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A NEW PAGE IN INSECTICIDAL PRODUCTION FOR THE PROTECTION OF VEGETABLE CROPS[1]

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World War II was the impetus that started economic entomology on its way to a broader and more efficient insect control. In this country, DDT was the organic insecticide responsible for all of this enthusiastic and fact finding research. DDT has been the guinea pig and standard for all of our organic insecticides, and practically every insecticide manufacturer has initiated a program to produce a material superior to DDT. As a result, we have many promising organics in the chlorinated series, such as chlordane (chlordan to the chemists), dichlorodiphenyl dichlorothane (DDD), methoxychlor, chlorinated camphene, and benzene hexachloride (low gamma and essentially pure gamma isomer base material). Of more recent introduction are the members of the phosphatic group—hexaethyl tetraphosphate, tetraethyl pyrophosphate and parathion. There still is a large and promising array of insecticides known only by their laboratory code numbers. Another group includes the botanicals such as pyrethrum, rotenone, Ryania, Sabadilla, nicotine, and others, all of which play an important part in agriculture.

It has become a common expression among research workers and representatives of manufacturers to remark "Am I confused?" It is obvious why we have this confusion, but fortunately this picture is being cleared as quickly as time and funds permit. As Garner said, "Every man after a certain age is entitled to his conclusions and confusions."

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[1] Presidential address, 1948 meetings.

Mailing Date: July 19, 1949

There isn't one of us present that can't remember back when the standard reply to an inquiry was, "if it is a chewing insect, use arsenicals or cryolite, if a sucking insect, use nicotine." If properly applied, a grower managed to produce a crop. Our new organics and inorganics have not entirely replaced our old insecticides because there still is a big demand for arsenicals, cryolite, nicotine, pyrethrum and rotenone where their past records have proven their value.

Enough time has now elapsed so that intelligent growers and the public realize that DDT did not end their insect problems. Such is true with our other organics. Too many of these are specific for a limited number of insects, some even to species within a genus. The growers' as well as the workers' ideal is one compound that is general for all chewing and sucking insects. We don't have any such material, so therefore, the doors have not been closed to research seeking for new and more powerful chemicals.

I dare say that more emphasis has been placed upon the importance of toxicity to man, toxicity to plants and harmful residues in the past five-years than in all of the time previous. Is it due to the fact that we have become more conscious of these factors or is it because our older materials did not present these problems? Every one understands the tolerance placed upon certain fruits and vegetables and this was used as a criterion for our research. We know that all insecticides should be treated as poisons and applied with care. We also know that many of our old insecticides were phytotoxic and were just not applied to plants. Harmful residues were explained under the heading of tolerance. Residues in the soil are an important factor. My own classic example is the application of lead arsenate in my garden to kill the grubs. I thought that the application would not last long in a sandy soil but would leach out. Such was not the case. I couldn't grow anything on it for three years. I have since learned that perhaps I could have corrected the problem but it was my garden and I didn't.

You see, we had our same problems before with the older materials, but perhaps did not place too much importance thereon. In many parts of Florida, the custom has been to clear off and prepare new land each year for a crop. It is true this did hold down certain insect populations, plant diseases, and prevented any soil residue problems. With new land each year becoming more scarce, growers are using the same fields over again.

Perhaps more alarm has been shown over the harmful residues left in the soil after heavy applications of organics for both soil inhabiting and aerial types of insects than ever before. Some very disquieting reports have been issued from the northern states on harmful effects of DDT in the soil to certain crops.

Florida being an insecticide manufacturers paradise has used great quantities of organic materials for the control of certain soil inhabiting insects. DDT was the first material used in the soil in any great quantities. Some greenhouse tests with peppers showed no significant difference up to 5,000 pounds actual material per acre. Tomatoes were more sensitive, significant reduction beginning with 800 pounds actual per acre. In a laboratory test, lettuce was grown in soil containing varying amounts of DDT up to 500,000 lbs. actual DDT per acre. There was no difference in the growth and appearance of the plants up to 50,000 pounds. The soil with the high amount was like putty, being half sand and half 50W DDT. This amount failed to kill the plants and after a month's time when the experiment was discarded, one dwarfed lettuce plant was removed to good soil, and it grew and produced a normal head of lettuce. These are all tremendous amounts of material, but we were attempting to reach a toxic range. Under our Florida conditions, it is doubtful if we will have to contend with a residual effect in the soil. We have not tested all of the new materials by any means and perhaps never will as it is a long process. You grow a crop under these conditions and follow up with the same or a different one to see how long these effects may be noted. Chlordane has been used up to 50 pounds per acre with no effect on the germination of seedlings of vegetables in seedbeds. The tobacco men have a different story as injury occurs there.

Phytotoxicity is of primary concern to every one. The new materials have a specificity toward plants. Some plants may be treated with safety at any time. Others have to be perfectly dry or burn will result to the new growth. This factor is one of the reasons why we like to apply our insecticides in the afternoon and evening. Phytotoxicity does not have to appear as damaged plants but may show only as decrease in yield. A field of cucurbits may look green and healthy and the grower is real proud of his insect control. Because he has not run any check he does not realize how many hampers are missing at the end of the harvest.

We briefly mentioned tolerance limits but now we think of our materials in terms of toxicity to man. All insecticides are poisons, but some are many times more toxic than others. It is this toxicity to man that is of the utmost concern to all. New materials appear so fast that they are not fully tested so, with many, there is still a question of doubt as to their safeness. Many of the new insecticides break down fairly rapidly under our sunlight conditions, thus enabling us to give the grower a little wider range of latitude of safety between the last application and harvest.

All growers want to combine their insecticides and fungicides and frequently include secondary nutritional elements. Think of the fungicides which include the carbamates and coppers and then the insecticides of the chlorinated and phosphate group—not to mention cryolite and the arsenicals. To this may be added the nutritionals such as iron, manganese, zinc, boron and copper, if no copper spray has been used. One time a grower called up and inquired about the advisability of mixing a carbamate and copper plus a chlorinated insecticide, some iron, manganese, zinc and then some ammonia. I told him I never tried such a combination and certainly would not advise it. He then said "I put her on". I am no longer confused, just numb.

