

ABUNDANCE AND REPRODUCTION OF *EUXESTA STIGMATIS*
(DIPTERA: OTITIDAE) ON SWEET CORN IN DIFFERENT
ENVIRONMENTAL CONDITIONS

D. R. SEAL, R. K. JANSSON AND K. BONDARI¹

University of Florida, Institute of Food and Agricultural Sciences,
Tropical Research and Education Center, Homestead, Florida 33031

¹Statistical and Computer Services, Coastal Plain Experiment Station,
The University of Georgia, Tifton, Ga. 31793-0748

ABSTRACT

The abundance of a picture-winged fly, *Euxesta stigmatis* Loew (Diptera: Otitidae), was studied on sweet corn in different environmental conditions. Adults were more abundant on plants in the sun than on plants in the shade. More adults were observed on tall plants than on medium and short plants. Females found on corn tassels had smaller ovaries with fewer mature eggs than those found on other corn plant parts (i.e., stem, ear, or leaf). Females with many eggs per ovary were observed at 0900 hours EST, but the number of eggs per ovary decreased as the day progressed. The

hosts of *E. stigmatis* in southern Florida included sweet corn, field corn, sorghum, sugarcane, guava, banana, atemoya, orchid, and potato. No larvae were found on orange.

Key Words: Abundance, habitat, distribution, Otitidae, maize

RESUMEN

Fue estudiada la abundancia de la mosca *Euxesta stigmatis* Loew (Diptera: Otitidae) en maíz dulce en diferentes condiciones ambientales. Los adultos fueron más abundantes en plantas al sol que en plantas a la sombra. Más adultos fueron observados en plantas altas que en plantas medianas y pequeñas. Las hembras encontradas en el penacho de la mazorca tuvieron los ovarios más pequeños con menos huevos maduros que las encontradas en otras partes de la planta. Fueron observadas hembras con varios huevos por ovario a las 0900 horas (hora estándar del este), pero el número de huevos por ovario disminuyó en la medida en que el día progresó. Los hospedantes de *E. stigmatis* en el Sur de la Florida incluyen maíz dulce, maíz de campo, sorgo, caña de azúcar, guayaba, banano, atemoya, orquídea y papa. No fueron encontradas larvas en naranja.

Sweet corn, *Zea mays* var. *rugosa* Bonaf, is an important winter crop in southern Florida and is valued at over \$5.7 million annually (Anonymous 1987). *Euxesta stigmatis* Loew (Diptera: Otitidae) is a serious pest of sweet corn in southern Florida (Seal & Jansson 1989) and in various Caribbean countries. Surveys conducted in 1989 (D.R.S., unpublished data) showed this insect to cause approximately 95% loss of sweet corn in nontreated fields. In some instances, economic loss has been reported even after the application of recommended insecticides. The *E. stigmatis* female oviposits inside the silks at the tip of corn ears. Larvae hatch 2-3 days after oviposition (Seal & Jansson 1989). Larval development takes place inside corn ears. Foliar application of insecticides has minimal effect on eggs and immature stages (Seal & Jansson 1995). During the late growing season optimum pesticide coverage is difficult to achieve because of the thick plant canopy. Few insecticides can be applied at the time of ear maturation because of days to harvest limitations. Nevertheless, several attempts have been made to manage this pest using insecticides (Bailey 1940, Hayslip 1951, Seal & Jansson 1989).

Proper pest management practice for *E. stigmatis* may be developed based on appropriate knowledge of its biology and behavior; however there is little published information on the biology and life history of *E. stigmatis*. App (1938) presented brief observations on its biology. Seal & Jansson (1989) elaborated on some additional aspects of the biology and management of this fly in Florida, and Seal & Jansson (1993) presented some information on its oviposition and development. Recently, Seal & Jansson (1995) studied the diel pattern of the sex ratio of *E. stigmatis* on different sweet corn plant parts.

The objectives of the present study were to provide additional information on the biology and the ecology of this pest. Specifically, we studied the habitat and host plants, weather effect, within plant distribution of females and diel pattern of egg supply of *E. stigmatis*.

