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STUDIES ON THE EFFICIENCY OF SYRPHID LARVAE, AS PREDATORS OF APHIDS ON WINTER WHEAT

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INTRODUCTION

Aphidophagous larvae of certain syrphid species can play a significant role in controlling populations of cereal aphids (Chambers and Adams, 1986, Storck-Weyhermüller, 1987; Poehling, 1988). An analysis of the factors that affect the efficiency of predation is necessary for improved IPM strategies and for computer based simulation models.

Besides the spatial and temporal coincidence of predator and prey, the efficiency of an antagonist depends on its consumption rate, which is modified by appetite, activity and density of the predator as well as the abundance of the prey (pest) and its rate of increase.

We studied the effect of prey density on the antagonistic potential of larvae of *Episyrphus balteatus* (Deg.), which is the predominant predator in winter wheat (Poehling, 1988).

MATERIALS AND METHODS

Semi-field

Table 1. Percentage reduction in aphid density due to syrphid larvae

Days after release	ratio of predator : prey		
	1:70	1:170	1:245
3	80	33	51
6	91	81	92

Second instar larvae of *E. balteatus* were released in $2 \times 5m^2$ cages in predator-prey-ratios of 1:70, 1:170, and 1:245. The aphid density was greatly reduced by syrphid larvae (Table 1.). The rates of efficiency, which were calculated

Key words: *Episyrphus balteatus*, *Syrphidae*, cereal aphids, predator efficiency.

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according to Abbott (1925), obtained in the different plots were comparable to an insecticide treatment giving a reduction in aphid density of 80–90%, after six days.

Field observations

This investigation was conducted in large winter wheat plots at Hiddestorf (Lower Saxony). A synthetic pyrethroid (Sumicidin 10; a. i.: Fenvalerate), which was only slightly toxic to syrphid eggs and larvae (Poehling, 1988), was used to establish different aphid densities in the field:

I: no insecticide treatment

II: 120 ml/ha Sumicidin 10 (recommended dose: 300 ml/ha) after reaching 9 (26.06.88 = EC 69) and 8 (20.06.89 = EC 67) aphids per ear and flag leaf.

III: 300 ml/ha Sumicidin 10 at the beginning of ear emergence (23.06.88 = EC 55).

Aphid densities and the abundance of natural enemies were recorded by random counting of 10 × 10 ears and flag leaves. Syrphid larvae forage mainly on the lower parts of plant. Thus, in 1989 whole plants (12 × 10) were checked for aphids and antagonists.

To improve the accuracy of the estimate of syrphid density another method was also used: all the shoots were cut from an $10cm^2$ area and thoroughly searched for preimaginal stages. This procedure was repeated at least 10 times per plot. In addition, larvae and pupae were collected from the field, weighed, transferred to petri dishes (∅5 cm) and kept under controlled conditions (20°C and 70–80% r. h.). The larvae were fed with a mixture of cereal aphids [i. e. *Metopolophium dirhodum* (Walk.), *Sitobion avenae* (F.), *Rhopalosiphum padi* (L.)]. After emergence the adults of the syrphids were determined.

Although all three of the above aphid species were common in Northern Germany, in both years, *S. avenae* was dominant. In 1988 the first record of cereal aphids was during ear emergence (EC 55) (Fig. 1.). In all treatments the aphids reached maximum abundance shortly before milkyripe (07.–11.06., EC 75). About ten days later the population collapsed (17.06.–2.06., EC 83). In the next year measurable aphid densities occurred three weeks earlier (18.05., EC 37) (Fig. 2.). Population peak density was reached at the end of June, followed by a rapid decline.

In both years *E. balteatus* proved to be the dominant species (Table 2.). *Metasyrphus corollae* (Fabr.), *Scaeva pyrastri* (L.) and *Sphaerophoria scripta* (L.) were less common.

In both years the syrphids showed a positive density dependent oviposition (Table 3.). The well timed egg-deposition in 1988 resulted in the early appearance of the young syrphid larvae. Different numbers of preimaginal stages were associated with the aphid densities I - III (Fig. 1.A — C).

In 1989 the syrphids started oviposition at nearly the same time (end of June) as in the previous year. However, at this time the aphid density was very high, consequently the syrphid larvae were not able to control the aphids. Furthermore, in this year, the most voracious third larval instar appeared after the aphid population had stated to decrease (Fig. 2.A - B).

