Scientific Papers. Series A. Agronomy, Vol. LXV, No. 2, 2022
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ENTOMOFAUNISTIC STUDY ON THE SPECIES *Silphium perfoliatum* L. IN THE REPUBLIC OF MOLDOVA

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Abstract

This article presents the results of entomofaunistic investigations on the species Silphium perfoliatum, known as a fodder, honey, energy, medicinal and ornamental crop. Under the climatic conditions of the Republic of Moldova, S. perfoliatum, starting with the 3rd year of vegetation, enters the generative phase, blooms, bears fruit and produces viable seeds. It is characterized by a staggered and long flowering period (52-63 days) that occurs in July-October. The monitoring of the entomofauna has allowed the determination of the spectrum of insects attracted by the S. perfoliatum plants in the flowering stage. Ten species of insects included in 6 families and 4 orders were determined. The species of the Apidae family (Apis mellifera, Bombus terrestris, B. lapidarius), recognized as the main species of pollinating and honey insects, had the highest frequency on flowers.

Key words*: Silphium perfoliatum, development, pollinating insects.*

INTRODUCTION

The role of insects is essential in plant life and also in nature in general. Insects are among the most diverse organisms on earth and comprise more than 60% of all known species (Bidau, 2018). They are responsible for pollination, as an essential process for plant reproduction. Approximately 90% of angiosperms rely on animal pollinators (Friedman & Barrett, 2009).

In recent years, the area cultivated with entomophilous plants has increased, respectively, the need for pollination has also increased. However, there is a decrease in the number of pollinating insects worldwide. In Europe, over the last 20 years, domestic honey bee populations alone have declined by 25%. The wild pollinating insects have experienced a similar situation (Kluser & Peduzzi, 2007).

There are a large number of insects that participate in pollination. In addition to the familiar ones, flies (representatives of the Diptera family), bumblebees, solitary bees, butterflies, moths, beetles, stingless bees also make a special contribution. The European honey bee (*Apis mellifera* L.), described as the most common pollinator and honey producer, enjoys special attention as compared with the other almost 20,000 known bee species (Kunast et al., 2014). The bee products obtained as a result of the activity of honey insects (honey, pollen, propolis, wax, royal jelly) are used as food, dietary, cosmetic and pharmaceutical resources, due to the rich content of biologically active substances (Eremia et al., 2002).

Silphium perfoliatum L. is a plant species of the family ASTERACEAE Bercht. & J. Presl (= COMPOSITAE Giseke.). It is a perennial herbaceous, polycarpic plant, native to North America, with erect stem, branched in the upper part. The leaves are light green, heart-shaped, opposite, the lower ones are petiolate, and the upper ones are fused around the stem, forming a cup that allows the efficient use of humidity and sunlight. The plant produces yellow flowers, 3-5 cm in diameter. The fruit of cup plant is a brown achene with a marginal wing used for wind dispersal. About 20-30 achenes with a length of 8-14 mm were produced in each flower head (Ţîţei & Cîrlig, 2020). Seed productivity reaches 290-450 kg/ha. The plant develops a tap root growing down to 3.5 m deep (Ţîţei & Roşca, 2021).

Multiple scientific studies have demonstrated that cup plant can be used in various fields. Knowledge about the entomofauna of cup plant is of great practical interest. To date, there are some data on harmful insects that could attack

the plants. Cup plant is described as a species less vulnerable to pests and diseases, and even if it is attacked, the production of seeds and biomass is not affected (Reinert et al., 2020). Murrel and Turner, in 2020, described the pests that can attack cup plant. The list includes harmful insects, fungi and viruses (Silphium virus caused by Dahlia endogenous plant pararetrovirus sequence (Dv EPRS) (Murrell & Turner, 2020). The useful entomofauna of cup plant is less studied worldwide, but, in the Republic of Moldova, this research is of great importance.

In recent years, cup plant has been listed among the promising honey plants, plants with high nectar productivity (58 kg/ha) (Muller et al., 2020; Muller & Bergher, 2020; Savin & Gudimova, 2019; Pastukhova, 2019), which allows collecting large quantities of honey, 150-450-560 kg/ha honey (Koltowski, 2005). Other sources mention that nectar productivity can reach up to 205.2-611.6 kg/ha, depending on the amount of mineral fertilizers used (Savin & Gudimova, 2019).

Cup plant blooms from late summer to late autumn and the flowers produce nectar and pollen, that is why plants are an important source of food for insects before the cold season, especially for bumblebees, which prepare the queen for hibernation (Amiet & Krebs, 2012; Mueller et al., 2020), being also a source of food for bees in the agricultural landscape (Decourtye, 2010). *Silphium perfoliatum* can support certain hoverfly groups when it is harvested late to ensure a flower supply through to September and when semi-natural habitats are maintained in agricultural landscapes (Muller & Dauber, 2016).

