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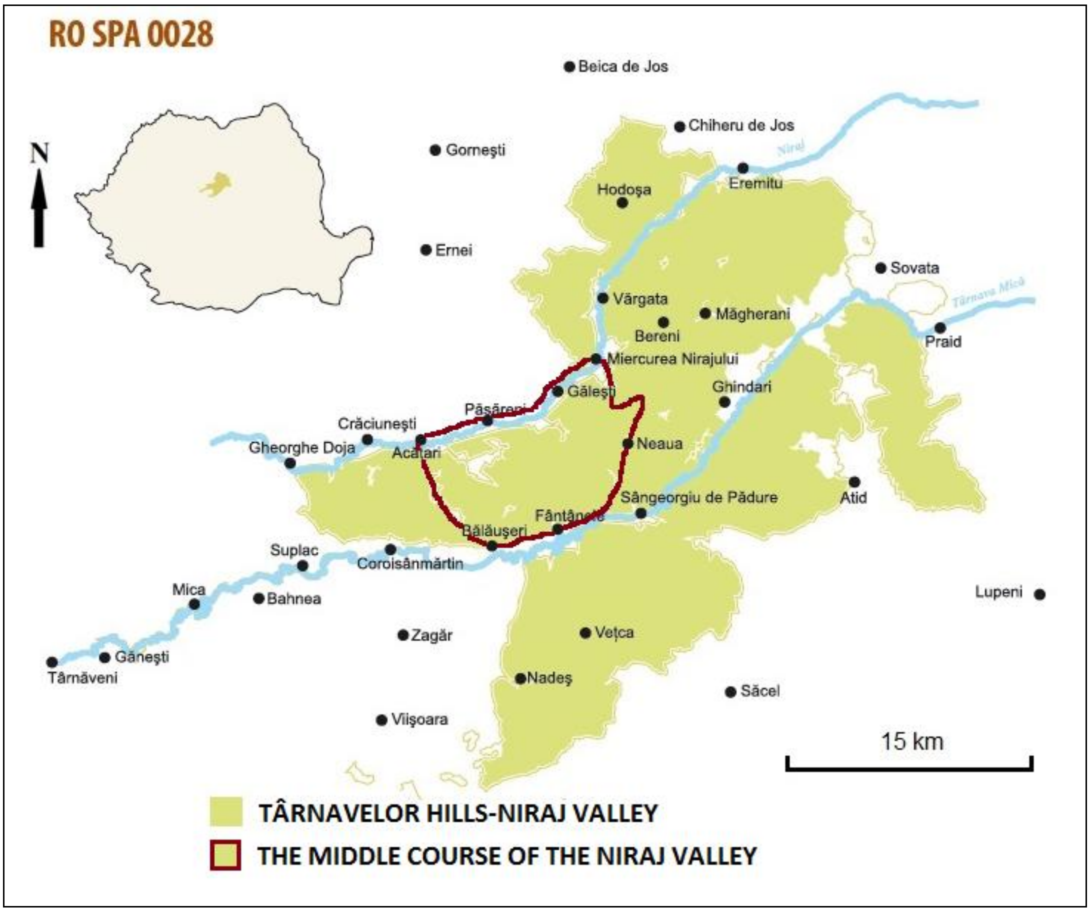
THE WOODY VEGETATION STRUCTURE FROM THE MIDDLE STREAM OF THE NIRAJ VALLEY; IT'S IMPORTANCE FOR THE AVIFAUNA
- PhD Thesis Summary -



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PhD Thesis Content

Introduction

The Associations of „Milvus Group” and Microregiunea Valea Nirajului-Nyárádmente in partnership with the Association of Microregiunea Târnava Mică-Bălăușeri-Sovata gained the rights to manage four Natura 2000 sites from the region of Niraj valley and Târnava Mică. Special Protection Area, Târnavelor Hills-Niraj Valley (ROSPA0028), is one of the four sites with a surface of 86.073 ha.

Protected areas need periodical activities of evaluating and monitoring biodiversity. The knowledge of the phytocoenotic composition of the areas is one of the most important elements for the effective protection and for assuring the long-term survival of the most valuable and threatened species and habitats.

Our aim was the study of the woody vegetation and also of the avifauna from the middle course of the Niraj valley, part of the Special Protection Area Târnavelor Hills-Niraj Valley, for a better knowledge of the habitats that play an important role in sustaining a large number of endangered birds or birds with priority protection status.

To fulfill our aim, we have proposed the following **objectives**:

1. identification and characterization of the woody associations from the middle course of the Niraj valley;
2. the description of the woody vegetation on habitat types according to the latest international regulations;
3. the qualitative structure assessment of the woody vegetation;
4. the qualitative study of the avifauna from the middle course of the Niraj valley;
5. the quantitative study of the bird communities from the woody vegetation;
6. the study of the structural and compositional factors with role in sustaining woodpeckers and other bird communities from the deciduous forests.

Thus our thesis fits in Biocoenology and it is meant to scientifically fundament the functioning of the woody ecosystems and the management measures of the protected areas from the studied region.

I. BIOCOENOLOGICAL STUDIES: GENERAL CONSIDERATIONS

1.1. Biocoenology and its place in the natural science

1.1.1. Biocoenology: definition and objectives

Biocoenology is a symbiological discipline. It can be defined like a complex science meant for biological systems organized above the population level: the biocoenoses. It synthesizes and integrates phytocoenological and zoocoenological studies, preferable microbiological studies too (Kratochwil, 1987, 1991).

1.1.2. Relationships between Biocoenology, Ecology, Symbiology

According to Juhász-Nagy (1986) Ecology studies the causes (why?), while Symphenobiology studies the phenomenon (how?) of community organizations. Ecology together with Symphenobiology forms the science of Symbiology that studies organization levels above the individual.

Kratochwil (1991) presents two systems for classifying biological disciplines:

- according with the first system, biology has two mean research spheres: Idiobiology which comprises disciplines that deal with organismic and infra-organismic studies, while Symbiology deals with supra-organismic levels;

- in the second system, the study of the biocoenoses appears like a part of the Ecology: Autecology means the study of the individual in his relations with the environmental factors; Synecology studies the interactions between different populations.

In another model, presented by Thienemann (1942, *ap.* Kratochwil, 1991), Ecology deals with three levels of organization of the living matter: the individual-through Autecology, the biocoenosis-through Synecology and the ecosystem-through the General Ecology.

Since the study of the biocoenoses can be done in symbiological and also in synecological manner, Kratochwil makes a comparison between the two approaches: 1. Symbology is descriptive and inductive, while Synecology is analytical and deductive; 2. Symbiology has led to systemic thinking, species playing a minor role, while Symbiology means the integration of autecological results in a higher level (that of the biocoenoses); 3. Symbiology doesn't focuses on the research of the effects of abiotic factors on plant and animal communities, while in Synecology this becomes a priority.

1.2. Biocoenological studies in Romania

1.2.1. The beginnings of the Biocoenology in Romania

The first biocoenological observations are closely related to phytocoenological studies, so that Synecology becomes a research field within Phytocoenology or Geobotany (also called Phytosociology).

1.2.2. Biocoenological studies in the second half of the XX.th century

The first attempts of combining phytocoenological researches with zoocoenological ones, were performed at Cluj (Kovács *et al.*, 1965-1970, Coldea *et al.*, 1987). These attempts have followed the traditions of the Biocoenology School, founded by Sukacev (1961). In Bucharest, the research team led by Popescu-Zeletin (1971) anticipated the International Biological Program (IBP, 1964-1974) with the ecological description of the Babadag Plateau. In Suceava, Seghedin *et al.* (1977) conducted some biocoenological studies in the Lunca Zamostei Natural Reserve.

1.2.3. Biocoenological studies in the first decade of the XXI century

In this period synecological researches are continued in various fields of Biology. From the symbiological studies we can mention among others the description of the urban environments from Cluj-Napoca (Cristea *et al.*, 2002), studies of plant and vertebrate communities of some reserves and national parks (Ion *et al.*, 2004, Chifu *et al.*, 2008) and trans-boundary reserves, inclusively (Ion *et al.*, 2009). Some interdisciplinary researches tried to present the Banat's Black pine site: the complexity of its biotopes and biocoenoses (Pătroescu *et al.*, 2007). In a project coordinated by the Romanian Academy (Otiman *et al.*, 2010) studies were made in the field of biodiversity and geo-diversity regarding the Ţara Haţegului-Retezat region and presenting the opportunities in eco-agriculture.

II. CHARACTERIZATION OF THE STUDY AREA

2.1. Geographical position and the boundaries of the study area

The study area is situated in the Târnavelor Plateau, in the middle course of the Niraj valley (N46.27117, E24.45289) and includes the localities: Acăţari, Văleni, Găieşti, Suveica, Murgeşti, Roteni, Gălăţeni, Păsăreni, Bolintineni, Troiţa, Bedeni, Găleşti, Adrianu Mic şi Adrianu Mare (Orbán, 1991).

The boundaries of the study area are national roads 13, 13A and county roads 151D, 135A, respectively. It covers an area of 14.987 ha. It is part of the Special Protection Area ROSPA0028 called Târnavelor Hills-Niraj Valley.

2.2. Geomorphology and geology

The Niraj-Târnava Mică Interfluve is a hilly and fragmented plateau, characterized by north-south oriented parallel and asymmetric interfluves. Landslides are common. The most common rocks are: argil, argil with marl and loamy sands from the Pontian age. At the surface, a couverture was formed in the Pleistocene, made up of argil and loam (Jakab *et* Sighişorean, 1983).

The East Transylvanian High Hills: is a hilly and strongly fragmented plateau where landslides are common. The most common rocks are: argil, sands, argil with marl and loamy sands. At the surface, a couverture was formed in the Pleistocene, made up of argil and loam (Jakab *et* Sighişorean, 1983).

The Mureş-Niraj Corridor: it is represented by floodplains, un-flooded meadows and terraces. The most common rocks are: on terraces-gravels covered with loam and sandy loams; in meadows-alluvium (Jakab *et* Sighişorean, 1983).

The Miercurea Niraj-Dămieni sector of the Niraj Corridor: it is characterized by floodplains and narrow terraces. The most common rocks are: on terraces-gravels covered with argillaceus loams and argil; in meadows-alluvium (Jakab et Sighişorean, 1983).

The territory is part of a depression- a geotectonic unit with a very deep subsistence. The crystalline basement was identified at a depth of 3000-5000 m (Josan, 1979).

2.3. Soil types

After the Romanian system of soil taxonomy (Florea *et* Munteanu, 2000, Blaga *et al.*, 2005), the soils present in the study area can be classified in various types and subtypes:

- *luvosol* (typical brown luvic soil) from the class of Luvisols (equivalent with the class of Argiluvisols) is the most common soil type in the area. It can be found on weak to moderate inclined slopes, regardless of exposure;
- *regosol* from the class of Protisols (equivalent with the class of Undeveloped soils) it is present on the inclined slopes;
- *phaeozem* (pseudorendzina) from the class of Cernisols (equivalent with the class of Mollisols) is present where the lithologic substrate is marl;
- the meadow part of the Niraj valley presents *aluviosol* and *hydromorphic* soil.

On less inclined slopes and horizontal fields the process of pseudogleisation can be observed (Amenajamentul U.P. VIII Gălăţeni, 2008, Mac, 1972, Josan, 1979).

2.4. Climate

The territory is benefitting from a mild-continental climate (Roșu, 1980):

- the average annual ***temperature*** is 8.5°C;
- the average annual ***precipitation*** value is 600 mm/m^2;
- the average ***atmospheric humidity*** is 70-80%;
- usually ***winds*** have a medium frequency and intensity; the area is subjected mostly to the influence of atmospheric circulation from the northern sector (Roșu, 1980, Amenajamentul, U.P. VIII Gălăţeni, 2008, *http://www.weatheronline.co.uk*).

2.5. The hydrographic network

The studied area belongs to drainage basin of the Mureș. Water collector in this area is River Niraj, a tributary of the Mureş. River *Niraj* rises from altitude of 1300 m from the volcanic mountains of Gurghiu. Natural course length is 79 km. It flows into the River Mureş near the locality called Ungheni.

Niraj Valley, on the middle course, has a width of about 2 km. The average flow rate is 3.6 m^3/s. The river brings large amounts of alluvial deposits during floods, so the river was named the "blonde Niraj" (after its yellow color).

300 years ago on the left side of the Niraj valley was built the Veţca channel. The channel collected the water coming from the hills preventing inundation of agricultural lands.

The main tributaries of Niraj in the middle course are the following rivulets: Fagului Mare, Dumitreştilor, Dorman, Niaroş (Tamaş), Lucion, Gălăţeni (Pădurea), Roteni and Suveica (Vaia) (Hajdu, 2010, Újvári, 1972).

2.6. Land use

Settlements in the study area are located on the right side of the River Niraj, and in the valley of the Lucion and Dorman rivulets. In the drainage basin of Niraj there were many lakes and swamps that have been drained to increase agricultural land area. In the socialist era, the main concern being cultivation of the cereals many orchards were cleared and the land has been used for growing cereals. Grasslands occupy a small area (9.92%) and are used as pasture or hayfields.

