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PHENOLOGY OF THE HONEYDEW MOTH, *CRYPTOBLABES GNIDIELLA* (MILLIERE) (LEPIDOPTERA: PYRALIDAE), ON AVOCADO IN ISRAEL

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ABSTRACT

The polyphagous honeydew moth, *Cryptoblabes gnidiella* (Milliere) (Lepidoptera: Pyralidae), is often associated with coccoids and their honeydew but may also infest avocado fruit as a primary pest. A 3-year study of its phenology in avocado groves and adjacent crops in Israel included weekly captures of male moths in pheromone traps and biweekly surveys for developing stages. The moth may complete its annual cycle in the avocado grove, overwintering as larvae on fresh or dry avocado fruits remaining on the trees, and developing also on avocado leaves infested with the pyriform scale, *Protopulvinaria pyriformis,* on *Paspalum dilalatum* weeds infested by the fungus *Claviceps paspali,* as well as on various other dry fruits, dry oleander flowers, etc. It prefers Haas fruits to those of other avocado varieties. Adult moths may migrate between avocado groves and adjacent crops. Pheromone traps were effective in trapping the moths, but no correlation could be established between the timing and number of captures and larval infestation of avocado fruit. Moths were trapped during March-April (5%), June-September (75%) and October-December (20%). More were trapped in young than in mature groves, and in adjacent crops. Five generations may develop in avocado groves per year: Overwintering moths emerge in March-April, giving rise to the first generation, adults of which appear in traps in early June; this generation does not cause any damage to avocado; three additional generations develop by September; and moths flying in October-November establish the overwintering generation.

KEY WORDS: Honeydew moth, *Cryptoblabes gnidiella,* phenology, pheromone traps, overwintering, host range, *Paspalum dilalatum,* avocado, Israel

INTRODUCTION

Avocado, a major cash and export crop in Israel, has been under an effective program of integrated pest management for more than twenty years (Swirski et al., 1981a, 1988). The polyphagous honeydew moth, *Cryptoblabes gnidiella* (Milliere) (Lepidoptera: Pyralidae), has been recorded as a pest of numerous crops and other plants in Israel and elsewhere (see Table 1). It is usually a secondary pest, associated with scale insects or mealybugs and their honeydew (Bodenheimer and Klein, 1934; Silvestri, 1951; Willcocks, 1922), but has been recorded also as a primary pest of avocado, grapes and other fruit (Schweig, 1950; Avidov and Harpaz, 1969; Wysoki et al., 1975).

The biology and phenology of the honeydew moth have been studied by Liotta and Mineo (1964) in Sicily, by Swailem and Ismail (1972) in Egypt, and by Srivastava and Singh (1973) in India. Avidov and Gothilf (1960) investigated it on citrus in the coastal plain of Israel and reported that it developed through 5 larval instars, had a temperature threshold of 13°C, and required 500 day-degrees for completion of one generation. In summer, a generation takes 5 weeks on citrus and 4 on grapes, whereas the overwintering generation may take up to 5 months. The pest may

TABLE 1
Recorded host plants of the honeydew moth. Host plants denoted with an asterisk are records from Israel

