The FLORIDA ENTOMOLOGIST

Volume 53 No. 2 *June 1970*

CONTENTS

Page

GENUNG, W. G.—*Flooding Experiments for Control of Wireworms Attacking Vegetable Crops in the Everglades* 55

PETERSON, A.—*Eggs from Miscellaneous Species of Rhopalocera-Lepidoptera* 65

REINERT, J. F.—*Description of the Pupa of* Aedes (Ochlerotatus) mitchellae (*Diptera: Culicidae*) 73

MUMA, M. H.—*Natural Control Potential of* Galendromus floridanus (*Acarina: Phytoseiidae*) *on Tetranychidae on Florida Citrus Trees* 79

GILBERT, I. H., H. K. GOUCK, AND C. E. SCHRECK—*Comparison of Four Chinchoninates, an Oxetanone, and Two Standard Skin Repellents Against* Aedes aegypti *and* Stomyxs calcitrans 89

WIRTH, W. W., AND F. S. BLANTON—*Notes on* Brachypogon kieffer (*Diptera: Ceratopogonidae*), *a New Species, and Two New Neotropical Genera of the Tribe Ceratopogonini* 93

GENUNG, W. G., AND M. J. JANES—*Further Investigations on Control of the Corn Stem Weevil,* Hyperodes humilis, *as a Pest of Field and Sweet Corn* 105

DEBARR, G. L.—*Characteristics and Radiographic Detection of Seed Bug Damage to Slash Pine Seed* 109

DENMARK, H. A., AND M. H. MUMA—Ricoseius loxocheles (*Phytoseiidae: Acarina*) 119

Society Honors W. L. Thompson 72

Minutes of 52nd Annual Meeting 123

Notices to Members 77, 92

Published by The Florida Entomological Society

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THE FLORIDA ENTOMOLOGIST is issued quarterly—March, June, September, and December. Subscription price to non-members $7.50 per year in advance; $2.00 per copy. Entered as second class matter at the post office at Gainesville, Florida.

Manuscripts and other editorial matter should be sent to the Editor, Entomology Department, University of Florida, Gainesville. Subscriptions and orders for back numbers are handled by the Business Manager, Box 12425, University Station, Gainesville, Florida 32601. The Secretary can be reached at the same address.

When preparing manuscripts, authors should consult *Style Manual for Biological Journals, 2nd Edition* (American Institute of Biological Sciences, Washington, D. C., 1964). For form of literature citations, see recent issues of THE FLORIDA ENTOMOLOGIST. Further, authors are referred to "Suggestions for preparation of manuscripts for THE FLORIDA ENTOMOLOGIST." Fla. Ent. 48 (2) : 145-146. 1965.

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This issue mailed July 22, 1970

FLOODING EXPERIMENTS FOR CONTROL OF WIREWORMS ATTACKING VEGETABLE CROPS IN THE EVERGLADES[1]

WILLIAM G. GENUNG
University of Florida, IFAS, Everglades Experiment Station

ABSTRACT

Either continuous or alternate flooding appears effective for control of *Melanotus communis* and *Conoderus* sp(p). The minimal effective continuous flooding period in these tests was 6 weeks. Since a 4-2-4 weekly alternation of flooding to drying repeatedly showed perfect control and since 2-2-2 alternations produced 71 to 87% mortality, it appears that a 3-2-3 alternation should normally be effective. Ecological factors resulting from flooding evidently are important and should be studied further. Birds attracted to impoundments are particularly beneficial.

During recent seasons a number of Everglades vegetable growers have expressed dissatisfaction with certain currently registered insecticides because of failure to control wireworms. Inspection revealed that the corn wireworm[2], *Melanotus communis* (Gyllenhal), was commonly involved in these failures although the populations often included the southern potato wireworm, *Conderus falli* Lane. It is not implied that wireworm "resistance" to these chemicals was involved in these alleged failures since extraneous factors could usually be implicated. Concurrently with these chemical failures, an increasing volume of questions was received relative to the merits of flooding, time required for wireworm control by flooding, and comparative effectiveness of alternate versus continuous flooding.

HISTORICAL BACKGROUND

A normally abundant water resource, usually available facilities, and water control knowhow have created an ideal situation in the Everglades for water utilization in the control of certain diseases, nematodes, possibly certain weeds, and most subterranean insects. Flooding organic soils for control of soil-borne pests is compatible with sound soil conservation practices since these soils oxidize continuously (due in part to action of aerobic bacteria) except when under water. Evans and Allison (1942) and Clayton (1943) discussed effects of excessive drainage on peat soils. Moore et al. (1949) recommended flooding for control of Sclerotinose disease, *Sclerotinia sclerotiorum* (Lib.) De By. Thames and Stoner (1953) found that flooding of growing low land rice effectively controlled root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood, on

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[1]University of Florida, IFAS, Everglades Experiment Station, Journal Series No. 3449.

[2]Not an approved common name by the Committee on Common Names of Insects of the Entomological Society of America although this name is in frequent use in the literature.

a subsequent vegetable crop. Fishler and Winchester (1964) found that flooding intermittently (2 weeks flooded, 2 weeks dried, and 2 weeks reflooded) controlled nematodes as effectively as 9 months of continuous flooding. Winchester (1964) discussed flooding among other cultural practices for control of nematodes in kenaf. Genung (1957) reported on the heavy and rapid mortality of cutworms *Feltia subterranea* (Fabricus) and *Agrotis ipsilon* (Rottemburg) observed under natural flooding, and more recently (1964) verified these observations in laboratory tests. Orsenigo (1967) found in weed control experiments that flooding might have merit for control of goosegrass. A search of the literature revealed that very little experimental data existed on wireworm control by flooding[3]. Thomas (1930) concluded that flooding for wireworms would be impracticable and ineffective. Everglades growers have practiced flooding for various purposes for a number of years but results were often contradictory insofar as wireworms are concerned. A need for some experimental information on the various aspects of flooding for wireworm control was evident and preliminary investigations in the laboratory and field were initiated. Atmospheric Temperatures during field investigations are given in Table 1.

TABLE 1. TEMPERATURES DURING FIELD FLOODING OPERATIONS FOR PERIOD COVERING OBSERVATIONS DURING 1966, 1967, AND 1969.*

Month	Year	Max.	Min.	Mean max.	Mean min.	Mean
July	1966	93.0	70.0	89.8	73.0	81.4
July	1967	94.0	68.0	90.9	70.7	80.8
July	1969	95.0	70.0	91.0	72.6	81.8
August	1966	94.0	68.0	90.8	71.4	81.1
August	1967	93.0	67.0	90.5	69.7	80.1
August	1969	94.0	65.0	89.7	70.6	80.1
September	1966	94.0	68.0	89.7	71.2	80.4
September	1967	92.0	65.0	89.3	69.5	79.4
September	1969	93.0	68.0	88.1	70.9	79.5

*Data are from official weather station records maintained at the Everglades Experiment Station.

EXPERIMENT 1

The purpose of this experiment was to determine the effect of different time increments of continuous flooding on corn wireworm mortality.

[3]A paper by M. Calvino (1922) on flooding for wireworms in Cuba is extant but the writer has not seen the original paper entitled: Nuovo metodo di lotta contro il pasador del tobacco a Cuba. Rev. Agric. Com. il trabajo V.P. lr, Havana Rae. X1, 104. The practice, as described in *Review of Applied Entomology* is a mere saturation and not flooding as practiced in the Everglades and would not be effective against our species.

MATERIALS AND METHODS: The treatments (time increments) included 6 different periods in comparison with an untreated check all of which were replicated 3 times in a randomized complete block design. Glazed, earthenware, 6-inch diam. crocks were partly filled with field collected soil and 10 field collected and apparently healthy, advanced instar larvae of *M. communis* were placed in each. Additional soil was then placed over the wireworms and firmed. Water was then added carefully, to avoid washing out or exposing the larvae. The water level was maintained about 3 inches above the soil in the 18 flooded crocks. The remaining 3 crocks constituted the check and were therefore not flooded. Since preliminary observations indicated that wireworms under flooding became relatively inactive in a short time, no food was supplied those in the treated crocks. Those in the check were supplied Irish potato halves just below soil surface. The flooding increments were: 3 days, 7 days, and weekly periods thereafter up to 35 days. As the time expired for each increment, the water was drained off and the soil carefully examined for live and dead wireworms, including any disintegrating parts, but the check was not examined until the expiration of the experiment. Those that survived were provided with food.

RESULTS: As shown in Table 2 mortality commenced with the 7-day treatment and generally increased thereafter. A delayed mortality (failure to survive 72 hr) after removal of water occurred in the flooded crocks. A

TABLE 2. MORTALITY PERCENTAGES OBTAINED WITH *Melanotus communis* UNDER DIFFERENT PERIODS OF SUSTAINED FLOODING DURING JUNE AND JULY 1966*

Time Increment	Initial Average % Mortality	Delayed Average % Mortality	Total Average % Mortality
3 days	0	0	0
7 days	3.3	10.0	13.3
14 days	3.3	10.0	13.3
21 days	23.3	10.0	33.3
28 days	33.3	43.3	76.6
35 days	63.3	13.3	76.6
Check	10.0	0	10.0

*Mortality in checks due mainly to cannibalism.

light mortality in the checks appeared to be due mainly to cannibalism even though ample food material had been supplied. An average of about 77% mortality was obtained after 35 days of sustained flooding, indicating that a greater time period would be required for control under heavy population conditions.

EXPERIMENT 2

This experiment was initiated to compare the recommended practice for nematode control (alternate flooding and drying) with results obtained in the continuous flooding experiment as given above.

MATERIALS AND METHODS: Two treatments (1) one week flooded, one week dried and one week reflooded and (2) two weeks flooded, two weeks dried, and two weeks reflooded (the standard flooding recommendation for nematodes) were set up in crocks as in Experiment 1, except that 15 wireworms were used per crock. These treatments and an untreated check were replicated 3 times. Food was provided in the checks as mentioned above.

RESULTS: In this experiment the first treatment was entirely inadequate (Table 3). A much better mortality was obtained in the second treatment

TABLE 3. MORTALITY PERCENTAGES OF *Melanotus communis* UNDER DIFFERENT TIME PERIODS OF ALTERNATE FLOODING AND DRYING DURING JUNE AND JULY 1966*

Weekly Alternation	Initial Average % Mortality	Delayed Average % Mortality	Time Average % Mortality
1 - 1 - 1	17.8	2.2	20.0
2 - 2 - 2	69.2	2.2	71.4
Check	8.9	0	8.9

*Mortality in checks due mainly to cannibalism.

but under conditions of heavy field infestation would be inadequate for grower needs. It appeared that some mortality in the check was due mainly to the cannibalistic tendency of the larvae.

EXPERIMENT 3

This experiment was conducted almost concurrently with Experiment 2 and the purposes were the same; but the present test was in a flooded field instead of the laboratory.

MATERIALS AND METHODS: 6-inch diam, screen wire, cylindrical cages were partly filled with soil and 10 wireworms added to each. The treatments and replications were the same as in Experiment 2. The cages were submerged in a flooded field until the soil in the cages was even with the soil line in the field. During the second 2-week period because of a temporary subsidence of the water, it was necessary to temporarily place the cages in tubs of water.

RESULTS: Both of the treatments gave better control (70% and 87% respectively) than the laboratory test, but even the results of the 2-week alternation would be barely adequate under very heavy field population conditions. (Table 4).

TABLE 4. PERCENT MORTALITY OF *Melanotus communis* LARVAE OBTAINED IN CAGES IN FLOODED FIELD. JUNE AND JULY 1966.*

Weekly Alternation	Initial Average % Mortality	Delayed Average % Mortality	Total Average % Mortality
1 - 1 - 1	70.0	0	70.0
2 - 2 - 2	80.0	6.7	86.7
Check	13.3	0	13.3

*Mortality in checks due mainly to cannibalism.

EXPERIMENT 4

This was an evaluation of (1) field flooding in comparison with 2 other conditions; (2) unflooded but treated with parathion the previous winter and (3) unflooded and with no recent history of insecticide treatment.

METHODS: About 1½ acres in preparation as a celery seed bed at the Everglades Experiment Station was flooded for 4 weeks, dried out for 2 weeks, and reflooded for 4 additional weeks. The second area was an adjacent comparable sized block that had been in sweet corn earlier in the spring and had been treated with parathion 5 lb/acre the previous winter. The unflooded check, a more distant comparable area, was selected because it had been continuously free from soil insecticidal treatment during recent years. Two-hundred evenly spaced soil cores 3 inches in diam and 6 inches deep were taken on all 3 areas after termination of flooding and examined by finely pulverizing and sifting the soil for wireworms.

RESULTS: As shown in Table 5, the flooded area samples were completely free of wireworms. The adjacent area treated the previous winter had

TABLE 5. RESULTS OF FIELD FLOODING FOR WIREWORM CONTROL IN COMPARISON WITH TWO OTHER CONDITIONS, DURING JUNE, JULY TO MID-SEPTEMBER 1966.

Treatment	Number Soil Samples	Number *M. Communis*	Number *Conoderus spp.*	Total Wire-worms	% Samples Positive
Flooded*	200	0	0	0	0
Insecticide**	200	10	0	10	5.0
Unflooded†	200	6	7	13	6.5

*4 - 2 - 4 weekly alternation
**Treated with parathion about 4 months previously
†No recent insecticidal history

more *M. communis* than the check but no *Conoderus* spp. A moderately high infestation occurred in the check area. If projected on a per acre basis the wireworm population in the check would undoubtedly be of economic proportions.

EXPERIMENT 5

This was almost identical with Experiment 4 except that the insecticidally treated area was replaced by a partially but insufficiently fallowed area.

RESULTS: No wireworms were found in the flooded area. The insufficiently fallowed area was moderately infested and the check quite heavily infested with wireworms. (Table 6).

TABLE 6. RESULTS OF FIELD FLOODING FOR WIREWORM CONTROL IN COMPARISON WITH TWO OTHER CONDITIONS DURING JULY, AUGUST TO MID-SEPTEMBER 1967.

Treatment	Number Soil Samples	Number *M. Communis*	Number *Conoderus spp.*	Total Wire-worms	% Samples Positive
Flooded*	200	0	0	0	0
Fallowed**	200	6	2	8	4.0
Unflooded	200	14	4	18	9.0

*4 - 2 - 4 weekly alternation.
**Fallow not perfectly maintained.

EXPERIMENT 6

In a test conducted in 1969, 2 additional conditions were compared with a 4-2-4 alternation with post flooding fallow well maintained. These were a 4-2-4 alternation where the post flooding fallow was rather inadequately maintained, and a continuously flooded treatment with inundation maintained without any lapse for 6 weeks. Because of factors beyond the writer's control it was possible to examine only 100 samples per treatment instead of the desired 200 samples.

RESULTS: Despite the reduced sample size a greater total number of wireworms as well as numbers of individual species were recorded in the check than in the previous field tests. A single wireworm and several corn rootworms indicate that some reinfestation is liable to occur in flooded fields unless the post flooding fallow is carefully maintained. The treatments and a full breakdown of data are shown in Table 7.

TABLE 7. COMPARISON OF EFFECTS OF ALTERNATE FLOODING AS RELATED TO GOOD AND MEDIOCRE POST FLOODING FALLOW AND IN COMPARISON WITH CONTINUOUS FLOODING.

Treatment	No. Samples	No. *M. communis*	No. *Conoderus sp.*	No. miscel.	Total Wire-worms	% Samples positive
Flooding* + good post flood fallow	100	0	0	0	0	0
Flooding** — good post flood fallow	100	1	0	0	1	1
Flooding† continuous	100	0	0	0	0	0
Check, no treatment	100	30	14	4	48	42

*4 - 2 - 4 alternation.
**4 - 2 - 4 alternation. In addition to wireworm 3 corn rootworms, probably *Diabrotica balteata* Le Conte, were taken under this treatment.
†Flooded for 6 weeks.

SOME ECOLOGICAL ASPECTS OF WIREWORM CONTROL BY FLOODING

Observations in both the field and laboratory show that 40% or more of wireworms under flooding or simulated flooding, may eventually make their way to the soil surface. In the field this percentage would be more vulnerable to attack by various aquatic organisms. Soon after flooding many semi-aquatic and wading birds move into the flooded areas. It is believed that the surfacing soil organisms including wireworms are a major attractions to birds in these impoundments. Under natural flooding in pastures, earth worms, white grubs, cutworms, and wireworms were observed at the surface where many birds were gathering. Brids observed at wireworm flooding sites included: mottled duck, *Anas fulvigula fulvigula* Ridgeway; king rail, *Rallus elegans elegans* Audubon; killdeer, *Charadrius vociferus vociferus* Linnaeus; snipe, *Capella gallinage delicata* (Ord); blacknecked stilt, *Himantopus mexicanus* (Muller); gulls *Larus* sp(p).; American egret, *Casmerodius albus egretta* (Gmelin); little blue heron, Florida *caerula caerula* (L.); white ibis, *Eudocimus albus* (L.); glossy ibis, *Plegadis falcinellus falcinellus* (L.); limpkin, *Aramus guarouna pictes* (myer); and Weston's boat tailed grackle, *Cassidix mexicanus westoni* Sprunt.[4]

In Laboratory experiments many of the wireworms under simulated

[4]Source for scientific names of birds: *Florida Bird Life*, Alexander Sprunt, Jr. 1954. Coward-McCann, Inc., New York, Nat. Audubon Soc. and Fla. Game and Fresh Water Fish Commission, Cooperating.

flooding were observed to have, after 2 to 3 weeks, a filamentous type of algal growth attached to the integument so firmly that the growth could not be removed without injury to the insect. Although pathogenicity of the organism was not established, it seems noteworthy that none of the affected larvae survived over 72 hrs when removed from the crocks.

Many predatory aquatic insects, reptiles, and amphibians find a suitable habitat in flooded fields but our knowledge of their possible effects on wireworms is at present too limited for comment.

Discussion

Flooding for wireworm control is a slow process. The time requirement may be one reason some growers feel wireworms cannot be drowned in practicable percentages. This method appears highly effective if continued for a long enough time and is in complete harmony with good organic soils conservation practices. In addition, flooding can be practiced when crop acreages are at a minimum, during the summer months. Besides drowning the current population, flooding prevents further oviposition during the period of inundation.

Reportedly wireworms soon reappear on land that has been flooded thus indicating a belief that previously flooded land holds affinity for the adult ovipositing elaterids. More probably, such lands are not maintained in a proper state of clean fallow prior to planting and resulting weed growth therefore encourages oviposition. It is important that the land be as well prepared for flooding as for planting and that the entire field is completely inundated. Field observations indicate that improperly prepared land results in poorer control by flooding than where reasonable care is taken. Wireworms have a better chance of survival where there are many unrotted stalks and other coarse organic debris. Unlevel land with many spots of protruding ground also contributes to poorer control.

It is evident that flooding for wireworm control produces an ecological situation in which benefits are derived from various biological agents among the most important of which are birds. It is also evident that our knowledge of what all these factors are and how they operate is very incomplete.

Flooding is not an unmixed blessing. That populations of carabid larvae and other predators in and on the soil were reduced was indicated by the sampling of flooded and unflooded areas. A determination of the full ecological effects of flooding on these lands would be a worthwhile study.

Conclusions

Alternate flooding and drying on a 4-2-4 weekly basis indicated excellent control of wireworms on organic soils. Since 5 weeks of continuous simulated flooding in the laboratory gave only about 77% control it was desirable to test 6 weeks of continuous flooding of carefully prepared land. This was done in the field in 1969 and excellent control was obtained. However, additional tests of this increment should be made. While

a 2-2-2 weekly alternate flooding to drying gave only fair control it can be projected from the data that a 3-2-3 alternation would probably be quite satisfactory. Since only *M. communis* was used in the laboratory tests and since that species and *Conoderus* sp. generally predominated in the field the results obtained are only considered applicable to those species.

Since field observations indicate that dehydration is more quickly lethal to wireworms than flooding, it is suggested that during dry seasons fields could, where feasible, be disked frequently to good advantage prior to flooding.

More field tests on the effectiveness of flooding should be conducted. These should also include careful observations on the ecological aspects both from the positive and negative sides.

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EGGS FROM MISCELLANEOUS SPECIES OF RHOPALOCERA-LEPIDOPTERA

ALVAH PETERSON
Ohio Historical Society Museum, Columbus, Ohio

ABSTRACT

Photographs and descriptions of several species of the Rhopalocera are presented. Similarly to the Heterocera, the eggs of the Rhopalocera described vary considerably in size, 0.5 mm to 2 plus mm. Their shapes may be round, conelike, somewhat flattened, elongated, or spindle-shaped. Their colors vary from near-white to yellow, green, orange, red, grey, to near black. The surface of the chorion may be smooth, rough, pitted, ridged, fringed, and adhesive to non-adhesive. Many are deposited singly and scattered or in flat or bunched masses.

During the past decade the author has devoted most of his research fun to collecting, photographing, and describing eggs of insects, especially eggs from many species of moths. Since 1961 he has published in the Florida Entomologist and elsewhere a number of papers on eggs of moths representing more than 25 families of the Heterocera.

In addition to the eggs of the Heterocera, eggs from a number of Rhopalocera have been obtained. This is the first paper by the author which presents eggs from several species of butterflies, skippers, and other Rhopalocera. These eggs were found in the field by observing and capturing females in the act of oviposition or were obtained by placing wild captured females in oviposition cages possessing plant tissues, especially leaves, stems, flowers, fruits, dry and moist paper towelling, wood, and other objects.

Eggs from a number of species of Rhopalocera were sent to me from several entomologists. Full credit is given to these persons. I am especially indebted to Mr. and Mrs. R. O. Kendall of San Antonio, Texas; also to J. H. Fales of Beltsville, Maryland, and to Kilan Roever of Phoenix, Arizona. Without this help the author might never have prepared this short paper. Here is hoping that other investigators may see fit to continue this fascinating study of the eggs of other Rhopalocera.

In the publication by Cyril F. dos Passos (1964) entitled A Synonymic List of the Nearctic Rhopalocera, one finds 10 families listed containing 682 species, namely Megathymidae—19 species, Hesperiidae—222 species, Papilionidae—22 species, Pieridae—58 species, Riodinidae—18 species, Lycaenidae—132 species, Libytheidae—2 species, Nymphalidae—146 species, Danaidae—4 species, and Satyridae—46 species.

Fig. 1 to 24 are microphotographs of one or more species from all of the above families except the Libytheidae. The original photographs were in color taken through a microscope on 35 mm Kodachrome II professional K.P.A. film under flood light. These were transposed to black and white Panatomic X film from which the black and white prints were made.

The eggs of the different species shown vary considerably in size, shape, color, surface texture, adhesiveness and distribution. Following are photographs and descriptions of the eggs of 24 species.

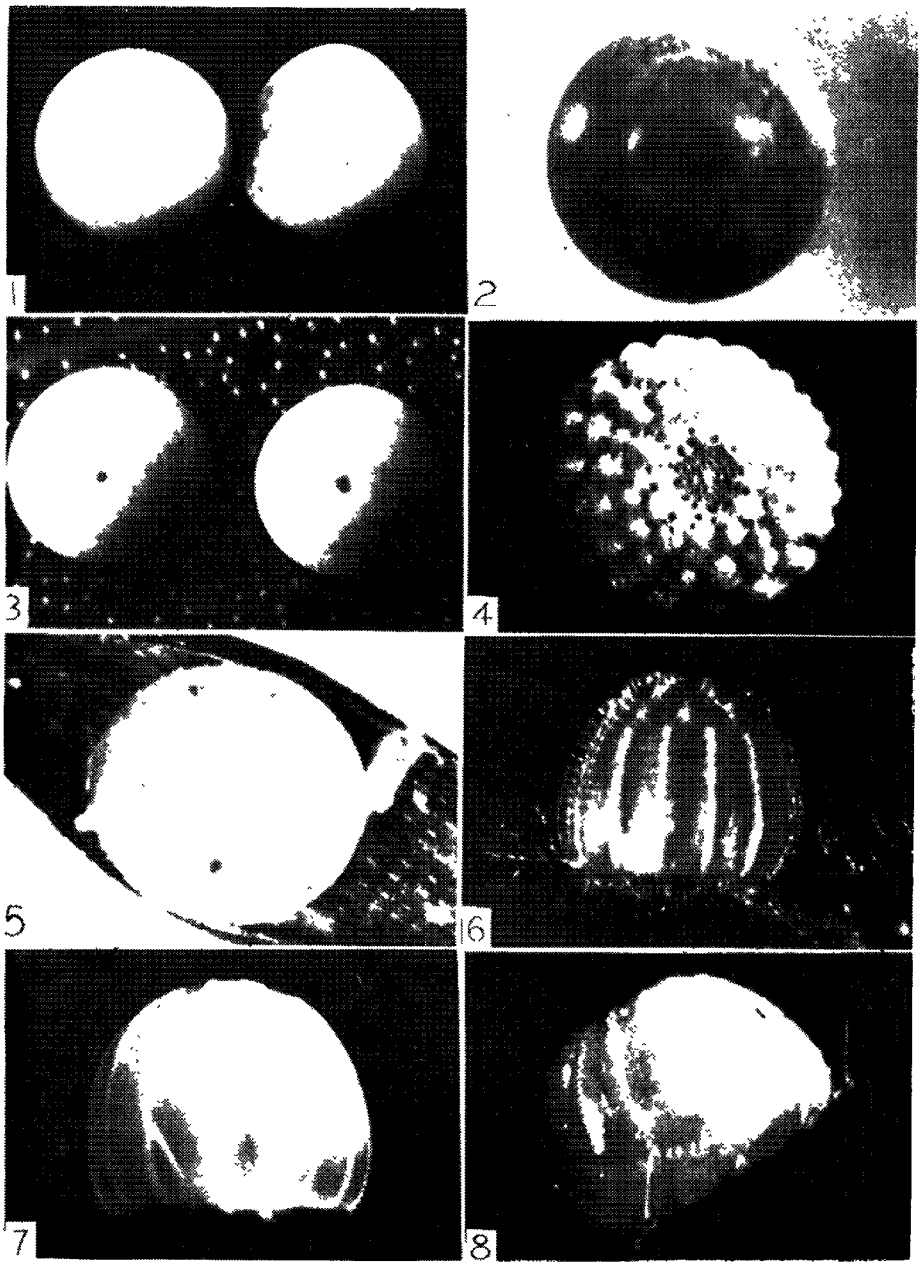
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Fig. 1. *Agathymus* sp., Megathymidae. Two views of the conelike eggs of an undescribed species. They are near white to cream colored when deposited, and nonadhesive.

Fig. 2. *Agathymus baueri* (Stallinger and Turner), Megathymidae. This large round egg has a concave bottom and a slightly depressed micropyle area at the top. When deposited, it is nonadhesive and light yellow. Near hatching time the color changes to a grey with red blotches.

Fig. 3. *Calpodes ethlius* (Stoll), Hesperiidae, larger canna leaf roller. The female deposits eggs singly, scattered and readily visible on the green foliage. Each egg is light gray in color, rounded, slightly flattened, and possesses a dark micropyle depression at the top center. Faint transverse granular lines occur on the chorion near the lower portion of the egg.

Fig. 4. *Atrytonopsis hianna* (Scudder), Hesperiidae. This ornate, slightly yellowish egg possesses a uniformly rough surface showing distinct rounded and pointed projections which extend in rows from the base of the egg to the depressed greenish micropyl area at the top. Some 10 or more projections exist in each vertical row.

