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Aphidius colemani Vier. (Hymenoptera, Braconidae, Aphidiinae) detected in cereal fields in Germany

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Abstract

Studies conducted in the 2000 cropping season at two different localities, Flaeming and Magdeburger Boerde in Germany, have provided new information on cereal aphid (*Sitobion avenae* (F.), *Metopolophium dirhodum* (Walker), and *Rhopalosiphum padi* (L.)) parasitoids in winter wheat; their species composition, relative abundance, hosts, and location effects. The average aphid population density was higher at Magdeburger Boerde and lower at Flaeming. Among the aphid species, *Sitobion avenae* was more abundant at Flaeming and *Metopolophium dirhodum* at Magdeburger Boerde. In total, eight species of primary parasitoids were recorded: *Aphidius colemani* Viereck, *Aphidius rhopalosiphi* DeStefani Perez, *Aphidius uzbekistanicus* Luzhetzki, *Aphidius ervi* Haliday, *Aphidius picipes* (Nees), *Ephedrus plagiator* (Nees), *Praon gallicum* Starý, and *Praon volucre* (Haliday). The predominant parasitoid species were *Aphidius colemani* and *Aphidius rhopalosiphi* on *Metopolophium dirhodum* and *Aphidius uzbekistanicus* on *Sitobion avenae*. A low number of hyperparasitoids were also recorded. *Aphidius colemani* was recorded for the first time in the open winter wheat fields in Germany, although it has been used as a biocontrol agent in glasshouses in many European countries and overseas. An analysis of the aforementioned information shows that *Aphidius colemani* detected as a parasitoid of cereal aphids in Germany is likely a result of an accidental escape of parasitoids from a glasshouse, as well as their successful overwintering and establishment in the area. This study provides baseline information essential for assessing future changes in aphid parasitoid species guild and dynamics in cereal fields in Germany.

1 Introduction

Cereal aphids are one of the most important yield limiting factors for the production of cereals worldwide (VICKERMAN and WRATTEN, 1979; WETZEL et al., 1987, 1981; HAND, 1989; WETZEL, 1995, 1985). Cereal aphids found infesting winter wheat in Germany include three species: English grain aphid, *Sitobion avenae* (F.), rose-grass aphid *(Metopolophium dirhodum)* (Walker) and bird cherry-oat aphid *(Rhopalosiphum padi)* (L.) (KRÖBER and CARL, 1991; FREIER et al., 1999). According to HASKEN and POEHLING (1995) and FREIER et al. (1999), *Sitobion avenae* is the most abundant species. Aphids on cereals are attacked by a wide spectrum of aphid-specific as well as polyphagous predators, hymenopterous parasitoids, and entomopathogenic fungi. From the long-term field investigation at two different localities (Flaeming and Magdeburger Boerde) in Germany, WETZEL (1995), POEHLING (1996), FREIER et al. (1999), and also FREIER et al. (1996a) reported that both aphid-specific and polyphagous predators have a significant impact on the population dynamics of cereal aphids in winter wheat. Statistical analysis from such long-term investigations showed that aphid population density stagnates or even decreases at predator densities higher than 5.3 Predator Units (PU)/m^2 (FREIER et al., 1999). STECHMANN (1990), HAGVAR and HOFSVANG (1991), and HASKEN and POEHLING (1995) also stated that hymenopterous parasitoids play an important role in reducing the population density of cereal aphids in winter wheat.

