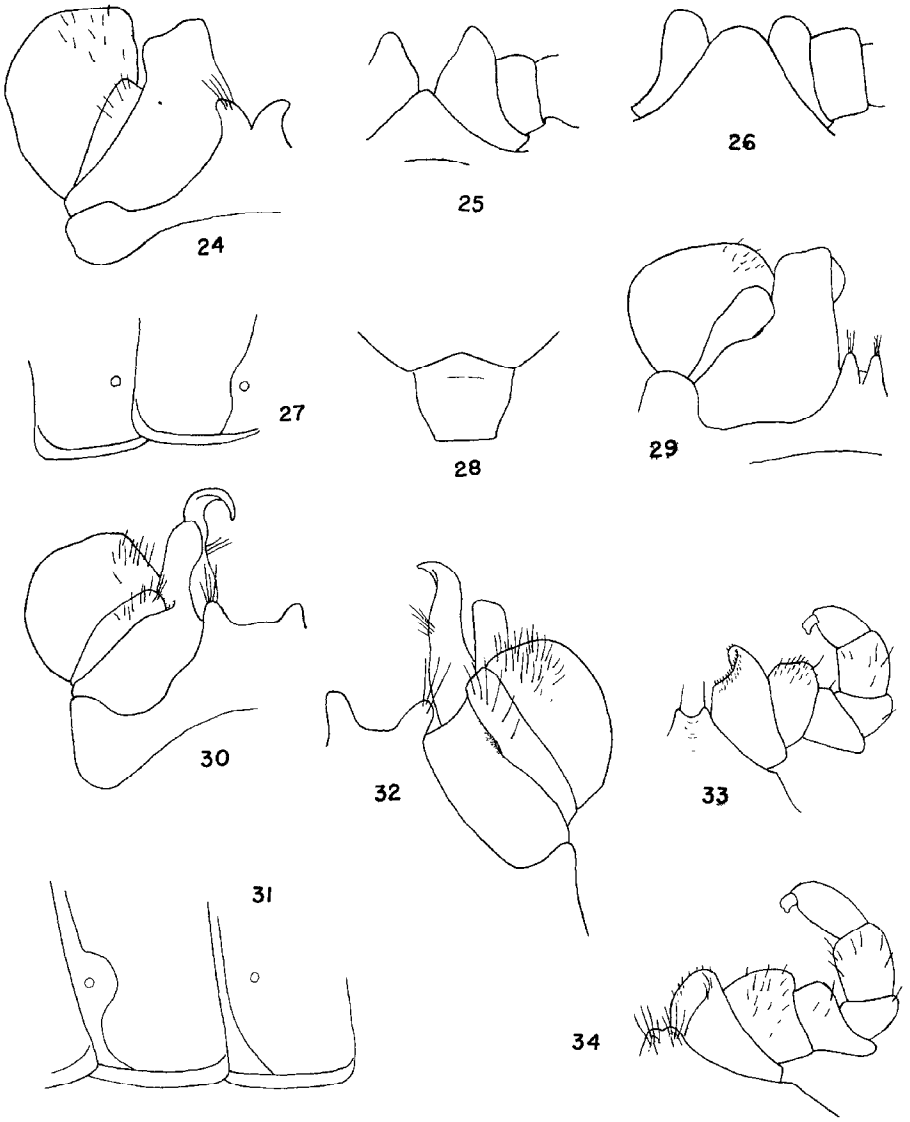

Fig. 24-26, *Polyzonium mutabile* Causey: 24. Left anterior gonopod (anterior view); 25. Sternum and basal joints of first legs (posterior view); 26. Sternum and basal joints of second legs (anterior view).

Fig. 27-29, *Polyzonium quadricauda* new species: 27. Segments 5 and 6 (lateral view); 28. Posterior end of body (dorsal view); 29. Left anterior gonopod and part of sternum (anterior view).

Fig. 30. *Hexaglena cryptocephala* McNeill. Left anterior gonopod and part of sternum of cotype (anterior view).

Fig. 31-34, *Polyzonium rosalbum* (Cope): 31. Segments 5 and 6 (lateral view); 32. Right anterior gonopod and part of sternum (anterior view); 33. Leg 1 and sternum (posterior view); 34. Leg 2 and part of sternum (anterior view).

Diagnosis: Outstanding characters are the broad and short gonopodial sternum abruptly enlarged at lateral limits; small, basally adjacent mesal lobes; and the very narrow sterna beginning on segment 4 and continuing thereafter.

Description: Length 7 mm, width 1.6 mm, 33 segments, the last 3 legless. Head somewhat crushed but appearing to be short and broad with straight sides meeting in front in about a 70° angle; antennae moderately stout and apparently not equalling sides of midbody when held laterally; ocelli 3-3, front interocular space exceeding diameter of an ocellus, posterior space 4 to 5 times as wide. Pores of segment 5 (Fig. 27) not especially low on sides, interzonal stria only slightly bulging behind pore; succeeding pores a little higher. Last segment (Fig. 28) is greatly protruded by the preservative but is truncate and laterally square angled, to which the specific name refers.

Anterior gonopod (Fig. 29) with coxal lobe high, wide, and obliquely truncate at apex which is thin and not bent caudad; joints 2 and 3 without large setae, the latter with a few small ones; joints 3 to 6 curving backward, inward, and then outward behind the coxal lobe; the short, stout, scoop-like sixth joint partly visible in front view; sternal lobes relatively small, short, and close together at base, terminating in the usual 3 or 4 setae that are very fine and short; outer limit of sternum unusually high and large. Legs 1 and 2 smaller but little more crassate than succeeding ones, the first with claw slightly thickened and subacute, the second claw less thickened, acute, and little larger than those thereafter. First sternum low and narrow; coxal lobes rising high above it and almost in contact. Second sternum low, moderately wide, apically straight across, the coxa each side low, rounded, and less elevated than preceding pair. Third sternum narrow, the coxae obviously separated, but thereafter all sterna very narrow, opposing coxae nearly touching. Pouch pits of third coxae large, transversely oval, succeeding ones smaller and almost round.

Polyzonium rosalbum (Cope)

Petaserpes rosalbus Cope 1870, p. 65; Bollman 1888, p. 343.

Hexaglena cryptocephala McNeill 1887, p. 328; type locality: Bloomington, Monroe Co., Indiana. NEW SYNONYMY.

This species has been reported from many parts of the eastern and north central states but not from near its type locality, given only as "western slope of the Cumberlands, in the northern part of East Tennessee." Before me are many specimens of a distinctive species from areas in northeastern Tennessee, adjacent Virginia, and elsewhere, that in all probability are *rosalbum*, of which the type no longer is known to exist. It now seems desirable to retrieve *rosalbum* from the synonymy to which it long has been relegated, and to establish a neotype for it from near its likely point of discovery, thought by R. L. Hoffman and me to have been in Scott Co., Tennessee. Accordingly a ♂ neotype has been selected from 3 ♂ and 4 ♀ collected NE of Dungannon, Scott Co., Virginia, at an elevation of 2,500 ft, by R. L. Hoffman and K. P. Brownell, 31 July 1965.

After careful examination of 3 ♂ and 4 ♀ cotypes of McNeil's *Hexaglena cryptocephala*, lent to me by the U. S. National Museum, no major

differences could be found to separate them from the southern ones that have been considered to be *P. rosalbum.* The seminal joints are somewhat more hooked (Fig. 30) and the pores of segment 5 are in much less prominent pads with the pores that follow higher than in typical *rosalbum,* characters hardly sufficient to sustain separation from that species. The other northern specimens seem to have their pores located quite as in *cryptocephala.*

Causey's (1951) figure of the gonopod of *P. mutabile,* on the basis of which Chamberlin and Hoffman (1958) placed her species as a synonym of *P. cryptocephalum,* shows so little similarity with the gonopod of the cotype of *cryptocephaha* that *mutabile* has been retained in its original status as a valid species.

In addition to the Indiana type locality of *H. cryptocephala* and the Virginia neotype locality of *rosalbum,* other localities are: KENTUCKY: 7 ♂, 2 ♀, 1 young, Dunkan Hollow, 4.5 mi. NE of Slade, Menifee Co., 31 August 1957, Leslie Hubricht; 7 ♂, 1 ♀, ravine near Wind Cave, 5.5 mi. S of McKee, Jackson Co., 1 September 1957, R. L. Hoffman; 1 ♀, 5 mi. W of Grayson, on U. S. 460, Carter Co., 22 April 1961, R. L. Hoffman and J. G. Barker; 1 ♀, Cumberland Fall State Park, Whitley Co., 8 September 1967, S. E. Neff and R. L. Hoffman. NEW YORK: 7 ♂, 2 ♀, 5 young, Marcellus, Onondaga Co., 11 June 1898, O. F. Cook; 2 ♂, Mendon Ponds, Monroe Co., 7 October 1954, W. B. Muchmore; 2 ♂, 3 ♀, Stony Brook State Park, Steuben Co., 1 August 1957, R. L. Hoffman and W. B. Muchmore; ♂ labelled "Taughannock, N. Y., Sept. 1921" by its collector, R. C. Shannon, probably refers to Taughannock Falls, Tompkins Co., NORTH CAROLINA: 2 ♂, 2 young, Fayetteville, Cumberland Co., 22 November 1948, W. L. Wray; 1 ♂, 5 ♀, 4 young, rocky upland woods, 3 mi. SE of Albemarl, Stanley Co., 19 October 1952, Leslie Hubricht; 1 ♂, Silvermine Recreation Area, Hot Spring, Madison Co., 2 August 1962, R. L. Hoffman; 3 ♂, 3 ♀, ravine, Paint Rock, Madison Co., 13 September 1952, Leslie Hubricht; 3 ♂, 3 ♀, ravine along Southern Ry., between Hot Springs and Paint Rock, Madison Co., 2 August 1962, R. L. Hoffman; 3 ♂, U. S. Hy. 70, .8 mi. E of N. C. Hy. 22, Madison Co., 23 July 1961, R. L. Hoffman. TENNESSEE: 1 ♂, along Forest Service road, *ca.* 4.5 mi. NE of Shell Creek, Carter Co., 17 July 1965, K. P. Brownell and R. L. Hoffman; 2 young, 3.5 mi. S of Archville, near Goforth Creek, Polk Co., 28 May 1958, Leslie Hubricht; 1 ♂, Forest Service road across Bald Mountain, *ca.* 4 mi. S of Camp Creek, Green Co., 1 August 1962, R. L. Hoffman. VIRGINIA: 1 ♂. 8 ♀, 1.5 mi. NE of Vera, Appomattox Co., 5 October 1952, Leslie Hubricht; 3 ♀, Grimleysville, Buchanan Co., 1 July 1951, R. L. Hoffman and W. B. Newman; 4 ♀, S side Mount Rogers, 4,500 ft. elev., Grayson Co., 27 September 1969, Radford College group trip; 1 ♂, 2 ♀, Draper Mountain above Pulaski, Pulaski Co., 4 October 1959, R. L. Hoffman and R. E. Crabill; 1 ♀ female, top of Clinch Mountain, Burkes Garden, Tazewell Co., 14 November 1965, Radford College Biological Club; young ♂, bluff along Bannister River, 1.5 mi. NW of Riceville, Pittsylvania Co., 25 February 1951, Leslie Hubricht; 1 ♀, S. S. Cole property, 10 mi. NE of Pulaski, Pulaski Co., July 1963, F. D. Staples; 2 ♀, Peaks of Otter, 2,800 ft. elev., Bedford Co., 14-15 October 1952, Leslie Hubricht; 1 ♀ W side of Clinch Mountain, 2,500 ft. elev., *ca.* 2 mi. S of Fugate Hill, Russell Co., 31 July 1965, R. L. Hoffman and K. P. Brownell; young ♂, Kibler Park, below Pinnacles Power House, Patrick Co., 8 April 1951, Leslie Hubricht: 1 ♂, Va. Hy. 58, 11 mi. E of Hiltons, Scott Co., 29 August 1962, R. L. Hoffman; young ♀, Buffalo Mountain, 3,500 ft. elev., Floyd Co., 24 October 1958, R. L. Hoffman. WEST VIRGINIA: 2 ♂, 1 ♀, rich woods along stream, 4 mi. NE of Swiss, Nicholas Co., 2 September 1965, R. L. Hoffman and K. P. Brownell; 1 ♀, bluff along W. Va. Hy. 12, *ca.* 4.2 mi. SE of Bellepoint, Summers Co., 12 December 1965, R. L. Hoffman; 1 ♀, Elk River Bluff, 7 mi. SW of Frametown, Braxton Co., 17 June 1956, Leslie Hubricht.

Diagnosis: Aside from details of the gonopods, this species may be distinguished from *bivirgatum*, the only other species in its general range, by the shorter and broader head; crassate anterior legs of ♂, particularly the third pair; shape of coxal lobes of legs 1 and 2; and the relatively low sternum between the second ♂ legs.

Description: Length 12 to 19 mm, a fifth or sixth as wide, the strongly convex body with 50 to 60 segments. Head short and broad, sides straight, meeting at an angle of above 70°; ocelli usually 3-3, but 4-4 in several specimens; rows separated in front by more than diameter of an ocellus, posterior separation 3 to 4 times as much; antennae not equalling sides of midbody when extended outward, joints rather thick. Pores of segment 5 moderately low on sides, opening from a slight depression in the usually large pore pad (Fig. 31), other pores at nearly same level although higher in northern specimens, a slight depression usually behind pores. Penultimate segment with posterior corners narrowly rounded, back margin shallowly to moderately emarginate at middle. Last segment broad and faintly rounded behind, sides strongly diverging cephalad. Anterior gonopod (Fig. 32) with coxal lobe rising behind joints 2 and 3; outer limit of sternum abruptly raised. Legs 1 and 2 (Fig. 33-34) with coxal lobes high, elongate, and somewhat hollowed on inner anterior surface; other joints rather short and thick; claws large, strongly curved, thin, broad, tip bluntly rounded; second sternum much lower than coxae; third legs large, crassate; coxae large, thick, and each with large, broadly oval pouch pit; claws slender, slightly curved, acute at tip like following legs; sternum wide. Other pregenital legs becoming gradually less crassate but thicker than postgenital ones, their pouch pits smaller but also oval; postgenital pits moderately large, round to broadly oval. Sterna of legs 3 to 8 very broad, those behind gonopods narrow, the coxae almost in contact.

