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ARTHROPODS ON ABANDONED APPLE TREES: COMPARISON OF ORCHARD VERSUS ALLEY

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Abstract

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Occurrence of arthropods on abandoned apple trees was studied in 2010 and 2011. The research was carried out in South Moravia (Czech Republic). Two sites were selected within this area – apple trees (*Malus domestica*) in an alley along a road and an abandoned apple orchard. At each location, arthropods were collected from 5 separate trees. Deltamethrin was applied into the treetops using a fogger. The killed arthropods were collected 15 minutes after the application. From among the collected data, 48 families were determined in accordance with a generalized linear model with a logarithmic-link function and Poisson distribution. As a result it was found that 33 families have significantly higher abundance in the abandoned orchard and 9 families in the alley. According to the Shannon-Wiener index, diversity of families was higher in the alley in both years (2010: H’ = 3.016, 2011: H’ = 3.177) compared to the abandoned orchard (2010: H’ = 2.413, 2011: H’ = 3.007).

Keywords: arthropod diversity, *Malus domestica*, fogger, pests, natural enemies

INTRODUCTION

An apple tree (*Malus domestica* Borkh.) is a traditional and most commonly grown fruit tree in the Czech Republic (Buchtová, 2012). Since the second half of the last century, this tree has often been grown in alleys around the roads. These trees are now left with virtually no management. Also, some abandoned apple orchards have been left for many years without intervention. Such trees then allow development of arthropod populations without significant anthropogenic influences. Decisive influence on the composition and abundance of arthropods that inhabit these apple trees comes in particular from the surroundings. The microclimate is also different. While in an abandoned orchard there is a high density of trees, such a habitat is then approaching the character of forest vegetation. On the contrary, abandoned apple trees growing in alleys along roads are scattered and more exposed to the weather.

Study of arthropod diversity on abandoned apple trees is significant from the perspective of the fruit growing business in nearby production orchards. Abandoned apple trees that grow near commercial plantations may be an important food source for many economically important pest antagonists. Likewise, these trees can be colonized by pests which then can spread to nearby commercial apple plantations. Migration of arthropods between natural habitats and agricultural crops has been documented in many studies (Duelli *et al.*, 1990; Dennis, 1992). Altieri and Schmidt (1986) confirmed spreading of sucking pests from nearby habitats into the orchards. Conversely, in the case of harmful tortricids (Tortricidae), spreading occurs to a minimum extent (Jeanneret and Charmillot, 1995). Miliczky and Horton (2005) confirmed the spread of beneficial arthropods from nearby natural habitats.

Abandoned apple orchards and alleys are also important for the ecological stability it the intensively agricultural used land. Such landscape is very common in the Czech Republic. In 2012 there were 47 903 agricultural companies, which 10% of them had more than 100 hectares per company of agriculture land (Czech Statistical Office, 2014). Landscape heterogeneity of some areas is quite low in the Czech Republic due to this circumstance.

Hendrickx *et al.* (2007) proof direct influence of land use intensity and land heterogenity on arthropod diversity. These authors also found the role of semi-natural habitats distance on species diversity in agricultural use land. Abandoned apples in orchards and alleys can play the role of semi-natural habitats.

Occurrence of arthropods on apple trees was already studied in the past. However, these studies were conducted primarily in commercial apple orchards. Oatman *et al.* (1964) found in 764 insect species on apple trees. Some studies were focused on the occurrence of specific groups – such as pest antagonists (Miliczky and Horton, 2005; Horton *et al.*, 2012). A common limiting factor in these studies is the methods of capture and collection of arthropods. Arthropods from the treetops are captured using sticky boards, strips of cardboard mounted on tree trunks, pheromone traps, light traps, and shaking off. If one method only is selected, only a portion of arthropods living in the tree can be captured. More effective but more demanding is a combination of various collecting methods. However, it is extremely time-consuming. From this point of view, the best method seems to be the application of a non-selective insecticide aerosol using a fogger. This method was first developed as a technique of applying insecticides against pests in greenhouses. For the purposes of studying diversity of arthropods in the trees, it was first used by Roberts (1973) in Costa Rica and Gagné (1979) in Hawaii. The history of insecticides application by means of fogging was described by Erwin (1983, 1989). The method of pyrethroids application using a fogger proved effective also in the study of diversity of beetles living in the trees in Papua New Guinea (Allison *et al.*, 1997). The advantage of this method is in particular its extent. The majority of arthropods living in a tree are struck in a single moment. If a non-selective insecticide is applied, a comprehensive sample of arthropods living in the treetop can be obtained. Conversely, arthropods living hidden under the bark or inside the wood are virtually unreachable by this method.

