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Cereal aphids, their parasitoids and coccinellids on oats in central Poland

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Abstract: The aim of this work was to study the complex role of coccinellids and parasitic Hymenoptera in reducing the populations of cereal aphids on oat crops. The studies were conducted in 1988–1991 in Dziekanów Polski near Warsaw. The dynamics of number of aphids and coccinellids and degree of parasitization of aphids by parasitoids were examined. Moreover, the species composition of the studied groups of insects was also determined.

The studies allowed to determine the occurrence of three species of cereal aphids: *Rhopalosiphum padi* L., *Sitobion avenae* F. and *Metopolophium dirhodum* Walk. The first two were the most numerous. The dynamics of the individual species was different in the separate years of the study. The first to appear was usually *R. padi.* On the studied fields eight species of predatory Coccinellidae and seven species of parasitic Hymenoptera belonging to the family Aphidiidae were found.

The studies revealed considerable differences in the abundance of the species of cereal aphids in the individual years, course of its dynamics and also synchronization between the development of aphids and their natural enemies. The role of aphidophages should be separately considered for the individual aphid species. *R. padi* is usually attacked by coccinellids after the peak of numbers, whereas *S. avenae* during the increase of population. *S. avenae* is also reduced to a considerable extent by parasitoids.

1 Introduction

Although in recent years many researchers have concentrated upon cereal aphids and their natural enemies, the joint effect of predators and parasitoids on aphid reduction is rarely analysed. Moreover, most studies are conducted on aphids occurring in winter wheat, whereas those in spring barley and oats are neglected. Despite the common view that these cereals are mostly attacked by one aphid, *Rhopalosiphum padi*, and occasionally by *Sitobion avenae* (Kröber and Carl, 1991), our earlier observations and also data of other authors from Poland (Pankanin-Franczyk and Ceryngier, 1991; Pankanin-Franczyk, in press; Gołębiowska and Złotkowski, 1988) show that *S. avenae*, like *R. padi*, permanently occurs in oats, and frequently in high numbers.

Also many data show that oats provide suitable habitat for aphid enemies, especially coccinellids. Clayhills and Markkula (1974) found that coccinellids were much more abundant in oats than in winter cereals. Also Honěk (1982a) noted that besides legumes, spring cereals were most abundantly colonized by *Coccinella septempunctata* of all the crops in Central Bohemia. As shown by Basedow (1982), at the beginning of the season, *C. septempunctata* preferred oats and then moved into wheat. Also, parasitoids are abundant in oats, and they can largely reduce cereal aphids Pankanin-Franczyk (in press).

The purpose of this paper is to analyse the complex role of coccinellids and parasitic hymenopterans in reduction of cereal-aphid populations in oats. The analysis comprised the occurrence of aphids and aphidophages, their species composition and abundance and also the degree of aphid parasitization.

2 Material and methods

The study was carried out in the region of Dziekanów Polski near Warsaw. The oat fields were located close to a forest and surrounded by other cereals, dominated by rye.

Numbers of aphids were estimated from direct counts on plants. Once a week, 100 plants were surveyed and all aphids were noted. Numbers of coccinellids were estimated from their observations on plants (in 1988) and from counts of all developmental stages on 0.5 × 0.5 m plots (1989–91). There were 10 plots in 1989 and 20 plots in 1990–91. Based on these counts, mean densities of coccinellids per m^2 were calculated. The level of aphid parasitization was estimated by dissection of aphids (100 aphids were a sample). To determine the species composition of parasitoids, live and mummified aphids were collected and kept in the laboratory until the emergence of adults. Adult parasitoids were identified to species.

3 Results

3.1 Species composition and number dynamics of aphids

In all study years, three species of aphids occurred in oats: *Rhopalosiphum padi* L., *Sitobion avenae* F., and *Metopolophium dirhodum* Walk. Differences were found in population dynamics of individual species among years. Typically, *R. padi* appeared first. In 1988, the population of this species increased rapidly, reaching a peak in the first 10-day period of June, and then rapidly declined (fig. 1a). In 1989–90, *R. padi* also appeared first but its abundance was very low (figs 2a and 3a). In 1991,

