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Abundance and species ratio of the multicoloured Asian ladybird beetle, *Harmonia axyridis* (Pallas, 1773) (Coleoptera: Coccinellidae) in some Hungarian habitats

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SUMMARY

The multicoloured Asian ladybird beetle (Harmonia axyridis (Pallas, 1773)) was used for a long time as successful biological control agent in the USA and Western Europe for reducing aphid, psyllid and scale populations in green houses, orchards and fields. However, it has been realized as an invasive alien species (IAS) threatening the diversity of native aphidophagous insects through competition and direct praying. In addition, H. axyridis became a horticultural pest consuming various fruits and adversely affecting the wine production. Regarding its direct influence to humans, it is now a nuisance when occurring at high densities in buildings and contacting people, furnishings and other articles. Unfortunately, little attention has been paid to the expansion and spread of feral populations of H. axyridis in many European countries, thus it has been found in 2008 also in Hungary, and regarding its establishment and spread in other European countries, it will occupy presumably quickly our territory. H. axyridis must be a hazard for our native ladybird beetle species as well as for other aphidophagous arthropods. In the New World and also in some European countries it became one of the dominant coccinellid species competing and preying on native ladybirds. Present study shows the abundance and species composition of coccinellid assemblages in some Hungarian habitats in order to assess the pressure of H. axyridis on native coccinellids and to report on its dispersion in the north-eastern part of the country.

Keywords: *Harmonia axyridis*, multicoloured Asian ladybird beetle, invasive species, Coccinellidae, Hungary, alfalfa, sunflower, peach tree, milkweed, sweeping, light trap, visual sampling, tritrophic interactions

INTRODUCTION

The multicoloured Asian ladybird beetle (*Harmonia axyridis* (Pallas, 1773)) is a well-known species overseas and in Europe which became of a well estimated natural enemy an invasive alien species (IAS), a pest. Its native distribution area includes southern Siberia, China and Japan (Chapin, 1965 in Koch, 2003). This coccinellid is often associated with trees and bushes in natural and agricultural settings in presence of available prey (Adriaens, Branquart, Maes, 2003). In addition, this semi-arboreal predator also occurs in various herbaceous habitats, including agricultural (Koch, 2003) and natural (Sebolt and Landis, 2004) systems. *H. axyridis* is an efficient predator preying mainly on homopterous insects (aphids, psyllids, scales; Hodek, 1996; Iablokoff-Khnzorian, 1982 in Adriaens et al., 2003) but feeding also on other insects (Lepidoptera, Coleoptera; Kalaskar and Evans, 2001) and nectar and pollen (LaMana and Miller, 1996). *H. axyridis* has had a great importance because of the voracity of its larvae capable for controlling aphid populations, and its cheap and simple rearing. It was released numerously as biological control agent in North America and Western Europe, and was used for controlling aphids in green houses, orchards and gardens (McClure, 1987 in Koch, 2003; Brown and Miller, 1998; Michaud, 1999). Biotop SAS (France), BioBest (Belgium) and Koppert (the Netherlands) as major companies commercialised it in Europe (Ferran et al., 1996).

Unfortunately, little attention has been paid to the expansion of feral populations of *H. axyridis* in most European countries. This is astonishing regarded the rising concerns over the negative influence of biological control agent introductions, and quick colonization of different American habitats by *H. axyridis*. In addition, the Asian ladybird beetle can be a household and fruit pest (Mannix, 2001; Foglia, 2002; Pickering et al., 2004; Huelsman et al., 2001). According to the most recent experiences, it is attacking natural or semi-natural ecosystems in numerous European countries (Adriaens, Branquart, Maes, 2003; Bathon, 2003, Majerus, 2005; Adriaens et al., 2003; Adriaens et al., 2008) and in Hungary, too. This exotic ladybird has been found first in 2008 in Hungary (Merkl, 2008), and regarding its spread in other European countries, it will likely be established within a year in our territory. *H. axyridis* must be a hazard for our native ladybird beetle species as well as for other aphidophagous arthropods by competition and intraguild predation (Cottrel and Yeargan, 1998; Snyder, Clevenger and Eigenbrode, 2004). In the New World and also in some European countries it became one of the dominant coccinellid species decreasing the native ladybird populations (Adriaens, Branquart, Maes, 2003; Koch et al., 2006; Adriaens et al., 2008; Brown et al., 2008).

