OVIPOSITION OF THE PAPAYA FRUIT FLY *TOXOTRYPANA CURVICAUDA* GERSTAECKER AS AFFECTED BY FRUIT MATURITY

J. E. PENA, R. M. BARANOWSKI AND R. E. LITZ
University of Florida, IFAS
Tropical Research and Education Center
18905 S.W. 280 St.
Homestead, FL 33031

ABSTRACT

A scale for assessing damage to papaya fruit by the papaya fruit fly *Toxotrypana curvicauda* Gerstaecker was used in the field to help detect egg and larval infestation. There were more eggs in green fruits than in ripe fruit, whereas more larvae were found in ripe fruit than in green fruit. Under laboratory conditions, papaya fruit fly preferred to oviposit in green papayas than in ripe fruit. In an experiment of the choice type, papaya fruit flies showed strong preference for oviposition in green wax domes than in yellow wax domes. The color preference of papaya fruit fly females was confirmed.

RESUMEN

Se utilizó en el campo una escala para evaluar el daño a la papaya por la mosca de la papaya, *Toxotrypana curvicauda* Gerstaecker para ayudar a detectar infestaciones de huevos y de larvas. Se encontró una mayor cantidad de huevos en los frutos verdes que en los frutos maduros, mientras que más larvas se encontraron en frutos maduros que en frutos verdes. Bajo condiciones de laboratorio, moscas de la papaya prefirieron poner los huevos en papayas verdes que en frutos maduros. En un experimento donde las moscas de la papaya podían escoger, ellas demostraron preferencia para poner los huevos en cúpulas de cera verde que en cúpulas de cera amarilla. Se confirmó el color preferido de la mosca de la papaya.

The papaya fruit fly (PFF) *Toxotrypana curvicauda* Gerstaecker almost exclusively uses the papaya *Carica papaya* L. (Knab & Yothers 1914) and occasionally fruit of mango *Mangifera indica* L. (Butcher 1952) as hosts. *Toxotrypana* occurs only in tropical America (Wolcott 1933) and in south Florida (Knab & Yothers 1914). Some cosmopolitan fruit flies, e.g., *Dacus dorsalis* Hendel, *D. cucurbitaceae* Coquillet and *Ceratitis capitata* (Weideman) also attack papaya in other tropical areas in the world (Seo et al. 1983) but generally they prefer ripe papayas.

Premature fruit maturity and fruit latex exudations have both been related to papaya fruit fly infestation (Knab & Yothers 1914). These plant reactions, however, could have been caused by other insects (Sloan 1946) or by pesticides (Sherman & Tanashiro 1959).

Stimuli eliciting the ovipositional response of PFF to its host are unknown. The PFF has been observed to oviposit in blossom buds and in a wide range of papaya fruits, 1.5 cm diam green fruit to 15 cm-diameter fruit that is almost completely ripe (Landolt & Hendrichs 1983) and undergoing a change in color from green to yellow. Factors such as fruit ripeness and color may play a role in the selection of fruits for oviposition.

In this study 3 aspects of the relationship between *T. curvicauda* and the papaya fruit have been considered:

(1) Are effects of PFF oviposition or larval activity precise measures of PFF population?

(2) To what extent do females discriminate between fruits with different degrees of ripeness?

(3) Does color affect oviposition?

Materials and Methods

Field Study

Visual observations of the possible effects of PFF infestations were made on 70 fruits collected from an insecticide-free commercial papaya planting (var. Cariflora) at Homestead, Florida, during August 1984. A visual classification of damaged and undamaged fruits was made. A grade scale of 0-6 was devised, based on personal observations and damage description by Mason (1922) and Knab and Yothers (1914) (Table 1). A RxC test of independence (Sokal & Rohlf 1969) was used to examine whether the percentages of fruits with eggs and larvae were independent of the papaya grade scale.

Laboratory Study

Papaya fruit flies used in color preference tests were obtained from a colony maintained in the laboratory at ca. 27°C under fluorescent lights that provided a photoperiod of LD 12:12. The colony was initiated with larvae that were collected in the field and which pupated in vermiculite. Adults were kept in screen cages (16.5 × 33 × 37 cm) and were provided with water (65 ml), sucrose (5.8 g) and honey. The effect of the degree of ripeness of papaya fruit on PFF ovipositional preference was studied. The ripeness of immature green, quarter-color, half-color, and ripe papayas was determined visually using the Nickerson Color Fan®. Fifteen females were exposed in each cage

TABLE 1. Classification of damaged and undamaged papaya fruits, var. Cariflora, based on field observations Homestead, Florida 1985.

