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FLIGHT PATTERNS OF MOTHS AS AN AID IN THE STUDY OF THEIR PHENOLOGY AND ECOLOGY IN ISRAEL (1).

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A B S T R A C T

During fifteen years of moth trapping by light, some annual flight patterns, dependent on climatic conditions, availability of host plants and the bionomics of certain species have been observed in Israel.

An attempt is made to analyse and use these flight patterns as aids in establishing the phenology, annual life cycle and bionomics of these species as well as their status, whether local residents or migrants.

INTRODUCTION

Since 1959 a survey of nocturnal moths by light traps was conducted at several sites in various parts of Israel. Insects belonging to several orders were trapped during the survey, but the Lepidoptera predominated. They belong to many families and represent a wide variety in their status and behaviour.

During the years some consistent patterns of flight have become apparent. It was evident that information thus obtained,combined with knowledge of local climatic conditions and biological data concerning the immature stages, could be used to establish the phenology of local insects.

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Israel is situated in a subtropical zone, with a mild winter (November to March), during which all rains fall. The long and hot summer (June to late September), is preceded by high temperatures, occurring sporadically in April-May; these heatwaves ("Sharav") are accompanied by very low relative humidities, which desiccate all forms of life (Winstanley, 1972). The natural growing season of wild vegetation occurs during winter and spring (November-May). This vegetation supports many insect species, on annuals, trees and shrubs. The summer is a period of lower physiological plant activity, except for the irrigated agricultural crops which support a rich insect fauna that finds its way into the light traps operating during that period. On the other hand, the spring, autumn and winter catches include a rich lepidopterous population, especially in spring and autumn. Winter species are also quite abundant, as very cold nights are rare even in winter. These populations draw attention, here as elsewhere (Spitzer, 1970).

METHODS

Light traps were installed in various parts of the country, representing desert, hilly countryside as well as agricultural irrigated areas and even neighboring natural open water sources.

The source of light in each trap was a 125-watt mercury vapour bulb, placed over a funnel to which four perpendicular wings were attached to prevent the moths from escaping. A small fan was installed over the funnel to drive the hovering moths into the container. Moths were collected in a jar containing an insecticide, placed below the funnel. Catches were daily recorded for subsequent analysis.

RESULTS AND DISCUSSION

Taking the insect species, not the individual, as a unit, and bearing in mind the prevailing climatic conditions and the agricultural techniques practiced, (especially irrigation), the analysis of accumulated data yielded much useful information regarding the phenology, annual life-cycle and possible migratory habits of the species involved.

Patterns of flight

In an earlier paper (Rivnay and Yathom, 1964), the various flight patterns of Agrotine species in Israel were outlined in four different models. These models, with some modifications, can be adapted to fit all nocturnal Lepidoptera in this area. These are:

a. Insects which are on the wing all year round, raising separate or overlapping generations, passing the cold winter in larval or pupal quiescence, mostly facultative, and resuming life processes whenever temperatures allow. Such a prolonged development causes the population to dwindle; catches during the cold months are low, and the spring development starts from a low threshold. This model fits many species developping on agricultural crops, available due to irrigation. The most notorious are polyphagous species such as *Spodoptera littoralis* (Boisduval), with very high populations building up; *Heliothis armigera* (Hübner) and *Phytometra chalcytes* (Esper) with lower population levels, and monophagous species such as *Sesamia cretica* Lederer which shows separate peaks indicating generations which do not overlap (Fig. 1A). Many other species, such as *Agrotis segetum* (Schiffermüller), *A. spinifera* Hübner and *Peridroma saucia* Hübner, show the same pattern (Rivnay and Yathom, 1964).

b. The second group also includes insects which are on the wing almost all year round, but in contrast to the first model, the season with little activity is the summer, when only a few individuals are present. In fall and winter, and especially during spring, high populations occur. These large populations leave almost no offspring and they dwindle to naught during summer. An example of this model is *Agrotis ypsilon* (Hufnagel), a notorious cosmopolitan pest, which has no diapause in any stage (Rivnay, 1964). Adult populations dwindle during summer, while moths which mature when high temperatures (over 25°C) prevail, are sterile. In spite of the total absence during summer, the adult population is renewed annually. The origin of this renewed population can be explained by examining moth catches at the different sites. In all except the most northern trap there occurs a lapse in *A. ypsilon* catches during the summer; the more southern the site of the trap, the bigger the gap. Only in the north were individual moths present throughout summer; this area is within flying range of the cooler Lebanon slopes, where the moth presumably aestivates (Rivnay, 1964). In India this species is known to be present during summer in the Himalayas (Fletcher, 1925).