The goal of this study has been to carry out the inventory of the entomofauna detected on *S. perfoliatum*, grown under the climatic conditions of the Republic of Moldova, as a high-potential honey plant, attractive for pollinating and honey insects.

MATERIALS AND METHODS

The research subjects were the plants of the cultivar 'Vital' of cup plant, *Silphium perfoliatum* L., which was created, registered in the Catalogue of Plant Varieties in 2012 and patented at the State Agency for Intellectual Property (Teleuță & Țîței, 2016), grown in the experimental sector of the "Alexandru Ciubotaru" National Botanical Garden (Institute), the collection of fodder and honey plants.

The experimental sector is composed of plants belonging to different botanical families, species with different, staggered flowering periods, which can serve as a source of food for insects for a long time. This contributes to the diversification of invertebrate fauna.

The growth and development rate of the studied species, in the years 2020-2021, was analyzed according to the methodologies: *Методика изучения фенологии растений и растительных сообществ,* (Beideman, 1974). *Методические указания по семеноведению интродуцентов* 1980.

In order to determine the insect species on the *S. perfoliatum* plants, biological surveys were carried out during the generative phase of the plants, especially in the flowering stage. The entomological monitoring was performed starting with the middle of June (when the flowering stage began), with an interval of 5-8 days. In total, more than 12 records and assessments were made in the flowering stage. Emphasis was placed on the morning (9: 00-12: 00) and afternoon hours (14: 00-16: 00). The observations were made in sunny weather, with no strong wind, sometimes in light rain. The determination of the taxonomic affiliation and the morphological spectrum of the insects was based on a series of direct observations in the field, on the diagonal of the experimental sector, taken photos and sample collections. Subsequently, in the laboratory, using manuals and entomological determination guides (Talmaciu & Talmaciu, 2014; Cozari, 2010, Perju, 1995; Plavilsciov, 1994; Mamaev, 1985), the list of pollinating insects was made, the trophic specialization was determined.

RESULTS AND DISCUSSIONS

Silphium perfoliatum L., under the climatic conditions of the Republic of Moldova, grows as an herbaceous perennial plant, with a growing season of about 205 days. The plants come out of dormancy in early spring when temperatures reach 3-5 C. Cup plant is propagated by transplanting the seedlings

grown indoors into the open field. *S. perfoliatum* passes into the generative phase starting with the 3rd year of development. Mature plants develop stems that can reach 250-370 cm in height. The leaves are 25-35 cm long and 16-22 cm wide (Țîței & Cîrlig, 2020). The research on the development rates made it possible to describe the phenological phases characteristic of the plants that had acclimatized under the conditions of the Republic of Moldova. In this article, more emphasis was laid on the generative stages (Table 1), to highlight the honey potential of cup plant and to determine the spectrum of insects that visit the plants.

Table 1. The initiation of generative stages depending on climatic conditions

Stages / Year	Budding (beginning)	Budding (full)	Flowering (beginning)	Flowering (full)	Flowering (end)
2020	16.06	23.06	22.06	04.07	25.08
2021	23.06	30.06	28.06	19.07	20.10

Based on the criteria used in beekeeping, honey plants are classified according to the time of flowering: early spring, spring, summer and autumn (Pîrvu, 2000). *S. perfoliatum* is attributed to the group with summer-autumn flowering. The budding stage begins in June. The staggered flowering extends over a period of 52-63 days, which positively influences the food supply for bees. The inflorescence (dichasium) is composed of 20-30 yellow flower heads with a diameter of 3-5 cm, each flower produces 20-30 seeds. The climatic conditions recorded in the growing seasons of 2020 and 2021 (Table 2) were favorable for plant growth and development, and any significant differences haven't been noticed.

Some changes were noticed at the onset of the generative phenological stages (budding, full flowering and end of flowering). As a result of the flowering, which occurs later in the season, the insects that are preparing for winter only benefit. The spring of 2021 was inhomogeneous in terms of temperature, but with favorable humidity levels for plant development. The autumn of 2021, as compared with that of 2020, was characterized by meteorologists as a season with an average air temperature by 2-3°C below the normal average (meteo.md). In September - November (2021), there was a deficit of rainfall, but the development of *S. perfoliatum* plants during this period was not affected.

