Seasonal Periodicity of Fall Armyworm, (Lepidoptera: Noctuidae) in the Caribbean Basin and Northward to Canada[1]

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ABSTRACT Sex pheromone traps were used to monitor the seasonal periodicity of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith), moth over a 2-year period at eight locations from French Guiana northward to Canada. Results indicated a seasonal progression of movement by fall armyworm from the southern most locations in the United States into Canada. Although the fall armyworm survives throughout the year in the Caribbean Basin, analysis of moth capture and meteorological data for the region provided no direct evidence that this reservoir of continuous populations contributed significantly to the influx of this pest into the temperate regions of North America where it normally does not survive the winter. Weather disturbances along the Atlantic seaboard of the northeastern U.S. and Canada in October 1984 and an associated precipitous decline in moth captures in pheromone traps supports a previous hypothesis of a return (southward) migration by fall armyworm.

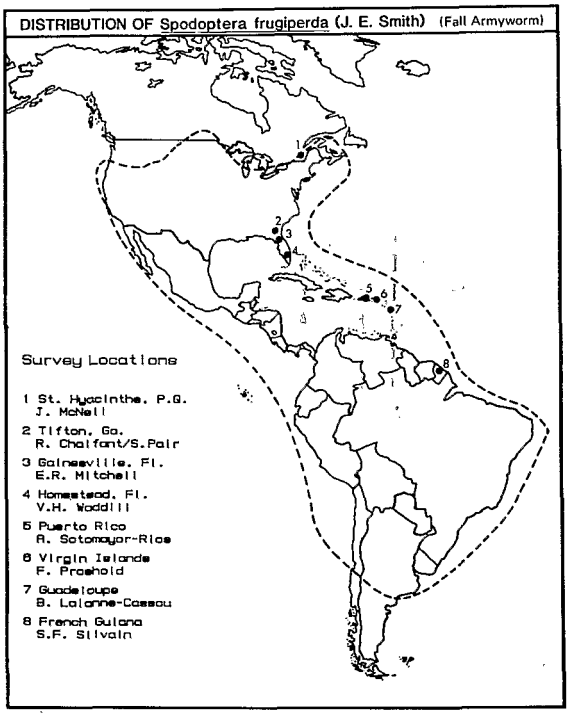


Fig. 1. Geographical distribution map of the fall armyworm (from Ashley 1986) showing the location of the adult population sampling sites and on-site cooperators.

and early summer, the FAW disperses northward into the eastern and central United States as well as into southeastern Canada (Mitchell 1979).

Prevailing winds during the spring are thought to largely determine the extent and direction of FAW adult movement. Luginbill (1928) recognized that the prevailing wind vectors in the southeastern United States consisted of south-southeasterly components during the spring months. More recently, Westbrook and Sparks (1986) compiled atmospheric data for the southern U.S., Mexico, Central America, and the Caribbean Islands for the period October 1976 - June 1977 in an attempt to explain the sudden and severe outbreak of FAW populations throughout the southeastern U.S. in 1977. Their analysis revealed atmospheric anomalies were significantly correlated with the population dynamics and dispersal of 1977 FAW populations. Retrogressive analysis of atmospheric trajectories targeted probable FAW overwintering regions — specifically southern Florida and possibly Cuba — which impacted the northerly advance of this pest into the southeastern U.S. in 1977. The present study was undertaken to determine the role of adult movement on FAW populations in overwintering areas and uninfested areas further north.

Materials and Methods

Adult sampling. Sex pheromone traps were used to monitor the seasonal periodicity of FAW at eight sites from French Guiana to Canada. Trapping commenced in April 1984 and ended in March 1986. International Pheromones Moth Traps (bucket traps; International Pheromone Systems, Merseyside, England) were baited with rubber septa containing the following blend of FAW sex pheromone (percentage by weight): (Z)-7-dodecen-1-ol acetate, 0.45%; (Z)-9-dodecen-1-ol acetate, 0.25%; (Z)-9-tetradecen-1-0l acetate, 81.61%; and (Z)-11-hexadecen-1-ol acetate, 17.69% (Mitchell et al. 1985). The baits were formulated by Terochem Laboratories, Ltd., Edmonton, Canada, and each contained 2 mg of the total blend.

Trapping sites are shown on the FAW distribution map (Figure 1). Three traps were located at each site in areas having suitable host plants, especially forage and other grass crops. Pheromone traps were operated throughout the year at all locations except Canada where they were deployed in late spring and removed in early winter. The traps were mounted ca. 1 m above ground level on metal poles. An inverted v-shaped, sheetmetal roof was mounted above each trap to protect it from rain and direct sunlight. Each trap contained a piece of Vapona® insecticide strip to kill captured moths. Traps at each site were positioned at least 1 km apart. The traps were checked and emptied on Tuesday and Friday of each week, and the pheromone baits and Vapona® strips were replaced biweekly.