Family	Host plant	Source
Actinidiaceae	*Actinidia* (kiwi)*	Present study
Anacardiaceae	Mango	Taher Sayed (1964)
Annonaceae	*Annona*	Wysoki et al. (1975)
Apocynaceae	*Nerium oleander**	Osorio (1977); present study
	Plumeria	Anonymous (1978)
Araliaceae	*Fatsia japonica**	Present study
Bromeliaceae	Pineapple	Anonymous (1974)
Caesalpiniaceae	Carob*	Rivnay (1962)
Caricaceae	Papaya	Chapot & Delucchi (1964); Talhouk (1969)
Chenopodiaceae	Beet	Willcocks (1922)
Ebenaceae	Persimmon*	Oppenheimer (1978); Izhar (1988)
Euphorbiaceae	Castor-oil plant*	Rivnay (1962); Willcocks (1922)
Gramineae	Maize*	Avidov & Harpaz (1969); Willcocks (1922)
	Millet	Talhouk (1969); Willcocks (1922)
	*Paspalum dilatatum**	Present study
	Pennisétum	Hardas et al. (1983)
	Rice	Sasmal & Kulshreshtha (1985)
	Sorghum*	Avidov & Harpaz (1969); Taley et al. (1974)
	Wheat	Talhouk (1969); Willcocks (1922)
Lauraceae	Avocado*	Wysoki et al. (1975)
Liliaceae	Garlic	Abul-Naser et al. (1974)
Malvaceae	Cotton*	Gough (1913); Rivnay (1962)
Meliaceae	Mahogany	Akanbi (1973)
Moraceae	Fig	Silvestri (1951); Willcocks (1922)
Myrtaceae	Guava	Talhouk (1969)
	Feijoa*	Present study
Oxalidaceae	Carambola*	Present study
Pinaceae	Pine*	Halperin (1980)
Podocarpaceae	*Amboyna*	Willcocks (1922)
Polypodiaceae	*Azolla anabaena*	Sasmal & Kulshreshtha (1985)
	Azolla pinnata	Takara (1981)
Proteaceae	*Macadamia**	Wysoki (1977)
Punicaceae	Pomegranate*	Avidov & Harpaz (1969)
Rosaceae	Apple*	Plaut (1971); Sorauer (1925)
	Apricot	Chapot & Delucchi (1964); Talhouk (1969)
	Loquat*	Schweig (1950); present study
	Mespilus (medlar)	Carter (1984)
	Peach*	Talhouk (1969); present study
	Pear*	Plaut (1971); present study
	Plum	Chapot & Delucchi (1964); Talhouk (1969)
	Quince	Talhouk (1969); present study
Rutaceae	Grapefruit*	Avidov & Gothilf (1960); present study
	Lemon	Janini (1923); Liotta & Mineo (1964)
	Orange*	Bodenheimer & Klein (1934); Janini (1923)
	Pomelith*	Present study
Salicaceae	Poplar	Willcocks (1922)
Tamaricaceae	Tamarisk	Gough (1913)
Thymelaeaceae	*Thymelaea*	Gough (1913); Talhouk (1969)
Vitaceae	Grape*	Anderson (1917); Avidov & Harpaz (1969); Gallo et al. (1988)

develop 5–6 generations a year on citrus in Israel, as compared to 3 in Sicily. However, when it develops on grapes in summer and on citrus during the rest of the year, it may have up to 7 annual generations.

The female sex pheromones of the honeydew moth have been identified, synthesized (Bjostad et al., 1981) and utilized effectively in monitoring its populations in vineyards (Gurevitz and Gothilf, 1982). Surveys of avocado groves indicated that honeydew moth populations, which had increased during outbreaks of the long-tailed mealybug, *Pseudococcus longispinus* Targioni Tozzetti, have decreased considerably following its effective biological control and the introduction of *Bacillus thuringiensis* preparations (Wysoki et al., 1975; Swirski et al., 1988). Nevertheless, severe injury may still be caused at times by its superficial feeding on the skin of avocado fruit, even in the absence of honeydew-producing Homoptera. The present study has been intended to contribute to our knowledge of the biology and phenology, with a view to improving the monitoring, of the honeydew moth on avocado in Israel.

MATERIALS AND METHODS

Monitoring by pheromone traps

Male moth populations were monitored by placing traps containing the female pheromone. The traps were triangular, open at both ends, made of white "Polygal" plastic (Yavnin and Yoffe, Tel Aviv), with a renewable strip of glue-covered plastic and a rubber evaporator containing the following mixture of synthetic aldehide isomeres:

500 mg (Z)-11-hexadecenal (Z11–16:Ald)
100 mg (E)-11-hexadecenal (E11–16:Ald)
500 mg (Z)-13-octadecenal (Z13–18:Ald)
100 mg (E)-13-octadecenal (E13–18:Ald)

Twelve traps were placed in the avocado grove of Kefar haHoresh (Yizre'el Valley), from April 1986 through December 1988. Some were placed in young plots (age 2–4 yr), others in intermediate (5–8 yr) and mature plots (8–11 yr). Two traps were placed in the avocado grove of Regba (Northern Coastal Plain), from November 1987 through December 1988, and two in the avocado grove of Gal'ed (Ephraim Mountains), from March through December 1988 — one in a young (4-yr-old) the other in a mature (10-yr) plot. The traps were hung on randomly selected trees, at a height of 1.5 m, were checked weekly and the evaporators replaced every 6 wk. Several additional traps were placed in various adjacent crops, such as pears and cotton.