MATERIALS AND METHODS

Habitat and Host Plants

Different habitats of *E. stigmatis* were surveyed for the presence of adults, immatures, and eggs in April, May and June, 1991. Habitats sampled included various fruits and vegetables and wooded and weedy areas. Qualitative and quantitative assessments were made by observing *E. stigmatis* adults 2 to 5 times in each habitat type at an interval of at least 7 days. We collected 5 to 30 specimens on each sampling date from each host, and the life stage of each specimen was recorded. The identity of pre-imaginal stages was confirmed by rearing them to the adult stage.

Weather

The response of *E. stigmatis* adults to sunny, cloudy, and rainy conditions was studied in a 0.4 ha sweet corn field (10-week-old) located in Homestead, FL on different dates in April, May and June, 1991. On a sunny day, the air temperatures ranged from 25-35°C. On a cloudy day, air temperatures ranged from 23-28°C, dewpoint 13-21.4°C, and barometric pressures 28-33 in Hg. A rainy day was characterized as a day when rain continued for 1 h or more.

We surveyed the field on 4 dates for each type of environmental condition. On each date, 10 plants were randomly selected and checked for *E. stigmatis* adults.

Effects of Sunlight and Plant Size on the Abundance of *E. stigmatis* Adults

The abundance of *E. stigmatis* on sweet corn plants in sunny and shaded conditions was determined in a nontreated 0.4-ha sweet corn field in which the mean \pm SE height of plants was 102 ± 5.1 cm ($n = 62$) and most of the plants (about 85%) were tasseling. In the morning at 1000 hours EST, sweet corn plants on the east side of the field received direct sunlight and the plants on the west side were in natural shade. The reverse was observed in the afternoon at 1400 hours EST. Eight sun-lit and 8 shaded plants were sampled randomly at 1400 hours EST and the number of *E. stigmatis* adults found on each plant was recorded. Light intensity for each plant was measured by stationing a light meter (Luna Pro F, Gossen, Germany) at a height of 70 cm along the stem above the ground. Sampling of plants under each environmental condition was replicated 5 times.

We also studied the abundance of *E. stigmatis* adults on sweet corn plants of 3 different heights, [short (≤ 70 cm), medium (71-119 cm), and large (120-165 cm), after tassels emerged. The field was planted to 'Silver Queen' sweet corn on 14 January 1991. Size differences among the plants were mainly due to the differences in the rate of plant growth. The field was divided into 5 uniform sections (about 0.1 ha each). As *E. stigmatis* adults settled on sweet corn plants at dawn (between 0600 and 0700 hours EST) and dusk (between 1800 and 1900 hours EST), 3 plants from each height category were randomly selected and the number of adults on each plant was recorded. Observations were made in each plot at these 2 times (dawn and dusk) 2 to 3 days a week for 4 consecutive weeks, between 25 March and 22 April, after tasseling.

Within Plant Distribution of Females and Diel Pattern of Egg Supply

This study was conducted using a 0.4 ha sweet corn field planted on 4 January 1991 and was not treated with insecticides. Field management was as discussed ear-

lier. *E. stigmatis* females ($n = 25$) were collected from 4 different locations on sweet corn plants (tassel, ear, stem, and leaf) at 0900, 1300, and 1700 hours EST each day for a 5 day period between 20 and 25 March. Collected females were preserved in 70% ethyl alcohol for later study. We recorded the length (posterior end of post abdominal segment to tip of head) and width (widest part of abdomen) of females. Females were then dissected in 0.7% saline solution under a stereo microscope (25 \times) to expose the ovaries. The lengths and widths of the ovaries, and the number of egg tubes in each ovary were recorded by using an ocular micrometer. Eggs were counted by severing the abdomen with iris scissors, cutting the sternum lengthwise, and transferring the ovaries to a dish containing 70% ethyl alcohol. We differentiated mature eggs [$n = 85$, 0.85 ± 0.004 , mean \pm SE, mm long, and 0.16 ± 0.001 (mean \pm SE) mm wide] by size. Immature eggs were exposed by puncturing the epithelial layer of the egg tubes. The number of mature eggs found in each ovary was recorded.