This model fits another well-known migrant, *Autographa gamma* L. which is a winter species in this country, appearing in Europe during summer when absent from Israel (Yathom and Rivnay, 1968), as shown in Fig. 1B.

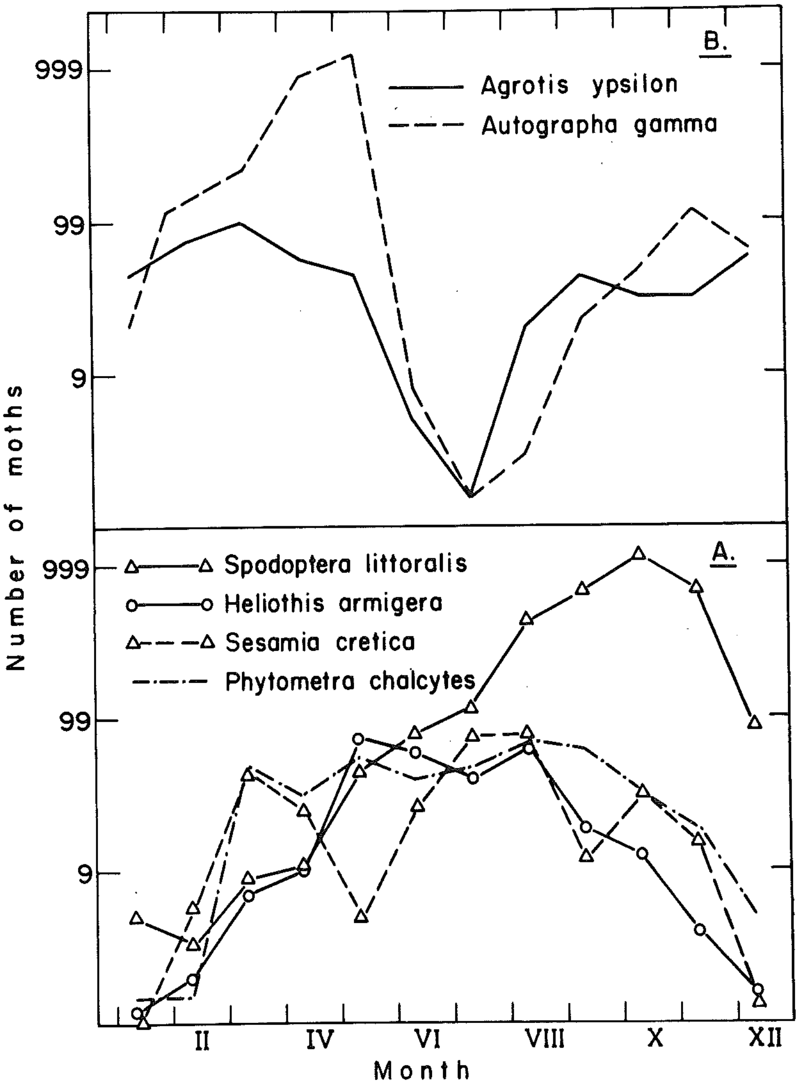

Fig. 1. Numbers of moths of six species caught in a light trap at En Harod, Israel. (Average per 10 nights for each month).

c. The third model is represented by a short flight period; the adults then oviposit and the larvae develop until they enter diapause and aestivate in this or the pupal stage. This model is typical of local univoltine species,