This work is based on the well-known fact that arthropods migrate between agricultural crops and nearby natural habitats. Abandoned apple trees may thus provide suitable habitats for parasitoids and predators during the period of time in which there is no appropriate prey for them due to insecticide application. Conversely, arthropod pests can migrate from the abandoned apple trees to nearby orchards. Based on a study carried out in Papua New Guinea, Allison *et al.* (1997) assume that predators that are not limited to only one prey will migrate more. Conversely, these authors believe that herbivores (pests) migrate less. These authors also found that predators often occur in the treetops in low abundances (only individual specimens within a species), while some species of herbivores can be very abundant.

In our study, we sought to answer the question of how the quantity and diversity of arthropods differ on abandoned apple trees along a road and in an abandoned orchard. At the same time we aim to assess, based on the acquired results, which of the studied habitats represents a potentially greater danger as a source of pests for nearby commercial apple orchards. Or, on the other hand, which of the two is a significant habitat for beneficial predators and parasitoids. These findings can then play an important role in forming agroecosystem management of Central-European landscape.

A comprehensive faunistic evaluation was already published in the paper by Šťastná and Psota (2013). The significance of true bugs (Hemiptera) in terms of plant protection was also already published (Hradil *et al.*, 2013).

MATERIAL AND METHODS

Two sites were selected with abandoned apple trees growing. Both sites were located in the Czech Republic, South Moravia, near the village of Velké Bílovice (district Břeclav). The first location was an apple orchard abandoned for more than 10 years which is situated 1.2 km to the northeast of the edge of the village (N 48°52’8.430”, E 16°55’7.752”). Many trees in this site were heavily attacked by the apple clearwing mooth (*Synanthedon myopaeformis* (Borkhausen, 1789)) whereas some trees have already died due to this attack. Successional processes were also apparent especially by strong abundance of dog rose (*Rosa canina* L.) and black elder (*Sambucus nigra* L.). On one side, the orchard was surrounded by an irrigation reservoir, from the other side by a road and a field of cereals. The second location was an apple-tree alley along a road, which was surrounded by fields. Canola (*Brassica napus* L.) was grown in this field in 2010 and corn (*Zea mays* L.) in 2011. This alley is situated approximately 1.6 km to the east of the edge of the village of Velké Bílovice (N 48°50’5.020”, E 16°52’18.732”). The road margins were mowed twice a year in both years of the research, always at the beginning of May and the end of August. Between these places there is a geodesic distance of 5.2 km.

Monitoring of arthropods on apple trees took place in 2010 and 2011. Arthropods were collected always between 8–10 AM and only in ideal conditions (no wind or rain). We used a product containing deltamethrin, a pyrethroid (50 gl^{-1}). This was added to a solution of water and polyglycolic dispersion containing diethylene in the amount of 915.12 gl^{-1}. The solution was 1:3 with the greater portion of water. Concentration of the active substance, deltamethrin, in the application liquid was 0.0025 gl^{-1}. The application was then performed using a fogger (Puls Fog). The device produces aerosol which saturates the entire top of the selected tree.

The killed material was collected from a canvas that was stretched under the tree. Fifteen minutes after the application we also shook the tree to obtain complete material. Within one collection we always obtained material from 5 trees at each site. Between application and putting the arthropods into ethylene glycol some 30–60 minutes passed by on average depending on treetop size of the selected tree. Within each collection different trees were selected. In total, we made three sample collections in 2010 (28. 4., 20. 5., 28. 4. and 9. 7.) in the alley and in the orchard. In 2011, we made two collections in the alley (9. 5. and 21. 6) and two collections in the orchard (11. 5. and 23. 6.). For each tree we recorded basic data on the proportion of dead woody material, tree age, phenological phase at the time of collection, tree height and circumference of the treetop. Based on the measured parameters, we also determined the volume of the treetop of each tree according to the methodology by Kolařík *et al.*, (2009). The measured data are shown in Tabs. I and II. Meteorological values in both years from studied area were obtained from the Czech Hydrometeorological Institute. Area of the abandoned orchard is approximately 5 ha. Speaking about area in the case of apple alley is difficult, but it is approximately 700 meters long and the trees are planted regularly. Thus comparing the selected locations in terms of size is tricky. Therefore the number of determined arthropods was then converted to 10 m^3 volume of the treetop. By means of this calculation it was possible to compare the results of the alley and the orchard without distortion due to different size of the treetops.

