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Investigations on the interaction between the apple leaf miner Stigmella malella and its parasite Cirrospilus vittatus in The Netherlands

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Abstract

Investigations during 1967 in a part of an experimental orchard where no insecticides were applied, showed that parasitism of larvae of the first generation of *Stigmella malella* by *Cirrospilus vittatus*, which is by far the most numerous parasite of this leaf miner in The Netherlands, was low and that parasitism of larvae of the second generation was much higher. It is concluded that the capacity of increase of the parasite is much larger than that of its host and that the parasite is an important potential factor in the natural control of the leaf miner. The factors that may be responsible for the discrepancy between the high population density of the parasite in autumn and the low density in spring are discussed.

Introduction

Although in The Netherlands there are about eight leaf miner species that may infest apple, only one, *Stigmella malella* (Stt.) (Lepidoptera, Stigmellidae), may become a serious pest now and then. Little or nothing is known about the causes of such local outbreaks. According to Cairaschi et al. (1963) and Cangardel (1964) parasitism by *Cirrospilus vittatus* Wlk. (Hymenoptera, Eulophidae) is no doubt the factor that in ordinary circumstances controls the leaf miner population in France. *C. vittatus* is also the main parasite of *S. malella* in The Netherlands (Evenhuis, 1965). The present paper is intended as a contribution towards appraising the value of the parasite in the natural control of the leaf miner.

Bionomics of the leaf miner and the parasite

The leaf miner hibernates as a pupa in a cocoon in the top soil layers at a depth of a few centimeters only; the summer generation also pupates here. In The Netherlands adults may emerge towards the end of April and throughout May. A second generation of adults appears in July and August, this generation being much more numerous

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than the first one (van Frankenhuyzen, 1964, 1965). In the Paris region of France even three generations have been recorded (Cairaschi et al., 1963). Little is known about the bionomics of the parasite. In agreement with investigations by Berg (1960) it was found that *C. vittatus* is an ectoparasite of older leaf miner larvae. Prior to oviposition the host is paralyzed as a results of stinging by the adult parasite and dies soon afterwards. The parasite larva thus completes its development on the dead host larva. Pupation occurs within the mine. As a rule the parasite larva develops solitary; in a few cases only was a single host larva found to be attacked by two parasite larvae. Soon after emergence the adult parasite chews its way through the upper epidermis covering the mine, making a round exit hole. This can easily be distinguished from the semicircular shaped slit made by the host larva when it leaves the mine for pupation in the soil.
The parasite hibernates, like many other Hymenopterous parasites, as a full-grown larva in a state of diapause. Hibernation occurs in the fallen apple leaves on the ground. Though *C. vittatus* may be bred from quite a number of leaf miner species, *Stigmella malella* appears to be one of the main hosts. The number of generations is unknown, but as development in mid-summer in The Netherlands lasts for about 4 weeks only, it may be assumed that there are more than two generations a year in our country (Evenhuis, 1965).

The abundance of C. vittatus in relation to other parasites of S. malella

Apple leaves with immature stages of parasites were collected in the experimental orchard Thedinghsweert and the parasites reared to the adult stage. The results are summarized in Table 1. From this table it may be concluded that *C. vittatus* was the dominant species throughout the summer. *Achrysocharella formosa* (Westw.) (Hymenoptera, Eulophidae) seems to be a rather numerous parasite of the leaf miner early in the season (cf. Evenhuis, 1965).

Experimental

In a part of the experimental apple orchard Thedinghsweert near Tiel (province of Gelderland) a weekly sampling programme was carried out from May until the end of October 1967. In this part of the orchard the only chemicals applied to the foliage were the fungicides captan and triamiphos against apple scab and apple mildew,

Table 1. Numbers of adult parasites reared from *Stigmella malella*

	Total	*Cirrospilus vittatus*	*Achrysocharella formosa*	*Tetrastichus sp.*[1]	*Percentage Cirrospilus vittatus*
July	64	48	15	1	75
August	60	54	6	0	90
September	28	27	1	0	96

[1] Identified by Mr. G. J. Gijswijt, Ankeveen

Tabel 1. Aantal volwassen parasieten gekweekt van Stigmella malella

respectively. Mixtures of these materials were sprayed throughout spring and summer at intervals of approximately 10 days.
For obtaining data on the changes in population density of both host and parasite and of the percentage parasitism, the following programme was carried out every week: (1) Thirty branches of each of eight full-grown trees were tapped above a funnel-shaped net according to the method of Steiner (1962). Adults of both leaf miner and parasite were collected and counted. (2) One hundred leaves were picked at random and the living, non-parasitized caterpillars in the mines counted. (3) One hundred almost or completely full-grown caterpillars were collected and the numbers of eggs, larvae and pupae of the parasite counted. As the parasite is an ectoparasite it is not too difficult to recognize its various stages.