Scale	Fruit description
0 =	Immature, green with no external symptoms of latex flow.
1 =	Immature, green, and with fresh latex flowing from the fruits, indicative of recent PFF oviposition.
2 =	Immature, green, and with dark-coagulated latex on the fruit, indicative of past PFF oviposition.
3 =	Fruit showing premature 1/4 color break, but firmly attached to the peduncle.
4 =	Fruit showing premature 1/4 color break, easily detached from peduncle, indicative of larval infestation.
5 =	Fruit showing 1/2 color break, firmly attached to the peduncle.
6 =	Fruit showing 1/2 color break, soft to the touch and with larval exit holes, indicative of present or past larval infestation.

(= one replicate) to the 4 different types of papaya fruits. This multiple choice experiment was replicated 8 times and conducted inside screen cages (16.5 × 22 × 37 cm). The number of perforations and eggs were recorded after 24 h. Data were analyzed by ANOVA and the means were separated by Duncan's Multiple Range Test. Later, an experiment of the multiple-choice type to determine PFF color preference was conducted inside screen cages. Oviposition substrates consisted of wax domes 7 cm in diameter and 3.5 cm high. To obtain domes of different hues that represented the colors of papaya fruit, green and yellow paraffin wax and petroleum jelly were mixed. Reflectance spectra of green and yellow colors were measured using the Nickerson Color Fan®. The color values were dark yellowish green = 10 GY 4/5, strong yellow green = 2.5 GY 6/8, strong greenish yellow = 7.5 Y 7/9, and strong orange yellow = 10 YR 7/10. Ten 6 day old females per cage (= one replicate) were tested. The experiment was replicated 6 times. The main criterion used for determining oviposition preference was the number of eggs that were laid in the dome. Counts of eggs were made daily and the positions of the domes in the cages were re-randomized daily. For the analysis of egg count data, analysis of variance was used and the means were separated by Duncan's Multiple Range Test at the P = 0.05 significance level.

Results

Field Study

The grade-scale study provided information on PFF oviposition and larval infestation of papaya fruit. Frequency of eggs and larvae in papaya fruit (Table 2) were dependent ($P < 0.05$) on the fruit grade scale. More eggs (Mean ± SE = 2.70 ± 1.87 and 2.04 ± 1.05; X^2 .005 [6] = 18.548) were obtained from fruit grades 1 and 2 than from any other types of fruit (0.0 ± 0.0). More larvae ($P < 0.05$; X^2 .005, [6] = 18.548 were obtained from 3, 4, 6, 2 and 1 grade-type fruit than from 0 or 5th grade. By using this grade scale, it was possible to partially determine egg and larval infestation in the field. The grade scale could be developed into a tool to help scouts select fruits with the best chance of containing PFF eggs or larvae.

Laboratory Study

The results of this multiple choice test (Table 3) demonstrated that females responded positively (P = 0.05) to a certain degree of fruit development, especially to

TABLE 2. Relationship between *Toxotrypana* eggs and larvae to different degrees of papaya ripeness and insect damage.

Grade scale	Mean eggs ± SE[a]	% fruit with eggs	Mean larvae ± SE[b]	% fruits with larvae
0	0.0 ±0.0	0	0.0 ±0.0	0
1	2.70±1.87	29	0.72±0.41	21
2	2.04±1.05	18	4.80±1.29	52
3	0.0 ±0.0	0	8.75±1.21	100
4	0.0 ±0.0	0	14.88±1.05	100
5	0.0 ±0.0	0	0.0 ±0.0	0
6	0.0 ±0.0	0	5.62±2.33	62

[a]X^2 .005 6 = 18.548; g—value (X^2 = 22.25) was significant at $P < 0.005$.
[b]X^2 .00t, 6 = 19.548; g—value (X^2 43.43) was significant at $P < 0.005$.

TABLE 3. OVIPOSITION OF *TOXOTRYPANA CURVICAUDA* FEMALES ON PAPAYA FRUITS WITH DIFFERENT DEGREES OF RIPENESS UNDER LABORATORY CONDITIONS (27±1°C; 75% R.H.).

Fruit characteristic	No. of perforations/ fruit[a]	Mean no. eggs/fruit	% total eggs
Immature green	10.5 a	55.0 a	68
Quarter color	3.3 b	3.81 b	5
Half color	5.4 b	9.45 b	12
Ripe	2.3 b	12.45 b	15

[a]Numbers followed by a different letter were significantly different at the P = 0.05 level.

TABLE 4. EFFECT OF GREEN AND YELLOW COLORS ON OVIPOSITION BY *T. CURVICAUDA* INTO PARAFFIN DOMES.

