APHID PARASITOID COMPLEX IN POTATO IN THE CONTEXT OF IPM IN BELGIUM

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ABSTRACT

Parasitic hymenoptera of potato aphids were collected and identified in 2000 and 2001 in 11 potato fields in Belgium. Nine Aphidiidae species, parasiting seven aphid species, were found: *Aphidius ervi, Aphidius matricariae, Aphidius picipes, Binodoxys angelicae, Diaeretiella rapae, Praon abjectum, Praon gallictum, Praon volucre* and *Toxares deltiger.*
A .ervi and *A. picipes* were the dominant and sub-dominant species, with 54% and 28% of the primary parasite collected, respectively. Both species and *T. deltiger* were found on *Aphis nasturtii, Aulacorthum solani, Macrosiphum euphorbiae* and *Myzus persicae,* the four most important aphid potato in Belgium. Parasitism rate of *A. nasturtii* and, to a lesser extent, *M. euphorbiae* was low compared to *A. solani* and *M. persicae.* Parasitism of *A. solani* was particularly high, with 63.5% in 2000 and 89.2% in 2001, and this species was the preferred host of several Aphidiid species.
The abundance of alternative hosts as other crops pest aphids or non-pest aphids on wild plants in agroecosystems could explains the efficacy of these species. The biological control of *A. nasturtii* and *M. euphorbiae* by parasitic hymenoptera was poorer, and several studies need to be undertaken to find suitable parasitic hymenoptera species effective on these aphids and agro-environmental measures able to promote them.

INTRODUCTION

Aphids belonging to the species *Aphis nasturtii* KALTENBACH, *Aulacorthum solani* (KALTENBACH), *Macrosiphum euphorbiae* (THOMAS) and *Myzus persicae* (SULZER) (Hemiptera: Aphididae) are considered as important entomophagous potato in Belgium (Roland, 1946; Jansen, 2000). However, recent observations show that insecticide application is only justified in one field out of six in the period 1994-2001 (Jansen, 2002). Biological aphid control by aphid natural enemies is one of the major reasons for the commonly observed low level of aphid populations and parasitic hymenoptera belonging to the Aphidiidae family seem to be a key aphid natural enemy in potatoes (Jansen, 2000).
With regard to the identification of parasitic species occurring in potato, several records have been mentioned in the literature (Griffith, 1960, Stary, 1960, Stary *et al.*, 1971, Stary, 1972; Stary *et al.*, 1973; Robert and Rabasse, 1977; Stary *et al.*, 1977). However, no records were available for Belgium. In the United Kingdom, *Aphidius ervi* HALIDAY, *Aphidius matricariae* HALIDAY, *Aphidius picipes* (NEES) and *Praon volucre* (HALIDAY) were found parasiting *A. solani, M. euphorbiae* and *M. persicae* in potato (Dunn, 1949). In Czechoslovakia, Stary also reported *A. ervi* on the same three aphid species (Stary, 1972, 1973), and *A. picipes* and *A. matricariae* on *M. persicae* only (Stary, 1966). In France, *A. ervi, A. picipes* and *A. matricariae* were identified on the same three aphid species (Robert and Rabasse, 1977). No parasitic hymenoptera were recorded on *A. nasturtii* on potato, while several parasitic species

were listed on this aphid on other host plants (Stary, 1966, Stary *et al.*, 1971). As this aphid can be particularly dangerous for potato, both because of its potentially high multiplication rate and its partial resistance to insecticides (Duvauchelle and Dubois, 1997; Delorme *et al.*, 1998), parasitism of this aphid in ware potato is of particular importance.
Regardless of the lack of information on potato aphid parasites in Belgium, prospective campaign were undertaken in 2000 and 2001 to identify parasitic species that occur in potatoes and to determine which ones could potentially be used in the context of potato aphid integrated or biological control. The results and discussion of these campaigns are presented in this publication.

MATERIALS AND METHODS

Observations were made in 2000 in 5 potato field located at Ciney, Corroy-le-Château, Hanret, Gembloux (Belgium, Namur) and Lillois (Belgium, Walloon Brabant) and in 2001 in 6 potato field at Balâtre, Corroy-le-Château, Florennes, Gembloux, Hanret (Belgium, Namur) and Nivelles (Belgium, Walloon Brabant). The fields were monitored once a week from mid-June to the beginning of August, corresponding to aphid apparition to final population decline. On each occasion, 100 upper and lower leaves were randomly sampled and each aphid and parasitic mummy found was counted and brought back to the laboratory. Aphids were identified with the help of a simplified key developed for aphid potatoes (Leclant, 1999). Several species difficult to identified were reported as "species group" as *Aphis frangulae* group and *Aphis fabae* group. Living aphids were reared on potato plants in the laboratory for 10 days at 20±2°C to obtain a maximum of aphid mummies and determine parasitism rate. Aphid mummies were identified by reference to this key taking into account characteristics as antennae (form, size, rhinaria), front, legs and cornicules. Mummies were individually kept till adult emergence. Adults of parasitic hymenoptera were kept in alcohol and sent to Pr. P. Stary for identification at the end of each prospective campaign.

