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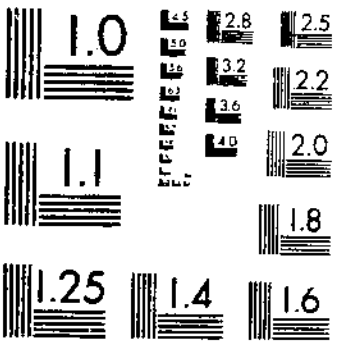

MICROCOPY RESOLUTION TEST CHART
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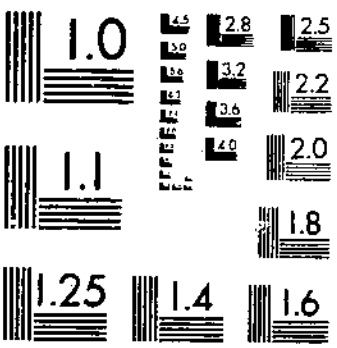

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Populations of the Oriental Fruit Moth in Peach and Apple Orchards in the Eastern States

by H. W. Allen
E. L. Plasket

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Several individuals have contributed to the data used in this bulletin, particularly G. J. Haeussler, who helped obtain the records of insects reared from twigs and fruits of peach in 1939, and M. H. Brunson, who supervised the sampling of twigs and fruits in 1939 and 1940 and compiled the records of infestation. Mr. Brunson was also responsible for the data on infestations in bearing peach for 1952 through 1954. The technique of sampling peach orchards, which has been followed for many years, had been worked out before 1939 with the assistance of W. P. Yetter, Jr.

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Populations of the Oriental Fruit Moth in Peach and Apple Orchards in the Eastern States

By H. W. Allen and E. L. Plasket, *Entomology Research Division, Agricultural Research Service*

From 1929 through 1954 much information on the abundance and distribution of the oriental fruit moth (*Grapholitha molesta* (Busck)) was obtained at Moorestown, N. J., in connection with the study of parasites and insecticides. Since orchardists are now able to reduce the fruit moth population nearly to the vanishing point, more attention should be given to unsprayed orchards in the vicinity of those that are well cared for. Migration from unsprayed fruit trees producing large populations of these moths could reduce the degree of control obtained in sprayed orchards.

Data on oriental fruit moth populations in New Jersey were gathered in 1939 and 1940, before insecticide controls became available, and in the Eastern States from 1952 through 1954, after organic phosphorus insecticides had come into general use in peach orchards. These data are presented in this bulletin. A few observations from other years have also been included.

While the literature on the oriental fruit moth is replete with observations on the percentage of fruit injured and the numbers of moths captured with sweetened baits, there are few reports in which data related to the spatial concept have been enumerated. Neiswander and Vogel (*5, pp. 91–94*)[1] found on an average about 8 hibernating cocoons per used picking basket in storage sheds in Ohio. Steiner (*7*) in 1929 and 1930 made a careful study of the numbers of oriental fruit moth hibernaculae on and about peach trees; his findings will be discussed at another place in this bulletin. Allen and Brunson (*1*) gave estimates on the numbers of oriental fruit moths per tree in peach orchards in New Jersey for 1938 and 1940, and Brunson and Allen (*4*) for 1938–42. Brunson (*2*) in 1944 and 1945 made observations on populations in nurseries in New Jersey and Maryland. In these nurseries he found only a few instances where any species with infested twigs had more than 1 larva per 1,000 trees. However, there were moderate numbers of larvae in any fruits of flowering crab apple and flowering quince that were present. In 1952 and 1953 Brunson (*3*) published estimates of the oriental fruit moth infestation in peach twigs in bearing orchards.

The oriental fruit moth has a considerable capacity for migration. Steiner and Yetter (*8*) found that the moths migrate freely between orchards up to ¼ mile apart, and not infrequently between orchards a mile apart.

Wherever feasible the counts and estimates of populations recorded in this bulletin are presented as the number of larvae maturing per tree. Since the number of peach trees per acre does not vary widely from 100, the average in New Jersey orchards being 93 according to

[1] Italic numbers in parentheses refer to Literature Cited, p. 13.