I: *Basic information about the trees on which monitoring was performed in 2010*

		Tree number	Treetop volume in m^3	Height of the tree	Estim. age	Estimated proportion of dead branches %	Phase at the time of collection
2010 Orchard	28. 4.	1	14	3	25–30	5	60 to 70% of flowers blooming
		2	25	3	25–30	5	60% of flowers blooming
		3	9	2.5	25–30	10	60% of flowers blooming
		4	14	2.5	25–30	25	60 % of flowers blooming
		5	17	3	25–30	5	90% of flowers blooming
		6	17	2.5	25–30	5	90% of flowers blooming
	20. 5.	1	14	2.5	25–30	20	Out of bloom, fruit up to 10 mm
		2	8	2.5	25–30	20	No fruit
		3	14	2.5	25–30	30	Out of bloom
		4	4	2	25–30	40	Out of bloom
		5	25	2.5	25–30	70	Out of bloom
	9. 7.	1	12	2.5	25–30	20	No fruit
		2	8	2.5	25–30	10	No fruit
		3	7	2.5	25–30	15	Rich fruitage, over 30 mm
		4	17	3.5	25–30	10	No fruit
		5	9	3	25–30	40	Very few fruits
2010 Alley	28. 4.	1	52	3.5	30	0	Beginning of flowering
		2	25	3.5	30	0	Beginning of flowering
		3	39	3.5	30	15	Beginning of flowering
		4	57	3.5	30	0	50% of flowers blooming
		5	77	2	30	35	No flowers
	20. 5.	1	34	3.5	30	5	Freshly out of bloom
		2	14	3	30	40	The tree did not flower at all
		3	39	3.5	30	2	The tree did not flower at all
		4	14	3.5	30	0	50% of flowers out of bloom
		5	52	2.5	30	20	Blooming
	9. 7.	1	39	3	30	20	No fruit
		2	57	3.5	30	3	No fruit
		3	57	3.5	30	35	No fruit
		4	39	3.5	30	10	Fruits to 35 mm, little
		5	70	3.5	30	0	Fruits of up to 35 mm, medium fruitage

II: *Basic information a bout the trees on which monitoring was performed in 2011*

		Tree number	Treetop volume in m^3	Height of the tree	Estim. age	Estimated proportion of dead branches %	Phase at the time of collection
2011 Orchard	11. 5.	1	14	2.5	25–30	10	No flowers
		2	19	2.5	25–30	5	Blooming, minimum fruitage
		3	19	3	25–30	15	Blooming, minimum fruitage
		4	14	3	25–30	0	No flowers
		5	9	2.5	25–30	40	No flowers
	23. 6.	1	30	3.5	25–30	35	Fruits to 25 mm
		2	17	3	25–30	20	Fruits to 25 mm
		3	17	3	25–30	35	Little of fruits to 25 mm
		4	14	2.5	25–30	10	Little of fruits to 25 mm
		5	19	3.5	25–30	30	Fruits to 25 mm
2011 Alley	9. 5.	1	25	3.5	30	10	Out of bloom
		2	39	3	30	30	Out of bloom
		3	57	3.5	30	5	Out of bloom
		4	57	3.5	30	35	Out of bloom
		5	77	4	30	10	Out of bloom
	21. 6.	1	39	4	30	5	Fruits about 30 mm
		2	77	4.5	30	0	Fruits about 30 mm
		3	57	4	30	15	No fruit
		4	77	4	30	30	Many fruits about 30 mm
		5	10	4	30	50	No fruit

Frequency of arthropods occurrence in specimen/10 m^3 was expressed using the following model

