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RANDOMIZED-BLOCK ARRANGEMENT FOR INSECTICIDE EXPERIMENTS ON CITRUS TREES

By HERBERT SPENCER and MAX R. OSBURN

United States Department of Agriculture, Agricultural Research Administration,
Bureau of Entomology and Plant Quarantine [1]

Since the end of World War II many new and promising insecticides have appeared on the commercial markets. Both State and Federal workers now have under way extensive experiments with these new materials on citrus trees, and a number of entomologists are employed by insecticide manufacturers to conduct grove experiments. In view of these developments, it seems appropriate to review an experimental design for comparing the effects of insecticides under orchard conditions, which consist of a randomized-block arrangement. This field-plot technique was adopted by the St. Lucie, Fla., laboratory of the Bureau of Entomology and Plant Quarantine more than ten years ago, after it was realized that variations in infestation between rows of trees were sometimes sufficient to invalidate the results of unreplicated row-treatment tests. Through repeated trials the randomized-block arrangement has proved to be a practical method for making true comparisons. Moreover, valid estimates of experimental error can be calculated readily from the data provided by this arrangement.

One of the problems which confront the experimentalist is natural variation in infestations. With scale insects, for example, no two citrus groves have exactly the same amount of infestation at any one time. Infestations differ in different localities, and in trees of different varieties, ages, sizes, and planted at different distances. Individual trees in a single

[1] K. W. Babcock, L. B. Reed, and especially F. M. Wadley, all members of this Bureau at the time this work was done, were very helpful in suggesting plot arrangements and methods of analysis.

grove may vary from no infestation to a heavy infestation; some tree rows may have more scales than others. Border trees adjacent to an older, heavily infested grove and along dusty roads usually have heavy infestations.

On the individual tree, scales are usually more numerous in the top, center, and skirt near the ground, generally as a result of poor spray coverage. Infestation on the north side may be quite different from that on the south side of a tree. One branch may have so many scales that it is killed, and another may have only a moderate infestation. Even the leaves on a single branch vary. Old leaves may have few scales, spring-flush leaves more, and new growth almost none. There is variation even among leaves of the same age and, indeed, in the number of scales on top surface and lower surface of the same leaf, or between right and left halves of a leaf.

The season of the year and the weather are important factors causing variations in infestation. A cold spell which causes defoliation may reduce infestations to a low level, and the most exposed trees may show the most effects. Excessive summer heat may influence the development of scales on one side of the trees more than on another side. Dashing rains and winds from one direction may change the pattern of infestation. Variations in the distribution of parasites, predators, and fungi affect the populations of their hosts.

The effect of this universal variability on the results of insecticide tests cannot be avoided completely by selecting locations for tests where the infestations are relatively constant. However, if a randomized-block arrangement with sufficient replications of the treatments is utilized and proper sampling techniques are followed, the effect of the factors that contribute to natural variation can be minimized.

In setting up a randomized-block experiment for comparing insecticides for control of scale insects on citrus, we include a set of unsprayed check trees to demonstrate the natural infestation. A standard insecticide, such as 1-percent emulsible oil, is also included for comparison with the new insecticides or combinations.

For a 10-treatment experiment a block of 120 trees or more is selected, with few skips, runts, or replants, and with a moderately heavy infestation, as nearly uniform as possible. After each tree has been examined, a map of the grove is prepared, and the missing trees, or those showing lack of uniformity, are indicated by symbols. There must be at least 100 uniform trees, excluding those in border and ditch-bank rows and those along dusty roads or on the outside edges of the block. On the map 10 compact blocks of 10 good trees each are marked off with circles. These blocks are numbered.

Code letters are assigned to each treatment, usually "O" for unsprayed, "A" for the standard spray, and "B", "C", "D", "E", etc., for the new insecticides or treatments to be compared. Ten corks marked with these code letters are put into a paper bag, and then drawn out one by one. The trees of block 1 are marked on the map with the letters as they are drawn. The corks are put back into the bag and then drawn again for a similar assignment of treatments to the trees in each of the other blocks. Thus the assignment of the treatments to the trees of a block is entirely by chance, and the blocks are randomized. The result is an experiment of ten blocks (replications), each of which contains one tree of each treatment. Each treatment is subjected equally to whatever variation in infestation exists between the different parts of a grove.

The trees are tagged with the code letter indicated on the map, to serve as a guide for the application of the different treatments. It takes longer to spray the scattered trees than to apply row treatments, but this disadvantage is more than offset by the elimination of possible effects on data from row variations or from variation between sections of the grove.

Sampling is done just before spraying, one month and three months after spraying, and at the end of the year. At shoulder level around each tree 20 or more leaves are cut off with scissors. New-growth leaves on which infestation has not had time to develop are not taken. The 20-leaf samples are put into separate 2-pound bags, which are marked with block and tree designations, and then folded and stuffed into 10-pound sirup cans. These cans are kept in a refrigerator at 45°-50° F. until the scale counts are made.

For making the counts a binocular microscope is used. The scales on the leaves are counted and then turned over to see if they are living. Records of total and living scales for each tree and each leaf are tabulated separately. If two men are making examinations, each examines 10 leaves from each tree; if there are three workers, each examines 7 from each tree, in which case the samples must comprise 21 leaves per tree. In this way the effect of variability between workers is minimized. If scales are numerous, only half of each leaf may be examined. The comparisons of the Florida red scale, mature females of which are present throughout the year, are based on living mature female scales per leaf, or per half-leaf.

When all samples have been examined, the tree totals, treatment totals, and block totals are calculated. Since the values so obtained are at best careful estimates, we must analyze the data statistically before drawing conclusions. Some idea of the within-treatment (between-tree) variations may be obtained by calculating the mean number of scales per tree-sample (or per leaf) and then the standard error for each treatment (Snedecor *1*, pp. 41 and 61). If the treatment values differ far beyond the limits of the standard errors, real differences due to the insecticide treatments may be assumed.