The primary objective of present study was to target habitat types regarded as important for the more restricted or stenotopic Hungarian coccinellids which might be impacted by the Asian ladybird colonisation. A secondary objective was to assess the abundance and species composition of coccinellid assemblages in these habitats in order to estimate the influence of *H. axyridis* on native ladybird species and also to collect data on its dispersion in the north-eastern part of our country. A tertiary objective was to provide an overall coverage of ladybird beetles in the landscape of Gödöllő and Debrecen than that obtained formerly if any. Of necessity the scope of the survey was restricted to what could be achieved by one surveyor in one season.

MATERIALS AND METHODS

Coccinellid individuals (adults, larvae and pupae) were collected in 2009 from early April until late September in Gödöllő (abandoned orchard (3 ha), alfalfa (3 ha) and sunflower (2,5 ha) field, stinging nettle (4 x 40 m^2) and common milkweed patches (4 x 25 m^2), a peach tree) and Debrecen (botanical garden (1,8 ha), alfalfa field (1600 m^2), experimental area (1,5 ha), stinging nettle stand (4 x 20 m^2). When selecting the collection sites it was important to sample wooden and herbaceous, semi-natural and agricultural habitats, each of them suitable for the Asian ladybird. Captures and observations were obtained by sweeping net (4 x 25 sweeps), visual sampling and light trap. The individuals captured by sweeping were taken into a freezer, then dried for a while and identified immediately. Light trap collected insects were identified after emptying the trap. Observed individuals were identified at the moment of observing and noted at once.

The colour forms of specimens collected were also determined. The geographical coordinates of sites in which *H. axyridis* was recorded were measured using Google Earth (©2009 Google™). *Table 1* contains the basic data of sampling.

Table 1

Basic data of collection in Gödöllő and Debrecen (2009)

Site	Geographical position	Habitat	Catching method	Frequency	Number of coccinellid individuals caught
Gödöllő	47°35'39″ N 19°22'56″E 209 m	abandoned orchard	sweep net	weekly	2
Gödöllő	47°35'45″ N 19°22'45″E 209 m	alfalfa field	sweep net	weekly	284
Gödöllő	47°35'45″ N 19°22'45″E 209 m	stinging nettle stand	sweep net	weekly	0
Gödöllő	47°35'48″ N 19°22'36″E 205 m	sunflower field	visual observation	periodically	125
Gödöllő	47°35'51″ N 19°22'23″E 210 m	peach tree	visual observation	periodically	113
Gödöllő	47°35'04″ N 19°23'02″E 207 m	common milkweed stand	visual observation	periodically	42
Total in Gödöllő					566
Debrecen	47°33'01″ N 21°36'20″E 116 m	botanical garden	sweep net	weekly	7
Debrecen	47°33'07″ N 21°36'19″E 114 m	alfalfa field	sweep net	weekly	294
Debrecen	47°33'10″ N 21°36'05″E 114 m	stinging nettle stand	sweep net	weekly	0
Debrecen	47°33'10″ N 21°36'05″E 114 m	experimental orchard	light trap	daily	195
Total in Debrecen					496
Total					1062