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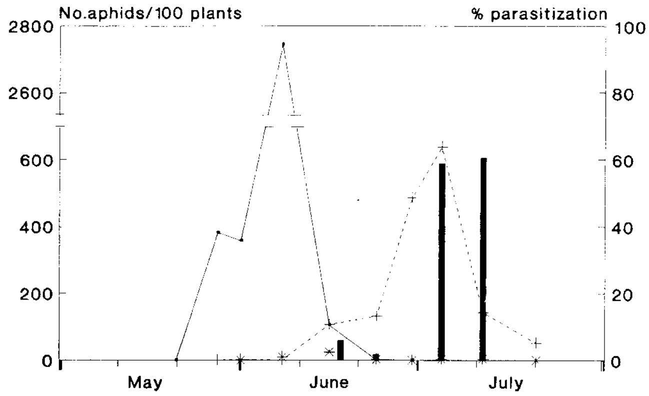

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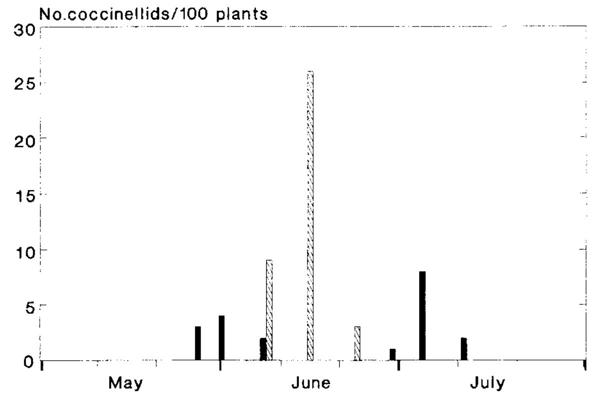

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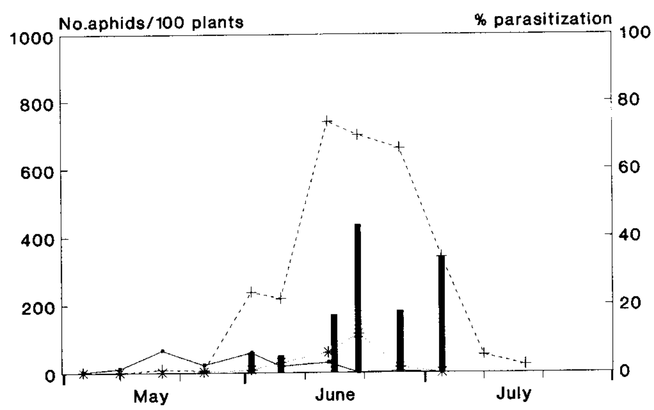

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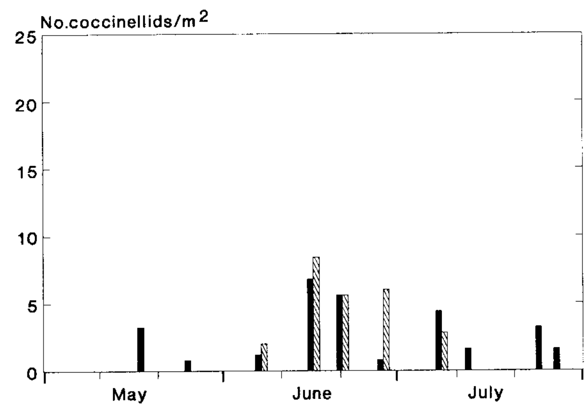

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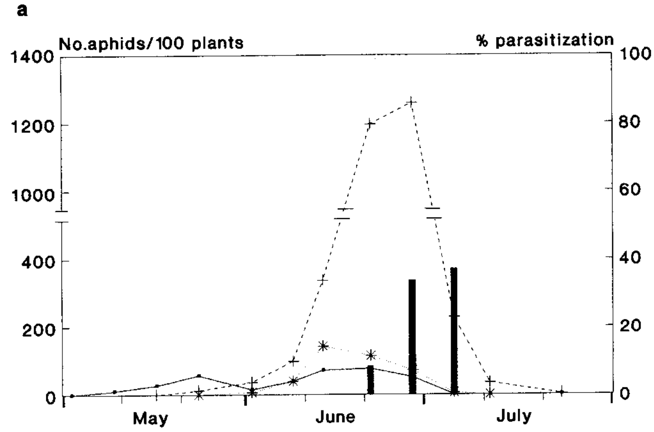