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FALL ARMYWORM, *SPODOPTERA FRUGIPERDA*, MALES CAPTURED AT THREE FLORIDA LOCATIONS IN TRAPS BAITED WITH VIRGIN FEMALES[1]

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ABSTRACT

The fall armyworm, *Spodoptera frugiperda* (J. E. Smith), was captured in traps baited with virgin females before larvae or eggs were observed on corn plants in Belle Glade, Sanford, and Gainesville, Florida. Adult fall armyworms were active in Belle Glade and Sanford prior to or during mid-March. Adult population peaks were not indicated by traps nearly as well as by observation of larvae in the whorl of young corn plants.

The fall armyworm, *Spodoptera frugiperda* (J. E. Smith), a serious pest of sweet corn in Florida, is potentially subject to area eradication because Luginbill (1928) reported that populations appear to be limited to south Florida during winter months. Knowledge of seasonal occurrence and spread northward of this insect from overwintering areas is important to an eradication program.

Snow and Copeland (1969) reported the effectiveness of traps baited with virgin females. Similar traps were used at 3 locations in Florida to study development of fall armyworm populations. At both Belle Glade and Sanford one trap was placed adjacent to corn fields, another one 1/2 mile away from corn plants. Only one trap, 1/4 mile from a corn field, was operated at Gainesville. The trap used was similar to the Steiner trap pictured by Snow and Copeland (1969); each trap was baited weekly with 5 virgin females and supplied with a shell vial of 10% sugar solution.

Table 1 shows the catches of males relative to the percent of sweet corn plants damaged by larvae. The trap catches at Belle Glade and Sanford did not indicate the first occurrence of adults because male fall armyworms were caught the first week of trap operation. Moreover at both locations, adults were trapped before larval feeding signs were noted in the whorl of corn plants. Population peaks were not indicated by the traps. Snow and others (personal communication) speculate that natural populations saturate the environment with pheromone and therefore the traps become less efficient.

These data demonstrate that fall armyworm adult activity at Belle Glade and Sanford, Florida, occurs prior to or during mid-March, before larval populations are observed on corn plants. This activity may relate to migration of adults into those areas or to a change in host plant species. However, overwintering in these areas of Florida during the winter of 1969-70 is doubtful since larvae were not seen during January and February and diapause has not been reported. The near absence of males in the

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TABLE 1. FALL ARMYWORM MALES CAPTURED IN STEINER TYPE STICKY TRAPS BAITED WITH 5 VIRGIN FEMALES DURING THE SPRING OF 1970 IN FLORIDA.

Date	Males per trap			% of sweet corn* plants damaged	
	Belle Glade	Sanford	Gainesville	Belle Glade	Sanford
17-24 March	4	1.5	0	0	0
25 March—3 April	4	0.0	1	0	0
4-8 April	3	3.0	0	0	0
8-14 April	4	1.5	1	First seen	0
15-22 April	5	1.0	0	Low	0
22-28 April	5	1.5	0	15	0
29 April—5 May	4	0.5	0	25	First seen
6-14 May	0.5	1.5	0	60	8
14-22 May	16	0.0	0	70-90	27
28 May—3 June	6	4.5	0	70-90	50
4-12 June	8	1.5	1	70-90	75

*At Belle Glade, 200 plants were observed per week while at Sanford 100 to 300 were inspected each week. As the percent plants damaged increased so did the number of larvae per plant.

Gainesville traps may relate to trap location, in woods near a corn field. On the other hand fall armyworm adults were consistently absent or scarce in blacklight traps during winter and spring at Gainesville. Blacklight trap collections at Gainesville from 1963 to 1970 show the earliest collection of fall armyworm adults was 4 April 1970; the latest first date was 16 May 1967. In 6 of 8 years the first moth was recovered during April. In all years *S. frugiperda* was limited to a scattered few individuals until June, and in some years, even June collections were low.

Snow and Copeland (1969) report movement of males into Georgia during May which means they would have to move through the latitude of the Gainesville area if they were moving to Georgia from central and south Florida.

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ALATE APHIDS CAPTURED IN YELLOW PANS PLACED AROUND A CORN FIELD IN NORTHEAST MISSISSIPPI[1]

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ABSTRACT

Yellow pan traps containing water were used to collect alate aphids around the periphery of a corn field located in northeast Mississippi. A total of 35 aphid species in 15 genera was captured in 10 traps during May through August 1969. Eighty-six percent of the trapped aphids were composed of 4 species: the pea aphid, *Acyrthosiphon pisum* (Harris) (51.3%); the spirea aphid, *Aphis spiraecola* Patch (15.0%); the corn root aphid, *Aphis maidiradicis* (Forbes) (10.1%) and the green peach aphid, *Myzus persicae* (Sulz.) (9.3%). Four other species accounted for 6.8% of the total aphid collection: the bean aphid, *Aphis fabae* Scopoli (2.9%); the ambrosia aphid, *Dactynotus ambrosia* (Thos.) (1.6%); *Capitophorus braggii* (Gill.) (1.2%); and *Myzocallis multisetis* (Tiss. & Boud.) (1.1%). Aphid activity was highest during May and August.

Maize dwarf mosaic (MDM), a destructive disease of corn in much of the corn growing regions of the United States, is caused by the aphid-borne, mechanically transmissible maize dwarf mosaic virus (MDMV) (Stoner 1968). The corn leaf aphid, *Rhopalosiphum maidis* (Fitch), was first incriminated as a vector of MDMV in studies by Stoner et al. (1964). Since this initial report of aphid transmission of MDMV, a number of other aphid species have been reported to be vectors of this virus. These include the green peach aphid, *Myzus persicae* (Sulzer); the apple grain aphid, *Rhopalosiphum padi* (L); the blue grass aphid, *Rhopalosiphum poae* Gill.; the pea aphid, *Acyrthosiphon pisum* Harris; the melon aphid, *Aphis gossypii* Glov.; *Dactynotus* sp.; the cowpea aphid, *Aphis craccivora* Koch; the spotted alfalfa aphid, *Therioaphis maculata* (Buckton); the cabbage aphid, *Brevicoryne brassicae* L.; the corn root aphid, *Anuraphis maidiradicis* (Forbes) (Bancroft et al. 1966); and the green bug, *Schizaphis graminum* (Rond) (Daniels and Toler 1969). Although other types of insects, including leafhoppers, beetles, and grasshoppers, have been tested as vectors of MDMV, only tests with aphids have been successful.

Aphids collected in yellow pan traps may be used as an indication of peaks of aphid flight activity. These peaks of activity reflect that segment of an aphid population which is able to alight and thus probably represent periods of greatest dispersal of an aphid infestation (Evans and Medler 1967).

Aphid activity during the corn growing season, particularly in the southern portion of the United States, is not well documented. Therefore, knowledge of aphid populations and their flight activity in the vicinity of corn fields where MDMV is prevalent is essential in assessing the potential of various species to spread of the mosaic virus in corn. This paper pre-

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sents trap collections of alate aphids taken from the periphery of a corn field in northeast Mississippi during a single corn growing season.

Methods and Materials

An isolated field of ca. 2 acres near State College, Mississippi, was selected for collection of aphids during the summer of 1969. A high incidence of MDMV disease was recorded in corn and Johnson grass in this field during the previous 3 years. The field was planted with Pioneer 309B hybrid dent corn on 23 April and harvested on 23 August.

Polystyrene plant trays[3], 8 × 12 × 2 3/4 in., painted with 2 applications of Canary Yellow Pratt and Lambert Effecto Enamel were used as collection traps. Ten yellow pans were filled 1/2 to 2/3 full of water and placed around the periphery of the field. Yellow pans on a bare soil background were shown to be more effective in attracting aphids than traps placed on a vegetative background (Moericke 1955). Broadbent (1948) found that traps placed above ground level were more effective in collecting aphids than traps placed on the ground surface. For increased efficiency in the present study, an area of ca. 6 ft diam was cleared of all vegetation and a 1 gal can (10 in. high), placed on the bare ground in the center of the cleared area, was used as a support for the yellow pan traps. The area around the traps was kept free of vegetation during the trapping period.

Beginning 2 May 1969, the yellow pan traps were used for 24-hr periods at weekly intervals for 16 consecutive weeks. Aphids were removed from the pans and preserved in 70% ethyl alcohol. The aphids were mounted on slides, identified, and numbers of each species were recorded. Similar traps were used by Evans and Medler (1967) to determine the flight activity of the corn leaf aphid on corn, and by Coon and Pepper (1968) to determine the abundance of aphids on small grain.

Results and Discussion

A total of 35 aphid species in 15 genera was collected from May through August 1969, with a range of 1 to 776 specimens for the various species (Table 1). Eighty-six percent of the trapped aphids were composed of 4 species: the pea aphid (51.3%); the spirea aphid, *Aphis spiraecola* Patch (15.0%); the corn root aphid (10.1%); and the green peach aphid (9.3%). Four other species accounted for 6.8% of the total aphid collection: the bean aphid, *Aphis fabae* Scopoli (2.9%); the ambrosia aphid, *Dactynotus ambrosia* (Thos.) (1.6%); *Capitophorus braggii* (Gill.) (1.2%); and *Myzocallis multisetis* (Tiss. & Boud.) (1.1%). The remaining 27 species each accounted for less than 1% of the total aphid collection taken during the sample period.

The total aphid collections during the sample period showed periods of apparent high flight activity in May and in August. The spring period of high aphid activity in the study area during 1969 coincides closely with the period when corn is in the seedling stage in northeast Mississippi. Aphids active during this period are potential transmitters of MDMV and thus may be significant in relation to the spread of MDMV from reservoir host plants to corn.

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[3]Purchased from Carolina Biological Supply Company, Burlington, North Carolina 27216.

TABLE 1. NUMBER OF ALATE APHIDS COLLECTED IN YELLOW PAN TRAPS FROM MAY THROUGH AUGUST 1969, STATE COLLEGE, MISSISSIPPI.

Aphid Species	May	June	July	August	Total	Percent
Acyrthosiphon pisum (Harris)	774	2	0	0	776	51.3
Aphis spiraecola Patch	20	0	0	208	228	15.0
Aphis maidicadicis (Forbes)	23	10	8	113	154	10.1
Myzus persicae (Sulz.)	137	3	0	1	141	9.3
Aphis fabae Scopoli	45	0	0	0	45	2.9
Dactynotus ambrosia (Thos.)	18	4	0	3	25	1.6
Capitophorus braggii (Gill.)	18	0	0	1	19	1.2
Myzocallis multisetis (Tiss. & Boud.)	18	0	0	0	18	1.1
Aphis hedarae Kaltenbach	11	0	0	2	13	0.8
Rhopalosiphum maidis (Fitch)	3	0	0	9	12	0.7
Aphis craccivora Koch	11	0	0	1	12	0.7
Periphyllus populicola (Thomas)	2	4	6	0	12	0.7
Aphis nerii Fonsc.	2	2	2	3	9	0.5
Aphis gossypii Glover	2	0	0	4	6	0.3
Aphis abbreviata (Patch)	3	2	0	1	6	0.3
Aphis coreopsidis (Thos.)	6	0	0	0	6	0.3
Aphis hilianthi Monell	3	0	0	2	5	0.3
Dactynotus erigronensis (Thos.)	5	0	0	0	5	0.3
Rhopalosiphum pseudobrassicae (Davis)	2	0	1	0	3	0.2
Amphorophora sonchii (Oestlund)	3	0	0	0	3	0.2
Lachnochaitophorus obscurus (Tissot)	0	0	0	3	3	0.2
Myzus porosus Sanderson	3	0	0	0	3	0.2
Capitophorus viminalis Monell	0	1	0	1	2	0.2
Macrosiphum rosae (Linnaeus)	2	0	0	0	2	0.2
Monellia nigropunctata Granovsky	2	0	0	0	2	0.2

Table 1 (Continued)

Aphid Species	May	June	July	August	Total	Percent
Myzocallis walshii (Monell)	2	0	0	0	2	0.2
Schizaphis graminum (Rond)	2	0	0	0	2	0.2
Aphis sambucifoliae Fitch	0	1	0	0	1	0.1
Calaphis betullela Walsh	1	0	0	0	1	0.1
Capitophorus hippophaes (Walker)	1	0	0	0	1	0.1
Dysaphis sp.	1	0	0	0	1	0.1
Myzus eriobotyrae (Tissot)	1	0	0	0	1	0.1
Rhopalosiphum fitchii (Sanderson)	1	0	0	0	1	0.1
Rhopalosiphum rhois (Monell)	0	1	0	0	1	0.1
Rhopalosiphum rufiabdominalis Mason	1	0	0	0	1	0.1

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DESCRIPTIONS OF THE PUPAE OF *AEDES (OCHLEROTATUS) ATLANTICUS* AND *AEDES (O.) TORMENTOR* (DIPTERA: CULICIDAE)[1]

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ABSTRACT

The pupae of *Aedes (Ochlerotatus) atlanticus* Dyar and Knab and *Aedes (Ochlerotatus) tormentor* Dyar and Knab are described and illustrated for the first time. Two tables list the range, mode, and mean number of branches of each pupal hair for the 2 species. Notes on the biology of the larvae and pupae are given.

The original descriptions of *Aedes (Ochlerotatus) atlanticus* and *Aedes (Ochlerotatus) tormentor* were published by Dyar and Knab in 1906. These written descriptions and illustrations were incomplete and based only on the fourth instar larvae. Complete descriptions, accompanied by illustrations, of the males, females, and fourth instar larvae were given by Carpenter and La Casse (1955). The first instar larvae were described and illustrated by Dodge (1966); the egg of *Aedes atlanticus* by Craig and Horsfall (1960).

In the present paper the pupae of *Aedes atlanticus* and *Aedes tormentor* are described and illustrated (Fig. 1-6) for the first time. Tables 1 and 2 list the range, mode, and mean number of branches of each pupal hair for these species. The chaetotaxy and morphological nomenclature follow Belkin (1962).

Aedes (Ochlerotatus) atlanticus Dyar and Knab

Cephalothorax (Fig. 1). Hairs C-1-5, 7-9 long, C-6 short, C-1-3 double, C-4-5, 8 usually with 4-5 branches, C-6 usually single, C-7 usually with 5-6 branches, C-9 usually double or triple.

Respiratory trumpet (Fig. 2). Strongly pigmented; several scattered tiny spine-like setae on distal 0.75 of inner surface; index 3.92-4.60.

