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PLANT SPECIES IMPORTANT FOR POLLINATING INSECTS. CASE STUDY: BĂICENI LOCALITY (BOTOŞANI COUNTY)

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Abstract: The aim of this paper is to point out plant species that are of benefit to pollinators, from the territory of the Băiceni (Botoșani county, NE region of Romania). The plant species were analyzed on the basis of the specialized literature as follows: bioform, flowering period, flower grouping, flower color, floral resources, melliferous potential. A number of 106 plant species belonging to 31 botanical families were identified; 41.50% are woody species and 58.50% are herbaceous species. The representative botanical families are: Rosaceae (19.81%), Fabaceae (14.15%) and Asteraceae (14.15%). The majority of the species recorded in the area of study have flowers grouped in inflorescences, blooming in spring and summer and are nectar-polleniferous. The color of the flowers varies from white, yellow, yellow-green to red, blue, purple. These species are an essential resource for pollinators (mainly for the honeybee) and thus contribute to keeping the ecological equilibrium of the ecosystems in the study area and to supporting local beekeeping.

Keywords: forest, meadow, life form, floral resources, melliferous potential

Introduction

Pollination is an important stage for plant fruiting and has benefits for mankind. According to Ollerton et al. (2011), globally, 87.50% of flowering plant species depend on biotic pollination; in temperate ecosystems 78% of plant species depend on animals for sexual reproduction. For species with biotic pollination, pollination is carried out by pollinating insects (honeybees, solitary bees, bumblebees, butterflies, moths, flies, beetles, etc.), hummingbirds, etc. Most pollinators in the temperate zone are insects (Reverté et al., 2016).

In the EU, approximately 84% of plant species and 76% of food production depend on bee pollination (https://www.europarl.europa.eu/news/ro/headlines/economy/); approximately 15 billion of the EU's annual agricultural income is attributed to pollinating insects (https://www.europarl.europa.eu/news/ro/headlines/society/). According to Vancea (2006), the honeybee is considered the most valuable pollinator for agricultural and fruit crops; its contribution to achieving additional yield increases is very high: 30-60% for sunflower; 50-60% for fruit trees per fruit.

Some studies indicate the existence of decline in pollinators, a fact that can affect the pollination service. The decline of pollinators would be due to the complex interaction between several factors such as: the reduction, fragmentation and loss of habitats, intensive agriculture, pesticide treatments, food availability, climate change, pollution, etc. (Kremen et al., 2002; Carvell et al., 2006; Harwood and Dolezal, 2020; https://www.fao.org/; https://www.europarl.europa.eu/news/ro/headlines/society/). According to Venjakob et al. (2016), the reduction of floristic diversity can alter the spatio-temporal resource use of pollinators. Among pollinating insects, butterflies are very sensitive to microclimate conditions and extremely sensitive to changes in the composition and structure of vegetation (Sawchik et al., 2005); are often used as bioindicators of ecosystem health (Bonebrake and Sorto, 2009).

Grasslands, forests, field crops, gardens and orchards provide favourable habitats for pollinators. These offer a variety of food sources such as nectar (for bees, bumblebees, butterflies, etc.), pollen (for bees, bumblebees), leaves (for butterflies' larvae), and also survival and reproduction spaces. Woody species (from forests, orchards and cultivated in gardens) provide food resources (pollen, nectar) for pollinating insects at certain times of the year when food resources are limited (especially in spring). Permanent meadows in Romania are a valuable plant resource for biodiversity, 238 melliferous species have been identified; the melliferous potential of permanent meadows in Romania was estimated at an average of 2-6 kg honey/ha (Motcă, 2010). In Romania there are concerns about the study of melliferous resources considering the importance of the pollination service offered by the honeybee as well as the importance of bee products. Among the studies related to the melliferous flora we list: Ion and Ion (2007); Motcă (2010); Covaliov et al. (2012); Dincă et al. (2014); Antonie (2017); Ion et al. (2018).

The purpose of this paper is to highlight the plant species with importance for pollinating insects (mainly for bees), from the territory of Băiceni (Botoșani county, NE region of Romania).

2. Materials and methods

The village of Băiceni is a component part of the Curtești commune (47°42′59.4″ N and 26°38′44.9″ E), which is located in the SW area of Botoșani county (NE region of Romania). The relief of the Curteşti commune is characteristic of the Moldavian Plain (a geomorphological unit that is part of the Moldavian Plateau), being made up of hills, hillocks and small plateaus with an altitude of less than 200 m. The surface of the administrative territory of the commune is 5783 ha (Plan urbanistic general, comuna Curtești, Județul Botoșani, 2009). The vegetation consists of deciduous forests, meadows, and agricultural crops.

