Bull. Inst. Zool., Academia Sinica 17(2): 103-108 (1978)

A POPULATION STUDY OF THE ORIENTAL FRUIT FLY, *DACUS DORSALIS* HENDEL (DIPTERA: TEPHRITIDAE), IN GUAVA, CITRUS FRUITS, AND WAX APPLE FRUIT IN NORTHERN TAIWAN

AN-LY YAO AND WEN-YUNG LEE

Institute of Zoology, Academia Sinica, Taipei, Taiwan, Republic of China

(Received August 22, 1978)

An-Ly Yao and Wen-Yung Lee (1978) A population study of the oriental fruit fly, *Dacus dorsalis* Hendel (Diptera: Tephritidae), in guava, citrus fruits and wax apple fruit in northern Taiwan. *Bull. Inst. Zool., Academia Sinica* 17(2): 103-108. This study is concerned with the population of the oriental fruit fly (*Dacus dorsalis* Hendel) in guava, citrus fruits, and wax apples in the three counties of northern Taiwan (Taipei, Hsin-chu and I-lan). The study period was the year from September 1976 to August 1977. Two research strategies were followed: (1) All of the fallen fruits from randomly selected trees in selected farms were collected periodically. Each fruit was analyzed for extent of infestation. (2) Traps baited with poisoned methyl eugenol were set up in the collecting stations to catch male fruit flies. These traps were inspected at constant intervals and the numbers of the trapped flies were counted. The population of the oriental fruit flies was found to be related to (1) the ripening seasons of the fruits, and (2) the types of fruits grown. *D. dorsalis* was the only tephritid recovered from the collected fallen fruits. Among those males caught by the baited traps, 99.5% were *D. dorsalis*; three other species, *D. nubilus*, *D. cucurbitae*, and *D. tau* made up the other 0.5%.

Although Hsin-chu County was included in the area where sterile fruit flies were released after September 1976, the results of this study were hardly affected by it.

This study is concerned with the relationship between the population density of the oriental fruit fly (*Dacus dorsalis* Hendel) and its major host, guava (*Psidium guajava* L.) in the three counties of Northern Taiwan (Taipei, Hsin-chu, and I-lan). The study lasted for one year (September, 1976 to August, 1977). It thus allowed observations on possible changes in the pest-host relationship which might have occurred during the different growing seasons of the fruit.

Guava was chosen as the subject because guava fruits are generally available throughout the year in the study area. It provides a good means for making seasonal observations. To facilitate comparative analyses on pest-host relationships, some other citrus fruits (*Citrus tankan* Hay, *C. poonensis* Hort, and *C. sinensis* Osb.) and wax apple (*Eugenia javanica* Lamk.) were also included in the study.

MATERIALS AND METHODS

Sampling and laboratory procedures

Twenty-two plots of land were selected from fruit farms in the study area. There were 6 plots in Taipei, 4 in Hsin-chu, and 12 in I-lan. Ten to 15 fruit trees were randomly sampled in each of the selectcd plots. Periodi-

Paper No. 200 of the Journal Series of the Institute of Zoology, Academia Sinica.

cally, the authors visited these trees and collected all of the fruits that fell from them. The collected fruits were promptly transported to the laboratory of the Institute of Zoology, Academia Sinica for analyses. They were first kept there for 7 to 10 days under laboratory conditions. This waiting period was deemed necessary as the larvae, if there were any inside, had to become mature before the subsequent treatment could proceed. Each fruit was then dissected. All of the larvae, if present, were removed. The larvae were counted and transferred to sand which was used as a medium for their pupation. After emergence, the adults were collected, identified, and counted. From this data, determinations of the numerical relationship between the parasitic insects (oriental fruit flies and/or any other) and the fruits were made.

Guava trees usually have a clearcut annual fruiting cycle. In most of the collecting stations the peak fruiting season was between September and December. From March to May, fruits were relatively common and abundant. But in the rest of the year, fruits were rather scarce. The fruiting season for wax apple was, however, in June and July. It was comparatively short, but before and after that, none of its fruit was found in the sampled plots. Citrus fruits were most abundant from October through December. A few of them were collected in January, but none was found in the rest of the year.

The selected plots were visited at a two-week interval during the abundant fruit period and at a four-week interval during the non-fruiting period. Since the fruiting seasons of these species were different, collecting the different samples at comparative time periods was not possible. Comparisons of the pest-host relationships between these fruit species had to be based on gross average only. The present study is thus handicapped by the impossibility of providing more in depth month-to-month comparisons.