Field and laboratory observations

Throughout the season, from fruit set to harvest during the 3-yr study, randomly selected fruit of various avocado varieties were examined in the three study groves at biweekly intervals for the presence of eggs and larvae of the honeydew moth. Occasional observations were made on dry avocado fruit, various weeds growing in and around the groves, and adjacent crops.

From November 1987 through March 1988, hundreds of dry avocado fruits, infested with what appeared to be honeydew moth larvae, were picked from the Kefar haHoresh grove and brought into the laboratory. Some of the larvae were reared on an artificial medium, others were kept on the dry fruit, in glass jars, under room and outdoor conditions. Larvae obtained from other hosts — e.g., dry oleander flowers, *Paspalum* and *Ricinus* weeds, dry grapes, dry fruit of pear, apple, peach, loquat and pomegranate — were reared on them to maturity and identified.

Conspecificity of moths from the various sources and laboratory stock was verified by preliminary, small-scale crossing tests. Opposite sexes were confined throughout their lifetimes in glass jars (24 cm high, 11 cm in diameter). A sugar solution was provided for nutrition, and strips of

honey-soaked paper served for oviposition and for feeding by hatching larvae. The females were dissected posthumously for presence of male spermatophores as evidence of mating, and the paper strips were examined for presence of eggs and larvae.

To determine any preferences of female moths to avocado fruit of different varieties, one fruit each of the varieties Haas, Fuerte, Reed, Horeshim and Pinkerton were placed together in ventilated, glass-covered plastic containers (29 × 35 × 15 cm) with 5–8 pairs of the honeydew moth. This was done in 15 replicates, and the place of each variety was changed from container to container, which were kept at 25 ± 1°C, 80–85% RH and 12–13 L for 5 days. The eggs laid on each fruit were then counted, and the results analyzed by Duncan's multiple range test.

Preliminary observations indicated that honeydew moth larvae were capable of developing to maturity on *Paspalum dilatatum* infected with the ergot fungus, *Claviceps paspali*, which produces honeydew-like secretions on the plant's inflorescences. The possible relationship between the fungus and moth development was therefore investigated. Four screen cages (20 × 20 × 20 cm) were placed over flowering *Paspalum* plants growing in the Kefar haHoresh avocado grove on May 4, 1988, when the plants were not infected, and again on October 9, 1988, when the inflorescences were infected with *Claviceps* and covered with copious secretions. Three pairs of moths were kept in each cage for 1 wk, after which the females were dissected for presence of male spermatophores. After 2 and 3 wk, the inflorescences were examined for presence of eggs and larvae.