Atmospheric Trajectories. Upper-air data for the stations in the southern U.S. and the Caribbean Basin during the study period were acquired from the National Climatic Data Center (NCDC). The data were available on a set of 9-track magnetic tapes as part of tape deck family TD-6201.

Upper-air soundings were recorded twice daily (0000 and 1200 UTC [Universal Coordinated Time]) as per international convention. The upper-air soundings quantified the vertical structure of temperature, humidity, wind velocity, and barometric pressure. Inter-station distances were typically 250 km. Generally, temporal changes in atmospheric variables decreased with altitude above the atmospheric boundary layer. The meteorological data (i.e., wind velocity) used in the analyses were restricted to the months of Dec. - Apr. for three consecutive years beginning in 1983.

Other noctuid moth species such as the corn earworm, *Helicoverpa zea* (Boddie), and tobacco budworm, *Heliothis virescens* (F.), have been observed flying at modal altitudes of about 500 m above ground level (AGL) (Wolf et al. 1986). A modal altitude of 500 m above sea level (MSL), which is nearly synonymous with 500 m AGL for the Florida Peninsula and the Caribben Basin, was used for calculating atmospheric trajectories representing FAW displacements.

Horizontal wind velocity components (i.e., westerly - easterly [zonal] and southerly - northerly [meridional]) were linearly interpolated at 500 m MSL from each vertical upper-air sounding. Wind velocity components were then statistically summarized for each station to note average and variability. Because wind velocity is a vector quantity (i.e., possessing magnitude and direction), it is necessary to analyze the (scalar) wind velocity components independently. Mean wind velocity components were added vectorially to produce a vector-mean wind velocity for each station.

It is important to note that a vector-mean is most meaningful when the directional variability of the wind remains relatively small (e.g., tradewinds). The vector-mean wind speed will always be less than or equal to the arithmetic mean

wind speed. Missing data were common for many stations in the Caribbean Basin; no attempt was made to normalize the incomplete data records with respect to complete data records from adjacent stations.

Results

Results of the 1984 - 86 FAW pheromone trapping survey are summarized in Figure 2. In 1984, the trap capture data indicated a seasonal progression of peak moth captures from North Florida to Canada. At the time the study was initiated in April 1984, the trap catch data indicated that the FAW population in Homestead, FL (location 4), was low, a typical situation for spring and summer months (Pair et al. 1986).

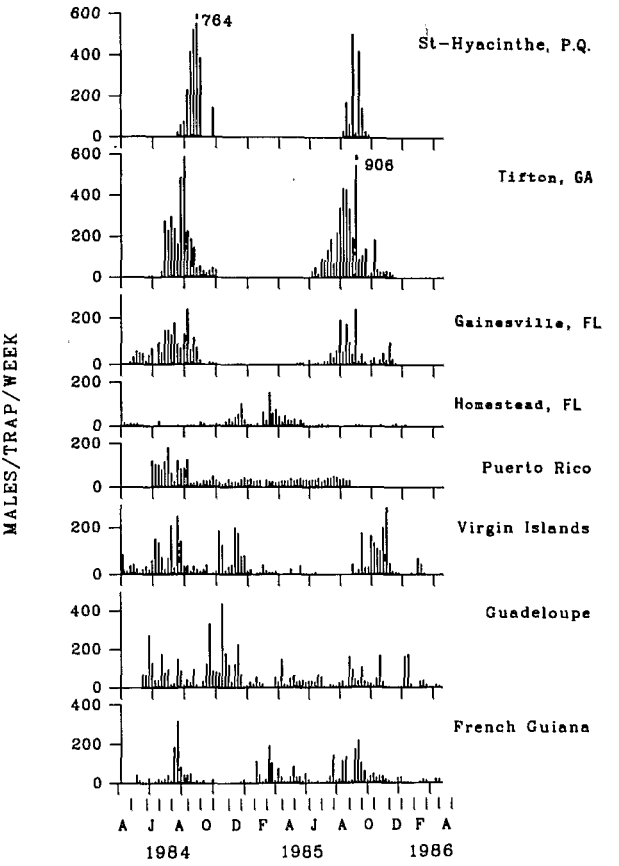


Fig. 2. Mean weekly captures of male fall armyworm moths in pheromone-baited bucket traps at selected survey sites in the Caribbean Basin, southeastern United States, and Canada (Apr. - Dec. 1984; Jan. - Dec. 1985; Jan. - Apr. 1986). Pheromone traps were not operated in Puerto Rico during week of February 17, 1985.