Trap catches of male *D. dorsalis*

Some specially designed plastic traps baited with poisoned methyl eugenol were set up at the sampled localities. Since methyl eugenol is an effective male lure for fruit flies (Steiner, 1952), these traps were meant for catching male fruit flies for subsequent evaluations. Usually, one trap was set up in a plot, but two or more needed if the orchard was larger than 20 hectares. Twice a month, the traps were inspected. In these instances, all of the flies caught by the traps were removed and counted, and the methyl eugenol bait replenished.

In the present study, Hsin-chu County was included into the sterile-flies release program area after September, 1976. The possibility that this study might have been affected by the presence of sterile flies was not totally precluded. However, the effect of this program on the present study was thought to be negligible as most of the sampled plots were at least 3 kilometers away from the nearest release station. According to Yao et al. (1977), the moving ability of the sterile *D. dorsalis* was at most 2.8 to 3.5 kilometers.

RESULTS

Infestation of guava fruits

The extent of infestation of guava fruits in Taipei, Hsin-Chu, and I-lan counties are summarized in Table 1. In addition to these, three indices of infestation as postulated by Haramoto and Bess (1970) were computed. They were (a) percentage of samples with and without tephritid larvae, (b) percentage of individual fruits with and without tephritid larvae, and (c) number of tephritid larvae per fruit (Table 2).

(a) Percentage of samples with and without tephritid larvae:

During the peak fruiting season of guava (between September and December), the project workers visited the sampled plots 22 times. Nineteen times, they collected one or more infested pieces of fruit. From January to August, 26 visits were made, 12 of which infested fruits were found. In the other words, from September to December, 13.6% of the samples were without tephritid larvae (86.4% with larvae). On the other hand from January to August, 53.8% of the samples were un-infested (46.2%

TABLE 1
Infestation of guava fruits in Taipei, Hsin-chu, and I-lan counties
(September 1976–August 1977)

Month	No. of fruits			% of fruits infested			No. of larvae			No. of larvae per fruit*		
	Taipei	Hsin-chu	I-lan	Taipei	Hsin-chu	I-lan	Taipei	Hsin-chu	I-lan	Taipei	Hsin-chu	I-lan
'76 9	28	276	78	28.6	97.5	21.8	114	2860	125	14	11	7
10	172	609	9	97.7	97.7	0.0	1602	6210	—	10	10	—
11	110	34	0	31.8	100.0	—	165	333	—	5	10	—
12	63	174	1	100.0	63.8	0.0	716	145	—	11	1	—
'77 1	130	174	100	16.2	11.5	0.0	36	95	5	2	5	5
2	0	0	0	—	—	—	—	—	—	—	—	—
3	73	76	79	21.9	13.2	7.6	63	80	23	4	8	4
4	116	158	17	11.2	4.4	82.4	82	25	148	6	4	11
5	0	72	0	—	5.6	—	—	21	—	—	5	—
6	0	0	3	—	—	100.0	—	—	105	—	—	35
7	0	0	0	—	—	—	—	—	—	—	—	—
8	0	284	0	—	38.4	—	—	855	—	—	8	—

* Numbers rounded to nearest integer.

TABLE 2
Infestation of guava fruits by counties in peak fruiting season and the rest of year

County	January to August (Non-peak fruiting season)					September to December (Peak fruiting season)				
	No. of samples	No. of fruits	I	II	III	No. of samples	No. of fruits	I	II	III
Taipei	10	319	60.0	15.7	3.6	8	373	87.5	73.5	9.5
Hsin-chu	8	764	12.5	19.6	7.2	10	1093	90.0	92.3	9.5
I-lan	8	199	42.9	12.1	11.7	4	88	75.0	19.3	7.4

I: % of samples infested.
II: % of fruits infested.
III: No. of larvae per fruit.

with larvae). This finding suggests that there was seasonal variation in the extent of infestation of guava fruits in the study area.

(b) Percentage of individual fruits with and without tephritid larvae:

Among those fruits collected during September to December, 83.7% of them had one or more larvae per fruit. Among those collected during January to August, only 17.5% of them had larvae inside.

When comparing these two indices, the extents of infestation of guava by fruit flies varied in accordance with the fruiting seasons and was more pronounced when the second index (% of individual fruits infested) was used as an indicator.

