Romanian Journal for Plant Protection, Vol. VII, 2014
ISSN 2248 – 129X; ISSN-L 2248 – 129X

BIODIVERSITY OF INSECT POPULATIONS FROM APOIDEA SUPERFAMILY IN AGRICULTURAL ECOSYSTEMS

*Traian Manole**

Research-Development Institute for Plant Protection, Pest organism laboratory, Bucharest, Romania

*corresponding author:
Research-Development Institute for Plant Protection
Bd. Ion Ionescu de la Brad nr.8, CP 013813, sector 1,
Bucharest, ROMANIA
Tel: 004-021-2693231 (32, 34)
Fax: 004-021-2693239
E-mail: traian.manole@gmail.com

Abstract
In the present study the numerical density and biodiversity of species of pollinating insects from superfamily Apoidea were evaluated in the three selected representative types of ecosystems in the two research areas: South Muntenia and South East region.These species are particularly useful in their work like pollinators of plants crops, thus being services furnishing species and resources for integrated agricultural management.Apoidea density of individuals was estimated using the method of linear transects in strips and was expressed by the number of individuals/ha and diversity was assessed using Shannon-Wienner index (diversity index H').The study identified a total (on the whole research area) of 106 species taxonomically classified into 7 families: Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae, Anthophoridae and Apidae.In the first area of research, South Muntenia three ecosystem types has selected: semi-natural (oak forest), alfalfa and sunflower and in the South East region the study was conducted in two types of agricultural ecosystems: alfalfa and sunflower. In the semi-natural ecosystem type 106 species were identified. The evaluation of density revealed the dominant species: *Andrena flavipes* Panz., *A. subopaca* Nyl., *Eucera tuberculata* F. and *Halictus maculatus* Smith. Diversity index had a high value (2.70) the best represented species being of the families Halictidae, Andrenidae, Anthophoridae and Megachilidae. In the agricultural ecosystem of alfalfa, 77 species have been identified, the dominant being *Bombus lucorum* L., *Apis mellifera* L., *Andrena gelriae* Vecht and *Melitta leporina* Panz.Diversity index was H' = 2.33 and families best represented were: Halictidae, Andrenidae and Anthophoridae. In the sunflower ecosystem 70 species were identified from which *Apis mellifera* L. *Lasioglossum pauxillum* Schr., *Nomada ruficornis* L., and *Anthophora crinipes* Smith, were dominant.Index H' value was 1.90 and species richness was highest for families: Halictidae, Andrenidae, Anthophoridae, Megachilidae and Apidae.In the South East Region, in the first type of agricultural ecosystem (alfalfa) 88 species were identified of which were dominant: *Bombus pratorum* L., *Rophites hartmanni* Friese, *Bombus terrestris* L., *Apis mellifera* L., *Andrena gelriae* and *A. flavipes* Panz.Diversity index (H'=2.33) with the biggest value was observed in most species of the families: Halictidae, Andrenidae, Megachilidae, Anthophoridae and Apidae.In the sunflower ecosystem a total of 70 species was identified from which the dominant populations were: *Apis mellifera* L., *Lasioglossum politum* Schenk., *Bombus pratorum* L., *Anthophora acervorum* L., *L. pauxillum* Schrank., *Nomada ruficornis* L. and *Andrena minutula* Kirby.Highest diversity (H'=1.90) characterized the species of the families: Halictidae, Andrenidae, Anthophoridae, Megachilidae and Apidae.

Key words: ecology conservation, agrosystems, wild pollinators

INTRODUCTION

The recognition that biodiversity offers humankind important services has led to a sea of change in thinking about the linkages among biodiversity, ecosystem function, and the economic

value of services arising from those functions (Daily, 1997). The annual net value of these services is considerable: it has been assessed in the billions of U.S. dollars (Costanza et al., 1997; Daily, 1997).Consideration of ecosystem services fall into two broad categories: direct services such material goods with tangible valuable financial on the market (like foods staff, raw materials and so on) and indirect nonmarketable services, this second category typically do not have a direct marketable value because they cannot be easily sold. Both services categories are ecological important functions ranging from sustaining ecological cycles to maintaining long-term sustainability of ecosystems (Myers, 1996; Schmitz, 2007).

Information system for assisting measures for sustainable use of natural capital as the foundation of sustainable economic development and social welfare requires a new approach to conservation strategy biodiversity and a set of tools to assess biodiversity as a supplier of goods and services. In this context, identification of taxa of fauna and flora, structure and function of guild (trofodynamic modules MTD) is strictly required for revealing the role in initiating and sustaining populations of the species mass flows, energy and information embodied in the flows of resources and services.

Increased demand for agricultural products, seeds, especially in case of perennial legumes crops, increased the interest in the study of insect pollinator both in terms of highlighting the diversity and species composition and the measures necessary to protect and maintain this diversity. Wild bees (Apoidea superfamily species) are insects through their function as pollinators and their role within this relationship relay an important service for plant and agricultural production.

Studies on the fauna species of bees in Romania have begun in the nineteenth century of the last millennium (Frivaldzky, 1873; Henrich, 1880 and 1884 Mocsary, 1874, 1897). Most data come from studies undertaken by Iuga, 1958; Palade, 1959; Knechtel, 1955; Scobiola-Palade, Goaga, 1972; Scobiola-Palade and al., 1974;Lehrer et al., 1979; Ciurdarescu, 1980, 1981, 1982; Warncke et al., 1980. Studies of the taxonomy of this group of insects were carried out so far in our country by Scobiola-Palade, being identified a total of 850 species (Scobiola-Palade, 1972). These papers contain information on the role and potential of these species for pollination of both wild plants and especially of important crop plants. Species density of pollinating insects, is an important ecological driver, especially for seed production of certain crops (alfalfa, sunflower,

perennial legumes etc.) so far not undertaken any studies in our country on the density and species richness of these species in agricultural crops. The results presented in this paper concerns the evaluation of numerical density of dominant species in both natural and anthropogenic areas.

