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THE WHORLWORM, *SPODOPTERA FRUGIPERDA*, IN CENTRAL AMERICA AND NEIGHBORING AREAS[1]

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ABSTRACT

Recent literature concerning *Spodoptera frugiperda* (J. E. Smith) from Central America and selected nearby areas is reviewed. The pest's distribution, importance, seasonal abundance, host plants, life cycle and biology, as well as its natural, cultural and chemical control are discussed.

The conspicuous, distinctive damage which the ubiquitous whorlworm[3], *Spodoptera frugiperda* (J. E. Smith), inflicts on a large number of crop plants, has made it the most discussed pest of food crops in Central America. The information presented herein was taken primarily from Central American and Panamanian literature published since 1970. Earlier references from the isthmus as well as works from other Latin American countries and the

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[3]This name is a translation of the Spanish term "gusano cogollero" and is used here because the North American term "fall armyworm" is not appropriate in the neotropics.

U.S. have been selectively included. Peairs and Saunders (1980) recently reviewed mostly temperate zone literature concerning the pest.

Distribution

The species is recorded from Mexico, all of Central America and Panama (McGuire and Crandall 1967). Its distribution extends eastward into the Caribbean and southward to northern Argentina and northern Chile (Ortega 1974). According to Sifuentes et al. (1969), the pest is found in all agricultural areas of Mexico but is most damaging in the more tropical southern and eastern states and territories. In Guatemala, the pest is important from sea level to at least 1500 m in elevation (Painter 1955).

Seasonal Abundance

Apparently, breeding of the whorlworm is continuous in areas of Central America where host plants are available during both the wet and dry seasons. In an irrigated area of El Salvador eggs have been encountered the year-round (Reyes and Andrews, unpub.). However, Whitcomb[4] reported that the species does not breed successfully in Venezuela during the dry season except in high humidity microclimates; eggs found during the dry season usually are not viable. The pest is most damaging at the onset of the rainy season from May to June in Panama on rice (Navas 1976) and pastures (Navas, in prep.). Snow et al. (1968), caught more moths in light traps on St. Croix at the outset of the rainy season. However, in Nicaragua and El Salvador, the pest causes more damage to maize (corn) and sorghum in the second (August) planting than in the first (May-June) (Sequiera et al. 1976, Andrews, unpublished data). Vaughn (1975) reports that as a genus, *Spodoptera* spp. causes more serious problems on cotton in Nicaragua during the dry season, i.e., after November. Pretto (1970) reported greater whorlworm damage in Panama on maize during the dry season. These conflicting reports may result from climatic differences or from a confusion of the concepts of abundance and damage potential.

Host Plants

Pretto (1970) listed maize, rice, sorghum, sugarcane, pasture grasses, soybean, peanuts, cabbage, alfalfa, clover, beans, potatoes, tomatoes, tobacco, pumpkins, spinach and cotton as hosts in Panama. Berry (1959) presented a similar list for El Salvador. Without specifying country, McGuire and Crandall (1967) reported many of these same plants as well as beets, lettuce, garlic, and onions. The pest caused severe damage in a pine tree nursery in Honduras (Howell 1978). While most authors list it as a pest of cotton, Vaughn (1975) considers *S. frugiperda* to be the least important member of the genus and only a potential pest of this crop in Nicaragua. Chereguino and Menéndez (1975) gave *Amaranthus spinosus* as an important weed host in El Salvador.

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[4]Personal communication from W. H. Whitcomb, Department of Entomology & Nematology, University of Florida, Gainesville, FL 32611.

Life Cycle and Behavioral Studies

The same authors indicated that in El Salvador the species went from egg-to-egg in 33.5 and 27.7 days on *A. spinosus* and maize, respectively. In the presence of appropriate hosts, 12 generations per year are possible. These authors recorded production of 206 to 1500 eggs per maize-reared female. In Cuba, 11.4 generations per year were predicted based on laboratory studies (Blahutiak 1970b). Blahutiak (1970a) observed a maximum fecundity of 1460 eggs. Foliage of maize is more nutritious than either millet or guinea grass (Blahutiak 1970c). In Peru, Escalante (1974), recorded an egg-to-egg period of 110 days and fecundity of only 400-500 eggs per female.