(c) Number of tephritid larvae per fruit:

This index also showed seasonal differences in the degree of infestation of guava. In Taipei and Hsin-chu, for instance, the average number of larvae per fruit from September to December was 9.5. It was higher than the average number for all other months (3.6 in Taipei, and 7.2 in Hsin-chu). The index computed for I-lan, however, revealed an exceptional case. From September to December, the average number of larvae per fruit in I-lan was 7.4, while from January to August, it was 11.7. This reverse was, however, possibly due to the presence of some unusually early ripening guava

fruits in I-lan. In June, there was no guava fruit found in Taipei and Hsin-chu Counties. But there were three pieces of completely ripe guava fruits (as suggested by their color and soft tissus) collected in one of the plots in I-lan in that month. They became the only available target hosts for *D. dorsalis* over the territory at that time. The fruit flies were thus attracted to lay eggs in them and thus gave rise to an exceptionally high rate of larvae per fruit. Upon dissection, they were found to be full of larvae, with an average of 35 larvae per fruit.

In general, therefore, all these indices reflect some variations in the extent of infestation of guava throughout the year. When the flies was more abundant, the indices of infestation were higher. When there were less ripe fruits available, the indices were also lower. The extent of infestation thus appears to be related to the ripening seasons of guava fruits.

Tephritid larvae abundance in other host fruits

Tables 3 and 4 show the infestation of various species of host fruits by *D. dorsalis*. The larvae population varied a great deal among the host trees and between their fruiting seasons as well. For example, in Taipei County, from September to December, there were on the average 10 larvae per fruit in guava, 11 per fruit in citrus fruits, and 0 per fruit in wax apple. On the contrary, in the two months of June and July, i. e., the peak fruiting season for wax apple, the average numbers of larvae per fruit in guava, citrus fruits, and wax apple were 0, 0, and 4 respectively.

TABLE 3

Infestation of citrus fruits in Taipei, Hsin-chu, and I-lan (September 1976–August 1977)

Month	No. of fruits			% of fruits infested			No. of larvae			No. of larvae per fruit*		
	Taipei	Hsin-chu	I-lan	Taipei	Hsin-chu	I-lan	Taipei	Hsin-chu	I-lan	Taipei	Hsin-chu	I-lan
'76 9	0	0	0	—	—	—	—	—	—	—	—	—
10	0	26	26	—	100.0	0	—	258	—	—	10	—
11	0	0	44	—	—	0	—	—	—	—	—	—
12	60	72	26	46.7	45.8	0	303	591	—	11	26	—
'77 1	56	41	65	3.6	0.0	0	7	—	—	4	—	—
2	0	0	0	—	—	—	—	—	—	—	—	—
3	0	0	0	—	—	—	—	—	—	—	—	—
4	0	0	0	—	—	—	—	—	—	—	—	—
5	0	0	0	—	—	—	—	—	—	—	—	—
6	0	0	0	—	—	—	—	—	—	—	—	—
7	0	0	0	—	—	—	—	—	—	—	—	—
8	0	0	0	—	—	—	—	—	—	—	—	—

* Numbers rounded to nearest integer.

TABLE 4

Infestation of wax apple in Taipei and I-lan (June–July, 1977)

Month	No. of fruits	% of fruits infested	No. of larvae	No. of larvae per fruit*
Taipei 6	419	0.00	—	—
7	289	1.04	5	2
I-lan 6	410	4.39	36	2
7	615	37.40	1106	5

* Numbers rounded to nearest integer.

Trap catches of male *D. dorsalis*

Over 99.5% of the male flies caught by the traps were *D. dorsalis*. Three other species, *D. nubilus*, *D. cucurbitae*, and *D. tau*, made up the other 0.5% of total catches. The number of *D. dorsalis* males caught by the traps varied among the three counties. But the upward and downward trends in the number caught followed a similar monthly patterns throughout the selected farms (Fig. 1). The pattern was, in fact, obviously related to the ripening seasons of the fruits. There were more male fruit flies trapped

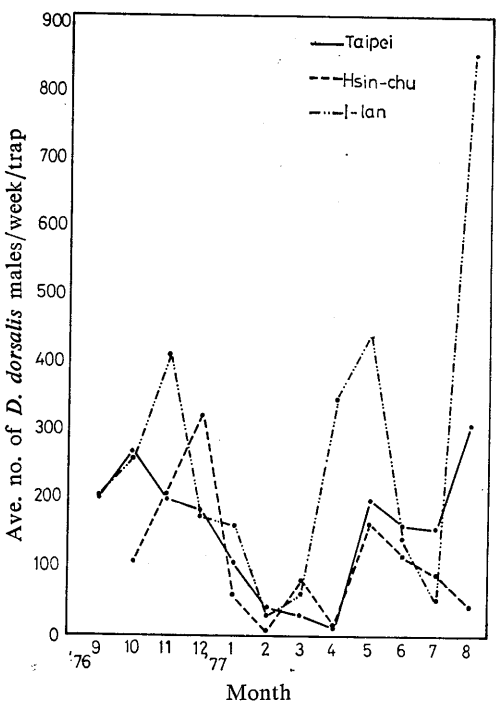

Fig. 1. Trap catches of male *D. dorsalis* in three counties.