Fig. 5. *Lerodea eufala* (Edwards), Hesperiidae. The egg is large, smooth, and light green in color. It becomes darker in color when ready to hatch.

Fig. 6. *Erynnis zarucco funeralis* (Scudder and Burgess), Hesperiidae. The eggs are somewhat coneshaped, yellowish green in color, possess a flat base, and are deposited singly. Twelve to 14 prominent vertical ridges occur on the sides of the egg. These extend from the base toward the apex. Transverse striae occur between the ridges.

Fig. 7. *Achlyodes thraso tamenund* (Edwards), Hesperiidae. The egg is yellowish brown, somewhat coneshaped, and deposited singly. The surface possesses 14 plus blunt vertical ridges with very faint cross striae between them.

Fig. 8. *Thorybes plades* (Scudder), Hesperiidae. The shiny, grass green eggs are deposited singly and possess 12 plus inconspicuous vertical ridges without transverse striae.

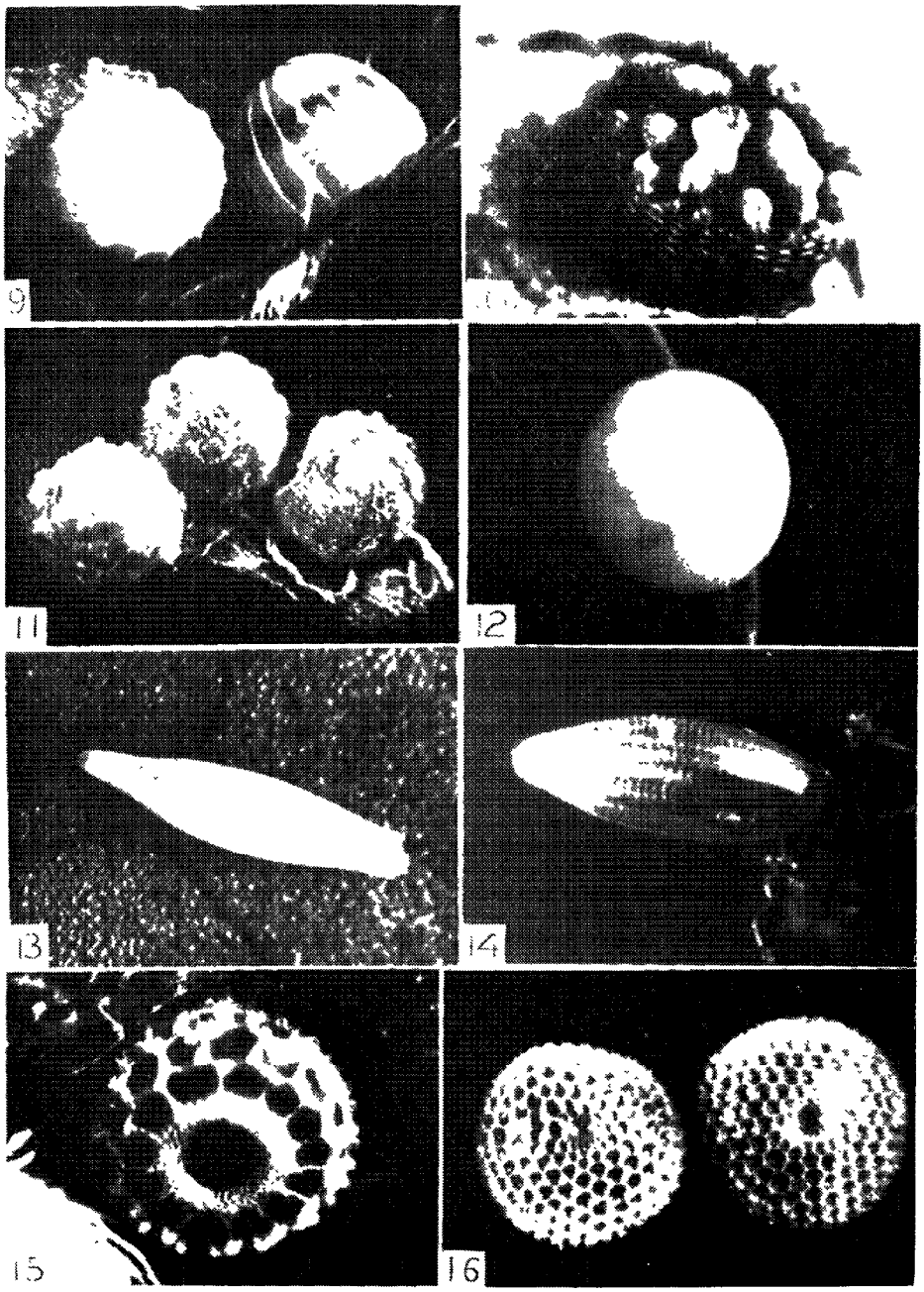
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Fig. 9. *Epargyreus clarus clarus* (Cramer), Hesperiidae. The eggs are deposited singly or adjacent to each other. Their overall color is light green and may show a distinct circular red band near the top. Fifteen prominent vertical ridges occur on the chorion with no distinct transverse striae between them.

Fig. 10. *Staphylus mazans mazans* (Reichert), Hesperiidae. The overall color is a medium brown. The lower half of each egg resembles a woven basket with transverse strands. The upper half of each egg possesses several irregular potato-like humps.

Fig. 11. *Battus philinor philinor* (Linnaeus), Papilionidae, pipevine swallowtail. The eggs are adhesive and usually deposited in irregular clusters. They are spherical and have a reddish orange to a dark color. The chorion is rough and irregular with faint indications of incomplete vertical ridges.

Fig. 12. *Papilio polyxenes asterius* (Stoll), Papilionidae. The egg is large, nearly spherical, quite smooth, and distinctly green.

Fig. 13. *Pieridae* sp. An egg found commonly on Acacia foliage in Florida. Each egg is greatly elongated and deposited in an upright position on the leaf. They are light green in color and possess very faint vertical lines on the chorion.

Fig. 14. *Colias eurytheme eurytheme* (Boisduval), Pieridae, alfalfa caterpillar. The egg is elongated, spindle shaped, near white to pink, and possesses 16 or more faint vertical ridges with transverse striae between them.

Fig. 15. *Lephelisca nemesis* (Edwards), Riodinidae. This small egg is very ornate, round, and doughnut shaped. Its overall color is purple with near white ridges about the 12 to 14 hexagonal or nearly round areas near the top and sides. At the top, a conspicuous near-white ring surrounds the micropyle area.

Fig. 16. *Strymon beon* (Cramer), Lycaenidae. Eggs are nearly spherical, near-white, and the chorion possesses many small round to hexagonal depressions bearing tiny projections on the ridges about each depression.

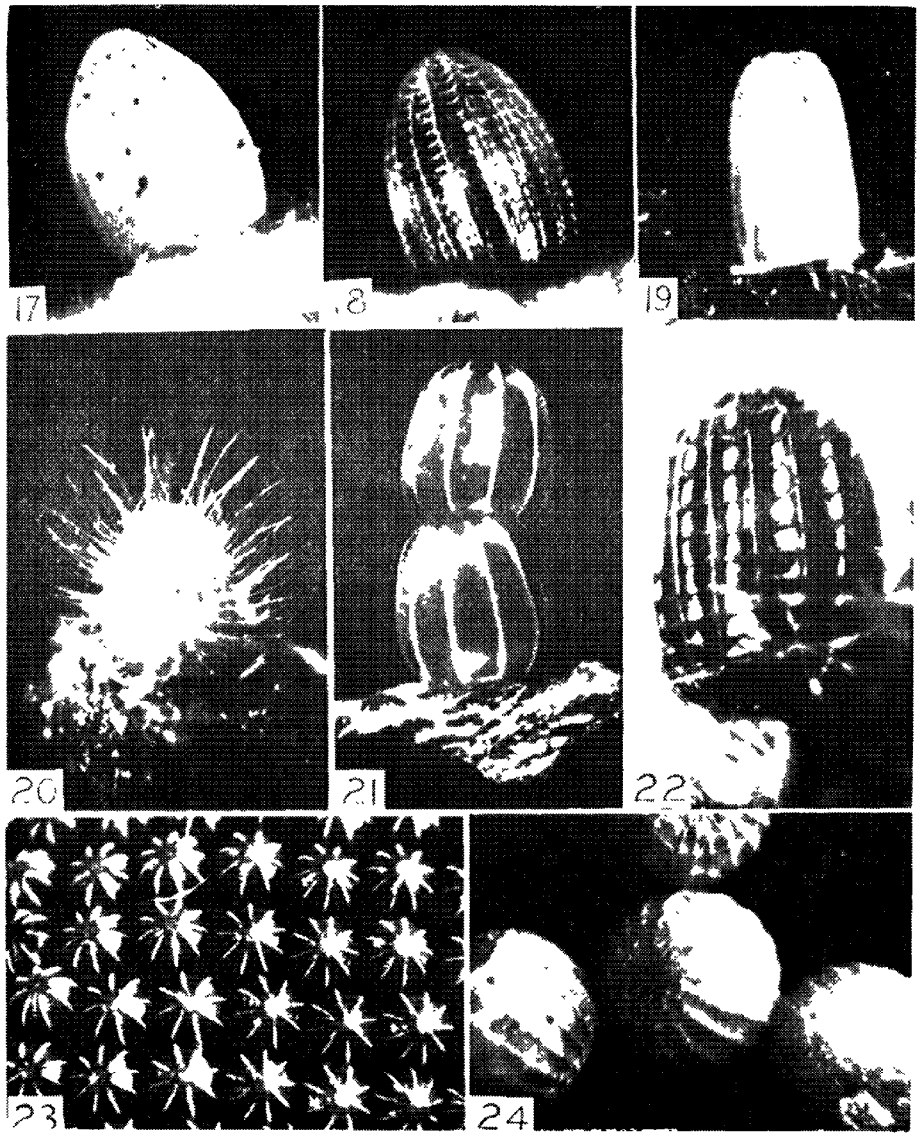
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Fig. 17. *Danaus plexippus plexippus* (Linneaus), Danaidae. Monarch butterfly. Each egg is somewhat coneshaped, single, and has a vertical position on the host plant. It is near white in color and possesses 25 or more inconspicuous vertical ridges which extend from the base of the egg toward the bluntly pointed top end. Faint transverse striae occur between the vertical ridges.

Fig. 18. *Danaus gilippus strigosus* (Bates), Danaidae. This prehatch, dark colored, coneshaped egg possesses 20 plus verticle ridges and transverse striae on the chorion between the ridges.

Fig. 19. *Heliconius charitonius vazquezae* (Comstock and Brown), Nymphalidae. The eggs are deposited singly and in a vertical position on host tissue. Each light colored egg is approximately twice as high as its diameter. Some 14 prominent rounded ridges extend from the base to near the top with inconspicuous transverse striae between the ridges.

Fig. 20. *Mestra amymone* (Menetries), Nymphalidae. This yellowish, conelike egg is deposited singly in a vertical position. It is unusual in that the 20 or more vertical ridges possess greatly elongated near-white filaments which project up and out from the chorion like a brush.

Fig. 21. *Polygonia interrogationis* (Fabricius), Nymphalidae. Two eggs, one on top of the other. Each egg is a dark shiny green with 10 vertical ridges which extend from the base of the egg toward the top where they are most prominent. Faint transverse striae occur between the ridges.

Fig. 22. *Agraulis vanillae incarnata* (Riley), Nymphalidae. An enlarged, nearly black, shiny prehatch egg possessing 14 plus prominent vertical ridges and 10 plus transverse striae between the ridges creating vertical series of somewhat square, shiny spots.

Fig. 23. *Nymphalis antiopa antiopa* (Linneaus), Nymphalidae, mourning-cloak butterfly. The female deposits her eggs in single clusters of 50 or more. This is a top view of some of the eggs in a cluster. Each of the prehatch, reddish brown eggs show 8 vertical ridges projecting from the chorion.

Fig. 24. *Cercyonis pegala texana* (Edwards), Satyridae. Several large, reddish, and somewhat irregular, spherical eggs each possessing 18 or more faint vertical ridges with inconspicuous transverse striae between them.

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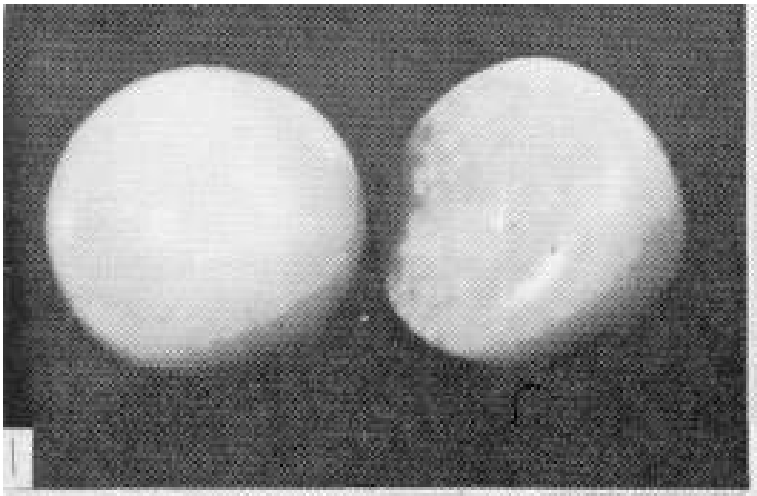
SOCIETY HONORS DR. WILLIAM L. "TOMMY" THOMPSON

William Louden Thompson was born at State College, Pennsylvania, in 1896. He obtained a B.S. degree at the present Pennsylvania State University in 1923, and he was granted an honorary D.Sc. degree by the University of Florida after his retirement. Tommy held positions in Florida as follows: Assistant entomologist, Florida State Plant Board 1925-27; assistant entomologist, Citrus Branch Station 1927-39; associate entomologist, Citrus Experiment Station, 1939-43; and entomologist for the period 1943-62, until his retirement. He was elected president of the Florida Entomological Society in 1935 and reelected in 1936—in times of depression days. In 1936, the financial condition of the Florida Entomological Society became very low. Tommy's work in and for the Society successfully introduced new life into it to turn its future along a bright path. He became a member of the Gamma Sigma Delta fraternity in 1959. He became an Honorary member of the Florida State Horticultural Society in 1962. Tommy did research work on insects affecting citrus and made direct contact with growers and others in the industry in a manner that gave him the image "Mr. Citrus Entomologist". He was thorough, honest, fair, and practical, and his conference "bedside manners" inspired growers with hope, confidence, and a desire to call on him again when the need arose. His publications number about 135 as junior or senior author, excluding preparations (sometimes in collaboration with other entomologists) of a monthly article for the Citrus Industry. Tommy was always well informed on the latest methods and pesticides. Members of the Thompson family are valued citizens in and about Lake Alfred where they reside. A son, their only child, is a citrus grove caretaker in the Indian River area.

Dr. Thompson retired in 1962 after more than 37 years of distinguished service in Florida.