Based on light trap data from Nicaragua, Vaughn (1975), and Sequiera et al. (1976), stated that moth abundance is cyclic and peak activity is correlated with the new moon. Our work (Reyes and Andrews, unpublished), using pheromone-baited sticky traps, does not support this assertion.

In maize, the species causes damage by feeding on the developing whorl, leaves and tassel; by gouging out areas of the stem; and by eating into the ear (Painter 1955). It also acts as a cutworm in Panama (Pretto 1970) and other Central American countries. It may be a borer in ear shanks and young stalks. Damage to developing ears is seldom severe and farmers are more concerned with the pest as a foliage feeder. It also feeds commonly on developing sorghum heads. Navas (1976) reported extremely high populations capable of eliminating upland rice plantings in Panama; when no vegetation is left, the larvae moved *en masse* to nearby fields. Whitcomb[4] reported it behaving in this same manner in maize in Venezuela. Apparently, this "true armyworm" behavior is uncommon in Central America; populations seldom are so high that mass migrations are seen.

Sifuentes (1967) in Mexico measured significantly more oviposition on and damage to maize than to sorghum when interplanted. His data are in accordance with our field observations and farmers' lore in El Salvador.

Abiotic Control

Salvadorean farmers contend that whorlworm outbreaks are most common in unirrigated maize and sorghum when the normally torrential daily rains fail for several days and small larvae are not drowned in the whorls or washed away. Temperature may limit whorlworm distribution in highlands.

Natural Enemies

Eleven parasitic insect species have been reared in Central America from whorlworm eggs and larvae. The species, along with countries where they were taken and references are listed in Table 1. Lacayo (1977) reported an average parasitization rate of 18% for 589 larvae collected in 3 areas of Nicaragua over a 7-month period. Tachinids were the most important group. Vaughn (1975) reported an average 19% parasitism of larvae over a 4-month period in a Nicaraguan cotton field. Cortés and Andrews (1979), recorded a maximum of 30% egg parasitism by *Trichogramma* sp. in untreated maize. Schotman and Lacayo (in prep.) have collected *Hexamermis* sp. in Nicaragua; it can parasitize over 50% of the larvae present in maize.

Efforts have been made both in Nicaragua and El Salvador (Cortés and

TABLE 1. PARASITES OF *Spodoptera frugiperda* RECORDED FROM CENTRAL AMERICA. LARVAE WERE COLLECTED FROM MAIZE OR SORGHUM.

Family	Genus and/or Species	Country	Reference
Braconidae	*Apantales* sp.	Nicaragua	Lacayo 1977
	Chelonus texanus (Cresson)	Nicaragua	Saénz and Sequeira 1972
		Nicaragua	Lacayo 1977
		El Salvador	Cortés and Andrews 1979
	C. (*Microchelonus*) sp.	El Salvador	Cortés and Andrews 1979
	Rogas laphygmae Viereck	Nicaragua	Saénz and Sequeira 1972
	Rogas sp.	Nicaragua	Lacayo 1977
Eulophidae	*Euplectrus* sp.	Nicaragua	Lacayo 1977
	Pachyscapha near *insularis* Howard	Nicaragua	Lacayo 1977
Ichneumonidae	*Pristomerus* sp.	Nicaragua	Lacayo 1977
Tachinidae	*Archytas marmoratus* (Townsend)	Nicaragua	Lacayo 1977
	Lespesia (= *Achaetoneura*)	Guatemala	Painter 1955
	archippivora (Riley)	Nicaragua	Saénz and Sequeira 1972
		Nicaragua	Lacayo 1977
Trichogrammatidae	*Trichogramma* sp.	Nicaragua	Lacayo 1977
		El Salvador	Cortés and Andrews 1979

Andrews 1979) to introduce the egg parasite *Telenomus remus* Nixon; there is no evidence that establishment has been achieved. Attempts have been made in Colombia to use *Neoaplectana carpocapsae* (W.) against *S. frugiperda* (Benjumea et al. 1978).