RESULTS

Monitoring by pheromone traps

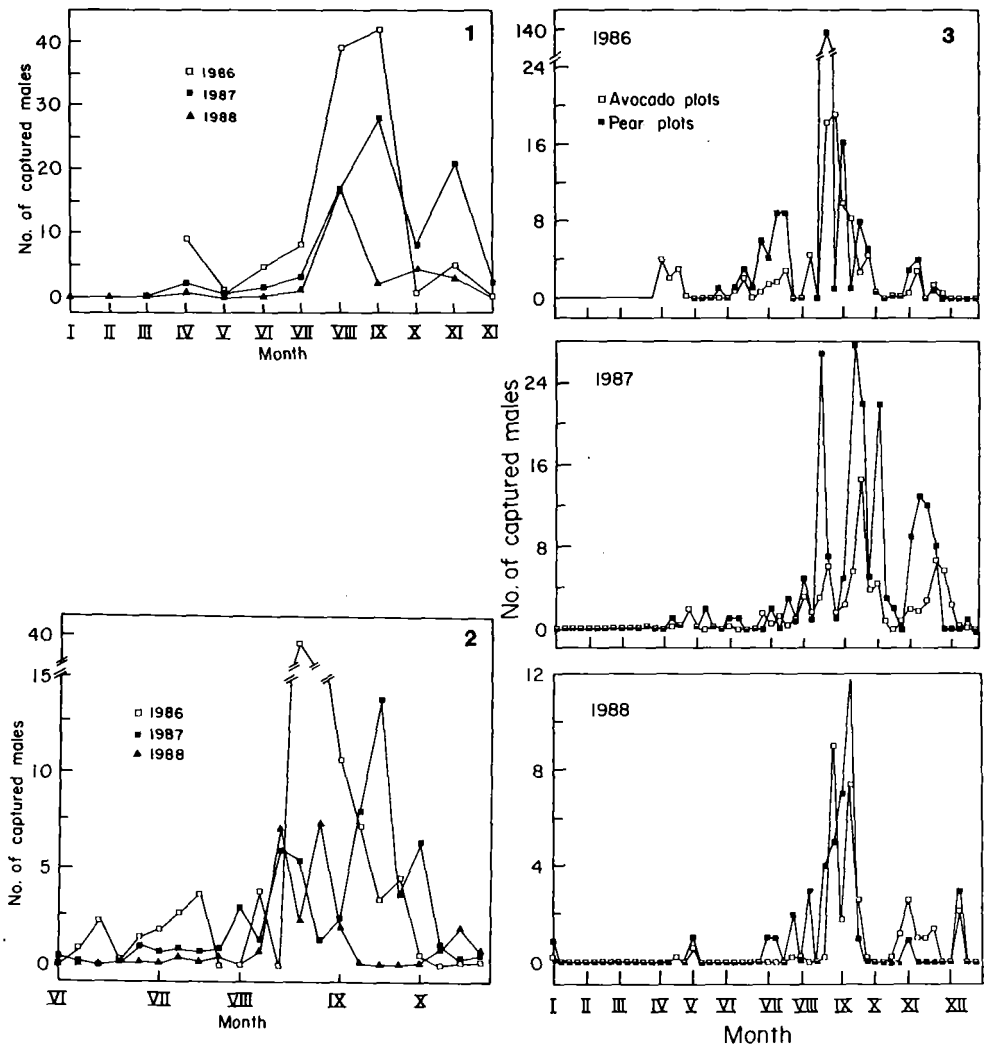
The results of male moth captures are presented in Figures 1–6.

In the Kefar haHoresh grove (Figs. 1, 3, 6), the first captures were always recorded in late March or early April and continued through April, indicating the emergence of the overwintering generation. Captures ceased for about a month in May, then resumed in June, indicating the appearance of the adults of the first generation, and increased during July–September, peaking from the second fortnight of August to mid-September. Only a few moths were captured during October, but then captures increased again in November and did not cease until the end of that month (in 1987 all these events were about 2 wk later than in the other study years, and captures did not cease until the end of December). No moths were captured during January, February and the first half of March.

In summary, the moths were trapped during March–April (5% of the total captured during any year), June–September (75%) and October–December (20%). A closer look at the June–September period (Fig. 2) indicates the presence of 3–4 distinct peaks.

In the Kefar haHoresh grove, the timing of captures was quite uniform in traps placed in the various plots, as well as in a trap placed in an adjacent pear orchard (Fig. 4). Capture quantities, on the other hand, differed considerably between plots (Fig. 6). Highest captures per trap were recorded in the pear orchard (140 moths during the peak week in 1986) and in the adjacent young avocado plots (90 moths during the same week). In intermediate-age plots they were considerably lower, and the lowest captures were recorded in mature plots. Quantities also varied among years (Fig. 2): Captures in 1986 were considerably higher than in subsequent years, and this corresponded to higher infestation rates on avocado fruit in 1986.