RESULTS AND DISCUSSION

1062 individuals of 12 ladybird species have been collected during the sampling. 564 individuals of 7 species were captured in Gödöllő and 449 individuals of 12 species in Debrecen. No specimen were caught or observed in the stinging nettle patches and only very few in the abandoned orchard or the botanical garden. In case of both sites the alfalfa fields proved to be the most diverse and abundant. The data of the sunflower field, the peach tree and the milkweed stands cannot be compared with the other records because of the irregularity of their sampling: the sunflower field was tilled by the owner after the second sampling; the ladybird population disappeared rapidly from the peach tree because of the collapse of aphid population; coccinellids started to visit the milkweed only very late (in August), after the colonization of *Aphis nerii* Boyer de Fonscolombe, 1841. As to the data of the light trap, these are founded on daily basis. However, these records are suitable to conclude the plant-prey-coccinellid (*H. axyridis*) association, the species presence and dispersion, the intensity of spreading and somewhat the species ratio.

In Gödöllő *H. axyridis* became the third most dominant species after *Coccinella septempunctata* (Linné, 1758) and *Adonia variegata* (Goeze, 1777) (Table 2). The frequency and abundance of other species like *Adalia bipunctata* (Linné, 1758), *Propylea qutuordecimpunctata* (Linné, 1758), *Coccinula quatuordecimpustulata* (Linné, 1758) and *Subcoccinella vigintiquatuorpunctata* (Linné, 1758) were low. These coccinellids are aphidiphageous except *S. vigintiquatuorpunctata* which is a polyphagous plant eater. All the Gödöllő species are common species to be found in various habitats and on host plants but preferring mainly, except *A. bipunctata* and *P. qutuordecimpunctata*, the low growing plants. As to *A. bipunctata* and *P. qutuordecimpunctata,* they seem to be opportunists, preferring the plant stands supported high aphid densities (Honěk, 1985).

Regarding the parameters of Debrecen samples, abundance was lower, species richness was higher than those of Gödöllő (Table 3). Accounting the species apart those of mentioned above, *Vibidia duodecimguttata* (Poda, 1761), *Harmonia quadripunctata* (Pontopiddian, 1763), *Adalia decempunctata* (Linné, 1758), *Scymnus frontalis* (Fabricius, 1787) and *Exochomus quadripustulatus* (Linné, 1758) had to be added. When summarizing first the individuals, *H. axyridis* predominated, which was followed by *A. variegata, C. septempunctata, S. frontalis*, P. *quatuordecimpunctata*, *V. duodecimguttata*, A. *bipunctata*, *H. quadripunctata*, *Coccinula quatuordecimpustulata*, *E. quadripustulatus*, *S. vigintiquatuorpunctata* and A. *decempunctata,* respectively.

