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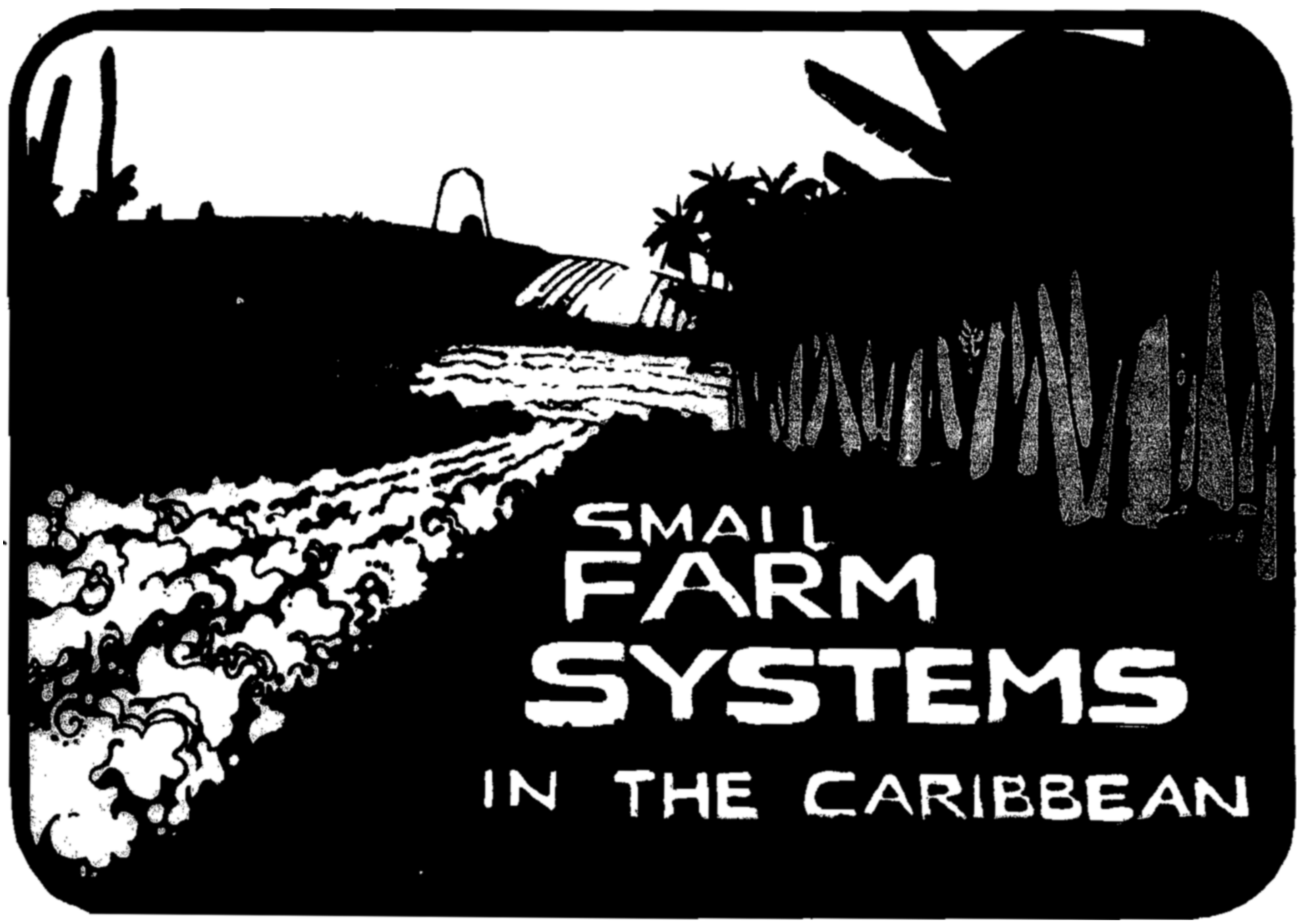

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Recent Advances in Research on Control and Biology of Pickleworm and Melonworm