Much more information can be obtained about our data if we submit them to an analysis of variance (Snedecor *1*, pp. 214-317). Variance is a numerical measure of variation, and the error variance for a mean is the square of its standard error. From the analysis of variance we may estimate the relative importance of the variation between leaves on individual trees (sampling error) and the variation between trees. The variation between trees includes the following:

(a) Variation between blocks (replication)
(b) Variation between treatments
(c) Variation due to other factors (experimental error)

The calculation of variance does not require higher mathematics, but merely involves adding the squares of the items involved, subtracting a correction term easily calculated, and dividing by the number of items involved less one. Before this division is made, the different estimates of variation are reduced to a common denominator, and the estimate for error is obtained by subtracting from the total. If the experimental error is low in comparison with the treatment variance, we may be reasonably certain that the differences in treatment values in the table are real and not due to chance variation.

By use of simple formulas (Snedecor *1*, pp. 406, 426) it is possible to calculate the least significant difference and least highly significant difference between treatment values. If two treatments differ in living scale populations more than the calculated least highly significant difference, the chances are 99 to 1 that one was actually more effective than the other.

The method of sampling to determine the scale infestation in the different treatments of extreme importance. As only fractional samples can be examined, the infestation estimates based on them differ from the whole, and to the extent to which they have been subjected to other causes of bias. If small samples are taken from each of the trees that are treated alike, it may be expected that the means will reflect the total infestation more accurately than means of large samples taken from only one or two trees. Bias can be avoided to a large extent by taking the samples at random in the manner which has been described.

From the sampling error and experimental error it is possible to test the probable effects of increasing the size of the sample and number of blocks (replications) on the treatment values. In our experiments with scale insects many such calculations have indicated that little increase in accuracy (reduction of standard error) is to be gained by increasing the number of leaves per tree from 20 to 50 or even to 100. More gain in accuracy comes from increasing the number of replications, but beyond 10 or 12 the diminishing returns in accuracy do not justify the extra work involved. With 20 leaves per tree and 10 replications, results from recent randomized-block experiments with insecticides against scale insects have been entirely satisfactory. This arrangement has been used also for insecticide experiments with the citrus rust mite, the citrus red mite, whiteflies, grasshoppers, the little fire ant, and, indeed, has been found suitable for experiments with many deciduous fruits and vegetable crops (Kelsheimer *2*).

By adopting the randomized-block arrangement for insecticide experiments on citrus, we have reduced the interference of variations in infestation between parts of groves and between rows. We have been able to segregate and compare the magnitude of treatment variations, which are our main interest, and other sources of variation in results. Small differences in results can be determined as significant and due to the insecticides, or as chance differences due to experimental variation. Proper sample size and the most adequate number of treatment replications can be determined for the particular insect under experiment. The excessively large size of the samples formerly examined can be reduced without loss in accuracy of results. From the randomized-block arrangement, with its opportunities for critical analysis of data, we can draw conclusions with much more assurance than from former arrangements.

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(1) SNEDECOR, G. W.
1946. Statistical methods, 4th ed. 485 pp. Ames, Iowa.

(2) KELSHEIMER, E. G.
1947. DDT treatments for control of mole-crickets in seedbeds. Fla. Agr. Expt. Sta. Bul. 434.

REPORT OF THE ANNUAL MEETING OF THE FLORIDA ENTOMOLOGICAL SOCIETY DECEMBER 12-13, 1947

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President Osburn requested each person to rise and give his name, business connection, and address. It was then announced that all committees except the auditing committee had been appointed. Mr. Norman C. Hayslip was named to this committee with the privilege of selecting someone else to assist him in auditing the books of the treasurer-business manager. Following these preliminaries, the president gave a few words of greetings to the society and then asked the vice president, Dr. E. G. Kelsheimer, to take the chair. Dr. Kelsheimer then presented Mr. Osburn as the first speaker of the day. Mr. Osburn's paper was titled "Comparison of DDT, Chlordane and Chlorinated Camphene for Control of the Little Fire Ant." After the presidential address, the other papers were presented in the order listed below:

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"Border Influences of Serpentine Leaf Miner Infestations in Potato Fields." D. O. Wolfenbarger.

"Results of the Use of Concentrated Sprays for Grasshopper Control." John R. King and J. T. Griffiths.

On Friday evening, the annual dinner was held at the Primrose Grill. The table was decorated in a Christmas motif by Mrs. Frank N. Young, wife of the chairman of the banquet committee. The dinner began with a vocal solo by Mr. D. U. Duncan acompanied on the piano by Mrs. Helen Wallace. President Osburn then introduced Dean Harold H. Hume, provost of agriculture at the University of Florida, who gave a most interesting discussion of the growth, problems, and needs of the University. Following Dean Hume's talk, the president introduced the speaker of the evening, Mr. W. G. Bruce of the U. S. Department of Agriculture, who addressed the society on the subject of the "Progress of Entomology." Fifty-eight members and guests attended the dinner.

On Saturday morning, December 13, at 8:30 A.M., the meeting of the society reconvened and was called to order by the president. The following papers were presented:

"Results of over 100 inches of Rains on the Mosquito Population of Palm Beach County." Ed. Seabrook.

"*Phyllophaga elizoria,* a Maybeetle, Damaging Young Orange Trees (Coleoptera, Melolonthininae)." W. H. Thames.

"Randomized Block Arrangement for Insecticide Experiments on Citrus Trees." Herbert Spencer and Max R. Osburn.

Following the presentation of papers, a business meeting of the society was called. The report of the secretary was approved without reading since it had been published previously in the *Florida Entomologist.* There was no old business. The president then called for new business. The secretary read a letter from the president of the Sociedad Entomologica Argentina requesting that the Florida Entomological Society exchange publications with it. This was approved by the members. The secretary presented the problem of exchanges of publications with other societies. It was then moved, seconded, and passed that the secretary be empowered to establish exchanges with other organizations. The possibility of securing subsidation for the publication of the *Florida Entomologist* from the University of Florida library was then suggested. It was moved and seconded, and then passed by the society, that subsidation would be acceptable to the organization. It was also moved and seconded and passed that the exchange library of the Florida Entomological Society be permanently housed in the University of Florida library, if it could be so arranged with the the University librarian.

The president then announced that the present treasurer-business manager, Mr. J. C. Crevasse, Jr., had submitted his resignation and that it was accepted by the executive committee.

Mr. W. G. Bruce thanked the society on behalf of the Texas Entomological Society for its expression of good wishes for the success of the Texas Society's annual meeting, and then returned the greetings to the Florida Society.