The research was carried out in the vegetation seasons of 2018, 2019. The plant species (from forests, grasslands, agricultural crops, gardens and orchards) were identified using the specialized bibliography (Săvulescu, 1952-1976; Ciocârlan, 2009; Sârbu et al., 2013). For the nomenclature of plant species was used *Plante vasculare din România. Determinator ilustrat de teren* (Sârbu et al., 2013). The species were analyzed based on the specialized literature, taking into account the following aspects: bioform type, flowering period, flower grouping, flower color (Săvulescu, 1952-1976; Kovács, 1979; Pârvu, 2002-2005; Ciocârlan, 2009; Sârbu et al., 2013); the resources offered by flowers (nectar and pollen) and the melliferous potential (Cîrnu, 1980; Pop, 1982; Pîrvu, 2002-2005; Karácsonyi, 2009-2010; Grozeva, 2011; Jarić

et al., 2013; Mačukanović-Jocić and Jarić, 2016; Güneș Özcan et al., 2016). Some observations were also made regarding the pollinating insects in aestival season of 2018. In the paper only a few common species of pollinating insects were mentioned, which were determined by Associate Professor Ion Cojocaru (Faculty of Biology, "Alexandru Ioan Cuza" University of Iași). The species were determined on the basis of specialized literature (Niculescu 1961, 1963, 1965; Stănoiu et al. 1979; Chinery 1988).

3. Results and discussion

Studies about the flora and vegetation of Botoșani county were published by Mihai (1970, 1971); Mititelu and Chifu (1994); Huțanu (2004); Tanase (2013). The study area has been little researched, Șchiopu et al. (2020) mentioned a list of meadows plant species in Băiceni (Botoșani county) and their economic importance.

In the flora of the study area 106 species belonging to 80 genera and 31 botanical families were identified (**Table 1.**). The botanical families with a large number of species are: Rosaceae with 21 species (19.81%), Fabaceae with 15 species (14.15%) and Asteraceae with 15 species (14.15%). The Lamiaceae family includes 7 species (6.60%). The other families are represented by a small number of species.

Of the 106 species, 44 are woody species (41.50%) and 62 are herbaceous (58.50%). 25 species (23.58% of the total) were identified in the forest ecosystem, 43 species (40.57%) in the meadow ecosystem and 38 species (35.85%) are cultivated (in fields or gardens). Regarding the spectrum of bioforms, a significant share of phanerophytes (42.45%) and hemicryptophytes (31.13%) was found. Next in descending order are therophytes (13.21%), geophytes (6.60%), hemitherophytes (4.72%) and chamaephytes (1.89%). Woody species, as well as herbaceous perennials provide food resources for pollinating insects over a long period of time.

Among the species of pollinating insects identified, we list: *Apis melifera* Linnaeus, 1758 (Ord. Hymenoptera, Fam. Apidae); 5 species of butterflies (ord. Lepidoptera: *Argynis paphia* Linnaeus, 1758 - Fam. Nymphalidae; *Colias croceus* Fourcroy, 1785 - Fam. Pieridae; *Pieris brassicae* Linnaeus, 1758 - Fam. Pieridae; *Iphiclides podalirius* Linnaeus, 1758 - Fam. Papilionidae; *Vanessa atalanta* Linnaeus, 1758 - Fam. Nymphalidae); *Eristalis tenax* Linnaeus, 1758 (Ord. Diptera, Fam. Syrphidae). Plants are essential food sources for butterflies (some species provide food resources for larvae, other species provide nectar for adults), but they also provide support and a suitable microclimate for their survival and reproduction (Sawchik et al., 2005).

Table 1. Representative botanical families and genera

Families	Genera	%	Species	%
Rosaceae	11	13.75	21	19.81
Asteraceae	14	17.50	15	14.15
Fabaceae	10	12.50	15	14.15
Lamiaceae	6	7.50	7	6.61
Liliaceae	4	5.00	4	3.77
Poaceae	4	5.00	4	3.77
Caprifoliaceae	3	3.75	4	3.77
Aceraceae	1	1.25	4	3.77
Others (20)	27	33.75	32	30.20
Total	80	100	106	100

Table 2. Flowering period of the species (%)

The flowering period	Cultivated species	Grassland species	Forest Species	Participation (%) of total species
Spring	34.21	0	64	27.36
Spring-Summer	23.68	11.63	20	17.92
Summer	10.53	48.84	16	27.36
Summer-Autumn	28.95	13.95	0	16.04
Spring finale-Autumn	2.63	25.58	0	11.32

In the case of the species identified in the study area, the host plants of the larvae can be: specimens of *Crataegus monogyna*, *Prunus spinosa*, *Urtica dioica*, etc. (for *Argynis paphia*); *Lotus corniculatus*, *Medicago falcata*, *Medicago sativa*, *Coronilla varia*, *Trifolium* sp., etc. (for *Colias croceus*); cabbage and other species of cultivated or wild brassicas (for *Pieris brassicae*); *Prunus spinosa*, *Prunus avium*, *Prunus cerasus*, *Pyrus communis*, etc. (for *Iphiclides podalirius*); *Urtica dioica* and other species (for *Vanessa atalanta*) (Niculescu, 1961; 1963, 1965). The adult specimens of *Argynis paphia* settle on the flowers of the species *Achillea millefolium*, *Carduus acanthoides*, *Ligustrum vulgare*, *Prunella vulgaris*, etc.; those of *Iphiclides podalirius* visit plants such as *Prunus spinosa*, *Carduus acanthoides*, *Medicago sativa*, etc. The *Colias croceus* species is found on cultivated land, meadows; *Pieris brassicae* occurs in vegetable gardens etc.; *Vanessa atalanta* is found in gardens, orchards, parks, etc and can visit flowers of *Carduus acanthoides*, *Sambucus* sp., *Ligustrum* sp. (Niculescu, 1961, 1963, 1965; http://www.eurobutterflies.com). *Eristalis tenax* is a cosmopolitan species; the adults are pollinators for some cultivated species (onion, soybean, carrot, sweet pepper, etc.) (Howlett and Gee, 2019).