G. W. Dekle
A. N. Tissot
D. W. Wolfenbarger, Chairman
Honors and Awards Committee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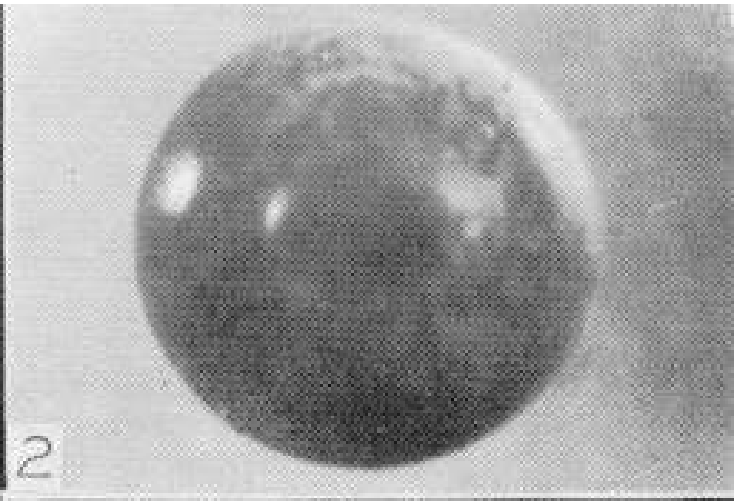
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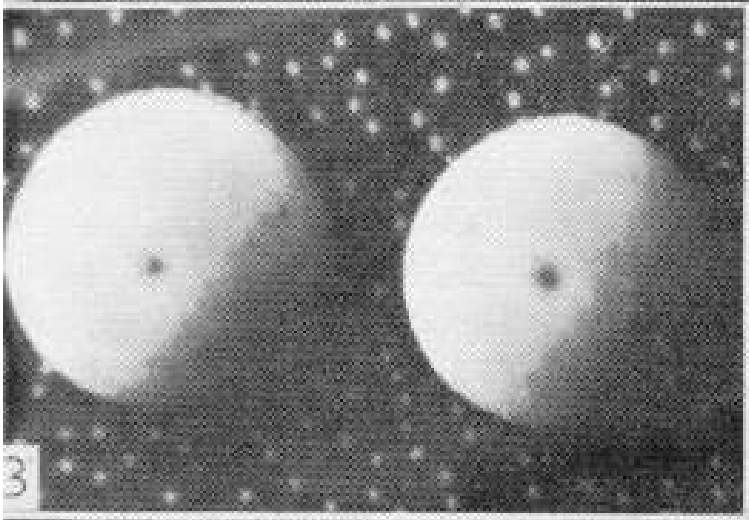
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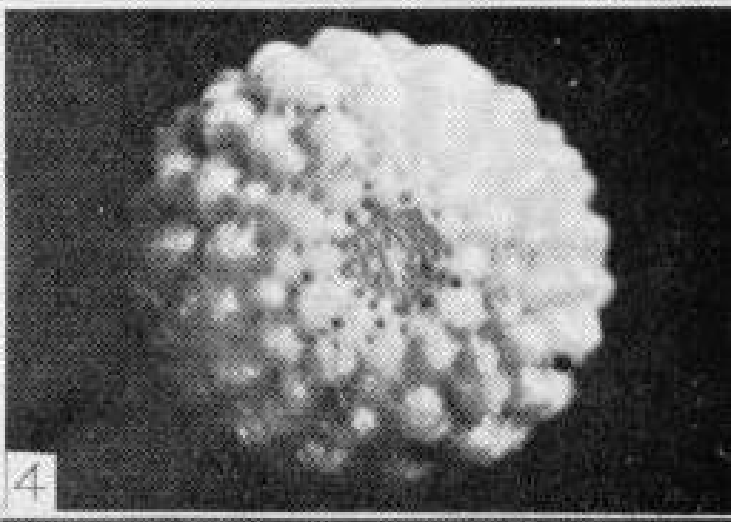
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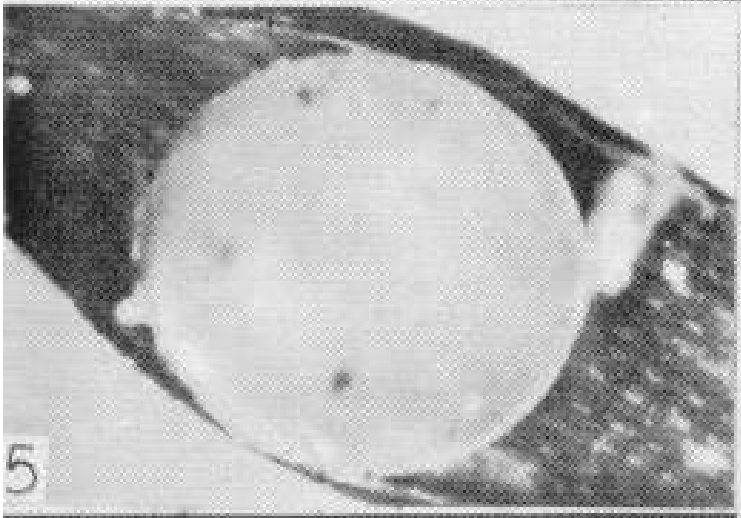
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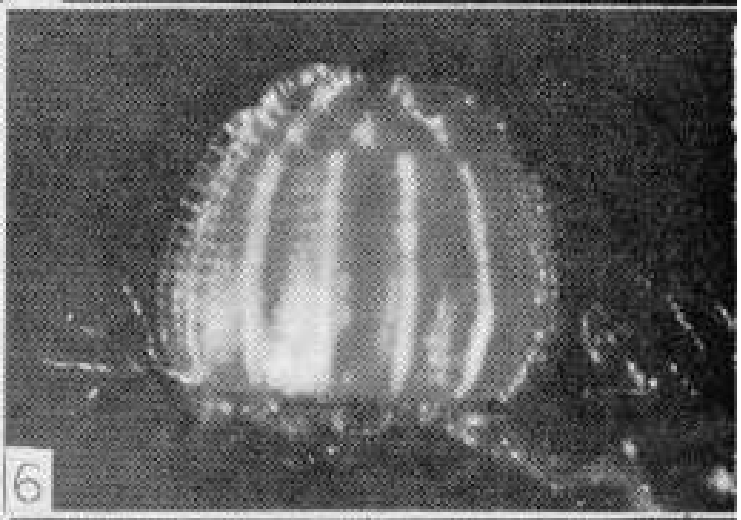
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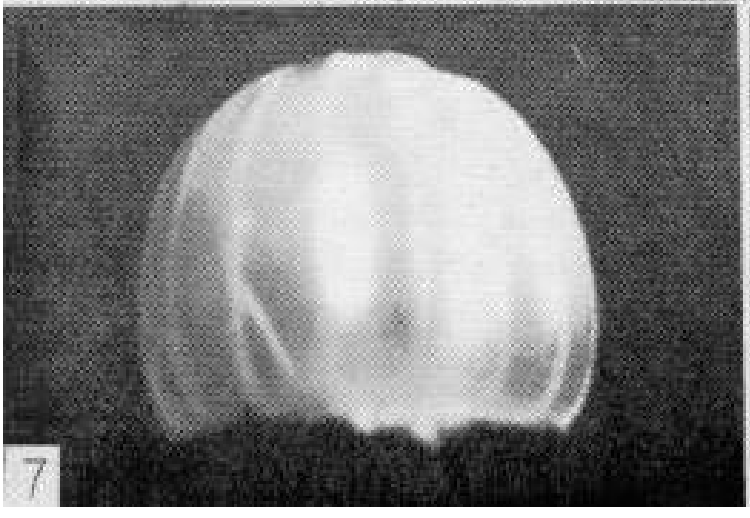
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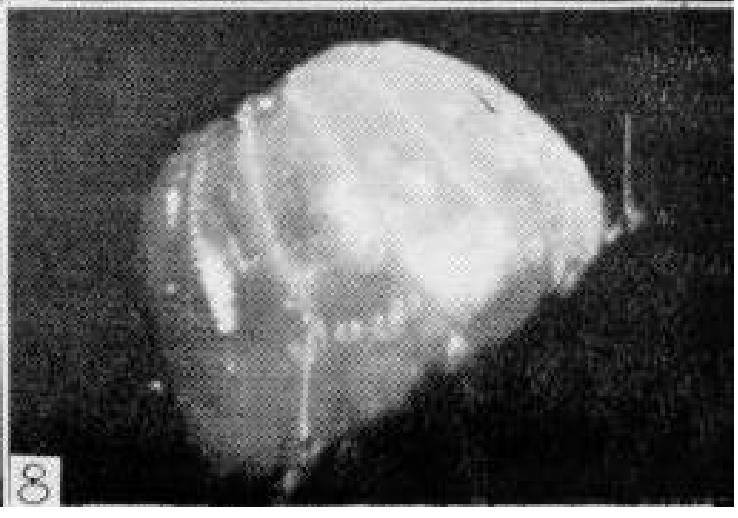
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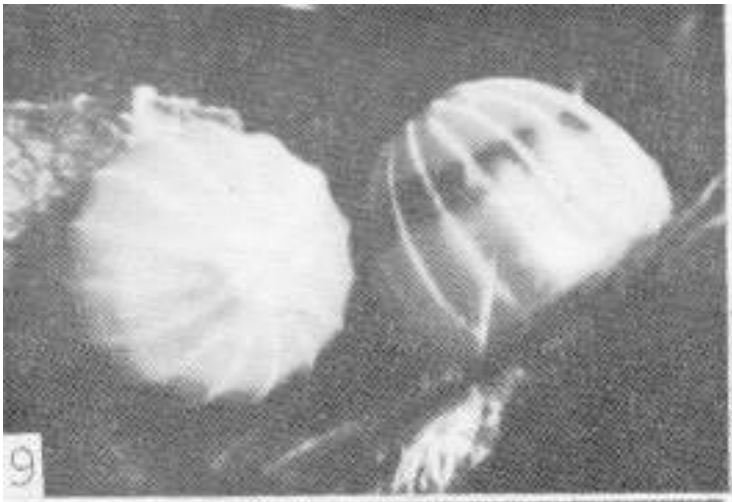
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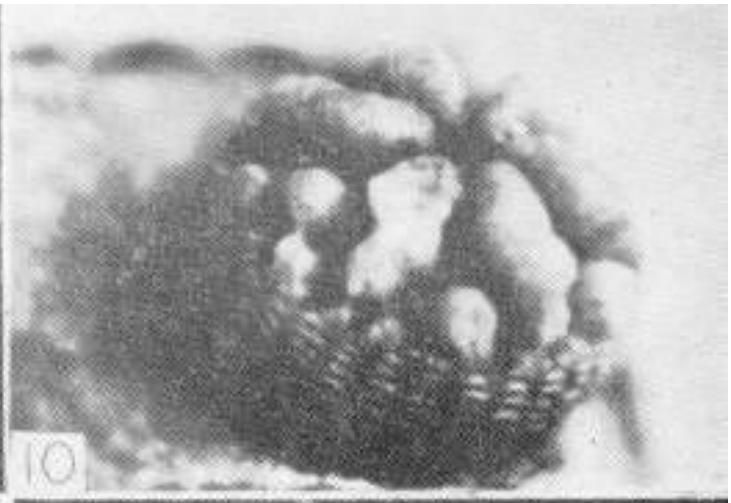
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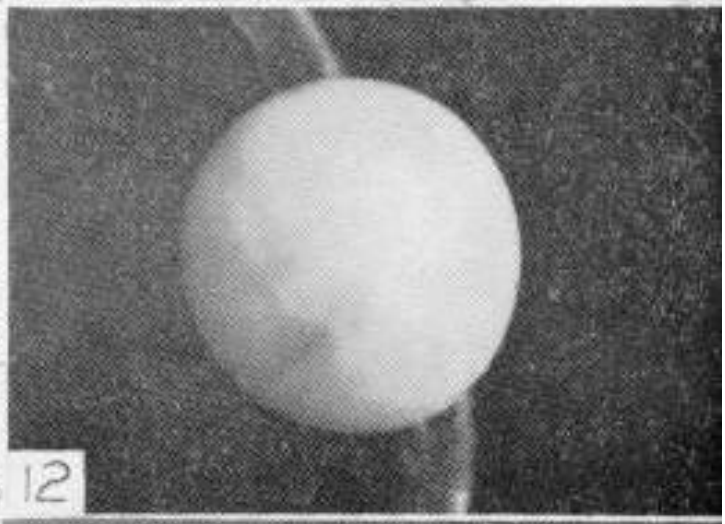
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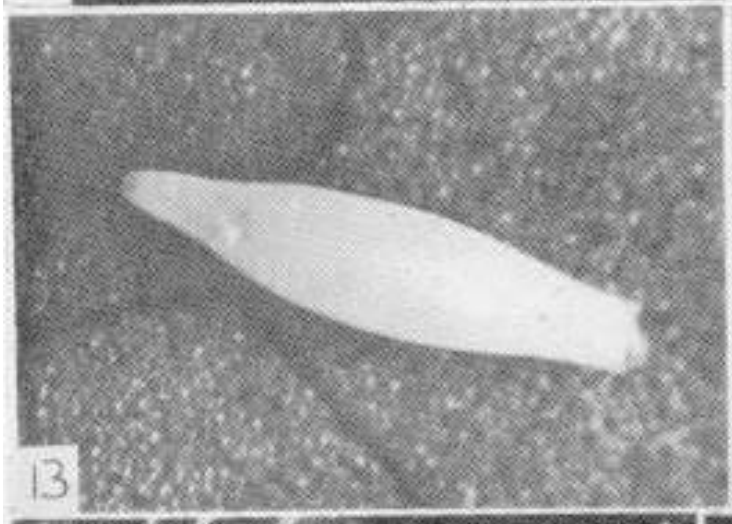
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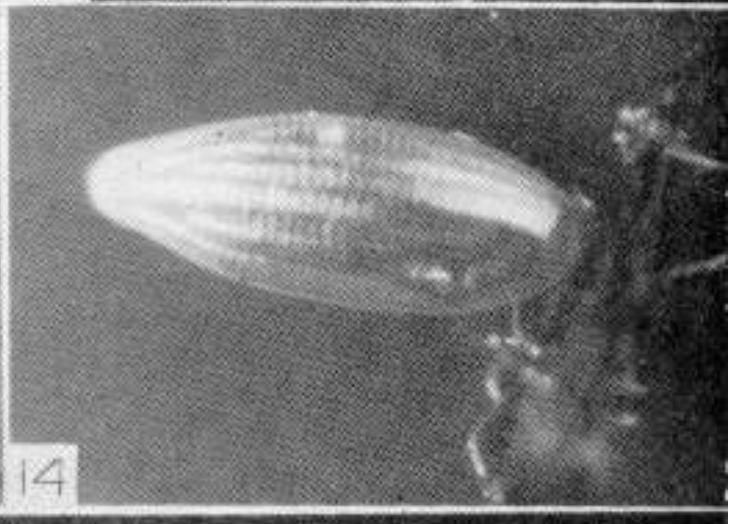
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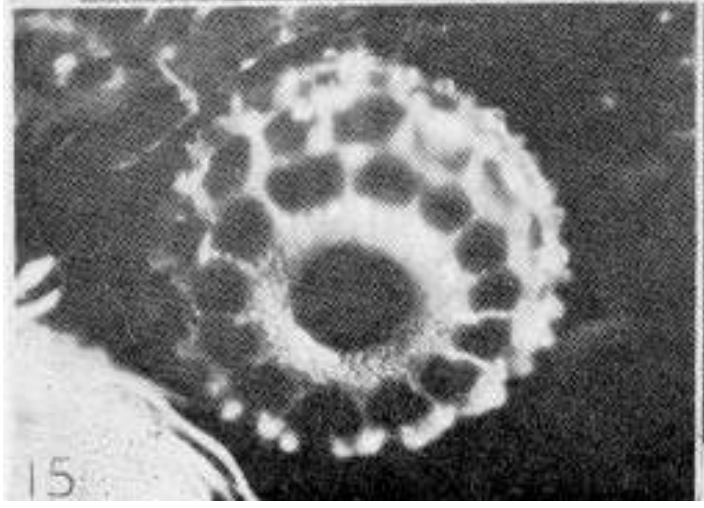
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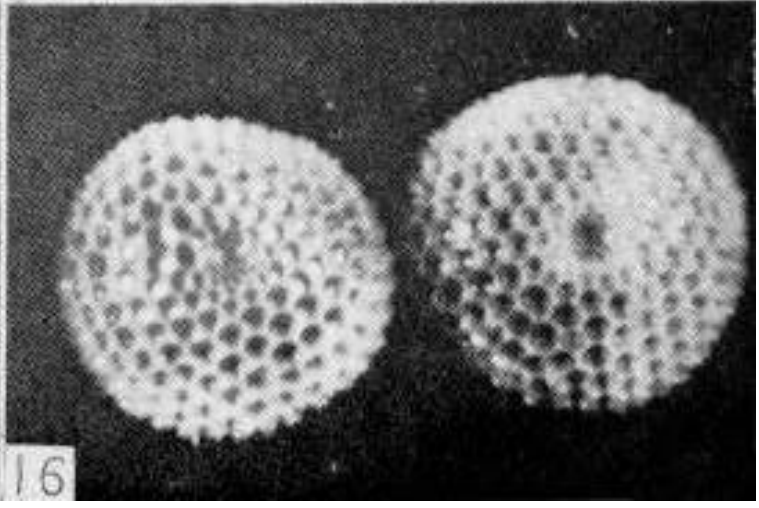
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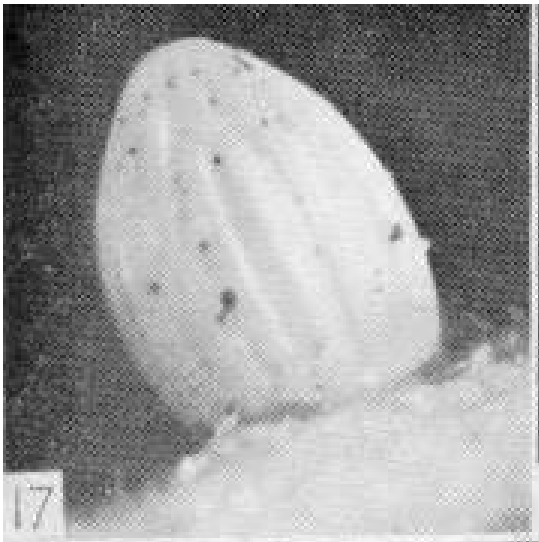
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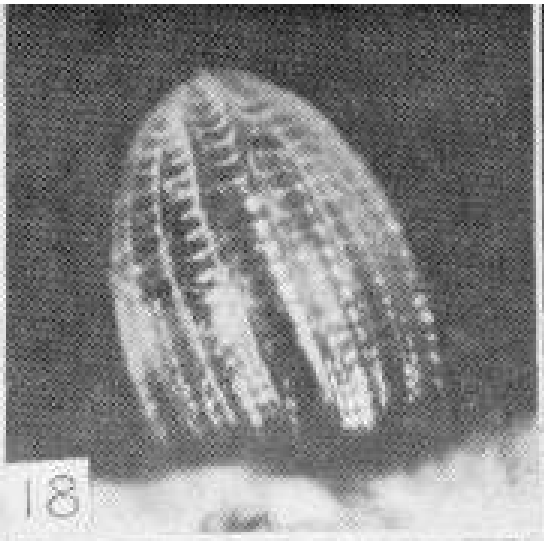
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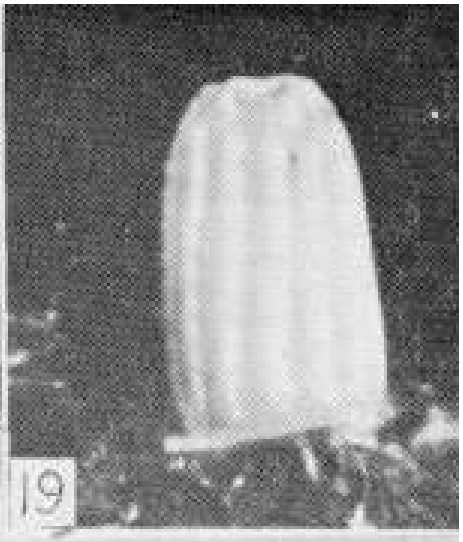
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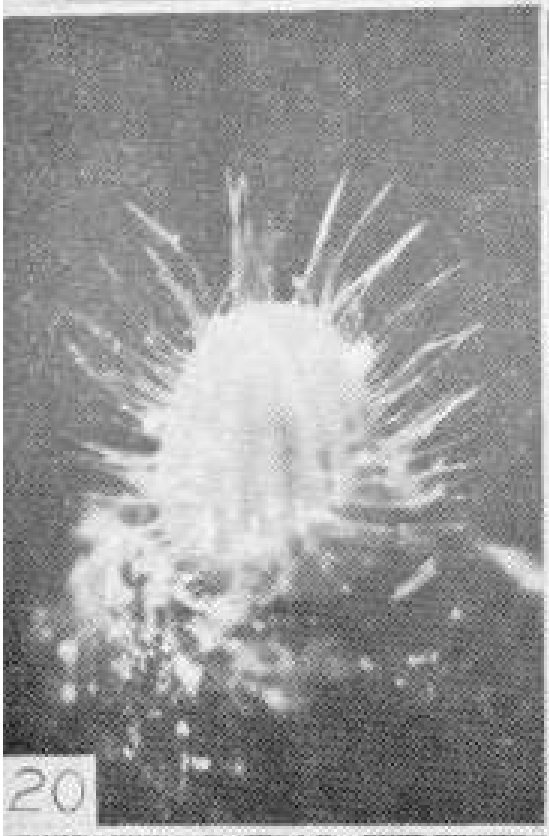
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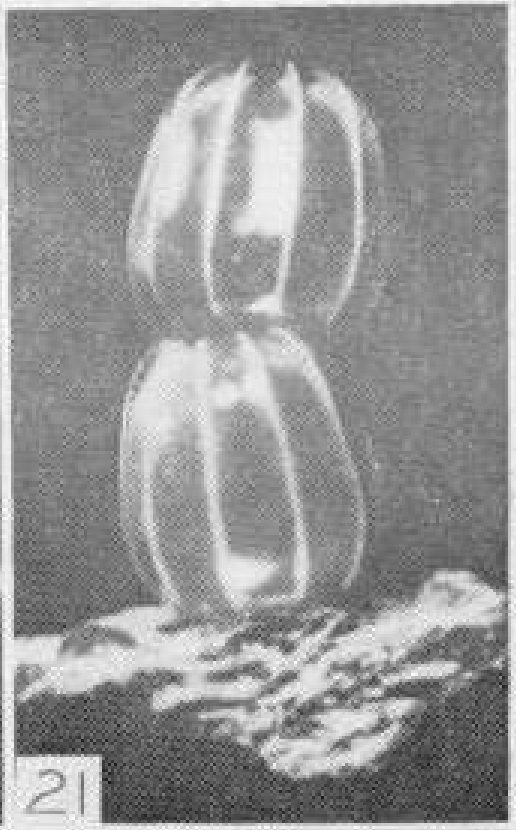
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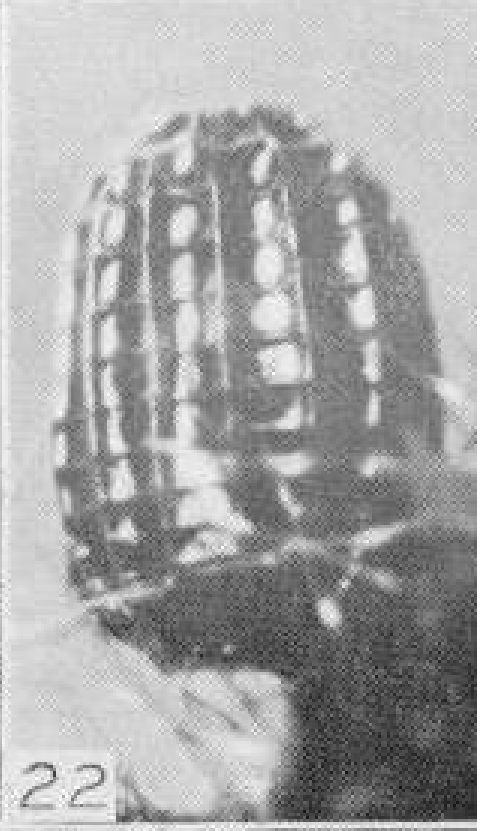
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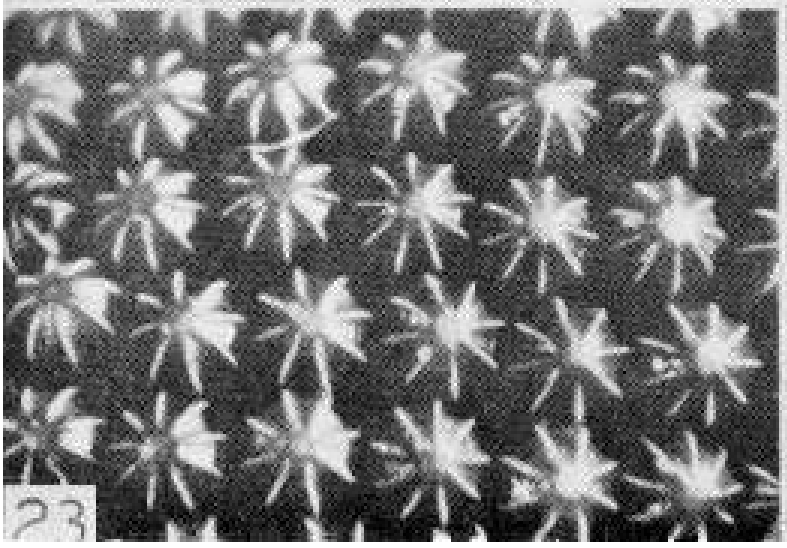
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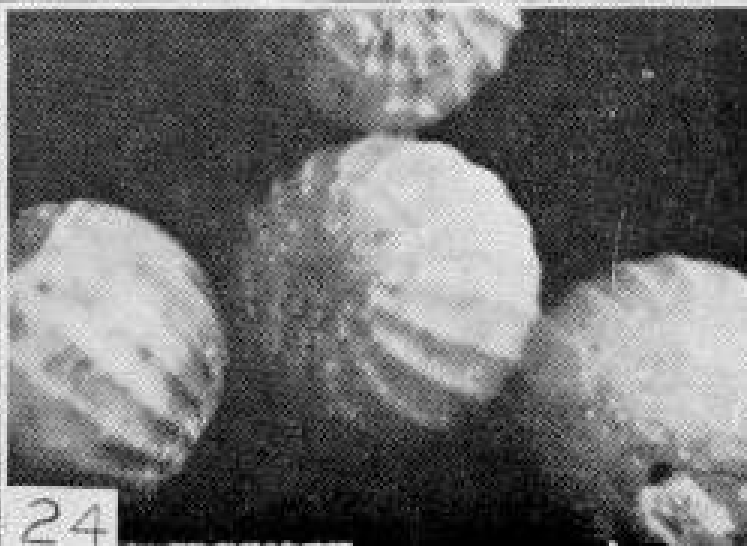
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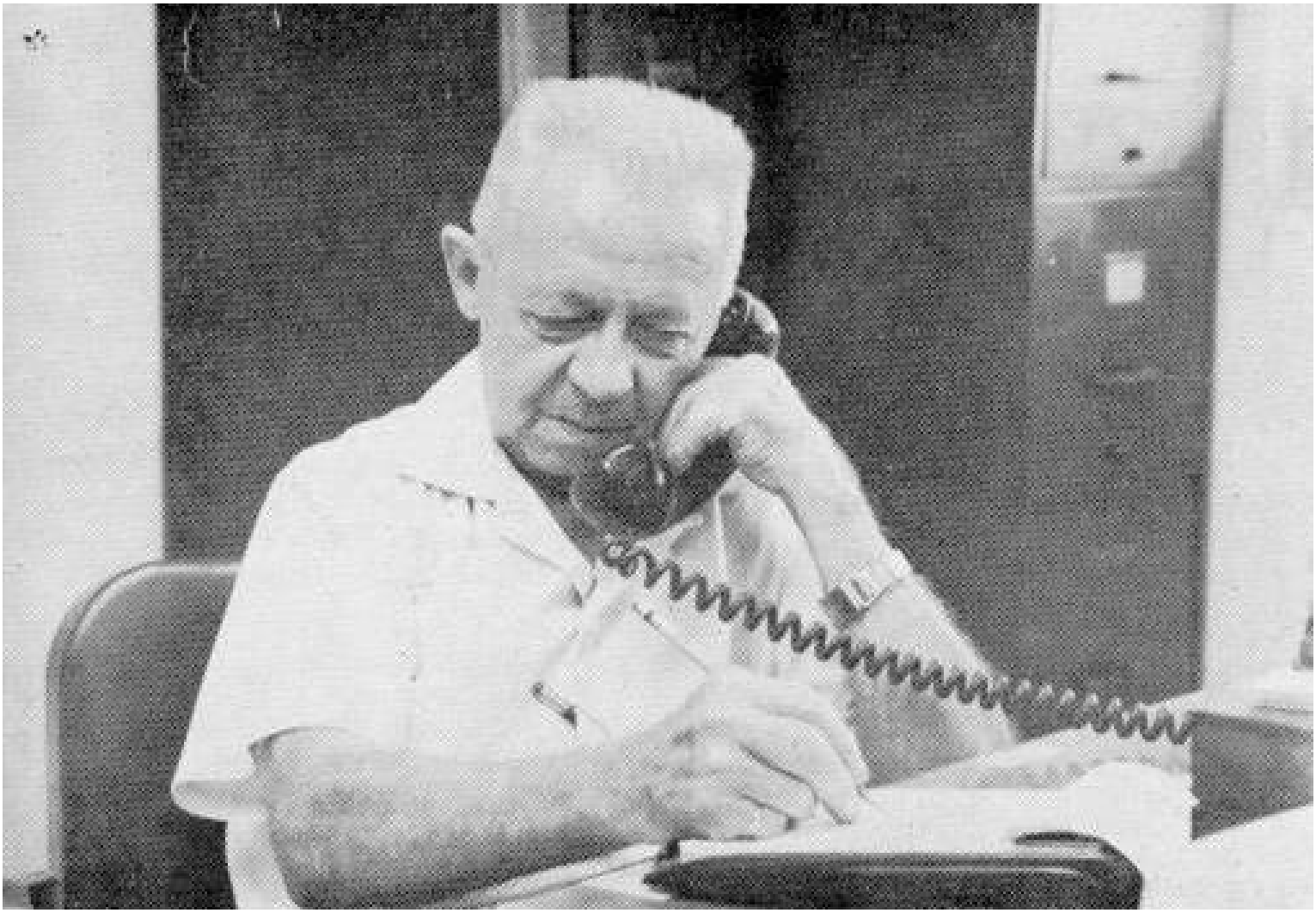

DESCRIPTION OF THE PUPA OF *AEDES* (*OCHLEROTATUS*) *MITCHELLAE* (DIPTERA: CULICIDAE)

JOHN F. REINERT[1]

Department of Entomology, University of Florida,
Gainesville, Florida 32601

ABSTRACT

The pupa of *Aedes* (*Ochlerotatus*) *mitchellae* (Dyar) is described and illustrated for the first time. A table lists the range, mode and mean number of branches of each pupal hair.

The original description of *Aedes* (*Ochlerotatus*) *mitchellae* was published by Dyar in 1905. A more complete written description, accompanied by illustrations of the male, female and larva, was given by Carpenter and La Casse (1955). The egg was described and illustrated by Craig and Horsfall (1960). In the present paper the pupa is described and illustrated (Fig. 1-3) for the first time. Table 1 lists the range, mode, and mean number of branches for each pupal hair. Chaetotaxy and morphological nomenclature used in this description follow that of Belkin (1962).

Aedes (*Ochlerotatus*) *mitchellae* (Dyar)

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

Respiratory trumpet (Fig. 2). Strongly pigmented; scattered tiny spine-like setae on distal 0.85 of inner surface; index 3.81-4.33.

Metanotum (Fig. 3). Hairs C-10-12 long, C-10 usually with 3-5 branches, C-11 single, C-12 usually double or triple.

Abdomen (Fig. 3). Hair 0-II-VIII minute, single; 1-I well developed with 24-37 branches on basal one third, 1-II short, 1-III moderately long, 1-IV-VII long, 1-II usually with 4-5 branches, 1-III usually with 4-6 branches, 1-IV-V usually with 3-4 branches, 1-VI usually triple, 1-VII usually double or triple; 2-I-VII short, 2-I usually double, 2-II-VII single; 3-I, III, VI long, 3-II, IV-V long, 3-I single, 3-II-III single or double, 3-IV usually with 4-6 branches, 3-V usually with 3-4 branches, 3-VI usually double, 3-VII usually triple; 4-I-III short, 4-IV-VI moderately long, 4-VII-VIII long, 4-I, VI usually with 4-5 branches, 4-II usually with 4-6 branches, 4-III usually with 3-4 branches, 4-IV, VII usually double or triple, 4-V usually with 5-6 branches, 4-VIII usually double; 5-I short, 5-II-III moderately long, 5-IV-VI extra long, 5-VII long, 5-I with 5-7 branches, 5-II usually with 4-5 branches, 5-III usually with 5-6 branches, 5-IV-VI usually triple, 5-VII usually double or triple; 6-I-II long, 6-III-

[1]Major, Medical Service Corps, U. S. Army. The opinions contained herein are the private ones of the author and are not to be construed as official or as reflecting the views of the Department of the Army. Fla. Agri. Experiment Station Journal Series No. 3541.

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

Hair	Range	Mode	Mean
	Cephalothorax		
1	2	2	2
2	2–3	2	2.2
3	2	2	2
4	3–5	3	3.5
5	3–5	4	3.7
6	3–4	4	3.6
7	3–7	4	4.6
8	4–5	4	4.3
9	2–3	2	2.1
	Metanotum		
10	3–6	4	4.2
11	1	1	1
12	2–4	2	2.7
	Abdomen I		
1	24–37	30	29.5
2	1–3	2	1.9
3	1	1	1
4	4–6	5	5.2
5	5–7	5	5.9
6	1	1	1
7	2–4	2	2.7
9	1	1	1
11	1–3	1	1.6
	Abdomen II		
0	1	1	1
1	4–7	5	5.1
2	1	1	1
3	1–2	1	1.4
4	4–7	5	5.2
5	4–7	5	5.1
6	1–2	1	1.4
7	2–5	3	3.1
9	1	1	1
14	1	1	1
	Abdomen III		
0	1	1	1
1	4–7	5	5.3
2	1	1	1
3	1–2	1	1.2
4	3–7	4	4.6
5	4–7	5	6.2
6	2–4	3	3.4
7	4–5	5	4.6
8	3–5	4	3.7
9	1	1	1
10	2–4	2	2.8
11	1	1	1
14	1	1	1
	Abdomen IV		
0	1	1	1
1	3–6	4	3.9
2	1	1	1
3	4–7	5	5.2
4	2–4	2	2.5
5	3–4	3	3.1
6	2–4	3	3.1
7	2–4	3	3.3
8	2–3	2	2.4
9	1	1	1
10	2–3	2	2.8
11	1	1	1
14	1	1	1
	Abdomen V		
0	1	1	1
1	3–4	3	3.2
2	1	1	1
3	3–5	3	3.5
4	3–7	5	5.3

Continued

TABLE 1. Continued

Hair	Range	Mode	Mean
	Abdomen V (Cont)		
5	2–4	3	3.1
6	2–4	3	2.9
7	4–7	5	4.8
8	2–4	3	2.9
9	1	1	1
10	1–2	1	1.4
11	1	1	1
14	1	1	1
	Abdomen VI		
0	1	1	1
1	2–4	3	2.8
2	1	1	1
3	2–3	2	2.2
4	4–6	4	4.3
5	2–4	3	3.1
6	2–4	3	2.7
7	1–2	1	1.3
8	3–4	3	3.3
9	1	1	1
10	1	1	1
11	1	1	1
14	1	1	1
	Abdomen VII		
0	1	1	1
1	1–3	2	2.2
2	1	1	1
3	2–4	3	2.8
4	2–3	2	2.4
5	2–4	3	2.9
6	4–6	4	4.6
7	1–2	2	1.6
8	2–5	4	3.6
9	3–6	5	4.6
10	1	1	1
11	1	1	1
14	1	1	1
	Abdomen VIII		
0	1	1	1
4	2–3	2	2.2
9	6–9	9	7.7
14	1	1	1
	Paddle		
1	1	1	1

VI moderately long, 6-VII short, 6-I single, 6-II single or double, 6-III, VI usually double or triple, 6-IV-V usually with 3-4 branches, 6-VII usually with 4 branches; 7-I-II, V-VI moderately long, 7-III-IV short, 7-VII long, 7-I, VII usually double, 7-II usually double or triple, 7-III, V usually with 4-5 branches, 7-IV usually with 3-4 branches, 7-VI single or double; 8-III-VII short, 8-III, VII usually with 3-4 branches, 8-IV-V usually double or triple, 8-VI usually triple; 9-I-VI short, 9-VII-VIII moderately long, 9-I usually single, 9-II-VI single, 9-VII stellate, usually with 5-6 branches, 9-VIII stellate, usually with 7 or 9 branches; 10-III-IV, VI-VII moderately long, 10-V long, 10-III with 2-4 branches, 10-IV double or triple, 10-V single or double, 10-VI-VII single; 11-I, III-VII short, 11-I usually single or double, 11-III-VII single; 14-II-VIII minute, 14-II-VIII single.

Paddle (Fig. 3). Ovoid with minute spicules along distal 0.25 of margin, midrib does not reach apex; 1-P short and single; index 1.14-1.43.