MATERIALS AND METHODS

Description on the research areas

The research was conducted in two agricultural areas in Romania, chosen as representative areas of development in localities situated about 60 km from Bucharest (Călugăreni and Comana) belonging to South Muntenia and Uzlina area (South East Region). The first area chosen near the Comana Nature Reserve (included in Natura 2000 ecological network) is situated in the Neajlov river basin. The structure of ecosystems type and the DPSIR (**d**rivers-**p**ressure-**s**tate-**i**mpact-**r**esponse) analysis from the EEA/R20/2001 model was perform by a scientific team belonging to DESDD (Vădineanu, 2004)(Figure 1).

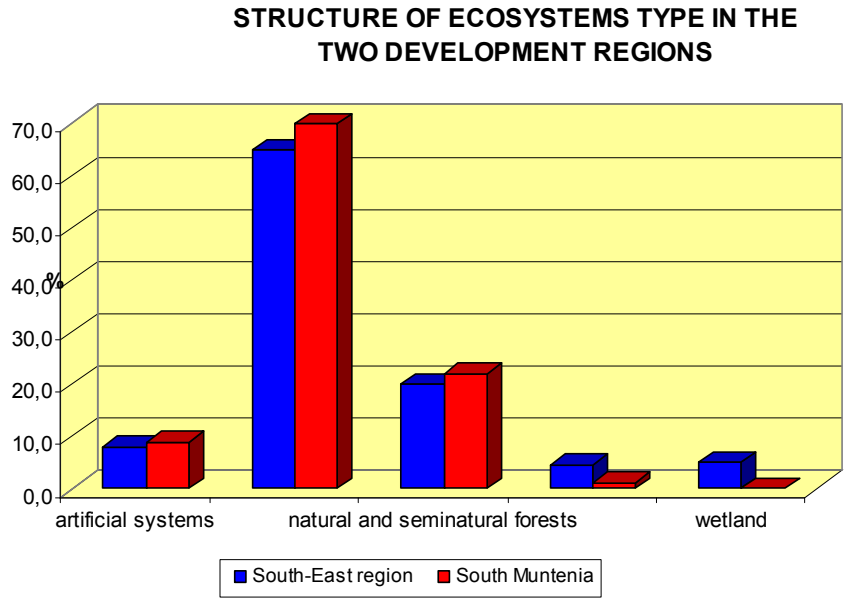

Figure 1 – The main structure distribution of ecosystems type in the two research areas

Were selected three ecosystem types: natural (oak forest edge), sunflower and alfalfa crops (Figure 2) in the South Muntenia Region versus the investigations that were carried out in the South East region only two types of agrosystems (alfalfa and sunflower). One of the biggest part of that area is belonging to Nature Reserve Comana – the unique of natural ecosystems

associations in the Natura 2000 network (Figure 3). Established research area in South Muntenia is a low plain in that large areas are cultivated (maize, alfalfa, sunflower) interspersed with noncultivated areas of grassland steppe or shrubs plant associations (Sorbus, Crataegus, Prunus etc.) and that agriculture is practiced intensively, which is the criterion that determined the choice of research area. Dominant soil type is leached chernozem with medium heavy texture generally formed on shale deep loess wind. The climate is continental with an average annual of temperature of 10.5^0C. Average amount of rainfall reaching 555 mm per year, 72% during the growing and flowering of the main crops, (i.e. the May-June months).

Figure 2 - Agricultural ecosystem (alfalfa) in the research area of South Muntenia region, Neajlov Basin (Nature Reserve Comana in Natura 2000 area)

Figure 3 - Landscape in the Nature Reserve Comana (Natura 2000 area)

Only 35% of annual precipitation falls during the summer.In the South East which includes Dobrogea Region, investigations were carried out in the Uzlina locality. Alluvial soils contain a broad spectrum (being met almost all soil types), but predominantly was the black earth cernozem with light and sandy texture. The city is included in the Danube Delta Biosphere Reserve and is located on an alluvial origin grind. The climate is varied from southern Mediterranean to Central European with Black Sea marine influences and temperatures ranging between -30^0C and 42^0C. Rainfall is contained, on average between 400 and 900 mm. Investigations were carried out as in the South Muntenia Region in the period 2011-2012 and in the South East region from April 2005 to July 2007. For each type of ecosystem composition and number and density of species was evaluated.

Species density

Apoidea density of individuals was estimated using the method developed by Banaszak since 1980, called the strip transect method or linear transects (Banaszak, 1980; 1987). This method is based on counting the number of individuals captured on a surface with a width of 1 meter and 200 m long with a speed not exceeding 10 m/min. Number of individuals captured on the surface of 200 m^2 was a sample and the number of individuals was expressed per hectare as a standard unit for all types of ecosystems.

Species diversity

Diversity (species richness) of Apoidea fauna identified was estimated with the Shannon-Wienner (diversity index (H'):

$$H' = - \sum p_i \times \ln p_i$$

where p_i is the average number of individuals/ha.

The degree of variation of the values of diversity to the maximum value was estimated using the correction index Pielou, 1975:

$$J' = \frac{H'}{\ln S}$$

where S is the number of species.

RESULTS AND DISCUSSIONS

The investigations carried out have allowed the identification of a total 106 species of wild bees for both two areas of research. This number is considered far from the real, existing in our country, especially in lowland areas cultivated with crop species attractive to pollinating insects. Investigated ecosystems differ considerably in terms of structure or composition of faunal species. Sunflower crops (Figure 4) are characteristic by solitary bees species from Anthophoridae, Andrenidae and Halictidae families, while alfalfa crops were mostly populated with social species from Megachilidae, Apidae and Melittidae families. This observation coincided with survey data conducted in Poland by Banaszak, (1983). The massive participation of the insects species from family Halictidae for pollination of sunflower is a test of the possibilities of these insects to overcome the barriers imposed by the pressure of human activities by adapting to survive under severe stress caused by the intensive agricultural management. Dominant species which were identified like very important for pollinating crops of legumes (alfalfa, clover) were *Andrena gelriae* Vecht, *A. flavipes* Panz., *Rophites canus* Evers., *Melitta leporina* Panz., *Eucera tuberculata* F., *E. interrupta* Bear, *E. clypeata* Erich., *Bombus lucorum* L., while those attracted by sunflower plants were *Halictus simplex* Blüth., *Apis mellifera* L., *Bombus terrestris* L., *B. sylvarum* L., *Andrena carbonaria* L.