Compatibility of material is of utmost importance. We think of compatibility in chemical, physical and biological terms. The manufacturers have screened their materials and stated on their labels that such a material can be used in safe combination with some and not with others, generally those of an alkaline nature. We are interested in all three phases because a material cannot settle out, curdle or in other ways mess up a spray machine. Particularly are we interested in the biological compatibility as it affects the control of our insects and fungi. Some very interesting phenomena have shown up in some of our carbamate and chlorinated combinations. Very definite chlorosis is visible, sometimes within 24 hours after application. This occurs on new growth of fast growing plants. It is not evident on older and slow growing plants. Its effect upon yield has not been evaluated.

Recently, I was asked by a group of interested citizens what was my opinion of the value of mosquito control and its effect upon wild life. My answer was in favor of it because it has been found that DDT, used with care, is not harmful to wild life. In this same connection, the bee keepers were quite alarmed about the insecticides used on cucurbits. They need not be, if the growers will cooperate and apply their insecticides on cucurbits in the afternoon and evening. Bees do not remain in cucurbit fields long after noontime. Applications that are made will be on old flowers. The new ones that open the next day are the ones that will be visited by the bees and there is less likelihood of the bees picking up the poison.

THE COMMERCIAL ANGLE

As previously stated, Florida uses a tremendous amount of insecticides. Thus the economic stake is considerable for every company is interested in placing its material before the public eye. Florida offers a year around growing program, something we often forget. Little if anything of commercial vegetable importance is grown in central and south Florida from June to August. But in northern Florida, crops are in full swing at that time. I mention this to show how complicated the picture is for the insecticide representative. At times the research man in particular sections is "talking to himself"—how about this representative I have mentioned? At times I become quite critical of some of the methods used to put across a material, but when I calm down, I realize they are in it for the money. Sometimes a product is put on the market prematurely. We all realize the lack of wisdom in doing this. We research men are likely to forget the amount of capital invested in a new product. We don't like the high prices demanded just because the company wants its returns from the pilot plant venture. This isn't the entire picture by any means. When a product is considered ready for the trade, a substantial inventory of the material must be in each district or area. Suppose a change in formulation is necessary before the present inventory is moved, then considerable readjustment must be made. This means then a re-education of that particular representative's clients, and may cause considerable grumbling.

The commercial representative can help the research work by discouraging the too frequent and sometimes promiscuous use of high priced insecticides. Many of these are sold on credit. A loss to one is a loss to all.

In summing up the manufacturer's side of the picture, they can help the research worker by adequately screening out their materials, giving generous samples for investigational work, and allowing the material to be tested a normal gestation period (a term used by my good friend, George Decker). Curious as it may seem, some concerns still are hesitant to supply adequate samples. One very well known firm just sent tiny exhibition samples and then expected full field reports back on the material. Those samples went in the waste basket. We generally ask for enough material to run two seasons; in that way we can test a batch lot in the fall and in the spring.

THE ROLE OF THE RESEARCH WORKER

The state research worker and the manufacturers work hand in hand. It is our duty to adequately and carefully evaluate material sent to us for experimental investigation. By that we mean a product ready for use if not already on the market. We cannot serve as screening depots and test a number of experimental materials. Florida is a wonderful testing ground by reason of the fact that crop production is a year around proposition somewhere in the state.

New materials appear so fast that we are able only to hit the high spots and are happy to report in a preliminary way on the toxicity to insect, phytotoxicity, toxicity to man, residual effects in the soil and then hope that we can come back later and do a more thorough job of evaluating the materials.

Everyone present knows how complex the situation is. It is no longer a job for the entomologist. He runs into problems that require the assistance of chemists, plant pathologists, plant and insect physiologists, toxicologists, ecologists, etc. Just to touch lightly on the last subject, the ecological relationship, a material may be specific for an insect in one section of the country and fail miserably elsewhere. This same condition may be true within a state.

In our rush, we have not had the time to evaluate these new materials under various weather conditions. Some materials respond well during dry weather, others in wet weather. Apparently, from recent tests conducted, a material needs only to be on the plant an hour's time to prove effective. We know of one material, very effective for subterranean insects, whose efficacy is increased following artificial watering or a light shower. This same material applied to a plant for aerial types of insects is again apparently activated by frequent rains and goes so far as to reduce the yield of the fruit. I mention these illustrations, as perhaps some of the reasons why a material may fail after apparently proving itself a good insecticide.

In conclusion, we have presented some of the facts as we see them. Yes, we are still confused. New products continue to be called to our attention. A new product is a new problem and limited time does not permit us to break down this confusion. We all do the best we can. We supply the manufacturers and growers with the best answers that only limited data provide. The challenge of the "new" is very demanding. We have turned a new page in insecticidal production and with plenty of energy and a dash of luck, we can keep pace and supply the information they are asking us to give.

OBSERVATIONS ON THE INCREASE OF APHIDS ON CELERY FOLLOWING THE APPLICATION OF COPPER A COMPOUND AS A FUNGICIDE

By J. W. WILSON
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For a considerable period of time the fact that application of certain materials to various crops tends to be followed by an increase of one or more insects, has been generally recognized by Entomologist and Plant Pathologist. For example, Folsom in 1927 attributed the initial infestations of aphids on cotton following the application of calcium arsenate to the positive phototrophic reaction of the winged females. Bonde and Snyder (1946 and 1947) reported a significant increase of aphid populations in potato plots sprayed with Bordeaux Basic Copper Sulfate, Karbam Z, Karbam Z and soap and Dithane. They also observed that aphid populations are often greater in fields sprayed with Bordeaux than in those receiving applications of neutral copper fungicide. Wylie (1948) reporting on his work on the control of aphids on celery with insecticides combined with fungicides stated that the aphid populations on the plots treated with Bordeaux were significantly greater than on the untreated plots. Thompson (1936, 1937 and 1940) observed the buildup of purple scale on citrus following the applications of Bordeaux. He found that the scale populations increased with the amount of residue deposited on the citrus leaf, and