The flowering period of identified plant species is long; it starts in early spring in the case of some forest species (*Cornus mas*, *Corylus avellana*) or fruit trees (*Armeniaca vulgaris* Lam. var. *communis*, *Armeniaca vulgaris* Lam. var. *amarella*) and ends in autumn (*Dahlia* sp., *Satureja hortensis*, *Symphyotrichum novi-belgii*, etc.). It was found that the largest number of species bloom in the spring (29 species; 27.36%) (*Chaenomeles japonica*, *Prunus avium*, *Ribes aureum*, most forest species) and in the summer (29 species) (*Helianthus annuus*; most meadow species such as *Echium vulgare*, *Onobrychis viciifolia*, *Prunella vulgaris*, etc.). The species that bloom in the spring-summer period (*Robinia pseudoacacia*, *Rosa canina*, *Tilia cordata*, etc.) and those that bloom in the summer-autumn period (*Calendula officinalis*, *Carduus acanthoides*, etc.) have a significant share (17.92% and 16.03% respectively). A smaller number of species (12 species; 11.32%) bloom staggered from May to September (October): *Convolvulus arvensis*, *Lotus corniculatus*, *Medicago lupulina*, *Trifolium pratense*, etc. (**Table 2.**; **Tables 4-6. of the Supplementary Material**). In our opinion, this high flowering period means diversified food resources (nectar, pollen) for different groups of pollinators.

Characteristics of flowers. The flower, through its characteristics (color, smell, nectar secretion, pollen production, arrangement, shape, size) has a main role in attracting pollinating insects. In 12 species (11%) the flowers are solitary (*Convolvulus arvensis*, *Cucurbita pepo*, *Cydonia oblonga*, *Prunus spinosa*, etc.) and in 94 species (89%) the flowers are grouped in inflorescences such as raceme, corymb, umbel, anthodium, capitulum,

panicle, ament, spike, cyme (**Tables 4-6. of the Supplementary Material**).

Some inflorescences are looser (raceme, panicle), while others are well structured, compact (Asteraceae). Concering the *flowers' color* (shades of the main colors) of the species identified in the study area, the dominant color is white (33.96%) followed by yellow (28.30%) and red (12.26%). Green (10.37%) and purple (3.77%) colors are less represented (**Table 3.**). Pollinating insects have a certain visual system of color perception. It has been shown that there are differences in the color of flowers perceived by humans and that perceived by pollinating insects: the yellow color perceived by humans can be perceived as green by bees; white color (which reflects all the radiation of the visible spectrum) can be perceived by bees as blue-green (Chittka et al., 1994). Studies by different authors have found that some pollinator species have innate preferences for certain colors: bees prefer blue, flies prefer yellow and white flowers, lepidoptera prefer pink and red flowers, beetles white and cream and wasps prefer brown and yellow flowers. The pollinator can use color as a signal of floral reward (pollen, nectar) (Reverté et al., 2016).

Regarding the food resources offered to pollinating insects, in this paper only pollen and nectar were considered, although some species (*Acer* sp., *Corylus avellana*, *Tilia* sp.) provide bees with other and other products (manna). Most of the identified species are nectar-polliniferous (**Tables 4-6. of the Supplementary Material**). Nectar is an important food resource for many pollinators, being the main source of carbohydrates, but it also contains amino acids in variable proportions; minerals and fatty acids (in low amounts). It is considered the most important floral reward for attracting pollinators (Venjakob et al., 2022). Nectar production varies depending on several factors: species, position of flowers on the plant, flowering stage, external factors, etc. (Cîrnu, 1980; Jabłoński and Kołtowski, 2005). According to Venjakob et al. (2022), total carbohydrate content in nectar is high in *Trifolium campestre* and *Lotus corniculatus*; the content of amino acids in the nectar is high in the species *Centaurea jacea*, *Taraxacum officinale*; the essential amino acids in the nectar are in large quantities in *Prunella vulgaris* and in small quantities in *Trifolium campestre*, *Trifolium repens*, *Trifolium pratense*, *Vicia cracca*. Pollen contains protein, lipids, carbohydrates, minerals, vitamins and is a food source especially for the honeybee.

The melliferous potential. For the area under study, a large number of melliferous species (98 species) that provide nectar and pollen for the honeybee was highlighted. Species with medium melliferous potential are representative (44 species; 44.83 %) (*Echium vulgare*, *Cydonia oblonga*, *Cucumis sativus*, *Malus domestica*, *Salvia nemorosa*, *Zea mays*, etc.).