Pitt and Brammer (*6*), tree estimates for peach are readily transformed into estimates per acre.

ENVIRONMENTAL FACTORS

Peaches are grown commercially in many counties of the Eastern States. In some counties commercial orchards are several miles apart, but peach culture tends to be concentrated and in many districts the orchards are less than a mile apart. However, even in an important peach-growing district such as Burlington County, N. J., which has approximately 3,000 acres of peach orchards, this crop occupies much less than 1 percent of the total area. Most of this acreage now receives regular insecticide treatment for control of the oriental fruit moth.

Abandoned peach orchards are not common, and in them the trees that survive more than a year or two usually have no fruit and the twig growth is unacceptable to the fruit moth. A few small bearing orchards still receive no insecticides except lead arsenate and paradichlorobenzene, which are not effective against the oriental fruit moth.

In 1956 a limited survey among the peach growers of Burlington, Camden, and Gloucester Counties in New Jersey showed that of 22 contacted, 91 percent sprayed for oriental fruit moth control and that 96 percent of their acreage of bearing peach was treated for this pest.

Almost one-fourth of the New Jersey peach acreage in 1946 was in nonbearing trees of 3 years or younger, according to Pitt and Brammer (*6*). Some growers spray the young trees to eliminate the first two generations of the oriental fruit moth, but many give them less careful attention than they do the bearing orchard. Row crops are frequently grown in nonbearing orchards, and these crops usually hinder or prevent early-season spraying of the young peach trees.

The large commercial apple acreage is generally well cared for and not likely to produce many oriental fruit moths. However, there is also a large acreage of abandoned or neglected apple. In the Coastal Plain abandoned apple trees tend to die out within a few years, but in the meantime some of the trees may set a normal crop, often more than 5,000 fruits per tree. Some years when the trees are nearly defoliated by insects or are heavily infected with scab, all the fruit may drop early in the season. In other years many of the trees may carry nearly a full crop throughout the growing season. In the hilly country west of the Coastal Plain, unsprayed mature apple trees also occur singly and in small groups in pastures and wooded ravines. In this area the trees persist many years in a fairly vigorous condition and are frequently well loaded with fruit.

Very late peach varieties such as the Krummel and Iron Mountain, and quince, once common in the Northeastern States, are now no longer grown except in a few localities. In respect to neighboring orchards, nurseries are not important sources of an oriental fruit moth infestation. They are few in number compared with fruit orchards, and Brunson (*2*) found that the nurseries rarely produce many fruit moths, either in fruit trees or in ornamentals.

Many susceptible orchard trees and ornamentals are grown which are not regularly sprayed for oriental fruit moth control. Village, suburban, or farm homes are frequently near commercial orchards and may have unsprayed trees or shrubs on which relatively large

numbers of oriental fruit moths mature. However, no data on such infestations are available.

POPULATIONS IN BEARING PEACH ORCHARDS

In 1939 and 1940 the observations were made on 12 orchards of bearing peach trees in Burlington, Mercer, and Gloucester Counties in New Jersey. All the infested twigs from marked sample trees were collected at 4- to 6-day intervals during the first two generations of the oriental fruit moth. In each orchard about 5 percent of the trees, regularly distributed through it, were used for these records. The numbers of mature larvae reared from the collected twigs were used to estimate the moth populations. At the time of each twig collection all fruits dropping from another series of marked sample trees (about 1 percent of all the trees in each orchard) were collected and the numbers of mature larvae issuing from them were recorded.

At harvest, the rate of injury was determined from 400 fruits taken at random from the trees in each orchard and also from another sample including all the ripe drops from 10 to 20 trees. These observations were made on the varieties Elberta and Summercrest, or others ripening at about the same time. The fruit load was estimated by counting the fruits at harvest on 10 trees in each orchard. The oriental fruit moth populations in bearing peach orchards in 1939 and 1940 are shown in table 1.