Lacayo (1977) reported that *Nomuraea* (= *Spicaria*) *rileyi* (Farlow) Samson was slightly more common than *Aspergillus flavus* Link and together they accounted for the death of 15% of the larvae collected. Vaughn (1975) reported 40% pathogen-induced mortality in an unspecified number of larvae collected in cotton during a 3-month period in Nicaragua. Kuno (1979) isolated a nuclear-polyhedrosis virus from *S. frugiperda* larvae in Puerto Rico.

References to predators are scarce. Painter (1955) recorded the ground beetle, *Onypterygia famini* Solier from Guatemala. *Doru* sp. commonly inhabits whorls of maize and sorghum where they have been observed feeding on small and medium sized larvae. Hueso de M.[5] reared these earwigs in the laboratory from egg to adult on a diet of whorlworm eggs and larvae. *Zelus* spp. and *Polistes* spp. take an undetermined percentage of the larvae. *Zelus* spp. can consume 2 to 3 medium sized larvae per day in the laboratory (Cortés and Andrews 1979). Vaughn (1975) listed 40 species as predators of *Spodoptera* spp.

Cultural and Mechanical Management Procedures

The poorest, small-scale farmers of Central America may hand pick and destroy larvae. Schotman[6] reported that many poor Nicaraguan farmers apply mud to whorls and obtain good control. He speculates that farmers may be innoculating soil inhabiting pathogens and parasites which attack the larvae. Sequiera et al. (1976), recommended planting maize and sorghum at the full moon to minimize risk of damage to very young plants. Navas (1976) recommended that heavily damaged upland rice should not be plowed under since yield reductions are often insignificant even when damage is spectacular. Pastures which are threatened with a strong challenge should be grazed immediately (Navas, in prep.). Altieri (in prep.), Carballo et al. (1980), and other researchers have begun to investigate the effects of different cropping systems and weed control practices on whorlworm populations.

Breeding for Resistance

Apparently the only sustained breeding activities in the region are those carried out by researchers at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and their cooperators at various national institutes. Mihn (1980) and Guiragossian (1980) summarized the results of these efforts to date in maize and sorghum, respectively. Preliminary or inconclusive attempts to encounter resistant maize varieties are reported by Lasso and González (1971), Vázquez et al. (1975), Alvarado (1978), and Silva (1978).

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[5]Personal communication, Arelí Hueso de Mira, Departamento de Parasitologia Vegetal, CENTA, San Andrés, El Salvador.

[6]Personal communication, Charles Schotman, OIRSA, San Salvador, El Salvador.

GRANULAR INSECTICIDES USED FOR CHEMICAL CONTROL

A common practice throughout Central America and Mexico is the application of granular insecticides directly into the whorl. Reports of the experimental use of granular formulations in Central America date from 1954 (Sarmiento et al. 1970). Anon. (1969) discussed a number of advantages to this approach. Persistence of granular formulations is greater than that of dusts or sprays. Applications may be made by hand without specialized equipment; this is particularly important for farmers who plant small areas and have limited economic means. In addition, the method is selective due to placement; sprays and dusts applied to the entire plant surface may favor the increase of stem borers and other pests because natural enemies are eliminated. Dry season outbreaks of the mite, *Oligonychus stickneyi* (McGregor), in maize in Tepalcingo, Mexico ceased when foliar applications of DDT and methyl parathion were discontinued in favor of application of granules to the whorls.

Other advantages to these low concentration formulations include safety in transportation, storage, preparation, and application. They also are multipurpose formulations, appropriate for application to both soil and foliage; farmers may make 1 purchase and use the product in a number of ways. Extremely low dosages of active ingredient are needed to obtain good control.