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Moore (1935) studied the reaction of the potato aphid to potato leaves sprayed with bordeaux and concluded that the winged females were attracted to the bordeaux sprayed leaves because of the greater amount of light reflected by the bordeaux sprayed leaves. Aphids caged on sprayed and unsprayed leaves did not increase faster on the sprayed leaves. There was no difference in the wave length of light reflected from the sprayed and unsprayed leaves, but more intense light was reflected from the bordeaux sprayed leaf surface. When fast green dye was combined with 5-5-50 bordeaux and applied to potato leaves the number of aphids was less than on the bordeaux sprayed leaves but greater than on unsprayed leaves.

During the fall of 1947 an experiment was conducted on pascal celery in which Fermate and Zerlate at one pound each to 100 gallons of water and Copper A Compound at five pounds to 100 gallons were applied at 7-day intervals as fungicides. Triton B 1956 at the rate of 160 cc. per 100 gallons was added to both fungicides as a spreader sticker. Eleven insecticides were combined with each of the fungicides when the aphid population became large enough to require treatment. The celery plants were transplanted to the field on October 28 and the application of fungicides was begun seven days later with a total of twelve fungicide applications for the season. Insecticides were combined with the fungicides December 9, 22 and January 16. The spray materials were applied by means of a pressure sprayer operating at 300 pounds pressure. The spray machine was equipped with a six row boom having three nozzles to each row. This equipment applied the spray material at the rate of 105 gallons per acre. The plots were arranged in a randomized block design with six replications. Aphid counts were made at approximately 7-day intervals beginning December 2, by recording the aphids on ten trifoliate leaves plucked at random from the two center rows of each plot. No other insect attacked the celery during the growing season. Very light and widely scattered infestations of red spider were found a few days before the celery was harvested. A sample of the aphids was identified by Dr. A. N. Tissot as *Aphis gossypii* Glover.

Table 1 lists the insecticides, the concentration and the source of the insecticides used.

TABLE 1.—LIST OF THE INSECTICIDES, CONCENTRATIONS AND SOURCE OF THESE INSECTICIDES APPLIED TO PASCAL CELERY IN COMBINATION WITH FFRMATE-ZERLATE AND COPPER A COMPOUND DURING THE GROWING SEASON 1947-48.

Treatment No.	Material	Amount per 100 Gallons Water	Source
1	25% DDT Emulsion	1 qt.	Rohm & Haas Company
2	6% gamma isomer Benzene Hexachlor.	4 lbs.	California Spray-Chemical Co.
3	25% gamma isomer BHC	1 lb.	California Spray-Chemical Co.
4	48% Chlordane Emulsion	2 qts.	U. S. Rubber Company
5	40% Chlorinated Camphene	4 lbs.	Pennsylvania Salt Company
6	50% H.E.T.P.	½ pint	California Spray-Chemical Co.
7	50% T.E.P.P.	½ pint	California Spray-Chemical Co.
8	50% Methoxy DDT	4 lbs.	E. I. Du Pont
9	25% Parathion	½ lb.	American Cyanamid Company
10	25% DDD Emulsion	2 qts.	Rohm & Haas Company
11	40% Colloidal DDT	1 qt.	Michigan Chemical Company
12	Check		

Table 2 presents a summary of the aphid counts made during the growing season. From this table it will be noted that with a few exceptions the aphid population on the plots treated with Copper A Compound is considerably greater than on the plots treated with Fermate-Zerlate. This is true in the plots receiving the two fungicides alone, as well as in the plots where the insecticides were combined with the fungicides. It will also be noted that the aphid population was not high at any time during the growing season.

In an effort to account for this larger aphid population on the plots receiving Copper A Compound as compared with the plots treated with Fermate-Zerlate, pH determinations were made of the water used to make up the spray materials, and of the spray mixtures. The pH of Copper A Compound mixtures

TABLE 2.—APHID POPULATIONS AT 7-DAY INTERVALS ON PASCAL CELERY TREATED WITH FERMATE-ZERLATE AND COPPER A COMPOUND IN COMBINATION WITH VARIOUS INSECTICIDES DURING THE CROP SEASON 1947-48.

Date of Counts	Fungicide	Treatment Number											
		1	2	3	4	5	6	7	8	9	10	11	12
12/2	Cu	56	35	71	75	52	78	106	61	65	58	100	55
	F-Z	63	78	43	96	65	113	32	33	72	54	58	53
12/16	Cu	70	84	64	132	85	46	30	79	22	70	48	211
	F-Z	41	49	51	44	25	36	36	77	11	7	27	139
12/22	Cu	45	133	106	176	113	173	110	346	95	97	72	274
	F-Z	93	38	61	45	57	36	55	92	17	47	60	241
12/30	Cu	67	146	82	71	106	118	129	116	54	43	34	348
	F-Z	73	56	63	66	57	70	72	84	93	43	60	196
1/6	Cu	112	161	126	250	70	138	155	104	64	47	79	342
	F-Z	71	65	81	113	58	68	81	55	80	13	40	151
1/12	Cu	150	148	308	97	55	155	265	104	143	31	35	297
	F-Z	92	91	87	136	38	48	91	34	36	16	55	82
1/21	Cu	135	71	80	170	121	225	118	122	18	29	172	217
	F-Z	48	28	21	77	27	49	30	28	41	38	31	45
1/26	Cu	67	62	51	199	48	77	47	37	18	13	39	77
	F-Z	14	21	7	29	16	13	11	23	29	7	16	13
2/2	Cu	69	59	51	259	118	111	71	51	33	30	80	18
	F-Z	17	16	18	114	30	95	11	25	33	44	26	9
2/10	Cu	32	49	51	71	72	46	50	46	55	62	95	72
	F-Z	64	63	24	51	40	51	34	26	74	31	34	20
2/20	Cu	29	38	60	50	45	25	31	37	67	39	57	63
	F-Z	6	42	34	11	14	24	18	38	79	35	27	57