A comprehensive review on the abundance, biology and use in biological control of aphid parasitoids is given by STARÝ (1970), KRÖBER and CARL (1991), HAGVAR and HOFSVANG (1991), and MULLER et al. (1999). STECHMANN (1990) named the following 7 species as generally abundant in central Europe: *Aphidius rhopalosiphi* DeStefani Perez, *Aphidius uzbekistanicus* Luzhetzki, *Aphidius ervi* Haliday, *Aphidius picipes* (Nees), *Ephedrus plagiator* (Nees), *Praon gallicum* Starý, and *Praon volucre* (Haliday). In Great Britain, the same species have been recorded, plus *Toxares deltiger* (Haliday) (POWELL, 1980), which is scarce. Later this species was also recorded in parts of Germany and France, but no mummies were found (POWELL, 1980; STARÝ, 1981; BORGEMEISTER and POEHLING, 1988; HÖLLER, 1990). These reviews also indicated big variations in the abundance and species composition of cereal aphid parasitoids between years and localities. Despite immense accumulated knowledge of biology, behaviour and host range, detailed and clear information on the impact of hymenopterous parasitoids (rate of parasitism) on cereal aphids in Germany is still lacking. Moreover, there is still no reliable method for estimating the rate of parasitism in cereal aphids.

It is also possible that deliberate introduction of exotic natural enemies for biological control purposes can

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Table 1. Frequency of primary parasitoids reared from live individuals of each aphid species collected from winter wheat at Flaeming (F) and Magdeburger Boerde (M) during the 2000 growing season.

Aphid species	No. of aphids reared		No. of aphids mummified	
	F	M	F	M
Sitobion avenae	457	617	30	34
Metopolophium dirhodum	454	587	39	46
Rhopalosiphum padi	49	76	4	2

change the species composition of the indigenous natural enemies. In this context, VÖLKL (1989) also stated that the introduction of an exotic species in an area can lead to structural changes in a parasitoid community.

A long-term field investigation on the occurrence and relationships of cereal aphids and their antagonists in winter wheat fields at two different localities, Flaeming and Magdeburger Boerde, is under investigation. The investigation has been focussing more on predators. The project is run by the Institute for Integrated Plant Protection, BBA, Kleinmachnow. As part of this multi-year project, a more detailed investigation with special emphasis on the occurrence of parasitoids and their impact on the population of cereal aphids was started in the year 2000. Such investigations carried out during the 2000 cropping season detected a relatively common presence of *Aphidius colemani* Vier. In the present contribution, the occurrence of *Aphidius colemani* in winter wheat fields at two different localities in east-central Germany is analysed and discussed. Moreover, the relative abundance of *Aphidius colemani* as compared with other native or previously established exotic parasitoid species and their impact on suppressing cereal aphid populations is discussed.

2 Materials and methods

2.1 *Study sites and sample collection*

Field samples were collected at two different localities, Flaeming and Magdeburger Boerde in east-central Germany. The collection site at Flaeming was characterized as moderately fertile and well structured, whereas the site at Magdeburger Boerde was characterized as well structured and very fertile. These fields were not subjected to insecticides, but normal farm practices were employed nearby and throughout the area.

In this investigation, a mixture of different instar nymphs and adults of *Sitobion avenae, Metopolophium dirhodum,* and *Rhopalosiphum padi* were randomly collected from large areas of winter wheat fields, ca. 20 ha at Flaeming and ca. 50 ha at Magdeburger Boerde. Samples were collected both from the centre and the edge of the fields. Moreover, to get more random and representative samples, aphids were also collected both from the leaves and ear parts of the plants. On each sampling date (16, 23, 30 June at Flaeming and 16, 23, 30 June and 13 July 2000 at Magdeburger Boerde), 320 aphids were collected; a total of 960 at Flaeming and 1280 aphids at Magdeburger Boerde were collected during the season (table 1). The samples were promptly transported to the laboratory in a cool box to prevent losses due to death and were kept the same until the next day when they were transferred to the rearing cages.

2.2 *Aphid rearing*

In this particular study, an indication of the abundance and distribution of aphid parasitoids was obtained by counting the number of parasitized/mummified aphids. This was achieved by rearing field-collected live aphids in the greenhouse. Wheat seeds were planted in plastic pots (14 cm diam.) and allowed to germinate. Each pot was thinned later to four tillers. Water was added to the soil surface every morning. The temperature and relative humidity were maintained at ca. 21 °C and 70 %, respectively, with a photoperiod of 16:8 h (light:dark). The plants were infested with a mixture of different instar nymphs and apterous adult aphids (one aphid/tiller) using a camel-hair brush. Clear tube-like gauze with screen aeration mesh (40 cm long, 15 cm diam.) were positioned over all pots following the introduction of aphids. In each experiment, aphids were allowed to feed for two weeks.