The density dependent oviposition and early decline in aphid abundance (at the time the syrphids hatched) resulted in a very similar availability of prey

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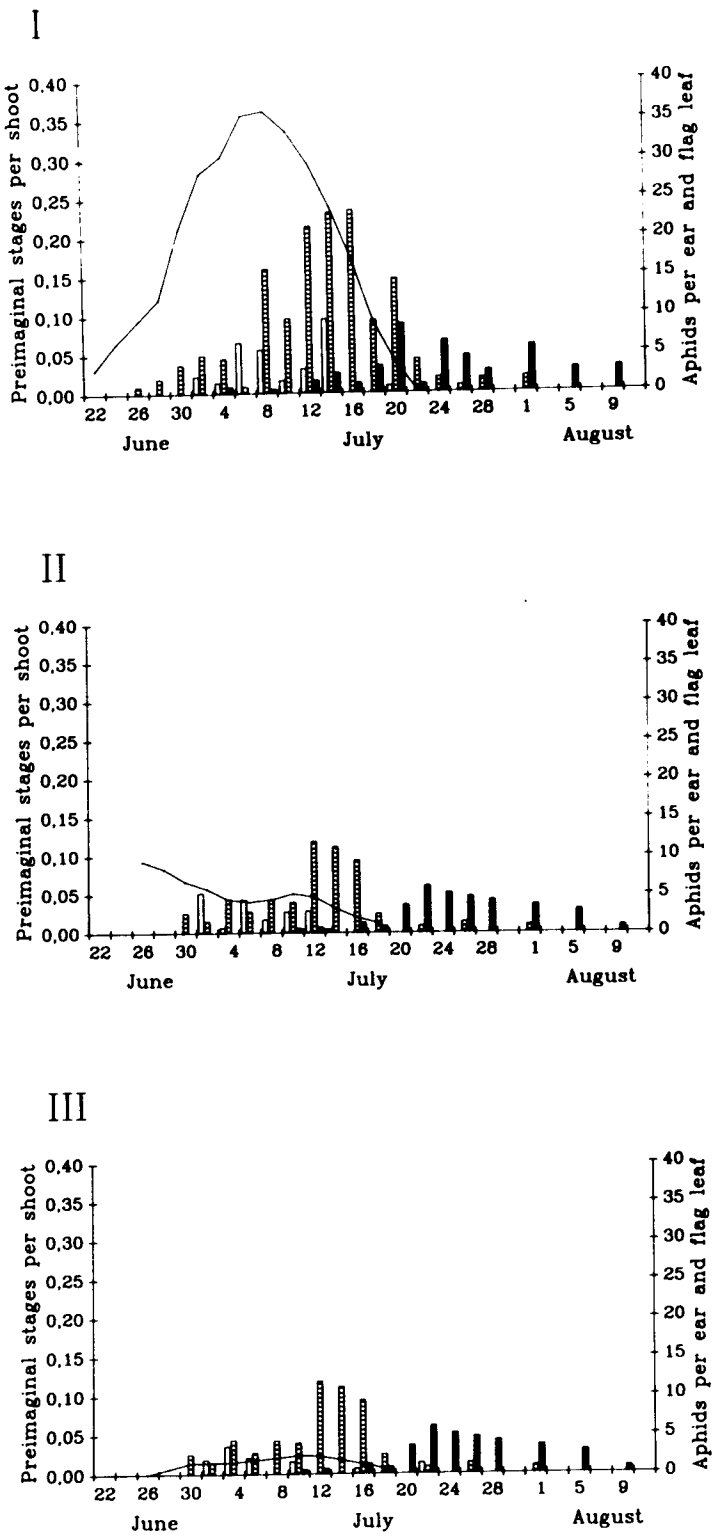

Fig. 1. Population dynamics of syrphids in 1988 with different levels of aphid infestation (I–III = A – C)