Results

Fig. 1 shows the numbers of moths and adult parasites at the various sampling dates. At the time the sampling started there were still some moths of the first generation present, which must have emerged from the overwintered pupae during May. Moths of the second generation were trapped in large numbers during July and August. *C. vittatus* adults appeared to be scarce until late summer and early autumn and most of them were collected when the moths were no longer present.
Fig. 2 shows two peaks in the numbers of *S. malella* larvae, at mid-June and the end of August, respectively, corresponding with the two generations. The maximum levels attained in the peaks indicate an approximate tenfold increase in population density. Fig. 2 also shows the course of parasitism. Parasitized larvae were first observed about the middle of June when there was a peak in the numbers of caterpillars of the first

Fig. 1. Changes in population density of adults of *Stigmella malella* (×———×) and of *Cirrospilus vittatus* (o– – – o) throughout the season

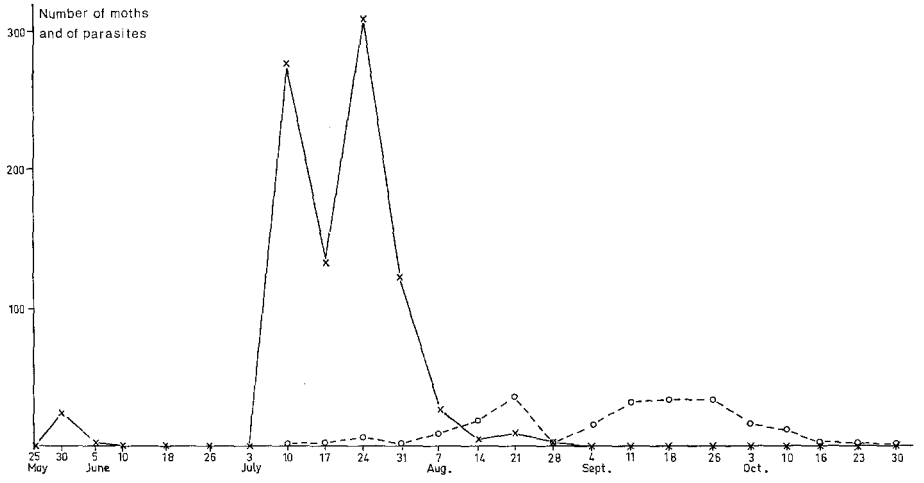

Fig. 1. Verloop van de populatiedichtheid van de imagines van Stigmella malella (×———×) en van Cirrospilus vittatus (o – – – o)

Fig. 2. Changes in population density of *Stigmella malella* larvae (×———×) and in the percentage of parasitism by *Cirrospilus vittatus* (o – – – o) throughout the season

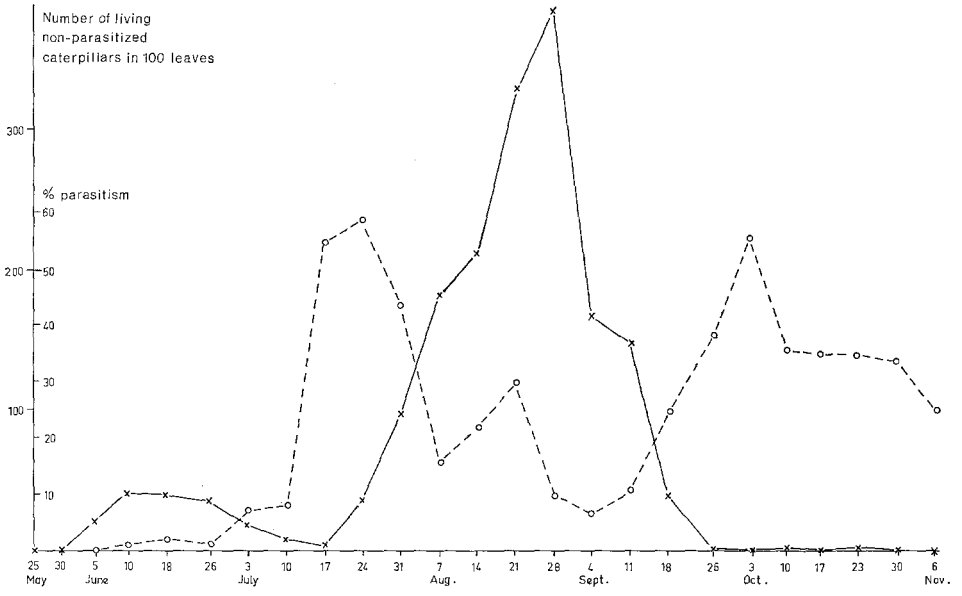

Fig. 2. Verloop van de populatiedichtheid van de larven van Stigmella malella (×———×) en van de parasitering door Cirrospilus vittatus (o – – – o)

generation of *S. malella*. Three peaks in the percentage of parasitism are clearly visible, namely in the second half of July, about the middle of August and in early October. The first and the third peaks are not important with respect to the effectiveness of the parasite as a control agent.