Studies conducted in Mexico by CIMMYT researchers (Anon. 1972, Anon. 1973) and those in Peru of Sarmiento et al. (1970), showed that under both tropical and subtropical conditions granular formulations gave better control of both the whorlworm and *Diatraea* spp. than did the application of identical amounts of active ingredient applied as a spray. Reyes and Andrews (1980) obtained excellent control applying only 0.19 kg a.i. of phoxim granular per hectare; a small, cheap, hand operated bamboo applicator which eliminates direct dermal contact with the granules was used successfully to apply controlled low dosages of granules to sorghum whorls.

OTHER FORMULATIONS USED

Sprays may be applied by larger farmers, usually using back pack applicators. Anon. (1974) showed that seed dressings or soil applications of some systemic insecticides afford a low degree of control. Small scale farmers sometimes apply dusts directly to whorls; this is especially common with aldrin.

ACTIVE INGREDIENTS EMPLOYED AND THE PROBLEM OF PHYSIOLOGICAL RESISTANCE

At present, phoxim is probably the most widely used compound for whorlworm control. On larger farms methomyl is often applied as a spray. Trichlorfon outperformed other compounds in Peru (Sarmiento and Arteaga 1976). Synthetic pyrethrins have been tested experimentally and in some cases gave control comparable to that of phoxim (Díaz et al. 1977, Garcia 1977, Mayorga and Andrews 1979). However, cost of control is less with phoxim (Hueso de M. and Reyes 1978). Other compounds frequently reported as effective include carbofuran and monocrotophos. Use of chlorinated hydrocarbons, especially aldrin and heptachlor, by small scale farmers continues in El Salvador.

Reference is often made, especially by Salvadorean researchers, to the problem of whorlworm resistance to insecticides. Unfortunately, almost no quantitative information is available. Without presenting data, Arévalo (1980) stated that in laboratory tests, larvae showed high levels of resistance to methyl parathion and phoxim. They exhibited moderate and low levels of resistance to aldrin and methomyl, respectively. Young[7] found that a Salvadorean population exhibited at least 10-fold resistance to carbaryl, but was susceptible to methomyl. Carbaryl has not been recommended since the early 1970's in Central America. Interestingly, recent reports from Mexico do not indicate resistance problems (Anon. 1973, Anon. 1974, Silva 1975, León 1978). One Peruvian report mentions erratic results with carbaryl (Sarmiento and Casanova 1975). Bolivian populations are resistant (Young 1979). Formerly trichlorfon was widely recommended but is now rarely used, perhaps due to the development of resistance. The widespread overuse of insecticides in cotton grown on the Pacific coastal plain of Central America is probably a major factor contributing to the problem of resistance throughout the region.

Number and Timing of Applications

Aguayo and Aburto (1976) and León (1978) reported that in areas of northern Mexico 1 application against the pest is sufficient. According to Morán and Sifuentes (1967) most agriculturalists in Michoacán, Mexico apply only once. Results of an unpublished survey conducted among small Salvadorean farmers showed that none of them applied insecticides more than twice; the majority felt it was necessary but did not apply due to lack of economic resources. Sarmiento et al. (1970) in Peru applied twice using a critical level of 30% infested plants. Anon. (1974) reported that a seed dressing plus 2 whorl applications of carbofuran at 2 and 4 weeks after plant emergence gave most effective and economical control of whorlworm and other maize pests in Veracruz, Mexico. Two whorl applications at 15-day intervals controlled whorlworm in Mexico, but a third at 45 days was recommended in order to control stem borers (Anon. 1971). In Guatemala, Turcios et al. (1978) recommended 2 whorl applications of phoxim granules at 14 and 28 days after plant emergence or 3 spray applications of a mixture of methamidophos and methomyl. Two or 3 applications of granular insecticides may be necessary depending on pressure and rainfall coincidence with time of application (Anon. 1972). Violic et al. (1972) and Alvarado (1976), concluded that 3 applications were necessary; the latter suggested that applications be made 5, 15, and 30 days after emergence. In El Salvador, Hueso de M. and Reyes (1978) applied granules 3 times to sorghum using a critical infestation level of 12%. Before switching to use of granular insecticides some Mexican farmers were applying DDT or methyl parathion 4 to 6 times per crop (Anon. 1969). Turcios et al. (1978) reported that some Guatemalan farmers commonly spray 5 to 6 times against the whorlworm.