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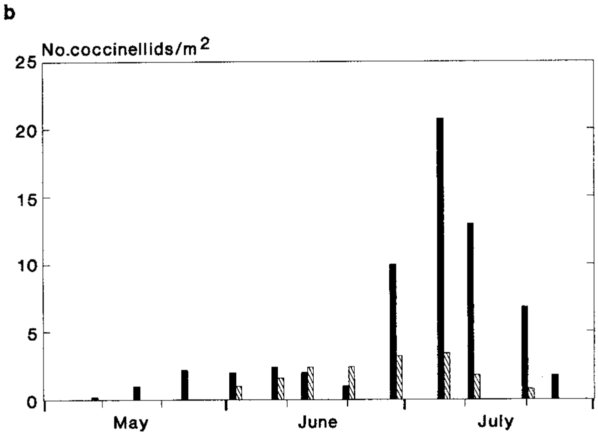

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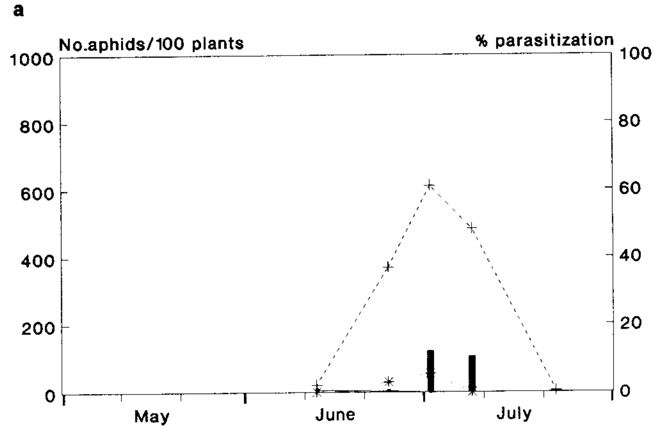

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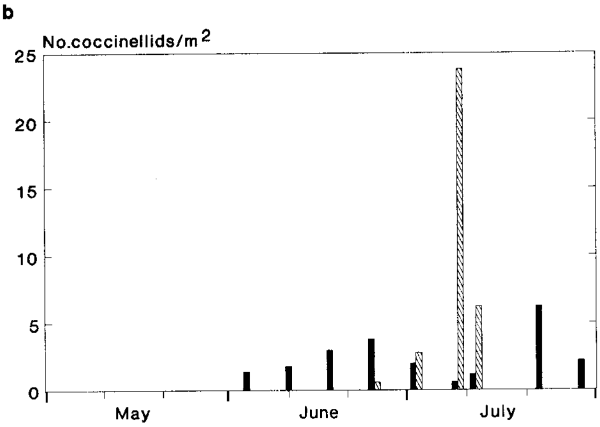

Figs 1–4. *Number dynamics and parasitization of aphids (a,* ———, R. padi*;* --- + ---, S. avenae*;* ···∗···, M. dirhodum*;* ■, *parasitoids) and number dynamics of coccinellids (b,* ■, *imagines;* ▨, *larvae) on oats. Fig. 1. a,b: 1988, Fig. 2. a,b: 1989, Fig. 3. a,b: 1990, Fig. 4. a,b: 1991*

this species occurred only occasionally (fig. 4a). The second species occurring in oats, *S. avenae*, usually appeared later. In 1988–90, its abundance was very low for about 3 weeks, and then rapidly increased to reach a peak (figs 1a–3a). In 1991, *S. avenae* appeared much later than in earlier years (fig. 4a). First aphids of this species were recorded in the second 10-day period of June. In that year, the period of maintenance of low population did not occur. The population rapidly increased after the first individuals appeared, reaching a peak at the beginning of July. These data show that the two species, *R. padi* and *S. avenae*, were most clearly separated in time in 1988, when they pratically did not overlap (fig. 1a). The third species occurring in oats, *M. dirhodum*, was present in low numbers in all the study years.

3.2 Number dynamics of coccinellids

Typically, first adults of the overwintered generation appeared with the first aphids or a little later. In 1991, adult coccinellids occurred in oats early in June, prior to the first aphids.

In 1988, coccinellid larvae were observed between June 7 and 26, in the period of peak and decrease in *R. padi* and increase in the *S. avenae* population. Adults of the new generation appeared late in June and in the first half of July, that is, in the periods of peak and decline of *S. avenae* (fig. 1b).

In 1989, the first coccinellid larvae were found early in June, when *S. avenae* and *M. dirhodum* populations were increasing. They were observed by early July, when *S. avenae* was decreasing (fig. 2b). Adults of the new generation were present in oats by the end of July.