Figure 4 - Agricultural ecosystem of sunflower in the research area South Muntenia, Neajlov Basin

Area Research South Muntenia Region
Semi-natural type of Ecosystems

The taxonomic structure and numerical density of wild bees species from Apoidea were presented in the Table 1. The main presence and distribution of wild bees species were in the semi-natural type of ecosystem from the area. In this type of ecosystem has been assigned an oak forest (grass meadows within the forest and adjacent fringe area) surrounded by areas planted with sunflowers and alfalfa. Inside the forest, vegetation compact portions were poorly represented and sporadic presence of pollinating insects. Grassy areas instead are visited by a large number of species, especially in May and June, during the flowering of plant species: *Lithospermum purpureocoeruleum* L., *Fragaria vesca* L. and *Veronica chamaedrys* L. Dominant species were *Andrena labiata* F., *A. subopaca* Nyl., *Anthophora acervorum* L. and *Eucera tuberculata* F. The Apoidea populations structure included in terms of taxonomic the families: Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae, Anthophoridae and Apidae (Table 1). Numerical density, expressed in numbers of individuals/ha was calculated by the method stated and data have revealed the dominant pollinator insect species in this ecosystem types (Table 1). This type of habitat hosts the largest number of species (106). The average density of individuals wild bees varied reaching the highest values in May (3,100 ind./ha) decreasing

progressively in June (932.5 ind./ha) and respectively at 400-750 ind./ha in July. Dominant species belonged to the family Andrenidae (Figure 5) of which stands *Andrena flavipes* Panz., *A. subopaca* Nyl., to Anthophoridae family (*Eucera tuberculata* F.), or Halictidae family (*Halictus maculatus* Smith.). Species diversity of Apoidea, calculated using the Shannon-Wiener index was 2.70 corresponding to the index J' = 0.80, figures indicating an increased value of this parameter versus anthropogenic ecosystems (Table 2). Family Halictidae is best represented in terms of species richness with a number of 38 species, followed by families Andrenidae, Anthophoridae and Megachilidae (Figure 6). These insects well represented in these areas provide important crop services included in the agricultural landscape, especially for sunflower crop.

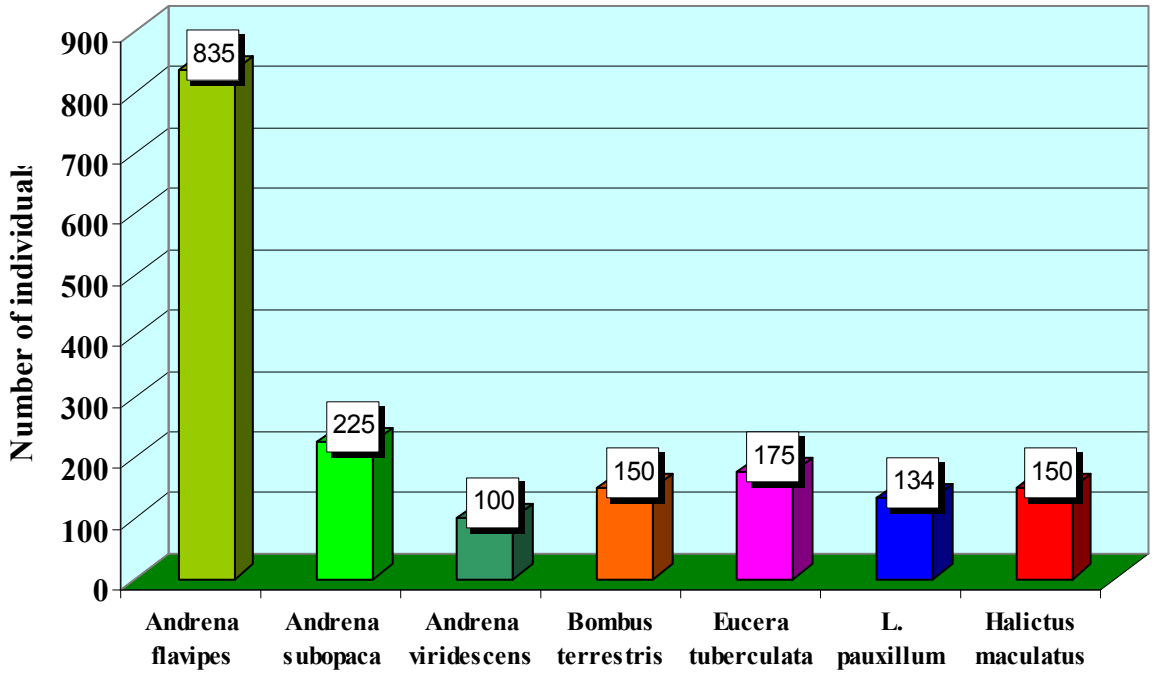

Figure 5 - The dominant species of Apoidea in the semi-natural ecosystem from South Muntenia region – Comana locality

