ARTHROPOD DIVERSITY IN AGROSYSTEMS UNDER DIFFERENT MANAGEMENT*

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Arthropod diversity under three different agro-ecosystem management practices was monitored in the following six agro-ecosystems in North Moravia (Czech Republic): spontaneous fallow, mulched meadow without biomass harvesting, intensive system with pesticides and synthetic fertilizers, and systems of intensive seed, organic seed, and organic hay production. Altogether 125 500 specimens representing 25 arthropod groups were collected in here within the years 2008–2010 by means of emergence traps (1 m^2 bottom area). In all variants, the highest number of taxa was found in the systems without biomass harvesting. The highest number of specimens was found in intensive systems. On the contrary, the lowest number of specimens was found in organic systems. Four dominant taxa (relative abundance > 5%) were evaluated: Sternorrhyncha, Collembola, Diptera, and Hymenoptera. Statistical analysis was carried out to evaluate the effect of different management practices on the occurrence of the dominant taxa in the mentioned agro-ecosystems. Diptera and Hymenoptera were the most frequent (however insignificant as concerns statistics) in systems without harvesting biomass. Sternorrhyncha and Collembola were significantly more abundant in intensive systems. The databank presented herein should hopefully contribute to further biological research in fields under different management practices.

organic farming; intensive agriculture; invertebrates; biodiversity

INTRODUCTION

In addition to its primary economic function (production of food, fibres) and contribution to food security, agriculture fulfils important environmental, social and cultural functions. The intensification and expansion of modern agriculture is amongst the greatest current threats to worldwide biodiversity. Over the last 40–50 years, dramatic declines both in the range and abundance of many species associated with farmland have been reported worldwide, leading to growing concern over the sustainability of current intensive farming practices.

Currently, biodiversity is understood as the most important natural resource and biodiversity issues (including nature conservation and environmental quality) are growingly perceived as one of the top global problems.

Soil macrofauna communities encompass a wide range of organisms performing various functions that regulate soil physical properties and chemical processes (Stinner, House, 1990; Lavelle et al., 1997). Invertebrates play a major role in soil fertility by enhancing mixing, macroporosity, humidification, and mineralization of organic matter (Francis, Fraser, 1998).

Purportedly "sustainable" farming systems such as organic farming are now seen by many as a potential solution to this continued loss of biodiversity and therefore receive substantial support in the form of subsidies through EU and national government legislation. The system of organic farming management defines three broad management practices (prohibition or reduced use of chemical pesticides and inorganic fertilizers, sympathetic management of non-cropped habitats, and preservation of mixed farming) that are largely intrinsic (but not exclusive) to organic farming, and that are particularly beneficial for farmland wildlife (Šarapatka et al., 2008).

Many previous studies dealt with comparing biodiversity in various farmland management practices covering a wide range of taxa. Hole et al. (2005) reviewed 76 such studies. Ground beetles (Coleoptera, Carabidae) along with earthworms, staphylinids, and spiders are among the most frequently studied groups of animals in relation to the impact of different agricultural practices on biodiversity.

Our study has focused on monitoring of arthropods variability in six sites under three various management systems in agriculture land (systems without biomass harvesting, intensive agriculture, and organic agriculture systems).

For a close and precise insight into the study area the choice of the collecting method is very important. To catch only autochthonous species and simultane-

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ously reach high taxonomic resolution, special-made emergence traps were used. Autochthonous specimens may be detected by means of soil samples, however, their identification is difficult. Most commonly used entomological methods (sweeping, Malaise traps, pan traps) do not allow to distinguish allochthonous species from the autochthonous (H o l e et al., 2005). During the preparation studies we found out that the soil contains a lot of premature stadiums of the species. This fact indicates that we were able to catch specimens evolved directly in the soil of the study area covered with the trap.

MATERIAL AND METHODS

Six grassy agro-ecosystem localities under three-different management practices were monitored in a three-year study (2008–2010). Each year emergence traps (1 trap per each locality) were exposed from May until August (for precise data see the Results) and emptied monthly.