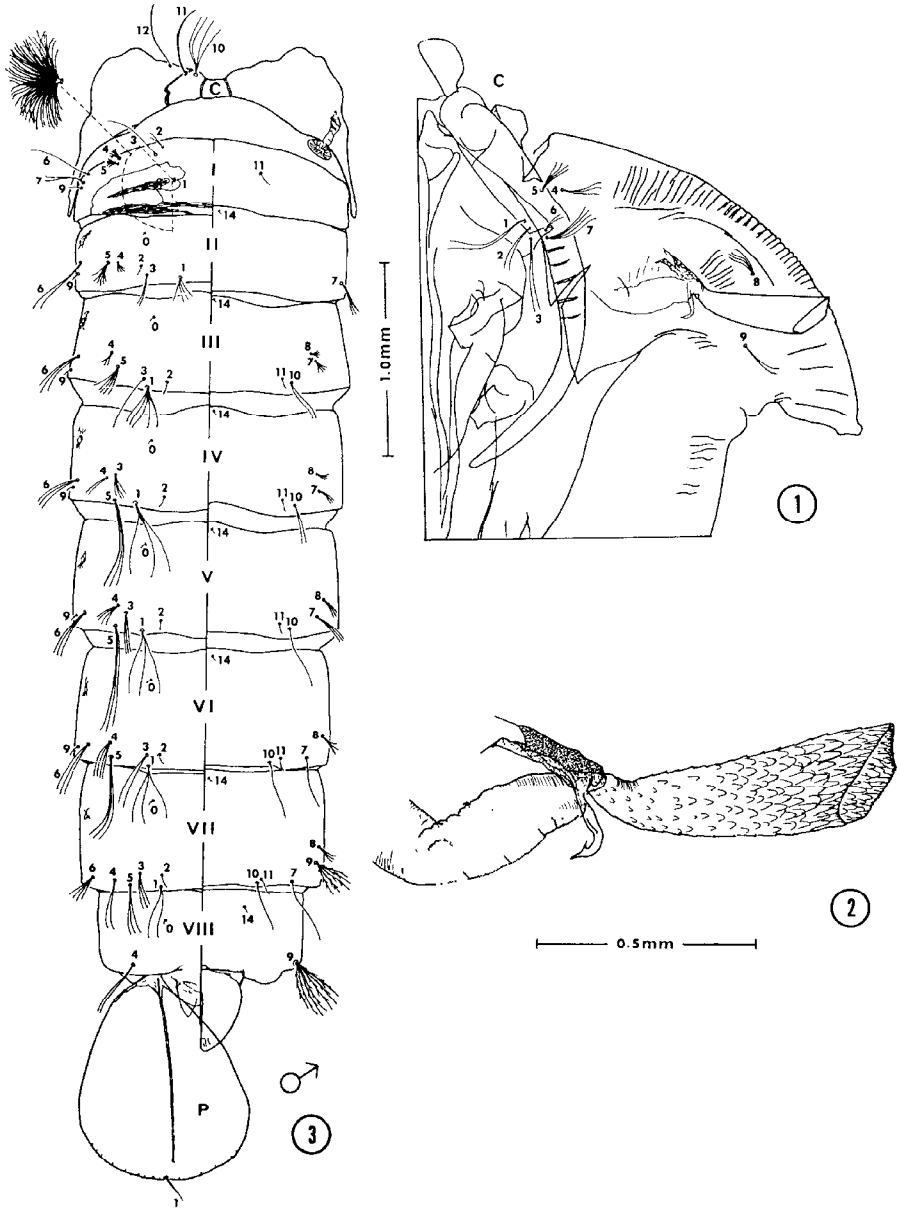

Fig. 1-3. Pupa of *Aedes mitchellae* (Dyar). Fig. 1. Cephalothorax. Fig. 2. Respiratory trumpet. Fig. 3. Metanotum and abdomen. C= cephalothorax, I-VIII=abdominal segments 1 through 8, P=paddle.

The above description is based on 4 male and 6 female associated pupal skins reared from larvae collected by the author at Gainesville, Alachua County, Florida on 17-18 January 1970. The larvae were collected from a partially shaded, temporary, fresh water pool approximately 3-5 inches deep with numerous tree leaves and dead grass on the bottom.

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The Florida Entomologist 53(2) 1970

INTERNATIONAL ORGANIZATION FOR BIOLOGICAL CONTROL (IOBC)

Plans for a new global organization in biological control, building from the existing "Organization Internationale de Lutte Biologica" (OILB), under the title given in the above heading, were consummated at Amsterdam in November 1969, as far as could be done at the time. New statutes were proposed and approved by delegates, and other agreements reached. It is hoped that the widest possible interest and support can be made evident before February 1971, at which time approval by the current OILB's General Assembly will presumably occur.

The following slate of candidates for the Executive Committee of the proposed new Council of IOBC was recommended by unanimous vote of the delegates in Amsterdam:

Paul DeBach, President
E. Biliotti, Vice President
Frank Wilson, Vice President
Vittorio Delucchi, Secretary General
Fred J. Simmonds, Treasurer

A fuller statement of the meeting in Amsterdam and of the aims and functions of this new organization, and the progress of developments in other respects is being published in The Bulletin of Entomological Society of America, to which interested parties are referred. Such interested parties should contact any of the above slate of candidates, or for the U.S., Dr. Reece Sailer.

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NATURAL CONTROL POTENTIAL OF *GALENDROMUS FLORIDANUS* (ACARINA: PHYTOSEIIDAE) ON TETRANYCHIDAE ON FLORIDA CITRUS TREES[1]

MARTIN H. MUMA

University of Florida, IFAS, Citrus Experiment Station,
Lake Alfred, Florida 33850

ABSTRACT

The identity, life cycle, food habits, and host-predator relationships of the predatory mite, *Galendromus floridanus* (Muma), are reviewed and new substantiating data are presented. It is concluded that the predator is capable of reducing six-spotted mite infestations but is probably ineffective in the natural control of the Texas citrus mite or citrus red mite.

The purpose of this paper is to evaluate the potential of *Galendromus floridanus* (Muma) in the natural control of spider mites, Tetranychidae, in Florida citrus groves. The following paragraphs present available historical information concerning this predatory mite.

Originally described as *Typhlodromus floridanus* Muma (1955), the species has been variously taxonomically assigned as *Typhlodromus* (*Typhlodromus*) *helveolus* Chant (1959); *Galendromus floridanus* Muma (1961); *Galendromus* (*Galendromus*) *floridanus* Muma (1963); *Metaseiulus floridanus*, Schuster and Pritchard (1965); and *Typhlodromus floridanus*, Chant and Baker (1965).

In the original description (Muma 1955), the species was recorded as feeding on six-spotted mites, *Eotetranychus sexmaculatus* (Riley); citrus red mites, *Panonychus citri* (McGregor); and Texas citrus mites, *Eutetranychus banksi* (McGregor). Later (Muma 1955A, 1958, 1961A, 1964, and Muma et al. 1961), evidence was presented and discussed concerning the association with and feeding of the species upon *E. sexmaculatus*. In most cases, however, the coincidence of the low host mite populations, high predator populations, higher temperatures, and increased rainfall prevented an evaluation of the predator as a biotic natural control agent.

Muma (1964) reported that the species was the sixth most common phytoseiid on Florida citrus leaves but represented only 2.8% of the total phytoseiid population on random leaf samples. The species was found to be most common in the central and west coast citrus-growing areas in the spring with a sex ratio of 1 male to 4 females. Despite these findings, however, Muma (1965) did not report the predator as a prevalent species on citrus owing, it was believed, to its remarkably consistent coincidence with sporadic infestations of the six-spotted mite.

The present paper presents additional experimental and observational data on *G. floridanus* which is known locally as the "tan mite." On the basis of these supplementary data, the biological control potential of the tan mite is reevaluated.

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[1]Florida Agricultural Experiment Stations Journal Series No. 3531.

Methods

Since the data presented here have been accumulated over a 16-year period and methods have been modified as new knowledge was gained, no consistent methods or techniques have been utilized. Therefore, pertinent procedures are detailed and discussed in preliminary paragraphs of each section.

Predator Identity

The species under consideration conforms to the following diagnoses. Females are typical phytoseiids of the genus *Galendromus* and subgenus *Galendromus* as delineated by Muma (1963). They are distinguished from the very closely related or synonymous *Galendromus gratus* (Chant) by proportionately longer L_2 and L_3, nodular dorsal scutal ornamentation between the opposite members of M_2, and a slightly longer spermatheca. The distinctly shorter M_1, longer peritreme, and larger size distinguish the species from *Galendromus longipilus* (Nesbitt), *G. occidentalis* (Nesbitt), *G. annectens* (DeLeon), and *G. ferrugineus* DeLeon. Males are readily distinguished from all other species of the genus and, as far as is known, from the family by possession of a pair of strong nodular processes between the opposite members of M_2 and a ventral connate process on the trochanter of Leg II.

The generic nomenclature is, as indicated by Pritchard and Baker (1962) and Schuster and Pritchard (1965), open to question. For the present, however, the genera *Galendromus* Muma, 1961 and *Metaseiulus* Muma, 1961 are conservatively maintained separately until the variation ranges of the type species have been determined. The overly conservative use of the genus *Typhlodromus* Scheuten, 1857, as proposed by Chant (1965) and Chant and Baker (1965), is untenable.

Predator Life Cycle

Data on the life cycle of the tan mite were obtained in 2 different ways. In 1956, 30 daily stage counts were made on 3 laboratory cultures of the predator, fed six-spotted mites, and maintained at 75° to 80° F. These data were then arrayed in bar graphs for each day, and the number of days between numerical peaks of each stage were computed. In 1967, individual newly hatched larvae were isolated in the laboratory on excised citrus leaves, in plastic boxes on water-saturated cotton batting at 80° F, fed six-spotted mites, and observed daily until maturity. The eggs were deposited in the laboratory by grove-collected females. Altogether, 27 individuals were reared to adults with this technique and the maximal, minimal, mean, and modal times for development computed.

Egg production and mating experiments were conducted in the laboratory at 80° F with laboratory-reared males and females.

The 1956 data did not produce any usable information on the duration of eggs, larvae, protonymphs, and deutonymphs but did indicate a complete cycle from egg to adult of 7 to 9 days. The 1967 data are arrayed in Table 1. From these results, it is obvious why the 1956 method did not

prove satisfactory; all stages completed development in 1 to 3 days. Both sets of data, however, indicated a maximum cycle of 9 days; and the 1967 data showed that development can be completed in a much shorter period of time—4 days.

TABLE 1. LIFE CYCLE, EGG DEPOSITION TO ADULT, OF FEMALE AND MALE *Galendromus floridanus* (Muma) WHEN FED SIX-SPOTTED MITES AT 80° F UNDER LABORATORY CONDITIONS.

	Days to Complete Development							
	Females (19)				Males (8)			
Stage	Maximum	Mean	Mode	Minimum	Maximum	Mean	Mode	Minimum
Egg	2	1.9	2	1	2	1.9	2	1
Larva	1	1	1	1	1	1	1	1
Protonymph	3	2.2	2	1	3	1.8	1–2	1
Deutonymph	3	2.7	1	1	3	1.8	2	1
Total	9	7.8	6	4	9	6.5	6–7	4

Egg production of laboratory-reared virgin females following primary mating varied from 16 to 45 eggs with a mean of 26.2 for 5 females. Females deposited eggs for 1 to 2 weeks, frequently depositing 6 or more eggs per day in a cluster. Males mated 2 or more times, depositing in the 5 females 1 spermatophore in each spermathecum. Females would not permit a second mating until after deposition of 20 or more eggs. Virgin females lived for 1 to 2 weeks but did not deposit eggs. Unmated males also lived for 1 to 2 weeks. Mating procedure and position was the same as that reported for other phytoseiids. For details, see Muma (1970) on mating of *Typhlodromalus peregrinus* (Muma).

PREDATOR FOOD HABITS

Studies on the food habits of the tan mite involved feeding observations under grove conditions and in the laboratory. Specimens, primarily adult females, were also isolated on excised citrus leaves in plastic boxes on water-saturated cotton batting in the laboratory at 80° F, and starvation, survival, and reproduction were used as indices of food suitability. Since the rate of host consumption is also pertinent, 31 females and 6 nymphs retained in plastic boxes as indicated above were also exposed to known numbers of the various growth stages of six-spotted mites.

Observations have demonstrated that although this predatory mite is most commonly associated with and is seen feeding upon six-spotted mites, it will also readily feed on other Tetranychidae. It has been observed several times, under grove conditions, feeding on the eggs and nymphs of citrus red mites and Texas citrus mites. It has also been observed in the laboratory feeding on eggs and active stages of *Tetranychus tumidiellus* Pritchard and Baker.

Laboratory experiments have demonstrated that the tan mite reproduces

readily and develops large populations when fed six-spotted mites, citrus red mites, and Texas citrus mites. On the other hand, the species lived for a limited time, up to 9 days, but did not reproduce when maintained on clean citrus leaves and when fed whitefly (*Dialeurodes* spp.) eggs and crawlers, Glover's scale (*Lepidosaphes gloveri* Newm.) eggs and crawlers, honey, honey and citrus pollen, and honeydew.

Laboratory experiments on rate of consumption and stages consumed were conducted in 1958 and 1967 using six-spotted mites as food. In 1958, 27 female tan mites tested for a total of 231 hours consumed a mean of 0.12 six-spotted mite eggs per hr., 0.10 nymphs per hr., and 0.20 adults per hr. In 1967, 4 female tan mites tested for 24 hrs., consumed a mean of 1.62 six-spotted mite eggs per hr., 0.33 nymphs per hr., and 0.00 adults per hr.; 6 nymphal tan mites tested for 45 hrs., consumed 0.37 six-spotted mite eggs per hr., 0.23 nymphs per hr., and 0.22 adults per hr.

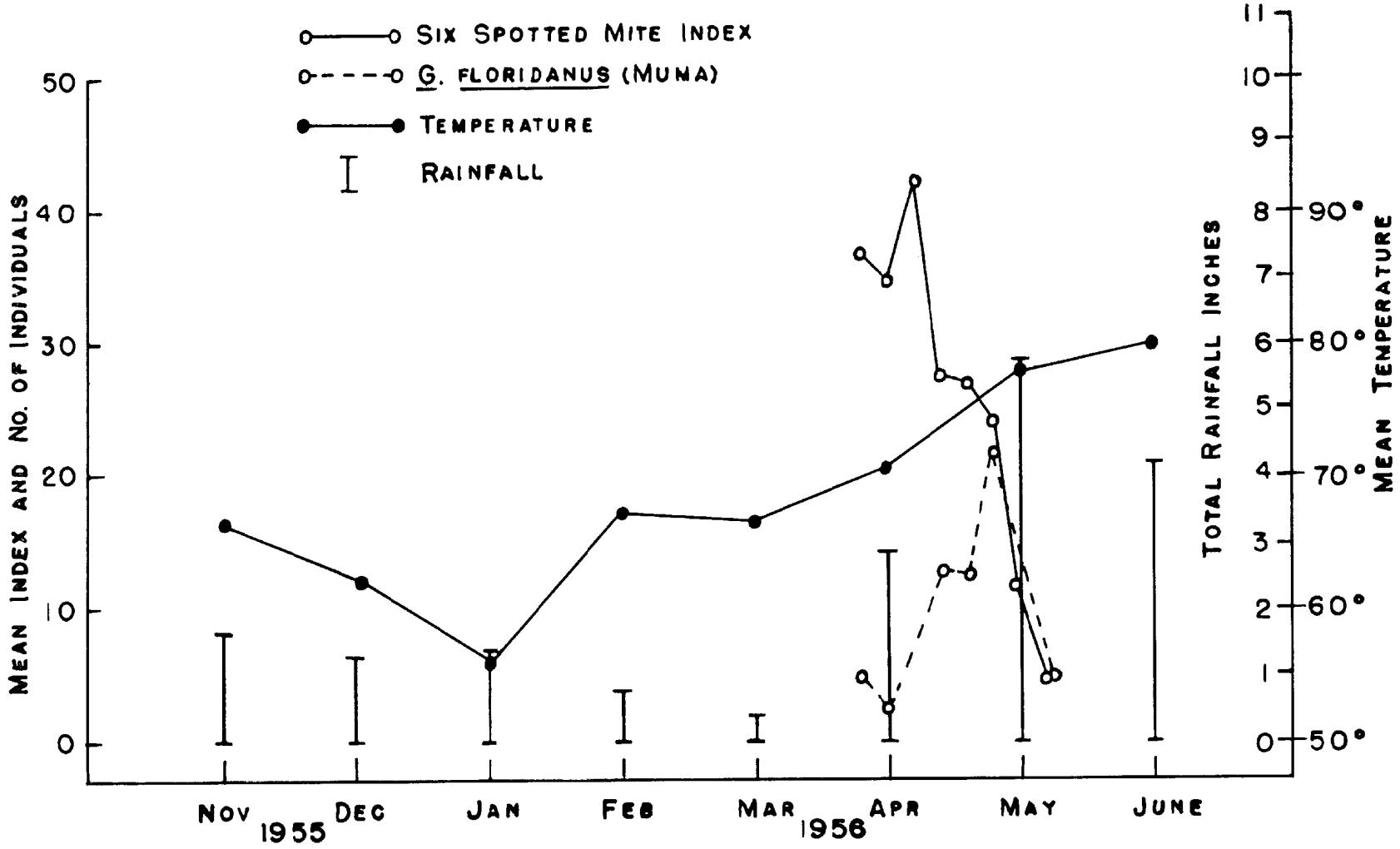
Host-Predator Relationships

The interrelationships of host and predator populations were studied in several ways in the laboratory and in groves. In the laboratory, the ability of the predator to survive and to attain high population levels on large host populations and to reduce host populations was tested on excised leaves, green oranges, and citrus seedlings. Grove studies included investigation of the coincidence of predators and hosts in host infestations, a survey of the leaf-to-leaf populations of hosts and predators, and a continuing population dynamics study involving population interactions of hosts and predators on leaves in groves indicating injurious host infestations. The methods utilized in the several studies are detailed below.

Excised citrus leaves were placed in plastic boxes on moist cotton batting and covered with a layer of moist cotton batting cut out so as to expose most of the lower leaf surface. The leaves were then infested with a tetranychid host and 1 gravid tan mite female. Such leaves were held at 80° F, examined daily, and the number of predatory mites recorded. Host mites were added as needed to maintain adequate food supply. When Texas citrus mites were used as hosts, the predator population increased in 2 to 3 weeks to numbers that could not be accurately counted without destroying the culture. The same results were obtained with citrus red mites or six-spotted mites as hosts.

Green oranges were placed in syracuse dishes for ease in handling. They were then infested with host tetranychids, six-spotted mites, citrus red mites, or Texas citrus mites, and held at 80° F until the fruit was heavily infested. Then, 1 to 4 gravid tan mite females were placed on each fruit. Within 2 weeks after addition of 1 or 2 predators, the predator populations increased to 20 to 30 mites per fruit. When more than 2 predators were added per fruit, the mite population was too numerous to count at the end of 2 weeks, or the host mite population was decimated and only 5 to 10 predators could be found on the test fruits.

Fig. 1. Mean index of six-spotted mites and number of *Galendromus floridanus* (Muma) in 7 grapefruit groves under varying winter and spring temperatures and rainfall during 1955-56 in Polk County, Florida.


SIX SPOTTED MITE INDEX
G. FLORIDANUS (MUNA)
TEMPERATURE
RAINFALL
MEAN INDEX AND NO. OF INDIVIDUALS
TOTAL RAINFALL INCHES
MEAN TEMPERATURE
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
10
11
50°
60°
70°
80°
90°
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
1955
1956

Citrus seedlings exhibiting 2 or more leaves in excess of the plumules were infested with host tetranychids, six-spotted mites, citrus red mites, and Texas citrus mites. Thirty days later, when the seedlings were heavily infested with the host mites, 5 gravid female tan mites were introduced on each of 2 seedlings; and 2 seedlings infested with six-spotted mites were retained without predators as controls. Two weeks later, all plants were examined for host and predator populations. Plants maintained as controls had many six-spotted mites; plants infested with six-spotted mites had no predators or host mites; plants infested with citrus red mites had no predators and only 1 or 2 eggs and nymphs of the host; plants infested with Texas citrus mites had no predators or host mites. Despite these evaluations, however, both six-spotted mites and citrus red mites recovered from the decimations and regained high population levels within 30 days. The Texas citrus mite infestations never recovered from the decimation.

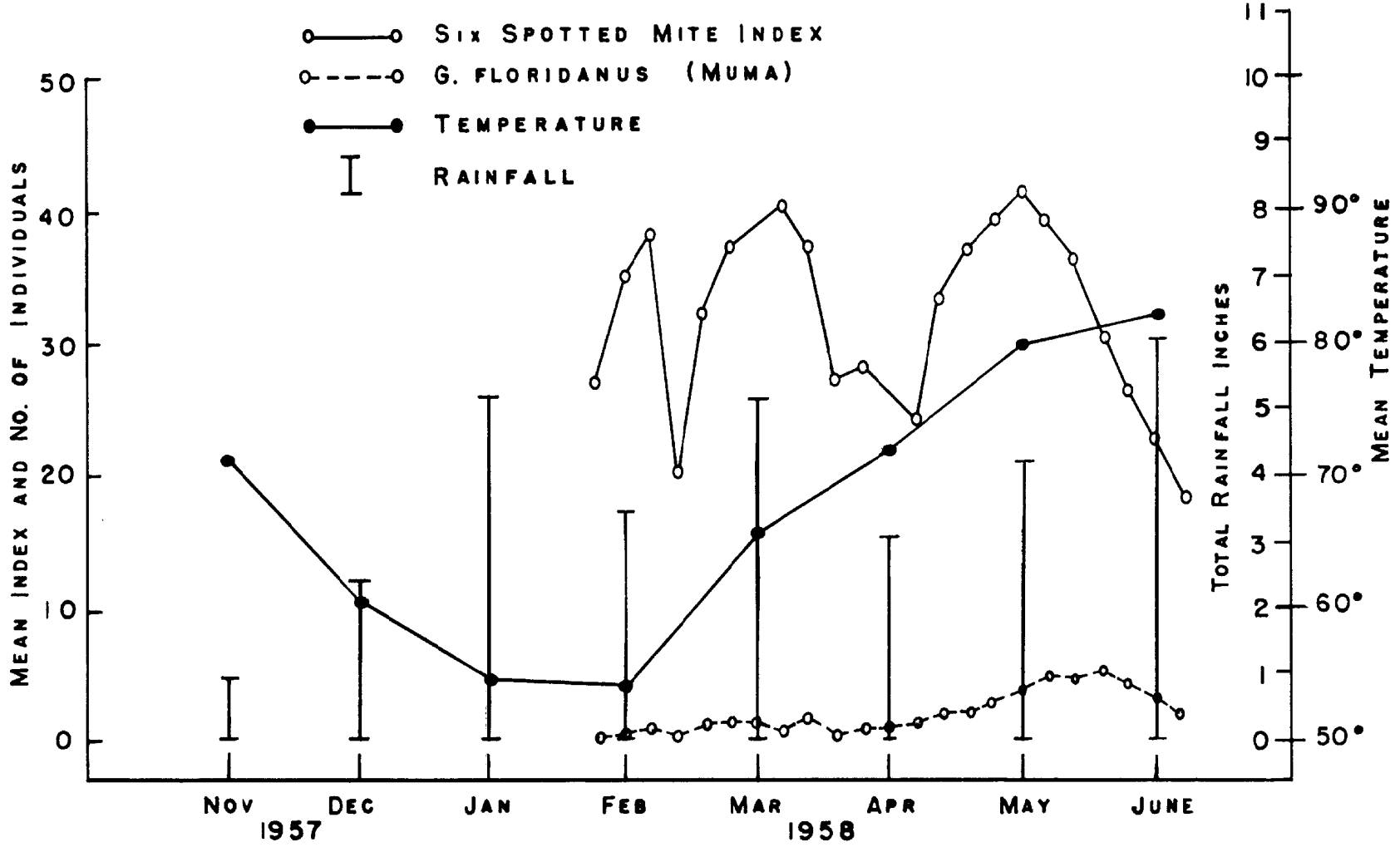
Grove studies were necessarily biased to groves exhibiting infestations of six-spotted mites during years when economically injurious infestations could be located. Indication of such infestations usually consisted of light to severe yellowing and cupping of old and new flush leaves. When such infestations were noted, 5 or more groves were selected as study groves and 1 sample was collected from each grove once a week until the six-spotted mite infestation virtually disappeared. Each sample consisted of 20 randomly selected but damaged leaves, which were placed in plastic boxes for transportation to the laboratory. In the laboratory, each leaf was examined under a dissecting microscope and the number of active stages of *G. floridanus* and *E. sexmaculatus* recorded. In the case of *E. sexmaculatus,* the leaf-by-leaf population was coded—0 for no mites, 1 for 1 to 50 mites, 2 for 51 to 100 mites, and 3 for 101 or more mites. This was done to reduce counting time since heavily infested leaves frequently supported 200 or more mites. The resulting data were then analyzed for coincidence of the predator with its host and for predator potential, as a biotic factor, in the control of its host on a leaf-to-leaf and grove-to-grove basis.

Coincidence of *G. floridanus* with *E. sexmaculatus* was remarkably high. Every study grove in every year sooner or later developed a population of the predator. In most cases, the predator appeared within 2 weeks after initiation of sampling.

The leaf-to-leaf relations of *G. floridanus* numbers with *E. sexmaculatus* infestation levels is shown in Table 2. These data show that on leaves exhibiting previous or current damaging infestations of six-spotted mites, the host mite populations were lower where the predator population was greater in every year except 1965. During 1965, the higher host mite populations sustained greater predator populations.

The population interrelationships of predator and host under grove conditions have been shown for 1953, 1954, and 1955, Muma (1955, 1958). Data for 1956, 1958, and 1965 are presented in Fig. 1, 2, and 3. In 1956, six-spotted mite infestations did not produce significant injury until late

Fig. 2. Mean index of six-spotted mites and number of *Galendromus floridanus* (Muma) in 10 grapefruit groves under varying winter and spring temperatures and rainfall during 1957-58 in Polk County, Florida.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TEMPERATURE
RAINFALL
MEAN INDEX AND NO. OF INDIVIDUALS
TOTAL RAINFALL INCHES
MEAN TEMPERATURE
0
10
20
30
40
50
1
2
3
4
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11
50°
60°
70°
80°
90°
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
1957
1958

March and disappeared in May following predator, temperature, and rainfall increases. In 1958, seriously damaging six-spotted mite infestations developed in late January and maintained high levels into the first week of June; during this year, temperatures and rainfall increased during May but the predator population remained low. In 1965, the six-spotted mite infestations did not develop until mid-April and never produced serious in-

TABLE 2. MEAN NUMBER OF *Galendromus floridanus* (MUMA) ON DAMAGED CITRUS LEAVES INFESTED WITH VARYING NUMBERS OF *Eotetranychus sexmaculatus* (RILEY) DURING 1953, 1954, 1956, 1965, AND 1966.