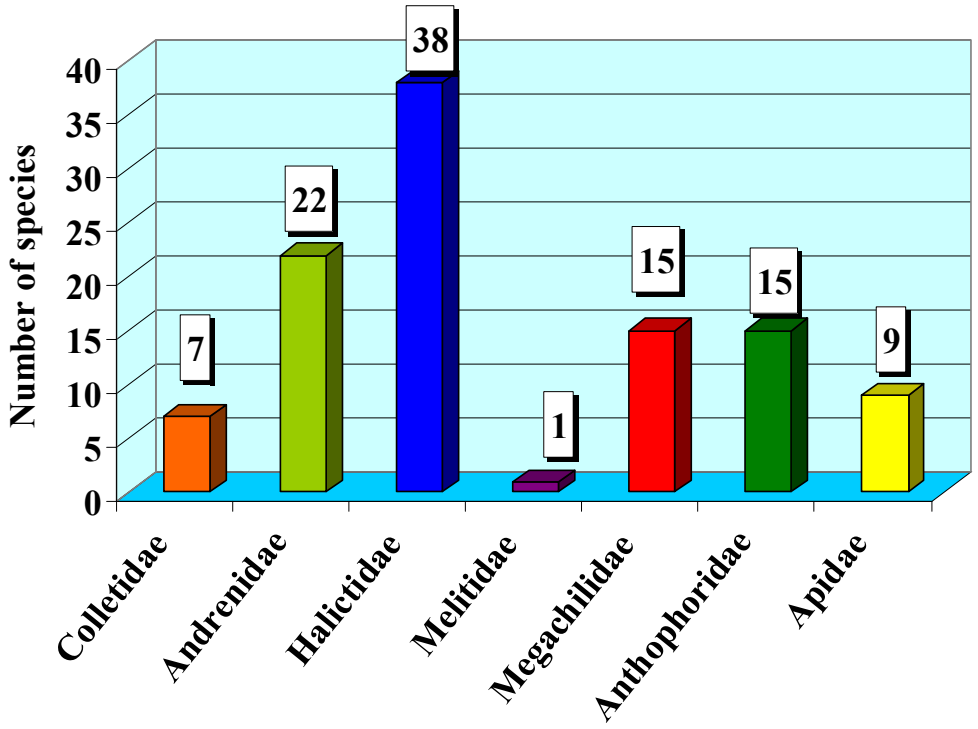

Figure 6 - The diversity of Apoidea species in the semi-natural ecosystem in South Muntenia - Comana locality

Agrosystems – research area Sud Muntenia Region

Two types of ecosystems selected by criterion of importance of seed production were investigated, wild bees populations being an important factor for providing this service to increase seed production through their pollen and nectar collecting activity, and by default pollinators function. In the case of agricultural ecosystem of alfalfa (agrosystem I) identified species belonging to the families Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae, Anthophoridae and Apidae (Table 1). Have been identified 77 species with average densities ranging from 4,700 ind./ha in May, 3,200 ind./ha in June and 1,700 ind./ha, respectively in July. The dominant species (recorded in May-July) were *Bombus lucorum* L., *Apis mellifera* L., of the Apidae family, *Andrena gelriae* Vecht, from Andrenidae family and *Melitta leporina* Panz., from Melittidae family (Figure 7). In terms of diversity recorded by various families of wild bees in alfalfa crops was revealed that the highest species richness was observed in the case of Halictidae, Andrenidae, Anthopohoridae, Apidae and Megachilidae families (Figure 8). It should be noted that although agricultural ecosystems was a less diversity (species richness) than natural

ecosystem, the role of effective pollinators of the superfamily Apoidea insect species is fulfill prevented by the much higher densities of wild bees recorded in these crops.

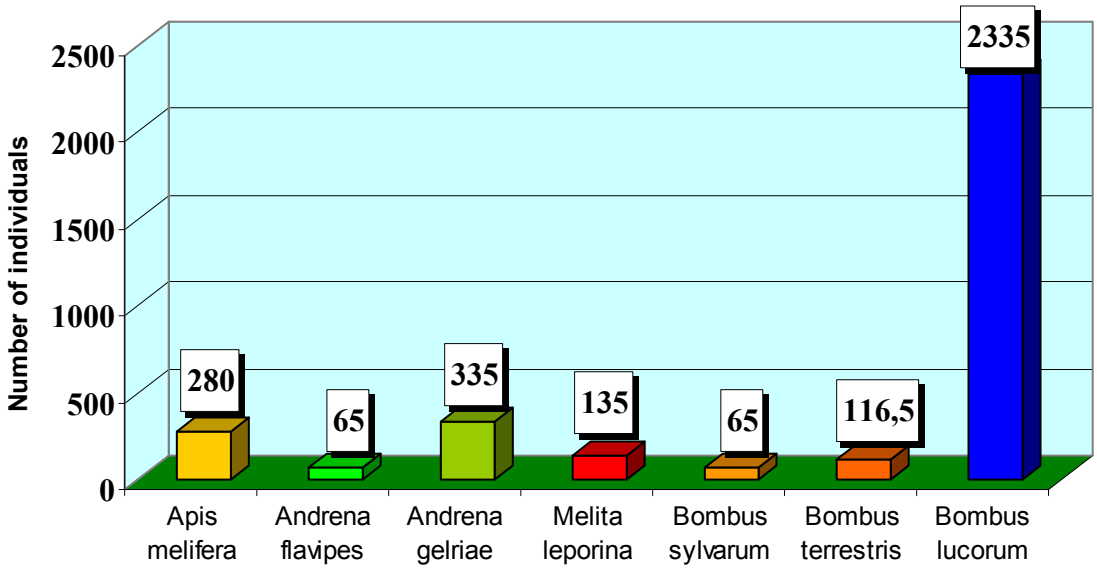

Figure 7 - The dominant species of Apoidea in alfalfa agrosystem in South Muntenia Region – Comana locality