Statistical Analysis

Data on habitat preference, abundance of adults on sweet corn plants of different heights, within plant distribution of females with different levels of reproductive maturity, and number of eggs in ovaries were transformed to square root of ($x+1$) prior to analysis of variance. The transformed data were analyzed by least squares analysis of variance (PROC GLM, SAS 1989), but means of the original data are presented in all tables and figures for ease of interpretation. The pairwise t-test option PDIFF of PROC GLM (SAS 1989) was used to separate the treatment means where significant statistical differences occurred. The Chi-square test (PROC FREQ, SAS 1989) was used to test the independence of the number of adults present on various plant heights and the number of weeks after tasseling had occurred.

RESULTS AND DISCUSSION

Habitat and Host Plants

Most adults were found on various tropical fruit and vegetable crops, but occasionally they were also found in wooded and weedy areas. Larvae and adults were by far the most abundant on sweet corn, followed by field corn and with very small numbers on other crops (Table 1). Both larval and adult stages were recorded from all crops, except that no larvae were found in orange groves. Sweet corn, field corn and sorghum became infested with *E. stigmatis* immediately upon appearance of the silks or seed heads. Other plants were infested only when they were decaying.

Weather

On cloudy days, abundance of *E. stigmatis* adults was 0.3 ± 0.1 (mean \pm SE) ($n = 40$) per sweet corn plant at the pretassel stage. On sunny days, adult abundance was greater (1.3 ± 0.1 , mean \pm SE) than on cloudy days 0.2 ($t = 7.37$, $df = 79$, $P \leq 0.01$). In general, adults exhibited decreased activity on rainy days and on sunny days when the wind velocity was >24 km per h.

Effect of Sunlight and Plant Size on the Abundance of *E. stigmatis* Adults

Adults occurred more frequently ($t = 6.2$, $df = 79$, $P \leq 0.01$) on the sunlit sweet corn plants [1.3 ± 0.2 (mean \pm SE) per plant] than on shaded ones (0.2 ± 0.1 , mean \pm SE).

TABLE 1. MEAN NUMBER \pm SE OF *E. STIGMATIS* LARVAE AND ADULTS ON DIFFERENT HOST PLANTS.

Host plants	Number of Plants	Mean' Number of	
		Larvae	Adults
Field corn	<i>Zea mays</i> L. 'Pioneer 305'	11.1 \pm 3.0b	0.6 \pm 0.1b
Sweet corn	<i>Zea mays</i> L. 'Silver Queen'	57.8 \pm 6.0a	1.3 \pm 0.2a
Sorghum	<i>Sorghum bicolor</i> Moench	0.2 \pm 0.0d	0.2 \pm 0.1c
Sugarcane	<i>Saccharum officinarum</i> L.	0.2 \pm 0.1d	0.2 \pm 0.1c
Guava	<i>Psidium guajava</i> L.	0.7 \pm 0.3d	0.2 \pm 0.1c
Banana	<i>Musa</i> spp.	0.3 \pm 0.3d	0.2 \pm 0.1c
Orange	<i>Citrus aurantium</i> L.	0.0 \pm 0.0d	0.1 \pm 0.1c
Atemoya	<i>Annona squamosa</i> L. \times <i>A. cherimolia</i> Miller	0.8 \pm 0.5d	0.2 \pm 0.1c
Orchid	<i>Dendrobium</i> spp.	0.7 \pm 0.4d	0.1 \pm 0.0c
Potato	<i>Solanum tuberosum</i> L.	0.3 \pm 0.2d	0.1 \pm 0.0c

'Means within a column followed by different lowercase letters are significantly different ($P < 0.05$). Square root ($x + 1$) transformation was applied prior to the analysis of variance, but means are detransformed to the original scale.