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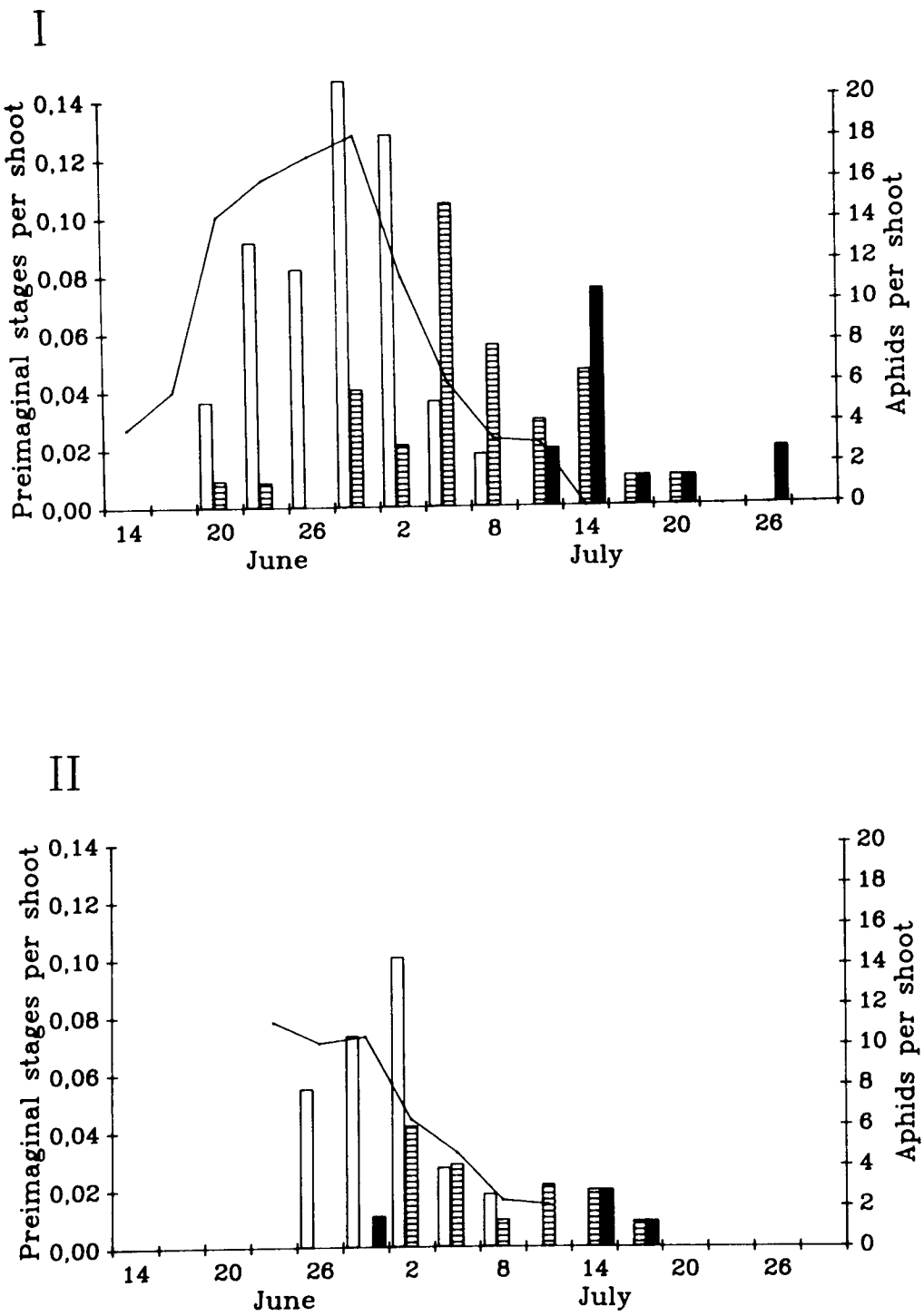

Fig. 2. Population dynamics of syrphids in 1989 with different levels of aphid infestation (I–II = A – B)

Aphids Eggs Larvae Pupae

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Table 2. Species composition of syrphids in 1988 and 1989

species	abundance 1988 % n	abundance 1989 % n
Episyrphus balteatus (Deg.)	93.8 (275)	91.0 (471)
Syrphus corollae (Fabr.)	1.0 (3)	3.0 (16)
Scaeva pyrastri (L.)	3.1 (9)	6.0 (30)
Sphaerophoria scripta (L.)	2.1 (6)	0.2 (1)

Table 3. Number of syrphid eggs laid per shoot in 1988 and 1989

level of aphid infestation	number of eggs per shoot 1988	1989
I	0.30	0.49
II	0.19	0.29
III	0.11	

for the third larval instar in the different treatments. Therefore, the resulting larval and pupal weights were similar in the two treatments (Table 4.). It is noteworthy that the mean larval and pupal weights in 1989 were lower than in 1988. This might be due to the low number of prey available in 1989, just sufficient to ensure successful preimaginal development. According to Schweizer (1987) *E. balteatus* does not pupate if the final larval weight is less than 22 mg.