was very slightly lower than the pH of the Fermate-Zerlate mixtures. Furthermore, there was no difference in the pH value of samples of the plant juices from the plots treated with the two fungicides. Thus it would appear that the pH of the spray mixtures or the pH of the plant juices had no influence on the aphid populations in these plots. It has been suggested that the Copper A Compound mixture might destroy the parasitic fungi attacking aphids and thus allow a more rapid increase in the numbers of aphids on the plots sprayed with Copper A Compound. No differences in the number of aphids killed by parasitic fungi was observed in the plots treated with these fungicides during the growing season. However, such an effect upon the parasitic fungi might have been unobserved because the aphid population was comparatively light in all of the plots. The amount of light reflected by leaves sprayed with these fungicides has yet to be measured. It has also been suggested that the applications of copper might have produced a physiological condition favorable to the multiplication of aphids. Plans have been made to test this hypothesis during the present growing season.

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A PRELIMINARY REPORT ON THE SNAIL *DRYMAEUS DORMANI* IN CITRUS GROVES IN FLORIDA

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An arboreal snail, *Drymaeus dormani* Binney, has been reported in citrus groves in Florida for many years. Often, growers have believed that the presence of these snails in their groves has been of great benefit. No real effort has ever been made to either substantiate or repudiate these claims. In the spring of 1946, the author started a study of this snail in three groves in Lake County and in one grove in Sumter County. The following discussion reports these observations and is an attempt to explain, in a preliminary way, the possible role of this snail in citrus culture in Florida. Continued observations will be necessary before more definite conclusions can be drawn.

HISTORICAL

In 1857, W. G. Binney (*1*)[1] described a snail taken by O. J. Dorman near St. Augustine as a new species, *Bulimulus dormani,* and in 1878, he (*2*) made a more complete and accurate description. A complete bibliography on description and synonomy is listed by Pilsbry (*6*) in his monograph on land shells written in 1946 and Norris (*5*), in 1947, described the activties of this snail in one grove in Lake County.

Following Binney's description, the snail was reported (*3*) near the Matangas River, at Port Orange, at Oak Hill in Volusia County, and on the Florida west coast between Cedar Keys and the Suwannee River. Simpson (*8*) in 1893, stated that he found several hundred shells in a heavy hammock north of the Manatee River, and that he also found the snail near Cunningham in Volusia County. In 1906, Sellards stated that the snail ranged as far north as the St. Johns River and south to the Caloosahatchee River. Pilsbry (*6*) lists the snail in Alachua, Duval, Marion, Webster, Manatee, Lee and Highlands counties. A variety *albidus* was created by Wright (*10*) from collections near Fatio in Volusia County, but considerable question is cast upon the validity of such a classification. In 1948, the author observed *D. dormani* in citrus groves in Lake, Sumter, Hernando, and Marion Counties and has reliable reports of its presence in groves near DeLand in Volusia County. To the

[1] Italic figures in parentheses refer to Literature Cited.

writer's knowledge, this species has not been reported south of Lake Okeechobee, and its range is confined to Florida. Pilsbry (*6*) stated that *dormani* is an apparent descendant of a Mexican species, and that it probably migrated to Florida via the southern United States in Pliocene times. It is, apparently, not closely related to any West Indian species.

BIOLOGY IN CITRUS GROVES

In discussing a generalized land snail, Binney (*2*) stated that they were usually vegetarians, that they laid their eggs in summer in the soil, and that they tended to be especially active at night or after a shower. During winter they hibernated by secreting a membrane-like structure, the epiphragm, across the opening of the shell. These generalities appear to fit *D. dormani* very well. Oviposition has been found to occur in the early part of the summer months. The onset of oviposition may vary from year to year, but it apparently extends over a period of six to eight weeks. In 1946, oviposition was well started by June 1; in 1947, it was delayed until about June 25; and in 1948, only a few eggs were seen by June 17. The onset of oviposition is probably partially determined by the onset of warm weather in the spring. However, there was an early spring in 1948, and the snails became active as early as February, but this did not result in early oviposition. This may have been due to the extremely dry weather which was experienced in May and June of 1948.

The eggs are laid in groups which vary from only a few to as many as 30, 40 or more. Since they are semi-buried, it appears that some effort is made to deposit the eggs so that leaves or other trash will partly cover them. They are laid near the base of a tree and the author has never observed them more than a few inches away from that general area. No data has been obtained on the necessary incubation period. There may be over a hundred eggs at the base of a tree and when they hatch, the lower part of the tree trunk may be literally covered with tiny snails measuring less than 2 mm. in diameter.

So far, the length of time required to reach maturity and the total life span have not been determined. Some evidence appears to indicate that the snails live at least three years, and possibly longer. They attain a maximum size such that the shell measures almost three centimeters in length. Tryon (*12*) suggests that terrestrial snails usually require two years to reach sexual maturity and that they live 6 to 8 years in captivity. Whether this applies to *D. dormani* will have to be further investigated.

The densities of the snail populations in the groves under observation have fluctuated from year to year. Heavy populations might occur for one or two years, and then this would be followed by a low population for the next year. The trees attain a slick appearance due to the feeding activities of the snails and an idea of the number of snails present may be calculated by the date when the trees are cleaned up. Where snails are common, this has been observed as early as mid-July, but when few snails are present, it has been delayed until as late as November. Mortalities are often heavy during the winter or fall months. In one grove there was a heavy population in October, but they died off before cold weather and very few snails lived to go into hibernation. During November and December, it was almost impossible to find a live snail in the grove. Cold weather may sometimes be a factor, but in this latter instance snail mortality cannot be attributed to low temperatures. Lack of food may have been a factor since the trees were free of sooty mold by mid-July. For the present, however, the reasons for the marked population changes from year to year must remain unexplained.