We compared three different managements (without biomass harvesting, intensive and organic agriculture systems), each twice repeated, used at six localities described below:

Localities without harvesting biomass (WHB)

Locality No. 1 "Zubří – nad Kuřínem – fallow" (49°28′43.3″N, 18°04′54.7″E, altitude 403 m a.s.l.): spontaneous fallow, without any agricultural management for more than 5 years prior to monitoring (formerly used as meadow for hay production), dominant species: *Agrostis stolonifera*. Long-term mean temperature: 7.5°C, average rainfall: 864.5 mm. Soil pH 5.3, topsoil 20 cm, P 27 $mg.kg^{-1}$, K 179 $mg.kg^{-1}$, Mg 63 $mg.kg^{-1}$.

Exposure of emergence traps: 25/4–20/8/2008, 30/4–18/8/2009, 10/5–1/9/2010

Locality No. 2 "Střítež nad Bečvou – mulch" (49°27′14.7″N, 18°02′36.7″E, altitude 420 m a.s.l.): meadow without harvesting, cutted biomass (2 cuts per year) left on the surface as mulch, dominant species: *Agrostis stolonifera*. Organic system without pesticides and synthetic fertilizers, 2–3 cuttings per year, system prevailed for more than 3 years before monitoring. Long-term mean temperature: 7.5°C, average rainfall: 864.5 mm. Loam soil, soil pH 5.3, topsoil 15 cm, P 14 $mg.kg^{-1}$, K 75 $mg.kg^{-1}$, Mg 180 $mg.kg^{-1}$. Exposure of emergence trap: 25/4–20/8/2008, 29/4–18/8/2009, 30/4–1/9/2010

Intensive agriculture systems (INT)

Locality No. 3 "Kelč" (49°28′00.4″N, 17°50′17.8″E, altitude 320 m a.s.l.): seed production system, dominant species: *Festuca pratensis*, cv. "Rožnovská". Intensive system with pesticides and synthetic fertilizers for more than 5 years prior to monitoring. Long-term mean temperature: 8.4°C, average rainfall: 693.2 mm. Clay-loam soil (soil pH 6.7, topsoil 30 cm, P 70 $mg.kg^{-1}$, K 182 $mg.kg^{-1}$, Mg 300 $mg.kg^{-1}$). Exposure of emergence trap: 5/5–20/8/2008, 29/4–8/8/2009, 10/5–1/9/2010

Locality No. 4 "Zubří" (49°28′08.7″N, 18°04′47.8″E, altitude: 363 m a.s.l.): seed production system, dominant species *Trisetum flavescens*, cv. "Rožnovský". Intensive system with pesticides and synthetic fertilizers for more than 2 years before monitoring. Long-term mean temperature: 7.5°C, average rainfall: 864.5 mm. Sandy loam soil (soil pH 5.3, topsoil 25 cm, P 29 $mg.kg^{-1}$, K 154 $mg.kg^{-1}$, Mg 99 $mg.kg^{-1}$).

Exposure of emergence trap: 14/4–20/8/2008, 28/4–18/8/2009, 28/4–1/9/2010

Organic agriculture systems (ORG)

Locality No. 5 "Klokočov" (49°46′23.7″N, 17°42′49.4″E, altitude: 550 m a.s.l.): seed production system, dominant species: *Festuca pratensis*, cv. "Rožnovská". Organic system without pesticides just with organic fertilizers for over 3 years. Long-term mean temperature: 10.5°C, average rainfall: 571.9 mm. Loamy soil (soil pH 5.7, topsoil 18 cm, P 57 $mg.kg^{-1}$, K 201 $mg.kg^{-1}$, Mg 110 $mg.kg^{-1}$). Exposure of emergence trap: 5/5–20/8/2008, 30/4–18/8/2009, 24/5–1/9/2010

Locality No. 6 "Střítež nad Bečvou – hay" (49°27′14.7″N, 18°02′43.5″E, altitude: 407 m a.s.l.): meadow used for hay production, dominant species: Agrostisstolonifera. Organic system without pesticides and synthetic fertilizers, 2–3 cuttings per year, this system prevails for more than 10 years. Long-term mean temperature: 7.5°C, average rainfall: 864.5 mm. Loam soil (soil pH 5.3, topsoil 15 cm, P 14 $mg.kg^{-1}$, K 75 $mg.kg^{-1}$, Mg 180 $mg.kg^{-1}$). Exposure of emergence trap: 25/4–20/8/2008, 29/4–18/8/2009, 30/4–1/9/2010