Metanotum (Fig. 3). Hairs C-10-12 long, C-10 usually with 5-6 branches, C-11 usually double, C-12 usually with 5-7 branches.

Abdomen (Fig. 3). Hairs 0-II-VIII minute, single; 1-I well developed, usually with 22-30 branches on basal one third, 1-II-VI long, 1-VII moderately long, 1-II usually with 8-9 branches, 1-III usually with 5-6 branches, 1-IV, VI usually with 3-4 branches, 1-V, VII usually triple; 2-I-VII short, single; 3-I-II, V-VII long, 3-III extra long, 3-IV moderately long, 3-I usually triple, 3-II-III usually double, 3-IV usually with 4-6 branches, 3-V usually with 3-4 branches, 3-VI-VII usually double or triple; 4-I-III short,

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TABLE 1. RECORD OF THE BRANCHING OF THE SETAE ON THE PUPAE OF *Aedes atlanticus*.

Hair	Range	Mode	Mean
	Cephalothorax		
1	2	2	2
2	2	2	2
3	2	2	2
4	3-7	4	4.5
5	4-7	5	4.9
6	1-2	1	1.2
7	4-7	5	5.4
8	2-6	5	4.3
9	2-4	3	2.8
	Metanotum		
10	5-7	5	5.4
11	2-3	2	2.1
12	3-8	5	5.5
	Abdomen I		
1	20-32	25	26.8
2	1	1	1
3	2-4	3	2.9
4	2-4	3	2.8
5	3-8	5	5.5
6	1	1	1
7	2-4	4	3.3
9	1	1	1
	Abdomen II		
0	1	1	1
1	7-11	8	8.9
2	1	1	1
3	2-4	2	2.2
4	3-6	4	4.7
5	4-5	4	4.3
6	1	1	1
7	2-4	3	2.7
9	1	1	1
	Abdomen III		
0	1	1	1
1	4-8	6	5.7
2	1	1	1
3	2-3	2	2.1
4	3-6	5	4.3
5	3-6	4	4.4
6	2-3	2	2.4
7	2-4	4	3.5
8	3-5	4	3.9
9	1	1	1
10	1-4	2	2.2
	Abdomen III (Continued)		
11	1	1	1
14	1	1	1
	Abdomen IV		
0	1	1	1
1	3-5	3	3.5
2	1	1	1
3	3-7	5	5.1
4	3-4	4	3.8
5	2-3	3	2.3
6	1-3	3	2.4
7	3-4	3	3.2
8	2-4	3	3.1
9	1	1	1
10	2-4	3	2.9
11	1	1	1
14	1	1	1
	Abdomen V		
0	1	1	1
1	3-4	3	3.1
2	1	1	1
3	2-4	3	3.1
4	5-9	8	7.2
5	2-4	2	2.4
6	2-3	2	2.1
7	3-9	6	5.5
8	2-4	3	3.1
9	1	1	1
10	1	1	1
11	1	1	1
14	1	1	1
	Abdomen VI		
0	1	1	1
1	2-5	3	3.3
2	1	1	1
3	2-4	3	2.8
4	5-6	5	5.4
5	2-4	2	3
6	2-3	2	2.1
7	1	1	1
8	3-4	3	3.1
9	1	1	1
10	1	1	1
11	1	1	1
14	1	1	1

Table 1 (Continued)

Hair	Range	Mode	Mean	Hair	Range	Mode	Mean
	Abdomen VII				Abdomen VII (Cont)		
0	1	1	1	10	1-2	1	1.1
1	2-3	3	2.8	11	1-3	2	1.8
2	1	1	1	14	1	1	1
3	2-4	3	3.4		Abdomen VIII		
4	3-4	3	3.4	0	1	1	1
5	3-4	4	3.7	4	2-4	3	2.6
6	6-13	12	9.6	9	5-10	7	7.1
7	1	1	1	14	1	1	1
8	3-4	3	3.4		Paddle		
9	2-3	3	2.5	1	1-2	1	1.2

TABLE 2. RECORD OF THE BRANCHING OF THE SETAE ON THE PUPAE OF *Aedes tormentor.*

Hair	Range	Mode	Mean	Hair	Range	Mode	Mean
	Cephalothorax				Abdomen II (Continued)		
1	2-3	2	2.3	4	3-7	3	3.8
2	2-3	2	2.3	5	3-5	3	3.7
3	2	2	2	6	1	1	1
4	3-6	4	3.9	7	2-4	3	3.1
5	3-5	5	4.2	9	1	1	1
6	3-4	3	3.2		Abdomen III		
7	3-5	4	3.8	0	1	1	1
8	3-5	3	3.6	1	3-7	5	4.8
9	3	3	3	2	1	1	1
	Metanotum			3	1-2	2	1.8
10	3-6	5	4.8	4	3-5	4	3.5
11	2	2	2	5	3-6	4	4.6
12	4-6	5	4.8	6	1-3	2	1.9
	Abdomen I			7	2-4	3	2.9
1	18-28	23	22.6	8	2-4	3	3.1
2	1	1	1	9	1	1	1
3	3	3	3	10	1-2	1	1.2
4	2-5	3	3.1	11	1	1	1
5	5-8	6	5.9	14	1	1	1
6	1	1	1		Abdomen IV		
7	2-4	2	2.5	0	1	1	1
9	1	1	1	1	2-4	3	2.8
	Abdomen II			2	1	1	1
0	1	1	1	3	4-6	5	4.9
1	7-11	8	8.4	4	2-4	2	2.4
2	1	1	1	5	2-3	2	2.1
3	2-3	2	2.1	6	2-3	2	2.4

Table 2 (Continued)

Hair	Range	Mode	Mean	Hair	Range	Mode	Mean
Abdomen IV (Continued)				Abdomen VI (Continued)			
7	1-2	2	1.5	7	1	1	1
8	2-3	2	2.2	8	2-3	2	2.4
9	1	1	1	9	1	1	1
10	1-3	1	1.5	10	1	1	1
11	1	1	1	11	1	1	1
14	1	1	1	14	1	1	1
Abdomen V				Abdomen VII			
0	1	1	1	0	1	1	1
1	2-4	3	2.6	1	1-3	2	2.2
2	1	1	1	2	1	1	1
3	2-4	2	2.7	3	2-4	3	3.1
4	4-8	6	6.1	4	2-4	3	3.1
5	2	2	2	5	3-5	4	3.7
6	1-3	2	2.1	6	6-13	10	9.8
7	3-6	3	4.1	7	1	1	1
8	2-3	3	2.7	8	3-6	4	3.7
9	1	1	1	9	2-3	2	2.2
10	1-2	1	1.1	10	1-2	1	1.4
11	1	1	1	11	1	1	1
14	1	1	1	14	1	1	1
Abdomen VI				Abdomen VIII			
0	1	1	1	0	1	1	1
1	2-3	3	2.7	4	2-3	2	2.3
2	1	1	1	9	6-9	8	7.3
3	2-3	2	2.1	14	1	1	1
4	3-6	4	4.4				
5	2-3	2	2.1	Paddle			
6	1-2	2	1.6	1	1	1	1

4-IV-VI moderately long, 4-VII-VIII long, 4-I, VIII usually double or triple, 4-II-III usually with 4-5 branches, 4-IV usually with 4 branches, 4-V usually with 7-8 branches, 4-VI with 5-6 branches, 4-VII with 3-4 branches; 5-I short, 5-II, IV-VI long, 5-III, VII moderately long, 5-I usually with 5-7 branches, 5-II with 4-5 branches, 5-III usually with 5-7 branches, 5-IV double or triple, 5-V usually double or triple, 5-VI with 2-4 branches, 5-VII with 3-4 branches; 6-I-II extra long, 6-III-VI long, 6-VII moderately long, 6-I-II single, 6-III double or triple, 6-IV usually double or triple, 6-V-VI usually double, 6-VII usually with 10-12 branches; 7-I-II, VI-VII long, 7-III-IV short, 7-V moderately long, 7-I, III usually with 3-4 branches, 7-II usually double or triple, 7-IV with 3-4 branches, 7-V usually with 4-6 branches, 7-VI-VII single; 8-III-VII short, 8-III, V usually with 3-4 branches, 8-IV, VI usually triple, 8-VII with 3-4 branches; 9-I short, 9-II-VI minute, 9-VII moderately long, 9-VIII long, 9-I-VI single, 9-VII double or triple, 9-VIII usually with 7-8 branches with brush tips; 10-III-VII long, 10-III usually double or triple, 10-IV usually triple, 10-V-VI

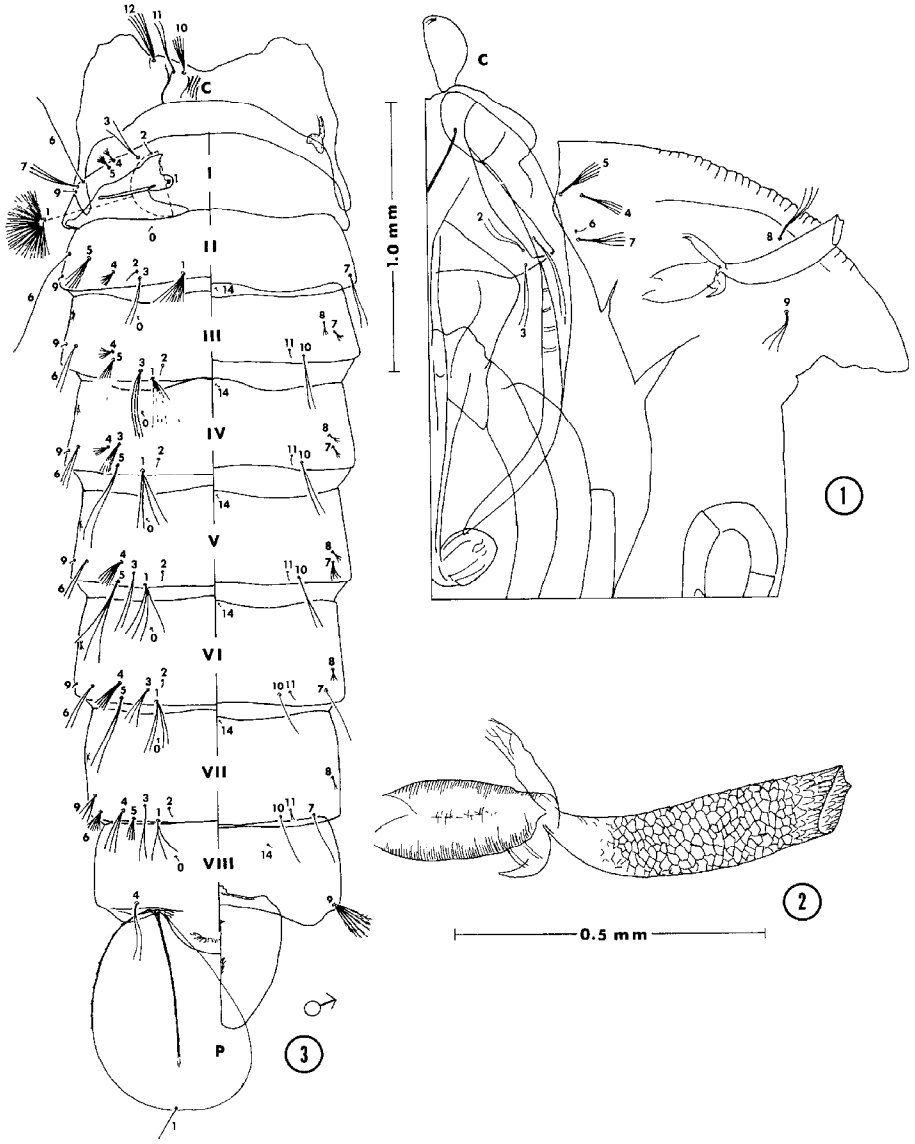

Fig. 1-3. Pupa of *Aedes atlanticus* Dyar and Knab. 1) Cephalothorax. 2) Respiratory trumpet. 3) Metanotum, abdomen and paddle. C = cephalothorax, I-VIII = abdominal segments 1 through 8, P = paddle.

single, 10-VII usually single; 11-III-VI short, 11-VII moderately long, 11-III-VI single, 11-VII usually double; 14-III-VIII minute, single.

Paddle (Fig. 3). Ovoid with minute serrations along basal 0.55 of outer margin, midrib does not reach apex; 1-P moderately long and usually single; index 1.19-1.33.

The above description is based on the following material collected by the author in Alachua County, Florida: 2 females, 16 August 1970, Micanopy; 4 males, 18 August 1970, 7 males and 5 females, 30 August 1970 and 4 males and 4 females, 2 September 1970, Gainesville.