Year	Number Counts	Mean Groves/ Count	Mean Leaves/ Count	Mean Number Predators/Leaf with Varying Numbers SSM			
				None	1 to 50	51 to 100	101 or more
1953	7	5	130	0.30	1.60	0.80	0.25
1954	9	8	177	0.45	0.55	0.43	0.26
1956	7	7	134	0.11	0.52	0.66	0.19
1965	10	5	96	0.62	0.73	0.34	0.95
1966	10	6	118	0.18	0.22	0.14	0.03
Mean	8.6	6.2	131	0.33	0.72	0.47	0.35

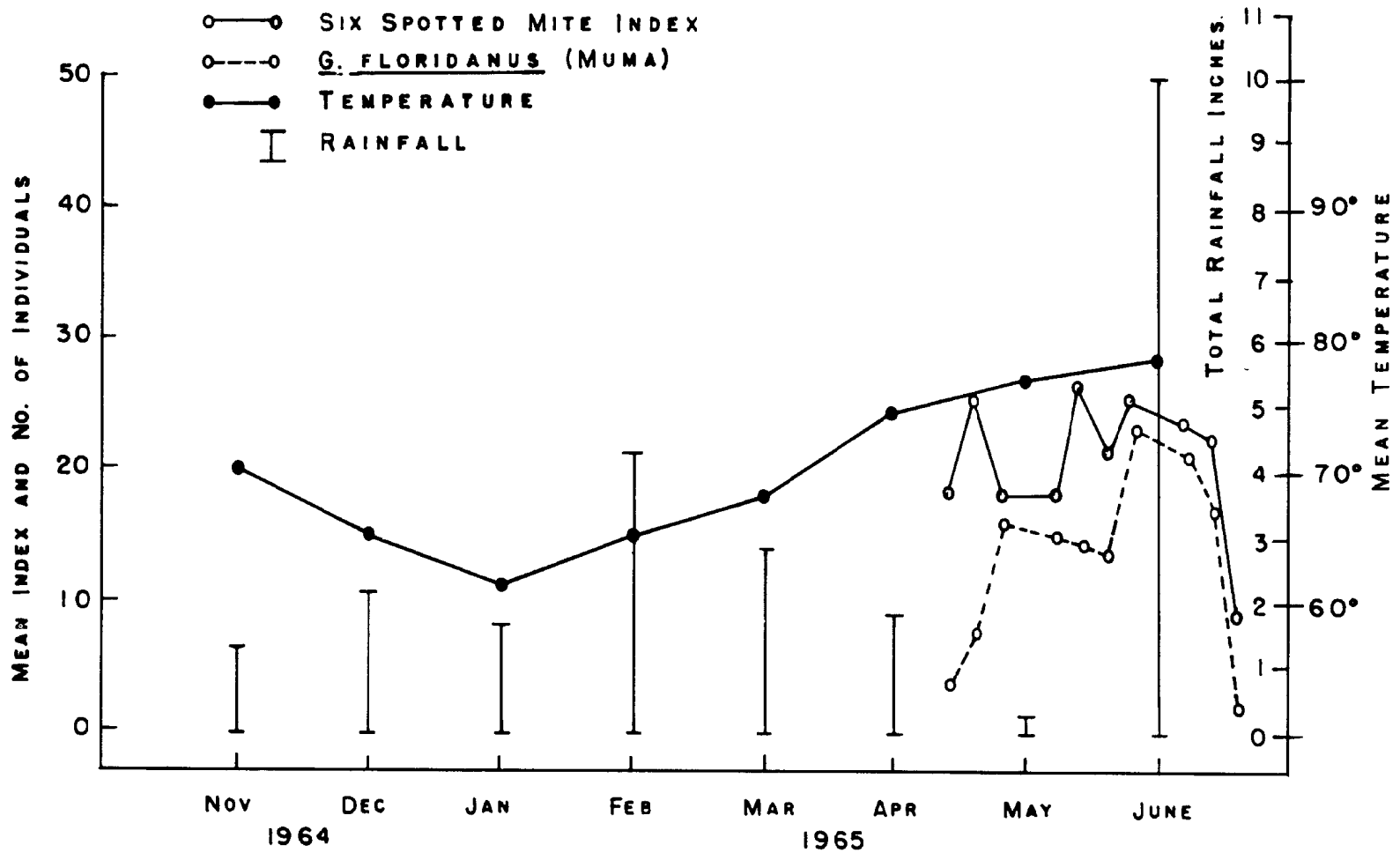
juries; spring temperatures were unusually high, rainfall was low until late May, and the predator population was variable.

DISCUSSION

Published data and data presented here indicate that the tan mite, *G. floridanus* (Muma), is primarily a tetranychid predator. It is usually associated with high host densities, which under grove conditions are most frequently represented by the webbing colonial six-spotted mite, *E. sexmaculatus* (Riley). The life cycle of the predator, from egg to adult, on six-spotted mites, varies from 4 to 9 days, with an average of 6 to 7 days. It feeds on all stages of its host with a slight preference for eggs and nymphs. The predator has a high rate of coincidence with six-spotted mite infestations where it exhibits an inverse predator-host relationship on both a leaf-to-leaf and temporal basis.

Although data presented by Muma (1955A, 1958) and in Fig. 1 through 3 and Table 2 here indicate that other factors such as temperature and humidity also influence six-spotted mite populations, there is little doubt that this predator is capable of causing and in many instances is responsible for natural control of six-spotted mite infestations. Since the predator seems to require highly localized or colonial host densities for population

Fig. 3. Mean index of six-spotted mites and number of *Galendromus floridanus* (Muma) in 5 grapefruit groves under varying winter and spring temperatures and rainfall during 1964-65 in Polk County, Florida.


SIX SPOTTED MITE INDEX
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TOTAL RAINFALL INCHES.
MEAN TEMPERATURE
50
40
30
20
10
0
11
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9
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5
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3
2
1
0
90°
80°
70°
60°
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
1964
1965

development, it is questionable that any predator control pressure is exerted by the species on infestations of citrus red mite or Texas citrus mite.

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COMPARISON OF FOUR CINCHONINATES, AN OXETANONE, AND TWO STANDARD SKIN REPELLENTS AGAINST *AEDES AEGYPTI*[1] AND *STOMOXYS CALCITRANS*[2], [3], [4], [5]

IRWIN H. GILBERT, HARRY K. GOUCK, AND C. E. SCHRECK
Entomology Research Division, Agr. Res. Serv., USDA
Gainesville, Fla. 32601

ABSTRACT

Five compounds (50% solutions in ethanol) were evaluated as skin repellents against caged *Aedes aegypti* (L.) and *Stomoxys calcitrans* (L.) by comparing the protection times obtained with the protection times obtained with 2 standard repellents, deet (25% solution in ethanol) and dimethyl phthalate (50% solution in ethanol). Against mosquitoes, the deet was significantly more effective than the candidate compounds or than dimethyl phthalate, and dimethyl phthalate was equal in effectiveness to the 4 cinchoninates and was less effective than 4-pentyl-2-oxetanone, which had a disagreeable odor. In the tests with *Stomoxys calcitrans*, 4-pentyl-2-oxetanone as a 50% solution in ethanol was more effective than deet and the other repellents; also, ethyl 3-ethylcinchoninate and butyl 3-methylcinchoninate as 50% solutions were about as effective as deet, buy ethyl 3-methylcinchoninate was only about half as effective as deet, and propyl 3-methylcinchoninate and dimethyl phthalate were the least effective.

A continuing program to evaluate and develop compounds as insect repellents for use on humans is maintained at the Insects Affecting Man and Animals Research Laboratory, Gainesville, Florida, of the Entomology Research Division (Smith 1958a,b). We were therefore interested when Yeoman and Lindberg (1968) reported at the XIII International Congress of Entomology, Moscow that certain cinchoninates were effective repellents against biting flies. Only 3 compounds of this chemical group had been evaluated as repellents by this laboratory (King 1954, Agricultural Research Service 1967), and none had been effective as mosquito repellents. This paper presents the results of laboratory evaluation of 5 candidate repellents, 4 of which were cinchoninates, to determine their potential as skin repellents against *Aedes aegypti* (L.) and *Stomoxys calcitrans* (L.).

TEST PROCEDURES

The test method used was that described by Gilbert et al. (1957a,b) and Smith (1958a,b). All candidate repellents were tested as 50% solutions in ethanol. Also, dimethyl phthalate (50% solution in ethanol) was used as one of the standards; the other standard, deet, was tested as 25%

[1]Diptera: Muscidae
[2]Diptera: Muscidae
[3]Mention of a pesticide in this paper does not constitute a recommendation of this product by the USDA.
[4]Research was conducted in part with funds transferred from the Medical Research and Development Command, Office of the Surgeon General, U. S. Army.
[5]Nelson Smith, D. R. Godwin, D. Smith, Ken Posey, and J. Jackson assisted in conducting the tests.

TABLE 1.—COMPARISON OF 5 EXPERIMENTAL COMPOUNDS AND 2 STANDARD SKIN REPELLENTS AGAINST *Aedes aegypti* AND *Stomoxys calcitrans*.

Repellents*	Protection time (min)		Ratio of protection time to deet	
	A. aegypti	*S. calcitrans*	*A. aegypti*	*S. calcitrans*
	Series I; Avg. 4 tests			
Deet	348	76	1.00	1.00
Ethyl 3-ethylcinchoninate	30	64	.09	.85
Butyl 3-methylcinchoninate	30	74	.09	.97
4-Pentyl-2-oxetanone**	215	262	.62	3.46
Dimethyl phthalate	38	30	.11	.40
(LSD 0.05 level)	24.6	21.3		
	Series II; Avg. 3 tests			
Deet	391	130	1.00	1.00
Ethyl 3-methylcinchoninate	30	70	.08	.54
Propyl 3-methylcinchoninate	30	30	.08	.23
Dimethyl phthalate	43	30	.11	.23
(LSD 0.05 level)	49.4	66.8		

*All compounds except deet were tested at a concentration of 50%; deet was tested at concentrations of 25%.
**Disagreeable odor.

solution in ethanol. (The lower concentration of deet was used to keep the test period within a normal working day.) Two series of tests were made: 3 candidate chemicals were evaluated in the first series and 2 in the second series; the 2 standard repellents were tested in both series.

One ml of a solution of a candidate repellent was spread evenly over one forearm of a test subject from the wrist to the elbow. The other forearm was treated similarly with another repellent, either one of the other candidate compounds or one of the standards. Each compound was thus paired with every other compound in a given series of tests. In the test with *A. aegypti*, each arm was exposed for 3 min. at about 30-min intervals in a cage of about 1500 avid 7 to 9-day-old females from the laboratory colony. Immediately thereafter, the same arms were exposed for 3 min. in cages containing about 1000 avid 3 to 4-day-old female *S. calcitrans*. The effectiveness of a repellent was based on the time a compound gave complete protection from bites, i.e. the time between the application and the first confirmed bite (one bite followed by a second within 30 min).

A balanced incomplete-block design was used for the analysis of variance of the data in each of the series (Gilbert et al. 1966), and the least significant differences (LSD) between any 2 repellents in each series were computed. Results are expressed as protection time in min. For the comparision of repellents within or between series, a ratio of the protection time (min) obtained with each candidate and with dimethyl phthalate to the protection time obtained with deet was computed.

Results

Table 1 includes the chemical names of the candidate compounds, the protection times obtained, and the ratio of the protection time of each material to deet (taken as 1). Against mosquitoes, deet was significantly more effective than the candidate compounds and than dimethyl phthalate in both series. 4-Pentyl-2-oxetanone, which gave an average protection time of 215 min., was 0.62 times as effective as deet and about 6 times more effective than dimethyl phthalate. However, the oxetanone had a disagreeable odor. The cinchoninates were equal in effectiveness to dimethyl phthalate.

In the test against *Stomoxys calcitrans*, 4-pentyl-2-oxetanone as a 50% in ethanol was more effective than deet as a 25%solution and the other repellents in both series. Ethyl 3-ethyl- and butyl 3-methylcinchoninate as 50% solutions were about equal in effectiveness to deet as a 25% solution, and ethyl 3-methylcinchoninate was about half as effective as deet. Propyl 3-methylcinchoninate and dimethyl phthalate were the least effective.

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The Florida Entomologist 53(2) 1970

ANNUAL MEETING

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NOTES ON *BRACHYPOGON* KIEFFER (DIPTERA, CERATOPOGONIDAE), A NEW SPECIES, AND TWO NEW NEOTROPICAL GENERA OF THE TRIBE CERATOPOGONINI[1]

WILLIS W. WIRTH AND FRANKLIN S. BLANTON
Systematic Entomology Laboratory, Entomology Research Division
Agr. Res. Serv., USDA[2] and Department of Entomology,
University of Florida, Gainesville, Florida 32601, respectively

ABSTRACT

Two new genera are described in the Ceratopogonini: *Baeohelea,* type-species *nana* n. sp. from Colombia and Dominica, and *Rhynchohelea,* type-species *monilicornis* n. sp. from California and Florida. Two species are transferred to *Baeohelea*: (new combinations) *Ceratopogon bourioni* Clastrier 1961 and *C. fuscipennis* Tokunaga 1964. *Brachypogon* is restored to generic rank and characterized, and in it are included (newcombinations): *Ceratopogon africanus* de Meillon 1929, *C. bergensis* de Meillon and Hardy 1953, *C. corius* de Meillon and Hardy 1954, *Palpomyia fuscivenosa* Lutz 1914, *Ceratopogon impar* Johannsen 1938, *C. insulicola* Tokunaga 1959, *C. novaguineae* Tokunaga 1964, *C. papuensis* Tokunaga 1964, *C. petersi* Tokunaga 1964, *C. sensegalensis* de Meillon and Wirth, 1955, *C. sitius* de Meillon 1959, and *C. vitiosus* Winnertz 1852. *Brachypogon fuscivenosus* Lutz is redescribed and *B. paraensis* n. sp. is described from Brazil.

The genus *Ceratopogon* Meigen and its relatives in the tribe Ceratopogonini have remained in a state of confusion ever since the original all-inclusive genus *Ceratopogon* was subdivided by Kieffer (1906, 1919, 1925), Goetghebuer (1920) Goetghebuer & Lenz (1934), and Edwards (1926). In the generic treatments by Edwards (1926), Goetghebuer & Lenz (1934), Macfie (1940), Johannsen (1943), and Wirth (1952), the tribe Ceratopogonini has grown to include the genera or subgenera *Alluaudomyia* Kieffer, *Anakempia* Kieffer, *Brachypogon,* Kieffer, *Ceratopogon* Meigen, *Fanthamia* de Meillon, *Isohelea* Kieffer, *Nilohelea* Kieffer, and *Psilohelea* Kieffer. Macfie (1940) recognized five genera in this group in two divisions: those with patterned, hairy wings, and unequal hind tarsal claws in the female (*Alluaudomyia* and *Fanthamia*), and those with unmarked bare wings and equal tarsal claws (*Ceratopogon, Isohelea,* and *Brachypogon*). Following Edwards (1926), the classification of the latter group was based on the extent of wing vein M2, it being entire in *Ceratopogon,* broadly interrupted at the base in *Isohelea,* and absent in *Brachypogon.* De Meillon in a series of papers (1929, 1939, 1953, 1954, 1959) kept pointing out the serious shortcomings of this system, and it was finally more or less abandoned in recent papers by Clastrier (1961) and Tokunaga (1964) who recognized only the genus *Ceratopogon* in this group.

Work by the present authors and Dr. Niphan Ratanaworabhan is progressing on a world-wide classification and key to the genera of the Ceratopogonidae. In the tribe Ceratopogonini we will not use the extent

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[1]This investigation was supported in part by. U. S. Army Medical Department Contract No. DA-49-193-MD-2177.

[2]Male address: c/o U. S. National Museum, Washington, D. C. 20560.

of vein M1 as a generic character, but will rely more on the condition of the radial cells, the separation of the eyes, various other modifications of the head, palpus and antenna, on the structure of the male and female genitalia, and to a lesser degree on wing macrotrichia and modifications of the tarsal claws. We are now describing two new genera and presenting a revised definition of *Brachypogon* in preparation for the broader and briefer treatment to be followed in the comprehensive paper.

We are greatly indebted to Dr. Niphan Ratanaworabhan and Miss Linda Heath for making the illustrations.

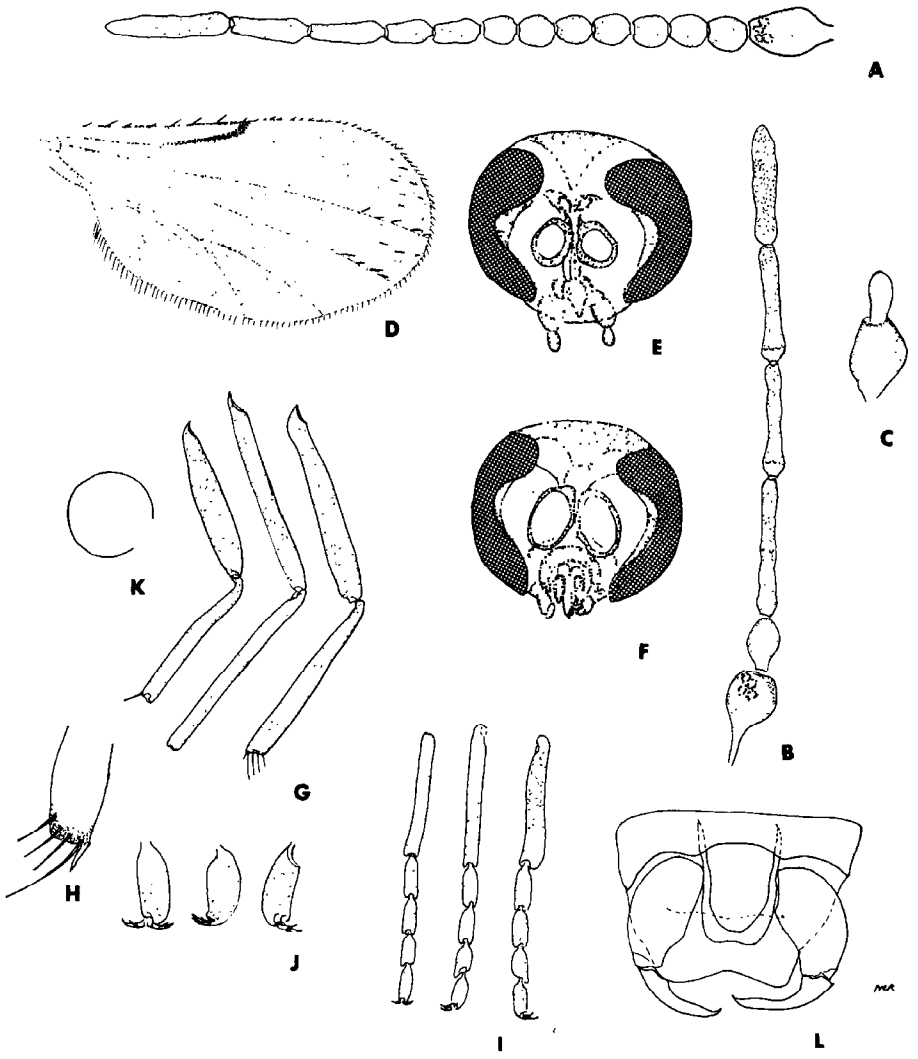

Fig. 1, *Baeohelea nana*: a, female antenna; b, male antenna; c, female palpus; d, female wing; e, female head; f, male head; g, femora and tibiae (left to right) of fore, mid, and hind legs; h, hind tibial comb; i, female tarsi (left to right) of fore, mid, and hind legs; j, female fifth tarsomere and claws (left to right) of fore, mid, and hind legs; k, female spermatheca; l, male genitalia.

Baeohelea, new genus (Fig. 1)

Type-species, *Baeohelea nana*, new species.

Head (Fig. 1e): Eyes broadly separated, with fine, short, interfacetal hairs. Female frons with a submedian pair of low, tuberculate swellings just above antennal bases. Female antenna (Fig. 1a) 15-segmented; third segment elongate, provided with 4-5 sensory pits bordered by short setae; segments 4-10 short oval, 11-12 long oval, 13-15 more elongate and tapering; verticils short. Male antenna (Fig. 1b) 7-10 segmented, the distal 2-4 segments much elongated, plume absent but segments provided with sparse, long verticils. Palpus (Fig. 1c) 2-segmented, the first (primitive third) swollen, with a few spoon-shaped sensilla borne on mesal surface near base; second segment slender. Proboscis greatly reduced, scarcely extending below ventral head margin; mandible vestigial.

Thorax broad, relatively flattened above, humeral pits not apparent. Legs (Fig. 1g) slender, without special armature or strong bristles; hind tibial comb (Fig. 1h) with 4 spines, a distinct spur present. Tarsi (Fig. 1i) without spines or armature, segments slender; claws of female (Fig. 1j) short, sharp, nearly straight, each provided with a short, hairlike, basal barb; male claws similar to those of female.

Wing (Fig. 1d) short and broad, distally rounded, anal angle reduced; costa reaching about two-fifths of wing length; radial cells obsolete, the radius somewhat thickened near costa; vein M2 complete nearly to base of medial fork; sparse, rather long macrotrichia present on distal fifth of wing.

Abdomen: Short and slender; female genital opening without special armature. Spermatheca (Fig. 1k) single, spherical, without neck, the opening of the duct broad. Male genitalia (Fig. 1L) quite small and poorly developed; ninth sternum a narrow ribbon; ninth tergum short and rounded, slightly bilobed without apicolateral processes; basistyle moderately broad, simple; dististyle slender, curved, with pointed tip; aedeagus in form of a high arch with the distal end broad and somewhat truncate; parameres not developed.

Baeohelea nana, new species

Female.—Wing 0.58 mm long. Thorax brown subshining; abdomen with 2 proximal segments whitish, distal segments dull brownish black; legs pale; wing glassy clear; halter pale. Antenna with lengths of flagella segments in proportion of 25-10-12-12-12-12-12-12-20-20-25-25-42. Costa extending to 0.41 of wing length. Spermatheca measuring 0.034 mm in diameter.

Male.—Similar to the female with differences as noted above. Wing 0.50 mm long; costa extending to 0.37 of wing length. Antenna 7-segmented, lengths of flagellar segments in proportion of 26-60-50-55-60; fourth segment (see Fig. 1b) frequently divided just past the basal swelling bearing the verticils. Genitalia as in Fig. 1L.

Distribution.—Colombia, Dominica, Eucador.

Types.—Holotype female, Pont Casse, Dominica, 2000 ft., 12 February 1965, W. W. Wirth, rain forest (Type no. 70647, USNM). Allotype male, Fond Figues River, Dominica, 13 March 1965, W. W. Wirth, light trap. Paratypes, 15 males, 10 females, as follows:

COLOMBIA: Rio Raposo, Valle, March-August 1964, V. H. Lee, light trap, 4 males, 1 female.

DOMINICA: Dleau Gommier, 15 February 1956, W. W. Wirth, stream margin, 1 male, 1 female; Fond Figues River, January-March 1965, W. W. Wirth, rain forest, 12 males, 6 females; Freshwater Lake, 21 January 1965, W. W. Wirth, 1 male, 1 female.

ECUADOR: Linje Chimborazo, July 1955, R. Levi-Castillo, 1 male, 1 female; Pambay, Napo Pastaza, March 1956, R. Levi-Castillo, 6 males.

Discussion. In Dominica, *Baeohelea nana* is confined to the rain forest at an elevation of about 2000 ft. or above. In its appearance it greatly resembles the small chironomid midge *Corynoneura* Winnertz and some of the small parasitic Hymenoptera. Its habits and breeding place are unknown.

The genus *Baeohelea* stands somwhat between *Alluaudomyia* and *Brachypogon*, but it has become greatly specialized and in many ways degenerated. The structure of the female antenna, the hyaline wing with reduced radial cells and scanty macrotrichia, and slender legs are remindful of *Alluaudomyia* of the *parva* group. The absence of radial cells and general structure of the male genitalia are similar to *Brachypogon*. The extreme reduction of the palpus and proboscis, the female tarsal claws, and the male antenna are unique in the Ceratopogonini. The generic name is taken from the Greek: *baeo* (tiny) + *heleia* (marsh dweller).

Ceratopogon bourioni Clastrier (1961) from France and *C. fuscipennis* Tokunaga (1964) from New Guinea are referred to *Baeohelea* (NEW COMBINATIONS) on the basis of their male and female antennal segmentation, palpal segmentation, similar head structure, including the wide eye separation and reduced proboscis, small simple tarsal claws, and all features of the male genitalia. These two species are very similar to each other and quite set apart from *B. nana*, however, in the presence of a small but complete second radial cell and of coarse microtrichia in the wing, and in the persence of 2 female spermathecae. In these two species the male antenna is 9 or 10-segmented and only the distal 2 or 3 segments are moderately to much elongated.

Rhynchohelea, new genus (Fig. 2)

Type-species, *Rhynchohelea monilicornis*, new species.

A small, stocky, black midge with bicolored legs and bare, smoky wings. Known only from the female.

Head (Fig. 2d): Eyes broadly separated, the arcuate line separating frons and vertex sharply demarcated and bordered by 3 setae on vertex; eyes with long interfacetal hairs. Clypeus broad; head bearing an elongate proboscis with apex broadly truncate and armed with several strong hooks and spines. Antenna (Fig. 2a) 14-segmented, moniliform, segments 7-11 slightly broader than long, 14 as long as 12-13 together, with blunt pointed tip; 3 short and scarcely expanded, provided with a sensory pit bordered by short setae; verticils very short. Palpus (Fig. 2b) 5-segmented, first segment indistinct, third segment very short and broad, bearing a small, deep, sensory pit. Mandible (Fig. 2e) well developed with about 8 distal teeth.

Thorax moderately broad and convex; mesonotum provided with scat-

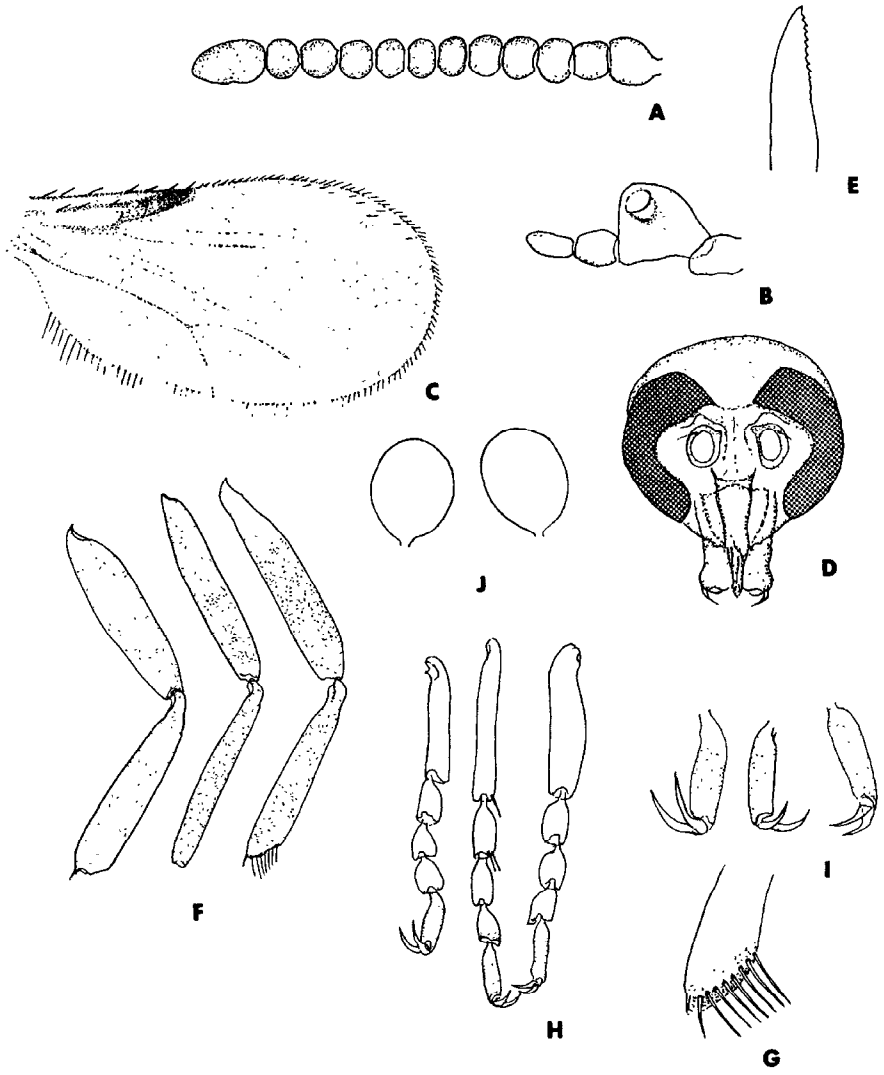

Fig. 2, *Rhynchohelea monilicornis*, female: a, antenna; b, palpus; c, wing; d, head; e, mandible; f, femora and tibiae (left to right) of fore, mid, and hind legs; g, hind tibial comb; h, tarsi (left to right) of fore, mid, and hind legs; i, fifth tarsomere and claws (left to right) of fore, mid, and hind legs; j. spermathecae.

tered, erect, moderately long hairs; scutellum with 2 pairs of marginal hairs. Legs (Fig. 2f) short and moderately stout, without special armature or long bristles; hind tibial comb (Fig. 2g) with 8 spines, the spur quite small. Tarsi (Fig. 2h) with some sharp ventral spines, more prominent on mid legs; basitarsi elongate, as long as next 3 tarsomeres combined, distal tarsomeres short, fourth not condiform, fifth unarmed ventrally; claws (Fig. 2i) sharp and slightly curved, without basal barb, moderately long on foreleg, short on mid and hind pairs.

