Travaux du Muséum National d'Histoire Naturelle «Grigore Antipa»	Vol. LIV (1)	pp. 263–281	© 30 Juin 2011

DOI: 10.2478/v10191-011-0016-0

THE IMPORTANCE OF FOREST ISLANDS FOR INVERTEBRATE BIODIVERSITY: A CASE STUDY IN WESTERN POLAND

TRAIAN MANOLE, JÓZEF BANASZAK, HALINA RATYŃSKA, IRINA IONESCU-MĂLĂNCUȘ, EUGENIA PETRESCU, GABRIELA MĂRGĂRIT

Abstract. Ecological landscape studies are carried out concerning the ecosystem biocenosis restore and conservation and to define the ecological terms like "ecosystem services" which have increasingly caught the interest of both environmental researchers and policy makers. Ecosystems, if properly protected and maintained, provide a wide array of valuable services to humans, ranging from the air purification by carbon sequestration to preserve biodiversity of natural capital. The agricultural landscape predominating in Western and Central Europe occupies a significant place in Poland deciding, to a large extent, about the quality of the whole natural environment. Forest island studies were carried out in the agricultural landscape of Western Poland, 15 km north-east of Poznań town. Ten forest islands of varying size (from 0.5 ha to 1.5 ha) were investigated. Flora and plant communities of small forests were examined and 58 plant associations were found. Small areas of forest islands became the refuges of forest plant species and invertebrate fauna in an agricultural landscape. Differentiation, number and domination structure of invertebrate fauna (Acari, Araneae, Apoidea and Curculionidae) were studied. The studied forest islands provide suitable conditions for survival and reproduction of many animal species, and for other accidental species which use these areas for feeding or as a temporary shelter.

Résumé. Les études d'écologie entreprises regardant l'architecture du paysage agricole ainsi que les connexions entre différentes formations structurelles (écosystèmes naturels, anthropiques, semi-naturels etc.) ont eu pour but la protection, la restauration et la conservation des biocénoses visées, par l'identification et la définition de certaines unités écologiques multi- ou bien surécosystémiques, des aires régionales ainsi que la mise en évidence du caractère d'unités fournisseures de services économiques ou de ressources. Les recherches écologiques regardant la notion de «landscape» sont déroulées avec une intensité particulière par un grand nombre de chercheurs travaillant dans beaucoup d'institutions scientifiques de la mappemonde tout entière. Le paysage agricole prédominant dans l'Ouest et le centre de l'Europe occupe une place significative en ce qui concerne sa distribution sur le territoire de la Pologne, en constituant presque 60% du territoire du pays, ayant une grande influence sur la qualité du milieu naturel tout entier. Les études sur les associations végétales arboricoles ou arborescentes («îles forestières») se sont déroulées au cours de la période 2004-2005 dans une aire représentative de la zone d'Ouest de la Pologne, à 15 km Nord-Est de la ville de Poznań. On a identifié et sélecté pour cette étude 10 de ces formations ayant des superficies variables (depuis 0,5 ha jusqu'à 1,5 ha). La flore et les communautés de plantes étudiées à l'intérieur de ces petits forets ont permis l'identification et l'examinassions d'un nombre de 58 associations végétales. Les aires représentatives, ayant de superficies différentes occupées par une végétation arboricole ou bien arborescente, constituent des refuges pour une riche diversité de la faune d'invertébrés dans le cadre du paysage agricole. La structure de la faune, la densité numérique et la dominance de certains groupes d'invertébrés (Acari, Araneae, Apoidea et Curculionidae) sont présentées dans ce travail. Les aires étudiées assurent des conditions propices pour la survie et la reproduction d'un bon nombre d'espèces animales, ainsi que pour les espèces qui ne sont pas caractéristiques, mais accidentelles dans l'aire, utilisant ces zones en tant que refuges et sources de nourriture temporaires.

Key words: Landscape ecology, biodiversity, forest islands.

INTRODUCTION

Landscape studies carried out from ecological point of view and concerning its restitution and conservation were initiated by the professor of Poznań Adam Mickiewicz University, Adam Wodziczko, before the Second World War

(Wodziczko, 1932, 1945, 1946). The term "physiocenosis" introduced by him to define an ecological unit of multi or over-ecosystem character still deserves our attention and popularization. Wodziczko precisely differentiates ecological and architectural aspects of a landscape. Therefore Wodziczko's physiocenosis and present understanding of a landscape can be considered identical. Landscape ecology is today intensely developed in many world centres and by many researchers (e.g. Risser et al., 1984; Forman & Godron, 1986; Turner, 1987; Urban et al., 1987; Baker, 1989; Turner & Gardner, 1991; Ryszkowski & Bałazy, 1992; Banaszak, 1993; Vos & Opdam, 1993). The agricultural landscape, predominating in the Western and Central Europe, occupies a significant place in these studies. In Poland, it constitutes about 60% of the country's territory deciding, to a large extent, on the quality of the whole natural environment. In the agricultural landscape of many European countries forests were reduced to small fragments surrounded by arable fields under intensive farming. Hence, human activity leads to breaking of habitats of many plant and animal species into small, isolated islands. These islands together with tree shelter belts and swards constitute refugees for fauna and flora and their importance is greater for more intensive farming (e.g. Czarnecki, 1956; Banaszak, 1983; Opdam et al., 1985; Dąbrowska-Prot, 1987, 1992; Kozakiewicz & Szacki, 1987; Dzwonko & Loster, 1989).

This work presents some results of research on flora and plant communities of forest islands on relation with density of some significant invertebrate groups like spiders, wild bees and coleopterans.

MATERIAL AND METHODS

General characteristics of the area

The investigated area was located about 15 km north-east of Poznań, on the edge of the Landscape Park "Zielonka Forest". It is enclosed by a complex of "Dziewicza Góra" (Virgin Mountain) forests, the "Kobylnica Forests" and the Główna River. There are areas under intensive farming (about 1,200 ha) between the villages Wierzenica, Wierzonka, Milno and Kicin (Fig. 1).

The morphological differentiation is also expressed in the vegetation cover. The discussed area is dominated by habitats of a poor series of oak-hornbeam forests – Galio sylvatici-Carpinetum (Wojterski et al., 1982). Rather small areas are occupied by the potential habitats of mixed forest (Querco roboris-Pinetum). Only in the valley of the river, along its tributaries and in local small depressions there are riverside forest habitats (Circaeo-Alnetum and Ficario-Ulmetum campestris) and habitats of fertile older forests (Ribo nigri-Alnetum).

The investigated area, although covering but a small surface, is characterized by a rich network of different forest islands. They have been developed primarily in the form of woodlots with a circumference of 100-200 m. The widest forestations with a natural character extend in a small tunnel valley running down to the valley of the Główna River. The fields of the Plant Breeding Station of Wierzenica-Wierzonka are separated by balks where single trees and shrubs grow. One can also encounter 20-30 m wide and several hundred meter long compact hedges (Pruno-Crataegetum). The field roads and paved roads are accompanied by one-row or two-row tree belts, whereby the tree plantation on both sides between the villages Wierzonka and Milno is particularly noteworthy. The plantation consists of Norway maple (*Acer platanoides*), sycamore (*Acer pseudoplatanus*) and oak (*Quercus robur*).