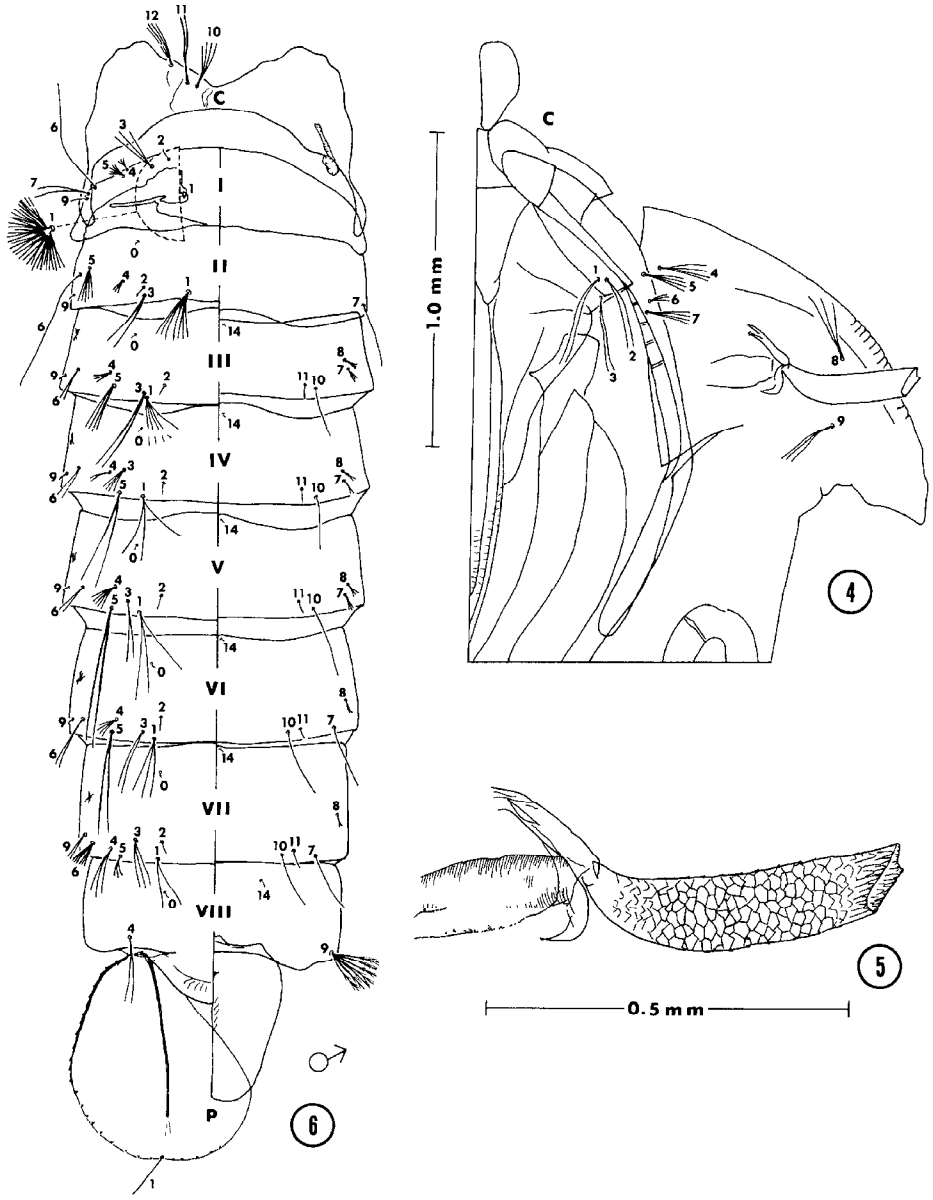

Fig. 4-6. Pupa of *Aedes tormentor* Dyar and Knab. 4) Cephalothorax. 5) Respiratory trumpet. 6) Metanotum, abdomen and paddle. C = cephalothorax, I-VIII = abdominal segments 1 through 8, P = paddle.

Aedes (*Ochlerotatus*) *tormentor* Dyar and Knab

Cephalothorax (Fig. 4). Hairs C-1-5, 7-9 long, C-6 short, C-1-2 usually double, C-3 double, C-4, 7-8 usually with 3-4 branches, C-5 usually with 4-5 branches, C-6 with 3-4 branches, C-9 triple.

Respiratory trumpet (Fig. 5). Strongly pigmented; several scattered tiny spine-like setae on distal 0.75 of inner surface; index 4.00-4.50.

Metanotum (Fig. 6). Hairs C-10-12 long, C-10, 12 usually with 4-5 branches, C-11 double.

Abdomen (Fig. 6). Hairs 0-II-VIII minute, single; 1-I well developed, usually with 21-23 branches on basal one third, 1-II-VI long, 1-VII moderately long, 1-II usually with 7-9 branches, 1-III usually with 4-5 branches, 1-IV-V usually double or triple, 1-VI usually triple, 1-VII usually double; 2-I-VII short, single; 3-I-II, V-VI long, 3-III extra long, 3-IV, VII moderately long, 3-I triple, 3-II-III, VI usually double, 3-IV usually with 4-5 branches, 3-V, VII usually double or triple; 4-I-III short, 4-IV-VI moderately long, 4-VII-VIII long, 4-I usually triple, 4-II-III, VII usually with 3-4 branches, 4-IV usually double, 4-V usually with 5-7 branches, 4-VI usually with 4-5 branches, 4-III double or triple; 5-I short, 5-II, VII moderately long, 5-III long, 5-IV-VI extra long, 5-I usually with 5-6 branches, 5-II, VII usually with 3-4 branches, 5-III usually with 4-5 branches, 5-IV, VI usually double, 5-V double; 6-I-II extra long, 6-III-V, VII moderately long, 6-VI long, 6-I-II single, 6-III, V usually double, 6-IV double or triple, 6-VI single or double, 6-VII usually with 7-10 branches; 7-I-II, VI-VII long, 7-III-V short, 7-I usually double or triple, 7-II usually with 3-4 branches, 7-III usually triple, 7-IV single or double, 7-V usually with 3-5 branches, 7-VI-VII single; 8-III-VII short, 8-III, VII usually with 3-4 branches, 8-IV-VI double or triple; 9-I-VI minute, 9-VII moderately long, 9-VIII long, 9-I-VI single, 9-VII double or triple, 9-VIII usually with 6-8 branches with brush tips; 10-III-VII long, 10-III, V usually single, 10-IV, VII single or double, 10-VI single; 11-III-VII short, single; 14-III-VIII minute, single.

Paddle (Fig. 6). Ovoid with minute serrations along basal 0.55 of outer margin and minute spicules along apical 0.45 of outer and inner margins, midrib does not reach apex; 1-P moderately long and single; index 1.19-1.43.

The above description is based on the following material collected by the author at Gainesville, Alachua County, Florida: 2 males, 18 August 1970, 6 males and 3 females, 30 August 1970 and 3 males and 2 females, 1 September 1970.

Taxonomic discussion. The following characters can be used to separate the pupae of the 2 species. *Aedes atlanticus* has hair C-6 usually single (double in 2 specimens), hair 7-IV with 3-4 branches, paddle without minute spicules along apical 0.45 of outer and inner margins, and abdominal segments I-V usually light brown in color while *Aedes tormentor* has hair C-6 with 3-4 branches, hair 7-IV single or double, paddle with minute spicules along apical 0.45 of outer and inner margins, and abdominal segments I-V usually dark brown in color.

Biological notes. All specimens were collected in the field as larvae and individually reared in the laboratory under outdoor light and temperature conditions. The *Aedes atlanticus* larvae from the location near Micanopy were collected from a small, shallow, fresh water pool shaded by grass and weeds located in a pasture, and they were associated with larvae of *Aedes dupreei, Anopheles crucians, Culex pilosus, Psorophora confinnis, Psorophora ferox,* and *Uranotaenia sapphirina.* At Gainesville the larvae of *Aedes atlanticus* and *Aedes tormentor* were collected together from several small, shallow, shaded forest pools containing moderately colored water and many leaves on the bottom. The larvae of these 2 species were

associated with larvae of *Aedes dupreei, Aedes infirmatus, Psorophora ciliata, Psorophora ferox,* and *Psorophora howardii.*

The length of time spent in the pupal stage for *Aedes atlanticus* ranged from 1 day 7 hours to 1 day 13 hours for males and 1 day 11 hours to 1 day 16 hours for females. For *Aedes tormentor* the length of time spent in the pupal stage ranged from 1 day 9 hours to 1 day 15 hours for males and 1 day 7 hours to 1 day 14 hours for females.

Additional information on the biology of these 2 species is given by Michener (1947), Carpenter and La Casse (1955), and King et al. (1960).

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CORN EARWORM, *HELIOTHIS ZEA*: SUSCEPTIBILITY TO INSECTICIDES[1]

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ABSTRACT

Dosage-mortality relationships between insecticides and the corn earworm, *Heliothis zea* (Boddie), were ascertained by topical microapplication of acetone solutions of technical insecticides. Field-collected larvae of 50±25 mg were tested, as were the same size larvae of laboratory-reared F_1 descendants of the same populations. Base lines of susceptibility established for new insecticides against laboratory-reared populations had LD_{50}'s of 68.8 ug/g for methomyl and 92.0 for Gardona® (2-chloro-1-[2, 4-dichlorophenyl] vinyl diethyl phosphate). LD_{50}'s for DDT were 100-200X those reported in 1959 for *H. zea* in North Carolina. The laboratory-reared larvae consistently had greater LD_{50}'s than the field-collected ones.

Entomologists have often been urged to establish base lines of susceptibility of economically important arthropods to new toxicants, and to monitor developing resistance to toxicants with careful dosage-mortality studies. This is routine work, but quite time consuming, and little has been done except with a few pests of major importance. Given the anarchy in testing, with diverse measuring procedures, only a small part of what has been done can be brought together for direct comparison.

This paper reports base lines for 2 insecticides newly cleared for use on corn against the corn earworm, *Heliothis zea* (Boddie), and measurements of corn earworm susceptibility to some older materials.

Field populations in different locations may have different "vigor" depending on nutrition, climate, diseases, etc. and consequently have dissimilar tolerances to insecticides. These dissimilarities are not necessarily from differences in resistance but may be "vigor tolerances" reflecting local environmental influences. Tolerances of the field populations were measured, but I felt that the tolerances should also be measured after the different populations had been reared under identical conditions for 1 generation. Both measurements should be highly useful, the first showing the degree of susceptibility under conditions growers have to deal with locally, and the second giving a direct comparison of susceptibility under the same, controlled conditions and thus giving a more reliable estimate of resistance.

METHODS AND MATERIALS

The plan was to sample populations from 3 or 4 representative areas of Florida and establish dosage-mortality regression lines for many insecticides against (a) the field populations and (b) their F_1 laboratory-reared

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[2]The technical assistance of Mrs. Mary Lou Schreiber is gratefully acknowledged.

descendants, the latter all having been reared under identical conditions. A small fraction of this information was assembled during 1969 and 1970. With the prospect of little further effort being soon allotted to this project, the available data are being put on the record.

While there are little firm data on migration of *H. zea*, it is surmised by many that this is a vigorous flyer whose individuals may fly many miles. The gene pool in a given location could change greatly from season to season. Thus one must consider that we probably can not monitor the resistance of a given population in a given location; we only measure the tolerance of those corn earworms which appear at that location at given times.

The corn earworms used were from populations in Sanford and Gainesville, Florida in 1969, and from Gainesville in 1970. Corn was brought to the laboratory in Gainesville and the earworms were removed and placed in 1 oz plastic cups. Chunks of corn were provided as food. Typically, the larvae were removed from the corn within 12-24 hr of when the corn was picked, and the larvae were exposed to the insecticides within 24-48 hr of picking. Tiny larvae had to be left several days in the cups to grow large enough to be tested. With the limited number of larvae available for testing, individuals in a rather large weight range were used. The larvae used weighed 50±25 mg; age or instar were not considerations in choice of test insects. Laboratory temperatures were 78-82°F and the photoperiod was 14 hr light: 10 hr dark.

Technical insecticides in acetone solution were applied in 1 ul quantities to the dorsum of the thorax by use of an ISCO Model M microapplicator. Larvae were returned to and held in their individual plastic cups after treatment. Mortality was recorded after 48 hr, with death in this case being the condition of complete moribundity where there was no visible response to prodding.

To get F_1 laboratory-reared descendants, 75-100 larvae from each field sampling were held aside and not tested. Resulting pupae were placed in oviposition cages and from this point on the corn earworms were reared as described by Burton (1969). This involves surface sterilizing the eggs with 0.157% sodium hypochlorite, and rearing the larvae on an artificial diet. When the larvae reached the 50±25 mg size, their susceptibility was ascertained by the same method described above.

Treatments were replicated 3-5 times when sufficient insects were available, and for the more reliable data, each point on the regression line was established with 30-50 larvae. Exceptions are noted in the table. There were 4-6 points on each curve. The probit analysis used was the computerized UCRBL 560 program of the University of California, Riverside.

Results and Discussion

Fortunately, the most reliable data are those most wanted—base lines with laboratory-reared corn earworms for methomyl and Gardona® (2-chloro-1-[2, 4-dichlorophenyl] vinyl diethyl phosphate). It is disappointing that there are not data from more populations and that there are not reliable data from field populations. Repeated samplings brought in from a given field were quite variable, and sometimes the more replicates attempted on field populations the more the difficulties. Larval field popula-

TABLE 1. SUSCEPTIBILITY OF FIELD AND LABORATORY POPULATIONS OF CORN EARWORM LARVAE OF 50 ± 25 MG TO INSECTICIDES.

Insecticide	Population	LD_{50} in ug toxicant per g body weight	95% confidence limits	
			Lower	Upper
Gardona	Field, Gainesville	11.4	6.6	16.3
Gardona	Field, Sanford	about 1.5*		
Gardona	Lab, Sanford	92.0	72.3	120.5
Methomyl	Field, Gainesville	about 5*		
Methomyl	Lab, Gainesville	68.8	39.4	120.5
DDT	Field, Gainesville	4,550	1,593	27,680
DDT	Field, Sanford	8,129	2,981	542,190
DDT	Lab, Sanford	36,550	25,430	74,190
Mevinphos	Field, Sanford	13.6**	4.7	22.7
Carbaryl	Field, Sanford	126.9**	13.7	340.2

*Eye-fitted lines. Data did not fit equation adequately.
**Not replicated. Data from 1/3-1/2 as many larvae as for others.

tions in the latter part of the 1969 season became increasingly heavily diseased.

When DDT was considered the material of choice for corn earworm control, Gast (1959) reported the LD_{50} to be 40±6 ug/g for North Carolina field populations of larvae close to the same size used here. Methomyl and Gardona were considerably more toxic than that against field populations in the present test (Table 1). Mevinphos showed about the same toxicity as the latter 2, with its LD_{50} being about 4X that reported by Gast for mevinphos. Carbaryl's LD_{50} was considerably higher than for these other insecticides and this is reflected in the more limited efficacy of carbaryl in field control trials.

The present tests revealed a 100-200 fold increased tolerance to DDT over the figure given by Gast. In tests conducted similarly to the present one, Wolfenbarger and Lowry (1969) showed a dose of 640 ug/g to cause only 8% mortality to a Texas corn earworm population. As others have also noted, it is practically impossible to get accurate data with DDT when so much is required. The heavy doses applied would literally coat the thorax with crystallized DDT.

The LD_{50}'s for laboratory-reared corn earworms were consistently higher than for field collected larvae. This was not specific but applied to all toxicants, with about a 5-15 fold increase involved. Others have noted the same phenomenon, with no suitable explanation given. I surmise that I selected for vigorous larvae in using those that survived the handling and rearing under artificial conditions; the biochemical or biophysical mechanism involved in the greater tolerance is still unknown, however.

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The Florida Entomologist 54(2) 1971

BOOK REVIEW

THE SYSTEMATICS OF THE TRIBE PLECTODERINI IN AMERICA NORTH OF MEXICO (Homoptera: Fulgoroidea, Achilidae). Lois Breimeier O'Brien, University of California Press, Berkeley and Los Angeles, California. University of California Publications in Entomology Vol. 64, 1971. 79 p., 157 Fig., and 1 plate of 8 photographs. $3.00.