Wing (Fig. 2c) short and broad, bluntly rounded distally, anal angle reduced; costa reaching to less than half of wing length; radial cells obsolete, the fused radial veins forming a distinct stigma; vein M1 obsolete distally, vein M2 entirely absent, mediocubital fork at same level as end of costa; macrotrichia absent; microtrichia coarse and dark, but forming a distinct pale line in middle of medial cell.

Abdomen: Short and rounded distally; genital opening without special armature. Spermathecae (Fig. 2j) 2, oval, with short, slender necks (3 present in the paratype).

Rhynchohelea monilicornis, new species

Female.—Wing 0.52 mm long. Head, thorax, and abdomen dark brown; antenna brown, palpus yellow; foreleg yellow except dark knee spot; and hind legs brownish, tarsi and bases of femora yellowish; wing smoky grayish brown, radius forming a dark stigma; halter with dark brown stem, the knob pale. Antenna with lengths of flagellar segments in proportion of 12-10-10-10-9-8-8-8-9-10-10-23. Costa extending to 0.41 of wing length. Spermathecae subequal, each measuring 0.030 by 0.024 mm.

Male.—Unknown.

Distribution.—California, Florida.

Types.—Holotype females, Torreya State Park, Liberty Co., Florida, 20 May 1966, H. V. Weems, light trap (Type no. 70648, USNM). One female paratype, Westmorland, Imperial Co., California, 6 April 1949, W. W. Wirth.

Discussion.—The generic name is taken from the Greek: *rhyncho* (nose, snout, muzzle) +*heleia* (marsh dweller). The striking feature of this genus is the short, broadly truncate proboscis provided distally with strong hooks and spines, and opposing this on each side, the well developed palpus with greatly expanded third segment. The antenna is developed similarly to that of many species of *Brachypogon* in which the segments are reduced to 14 and the intermediate segments are reduced in size. The wing is much like that of *Brachypogon*, with even greater reduction of the media, and M1 becoming obsolete distally. The wing is superficially similar to that of *Baeohelea fuscipennis* (Tokunaga) from New Guinea, but in that species the second radial cell is distinct and the costa is much longer.

Genus *Brachypogon* Kieffer

Brachypogon Kieffer, 1899: 69. Type-species, *Ceratopogon vitiosus* Winnertz, by original designation.

Brachypogon has nearly unanimously been accepted as a subgenus of *Ceratopogon* based upon the complete lack of vein M2 and the obsolescence of the radial cells. A survey of the species which have been placed in *Brachypogon* on the basis of these characters shows some important common features apart from the wing venation. The eyes are always contiguous on the midline; the palpi are 5-segmented, the third bearing a small deep pit; the antennae are 14 or 15-segmented, the intermediate segments or the female usually reduced in size, and the male bearing a plume; there is 1 spermatheca present; the male genitalia have the ninth tergum tapering but without strong apicolateral processes; basistyles usu-

ally rather stout; dististyles gradually curved and tapering; aedeagus a simple, moderately broad, distally tapering plate with short basal arms; parameres usually 2 moderate size submedian processes, sometimes fused in an H-shaped or U-shaped piece. In the wing venation the absence of radial cells due to the fusion of the branches of the radius is a constant feature in *Brachypogon* as here defined, but the extent of vein M2 is useless, except that no *Brachypogon* species has it complete to the base. The species of *Baeohelea* and *Rhynchohelea* which also lack radial cells and vein M2 differ greatly from *Brachypogon* in having widely separated eyes, reduced or highly modified proboscis and palpi, and the male genitalia with very short ninth tergum, aedeagus with long anterior arms and broadly rounded apex, and reduced parameres.

A complete description of the type-species *B. vitiosus* (Winnertz), has never been made, and material is not available for its description here. As an example of the genus the description and illustration of the following species is made in some detail, showing the generic features as well as the specific characters.

Brachypogon parasensis, new species (Fig. 3)

Female.—Wing 0.95 mm long. A pale yellowish brown species; legs pale yellow, knee spots brownish, hind tibia with median brownish band; wing whitish with 3 prominent small brown anterior spots (on r-m crossvein, on end of costa and radius, and in middle of cell R5) and brown streaks in cells M1 and M2 directly behind the spot in cell R5; halter pale.

Head (Fig. 3f): Eyes contiguous on midline, with fine interfacetal hairs. Antenna (Fig. 3a) long and slender, with lengths of flagellar segments in proportion of 23-15-15-15-16-18-20-20-30-35-40-35-35; distal sensory pit present on third segment. Palpal segments (Fig. 3d) with lengths in proportion of 10-15-30-15-25; third segment slightly swollen, 2.5 times as long as broad, with a small, deep, round, sensory pit. Proboscis well developed, elongate; mandible (Fig. 3g) with 7-8 large teeth.

Thorax: Moderately broad and convex; mesonotum with scattered, moderately long hairs; scutellum with 4 marginal hairs. Legs (Fig. 3h) moderately slender, with scattered short hairs; femora unarmed; hind tibial comb (Fig. 3i) with 6 spines, spur small; tarsi (Fig. 3j) with a few sharp ventral spines at apices of tarsomeres; fourth segment short and simple, fifth slender; claws (Fig. 3k) long and slender, subequal, each with small basal barb on inner side.

Wing (Fig. 3e): Radial cells both obsolete; costa extending to 0.60 of wing length; tips of costa and radius thickened forming a distinct stigma; vein M1 slightly undulating, vein M2 obsolete at base; microtrichia inconspicuous, macrotrichia absent.

Abdomen: Yellowish; constricted distally from seventh to tenth segment; eighth segment in form of a yellowish sclerotized ring. Spermatheca (Fig. 3m) single, obliquely ovoid, with short conical portion tapering to duct, measuring 0.073 mm in both length and breadth.

Male.—Similar to the female with the usual sexual differences. Antenna (Fig. 3b) with segments 3-13 fused, 13-15 with lengths in proportion of 53-44-50, 13-14 with long verticils; plume well developed. Palpus (Fig. 3c) as in female. Claws (Fig. 3L) short and equal. Genitalia (Fig. 3n) with

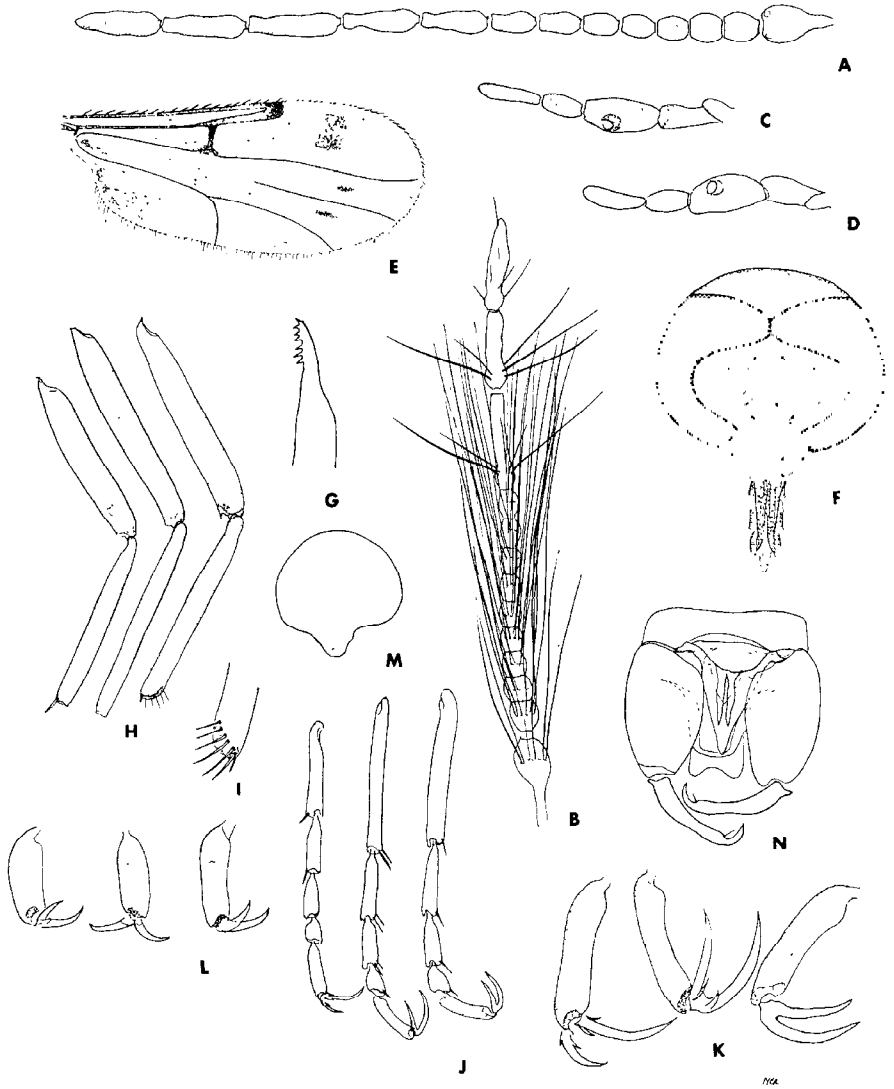

Fig. 3, *Brachypogon paraensis*: a, female antenna; b, male antenna; c, male palpus; d, female palpus; e, female wing; f, female head; g, female mandible; h, femora and tibiae (left to right) of fore, mid, and hind legs; i, hind tibial comb; j, female tarsi (left to right) of fore, mid, and hind legs; k, female fifth tarsomere and claws (left to right) of fore, mid, and hind legs; l, male fifth tarsomere claws (left to right) of fore, mid, and hind legs; m, female spermatheca; n, male genitalia.

ninth sternum short and transverse; ninth tergum tapering abruptly to rather narrow distal portion with bilobed apex. Basistyle moderately stout, straight; dististyle long and slender, slightly curved, abruptly narrowed and slightly bent distally with a sharp tip. Aedeagus with broad, low basal arch, tapering to slender, blunt-pointed tip; a pair of strongly sclerotized, pointed, submedian processes extending caudad from arch about two-thirds way to tip. Parameres fused in a short, strongly

sclerotized sclerite articulating at base with inner corners of basistyles and distally with bases of the submedian dorsal processes of aedeagus, with a slender median point extending caudally between the submedian dorsal processes.

Distribution.—Brazil.

Types.—Holotype female, allotype male, 10 male, 15 female paratypes, Mission Tiriyos, Rio Paru, Para, Brazil, 14 March 1962, E. J. Fittkau, at light (Type no. 70649, USNM).

Discussion.—This species is closely related to *B. fuscivenosus* (Lutz) with close agreement in wing venation, head structure including antennae and palpi, and details of the legs and abdomen. Specific differences are found in the number of antennal segments bearing sensory pits, the wing markings, body color, shape of the spermatheca, and small details in the structure of the male genitalia. Both species differ somewhat from other *Brachypogon* species available for study in their long antennae, somewhat more bristly legs, and longer and more perpendicular r-m cross-vein.

Brachypogon fuscivenosus (Lutz), NEW COMBINATION (Fig. 4)

Palpomyia fuscivenosa Lutz, 1914: 94 (Male, female; Brazil; Fig. wing); Floch and Abonnenc, 1942: 4 (French Guiana; Fig. wing, palpus).
Parabezzia fuscivenosa (Lutz; Lane, 1945: 370 (types redescribed; Brazil; Fig. male genitalia).

Female.—Wing 0.96 mm long. A dull grayish brown species, mesonotum heavily greenish-gray dusted; legs yellowish, knee spots blackish, mid and hind coxae, trochanters, femora, tibiae, and tarsi brown; wing (Fig. 4c) whitish, with deeply infuscated lines along veins and 2 prominent dark brownish spots, one covering 4-m crossvein and the other across the swollen apex of costa and radius and extending caudad about a third-way across cell R5. Eyes continguous, with long interfacetal hairs. Antenna (Fig. 4a) with lengths of flagellar segments in proportion of 30-20-20-20-20-20-20-20-30-32-38-40-40, distal sensory pits present on segments 3-6. Palpal segments (Fig. 4b) with lengths in proportion of 10-25-31-23-25; third segment moderately swollen, 1.7 times as long as greatest breadth, with a moderately large, round, shallow, sensory pit. Mandible with 8 teeth. Legs moderately stout, with scattered, short, stout, stiff, erect bristles; hind tibial comb with 8-9 spines; claws long and curved, 0.6 as long as fifth tarsomere, each with prominent internal barb at base. Wing (Fig. 4c) with costa extending to 0.60 of wing length; radial cells obsolete, end of costa and radius greatly thickened, forming a prominent stigma; r-m cross-vein unusually long and nearly perpendicular, vein M2 obsolete at extreme tip and for about proximal fourth of its length; macrotrichia absent. Halter pale. Abdomen grayish brown; eighth segment heavily sclerotized on sternum with an angular posterior median cleft. Spermatheca (Fig. 4d) single, subspherical with a long subconical neck, measuring 0.095 + 0.022 (neck) by 0.086 mm (some Panama specimens with the neck quite slender).

Male.—Similar to the female with the usual sexual differences; antennal segments 3-13 fused, segments, 13-15 with lengths in proportion of 70-55-53; plume well developed. Genitalia (Fig. 4f) large and heavily sclerotized; ninth tergum tapering with a bluntly truncated apex; basistyle

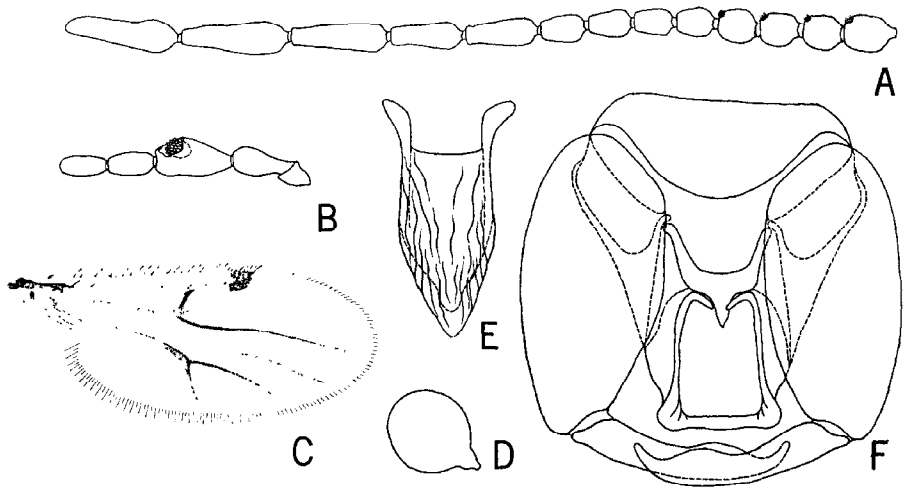

Fig. 4, *Brachypogon fuscivenosus*: a, female antenna; b, female palpus; c, female wing; d, spermatheca; e, male aedeagus; f, male genitalia, aedeagus removed.

moderately stout, not curved; dististyle moderately stout, nearly straight, apical portion with cancavity on inner side, with bent, slender tip. Aedeagus (Fig. 4e) about 2.5 times as long as broad, basal arms short and stout, only slightly diverging, basal arch rounded, main portion tapering to a bluntly rounded point, ventral surface wrinkled, dorsal side provided with a semi-hyaline sheath with pointed apex slightly surpassing tip of aedeagus proper. Mesal side of ninth tergum distally with a large, quadrate, strongly sclerotized thickening with anterior margin notched to fit the base of the U-shaped parameres.

Distribution.—Florida, Mexico, Panama, French Guiana, Brazil, Jamaica, Virgin Islands.

Specimens Examined.—

FLORIDA: Everglades city, Collier Co., February 1949, June 1950, Davidson, light trap, 18 specimens; Key Largo, Monroe Co., 30 May 1950, Buderus, light trap, 2 females, 16 March 1965, S. Kemp, light trap, 3 males; Lake Worth, 9 August 1951, W. W. Wirth, light trap, 1 female; Longboat Key, Manatee Co., 27 April 1956, light trap, 1 male; Palm Beach Co., August 1953, E. L. Seabrook, light trap, 1 female; Sanibel Island, Lee Co., 24 April 1956, Woodring, light trap, 1 female; Vero Beach, April 1956, 1959, October 1958, Ent. Res. Center, light trap, 11 males, 36 females.

JAMAICA: Duncans, 25 February 1958, D. J. Lewis, 1 female; Runaway Bay, February 1969, W. W. Wirth, light trap, 1 female.

MEXICO: Cozumal, Espirito Santo Bay, 5 April 1960, J. F. G. Clarke, 2 females; Quintano Roo, Puento dc Morelo, June 1961, light trap, 1 female.

PANAMA: Almirante, Bocas del Toro Prov., April 1953, F. S. Blanton, light trap, 1 female; Chame, Panama Prov., 3 April 1951, F. S. Blanton, light trap, 2 females; Fort Knobbe, Camaron, C. Z., 23 June 1952, F. S. Blanton, light trap, 7 males, 6 females; France Field, C. Z., 22 April 1952, F. S. Blanton, light trap, 1 male, 1 female; Galeta Point, C. Z., 15 Sep-

tember 1958, S. Breeland, emergence trap, 1 male, 1 female, 26 August 1952, F. S. Blanton, light trap, 2 males, 2 females; Garachine, Darien Prov., February 1963, F. S. Blanton, light trap, 2 males; Mojinga Swamp, Fort Sherman, C. Z., January 1953, F. S. Blanton, light trap, 1 female; Patino Pt., Darien Prov., 21 July 1952, F. S. Blanton, light trap, 1 male, 2 females.

VIRGIN ISLANDS: Lameshur Bay, St. John, 5 September 1961, R. W. Williams, emergence trap, 2 males, 2 females.

List of Species of Genus *Brachypogon* Kieffer

africanus (de Meillon) 1929:248 (*Ceratopogon*, subgenus *Brachypogon*) Transvaal (Fig. wing, male genitalia; male only). N. COMB.

bergensis (de Meillon and Hardy) 1953:26 (*Ceratopogon*) Cape Prov., S. Africa (male; Fig. wing, hind leg, aedeagus, parameres). N. COMB.

corius (de Meillon and Hardy) 1954:69 (*Ceratopogon*) Cape Prov., S. Africa (male; Fig. wing, genitalia). N. COMB.

fuscivenosus (Lutz) 1914:94 (*Palpomyia*) Brazil (male, female; Fig. wing). N. COMB.

impar (Johannsen) 1938:223 (*Ceratopogon*, subg. *Brachypogon*) Puerto Rico (female). N. COMB.

insulicola (Tokunaga) 1959:350 (*Ceratopogon*, subg. *Brachypogon*) Caroline Islands (female; Fig. antenna, palpus, wing, spermatheca). N. COMB.

novaguineae (Tokunaga) 1964:294 (*Ceratopogon*) New Guinea (male, female; Fig. antennae, palpi, wings of male and female, male genitalia). N. COMB.

papuensis (Tokunaga) 1964:296 (*Ceratopogon*) New Guinea (male female; Fig. male, female antennae, female palpus, wing, male genitalia). N. COMB.

paraensis Wirth and Blanton, new species, Brazil (male, female; Figs.).

petersi (Tokunaga) 1964:293 (*Ceratopogon*), New Guinea (male, Fig. antenna, palpus, wing, genitalia). N. COMB.

senegalensis (de Meillon and Wirth) 1955: 275 (*Ceratopogon*, subg. *Brachypogon*) Senegal (male, Fig. genitalia). N. COMB.

sitius (de Meillon) 1959:345 (*Ceratopogon*, subg. *Brachypogon*) Natal (male; Fig. genitalia). N. COMB.

vitiosus (Winnertz) 1852:49 (*Ceratopogon*) Europe (male, female; Fig. wings, male palpus).

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FURTHER INVESTIGATIONS ON CONTROL OF THE CORN STEM WEEVIL, *HYPERODES HUMILIS*, AS A PEST OF FIELD AND SWEET CORN [1] [2]

WILLIAM G. GENUNG, AND MELVIN J. JANES

University of Florida, IFAS, Everglades Experiment Station, Belle Glade

ABSTRACT

After a dozen years corn stem weevil continues as an economic pest in the Everglades. While standard phosphatic soil insecticide treatments indicated reasonable commercial control, all experimental phosphate and carbamate insecticides tested as foliar and soil treatments showed great promise. The following materials looked particularly effective: carbofuran; R-2596, 0-ethyl-S-p-chlorophenyl ethylphosphonodithioate; UC-34096, 4-([(dimethylamino) methyline]amino)-m-tolyl methylcarbamate; Fundal, N,N-dimethyl-N'-(2-methyl-4-chlorophenyl) formamidine hydrochloride; Gardona®, 2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate; VCS-506, 0,2,5-dichloro-4-bromophenyl-0-0-methylphenylthiophosphonate; Monitor, 0-S-dimethyl phosphoramidithioate; Lannate®, S-methyl N-[(methylcarbamoyl) oxy] thioacetimidate; Ortho Bux®, m-(1-ethylpropyl) phenyl methylcarbamate mixture (1-4) with m-(1-methyl=butyl) phenyl methylcarbamate; and Dursban, 0,0-diethyl 0-(3,5,6-trichloro-2-pyridyl) phosphorothioate.

Although the corn stem weevil, *Hyperodes humilis* (Gyllenhal), a widely occurring curculionid, is reported by Blatchley and Leng (1916) to range from Newfoundland and Quebec to Montana and thence south to Kansas and Mississippi, the species is recognized as an economic pest only on the organic soils area of the Everglades, where it made its debut as an injurious species over a decade ago. More recent grower reports of damage on Florida sandy soils in the Immokalee and Devils Garden areas and on similar soils on the Lower East Coast are to be investigated. The authors recently (1969) described the damage and discussed the current status and control of this insect as a pest of sweet corn. The previous economic literature, consisting entirely of the work of E. D. Harris and Harris and J. R. Orsenigo, was reviewed at that time. The present paper gives results of the authors' experimental control of corn stem weevil obtained since their previous (1969) report.

METHODS AND MATERIALS

Corn stem weevil control was considered an important aspect of 2 experiments conducted during the spring of 1969. These were: 1) a general sweet corn (Florigold variety) insect spray trial, and 2) a general subterranean insect control test with field corn (Funk 5945) as the test crop. The tests were randomized complete block design experiments. Plots were 25

[1]University of Florida, IFAS, Experiment Stations Journal Series No. 3526.

[2]Research aided by grants-in-aid from Shell Chemical Co., Chevron Chemical Co., and Niagara Chemical Division.

ft. long, 4 rows (3ft. between rows) wide and separated by alleyways on all sides.

The spray trial had 10 spray treatments, 1 granular systemic (Furadan) soil treatment and 2 checks. One check like all the spray treatments had a broadcast application of Niran (methyl-ethyl parathion) 6-3 E at 4 lb/acre disked in for wireworm control. The other check was untreated. The treatments were replicated 5 times. The corn was planted February 26; results were taken March 26-27 after 2 weeks of sprays—3 per week. The insecticides, formulations, and amounts of active material applied/acre/application are given with results in Table 1.

TABLE 1. CONTROL OF THE CORN STEM WEEVIL ON SWEET CORN, WITH SPRAYS, EVERGLADES EXPERIMENT STATION, SPRING 1969

Insecticide*		Lb. AI/acre	% injury free plants**
Furadan	75 WP	1.0	100 a
Gardona	75 WP	1.0	100 a
UC 34096	100 SP	1.0	100 a
C 9491	50 WP	1.5	99 a
Fundal	98 SP	0.5	99 a
Furadan	10 G†	4.0	99 a
Monitor	4 E	1.0	99 a
VCS 506	3 E	1.0	99 a
Dylox	50 WP	1.0	97 a
Lannate	90 SP	0.5	97 a
Lannate	90 SP	0.25	93 ab
Check No. 1		—	88 b
Check No. 2 - Untreated		—	38 c

*Niran 6-3 applied broadcast prior to seeding, 4 lb/acre for wireworm control, on all sprayed plots and check No. 1: Check No. 2 not treated.

**Means followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

†Placed in soil in band prior to seeding.

In the subterranean insect trial all insecticides were applied in the row in a single application on April 1, and the furrows covered within a few minutes of application. The compounds tested were all in granular formulations. The furrows were re-opened and the corn seed planted 1 week later. Treatments were replicated 4 times. The materials used and amounts of active ingredients applied per acre are given with results in Table 2. These amounts were concentrated in a 6-inch band in the row.

Chemical names of the newer proprietary compounds tested in these experiments are:[3]

[3]Chemical names of UC-34096, VCS-506, and Monitor were from the respective company sources; all others are from Eugene Kenaga and William E. Allison, 1969, Commercial and Experimental Organic Insecticides, Bull. Entomol. Soc. Amer. 15(2), 85-148.

Ciba C 9491—0-(2,5 dichloro-4-iodophenyl) 0,0-dimethyl phosphorothioate
Lannate®—S-methyl N-[(methylcarbamoyl)oxy] thioacetimidate
UC-34096—4-([(dimethylamino)methyline]amino)-m-tolyl methylcarbamate hydrochloride
Gardona®—2-chloro-1-(2,4,5-trichlorophenyl)vinyl dimethyl phosphate
Dursban—0-0-diethyl 0-(3,5,6-trichloro-2-pyridyl) phosphorothioate
Ortho Bux®—m-(1-ethylpropyl) phenyl methylcarbamate mixture (1-4) with m-(1 methyl = butyl) phenyl methylcarbamate
GS-13005—S-[(2-methoxy-S-oxo-Δ^2-1,3,4-thiadiazolin-4-yl)methyl] 0,0-dimethyl phosphorodithioate
Mocap®—0-ethyl S,S-dipropyl phosphorodithioate
R-2596—0-ethyl-S-p-chlorophenyl ethylphosphonodithioate
VCS-506—0-2,5-dichloro-4-bromophenyl-0-0-methylphenylthiophosphonate
Fundal, N,N-dimethyl-N'-(2 methyl-4-chlorophenyl) formamidine hydrochloride
Monitor—0-S-dimethyl phoshoramidithioate

Stem weevil counts were made on a 20-plant random sample per plot by examination under a binocular microscope in the laboratory. The number of plants with either eggs, mines, larvae, or pupae were recorded and the percent of infested plants determined.

TABLE 2. CONTROL OF CORN STEM WEEVIL ON FIELD CORN WITH GRANULAR INSECTICIDES APPLIED IN THE ROW, EVERGLADES EXPERIMENT STATION, SPRING 1969.