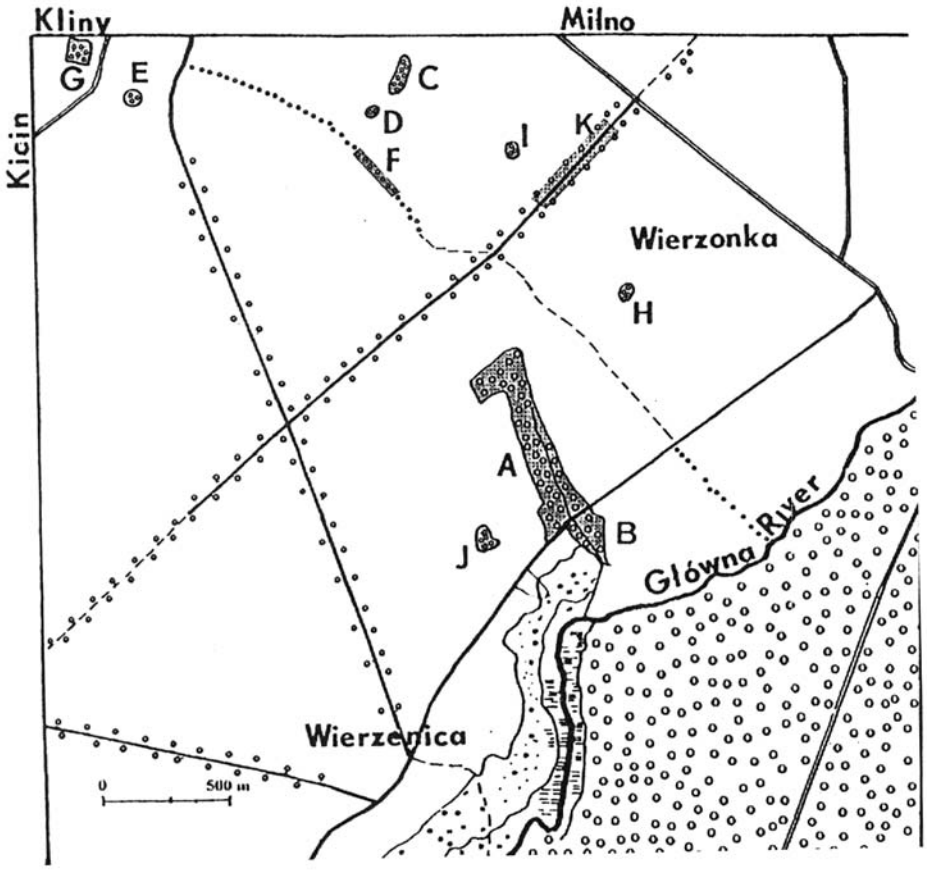

Fig. 1 - The map of the investigated area (A - J, selected forest islands).

Furthermore, several trees are recorded as natural monuments within the discussed area. They are magnificent white poplars (*Populus alba*), oaks (*Quercus robur*) and wild pear (*Pyrus communis*) (Banaszak & Ratyńska, 1993).

Analysis of aerial photographs of the investigated area

For the analysis of some elements of natural environment, slides spectral-zone aerial photographs and panchromatic photos taken in several time intervals were used. The most valuable source of information proved to be spectral-zone photographs taken in 1:10 000 scales.

Analysis of field and roadside forest communities revealed that at generally preserved network of these structures, local changes of their state and size can be observed. The longest (over 1 km long) belt of field forest enclave stretching from Kliny village in the south-west direction has clearly developed two levels. Its present state, as compared to the forties, is more regular with smaller of breaks.

Analysis of the roadside tree belts in the northern part reveals missing tree stretch about 360 m long, while in the southern part increase in the tree stretch on the 500 m long segment as well as forestation of the second row on the length of about 700 m.

Vegetation

The field studies were carried out in the vegetation seasons 1991-1993. For the purpose of this paper 10 field forest communities (Fig. 1) (A-J) localized mainly within oak-hornbeam and carr forest habitats: A – "Duży wąwóz"; B – "Maly wąwóz", C – " Duże zadrzewienie", D – "Osikowe", E – "Jesionowe", F - "Długi pas czyżni", G – "Stary cementarz (dębowe)", H – "Głogowe", I – "Wiązowe", J – "Sosnowe (Żalik)".

The focus of interest was concentrated on the level of the vegetation cover organization and on the complexes of plant communities. The latter are understood in a similar way as Matuszkiewicz (1990), as spatially distinguished, repeated functional systems of related facia, preserving a relative structural and genetic homogeneity. All the above mentioned forestations were treated as one complex of plant communities. Phytosociological relieves were made of them according to the generally accepted Braun-Blanquet method and the role of species was played by the plant communities.

In general, the accepted systematic of the distinguished phytocenons agrees outline with the description of Matuszkiewicz (1981).

Study of invertebrates

The mite fauna studies were carried out in four communities (C, D, H, J) in spring and autumn 1992. 100 cm^3 samples were taken, representing two soil levels: 0-5 cm and 6-10 cm, in 10 repetitions. Acari were driven away in Tullgren apparatus and preserved in 70% ethyl alcohol.

The spiders – Araneae – were collected using the following methods:

a) entomological scoop;
b) soil traps;
c) shaking branches, trees and shrubs;
d) search in the shrub, herbs, grass and litter layers;
e) collecting from under stones, fallen tree trunks and branches, and from under tree bark;
f) catching spiders with nets and those running in the surface litter, stones, fallen trees.

The samples for spider study were collected from May to October, twice a month (in 1991) and once a month (in 1992). Each time the tree, under growth, vegetal cover and litter layers were searched as well as the ground under stones.

Coleoptera (Curculionidae): the material was gathered in July 1993 from the following areas: Wąwóz, Duże, Pasowe, Głogowe, Wiązowe, Żalik. Quantitative samples were taken using soil traps (Barber traps). The soil Barber traps were displayed and installed in random way, for each plot we had 10 traps disposed on line or in circle but the distance between two traps were of 10 m. For the whole period we had four period of collection (one collection/week).

The studies on Apoidea were carried out in six communities (Żalik and Głogowe – from 1990, Duże, Wiązowe and Osikowe – from 1992, and Droga – from 1993). Quantitative samples were taken from April to September, in two or three week periods. The belt method was applied (Banaszak, 1980, 1983). In two communities (Wiązowe and Duże) the samples were divided into the internal ones, collected within a community (at least a few meters from its edge) and the external ones, collected in the contact zone between a community and surrounding fields.

RESULTS

Vegetation

The total number of plant communities observed in the investigated forestations is 58. With reference to the phytocenons included, the most differentiated is the forest overgrowing the largest ravine running to the Glówna River (complex 1, tab. 1). Taking into consideration the degeneration forms, 46 plant communities were found here. In this respect, the small-area field refugees (only 8-9 phytocenons) are the poorest.

Table 1

The composition and quantitative relations of the plant communities created in the forest islands.