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USDA, ARS, in cooperation with other institutions, has been conducting research on pickleworm and melonworm (*Diaphania* spp.: Pyralidae) for several years. Recent advances in this research are given. Topics discussed include: research on plant resistance in cucumber and squash, role of oviposition stimulants, foreign exploration and importation of parasites from South America and the Caribbean, and population dynamics of *Diaphania* spp. in tropical Florida.
Keywords: *Diaphania nitidalis, Diaphania hyalinata, Cucurbita, Cucumis.*

A mainstay of small farm operations is vegetable production, with cucurbit vegetables, such as cucumber and squash, being an important part of vegetable farming. For example: in North Carolina almost 40,000 acres of cucumbers are grown, mostly on small farms. In the southeastern U.S. the key insect pest of cucurbits is the pickleworm, *Diaphania nitidalis* Stoll. The pickleworm causes primary injury by burrowing into fruit and rendering them unfit for market. Since shippers and packers, particularly pickle processors, cannot tolerate infested or damaged fruit reaching the consumer, the economic threshold for the pickleworm is very low. Thus, when pickleworm are present frequent applications of insecticide are necessary to control the pest. The pickleworm undergoes an annual expansion and contraction of its range in the eastern U.S. Populations move slowly north in spring and summer and then retreat south during autumn and winter as freezing temperatures kill pickleworms and available host plants. Eventually midwinter populations are restricted to southern Florida (Dupree et al., 1955). A closely related species, the melonworm, *Diaphania hyalinata* L., has similar biology, except that it is strictly a defoliator. It can build up to economic levels in more southern areas in the U.S., such as Florida and South Carolina. Both species are present in northern South America and Caribbean islands.

The United States Vegetable Laboratory in Charleston, S.C., has taken the lead in coordinating research on biology and alternative control measures for these pests. In this paper we will summarize our progress in selected aspects of this work.

Plant Resistance Studies

Most of our work on plant resistance of cucurbits to pickleworm and melonworm at Charleston and cooperating institutions has involved the roles and relative importance of antibiosis and oviposition nonpreference as resistance mechanisms.

In order to facilitate testing for antibiosis to pickleworm among over 1,000 cucumber cultivars and breeding lines, we developed a simple laboratory method using detached leaves. In essence, the tests involved placing newly-hatched larvae on leaves and enclosing them in plastic petri plates for several days. The plates were then opened to count the larvae and score the leaves for damage using a scale of 1 (little damage) to 9 (very heavy damage). The exact methods differed slightly depending on whether the test was a preliminary screening of all lines or later tests of the most resistant and most susceptible. Of the 1,160 lines tested in the initial screening test, 8 were selected for further studies (5 resistant and 2 susceptible). These lines and their performance are shown in Table 1. The range of scores from most resistant to most susceptible was narrow, ranging from 3.0 to 6.5, or 3.1 to 4.5 depending on the test. In a further study, a parent-progeny regression analysis run on a population developed from the resistant lines revealed a heritability of nearly 0 (Wehner et al., 1983). Another series of antibiosis tests run on a number of cultivated species of cucurbits found that only *Lagenaria siceraria*, an inedible species of gourd, demonstrated a significant degree of resistance (Elsey, 1981). This and the cucumber work indicates that antibiosis among cucurbit vegetables may not be a useful factor in breeding for pickleworm resistance.

Studies of oviposition nonpreference have focused on differences between glabrous and pubescent cucumbers, comparisons of pickleworm resistant and susceptible squash species, and a study of the chemical factors involved.