RESULTS

Parasitism rates of aphids found in potato in 2000 and 2001 are given in Table 1. For the same aphid species, these rates were rather similar in 2000 and 2001. However, there were great differences between aphid species. The parasitism rate of *A. solani* was particularly high, with 63.5% and 89.2% in 2000 and 2001, respectively. *Myzus persicae* was parasited up to 37%, while *A. nasturtii* and, to a lesser extend, *M. euphorbiae* were poorly parasitised. Parasitism rate seemed to be negatively correlated with aphid abundance. However, a specific study on population dynamics on both aphid and parasitoid with an appropriate statistical analysis must be undertaken to confirm or not these trends.
Details of results of parasitic hymenoptera species identification are given in Table 2. A total of 546 parasitic hymenoptera was obtained (409 in 2000, 137 in 2001), with 422 primary parasite and 124 hyper-parasite.

From Table 2, two catalogue lists were compiled, A list indicating the aphid spectrum used as host for each parasitic species, and B list indicating the parasite spectrum for each aphid species found in potato.

Table 1. Parasitism rate of potato aphids in 2000 and 2001 (total of 11 potato field).

	2000		2001	
	Total aphids	Parasitism rate	Total aphids	Parasitism rate
Aphis nasturtii	913	1.5 %	155	11.6 %
Aulacorthum solani	397	63.5 %	111	89.2 %
Macrosiphum euphorbiae	1282	10.1 %	279	9.3 %
Myzus persicae	188	35.1 %	278	36.7 %
Aphis fabae	171	1.8 %	22	0.0 %
Aphis frangulae	12	8.3%	-	-
Brachycaudus helicrysi	-	-	28	6.7 %

Table 2. Aphid parasitic hymenoptera found in ware potato fields in Belgium in 2000 and 2001.

	A. fabae	*A. frangulae*	*A. nasturtii*	*A. solani*	*B. helicrysi*	*M. euphorbiae*	*M. persicae*	Total
2000, 5 site								
Aphidiidae								
A. ervi	-	-	4	84	-	31	38	157
A. matricariae	-	-	-	-	-	-	6	6
A. picipes	-	-	-	73	-	7	23	103
B. angelicae	3	2	-	-	-	-	-	5
D. rapae	-	-	5	-	-	-	1	6
P. abjectum	-	-	1	-	-	-	-	1
P. gallicium	-	-	1	4	-	-	1	6
P. volucre	-	-	-	6	-	2	3	11
T. deltiger	-	-	1	8	-	8	2	19
Praon sp.	-	-	1	1	-	-	1	3
Aphidius sp.	-	-	-	-	-	-	1	1
Aphelinidae								
Aphelinus sp.	-	-	-	3	-	5	-	8
Hyperparasites	-	-	-	51	-	18	14	83
Total	3	2	13	230	0	71	90	409
2001, 6 site								
Aphidiidae								
A. ervi	-	-	5	27	-	6	32	70
A. matricariae	-	-	-	-	2	-	3	5
A. picipes	-	-	2	11	-	-	4	17
P. gallicium	-	-	-	1	-	-	-	1
P. volucre	-	-	-	1	-	-	-	1
T. deltiger	-	-	-	1	-	-	-	1
Aphelinidae								
Aphelinus sp.	-	-	-	1	-	-	-	1
Hyperparasite	-	-	5	20	-	2	14	41
Total	0	0	12	62	2	8	53	137