In 1990, coccinellid larvae did not have a marked peak, and their development was largely extended in time. Larvae were observed from June 1 to July 20, that is, throughout almost the developmental period of aphid populations. The decline of *S. avenae* coincided with an unusually intense appearance of adult coccinellids of the new generation (fig. 3b).

In 1991, the appearance of coccinellids in oats was delayed. Larvae were observed at the end of June. They reached a high peak in the first ten-day period of July, thus when *S. avenae* declined (fig. 4b).

3.3 Reduction of aphids by parasitoid

The aphid *R. padi* was rarely attacked by parasitoids (0–3%). Thus figs 1a–4a show the results of parasitism only on the aphid *S. avenae*. In 1988, the reduction of this aphid was over 60% at the peak, whereas it was about 40% in 1989 and 1990, and merely 12% in 1991. Although in all the years the degree of *S. avenae* parasitizing was highest at the peak or after the peak, in 1989 a small proportion of aphids was parasitized already in the phase of *S. avenae* increase, which means that synchronization in the host-parasitoid system was higher in that year.

Table 1. *Species composition and percentage of coccinellids*

Species	Years 1988	1989	1990	1991
Coccinella septempunctata	57.7	63.0	33.4	41.0
C.quinquepunctata	21.8	19.2	21.9	35.0
Propylea quatuordecimpunctata	12.8	11.0	36.9	8.5
Coccinula quatuordecimpustulata	5.1	2.7	6.3	11.1
Adonia variegata	1.3	–	–	–
Hippodamia tredecimpunctata	1.3	–	–	–
Rhyzobius litura	–	4.1	1.6	3.4
Scymnus sp.	–	–	–	0.9

Table 2. *Species composition and percentage of parasitoids of* Sitobion avenae

Species	Years 1988	1989	1990	1991
Aphidius uzbekistanicus	77.3	15.9	56.6	40.0
A. rhopalosiphi	1.6	6.6	1.6	5.8
A. ervi	2.2	54.4	20.0	7.3
A. picipes	3.8	3.2	–	3.3
Praon volucre	13.5	16.8	21.6	43.3
P. gallicum	0.5		–	–
Ephedrus plagiator	1.1	3.1	–	–
Diaeretiella rapae	–	–	–	0.4

3.4 Species composition and dominance structure of aphidophage communities

3.4.1 Coccinellids

A total of eight predatory coccinellids[1] were recorded from the oats under study: *Coccinella septempunctata* (L.), *Coccinella quinquepunctata* (L.), *Propylea quatuordecimpunctata* (L.), *Coccinula quatuordecimpustulata* (L.), *Rhyzobius litura* (Fabr.), *Adonia variegata* (Goeze), *Hippodamia tredecimpunctata* (L.), and *Scymnus* sp. Usually, the most abundant species were *C. septempunctata* and *C. quinquepunctata*, but in 1990 also *P. quatuordecimpunctata* was abundant (table 1).

3.4.2 Parasitoids

The community of parasitoids of the aphid *S. avenae* consisted of seven species of the family Aphidiidae: *Aphidius uzbekistanicus* Luzh., *A. rhopalosiphi* De Stefani Perez, *A. ervi* Haliday, *A. picipes* Nees, *Praon volucre* Haliday, *Ephedrus plagiator* Nees and *Diaeretiella rapae* M' Intosh. The dominance structure differed among years. *A. uzbekistanicus* predominated in 1988 and 1990, *A. ervi* in 1989, and *A. uzbekistanicus* and *P. volucre* co-dominated in 1991 (table 2).

4 Discussion

Large differences have been found in the abundance of aphids occurring in oats in different years. Also seasonal population dynamics and synchronization of the devel-

[1] *Tytthaspis sedecimpunctata* L. recorded occasionally in high numbers was excluded from the analysis because it is not a typical aphidophagous species.

opment of aphids and their natural enemies showed year-to-year differences.

Certainly, weather conditions in spring and summer were one of the factors responsible for differences in aphid numbers. This relationship, however, cannot be unequivocally shown because weather affected not only aphids but also their natural enemies. In the first three years of the study temperatures in April and May were above the long-term mean. In these years, the coincidence of aphids and coccinellids was highly synchronized, and in 1989 the appearance of parasitoids was also highly synchronized. In 1990, peak numbers of *S. avenae* were about twice as high as in other years, which can be related to high temperatures and low rainfall in June. A clear effect of weather on the appearance of aphids and their enemies was observed in 1991. The appearance of both these groups was delayed (mean temperatures of May and June below long-term average, and, in addition, heavy rainfall). In that year the synchronization between aphids and coccinellids was lower. Although adult coccinellids appeared earlier than aphids, intense foraging by larvae took place when *S. avenae* started declining. The same pattern was also observed by CARTER et al. (1980) and PANKANIN-FRANCZYK and CERYNGIER (1991). Also the reduction of aphids by parasitoids was lower in that year.