The snails usually go into hibernation in December. They seek shelter in cracks and crevices in the trees and under trash at the base of the trees. A few, however, remain on the foliage or on exposed limbs and go dormant there. They secrete a membrane-like structure (the epiphragm) across the opening of the shell, and securely attach themselves to some substratum. They remain there until warm weather, when they appear to become active at about the same time that the trees begin to grow.

EFFECTS OF SNAILS IN GROVES

The food habits of this snail have not been fully determined. Binney (*2*) states that land snails are largely vegetarians, and Pilsbry (*6*) describes a related species which feeds on minute algae on the trees. *D. dormani* obviously eats sooty mold, and it would appear that this was its main food source. Large lichens on the limbs and trunks and entomogenous fungi on white flies are not eaten, but green algal growth is removed from the wood. In the late summer and fall of the year, all the sooty mold may be gone so that the trees appear to have been oiled. The leaves are slick and glossy, and the wood is smooth and clean. The appearance of the wood is quite characteristic and at any season will serve as an easy guide to the trees which have or have recently had snail infestations.

In 1906, Sellards (*7*) discussed the fact that *D. dormani* removed sooty mold. In fact, this was what made the snail a valuable ally at the turn of the 20th century. At that time fruit was not regularly washed and then packed as is the case today. It was simply picked, put in a barrel, and shipped north. The advent of the whitefly and its attendant sooty mold forced the citrus man to wash his fruit before packing it. This added a new and expensive operation. However, where the snails had first cleaned the fruit, the washing was unnecessary. It is easy to understand why growers desired to maintain snails in their groves. The situation facing the grower today is entirely different, and different evaluations must be made of the snails and their cleaning activities.

Some citrus growers believe that the snails actually eat the scale insects on the trees, but the author has found no justification for such a claim and Norris (*5*) stated that it was doubtful that they ate scales. Purple and red scale populations have been checked at regular intervals in three groves with snail populations for more than two years. During that same period, scale infestations were checked in other groves on similar pest control programs. In these groves, zinc, copper and oil sprays were not used and only sulfur was applied. The data are too extensive to reproduce here and definite conclusions must await additional study. However, some of the groves had relatively heavy purple scale infestations and some had very light ones. Groves with and without snails were in both categories, and it could not be concluded that there were any less scales in the snail infested groves. Florida red scales were not a problem in any of them. In snail infested groves, a number of leaf samples were divided as to those which had been cleaned of sooty mold by the snails and those which had not. Less purple scales were found on the clean leaves. The author cannot conclude that the scales were removed by the snails, but rather that the lack of residue was the important factor and that as suggested by Thompson (*11*) and Holloway (*4*), purple scale is more prevalent in the presence of inert residues. It is possible that clean leaves may be a factor in maintaining low scale infestations, and therefore that snail infested groves would be expected to have less scales than other groves. Whether this be true or not, scale insect infestations could not be considered to have been a limiting factor in any of the groves involved.

No claims have been made by growers for the control of other citrus insects. In general, it has been noted that insect populations were similar in groves both with and without snail populations when these groves were not sprayed with compounds of zinc and copper, and with an oil emulsion. Thus, there were usually low scale and purple mite infestations and sometimes high rust mite incidence. These conditions are undoubtedly related to the fact that a biological balance has been attained such that scales and purple mites do not usually produce excessive injury. It is however, necessary to apply some sulfur if the grower wishes to produce fruit free from rust mite injury.

The problem of melanose should also be considered. Although no copper was sprayed in any of the snail-populated groves discussed above, the author did not observe serious melanose infection on oranges in either 1946, 1947, or 1948. Excessive melanose was noted on grapefruit in one of the groves. Although snails have been collected in abundance from the dead wood, and it is possible that they may eat melanose spores, no actual evidence of such has been obtained. It must also be noted that snail activity is at a minimum during the spring, when melanose control would be essential. Populations are low at that time, and there is little evidence of any cleaning activity.

YIELD AND COST OF PRODUCTION DATA

It is difficult to obtain accurate production records and also difficult to get the proper groves for comparisons. Table 1 shows yield and cost data for three groves in Marion County. All are close together and are operated by the same production man. The one with snails is the oldest and the trees are definitely larger than in the other two. All three are on virtually identical fertilizer and pest control programs. Costs for these groves and for those discussed below have been calculated on the basis of standard fertilizer material costs given the author by different concerns; standard dealer insecticide prices; and ¾ cent per gallon for the application of sprays and 1½ cents per pound for the application of dusts. In addition, miscellaneous charges include discing, chopping, and fertilizer distribution, all at $1.25 per acre, and taxes at $12.00 per acre. No pruning, irrigation, depreciation, etc., are included. Table 1 indicates that the presence of snails neither reduced the cost of production nor increased the yield in the groves considered.

TABLE 1.—A COMPARISON OF YIELD AND COST OF PRODUCTION IN THREE GROVES WITH THE SAME FERTILIZER AND PEST CONTROL PROGRAMS.

Variety	Pineapple		Parson Brown		Mixed Pineapple and Parson Brown	
Snails	No		No		Yes	
Year	Boxes per Tree	Cost per Box	Boxes per Tree	Cost per Box	Boxes per Tree	Cost per Box
1943	6.9	......	3.8	......	5.1	......
1944	5.9	......	3.6	......	5.2	......
1946	6.9	17¢	5.7	17¢	6.6	18¢
1947	3.7	29¢	5.9	17¢	6.1	25¢
Average	5.9	23¢	4.8	17¢	5.8	21½¢

Table 2 compares yield and cost data for two groves in Lake County. Both are old groves and are situated within a few miles of each other on the west side of the same lake. Both are cared for by the same cooperative association and have similar cultural and fertilizer practices. However, Grove A has no snails and is on a complete spray program which included the use of zinc, copper, DN, sulfur, and an oil emulsion while Grove B has snails and is treated only with dusting sulfur. The groves are both interplanted with various varieties and are essentially comparable. However, in Grove A, only 22 per cent of the trees are seedlings and grapefruit, while in Grove B, 37 per cent of the trees fall into these two varieties. In spite of this differential, Grove A has averaged almost twice as much fruit per acre as Grove B during the past three years. The fruit has cost more to grow on a per box basis with the discrepancy caused by the difference in spray and dust costs. It will be noted that although spray costs averaged 11 cents more per box in Grove A, miscellaneous charges averaged 4 cents per box less. This latter figure represents fixed charges, but does not include depreciation, interest on investment, etc. The cost per box for such fixed overhead is directly tied up with yield and decreases

TABLE 2.—A COMPARISON OF YIELLD AND COST DATA FOR TWO SIMILAR GROVES.