Dr. A. N. Tissot read a letter addressed to the late Professor J. R. Watson from an entomologist in Germany. The letter described the plight of the scientists in Europe and requested that, if possible, the society send some sort of aid. It was suggested that each person present might contribute fifty cents, the total sum collected to be used in sending food to the writer of the letter. A total of $20.50 was obtained and turned over to Dr. Tissot for purchase of food and cost of mailing.

Dr. J. T. Griffiths raised the question of the site for the next annual meeting of the Society and suggested that it not be held in Gainesville. Dr. Travis extended an invitation for the meeting to be held in Orlando, during which time the members of the organization would have an opportunity to inspect the U. S. D. A. laboratory there and see the methods of research being used in the study of insecticides. It was moved and seconded that the next annual meeting be held in Orlando. The society approved unanimously. There was some discussion about the date of the meeting; however, it was decided to let the executive committee decide the matter.

The report of the membership committee was then called for by the president. In the absence of the chairman of the committee, Dr. Frank N. Young presented the names of the persons listed below for the following classes of membership:

Associate members to be active members:

R. E. Bellamy
J. M. Bellows
I. J. Cantrall
C. M. Crutchfield
C. J. Goin
W. B. Gresham, Jr.
J. T. Griffiths
A. B. Grobman
J. S. Haeger
E. R. Jones, Jr.
R. B. Kleinhans
Douglas Maughn
W. H. Merrill
R. C. Morris
Thomas Smyth

Associate membership:

P. S. Arey	J. R. King
Mrs. Ernestine Basham	F. P. Lawrence
W. J. Decker	J. D. Rebstock
Fred Dexheimer	Ed. Seabrook
J. J. Diem	C. C. Skipper
Kelvin Dorward	D. J. Taylor
P. E. Frierson	H. T. Vanderford
L. A. Hetrick	R. K. Voorhees
D. W. Hookom	R. T. Wallace
S. B. Hopkins, Jr.	M. J. Westfall

Student membership:

C. E. Bingaman	W. W. Neel
Herndon Dowling	G. R. Reid
S. K. Eshleman	R. V. Roig
R. W. Hudson	D. R. Sapp
E. W. Knetch	E. L. Solomon
E. R. Krestensen	M. L. Wright, Jr.

Dr. J. W. Wilson moved that the report of the membership committee be accepted and that the persons named be accepted as recommended. The motion was seconded and passed unanimously.

Because of the absence of the treasurer-business manager, a financial report was not given.

The president then called for a report of the nominating committee. The chairman, Dr. A. N. Tissot, presented the following candidates:

President—E. G. Kelsheimer

Vice President—M. C. Van Horn

Secretary—Lewis Berner

Treasurer-business manager—G. W. Dekle (for two years to fill out the unexpired term of J. C. Crevasse, resigned)

Editor of the Florida Entomologist—H. K. Wallace

Associate editor—G. B. Merrill

Member of Executive Committee—J. T. Griffiths (two year term)

It was moved and seconded that nominations be closed. Mr. W. G. Bruce requested that the secretary be instructed to cast a unanimous ballot for the election of the above named candidates. This was passed by the society.

Mr. Max Osburn, retiring president of the society, then turned the chair over to the incoming president, Dr. E. G. Kelsheimer.

Mr. Hayslip, who earlier in the meeting had been appointed to the auditing committee, requested that a Gainesville member be substituted in his place to audit the books of the resigning treasurer-business manager. Dr. Kelsheimer then appointed Dr. A. N. Tissot to this committee.

The annual meeting was adjourned at 10:15 A.M.

A total of fifty-three persons signed the attendance registry.

Respectfully submitted,
LEWIS BERNER,
Secretary

COMPARISON OF DDT, CHLORDANE, AND CHLORINATED CAMPHENE FOR CONTROL OF THE LITTLE FIRE ANT

By MAX R. OSBURN
United States Department of Agriculture
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine

The presence of the little fire ant (**Wasmannia auropunctata** [Roger]) in the United States, was first noted by Smith (1929) in 1929, in Florida. Later in the same year Wheeler (1929) reported that he had received specimens of this ant from Florida in 1924. Several years later Keifer (1937) reported that the little fire ant was established in Los Angeles County, California.

Since its discovery in southern Florida, the little fire ant has spread northward into nearly all sections of the peninsula. At the present time it is a serious household pest in many areas, and an important pest to citrus-grove workers in some sections along the east coast of Florida (Spencer 1941, Osburn 1945). Recently Wolfenbarger (1947) reported that it caused disturbance among fruit pickers in a large guava grove near Opa Locka, Fla. According to Wheeler (1929) it is probably that the little fire ant may eventually become established in green houses in many parts of the United States, but will be able to survive out-of-doors only in the tropical portions of the country.

The worker ants visit the citrus trees to obtain honeydew secreted by aphids, mealybugs, whiteflies, and other insects. In heavily infested groves millions may be present. At times the trunks of citrus trees take on a reddish-brown cast, owing to the presence of so many individuals moving up and down the trees. The worker ants are small, and ordinarily not aggressive. They usually sting only when they are pressed or confined between the clothing and the skin. When trapped under these conditions—it is practically impossible to work in a heavily be substituted in his place to audit the books of the resigning treasurer-business manager. Dr. Kelsheimer then appointed Dr. A. N. Tissot to this committee.

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In citrus groves the ant nests in the soil or under fallen branches, leaves, fruit, or almost any type of debris found on the ground. The nests have no definite form, and consist of clusters of ants that vary considerably in numbers. In some of these nests workers, one or more queens (with or without wings), and eggs, larvae, and pupae have been found. In others only workers seem to be present, although the other forms may be farther down in the soil. The nests seem to be temporarily located, and during periods of extreme dryness the ants go deeper into the ground. Under extremely wet weather and flood conditions entire colonies may be found up in the limb crotches of trees or under pieces of loose bark.

DDT sprays and dusts have been very effective in killing the little fire ant and preventing troublesome reinfestations for periods of two months or longer, depending upon the concentration and quantity of material used (Osburn and Stahler 1946). One cooperative growers' association in St. Lucie County, Fla., treated over 400 acres of citrus during the past season in order that its grove hands could work without discomfort.