Insecticide		Lb. AI/acre	% injury free plants*
N-2596	10 G	4	100 a
Furadan	10 G	4	99 a
Furadan	10 G	8	99 a
Lannate	5 G	4	99 a
Dursban	5 G	4	96 ab
Furadan	10 G	2	96 ab
Ortho Bux	10 G	6	96 ab
Ortho Bux	10 G	2	95 ab
N-2596	10 G	2	94 ab
Dursban	5 G	2	92 ab
Lannate	5 G	2	92 ab
GS-13005	5 G	4	92 ab
Mocap	10 G	4	90 b
Mocap	10 G	2	90 b
Diazinon	14 G	4	89 b
Check - untreated		—	64 c

*Means followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

RESULTS

All insecticide treatments (including the treated check) in both experiments were significantly better than the untreated checks at the 5% level of significance, using Duncan's multiple range test (Tables 1 and 2). In the spray test the percent injury free plants was very high ranging from 93 to 100%. The only granular treatment in the test (Furadan 10 G) was in the same range of significance as the better treatments. These data are shown in Table 1. Similarly, very good control was indicated by most of the experimental compounds in the subterranean insect trial (Table 2). High and low rates of most of these compounds were tried, and the higher rates usually produced more undamaged plants. The standard, diazinon, gave nearly 89% undamaged plants. Since the Niran treated check in the spray trial gave an almost identical figure it can be concluded that standard soil treatments for wireworm control result in considerable control of corn stem weevil (Tables 1 and 2). Many new compounds used either as sprays or granular soil applications show great promise for stem weevil control.

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CHARACTERISTICS AND RADIOGRAPHIC DETECTION OF SEED BUG DAMAGE TO SLASH PINE SEED

GARY L. DEBARR

Southeastern Forest Experiment Station, Forest Service,
U. S. Department of Agriculture, Forestry Sciences Laboratory,
Athens, Georgia

ABSTRACT

A leaf-footed bug, *Leptoglossus corculus* (Say), and the shield-back bug, *Tetyra bipunctata* (H. + S.), feed on seeds of the major pine species grown in seed orchards in the Southeast. Characteristics of the inconspicuous damage caused by these seed bugs are described, along with the use of radiography to detect damage in mature seed. At least 82% as many damaged seeds were detected on radiographs as could be detected in ocular examination at 60X.

In my research on seed orchard insects the need arose for a simple, accurate method of detecting inconspicuous seed damage by two sucking insects: a leaf-footed bug, *Leptoglossus corculus* (Say) (Hemiptera: Coreidae), and the shield-back bug, *Tetyra bipunctata* (H. + S.) (Hemiptera: Pentatomidae) (Fig. 1). Gilbert et al. (1967) studied the bionomics of *T. bipunctata* in association with jack pine, *Pinus banksiana* Lamb., and suggested that this species fed on developing pine seeds. DeBarr (1967) first

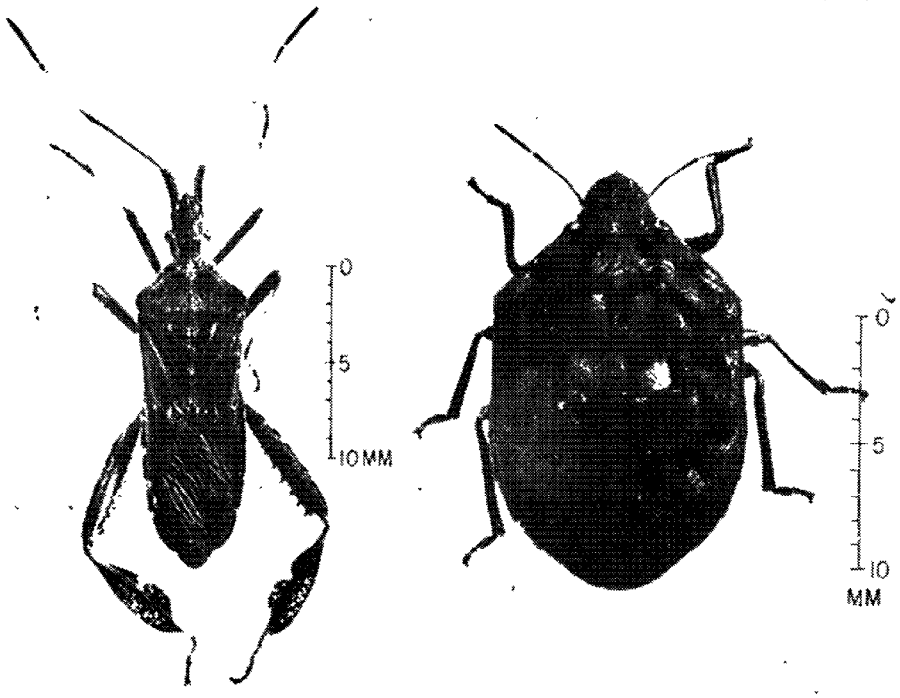

Fig. 1.—Left: adult of the leaf-footed bug, *Leptoglossus corculus* (Say); right: adult of the shield-back bug, *Tetyra bipunctata* (H. + S.).

reported that *T. bipunctata* and *L. corculus* damaged the seeds of slash pine, *P. elliottii* Engelm., and longleaf pine, *P. palustris* Mill., in southern pine seed orchards. Krugman and Koerber (1969) discussed the effects of cone feeding by a related species, *Leptoglossus occidentalis* Heideman, on development of seed in ponderosa pine (*P. ponderosa* Laws.). They emphasized the difficulty in detecting seed bug damage to immature seed.

This paper describes the characteristics of slash pine seed damage by *L. corculus* and *T. bipunctata*, along with results of an evaluation of radiography for detecting damage in mature seed.

Seed Damage

Leptoglossus corculus and *T. bipunctata* are well adapted to feeding on pine seeds. Their mouth parts consist of a long, slender proboscis containing a bundle of 4 interlocking, bristle-like stylets encased in a retractable sheath. To reach a seed lying along the cone axis within a closed cone, the insect inserts its stylet bundle through alternate layers of cone scales and seed wings (Fig. 2). Punctured cone scales seldom exhibit external symptoms that might indicate the presence of damaged seeds within a cone.

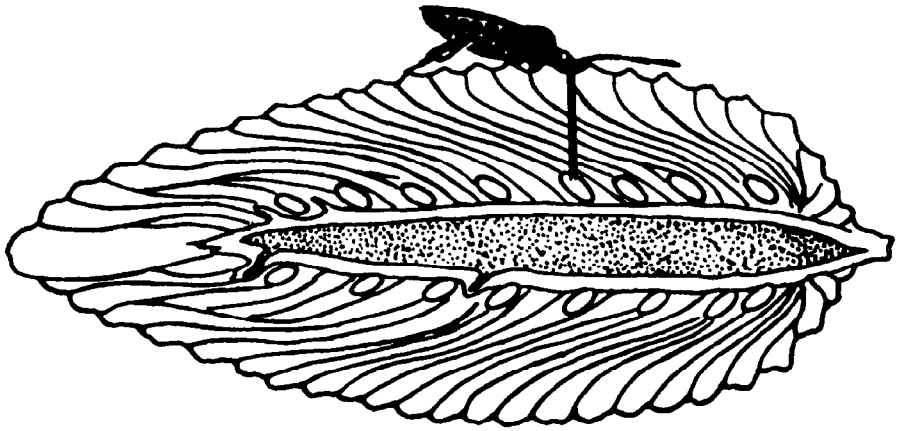

Fig. 2.—Longitudinal diagram of a slash pine cone showing how the stylets of seed bugs penetrate alternate layers of cone scales and seed wings to puncture seeds lying along the cone axis.

Damaged seeds also lack conspicuous symptoms; the stylet puncture hole in the seedcoat is the only visible external evidence of seed damage. On a dark-colored seedcoat the damage often appears as a minute white fleck, 0.29 ± 0.08 mm in diameter (Fig. 3a). This fleck is caused by partial digestion of the seedcoat by the insect's saliva. Located in the center of the fleck is a puncture hole, 0.06 ± 0.01 mm in diameter (Fig. 3b). In some cases, however, the puncture hole closes after the stylets are withdrawn. If damage occurs before the seedcoat is completely developed, the hole is difficult to detect.

Damage to the endosperm varies with the length of time the insect feeds. When feeding is undisturbed, the entire endosperm can be reduced to a shrunken remnant. If the insect withdraws its stylets shortly after penetrating the seedcoat, only a small necrotic area develops in the endo-

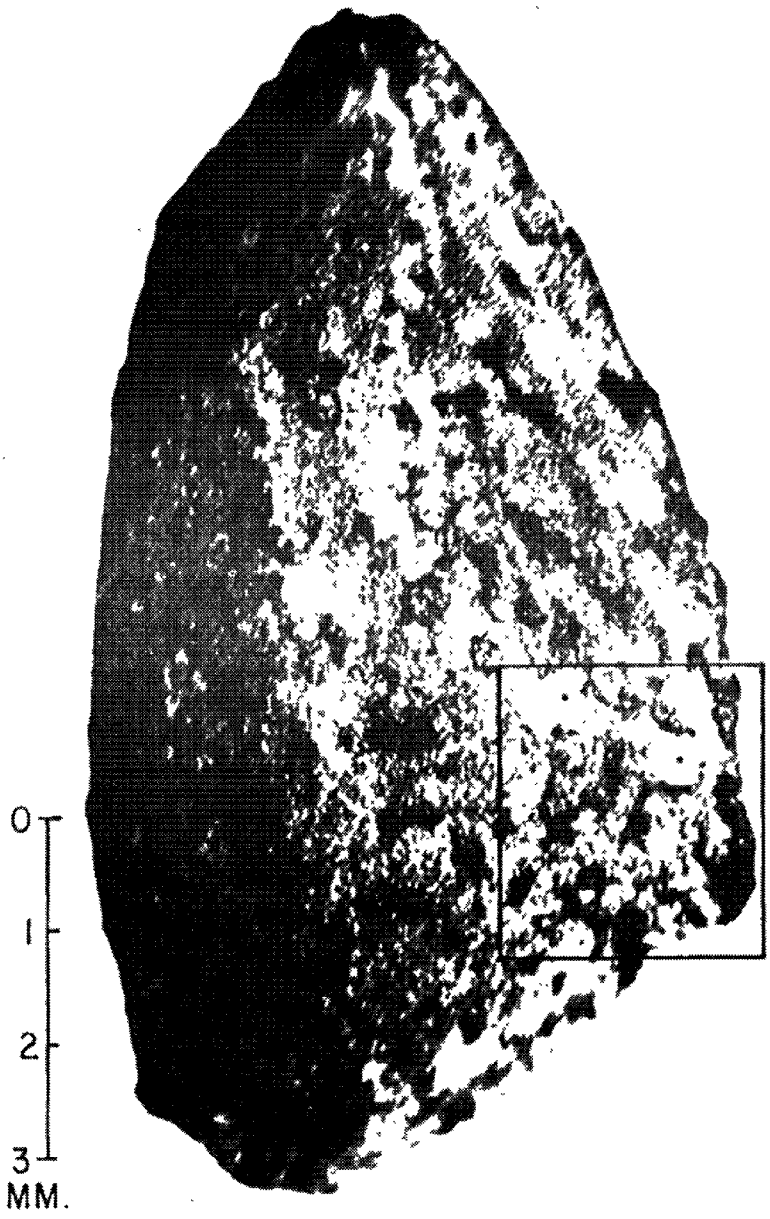

Fig. 3a.—Slash pine seed with two minute flecks caused by saliva of *T. bipunctata.*

sperm beneath the puncture hole. But, even slight damage to the endosperm may reduce the chance that a seed will germinate successfully. In addition, the puncture hole in the seedcoat also provides an entrance port for pathogens.

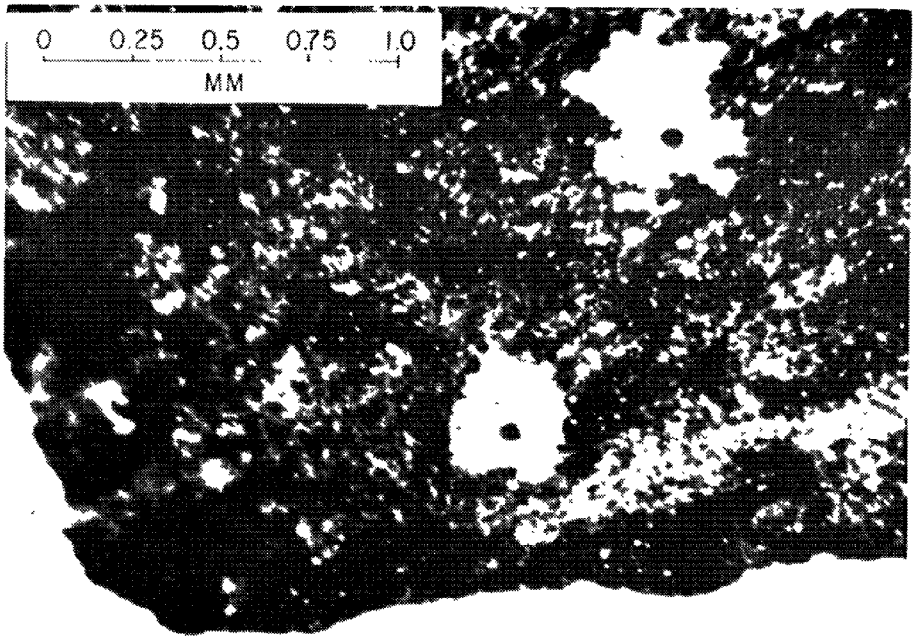

Fig. 3b.—Enlarged view of the flecks in fig. 3a showing holes where insect's stylets penetrated the seedcoat.

Damage Detection

Unopened, second-year cones of slash pine were collected from 2 trees about 2 weeks prior to cone-maturity, and stored at 2° C. During a period of 4 months these cones were periodically removed from cold storage and used to maintain laboratory colonies of nymphs and adults of *L. corculus* and *T. bipunctata*. The cones were placed in 1-gal. glass jars and exposed to colonies of feeding insects for periods ranging from 7 to 28 days. Then the cones were removed and allowed to open fully; cones failing to open were dissected. The seeds from each cone were collected separately and stored in glass vials.

The seeds were glued in rows on sheets of white paper, which were placed directly over ready packs of type AA industrial X-ray film. Exposures were made with a Picker Industrial X-ray unit, Model No. 805D at 15 KV, 3 ma, 6 sec. at a 30-inch focal-film distance.

Radiographs were evaluated on a small light box. Based on the radiographic image (Fig. 4), each seed was classified as:

A. *Sound*—Endosperm undamaged: no necrotic areas; appeared a solid white.

B. *Hollow*—Seeds empty; no necrotic areas or collapsed endosperm; trace of shriveled, aborted gametophyte present.

C. *Damaged by seed bugs*—Endosperm partially destroyed; often with small, dark, necrotic areas; endosperm shrunken, partially collapsed, or almost entirely missing.

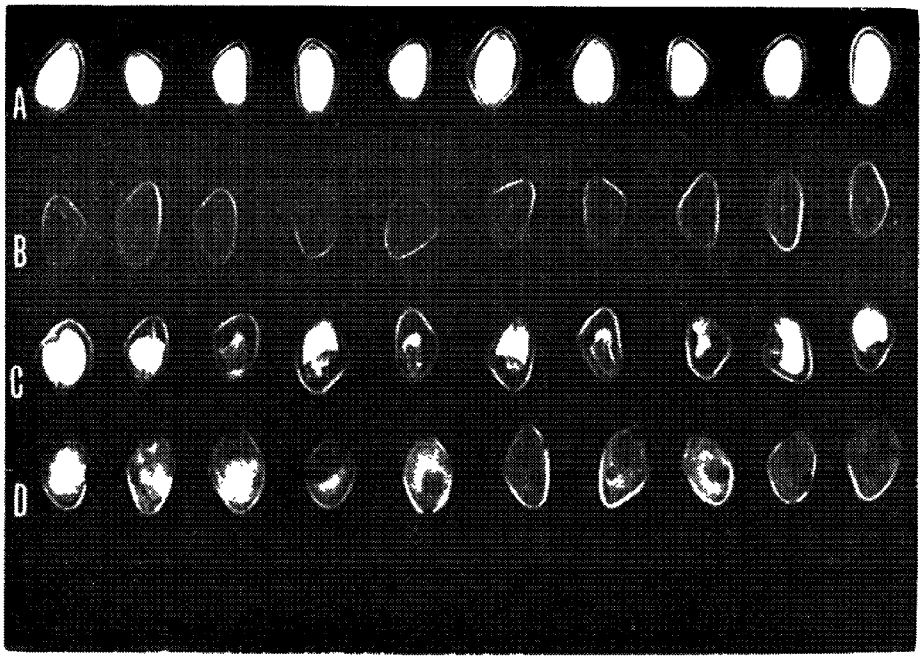

Fig. 4.—Radiograph showing slash pine seeds that are sound (A), hollow (B), damaged by seed bugs (C), and damaged by seedworms (D).

D. *Damaged by the slash pine seedworm*[1]—Endosperm destroyed; packed with granular larval frass; frass often appeared as grey concentric rings.

To evaluate accuracy of the radiographic interpretations, each seedcoat was examined ocularly using 60X magnification and determined to be:

1. *Not damaged by insects*—Seedcoat without a stylet puncture hole or seedworm larval entrance or exit hole.

2. *Damaged by seed bugs*—Seedcoat with a stylet puncture hole.

3. *Damaged by seedworms*—Seedcoat with the characteristic seedworm larval entrance or exit hole.

A total of 2,956 seeds from 62 cones exposed to the 2 laboratory insect colonies was examined ocularly and radiographically. In addition, a random sample of 10 slash pine cones was collected from an orchard where *L. corculus* and *T. bipunctata* had been observed on numerous occasions. The seeds were extracted and classified as described above. The radiographic interpretations were then compared with the ocular examinations.

Results

For cones exposed to the laboratory colonies, the radiographic technique provided 92% accuracy or better in distinguishing sound seeds, naturally hollow seeds, and seeds damaged by seed bugs or by seedworms. Radiographic and ocular examinations yielded similar counts of seeds in each category (Table 1).

[1]*Laspeyresia anaranjada* Miller (Lepidoptera: Olethreutidae).

TABLE 1.—COMPARISON OF RADIOGRAPHIC AND OCULAR (60X) EXAMINATIONS OF SLASH PINE SEED FOR SEED BUG DAMAGE.

Seed bug species	Sample size		Classification technique	Classification of seed				
						Not damaged by insects		
	Cones	Seeds		Bug damaged	Seedworm damaged	Sound	Naturally hollow	Total
T. bipunctata	35	1,395	X-ray	497	21	482	395	877
			Ocular	485	28	.....	.....	882
L. corculus	27	1,561	X-ray	451	49	707	354	1,061
			Ocular	404	52	.....	.....	1,105
Both species	62	2,956	X-ray	948	70	1,189	749	1,938
			Ocular	889	80	.....	.....	1,987

TABLE 2.—CLASSIFICATION OF SEED DAMAGE DETECTED BY OCULAR (60X) AND RADIOGRAPHIC METHODS.

Ocular classification	Total seed in each class by ocular examination	X-ray classification				Seed misclassified by X-ray**
		Sound	Naturally hollow	Bug-damaged	Seedworm-damaged	
Not damaged by insects	1,987	1,189*	663*	135	0	135
Bug-damaged	889	0	83	805*	1	84
Seedworm-damaged	80	0	3	8	69*	11
Total	2,956	1,189	749	948	70	230

*Number of seed correctly classified by X-ray.
**Seed misclassified by X-ray — total number of seed in each ocular classification minus the number correctly classified by X-ray.

None of the seeds identified as sound on the radiographs exhibited the puncture hole. On the radiographs, 948 seeds were classified as damaged by seed bugs (Table 2). Ocular examination of these seeds revealed that 1% was damaged by seedworms and 85% damaged by seed bugs. The remaining 14% of the 948 seeds had no puncture holes. These seeds were cut open; more than half had shrunken or collapsed endosperms, many of which were covered with fungal mycelium.

Of the seeds classified as hollow on the basis of radiographs, 11% had a puncture hole in their seedcoats. These seeds may have been severely damaged by insects or could have been empty before the insects penetrated them.

Discussion

Overall there was close congruity between the radiographic detection of seed bug damage and ocular detection of damage. Ninety-one percent of the seed damaged by seed bugs in the laboratory and 82% of those damaged in the field were correctly distinguished on the radiographs. Severely fed-upon seeds, or seeds damaged in the early stages of their development are not always distinguishable from naturally hollow seeds. Thus, estimates of seed bug damage based on radiographs of mature seed are conservative. On radiographs, seedworm damage was easily distinguished from seed bug damage.

Mature slash pine seeds show no obvious external evidence of damage by *L. corculus* and *T. bipunctata*. The minute stylet puncture hole in the seedcoat is the only reliable visible indication of seed damage, and it can only be observed by time-consuming scrutiny of each individual seedcoat under considerable magnification. Although future studies are needed to evaluate the extent of seed bug damage to immature seeds, radiography, for the present, should prove to be a valuable tool for forest entomologists involved in damage surveys and in research on sucking insects destroying pine seeds. It can be used in slash pine seed orchards and production areas as a survey method to scan quickly large samples of seed and detect seed bug damage. In addition, it should provide researchers with an efficient method of evaluating the effectiveness of insecticides for seed bug control in orchards because of the rapidity with which the presence of damaged seed can be detected.

Acknowledgements

Special appreciation is expressed to Harry O. Yates III, Principal Entomologist, and William Lewis, Biological Aid, Forest Service, USDA, Forestry Sciences Laboratory, Athens, Georgia, for their assistance in making radiographs.