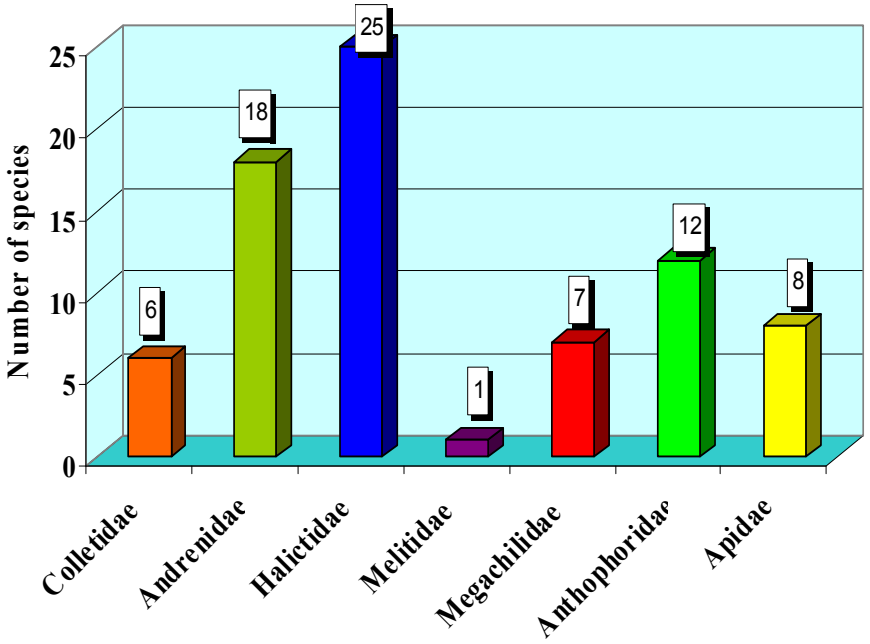

Figure 8 - Apoidea species diversity in agricultural ecosystems (alfalfa) in South Muntenia Region – Comana locality

Crops are developing and uniform flowering, almost at the same time (phenophases) an important food resource for these species. Their effectiveness is enhanced by the fact that many of these species are colonial species have the ability to store food resources in special nests. In this way their intense work of supply is a more efficient service given the period of flowering in case of plant species that pollination is only fulfill by insect and even specific to a certain species of wild bees.

In the culture of sunflower (agrosystem II) was noted the presence of 70 wild bees species of the families Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae, Anthophoridae and Apidae. Although it can be said that alfalfa is proving competitive with sunflower, though many species reach high densities per unit area chosen (3,665 ind./ha in average density value). The dominant species were from the family Apidae (especially *Apis mellifera* L.) and *Lasioglossum politum* Sch., *Bombus pratorum* L., *Anthophora acervorum* L. and *Lasioglossum pauxillum* Schr. (Figure 9). In terms of species diversity of Apoidea, this is reflected by the high value of the Shannon-Wiener index which reach the value of 1.90 corresponding to J'= 0.79. In terms of biodiversity most species belonging to the families Halictidae, Andrenidae, Anthophoridae, Megachilidae and Apidae (Figure 10).

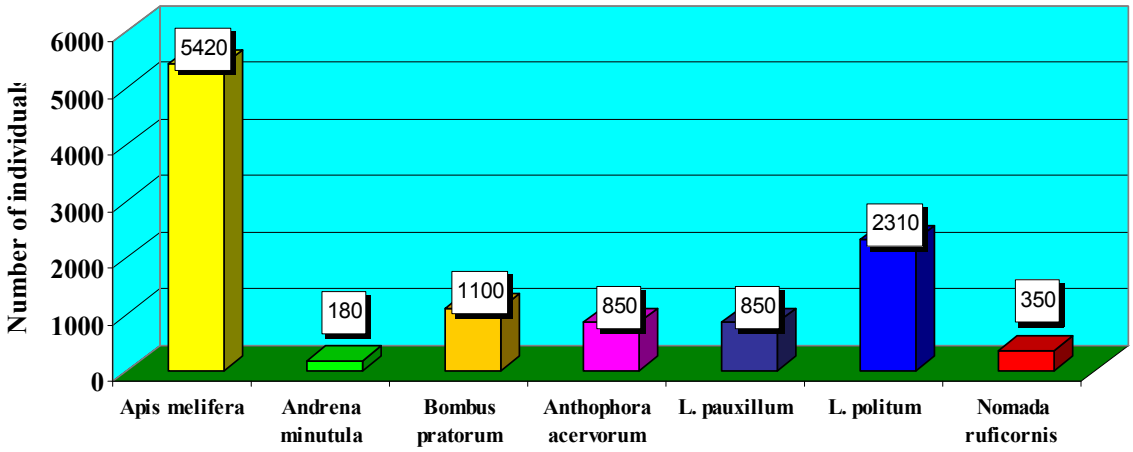

Figure 9 - The dominant species in sunflower crop in South Muntenia Region – Călugăreni locality (Neajlov basin)

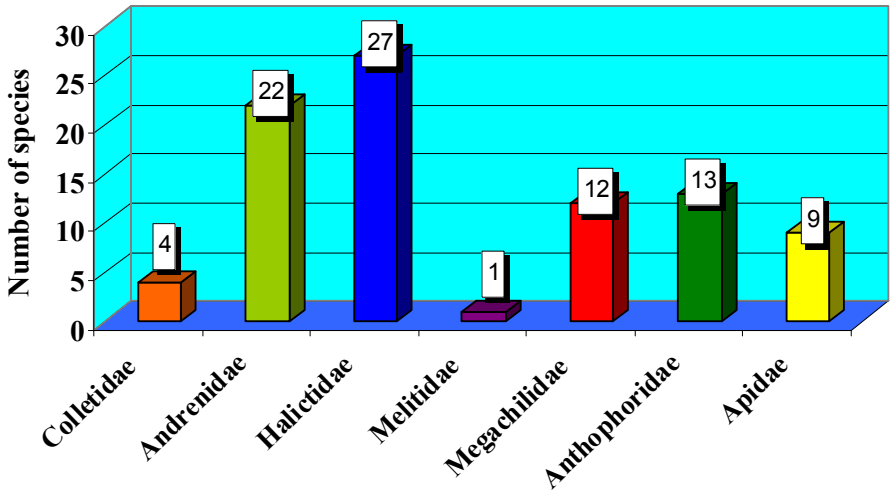

Figure 10 - Species diversity of Apoidea in sunflower crop in South Muntenia – Călugăreni locality (Neajlov basin)

Agrosystems - South East research area

In the case of alfalfa ecosystem 88 wild bees species were identified with high density per hectare standing out in this case that a low diversity is compensated by a large number of individuals per unit of surface (Table 3). The dominant species were from the Apidae family (*Bombus pratorum* L., *B. terrestris* L., and *Apis mellifera* L.), Halictidae family (*Rophites hartmanni* Friese), and Andrenidae (*Andrena gelriae* şi *A. flavipes* Panz.) (Figure 11) .