Collecting method

To catch only autochthonous species and simultaneously reach appropriate taxonomic resolution, emergence traps were used (Fig. 1). The traps (1 trap per each locality) of quadrangular pyramid shape (effective capture area = bottom of the trap = 1 m^2) were made of fine polyamide fabric (mesh less than 0.1 mm). Sides of the trap were shallowly buried into soil to prevent allochthonous immigrants to enter the trap. Collecting head was filled with 70% ethyl alcohol. The trapped material was collected ca. monthly by simple inserting new collecting bottle, the old being stored in the freezer (–20°C). Emptying the trap, we changed the location of the trap to minimize topical

Fig. 1: Emergence trap (photo by author)

effect and to avoid unnecessary replicates, which, according to our preliminary experiments, add little additional information to this relatively large area sampling. Thus, in this experiment, ca. 4 m^2 of each locality was monitored per one year.

RESULTS

Altogether 123 500 specimens representing 25 arthropod groups were collected in six study sites in the years 2008–2010.The dominance classification used in this paper is shown in Table 1.

Dominant groups

The following four arthropod groups were dominant (exceeding relative abundance of 5%): Sternorrhyncha (47 526 specimens, 38.5%), Diptera (29 080 specimens, 23.5%), Collembola (27 871 specimens, 22.6%), and Hymenoptera (7 332 specimens, 5.9%). The dominant groups comprised 90.5% of all the specimens found. The numbers of the specimens of the groups exceeding 5% of relative abundance obtained at different sampling sites are displayed in Fig. 2.

Table 1. The scale of dominance groups

Dominance	%
Dominant	> 5
Subdominant	1–5
Minor	< 1

The total number of the specimens in two of the dominant taxa (Sternorrhyncha and Collembola) was the highest in intensive systems, Diptera and Hymenoptera specimens were the most frequent in systems without harvesting biomass. Interestingly, Hymenoptera was not a dominant taxon in intensive systems (2.6% dominance).

Statistical analysis (ANOVA) revealed significant differences between Sternorrhyncha and Collembola at the individual localities. The relationships between the localities are shown in Table 2. No significant differences were detected in Diptera and Hymenoptera groups.

Subdominant groups

Further three taxa exceeded relative abundance of 1%: Araneae 1.3%, Auchenorrhyncha 2.1%, and

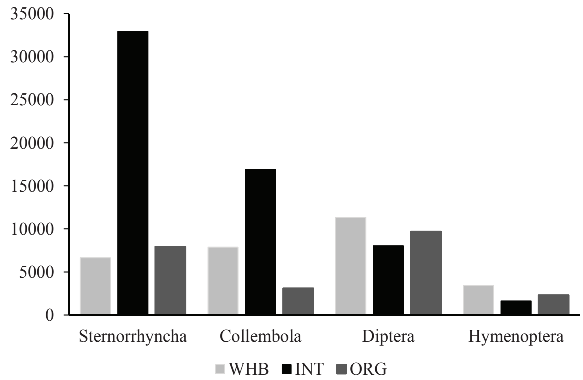

Fig. 2. Number of specimens of dominant groups. WBH: localities without harvesting biomass, INT: intensive, ORG: organic systems

Table 2. *P*-values between localities in two of dominant arthropod groups

Taxa		WBH	INT	ORG
Sternorrhyncha	WBH	–	0.007716**	0.964055
	INT	0.007716**	–	0.016276*
	ORG	0.964055	0.016276*	–
Collembola	WBH	–	0.070546*	0.551851
	INT	0.070546*	–	0.004186**
	ORG	0.551851	0.004186**	–

WBH = without harvesting biomass, INT = intensive agriculture systems, ORG = organic agriculture systems

*$P < 0.05$, **$P < 0.01$

Table 3. Number of specimens of groups exceeding 1% of relative abundance

Taxa	WHB	INT	ORG
Araneae	533	488	632
Auchenorrhyncha	1367	477	811
Coleoptera	1449	1730	1679+
Total	3349	2695	3122

WBH = without harvesting biomass, INT = intensive agriculture systems, ORG = organic agriculture systems

+dominance > 5% in the particular site

Coleoptera 3.9%. Subdominant groups displayed 7.4% relative abundance. The numbers of the specimens of these groups arranged according to management techniques are summarized in Table 3.