At the periods concerned the population density of the caterpillars was very low, as can be seen in Fig. 2; hence the percentage of parasitism must have risen. The second peak, however, is important as it appears only shortly before the high peak of caterpillar numbers. The percentage of parasitism in the second generation of caterpillars is much higher than in the first one, in spite of the approximately tenfold increase in leaf miner numbers.

Discussion

The fact that the percentage of parasitism is higher in the much larger second generation of the leaf miner caterpillars than in the first one indicates that the capacity of increase of the parasite is considerably larger than that of its host. In *Aphelinus mali* (Hald.), which in The Netherlands is a not very effective parasite of the woolly apple aphid, *Eriosoma lanigerum* (Hausm.), the capacity of increase of the parasite is much smaller than that of its host (Evenhuis, 1958, 1962). The capacity of increase is a function of the rate of development, the number of progeny, the sex ratio, the duration of the reproductive period and the distribution of the progeny during that period. These factors have not hitherto been studied in the leaf miner and its parasite.

The higher capacity of increase of the parasite means that it may be an important factor in the natural control of the host. However, because of its scarcity in spring and early summer, this parasite appeared ineffective in exercising sufficient control of the leaf miner in the crucial initial phase of the outbreak. It may be suggested that if the population density of the parasite had been large enough in June, it might have reduced the first generation of leaf miner caterpillars to such a degree that the second generation would never have reached such a high population density. In this event a much smaller infestation of the leaves would have resulted.
For the striking difference in the population density of *C. vittatus* during autumn and during spring the following factors may be responsible.
(1) As previously mentioned, the parasite hibernates in fallen leaves. In Dutch apple orchards many leaves are blown away by autumn storms.
(2) As can be inferred from Fig. 2, *S. malella* larvae became increasingly scarce in the second half of September, whereas *C. vittatus* was still numerous during and after that period. It is therefore likely that much of the potential progeny is wasted by lack of available hosts.
The high percentage of parasitism in late summer and autumn, as mentioned by d'Aguilar (1959), Cairaschi et al. (1963) and Cangardel (1964), does not necessarily mean that the parasite is effective in this part of the year. It is merely a result of the disappearance of the caterpillar hosts, which migrate to pupate in the soil; thus fewer hosts become available for parasitizing. The same phenomenon was observed with the apple-grass aphid, *Rhopalosiphum insertum* (Wlk.) (Hemiptera, Aphididae); in this case the percentage of parasitism by *Monoctonus cerasi* (Marshall) increased in the second half of May when the aphid migrated to grasses, where the parasite does not follow it (Evenhuis, 1968).
From the foregoing statements it may be concluded that *Cirrospilus vittatus* is an important potential factor in the natural control of *Stigmella malella*. However, we do not yet know enough about certain facts. We need especially a better knowledge of the reasons for the discrepancy between the high population density of the parasite in autumn and the low one in spring. This might lead to a better understanding of the incidental and local outbreaks of the leaf miner pest in summer.

Acknowledgment

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Samenvatting

Onderzoek naar de wisselwerking tussen de appelbladmineerder Stigmella malella en zijn parasiet Cirrospilus vittatus in Nederland

Cirrosspilus vittatus is in Nederland verreweg de talrijkste parasiet van de appelbladmineerder *Stigmella malella* (Tabel 1).
In de proefboomgaard Thedinghsweert bij Tiel werd het verloop van de populatiedichtheid van de imagines van mineerder en parasiet (Fig. 1) en van de mineerderrupsen, benevens hun parasitering (Fig. 2), gedurende 1967 wekelijks nagegaan. Het

bleek dat de tweede generatie van de mineerderrupsen, hoewel veel talrijker dan de eerste, voor een veel hoger percentage beparasiteerd werd. Daaruit wordt geconcludeerd dat de vermeerderingscapaciteit van de parasiet belangrijk groter moet zijn dan die van haar gastheer en dat de parasiet een belangrijke potentiële factor is in de natuurlijke beheersing van de mineerderpopulatie.
De factoren die verantwoordelijk kunnen zijn voor het grote verschil in de populatiedichtheid van de parasiet aan het einde en aan het begin van het seizoen, worden besproken.

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