In a small field (0.2 ha), the number of *E. stigmatis* adults were greater (2.7 ± 0.6 , mean \pm SE) on the first row of the east side of the field than on the first row (0.3 ± 0.1 , mean \pm SE) of the west side of the same field in the morning. In the late afternoon (1600-1800 hours EST), adults per plant were more abundant on the west side of the field ($n = 30$, 3.3 ± 1.2 , mean \pm SE) where light intensity was approximately 7,000 foot-candles than on the east side of the field ($n = 30$, 0.2 ± 0.1 , mean \pm SE) where light intensity was approximately 5,000 foot candles. At 1830 hour, light intensity below the canopy was approximately 3,000 to 3,500 foot-candles, when adults were observed to move to the top of plants where the light was somewhat brighter (approximately 4,000 foot-candles). Light intensity appears to play an important role in the determination of feeding and ovipositional activities and in the synchronization of mating behavior of this fly. Such influences of light on feeding, oviposition and mating of tephritid fruit flies was reported by several authors (Tzanakakis & Economopoulos 1967, Boller 1965, Flitters 1964, Barton Browne 1956, Myers 1952).

Results of the Chi-square tests (Table 2) indicated that the abundance of adult flies on corn plants 1-4 weeks after tasseling depended on the size of the corn plants. *E. stigmatis* adults were more abundant on tall plants both in the morning (82% of the total adult population) and evening (86% of the total adult population). Fly abundance did not differ significantly between medium and short plants either in the morning (11% vs. 7% adults, respectively) or evening (9% vs. 5% adults, respectively) samples. Tall plants were exposed to more intense light that may have attracted adults in larger numbers than shorter plants.

Irrespective of plant size, abundance of adults increased with increasing age of corn plants up to 3 weeks after anthesis (Table 2). Abundance increased linearly up to the third week after tasseling, but a significant decrease was observed thereafter.

Within-Plant Distribution of Adult Females

The length of females, irrespective of their locations on a sweet corn plant, did not differ significantly (Table 3). Females with a wider abdomen occurred on stems, but no significant differences were observed among the females collected from the other 3 parts of the sweet corn plants.

Irrespective of the locations, each ovary contained 48 to 56 egg tubes, each tube containing one mature egg. The lengths and widths of ovaries possessed by females found on stems were significantly greater than those of the females found on leaves (Table 3).

Accordingly, the number of unlaidd eggs per female collected from stems was the greatest, followed in decreasing order by those collected from ears, leaves, and tassels (Table 3). The comparatively smaller ovary lengths of adult females found on tassels was probably the result of the presence of fewer eggs than in females collected on other plant parts. We found that after oviposition, most of the adult females moved to tassels for subsequent mating during the day time. Adults often moved to the tassels at the end of the day (light intensity, <3,000 foot-candles) possibly for mating and shelter. Most of these females had no eggs in their ovaries. Correlations between the length and width of the adult females ($r = 0.68$) and between length and width of their ovaries ($r = 0.74$) were significant ($P < 0.05$), indicating that an increase in the body length or ovarian length is associated with an increase in corresponding widths of the body or ovary. Also, correlations between the width of an adult and the length ($r = 0.54$) or width ($r = 0.61$) of the ovary were positive and statistically significant ($P \leq 0.05$) indicating that the wider the body size of an adult, the wider and longer the ovarian size. Adult body width, ovarian length, and ovarian width were positively corre-

TABLE 2. NUMBERS OF *E. STIGMATIS* ADULTS ON SWEET CORN PLANTS OF DIFFERENT SIZES AT DIFFERENT WEEKS AFTER TASSELING.

Week After Tasseling ¹	Plant (<i>n</i>)	Plant Size ²			Percentage of Total	Total
		Large	Medium	Small		
Morning						
1	48	10	2	1	13	1
2	72	321	28	17	366	28
3	72	519	82	58	759	58
4	72	123	29	15	167	13
All weeks Total	264	1073	141	91	1305	—
% Total	—	82	11	7	100	—
Chi-square with 6 <i>df</i> = 17.5, <i>P</i> = 0.008						
Evening						
1	48	7	2	0	9	1
2	72	428	34	21	483	34
3	72	696	69	47	812	57
4	72	88	18	11	117	8
All weeks Total	264	1219	123	79	1421	—
% Total	—	86	9	5	100	—
Chi-square with 6 <i>df</i> = 16.5, <i>P</i> = 0.011						

¹Samples taken on 2 (week 1 only) or 3 different dates from 24 plants per plant size each.²Plant size categories: Small (< 70 cm), Medium (71-119 cm), Large (120-165 cm).

lated with the number of matured eggs per female. These results indicate a link between the adult female's shape, size, and reproductive performance.