Deciduous forests (about 2809 ha) are stationed on the left side of the Niraj and belong to the Forest Departments from Târgu-Mureş and Ghindari.

Woody vegetation is characterized by oak, sessile oak and hornbeam forming the association *Querceto-Carpinetum transsilvanicum*. On the northern slopes, near the streams, besides these species, beech becomes dominant. These forests dominated by beech and hornbeam belong to *Carpino-Fagetum* (*Fageto-Carpinetum transsilvanicum, ap.* Csűrös, 1963). On a smaller surface (less than 10% from the forests) there are coniferous and deciduous plantations. Floodplain vegetation, which was once represented by floodplain forests (forests of poplar, willow and alder), is characterized by narrow strips of shrubs and coppices (Csűrös, 1963). Hedges are widely disseminated through meadows with species like *Crataegus monogyna*, *Prunus spinosa*, *Rosa canina*, indicating places where forests once were present.

Orchards were once famous, supplying a large quantity of fruits for the region (plums, cherries, apples, pears). Since the 1700s, until the period of collectivization, the surroundings of Adrianu Mic and Adrianu Mare, were the most famous areas in fruit production, especially cherries (according to locals Sipos Imre from Troița, Bakó Mihály from Bedeni and Szabó Zoltán Attila from the Focus Eco Center; Török, 2008).

III. THE WOODY VEGETATION FROM THE MIDDLE STREAM OF THE NIRAJ VALLEY

3.1. Materials and methods

For describing plant communities, we used the phytosociological research method of Central European School (Braun-Blanquet, 1964). A total of 136 relevés were made during the years 2011-2012.

Identification and classification of plant associations in the phytocoeno-system was done after Coldea (1991), Sanda (2002) and Sanda *et al*. (2008).

Habitat classification was made according to Doniță *et al.* (2005) and Gafta *et* Mountford (2008).

Floristic richness was calculated for each of the studied associations (total number of plant species found in one association). Because it was not possible to make an equal number of surveys for all of the studied associations, and sample size was different depending on vegetation types (400 m^2-in forests, 100 or 50 m^2-în scrubs), we have calculated the floristic richness of each sample and we have reported it to an area of 1 m^2.

Kruskal-Wallis test was used to compare the floristic richness/1 m^2 in different associations and the Mann-Whitney U test, to determine whether these differences are significant or not (Kosiński *et* Kempa, 2007).

In the qualitative structure analysis of the plant communities, the spectrums for bioforms (method Diemont), geoelements, ecological indices and genetic types were elaborated (Csűrös *et* Csűrös-Káptalan, 1966, Csűrös *et al.*, 1970, Cristea *et al.*, 2004). We have calculated the altitudinal index (K_a) developed by Pop *et* Drăgulescu (1983). Its value indicates the climate, the vegetation zone and the intensity of disturbing factors. The diploid index (I.D.) was also calculated. It represents the ratio of diploid and polyploid species (Cristea *et al.*, 2004). Bioforms and geoelements were established after Ciocârlan (2009). Composition in economical categories was made according Csedő (1980), Ciocârlan (2009), Oroian (1995) and Pop (1982).

3.2. Results and discussions

3.2.1. Classification of the woody phytocoenoses

The associations have been included in the following phytocoeno-system:

SALICETEA PURPUREAE Moor 1958

Salicetalia purpureae Moor 1958

Salicion triandrae Th. Müller et Görs 1958

Salicetum triandrae Malcuit 1929

Salicion albae Soó 1930 em. Th. Müller et Görs 1958

Salici-Populetum Meijer-Drees 1936

QUERCO-FAGETEA Braun-Blanquet et Vlieger in Vlieger 1937 em. Borhidi 1996
Fagetalia sylvaticae Pawlowski in Pawlowski et al. 1928
Symphyto cordati-Fagion Vida 1959
Lathyro hallersteinii-Carpinenion Boşcaiu et al. 1982
Carpino-Fagetum Paucă 1941
Carpino-Quercetum petraeae Borza 1941
Quercetalia roboris R. Tüxen 1931
Genisto germanicae-Quercion Neuhäusl et Neuhäuslová-Novotná 1964
Genisto tinctoriae-Quercetum petraeae Klika 1932 subas. *melicetosum uniflorae* (Gergely 1962) Sanda et Popescu 1999
RHAMNO-PRUNETEA Rivas Goday et Borja Carbonell 1961
Prunetalia spinosae R. Tüxen 1952
Prunion spinosae Soó 1951
Pruno spinosae-Crataegetum (Soó 1927) Hueck 1931

3.2.2. Description of the forest and scrub habitats

Salicetum triandrae Malcuit 1929

Its phytocoenoses grow in form of a continuous strip along the River Niraj, just above the flowing water or on higher places of the riverbanks, at an altitude of 310-330 m above sea level. In the association 50 vascular plant species were identified.

The *Salicetum triandrae* association fits in the habitat type: **Thickets of willow** (*Salix triandra*) (code: **R4416**).

Salici-Populetum Meijer-Drees 1936

Phytocoenoses of *Salici-Populetum* association appear in the form of a narrow band accompanying the upper part of water courses, at 320-350 m above sea level. In the association 98 vascular plant species were identified. The tree layer is rare with the clotting of the crown of 0.5-0.6. In some places the succession of the vegetation is observed from willow shrubs to alluvial forests.

The *Salici-Populetum* Meijer-Drees 1936 association (Syn.: *Salicetum albae* Issler 1924 s.l.=*Salicetum albae-fragilis* R. Tüxen 1937) belongs to the habitat type: **Danube forests of White Willow** (*Salix alba*) **with** *Rubus caesius* (code: **R4407**).

Carpino-Fagetum Paucă 1941

Hornbeam-beech forests from the study area inhabit restricted areas (less than 5% from the study area), the depths of streams and narrow valleys on luvosol (at 380-480 m above sea level). In the *Carpino-Fagetum* association 59 vascular plants were identified.

The association represents the following habitat type: **Dacian forests of beech** (*Fagus sylvatica*) **and hornbeam** (*Carpinus betulus*) **with** *Carex pilosa* (code: **R4119**).

Carpino-Quercetum petraeae Borza 1941

(Syn.: *Querco petraeae-Carpinetum* Soó et Pócs 1957)

Phytocoenoses of the association evolved from oak forests as a result of oak deforestation. The forests inhabit mainly less or moderately inclined slopes (5°-20°), at an altitude of 400-500 m above sea level, on slopes with northern exposure and weak acid luvosol. These phytocoenoses occupy the largest area (about 80%) of the deciduous forest habitats in the middle stream of the Niraj valley. In the shaded and sloped (10°-30°) valleys of the streams, or at higher altitudes (500-600 m) beech appears with abundance-dominance values from 1 to 3. In the *Carpino-Quercetum petraeae* association 118 vascular plants were identified.

Because *Lathyrus hallersteinii* was identified in only one of the 88 relevés, the phytocoenoses of the association were not assigned to *Lathyro hallersteinii-Carpinetum*, as in the case of many other studies.

The association *Querco petraeae-Carpinetum* Soó et Pócs 1957 fits in the habitat type: **Dacian forests of sessile oak** (*Quercus petraea*), **beech** (*Fagus sylvatica*) **and hornbeam** (*Carpinus betulus*) **with** *Lathyrus hallersteinii* (code: **R4124**).

Genisto tinctoriae-Quercetum petraeae Klika 1932
subas. *melicetosum uniflorae* (Gergely 1962) Sanda et Popescu 1999
(Syn.: *Melico uniflorae-Querceto petraeae* Gergely 1962)

Forests are installed on the crest of the hills or on the upper part of the slopes on luvosol at 500-550 m above sea level. It is representing about 8% of the deciduous forest habitats from the study are. In the sessile oak forests 75 vascular plants were identified.

The association *Genisto tinctoriae-Quercetum petraeae* Klika 1932 (Syn.: *Luzulo albidae-Quercetum petraeae* (Hillitzer 1932) Passarge 1953 em. R. et Z. Neuhäusl 1967) fits in the habitat type: **Dacian forests of oak** (*Quercus petraea*) **and beech** (*Fagus sylvatica*) **with** *Festuca drymeia* (code: **R4129**).

Pruno spinosae-Crataegetum (Soó 1927) Hueck 1931

Crataegus monogyna and *Prunus spinosa* bushes are encountered at the edge of woods, on cleared sites or sunny coasts. Besides the two edifying species, in the shrub layer other species were found too: *Acer campestre*, *A. platanoides*, *Cerasus avium*, *Clematis vitalba*, *Cornus sanguinea*, *Euonymus europaea*, *Euonymus verrucosa*, *Ligustrum vulgare*, *Quercus robur*, *Rosa canina*, *Viburnum opulus*. In 14 relevés 112 species were indentified. This is due to the edge effects which appear in the case of small habitat fragments.

The association *Pruno spinosae-Crataegetum* (Soó 1927) Hueck 1931 represents the following habitat type: **Ponto Pannonic scrubs of blackthorn** (*Prunus spinosa*) **and hawthorn** (*Crataegus monogyna*) (code: **R3122**).

According to other authors (Gafta *et* Mountford, 2008) the association is not indicated in this habitat type, because its distribution exceeds the Peri-Pannonic area.

3.2.3. The qualitative characterization of the woody phytocoenoses

The floristic richness (estimated as the absolute number of plant species in all of the relevés) has different values in the six associations: *Salicetum triandrae Malcuit* 1929: 50 species, *Salici-Populetum Meijer-Drees* 1936: 98 species, *Carpino-Fagetum* Pauca 1941: 59 sp., *Carpino-Quercetum petraeae* Borza 1941: 118 species, *Genisto tinctoriae-Quercetum petraeae* Klika 1932 subas. *melicetosum uniflorae* (Gergely 1962) Sanda et Popescu 1999: 75 species and *Pruno spinosae-Crataegetum* (Soó 1927) Hueck 1931: 112 species. The number of species increases with the area occupied by the phytocoenoses. The number of species is also influenced by the evolutionary stage of the phytocoenoses and the degree of human intervention. The association *Carpino-Quercetum petraeae* occupies the largest area (about 80%) of the deciduous forest habitats (Domokos *et* Cristea, 2013) and has the maximum number of the species.

Analyzing **floristic richness/1 m²**, we have found that the tickets of willow and the blackthorn and hawthorn scrubs have significantly higher number of species than the other studied habitat types (Kruskal-Wallis, ANOVA, $H = 62.06$, $p < 0.0001$). The number of species/1 m^2 in the white willow forests is significantly higher than in beech-hornbeam forest ($z = -2.90$, $p = 0.00366$) or in sessile oak, beech and hornbeam forests ($z = -3.45$, $p = 0.00051$). Also the species number in sessile oak forests is significantly higher than in sessile oak, beech and hornbeam forests ($z = -2.99$, $p = 0.00273$) (Fig. 1).

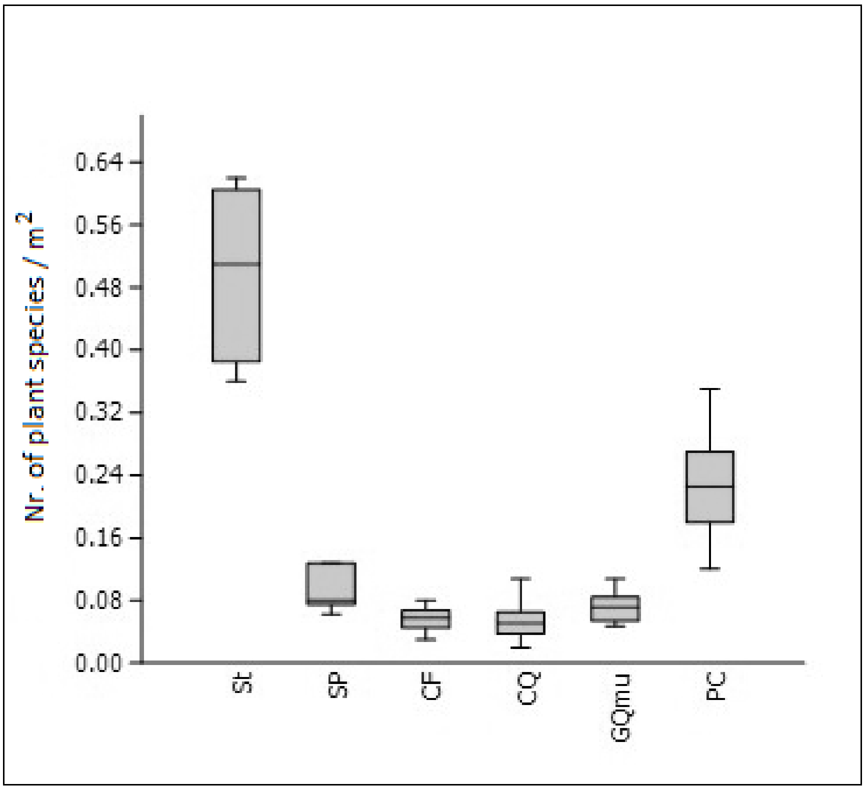

Fig.1. Floristic richness in different phytocoenoses; **Abbreviations: St**-*Salicetum triandrae*, **SP**-*Salici-Populetum*, **CF**-*Carpino-Fagetum*, **CQ**-*Carpino-Quercetum petraeae*, **GQmu**-*Genisto tinctoriae-Quercetum petraeae* subas. *melicetosum uniflorae*, **PC**-*Pruno spinosae-Crataegetum*

The spectrum of bioforms was performed by the method Diemont. As expected the phanerophytes (Ph) dominate, being followed by hemicryptophytes (H).