TABLE 1.—*Estimated number of oriental fruit moth larvae per tree of bearing peach in New Jersey, 1939 and 1940*

County and orchard number	First generation—		Second generation—		Third generation—
	In twigs	In immature fruit	In twigs	In immature fruit	In ripe fruit
	Observations in 1939				
Burlington:					
Orchard 1	13.9	5.7	11.3	3.7	252
2	9.3	5.9	5.9	.7	172
3	7.6	3.5	5.8	1.5	118
4	10.5	4.9	11.2	2.5	53
Mercer:					
Orchard 1	7.6	.7	2.9	1.0	168
	Observations in 1940				
Burlington:					
Orchard 1	10.0	2.9	24.0	0.9	182
2	31.2	9.8	18.2	4.8	341
3	38.1	6.5	44.4	10.8	266
4	8.0	2.1	7.4	1.8	242
Gloucester:					
Orchard 1	15.1	2.9	20.5	4.1	94
2	7.7	1.6	13.7	2.0	85
3	9.1	2.7	6.5	10.0	357

In 1939 there were 3,497 trees in the orchards observed. Of this total, 173 were twig-sample trees and 33 were immature-fruit-sample trees. During the first two generations, about 7,700 infested twigs and 39,700 immature fruits were collected from these sample trees. In addition, 2,000 ripe fruits were picked from the trees and 2,360 ripe-fruit drops were collected and examined. The estimated fruit load per tree in these orchards ranged from 419 to 720.

In 1940 there were 6,641 trees in the orchards observed. There were 355 twig-sample trees and 63 immature-fruit-sample trees. From these trees, about 59,100 infested twigs and 38,170 immature fruits were collected. In addition to 3,150 fruits picked from the trees at harvest, 3,250 ripe drops were also examined. The estimated ripe-fruit-load per tree ranged, in the several orchards, from 494 to 1,234 fruits.

From 1952 through 1954 the collections of infested twigs were much less extensive, the survey of infestation in immature fruits had been discontinued, ripe-fruit drops were no longer examined, and fruit-load counts were no longer made. However, the method of estimating injury in tree fruit at harvest remained the same in other respects. Data on the fruit load of bearing peaches in southern New Jersey at harvest that had been obtained over a period of 5 years by counting the fruits on 580 trees in 58 orchards showed an average load of 688 peaches. This average was used in 1952–54 as a seasonal average in estimating the larvae per tree at harvest. Population estimates were made in several orchards in Burlington County. All the infested twigs were collected from 10 marked sample trees located about the periphery of each orchard surveyed. The insects in the twigs were reared and the estimates per tree were based on the larvae which matured.

For 1952–54 the results of observations in orchards receiving applications of insecticides for oriental fruit moth control are separated from those where no such control was used. In all the orchards sprayed to control this moth, parathion or some equivalent phosphorus insecticide was used. Data on populations in bearing peach orchards for these years are presented in table 2.

First generation.—It seems evident that in 1939 and 1940, as well as in many other years before organic phosphorus insecticides were used, a large portion of the first-generation larvae developed in commercial peach orchards. In the 12 bearing orchards surveyed those years in the 3 New Jersey counties, the first-generation population in twigs ranged from 7.6 to 38.1 and averaged 14 larvae per tree. There seems to have been as great a variation between orchards as between counties. As shown in table 1, the number of larvae developing in the small immature peaches varied widely from orchard to orchard without any apparent relationship to other data. The larvae reared from immature fruit drops ranged from 8 to 39 percent of the total larvae reared.

Now that phosphorus insecticides are being widely used in early-season sprays in commercial peach orchards, first-generation populations have been tremendously reduced in bearing orchards. For 1952–54 the average population in the orchards sprayed for control of the oriental fruit moth was 0.14 larva per tree, or about 1 larva

to 7 bearing trees, whereas in those not sprayed for fruit moth control, the average was estimated to be 6.1 larvae per tree, or about 40 times the population of the sprayed orchards.