This table shows that specimens of Araneae were most abundant in organic systems, of Auchenorrhyncha in systems without harvesting biomass, and those of Coleoptera were slightly more abundant in intensive systems. The last group was dominant in ORG system (6.1%). Altogether slightly more specimens were found out under systems without biomass harvesting, while their lowest numbers were yielded by intensive systems.

Minor groups

All other groups of arthropods found were classified as minor, with the total relative abundance lower than 1%. These groups covered 2.4% of overall relative abundance. Numbers of specimens are summarized in Table 4.

Here, again, the lowest number of specimens was found in intensive systems, but – in comparison with subdominant groups – organic systems showed a higher number of specimens. Heteroptera and Thysanoptera were minor in total scale, but within the organic systems they were subdominant.

DISCUSSION

Altogether 123,500 specimens representing 25 arthropod groups were found at six study sites in the years 2008–2010. Four arthropod groups were dominant (exceeding relative abundance of 5%): Sternorrhyncha (47 526 specimens, 38.5%), Diptera (29 080 specimens, 23.5%), Collembola (27 871 specimens, 22.6%), and Hymenoptera (7 332 specimens, 5.9%). Dominant groups comprised 90.5% of all specimens found. The greatest total number of specimens was found in intensive systems, namely because of a very high abundance of Sternorrhyncha. Interestingly, under intensive systems, where pesticides and herbicides are used namely against plant and cereal pests, the abundance of Sternorrhyncha was higher than in other systems. This may be due to the short-term effect of insecticides on aphid densities while later in the season aphid abundance increases (following the study by Krauss et al., 2011). Application of pesticides, especially insecticides and fungicides, has negative effects on the potential for biological pest control (Geiger et al., 2010). Despite that fact, the presence of a high amount of aphid's specimens at the locality provides good living conditions for their predators, e.g. Coleoptera (Östman, 2004). This also corresponds to the fact that the highest number of Coleoptera was found in intensive systems.

Collembola showed under various management regimes lower differences than Sterhorrhyncha (similar results reported by Yeates et al., 1997; Alvarez et al., 2001). Further three taxa exceeded relative abundance of 1%: Araneae, Auchenorrhyncha, and Coleoptera. Subdominant groups displayed 7.4% relative abundance. Coleoptera was subdominant in total scale, but within the organic systems this group was dominant. This fact confirmed the studies by

Table 4. Number of specimens of minor groups (< 1% of relative abundance)

Taxa	WHB	INT	ORG
Caelifera	40	42	102
Opilionida	58	8	75
Lepidoptera	88	24	78
Dermaptera	119	44	79
Heteroptera	123	212	348+
Thysanoptera	265	198	275+
Others	20	16	16
Total	713	544	973

WBH = without harvesting biomass, INT = intensive agriculture systems, ORG = organic agriculture systems

+dominance > 1% in the particular system

Andersen, Eltun (2000) and Brooks et al. (1995).

All other groups of arthropods found were classified as minor, with relative abundance lower than 1%. These taxa covered 2.4% of overall relative abundance. Heteroptera and Thysanoptera were minor in total scale, but within the organic systems they were subdominant. Heteroptera showed a high number in the organic agriculture system in contrast to studies by Moreby (1996) and Reddersen (1997).

CONCLUSION

The diversity of arthropods occurring in various agro-ecosystems under different management conditions was evaluated during a several years lasting research.

Surprising was the presence of a large number of plant pests in the intensive farming system, maybe due to the fact that the intensively cultivated field is not involved in vegetation (especially at the beginning of the growing season) and aphids are attracted by separately growing plants that are more attractive to them than well developed vegetation cover with slow growing plants. Short-term pesticides are not so effective for the management and it could have a negative economic impact on the farmer. On the other hand, a huge number of aphids are a good food supply for the predators such as Coleoptera, many of them being red-list species. From our viewpoint, the group of Collembola is also important. These organisms contribute very significantly to the organic matter decomposition process and thus represent a substantial part of the nutrient cycle in the farmland.

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