The values of K_a vary between 12 and 55.8%, which means that most of the associations are well conserved. Only riverine forests and willows present a strong anthropogenic pressure (Tab. 1.) to which is added the destructive action of floods.

Table1. ***The values of the altitudinal index (K_a) and diploid index (I.D.)***

Association/subassociation	**K_a**	**I.D.**
Salicetum triandrae	55%	0.72
Salici-Populetum	55.8%	1.13
Pruno spinosae-Crataegetum	28.8%	1.23
Carpino-Fagetum	12%	1.05
Carpino-Quercetum petraeae	21.1%	0.84
Melico uniflorae-Querceto petraeae	22.8%	1.31

The Euro-Asian (Eua) element represents the highest percentage in **the spectrum of geolements**. European (E) and Central European (Ec) elements are also well represented.

The studied habitats give shelter for 14 plant species with **endangered, rare, vulnerable, endemic and relict** status: *Dentaria glandulosa* (End. carp.); species registered on the Romanian Red List (Oltean *et al.*, 1994): *Neottia nidus-avis, Platanthera bifolia, Cephalanthera damasonium*, *Lilium martagon*; species with peculiar areal of distribution: *Lathyrus hallersteinii*, *Crocus vernus* (Carp-balc), *Helleborus purpurascens* (DB), *Melampyrum bihariense* (DB); species in the category of threat for entire Carpathians, but not in Romania (Witkowski *et al.*, 2003): *Erythronium dens-canis*, *Adonis aestivalis*; IUCN Red List of Threatened Species: *Alnus glutinosa*; relicts (Sârbu *et al.*, 2013): *Sanicula europaea*- tertiary relict, *Cnidium dubium*- possible glacial relict.

The spectrum of ecological categories based on **edaphic humidity** (U) shows that the association *Carpino-Fagetum* represents the most humid habitat type from the deciduous forests. In the meadow part of the Niraj, the plant communities present some hygrophiles ($U_{4.5,\ 5}$) and also hydrophiles (U_6). In the case of blackthorn and hawthorn scrubs plant with xerophylous and mesophylous characters are dominating.

From the point of view of **temperature** micro-mesothermal ($T_{2.5,\ 3}$) species dominate.

Regarding the soil reaction acid-neutrophylous (R_3), slightly acid-neutrophylous (R_4) and euryionic (R_0) species are in higher proportions.

The lowest **I.D. value** was obtained for the pioneer association *Salicetum triandrae* (Tab. 1.). Oak-hornbeam forests have an I.D. value close to the association *Salicetum triandrae*. Polyploidy provides high resistance and higher competitive capacity for species (Cristea *et al.*, 2004). The low index suggests that the association *Carpino-Quercetum petraeae* evolved under the strong pressure of the perturbing factors.

The analysis of economical categories reveals the high number of melliferous (Me.) and medicinal (Md.) species with the maximum in oak-hornbeam forests, followed by riverside coppices and riverside thickets.

IV. BIRD COMMUNITIES OF THE WOODY VEGETATION FROM THE MIDDLE STREAM OF THE NIRAJ VALLEY

4.1. The qualitative study of the avifauna from the middle course of the Niraj valley

4.1.1. Materials and methods

For the qualitative analysis of the avifauna *line transects method with unlimited width* was used in the case of forest edges, riverside coppices and riverside thickets, open habitats, localities (including orchards), and the *point counts method with unlimited radius,* within forests. Data were collected during 2007-2012 in all months of the year.

The taxonomic structure of avifauna, the scientific names and the systematic classification were made after the Hamlyn Guide (Bruun *et al.*, 1999). For each species were noted the following data: phenological category, zoogeographical origin (Voous, 1960), trophic regime (Shaw *et* Perrins, 1998), protective status, foraging and nesting places and nest type.

The analysis of protective status of the avifauna was performed according to: EGO 57/2007, on the regime of natural protected areas, conservation of the natural habitats, wild flora and fauna; Law 13/1993-Romania's accession to the Convention on the conservation of wildlife and natural habitats in Europe, adopted in Bern (19 September 1979); the Council Directive on the conservation of the wild birds (79/409/CE) and the Law 13/1998-Romania's accession to the Convention on the Conservation of Migratory Species of Wild Animals, adopted at Bonn (23 June 1979).

4.1.2. Results and discussions

4.1.2.1. Specific and taxonomic composition of avifauna

A total of **114 bird species** were identified. Their presence was reconfirmed over several years (2005-2012). The species represent 30.5% from the Romanian avifauna and 21.7% from the European avifauna. The species were classified in 13 orders and 35 families.

The best represented order is the *Passeriformes* with 69 species, followed by *Falconiformes* (11 species), *Piciformes* (8 sp.), *Strigiformes* (5 sp.) and *Columbiformes* (4 sp.). The orders *Ciconiiformes*, *Galliformes*, *Charadriiformes* and *Coraciiformes* are represented each by 3 specis. Less represented are the orders *Gruiformes* (2 sp.), *Anseriformes* (*Anas platyrhynchos*), *Cuculiformes* (*Cuculus canorus*) and *Caprimulgiformes* (*Caprimulgus europaeus*).

Comparing this taxonomic structure with the results of other studies that targeted the avifauna of some regions from Romania (Munteanu, 2000, Trelea, 2002, Rang, 2002, David, 2008a, 2008b, Moga 2009) difference could be observed regarding the taxonomic structure and specific composition, due to the richer hydrographic network of these regions.

4.1.2.2. The phenological analysis of the avifauna

The **breeding species** (92 sp.) are in higher number than the **non-breeding** ones (22 sp.).

From the breeding species the highest number is held by **summer visitors** (51 sp.), followed by **residents** (39 sp.). This results show the capacity of the study area in sustaining the avifauna in breeding and feeding processes.

Most nesting birds preferred forests as breeding habitats (50 sp.).

4.1.2.3. The zoogeographical analysis of the avifauna

The species belong to 13 faunal types from 33 faunal types present in Europe (Voous, 1960) and 24 faunal types present in Romania (Munteanu, 1974). Species from Palaearctic type dominate (Pal, 49 sp.), followed by European (E, 19 sp.) and European-Turkestanian (ET, 16 sp.) ones.

4.1.2.4. The analysis of the trophic regime

Most of the species are insectivore (In, 42 sp.), followed by the zoofage-polyphagous birds (ZOO-P, 25 sp.), omnivores (Om, 23 sp.), carnivores-predators (CP, 12 sp.), vegetarians-seminivora (VS, 11 sp.) and piscivorous birds (Ih, 1 sp.).

Agricultural lands, grasslands, the localities and the deciduous forests have a more various food offer comparing with other habitats.

4.1.2.5. Bird species diversity

Most of the species have been observed in deciduous forests (64 sp.). The woody vegetation and the localities support both breeding and feeding birds, while open habitats (agricultural lands, grasslands) and the shore show a discrepancy between the ability to offer food and breeding support (Fig. 2.).

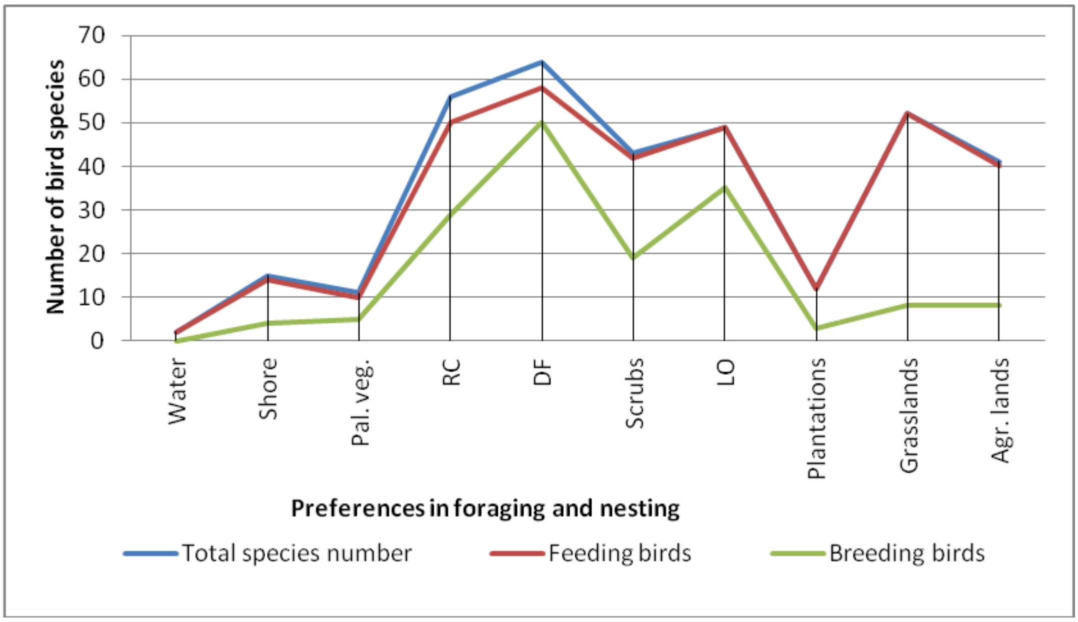

Fig.2. The number of species according with feeding and nesting preferences; **Abbreviations: Pal. veg.**-palustrine vegetation (reeds), **RC-** riverside coppices, **DF**-deciduous forests, **Scrubs**-blackthorn and hawthorn scrubs, **LO**-localities and orchards, **Plantations**-coniferous plantations, **Grasslands**-mainly pastures and hayfields, **Agr. lands**-agricultural lands

The *alpha diversity* is higher in forests (67 species) and in water-related habitats (64 sp.). The analysis of *beta diversity* according to Whittaker (1960) (Koleff *et al.*, 2003) shows a similarity between the birds community from water-related habitats, blackthorn and hawthorn scrubs and the other habitat types. The bird community from the forests is much different from that of grasslands and agricultural lands, while the last two resemble very much in composition. The distribution of birds in the study area depends on the coverage achieved by the woody vegetation.

4.1.2.6. The protective status of the avifauna

According to the Emergency Ordinance no. 57 from 20 June 2007, in the study area, there are a number of **20 bird species** (17.5% from total species number) whose conservation requires the designation of special areas of conservation. More than half of these species (11 sp.-55%) are feeding and breeding in deciduous forests.

Grasslands are feeding habitats for 50% from the species that benefit protection according to the same Emergency Ordinance.

Some of these species are in higher numbers (*Dendrocopos medius*, *Lanius collurio*, *L. excubitor*, *L. minor* and *Lululla arborea*) and others are rare (*Dendrocopos leucotos*, *Ficedula albicollis*).

Also have been reported **31 bird species** (27% from the total species number) of national interest, which need strict protection. Most of them are feeding and breeding in the deciduous forests (21 species-70%). *Jynx torquila* is considered a rare, but constant species, being reported in each year in the study area. *Locustella fluviatilis*, *Merops apiaster* and *Sitta europaea* are very common species in the study area, the last two with a great abundance.

The conservation value of the forests is evidenced not only by the number of protected species, but also by the land use in the study area.

4.2. The quantitative study of the woody vegetations avifauna

4.2.1. Materials and methods

The quantitative assessment was done in May and June, 2013 with the following field methods:

-in forests-the *fixed-radius point counts method* (Bibby *et al.*, 2000), all detected birds within 50 m radius are counted, for 10 minutes.

-in coppices, scrubs and orchards-the *line transects method with limited width* (Bibby, 2004), all birds seen or heard on a strip with an area equivalent to a circle with a radius of 50 m are counted.

In all cases, quantitative evaluation was performed between 6-10 in the morning, in favorable conditions, without rain or wind.

The species frequency was given in percentage by the ratio of the number of samples in which a species was present and the total number of samples.

Dominance (the relative frequency of the species) was calculated according to the method of Turček (1956). The species with the value of $p_i \geq 0.05$ were considered dominants (Fulco *et* Florenzano, 2008, Angelici *et al.*, 2012).

Principal coordinate analysis (PcoA) was chosen for ordering bird communities. To obtain the ordering *Bray-Curtis* and *Jaccard* indices were used.

In the *analysis of bird community structure*, species were assigned to different **ecological categories** based on their habitat preferences, according to Kelemen (1978), Fuller (1995), McCollin (1998), Mikusiński *et al.* (2001).

Indicator species value (ISV) (Dufrene *et* Legendre, 1997) was calculated for identifying the characteristic species of certain groups, which were obtained by classifying or ordering the samples.

We have adopted the calculation of alpha, beta and gamma diversity: ***alpha diversity***-represents the diversity at the level of samples, ***gamma diversity***-diversity at the level of associations, ***beta diversity*** ("β-turnover diversity index")-indirectly indicates the spatial heterogeneity and it is the ratio of gamma and alpha diversity at the level of the associations (Koleff *et al.*, 2003, Magurran, 2004, Angelici *et al.*, 2012).