TABLE 2.—*Estimated number of oriental fruit moth larvae per tree of bearing peach in Burlington County, New Jersey, 1952–54*

Spray used for oriental fruit moth control	First generation		Second generation		Third generation	
	Number of orchards	Average number of larvae	Number of orchards	Average number of larvae	Number of orchards	Average number of larvae
	Observations in 1952					
Early	5	0.2	5	0.7	5	22.7
Preharvest					3	11.5
None	2	9.4	2	12.2	6	168.0
	Observations in 1953					
Early	5	0.1	5	0.4	5	13.1
Preharvest					4	4.9
None	3	7.4	3	16.7	6	121.0
	Observations in 1954					
Early	4	0.1	4	0.4	4	5.5
Preharvest					4	10.5
None	3	2.5	3	9.5	5	63.0
	Averages, 1952–54					
Early	14	0.14	14	0.6	14	14.4
Preharvest					11	8.7
None	8	6.1	8	12.9	17	121.0

Second generation.—In the same orchards observations were made on the infestation by the second generation of the fruit moth. Before organic phosphorus insecticides were used, bearing peach orchards were usually heavily infested during the second generation, and both succulent twigs and immature fruits were attacked. The estimates of this generation in infested twigs in these orchards in 1939 and 1940 (table 1) ranged from 2.9 to 44.4 and averaged 14.3 larvae per tree in twigs.

Although the oriental fruit moth has a reproductive potential of about 75 to 1, this strong capacity for increase apparently was generally ineffective in these peach orchards. In fact, in 7 of the 12 orchards the population of the second generation was smaller than

that of the first. During the second generation a considerable fraction of the population occurs in immature peaches. This fraction also varied even more widely in the second than in the first generation, ranging from 4 to 63 percent of the larvae maturing in twigs.

When phosphorus insecticides were used in 1952–54, although the early applications were usually terminated about a month before second-generation larvae began to appear, the populations in the early sprayed orchards remained very low. The average of 0.6 larva per tree for the 3 years observed is a fourfold increase from the first-generation population, but is less than one-twentieth of the population in the bearing orchards not sprayed for control of the oriental fruit moth, and about one-twenty-fifth of the second-generation population observed in twigs in 1939 and 1940.

Third generation.—The third generation of the oriental fruit moth occurs mostly during the harvest period of the most abundant varieties of peaches such as Elberta and Summercrest. During this period and for the remainder of the season, peach twigs are woody and no longer acceptable, and nearly all the larvae infest the fruit. In 1939 and 1940 the estimated population of larvae in the orchards increased sharply during the third generation (table 1), with no apparent relation to the numbers present during the previous generation. For example, in orchard 4 in Burlington County the population increased from 7.4 to 242 larvae per tree, but only from 20.5 to 94 larvae in orchard 1 in Gloucester County. The number of third-generation larvae per tree in the 12 orchards ranged from 53 to 357 and averaged 194 larvae. In all orchards there was a substantial increase from the level of second generation populations.

In 1952–54 in the well-sprayed bearing peach orchards (table 2) the third-generation fruit moth population was reduced greatly below the large numbers found in the orchards before insecticides effective against the fruit moth were commonly used. In orchards receiving preharvest sprays the average infestation was about one-fourteenth of that found in the few orchards that received no spray for fruit moth control, and was less than one-twentieth of that in the orchards in 1939 and 1940 before effective insecticides became available. In the orchards receiving only early-season insecticides against the oriental fruit moth (1952–54), there was a substantial increase from 0.6 larva per tree in the second generation to 14.4 larvae in the third. However, this average was still relatively insignificant and far less than the 121 larvae per tree observed in orchards that received no spray for oriental fruit moth control.

Our data indicate that, of the acreage of bearing peach which receives spray applications for oriental fruit moth control, a large portion maintains very scanty populations during the first three generations, much less than those prevailing before insecticide control was available. Thereafter, there are neither twigs nor fruit to sustain a larval population. The small portion of the acreage of bearing trees not receiving any treatment for oriental fruit moth control continues to produce heavy concentrations of these moths during the first three generations, but particularly in the third generation which attacks the fruit at harvest.

POPULATIONS IN YOUNG PEACH ORCHARDS

A study of the oriental fruit moth populations in young peach trees in New Jersey and New York was made from 1952 through 1954. Normally the tender twigs in peach trees of prebearing age are infested during the first two generations of this moth, but after the twigs harden in July this infestation almost disappears.