Tabel 3. Flowers' color of identified species

The flowers color	Shade of the main color	Number of species	Participation (%)
White	white pink, white yellow, greenish white	36	33.96
Blue	blue gray, deep blue, violet blue	7	6.60
Yellow	creamy yellow, yellowish, greenish yellow	30	28.30
Pink, red	purplish pink, bright red, purple	13	12.26
Green	Greenish, yellowish green	11	10.38
Violet	light purple	4	3.78
Multicolored		5	4.72

Following in descending order are the species with a small melliferous potential (23 species; 23.4%) (*Lonicera caprifolium*, *Lotus corniculatus*, *Medicago lupulina*, *Rosa canina*, *Satureja hortensis*, etc.) and those that provide food for bees (nectar, pollen) sporadically and for a short time (20 species; 20.40%) (*Centaurea jacea*, *Calendula officinalis*, *Dahlia* sp., etc). The species with high melliferous potential (*Brassica rapa*, *Onobrychis viciifolia*, *Acer campestre*, *Acer tataricum*, *Tilia cordata*, *Tilia platyphyllos*, *Trifolium repens*) and with very high melliferous potential (*Helianthus annuus*, *Rubus idaeus*, *Robinia pseudoacacia*, *Tilia tomentosa*) represent respectively 7.14% and 4.08%. Among the melliferous species identified in the study area that are characterized by a high polliniferous potential, the following are listed: *Corylus avellana*, *Prunus avium*, *Prunus cerasus*, *Pyrus communis*, *Prunus spinosa*, *Malus domestica*, *Taraxacum officinale*, *Acer tataricum*, *Onobrychis viciifolia*, *Trifolium repens*, *Rubus caesius*, *Rubus idaeus*, *Dahlia* sp., *Rosa canina*, *Zea mays*.

Regarding the botanical families with the most representatives identified in the study area, the following aspects can be specified. The species of the Rosaceae family are mostly woody plants, both cultivated (trees and fruit-bearing shrubs) and forest species, which bloom in spring or spring-summer and show white or white-pink flowers. These species are valuable because they provide nectar and pollen in the early period necessary for the reproduction and development of bee families and for production pickings. The species of the Asteraceae family are spontaneous as well as cultivated, with variously colored flowers (white, yellow, purple, blue), grouped in inflorescences, in some cases of large size (*Helianthus annuus*, *Dahlia* sp., *Tagetes erecta*, *Zinnia elegans*) and with long flowering period (summer, summer-autumn). They attract a wide variety of pollinating insects (bees, bumblebees, butterflies, hoverflies, etc.) (Jabłoński and Kołtowski, 2005; Rolling and Gouson, 2019; Michelot-Antalik et al., 2021). From the point of view of the melliferous potential among the cultivated species, the *Helianthus annuus* species stands out, cultivated on a large area in the study area. Among the spontaneous, valuable species are *Taraxacum officinale*, *Carduus acanthoides*, *Inula britannica*, *Cichorium intybus*, *Centaurea jacea* (Cîrnu, 1980, Jarić et al., 2013; Mačukanović-Jocić and Jarić, 2016). From the Fabaceae family, most of the species identified in the study area are specific to the meadow ecosystem, 66% are hemicryptophytes. It stands out for its long flowering period (**Tables 4-6. of the Supplementary Material**), with variously colored flowers (white, yellow, pink, red, purple) which represent valuable sources of nectar and pollen. Studies have shown that they attract different pollinating insects (bees, bumblebees, butterflies, etc.) (Jabłoński and Kołtowski, 2005; Venjakob et al., 2016; Michelot-Antalik et al., 2021). The species *Onobrychis viciifolia*, *Trifolium repens*, *Trifolium pratense*, *Vicia craca*, *Lotus corniculatus*, *Medicago falcata*, *Medicago lupulina* are considered very good plants that produce nectar and pollen (Cîrnu, 1980; Jarić et al., 2013; Mačukanović-Jocić and Jarić, 2016). *Robinia pseudoacacia* is known as a good nectariferous species; the estimated nectar production was between 1.6-3.7mg nectar/flower/day with a sugar concentration of 34-67% (Papadopoulou et al., 2018).

Conclusions

In the study area, 106 plant species were identified that provide food for pollinating insects. Of these, 41.50% are woody species

and 58.50% are herbaceous species. Most of the species identified in the study area have flowers grouped in inflorescence. All species bloom in the active season for pollinating insects. The flowers show a variety of colors (white, yellow, red, greenish, blue, purple and their shades), which is very attractive to pollinating insects (especially bees). The identified species represent an important resource for pollinators and thus contribute to maintaining the ecological balance of the ecosystems in the study area. They also support beekeeping in the area.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