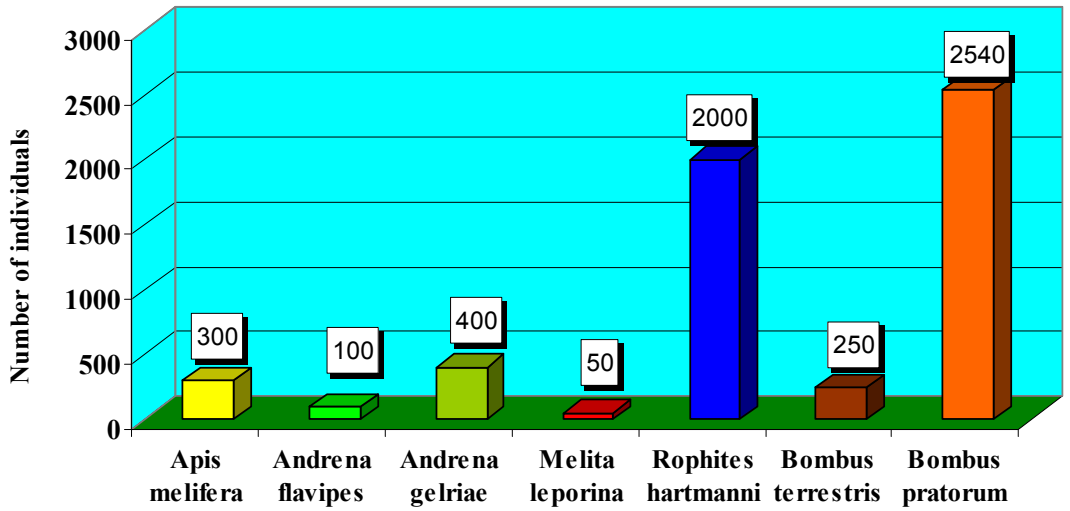

Figure 11 – The dominant species of wild bees (Apoidea) in the alfalfa crop in the South East Region - locality Uzlina

Species diversity of Apoidea, presented a high Shannon-Wiener index (2.33) corresponding to the index J' = 0.70. The diversity of Apoidea species observed in this agricultural ecosystem were illustrated in Figure 12. The results show that most numerous species belonging to the family Halictidae followed in order by the family Andrenidae, Megachilidae, Apidae and Anthophoridae. In the culture of sunflower (agrosystem II) (Figure 13) the presence of 70 species of the families Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae, Anthophoridae and Apidae was noted. The dominant species were *Apis mellifera* L., *Lasioglossum politum* Schenk., *Bombus pratorum* L., *Anthophora crinipes* Smith., *L. pauxillum* Schrank., *Nomada ruficornis* L. and *Andrena minutula* Kirby (Figure 14). Species diversity of Apoidea, amounted to 1.90 Shannon-Wiener index, corresponding to the index J' = 0.79 (Table 4). It is highlighted with the highest species richness of Halictidae family followed the Andrenidae family, Anthophoridae, Megachilidae and Apidae (Figure15).

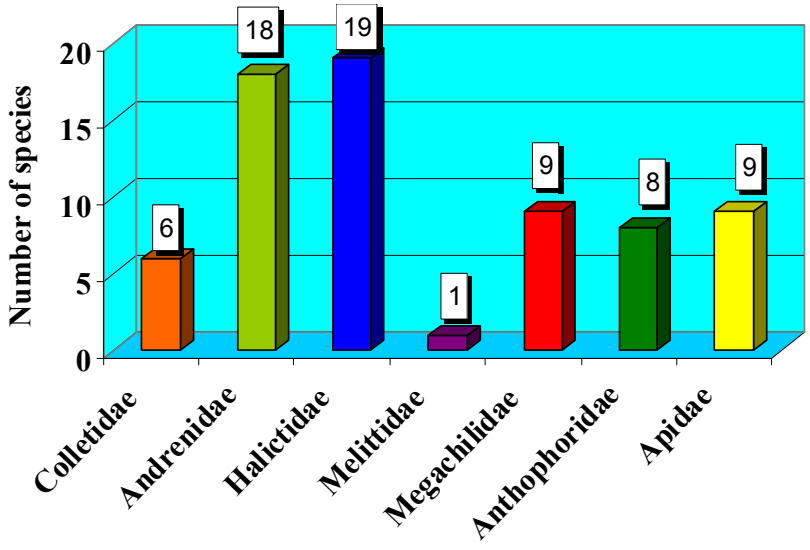

Figure 12 – Species diversity of Apoidea in the alfalfa crop in the South East Region - locality Uzlina

Figure 13 - Agricultural ecosystem (sunflower) in the research area of South East region

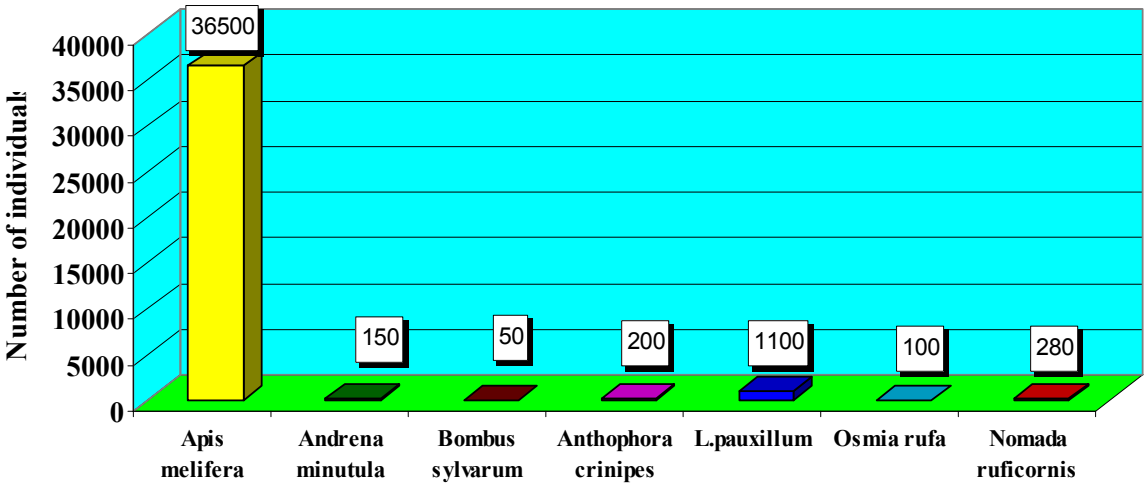

Figure 14 - The dominant species of Apoidea in sunflower crop in the South East Region - locality Uzlina