Observation was made every day for mummified aphids. Whenever found, the mummies were collected and placed individually in small glass vials (30 mm in length and 9 mm in diam.) stoppered with cotton, which were kept at 18 °C in the laboratory. The vials were provided regularly with pieces of fresh foliage to moderate humidity. These were inspected regularly, and the emerging Hymenoptera were counted and preserved in 70 % ethanol for identification. Percentage of parasit-

Table 2. List of primary parasitoids and hyperparasitoids that emerged from the mummies of each aphid species collected from winter wheat at Flaeming (F) and Magdeburger Boerde (M) during the 2000 growing season.

Taxon	No. of parasitoids from host species					
	Sitobion avenae		*Metopolophium dirhodum*		*Rhopalosiphum padi*	
	F	M	F	M	F	M
Primary parasitoids						
Aphidius colemani	6	7	21	5	4	0
Aphidius rhopalosiphi	2	2	7	25	0	1
Aphidius uzbekistanicus	2	16	3	8	0	0
Aphidius picipes	0	2	0	2	0	0
Aphidius ervi	0	0	0	1	0	0
Ephedrus plagiator	5	3	1	1	0	0
Praon gallicum	1	0	2	2	0	0
Praon volucre	6	2	4	3	0	1
Hyperparasitoids						
Charipine spp.	2	1	5	0	0	0
Chalcid sp.	1	0	0	0	0	0
Dendrocerus sp.	1	0	0	0	0	0

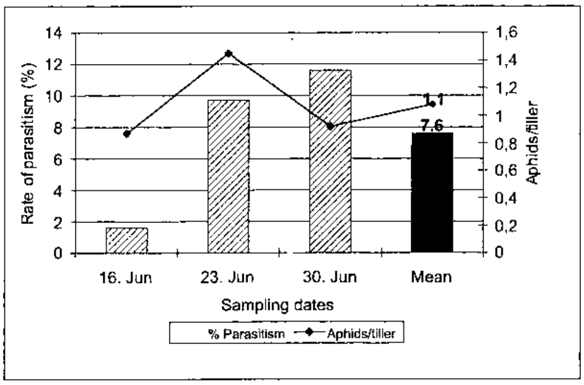

Fig. 1. The average population density and rate of parasitism of cereal aphids in winter wheat at Flaeming during the 2000 cropping season.

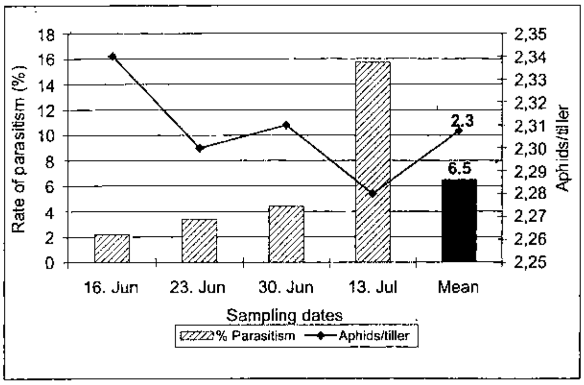

Fig. 2. The average population density and rate of parasitism of cereal aphids in winter wheat at Magdeburger Boerde during the 2000 cropping season.

ism and their prevalence was derived by dividing the number of aphids killed by a particular species of parasite by the number of dead plus living aphids (DEAN et al., 1981).

2.3 *Identification*

All identifications were carried out by the senior scientist (parasitoids specialist) Dr. Peter STARÝ in the Czech Republic. Voucher specimens were deposited in collections at the Federal Biological Research Centre, Kleinmachnow.