Since DDT first appeared as an insecticide, other chemicals have been developed which are showing insecticidal properties. Two of these, chlordane and chlorinated camphene, became availaible for experimental work during 1947. After preliminary tests indicated that they were effective against the little fire ant, critical field tests were made to compare their residual qualities.

EXPERIMENTAL PROCEDURE

The tests were carried on in St. Lucie County in an old grapefruit and orange grove that was heavily infested with the little fire ant. The sprays were prepared by dissolving 8 ounces of either technical DDT, technical chlordane, or technical chlorinated camphene in one-half gallon of Number 2 fuel oil, adding 19 ml. of phthalic glyceryl alkyd resin to make a stock emulsion, and then diluting the emulsion with water to make 100 gallons. The concentration of 8 ounces per 100 gallons was chosen because this amount of DDT has provided the best control with a minimum of cost. Generally, lesser quantities of DDT are not so effective, and little is gained by using greater amounts. Even though previous work had shown that oil sprays used alone at a concentration as high as 1.6 per cent were ineffective in controlling the little fire ant, a spray containing ½ gallon of fuel oil per 100 gallons of water was included in the experimental setup as a check. The sprays were applied thoroughly with a power outfit to the tree trunks and larger lower branches. Approximately 4 gallons of spray was used per tree.

The experimental design was that of randomized blocks. There were five replications of each treatment, and a single tree in each block received each treatment. Before the treatments were applied, a band 1 inch wide was stenciled with white paint around each tree trunk, below the lowest branch at from 2 to 3 feet above the ground level. The circumference of the tree trunks at this point ranged from 29 to 38 inches. At intervals following the applications, the treatments were compared by recording the number of ants on five of these bands per treatment, or a total area of slightly more than 1 square foot of tree-trunk surface per treatment. The data were analyzed statistically.

RESULTS AND DISCUSSION

A summary of the results is presented in Table 1.

TABLE 1.—NUMBER OF LITTLE FIRE ANTS FOUND ON CITRUS TREES AT INTERVALS AFTER TREATMENT WITH SPRAYS CONTAINING EQUAL AMOUNTS OF DDT, CHLORDANE, AND CHLORINATED CAMPHENE. TREES SPRAYED ON JUNE 27, 1947.

Treatment (8 oz. of specified material in ½ gal. No. 2 fuel oil [1] per 100 gal. of water)	July 10	July 24	Aug. 7	Aug. 22	Sept. 5	Sept. 26	Oct. 27
DDT	1	0	17	126	20	21	3
Chlordane	1	0	29	65	25	7	13
Chlorinated camphene	1	3	6	60	42	51	11
Fuel oil alone (check)	225	294	658	793	884	411	99
Difference required for significance at 5% level	50	60	171	119	112	262	44

[1] Fuel oil in all treatments made emulsifiable by adding 19 ml. of phthalic glyceryl alkyd resin to the oil.

The data, taken at approximately biweekly intervals from the time of application through September 26, and again on October 27, 1947, showed that DDT, chlordane, and chlorinated camphene were equally effective against the little fire ant, and that the fuel oil used alone was of no value. At no time was there a significant difference in effectiveness between the three insecticides; on each examination date all of them were significantly better than the oil alone.

The three treatments reduced and held the infestation to a low level until August 22, when their effects seemed to be disappearing, as more ants were found than on previous dates. Apparently the increases were due to ants that had developed after the materials were applied, and had not been exposed to the spray residues long enough to be affected. In confirmation of this theory, large numbers of dead ants that had not been there on August 22 were found at the bases of treated trees at the time of the next examination. On September 5, fewer ants were recorded in the three effective treatments, whereas the infestation increased in the oil treatment. These reductions were probably due to the residual qualities of the materials.

In the treatment consisting of fuel oil alone the ant infestation increased steadily until September 5. Shortly thereafter, during the week of September 14, a hurricane accompanied by heavy rains caused a reduction in ant activity, so that on September 26 only about half as many ants were present on the check trees as were found on September 5. Continued heavy rains and flooded grove conditions throughout the last of September, and most of October, were responsible for a further reduction in ant activity, as reflected in the records made on October 27.

The results of the work indicate that both chlordane and chlorinated camphene compare favorably with DDT for control of the little fire ant.

SUMMARY

Sprays containing equal quantities of DDT, chlordane, or chlorinated camphene in No. 2 fuel oil were compared for the control of the little fire ant (*Wasmannia auropunctata* [Roger]) on citrus trees. At the rate of 8 ounces per 100 gallons of water, the three materials were found to be equally effective and to reduce infestations significantly for a period of at least 12 weeks, when sprayed on trunks and larger limbs. No. 2 fuel oil used alone at a strength of 0.5 percent was of no value.

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BORDER EFFECTS OF SERPENTINE LEAF MINER ABUNDANCE IN POTATO FIELDS

D. O. WOLFENBARGER
Sub-Tropical Experiment Station

The manner in which insects infest plants and distribute themselves in a field is of interest and may be of value in determining control measures. Insects may be in a field prior to seedbed preparation and planting and infest plants as they begin growth. They may infest plants in the seedbed and be dispersed by man during transplanting. They may enter a field from the outside during the growth of the crop and become dispersed evenly over a field. They may, on the contrary, be unequally distributed because more insects stopped along the field border near the point of entry. Equalization of population or small and insignificant differences in distributions of a species over fields are attributable to two factors operating singly or in combination. These are (1) dispersability of an insect species, and (2) small fields or short distances under observation. These factors are considered to be operating where it appears that insects are evenly dispersed.

Interest is directed in this presentation to unequal distribution of insects, particularly to those cases in which more insects were observed nearest the insect sources outside of a field. It is recognized that unequal distribution of insects over a field, or border effects, may result from (1) unequal disper-

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Interest is directed in this presentation to unequal distribution of insects, particularly to those cases in which more insects were observed nearest the insect sources outside of a field. It is recognized that unequal distribution of insects over a field, or border effects, may result from (1) unequal dispersion from an outside source, (2) a converging or massing of individuals of a species in areas with more favorable local conditions, or (3) other factors. In this presentation the border effects of the serpentine leaf miner, *Liriomyza pusilla* (Meig.), in potato fields are attributed to unequal dispersion from outside sources.