First generation.—Observations on the first-generation moths were made in peach orchards of prebearing age in Burlington County in 1952. All the infested twigs from a definite number of sample trees were collected twice during the peak of first-generation injury. A study of earlier records showed that the number of larvae reared from two collections at the peak of infestation was about half the total for the entire generation. Therefore, the population was estimated by multiplying by 2 the number of insects reared per tree.

The estimated first-generation population per tree in 5 unsprayed orchards of prebearing age ranged from 0.1 to 4.2 larvae per tree and averaged 2.1 larvae—much less than the usual number infesting twigs in bearing unsprayed peach trees. However, it was greater than that reared from bearing trees sprayed for control of the oriental fruit moth. In 5 orchards of young trees in the same county that had received early applications of organic phosphorus insecticides, the estimates ranged from 0 to 1.9 larvae and averaged 0.6 larva per tree.

Second generation.—In 1953 an estimate was made of the second-generation larvae in twigs of unsprayed peach trees of prebearing age or with only a partial crop in orchards in New York and New Jersey. The procedure was similar to that described for the first generation. It had been determined from numerous earlier observations that the total number of second-generation fruit moths was about equal to the number reared from two collections made at the peak of the brood times 1.41. This factor was used in obtaining the estimate.

The estimated numbers of larvae per tree in 8 young orchards not sprayed for oriental fruit moth control were as follows: In New York—Orange County, 5.3, 7.9, and 31.2; Ulster County, 11.1 and 15.4. In New Jersey—Sussex County, 2.7; Warren County, 4.0 and 14.1 larvae. Average—11.5 larvae.

These infestations were not dense and even seemed light when compared with those in bearing peach trees in 1939 and 1940. However, when compared with infestations in bearing peach trees in 1952 and 1953, they were estimated, on the average, to be about 15 times as heavy as the populations of the bearing orchard sprayed with organic phosphorus insecticides during the first generation, and 19 times as heavy as those during the second generation. Since a large acreage of young peach trees was not sprayed, and much of it was close to bearing orchards, most of the first two generations of moths emerging in peach trees probably originated in the young trees and were within easy migrating distances to the bearing trees.

POPULATIONS IN APPLE ORCHARDS

In unsprayed apple orchards.—In 1952 through 1954 a study was made of the oriental fruit moth population present in unsprayed apple orchards in Connecticut, New York, New Jersey, Maryland, Virginia, West Virginia, and North Carolina. The results are shown in table 3.

Field collections, usually of about 20 pounds of fruit, were taken in a random transit of the orchards. The fruits were counted and enclosed in cloth-covered trays which had been heated to destroy any stray insects. After being held for 20 days at forcing temperatures, each tray was discarded to avoid any error due to a second generation that might be propagated by emerging moths. The number of larvae that matured per 1,000 fruits collected was used in estimating the degree of infestation.

Since the fruit load on unsprayed trees is so variable, estimates of the average number of oriental fruit moth larvae per tree would have little significance. Some unsprayed trees are very heavily loaded and start the season with more than 10,000 fruits; others may have no fruits. As the season progresses the number of trees without fruit increases, and there is a continuous reduction in the numbers of fruits in heavily loaded trees, although in some seasons a large number of trees carry a nearly normal load until October.

For the second generation 43 samples of apples were obtained from orchards in 9 counties distributed in New Jersey, Maryland, West Virginia, and Virginia. Moderate to large populations were found in Atlantic, Burlington, and Gloucester Counties, N. J.; Washington County, Md.; and in Berkeley and Jefferson Counties, W. Va. Since the fruit load on many trees was heavy early in the season, presumably up to 13,000 per tree, the population often exceeded 100 larvae per tree and in some trees may have exceeded 1,000 larvae.

Late in July 1956 the fruits on one unsprayed mature apple tree in vigorous condition and moderately well loaded were picked and counted. A total of 13,240 fruits was obtained, certainly not the maximum number for trees in the area surveyed. From a sample of 400 fruits taken at this time, 27 moths were reared. The estimated population of the second generation in this tree at the time the count was made was 894 larvae. Since the sample included only the larvae and eggs then present, it is an underestimate of the population that would have matured during the whole of the second generation, which lasts about a month. The rate of infestation on this tree was 68 larvae per 1,000 fruits, which was higher than the average for second-generation infestations found in 7 unsprayed orchards sampled in southern New Jersey.