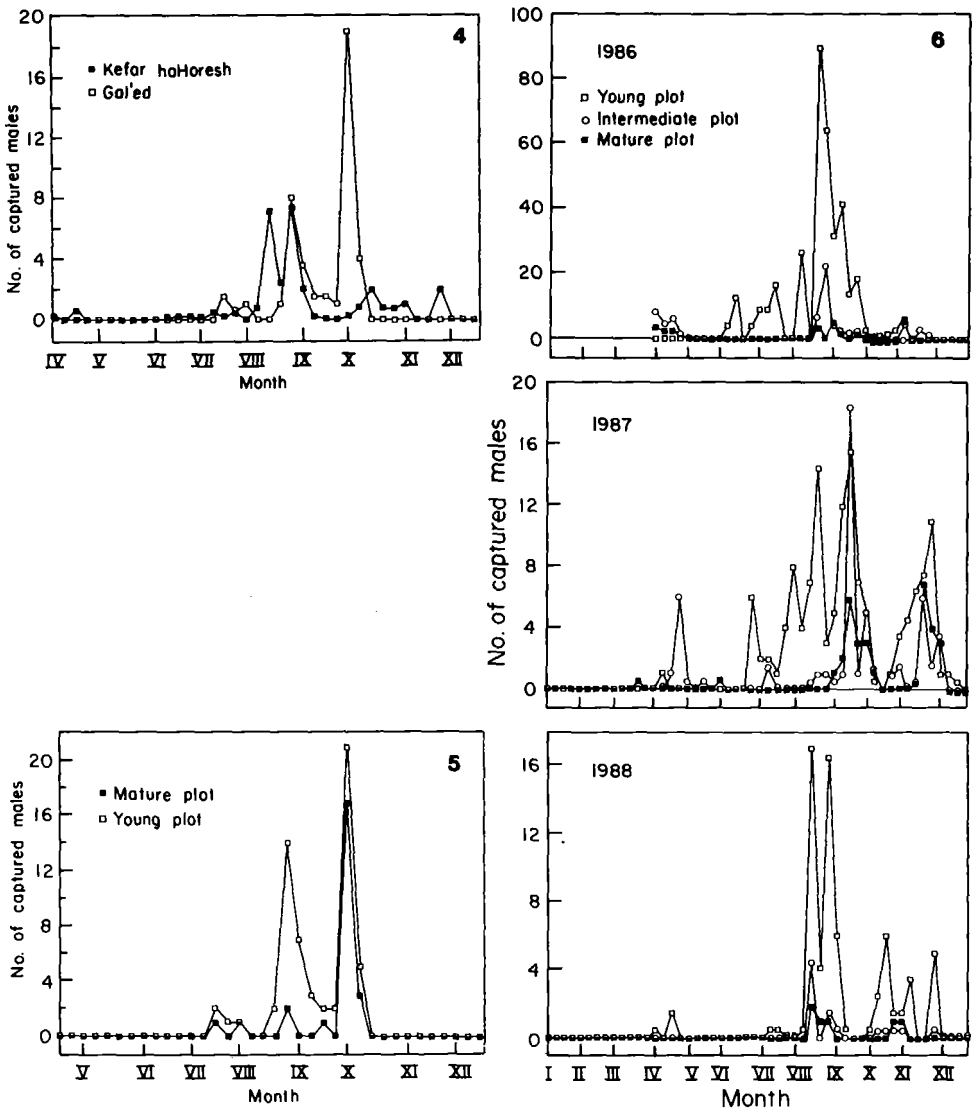
Captures in the Gal'ed grove did not coincide with those in Kefar haHoresh (Fig. 4). In 1988, the first moths were captured there only in July, the peak was recorded at the beginning of October, and no moths were captured in November. In Gal'ed, too, more moths were captured in the young plot than in the old one (Fig. 5). In the Regba grove, only a few moths were captured during September, 1988.



Figs. 1–3. 1. Capture of male honeydew moths in pheromone traps, Kefar haHoresh avocado grove, 1986–88 (monthly means, 12 traps). 2. Capture of male honeydew moths in pheromone traps, Kefar haHoresh avocado grove, June–October 1986–88 (weekly counts). 3. Capture of male honeydew moths in pheromone traps, Kefar haHoresh acovado grove and pear orchard, 1986–88 (weekly counts).

Field and laboratory observations

Very low rates of infestation by honeydew moth larvae were observed on avocado fruit. In the Kefar haHoresh grove they were found only from the end of August and on in 1986 and 1987 (but not in 1988), especially in young plots and in the Haas variety. A few were occasionally found on Fuerte and Horeshim fruit. Later, during September–November, they were found, mainly in Haas, also in mature plots. In the Regba grove, a few larvae were observed on fruit at the end of August, 1987 and 1988. No larvae were found in the Gal'ed grove. The larvae were usually found at contact points between fruits, leaves and fruit, or stem and fruit, or in rolled, dry leaves, but



Figs. 4–6. 4. Capture of male honeydew moths in pheromone traps, Kefar haHoresh and Gal'ed avocado groves, 1988 (weekly counts). 5. Capture of honeydew moths in pheromone traps, young and mature plots, Gal'ed avocado grove, 1988 (weekly counts). 6. Capture of male honeydew moths in pheromone traps, young, intermediate and mature plots, Kefar haHoresh avocado grove, 1986–88 (weekly counts).

occasionally also on single, exposed fruit. Scattered Haas trees had up to 23 foci of infestation, containing different larval instars together as well as pupae, whereas adjacent trees were not infested at all. Although some of the infested trees also carried low populations of the long-tailed mealybug, honeydew moth larvae were observed to complete their development on avocado fruit in the absence of mealybugs or honeydew.