The views presented in literature on the limiting effect of specialized predators such as coccinellids on aphid populations in cereals are inconsistent. In some parts of Europe aphid-specific predators are the main factor preventing mass appearances of aphids (OHNESORGE and SCHIER, 1989). According to many authors, however, coccinellids do not play an important role in aphid control because they appear in relatively low numbers and only when aphids reach a certain level of abundance. Based on differences in the reproductive potential between aphids and coccinellids and the delay in coccinellid development relative to that of aphids, it is assumed that the appearance of coccinellids (especially the most effective older instars) takes place in the period of aphid decline (HOLMES, 1984; CHAMBERS et al., 1986; CHIVERTON 1986). Only a few authors (RAUTAPÄÄ, 1976; CARTER et al., 1980) show that the importance of the overwintered generation of adult coccinellids should not be neglected, as they appear earlier and can efficiently reduce the development of aphid populations in cereals.

The results of our study suggest some conclusions concerning the way of estimating the efficiency of natural enemies in controlling cereal aphids. It seems that when analysing the role of aphidophages, we should consider the specific character of a given crop and also the species of aphids.

Under conditions of Central Poland, only *R. padi* and *S. avenae* can reach high numbers in cereals. As shown earlier (PANKANIN-FRANCZYK, 1982, 1987, 1990; PANKANIN-FRANCZYK and CERYNGIER, 1991; PANKANIN-FRANCZYK, in press), the occurrence and number dynamics of aphids in spring cereals such as oats clearly differ from those in winter cereals such as rye. Most often only one species, *S. avenae*, dominated in rye, whereas *R. padi* was sporadic. In oats, however, usually these two species occurred, and *R. padi* appeared much earlier than *S. avenae*. In most cases the abundance of *R. padi* increased before the appearance of intensively foraging instars of coccinellids. The activity of larval stages of coccinellids in some years can rapidly reduce *R. padi* after the peak (this happened in 1988). It should be noted that this species is also weakly reduced by parasitoids. A low level of this aphid in some years can be accounted for by the activity of adult coccinellids of the overwintered generation that appear together with aphids. They can reduce aphid population already in the phase of growth.

Coccinellids play a different role in controlling *S. avenae* population. This aphid appears in oats much later than *R. padi*. Typically, most voracious coccinellid larvae appear in the period of *S. avenae* increase, and they limit peak numbers of this aphid. Also parasitoids largely reduce populations of this species, although they are most active at the peak or at the beginning of population decline. Only in some years, when weather conditions are favourable, synchronization is a little better.

The coccinellid and parasitoid communities attacking aphids found in this study consist of the species common in other European countries. Typically, cereals are dominated by *C. septempunctata* and *P. quatuordecimpunctata*, the latter being more abundant in winter crops (DEAN, 1974, 1982; POTTS and VICKERMAN, 1974; HONĚK, 1979, 1982b). *C. septempunctata* and, even more so, *C. quinquepunctata* show preference for spring cereals, where microclimate is different (HONĚK 1979, 1982b).

The most important parasitoid in cereal aphid control is *A. uzbekistanicus* (STARÝ, 1972, 1976; RABASSE and DEDRYVER, 1983). Also *A. picipes*, *A. ervi*, *E. plagiator* and *P. volucre* can largely reduce aphids (BORGEMEISTER and POEHLING, 1988). The change in the dominance of parasitoid species we observed among years was also noted by other authors (CARTER et al., 1980, DEAN et al., 1981; KUO-SELL et al., 1989; BORGEMEISTER and POEHLING, 1988; WRATTEN and POWELL., 1990; BORGEMEISTER et al., 1991). It was due to a number of climatic and ecological factors.

This study has shown that oats are an interesting crop with respect to the relations in parasitoid-host and prey-predator systems. Among the two aphid species of economic importance, *R. padi* and *S. avenae*, mostly the latter was attacked by natural enemies such as coccinellids and parasitoids. It seems that more detailed studies on relationships among different aphids and aphidophages attacking them, and also attention to specific character of a given crop can provide useful information and become the basis for developing biological programmes and integrated aphid control in cereals.

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