Refinements in the systematics of the Fulgoroidea have come at a slower pace than in the closely related cicadelloidea. Primarily this is due to the greater economic importance of leafhoppers. Occasionally a significant work comes along on planthoppers, and the tribal revision by Dr. Lois O'Brien is one of these. It is a thorough treatment of the Plectoderini in North America but has valuable comparisons with the world achilid fauna, particularly that of the neotropics.

Before this revision, the 32 previously known plectoderine species in North America were all referred to the genus *Catonia*. Now Dr. O'Brien proposes that these and 8 new species belong to 6 genera. The majority of the species are western in distribution. Arizona is the only state where more than 3 genera are found (5 of the 6 genera). Florida has 3 genera and at least 10 species. All taxa can be keyed without the use of male genitalic characters, although line drawings are included for each species. A supplementary key based on the male genitalia is provided for *Catonia*.

The revision is based on an evaluation of morphology and host associations. Notes on distribution, ecology, life history, and behavior make the publication valuable to the general worker as well as to the specialist and others who will make good use of it as an identification manual. The author points out that much remains to be learned about the food habits of achilids, but in general, the adults feed on the sap of trees and shrubs, and the nymphs are believed to feed on fungi. The quality of the paper, printing, and reproductions is consistent with the usual high standard of the series.

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INFLUENCE OF HOST PLANT PHYSIOLOGY ON POPULATIONS OF *TETRANYCHUS URTICAE* (ACARINA: TETRANYCHIDAE) INFESTING STRAWBERRY PLANTS IN PENINSULAR FLORIDA[1]

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ABSTRACT

Differences in *Tetranychus urticae* Koch populations on fruiting and non-fruiting strawberry (*Fragariae* × *ananassa*) plants indicated that mites are influenced by host plant physiology. Leaf samples from fruiting plants had large populations of spider mites, but samples taken from vegetatively growing, non-fruiting plants had few or no mites. Analysis of leaves from fruiting plants showed higher levels of sucrose than leaves from non-fruiting plants. Phorate treated vegetative plants showed increased mite density. These data suggest that important feeding components, perhaps sugars in strawberry leaves, are influenced by host plant physiology and in turn affect the spider mite populations.

Spider mites have long been a major problem for strawberry growers. Even prior to use of synthetic organic pesticides, red spiders caused severe damage to plants particularly during the fruiting season. Strawberry plants are usually set in the field during late September or October in Florida and begin to flower in late December and January. Spider mites are usually not a problem for the first 2 or 3 months but begin to build up in early spring, thrive throughout the berry producing period, then disappear from the summer nurseries.

Several researchers classed spider mites as the most serious arthropod pest of strawberries in Florida (Brooks et al. 1932; Brooks and Kelsheimer 1951, 1961) and in Virginia (Brittingham 1956). Brooks et al. (1932) observed large populations on fruiting plants but not on nursery plants. The decline and absence of mites in nursery plantings were attributed to effects of frequent, heavy, summer rains or overhead irrigation. The possibility of physiologically different plants was not considered.

The influence of nutrient levels on plants and subsequent influence on spider mite development has been demonstrated. Rodriguez (1954, 1960), Rodriguez et al. (1960), Henneberry (1962a,b) and others have contributed to knowledge relating influences of phosphorus, nitrogen and other elements within plant cells, sugars, and gibberellin to mite fecundity and population development. Rodriguez and Campbell (1961) found that total sugars were reduced by the hormone gibberellin and suggested that an optimal level of sugar was necessary for mite population development, although reducing sugar was not significantly correlated with mite population in their experiments.

Chaplin et al. (1968) experienced difficulty in infesting seedlings with mites in a greenhouse during April and August but not in November. They believed the difficulty was due to physiological growth conditions of the seedlings.

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Methods and Materials

Two plantings were made, 1 in a fruiting field, the second in a nursery for plant production. In the first, 'Florida 90' plants were set 15 October 1969 on black plastic mulch in raised beds of Leon fine sand. Fertilizer at 1,000 lb/acre of 18-0-25 was applied in a center band atop the beds prior to mulching. Seep irrigation was used. Plots consisted of 20 plants in double rows of 10 plants each set on 12 inch centers. Experimental design was a random block with 3 replications. Acaricides were applied with a hand sprayer. Samples of 10 leaves were taken from each plot at irregular intervals and brushed with a Henderson and McBurnie (1943) mite brushing machine. Counts were made of eggs and mites under 15x magnification. Notes concerning condition of plants were taken at the time of sampling.

Weather records of daily temperature and rainfall were kept throughout the growing season on a hygrothermograph recorder maintained by the U. S. Weather Bureau on the experimental farm where the work was conducted.

Leaf samples for analysis were taken during fruiting (10 March 1970), and post-harvest (21 April 1970) periods. Sugars were extracted in 80% alcohol, chromatographed with a solvent of butanol, acetic acid and water and developed with p-Anisidine hydrochloride.

The second planting was 'Solana' seedlings without leaves set into a nursery 20 April 1970. Plots treated included soil applications of Zinophos® (0,0-diethyl-0-2-pyrazinyl phosphorothionate)+phorate covered with various mulches. Leaf samples and counts were made during the summer to ascertain population levels of mites in the nursery.

Results and Discussion

Scattered populations appeared in the fruiting field in early February. To obtain uniform infestation, 1 field collected strawberry leaflet with 50 or more mites was placed in every clone of each plot. Subsequent samples yielded different numbers but consistent populations. After an initial decrease, average population density of mites and eggs increased rapidly for an extended period, then suddenly decreased to a very low level (Fig. 1).

Average and maximum temperatures (Fig. 1) for the week preceding each sample gave no clue or reason for the sudden population decline. Rainfall was an unlikely factor since the spring dry season was in progress and only 0.12 inches rain fell during April, the time of the population decline. Natural enemy populations were minimal and absent on treated foliage. Host plant foliage was abundant and not severely damaged by mites since many of the plots received chemical treatments.

Population development differed on chemically treated and untreated plots. On untreated checks (Fig. 1) adult population decline was preceded by a decline in egg population. Host plant nutrition is a key factor in mite fecundity (Henneberry 1962a) and untreated plots severely damaged by large populations were inadequate to sustain egg production. In contrast, chemically treated plots had low but consistent mite densities (Fig. 1) and egg density declined only after the population of adults had declined. Untreated plots showed population build up, exhaustion of food

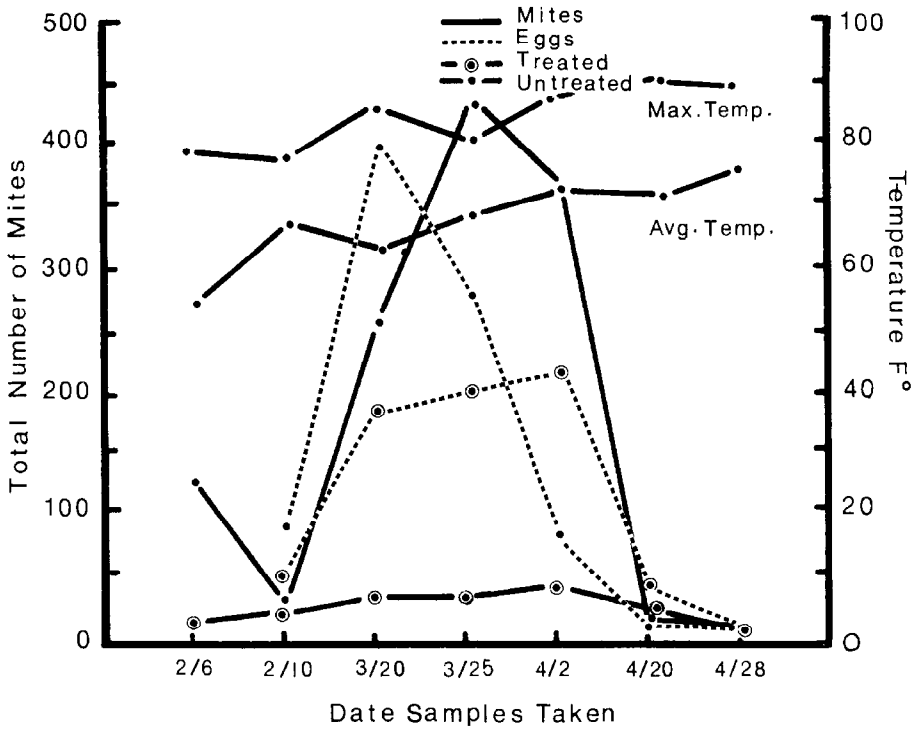

Fig. 1. Seasonal spider mite density on treated and untreated "Florida 90" strawberry plants.

supply, then population decline beginning with reduced fecundity. Chemically treated plants, on the other hand, were not exhausted since plants remained healthy and egg density was greater than adult density.

Concentration of sucrose was greater in leaves taken from fruiting plants than in leaves taken from post-harvest, non-fruiting plants. The physiological change in the host plant evidenced by cessation of fruiting and by the beginning of vegetative growth corresponded to the decline in sugar level and the decline in mite density. These data indicate that fruiting plants are more suitable hosts for mites than vegetatively propagating plants. One difference between fruiting and non-fruiting plants was sugar content, however, other leaf constituents of the physiologically altered plant might also influence feeding of spider mites.

Only the first leaf sample taken from the nursery plants had mites. Samples taken 16 days after setting the field showed populations of spider mites on plots treated with Zinophos+phorate but not on check plots (Table 1). Silver polyethylene plastic mulched plots had higher mite densities than unmulched plots or plots with black paper mulch. Larger numbers of mites than eggs on check plots and plots receiving low rates of Zinophos+phorate indicated a declining population. The converse was true of treatments with higher rates of Zinophos+phorate, and egg density exceeded mite density. This suggests that Zinophos+phorate altered the plant to a more suitable host for mite population development. The effect of Zinophos+phorate on strawberry is not known but Hackaylo

TABLE 1. *Tetranychus urticas* KOCH POPULATIONS IN 'SOLANA' STRAWBERRY NURSERY PLANTS, 1970.

Treatment	Form	Rate lb act./A	Type Mulch	Total number/4 replications* Eggs	Mites
Control	—	—	—	2	18
Control	—	—	Black paper	0	0
Control	—	—	Silver poly	2	8
Zinophos + phorate	15G	4.5	—	2	8
Zinophos + phorate	15G	9.0	—	36	24
Zinophos + phorate	15G	4.5	Black paper	18	44
Zinophos + phorate	15G	9.0	Silver poly	102	74

*1 sample of 15 leaflets per replication.

(1957) demonstrated increased carbohydrate levels in leaves of seedling cotton plants treated with phorate.

Data from fruiting and from non-fruiting plants, from leaf analyses for sugar, and from effects of Zinophos+phorate suggest that host plant physiology is critical in the development of spider mite populations on strawberries. The population density of mites on this crop appears to respond positively to sugar level. Sugar levels were low in non-fruiting plants and mite populations were not sustained in summer nurseries.

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PARASITES OF *PHYTOMYZA VOMITORIAE* AND *PHYTOMYZA ILICICOLA* (DIPTERA: AGROMYZIDAE) FROM FLORIDA[1]

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ABSTRACT

Eulophid parasites of *Phytomyza vomitoriae* Kulp collected at Dover, Florida from infested leaves of *Ilex vomitoria* Ait. are *Chrysocharis* sp., *Derostenus* sp., *Diglyphus intermedius* (Girault), and *Zagrammosoma multilineatum* (Ashm.). Eulophid parasites reared from *Phytomyza ilicicola* Loew collected from Gainesville, Florida from *Ilex opaca* Ait. are *Closterocerus cinctipennis* (Ashm.), C *tricintus* (Ashm.), and *Pediobius lithocolletidis* (Ashm.).

Kulp's (1968) investigations of the *Phytomyza* spp. infesting *Ilex* spp. in North America resulted in a clarification of the existing complex and in the description of 5 new species. *Phytomyza ditmani* Kulp so far seems to be restricted to *Ilex decidua* Walt. and *Ilex serrata* Thunb. while *Phytomyza glabricola* Kulp mines the leaves of *Ilex glabra* (L.) Gray. *Phytomyza opacae* Kulp forms linear type mines in the leaves of *Ilex opaca* Ait., *Ilex cumulicola* Small, *Ilex aquifolium* L. (Morris), and *Ilex aquifolium* L. (Eldredge). *Phytomyza verticillatae* Kulp produces a linear-blotch type mine in the leaves of *Ilex verticillata* (L.) Gray, and the only known host plant for *Phytomyza vomitoriae* Kulp is *Ilex vomitoria* Ait.

Parasites were known for all of the members of this complex with the exception of *P. vomitoriae*. The purpose of this paper is to report rearings of parasites from *P. vomitoriae* and *P. ilicicola*.

Kulp (1968) reported parasites from *P. ilicicola* as follows: (Hymenoptera:Braconidae) *Opius striatriventris* Gah.; (Hymenoptera:Eulophidae) *Closterocerus tricinctus* (Ashm.), *Pediobius amyntas* (author not located) and *Pnigalio guttiventris* (Gir.); and (Hymenoptera:Pteromalidae) *Halticoptera* sp.

Kulp stated that the life history and parasites of *P. vomitoriae* are not known but that 2 larvae he examined form irregular-linear mines in the leaves of *I. vomitoria*. He examined specimens from California and Georgia.

Dr. Howard V. Weems, Jr. sent the author a large package of *I. vomitoria* leaves freshly mined by agromyzid larvae. The leaves, which were collected by D. A. Vaughan, 24 January 1969, at Wilson's Wholesale Nursery in Dover, Florida, were placed into rearing containers and covered with cloth.

P. vomitoriae (Det. K. A. Spencer) and its parasites were reared from the leaves. All of the reared parasites, except where noted, were deposited

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in the Florida State Collection of Arthropods, Gainesville, Florida. The parasites of *P. vomitoriae* are as follows:

Hymenoptera: Eulophidae

Chrysocharis sp. (Det. B. D. Burks). 6 males.

Derostenus sp. (Det. B. D. Burks). 29 adults.

Diglyphus intermedius (Gir.). (Det. B. D. Burks). 4 adults.

Zagrammosoma multilineatum (Ashm.). Det. B. D. Burks). 1 female.