When omitting the light trap data, the order of dominance changed considerably: *A. variegata*, *C. septempunctata*, *S. frontalis*, *H. axyridis* etc. That means that the ratio of *H. axyridis* in Gödöllő could be approximately 16% and that of in Debrecen about 6%. Both data show the strong establishment and competition of Asian ladybird in the sampled sites and habitats. As to the light trap records (Asian ladybird amounted 87% of the total capture) these demonstrate the extraordinarily spreading ability of *H. axyridis*. *S. frontalis* and *V. duodecimguttata* prefer low herbaceous vegetation but *A. decempunctata* favours deciduous trees and shrubs. As to *H. quadripunctata* and *E. quadripustulatus,* they have a preference for woody vegetation. *H. quadripunctata* can be almost invariably found on pine (*Pinus* sp.) trees *but E. quadripustulatus* is *c*ommon often on *Pinus* and *Picea* spp. but also on deciduous trees. This is logical because there were various coniferous trees in both, the abandoned orchard and the botanical garden. All coccinellids studied are aphidophagous except the mycophagous *V. duodecimguttata* and the phyllophagous *S. vigintiquatuorpunctata.* These species evidently cannot be competitors *of H. axyridis* but they can serve as a prey for it. Regarding the different sites, the coccinellids generally visited habitats suitable for their preference. It was remarkable the very low coccinellid abundance and species richness of the orchard in Gödöllő and those of the botanical garden in Debrecen. The main reason for this can be the unusually scarcity of aphids. In contrast, the aphid population (*Acyrtosiphon pisum* (Harris, 1776), *Aphis craccivora* Koch 1854) was continually high in the alfalfa stands at both sites. Abundance and species composition of ladybirds in the alfalfa fields and the habitats with deciduous and coniferous trees in both localities was similar. *H. axyrides* was caught and observed on *Anoecia corni* (Fabricius, 1775) (host plant (= hp) : *Cornus sanguinea* Linné 1753), *Aphis spiraephaga* Müller, 1961 (hp: *Spiraea* x *vanhouttei* (Briot) Zabel 1884) in Debrecen, and on *Aphis fabae* Scopoli 1763 (hp: *Euonymus europeus* (Linné, 1753)) in Gödöllő. Aphid species used by *H. axyridis* and other coccinellids in the other sites are *A. fabae* Scopoli 1763 (hp: *Chenopodium album* Linné, 1753, *Ambrosia artemisiifolia* Linné, 1753) in the sunflower field; *Hyalopterus amygdali* on the peach tree; *A. nerii* on the common milkwood. The density of aphids was very important in the observed intervalum, that is the leaves were heavily infested by aphids. It was remarkable to observe that there were no *H. axyridis* individuals, either adults or larvae around the *Brevicoryne brassicae* colonies on the *Sinapis arvensis* Linné, 1753 plants, however, the *C. septempunctata* density (adults and larvae) was considerable. Leaves and shoots were completely covered by *B. brassicae* specimens. It seems that the polphageous *H. axyridis* did not prefer this aphid. This aversion of *H. axyridis* has not been documented yet (Koch et al., 2003; Koch et al., 2006; Brown et al., 2008). Most publications underlined the drastic competitive influence of *H. axyridis* on other coccinellids, however, they reported this rarely in terms of abundance or % of dominance (Adriaens, Branquart, Maes, 2003; Koch et al., 2006; Adriaens et al., 2008; Brown et al., 2008). *H. axyridis* was first found in the wild in Belgium in 2001. Five years later it was the most numerous lady beetle in Flanders (northern part of Belgium). Regarding its occurrence, it was the second highest occurring coccinellid after *C. septempunctata* in Flanders, and in Belgium as a whole its occurrence was the fifth highest after *C. septempunctata, P. quqtuordecimpunctata, A. bipunctata* and *Thea vigintiduopunctata* (Brown et al. 2008). In

Switzerland three years after the first detection of Asian ladybird it became the seventh most abundant species on trees and shrubs (Brown et al. 2008). *H. axyridis* comprised 1,5% (N=1110) of lady beetles collected in Manitoba (Canada) after a year of its first founding (Wise, Tarnack and Roughley 2001). In relation to these data, our records (*Table 2* and *3*) are realistic and show a quick and firm extension of *H. axyridis* in the sampled localities.

Table 2

Species composition of coccinellids collected in Gödöllő (2009)

Site	HA	C7	AV	A2	P14	V12	C14	H4	A10	S24	SF	E4	LC	Total
Abandoned orchard	2													2
Alfalfa field	6	92	165	2	7		6			4			2	284
Sunflower field	12	113												125
Peach tree	65	41	2	5										113
Milkweed stand	6	13	23											42
Total	91	259	190	7	7		6			4			2	566
%	16.1	45.8	33.6	1.2	1.2		1.1			0.7			0.4	

Abbreviations: HA: Harmonia axyridis, C7: Coccinella septempunctata, AV: Adonia variegata, A2: Adalia bipunctata, P14: Propylea quatuordecimpunctata, V12: Vibidia duodecimpunctata, C14: Coccinula quatuordecimpustulata, H4: Harmonia quadripunctata, A10: Adalia decempunctata, S24: Subcoccinella vigintiquatuorpunctata, SF: Scymnus frontalis, EQ: Exochomus quadripustulatus, LC: Larvae of Coccinellidae

Table 3

Species composition of coccinellids collected in Debrecen (2009)