A substantial number of FAW adults was recorded at Gainesville, FL (location 3), during spring (April - May) 1984, but few FAW were captured at Tifton, GA (location 2), during the same time period. Large numbers of FAW were captured at Gainesville and Tifton during the ensuing summer months (July through mid-September). Captures of FAW moths at St. Hyacinthe, Canada (location 1) increased greatly during September 1984 correspondent with trap catches at Tifton and Gainesville (Figure 2).

During the winter of 1984 - 1985, the FAW population at Homestead, FL (location 4), followed the typical trend of discrete generations with increasing numbers of moth captures December through mid-March. Thereafter, the FAW moth population remained relatively low thoughout the late spring, summer and fall. However, the northward seasonal progression of FAW captures noted for Gainesville, Tifton, and St. Hyacinthe in 1984 was not evident in the 1985 trapping data.

There was no clear indication that FAW populations developing in areas of the

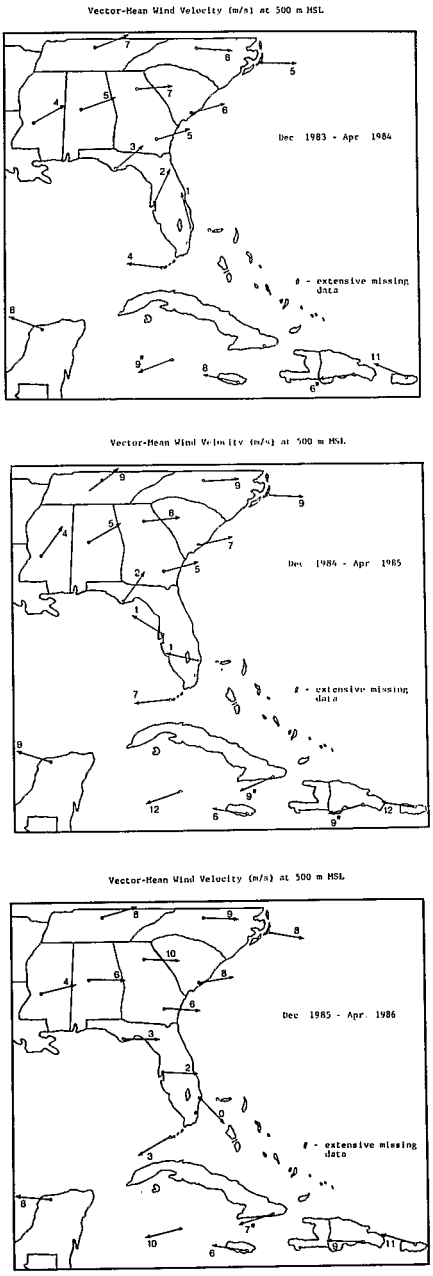


Fig. 3. Vector-mean wind velocity (m/s) for the southeastern U.S. and the Caribbean Basin (Top) Dec. 1983 - Apr. 1984, (Middle) Dec. 1984 - Apr. 1985, and (bottom) Dec. 1985 - Apr. 1986.

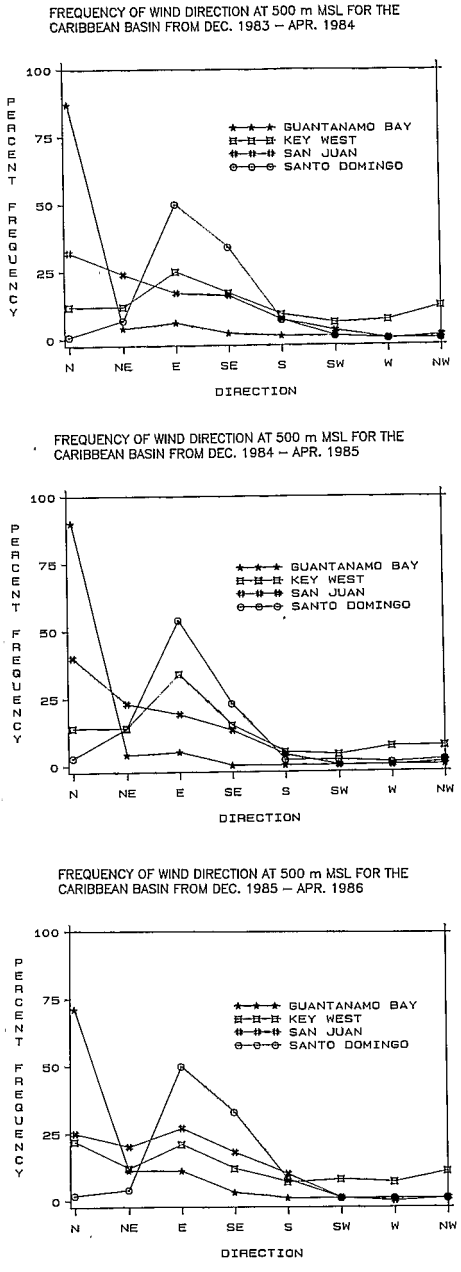
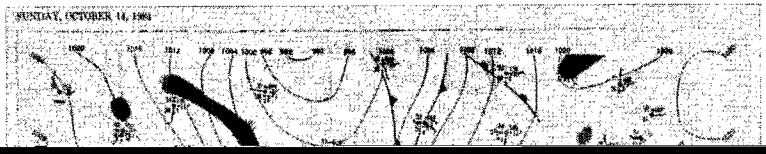