Dry, shrivelled Haas and Fuerte fruit, remaining on the trees in the avocado groves of Kefar haHoresh and Yif'at, were found in September 1987 to be infested with numerous larvae and pupae of the honeydew moth. Such fruit, which dry up for various physiological causes not related to pest infestation and may remain attached to the trees even long after harvest, were found to harbor larvae throughout winter, protected by silk threads in nooks and crannies of the skin, whereas similar fruit that had fallen to the ground were not infested at all. Other insects found on these fruit included larvae of the carob moth, *Ectomyelois ceratoniae* (Zeller) and *Ephestia* spp., bark beetles and Psocoptera. This phenomenon was not observed in 1988, but was repeated in 1989 and 1990. Interestingly, although numerous honeydew moth larvae were present on dry fruit, fresh avocado fruit was almost free of infestation.

During the winter of 1987/88, dry fruit infested with honeydew moth larvae were collected from the Kefar haHoresh grove (Table 2) and kept in glass jars under outdoor conditions. Pupation was observed in February, and adult emergence began at the beginning of March.

TABLE 2
Presence of honeydew moth larvae on dry avocado fruit at Kefar haHoresh

	Haas			Fuerte		
Date	No. fruits examined	Percent infested	Larvae per fruit	No. fruits examined	Percent infested	Larvae per fruit
xi.1987	13	100	3.8	–	–	–
xii.1987	173	21	1.7	84	63	5.3
i.1988	54	6	1.5	35	77	3.4
Total	240	34	2.0	119	67	4.7

Honeydew moth larvae were found also on other fruits: dry pears (Kefar haHoresh, i–v.1988; Giv'at Ada, ii.1989), grapes (Bet Dagan, x–xi.1987), loquats (Kefar haHoresh, viii–ix.1988; Giv'at Ada, in greenhouse, ii–iv.1990), pomegranates (Ramat Hadar, i.1989), apples (Giv'at Ada, iii.1990) and peaches (Kefar haHoresh, ii.1990).

Larvae were also found developing in and around avocado groves on *Paspalum dilatatum* inflorescences infected with the ergot fungus, *Claviceps paspali*. They were first observed in the Kefar haHoresh grove in September 1986, and again there and in adjacent groves and fallow fields from May 1987 through March 1988. When infested inflorescences were placed in glass jars under outdoor conditions in mid-January, moth emergence was observed from mid-March and on. Other hosts included leaves of Nabal avocado and *Fatsia japonica* infested with the pyriform scale and covered with copious amounts of honeydew, flowers and fruit of castor-oil plants, *Ricinus communis*, carambola and kiwi fruit, feijoa stems (in girdling sites) and dry oleander flowers, as well as pomegranates (in fruit crowns, with mealybugs), pears (on fresh fruit and young shoots) and citrus. Adult moths were observed to emerge from all these hosts, except carambola and feijoa. They were all identified as *Cryptoblabes gnidiella*, and preliminary crossing tests (Table 3) confirmed that they were indeed all conspecific. Figure 7 presents the possible phenological cycle of the honeydew moth in Israel, based on these findings.

Infestation and preference of avocado fruit

The rate of infestation of fresh avocado fruit by honeydew moth larvae varied between seasons