The ***Shannon diversity index*** and the ***equitability*** were calculated at the level of samples.

The comparison of the variables was made with the Kruskal-Wallis test. The significance of the differences was checked with the Mann-Whitney U post-hoc test. The ordering and the calculation of diversity indices were performed using the statistical program Past (v. 2.17c).

Indicator species value was calculated in R statistics with the labdsv library (Roberts *et* Oksanen, 2006).

4.2.2. Results and discussions

The most **frequent species** are: in the tickets of willow-*Hirundo rustica* and *Sylvia communis*; in the white willow forests-*Oriolus oriolus*; in the deciduous forests-*Fringilla coelebs*; in the blackthorn and hawthorn scrubs-*Emberiza citrinella* and *Lanius collurio*; in orchards-*Garrulus glandarius*.

The **dominant species** are: in the tickets of willow-*Acrocephalus palustris*, *Aegithalos caudatus*, *H. rustica*, *Sylvia atricapilla*, *S. communis*; in the white willow forests-*Motacilla alba*, *O. oriolus*, *Turdus pilaris*; in beech and hornbeam forests-*Erithacus rubecula*, *F. coelebs*, *Parus major*, *Sitta europaea*, *S. atricapilla*, *Turdus merula*, *T. philomelos*; in oak and hornbeam forests-*Dendrocopos medius*, *E. rubecula*, *F. coelebs*, *P. major*, *S. europaea*, *T. merula*; in sessile oak forests-*Dendrocopos medius*, *F. coelebs*, *P. major*, *P. palustris*, *S. europaea*, *S. atricapilla*; in the blackthorn and hawthorn scrubs-*Carduelis cannabina*, *E. citrinella*, *L. collurio*, *Merops apiaster*, *P. major*, *Passer montanus*; in orchards-*Carduelis cannabina*, *G. glandarius*, *H. rustica*, *P. major*, *T. merula*.

Diversity parameters of bird communities in different woody associations are presented in table 2.

Table2. ***Diversity parameters of bird communities calculated for different plant associations***

	CQ	**CF**	**GQmu**	**PC**	**SP**	**St**	**Orchards**
Number of individuals	16.04 (± 8.27)	9.86 (± 3.67)	11.67 (± 4.58)	11.00 (± 4.85)	29.83 (± 4.57)	16.50 (± 4.20)	18.25 (± 3.32)
Shannon H	1.80 (± 0.49)	1.54 (± 0.29)	1.71 (± 0.23)	1.73 (± 0.18)	2.24 (± 0.12)	1.68 (± 0.31)	2.31 (± 0.25)
Equitability J	0.93 (± 0.03)	0.94 (± 0.03)	0.93 (± 0.04)	0.94 (± 0.01)	0.88 (± 0.04)	0.88 (± 0.02)	0.95 (± 0.01)
Gamma diversity	40.00	14.00	19.00	25.00	32.00	14.00	32.00
Alfa diversity	7.64	5.42	6.50	6.40	12.66	7.00	11.50
Beta diversity	5.23	2.58	2.92	3.90	2.52	2.00	2.78

Abbreviations: **St**-*Salicetum triandrae*, **SP**-*Salici-Populetum*, **CF**-*Carpino-Fagetum*, **CQ**-*Carpino-Quercetum petraeae*, **GQmu**-*Genisto tinctoriae-Quercetum petraeae* subas. *melicetosum uniflorae*, **PC**-*Pruno spinosae-Crataegetum.*

The **ordering** of bird communities on the base of *Bray-Curtis index* (Fig. 3.) birds are grouped in a community typical to the deciduous forests and in another community typical to the coppices and scrubs (PC1: 13.71%, PC2: 8.95%). Orchards have a bird community influenced by the birds of forest habitats.

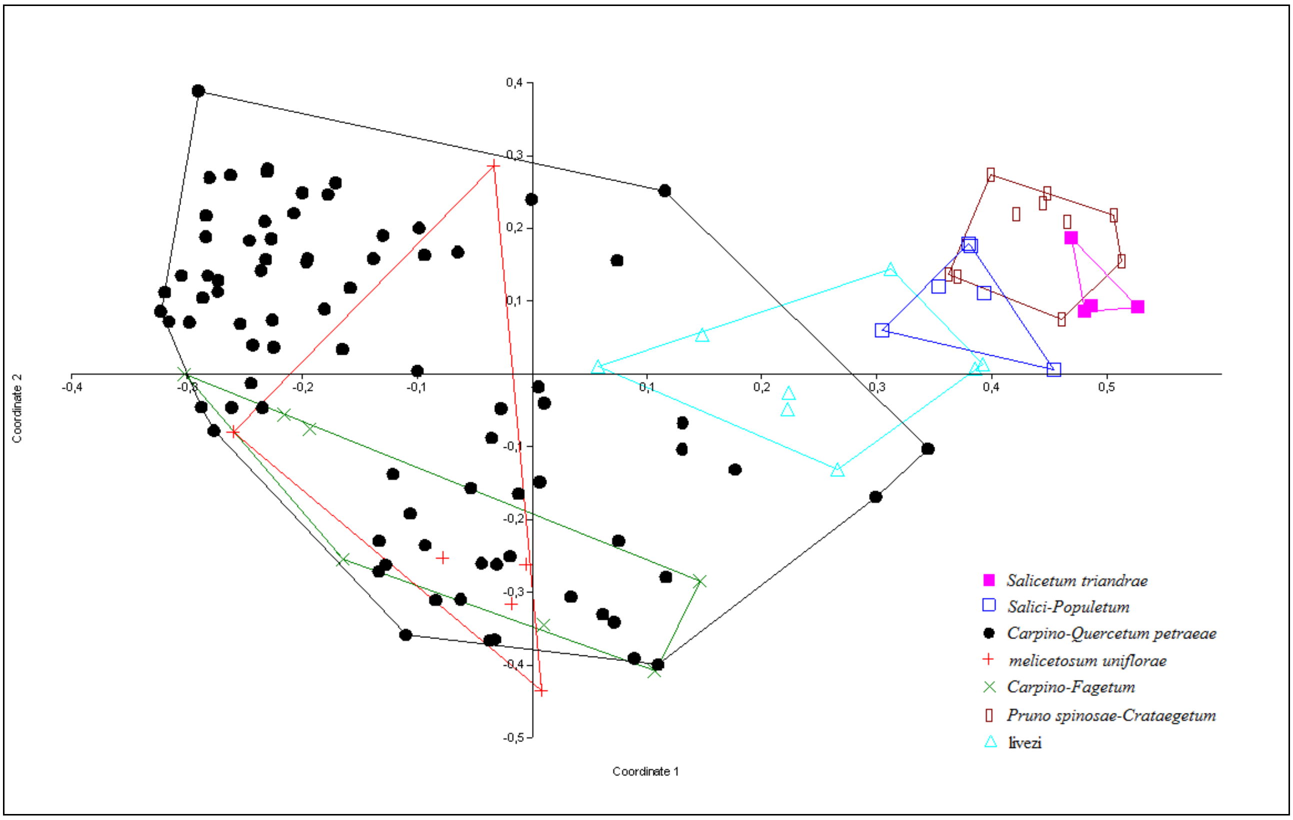

Fig.3. PCoA of the bird communities from the woody vegetations based on the Bray-Curtis index

The ordering of bird communities on the base of presence / absence data (*Jaccard index*) (Fig. 4.) confirms the grouping in a community typical to the deciduous forests and in another community typical to the coppices and scrubs (PC1: 13.46%, PC2: 8.34%). As a result of the ordering, the community typical to the association *Salici-Populetum*, shows a better differentiation from the deciduous forests. The orchards located on the hills and the forests located nearby, share many of the bird species.

The **analysis of ecological structure** of the bird communities (Fig. 5.) shows that the samples from forests and orchards are more abundant in species associated with closed forest habitats (forest specialists) than samples from other plant associations. Species occurring in localities are more abundant in the riverside coppices and shrubs and in orchards.

The **characteristic species** (with a significant indicator value) for the different plant associations are: in orchards-*Passer domesticus*, *Garrulus glandarius*, *Sturnus vulgaris*, *Galerida cristata*, *Carduelis cannabina*; in the blackthorn and hawthorn scrubs-*Emberiza citrinella*, *Lanius collurio*, *Merops apiaster*, *Saxicola torquata*; in the white willow forests-*Hirundo rustica*, *Turdus pilaris*, *Motacilla alba*, *Oriolus oriolus*, *Pica pica*, *Cuculus canorus*, *Falco subbuteo*, *Vanellus vanellus*, *Locustella fluviatilis*, *Passer montanus*, *Buteo buteo*, *Troglodytes troglodytes*, *Dendrocopos syriacus*, *Luscinia luscinia*; in the tickets of willow-*Sylvia communis*, *Aegithalos caudatus*, *Phasianus colchicus*, *Lanius excubitor*, *Acrocephalus palustris*; in the deciduous forests-*Fringilla coelebs*, *Dendrocopos medius*, *Erithacus rubecula*, *Sitta europaea*, *Turdus philomelos*.

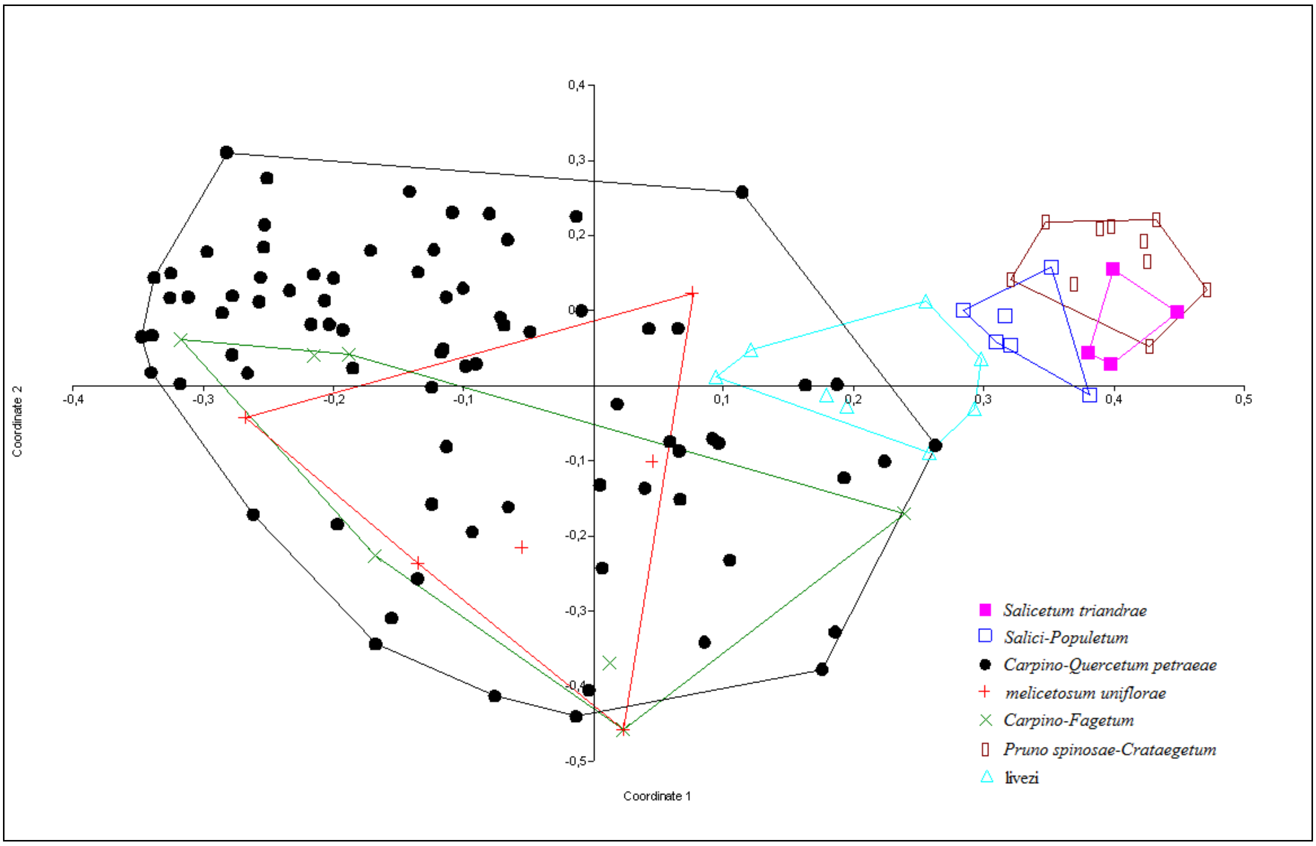

Fig.4. PCoA of the bird communities from the woody vegetations based on the Jaccard index