Color of dome	Avg. no. of eggs[a]	% of total
dark green	15 a	47
yellow green	6 b	18
greenish yellow	4 b	13
orange yellow	7 b	22

[a]Numbers followed by a different letter were significantly different at the P = 0.05 level.

immature dark green, and less to quarter color and ripe fruit. This behavior indicates that physical characteristics such as fruit color may be important for the selection of the oviposition site. Because changes in the chemical properties of ripening papaya fruit may also have an equally important effect on ovipositional behavior, the response of PFF females to color alone was determined.

The results (Table 4) demonstrated a strong color preference of the papaya fruit fly. About 46% of the eggs were laid in the dark green domes, followed by yellow green domes (18%) and orange-yellow domes (22%), and less for greenish yellow domes (13%). For example, the mean number of eggs laid in dark green domes was 15 (P = 0.05) compared to mean numbers of 6, 4 and 7 eggs laid in the other domes. The strong preference for the dark green domes indicated that this color constitutes a strong stimulus to the fruit-seeking papaya fruit fly females.

ACKNOWLEDGMENTS

This research was partially supported by USDA Cooperative Agreement No. 5B-7B30-9-116. Florida Agricultural Experiment Stations Journal Series No. 6537.

REFERENCES CITED

BUTCHER, F. G. 1952. The occurrence of papaya fruit fly in mango. Proc. Florida State Hort. Soc. 65: 196.

KNAB, F., AND W. W. YOTHERS. 1914. Papaya fruit fly. J. Agric. Res. 2: 447-453.
LANDOLT, P. J., AND J. HENDRICHS. 1983. Reproductive behavior of the papaya fruit fly *Toxotrypana curvicauda* Gerstaecker (Diptera: Tephritidae). Ann. Entomol. Soc. America 76: 413-417.
MASON, A. C. 1922. Biology of the papaya fruit fly *Toxotrypana curvicauda* in Florida. U.S. Dept. Agric. Bull. 1081-1-10.
SEO, S. T., C TANG, S. SANIDAD, AND T. TAKENABA. 1983 Hawaiian fruit flies. (Diptera: Tephritidae): variation of index of infestation with benzyl isothiocyanate concentration and color of maturing papaya. J. Econ. Entomol. 76: 535-538.
SHERMAN, M., M. TAMASHISO. 1959. Toxicity of insecticides and acaricides to the papaya, *Carica papaya* L. Hawaii Agric. Exp. Station, U. of Hawaii. Tech. Bull. 40: 56 p.
SLOAN, W. J. 1946. The fruit spotting bug. Queensland Agric. J. 1: 229-233.
SOKAL, R., AND F. ROHLF. 1969. Biometry: The principles and practice of statistics in biological research. W. H. Freeman and Co., San Francisco. 776 p.
WOLCOTT, G. N. 1933. Economic entomology of the West Indies. Clay and Sons, Ltd., Bengay, Suffolk. 688 p.

THRIPS IN AND AROUND THE COCONUT PLANTATIONS IN JAMAICA, WITH A FEW TAXONOMICAL NOTES (THYSANOPTERA)

K. SAKIMURA
Bishop Museum
Honolulu, Hawaii 96817

ABSTRACT

In and around the coconut plantations in Jamaica, 107 species of thrips were collected or caught by sticky traps. Prior to this collection, thrips recorded from the island were highly limited. Species repeatedly collected from coconuts were *Franklinella bruneri* Watson, *F. kelliae* Sakimura, and *F. insularis* (Franklin) (flower feeders); *Anisopilothrips venustulus* (Priesner) and *Heliothrips haemorrhoidalis* (Bouché) (fruit feeders); *Hoplandrothrips flavipes* Bagnall (fungal growth feeder); and *Karnyothrips merrilli* (Watson) (predator). Of every species enumerated, their extra distributions within the Caribbean areas were searched through the published data as well as accumulated holdings in museum collections. Twenty-two species of *Frankliniella* were collected, and a key to them is provided. Two new synonymies are designated, and a species is partly redescribed.

RESUMEN

Dentro y alrededor de plantaciones de cocos en Jamaica, 107 especies de "thrips" fueron colectadas o atrapadas en trampas pegajosas. Anteriormente a esta colección, el registro de "thrips" de la isla era muy limitado. Especies repetidamente colectadas en cocos eran *Frankliniella bruneri* Watson, *F. kellia* Sakimura, y *F. insularis* (comedores de flores); *Anisopilothrips venustulus* (Priesner) y *Heliothrips haemorrhoidalis* (Bouche) (comedores de frutas); *Hoplandrothrips flavipis* Bagnall (comedores de hongos); y *Karnyothrip merrilli* (Watson) (depredador). De cada especie enumerada, su distribución extra dentro del área del Caribe fue indagada a traves de datos publicados,