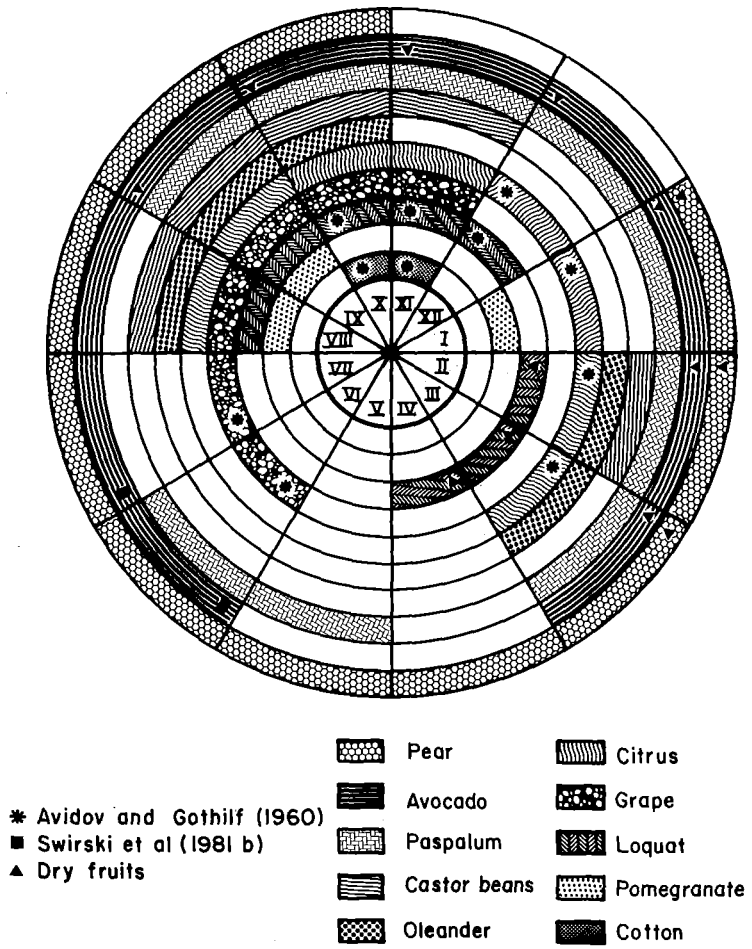


Fig. 7. Phenological cycle of honeydew moth larvae in Israel on various host plants.

and varieties. When batches of 1000–24,000 fruits were inspected, the Haas variety in Kefar haHoresh was found to be lightly infested during the 1986/87 and 1987/88 seasons, mostly in plots adjacent to infested pear orchards: 0.54–0.78% of the fruit were infested in August–October 1986, 0.13–0.18% in August–December 1987, and 0.06% in January 1988. Reed, Nabal, Fuerte and Horeshim fruit were almost free of infestation during these seasons, and no infestation at all was detected in any variety at Kefar haHoresh, Regba and Gal'ed during the 1988/89 season.

Although moths were captured in pheromone traps in the Kefar haHoresh grove as early as March, larvae were never found on fruit before the last week of August. In 1986, following moth captures during July–September, larvae were observed feeding on fruit until the end of October, whereas in the 1987/88 season, following numerous captures in November, the infestation was extended through January. In other seasons and groves, however, there was no apparent correlation between moth captures and larval infestations. Unlike the dry fruit, which harbored numerous larvae throughout winter, fresh fruit remaining on the trees after harvest, sometimes until May–June of the following year, were never infested.

TABLE 3
Results of preliminary crossing tests between honeydew moths from various sources

No. of replicates	Source		No. of individuals tested		No. of spermatophores in female body	Presence of eggs, larvae
	Females	Males	Females	Males		
1	lab stock	pear	1	1	1	+
2	pear	lab stock	1	2	1	+
2	lab stock	avocado (Haas, dry)	2	1	1	+
2	avocado (Haas, dry)	lab stock	1	2	1	+
2	lab stock	*Paspalum*	2	1	2	+
2	*Paspalum*	lab stock	1	2	1	+
1	avocado (Haas, dry)	pear	1	1	1	+
1	oleander	lab stock	1	3	–	–
1	lab stock	oleander	3	1	1	+
1	loquat, dry	lab stock	1	1	1	–
1	oleander	loquat, dry	1	1	–	–
1	avocado leaves w/pyriform sc.	lab stock	1	1	1	+

The results of preference tests are presented in Table 4. By far most of the eggs were laid on Haas fruit, followed by the Pinkerton and Horeshim varieties. The eggs were laid singly or in small groups; on smooth-skinned fruit such as Reed and Fuerte they were usually laid in sites of slight injury, whereas on the rough-skinned varieties Haas, Pinkerton and Horeshim they were mostly laid in skin pits and around fruit stems. Once again, these tests demonstrated the ability of the honeydew moth to attack avocado fruit in the absence of Homoptera or honeydew.

