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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, Fleeming and Magdeburger Boerde in Germany, have provided new information on cereal aphid (Sitobion avenue (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 Fleeming. Among the aphid species, Sitobion avenue was more abundant at Fleeming and Metopolophium dirhodum at Magdeburger Boerde. In total, eight species of primary parasitoids were recorded: Aphidius colemans Viereck, Aphidius rhopalosiph DeStefani Perez, Aphidius uzbekistanicus Luzhetzkii, Aphidius ervi Haliday, Aphidius picus (Nees), Ephedrus plagiator (Nees), Prason galiicum Stary, and Prason volucre (Haliday). The predominant parasitoid species were Aphidius colemans and Aphidius rhopalosiph on Metopolophium dirhodum and Aphidius uzbekistanicus on Sitobion avenue. A low number of hyperparasitoids were also recorded; Aphidius colemans 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 colemans 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; HASS, 1989; WETZEL, 1995; 1985). Cereal aphids found infesting winter wheat in Germany include three species: English grain aphid, Sitobion avenue (F), rose-grass aphid (Metopolophium dirhodum) (Walker) and bird cherry-oat aphid (Rhopalosiphum padi) (L) (KROBER and CARL, 1991; FREIER et al., 1999). According to HASKEN and POELING (1995) and FREIER et al. (1999), Sitobion avenue 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 (Fleeming and Magdeburger Boerde) in Germany, WETZEL (1995), POELING (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/m²) (FREIER et al., 1999; STECHMANN (1992), HAGVAR AND HOVSANG (1991), and HASKEN AND POELING (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 STARY (1970), KROBER AND CARL (1991), HAGVAR AND HOVSANG (1991), and MULLER et al. (1999). STECHMANN (1990) named the following 7 species as generally abundant in central Europe: Aphidius rhopalosiph DeStefani Perez, Aphidius uzbekistanicus Luzhetzkii, Aphidius ervi Haliday, Aphidius picus (Nees), Ephedrus plagiator (Nees), Prason galiicum Stary, and Prason volucre (Haliday). In Great Britain, the same species have been recorded, plus Toxotes delitiger (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; STARY, 1981; BORGMESTER and POELING, 1988; HOLMER, 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
The collection site at Fleming 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 insect 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 Fleming 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 Fleming and 16, 23, 30 June and 13 July 2000 at Magdeburger Boerde), 320 aphids were collected; a total of 960 at Fleming 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 insect 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-
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, Kleinnachnow.

3 Results

3.1 Primary parasitoids

Eight species of primary parasitoids - Aphidius colemani Vier., Aphidius rhopalosiphii DeStefani Perez, Aphidius uzbekistanicus Luzhetski, Aphidius ervi Haliday, Aphidius piipes (Nees), Epehrus plagiator (Nees), Prasgalicium Stary and Prasvolucr (Haliday) - were found attacking Sitobion avenae (F.), Metopolophium dirhodum (Wallner) 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 (ass-native) residents in the country.

3.2 Aphis 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 rhopalosiphii, 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 rhopalosiphii 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. Epehrus plagiator and Prasgalicium were obtained only occasionally from the mummies of Sitobion avenae and Metopolophium dirhodum. Aphidius ervii (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 ervii, which attacked only Metopolophium dirhodum; however, only Aphidius colemani, Aphidius rhopalosiphii, and Prasvolucr attacked Rhopalosiphum padi. In general, only Aphidius colemani, Aphidius rhopalosiphii, 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-
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.*, *Charipte spp.* and *Dendrocerus spp.* Hyperparasitoids only from the genus *Charipita* 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, 89% (*n = 8*) being from the second sampling dates. Moreover, 50% of the hyperparasitoids were obtained from the mummies of *Sitobion avenue* 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 (Stark, 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 plataenis* 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; Stark, 1975). Occasional field sampling 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 Schelten 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 (Huch, 1997, also pers. info., 2000). Stark (1995a, 1995b) 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 spread 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 (Stark, 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 (Star*š*, 1995a, 1995b) 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 (Star*š*, 1995a) as follows: Various aphid species at least of the following common genera such as *Aphyis*, *Brachycerus*, *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 Star*š*, et al. (1985) and Autrique et al. (1989). Moreover, out-transfer trials proved this strain to parasitize at least *Aphyis craccivora*, *Aphyis fabae*, *Diuraphis noxia*, *Myzus persicae*, *Rhopalosiphum padi* and *Schizaphis graminum* in the laboratory (Star*š*, 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 Pize and Allison, 1991; Starš, 1995a, b, 2002).

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 (Starš, 1995b).

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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