Variation in diel pattern of mating behavior has been observed in some tephritid fruit flies, including some pest species, although most of these flies mate at dusk under low light intensities of less than 1,000 lux (Fletcher 1987). In contrast, *Dacus oleae* (Gmelin) flies prefer to mate in the afternoon at high light intensities (Arakaki et al. 1984, Lee et al. 1983, Suzuki & Koyama 1981, Qureshi et al. 1974, Tychsen & Fletcher 1971).

Diel Pattern of Egg Supply in the Ovaries

The greatest numbers of eggs in the ovaries of females were recorded at 0900 hours EST for females collected on all 4 plant parts (Fig. 1). Numbers of eggs decreased per female significantly at 1300 hours EST, especially for those females found on tassels or leaves, suggesting that the optimum egg laying period of *E. stigmatis* was between 0900 and 1300 hours EST. The present finding is in agreement with Seal & Jansson (1993) who reported that *E. stigmatis* oviposited the highest numbers of eggs between 0900 and 1300 hours EST. It was evident from the condition of the ovaries that egg-laying females were abundant on ears, leaves and stems of corn. Very few egg-laying females were found on tassels.

TABLE 3. MEANS¹ OF ADULT SIZE AND REPRODUCTIVE TRAITS OF *E. STIGMATIS* FEMALES COLLECTED FROM DIFFERENT LOCATIONS ON SWEET CORN PLANTS.

Location on Plant	Adults (n)	Adult Size ²		Ovary Size ²		Number of Eggs/Female
		L	W	L	W	
Tassel	21	4.9a	1.0b	0.8b	0.6a	3.0c
Ear	13	4.9a	0.9b	1.1a	0.5b	29.2ab
Stem	15	5.1a	1.2a	1.1a	0.6a	38.6a
Leaf	19	4.9a	1.0b	0.9b	0.5b	21.3b
SE of mean		0.09	0.03	0.04	0.03	5.6

¹Means within a column followed by different lowercase letters differ (P < 0.05).²L, length (mm); W, width (mm).

Females located on the tassels had few eggs at 1300 hours EST. By contrast, at 0900 hours EST, some females collected from tassels had a full complement of eggs in their ovaries. Upon dissection, the ovaries of some females collected from different locations on the plant at different times (0900, 1300 and 1700 hours EST) contained between zero and a full complement of eggs. These results indicated that egg maturation in *E. stigmatis* proceeds continuously throughout the day and the night to reach a maximum in the morning.

In conclusion, our study showed that *E. stigmatis* was much more abundant on sweet corn than on other host crops and that the adults were more active in sun than in shade. Females with greater numbers of mature eggs were more abundant on stems than on other plant parts. We observed adults moving to tassels at the end of the day. Because of the variable abundance of adults in different locations on corn plants at different times of the day, selective, prudent and timely use of insecticide appears to be an important management strategy for *E. stigmatis*. This information may be useful in the quest for a combination of biorational chemical treatments with biological and cultural measures to achieve environmentally sound integrated pest management of *E. stigmatis*.

ACKNOWLEDGMENTS

We thank P. R. Espinosa and J. M. Hazel for their technical assistance; Drs. R. E. Foster, Department of Entomology, Purdue University, and G. S. Nuessly, Univ. of Florida, I.F.A.S., Everglades Research and Education Center, Belle Glade, FL, for reviewing the manuscript. We thank J. Alger for providing commercial fields, sweet corn seed, and other miscellaneous supplies. The research was supported in part by a grant from Alger Farms, Homestead, FL. This is Florida Agricultural Experiment Station Journal Series No. R-05310.