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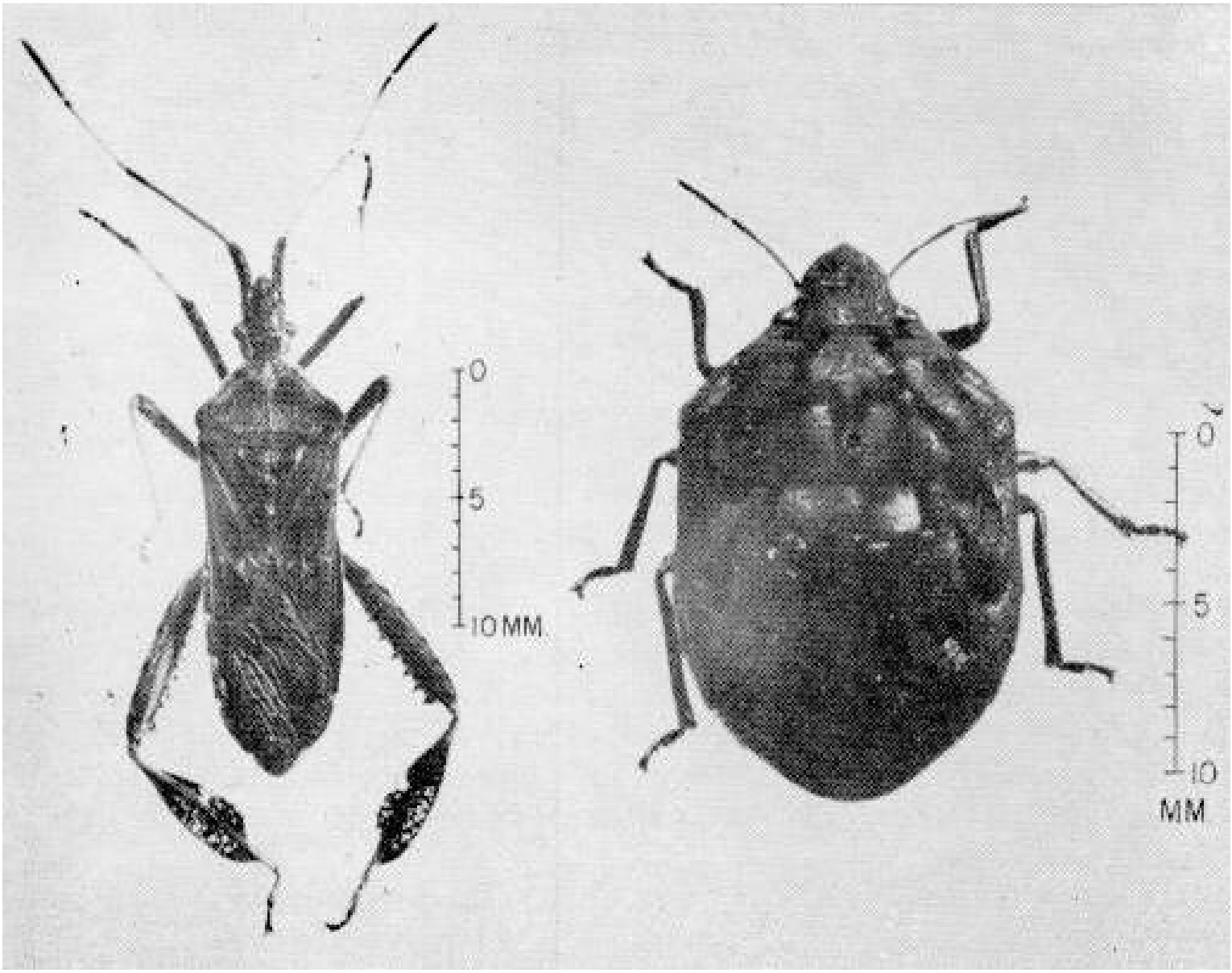
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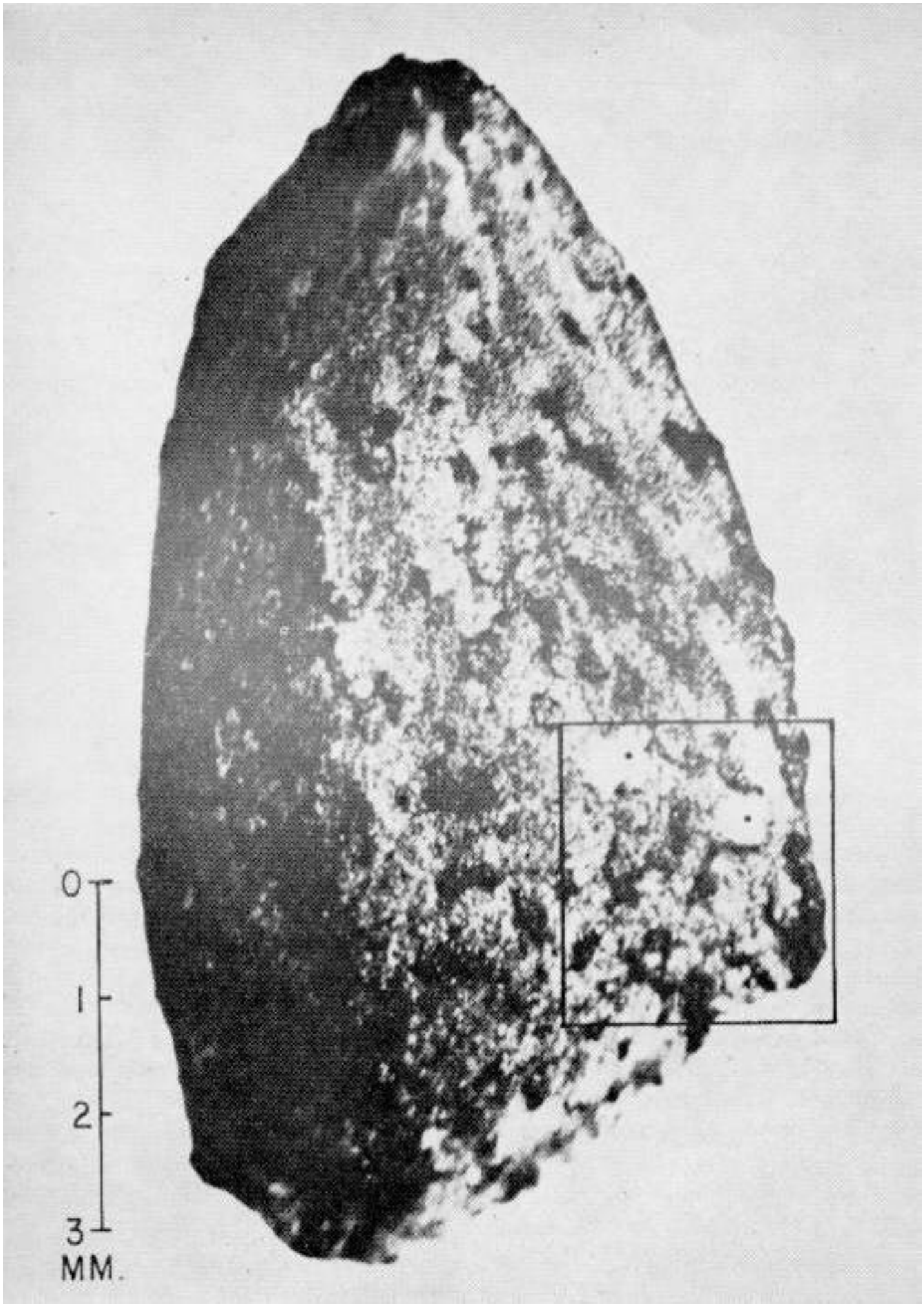
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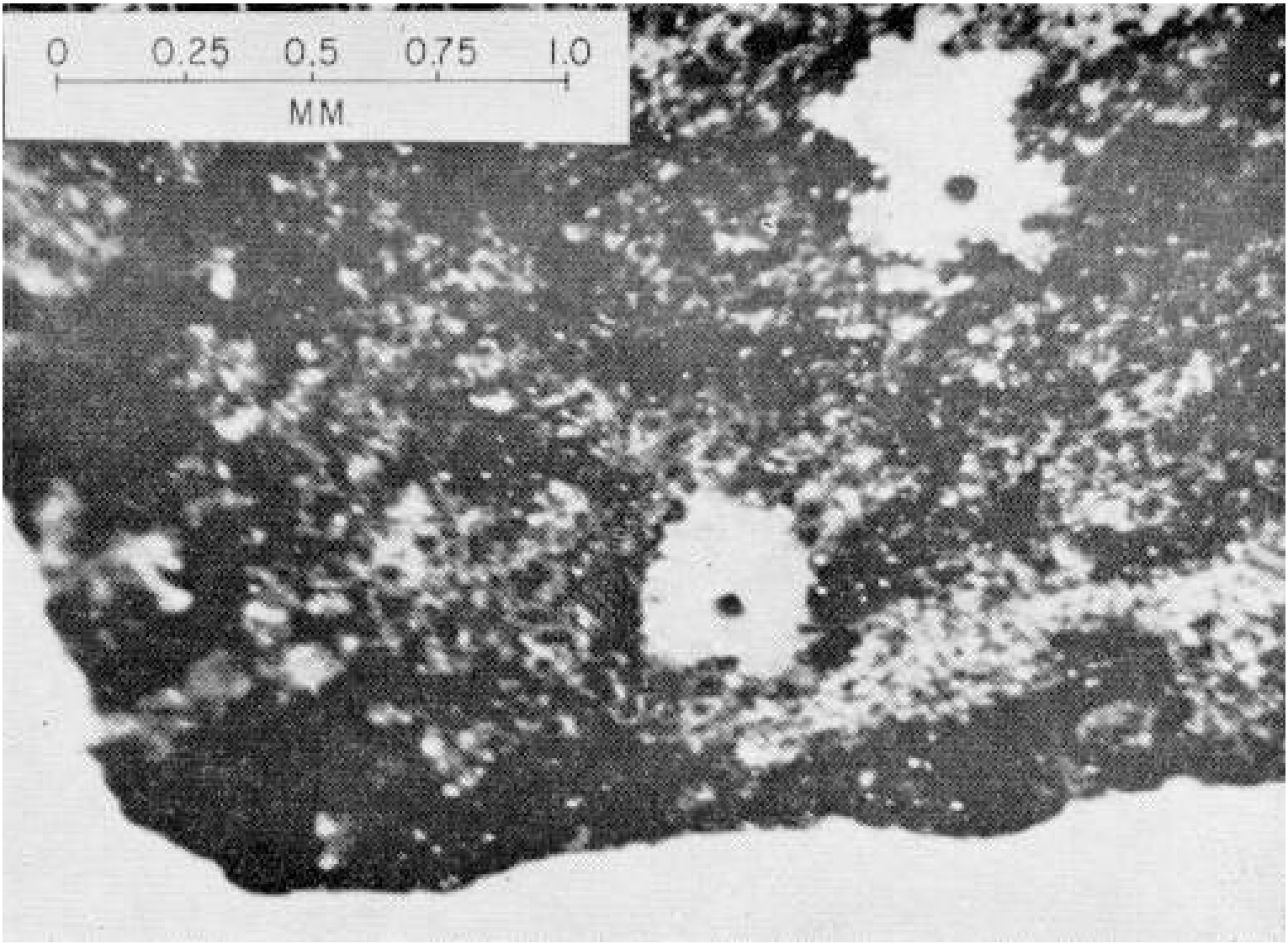
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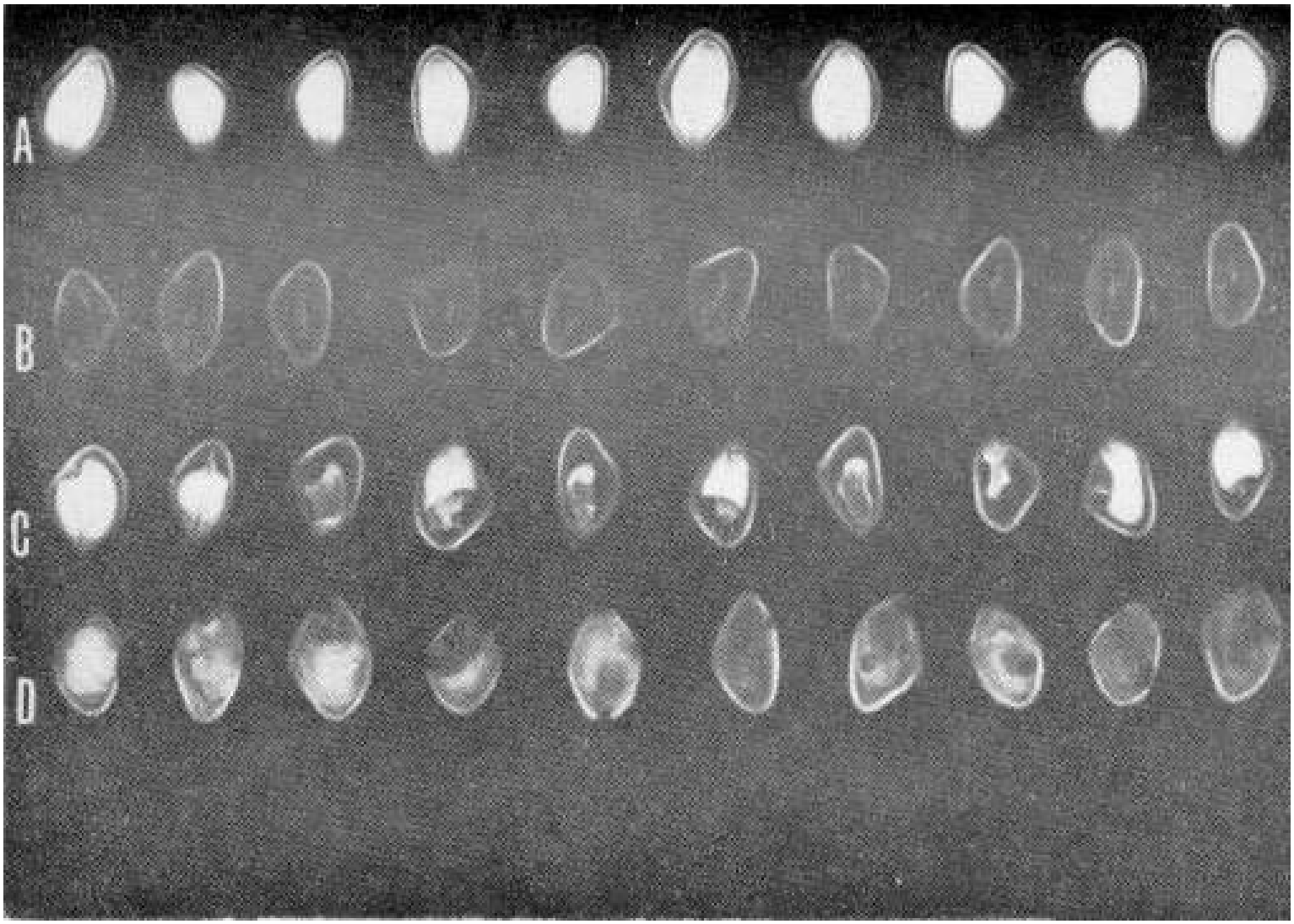
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RICOSEIUS LOXOCHELES (PHYTOSEIIDAE: ACARINA)[1], [2]

H. A. DENMARK AND MARTIN H. MUMA

Chief of Entomology, Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville 32601, and Entomologist, University of Florida Citrus Experiment Station, Lake Alfred 33850, respectively

ABSTRACT

A second specimen of *Ricoseius loxocheles* (De Leon) has been found, redescribed and illustrated to correct errors in the original description. This specimen is from Brazil.

The late Dr. Donald De Leon (1965: 128) described a most unusual phytoseiid, *Amblyseius* (*Ricoseius*) *loxocheles* De Leon, on *Cordia alliodora* from Puerto Rico. Muma and Denmark (1968:233) elevated *Ricoseius* to generic status. Recently a second specimen of *R. loxocheles* was collected by Dr. Carlos Flechtmann from Piracicaba, Sao Paulo, Brazil. The holotype is badly damaged and poorly oriented, resulting in errors of interpretation of setal number and position by De Leon (1965), and Muma and Denmark (1968).

The description and drawings in this paper are of the Brazilian specimen and are presented to correct previous errors. Body length and width, length of setae, and profile of spermatheca of the Brazilian female vary somewhat from those of the holotype, but these are believed of no specific importance.

Unusual characteristics of this genus are 3 pairs of scapular setae, form and position of ventrolateral and caudal setae, very long and knobbed-setaceous dorsal setae, and the number and position of knobbed-bacillate to knobbed-setaceous leg setae.

Generic diagnosis: Females (Fig. 1) characterized by 4 pairs of dorsal setae with D_3 and D_4 very long and knobbed-setaceous; 2 pairs of median setae with M_2 very long and knobbed-setaceous; 9 pairs of lateral setae with most very long and knobbed-setaceous; 3 pairs of scapular setae on the interscutal membrane with all knobbed-setaceous, verticals knobbed-setaceous; 3 pairs of sternal setae; 3 pairs of preanal setae; 1 or more knobbed bacillate or knobbed-setaceous setae on genu I to IV; similar setae on the femur, tibia, and tarsus of leg IV, the tibia of legs I and II, and femur of leg III. Setae in the positions of Sge I and Sge II are not macrosetae. Genu II formula is $2\text{-}\frac{2,2}{0\,0}\text{-}1$ and genu III is $1\text{-}\frac{2,2}{1}\text{-}1$ (terminology follows Evans 1963). Tarsus I has 3 bacillate setae with the proximal one being the shortest. It is a typical amblyseiine with 4 pairs of laterals well anterior to D_3.

[1]Contribution No. 170, Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture and Consumer Services.

[2]Florida Agricultural Experiment Stations Journal Series no. 3529.

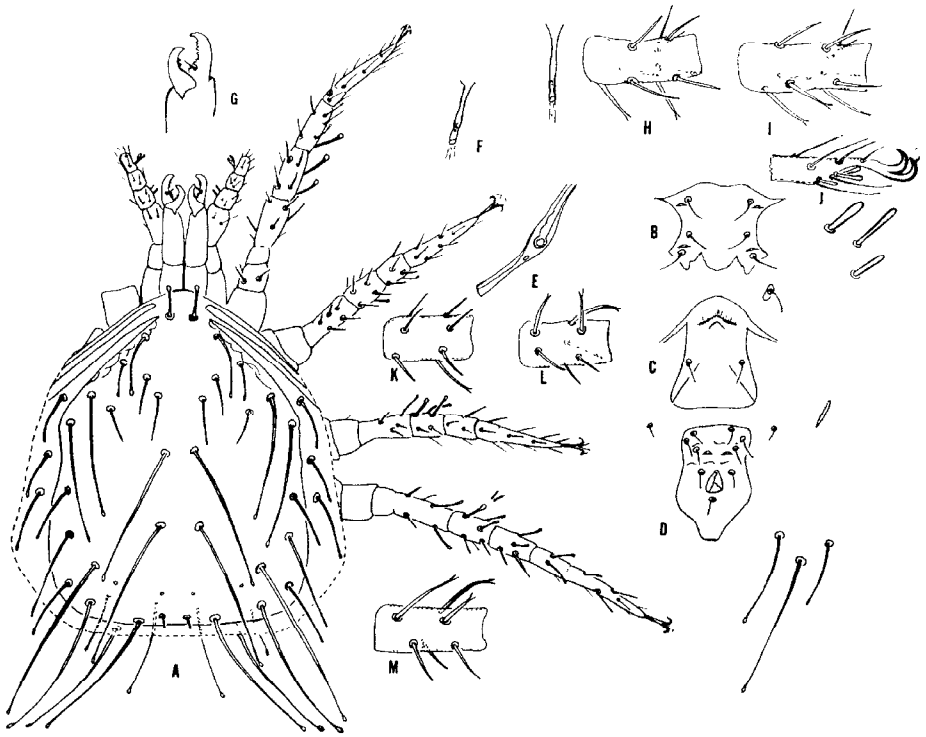

Fig. 1: Female. A. dorsal and leg structure and setation; B. ventral scuta and setation; C. genital scuta and setation; D. ventrianal scutum and setation; E. posterior peritremal and stigmatal development; F. spermathecal structure showing variation, figure on the right is of holotype; G. cheliceral structure; H. genu leg I; I. tibia leg I; J. tarsus leg I with enlarged bacillate setae; K. genu leg II; L. genu leg III; M. genu leg IV.

Species diagnosis: Female. Dorsal scutum smooth, 361μ long and 236μ wide at L_4. Sternum slightly wider than long, smooth, and lobate posteriorly. Genital scutum longer than wide and slightly creased. Ventrianal scutum longer than wide, slightly creased with a pair of pores, and with 3 pairs of preanal setae. Peritremes long, extending forward to between L_1 and verticals. Stigmatal scutum with one distinguishable secondary pore. Chelicerae medium; fixed fingers with 10 to 12 denticules; movable fingers with 2 denticules. Legs ranked in size: 4123.

Male: Unknown.

Specimens examined: Female holotype, Cayey Mt., Puerto Rico, 28 August 1963 (D. De Leon), on *Cordia alliodora* in the Museum of Comparative Zoology, Harvard; 1 female, Piracicaba, Sao Paulo, Brazil, September 1966 (Carlos Flechtmann), on *Morus alba* L.

Discussion: Nothing is known about the biology or food habits. The Brazilian host plant was re-examined by Dr. Flechtmann, but no other specimens were found.

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Minutes of the 52nd Annual Meeting of The Florida Entomological Society

The 52nd Annual Meeting of The Florida Entomological Society was held at the Sheraton Hotel, Fort Lauderdale, Florida, on 10-12 September 1969. A pre-meeting "Bull Session" of selected topics was held the evening of the 10th with Dr. L. C. Kuitert as Moderator.

President John B. O'Neil opened the convention at 9:00 AM on 11 September. Thirty-one papers were presented. Registrations at the meeting totalled 149.

The first business meeting was called to order at 11:30 AM on 11 September. Over 100 members were present.

The minutes of the 51st Annual Meeting were presented by the Secretary as published in Vol. 52, No. 1 of *The Florida Entomologist.* The minutes were approved as read.

President O'Neill appointed the following committees:

Resolutions:	Leland A. Davis
	Dale H. Habeck
	Willard H. Whitcomb, Chairman
Auditing:	Harry H. Samol
	Ralph B. Workman
	Robert E. Waites, Chairman

The meeting was adjourned at 12:00 noon.

The final business meeting was convened by President O'Neil at 10:55 AM on 12 September. Approximately 50 members were present.

Report of the Membership Committee

At the present time there are 400 memberships in our Society: 309 in Florida; 200 institutional subscriptions, 27 in Florida, making a total of at least 600 parties interested in our Society.

The Florida Enomologist is sent to 328 locations in Florida, 82 more elsewhere in the Southeastern United States. Copies go to every state except Vermont and Alaska, and it is sent to 14 countries in Central and South America and the Caribbean. A total of 43 countries around the world receive it.

Our committee suggests to next years' committee that if an application for membership were included with an early issue of *The Florida Entomologist,* perhaps this would encourage recruitment.

D. L. Bailey
R. C. Bullock
D. B. Lieux
R. A. Crossman, Jr., Chairman

Report of the Honors and Awards Committee

The Florida Entomological Society through its committee of G. W. Dekle, A. N. Tissot, and D. O. Wolfenbarger, Chairman, extended honors to Dr. William Louden "Tommy" Thompson of Lake Alfred, Florida. Dr. Thompson was unable to attend the 52nd Annual Meeting, so Dr. Martin H. Muma was asked to accept the plaque for Dr. Thompson and present it to him later at an appropriate time. This was done during November 1969 in ceremonies at the University of Florida Citrus Experiment Station at Lake Alfred. Dr. Muma, a fellow entomologist at the Experiment Station, presented the plaque in the presence of three others who were Dr. Thompson's colleagues in entomological research work, Drs. R. F. Brooks, R. B. Johnson, and W. A. Simanton. A photograph and account of this presentation appeared in the *Winter Haven News Chief* newspaper.

Elsewhere in this issue of *The Florida Entomologist* is a photograph of Dr. Thompson accompanied by the Report of the Honors and Awards Committee.

F. W. Mead, Secretary

Report of the Necrologist

A member deceased since our last meeting is John W. Davis, Tavares, Florida, on 3 February, 1969.

Report of the Entomology in Action Committee

During 1969, the Entomology In Action Committee developed and built a new exhibit, "Public Health Careers in Entomology." This exhibit is in addition to the original exhibit, "Careers in Entomology." These exhibits are available to any member for use in talks or displays. In past years the exhibit has been used for bank lobbies, malls, schools, junior colleges, fairs, and various other meetings and occasions. Try to remember them and put them to good use.

The Entomology In Action slide set was used by W. G. Gresham, Jr., at Winter Park in a "Visiting Scientist" lecture to high school students; R. A. Crossman, Jr., at Winter Haven in the "Matchmaker Program for Talent Development" to junior high school students; R. C. Bullock at Ft. Pierce to Boy Scouts; R. W. Brown, and F. W. Mead at Gainesville to Boy Scouts; and S. H. Kerr at Gainesville.

The condition of the slide set has degenerated over the years to the point that one inadequate set remains. The committee recommends that future Entomology In Action Committees renovate and up-date these slides and the accompanying script.

In 1969, the Society granted a $150.00 stipend to John Strayer in support of development of a Leader's Entomology Kit. This kit is a training aid designed for leaders to show youth what entomological equipment is and how it is used. Money from this stipend was used to purchase equipment for assembling the first kits. The kit was developed during 1969 and ten kits have been sold. After initial demand is met the money from this assistance will be used further in the state 4-H Entomology Recognition and Awards Program. Persons interested in further details about the kit should contact John Strayer.

John E. Porter
Frank A. Robinson
John R. Strayer, Chairman

Report of the Public Relations Committee

At the final business meeting the Chairman of the Public Relations Committee read a comprehensive report of the many activities of entomologists in Florida. The entomological activities of the following agencies were dealt with in some detail: Florida Department of Agriculture and Consumer Services; University of Florida Dept. of Entomology and Nematology (teaching, extension, and research both at Gainesville and in the far-flung experiment station system); State Board of Health; and two laboratories of the USDA Agricultural Research Service at Gainesville. The older of these two laboratories is, "The Insects Affecting Man and Animals Laboratory." Its staff of 25 professional entomologists and 30 technicians was busy during 1969 on the development of control measures for use against insects that are deleterious to the health of man or which are annoying to man. The personnel of this laboratory made 16 talks on entomology to non-entomological groups totalling approximately 1000 people. A list of the scientific papers published and submitted for publication by this staff was attached to and made an official part of the Public Relations Committee Report. The newer of the two USDA laboratories is devoted to research on insect attractants, behavior, and basic biology. It was officially opened during March 1969. A several page report by Carroll N. Smith on the purposes of this new laboratory was made a formal part of the Public Relations Committee Report.

Two past presidents of The Florida Entomological Society retired during 1969. They were E. G. Kelsheimer of the University of Florida Gulf

Coast Experiment Station at Bradenton and W. C. Rhoades of the North Florida Experiment Station at Quincy. Both men performed long and faithful service to the Society and to Florida entomology.

Another highlight from the Committee Report is that entomology has an important part in the West Florida Natural Resources Council recently formed by the Governor. One of the three tasks forces of the Council is related to the "dog fly" (stable fly). Drs. W. G. Eden and D. E. Weidhaas from Gainesville and Dr. A. J. Rodgers of Panama City will be leaders in this phase.

Dr. Eden spent three months in South Vietnam, working with the National Agricultural Center in organizing a University of Florida program for improvement of instruction in agriculture. This work is under a United States AID special contract to the University of Florida, which now has a team in Saigon. The student society, Alpha Zeta, at the U. of Florida, elected Dr. Eden "Professor of the Year" in the College of Agriculture, a highly coveted award.

The Committee Report noted that R. E. Dixon spoke to the Westside Civitan Club of Jacksonville on "Entomology as a Career." As Representative to the Florida State Legislature, 25th District, Mr. Dixon reported that membership of the Fertilizer and Pesticide Technical Committees was enlarged by the Legislature. House Bill No. 409 gives the Commissioner of Agriculture additional licensing and regulatory authority over pesticides by providing for the licensing and regulation by him of the sale, possession and use of restricted pesticides. House Bill No. 299 gives the Commissioner of Agriculture the authority to issue, hold, remove, or stop orders for any pesticide held in violation of the pesticide law, and House Bill No. 304 permits bulk delivery of pesticides subject to rules and regulations of the Department of Agriculture.

The Florida Structural Pest Control Law, originally passed in 1947, was substantially changed. The former Pest Control Commission has been eliminated and all the administrative responsibilities of this law have been placed under the jurisdiction of the Bureau of Entomology, Florida State Board of Health.

Legislation was introduced during the past session which would have banned the use of several important insecticides within the State. None of this type of legislation was passed at this time, but it is felt that it will be reintroduced in future legislative sessions. Entomologists should keep a sharp eye open for this type of legislation in the future as it so closely relates to the health, sanitation, comfort, and economic welfare of the State.

The full text of the Public Relations Committee report may be borrowed from the Society Secretary on request.

W. C. Adlerz
W. G. Eden
M. J. Janes
R. B. Johnson
W. B. Gresham, Jr., Chairman

Report of the Auditing Committee

The Auditing Committee has examined the books of the Business Manager for the fiscal year ending 31 July 1969, and has found them to be in good order and in balance. We wish to commend R. D. Patterson for the orderly manner in which he has kept the books.

H. H. Samol
R. B. Workman
R. E. Waites, Chairman

REPORT OF TREASURER-BUSINESS MANAGER FOR YEAR ENDING JULY 31, 1969

RECEIPTS:	
Cash used for change at 51st Ann. Mtg. in Clearwater	$ 100.00
Registration fees	402.00
Hospitality Hour contributions	340.00
Dues	1544.00
Subscriptions	916.00
Advertisements	711.53
Reprints and plates	2286.76
Back issues	683.54
	6983.83
Cash on hand July 31, 1968	2825.93
	$9809.76
DISBURSEMENTS:	
Cash used for change at 51st Ann. Mtg. in Clearwater	100.00
Programs for 51st Ann. Mtg.	91.74
Jack Tar Hotel	492.66
Art work Ent. Soc. banner	7.35
Entomology in Action, 4H foundation	150.00
Overpayment refund	2.00
Supplies for Business Manager	12.64
Cabinets for Florida Entomologist journals (back issues)	170.21
Postage and box rent	80.71
Storter Printing Co.—Fla. Entomologist reprints, etc.	3209.94
Help for Business Manager (Mrs. J. Shuler)	170.25
Plaque	30.50
	4518.00
Cash on hand July 31, 1969	5291.76
	$9809.76
ASSETS:	
Savings Account—	
Guaranty Federal Savings & Loan Assn. balance	2778.88
Interest earned	127.14
	$2906.02
Cash on hand July 31, 1969	5291.76
Total	$8197.78

R. S. Paterson, Business Manager

REPORT OF THE RESOLUTIONS COMMITTEE

BE IT RESOLVED by the Florida Entomological Society that:

The Society shall recommend and support all efforts to have the State of Florida provide funds to construct a biological control unit at the headquarters of the Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, for the purpose of providing adequate and safe space to conduct investigations of promising, exotic biological control agents.

The Society recognizes the importance of this facility to the field of entomology specifically and to agriculture in general because of the limited uses of certain chemical pesticides.

The Society further recognizes that no other organization has such a facility for these investigations.

The Society will send copies of this resolution to the Commissioner of Agriculture, Director of the Division of Plant Industry, Florida Agricultural Council, and the Florida Entomological Society Chairman of Public Relations to distribute to those legislators serving on committees for agriculture in Florida and other interested agencies and associations.

BE IT RESOLVED by the Florida Entomological Society that:
The Society favors the establishment of an Arthropod Pathogen Center at Florida Technological University at Orlando and gives to the effort to establish such an institute its whole-hearted support.

Said institute will be concerned specifically with the diagnosis of insect diseases and maintenance of cultures of the various pathogens.

A committee be appointed to give advice in the establishment of the center.

The above-mentioned committee consist of co-chairmen W. G. Eden and George Allen and members Clay McCoy, G. E. Greene, R. E. Lowe, and W. H. Whitcomb.

WHEREAS the Society is aware and deeply appreciative of the efforts and time of the Local Arrangements Committee in providing excellent facilities and

WHEREAS the Program Committee has provided an interesting array of papers, including those by the invitational speakers,

BE IT RESOLVED THAT: the chairmen and members of these and all other standing committees and the officers of the Society be given a grateful vote of thanks.

WHEREAS the members of the Society appreciate the accommodations and services of the Sheraton Hotel,

BE IT FURTHER RESOLVED THAT: the Secretary write a letter to the Management expressing the thanks of the Florida Entomological Society.

L. A. Davis
D. H. Habeck
W. H. Whitcomb, Chairman

REPORT OF THE NOMINATING COMMITTEE

The Nominating Committee offers the following slate of officers for 1970:

President:	H. A. Denmark
Vice President:	L. C. Kuitert
Secretary:	F. W. Mead
Treasurer:	J. R. Strayer
Executive Committee:	J. T. Reinhardt
	A. G. Selhime

R. M. Baranowski
J. L. Taylor
W. G. Eden, Chairman

A motion was made, seconded, and approved for the Secretary to cast a unanimous ballot for the nominees presented by the Nominating Committee.

The gavel was turned over to incoming President Harold A. Denmark.

The meeting was adjourned at 11:30 AM.

F. W. Mead, Secretary