Forest island mark number	A	B	C	D	E	F	G	H	I	J
	8	9	4	5	7	10	6	2	3	1
Potential habitat	C-A F-U G-C	F-U	C-A F-U G-C	F-U G-C	F-U	G-C	G-C	G-C	G-C	G-C P-Q
Number of communities	43	17	19	9	8	18	12	11	9	13
Forest communities										
Circaeo-Alnetum	1	.	.	.	.	.	.	.	.	.
Ficario-Ulmetum	4	5	.	.	.	.	.	.	.	.
F-U. geranietyzation	.	.	2m	3	1	.	.	.	.	.
Galio-Carpinetum geranietyzation	2a	.	3	.	.	.	.	.	5	.
G-C. pinetyzation	2m	.	.	.	.	.	.	.	.	.
Querco roboris- Pinetum	+	.	.	.	.	.	.	.	.	.
Chelidonio-Robinetum	.	.	+	.	.	.	.	.	.	.
Populus tremula com. juv.	.	.	.	.	.	+	.	.	.	.
Pinus sylvestris com.	.	.	.	.	.	.	.	.	.	%
Σ	5	1	3	1	1	1	-	-	1	1
Shrub communities										
Salicetum pentardo-cinereae	+	.	.	.	.	.	.	.	.	.
Rhamnus cathartica com.	+	.	.	.	.	.	.	.	.	.
Cuscuto-Humuletum lupuli	+									
Convolvulo-Rubetum caesii	+	+	.	.	.	.	.	.	.	.
Sambucetum nigri	3	+	2m	3	3	2b	2b	.	.	.
Pruno-Crataegetum	2a	1	4	2a	2b	%	+	4	.	1
Rubus caesious com.	+	.	r	.	.	.	.	1	.	+
Rosa sp. com.	.	.	.	.	.	r	.	.	.	.
Syringa vulgaris com.	.	.	.	.	.	.	3	.	.	.
Licietum halimifolii	.	.	.	.	.	.	r	.	.	.
Σ	7	3	3	2	2	3	4	2	-	2
Wetland communities										
Phragmitetum communis	r	.	.	.	.	.	.	.	.	.
Caricetum gracilis	+	.	.	.	.	.	.	.	.	.
Cardamino-Beruletum erecti	+	.	.	.	.	.	.	.	.	.
Caricetum vulpinae	+	.	+	.	.	.	.	.	.	.
Phalaridetum arundinaceae	.	.	1	.	.	.	.	.	.	.
Σ	4	-	2	-	-	-	-	-	-	.
Meadow and sward communities										
Scirpetum silvatici	r	.	.	.	.	.	.	.	.	.
Potentilla reptans com.	r	.	.	.	.	.	.	.	.	.

Table 1 (continued)

Forest island mark number	A	B	C	D	E	F	G	H	I	J
	8	9	4	5	7	10	6	2	3	1
	C-A		C-A							
Potential habitat	F-U	F-U	F-U	F-U	F-U					
	G-C		G-C	G-C		G-C	G-C	G-C	G-C	G-C
										P-Q
Number of communities	43	17	19	9	8	18	12	11	9	13
Bromus inermis com.	+	.	.	.	.	.	.	.	.	.
Poetum trivialis	1	.	1	.	+	.	.	.	.	.
Festuca ovina sl. com.	1	.	.	.	.	.	.	.	.	2m
Arrhentheretum medioeuropaeum	2m	.	.	.	.	r	.	1	2a	1
aff. Rumici-Alopecuretum	.	.	r	.	.	.	.	.	.	.
Σ	6	-	2	-	1	1	-	1	1	2
Tall herb communities										
Eupatorietum cannabini	r	.	.	.	.	.	.	.	.	.
Chaerophylletum aromatici	r	.	.	.	.	.	.	.	.	.
Chelidonium majus com.	r	+	.	.	.	.	.	.	.	.
Helianthetum tuberosi	r	+	.	.	.	.	.	.	.	.
Impatiens parviflora com.	+	+	.	.	.	.	.	.	.	.
Urtico-Aegopodietum	3	3	.	.	.	.	.	.	.	.
Anthriscetum silvestris	r	+	.	.	.	2m	.	+	.	.
Alliario-Chaerophylletum	+	+	r	1	.	+	.	.	.	1
Alliarietum officinalis	1	.	2m	2m	.	2m	.	+	+	.
Urtica dioica com.	2m	2b	3	3	2b	3	2b	3	1	2m
Galio-Veronicetum	+	+	1	.	2m	2m	2b	+	2m	+
Trifolio-Geranietea cl. com	+	.	.	.	.	+	.	.	.	+
Conium maculatum com.	r	.	.	.	.	r	.	.	.	.
Galeopsis tetrahit com.	.	.	r	.	.	.	.	.	.	.
Σ	13	8	5	3	2	7	2	4	3	4
Clearcut communities										
Epilobietum angustifolii	+	.	.	.	.	.	.	.	.	.
Calamagrostetum epigei	+	.	.	.	.	r	.	.	.	r
Rubetum idaei	+	.	.	.	.	+	.	+	.	r
Σ	3	-	-	-	-	2	-	1	-	2
Ruderal communities										
Rumex obtusifolius com.	+	.	.	.	.	.	.	.	+	.
Tanaceto-Artemisietum	+	+	+	.	.	.	.	.	.	.
Leonario-Arctietum	1	+	.	.	3	r	r	.	.	.
Leonuro-Arctietum	1	+	.	.	3	r	r	.	.	.
Leonuro-Ballotetum	1	2a	+	+	.	+	+	2b	2a	.
Convolvulo-Agropyretum	.	.	.	.	.	+	.	.	.	.
Saponaria officinalis com.	.	.	.	.	.	.	1	.	.	.
Lamium album com.							+	.	.	.
Σ	4	3	2	1	1	3	4	1	1	-
Field-accompanying commmunities										
Bromus tectorum com.	2m	2a	.	.	.	.	.	.	.	2m
Agropyron repens com.	3	2b	2b	3	.	4	2a	3	4	3
Stellaria media com.	+	.	+	+	+	.	+	2m	+	.
Σ	3	2	2	2	1	1	2	2	2	2

The greatest participation of the communities with a character similar to the natural and semi-natural one was found in the ravines, running to the Glówna River (complexes 1, 2, tab.1).

Soil mites - Acari

Four investigated field forest communities (C, D, H, J) were dominated by 25 mite species of the Gamasida order (Tab. 2). The greatest number of the Gamasida species was observed in the community of the largest area-19, while in the remaining ones it was from 9 to 11. *Alliphis siculus*, *Amblyseius* sp., *Hypoaspis aculeifer* and *Leioseius bicolor* appeared on all investigated surfaces.

Table 2

Species composition of Gamasida in the studied forest islands.

SPECIES	FOREST ISLAND			
	Duże	Osikowe	Wiązove	Głogowe
Alliphis siculus (Oudemans)	+	+	+	+
Amblyseius obtusus (C. L. Koch)	-	-	+	+
Amblyseius sp.	+	+	+	+
Arctoseius cetratus (Sellnick)	+	+	+	-
Dendrolaelaps foveolatus (Leitner)	+	+	-	-
Hypoaspis aculeifer (Canestrini)	+	+	+	+
Hypoaspis austriaca (Sellnick)	+	-	-	-
Hypoaspis praesternalis Willmann	+	+	+	-
Hypoaspis vacua (Michael)	+	-	+	-
Leioseius bicolor (Berlese)	+	+	-	+
Macrocheles sp.	+	-	-	-
Nenteria breviunguiculata (Willmann)	-	-	+	-
Pachylaelaps furcifer Oudemans	+	-	-	-
Pachyseius humeralis Berlese	+	-	-	+
Parasitus kraepelini (Berlese)	+	-	-	-
Pergamasus lapponicus (Tragardh)	+	-	-	-
Pergamasus misellus (Berlese)	+	-	-	-
Pergamasus runciger (Berlese)	+	+	-	-
Proctolaelaps pygmaeus (Muller)	-	-	-	+
Rhodacarellus subterraneus Willmann	-	-	-	+
Trachytes aegrota (C. L. Koch)	+	-	-	-
Uropoda minima Kramer	+	+	+	-
Veigaia nemorensis (C. L. Koch)	+	+	+	-
Zercon sp.	-	-	+	+
Total species	19	11	12	9

The general number of mites in the studied units was high-from 23.4 to 204.4 thousand of individuals/m^2 (Tab. 3).