3 Results

3.1 *Primary parasitoids*

Eight species of primary parasitoids – *Aphidius colemani* Vier., *Aphidius rhopalosiphi* DeStefani Perez, *Aphidius uzbekistanicus* Luzhetzki, *Aphidius ervi* Haliday, *Aphidius picipes* (Nees), *Ephedrus plagiator* (Nees), *Praon gallicum* Starý and *Praon volucre* (Haliday) – were found attacking *Sitobion avenae* (F.), *Metopolophium dirhodum* (Walker) and *Rhopalosiphum padi* (L.) (table 2). *Aphidius colemani* represents a non-native species of a new introduction in Germany. The remaining species constitute native or long-standing (as-native) residents in the country.

3.2 *Aphid abundance and rate of parasitism*

Figures 1 and 2 show the population density and the rate of parasitism for cereal aphids. From the figures, it can be seen that the mean number of aphids per tiller was not significantly different among the sampling dates both at Flaeming and Magdeburger Boerde. However, the average aphid population density was higher at Magdeburger Boerde (2.3 aphids/tiller) and lower at Flaeming (1.1 aphids/tiller). Among the species of cereal aphids found in the study areas, *Sitobion avenae* was more abundant at Flaeming, whereas *Metopolophium dirhodum* was more abundant at Magdeburger Boerde and less so at Flaeming. *Rhopalosiphum padi* remained at a very low population level in both localities throughout the season (data not presented).

We obtained 144 individual primary parasitoids from 2240 reared aphids collected from two different localities during the 2000 cropping season. Table 2 lists primary parasitoids and hyperparasitoids based upon identification of 155 specimens reared from live aphids (table 1). The rate of parasitism averaged over the sampling dates was 7.6 % and 6.5 % at Flaeming and Magdeburger Boerde, respectively. This indicates that there was no significant difference ($P > 0.05$) in the average rate of parasitism between the two localities, but there was a significant difference ($P > 0.05$) among the sampling dates in both localities (figs 1 and 2). The rate of parasitism was lower on the first sampling dates in both localities and increasingly significant thereafter, reaching the maximum on the last sampling dates. Figures 1 and 2 also demonstrate that the rate of parasitism followed the same trend throughout the sampling dates in both localities. Moreover, *Aphidius colemani, Aphidius rhopalosiphi*, and *Aphidius uzbekistanicus* were the dominant parasitoid species in both localities to suppress the aphid populations.

3.3 *Parasitoid species relative abundance*

Among primary parasitoids, *Aphidius colemani* was the dominant species at Flaeming, attacking mostly *Metopolophium dirhodum* (21.5 % of the primary parasitoids examined, $n = 31$) and less frequently *Rhopalosiphum padi*, whereas *Aphidius rhopalosiphi* was the dominant parasitoid species at Magdeburger Boerde also attacking mostly *Metopolophium dirhodum* (19.4 % of the primary parasitoids examined, $n = 28$). *Sitobion avenae* was mostly attacked by *Aphidius uzbekistanicus* at Magdeburger Boerde. *Ephedrus plagiator* and *Praon gallicum* were obtained only occasionally from the mummies of *Sitobion avenae* and *Metopolophium dirhodum. Aphidius ervi* ($n = 1$) was recorded occasionally only at Magdeburger Boerde from the mummies of *Sitobion avenae*. Among the eight primary parasitoids listed in Table 2, all were found to attack both *Sitobion avenae* and *Metopolophium dirhodum* except *Aphidius ervi,* which attacked only *Metopolophium dirhodum*; however, only *Aphidius colemani, Aphidius rhopalosiphi,* and *Praon volucre* attacked *Rhopalosiphum padi.* In general, only *Aphidius colemani, Aphidius rhopalosiphi,* and *Aphidius uzbekistanicus* appeared to be important in this particular cropping season (figs 3 and 4). Among the species of cereal aphids found in the study areas, *Metopo-*

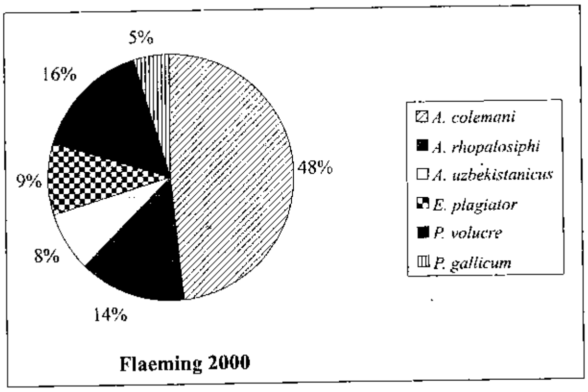

Fig. 3. Abundance and species composition of cereal aphid parasitoids in winter wheat fields at Flaeming during the 2000 cropping season.