$$y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_l + e_{ijkl},$$

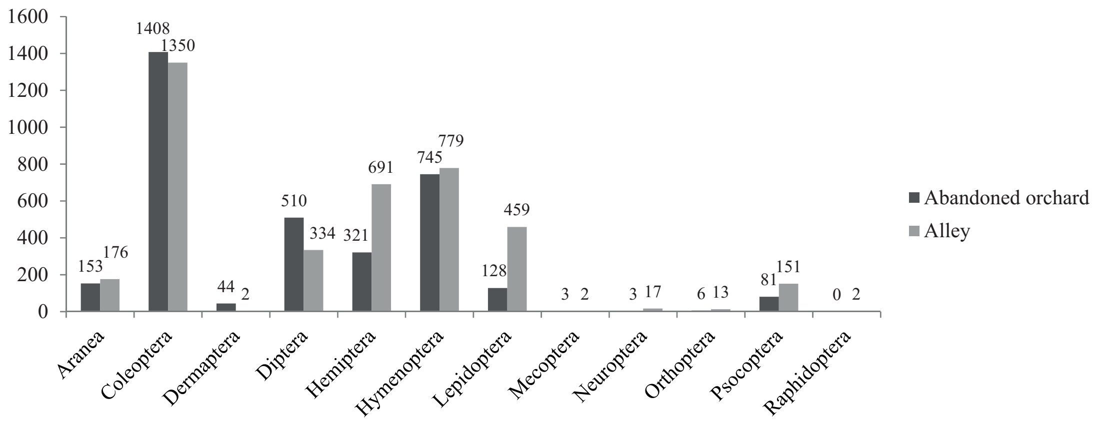
where is a general constant, effect of the ith year, effect of jth environment, effect of kth collection, effect of lth family, and random error. Acquired arthropod occurrence data do not have normal distribution as well as their random errors. Due to this circumstance, a classical linear model could not be used to evaluate the data, thus a generalized linear model GLiM (McCullagh and Nelder, 1989) with a logarithmic-link function and Poisson distribution implemented in the statistical system of GenStat (GenStat, 2012) was applied for statistical evaluation. Within this model 48 selected families with the highest abundances (with frequencies of 3–72 specimens) which occurred in both habitats were evaluated. The obtained predictions then correspond to the actual statistical model. Further, the diversities of all families captured in both habitats were compared utilizing Shannon-Wiener index of species diversity (Shannon and Weaver, 1949).

RESULTS

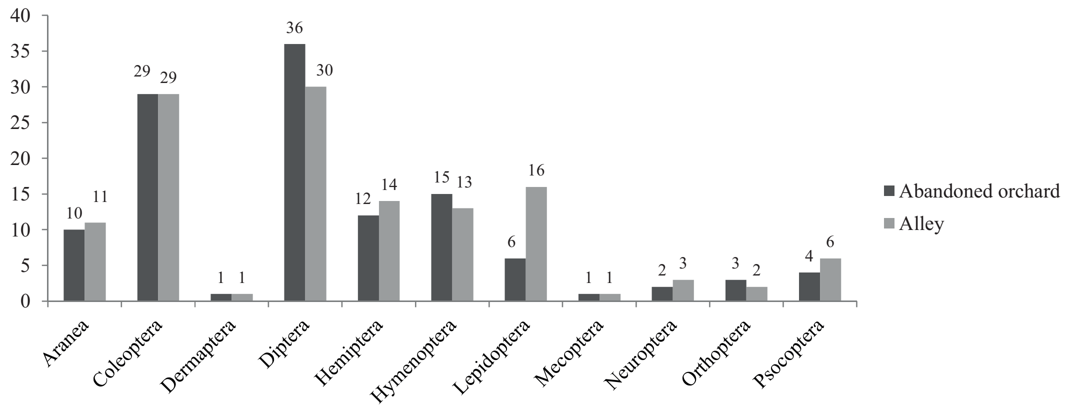
The number of individual orders in the alley and orchard in both years is shown in Fig. 1 and the number of families in Fig. 2. Average abundance of specimens of the identified families converted to treetop volume of 10 m^3 is presented in Tab. III.

Based on the generalized linear model (Tabs. IV and V), it was found that 33 families have significantly higher abundance in the orchard. Out of that, 12 families representatives are mainly zoophages (Anthocoridae, Braconidae, Cantharidae, Carabidae, Dictynidae, Chalcidoidea, Linyphiidae, Nabidae, Philodromidae, Salticidae, Staphylinidae, Thomisidae), 7 families are formed by in most cases phytophagous species (Cicadellidae, Curculionidae, Chrysomelidae, Lymantriidae, Noctuidae, Scraptiidae, Tortricidae), and species of four families are bound to wood by their development and food (Cerambycidae, Elateridae, Latridiidae, Salpingidae). 4 families are formed by omnivorous (Forficulidae) zoophagous and phytophagous species (Formicidae, Eurytomidae, Miridae). Next, a statistically significantly higher occurrence of 5 families (Hybotidae, Chironomidae, Lauxaniidae, Muscidae, Sciaridae) of Diptera order was recorded. However, in this case, only adult specimens most likely looking for a shelter in the tree were captured. Species of the Psocidae whose diet may be various organic material also dominated in the orchard.