Table 3

Density (in thousand of ind./1m^2) of Acari in the studied forest islands.

ACARI-GROUP	FOREST ISLAND			
	Duże	Osikowe	Wiązove	Głogowe
Gamasida	7.5	1.5	1.5	4.3
Others	196.9	65.0	21.9	100.5
Total	204.4	66.5	23.4	104.8

Table 4

Spider families and species number in vegetal cover of forest islands.

FAMILY	NUMBER OF SPECIES		
	Żalik	Głogowe	Wiązowe
Dictynidae	1	-	-
Dysderidae	1	1	1
Pisauridae	1	1	-
Theridiidae	5	7	7
Lycosidae	5	3	3
Clubionidae	-	1	1
Araneidae	3	3	2
Tetragnathidae	1	1	1
Linyphiidae	4	5	6
Thomisidae	1	1	-
Salticidae	-	1	1
Agelenidae	1	-	-
12	23	24	22

In each forest island the number of mites was different and on the surfaces C and H it was much greater than 100 thousand individuals/m^2 and it was comparable to the one observed in patches of fresh coniferous forest with moss in the vicinity of Włocławek (Seniczak et al., 1987). Whereas in the D and J objects the total number of mite fauna did not vary from that found in multi-species forestations (over 0.5 ha) on dry habitat near Turew (Seniczak et al., 1987, 1991 a, b; Kaczmarek, 1990).

Spiders – Araneae

In all, 100 samples of forest litter and soil were taken, which yielded 12,420 spiders. So far 56 species of spiders included in 13 families have been described. Among the richest families in species there are: Araneidae – 12 species, Theridiidae

Table 5

Spider families and species number in layer of trees and high bushes of forest islands.

FAMILY	NUMBER OF SPECIES		
	Żalik	Głogowe	Wiązowe
Dictynidae	1	1	1
Araneidae	8	8	9
Tetragnathidae	2	2	2
Linyphiidae	1	1	1
Theridiidae	7	7	7
Clubionidae	1	1	1
Anyphaenidae	1	1	1
Thomisidae	4	3	3
Salticidae	2	2	1
9	27	26	26

– 11, Linyphiidae – 8, and Thomisidae – 6. Among all families, four are represented by one species: Dictynidae, Dysderidae, Pisauridae and Anyphaenidae. In samples, three genera were the most frequently encountered: *Araneus*, *Theridion* and *Pardosa*.

Pollinating insects – Apoidea

Up to now, the results indicate that the investigated field forest communities are settled by a large number of Apoidea, though there are clear differences both between the forests and various study years (Tab. 6). Mean seasonal density of

Table 6

Apoidea mean density per season (ind./ha) in forest islands.

FOREST ISLAND	YEAR	WILD BEES	*APIS MELLIFERA*	APOIDEA (WILD BEES+*APIS*)
Żalik	1991	400.0	106.2	506.2
	1992	350.0	10.0	360.0
Głogowe	1991	472.7	540.9	1,013.6
	1992	290.0	186.4	477.3
	1993	2,175.0	275.0	2,450.0
Duże	1992	347.9	75.0	422.9
	1993	678.5	121.4	792.9
Wiązowe	1992	200.0	100.0	300.0
	1993	964.3	42.9	1,007.1
Osikowe	1992	293.7	18.7	312.5
	1993	1,125.0	100.0	1,225.0
Droga	1993	600.0	85.7	685.7

Apoidea was from 300 indiv./ha to 2,450 indiv./ha. At the time of the highest number, spring months (April, beginning of May), the maximal numbers reached 7,000 indiv./ha (Głógowe). At the present state of research, it is possible to state that the number of bees in a given forest island depends on food base, i.e. on the presence of pollen and nectar produced by plants, and on the occurrence of convenient nesting sites. The differences in the number in various seasons also indicate the considerable effect of weather conditions on bee populations. Different densities were found inside the forests and on their edges. The contact zones between a forest and a field have much greater densities than internal parts which are related to the distribution of fodder plants. On the edges, communities rich in nectar plants are developed resulting in Apoidea accumulation in this zone. The mean density in the contact zone varied from 590 indiv./ha to 1,835.7 indiv./ha, while that inside the forest island was from 10 indiv./ha to 328.5 indiv./ha. Despite significant differentiation in Apoidea number in forest islands, it is possible to notice similarities appearing in all investigated sites. Among them there is the course of the number dynamics. In each investigated forest two clear-cut peaks were observed: spring–with predomination of *Andrena* (the most numerous is *A. nigroaena*), and summer – with predomination of *Bombus* (*B. terrestris*, *B. pascuorum*) (Figs 2, 3).

The weevils fauna – Curculionidae

In the investigations carried out on agricultural landscape near Poznań 36 species of Curculionidae from 6 subfamilies: Otiorhynchinae, Brachyderinae, Curculioninae, Calandrinae, Apioninae and Rhynchitinae (Tab. 7) were found.

Also, the investigated habitats differed considerably in their species composition as is shown in the figure 5.

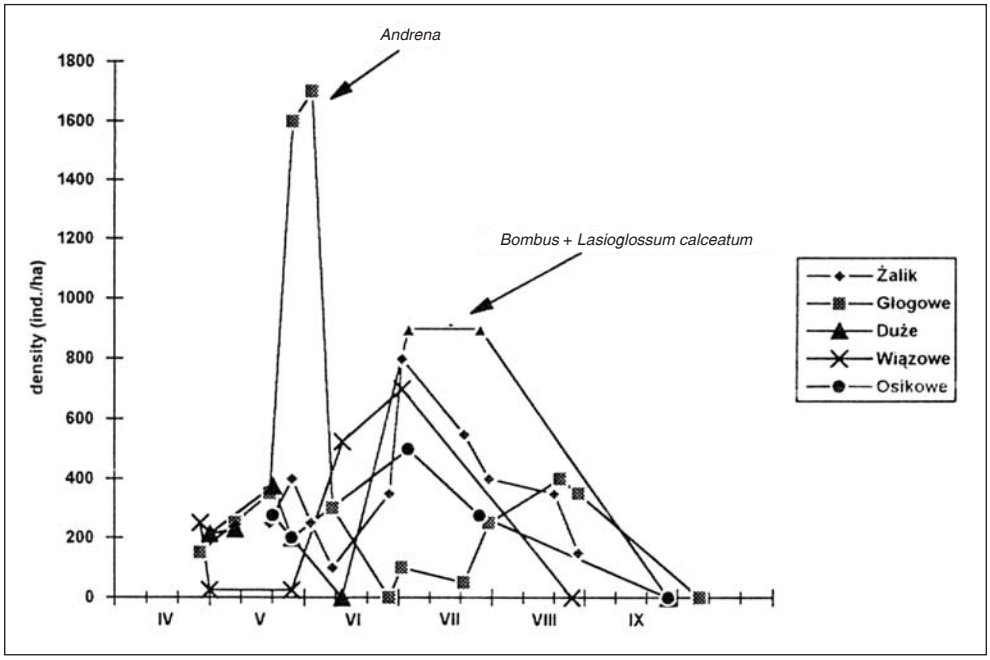

Fig. 2 - Dynamics of Apoidea density in the studied forest islands.