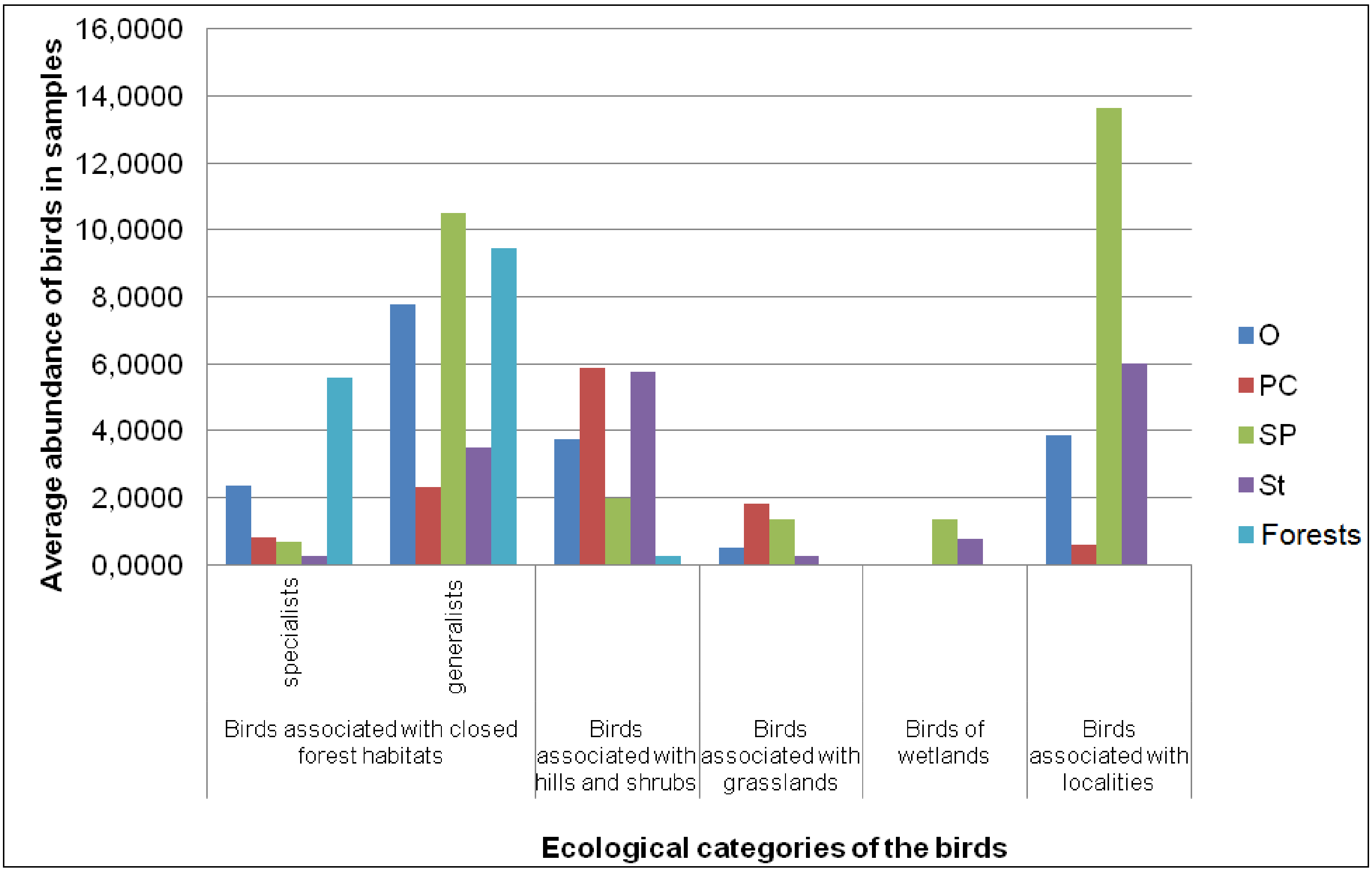

Fig.5. The abundance of different ecological categories in the studied plant associations; **Abbreviations: O**-orchards, **PC**-*Pruno spinosae-Crataegetum*, **SP**-*Salici-Populetum*, **St**-*Salicetum triandrae* and forests

Our study shows that the mosaics formed by the woody vegetation have a different structure and composition of bird communities than the compact and large size deciduous forests. These mosaics have in their composition many edge species (*Lanius collurio*, *Emberiza citrinella*, *Passer montanus*, *Sturnus vulgaris*, *Oriolus oriolus*, *Pica pica* and so on). Bird communities in deciduous forests were not differentiated by the type of the forests.

Analyzing bird species richness (**alpha diversity**), **abundanc**e, **diversity** and **equitability** in each of the associations, significant differences were observed (Fig. 6-9.). Regarding species richness and abundance (diversity, inclusively), the values are often higher in areas of eco-tone than in the interior of the phytocoenoses (Sisk *et* Battin, 2002, Batáry *et al.*, 2014).

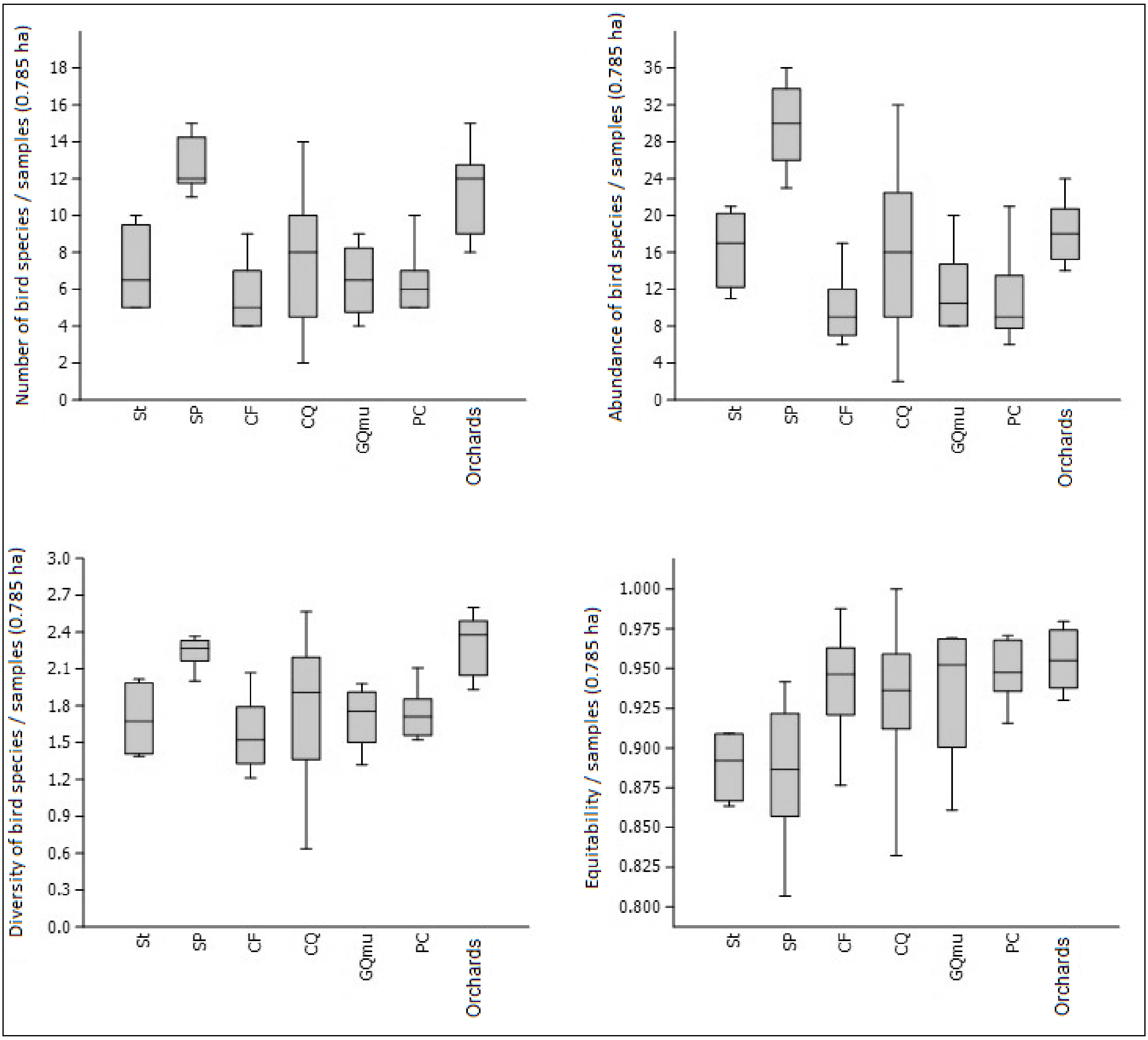

Fig.6-9. Species richness, abundance, diversity and equitability in different phytocoenoses; **Abbreviations: St**-*Salicetum triandrae*, **SP**-*Salici-Populetum*, **CF**-*Carpino-Fagetum*, **CQ**-*Carpino-Quercetum petraeae*, **GQmu**-*Genisto tinctoriae-Quercetum petraeae* subas. *melicetosum uniflorae*, **PC**-*Pruno spinosae-Crataegetum*, and **orchards**

The value of **beta diversity** is the highest in the association *Carpino-Quercetum petraeae* (5.23). The lowest spatial heterogeneity from the deciduous forests was calculated for the beech and hornbeam forests (2.57). Comparing the values of all associations, we found the lowest spatial heterogeneity in the association *Salicetum triandrae* (2.00). Equitability and beta diversity has lower values where perturbing factors have a stronger influence on communities (Magurran, 2004, Angelici *et al.*, 2012). The ecological study of the vegetation also shows that tickets of willow are pioneer associations and together with the riverine coppices denote a strong anthropogenic influence. The association *Carpino-Quercetum petraeae* occupies the largest surface from all of the woody associations and it has the highest beta diversity value. This is due to the structural heterogeneity of the forests: trees belonging to different species and different ages, the shrub and herbaceous layer is more or less developed (Domokos, 2013, Domokos *et* Cristea, 2013, Domokos *et* Cristea, 2014).

Orchards are important habitats for birds. In the study area many ancient Transylvanian varieties of apple are cultivated (Nagy-Tóth, 1998): 'Șovari', 'Török Bálint', 'Pătul', 'Budai Domokos' and 'Poinic'. Unfortunately extensive orchards are abandoned because of their low economic value. It would be important in the future to improve the marketing of local products in the detriment of imported varieties and to support the extensive orchards and their maintenance without chemicals.

V. STRUCTURAL FACTORS OF THE WOODY VEGETATION WITH IMPORTANCE IN SUPPORTING THE AVIFAUNA

5.1. Effects of forest structure on woodpeckers (*Picidae*)

5.1.1. Introduction

Studying woodpeckers is important for several reasons: woodpeckers have a stronger affinity to forests than most other bird taxa (Winkler *et al.*, 1995); the degree of anthropogenic change in forest habitats seems to be reflected by their distribution (Mikusiński *et* Angelstam, 1997); woodpeckers are proposed and also used as general indicators of forest biodiversity or as specific indicators of forest birds (Jansson, 1998, Mikusiński *et* Angelstam, 1998, Mikusiński *et al.*, 2001, Nilsson *et al.*, 2001, Roberge *et* Angelstam 2006, Virkkala, 2006, Drever *et al.*, 2008); cavities for secondary cavity-nesters are also provided by woodpeckers (Wesołowski, 2011); trough theit activities woodpeckers also play a role in wood decomposition processes (Jackson, 1977, Farris *et al.*, 2004, Jackson *et al.*, 2004).

The objectives of this study were: (1) to investigate the abundance and distribution of sedentary woodpecker species in the managed forests from the Niraj valley; (2) to describe the nest-site characteristics of the sedentary woodpeckers in forests managed for timber extraction; (3) to study the effect of different environmental factors (altitude, slope, canopy cover, distance between trees, distance to forest edge, relative abundance-, dominancy-abundance-, diversity-, diameter- and height of trees) on abundance and on choice of nesting-site of each woodpecker species.

5.1.2. Materials and methods

5.1.2.1. Study site

The study was conducted in forested habitats from the Niraj valley (N46 27.117, E24 45.289). In the study area there are 10 forest fragments which were divided for forestry purposes in different sized forest sections (Fig. 10.). The sections were further divided into 115 forest plots between 0.1 and 37.6 ha.