List A. List of aphid host used by parasitic hymenoptera in potato in Belgium	**List B.** List of parasitic hymenoptera found parasiting potato aphid in Belgium
HYMENOPTERA APHIDIIDAE ***Aphidius ervi* (n=227)** *Aphis nasturtii (4.0%)* *Aulacorthum solani (48.9%)* *Macrosiphum euphorbiae (16.3%)* *Myzus persicae (30.8%)* ***Aphidius matricariae* (n=11)** *Brachycaudus helicrisy (18.2%)* *Myzus persicae* (81.8%) ***Aphidius picipes* (n=120)** *Aphis nasturtii (1.7%)* *Aulacorthum solani (70.0%)* *Macrosiphum euphorbiae (5.8%)* *Myzus persicae (22.5%)* ***Binodoxys angelicae** (n=5)* *Aphis fabae group* (60.0%) *Aphis frangulae* group *(40.0%)* ***Diaeretiella rapae* (n=6)** *Aphis nasturtii (83.3%)* *Myzus persicae (16.7%)* ***Praon abjectum* (n=1)** APHIS NASTURTII (100.0%) ***Praon gallicium** (n=7)* *Aphis nasturtii (14.3%)* *Aulacorthum solani (71.4%)* *Myzus persicae (14.3%)* ***Praon volucre* (n=12)** *Aulacorthum solani (58.3%)* *Macrosiphum euphorbiae (16.7%)* *Myzus persicae (25.0%)* ***Toxares deltiger*** (n=20) *Aphis nasturtii (2.5%)* *Aulacorthum solani (45.0%)* *Macrosiphum euphorbiae (42.5%)* *Myzus persicae* (5.0%) HYMENOPTERA APHELINIDAE ***Aphelinus* sp (n=9)** *Aulacorthum solani* **(44.4%)** Macrosiphum euphorbiae (55.6%)	**I. Aphids of economic importance:** ***Aphis nasturtii*** (n=20) *Aphidius ervi (45.0%)* *Aphidius picipes (10.0%)* *Diaeretiella rapae (25.0%)* *Praon abjectum (5.0%)* *Praon gallicium (5.0%)* *Toxares deltiger (5.0%)* ***Aulacorthum solani*** (n=221) *Aphelinus* sp (1.8%) *Aphidius ervi (50.2%)* *Aphidius picipes (38.0%)* *Praon gallicium (2.3%)* *Praon volucre (3.2%)* *Toxares deltiger (4.1%)* ***Macrosiphum euphorbiae*** (n=59) *Aphelinus* sp *(8.5%)* *Aphidius ervi (62.7%)* *Aphidius picipes (11.9%)* *Praon volucre (3.4%)* *Toxares deltiger (13.6%)* ***Myzus persicae*** (n=115) *Aphidius ervi* (60.9%) *Aphidius matricariae (7.8%)* *Aphidius picipes (23.5%)* *Diaeretiella rapae (0.9%)* *Praon gallicium (0.9%)* *Praon volucre (2.6%)* *Toxares deltiger (1.7%)* II. Other potato aphids ***Aphis fabae* group** (n=3) *Binodoxys angelicae (100.0%)* ***Aphis frangulae*** group (n=2) *Binodoxys angelicae (100.0%)* ***Brachycaudus helicrysi*** (n=2) *Aphidius matricariae (100.0%)*

A total of 9 aphidiid species were identified parasiting 7 aphid species. Eight of these parasitic species were found on at least one of the four most economically important aphid species found in ware potato in Belgium (*A. na-*

sturtii, *A. solani*, *M. euphorbiae* and *M. persicae*). *A. ervi*, *A. picipes* and *Toxares deltiger* (HALIDAY) were found on these four aphid species and *P. volucre* and *Praon gallicum* STARY on three of these four species. Other aphidiid species, *A. matricariae*, *Binodoxys angelicae* (HALIDAY), *Diaeretiella rapae* (M'INTOSH) and *Praon abjectum* (HALIDAY), had a limited number of aphid hosts and were found only in small numbers. *B. angelicae* was recorded only on *A. fabae* group and *A. frangulae* group, which are not considered economically important in potato, while *A. frangulae* could sometimes be as dangerous as *A. nasturtii* in a limited number of fields.
A. ervi was the most abundant parasitic species, accounting for 54.3% of the recorded species. This parasitic hymenoptera was the dominant species of the four relevant aphid species. *Aphidius picipes* was also very common, and the secondmost important species for *A. solani*, *M. euphorbiae* and *M. persicae*. *A. ervi* and *A. picipes* together accounted for 74–88% of the parasitism. *A. picipes* was also recorded on *A. nasturtii*, but only in small numbers.
Several aphelinid specimens were found as primary parasitoids of potato aphids, as were some hyper-parasite specimens belonging to the Chalcidiae, Cynipidae and Megaspilidae families. These hymenoptera were left unidentified.