Compared with the abandoned orchard, statistically significantly higher abundance was detected in 9 families only. Whereas out of that, species of 3 families are zoophagous (Coccinellidae, Ichneumonidae, Theridiidae) and species of 5 families are phytophagous (Attelabidae, Geometridae, Pentatomidae, Psyllidae,



1: *Quantitative distribution of individual orders in the alley and orchard*



2: *Numbers of families of individual orders*

Tingidae). Species of Anthribidae family are then developmentally bound to rotting organic matter of vegetable origin. Specimens from the Syrphidae whose larvae are important zoophages, as well as representatives of the Crabronidae were detected only in the alley.

The abundance of 4 families did not statistically significantly differ in the orchard and in the alley. One family of these is zoophagous (Araneidae), one family is bound to wood (Nitidulidae), and one family of Aphidoidea is phytophagous. Larvae of the Anthomyiidae family can feed on plant material, but only adults were captured in the treetops.

Shannon-Wiener Diversity Index

Diversity index of families was higher in the alley in both years (2010: H’ = 3.016, 2011: H’ = 3.177) compared to the abandoned orchard (2010: H’ = 2.413, 2011: H’ = 3.007). Tab. VII presents a comparison of the recorded values of the Shannon-Wiener diversity index of families in other environments.

DISCUSSION

That most of the statistically evaluated families were more abundant per unit of 10 m^3 of the treetop volume in the abandoned apple orchard (Tab. III). We believe that it is mainly due to the habitat. In the abandoned orchard, apple trees dominate within the trees in general, and they grew there densely, thus providing ideal food source for phytophagous species that use the apple tree as a host plant. Herbal and other woody vegetation are left without any interference and even here there may be amounts of arthropods which then may occasionally migrate into the tops of apple trees. It can therefore be assumed that the carrying capacity of the orchard habitat is higher than the habitat of solitary apple trees in the alley. It may also be affected by the mowing of the herb layer in the alley.

Also the impact of weather on the lower activity of some species is evident. Colder weather resulted in lower abundances of certain species in 2010 in both habitats, as a result of which the values of diversity index were lower (Tab. VII).

In both studied habitats, potentially dangerous species as well as predators and parasitoids were detected.

Statistically significantly higher abundances of 12 zoophagous families were recorded in the abandoned orchard compared to the alley. Out of that, species of 10 families are mostly polyphagous. Only species of two families are narrowly

III: *Average abundance of specimens of the identified families converted to treetop volume of 10 m³ (2010A – collection 20. 5.; 2010B – collection 28. 6.; 2010C – collection 9. 7.; 2011A – collection orchard 11. 5., collection alley 9. 5.; 2011B – collection orchard 23. 6., collection alley 21. 6.)*