1. Antonie I (2017) A melifer base from Mărginimea Sibiului. Case study Sălișteː Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development 17(4): 51-57
2. Bonebrake TC, Sorto R (2009) Butterfly (Papilionidea and Hesperioidea) rapid assessment of a Coastal Countriside in EI Salvador. Tropical Conservation Science 2: 34-51
3. Carvell C, Roy DB, Smart SM, Pywell RT, Preston CD, Goulson D (2006) Declines in forage availability for bumblebees at a national scale. Biological Conservation 132: 481-489. doi.10.1016/j.biocon.2006.05.008
4. Chinery M (1988) Insectes d' Europe occidentale. Les Editions Arthaud, Paris
5. Chittka L, Shmida A, Troje N, Menzel L (1994) Ultraviolet as a component of flower reflection, and the color perception of Hymenoptera. Vision Research 34(11): 1489-1508. DOI: 10.1016/0042-6989 (94)90151-1
6. Ciocârlan V (2009) Flora ilustrată a României. Pteridophyta et Spermatophyta. Edit. Ceres, București
7. Cîrnu I (1980) Flora meliferă. Edit. Ceres, București
8. Covaliov S, Doroftei, Negrea BM (2012) Assessment of vegetal resources in Danube Delta, Romania. Advances in Agriculture & Botanics - International Journal of the Bioflux Society 4(2): 54-72
9. Dincă N, Barbu I, Dunea D (2014) An inventory of floristic composition in permanent grasslands of Rucăr-Bran corridor: application and perspectives of melliferous potential. Scientific Papers Ser. A. Agronomy LVII: 157-162
10. Grozeva N (2011) Possibilities for providing bee pasture from nectariferous plant in Sinite Kamani Natural Park - Sliven. Trakia Journal of Sciences 9(2): 15-21
11. Güneş Özcan N, Aksoy N, Degermenci AS (2016). Melliferous plants of Hasanlar Dam (Duzce-Yigilca) and surroundings. Ormancilik Dergisi 12(2): 44-65
12. Harwood GP, Dolezal AG (2020) Pesticide-virus interactions in honey bees : Challenges and opportunities for understanding drivers of bee declines. Viruses 12(5): 566. doi:10.3390/v12050566
13. Howlett BG, Gee M (2019) The potential management of the drone fly (*Eristalis tenax*) as a crop pollinator in New Zealand. New Zealand Plant Protection 72: 221-230. doi.10.30843/nzpp.2019.72.304

14. Huțanu M (2004) Diversitatea florei vasculare, a vegetației și a macromicetelor din Bazinul Jijiei (Jud. Botoșani). Edit. ”Gh. Asachi”, Iași
15. Ion N, Ion V (2007) Melliferous charactheristics of spontaneous Lamiaceae species, identified in the Danube Valley. Lucrări ştiinţifice Zootehnie şi Biotehnologii, Timişoara 40(2): 71-79
16. Ion N, Odoux JF, Vaissière BE (2018) Melliferous potential of weedy herbaceous plants in crop fields of Romania from 1949 to 2012. J. Apic. Sci 62(2): 149-165
17. Jabłoński B, Kołtowski Z (2005) Nectar secretion and honey potential of honey-plants growing under Poland’s conditions - part XV. Journal of Apicultural Science 49(1): 59-63
18. Jarić S, Mačukanović-Jocić M, Mitrović M, Pavlović P (2013). The melliferous potential of forest and meadow plant communities on Mount Tara (Serbia). Environ. Entomol 42: 724-732
19. Karácsonyi K (2009-2010) Flora dealurilor Tășnadului și a colinelor marginale. Studii și Comunicări, seria Științele Naturii, Satu Mare, Ed. Muzeului Sătmărean X-XI: 41-90
20. Kolomiets I, Codreanu L (2015) Ecological details of forming convergent corolla painting. Noosfera 15:53-59
21. Kovács AJ (1979). Indicatori biologici, ecologici și economici ai florei pajiştilor. Redacția de Propagandă Tehnică Agricolă, București
22. Kremen C, Williams N, Thorp R (2002) Crop pollination from native bees at risk from agricultural intensification. Biological Sciences 99(26): 16812-16816. http:// doi.org/10.1073/pnas.262413599
23. Mačukanović-Jocić M, Jarić S (2016). The melliferous potential of apiflora of Southwestern Vojvodina (Serbia). Arch. Biol. Sci Belgrade 68(1): 81-91. DOI:10.2298/ABS150427130M
24. Michelot-Antalik A, Michel N, Goulnik J, Blanchetête A, Delacroix E, Faivre-Rampamnt P, Fiorelli JL, Galliot JN, Genoud D, Lanore L, Le Clainche I, Le Pashier MC, Novak S, Odoux JF, Brunel D, Farrugia A (2021) Comparison of grassland plant -pollinator network on dairy farms in three contrasting French landscape. Acta Oecologia 112. http://doi.org/10.1016/j.actao.2021.103763
25. Mihai Gh (1970) Cercetări asupra evoluției și succesiunii asociațiilor vegetale din bazinul Bașeului (jud. Botoșani). Stud. Com. Muz. Șt. Nat. Bacău: 137-142
26. Mihai Gh (1971) Vegetaţa pajiştilor xerofile din bazinul Başeului (judeţul Botoşani), St. Com., Muz. Şt. Nat., Muz. Jud. Suceava. 2(1): 95-110
27. Mititelu D, Chifu T (1994) Flora și vegetația județului Botoșani. Stud. Com. Muz. Șt. Nat. Bacău. 13(1980- 1993): 109-126
28. Motcă G (2010) Experimental results concerning grasslands multifunctional exploitation. Romanian Journal of Grasslands and Forage Crops 2: 27-36
29. Narbona E, Wang H, Ortiz PL, Arista M, Imbert E (2018) Flower color polymorphism in the Mediterranean Basin: occurrence, maintenance and implications for speciation. Plant Biology 20: 8-20. doi.10.1111/plb. 12575
30. Niculescu EV (1961, 1963, 1965). Fauna Republicii Populare Române. Vol. XI Insecta, fasc. 5, 6, 7. Edit. Acad. Republicii Populare Române, București
31. Ollerton J, Winfree R, Tarrant S (2011) How any flowering plants are pollinated by animals? Oikos 120: 321-326
32. Papadopoulou F, Tentsoglidou M, Pavloudakis F, Papadimopoulos N, Papadopoulou I, (2018) Evaluation of