Year	Grove A — No Snails *						Grove B — Snails **					
	Boxes per Tree	Boxes per Acre	Cost per Box				Boxes per Tree	Boxes per Acre	Cost per Box			
			Fert.	Spray	Misc.	Total			Fert.	Spray	Misc.	Total
1945	4.0	338	21¢	14¢	6¢	41¢	3.1	225	25¢	2¢	9¢	36¢
1946	5.1	435	20	15	5	40	2.1	209	23	2	10	35
1947	5.3	452	12	11	4	27	3.6	260	12	2	8	22
Average ..	4.8	408	18¢	13¢	5¢	36¢	2.9	231	20¢	2¢	9¢	31¢

* Spray program includes use of DN, Zn, Cu, S, and oil.

** Pest control program consists of S dust only.

materially as yields increase. Although Grove B grows cheaper fruit, its yield is materially reduced and fixed charges are of greater significance in figuring costs.

Figures on the per cent of fruit sent to the cannery from each of these two groves are available for comparison in only three years. In 1943 and 1944, there was very little difference (See Table 3), but the per cent was slightly in favor of the sprayed grove. In 1947, when grades were considerably tighter, there was a striking difference in favor of the grove without snails.

TABLE 3.—A COMPARISON OF THE PER CENT OF FRUIT SENT TO THE CANNERY.

Variety	1943		1944		1947	
	Grove A	Grove B	Grove A	Grove B	Grove A	Grove B
Parson Brown	11	0	12	31	11	....
Seedling	20	34	49	41	53	81
Pineapple	27	37	35	49	33	95
Valencia	24	21	12	12	42	58
Average	21	23	27	33	43	76

No sweeping conclusions may be drawn from the yield and cost data presented here. Tendencies are evident, but more information is needed. There is certainly no evidence here to indicate that snail infested groves have yielded material benefits to their owners. Apparently, the snails do no harm, and when a grower does not wish to use a complete spray program, it is possible that they are of some benefit. However, this conclusion is not substantiated by any data collected by the author.

SUMMARY AND CONCLUSIONS

The activities of the snail, *Drymaeus dormani,* were studied in citrus groves in Florida for more than two years. Eggs were laid in June and July and hatched in July and August of each year. The snails hibernate in crevices and cracks in the trees during the winter months.

The snails feed on sooty mold and green algae on the trees. No evidence was found to indicate that they feed on infesting purple or Florida red scale populations. Scale infestations in snail groves were similar to those found in other nearby groves on similar pest control programs.

Cost and yield data for three groves on identical pest control programs did not show increased yield or decreased costs due to the presence of snails.

Cost and yield data from two similar groves, one with snails on a sulfur dust program, and one without snails on a complete spray program, showed that the grove with the complete spray program produced almost twice as much fruit per acre for a little more cost per box. Less fruit went to the cannery from the sprayed grove.

No detrimental effects of snails were noted, but data collected, so far, does not support the reported benefits attributed to snail populations in the grove.

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FIELD NOTES ON A COLOR VARIANT OF THE TWO-STRIPED WALKINGSTICK, *Anisomorpha buprestoides* (Stoll)[1]

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Large walkingsticks of a peculiar black and white coloration were first observed by the writer late in 1947 at Juniper Springs, Marion County, Florida. In October 1948 these same walkingsticks were found to be very abundant near Salt Springs, Marion County, Florida. Specimens were collected and submitted to the United States National Museum for examination. Mr. C. F. W. Muesebeck reported that the specimens had been examined by Dr. A. B. Gurney who considered the insects to be a color variation of *Anisomorpha buprestoides* (Stoll). The National Museum specialists urged that cage studies of these insects be made in order to definitely determine the correct taxonomic status.

In size and structure the black and white walkingsticks agree with descriptions of *Anisomorpha buprestoides* (Stoll). Several thousand pairs of the black and white form have been examined by the writer as well as a large number of pairs of the more typical brown form of *Anisomorpha buprestoides.* In the black and white walkingsticks the anterior margins of the joints of the antennae are consistently ringed with white. Also the tergites of the thorax and abdomen are each consistently margined with a black band posteriorly. This brings about interruptions of the "two dorsal light stripes" from which the approved common name of *Anisomorpha buprestoides* is derived. Comparable markings have not been found during examination of many pairs of typical *Anisomorpha buprestoides.*

The area where large numbers of the black and white walkingsticks have been found is a typical Florida scrub. Excessively drained sandy soil characterizes such an area. Typical plants of the scrub are the sand pine, *Pinus clausa* Vasey, Chapman oak, *Quercus chapmani* Sarg., myrtle oak, *Quercus myrtifolia* Willd., turkey oak, *Quercus laevis* Watt., tree lyonia, *Lyonia ferruginea* Nutt., rosemary, *Ceratiola ericoides* Michx., and the palmetto, *Sabal etonia* Swingle.[2]

Apparently the oaks are the favored food plants of the black and white walkingsticks. Feeding has also been observed on the

