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On the parasitization of the ladybird *Coccinella septempunctata* L. (Col., Coccinellidae)

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Abstract: The present study deals with entomoparasites of *Coccinella septempunctata* L. in cereals, mainly in winter wheat. Sections of monthly sampled adult ladybirds during one year in different habitates at Staaken (Berlin) gave two peaks of parasitization with *Perilitus coccinellae* (Schrank) (Hym., Braconidae): (1) 33% in March (hibernation site); and (2) 12.5% in June (winter wheat). Populations of the ladybird investigated during the seasons in 1993 and 1994 in winter wheat at three locations (Berlin-Staaken, Fläming, Magdeburger Börde) showed a similar sharp increase in degree of parasitization with *Perilitus coccinellae* in the second half of June. Maximum of parasitization reached from 12.3% (Fläming, 1993) to 25% (Börde, 1993) and was a result of the act of the first newly emerged adult wasps. Main parasite of the coccinellid pupae was *Phalacrotophora fasciata* (Fallen) (Dip., Phoridae) with parasitization rates between 4.9% (Börde) and 20.2% (Fläming). *Oomyzus scaposus* (Thompson) (Hym., Eulophidae, Tetrastichinae) was found only at two locations with low rates: 0.9% (Fläming) and 1.4% (Berlin). Experiments in climatic chambers with alternating temperatures gave new results for the effect of *Perilitus* on the fertility of matured female ladybirds. At relatively high temperatures (25°C middle of day) daily numbers of coccinellid eggs increased for a period of a week immediately after parasitization. Though mortality was high (70.6%) at this condition, half of the surviving females began egg deposition 12 days after emergence of the *Perilitus* larva.

1 Introduction

Within the estimation of the predatory effect of ladybirds the relevance of biotic mortality factors is discussed. *Coccinella septempunctata* L. is regularly found in early summer in cereals and is attributed to have some importance as an antagonist of cereal aphids (Hom., Aphididae) together with other predators. The aim of the study was to clarify which parasitic insects occur in the coccinellid population at this phase and whether they are responsible for a notable effectiveness depression.

2 Material and methods

2.1 Field investigations and beetle sections

Adults of *C. septempunctata*, 30–40 individuals at every assay, were sampled weekly in May, June and July in 1993 and 1994 in cereals at two locations (Northern Fläming and Magdeburger Börde). Additionally, in 1994 monthly samplings during the year at Berlin-Staaken were carried out in different habitats according to the appearance of *C. septempunctata*. Sections of the sampled beetles gave rates of parasitization. Further investigations in 1994 dealed with the pupae of the ladybird. The pupae were sampled three times at any location, the same three as described above, and were held under laboratory conditions with 20 ± 5 C until emergence of the adult beetle or the parasites.

2.2 Experiments in climatic chambers

In 1993 and 1994 special experiments were done under controlled climatic conditions to quantify the influence of parasitization with *Perilitus coccinellae* on the fertility and mortality of female *C. septempunctata*. The investigations took place under alternating temperatures as follows: 1) 20°C average (day/night = 23/14°C); and 2) 25°C (28/19°C). The other conditions (daylength = 16 h with 15 000 Lux, *c.* 65% RH) were equal. The initial *Perilitus* stock was obtained from samples of hibernating ladybirds at Berlin-Staaken. For parasitization five fertile *C. septempunctata* females were kept together with a single *Perilitus* wasp in a plastic box (160 × 160 × 80 mm) for one day. After that the ladybirds were held individually in glasses (d = 60 mm, h = 60 mm, closed with gauze) and were fed with *Sitobion avenae* (Fabr.) (Hom., Aphididae) under daily control of vitality. If present, numbers of eggs per female and day were counted. The experiments, four at any temperature regime, finished with the death of the beetle or 20 days after emergence of the parasite. In addition to fertility and mortality of the ladybirds, the length of development stages of the parasite and its surviving rate were recorded.