TABLE 5
Average numbers of weekly trap catches of male *D. dorsalis* (September 1976–August 1977)

Month	County		
	Taipei	Hsin-chu	I-lan
'76 9	204	—	205
10	272	110	260
11	200	205	409
12	188	322	181
'77 1	108	57	164
2	43	9	30
3	31	81	61
4	13	15	350
5	200	164	444
6	165	117	143
7	160	92	51
8	313	43	860
Mean±S.D.	158.1±93.5	110.5±92.0	263.2±232.1

during the peak fruiting periods than at any other time during the rest of the year. From January through April, the average number of catches in the three counties were significantly below the total mean for the whole study period (Table 5).

Particular attention was paid to the trap catches in Hsin-chu County. Only 0.4% of them were marked sterile flies. The sterile-flies release program therefore had very little affect on the results of this reseach study.

DISCUSSION

Throughout this study, *D. dorsalis* was the only tephritid recovered from the collected fruits of guava, citrus, and wax apple.

The previous findings suggest that fruits were more seriously infested in their ripening seasons. This seasonal pattern of pest-host relationship should not be ignored while formulating measures to curb the damage of fruit flies.

A comparison of the Table 1, and Tables 3 to 4 reveals that guava was the most seriously infested by fruit flies among all the species of fruits studied. The sampled citrus fruits were not infested by fruit flies in I-lan deserves much attention. This might have been due to the presence of some varieties of citrus fruits which were particularly resistant to infestation by fruit flies. Investigations revealed that in I-lan, *Citrus tankan* and *C. sinensis* were the most widely planted varieties of the citrus. The fruits of these varieties have hard and tight coverings which could possibly have prevented fruit flies from depositing eggs in them. In Taipei and Hsin-chu, on the contrary, *C. poonensis* is more widely planted. The fruit of *C. poonensis* has a soft skin and is more readily infested by the fruit fly.

The citrus fruits grown in I-lan were not so seriously infested when compared to the other two counties was not due to a smaller population of fruit flies there. The monthly average catch of male *D. dorsalis* in I-lan exceeded that of either of the other 2 counties (158.1± 93.5/month in Taipei; 110.5±92.0/month in Hsin-chu; and 263.2±232.1/month in I-lan).

Careful selection of fruit species grown in orchards could therefore be considered as a possible strategy to further reduce infestation of fruit flies.

Acknowledgements: This research was supported by grant No. NSC-66B-0201-03(24) from the National Science Council, Republic of China. All of these trap caught tephritid species were identified by Mr. Yi-hsiung Tseng, Bureau of Commodity Inspection and Quarantine, Tainan, Taiwan, whose contribution is gratefully acknowledged.

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臺灣北部東方果實蠅 (*Dacus dorsalis* Hendel) (雙翅目：果實蠅科) 蟲口密度調查

姚 安 莉　　李 文 蓉

一九七六年九月起至一九七七年八月止，本研究室進行調查東方果實蠅 (*Dacus dorsalis* Hendel) 於臺灣北部發生情形。調查的寄主果實爲番石榴、柑桔類及蓮霧。調查方式有二：(1)定期收集果園落果，觀察並記錄果實蠅幼蟲爲害情形；(2)於田間懸掛以含毒甲基丁香油爲雄性誘引劑之誘殺器，記錄田間蟲口發生數目。發現蟲口密度與(1)果實成熟季節，及(2)寄主果實種類有關。所有由田間落果所收集蛹體中羽化出來的果實蠅均爲 *D. dorsalis*。由誘殺器誘得的雄蠅 99.5% 爲 *D. dorsalis*；其它 0.5% 爲 *D. nubilus*, *D. cucurbitae* 及 *D. tau*。新竹縣雖自一九七六年九月起列入不孕性蠅釋放地區，但於本實驗工作選擇地區並不太受不孕性蠅影響，因爲新竹縣誘得蟲隻中僅 0.4% 屬於不孕性蠅。