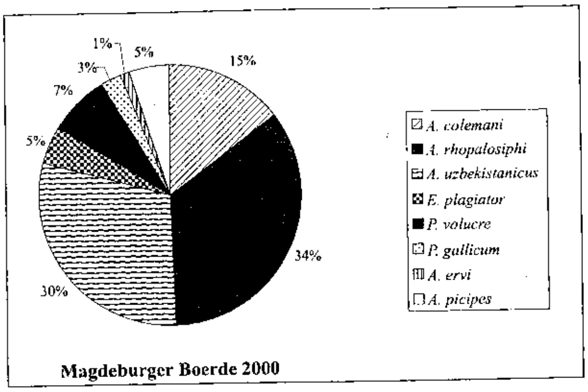

Fig. 4. Abundance and species composition of cereal aphid parasitoids in winter wheat fields at Magdeburger Boerde during the 2000 cropping season.

lophium dirhodum was most common subject of attack by parasitoids. *Rhopalosiphum padi* populations on winter wheat were usually at low levels and manifested low parasitism (table 1).

3.4 Hyperparasitoids

Hyperparasitoids obtained from various aphid mummies included *Chalcid* spp., *Charipine* spp. and *Dendrocerus* spp. Hyperparasitoids only from the genus *Charipine* were recorded at Magdeburger Boerde, whereas all three genera were recorded at Flaeming. All hyperparasitoids were obtained during the first and the second sampling dates, 80 % ($n = 8$) being from the second sampling dates. Moreover, 50 % of the hyperparasitoids were obtained from the mummies of *Sitobion avenae* and 50 % from *Metopolophium dirhodum*.

4 Discussion

In spite of the extensive use of *Aphidius colemani* as a biocontrol agent in glasshouses in many countries of Europe and even overseas (TAKADA, 1998; Fernandez and NENTWIG, 1997; KOPPERT, 1999), the true origin of the commercially used populations is still not quite clear and is worthy of explanation.

Aphidius colemani (as *Aphidius* spp.) was collected in East Africa, sent for propagation in the C.I.B.C. Pakistan Station, and from there to England for biological control of *Myzus persicae* (Sulzer) in glasshouses (STARÝ, 1975). This might indicate the East African origin of the English populations. There is no information from the field including other host aphid species.

A population of *Aphidius colemani* (= *Aphidius platensis* Br.) was found in 1973 and maintained for subsequent years for research in glasshouses in Norway; it was believed to have been introduced accidentally by plant material from abroad (HOFSVANG and HAGVAR, 1975; STARÝ, 1975). Occasional field samples of various aphids yielded some from the glasshouse environment, but did not determine the target in the field (HOFSVANG and HAGVAR, 1983).

Also, the occurrence of *Aphidius colemani* in a glasshouse in Holland was unexpected, whereas there have been several intentional and unintentional introductions in other areas of the world: the closest of these to Holland were the Norwegian glasshouses and the British Isles. This population apparently has represented the source material produced by KOPPERT (Note: Our opinion was fully verified by J. VAN SCHELT and KOPPERT on 15 January 2001). There is no information from the field in this country.

In the Czech Republic, one part of the material utilized in glasshouses originated from introductions of the KOPPERT material from Holland, another part belonged to a Chilean strain (HLUCHÝ, 1997, also pers. info., 2000). STARÝ (1995a, 1999b) intentionally released *Aphidius colemani* (a Chilean strain) on several aphid species, and the parasitoid became established in several areas of the Czech Republic.