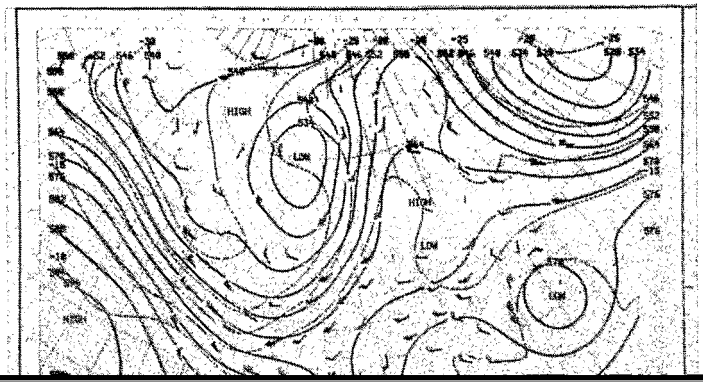
Fig. 4. Wind direction frequency (%) for the southeastern U.S. and the Caribbean Basin (Top) Dec. 1983 - Apr. 1984, (Middle) Dec. 1984 - Apr. 1985, and

documented perennial FAW habitats and the southeastern U.S. The modal wind direction frequency at Key West shifted from easterly (1983 - 84 and 1984 - 85) to northerly in 1985 - 86 (Figure 4). Otherwise no significant inter-annual differences appeared in the wind direction frequencies.

Close scrutiny of synoptic weather maps for October, 1984, revealed substantial atmospheric transport opportunities for northward and southward migration of FAW moths. Weekly trap captures at St. Hyacinthe, Canada (location 1), decreased from 386 moths during the week of September 30 to <2 moths per trap the weeks of October 7 and 14, 1984. The decreased trap capture corresponded with the northward movement of Hurricane Josephine along the North Atlantic coast of the U.S. from Oct. 12 - 14, 1984 (Figures 5 and 6). Strong northerly winds from Quebec southward along the Atlantic seaboard were forced several days prior, during, and after the hurricane passage and enhanced opportunities for return (southward) migration of FAW. Pair et al. (1987) described similar atmospheric transport observations and associated trap capture data to corrobrate the hypothesis of return migration of FAW from the Texas High Plains in September, 1984.

A smaller but definite late-season spike in trap captures of FAW at St. Hyacinthe occurred during the week of October 29, 1984. A deep low pressure system in the Hudson Bay, Canada, strongly forced warm air northward ahead of a cold front which briefly provided excellent northward atmospheric transport potential for fall armyworm migration into Quebec (Figures 7 and 8).

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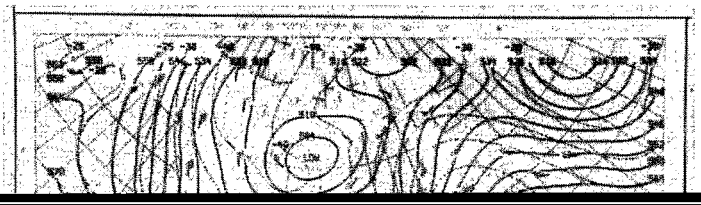

atmospheric transport conditions frequently are imbedded within the record of otherwise persistent non-beneficial (i.e., westerly or northerly) atmospheric transport conditions (Westbrook and Sparks 1986).

In this study, moth captures in pheromone traps plus analysis of wind currents provided circumstantial evidence of movement by FAW between the Antilles and the continental U.S. and between the U.S. and Canada. Nevertheless, pheromone trapping alone does not appear sufficient to detect migratory FAW moths. Future studies on the migration of FAW — and probably other migrant insect pests — would be enhanced greatly through use of multiple detection techniques including pheromone traps, light traps, mark and recapture, radar, and characterization studies such as flight capacities, and genetic analyses.

Acknowledgments

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