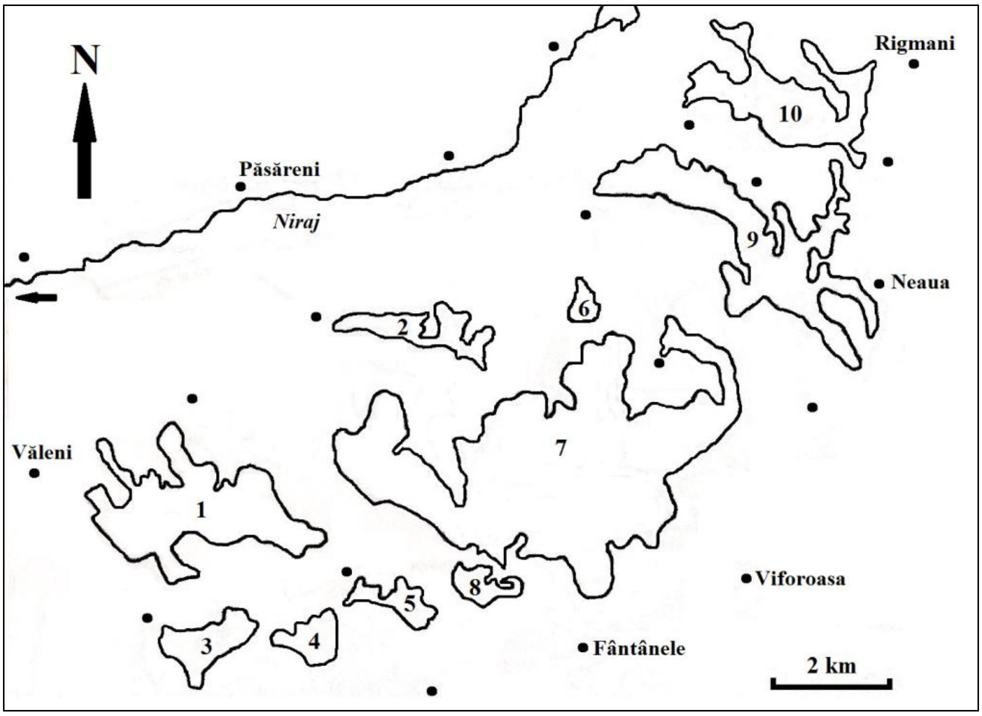

Fig.10. Map of the studied forest fragments from the Niraj valley: 1. Roteni and Văleni; 2. Păsăreni; 3. Găiești; 4. Suveica and Șanț; 6. Gălești; 7. Tamaș, Bedeni, Troița, Dealu de Mijloc and Fântânele; 8. Bisericii; 9. La Săgeata; 10. Dumitreștilor, Coasta Scaunului, Neaua and Sântana

5.1.2.2. Data collection

The number and distribution of territorial woodpeckers was established by the *method of calls and drumming* during the pre-breeding period (March-April 2012) (Kosiński *et al.*, 2004, Kosiński *et* Kempa, 2007, Pasinelli, 2007, Ćiković *et al.*, 2008, Kajtoch *et al.*, 2012).

The Global Positioning System (GPS) was used to identify the position and distance between neighboring nesting trees. **Parameters of nesting sites** were recorded: tree species, diameter of tree at breast height (dbh), tree- and nest height, placement of the nest-holes (main trunk vs. branch), tree viability (live vs. dead). To ensure that the effort was homogeneous over the whole study area, observations were made systematically in each of the 10 forest fragments. A total of 43 days were spent on fieldwork in March and April and other 2 months (May and June).

Also **woodland composition and structure** were investigated: canopy cover (%), abundance-dominance of trees / 400 m^2. Using the *line transect method* in forests, the relative abundance- and diversity of trees (Shannon-Weaver index), mean distance between trees, tree height and dbh / 100 m was calculated (Cristea *et al.*, 2004). Habitat variables were collected during the vegetation period in 2012 and 2011.

5.1.2.3. Data analysis

The crude **density** of the woodpeckers was obtained by dividing the number of territorial birds with the total area of the forest plots. The Clark-Evans model of distance between nearest-neighbor was used to examine the **distribution of the nesting sites** (Clark *et* Evans, 1954, Fernandez *et* Azkona, 1996, Kosiński *et* Kempa, 2007).

Since most variables had unequal variances and sample size Kruskal-Wallis test was used to compare nest tree characteristics among the woodpeckers. Variables with significant Kruskal-Wallis test were tested post-hoc with pairwise Mann-Whitney U test to identify the difference between woodpecker species. Data were Bonferroni corrected.

Associations between woodpecker species and commonest tree species were examined using *canonical correspondence analysis* (CCA), for all woodpecker species recorded at least five times (Laiolo, 2002).

Principle component analysis (PCA) was chosen to reveal patterns in structural parameters of forest.

Linear multiple regression was applied to quantify the strength of the relationship between woodpeckers abundance and explanatory variables (abiotic, structural and compositional parameters).

Kruskal-Wallis test (Mann-Whitney pairwise post-hoc test, Bonferroni corrected data) was performed to compare abiotic, structural and compositional parameters in **unoccupied** and **occupied plots** by the five most abundant woodpecker species. For this data from 94 out of the 115 plots was used. The other 21 plots were excluded, because their sizes were too small and negatively influenced the woodpecker abundance. All statistics were performed with the statistical package XLSTAT (Addinsoft 2013) and PAST (ver. 2.17c).

5.1.3. Results and discussions

The densities and number of all woodpecker species is shown in table 3.

Table3. ***Number of territories and density of woodpecker species in studied forests***

Species	No. of holes	No. of territories	Density (pairs 10 ha^{-1})
Picus viridis	5	6	0.02
Picus canus	8	10	0.04
Dendrocopos major	18	21	0.08
Dendrocopos medius	76	81	0.31
Dendrocopos leucotos	2	2	0.01
Dryocopus martius	18	18	0.07

The nests of *D. major* had a uniform distribution in the best conserved forest fragment (7). The sparse presence of the species in the study area is due to the current forestry practices which led to the selective harvesting of the *Quercus* genus. The nests of *D. medius* had an aggregate distribution. Individuals were concentrated in areas with favorable environmental factors: suitable trees for excavation (aspen, large dbh sessile oaks or wild cherry).

In the case of *D. martius*, nest-sites were uniformly distributed. It seems that the scattered distribution of beech with lime in oak-hornbeam forest stands supports the presence of this species. Nests of *D. medius* and *D. martius* presented a random distribution in two forest fragments (10 and 1, respectively). Random distribution might occur in conditions of homogeneous environments (Tab. 4.).

Table4. ***Clark-Evans nearest-neighbor analysis of nesting tree distribution of the most abundant woodpeckers from the studied forests***

Species	***D. major***		***D. medius***			***D. martius***		
Forest fragments	**7.**	**9.**	**10.**	**7.**	**1.**	**9.**	**7.**	**1.**
N	10	17	7	31	20	5	9	4
rA	0.75	0,12	0,60	0.20	0.11	0.90	0.60	0.44
rE	0.46	1.28	0.61	0.82	1.15	0.52	0.44	0.51
R	1.62	0.09	0.99	0.25	0.10	1.74	1.37	0.87
σE	0.09	0.02	0.08	0.03	0.03	0.11	0.10	0.13
c	**3.24***	**46.89***	0.08	**21.36***	**40.54***	**3.37***	**1.63***	0.54
[rA-rE]	0.29	1.16	0.01	0.61	1.03	0.38	0.16	0.07
Two-sided p value	0.001	< 0.001	0.934	< 0.001	< 0.001	< 0.001	0.103	0.596

Abbreviations: **N**-he number of nest-trees used as center of measurement; **rA**-the mean of the series of distances to nearest neighbor; **rE**-the mean distance to nearest neighbor expected in an infinitely large random distribution of density rho; **R**-the measure of the degree to which the observed distribution departs from random expectation with respect to the distance to nearest neighbor; **σE**-the measure of the degree to which the observed distribution departs from random expectation with respect to the distance to nearest neighbor; **c**-the standard variant of the normal curve; **p-** probability of a greater difference between rE and rA; *****-significant values.

Sessile oak was the most commonly used tree species by *D. medius* and *P. viridis,* beech by *D. martius* and aspen by *P. canus*. *D. major* made the nest-holes often in aspen and sessile oak. The nesting-holes of *D. leucotos* were found in sessile oak (Tab. 5.).

Results of **CCA** accounted for the first two axes 92.14% of the variability in the data (F1: 75.92%, F2: 16.21%). *D. martius* was associated mostly with beech but lime too, *P. viridis* with sessile oak and lime, *D. medius* with oak and wild cherry. *D. major* și *P. canus* were present when relative abundance of hornbeam, oak (*Quercus robur*) and aspen increased (Fig. 11.).

PCA on forest structure parameters accounted 86.21% of the total variances by the first tree principal components (Tab. 6.). The first principal component (PC1 = 44.60%) represented a gradient from the canopy height and tree dbh against distance between trees. The second component (PC2 = 26.84%) represented a gradient from tree diversity and canopy cover against distance between trees. Finally, Shannon-Weaver diversity of trees provided the major loading on the PC3 (14.77%).

D. major preferred as nesting trees sessile oaks with dbh larger than 30 cm and *D. medius* with dbh larger than 40 cm. The maintenance of both species requires sessile oak-dominated forests older than 80-120 years. In the case of *D. martius* thick, old sessile oak-dominated forests with beech (nesting trees with dbh larger than 60 cm, older than 150 years) are necessary. Woodpeckers, especially *P. canus*, will also benefit from maintaining of large aspens (dbh larger than 25 cm, older than 40 years).

Table5. ***Nest-trees used by woodpeckers in studied forests; number of nest-holes found (N) and percentage values (%) in particular tree species, tree species average frequencies and relative abundance values are given***

Tree species (average frequencies and relative abundances)		***P. viridis***	***P. canus***	***D. major***	***D. medius***	***D. leucotos***	***D. martius***	**Total nest-holes in particular tree species**
C. betulus	N	0	0	0	1	0	0	1
(100%, 0.50)	%	0.00	0.00	0.00	100.00	0.00	0.00	0.79
C. avium	N	0	0	1	5	0	0	6
(9.57%, 0.004)	%	0.00	0.00	16.67	83.33	0.00	0.00	2.36
F. sylvatica	N	0	0	0	2	0	10	12
(34.04%, 0.07)	%	0.00	0.00	0.00	16.67	0.00	83.33	9.45
P. tremula	N	1	7	8	29	0	2	47
(21.27%, 0.03)	%	2.13	14.89	17.02	61.70	0.00	4.26	37.01
Q. petraea	N	3	1	8	37	2	3	54
(98.93%, 0.35)	%	5.56	1.85	14.81	68.52	3.70	5.56	42.52
Q. robur	N	0	0	0	1	0	1	2
(10.63%, 0.005)	%	0.00	0.00	0.00	50.00	0.00	50.00	2.70
T. cordata	N	1	0	1	1	0	2	5
(21.27%, 0.01)	%	20.00	0.00	20.00	20.00	0.00	40.00	6.76
Total nest-holes	N	5	8	18	76	2	18	127
of particular bird species	%	3.93	6.29	14.17	59.84	1.57	14.17	100.00

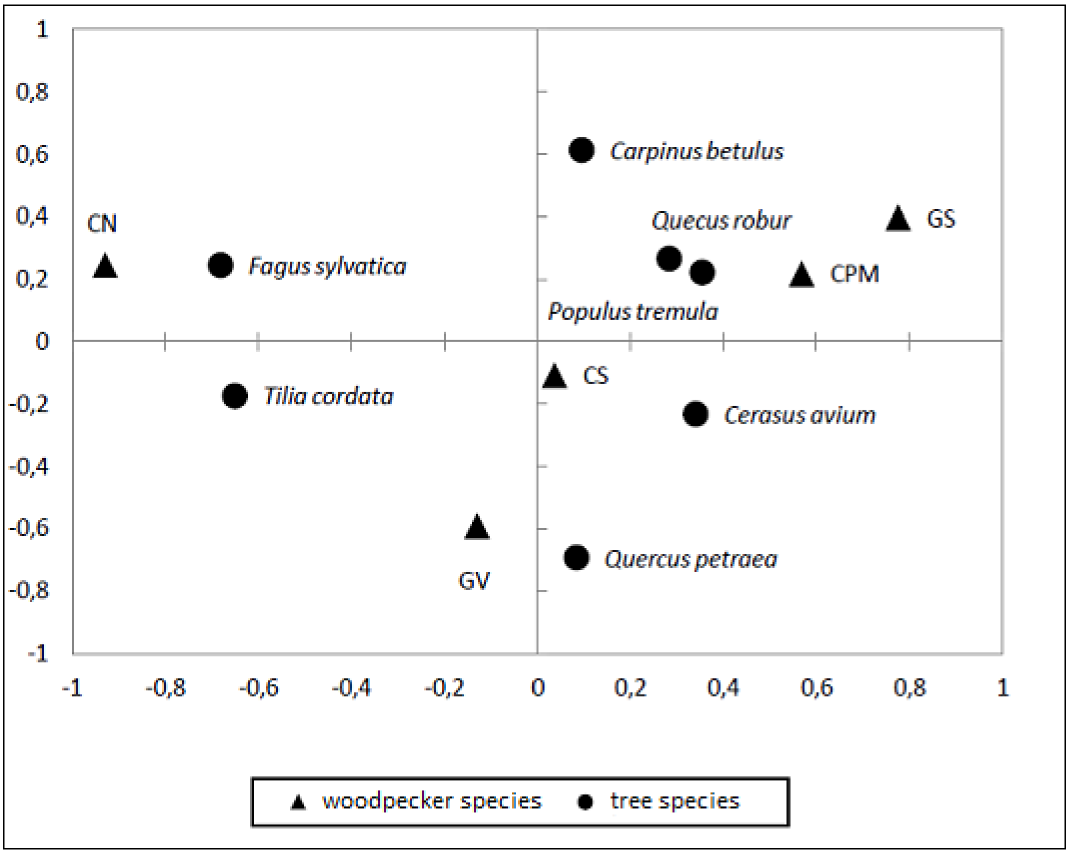

Fig.11. Relationship between woodpecker species and the commonest tree species resulted by CCA; **Abbreviations: GS**-*Picus canus*, **GV**-*Picus viridis*, **CPM**-*Dendrocopos major*, **CS**-*Dendrocopos medius*, **CN**-*Dryocopus martius*

Table6. ***Results of principal component analysis on forest structure data in the studied plots; the highest loadings are given in bold type***

Forest structural variable	Factor loadings		
	F1	F2	F3
Trees dbh (cm)	**0.88**	0.21	-0.19
Trees height (m)	**0.85**	0.22	-0.33
Trees diversity (Shannon Weaver index)	0.46	**0.52**	**0.71**
Canopy cover (%)	-0.32	**0.80**	-0.28
Distance between trees (m)	**0.62**	**-0.57**	0.04
Eigenvalue	2.23	1.34	0.73
Variability (%)	44.60	26.84	14.77

The ***Linear multiple regression*** analysis showed that tree dbh, tree species diversity, oak and aspen relative abundance and altitude have highly significant effect on woodpecker abundance (Tab. 7).