REFERENCES CITED

- ANONYMOUS. 1987. Dade County Agricultural Statistics.
 APP, B. A. 1938. *Euxesta stigmatis* Loew, an otitid fly infesting ear corn in Puerto Rico. J. Agric. Univ. Puerto Rico. 22: 181-8.

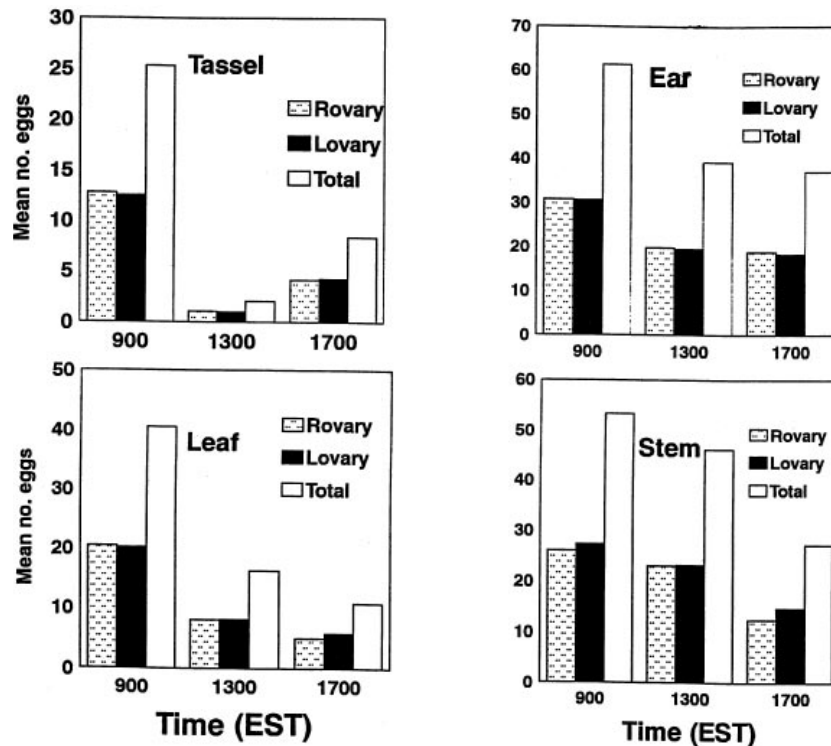


Fig. 1. Diel pattern of egg supply of *E. stigmatis* females on different parts of sweet corn plants. Rovary, right ovary; Lovary, left ovary; EST, eastern standard time ($n = 25$ adults).

- ARAKAKI, N., H. KUBA, AND H. SOEMORI. 1984. Mating behavior of the oriental fruit fly, *Dacus dorsalis* Hendel (Diptera: Tephritidae). Appl. Entomol. Zool. 19: 42-51.
- BAILEY, W. K. 1940. Insecticidal control of corn-silk fly. Puerto Rico Exp. St. Circ. Vol. 23.
- BARTON BROWNE, L. 1956. The effect of light on the fecundity of the Queensland fruit fly, *Strumeta tryoni*. Australian J. Zool. 5: 145-158.
- BOLLER, E. F. 1965. Beitrag zur Kenntnis der Eiablage und Fertilität der Kirschenfliege *Rhagoletis cerasi*. Mitt. Schweiz. Entomol. Ges. 38: 194-202.
- FLETCHER, B. S. 1987. The biology of dacine fruit flies. Annu. Rev. Entomol. 32: 115-144.
- FLITTERS, N. E. 1964. The effect of photoperiod, light intensity, and temperature on copulation, oviposition, and fertility of the Mexican fruit fly. J. Econ. Entomol. 57: 811-813.
- HAYSLIP, N. C. 1951. Corn-silk fly control on sweet corn. Florida Cooperative Extension Circular S-41: 1-5.
- LEE, L. W. Y., T. H. CHANG, AND C. K. TSANG. 1983. Sexual selection and mating behavior of normal and irradiated oriental fruit flies. CEC/IOBC Symp., Athens, 1982. Rotterdam, Balkema. p. 439-444.