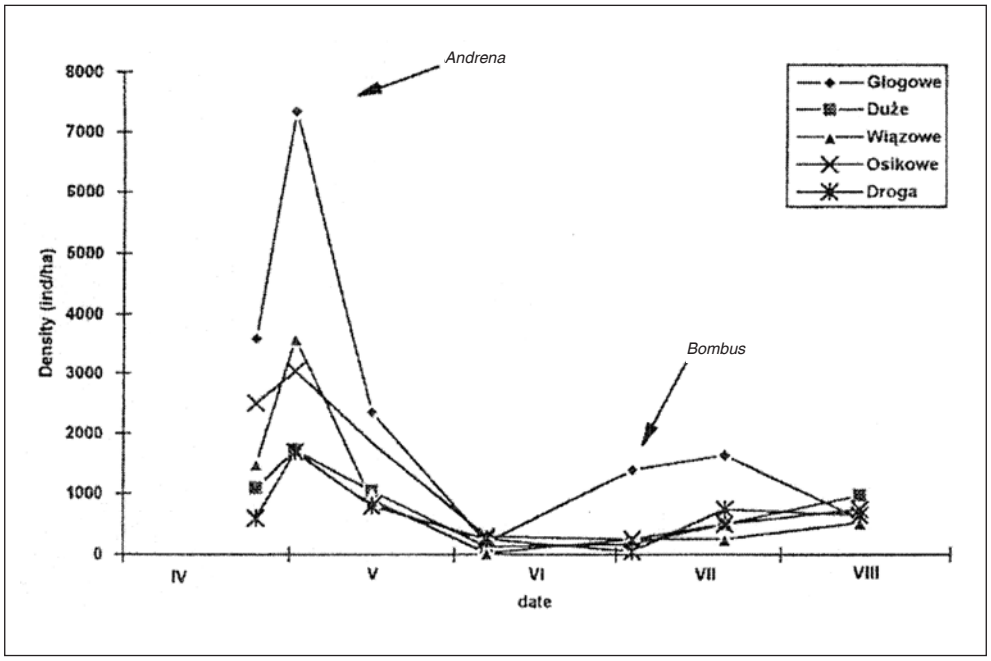

Fig. 3 - Dynamics of Apoidea density in the studied forest islands.

DISCUSSIONS

Relatively slight changes were made in land utilization but in two places forestation took place while in one forest was felled. The spectral-zone photographs facilitated also describing changes in the range of each cultivated area. In the north-west part, near Milno and Kicin fields, they were enlarged while in the south-east near Wierzonka their parceling and non-farming utilization took place.

In the south-eastern part, more variable hipsometrical photographs reveal characteristic structure of small effluvial cones as slope bottoms and thin lines intruding highland, being traces of small erosion cuts.

During the field studies carried out far, 10 different forest islands were subjected to particular studies (patch and belt refuges). The floristic composition of the stands has a semi-natural character. However, due to the small area, influence of the surrounding cultivations is frequently a strong one. The uncontrolled felling of trees and the absence of cultivation treatments create various forms of degeneration. Particularly noteworthy within the tall herb communities (due to the occupied area) are patches with dominating blackthorn (Pruno-Crataegetum) and elder (Sambucetum nigri). A somewhat different character is shown by the already historic materials referring to the cemetery in Kliny (G) (Fig. 1). In the summer of 1992 that area was ordered, some trees and all shrubs were cut out and herbaceous plants were destroyed. The shrub layer was built here of lilac (*Syringa vulgaris*) and elder (*Sambucus nigra*).

The communities of herbaceous species of the investigated forestations are grouped in three main groups: phytocenoses of skirt community, ruderal and field character whose genesis is connected with the direct neighbourhood of cultivated

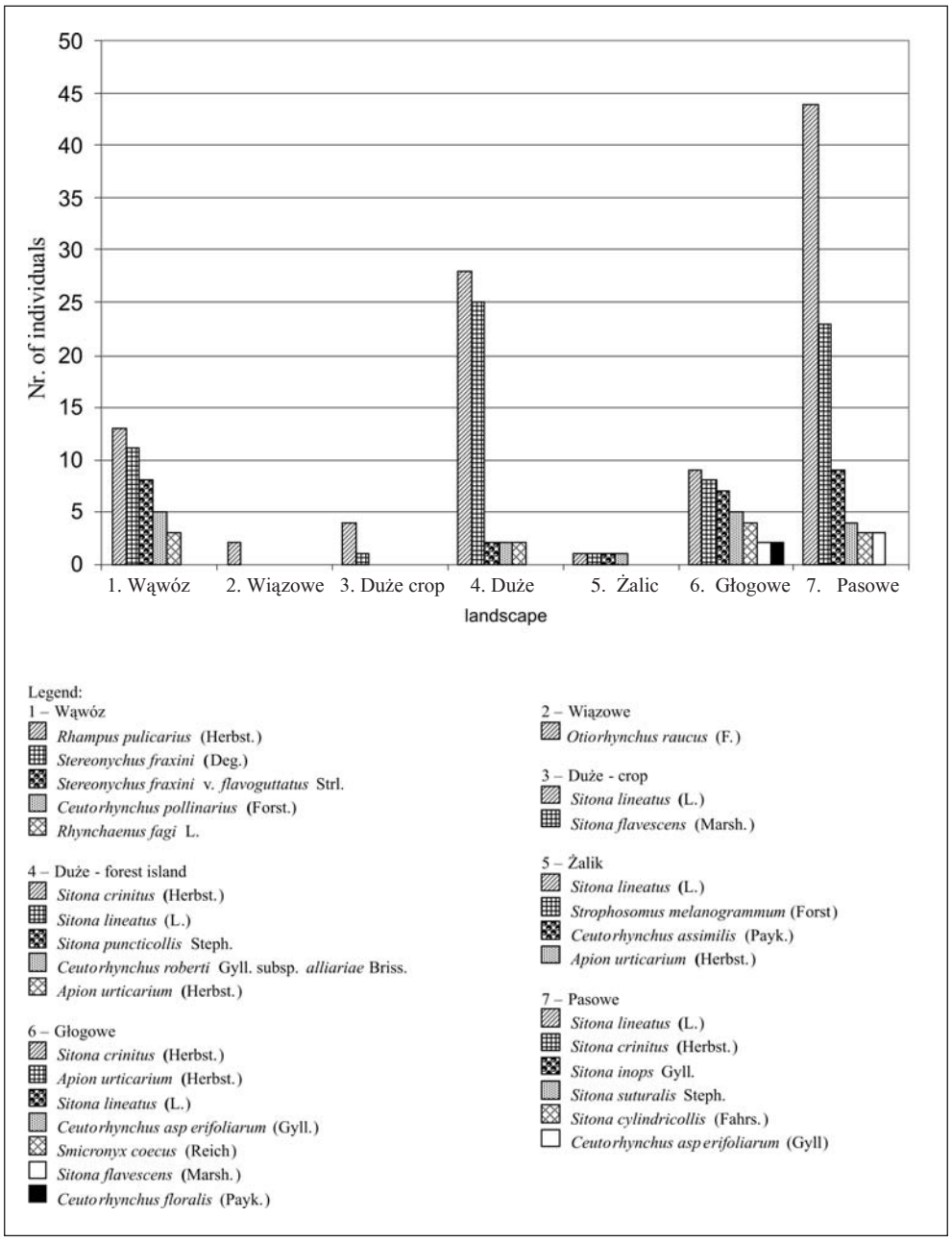

Fig. 4 - Dominance structure of Curculionidae species in the forest islands of Polish agricultural landscape.