Monitoring

Vaughn (1975) used black light traps to measure seasonal abundance of

[7]Personal communication, John R. Young, Southern Grain Insects Research Laboratory, Tifton, GA 31794.

adults. Reyes and Andrews (unpublished) used pheromone-baited sticky traps to measure adult abundance during a 9-month period in 1979. However, farmers and researchers must usually rely on visual inspections of plants for signs of damage. Silguero (1976) reported preliminary results of a study to determine the optimum method and sample size for making decisions regarding control; he reported as few as 5 plants in each of 16 different sites in a field may be checked in order to obtain accurate damage estimates.

Our unpublished work (Andrews and Reyes) in El Salvador indicates that the use of artificial oviposition substrates may be a useful and economical means of measuring female moth activity; vertical objects which project ca. 1 m above the plant canopy and present horizontally-oriented oviposition sites are favored.

Yield Reductions and Economics of Whorlworm Control

Many workers who have evaluated insecticides for control of whorlworm have reported significant yield increases ranging up to several metric tons per hectare in treated plots as compared to untreated checks. In most instances, increased yields are well correlated with decreased whorlworm damage, and control of the whorlworm is credited with the increases. Examples include Silva (1975), Aguayo and Aburto (1976), Garcia L. (1977), Díaz et al. (1977), Cassalette-Davila et al. (1977), Trucios et al. (1978), and León (1978).

However, there are some reports in which large yield increases occurred in the absence of, or were uncorrelated with decreases in whorlworm damage (Anon. 1974, Alvarez 1977). Apparently, other phytosanitary problems may influence yields as much as the whorlworm. Other whorl-inhabiting insects which have been shown to affect yield include *Diatraea* spp., *Euxesta* spp., and *Dalbulus maidis* (DeLong and Wolcott), a vector of corn stunt. Insecticide applications aimed at the whorlworm can dramatically reduce the populations of these species and observed yield increases may be due in part to control of these nontarget pests. Studies in which the effects of insecticides on these pests have not been measured cannot be considered to have shown the damage potential of the whorlworm, regardless of the correlation between whorlworm densities and yield.

Galt and Peairs working together in Mexico (Contreras et al. 1977) reported maximum losses due to whorlworm feeding of 29% with average losses on experiment station grounds of 17%. In El Salvador, Hueso de M. and Andrews (unpublished data) observed statistically insignificant 8% yield losses in maize which had been hand infested once with late instar larvae at 3, 4, or 5 weeks of age as compared to check rows which were not infested. Rows infested at 6 and 7 weeks of age yielded slightly more than the check. In all cases at least 60% of the plants infested showed noticeable to severe damage symptoms. Yield reductions up to 51% were recorded in sorghum using the same methodology; plant stands which were attacked early in their development yielded less than those which were attacked later. Obando and van Huis (1977b) simulated constant whorlworm pressure of varying intensities using a cork punch to damage maize leaves. They reduced yields 63% by making 2 holes per new leaf twice per week for the first month after emergence. Less severe treatments reduced yields less drastically.

Navas (1976) simulated *S. frugiperda* damage to upland rice and with most varieties observed no statistically significant, consistent pattern of yield reduction; with 1 variety, however, yields were reduced up to 45%, depending upon age of the plant at time of attack.

Sarmiento and Casanova (1975) in Peru and Obando and van Huis (1977a) in Nicaragua established economic injury levels in maize by applying insecticides at varying whorlworm densities. Both concluded that 10-12% damage justified treatment. Salvadorean workers have considered 12-15% infestation as a critical level (Díaz et al. 1977, Mayorga et al. 1978, Hueso de M. and Reyes 1978).

The idea of an economic injury level; i.e., a "break even" point may be inappropriate for small-scale Central American farmers with limited economic resources. Unless the return on the application promises to be several fold greater than the investment, the money will be better utilized for purchase of improved seed, fertilizer or other high payoff input.

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