3 Results

3.1 Field data

The only entomoparasite of adult *C. septempunctata* was found to be *P. coccinellae*. The parasitization rates during one year at Berlin-Staaken are shown in table 1. After a high rate in hibernating ladybirds in winter 1993/94 the value decreased until the beginning of June, when it increased distinctly in June up to 12.5%. In July parasitization was again lower and increased in September. The investigation of *C. septempunctata* populations in cereals at three different locations during 2 years of observation showes in all cases a very similar

Table 1. Parasitization of Coccinella septempunctata *with* Perilitus coccinellae *during one year*

Habitat	Date	N	Rate of parasitization (%)
Hibernation site	March 03	21	33.0
Fallow ground	April 26	29	3.4
Oat	June 05	30	3.3
Winter wheat	June 12	16	12.5
Oat	July 17	52	5.8
Meadow with weeds	September 14	30	10.0
Hibernation site	November 19	24	8.3
Hibernation site	February 01	42	9.5

sharp increase in the degree of parasitization with *P. coccinellae* in the second half of June after a relatively low level in May and the beginning of June. Maxima of parasitization were: 1) 25% (Börde; July 5, 1993; $n = 60$); 2) 23.9% (Fläming; June 20, 1994; $n = 47$); 3) 17.6% (Börde; July 7, 1994; $n = 34$); 4) 12.5% (Berlin, June 12, 1994; $n = 16$); 5) 12.3% (Fläming; June 16, 1993; $n = 57$). All maxima were derived from samples in winter wheat fields except one from a meadow with weeds next to winter wheat (Börde, 1994). In every case female ladybirds with 58.3% (54.5–62.5%) had higher parasitization rates than males.

The mortality and parasitization of the pupae of *C. septempunctata* is to be seen in table 2. Berlin-Staaken and Fläming with relatively high mortality rates due to parasitization of *Phalacrotophora fasciata* Fallen and additional occurence of Tetrastichinae (*Oomyzus scaposus* Thomson) showed more similarity in comparison with the third location (Börde) where parasitization of *Phalacrotophora* was low and Tetrastichinae absent.

3.2 Experiments in climatic chambers

The development of the several stages of *P. coccinellae* and mortality showed temperature dependence. If the average daily temperature increased from 20 to 25°C, the total development time of the parasite shortened from 27.0 ± 0.82–23.0 ± 0.71 days (mean ± SE), but its general survival decreased from 37.5–11.8%. The effect of parasitization with *P. coccinellae* on the fertility and mortality of female coccinellids was very different at the two temperature regimes investigated (see fig. 1).

At 20°C daily average the number of eggs per female decreased within 5.1 ± 0.50 days (mean ± SE) progressively. In this case the average amount of eggs laid per female after the parasite attack was 146.5 (± 25.27 S.E.). The survival rate was 36.4% with lasting infertility of all females. In contrast, ladybird females held at 25°C daily average showed high daily egg numbers immediately after parasitization with 8.0 ± 1.45 (mean ± SE) days duration of fertility, significant longer than at 20°C ($P < 0.05$), and the total amount of eggs was 464.8 ± 120.82 per female (mean ± SE), higher with significance ($P < 0.05$) than at 20°C. The average daily egg number per parasitized female was significant ($P < 0.05$) higher at the 2nd and 4th day. Though mortality of the ladybirds was higer (70.6%) than at the lower temperature half of the surviving females did not lose their fertility and begun again with egg laying 12 days after the emergence of the *Perilitus* larva.

4 Discussion

P. coccinellae, a very common coccinellid parasite (Smith, 1953), only turned out to have importance for adult *C. septempunctata*. After high parasitization rates in hibernating ladybirds, the value decreased in spring because of inactivity or mortality of the attacked beetles. By the middle of June, when ladybirds were numerous in cereals, a sharp increase of parasitization could be proven. This was surely due to the activity of the newly emerged adult *Perilitus* generation. After a parasitization maximum which reached nearly one fourth of the coccinellid population in winter wheat the parasitization rate decreased again. It is not clear whether inactivity or mortality was the most important reason for this decrease but from our point of view it is enough to know that the beetles were no longer active as aphid predators.

Another detail for the importance of *Perilitus* parasitization is the preference for attacking female ladybirds, which are known for their greater predatory effect. The higher proportion of parasitized females is obtained from several authors (Cartwright et al., 1982; Parker et al., 1977).