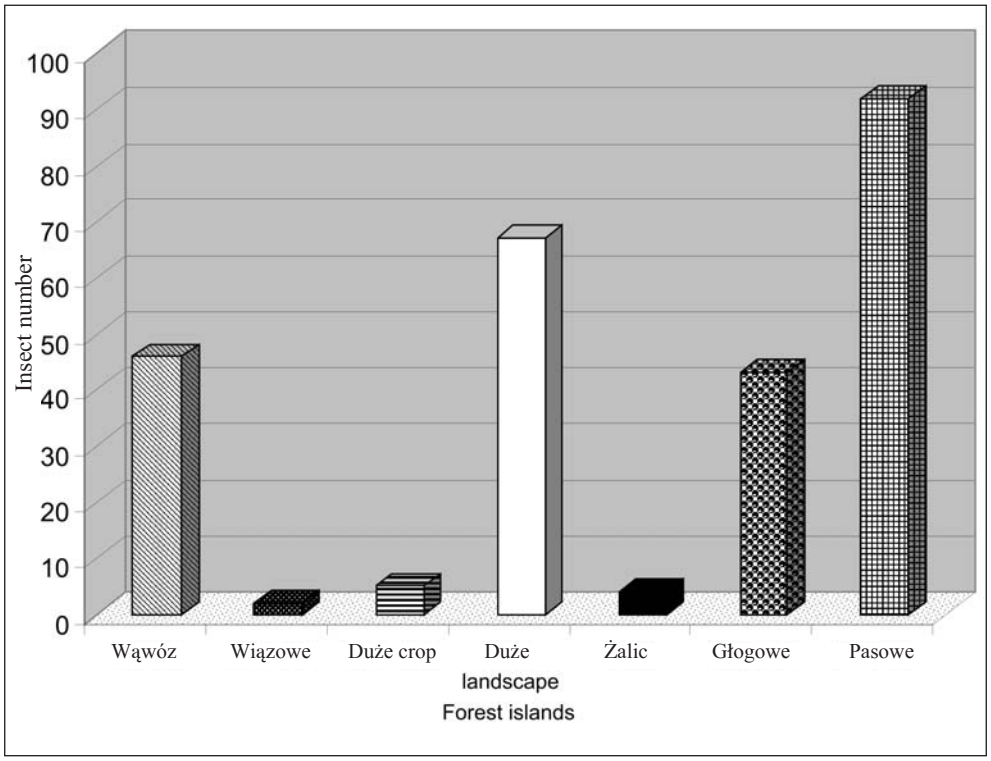

Fig. 5 - Density of weevils in the forest islands of the agricultural landscape area near Poznań.

fields. The first is mainly represented by patches with *Urtica dioica*, patches of the Alliarietum officinalis and Alliario-Chaerophylletum and Galio-Veronicetum. The ruderal associations, whose presence, similarly to that of segetal communities, is the result of strong anthropic pressures, do not occupy any major area. The phytocenoses with Balloto-Leonuretum and Leonuro-Arctietum are the most widespread among them. It must be stressed that the distinction between nitrophilous skirt communities, the Galio-Calystegietalia order, ruderal phytocenosis and the Onopordietalia order has sometimes a somewhat arbitrary character. Among the communities whose presence is closely connected to the neighboring cultivated fields, and reference to the size of area patches, *Agropyron repens* dominates. In the majority of the discussed forestations, phytocenoses with *Stellaria media* were also observed. Among the studied forestations, they are distinguished by the presence of well preserved Ficario-Ulmetum campestris and such phytocenons as Urtico-Aegopodietum, Convolvulo-Rubetum caesi, Helianthetum tuberosi and communities with *Chelidonium majus* (i.e. nitrophilous skirt communities).

On the borders (edges) with southern and western exposure, phytocenons have a mezzo-xero-thermophil character and occur with species as: *Euphorbia cyparissias*, *Poa pratensis* ssp. *angustifolia*, *Gallium mollugo.* One can also encounter here patches of grass and ruderal vegetation. On the edges of forestations

Table 7

Spectrum of weevil fauna (Coleoptera: Curculionidae) in the forest island near Poznan.

Species	Wawøz		Wiązowe		Duże crop		Duże Landscape		Żalik		Głogowe		Pasowe	
	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha
Subfam. Otiorrhynchinae														
1. *Otiorhynchus* (s.str.) *raucus* (F.)	-	-	2	100	-	-	1	50	-	-	-	-	1	50
2. O. (*Dorymerus*) *intrusus* Reich.	-	-	-	-	-	-	-	-	-	-	-	-	1	50
3. *Phyllobius* (*Dicletus*) *argentatus* (L.)	-	-	-	-	-	-	-	-	-	-	1	50	1	50
4. *Ph.* (s.str.) *arborator* (Herbst.)	-	-	-	-	-	-	-	-	-	-	-	-	2	100
Subfam. Brachyderinae														
5. *Sitona griseus* (F.)	1	50	-	-	-	-	-	-	-	-	-	-	-	-
6. *S. flavescens* (Marsh.)	-	-	-	-	1	50	1	50	-	-	2	100	-	-
7. *S. lineatus* (L.)	-	-	-	-	4	200	25	1,250	1	50	7	350	44	2,200
8. *S. puncticollis* Steph.	-	-	-	-	-	-	2	100	-	-	1	50	-	-
9. *S. crinitus* (Herbst.)	-	-	-	-	-	-	28	1,400	-	-	9	450	23	1,150
10. *S. suturalis* Steph.	-	-	-	-	-	-	-	-	-	-	-	-	4	200
11. *S. inops* Gyll.	-	-	-	-	-	-	-	-	-	-	-	-	9	450
12. *S. cylindricollis* (Fahrs.)	-	-	-	-	-	-	-	-	-	-	-	-	3	150
13. *Strophosomus melanogrammum* (Forst.)	-	-	-	-	-	-	-	-	1	50	-	-	-	-
Subfam. Curculioninae														
14. *Curculio glandium* Marsh.	1	50	-	-	-	-	-	-	-	-	-	-	-	-
15. *C. crux* F.	1	50	-	-	-	-	-	-	-	-	-	-	-	-
Subfam. Calandrinae														
16. *Ceutorhynchus* (s.str.) *quadridens* (Panz.)	1	50	-	-	-	-	1	50	-	-	1	50	-	-
17. *C.* (*Ethlecus*) *pollinarius* (Forst.)	5	250	-	-	-	-	1	50	-	-	-	-	-	-
18. *C.* (*Calosirus*) *posthumus* Germ.	1	50	-	-	-	-	-	-	-	-	-	-	-	-

Table 7 (continued)