TABLE 4
Honeydew moth eggs laid on avocado fruits of various varieties in laboratory preference tests*

Variety	Haas	Pinkerton	Horeshim	Fuerte	Reed
Total eggs laid	1535	403	287	111	74
Average no. of eggs per fruit	102.33 a	26.87 b	19.13 b	7.4 b	4.93 b

*Different letters indicate a significant difference ($P < 0.05$), Duncan's multiple range test.

Development on *Paspalum dilatatum*

Although all female moths used in these experiments had mated, as evidenced by the presence of spermatophores in their bodies, no eggs or larvae were found on uninfected *Paspalum* inflorescences. On the other hand, first-instar honeydew moth larvae were found developing in 3 out of 4 replicates on inflorescences infected with *Claviceps paspali.*

DISCUSSION

The main factor affecting the phenology of the honeydew moth is its broad polyphagy. It has been recorded from numerous host plants, usually in association with various Homoptera and their honeydew, and has also been recorded as a predator of whiteflies and other Homoptera (Clausen, 1940). In the present study, larvae were found feeding on honeydew produced by the pyriform scale, as well as on the scale insects themselves. A related species, *Cryptoblabes aphidivora* Yoshiyasu and Ohara (later transferred to the genus *Dipha*) was recorded as a predator of aphids in Japan (Arakaki and Yoshiyasu, 1988). In fact, the honeydew moth itself was even considered at a time as a candidate for importation into the United States, as a beneficial natural enemy of mealybugs (Clausen and Berry, 1932). On certain hosts, such as grapefruit, it is unable to develop in the absence of mealybugs (Avidov and Gothilf, 1960). However, on others, including avocado, it is capable of developing as a primary pest. Haas, with rough-skinned fruit growing in bunches, is the most susceptible avocado variety.

In Israel, the moth overwinters as larvae. In avocado groves, most of the overwintering population is found in dry fruit, and various other dry fruits such as pears, apples, peaches, grapes, loquats, pomegranates and castor beans also provide overwintering and developmental sites. Similarly, honeydew moth larvae have been recorded on dry lemons in Sicily (Liotta and Mineo, 1964), in stored garlic bulbs and dry cotton bolls in Egypt (Abul-Nasr et al., 1974; Swailem and Ismail, 1972; Willcocks, 1922) and as pests of dried fruits and seeds (Corbet and Tams, 1943). A related species, *Cryptoblabes aliena* Swezey, was also recorded on dry fruit in Hawaii (Zimmerman, 1958). No diapause has been observed in overwintering larvae (see also Gurevitz et al., 1969).

Paspalum dilatatum inflorescences infected with the ergot fungus, *Claviceps paspali*, provide yet another developmental site for the honeydew moth in and around avocado groves, mainly in spring and fall. *Claviceps* spp. infect various other Gramineae in Israel, and these should also be investigated as possible sources of the honeydew moth.

Lack of correlation between moth captures in pheromone traps and larval infestation of fruit precludes, for the time being, reliance on such traps for determining an economic threshold for the honeydew moth in avocado groves. It is quite possible that some of the moths trapped in the groves were migrants from adjacent infested crops and other nearby sources.

In the avocado groves of Israel, the honeydew moth is capable of developing five generations per year. Adults of the overwintering generation emerge in spring (March–April) from overwintering sites in and around the groves, but inasmuch as no suitable hosts are present in the groves at that time — not even ripe fruits remaining from the previous season are attacked — it may be assumed that most of these moths migrate to other areas. Adults of the first generation are captured in June, and from then through September there are several waves of increasing amplitude, indicating the presence of two or three overlapping generations. This is corroborated by the presence of all developmental stages together during summer and fall, and by observed variation in developmental time under the same conditions (Avidov and Gothilf, 1960; Gurevitz et al., 1969). Then, moths flying during October–December establish the overwintering generation, which survives as larvae on dry avocado fruit and on various weeds (castor beans, *Paspalum*) in and around the groves.

In conclusion, the honeydew moth is capable of attacking avocado fruit, especially Haas, as a primary pest. It overwinters as larvae in avocado groves or in adjacent areas, and may be present in the groves throughout the year. It may be assumed that adult moths migrate between avocado groves and adjacent areas. Pheromone traps effectively capture male moths, but there is no clear correlation between the captures and larval infestation of avocado fruit. Five generations may be present in avocado groves per year.

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