In general, *Aphidius colemani* has been classified as a species of probably Oriental origin that has become accidentally widespread in most of the subtropical and tropical areas of the world. However, it seems to be agreed to represent a group species that needs further taxonomic treatment (STARÝ, 1975, 1995b; TAKADA, 1998).

An analysis of the aforementioned information shows that *Aphidius colemani* detected as a parasitoid of small cereal aphids in Germany is the result of an accidental escape of parasitoids from a glasshouse, as well as their successful overwintering and establishment in the area. Due to commercial production/application network in Europe, the origin of the field populations in Germany probably goes back to the KOPPERT material.

4.1 Biological contamination

Any escape whatever of a biological control agent to a non-target environment may be hazardous, resulting potentially in a biological contamination that might adversely affect some native species and ecosystems. Such a possibility may be easy and common for the biocontrol agents utilized in glasshouses. On the other hand, many of these agents are said to be restricted to these environments, being incapable of survival in the open, in the event of an accidental escape.

Our evidence on *Aphidius colemani* (KOPPERT strain) has proved its survival in the outdoor environment and, moreover, the species has become established in the field in some areas of Germany.

The establishment of *Aphidius colemani* in the field in Germany as well as some evidence from the neighbouring Czech Republic (STARÝ, 1995a, 1999b) has, however, had positive effects, though an accidental contamination, for at least to three reasons:

a) *Aphidius colemani* has been found to contribute to the natural control of aphid pests by native parasitoids on cereals.

b) It supplements the aphid parasitoid biodiversity in the agroecosystems and in the cultivated landscape in general.

c) The host range of the parasitoid can be significantly predicted also in Germany, being derived from the respective world evidence (STARÝ, 1995a) as follows: Various aphid species at least of the following common genera such as *Aphis, Brachycaudus, Diuraphis, Myzus, Rhopalosiphum* may be expected to become parasitized. As mentioned earlier, the KOPPERT strain is derivable from East African populations. Extensive information on *Aphidius colemani* in Africa south of the Sahara desert is included in STARÝ et al. (1985) and AUTRIQUE et al. (1989). Moreover, out-transfer trials proved this strain to parasitize at least *Aphis craccivora, Aphis fabae, Diuraphis noxia, Myzus persicae, Rhopalosiphum padi and Schizaphis gramineum* in the laboratory (STARÝ, in press).

4.2 *Preventive biological control*

Annual crop agroecosystems such as cereals are generally open and thus potentially vulnerable through the expansion of various exotic pests throughout the world.

The Russian wheat aphid, *Diuraphis noxia*, is well known as one of the updated cases in several parts of the world covering – recently – even central Europe: Originating in some areas of central Asia to the Middle East, the aphid has expanded in several directions, including the Mediterranean, from where some adventive expansion routes have covered even central Europe; recently, *Diuraphis noxia* was also detected in Germany (for general information, history, etc., see PIKE and ALLISON, 1991; STARÝ, 1999a, b, 2000).

An analysis of the native natural enemies (including parasitoids) in the neighbouring Czech Republic has documented a relatively high adaptation of these natural control agents (predators, parasitoids, fungi) to this well-established and locally/seasonally overpopulated exotic pest. *Aphidius colemani* (a Chilean strain) was also intentionally released to supplement the native parasitoids and become established on the target aphid (and on some other aphids) in several areas of the country (STARÝ, 1999b).

From the aforementioned point of view, the accidental escape to the outdoors and field establishment of the parasitoid (KOPPERT strain) on *Rhopalosiphum padi* on cereals thus represents a case of (unintentional) biological control efforts, i. e. an introduced biocontrol agent is present (established) prior to the occurrence of the target pest (model: *Diuraphis noxia*) but on an alternate host (model: *Metopolophium dirhodum*).

In our opinion, the determination of *Aphidius colemani* as a parasitoid of *Diuraphis noxia* is merely a matter of time – when this aphid becomes more widespread and reaches higher population levels in Germany.

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