Table 4. Mean larval and pupal weights of E. balteatus

	larval weight in [mg] 1988	1989	pupal weight in [mg] 1988	1989
I	28 a[1]	20 a	34 a	22 a
II	27 a	28 a	31 b	20 a
III	22 b		24 c	

[1]Values followed by the same letter are not significantly different (Scheffé $p \leq 0.05$)

CONCLUSION

E. balteatus made up almost 90% of total syrphids encountered. This dominance of *E. balteatus* has been observed also by other authors (Storck-Weyhermüller, 1987; Schier, 1988). However, it is not typical to observe so few species. Faunistic studies of cereals record other species for example, *Metasyrphus luniger* (Meig.), *Syrphus vitripennis* (Meig.), *Scaeva pyrastri*, (Laska and Starý, 1980) and *Melanostoma* sp. and *Platycheirus* sp. (Sol, 1965; Honek, 1983).

Semi-field

The quantification of the potential voracity of syrphid larvae (of predation efficiency) revealed that even at a predator-prey ratio of 1:245 the aphids were nearly complete eliminated. Similar observations are described by Storck-Weyhermüller (1987), who found that a ratio of one predator (syrphids) to 400 aphids may result in a 20% reduction. With the exception of the predator-prey-ratio of 1:70 (212 syrphid larvae per m^2), the abundance of syrphid larvae (92 and 128 larvae per m^2) is not unrealistic, because in 1988 the maximum abundance reached 143 larvae per m^2. Other authors cite larval densities of only 40–50 individuals per m^2 (Chambers and Adams, 1986; Poehling et al., 1991; Hasken, 1988). However, their actual abundance is frequently underestimated by visual surveys (Dean, 1983). This error can be overcome only by time-consuming searching and counting of the syrphids present on shoots removed from the field. Nevertheless, in most years the impact of syrphid larvae in the field will be low for the following reasons: first, high numbers of larvae occurred only in one year and second, the more heterogenous age structure of the larvae in the field might lead to a lower, but longer-lasting effect.

Syrphids have proved to be very effective antagonists in other ecosystems. Wnuk (1977) reported on the antagonistic potential of *E. balteatus* in the case of *Aphis pomi* (De Geer). Furthermore (Chambers, 1986) has assessed the value of syrphids in biological control systems under glass.

Field records

The effectiveness of natural enemies is dependent on their ability to synchronize their activity with that of the aphid and so regulate aphid abundance (Rautapää, 1976). The late oviposition was the main reason for the poor effectiveness of syrphid larvae in 1989.

In contrast to the results of other authors (Chandler, 1968; Chambers and Adams, 1986), who recorded initial oviposition at 1–5 aphids per plant, the first oviposition by *E. balteatus* in untreated control plots in 1989 was observed at 14 aphids per shoot (Fig. 2 A). The late appearance of syrphids resulted in their having little impact on the population dynamics of the cereal aphids. It is well known that syrphids migrate over long distances in autumn and spring (Bastian, 1986). Such a migration from the south might account for the time-lag.

In 1988 the predator and prey populations were better synchronized. The decline in the aphid populations started when the aphids were not yet negatively affected by plant quality (EC 75, milkyripe). At this time the syrphid larvae were the only predators which were present in a high numbers. Together with the entomopathogenous fungi they were responsible for the suppression of aphid abundance.

The abundance of the antagonist is also important (Solomon, 1949). Syrphid larvae showed both "functional" and "numerical responses". The numerical response is demonstrated by the correlation between egg-laying and aphid infestation (Schier, 1988; Storck-Weyhermüller, 1987; Rautapää, 1976). Furthermore, the laying of syrphid eggs next to or within aphid colonies ensures a high survival rate of the newly hatched larvae (Bombosch, 1962). A high level of aphid infestation did not only affect the abundance of syrphid larvae, but

resulted in heavier larvae and pupae, which indicates an increased feeding activity, and therefore a functional response. The dependence of larval consumption upon prey quantity was also observed by Scott et al. (1984) with *M. corollae*. Furthermore, the functional response of syrphid larvae exhibits an age specific pattern (Ankersmit et al., 1986). More data is needed before syrphids can be used in IPM.

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