Larvae of the serpentine leaf miner, restricted as they are to feeding between leaf surfaces, disperse very short distances, in terms of inches, from the point of egg deposition. Pupae of the leaf miner may be distributed by dispersion agents such as man, wind, water, or by other agents. The distance might be considerable but is usually negligible. The adult fly is the active disperser of the species. It was reported by Webster and Parks (1913) that the adult serpentine leaf miners emerging from hibernation "do not travel far before oviposition takes place." Information on definitive distances to which the serpentine leaf miner disperses are as woefully lacking as are those of most other insect species.

Marginal influences of fly activities were reported by Wolfenbarger (1947) for the severe leaf miner infestations recently encountered. As they became more abundant border effects were distinctly observed in several fields of tomatoes and potatoes, in large commercial fields. The tomato plants, first started in the fields in the area, attained large size and were heavily infested before the potatoes were attacked, so the tomato plants might have appeared to be a primary host plant of the insect.

Near the time of tomato maturity, the potato plants had grown so that they were attractive to the leaf miner adults. Definite fly dispersions were observed at this time. There were gradual and continuous movements of flies occupying days or even weeks of time. Flies were collected in nets, they were observed on the leaves, and a few days later plant symptoms of infestations were in evidence. These observations demonstrated that more flies were present where potatoes were planted to the west of tomatoes. Dispersion effects were less evident in potato fields to the south and to the north, and least to the east of tomato fields, showing decidedly directional effects.

Insects are generally considered to have their dispersion activities altered but little by winds. During the preparation of a summary on the dispersion of small organisms, Wolfenbarger (1946), references were encountered in which authors reported or alluded to winds which actively dispersed insects. Part of these references were devoid of numerical evidence. Most references which gave data showed little or no directional influence of insect dispersion attributable to winds. Insects, in general, are believed to seek shelter from winds which blow them about; they tend to control their dispersion activities. It is expected, however, that exceptions to this generality must occur.

During the observations on the dense leaf miner infestations the prevailing winds, although gentle, were from easterly directions. They were damp winds from the ocean but had passed over some 3 to 6 miles of land. It seems likely that the winds may have been instrumental in aiding dispersions toward the west. It might be questioned, however, whether the wind was an agent of propulsion toward the west or whether there was a repulsion affecting the easterly direction of fly dispersion.

OBSERVATIONS

LEAF MINES: In one large 80-acre field of potatoes, bordered on the east end by tomatoes, leaf miner infestation evidence was very marked. Counts of leaf mines per potato leaf were made at different distances from the end of the field. The average number of leaf mines decreased with distance increase from the margin of the potato field, as shown by the data in Table 1.

TABLE 1.—NUMBER OF SERPENTINE LEAF MINER MINES PER POTATO LEAF AT DISTANCE FROM FIELD BORDER.

Distances classes, feet	0-40	41-80	81-120	121-160	161-200	201-240	241-280
Avg. No. of mines per leaf	76	67	64	56	31	30	17

A regression curve was drawn from these data, according to the regular method of least squares, except that distances were transformed to logarithms as discussed by Wadley and Wolfenbarger (1944). The curve is expressed by the formula:

$$\text{Expected number of leaf mines} = 152.3708 - 50.6919 \text{ (log of distance)}.$$

The curve is illustrated in Fig. 1. The coefficient was found to be highly significant. At distances greater than about 300 feet the border effects were reduced to low levels. Beyond this distance infestations appeared to be more or less uniform in the remainder of the field.

The rates of border effects observed in other fields appeared similar to the one illustrated above. More marked differences were observed in fields during the earlier stages of in-

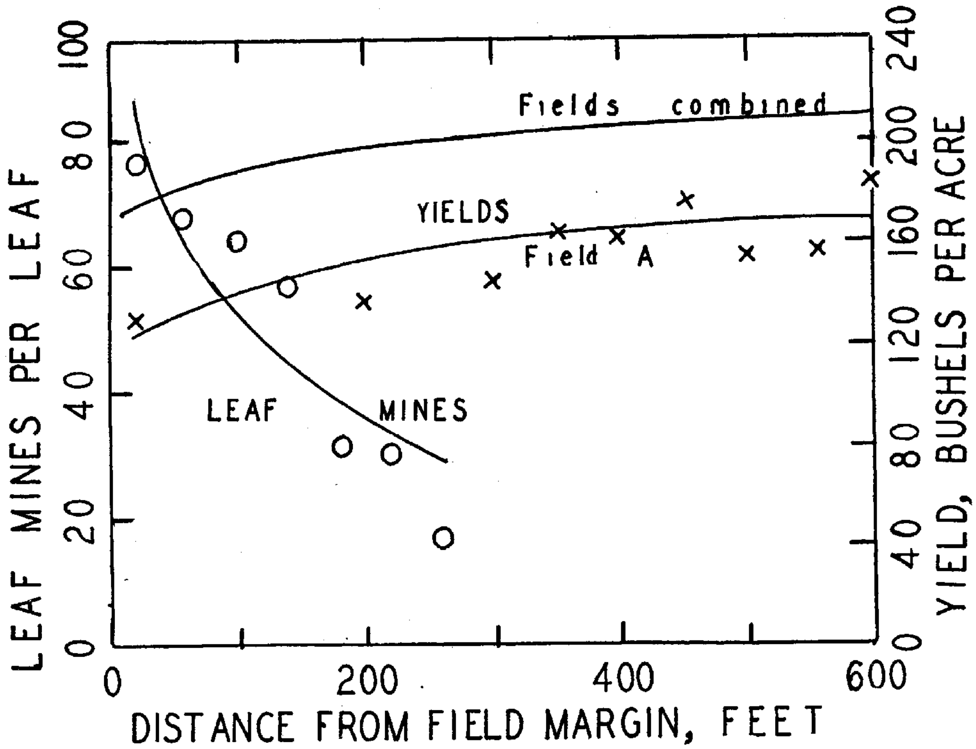

Figure 1.—Serpentine leaf miner injuries and potato yields as related to field border.

festation than in the later ones. These differences were due to primary invasions since insufficient time had passed for the flies to have developed on potatoes. In later stages of infestations a greater equalization of leaf mines over the fields was evident. The equalization of units at later times or in later stages of infestation was a factor discussed by the author, Wolfenbarger (1946), in a summary on dispersion, under the subhead of, "Dispersion Equalization in Time Sequences." This factor is undoubtedly a matter of slight importance in some cases and of considerable importance in others.