Comparing abiotic, structural and compositional parameters in **occupied** vs. **unoccupied plots** significant differences were found in cases of *D. medius* and *D. martius*.

D. medius is present were sessile oak older than 80 years (dbh larger than 35 cm) dominates the tree layer. Mean dbh of sessile oak in occupied plots is 45.56 cm (SD: 5.91, N = 39). *D. martius* is present where beech is older than 90 years (dbh larger than 35 cm). Mean dbh of beech in occupied plots is 57.01 cm (SD: 15.68, N = 11). Plots occupied by both species had a higher tree diversity index than unoccupied ones.

Table7. ***Results of Linear multiple regression analysis; parameters that significantly entered in model are listed***

Variables	Coeff.	Std. err.	t	p	R^2	F	p
Dbh (cm)	0.05	0.02	2.58	0.0115	0.13	4.50	<0.0001
Trees diversity	0.88	0.38	2.27	0.0252	0.19		
Relative abundance of *Populus tremula*	6.85	2.83	2.41	0.0179	0.07		
Relative abundance of *Quecus petraea*	1.68	0.81	2.05	0.0428	0.01		
Altitude (m)	-0.01	0.005	-2.39	0.0189	0.01		

5.2. Effects of forest structures on the avifauna

5.2.1. Materials and methods

Ecological categories were established for each recorded bird species on the base of phenology, trophic regime, breeding and foraging behavior.

The total biomass of birds was calculated in every sampling point using the average value of species body weight (Shaw *et* Perrins, 1998) for females and males.

We have calculated the Shannon diversity index for birds in every sampling point.

Principle component analysis (*PCA)* was chosen to reveal patterns in structural parameters of forest (see **chapter V.**, **subchapter 5.1.**).

Linear multiple regression was applied to quantify the strength of the relationship between species richness, diversity, biomass, abundance of bird species from different ecological categories and the explanatory variables (abiotic factors, structural and compositional parameters of the forests).

We analyzed the **usefulness of particular woodpecker species**, in predicting the species richness of other forest birds. The hypothesis was that plots occupied by territorial woodpeckers have higher number of bird species (others than woodpeckers) than unoccupied plots. Therefore, the results about species richness in different sample points (plots) obtained in May-June 2013 were compared in occupied vs. unoccupied plots (results obtained in the pre-reproductive period, March-April 2012). We used 94 plots in the analysis, in which bird species richness was not influenced by the size of the plot (*simple linear regression*, $r^2 = 0.002$, n = 94, coeff. = 12.74, p = 0.65).

5.2.2. Results and discussions

Trees diameter and **trees height** had a positive influence on bird species richness, abundance and biomass. The age of the forests influenced the abundance of birds feeding on trunk, in the canopy and on the ground. The abundance of hole-nesters and birds nesting in the crown was positively correlated with forest age. Resident species abundance was also higher in forests with older trees.

The increase of **relative abundance of sessile oak** (lower relative abundance of hornbeam) had a positive effect on bird species richness and diversity.

Tree species like **aspen** and **wild cherry** created favorable nesting places and foraging places for many birds. Unfortunately, the frequency of these species in the forests is reduced (21.27%, and 9.57% respectively).

The **development of shrub layer**, especially the higher abundance values of *Crataegus monogyna* and *Sorbus torminalis*, had a positive effect on shrub nesters and under storey nesters. The frequency of both species is reduced (7.44%, and 2.12% respectively).

The greater the distance from **forest edge** (as we are moving into forests interior) the lower is the migratory bird abundance. Migratory birds often prefer open woody vegetation structures like coppices with reduced canopy cover (Fuller, 1995).

In some cases, **slope** had a negative influence on abundance of birds nesting in crown and resident birds. This could be explained by the fact that young beech-hornbeam forests from the study area are encountered in steep valleys. In these forests the canopy is not completely developed and food source is limited.

The most common woodpeckers, *Dendrocopos major*, *D. medius* and *Dryocopus martius*, were used as **indicators of forest bird richness**. Table 8 presents a significantly greater number of bird species (others than woodpeckers) in plots occupied by woodpeckers than in unoccupied forest plots. Woodpecker survey (the distribution of territorial woodpeckers) could be an important tool for land managers in assessing the diversity of forest birds and trees.

Table8. ***Number of forest species in plots occupied and unoccupied by particular woodpecker species (unpaired two-tailed t test)***

Woodpecker species	**No. of forest bird species (excluding woodpeckers)**			
	Woodpecker present	**Woodpecker absent**	**t**	**p**
Dendrocopos major	7,41 (N = 17)	5,93 (N = 77)	2,42	0,0174
Dendrocopos medius	7,58 (N = 39)	5,21 (N = 55)	5,58	< 0,0001
Dryocopus martius	8,94 (N = 17)	5,59 (N = 77)	6,38	< 0,0001

General conclusions

In literature there are many general descriptions on bird communities of different habitat types. Our study is the first to demonstrate bird species grouping by the type of the woody vegetation based on statistical processing of field data.

Also based on observations and statistical processing correlations between structural, compositional and abiotic factors of the woody vegetation and birds were highlighted.

Woodpeckers (birds with the strongest affinity to forests in Europe) survey and their use as indicators of habitat quality or forest bird diversity are the first attempts in Romania.

Our researches have a practical importance too. The results will be used in the elaboration of the management plan for the special protection area Târnavelor Hills-Niraj Valley.

Selected Bibliography

1. ANGELICI, C., BRUNELLI, M., BATTISTI, C., 2012, Breeding birds in agro-forest habitat types (Nazzano, Tevere-Farfa Nature Reserve, central Italy): evidencing patterns following a dominance/diversity approach, *Avocetta*, **36**: 97-102.
2. BATÁRY, P., FRONCZEK, S., NORMANN, C., SCHERBER, C., TSCHARNTKE, T., 2014, How do edge effect and tree species diversity change bird diversity and avian nest survival in Germany's largest deciduous forest?, *Forest Ecol Manag*, **319**: 44-50.
3. BIBBY, C.J., 2004, Bird diversity survey methods, pp. 1-17. In: Sutherland, J.W., Newton, I., Green, R.E. (*eds*.), *Bird Ecology and Conservation: A Handbook of Techniques*, Oxford University Press, Oxford.
4. BIBBY, C.J., BURGESS, N.D., HILL, D.A., MUSTOE, S.H., 2000, *Bird census techniques*, vol. 2., Academic Press, London.
5. BLAGA, GH., FILIPOV, F., RUSU, I., 2005, *Pedologie-Manual Universitar*, Ed. Academic Press, Cluj-Napoca.
6. BRAUN-BLANQUET, J., 1964, *Pflanzensoziologie, Grundzüge der Vegetationskunde*, 3th ed., Springer-Verlag Berlin, Wein, New York.
7. BRUUN, B., DELIN, H., SVENSSON, L., 1999, *Hamlyn Guide*, Versiunea Românească, Munteanu, D., *Păsările din România şi Europa-Determinator ilustrat*, Octopus Publishing Group Ltd, London.
8. CHIFU, T., MANOLIU, A., TOMA, C., 2008, *Parcul Naţional Călimani: studii ecologice şi de biodiversitate*, Ed. Alma Mater, Cluj-Napoca.
9. ĆIKOVIĆ, D., BARIŠIĆ, S., TUTIŠ, V., KRALJ, J., 2008, Woodpeckers in the Croatian Karst Mountains, *Bird Census News*, **21**, *1*: 2-15.
10. CIOCÂRLAN, V., 2009, *Flora ilustrată a României*-Pteridophyta et Spermatophyta, Ed. Ceres, Bucureşti.
11. CLARK, J.P., EVANS, C.F., 1954, Distance to the Nearest Neighbor as a Measure of Spatial Relationship in Populations, *Ecology*, **35**, *4*: 445-453.
12. COLDEA, GH., 1991, Prodrome des associations végétales des Carpates du sud-est (Carpates Roumaines), *Docum. Phytosoc.*, Camerino, **13**: 317-539.
13. COLDEA, GH., TÄUBER, F., POP, A., BARTÓK, K., MUNTEANU D., 1987, Cercetări biocenologice în ecosistemele forestiere din dealurile Sălajului, Zalău, *Acta Mus. Porolensis*, Muz. Ins. Arta, **11**: 479-492.
14. CRISTEA, V., BACIU, C., GAFTA, D. (*eds*.), 2002, *Municipiul Cluj-Napoca şi zona periurbană: studii ambientale*, Ed. Accent, Cluj-Napoca.
15. CRISTEA, V., GAFTA, D., PEDROTTI, F., 2004, *Fitosociologie*, Ed. Presa Universitară Clujeană, Cluj-Napoca.
16. CSEDŐ, K. (*red*.), 1980, *Plantele medicinale şi condimentare din judeţul Harghita*, Tipografia Târgu-Mureş
17. CSŰRÖS, Ş., 1963, Scurtă caracterizare generală a vegetaţiei din Transilvania, Bucureşti, *Acta Horti Bot. Bucurest*. /1961-1962/ *2*: 825-853.
18. CSŰRÖS, Ş., CSŰRÖS-KÁPTALAN, M., 1966, Caracterizarea unor asociaţii de plante din Transilvania pe baza indicilor ecologici, *Contrib. Bot.*, **6**: 163-179.
19. CSŰRÖS, Ş., CSŰRÖS-KÁPTALAN, M., RESMERIŢĂ, I., 1970, Indicii ecologici: umiditate, temperatură, reacţia solului şi valoarea furajeră a celor mai importante specii din pajiştile Transilvaniei, II., *Studia Univ. Babeş-Bolyai, Biol*., **1**: 9-14.
20. DAVID, A., 2008a, *Cercetări faunistice, biologice şi ecologice asupra populaţiilor de păsări din Câmpia Fizeşului*, teză de doctorat, Univ. "Babeş-Bolyai", Cluj-Napoca.
21. DAVID, A., 2008b, *Ecologia populaţiilor de păsări din Câmpia Fizeşului*, Presa Univ. Clujeană, Cluj-Napoca.
22. DONIŢĂ, N., POPESCU, A., PAUCĂ-COMĂNESCU, M., MIHĂILESCU, S., BIRIŞ I.A, 2005, *Habitatele din România*, Ed. Tehnică Silvică, Bucureşti.