During March 1969 the author received a shipment of infested leaves of *Ilex* sp. probably *opaca* collected by John R. Strayer, Extension Entomologist, University of Florida Experiment Station, Gainesville, Florida, dated 26 March 1969. The reared leafminer was determined by K. A. Spencer as *P. ilicicola*. *Closterocerus cinctipennis* (Ashm.) (Hymenoptera: Eulophidae) (Det. B. D. Burks) was the only parasite associated with *P. ilicicola* during the March rearing. A single specimen was reared.

A third shipment of infested leaves of *I. opaca* was received in April 1969. They were collected by John R. Strayer, Gainesville, Florida, 10 April 1969. The *P. ilicicola* (Det. K. A. Spencer) in this sample had the greatest number of parasites. The recorded data are:

Hymenoptera: Eulophidae

Closterocerus tricintus (Ashm.). (Det. B. D. Burks). 3 adults.

Pediobius lithocolletidis (Ashm.). (Det. B. D. Burks). 6 adults.

Retained for the U. S. National Museum Collection.

Acknowledgments

Thanks are due Dr. Leslie A. Kulp, Acting Head, Indexing Section, National Agricultural Library, and John R. Strayer for their constructive criticisms of this paper; Dr. B. D. Burks, Entomology Research Division, USDA., for the Eulophidae determinations; Dr. K. A. Spencer, London, England, for Agromyzidae determinations; and to Dr. H. V. Weems, Jr., John R. Strayer, and D. A. Vaughan for providing the agromyzid infested holly leaves.

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AN EPIZOOTIC OF *SPICARIA RILEYI* ON THE VELVETBEAN CATERPILLAR, *ANTICARSIA GEMMATALIS*, IN FLORIDA

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North Florida Experiment Station, Quincy
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ABSTRACT

An epizootic caused by the entomogenous fungus *Spicaria rileyi* (Farlow) occurred among populations of the velvetbean caterpillar, *Anticarsia gemmatalis* Hübner on soybeans, *Glycine soja*, Sieb. and Zucc. in August and September 1970. The natural outbreak was monitored in Quincy where environmental conditions favoring development of the fungus prevailed during July through September. The development of the epizootic was related to the build-up of insect populations, and the development and dissemination of the fungus.

Although the occurrence of natural outbreaks of *Spicaria rileyi* (Farlow) on various insects has been known in Florida for many years, the use of this pathogen in a biological control program has never been attempted. Watson (1916a, 1916b) was the first to report the effectiveness of *Botrytis rileyi* (=*S. rileyi*) in Florida as the etiologic agent of the disease known as "cholera". This disease was the most effective check on populations of the velvetbean caterpillar, *Anticarsia gemmatalis* Hübner during September and October of 1914 and 1915 on velvetbeans, *Stizolobium deeringiaum*, Bort. Hinds and Osterberger (1931) reported that *Spicaria prasina* (Maulb.) Saw (=*S. rileyi*) was an important factor in suppressing the final fall generation of the velvetbean caterpillar during September and October of 1929 and 1930. Ellisor and Graham (1937) cited the importance of *S. prasina* in conjunction with the parasite *Trichogramma minutum* Riley in control of velvetbean caterpillar on alfalfa. The importance of *S. rileyi* as a natural control agent of the cabbage looper, *Trichoplusia ni* (Hübner), was cited by Getzin (1961) in Texas and by Behnke and Paschke (1966) in Indiana and Wisconsin. Canerday and Gudauskas (1966) in Alabama reported the fungus frequently associated with the soybean looper, *Pseudoplusia includens* (Walker). The senior author (unpublished data) observed epizootics of *S. rileyi* in August and September of 1966-1968 on *Heliothis zea* (Boddie) and *H. virescens* (Fabricius) on cotton in Mississippi.

METHODS

Temperature, humidity, larval counts, and incidence of disease were recorded during July through October 1970 to monitor the development of the epizootic. A 2 ft shake cloth (Barnes and Jones 1970) was used in weekly randomized sampling in three 1-acre plots to determine larval counts per foot of row. Larvae were collected individually from 20 sepa-

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TABLE 1. TEMPERATURE AND RELATIVE HUMIDITY READINGS RECORDED FURNISHED BY THE NATIONAL WEATHER SERVICE AT QUINCY, FLORIDA, 1970.

Month	Temperature in °C			% Relative Humidity
	High	Low	Ave.	
July	32.4	20.6	26.5	80
August	31.6	21.4	26.5	82
September	32.1	20.1	26.1	76

TABLE 2. VELVETBEAN CATERPILLAR LARVAL COUNTS AND PERCENT INFECTIONS WITH *S. rileyi* ON SOYBEANS, AT QUINCY.

Date	Larval Count per foot of row	Percent Infected Larvae
8-24	1	2
8-31	5?	10
9-11	55	22
9-19	13	63
9-26	2	92
10-3	0	—*
10-10	1	—
10-17	0	—

*Larvae were no longer present in the field of soybean plants.

rate locations in each plot. Disease incidence was determined by maintaining the larvae individually on soybean leaves in the laboratory under average temperature and humidity conditions recorded in the field. Mortality was recorded for 7 days.

EPIZOOTOLOGY

The course of the epizootic was recorded at Quincy from 24 August to 17 October. Getzin (op. cit) reported the optimal environmental conditions for the development of *S. rileyi* to be a high relative humidity and a temperature of 25° C. These conditions prevailed during the test period with an average temperature of approximately 26° C and a relative humidity above 75% (Table 1).

Table 2 shows that the progress of the epizootic was related to the density of velvetbean caterpillar larvae. Although the pathogen occurs naturally, it required several generations before sufficient spores became available to control the insect population. *S. rileyi* infected velvetbean caterpillar larvae exhibited typical symptoms of the disease. A decrease in activity was followed by death and mummification. The cadavers first appeared white due to the emergence of developing hyphae of the fungus but later took on a green appearance due to the production of the green conidia. The production of conidia was dependent upon humidity.

Discussion

These data indicate that the development of the epizootic was related to the density of velvetbean caterpillar larvae and availability of *S. rileyi*. If future studies confirm this relationship, consideration might be given to the possibility of artificially disseminating *S. rileyi* spores in a biological control program. Applications could be made when favorable environmental conditions are present and velvetbean caterpillar infestations are imminent to prevent a lag in the development of the disease.

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THE SPIDER GENUS *DRYMUSA* IN THE NEW WORLD (ARANEAE: SCYTODIDAE)

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ABSTRACT

The 2 known species of this genus in the New World (*Drymusa nubila* Simon and *D. simoni* Bryant) are redescribed; *D. nubila* is illustrated for the first time, and the lectotype is designated. A new species (*D. dinora*) is described from the Pacific coast of Costa Rica, with notes on habitat and distribution. This is the first record for the genus in the continental Neotropics and on the Pacific side, since the known species are from the Caribbean Islands and South Africa.

FAMILY SCYTODIDAE BLACKWALL

Scytodidae Blackwall, 1864: 379.
Sicaroidae Keyserling, 1880: 2.
Sicariidae Simon, 1890: 81.
Scytodidae: Gertsch, 1967: 130. The family is modified to include only three genera: *Scytodes, Loxosceles* and *Drymusa.*

Type-genus: *Scytodes* Latreille (1804)

Family of Ecribellate spiders in the Haplogynae, separated from the related families by the following combination of characteristics: chelicerae joined at base; 6 eyes in 3 diads; bulb with a simple slender embolus; tracheal spiracle located on midventral line, near spinnerets; colulus conspicuous.

GENUS *Drymusa* SIMON

Drymusa Simon, 1891:571; Simon, 1893:276-277; Waterhouse, 1902: 115: Petrunkevitch, 1928:109; Gerhardt and Kastener, 1938:596; Bryant, 1948:363-365; Bonnet, 1956:1609.
Type-species: *D. nubila* Simon
Diagnosis: Genital groove very long, with heavily sclerotized lips in adults of both sexes. Thoracic portion of carapace with a V-shaped dark pattern, its apex on the thoracic groove and the arms extending forward.

Distinguished from *Scytodes* by the depressed carapace, a much wider clypeus (at least 2 ocular diameters in width), a shallow thoracic groove or pith (inconspicuous in *D. nubila*); short colulus (inconspicuous in males); chitinous depressions (if present) associated with lung slits (as opposed to behind the genital groove in *Scytodes*); the ♂ bulbus located at the tip of the tarsus.

More closely related to the genus *Loxosceles*, but separated by the presence of a third claw and the leg formula (i.e. the third being the longest, in *Loxosceles* the second or the forth is the longest).

KEY TO THE SPECIES OF *Drymusa* IN THE NEW WORLD

1. Metatarsus I with strong recurved setae (Fig. 1). Genital groove located within posterior half of ventral abdominal surface (Fig. 2).

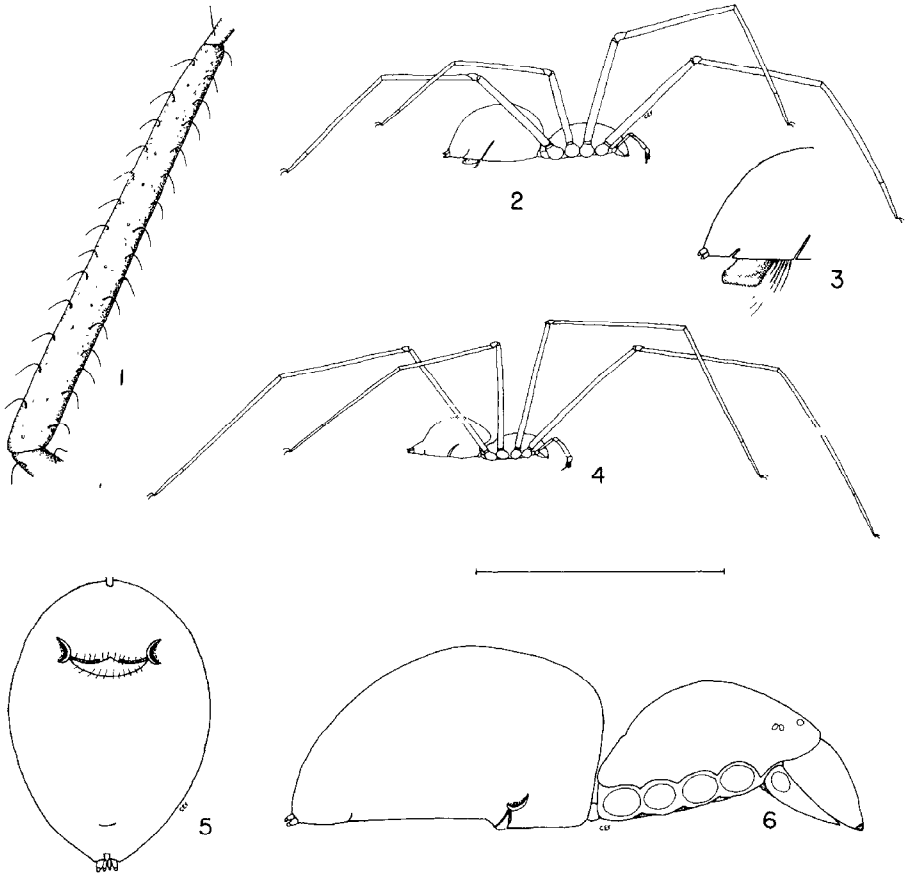

Fig. 1-3—*Drymusa simoni* Bryant (♂): 1) metatarsus I, lateral view; 2) general aspect, lateral view; 3) chitinous lobe on ventral abdominal surface, lateral view.

Fig. 4—*Drymusa dinora* Valerio, n. sp. (♂): general aspect, lateral view.

Fig. 5-6—*Drymusa nubila* Simon (♀): 5) abdomen, ventral view; 6) general aspect, lateral view. (Scale line: 2.00 mm for Fig. 1, 3, 5-6; 7.50 mm for Fig. 2 and 4)

Chitinous lobe on midventral line of abdomen just anterior to tracheal slit (Fig. 3) ..... *D. simoni* Bryant

1.′ Metatarsus I lacking recurved setae. Genital groove located within anterior half of ventral abdominal surface. No chitinous lobe on ventral abdominal surface 2

2. No external plates associated with genital groove, one chitinous depression (fovea) associated with each lung slit (Fig. 5). Abdomen ovoid and not pointed posteriorly. Genital groove located within anterior third of the distance between pedicel and spinnerets (Fig. 6) ..... *D. nubila* Simon

2.′ External chitinous plates associated with genital groove (Fig. 9), chitinous depressions absent. Abdomen highly globose and pointed behind tracheal slit (Fig. 8). Genital groove located near middle of the distance between pedicel and spinnerets ..... *D. dinora* Valerio, n. sp.

Drymusa is a small genus of spiders with 3 species known from South Africa and 2 from the Caribbean region. The discovery of a new species on the Pacific side of Costa Rica, seems significant in terms of the zoogeographic distribution of the group. The new species described in this paper, was found in a lowland rain forest, where both males and females spin loose webs on the underside of fallen logs; they can be easily missed by collectors since they remain on the log when it is turned over and are well camouflaged by their dark color. In addition they are not likely to be collected in litter samples. A similar explanation might account for the poor representation of the other species in collections.

I was able to study the syntype series of *Drymusa nubila* Simon, from the British Museum (Natural History), and the type material of *D. simoni* Bryant, from the Museum of Comparative Zoology, Harvard University (except for the subadult ♀, which was not available).

I wish to thank the following for the loan of specimens: Dr. M. Vachon, Museum National d'Histoire Naturelle, Paris; Mr. D. J. Clark, British Museum (Natural History), London; and Dr. H. W. Levi, Museum of Comparative Zoology, Harvard University, Cambridge. Dr. J. Reiskind, Department of Zoology, University of Florida, Dr. H. W. Levi, and Dr. W. J. Gertsch gave valuable help and a critical review of the manuscript.

Drymusa nubila Simon
(Fig. 5-6)

Drymusa nubila Simon, 1891:572; Petrunkevitch, 1911:117; Lutz, 1915: 80.

The original description (not illustrated) was based on 4 females from Saint Vincent Island. The illustrations and measurements in the present paper are based on the lectotype designated by the author and returned to the British Museum (Natural History).

Diagnosis: Abdomen ovoid, lacking chitinous plates and lobes, but a conspicuous fovea associated with each lung slit. Genital groove placed on anterior third of ventral abdominal surface. Closely related to *D. capensis* Simon from South Africa.