TABLE 2.—POTATO YIELDS AT DISTANCES FROM THE EASTERN EDGES.

Field designation		**Observations**										
A	Ft. from margin	18	200	300	350	400	450	500	550	600		
	Yield, bu. per A.	129	136	143	165	163	177	155	163	184		
B	Ft. from margin	9	34	56	78	119	150	193	228	268	303	349
	Yield, bu. per A.	239	193	209	238	184	268	295	270	232	314	259
C	Ft. from margin	25	127	229	331	433	535					
	Yield, bu. per A.	134	154	141	113	132	157					

YIELD RESULT: Sections of potato rows were measured, dug, and the yield data were converted to bushels per acre, as taken from each of three potato fields at different distances from the eastern edges. These data are summarized in Table 2.

Border effects of leaf miner dispersions were observed repeatedly in each of these fields. Two curves were drawn for these yield data. The field designated "A" in Table 2 was the field in which the data on leaf mines (Table 1) were collected. A curve was drawn to smooth these data, Fig. 1, "Field A." Another curve was drawn from the combination of data from the three fields, Fig. 1, "Fields combined." These indicate the magnitude of yield increases with distant increases. The generalized regression formula obtained from the data in Table 2 is:

$$\text{Expected yield} = 131.2942 + 28.5678 \text{ (log of distance)}.$$

The results of computations from the use of the formula for selected distances showing the theoretical or expected yield at each are given as follows:

Distance, ft. from field border	9	100	300	400	600
Yield, bu. per acre	171	188	202	206	211

A comparison of the curves illustrating yields, Fig. 1, shows similar curvilinearities, indicating how the data from the one field tended to agree with those of the combined fields.

In a consideration of the curves, Fig. 1, the leaf mines' curve bends more sharply than those of the yields. This is attributed to the equalization of fly population, as discussed above. The data on leaf mines per leaf were taken at a time when the border effects were more marked. The yield data on the other hand, include effects of accumulated attacks of the miner over the growth period of the plants.

SUMMARY — Dense populations of the serpentine leaf miner developed in tomato fields and dispersed in westerly directions into adjoining potato fields. Data taken on the rate of decrease as related to distance increase from the field border showed that at about 300 feet leaf mines reached low levels that were general for the entire fields. Potato yields in three fields were found to increase with distance increase from the border where, based on the regression formula, 171 bushels per acre at 9 feet from the border increased to 202 bushels per acre at 300 feet.

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A NOTE ON THE PREDACIOUS HABIT OF THE MIRID

Cyrtopeltis varians (Dist)

By J. W. WILSON, *Entomologist*
Florida Agricultural Experiment Station

During the course of investigations, at the North Florida Experiment Sation, Quincy, Florida in July, August and September, 1947, of means of controlling the green peach aphid, *Myzus persicae* (Sulz.), a small brown mirid was observed in large numbers on numerous occasions feeding on this aphid. During September, in a two acre field of shade tobacco that had been harvested and allowed to produce suckers, this mirid became so abundant that the previously heavy infestation of *Myzus persicae* was practically destroyed. In a tobacco seed bed planted for experimental purposes the mirids reduced the aphid population to such a point that investigation of chemicals for apid control could not be continued. Specimens were sent to Dr. C. F. W. Muesebeck, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, for identification. These specimens were identified by Dr. R. I. Sailer as *Cyrtopeltis varians* (Dist.). In his letter, Dr. Muesebeck stated that this insect had been reported as a predator on the suckfly *Dicyphus minimus* Uhl. and as injurious to tomatoes. From these reports it seems that *C. varians* may be both predacious and phytophagous. On one occasion during August several specimens (6 to 10) of *C. varians* were observed in the field feeding on about a third instar larva of *Protoparce sexta* (Johan.). Since this insect was observed only once in the act of feeding on a small tobacco hornworm larva it is not known that it will attack larger hornworm larvae.

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RECORDS OF STONEFLIES FROM FLORIDA (PLECOPTERA)

By LEWIS BERNER
Department of Biology and Geology
University of Florida

Stoneflies are not a conspicuous element in the insect fauna of Florida. Because of the paucity of species over most of the state, only five forms have thus far been recorded in the literature. These are *Pteronarcys dorsata* (Say) listed by Claassen in 1931,[1] and *Taeniopterayx maura* (Pictet), *Leuctra decepta* Claassen, *Acroneuria xanthenes* (Newman), *Acroneuria lycorias* (Newman) recorded by Frison in 1942.[2]

During the years 1937-1940, several lots of stoneflies were collected by the writer while gathering material on mayflies. These specimens were sent to the late Dr. T. H. Frison, chief of the Illinois Natural History Survey, for identification. It appeared advisable to the author to publish the list of Dr. Frison's identifications so that there might be established a basis for future Plectoptera work in Florida.

Occasional specimens from southern Alabama and from Georgia were also taken. Records of those specimens, also identified by Dr. Frison, are included in this paper.

The classification followed below is that established by Frison in his most recent work on the Plecoptera.[2]

Family Pteronarcidae

Pteronarcys sp.

Florida: Liberty Co., River Junction. March 17, 1939.

Family Taeniopterygidae

Taeniopteryx nivalis (Fitch)

Florida: Holmes Co., Sandy Creek. December 11, 1937 and December 14, 1939. Liberty Co., Sweetwater Creek, Torreya State Park. December 1, 1939. Washington Co., Holmes Creek. December 11, 1937 and December 14, 1939.

Georgia: Burke Co., Briar Creek. September 5, 1938. Coll. H. H. Hobbs.

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[1] Claassen, Peter W. 1931. Plecoptera Nymphs of America (North of Mexico.) Charles C. Thomas, Publisher, Springfield, Illinois.