Site	HA	C7	AV	A2	P14	V12	C14	H4	A10	S24	SF	E4	LC	Total
Botanical garden	7											2		9
Alfalfa field	13	44	132	2	17		2			2	35		47	294
Experimental orchard	168	1		6	1	9	2	5	1					193
Total	188	45	132	8	18	9	4	5	1	2	35	2	47	496
%	37.9	9.1	26.6	1.6	3.6	1.8	0.8	1.0	0.2	0.4	7.0	0.4	9.5	
Total[a]	20	44	132	2	17		2			2	35		47	301
%	6.6	14.6	43.9	0.7	5.6		0.7			0.7	11.6		15.6	

[a] without the light trap capture

Table 4

Percentage of different developmental and adult colour forms

Site	succinea	spectabilis	conspicua	L	P	Total
Abandoned orchard G	2					2
Alfalfa field G	4			2		6
Sunflower field G	12					12
Peach tree G	21	1	3	30	10	65
Milkweed stand G	3	3				6
Botanical garden D	4			3		7
Alfalfa field D	9	1		3		13
Experimental orchard D	161	3	4			168
Total	216	8	7	38	10	279
%	77.4	2.9	2.5	13.6	3.6	

L: larvae, P: pupae

The proportion of colour forms of the collected *H. axyridis* individuals have been counted (*Table 4* and *5*). All the in Europe reported colour forms have been observed at both localities. The colour form composition of Asian lady beetle was most similar to the Italian data (Burgio et al., 2008), though the form conspicua was not found there (*Table 6*).

Table 5

Percentage of adult colour forms

Site	succinea	spectabilis	conspicua	Total
Abandoned ochard G	2			2
Alfalfa field G	4			4
Sunflower field G	12			12
Peach tree G	21	1	3	25
Milkweed stand G	3	3		6
Botanical garden D	4			4
Alfalfa field D	9	1		10
Experimental orchard D	161	3	4	168
Total	216	8	7	231
%	93.5	3.5	3.0	

Table 6

Percentages of *H. axyridis* colour forms in some countries

Country	time	succinea	spectabilis	conspicua	melanic (unspecified forms)	N	Reference
Belgium	2004-2006	71	19	6	4	5164	Adriens et al. 2008
England	2005	79	14	7		6180	M. Majerus unpublished in Brown et al. 2008
Italy (northern part)	2008	98	2			1049	Burgio et al. 2008
Czech Republic	2006-2007	88			12	51	O. Nedved unpublished in Brown et al. 2008
Luxembourg	2004	85	11	4		28	Schneider and Loomans, 2006
Denmark	2006-2007	100				16	J. Pedersen unpublished in Brown et al. 2008

CONCLUSIONS

It was expected at the commencement of the survey that broadleaf trees, and particularly those near a woodland, would be productive. This was not the case. Of the two habitats predominated with broadleaf trees visited, both produced any ladybirds at all and these comprised small numbers of a common native species except of *H. axyridis*. The main cause of this could be the low aphid density and also the irregular temporary aphid distribution. E.g. there were practically no aphids (*A. fabae*) after 5 May in the abandoned orchard, and any of the trees and shrubs has been infested during the vegetation period. Similarly, only few aphids (*A. corni*)

were observed during a relatively short period on *C. sanguinea* and also the population of *A. spiraephaga* collapsed early in the botanical garden. *H. axyridis* was the 4th and 5th species in terms of abundance in the alfalfa fields which compared to the Belgian data (Adrians et al., 2008) shows a quick establisment and colonisation. Peach, milkweed and sunflower were more productive with 58, 14 and 10% of dominance of *H. axyridis*, respectively, making so it the first, second and third most abundant species. As to the stinging nettle stands, no coccinellids was found at both localities in spite of the relatively high aphid density in May. Regarding the variability of *H. axyridis*, all the in Europe reported colour forms have been observed at both localities.

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