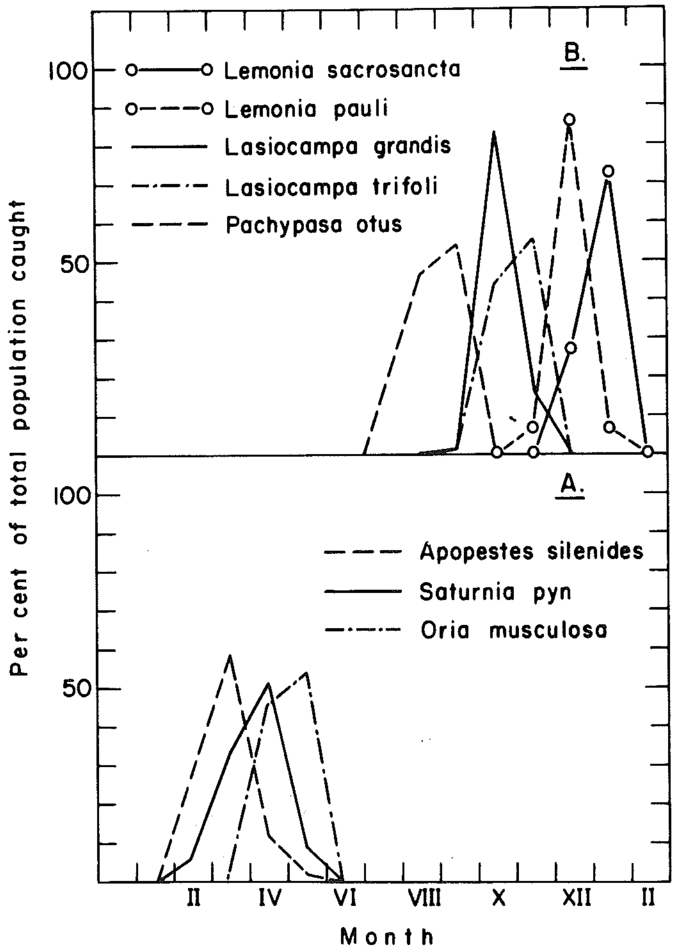

Fig. 2. Numbers of moths of various species caught in a light trap at En Harod, Israel. (Average per 10 nights for each month).

which thus avoid adverse hot and dry summer conditions. It fits many species, including some spring flying ones, such as *Saturnia pyri* Schiffermüller which is on the wing around March-April in this area (Rivnay and Sobrio, 1963). Other spring species shown in Fig. 2A include *Apopestes silenides* Staudiger and *Oria musculosa* Hübner. The latter species, a pest of small grain crops, is quite abundant during some years (Yathom, 1971), but has not yet been observed to cause damage in this country. As its hosts are absent during summer, one may assume that oviposition occurs during the short flight period in spring; its mode of aestivation until the next active season is not yet known. It may do so either as a first instar larva within the egg, as it hibernates in Italy (Solinas, 1971), or as a neonate larva, like *Syringopais temperatella* Lederer in Israel (Rivnay, 1950).

Fall and winter species are quite abundant: Fig. 2B represents some whose adults appear between September and January. They oviposit then and their larvae emerge and feed before the onset of drought and heat, aestivating either as fully grown larvae or pupae.

d. The fourth model represents two distinct peaks of flight, in early winter and again in spring. It includes some very notorious migrants, such as *Triphaena pronuba* (L.) and *Agrotis puta* Hübner, whose immature stages are absent during the summer months, as *T. pronuba* is known to be unable to bread at temperatures over 25°C (Madge, 1962).

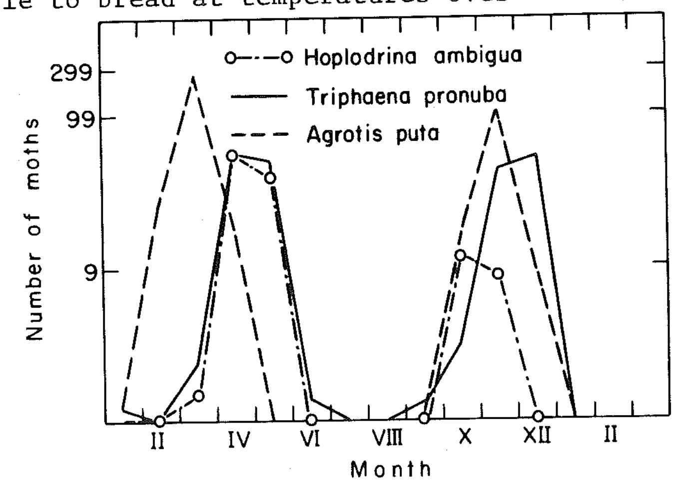

Fig. 3. Numbers of moths of three species caught in a light trap at En Harod, Israel. (Average per 10 nights for each month).

This pattern is also represented by *Hoplodrina ambigua* Schiffermüller and *Caradrina bodenheimeri* Draudt (Yathom, 1971). The fate of the immature stages of some insects that are not considered agricultural pests is less known, but this model would fit these species as well. *H. ambigua* and *C. bodenheimeri* seem to breed a local generation in the winter, the adults of which are on the wing in the spring, while the autumn generation's origin is not known.