Description: FEMALE (lectotype): Total length 4.5 mm. Carapace 1.7 mm long and 1.4 mm wide, pale in color with reddish brown patterns (color notes according to Simon, 1891; specimen now completely discolored), apparently very similar to those of *D. dinora* (Fig. 9). Clypeus 2 ocular diameters in width, each lateral diad separated by more than 2 ocular diameters from anterior one. Sternum as long as wide (0.9 mm), very dark in color. Pedipalpi 2.1 mm in length, tibiae and tarsi heavily sclerotized with strong setae on medial side. Legs relatively very long: 12.7 mm, 12.1 mm, 9.7 mm, and 11.7 mm respectively (first one being 7.5 times longer than carapace), lacking recurved setae.

Abdomen black, ovoid, lacking lobe on midventral line; genital groove with sclerotized lips but chitinous plates absent. Two chitinous foveae located laterally to genital groove, associated with lung slits (Fig. 5).

MALE: Unknown.

Distribution: Known only from the type material collected in Saint Vincent Island. An additional specimen in the MNHN, Paris, is also from this island.

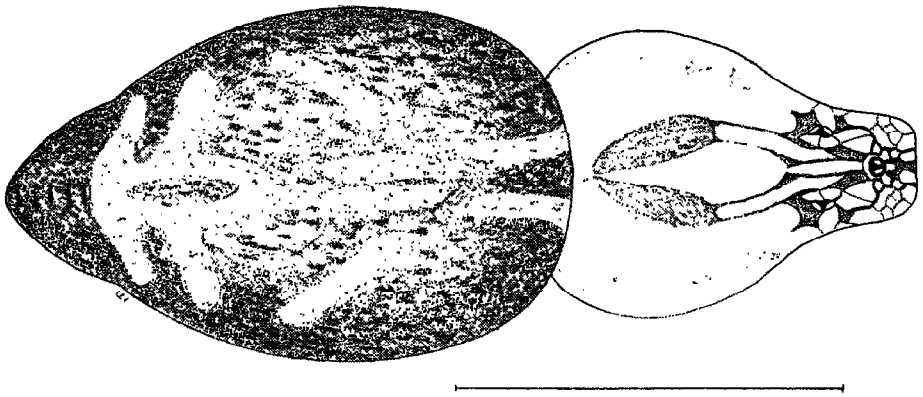

Fig. 7—*Drymusa dinora* Valerio, n. sp. (♀). Color patterns, dorsal view. (Scale line: 2.00 mm)

Drymusa simoni BRYANT
(Fig. 1-3)

Drymusa simoni Bryant, 1948:363-365.

The original description was based on a male, and subadults of both sexes were also available. All material was collected in Haiti and deposited in the Museum of Comparative Zoology at Harvard University.

Diagnosis: Longitudinal chitinous lobe projecting from ventral surface of abdomen, just anterior to tracheal slit (Fig. 3). Metatarsi I with recurved setae (Fig. 1). Genital groove placed on posterior half of ventral abdominal surface.

Description: MALE (Holotype): Total length 5.2 mm. Carapace 2.5 mm long and 1.8 mm wide, pale brown with dark color patterns similar to those of *D. dinora* (Fig. 9). Clypeus nearly 3 ocular diameters in width. Sternum slightly longer than wide, dark brown in color; labium and endites dark brown in color. Pedipalp 1.6 mm in length; tibia with a ventral row of strong setae; bulb spherical, embolus nearly as long as the bulb, straight with tip abruptly curved. Legs relatively short and stout (Fig. 2): 12.1 mm, 10.6 mm, 8.1 mm and 10.1 mm in length respectively (First one being 4.8 times as long as the carapace), light brown in color; metatarsi I covered with strong recurved setae (a few on tibia I also) (Fig. 1).

Abdomen oval, very dark in color. Longitudinal chitinous lobe (0.3 mm long and 0.2 mm wide) projecting from ventral surface just anterior to tracheal slit, thickened at ventral edge; tuft of long setae located at base of chitinous lobe, between it and genital groove (Fig. 3). Genital groove displaced posteriorly, located within posterior half of abdominal length.

FEMALE: Unknown. Subadult with coloration similar to that of male and chitinous lobe on ventral abdominal surface present (Bryant, 1948).

Distribution: Known only from the type material, collected in Haiti.

Drymusa dinora VALERIO, NEW SPECIES
(Fig. 7-13)

The species is named for my wife, Dinora.

Type data: Female holotype, 1 ♂, 2 ♀, and 9 immature specimens col-

lected by the author on 20 July 1969, near Rincón, Osa, Puntarenas Province, Costa Rica (original number CEV-819), and all kept in the Museo de Zoología, Universidad de Costa Rica (number UCR-213-15-1), except for 1 ♀ donated to the American Museum of Natural History, New York.

Diagnosis: Abdomen pointed behind tracheal slit (Fig. 8). Female with 2 ventral abdominal chitinous plates associated with genital groove (Fig. 9). Distinguished from *D. nubila* Simon by the presence of 2 ventral abdominal plates and the absence of lateral foveae in the epigynum.

Easily separated from *D. simoni* by the absence of the medial longitudinal lobe protecting tracheal slit (Fig. 3); the absence of recurved setae in metatarsi and tibiae (Fig. 1); the more slender and longer legs (Fig. 2 and 4), and details in the ♂ palpus (in *D. simoni* tip of embolus abruptly curved, as illustrated by Bryant, 1948).

Descriptions: FEMALE (Holotype): Total length 4.1 mm. Carapace 1.9 mm long and 1.6 mm wide, pale yellow with dark brown patterns as shown in Fig. 7; cephalic region covered by small geometrical figures, and thoracic portion dominated by 2 large oval dark areas extending backwards and converging at thoracic groove. Clypeus nearly 2 ocular diameters in width; each lateral diad separated by 1¼ ocular diameters from anterior one. Sternum wider than long (0.9 and 0.8 mm), dark brown in color; labium and endites of same color; chelicerae 1.0 mm in length, reddish brown, with 2 distinct denticles on promargin of fang furrow and a series of 4 smaller ones on retromargin (Fig. 10), stridulating ridges absent; pedipalpi 2.0 mm in length, pale yellow, robust; legs relatively very long (first one 6.4 times longer than carapace); coxae equal in length (0.4 mm), pale yellow with brown stripes; trochanters equal in length (0.2 mm); femora light yellow with a wide dark brown ring in the middle of its length and another one at apex; tibia light yellow with a dark ring near base; metatarsi and tarsi light brown (see Table I for measurements), lacking recurved setae.

Abdomen nearly black in color with white markings as shown in Fig. 7, very globose and extending forward over cephalothorax, its dorsal length nearly 0.3 mm greater than ventral length, and sharply pointed behind tracheal slit, with 5 deep wrinkles in dorsal surface, and spinnerets at apical end. Genital groove long with heavily sclerotized lips and 2 additional chitinous plates; one located between lung areas, transverse in position and very large (0.5 mm long and 1.2 mm wide), showing inconspicuous notches probably associated with atriobursal orifices; second plate between genital groove and tracheal slit, smaller (0.7 mm long and 0.5 mm wide), longitudinal and truncate at base (Fig. 9). Seminal receptacles apparently very small, widely separated from each other and lying on dorsal surface of anterior chitinous plate.

MALE: Total length 3.8 mm. Carapace 1.8 mm long and 1.5 mm wide; same coloration as in female. Clypeus narrower than in female and lateral diads separated by only 1 ocular diameter from anterior one. Pedipalp stout (Fig. 11-13), 1.6 mm in length; femur subcylindrical like that of female; tibia slightly curved and incrassated near base on ventral side, nearly equal to femur in length; tarsus relatively long, expanded at base on dorsal and concave on ventral surface, with a row of heavy setae apically located on lateral side; bulb spherical, 0.18 mm in diameter, with

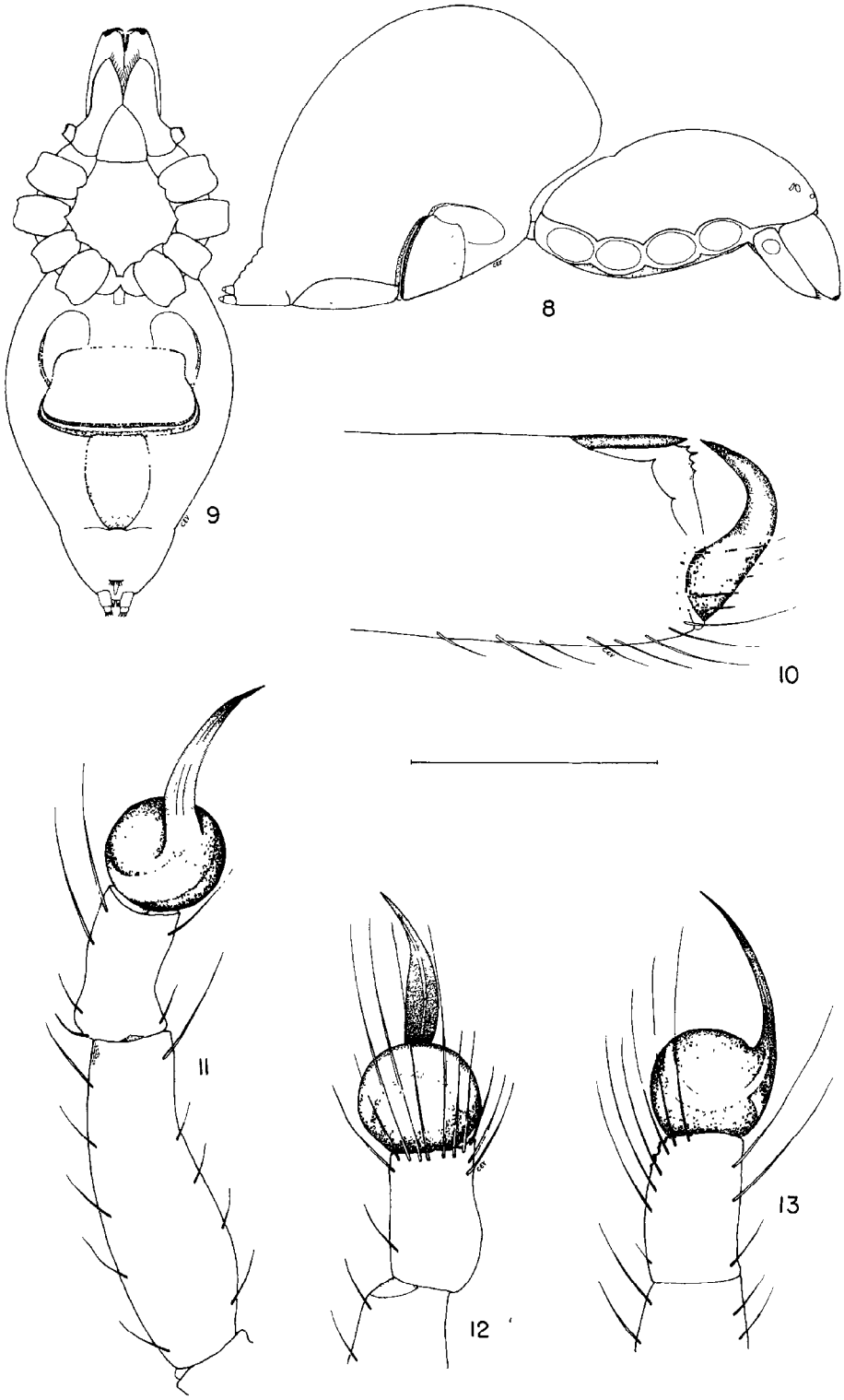

Fig. 8-13—*Drymusa dinora* Valerio, n. sp. Fig. 8-10 ♀: 8) lateral view; 9) ventral view; 10) left chelicera, ventral view. Fig. 11-13 ♂ right pedipalp: 11) lateral view; 12) medial view; 13) frontal view. (Scale line: 2.00 mm for Fig. 8-9; 0.36 mm for Fig. 10-13)

TABLE 1. LENGTH IN MM OF THE LEG SEGMENTS IN THE ♀ HOLOTYPE, *Drymusa dinora* N. SP. (TOTAL BODY LENGTH: 4.1 MM; CARAPACE 1.9 MM LONG AND 1.6 MM WIDE)

	Palpus	I	II	III	IV
femur	0.7	3.2	3.0	2.4	3.0
patella	0.3	0.5	0.5	0.4	0.5
tibia	0.5	3.6	3.1	2.4	3.0
metatarsus	—	3.8	3.3	2.7	3.2
tarsus	0.5	1.1	1.1	0.9	1.1
Total	2.0	12.2	11.0	8.8	10.8

a thin laterally flattened embolus, 0.29 mm long and curved medially. Legs longer and more slender than those of female: 14.1 mm, 12.8 mm, 9.9 mm and 12.8 mm (first one being 7.8 times longer than carapace). Abdomen similar in shape and coloration to that of female, lacking chitinous plates on ventral surface.

Distribution: It is likely that this species is limited to the floor of the lowland rain forests around the Golfo Dulce, since this region is ecologically isolated. North and southeast of it, the rain forest is interrupted by dry formations and cultivated areas, and the east side is bordered by the high Talamanca mountains. Besides, it was not reported in an extensive survey in the ground fauna of a similar forest in Panamá (Williams, 1941).

Remarks: At first, the dorsal wrinkles in the pointed portion of the abdomen (Fig. 8) were thought to be traces of embryonic segmentation, but their absence in the immature specimens shows they are a secondary characteristic.

D. dinora resembles *D. silvicola* Purcell, from South Africa, in the presence of a chitinous plate located posterior to the genital groove. There is also a remarkable similarity, in the shape of the abdomen, between *D. dinora* and *Scytodes coronata* Thorrel (Millot, 1947) from tropical Africa.

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FAR INFRARED STIMULATION OF INSECTS WITH THE GLAGOLEWA-ARKADIEWA "MASS RADIATOR"

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ABSTRACT

Several species of insects were subjected to far infrared (IR) radiation from a Glagolewa-Arkadiewa "mass IR radiator." All insects responded to the radiator with antennae movement, antennae cleaning behavior, or oviposition. In antennectomized male corn earworm moths, *Heliothis zea* (Boddie), significant differences in mating success were related to the length of antennae removed. This indicates that the antennal sensilla, whose pattern is repeated on each segment, and not the total antenna, is responsible for far IR detection.