Observations for the third generation were more extensive. A total of 103 samples was obtained from 20 counties from eastern Connecticut to northern North Carolina, and oriental fruit moths were reared from all but 3. In 1954, when midsummer was generally unfavorable to the oriental fruit moth, many samples yielded no fruit moths and the averages were frequently less than 10 larvae per 1,000 fruits. However, large numbers were reared from some of the samples from Connecticut.

TABLE 3.—*Oriental fruit moth larvae per 1,000 fruits in unsprayed apple orchards, 1952–54*

State and county	Second generation			Third generation			Overwintering generation		
	Number of orchards	Number of larvae		Number of orchards	Number of larvae		Number of orchards	Number of larvae	
		Range	Average		Range	Average		Range	Average
	Observations in 1952								
New Jersey:									
Atlantic				4	49–328	162			
Burlington	11	2–42	16	11	12–265	80			
Camden				3	11–132	65			
Gloucester				3	4–138	61			
Salem				2	21–136	78			
	Observations in 1953								
New York:									
Orange				4	62–107	76			
Ulster				5	0–104	33			
New Jersey:									
Atlantic	3	27–294	131	2	21–29	25			
Burlington	8	5–82	32	4	99–179	142			
Camden				1		45			
Cumberland	1		0						
Gloucester	7	80–424	266	4	43–292	154			
Sussex				7	0–44	13			
Warren				7	0–78	22			
	Observations in 1954								
Connecticut:									
Fairfield				1		435			
Hartford				3		0	1		63
Middlesex				2	10–39	24	1		79
New Haven				3	0–259	115	2	181–214	198
New London				2	0–30	20	1		21
New York:									
Orange				4	62–107	76	1		28
Ulster				5	0–104	33	2	33–1357	695
New Jersey:									
Burlington				4	0–31	15	3	17–963	483
Camden							2	31–428	230
Gloucester							2	39–93	66
Sussex				2	0–6	3	2		0
Warren				3		0	2	31–57	44
Maryland:									
Washington	6	0–56	13	9	0–23	5	4	8–52	30
West Virginia:									
Berkeley	1		75	3		0	2	50–71	65
Jefferson	2	31–75	53	4	0–11	3	1		0
North Carolina:									
Alexander				2	0–8	4	2	39–462	250
Surry				1		4	1		329
Wilkes				2	0–11	6	2	131–322	226
Virginia:									
Albemarle	3	0–9	4						
Shenandoah	1		0						

In 1952 and 1953 much larger numbers were reared, with evidence of moderately heavy concentrations in orchards in the Hudson Valley and southern New Jersey. With probable fruit loads as high as 10,000 per tree, in numerous orchards single trees probably produced as many as several hundred oriental fruit moths during the third generation. There was no uniformity in the rate of infestation from year to year, and the second-generation infestation in an orchard was sometimes greater, sometimes less than that of the third generation.

Observations on the overwintering generation are available only for 1954. Samples were collected from 31 orchards in 17 counties from eastern Connecticut to northern North Carolina. No oriental fruit moths were reared from samples from 3 of the orchards, but moderate to large numbers were obtained from the others. With many trees bearing at least a thousand fruits at that time, there were again many single trees with infestations of several hundred larvae. Heavy concentrations were general in these States. There was evidence of a sharp increase in the population of the oriental fruit moth in unsprayed apple from the third to the overwintering generation.

In sprayed apple orchards.—Although in the early years of oriental fruit moth infestation a number of observers recorded rather heavy injury to apple, no information was usually reported on the insecticide schedules employed. The authors have never observed a heavy infestation of this moth in apple orchards where the codling moth was being effectively controlled.

In 1932, 11 samples of apples from roadside markets in Burlington County were examined. The varieties were Grimes Golden, Delicious, Stayman, and Rome, all likely to be infested with the oriental fruit moth. Most of the samples probably came from poorly sprayed orchards, since the average codling moth injury was about 11 percent. The average oriental fruit moth injury was 3.3 percent, and in lightly loaded trees this average would give at least 33 larvae per tree. Heavily loaded trees might have five times as many.