Species	Wawøz		Wiązowe		Duże crop		Duże Landscape		Żalik		Głogowe		Pasowe	
	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha	No of ind.	ind./ha
19. *C.* (s.str.) *assimilis* (Payk.)	-	-	-	-	-	-	1	50	1	50	-	-	1	50
20. *C. assimilis* (s.str.) v. *litturatus* Sch.	1	50	-	-	-	-	-	-	-	-	-	-	-	-
21. *C.* (s.str.) *roberti* Gyll.	-	-	-	-	-	-	-	-	-	-	1	50	-	-
22. *C. roberti* Gyll. subsp. *alliariae* Briss.	-	-	-	-	-	-	2	100	-	-	-	-	-	-
23. *C.* (*Hadroplontus*) *asperifoliarum* (Gyll.)	-	-	-	-	-	-	1	50	-	-	5	250	3	150
24. *C.* (*Calosirus*) *floralis* (Payk.)	-	-	-	-	-	-	-	-	-	-	2	100	-	-
25. *Sibinia pellucens* (Scop.)	-	-	-	-	-	-	1	50	-	-	-	-	-	-
26. *Stereonychus fraxini* (Deg.)	11	550	-	-	-	-	-	-	-	-	-	-	-	-
27. *S. fraxini* v. *flavoguttatus* Stier.	8	400	-	-	-	-	-	-	-	-	-	-	-	-
28. *Rhynchaenus* (*Euthoron*) *fagi* L.	3	150	-	-	-	-	-	-	-	-	-	-	-	-
29. *Rhamphus pulicarius* (Herbst.)	13	650	-	-	-	-	-	-	-	-	-	-	-	-
30. *Rhamphus oxyacanthae* (Marsh.)	-	-	-	-	-	-	1	50	-	-	-	-	-	-
31. *Smicronyx coecus* (Reich)	-	-	-	-	-	-	-	-	-	-	4	200	-	-
Subfam. Apioninae														
32. *Apion* (*Taeniapion*) *urticarium* (Herbst.)	-	-	-	-	-	-	2	100	1	50	8	400	2	100
33. *A.* (*Catapion*) *burdigalense* (Wenck.)	-	-	-	-	-	-	-	-	-	-	1	50	-	-
34. *A.* (s. str.) *aestimatum* Fst.	-	-	-	-	-	-	-	-	-	-	-	-	1	50
Subfam. Rhynchitinae														
35. *Rhynchites (Coenorrhinus) aequatus* (L.)	-	-	-	-	-	-	-	-	-	-	1	50	-	-
36. *Attelabus nitens* (Scop.)	-	-	-	-	-	-	-	-	-	-	-	-	1	50

with northern and eastern exposures nitrophilous edges communities definitely dominate.

Small-areas of forest islands become also the refuges of forest species in the agricultural landscape. During the investigations (and excluding trees and shrubs) tree species of fern have been found: *Dryopteris spinulosa*, *D. filix-mas* and *Pteridium aquilinum*, numerous grasses: *Poa nemoralis*, *Festuca gigantea*, *Brachypodium sylvaticum*, *Dactylis acschersoniana*, *Melica nutans* and also *Scrophularia nodosa*.

The so called ecological lands also present enclaves which supply refugees for species and communities of perennial vegetation with a semi-natural character. Intensive utilization of arable land consists of maintaining cultivated phytocenosis in the early stage of succession. The cultivations usually change every year or every second year. Perennial herbaceous vegetation and grasses can develop only on the field edges, on balks, in field forestations and in inaccessible places like slopes, ravines, local depressions etc.

The observed large differentiation of the mite species number in the studied forest communities can be related to their size. On greater objects (Fig. 1 C, J) larger number of plant communities and more flora species (Banaszak, 1993), and their greater biocoenosis stability appeases the effects of agro technical treatments and creates better conditions for mite fauna life. In the C field forest also the highest level of actual water content of soil, unhopefully, favours development of the majority of mite groups. High number of mite species in the J forest at relatively low water content level resulted mainly from high proportion of Acari better adjusting to periodical deficit of soil water.

The small area field forest communities do not develop in their internal parts stable micro-environmental conditions, and stratification of their plant communities is often considerably disturbed. There, practically the whole refuge functions as an edge community (Ranney et al., 1981). The results of investigations concerning mite species diversity reveal relatively great differentiation concerning both the number and species composition of Gamasida living in the discussed forest islands. Analysis of the domination structure of these mites indicates also greater stability of populations in the greatest forest (C) as compared to the remaining ones. Occurrence of *Alliphis siculus*, *Nenteria breviunguiculata*, *Arctoseius cetratus* and *Rhodacarellus subterraneus* populations in the investigated forests makes their mite fauna similar to that found in soils under permanent cultivation.

Fauna of spiders of the studied sites seems to be relatively rich considering small area of the field forest communities. In the forest islands two plant layers are clearly separated. Therefore the collected specimens were qualified according to their association to the layer of trees and high bushes or to the vegetal cover and litter. On the basis of this distinction the differences between both forest floors were established (Tabs 4 and 5). The lower layer is richer in families, poorer in species but more numerous (according to estimations). The spider fauna of the upper floor is more differentiated with respect to species but less numerous. The number of spiders in sampling periods varied considerably. On basis of the general estimation the following changes in the number of collected specimens were observed: great number of spiders in the period May – mid June, falls in the number of collected specimens in July and August and gradual increase till October.

The number of the species of Curculionidae has been strictly connected to the forestation and the number of plant species. Significantly higher density has

been observed in the large forest islands where large number of species of the plant communities is growing (Fig. 4). Most part of these species of plant communities are the host-plants and the source of food for insects. From this point of view we considered three ecological categories of weevil species:

- species characteristics, strictly connected to the host-plant;
- species of passage for which the forest islands are only a temporary source of food;
- species non-characteristics which accidentally appear in this habitat.

Conclusions

The investigated forest islands are settled by species richness of invertebrate arthropod fauna (Acari, Araneae, Apoidea, Curculionidae), though these habitats differ with respect to fauna composition corresponding to floristic differentiation. The greatest number of species was found in the forest enclave with the largest area. The studied forest islands also have relatively high number of invertebrate fauna as compared to, e.g. greater forest patches. In case of Apoidea and Acari, record densities were found, comparable to the richest habitats of natural character. For flying insects, forest islands are a permanent habitat (particularly for smaller species of wild bees and some Curculionidae) or a place where they appear for short time to get nectar.

The formation of the landscape according to the requirements of the present ecological knowledge should strive to preserve (or reconstruct) its mosaic character. In areas, where agricultural land dominates, the elements of arborescent plants should be absolutely protected and fragments of balks should be left unutilized.

ACKNOWLEDGEMENTS

We are so grateful to Prof. dr. Lech Ryszkowski, director of Plant Protection Institute from Poznań and also to dr. Jerzy Karg, head of Experimental Station of Agrobiology and Forestry from Turew for kindly permission and technical help and support for carring out this study. Also, we thanks to the anonymous scientific referees for their useful advice regarding this paper.

IMPORTANȚA REFUGIILOR FORESTIERE PENTRU BIODIVERSITATEA NEVERTEBRATELOR: UN STUDIU DE CAZ ÎN VESTUL POLONIEI

REZUMAT

Studiile de ecologie privind arhitectura peisajului agricol şi conexiunile dintre diferitele formaţiuni structurale (ecosisteme naturale, antropice, seminaturale etc.) întreprinse au avut drept scop protejarea, restaurarea şi conservarea biocenozelor vizate prin identificarea şi definirea unor unităţi ecologice multi- sau supra-ecosistemice, arii regionale şi evidenţierea caracterului de unităţi furnizatoare de servicii economice sau de resurse.

Cercetările ecologice privind noţiunea de „landscape” sunt deosebit de intens desfăşurate de foarte mulţi cercetători din multe instituţii ştiinţifice de pe întregul mapamond. Peisajul agricol predominant în vestul şi centrul Europei ocupă un loc semnificativ în ceea ce priveşte distribuţia pe teritoriul Poloniei, constituind aproape 60% din teritoriul ţării, influenţând într-o mare măsură asupra calităţii întregului mediu natural.