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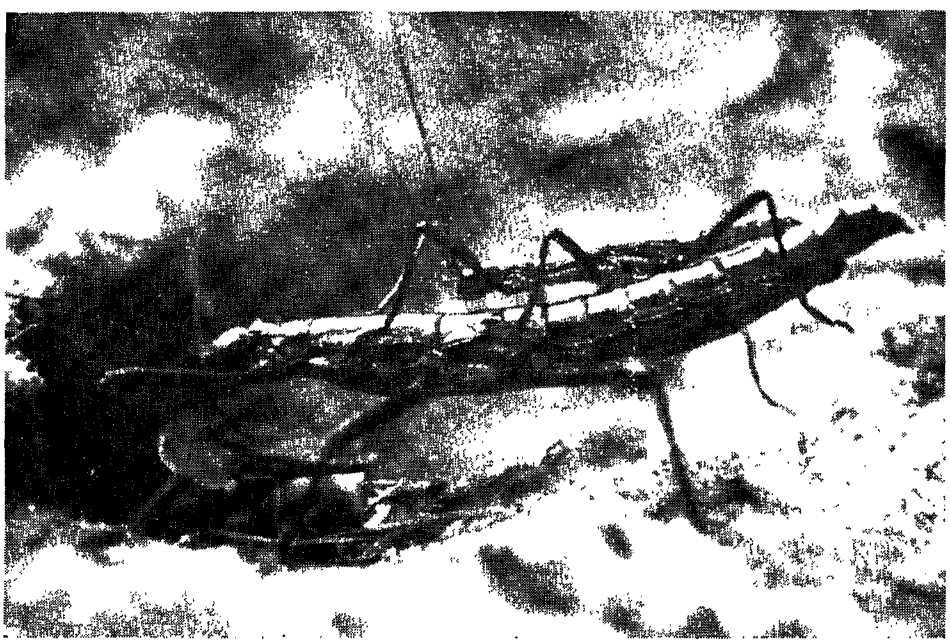
[1] Order Orthoptera, Family Phasmidae.

[2] Plant identifications were made by Miss Lillian Arnold of the University of Florida Agricultural Experiment Station.

foliage of rosemary and the tree lyonia. Fronds of the palmetto are a frequent resting place for the insect but no indication of feeding on this plant could be found. Occasionally the insects have been collected from the trunks of the sand pine but it is doubtful that the foliage of this tree would be acceptable as food.

Perhaps the most interesting observations made on the black and white walkingsticks were those on the oviposition habits of the insects. It is quite generally accepted that the eggs of walkingsticks are dropped randomly and indescriminately upon the ground beneath the food plants of the adults. Blatchley states that "the eggs are dropped loosely and singly upon the ground by the mother". Comstock has written that "the eggs are scattered on the ground beneath the plants upon which the insects feed, the female, unlike most Orthoptera, making no provision for their safety". In the black and white form of *Anisomorpha buprestoides* many females were observed to be digging small pits in the sandy soil, the eggs being dropped into these pits and sand being scratched over them by the females. Although no leg modifications for digging are apparent, both the prothoracic legs and the mesothoracic legs are used for this purpose. The mesothoracic legs are used exten-

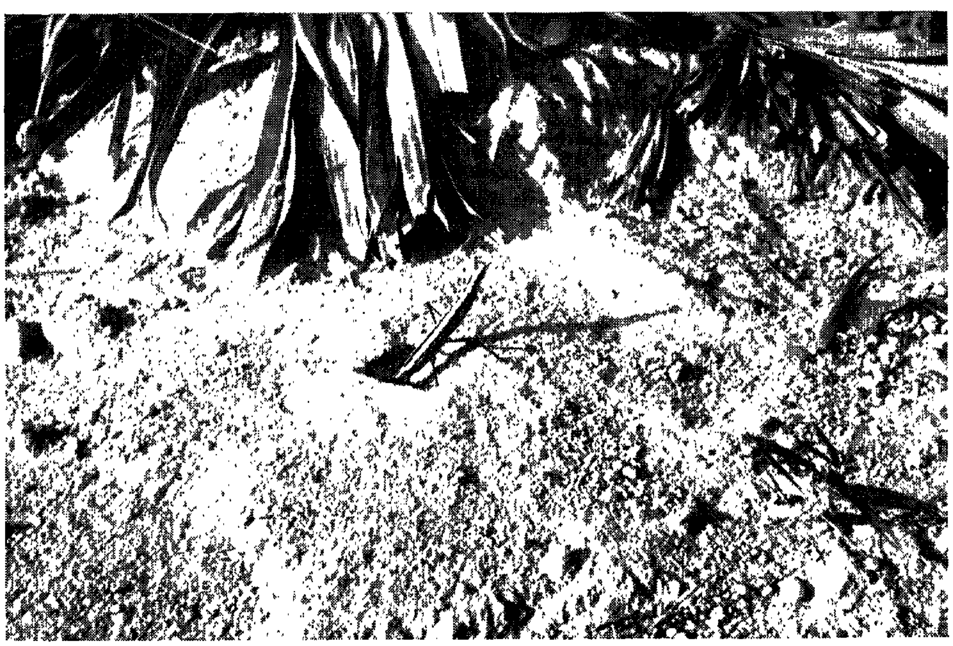


Pair of walkingsticks over excavation in sandy soil, in which the eggs are deposited. Photo by W. D. Sudia.

sively for covering up eggs that have been dropped into the depressions. Apparently not more than eight or ten eggs are laid into a hole; the female moves away and selects another location.

The male insect frequently remains attached to the female during the process of oviposition. At first sight this appears to be copulation but the male genitalia are attached to the ventral portion of the segment anterior to the genital segment of the female. Relative to *Anisomorpha buprestoides,* Littig has stated that "in the act of copulation this organ (aedeagus of the male) is typically inserted into the vulva, (8th sternite of female) as many specimens were collected in this position. Nevertheless, several males and females were collected with the male organ inserted into a midventral opening posterior to the 7th female sternite which is possibly a primative gonopore". Perhaps this is merely a means of aiding the diminutive male in clinging to the body of the female.