In 1940 an examination was made at harvesttime of 11 samples of apples from well-sprayed commercial orchards in Burlington County, of the varieties Wealthy, Red Delicious, and Stayman. Less than 0.2 percent of the fruit was injured by the oriental fruit moth. Even on heavily loaded trees this average would give a population of scarcely 10 larvae per tree.

DISCUSSION

As these data show, there has been a significant change in the distribution of the oriental fruit moth population since organic phosphorus insecticides have been commonly employed in peach orchards. Over a large portion of the mature peach acreage, which formerly produced large numbers of these moths in each of the first three broods, there are now very few.

During the first and second generations moderate to dense populations were observed only in unsprayed young peach orchards and in the occasional mature orchards where the organic insecticides had not been employed. At the time of the second generation the young apples have started to grow, and moderate to dense concentrations of fruit moths also occur in unsprayed apple.

At the time of the third generation, peach twigs have hardened so that until the end of the year the oriental fruit moths breed chiefly in the fruit. Only small numbers manage to establish themselves in well-sprayed peach orchards, and most of them are removed with the harvested fruit before the worms have become full grown. Of the very few which cocoon in the orchard, a considerable portion emerge in August or early in September and have to migrate out of the peach orchard to locate acceptable food. Steiner (*7*) in 1932 showed that mature Elbertas, with a normal crop which was moderately infested, had an average of only 2.5 hibernating cocoons per tree. The number now hibernating in well-sprayed Elberta probably average far less than 1 per tree. During the third generation, unsprayed apple continues to sustain a large portion of the population, although during unfavorable weather the number may be less than during the second generation.

The capacity of unsprayed apple to produce large populations of the oriental fruit moth, particularly in abandoned orchards that are not pastured, is greatly enhanced during the third and later generations by the presence of an abundance of food until the end of the season. Since the fruits remain on the trees or on the ground beneath them until they decay, the population is not reduced by a removal at harvest of the wormy fruit, and there is no necessity for migration of moths in search of acceptable food. Since quinces and late peaches are no longer commonly grown, unsprayed apple, which is frequently heavily infested, apparently produces most of the overwintering generation.

Our studies indicate that the first generation has become the most vulnerable period in the seasonal cycle of the oriental fruit moth. It is possible that skillful use of insecticides in the few bearing peach orchards and in the young orchards that have not previously received early sprays for oriental fruit moth control would reduce the population for any district to an extremely low level. There is no other period during the year when the population for the entire district can be reduced by means that are readily available.

The distribution of the oriental fruit moth population during the second generation is especially important, since the moths of this generation produce the worms that are chiefly responsible for injury to the peach crop. Unsprayed apple trees bearing fruit, or peach orchards not sprayed for oriental fruit moth control, that are within migrating distance of well-sprayed peach orchards may provide an influx of migrating moths into such orchards. The portion of the second generation surviving parasites in unsprayed peach orchards is usually low and is frequently less than 10 percent, but the portion surviving in unsprayed apple is much higher—74 percent in our observations for 1953. Unsprayed apple, therefore, becomes increasingly important as a source of oriental fruit moth infestation.

Disregarding the factor of parasitism, well-sprayed bearing peach orchards in southern New Jersey in 1952–54 produced during the second generation about 50 to 60 oriental fruit moths per acre. Since at the time of this generation fruit loads up to 10,000 per tree were not uncommon in apple, the data in table 3 indicate that there are single unsprayed trees which produce more than a thousand fruit moths during this brood, or as many as produced on 18 to 20 acres of well-sprayed peach.

SUMMARY

In many years of study of parasites and insecticides for the control of the oriental fruit moth (*Grapholitha molesta* (Busck)) in the Eastern States, many data on population densities were collected at Moorestown, N. J. Data obtained in 1939 and 1940 are presented to show the status of infestations before insecticide controls were available, and from 1952 through 1954 after such controls had been developed. The best crop protection is obtained in orchards which are not only well sprayed but which are not exposed to large migrations of moths from nearby foci of infestation. Data are presented to show where and at what times such infestations may exist.