Studiile asupra asociaţiilor vegetale arboricole sau arborescente („forest islands”; „insule forestiere”) s-au desfăşurat în perioada 2004-2005 într-o arie reprezentativă din zona de vest a Poloniei, la 15 Km nord-est de oraşul Poznań. Au fost identificate şi selectate pentru studiu 10 asemenea formaţiuni de mărimi variabile (de la 0,5 ha la 1,5 ha). Flora şi comunităţile de plante studiate în interiorul acestor mici păduri au permis identificarea şi examinarea unui număr de 58 de asociaţii vegetale.

Ariile reprezentative, cu suprafețe de diferite mărimi ocupate de vegetație arboricolă sau arborescentă, constituie refugii pentru o bogată biodiversitate a faunei de nevertebrate în cadrul peisajului agricol. Structura faunistică, densitatea numerică și dominanța unor grupe de nevertebrate (Acari, Araneae, Apoidea și Curculionidae) sunt prezentate în lucrare. Ariile studiate asigură condiții propice pentru supraviețuirea și reproducerea multor specii animale cât și pentru speciile necaracteristice, accidentale arealului care folosesc aceste zone pentru refugiu și hrană temporare.

LITERATURE CITED

BAKER, W. L., 1989 - Landscape ecology and nature reserve design in the boundary Waters Canoe Area, Minnesota. Ecology, 70: 23-35.

BANASZAK, J., 1980 - Studies on methods of censuring the numbers of bees (Hymenoptera: Apoidea). Polish Ecological Studies, 6 (2): 335-366.

BANASZAK, J., 1983 - Ecology of bees (Apoidea) of agricultural landscape. Polish Ecological Studies, 9: 421-505.

BANASZAK, J., (ed.), 1993 - Krajobraz ekologiczny. Wyższa Skoła Pedagogiczna, Bydgoszcz, 456 pp. (in Polish)

BANASZAK, J., H. RATYŃSKA, 1993 - Field forestations as a refuges and places for ecological investigations. Chrońmy Przyrodę Ojczysta, 55-60.

CZARNECKI, Z., 1956 - Materials for bird ecology nesting in the field forestations. Ekologia Polska, A, 4 (13): 379-417.

D□BROWSKA-PROT, E., 1987 - The mid-field woodlots in the agricultural landscape. Wiadomosci Ekologiczne, 33 (1): 47-59.

D□BROWSKA-PROT, E., 1992 - The role of forest islands in the shaping of the structure and entomofauna function in an agricultural landscape. Ekologia Polska, 39 (4): 481-516.

DZWONKO, Z., S. LOSTER, 1989 - Species richness of small woodlands on the western Carpatian foothills, Vegetatio, Dordrecht, 76: 15-27.

FORMAN, R. T. T., M. GODRON, 1986 - Landscape ecology. New York: John Wiley and Sons.

KACZMAREK, S., 1990 - Akarofauna glebowa (Acari) zadrzewień robinowych w krajobrazie rolniczym okolic Turwi ze szczególnym uwzględnieniem Gamasida. Wydawnictwo, SGGW-AR, 191 pp. (in Polish)

KOZAKIEWICZ, M., J. SZACKI, 1987 - Drobne ssaki środowisk izolowanych, wyspy na lądzie czy tylko populacje wyspove? Wiadomosci Ekologiczne, 33: 31-45. (in Polish)

MATUSZKIEWICZ, A., 1990 - Kompleks krajobrazowo-roślinny jako określony typ układu ecologicznego (na wybranych przykładach). (w.) Problemy ochrony i kształtowania środowiska przyrodniczego na obszarach zurbanizowanych. cz. II 22 SGGW-AR CPBP 04.10. Ochrona i kształtowanie środowiska przyrodniczego. Warszawa. (in Polish)

MATUSZKIEWICZ, W., 1981 - Guide to determination of plant communities in Poland. Państwowe Wydawnictwo Naukowe, Warszawa: 1-300.

OPDAM, P., G. RIJSDIJK, F. HUSTINGS, 1985 - Bird communities in small woods in an agricultural landscape: effects of area and isolation. Biological Conservation, 34: 333-352.

RANNEY, J. W., M. C. BRUNER, J. B. LEVERISON, 1981 - The importance of edge in the structure and dynamics of forest islands. Pp. 68-95. *In*: R. L. Burgess, D. M. Sharpe (eds), Forest island dynamics in main-dominated landscape. Springer, Berlin.

RISSER, P. G., J. R. KARR, R. T. T. FORMAN, 1984 - Landscape ecology: directions and approaches. Special. Pub. No. 2 Illinois Natural History survey, Champaign.

RYSZKOWSKI, L., S. BAŁAZY, 1992 - Wybrane problemy ekologii krajobrazu. Zakład Badań Środowiska Rolniczego I Leśnego PAN, Poznań, 210 pp. (in Polish)

SENICZAK, S., G. GÓRNIAK, S. KACZMAREK, 1987 - Zróżnicowanie akarofauny glebowej (Acarida) w wybranych ekosystemach okolic Turwi. Zesztita Naukowe ATR, 15: 68-136. (in Polish)

SENICZAK, S., S. KACZMAREK, A. KLIMEK, 1991 a - Akarofauna glebowa (Acari) wybranych zadrzewień śródpolnych okolic Turwi, cz. I. Zesztita Naukowe ATR, 19: 143-152. (in Polish)

SENICZAK, S., S. KACZMAREK, A. KLIMEK, 1991 b - Akarofauna glebowa (Acari) wybranych zadrzewień śródpolnych okolic Turwi, cz. II. Zesztita Naukowe ATR, 21: 111-123. (in Polish)

TURNER, M. G. (ed.), 1987 - Landscape heterogenity and disturbance. New York: Springer Verlag.

TURNER, M. G., R. H. GARDNER, (eds), 1991 - Quantitative methods in landscape ecology. The analysis and interpretation of landscape ecology. The analysis and interpretation of landscape heterogenity. New York: Springer Verlag.
URBAN, D. L., R. V. O'NEIL, H. H. SHUGART, 1987 - Landscape ecology. Bioscience, 37: 119-127.
VOS, C. C., P. OPDAM, (eds), 1993 - Landscape ecology of a stressed environment. Publ. Chapman and Hall, London, 310 pp.
WODZICZKO, A., 1932 - Ochrona przyrody nową gałęzią wiedzy. Chrońmy Przyrodę Ojczysta, 12. (in Polish)
WODZICZKO, A., 1945 - O uprawie krajobrazu. Chrońmy Przyrodę Ojczysta, 1: 16-25. (in Polish)
WODZICZKO, A., 1946 - Ochrona przyrody jako nauka i jej potrzeby. Chrońmy Przyrodę Ojczysta, 12: 8-15. (in Polish)
WOJTERSKI, T., H. WOJTERSKA, M. WOJTERSKA, 1982 - Potential natural vegetation of central Wielkopolska. Badania Fizjografia Nad Polską Zachstenie S. B., 32: 7-35.

Received: February 15, 2010
Accepted: April 29, 2011

Traian Manole, Irina Ionescu-Mălăncuş,
Eugenia Petrescu, Gabriela Mărgărit
Research-Development Institute for Plant Protection,
8 Ion Ionescu de la Brad Bvd, District 1, Bucharest-Romania
e-mail: traian.manole@gmail.com

József Banaszak, Halina Ratyńska
Katedra Biologii i Ochrony Środowiska WSP,
Bydgoszcz, Poland
e-mail: halrat@wp.p