Table 2. Meteorological indices in the studied period

Year	Indices	Months												
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**M**
2020	**t°C**	1.5	4.4	8.4	11.8	14.4	21.8	23.7	24.0	20.8	14.6	4.8	1.8	12.7
	P. mm	9	23	19	4	69	86	85	5	75	81	32	74	562
2021	**t°C**	0.1	-0.3	3.8	8.5	15.3	20.2	24.0	21.7	15.7	10.2	6.8	0.8	10.6
	P. mm	39	43	36	39	101	86	114	118	6	1	12	71	666

Note: M - annual average; P - amount of precipitation

According to the production potential (kg/ha), honey plants are classified into 6 groups. Depending on the climatic conditions and the geographical area in which they grow, *S. perfoliatum* plants fall into the group 4 (101-200 kg/ha), 5 (201-500 kg/ha) and group 6 (over 500 kg/ha).

Cup plant, being known as a multi-purpose crop, is also a high potential honey plant, therefore, it is necessary to study the pollinating honey-producing entomofauna interested in this species, especially in the flowering stage.

The research on pollinating and honey insects in the growing season of 2020, 2021, with the weather conditions corresponding to the area and the year, according to the study of the generative organs (flower buds, flowers), detected the presence of 10 species of insects on *S. perfoliatum* plants. Systematically, they are

classified into 6 families (Apidae, Halictidae, Syrphidae, Sarcophagidae, Cerambycidae, Satyridae) and 4 orders (Hymenoptera, Diptera, Coleoptera, Lepidoptera) (Table 3).

Table 3. The diversity of entomofauna on *S. perfoliatum* plants

No	Order	Family	Species	Trophic spectrum
1	Hymenoptera	Apidae	*Apis mellifera* (Linnaeus, 1758)	Pollen and nectar
2			*Bombus terrestris* (Linnaeus, 1758)	Pollen and nectar
3			*Bombus lapidarius* (Linnaeus, 1758)	Pollen and nectar
4			*Bombus hortorum* (Linnaeus, 1761)	Pollen and nectar
5		Halictidae	*Lasioglossum malachurum* (Kirby, 1802)	Pollen and nectar
6	Diptera	Syrphidae	*Eristalis tenax* (Linnaeus, 1758)	Phytophagous
7			*Sphaerophoria scripta* (Linnaeus, 1875)	Phytophagous
8		Sarcophagidae	*Sarcophaga carnaria* (Linnaeus, 1758)	Plant liquids
9	Coleoptera	Cerambycidae	*Agapanthia villosoviridescens* De Geer.	Phytophagous
10	Lepidoptera	Satyridae	*Maniola jurtina* (Linnaeus, 1758)	Pollen and nectar

They are species with phytophagous trophic specialization, which feed on nectar, pollen and other plant liquids. The entomofauna was more abundant from the beginning of July to the middle of October, period which coincides with the flowering stage of the plants, which provides favorable conditions for the nutrition and reproduction of insects.

The taxonomic classification of the entomofauna allows identifying the maximum share, which belongs to the species of the order Hymenoptera (50% of the total number of determined insects), Diptera with 30%, Coleoptera - 10% and the order Lepidoptera with 10%. The species from the Apidae family (*Apis mellifera*, *Bombus terrestris*, *B. lapidarius*) (Figure 1, 2), had the maximum frequency on flowers, being present throughout the day on the cup plant flowers. The honey bee collects food from a cup plant flower for about 20 sec. On days with high temperatures, without wind, 2-3 bees and 1-2 bumblebees can simultaneously be on a shoot.

The representative of the family Syrphidae, *Eristalis tenax* (Figure 3) is a species quite common on cup plant flowers, especially in September and October. It feeds on flower nectar and plays an important role in pollinating entomophilous plant species.

Figure1. The species *Bombus terrestris* on a cup plant flower

Figure 2. The species *Apis mellifera* collecting *pollen*

Figure 3. The species *Eristalis tenax*

Figure 4. *S. perfoliatum* flower with the pollinating insect *Lasioglossum malachurum*

The species *Lasioglossum malachurum* (Figure 4) was observed less frequently on flowers, as solitary individuals, but it has an important function in the pollination process.

Several researchers from South Dakota described 3 species of insects found on *S. perfoliatum* plants that have not yet been found on other plant species (*Eucosoma giganteana*, *Acanthocaudus* n. sp., and the aphid *Uroleucon* cf. *ambrosiae*). These species, at different stages of life, can be harmful to the growth and development of cup plant, reducing the level of reproduction (because of the damage to the apical meristematic tissues, including flower buds) and productivity (Johnson, 2011, Johnson et al., 2019).