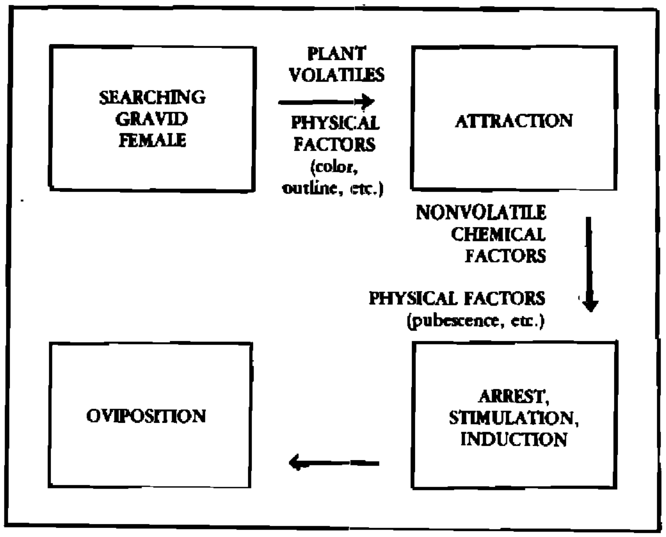
Foliage of cucumber and muskmelon is normally pubescent but glabrous mutants have been described (Foster, 1963; Robinson and Mischanec, 1964). Pulliam (1979) reported that glabrous cucumber plants seemed to be nonpreferred for pickleworm oviposition. Follow-up work by Elsey and Wann (1982), using artificial infestations of moths and following natural populations in the field, found that both pickleworm and melonworm preferred to oviposit on the pubescent plant type (Tables 2 & 3). Unfortunately, the glabrous cucumber is less vigorous than the pubescent type, which may limit its use by plant breeders.

Several studies on pickleworm resistance in squash have found that some *Cucurbita moschata* Poir cultivars have lower infestations of pickleworm than more susceptible species (Brett et al, 1961; Dilbeck and Canerday, 1968; Dilbeck et al., 1974), but the mechanism for this resistance was not known. In the summer of 1984 we have compared egg and larval infestations on two *C. moschata* cltivars, Butternut and Calabaza with a susceptible *Cucurbita pepo* L. cultivar, Tablequeen. During the peak oviposition period *ca.* 10 times as many *Diaphania* spp. eggs were found on Tablequeen and subsequently higher numbers of both pickleworm and melonworm larvae (Table 4). Laboratory tests, to date, have failed to detect any larval antibiosis or preference factors among the three cultivars, so we we feel that oviposition nonpreference is the most important resistant mechanism in the *C. moschata* cultivars.

It is probable that chemical differences among these three cultivars are responsible for the observed oviposition nonpreference. Thus, we have been looking closely at the chemical influences on pickleworm oviposition using a yellow squash variety in the species *C. pepo*. We have found that ethanol extracts of foliage from which the volatile components have been removed contain chemicals that stimulate oviposition when sprayed on a suitable medium (pads of fiberglass insulation). We have further found that pumping air containing squash volatiles into pads sprayed with extract increases oviposition over pads with extract only. From these and other experiments we can outline the following hypothesized mode of action (Fig. 1).

We are now in the process of testing the model and trying to identify the volatile and nonvolatile chemicals involved.

FIGURE 1.



Biology in Southern Florida

Laboratory tests at Charleston have demonstrated, at least theoretically, the potential of controlling pickleworm by release of irradiated substerile male moths (Elsey and Brower, 1983). The constriction of the overwintering range of melonworm and pickleworm to southern Florida presents the limited geographical range that is a prerequisite of the sterile male technique. However, before this or any other region-wide control technique is implemented, a thorough study of the species biology in its overwintering refuge is necessary. Therefore, in early 1983 the USDA and University of Florida initiated a cooperative study of pickleworm and melonworm biology in southern Florida. The objectives of the study were to determine the seasonal fluctuations in density of the two species on trap crops of cucumber and squash, commercial cucurbit fields, and stands of potential weed hosts at several locations. Additional information was to be gathered on incidence of parasitism. Much of this work is still in progress and it is too early for a comprehensive report; however, interesting information on the importance of wild hosts is already available.

TABLE 1. Performance of eight selected cucumber lines in two antibiosis tests.

Rank	Cultivar or Line	Detached-leaf Test Score[z] Test 1	Detached-leaf Test Score[z] Test 2
1	C541 C2	3.0	3.1
2	Pemscore	3.0	3.2
3	PI 205996	3.0	3.2
4	RS 79031	3.0	3.3
5	Earlipik 14	3.5	1.5
1158	MSU 581 H	5.5	5.0
1159	PI 263079	6.5	4.3
1160	VDP No. 328	6.5	4.5

[z]leaf damage scored 1 to 9 (1 = no damage, 9 = leaf tissue between veins completely eaten).

TABLE 2. Oviposition by *Diaphania* moths on glabrous and pubescent cucumber in screenhouse.