DISCUSSION

The research work in 2000 and 2001 enabled a comprehensive list of parasitic hymenoptera found on potato aphids to be drawn up. *A. ervi*, *A. matricariae*, *A. picipes* and *P. volucre* were known from previous works (Dunn, 1949; Stary, 1966; Robert and Rabasse, 1977), but *B. angelicae*, *D. rapae*, *P. abjectum*, *P. gallicium* and *T. deltiger* were not previously been reported on potato aphids in potato fields in Europe. The parasitic hymenoptera found on *A. nasturtii* (*A. ervi*, *A. picipes*, *D. rapae*, *P. abjectum*, *P. gallicium* et *T. deltiger)* are the first records for this species in potato. These parasites differed from those known for this species on the common buckthorn (*Rhamnus catharticus* L.), its primary host:*Lipolexis gracilis* FÖRSTER, *Lysiphlebus fabarum* (MARSHALL) and *B. angelicae* (HALIDAY) (Stary *et al.*, 1971), while *B. angelicae* was found in potato on *A. frangulae* group and probably could be found if sampling size was increased.
From a quantitative point of view, *A. ervi* and *A. picipes* were the dominant and sub-dominant species in ware potato. Both species were found on the four most important potato aphids and together accounted for between 55% (*A. nasturtii*) and 88% (*A. solani*) of the primary parasites collected. These results confirm those previously obtained (Dunn, 1949; Robert and Rabasse, 1977). *Aphidius matricariae* was very scarce in potato and only found on *M. persicae* as potato aphid. *Aphidius colemani* VIERECK, used for biological control of *M. persicae* in glasshouses, was not found at all while its aphid host was present in all monitored fields.
A. ervi and *A. picipes* are considered as rather polyphagous parasites and can be found on several aphid species, including pest aphids of several crops. In leguminous crops, *A. ervi* and *A. picipes* are the most important parasites of the green pea aphid, *Acyrtosiphon pisum* (HARRIS) (Stary, 1972). In cereals, both species are found on several aphid species, such as *Sitobion avenae* (F.), *Metopolophium dirhodum* (WALKER) and *Rhopalosiphum padi* (L.),

even if they are not considered to be the dominant parasitic species on these aphids (Latteur, 1973; Latteur and Destain, 1979; Borgemeister and Poehling, 1988; Höller, 1990). In 2000 and 2001, all potato fields selected for this research were located near to at least one wheat or barley field. *Aphidius ervi* has also been reported on several aphid species not related to cultivated plants but found in great numbers in agro-ecosystems, such as *Micropolophium carnosum* (BUKT.) on the perennial stinging nettle (*Urtica dioica* L.) (Perrin, 1975; Cameron *et al.*, 1984). The dominance of parasitic species such as *A. ervi* and *A. picipes* could be explained by the abundance of alternative aphid hosts in cereals, leguminous cultivated plants or field borders.

Parasitism rates measured in the field indicated that *A. ervi* and *A. picipes* provided satisfactory biological control of *A. solani* and *M. persicae* in 2000 and 2001, with up to 89% of parasitism. For *A. nasturtii* and, to a lesser extent, *M. euphorbiae*, parasitim rates were much lower in 2000 and 2001 and it is no assumed that at these rates parasites were able to control aphid outbreak if aphid pressure increased. Thus, there is a need to improve activity or abundance of parasitic hymenoptera related to *A. nasturtii* and *M. euphorbiae*. The case of *A. nasturtii* is particularly interesting because this aphid is potentially highly dangerous for potato crops and difficult to control with insecticides.

From the literature, several methods could be exploited to improve parasitic hymenoptera activity in the field. Intercropping systems (Stary, 1972) have been proposed, the pest aphid of one crop being used as a parasitic hymenoptera reservoir for the other crop. Another system that has been used in glasshouses involves installing parasitic hymenoptera populations on alternative non-pest aphid species, feeding on an alternative host plant. Through this method, parasitic hymenoptera are present in the environment before the pest aphid occurs and the build-up of the pest aphid population can be avoided (Stary, 1993). The success of these actions is usually linked with the ability of a given parasitic species to transfer from one aphid species to another one. Several laboratory studies have indicated the difficulty of most aphidiid species being able to do that without losses of aphid control efficacy (Cameron *et al.*, 1984; Pungerl, 1984; Powell and Wright, 1988).

With regard to *A. nasturtii*, the research in 2000 and 2001 indicated that *A. ervi* and *A. picipes* were the most important parasites of this aphid, with *D. rapae*. However, *A. ervi* and *A. picipes* seems to preferred other aphids as hosts and do not appear to be potentially useful for the biological control of *A. nasturtii*. In contrast, *D. rapae* does appear to be a potentially useful species. *D. rapae* is an important parasite of *Brevicoryne brassicae* (L.), which often occurs on oilseed rape and cabbage crops. Intercropping systems based on these crops and potatoes could be investigated. *D. rapae* is also found on such aphids as *Brachycaudus* sp. and *Hayhustria atriplicis* (L.), which occur on several wild plant species growing in field borders. Thus, the biological control of *A. nasturtii* could be improved by the promotion of populations of *D. rapae* in the agro-ecosystems, if these populations can effectively parasitise *A. nasturtii*. The search for other parasitic hymenoptera species related to *A. nasturtii* could also be initiated.

In conclusion, this study has shown that several aphidiid species occur on potato aphids. *Aphidius ervi* and *A. picipes* were the dominant aphidiid species and apparently provided satisfactory biological control of *A. solani* and

M. persicae in potato. The biological control of *A. nasturtii* and *M. euphorbiae* by parasitic hymenoptera was poorer, and studies are needed to find parasitic hymenoptera species that are effective on these aphids and agroenvironmental measures to promote these parasite species should then be put in place.

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