honey producing potential of *Robinia pseudacacia* in reforested old lignite mines in West Macedonia. Journal of Environmental Science and Engineering B7: 354-359. doi:10.17265/2162-5263/2018.09.005
33. Pârvu C (2002-2005). Enciclopedia plantelor - plante din flora României. Vol. I-IV. Edit. Tehnică, București
34. Pop I (1982) Plante spontane și subspontane cu valoare economică din flora R.S. România. Contrib. Bot. Cluj-Napoca: 131-142
35. Reverté S, Retana J, Gomez JM, Bosh J (2016) Pollinators show flowers color preferences but flower with similar colours do not attract similar pollinators. Ann Bot 118 (2): 249-257. doi: 10.1093/aob/mcw103
36. Rolling R, Gouson D (2019) Quantifying the attractiveness of garden flowers for pollinators. Journal of Insect Conservation 23:803-817. http://doi.org/10.1007/s10841-019-00177-3
37. Sawchik J, Dufrêne M, Lebrun P (2005) Distribution pattern and indicator species of butterfly assemblages of wet meadows in Southern Belgium. Bel J Zool 135(1): 43-52
38. Sârbu I, Ștefan N, Oprea A (2013). Plante vasculare din România: determinator ilustrat de teren. Edit. Victor B Victor, București
39. Săvulescu T (red) (1952-1976) Flora Republicii Populare Romîne/Flora Republicii Socialiste România, vol. I-XIII. Edit. Acad. R.P.R./ R.S.R., București
40. Stănoiu I, Bobârnac B, Copăcescu S (1979) Fluturii din România. Edit. Scrisul Românesc, Craiova
41. Șchiopu F, Stratu A, Irimia I (2020) Aspects regarding flora and the economic importance of some plant species from the local meadows of Băiceni (Botoșani County). Analele Ştiinţifice ale Universităţii „Al. I. Cuza" Iaşi s. II a. Biol. veget., 66: 13-29
42. Tanase C (2013) Flora şi vegetaţia pajiştilor din bazinul Valea Morişca (jud. Botoşani). Edit. Stef, Iași
43. Vancea R (2006) Polenizarea plătită - importanță, avantaje și beneficii. https://www.eurohonig.com/targ2006/Radu Vancea.htm. Accesed 16 Aug 2023
44. Venjakob C, Klein AM, Ebeling A, Tscharntke T, Scherber C (2016) Plant diversity increases spatio-temporal niche complementarity in plant– pollinator interactions. Ecology and Evolution 6: 2249–2261. doi.10.002/ece3.2026
45. Venjakob C, Ruedenauer FA, Klein AM, Leonhardt SD (2022) Variation in nectar quality across 34 grassland plant species. Plant Biology 24: 134-144. doi: 10.1111/plb.13343
46. 2009. Plan urbanistic General Comuna Curtești, județul Botoșani, vol I, Memoriul general de urbanism. https://primariacurtestibt.ro/pug-memoriul-general-si-regulament-2/. Accesed 11 Aug 2023
47. https://www.europarl.europa.eu/news/ro/headlines/society/20191129STO67758/de-ce-este-in-declin-populatia-albinelor-si-a-altor-polenizatori-infografic.Accesed 21 Aug 2023
48. https://www.europarl.europa.eu/news/ro/headlines/economy/20180122STO92210/protejarea-albinelor-si-combaterea-importurilor-de-miere-contrafacuta-in-europa. Accesed 21 Aug 2023
49. https://www.fao.org/news/story/en/item/1194910/icode/. Accesed 21 Aug 2023
50. http://www.eurobutterflies.com/sp/. Accesed 22 Aug 2023