Entomologists have long known that moths and many other night flying insects are attracted to the emissions of mercury quartz lamps. Much entomological work has been devoted to studies on the attraction of insects to such lamps in the visible and near ultra violet region of the spectrum. Callahan (1965a) pointed out that there are many infrared (IR) frequencies emitted by such lamps. He hypothesized that some of the attraction might lie in the far IR region of the spectrum. Traditionally this is the portion of the spectrum defined by physicists as lying between 10 and 1000 micrometers (1 millimeter). In textbooks this is the region labeled "far infrared radiation" although it has lately become common practice to designate the radiations in the far IR region as submillimeter radiation.

Grant (1948), an electrical engineer, utilizing measurements from entomological drawings, applied dielectric waveguide theory to insect antennal pits. Based on these measurements he reasoned that much of their sensing must lie in the far IR region of the spectrum. Callahan (1965a) applied dielectric antenna theory to the spines and sensilla of insects and showed that, theoretically, insects should be able to detect intermediate and far IR radiation. Callahan (1965b) suggested that the far IR portion of the IR spectrum was the most likely region of the spectrum to which insects would respond. He based this on measurements of the antennal sensilla of night flying moths. He pointed out that such research should be confiened to atmospheric windows where good transmission of IR is obtainable. He was the first to use coherent radiation lasers in behavioral experiments with insects (Callahan 1968, 1969a). He also suggested that cyanide and water lasers should be used in the far IR region to test a wide range of IR emissions. Preliminary tests utilizing a cyanide laser at Georgia Institute of Technology (USDA Coop. Agreement (1966) 12-14-100-9071(33)) demonstrated that the corn earworm moth, *Heliothis zea* (Boddie), did respond by attraction to 337 micrometer (μm) radiation. (Final Report Project No. A-985, Dec. 1970, Georgia Institute of Technology.)

METHODS

Because of the difficulties and expense of producting such frequencies with lasers, a mass IR radiator was constructed patterned after that of A. Glagolewa-Arkadiewa (1924), a physicist at the Magnetic Laboratory of Moscow University, who designed equipment which emitted electromagnetic

waves between 82 μm and 1.8 mm. With this simple IR system, behavioral experiments were conducted in the present study by radiating insect antennae with IR emissions from the "mass radiator." The machine (Fig. 1) consists of a mass of metal filings, brass or steel, suspended in a viscous mineral oil. The filings are agitated by continually stirring them with a mixer. A small insulated wheel is rotated through the filings so that the filings are picked up and conveyed across the surface of the wheel. A high voltage induction coil spark is sent to the wheel in such a manner that a discharge takes place through the suspended metal particles. The particles acting as minute vibratory substances, or miniature oscillators, radiate in the visible and far IR portion of the spectrum. Black polyethylene plastic was used as a far IR pass filter between the insect and "mass radiator" to

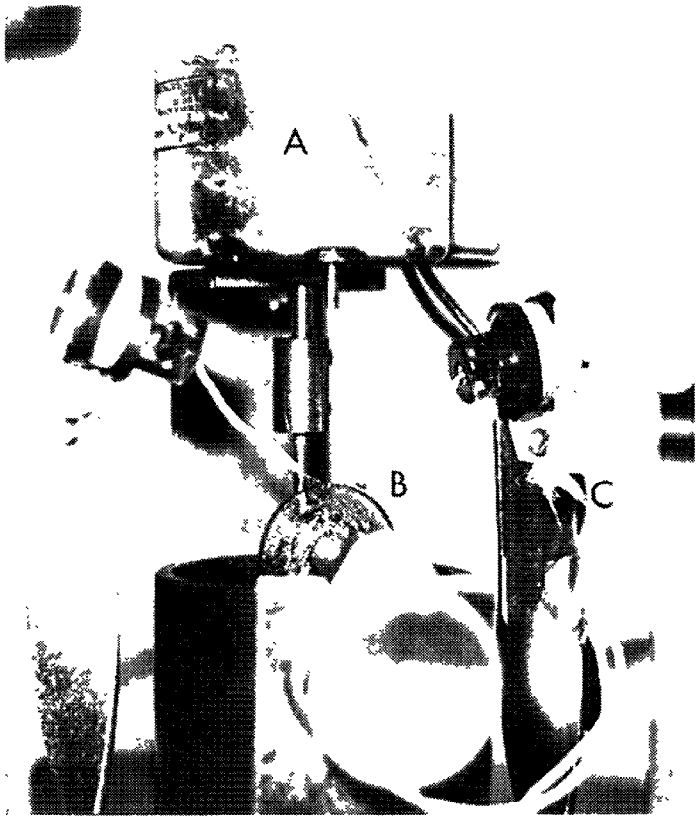

Fig. 1. Glagolewa-Arkadiewa "mass radiator." A) mixer, B) rotating wheel with high-tension electrodes at top surface, C) corn earworm moth in position. Black polyethylene plastic was used between the moth and radiator to filter out visible light from the spark gap.

eliminate visible radiation from the spark gap. The radiation is dependent upon the size of the particles used. Most of the electromagnetic output lies between 82 and 1000μm (Table 1). Several of these frequencies, 200, 280, 350 and 450 um fall in regions where there is excellent atmospheric transmission through the water vapor of the air. The rest of the frequencies are also transmittable through the water vapor of the air, although at ranges

below 50% transmission. Several of the frequencies from a mercury quartz lamp (218, 300 and 343 um) lie very close to radiations from the mass laboratory radiator.

TABLE 1.—FAR INFRARED PEAK OUTPUT OF THE GLAGOLEWA-ARKADIEWA "MASS RADIATOR" AND A MERCURY QUARTZ LAMP.

Mass Radiator—μm (from A. Glagolewa-Arkadiewa (1963))			Mercury Quartz Lamp—μM
82	225	550	218
129	280 W	800	
150	300	900	300
180	350 W	1.2 mm	343 W
200 W	450 W	1.8 mm	

W = good atmospheric windows.

RESULTS

Adults of the corn earworm, the fall armyworm, *Spodoptera frugiperda* (J. E. Smith), the cabbage looper, *Trichoplusia ni* (Hübner), the imported fire ant, *Solenopsis saevissima richteri* (Forel), and the wasps *Polistes metricus* Say and *Polistes annularis* (L.) were tested for response. Ten specimens of each species of moth were tested and responded to the radiator with antenna movements and also with a characteristic curving of the abdomen. Three specimens of the corn earworm moth that had been mated were stimulated to oviposit within a few seconds of radiation. Five specimens of each wasp species were tested, and they responded by rubbing the forelegs on the antenna in what was a typical antennal cleaning response. Fire ants mounted close to the radiation responded by violent movement of the legs and the antenna.

R. H. Wright (1963) pointed out that low frequency molecular vibrations and rotations possibly provide the physical basis of odor. The region of the spectrum that he has been most concerned with is the far IR portion between 20 and 200 μm. As Wright pointed out, the main restriction on the excitation of molecules is a quantum mechanical one which relates the energy of excitation to the frequency and thus limits the modes which can be excited at room temperature to those of low frequency (far IR). It is interesting to note that the mass vibrator covers portions of the same region of the spectrum.

Some preliminary experiments were also performed to determine the behavioral response and the success of mating of antennectomized male corn earworm moths with different lengths of antennae removed. There was no behavioral response to the "mass radiator" when the entire antenna was cut off or coated with a dielectric material such as polystyrene Q-dope. The results of these mating experiments are shown in Table 2. In each test 10 pairs of moths were confined in 54 Ft^3 cages for 72 hr. The differences in response were highly significant past the 0.01 level of probability. With two-thirds of the antenna missing the males were still able to mate with the females as shown by spermatophore counts. The results indicate that the sensilla types (whose pattern is repeated each segment (Callahan 1969)) are responsible for the detection of these far IR frequencies and not the total length of the antenna as such. An axiom of resonating antennae sys-

TABLE 2.—MATING SUCCESS, BASED ON PRESENCE OF SPERMATOPHORE, FOR CAGED POPULATIONS OF CORN EARWORM MOTHS WITH INTACT AND ANTENNECTOMIZED MALES.

No. of moth pairs	Percentage of mating of females caged with males with indicated portion of antennae removed			
	All	2/3 off	1/3 off	None
10	0	30	40	70
10	0	20	40	80
10	0	10	40	50
10	0	30	50	50
10	0	10	40	60
10	0	20	50	70
Mean	0	20.00	45.00	63.00

All means are significantly different (0.01 level) according to Duncan's multiple range test.

tems is that the length of the antennae should be of the same dimensions as the received or transmitted frequency, or some quarter or half wavelength dimension. Noctuid antennae sensilla range from 10 to 150 um in length and are arranged in arrays on the various species. The "mass radiator" frequencies fit the physical dimensions of the sensilla. With the entire antenna removed no mating took place. The experiments indicate that the IR sensory system of the insect antenna is directly related to frequencies in the IR regions of the spectrum. Such frequencies, as Wright (1963) pointed out, come from molecular vibrations and rotations. More studies are in progress using various far IR lasers to test moth response to far IR electromagnetic radiation.

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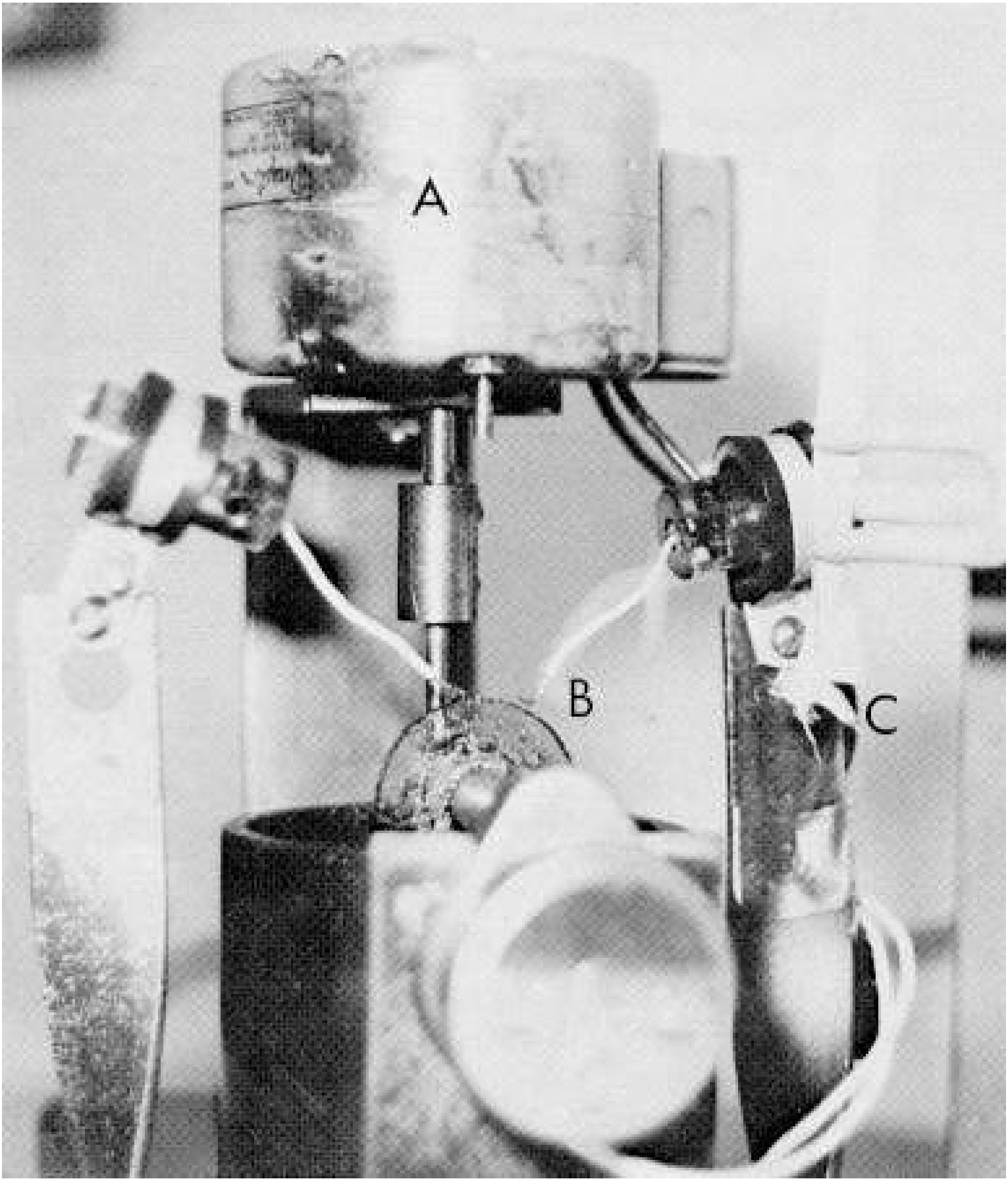
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PACHYDIPLAX LONGIPENNIS (ODONATA: ANISOPTERA): RECORDS OF NIGHT ACTIVITY

S. W. FROST

The Pennsylvania State University, University Park, Pa.

ABSTRACT

In 1 month's time 96 *Pachydiplax longipennis* Burmeister were collected in light traps operated between 9 PM and dawn.

Pachydiplax longipennis Burmeister is a common species throughout the United States and has been recorded frequently from Florida. It is also known from Lower California, Mexico, and Bermuda. From 2 April to 3 May 1970 the writer took 96 specimens (43 ♂, 53 ♀) in a light trap operated at the Archbold Biological Station, Florida. Thirty-one were taken between 9 and 10 PM, 11 between 10 and 11 PM, and the majority, 54, were taken between 10 PM and dawn.

These records provide new information on the night activity of Odonata. It has been generally believed that they are not night flyers, and that they are not strongly attracted to light. Those that had been seen flying at night and attracted to light were assumed to have been disturbed into flight by wind or other movements. The writer has collected 17 species and over 200 specimens in light traps during the past 12 years. Many were taken on very calm nights.

The Florida Entomologist 54(2) 1971

NOTICE OF ANNUAL MEETING

The Fifty-Fourth Annual Meeting of the Florida Entomological Society will be held at the Sheraton Jacksonville Hotel, 565 South Main Street, Jacksonville, Florida on September 8-10. The Program Committee under the leadership of Bill Gresham has been hard at work and will soon be contacting members for titles for papers. The program should be a great one.

The Local Arrangements Committee under the direction of John Mulrennan, Jr. should come up with some unusual things for members and an excellent program for the ladies. Plan now to attend.

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