Apparently *Anisomorpha buprestoides* is one member of the Family Phasmidae that makes some provision to insure the hatching of eggs by digging them into the sandy soil. Perhaps the covering of sand assures optimum humidity conditions for the hatching of the eggs. The soil cover over the eggs may



Female of *Anisomorpha buprestoides* excavating pit in sandy soil for purposes of oviposition. Photo by W. D. Sudia.

serve to protect them from foraging birds or other predators. It seems doubtful that eggs beneath the shallow soil cover would survive winter fires that frequently burn over scrub areas but this is worth some consideration.

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INSECTS FROM BURROWS OF *PEROMYSCUS POLIONOTUS*

The following records of commensal or parasitic insects found in the burrows of the white-footed mice, *Peromyscus polionotus polionotus* (Wagner) and *P. polionotus rhoadsi* (Bangs) in Florida may be of interest in connection with the ecology of those forms:

In burrows of *P. polionotus polionotus:*

Siphonaptera—

Ctenophthalmus pseudagyrtes Baker (Det. J. Bequaert).

Jackson Co., Marianna, April 3, 1938, 1 specimen, C. C. Goff. Recorded only as a parasite of the Pocket Gopher, *Geomys bursarius* (Shaw), by Fox (U. S. D. A., Misc. Publ. 500, 1943).

In burrows of *P. polionotus rhoadsi:*

Orthoptera—

Arenivaga floridensis Caudell (Det. T. H. Hubbell).

Marion Co., Ocala National Forest, "Big Scrub" 11 mi. east of Ocala, March 11, 1939, F. N. Young [1 juv. ♀].

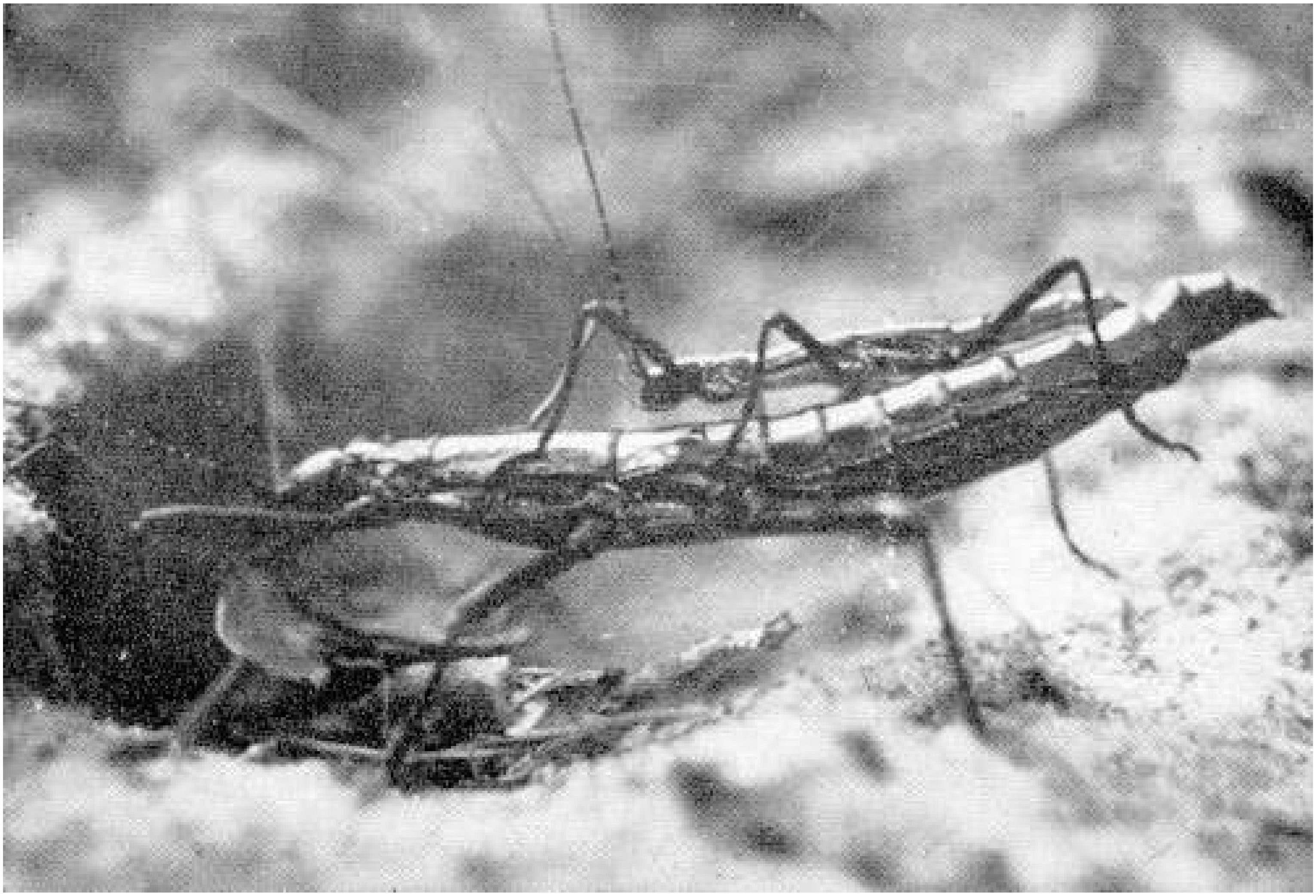
Ceuthophilus latibuli Scudder (All det. T. H. Hubbell).

Lake Co., Cassia, March 28, 1938, C. C. Goff [1 adult]; Emeralda, March 25, 1938, C. C. Goff [5 adults and juvs.]; Tavares, March 5, 1938, C. C. Goff [6 adults and juv.].

Marion Co., Ocala National Forest, "Big Scrub" 11 mi. east of Ocala, March 11, 1939, F. N. Young [7 juvs.].

Orange Co., Zellwood, March 23, 1938, C. C. Goff [1 adult].

—Frank N. Young, Department of Biology,
University of Florida, Gainesville.



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