Supplementary Material

Table 4. Plant species identified in meadows

Scientific name / Family	Period of blooms	Flower grouping	Flower color	Floral resource
Achillea millefolium L. / Asteraceae	VI - VIII	anthodium	white	NP
Achillea setacea Waldst. et Kit. / Asteraceae	VI - VIII	anthodium	white	NP
Agrimonia eupatoria L. subsp. *eupatoria* / Rosaceae	VI - VIII	raceme	yellow	N
Anthyllis vulneraria L. subsp. *polyphylla* (DC.) Nyman / Fabaceae	V - VIII	capitulum	yellow	NP
Arctium lappa L. / Asteraceae	VII - VIII	anthodium	purple	PN
Carduus acanthoides L. / Asteraceae	VI - IX	anthodium	red purple	NP
Centaurea jacea L. / Asteraceae	VI - IX	anthodium	pink	N
Chelidonium majus L. / Papaveraceae	V - IX	umbel	yellow	PN
Cichorium intybus L. / Asteraceae	VII - IX	solitary	blue	NP
Convolvulus arvensis L. / Convolvulaceae	V - IX	solitary	white	PN
Coronilla varia L. / Fabaceae	VI - VIII	umbel	white pink	PN
Dactylis glomerata L. / Poaceae	VI - VII	panicle	greenish	P
Echium vulgare L. / Boraginaceae	VI - VIII	cyme	blue	NP
Eryngium campestre L. / Apiaceae	VII - VIII	capitulum	greenish white	N
Eryngium planum L. / Apiaceae	VII - VIII	capitulum	blue gray	NP
Galium verum L. / Rubiaceae	VI - VIII	cyme	yellow	PN
Inula britannica L. / Asteraceae	VII - IX	anthodium	yellow	P
Lathyrus tuberosus L. / Fabaceae	VI - VIII	raceme	red	N
Lavatera thuringiaca L. / Malvaceae	VI - VIII	solitary	pink	PN
Linaria vulgaris Mill. / Scrophulariaceae	VI - IX	raceme	yellow	NP
Lolium perenne L. / Poaceae	V - IX	spike	greenish	P
Lotus corniculatus L. / Fabaceae	V - IX	umbele	yellow	NP
Medicago falcata L. / Fabaceae	V - IX	capitulum	yellow	NP
Medicago lupulina L. / Fabaceae	V - IX	capitulum	yellow	NP

Onobrychis viciifolia Scop. / Fabaceae	VI - VIII	raceme	pink	NP
Papaver rhoeas L. / Papaveraceae	V - VI	solitary	bright red	PN
Phleum pratense L. subsp. *pratense* / Poaceae	VI - VIII	panicle	greenish	P
Polygonum aviculare L. / Polygonaceae	VI - X	flowers: in fascicles	white pink	NP
Potentilla argentea L. subsp. *argentea* / Rosaceae	VI - VII	biparous cyme	yellow	P
Prunella vulgaris L. / Lamiaceae	VI - VIII	cyme	purple	NP
Rubus caesius L. / Rosaceae	V - IX	corymbe	white	NP
Salvia nemorosa L. subsp. *nemorosa* / Lamiaceae	VI - VIII	cyme	deep blue	NP
Salvia pratensis L. subsp. *pratensis* / Lamiaceae	V - VII	cyme	blue purple	NP
Scabiosa ochroleuca L. / Dipsacaceae	VI - VIII	capitulum	creamy yellow	PN
Medicago sativa L. / Fabaceae	V - IX	raceme	purple	NP
Taraxacum officinale Weber / Asteraceae	IV - VI	anthodium	yellow	NP
Teucrium chamaedrys L. / Lamiaceae	VI - VIII	cyme	purplish pink	NP
Thymus pannonicus All. subsp. *auctus* (Lyka) Soó / Lamiaceae	V - VIII	cyme	purplish pink	NP
Trifolium campestre Schreb. / Fabaceae	V - IX	capitulum	yellow	NP
Trifolium pannonicum Jacq. / Fabaceae	VI - VIII	capitulum	white	NP
Trifolium pratense L. subsp. *pratense* / Fabaceae	V - IX	capitulum	red	NP
Trifolium repens L. subsp. *repens* / Fabaceae	V - IX	capitulum	yellow	NP
Vicia cracca L. / Fabaceae	VI - VIII	raceme	purple	NP
Legend: N= nectar, P= pollen				

Table 5. Cultivated plant species

Scientific name / Family	Period of blooms	Flower grouping	Flower color	Floral resources
Armeniaca vulgaris Lam. var. *communis* Schübl. et Mart. / Rosaceae	III - IV	corymb/umbel	white	NP
Armeniaca vulgaris Lam. var. *amarella* (Rchb.) Buia / Rosaceae	III - IV	corymb/umbel	white	NP