Family	2010A		2010B		2010C		2011A		2011B	
	Orchard	Alley	Orchard	Alley	Orchard	Alley	Orchard	Alley	Orchard	Alley
Araneidae	0	0.074	0	0.634	0.118	0.338	0.248	0.654	0	0.478
Dictynidae	0.723	0	3.116	0.116	0.722	0.035	2.455	0	0.917	0
Linyphiidae	0.118	0	0.143	0.097	0	0	0.526	0.051	0.419	0.434
Philodromidae	0	0	0	0.268	0.284	0.115	0.143	0.026	1.354	0.318
Salticidae	0.222	0	0.786	0.143	0.333	0.108	1.850	0.157	0.340	0.417
Theridiidae	0	0	0	0	0	0.496	0	0.061	0.230	0.631
Thomisidae	0	0	1.061	0.452	0.167	0.057	1.643	0.321	0.118	0.406
Attelabidae	0.920	9.074	2.179	2.580	0	0.771	0	0	0.328	0.035
Cantharidae	0.080	0.218	3.990	4.690	0	0.138	3.880	1.038	0	0.035
Carabidae	0	0.269	0.500	0	0.118	0.035	0.143	0.051	0.643	0.252
Cerambycidae	1.428	0.125	5.508	0	0.340	0	1.580	0.298	0.567	0.200
Chrysomelidae	4.114	1.289	4.080	3.831	0.872	0.470	1.519	0.388	0.118	2.008
Nitidulidae	3.430	2.622	0.964	2.374	0	0.386	0	0.140	0.236	0
Salpingidae	0	0	0	0	0	0	0.925	0	1.415	0.052
Scraptiidae	0.316	0.832	4.464	1.258	0	0	5.368	1.283	0.211	0
Staphylinidae	0.080	0.735	0	0.284	0.118	0.035	0.781	0.176	0.550	0.086
Anthribidae	0	0	0.143	0	0.25	1.023	0	0	0.563	1.537
Coccinellidae	0.588	1.583	0.143	0.246	0.367	0.977	2.165	1.003	0.680	2.165
Curculionidae	20.150	0.862	48.615	3.121	0.707	0.847	43.988	1.293	2.005	9.352
Elateridae	0	0.272	0	0.154	0.5	0.051	0	0.115	8.192	0.356
Latridiidae	12.649	0.775	0.714	0.985	0.568	0.086	2.026	0.546	0.118	1.640
Forficulidae	0	0	1.429	0	0.985	0.029	0	0	3.640	0.035
Anthomyiidae	0	0.038	0	0	0	0.249	0.248	0.035	0.172	0.296
Chironomidae	0.538	0.131	0.651	0.038	0.555	0.051	8.870	0	3.478	0.051
Hybotidae	0	0.268	2.089	0.328	0	0	13.759	0.313	4.235	0.026
Lauxaniidae	0	0.051	2.000	0.192	0.778	0.268	1.338	0.140	2.076	0.594
Muscidae	0	0.035	0.080	0.251	0.222	0.092	1.060	0.409	0.756	0.409
Sciaridae	1.375	0.248	1.748	0.663	0	0.086	1.977	0.105	1.074	0.909
Syrphidae	0	0	0	0	0	0.265	0	0	0	0.609
Anthocoridae	0.848	1.223	0	0.240	0	0.044	3.383	1.510	0.118	1.818
Aphidoidea	0.916	0.176	1.214	9.341	0	0.940	8.330	0.668	0.693	1.515
Cicadellidae	0	0	0	0.286	0.470	0.035	0.534	0.269	2.632	2.711
Miridae	0	0	0.720	1.143	1.639	0.217	1.383	0.771	2.050	1.756
Nabidae	0	0.463	0	0.819	0.991	0	3.479	0.051	0.470	0.473
Pentatomidae	0	0	0.32	0.038	0	0.150	0.211	0	0.471	1.815
Psyllidae	0.118	0	0.143	0	0	0	8.094	0.272	1.059	0.543
Tingidae	0	0	0	0.38	0	0.121	0.105	0	0.067	0.038
Braconidae	0.143	0	0.731	0.097	0.118	0.316	3.308	0.103	3.298	3.484
Chalcidoidea	0.589	0.077	0.429	0	0	0.086	8.583	0.288	1.332	2.779
Formicidae	8.869	0.215	7.146	7.636	1	1.605	36.959	15.321	21.089	0
Ichneumonidae	0.223	0.160	0.143	0.297	0	0.035	1.203	0.140	1.450	3.598
Eurytomidae	0	0	0	0	0	0	1.214	0	0.546	0.061
Crabronidae	0	0	0	0	0	0	0.714	0	1.231	0
Geometridae	0.160	3.340	0.250	0.519	0	0	3.171	4.135	0.118	0.762
Lymantriidae	0.206	0.035	3,071	3.558	0	0	2.621	0.900	0	0.324
Noctuidae	0	0.794	3.214	1.361	0	0.108	5.383	4.757	0.118	0.051
Tortricidae	0	0.182	0	0.610	0	0.138	1.090	0.192	0.143	0.399
Psocidae	0	0	0	0	0.758	1.140	0	0	8.332	4.447

IV: *Accumulated analysis of deviance*

Change	Df	Deviance	Mean deviance	Devaince ratio	Approx chi pr
+ YEAR	1	1345.40	1345.40	1345.40	< .001
+ ENVIRON	1	6625.84	6625.84	6625.84	< .001
+ PERSUANCE	1	4072.13	2036.06	2036.06	< .001
+ FAMILY	47	36391.16	774.28	774.28	< .001
Residual	295	26164.76	88.69		