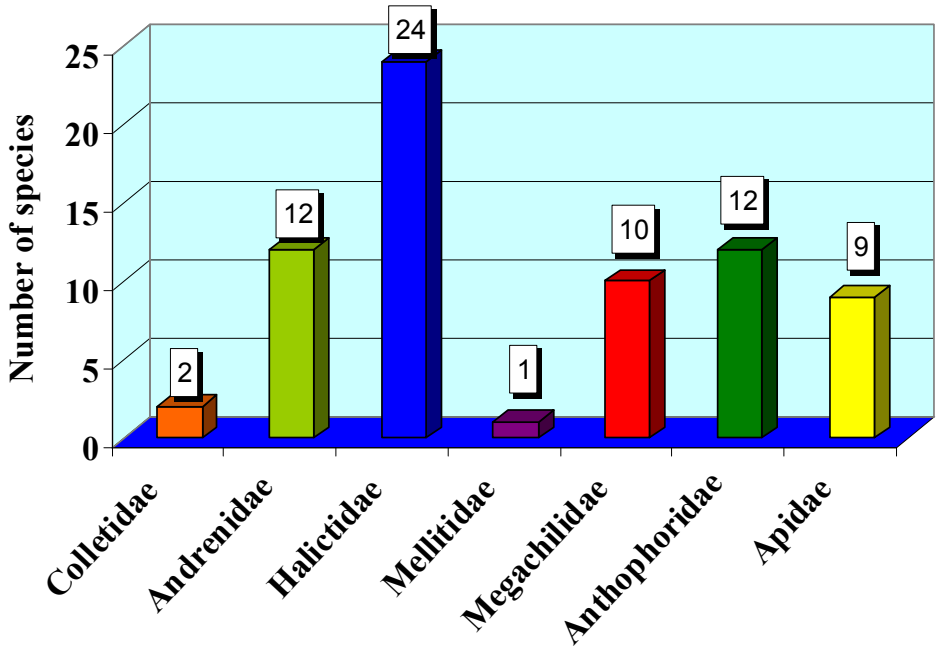

Figure 15 - Species diversity of Apoidea in sunflower crop
in the South East Region – Uzlina locality

CONCLUSIONS

- The case study was aimed at highlighting the faunal structure, density and diversity of species of wild bees (Apoidea) which had an important role as service furnishing in agricultural ecosystems crop (alfalfa, sunflower) that high seed production is ensured by the activity of these species, the most important pollinators;
- Research has allowed the taxonomic identification of a number of 106 species for the whole two research areas: **South Muntenia Region** and **South East Region**;
- The study revealed the superfamily Apoidea with some important faunal resources. Were identified, in terms of taxonomic field 7 families: Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae, Anthophoridae and Apidae;
- Investigated ecosystems shows important differences in species composition. Wooded areas and grassy characteristics such as the presence of solitary species of the family Andrenidae or Anthophoridae while farmland and generally open fields were characterized by the presence of abundant colonial species of the family Halictidae. Estimating diversity using index Shannon-Wiener revealed important differences in terms of this parameter. In the semi-natural type of

ecosystem this index ranged between 2.26 and 2.70 while of agricultural ecosystems, the values were between 1.74 and 2.33;

- In the semi-natural type of ecosystem 106 species were identified. The evaluation revealed the dominant species density: *Andrena flavipes* Panz., *A. subopaca* Nyl., *Eucera tuberculata* F. şi *Halictus maculatus* Smith.Diversity index had a high value (2.70) the best represented species being of the families Halictidae, Andrenidae, Anthophoridae and Megachilidae;
- In the agricultural ecosystem of alfalfa from **South Muntenia region** have been identified 77 species, the dominant being *Bombus lucorum* L., *Apis mellifera* L., *Andrena gelriae* Vecht and *Melitta leporina* Panz. Diversity index was H' = 2.33 and the families best represented were: Halictidae, Andrenidae and Anthophoridae;
- In the sunflower ecosystem from South Muntenia region 70 species of wild bees were identified from which the dominant were *Apis mellifera* L., *Lasioglossum pauxillum* Schr., *Nomada ruficornis* L., and *Anthophora crinipes* Smith. Index H' value was 1.90 and species richness was highest for families: Halictidae, Andrenidae, Anthophoridae, Megachilidae and Apidae;
- In the **South East Region**, on the first type of agricultural ecosystem (alfalfa) 88 species of wild bees were identified of which were dominant: *Bombus pratorum* L., *Rophites hartmanni* Friese, *Bombus terrestris* L., *Apis mellifera* L., *Andrena gelriae* and *A. flavipes* Panz. Diversity (H' = 2.33) was observed in the most species of the families: Halictidae, Andrenidae, Megachilidae, Anthophoridae and Apidae;
- In the sunflower ecosystem a total of 70 species was identified and the dominant were *Apis mellifera* L., *Lasioglossum politum* Schenk., *Bombus pratorum* L., *Anthophora acervorum* L., *L. pauxillum* Schrank., *Nomada ruficornis* L. and *Andrena minutula* Kirby. Highest diversity (H' = 1.90) characterized the species of the families: Halictidae, Andrenidae, Anthophoridae, Megachilidae and Apidae;
- Average number of individuals per hectare was similar for both natural ecosystems and agrosystems selected with a value of around 1,000 ind./ha. In alfalfa crops this value was three times higher on a high intake of food and attracting a large number of insects in areas of adjacent

refuge. In the natural forest areas this value was 3 times higher, 4 times in ruderal vegetation zones and 17 times higher for agrosystems (alfalfa and sunflower);

Acnowledgements

This study was financed from the Programme „Research of Excelency", project no 626 MENER/2005: „The role of populations/species in the generation of resources and services as a basis for policies and strategies for biodiversity conservation"- PROMOTOR and NUCLEU Programme PN-09-40-01-02/2014: „New technological and environmentally optimized solutions for crop protection" – PROPLANT.