In addition to the above-mentioned flight patterns and the conclusions drawn from them, more information concerning the status of the species,its phenology and its life cycle can be extracted from the data. The status of a species, whether a local resident or a migrant, can be established from its catches. Populations of migrant species highly fluctuate from one year to the next. Fluctuations may also occur in local resident species, but they are less drastic, as there is a gradual build up, and populations of one year originate in those of the previous year or of the foregoing generations. Local agricultural pests may also exhibit high fluctuations from one year to the next, but in this case the populations are the outcome of a local gradual build up, whereas with migrants it is very steep and abrupt, and is usually followed by a drastic drop, as shown in Fig.4 for two notorious migrant species, *Heliothis peltigera* Schiffermüller and *H. nubigera* Herrich-Schaeffer.

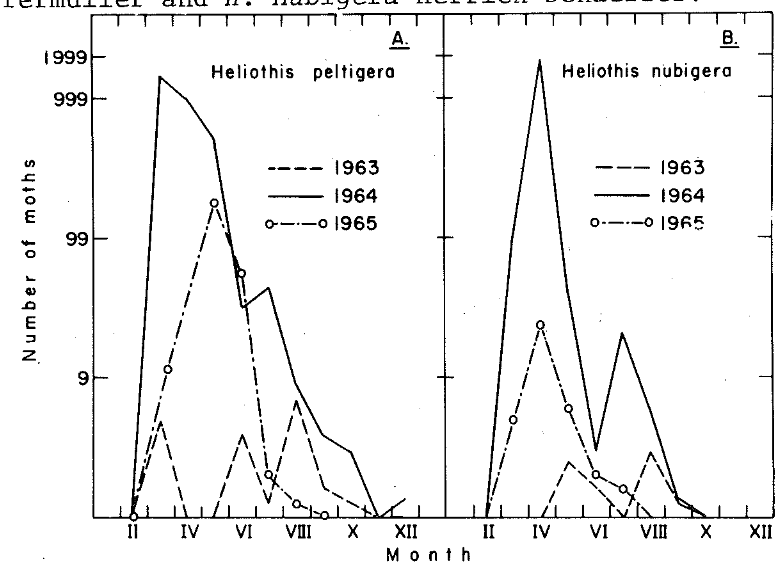

Fig. 4. Numbers of *Heliothis peltigera* and *H. nubigera* moths caught in a light trap at Jerusalem. (Average per 10 nights for each month).

A migrant species which is also an agricultural pest shows a different pattern in an agricultural area, as compared to an uncultivated one. This is well represented by *Spodoptera exigua* Hübner, whose migratory habits have been proven in this country (Yathom, 1971). Fig. 5 represents the annual fluctuations occurring in an intensively cultivated inland valley (En Harod) and in Jerusalem, in the barren Judean Hills.

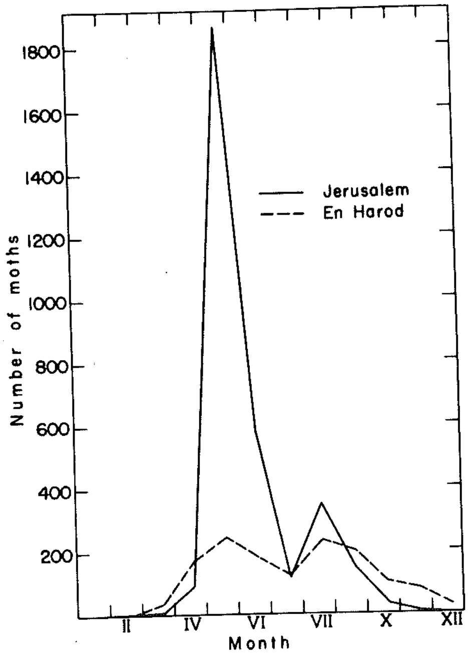

Fig. 5. Numbers of *Spodoptera exigua* moths caught in light traps in En Harod and Jerusalem. (Average per 10 nights for each month).

The data of the flight period of insects reflect the seasons of adult activity, and early catches serve as an excellent indicator of the early activity of a species. A surprisingly accurate correlation between the emergence of corn pests in the spring from overwintering stubble, and the appearance of these insects in traps, was observed in 1972. *Sesamia cretica* moths first appeared in light traps at the end of February and reached peak numbers during March-April; emergence from stubble began in mid February and peak emergence occurred in March (V. Melamed-Madjar, personal communication, 1973). With the aid of additional information concerning immature stages, the life cycle of the species can be established. The number of generations can easily be figured out, and if there is a period of no activity, due to low temperatures or low humidity combined with high temperatures, it is apparent when activity is resumed.

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