ENVIRON = environment, PERSUNACE = term of observation

V: *Occurrence of selected families in the alley and the abandoned orchard*

Order	Family	Alley prediction	s.e.	Orchard prediction	s.e.	Difference	LSD	Dominance of occurrence
Araneae	Araneidae	22.31	2.13	21.86	2.90	0.45	7.08	=
Araneae	Dictynidae	7.20	2.55	80.53	4.04	−73.33	9.41	♣
Araneae	Linyphiidae	8.37	1.53	14.20	1.74	−5.83	4.55	♣
Araneae	Philodromidae	9.74	1.60	30.71	3.26	−20.97	7.15	♣
Araneae	Salticidae	10.80	1.69	35.70	2.69	−24.90	6.26	♣
Araneae	Theridiidae	20.71	2.68	9.24	2.79	11.47	7.61	•
Araneae	Thomisidae	16.33	2.07	39.23	3.22	−22.90	7.53	♣
Coleopetra	Attelabidae	128.41	5.10	38.79	2.87	89.62	11.53	•
Coleopetra	Cantharidae	62.28	3.55	112.80	5.67	−50.52	13.18	♣
Coleopetra	Carabidae	7.69	1.38	18.43	2.20	−10.74	5.12	♣
Coleopetra	Cerambycidae	8.12	1.46	98.18	4.46	−90.06	9.25	♣
Coleopetra	Chrysomelidae	80.94	4.05	51.93	3.25	29.01	10.23	♣
Coleopetra	Nitidulidae	73.80	4.45	72.01	4.73	1.79	12.80	=
Coleopetra	Salpingidae	2.25	1.46	43.56	4.03	−41.31	8.44	♣
Coleopetra	Scraptiidae	47.90	3.69	109.79	4.83	−61.89	11.96	♣
Coleopetra	Staphylinidae	6.69	1.17	19.11	2.18	−12.42	4.87	♣
Coleopetra	Anthribidae	91.34	8.11	20.86	3.01	70.48	17.02	•
Coleopetra	Coccinellidae	44.43	3.00	39.76	2.84	4.67	10.95	•
Coleopetra	Curculionidae	157.01	5.64	1171.09	15.42	−1014.08	32.34	♣
Coleopetra	Elateridae	9.94	1.42	310.42	15.09	−300.48	29.86	♣
Coleopetra	Latridiidae	40.77	2.88	162.89	5.75	−122.12	12.66	♣
Dermaptera	Forficulidae	2.14	1.24	125.14	7.41	−123.00	14.18	♣
Diptera	Anthomyiidae	7.69	1.38	7.82	1.71	−0.13	4.32	=
Diptera	Chironomidae	4.37	1.13	142.00	5.37	−137.63	10.80	♣
Diptera	Hybotidae	7.21	1.24	279.96	8.87	−272.75	17.64	♣
Diptera	Lauxaniidae	12.78	1.61	81.63	4.64	−68.85	9.67	♣
Diptera	Muscidae	12.17	1.57	27.91	2.71	−15.74	6.17	♣
Diptera	Sciaridae	20.80	2.02	65.49	3.73	−44.69	8.35	♣
Diptera	Syrphidae	30.69	4.69	*	*			
Hemiptera	Anthocoridae	41.75	2.98	56.83	3.86	−15.08	9.60	♣
Hemiptera	Aphidoidea	128.21	5.10	118.48	5.01	9.73	14.08	=
Hemiptera	Cicadellidae	43.45	3.38	63.15	4.68	−19.70	11.36	♣
Hemiptera	Miridae	51.35	3.68	76.36	4.49	−25.01	11.42	♣
Hemiptera	Nabidae	12.42	2.07	68.99	4.27	−56.57	9.34	♣
Hemiptera	Pentatomidae	43.89	4.38	14.22	1.99	29.67	9.47	•
Hemiptera	Psyllidae	15.26	2.39	99.83	4.60	−84.57	10.21	•
Hemiptera	Tingidae	17.12	2.12	2.98	1.05	14.14	4.67	•
Hymenoptera	Braconidae	52.66	3.73	77.49	3.97	−24.83	10.72	♣
Hymenoptera	Chalcidoidea	39.95	3.15	115.72	4.96	−75.77	11.56	♣
Hymenoptera	Formicidae	331.31	9.48	761.12	12.43	−429.81	30.74	♣