REFERENCES

BANASZAK, J., 1980 – Studies on methods of censusing the numbers of bees (Hymenoptera:Apoidea), Pol. Ecol. Stud., 6, 2: 355-366.

BANASZAK, J., 1983 – Ecology of bees (Apoidea) of agricultural landscape, Pol. Ecol. Stud.,9, 4: 421-505.

BANASZAK, J., 1985 – Impact of agricultural landscape structure on diversity and density of polinating insects, INRA Publ., Paris, 36:77-84.

BANASZAK, J., MANOLE, T., 1987 – Diversity and density of pollinating insects (Apoidea) in the agricultural landscape of Romania. Bull. Entomol. De Pologne, tom 57: 747-766.

CIURDĂRESCU, G., 1980a – Zonele de semnalare a insectelor polenizatoare în România. Genul Halictus Latr. (Hymenoptera:Apoidea), Probl. Prot. Plant., 8, 1:13-45.

CIURDĂRESCU, G., 1980b – Zonele de semnalare a insectelor polenizatoare în România. Genul Anthidium Fabr. (Hymenoptera:Megachilidae), Anale ICCPT Fundulea, 45:373-384.

CIURDĂRESCU, G., 1981a – Zonele de semnalare a insectelor polenizatoare în România. Genul Panurgus Latr., Probl. Prot. Plant., 9, 3: 189-195.

CIURDĂRESCU, G., 1981b – Zonele de semnalare a insectelor polenizatoare în România. Genul Xylocopa Latr., Probl. Prot. Plant., 9, 1: 39-45.

CIURDĂRESCU, G., 1981c – Zonele de semnalare a insectelor polenizatoare în România. Genul Osmia (Hymenoptera:Megachilidae), Anale ICCPT Fundulea, 47:287-302.

CIURDĂRESCU, G., 1982a – Zonele de semnalare a insectelor polenizatoare în România. Genul Andrena Fabr., Probl. Prot. Plant., 10, 1: 27-90.

CIURDĂRESCU, G., 1982b – Zonele de semnalare a speciei *Meliturga clavicornis* Latr. (Andrenidae:Hymenoptera) în România, Probl. Prot. Plant., 10, 2: 103-105.

COSTANZA, R., d'ARGE, R., de GROOT, R., FARBER, S., GRASSO, M., HANNON, B., LIMBURG, K., 1997 – The value of the world's ecosystem services and natural capital. Nature 387:253-260.

DAILY, G. C., 1997 – Nature's services: societal dependence on natural ecosystems. Washington, D.C: Island Press.

FRIVALDZKY, I., 1873 – A latani Kirandulasain Orşova, Mehadia es Korniareva videkein.

Magyar orvosak es Termeszetvizsgalokvissg. Vagl. Ed. Munk., 16: 1-48.
HENRICH, C., 1884 – Verzeichniss der im Jahre 1879-1883 bei Hermannstadt beobachteten Blumenwespen (Anthophilia), Verh. Mitt. Siebenbürgischen Ver. f. Naturwiss. Hermannstadt, 30: 179-182, 31: 52-60, 32: 122-125, 33: 115-116, 34: 136.
IUGA, V., G., 1958 - Hymenoptera-Apoidea. Fam. Apidae, Subfam. Anthophorinae. Fauna RPR, Insecta, 9, 3: 1-270.
IUGA, V., SCOBIOLA-PALADE, X., 1959 – Despre principalele Apoidee polenizatoare ale lucernierelor, Omagiu lui Traian Săvulescu la împlinirea a 70 de ani, Ed. Did. Ped., pag. 337-346.
KNECHTEL, W., K., 1955 – Hymenoptera. Subfamilia Apinae, Fauna RPR, Insecta, 9, 1: 1-111.
LEHRER, A., Z., CIURDĂRESCU, G., 1979 – Răspândirea şi zonarea insectelor polenizatoare în RSR. Genul Bombus Latr. (Apoidea:Hymenoptera), Anale ICCPT Fundulea, 24: 405-413.
MOCSARY, A., 1897 – Fauna Regni Hungariae Hymenoptera, Budapesta, pag. 520-532.
MYERS, N., 1996 – Environmental services of biodiversity. Proceedings of the National Academy of Science USA 93:2764-2769.
SCHMITZ, J. O., 2007 – Ecology and ecosystem conservation. Washington, D.C: Island Press, pag. 102-114.
SCOBIOLA-PALADE, X., Goagă, A., 1972 – Contribuţii la cunoaşterea familiei Halictidae (Hymenoptera:Apoidea) din partea centrală a Moldovei, Studii şi Comunicări, 5: 135-144.
SCOBIOLA-PALADE, X., OSICINIUK, A., 1974 – Données concernant le genre Halictus (Hymenoptera:Halictidae) de Roumanie, Trav. du Mus. d'Histoire Natur. „Grigore Antipa", 15: 259-266.
VĂDINEANU, A., 2004 – Managementul dezvoltării – o abordare ecosistemică, Ed. Ars Docendi, pag. 207-269.
WARNCKE, K., SCOBIOLA-PALADE, X., 1980 – Données sur les Hymenopteres Andrenidae (Apoidea) de Roumanie, Trav. du Mus. d'Histoire Natur. „Grigore Antipa", 21:163-175.
WILKANIEC, Z., WÓJTOWSKI, F., SZYMAŚ, B., 1985 – Some investigations on the solitary bee *Rophitiodes canus* Ev. (Apoidea:Halictidae) nesting in alfalfa seed plantations, Zool. Poloniae, 32: 139-151.