Plant type	X̄ eggs/plant Pickleworm	X̄ eggs/plant Melonworm
Glabrous	18.5a	15.9a
Pubescent	114.2b	47.1b

Preliminary surveys found the *Melothria pendula* L., creeping cucumber, and *Momordica chorantia* L., wild balsam apple, were abundant throughout Florida, therefore our field and laboratory work to assess the importance of wild hosts was concentrated on these two species. From November 1983 through April 1984 at three locations in southern Florida, 79 pickleworms were found on *Melothria* and 0 on *Momordica* while 8 melonworms were found on both species. Survival of newly hatched melonworm and pickleworm on *Melothria* foliage was equal to that of the cucumber check, but development was somewhat delayed. Survival on *Momordica* was 0 for both species. No feeding was observed and the larvae wandered the leaves until they eventually starved to death. The lack of pickleworm on *Momordica* in the field can be explained by their failure to feed on excised foliage, but since melonworms also did not survive, their presence in field sample is puzzling. We are investigating the possibility of a melonworm race adapted to feeding on *Momordica*. The presence of both species in field samples of *Melothria*, their ability to feed and develop on the weed, and its abundance throughout southern Florida indicate that *Melothria* is a very important alternate host.

Biological Control

The impact of natural enemies on pickleworm and melonworm in the U.S. decreases in a northernly direction. In a two year study in North Carolina (Van Balen, 1976) no parasites were found on pickleworm. In the Charleston, S.C. area an unidentified species of *Apanteles* attacks both species consistently late in the season and egg parasitism by *Trichogramma* can be high (Elsey, 1980). Nothing was known concerning parasitism in southern Florida prior to the start of our biology study there, but we suspected there would be more parasite species involved. Dr. Jorge Peña has found the following species of hymenopterous parasites in southern Florida during the last 18 months.

Apanteles sp.	Braconidae
Hypomicrogaster sp.	Braconidae
Gambus ultimus	Ichneumonidae
**Pristomerus spinator*	Ichneumonidae
Temelucha sp.	Ichneumonidae
Ictoplectis inquisitor	Ichneumonidae
**Casinaria infesta*	Ichneumonidae
Spilochalcis sp.	Chalcididae
Ceraphron sp.	Ceraphronidae

TABLE 3. Mean number *Diaphania* spp. eggs (pickleworm and melonworm) on glabrous and pubescent cucumber plant.

	Diaphania spp. Glabrous	eggs/plant Pubescent
8/19	.5	6.0
8/26	1.2	31.2
9/3	.2	2.3

Dr. Peña has also collected in his native country, Colombia, and found:

Polycrytus sp.	Ichneumonidae
**Cardiochiles* new sp.	Braconidae
Hypomicrogaster sp.	Braconidae
Brachmeria sp.	Chalcidae
**Spilochalcis* sp.	Chalcidae

*Under culture at Homestead, FL.

TABLE 4. Field infestation of pickleworm and melonworm on squash cultivars Tablequeen, Butternut, and Calabaza.

	X eggs/plant[a]	X larvae/plant[b]	
		Melonworm	pickleworm
Tablequeen (C. pepo)	41.9 a	40.1 a	4.9 a
Butternut (C. moschata)	3.7 b	5.2 b	.9 b
Calabaza (C. moschata)	4.0 b	4.6 b	.2 b

a X of counts on 8/1 and 8/8

b X of counts on 8/8 and 8/14

On St. Croix, Knausenberger and Bland have found two new species of Ichneumonid parasitizing melonworm, the most important being *Agrypon caribbaeum* (Bland, 1984). I have found in laboratory tests that this species also successfully parasitizes the pickleworm. I found in Puerto Rico a uniparental species of Trichogramma that is currently under culture at Beltsville, MD. From this limited amount of work, it would seem there is great potential for finding effective parasites in northern South America and the Caribbean basin for release in Florida for more effective natural control of pickleworm and melonworm in the U.S.

TABLE 5. Survival and first stage duration of first instar pickleworm and melonworm larvae.

Host	% survival		Days to first molt	
	Pickleworm	Melonworm	Pickleworm	Melonworm
Cucumber	84.0a	94.0a	2.1a	2.2a
Melothria	78.0a	90.0a	3.7b	2.8b
Momordica	0b	0b	-	-

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