Brassica rapa L. / Brassicaceae	V - VI	raceme	creamy yellow	NP
Calendula officinalis L. / Asteraceae	VI - X	anthodium	yellow	NP
Callistephus chinensis (L.) Nees / Asteraceae	VII - X	anthodium	multicolored	P
Chaenomeles japonica (Thunb.) Lindl. ex Spach / Rosaceae	IV	solitary	red	NP
Cucumis sativus L. / Cucurbitaceae	VI - IX	male flowers - in fascicles; female flowers are solitary	yellow	NP
Cucurbita pepo L. / Cucurbitaceae	V - IX	solitary	yellow	NP
Cydonia oblonga Mill. / Rosaceae	V - VI	solitary	white pink	NP
Dahlia sp. / Asteraceae	VII - X	anthodium	multicolored	NP
Gladiolus x *hybridus* C.Morren / Iridaceae	VII - X	raceme	multicolored	PN
Gleditsia triachanthos L. / Fabaceae	VI	raceme	greenish	NP
Helianthus annuus L. / Asteraceae	VII	anthodium	yellow	NP
Hemerocallis fulva (L.) L. / Liliaceae	V - VIII	raceme	orange	PN
Hosta plantaginea (Lam.) Asch. / Liliaceae	VII - IX	raceme	white	N
Hyacinthus orientalis L. / Liliaceae	III - IV	raceme	multicolored	NP
Lilium candidum L. / Liliaceae	V - VI	raceme	white	NP
Lonicera caprifolium L. / Caprifoliaceae	V - VI	cyme	white yellow	NP
Malus domestica (Suckow) Borkh. / Rosaceae	IV - V	raceme	pinkish white	NP
Ocimum basilicum L. / Lamiaceae	VI - X	cyme	white	NP
Paeonia officinalis L. / Paeoniaceae	IV - V	solitary	pink	P
Philadelphus coronarius L. / Hydrangeaceae	V - VI	raceme	white	NP
Prunus avium (L.) L. / Rosaceae	IV	corymb/umbel	white	NP
Prunus cerasus L. / Rosaceae	IV - V	corymb/umbel	white	NP
Prunus cerasifera Ehrh. / Rosaceae	IV	corymb/umbel	white	NP
Prunus domestica L. / Rosaceae	IV	corymb/umbel	white	NP
Pyrus communis L. / Rosaceae	IV - V	corymb/umbel	white	NP
Ribes aureum Pursh / Grossulariaceae	IV - V	raceme	yellow	NP
Rosa sp. / Rosaceae	VI - VIII	solitary	multicolored	NP

Rubus idaeus L. / Rosaceae	VI - VII	raceme	white	NP
Satureja hortensis L. / Lamiaceae	VII - X	cyme	white pink	NP
Symphyotrichum novi-belgii (L.) G.L.Nesom / Asteraceae	VIII - X	anthodium	violet blue	NP
Syringa vulgaris L. / Oleaceae	IV - V	raceme	light purple	NP
Tagetes erecta L. / Asteraceae	V - VIII	anthodium	yellow	NP
Vitis vinifera L. / Vitaceae	V - VII	biparous cyme	greenish yellow	NP
Viburnum opulus L. f. *roseum* (L.) Nyár. / Caprifoliaceae	V - VI	cyme	white	NP
Zea mays L. / Poaceae	VI - X	panicle	yellowish	P
Zinnia elegans Jacq. / Asteraceae	VII - X	anthodium	multicolored	PN
Legend: N= nectar, P= pollen				

Table 6. Plant species identified in forest

Scientific name / Family	Period of blooms	Flower grouping	Flower color	Floral resource
Acer campestre L. / Aceraceae	IV - V	corymb	greenish	NP
Acer platanoides L. / Aceraceae	IV - V	corymb	greenish yellow	NP
Acer pseudoplatanus L. / Aceraceae	IV - V	panicle	yellowish green	NP
Acer tataricum L. / Aceraceae	IV - V	panicle	yellowish white	NP
Cornus mas L. / Cornaceae	II - III	umbel	yellow	NP
Corylus avellana L. / Corylaceae	II - III	male flowers- catkins; female flowers - fascicles	yellow	P
Crataegus monogyna Jacq. / Rosaceae	V - VI	corymb	white pink	NP
Fagus sylvatica L. / Fagaceae	IV - V	male flowers- capitulum; female flowers - in pairs	greenish	NP
Fraxinus excelsior L. / Oleaceae	IV - V	panicle	greenish yellow	P
Ligustrum vulgare L. / Oleaceae	VI - VII	panicle	white	NP
Malus sylvestris (L.) Mill. / Rosaceae	V	solitary	white pink	NP
Populus alba L. / Salicaceae	III - IV	catkin	greenish	P

Prunus avium (L.) L. var. *avium* / Rosaceae	IV	corymb	white	NP
Prunus spinosa L. / Rosaceae	IV	solitary	white	NP
Pyrus pyraster (L.) Medik. / Rosaceae	IV - V	corymb	white	NP
Quercus petraea (Matt.) Liebl. / Fagaceae	V	male flowers- catkins; female flowers-spike	yellowish green	P
Quercus robur L. / Fagaceae	IV - V	male flowers- catkins; female flowers-spike	yellowish green	P
Robinia pseudoacacia L. / Fabaceae	V - VI	raceme	white	NP
Rosa canina L. / Rosaceae	V - VI	solitary	pink	NP
Sambucus nigra L. / Caprifoliaceae	V - VI	cyme	white	NP
Tilia cordata Mill. / Tiliaceae	VI - VII	cyme	pale yellow	NP
Tilia platyphyllos Scop. / Tiliaceae	VI - VII	cyme	pale yellow	NP
Tilia tomentosa Mnch. / Tiliaceae	VI - VII	cyme	pale yellow	NP
Ulmus glabra Huds. / Ulmaceae	III - IV	fascicle	greenish	P
Viburnum lantana L. / Caprifoliaceae	V - VI	cyme	white	NP
Legend: N= nectar, P= pollen				