Balduf (1926) pointed out that the effect of parasitization on the ladybird reached from early death to complete recovery. The results described for female fertility in the course of parasitization confirm the assumption that *Perilitus* larvae within the host do not destroy any tissue of vital importance but only feed on the fat body as observed by Sluss (1968). Death of the host cannot be an intention, since the larva needs a vital host. Later, after the emergence of the developed parasite larva, mortality of the ladybird seems to be rather a death of hunger if the beetle remains on the cocoon.

The infertility of the female ladybirds as a consequence of *Perilitus* attack was described by, e.g. Maeta

Table 2. Parasitization of C. septempunctata *pupae at three locations*

	Börde	Berlin-Staaken	Northern Fläming
Sampling period	June 23–July 07	June 03–July 10	June 28–July 07
Number of pupae sampled	61	72	114
Total mortality [%]	8.2	23.6	22.8
Parasitization rate for			
Phalacrotophora fasciata	4.9	15.3	20.2
Tetrastichinae	—	1.4	0.9

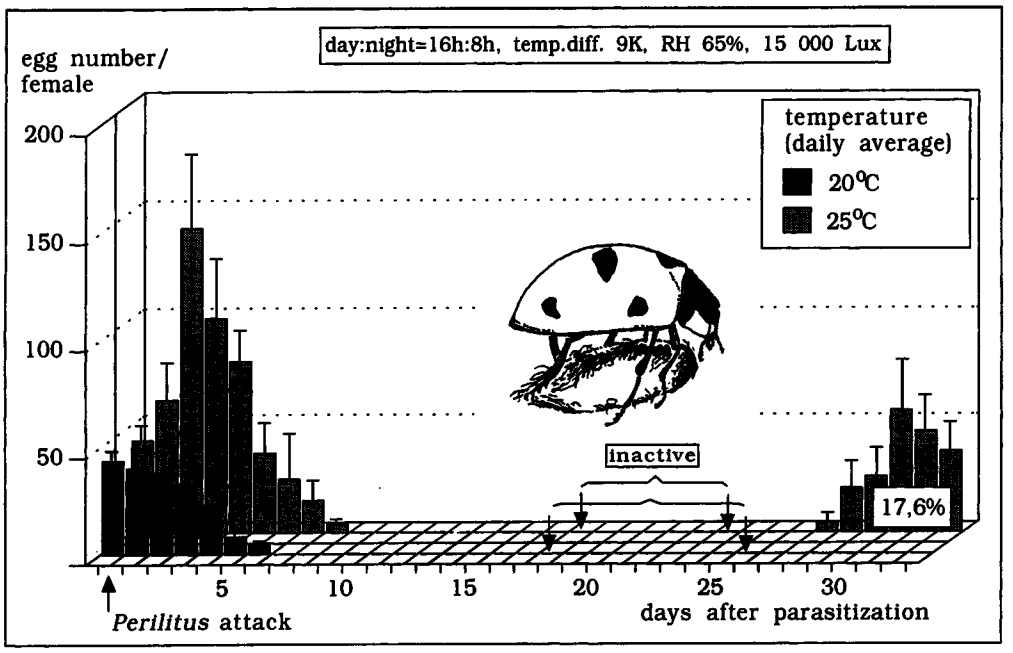

Fig. 1. Average daily egg number of Coccinella septempunctata *(S.E.) after parasitization with* Perilitus coccinellae *in climatic chambers. (17.6% of parasitized females begun again with egg laying at 25°C daily average)*