[2] Frison, T. H. 1942. Studies of North American Plecoptera with special reference to the fauna of Illinois. Bull. Ill. Nat. Hist. Sur. Vol. 22, Art. 2.

Family Nemouridae

Nemoura venosa Banks

Florida: Leon Co., Tallahassee. March 18, 1939. Liberty Co., Torreya State Park. May 7, 1933.

Family Leuctridae

Leuctra decepta Claassen

Florida: Leon Co., 12 miles west of Tallahassee. November 30, 1939.

Leuctra triloba Claasseen

Florida: Leon Co., 12 miles west of Tallahassee. November 30, 1939.

Leuctra sp.

Georgia: Lumpkin Co., Walnut Creek. April 29, 1938.

Family Perlidae

Atoperla ephyre (Newman)

Florida: Holmes Co., Sandy Creek. December 11, 1937. Liberty Co., Torreya State Park. December 10, 1937.

Alabama: Escambia Co., Perdido Creek at U. S. Hwy. 31. June 3, 1940.

Neoperla clymene (Newman)

Florida: Alachua Co., Hogtown Creek, Gainesville. February 19, 1934. Gainesville. January 8, 1938, January 16, 1938, and February 3, 1938. Worthington Springs. February 5, 1939. Bay Co., 26 miles north of Panama City at Fla. Hwy. no. 77. June 8, 1938. Hamilton Co., Jasper. February 4, 1938. Hillsboro Co., Six-Mile Creek, near Tampa. March 26, 1938. Bell Creek. March 26, 1938. Okaloosa Co., Niceville. June 7, 1938. 9.1 miles west of Walton Co. line at Fla. Hwy. no. 20. May 31, 1940.

Georgia: Dougherty Co., Lake Worth, Albany. June 26, 1940. Coll. H. H. Hobbs.

Perlesta placida (Hagen)

Florida: Alachua Co., Hatchet Creek. October 11, 1939. Bay Co., 26 miles north of Panama City at Fla. Hwy. no. 77. June 8, 1938. Gadsden Co., River Junction. March 17, 1939. 5 miles south of River Junction. June 6, 1940. Hamilton Co., Jasper. February 4, 1938. Jackson Co., Blue Springs Creek, Marianna. May 5, 1939 and June 5, 1940. Leon Co., Tallahassee. March 16, 1939 and June 5, 1938. Liberty Co., Little Sweetwater Creek. June 10, 1938. Sweetwater Creek, Torreya State Park. June 10, 1938. Okaloosa Co., Crestview. December 12, 1937. 5.1 miles west of Walton Co. line at Fla. Hwy. no. 20. May 31, 1940. Walton Co., 5.4 miles west of Washington County line at Fla. Hwy. no. 20. May 31, 1940. 9.5 miles west of Portland. May 31, 1940. Portland. April 13, 1938. Freeport. April 2, 1939. Washington Co., Holmes Creek. April 2, 1938.

Georgia: Jones Co., 10 miles north of Macon. April 30, 1938. Rabun Co., Small creek flowing into Lake Burton. June 22, 1940. Coll. H. H. Hobbs.

Alabama: Baldwin Co., Dyas Creek, Dyas. June 3, 1940. Elmore Co., 4 miles east of intersection of Hwys. no. 14 and 45, Mortar Creek. June 5, 1940. Mobile Co., 3.5 miles south of Irvington. June 2, 1940.

Acroneuria lycorias (Newman)

Florida: Liberty Co., Little Sweetwater Creek. June 10, 1938.

Acroneuria arenosa (Pictet)

Florida: Jackson Co., Blue Springs Creek, Marianna. June 5, 1940.

Acroneuria ruralis (Hagen)

Florida: Jackson Co., Blue Springs Creek, Marianna. June 5, 1940.

Georgia: Dougherty Co., Lake Worth, Albany. June 26, 1940. Coll. H. H. Hobbs.

Acroneuria xanthenes (Newman)

Florida: Liberty Co., Torreya State Park. December 10, 1937.

Georgia: Jones Co., 10 miles north of Macon. April 30, 1938.

Acroneuria abnormis (Newman)

Florida: Wakulla Co., Smith Creek. June 5, 1938. Leon Co., Small stream flowing into the Ochlocknee River. June 5, 1938.

Georgia: Lumpkin Co., Walnut Creek. April 29, 1938.

Acroneuria sp. B (as designated by Dr. Frison)

Florida: Gadsden Co., River Junction. June 30, 1939. Leon Co., Tallahassee. March 17, 1939. Liberty Co., Sweetwater Creek. December 10, 1937 and July 1, 1939. Okaloosa Co., Niceville. June 7, 1938. Walton Co., Freeport. April 2, 1939.

Georgia: Brian Co., Canoochee River. December 18, 1939. Coll. H. H. Hobbs. Screven Co., Beaver Dam Creek. September 7, 1938. Coll. H. H. Hobbs.

Neophasganophora capitata (Pictet)

Florida: Gadsden Co., River Junction. March 17, 1939.

Togoperla immarginata (Say)

Alabama: Mobile Co., 1.4 miles south of Kushla, Seabury Creek. June 3, 1940.

Togoperla kansensis (Banks)

Florida: Bay Co., 26 miles north of Panama City. June 8, 1938. Jackson Co., Blue Springs Creek, Marianna. June 5, 1940. Okaloosa Co., Crestview. December 12, 1937. Niceville, June 7, 1938. Shoal River, December 11, 1937. Walton Co., Freeport. April 2, 1939. Ebro. June 7, 1938.

Georgia: Baker Co., Newton. October 29, 1938. Coll. F. N. Young.

Family Isoperlidae

Isoperla confusa Frison

Florida: Alachua Co., Worthington Springs. February 5, 1939.

A NEW APHID ON SWEET POTATO[1]

CLYDE F. SMITH
Raleigh, North Carolina

The description of this genus and species is based on material which was submitted to the writer by Dr. A. N. Tissot of Florida Agricultural Experiment Sation. Material was subsequently sent to Doctors E. O. Essig, G. F. Knowlton, and Professors M. A. Palmer and J. O. Pepper. The writer wishes to express his appreciation to the above named lady and gentlemen for their opinions concerning this genus and species.

Xenopterygus new genus

This genus seems most closely related to the Tribe, *Fordini*; however, many of the characters resemble those of the Tribe, *Prociphilini*.