23. DREVER, M.C., AITKEN, K.E.H., NORRIS, A.R., MARTIN, K., 2008, Woodpeckers as reliable indicators of bird richness, forest health and harvest, *Biol Conserv*, **141**, *3*: 624-634.
24. DUFRENE, M., LEGENDRE, P., 1997, Species assemblages and indicator species: The need for a flexible asymmetrical approach, *Ecol Monogr*, **67**: 345-366.
25. FARRIS, K.L., HUSS, M.J., ZACK, S., 2004, The role of foraging woodpeckers in the decomposition of ponderosa pine snags, *The Condor*, **106**: 50-59.
26. FERNANDEZ, C., AZKONA, P., 1996, Influence of forest structure on the density and distribution of the White-Backed Woodpecker *Dendrocopos leucotos* and Black Woodpecker *Dryocopus martius* in Quinto Real (Spanish western Pyrenees), *Bird Study*, **43**: 305-313.
27. FLOREA, N., MUNTEANU, I., 2000, *Sistemul Român de Taxonomie a Solurilor*, Ed. Univ. "Alexandru Ioan Cuza", Iaşi.
28. FULCO, E., FLORENZO, G.T., 2008, Composizione e struttura della comunità ornitica nidificante in una fagetta della Basilicata, *Avocetta*, **32**: 55-60.
29. FULLER, R.J., 1995, *Bird life of woodland and forest*, Cambridge University Press, Cambridge.
30. GAFTA, D., MOUNTFORD, J.O., (*eds.*), 2008, *Manual de interpretare a habitatelor Natura 2000 din România*, Ed. Risoprint, Cluj-Napoca.
31. HAJDU, Z., 2010, *Ivóvízkutak nitrátszennyeződése a Nyárád vízgyűjtőjében*, Ed. Did. şi Ped., Bucureşti.
32. ION, C., ZAMFIRESCU, Ş.R., ION, I., 2009, Aspects Concerning the Diversity of vertebrate Fauna on the Prut Valley Region-Arguments for a Transboundary Nature Reserve, *An. Ştiinţ. Univ. Al. I. Cuza Iaşi, s. Biol. Anim.*, **55**: 199-213.
33. ION, I., OPREA, A., ZAMFIRESCU, Ş., ION, C., ION, E., 2004, The conservation of the terrestrial vertebrates from the protected areas and natural reserves of Moldavia, Iaşi, *An. Ştiinţ. Univ. Al. I. Cuza Iaşi, s. Biol. Anim*., **50**: 279-292.
34. JACKSON, J.A., 1977, Red-cockaded Woodpecker (*Picoides borealis*) in: Poole, A., Gill, F. (eds.), *The birds of North America*, *85*, The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists'Union, Washington DC.
35. JACKSON, J.A., JACKSON, B.I.A., 2004, Ecological relationship between fungi and woodpecker cavity sites, *The Condor*, **106**: 37-49.
36. JAKAB, S., SIGHIŞOREAN, V., 1982, Regionarea pedogeografică a judeţului Mureş, *Marisia, Studii şi Mat., Studia Scient. Nat.*, **1**, *9-12*:13-16.
37. JANSSON, G., 1998, Guild indicator species on a landscape scale: an example with four avian habitat specialists, *Ornis Fennica*, **75**: 119-127.
38. JOSAN N., 1979, *Dealurile Târnavei Mici-Studiu geomorfologic*. Ed. Acad. Române, Bucureşti.
39. JUHÁSZ-NAGY, P., 1986, *Egy operatív ökológia hiánya, szükséglete és feladatai*, Akadémiai Kiadó, Budapest.
40. KAJTOCH, Ł., FIGARSKI, T., PEŁKA, J., 2012, The role of structural elements of forests in determining the occurrence of two specialist woodpecker species in the Carpathians, Poland, *Ornis Fennica*, **89**: 1-18.
41. KELEMEN, A., 1978, *Madaraskönyv*, Kriterion, Bukarest.
42. KOLEFF, P., GASTON, K.J., LENNON, J.J., 2003, Measuring beta diversity for presence-absence data, *J Anim Ecol*, **72**: 367-382.
43. KOSIŃSKI, Z., KEMPA, M., 2007, Density, distribution and nest-sites of woodpeckers *Picidae*, in a managed forest of western Poland, *Pol. J. Ecol.*, **55**, *3*: 519-533.
44. KOSIŃSKI, Z., KEMPA, M., HYBSZ, R., 2004, Accuracy and efficiency of different techniques for censusing territorial Middle Spotted Woodpeckers *Dendrocopos medius*, *Acta Ornithol*, **39**, *1*: 29-34.
45. KOVÁCS, A., BECHET, M., COLDEA, GH., KORODI, GÁL, I., TÖVISSI, I., DRĂGAN-BULARDA, M., TEODORESCU, M., 1970, Cercetări biogeocenologice în Pădurea Mănăştur-Cluj, Cluj-Napoca, *Contrib. Bot.*, 271-304.
46. KOVÁCS, A., COLDEA, GH., BECHET, M., KORODI, GÁL., I., DRĂGAN-BULARDA, M., 1969, Cercetări biocenologice în Pădurea Dezmir-Cluj, Cluj-Napoca, *Contrib. Bot.*, 245-274.

47. KOVÁCS, A., COLDEA, GH., KORODI, GÁL, I., KISS, ST., DRĂGAN-BULARDA, M., 1968, Cercetări biocenologice în Pădurea Lomb-Cluj, Cluj-Napoca, *Contrib. Bot*., 361-383.
48. KRATOCHWIL, A., 1987, Zoologische Untersuchungen auf pflanzensoziologischem Raster-Methoden, Probleme und Beispiele biozönologischer Forschung, Göttingen, *Tüxenia*, **7**: 13-51.
49. KRATOCHWIL, A., 1991, Zur Stellung der Biozönologie in der Biologie, ihre Teildisziplinen und ihre methodischen Ansätze, Freiburg , *Beih. Verh. Ges. f. Ökologie*, **2**: 9-44.
50. LAIOLO, P., 2002, Effects of habitat structure, floral composition and diversity on forest bird community in north-western Italy, *Folia Zool*, **51**, *2*: 121-128.
51. MAC, I., 1972, *Subcarpaţii Transilvăneni dintre Mureş şi Olt-Studiu geomorfologic*, Ed. Acad. Române, Bucureşti.
52. MAGURRAN, A., 2004, *Measuring biological diversity*, Blackwell Publ., Malden.
53. MCCOLLIN, D., 1998, Forest edges and habitat selection in birds: a functional approach, *Ecography*, **21**, *3*: 247-260.
54. MIKUSIŃSKI, G., ANGELSTAM, P., 1997, European woodpeckers and anthropogenic habitat change: a review, *Die Vogelwelt*, **118**: 277-283.
55. MIKUSIŃSKI, G., ANGELSTAM, P., 1998, Economic geography, forest distribution and woodpecker diversity in central Europe, *Conserv Biol*, **12**: 200-208.
56. MIKUSIŃSKI, G., GROMADZKI, M., CHYLARECKI, P., 2001, Woodpeckers as Indicators of Forest Bird Diversity, *Conserv Biol*, **15**, *1*: 208-217.
57. MOGA, I.C., 2009, *Studiul avifaunei din Podişul Mediaşului şi a unor zone limitrofe*, teză de doctorat, Univ. "Babeş-Bolyai", Cluj-Napoca.
58. MUNTEANU, D., 1974, Analiza zoogeografică a avifaunei române, *Stud. Com. Muz. „Țării Crișurilor", Nymphaea*, Oradea, **2**: 27-69.
59. MUNTEANU, D., 2000, *Avifauna bazinului montan al Bistriţei moldoveneşti*, Ed. Alma Mater, Cluj-Napoca.
60. NAGY-TÓTH, F., 1998, *Régi erdélyi almák*, Erdélyi Múzeum-Egyesület, Kolozsvár.
61. NILSSON, S.G., HEDIN, J., NIKLASSON, M., 2001, Biodiversity and its Assessment in Boreal and Nemoral Forests, *Scand J Forest Res*, **3**: 10-26.
62. ORBÁN, B., 1991, *A Székelyföld leírása*, Európai Idő Kiadó "EURID" KFT, Sepsiszentgyörgy.
63. OROIAN, S., 1995, Flora Târgu-Mureşului oglindită în colecţia botanică Nagy Ödön, *Marisia, Studia Scient. Nat*., **2**, *23-24*: 197-233.
64. OTIMAN, P.I. (*red.*), 2010, *Conservarea geo- şi biodiversităţii şi dezvoltarea durabilă în Ţara Haţegului-Retezat, vol. I.: Geo- şi biodiversitatea în Ţara Haţegului-Retezat*, Ed. Acad. Rom., Bucureşti.
65. PASINELLI, G., 2007, Nest site selection in middle and great spotted woodpeckers *Dendrocopos medius* & *D. major*: implications for forest management and conservation, *Biodiversity and Conservation*, **16**, *4*: 1283-1298.
66. PĂTROESCU, M., CHINCHEA, I., ROZYLOWICZ, L., SORESCU, C. (*eds.*), 2007, *Pădurile cu pin negru de Banat (*Pinus nigra *ssp.* banatica*) sit NATURA 2000*, Ed. BRUMAR, Timișoara.
67. POP, I., 1982, Plante spontane şi subspontane cu valoare economică din flora R. S. România, *Contrib. Bot.*, **22**: 131-142.
68. POPESCU-ZELETIN, I. (*red.*), 1971, *Cercetări ecologice în Podişul Babadag*, Ed. Acad. R.S. România, București.
69. RANG, C.P., 2002, *Studiul dinamicii unor comunități de păsări din bazinul mijlociu al râului Siret incluzând zonele lacurilor de acumulare*, Publicaţiile Societăţii Ornitologice Române, Cluj-Napoca.
70. ROBERGE, J.M., ANGELSTAM, P., 2006, Indicator species among resident forest birds-A cross-regional evaluation in northern Europe, *Biol Conserv*, **130**, *1*: 134-147.
71. ROBERTS, D.W., OKSANEN, J., 2006, *Labdsv: Laboratory for dynamic synthetic vegephenomenology. R package version*, 1-2.
72. ROȘU, A., 1980, *Geografia fizică a României*, Ed. Did. și Pedag., București.
73. SANDA, V., 2002, *Vademecum ceno-structural privind covorul vegetal din România*, Ed. Vergiliu, Bucureşti.

74. SANDA, V., ÖLLERER, K., BURESCU, P., 2008, *Fitocenozele din România-sintaxonomie, structură, dinamică şi evoluţie*, Edit. Ars Docendi, Bucureşti.
75. SEGHEDIN, T., FILIPAŞCU, A., BOŞCAIU, N., 1977, Cercetări biocenologice în rezervaţia naturală Lunca Zamostei, *Stud. şi Com. de Ocrot. Nat.*, Suceava, **4**: 79-86.
76. SHAW, D., PERRINS, C.M., 1998, *The complete birds of the Western Palearctic on CD-ROM*, Oxford: Oxford University Press.
77. SISK, T.D., BATTIN, J., 2002, Habitat edges and avian ecology: geographic patterns and insights for western landscapes, *Stud Avian Biol-Ser*, **25**: 30-48.
78. TÖRÖK, V., 2008, *Szentháromság tornya, jaj de messzire látszik*, AMM Kiadó, Kolozsvár.
79. TRELEA, S., 2000, *Avifauna Depresiunii Rădăuți*, Ed. Risoprint, Cluj-Napoca.
80. ÚJVÁRI, I., 1972, *Geografia apelor României*. Ed. Ştiinţifică, Bucureşti.
81. VIRKKALA, R., 2006, Why study woodpeckers? The significance of woodpeckers in forest ecosystems, *Ann Zool Fenn*, **43**: 82-85.
82. VOOUS, K.H., 1960, *Atlas of European Birds*, Thomas Nelson and Sons, New York.
83. WESOŁOWSKI, T., 2011, ‘‘Lifespan’’ of woodpecker-made holes in a primeval temperate forest: A thirty year study, *Forest Ecol Manag*, **262**: 1846-1852.
84. WINKLER, H.D.A., NURNEY, C., NURNEY D., 1995, *Woodpeckers-a guide to the woodpeckers, piculets and wrynecks of the world*, Pica Press, East Sussex.

*** *http://palaeo-electronica.org/2001_1/past/issue1_01.htm*
*** *http://www.cran.r-project.org/*
*** *http://www.iucnredlist.org/*
*** *http://www.natura2000.ro/*
*** *http://www.valeanirajului.ro/attachments/article/69/PDL%20versiunea%203.pdf*
*** *http://www.weatheronline.co.uk*
*** *www.milvus.ro/ariiprotejate/*
*** *www.valeanirajului.ro/natura2000*
*** Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
*** Directiva Consiliului din 2 aprilie 1979 privind conservarea păsărilor sălbatice (79/409/CEE)
*** LEGE Nr. 13 din 8 ianuarie 1998 pentru aderarea României la Convenţia privind conservarea speciilor migratoare de animale sălbatice, adoptată la Bonn la 23 iunie 1979
*** Ordonanţa de urgenţă nr. 57/2007 privind regimul ariilor naturale protejate, conservarea habitatelor naturale, a florei şi faunei sălbatice
*** Regia Națională a Pădurilor ROMSILVA, Institutul de Cercetări și Amenajări Silvice, Amenajamentul U.P. VIII Gălăţeni, Ocolul Silvic Târgu Mureş, Direcţia Silvică Târgu Mureş, 2008
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- Plant communities

List of published scientific papers with content from the thesis

Articles in journals indexed in ISI

1. DOMOKOS, E., CRISTEA, V., 2014, Effects of managed forests structure on woodpeckers (*Picidae*) in the Niraj valley (Romania): Woodpecker populations in managed forests, *North-West J. Zool*, **10**, *1*: 110-117. **IF$_{2013}$ = 0.700** [2013 Journal Citation Reports ®, Science Edition, (Thomson Reuters 2013)]

Articles in journals indexed in IDB

1. DOMOKOS, E., 2013, The ecological characterization of the forestry associations from the middle stream of the niraj valley (Romania, Mureş county), *An. Ştiinţ. Univ. Al. I. Cuza Iaşi, Sect. II a. Biol. veget.*, **59**, *2*: 99-106.
2. DOMOKOS, E., CRISTEA, V., 2013, The Woody Vegetation in the Middle Stream of the Niraj Valley (Romania, Mureş County), *J. Plant Develop*, **20**: 149-162.

Other articles / scientific communications at conferences or sessions

1. DOMOKOS, E., The qualitative structure of the forestry associations from the middle stream of the Niraj valley (Romania, Mureș county), *Sesiunea ştiinţifică anuală a Facultăţii de Biologie, Sect. Biologie vegetală*, 24-26 Octombrie 2013, Facultatea de Biologie, Universitatea ,,Alexandru Ioan Cuza" din Iaşi, abstract, p. 35.
2. DOMOKOS, E., 2012, Biocönológiai kutatások a Nyárád völgyének középső szakaszán, *Erdélyi Múzeum Egyesület: Fiatal Műszakiak Tudományos Ülésszaka-International Scientific Conference*, **17**: 103-106.
3. DOMOKOS, E., 2011, Biocönológiai kutatások Romániában, *Erdélyi Múzeum Egyesület: Fiatal Műszakiak Tudományos Ülésszaka-International Scientific Conference*, **16**: 75-78.