Order	Family	Alley prediction	s.e.	Orchard prediction	s.e.	Difference	LSD	Dominance of occurrence
Hymenoptera	Ichneumonidae	42.80	2.95	31.79	2.60	11.01	7.73	•
Hymenoptera	Eurytomidae	2.52	1.46	32.76	3.50	−30.24	7.46	♣
Hymenopetra	Crabronidae	26.80	3.78	*	*			
Lepidoptera	Geometridae	92.83	4.44	39.42	2.89	53.41	10.43	•
Lepidoptera	Lymantriidae	51.08	3.29	84.74	4.91	−33.66	11.64	♣
Lepidoptera	Noctuidae	71.81	3.82	121.58	5.83	−49.77	13.73	♣
Lepidoptera	Tortricidae	15.42	1.77	23.08	2.93	−7.66	6.75	♣
Psocoptera	Psocidae	199.10	12.03	324.69	15.45	−125.59	38.13	♣

= no statistical difference in the occurrence, ♣ significantly higher abundance in the orchard, • significantly higher abundance in the alley. Column s.e. is standard deviation of predicted occurrence value.

VI: *Meteorological values in both years from studied area (source: Czech Hydrometeorological Institute)*

	2010		2011	
Month	**Average temperature (°C)**	**Precipitation (mm)**	**Average temperature (°C)**	**Precipitation (mm)**
I.	−3.7	60.6	−0.6	32.0
II.	−0.2	22.7	−0.9	6.4
III.	5.2	10.5	5.6	41.1
IV.	10.4	56.3	12.6	40.9
V.	14.3	140.1	15.7	41.9
VI.	19.0	94.7	19.7	47.6
VII.	22.2	84.1	19.2	77.6
VIII.	19.4	91.3	20.8	27.7
IX.	13.9	57.9	17.2	23.5
X.	7.3	16.8	9.4	24.5
XI.	7.0	32.2	2.9	0.0
XII.	−3.6	26.2	2.2	23.0

VII: *Shannon-Wiener diversity index of families for different habitats (H')*

Habitat	H'
Alley 2010	3.016
Abandoned orchard 2010	2.413
Alley 2011	3.177
Abandoned orchard 2011	3.007
Apple orchard without chemical sprays – eastern Algeria[a]	1.4
Apple orchard with limited chemical protection – eastern Algeria[a]	1.38
Apple orchard with common chemical protection – eastern Algeria[a]	2.5

a: Frah *et al.*, 2009

specialized in terms of food. It can be expected that abundant species of polyphagous zoophages will be one of the major factors limiting the growth of phytophages abundance. Thus, it can be expected, that potentially harmful phytophageous species in abandoned orchards do not present a danger for nearby commercial orchards thanks to the predator's pressure of zoophages. Results obtained by Brown and Schmitt (2001) correlate with this hypothesis as well. They conducted a research in 1991 on apple trees, peach trees, and cherry trees in orchards with different methods of management. The highest diversity of predators and parasitoids was found in the orchard, which was left 6 years without management. Also the study by Brown *et al.* (1988) confirms a hypothesis that abandoned orchards can be sources of beneficial insects. They conducted a research on arthropods on apple trees in abandoned apple orchards and production orchards in some states of the USA. Beneficial species dominated over pests in almost all cases in abandoned orchards, unlike in orchards with management. On the other hand, abundances of zoophages in the alley are not that high, thus it is more probable that some phytophagous pests might become overabundant and might spread further.

Diversity of arthropod families on an apple tree in the abandoned orchard as well as in the alley is higher than the diversity found in production orchards in Algeria (Frah *et al*., 2009). It is also significantly higher than in the cornfield in Spain (Ponce *et al*., 2011). However, a significant role can be played by considerable climatic differences between the two environments in this issue. Landis *et al*. (2000) affirm that habitats offering alternative prey, pollen, nectar, shelter, and wintering site for beneficial insects are necessary in agrarian land to support natural enemies of pests. Our results indicate that abandoned orchards are exactly such habitats for a number of beneficial insect species. Abandoned apple trees can thus pose valuable habitat for many species of arthropods in intensively agricultural used land. More involved apple alleys can then also be an important migration bio-corridor. Importance of tree habitats in terms of pest management is confirmed by a number of other studies (Dix *et al*., 1995; Leius, 1967; Tamaki and Halfhill, 1968; Corbett and Rosenheim, 1996; Grout and Stephen, 1995).

CONCLUSION

Based on our observations, it was confirmed that zoophagous families have a higher abundance in the abandoned orchard and we can assume that in this habitat there is a lower probability of over population of potentially harmful phytophagous species which could then spread to a neighboring production plantations. In contrast, this risk is significantly higher in the alley. One reason may be that the surrounding of the alley is constantly changing (different crops in the field, influence of the road) as a result of which the successional processes are disrupted, which rather suits calamity-causing species.

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