In studies of populations in bearing peach orchards in New Jersey in 1939 and 1940, on an average there were 14.0 larvae per tree in twigs during the first generation and 14.3 during the second generation. In the third generation the average was 194 larvae per tree in the fruits at harvest. From 1952 through 1954, the populations in well-sprayed bearing peach orchards was about one-hundredth as much in the first generation, one twenty-fifth as much in the second generation, and one-twentieth as much in the third generation.

Despite the decimation of oriental fruit moth populations in well-sprayed peach, moderate to heavy populations continue to be produced in young unsprayed peach orchards and in neglected, unsprayed apple orchards. There are large acreages of both the unsprayed peach and apple, and much of it is located within easy migrating distance of well-cared-for peach.

In young peach orchards in Burlington County, N. J., estimated from rather limited observations, the number of larvae produced per unsprayed tree during the first generation was about 15 times as great as that in bearing sprayed orchard, and during the second generation 19 times as great. Despite these large differences, only 2.1 first-generation larvae were reared per tree from unsprayed young peach trees. For the second-generation populations in New York and New Jersey there were 11.5 larvae per tree.

Observations made on unsprayed apple from eastern Connecticut to northern North Carolina from 1952 through 1954 show that moderate to heavy infestations occur generally from the time of the second generation until the end of the season. In the area studied, unsprayed apple appears to be responsible for producing most of the oriental fruit moths maturing from August until the issuance of the last overwintering larvae. The number reared per 1,000 fruits ranged from a few or none to as many as 424 for the second generation, 435 for the third generation, and 1,357 for the overwintering generation. Many single apple trees produced far more larvae than did several acres of well-sprayed peach trees.

Bearing peach orchards which receive no insecticides for oriental fruit moth control continue to be nearly as heavily infested as before effective sprays were available, but such acreage is comparatively small. Very late peaches are now grown in only a very small part of the area occupied by fruit, and they no longer contribute a considerable portion of the overwintering population.

LITERATURE CITED

(1) ALLEN, H. W., and BRUNSON, M. H.
1943. THE EFFECT OF PROXIMITY OF APPLE ON THE EXTENT OF ORIENTAL FRUIT MOTH INJURY IN PEACH ORCHARDS. Jour. Econ. Ent. 36: 879–882.

(2) BRUNSON, M. H.
1946. THE ORIENTAL FRUIT MOTH [GRAPHOLITHA MOLESTA] ON NURSERY STOCK. Jour. Econ. Ent. 39: 797–800.

(3) ———
1955. EFFECT ON THE ORIENTAL FRUIT MOTH OF PARATHION AND EPN APPLIED TO CONTROL THE PLUM CURCULIO ON PEACH. Jour. Econ. Ent. 48: 390–392.

(4) ——— and ALLEN, H. W.
1944. MASS LIBERATION OF PARASITES FOR IMMEDIATE REDUCTION OF ORIENTAL FRUIT MOTH INJURY TO RIPE PEACHES. Jour. Econ. Ent. 37: 411–416.

(5) NEISWANDER, R. B., and VOGEL.
1930. THE ORIENTAL FRUIT MOTH. *In* Forty-Ninth Annual Report 1929–1930. Ohio Agr. Expt. Sta. Bul. 470, 270 pp.

(6) PITT, D. T., and BRAMMER, W. H.
1947. THE RESULTS OF A SURVEY OF PEACH TREE POPULATION IN NEW JERSEY DURING 1946. N. J. Dept. Agr. Cir. 369, 73 pp.

(7) STEINER, L. F.
1932. OBSERVATIONS ON THE DISTRIBUTION OF HIBERNATING ORIENTAL FRUIT MOTH WORMS. Jour. Econ. Ent. 25: 864–868.

(8) ——— and YETTER, W. P., JR.
1933. SECOND REPORT ON THE EFFICIENCY OF BAIT TRAPS FOR ORIENTAL FRUIT MOTH AS INDICATED BY THE RELEASE AND CAPTURE OF MARKED ADULTS. Jour. Econ. Ent. 26: 774–788.

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