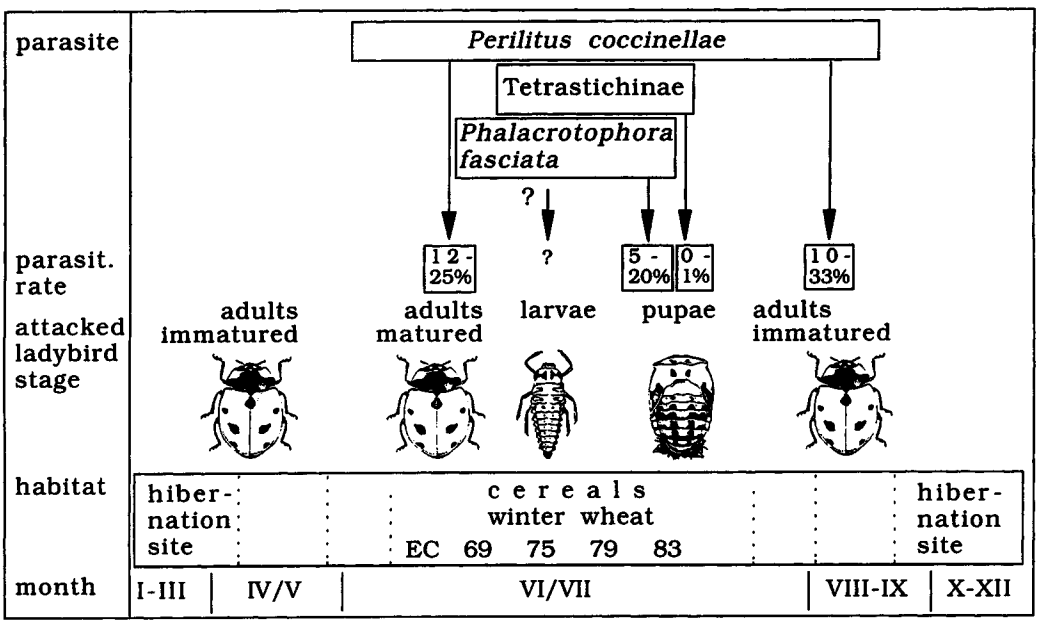

Fig. 2. Observed parasite attacks on Coccinella septempunctata

(1969), but detailed data for this phenomenon were not given. The present study shows that female *C. septempunctata* lost their ability to lay eggs within one week and that in the case of high temperature daily egg numbers increased for a short period and some of the surviving beetles were able to move away from the cocoon and begin with egg deposition again after a successful parasitization with complete *Perilitus* development. The mentioned increase in egg number was characterized by enormous deviations between the females. Besides of this the high temperatures caused higher mortality of the ladybird hosts as well as lower success of parasitization (rising of an adult *Perilitus* individual) with accelerated development. At this regime nearly 65% of the beetles died without visible symptoms, that means no emergence of the *Perilitus* larva was observed, whereas at the lower temperature the corresponding value was only 36%. The relatively low number of observed cocoons resulted obviously from this high *Perilitus* larval mortality as a consequence of an early death of the host.

In comparing the thermal requirements of *P. coccinellae* for its development, Obrycki and Tauber (1978) presented data, with the course of daily temperatures in the middle of many years giving two generations of *Perilitus* adults in the studied region, the first at the end of June and the second in the middle of August. Klausnitzer (1969) gave the same number

of generations. However, a similar comparison with temperatures for the year 1994 showed three possible generations.

Only little is known about the importance of entomoparasites as a mortality factor of coccinellid larval and pupal stages. Remarkable parasitization rates of ladybird pupae were only established for *Phalacrotophora fasciata*. This phorid fly was detected by several authors in European coccinellids (HODEK, 1973). Its presence at all three locations investigated is confirmed by SEMYANOV (1986), who finds *P. fasciata* very common among *C. septempunctata*. The high rates at Berlin and the Northern Fläming indicate some importance of this parasite as a pupal mortality factor in some regions.

In connecting parasites with limitation of coccinellid predation in cereals it is of fundamental importance to have a look at the timing of the parasite attacks (see fig. 2). Of major interest in this context is the first *Perilitus* attack, because the predatory effect of *C. septempunctata* is highest at the time of increasing aphid infestation, that means between end of flowering (EC 69) and dough stage (EC 83) of winter wheat. The described *Perilitus* attack has two important consequences: 1) loss of activity for 12–25% of the coccinellid adults; and 2) decrease of fertility and therefore of potential predatory larval quantity.

The effect of parasites on coccinellid larvae is not so clear and might be the object of further investigations.

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