CHARACTERS: Cornicles absent. Wax plates present but poorly developed on head, well developed on thorax (see Fig. 1) and on abdomen. *Alate vivipara* with six-segmented antennae, sensoria broadly transverse to oval; secondary sensoria fringed. Fore wings with the media simple, hind wings with both media and cubitus present.

TYPE SPECIES: *Xenopterygus ipomoiae*

Xenopterygus ipomoiae n. sp.

The distinguishing characteristics of this species are the fringed secondary sensoria which are often coalesced; chitinous islands in the primary sensorium on antennal V; and the irregular enlargements along the cubitus and first anal of the fore wing and along the cubitus of the hind wing.

ALATE VIVIPARA: Color of living specimens not known. Cleared specimens show the following characteristic coloration: dark brown to fuscous on antennae, head, thorax, legs, and transverse bars on the dorsum of the abdominal segments, especially segments of IV, V, and VI. Some of the teneral specimens do not show the conspicuous dark bars on the abdomen and the appendages are lighter in color.

MEASUREMENTS: Body 1.8 to 2.2; width through eyes .38 to .43; antennal III, .23 to .27; IV, .07 to .09; V, .10 to .12; VI, .08

[1] Research Contribution No. 1 published with the aid of the State College Research Fund, Department of Zoology, North Carolina State College of Agriculture and Engineering of the University of North Carolina.

to .10 plus .02 to .04; rostrum reaching between 2nd and 3rd coxae; rostral IV, plus V, .09 to .10; hind tibiae .72 to .93; hind tarsi .15 to .18; cornicles absent.

Antennal III with 7 to 15 sensoria, some of the sensoria are usually coalesced especially toward the distal end of the segment; antennal IV, with 1 to 2 sensoria; antennal V without secondary sensoria, primary sensorium with one or two chitinous islands bearing 1 to 2 hairs (see Fig. 1); antennal VI without secondary sensoria, primary sensorium with or without chitinous island bearing hair. Primary and secondary sensoria fringed. Fore wings with media simple, cubitus and 1st anal with irregular enlargements especially near the basal area. Hind wings with both media and cubitus, cubitus with enlarged areas. Hairs on hind tibiae short and spine-like, less than one-half diameter of segment bearing them.

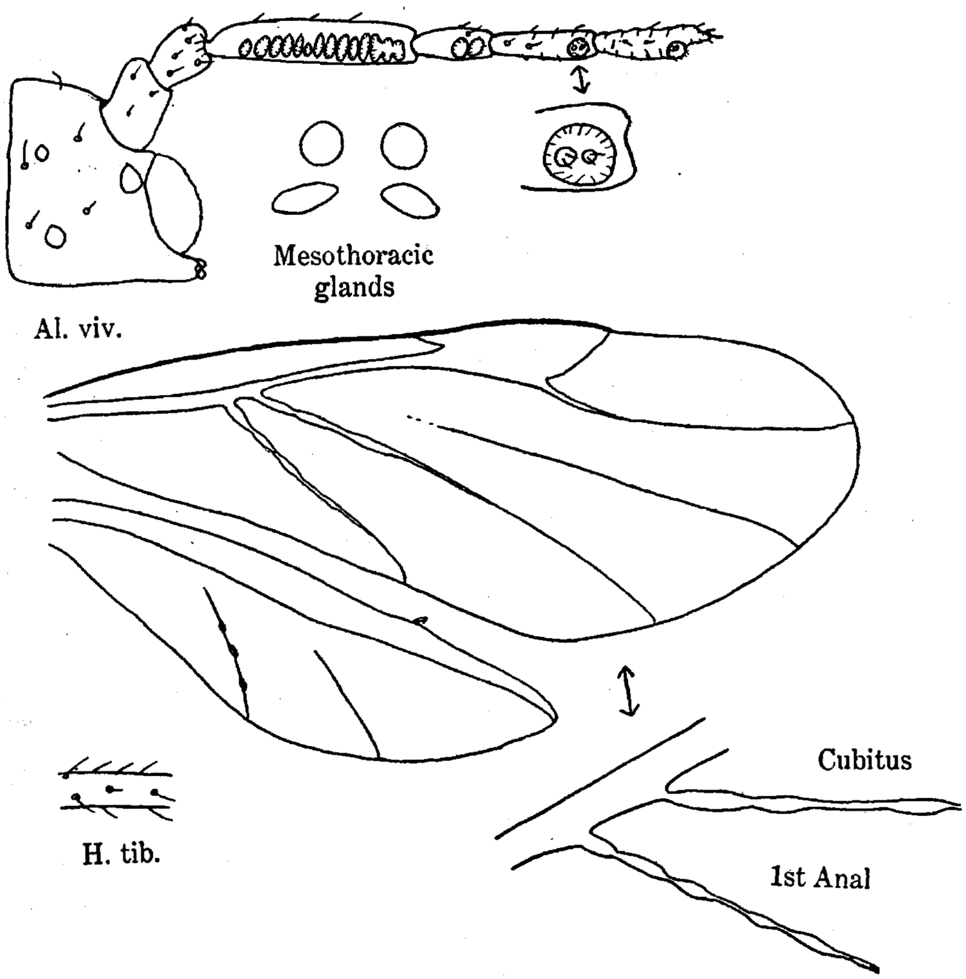

Figure 1.—*Xenopterygus ipomoiae* Smith.

TYPES: Holotype and paracotypes in the U. S. National Museum; Paracotypes and/or paratypes in the collections of Dr. A. N. Tissot and the writer.

TYPE LOCALITY: Clewiston, Florida.

COLLECTIONS: Clewiston, Florida, on roots of sweet potato (*Ipomoia batatas* [L.] Lam.) June 1, 1945, holotype slide (3 specimens) and 11 Paracotype slides (22 specimens); during June, 1944, 30 paratype slides, all collections by W. D. Wylie.

One specimen was located in the U.S.N.M. labeled "on Dasheen leaf, Guaynabo, Puerto Rico, Flaxon Anderson Mills, Coll. Dec. 19, 1932, San Juan 3355." This specimen had the antennae missing but the other characters seemed to be the same as the material from Florida.