Honey bee participates in the cross-pollination of agricultural crops, and as a result, increases the quality and quantity of seeds and fruits. The value of the production obtained from agricultural crops as a result of pollination by honey bees is tens of times higher than the cost of bee products in general (Eremia, 2002). As a result of the activity of the insects, the seed productivity of the plants increases considerably. About 20-30 seeds can develop in a cup plant flower. The weight of 1000 seeds is 20.26±0.32 g, and one gram contains 53±3.61 seeds (seeds from the 2020 harvest).

CONCLUSIONS

Under the climatic conditions of the Republic of Moldova, *S. perfoliatum* demonstrates a high adaptive potential, with a staggered flowering period that lasts from July to October. The biological surveys have determined the spectrum of pollinating and honey insects on *S. perfoliatum* plants. The entofaunal list has been made, which includes 10 species of insects, of 4 orders (Hymenoptera, Diptera, Coleoptera, Lepidoptera) and 6 families (Apidae, Halictidae, Syrphidae, Sarcophagidae, Cerambycidae, Satyridae). These insect species have phytophagous trophic specialization. The species of the order Hymenoptera are the most numerous - 50% of the total determined insects. The research and introduction of new plant species will help increase the range of plant resources, honey plants in particular, forming a sequence of food sources for pollinating and honey-producing insects.

ACKNOWLEDGEMENTS

The study has been carried out in the framework of the project: 20.80009.5107.02 “Mobilization of Plant Genetic Resources, Plant Breeding and as Forage, Melliferous and Energy Crop in Bioeconomy”.

REFERENCES

Amiet, F., & Krebs, A. (2012). Bienen Mitteleuropas - Gattungen, Lebensweise, Beobachtung. *Wien: Haupt. Verlag*. Bern, Stuttgart.

Bidau, C. (2018). Doomsday for insects? The alarming decline of insect populations around the world. *Entomology, Ornithology, and Herpetology* 7:e130.

Cozari, T. (2010). *Insectele, mică enciclopedie*. Chişinău, MD: ARC Ştiinţa.

Eremia N., Mihailova I. & Dabija T. (2002). Caracterele morfo-metrice ale albinelor melifere. În: *Ştiinţa agricolă, nr. 2*. Chişinău. 38–43.

Friedman, J., Barrett, S. (2009). Wind of change: New insights on the ecology and evolution of pollination

and mating in wind-pollinated plants. *Annals of Botany, 103*. 1515–1527.

Johnson, P. & Arvid Boe. (2011). Three interesting insects and the cause of reduced vigor of cup plant (*Silphium perfoliatum*) in agronomic plantings. *Proceeding of the South Dakota Academy of Science, 90*. 209.

Johnson, P., Arvid Boe1, & Abigail P. Martens. (2019). Eucosma giganteana *(riley) and* Silphium perfoliatum *l., morphological variation in an insect-plant association in eastern South Dakota. Proceedings of the South Dakota Academy of Science, 98*. 91–100.

Kluser, S., & Peduzzi, P. (2007). Global Pollinator Decline: *A Literature Review*. UNEP/GRID-Europe, 10 p.

Koltowski 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.

Künast Ch., Riffel M., Graeff, R. & Whitmore G. (2014). *Polenizatorii şi agricultura. Productivitatea agricolă şi protecţia polenizatorilor*. 48 p.

Mueller, A., Berger, C., Schittenhelm, S., Stever-Schoo, B. & Dauber, J. (2020). Water availability affects nectar sugar production and insect visitation of the cup plant *Silphium perfoliatum* L. (Asteraceae). *Journal Agronomy and Crop Science, 206*. 529–537.

Mueller, A., Biertümpfel, A., Friedritz, L., Power, E., Wright, G.; & Dauber, J. (2020). Floral resources provided by the new energy crop, *Silphium perfoliatum* L. (Asteraceae). *J. Apic. Res*., *59*. 232–245.

Müller, A., & Dauber, J. (2016). Hoverflies (Diptera: Syrphidae) benefit from a cultivation of the bioenergy crop Silphium perfoliatum L. (Asteraceae) depending on larval feeding type, landscape composition and crop management. *Agricultural and Forest Entomology*. DOI: 10.1111/afe.12175.

Murrell, E. & Turner, K. (2020). *Guide to known Silphium patogens and pets.* Then Land Institute. Kansas. 13 p.

Pastukhova, M. (2020). The place of *Silphium perfoliatum* in the nectariferous conveyor in the conditions of the south-west of Belarus. Bull. Belarus. *State Agric. Acad*. 2019, 3, 88–92. Agriculture 10, 640 18 of 22.

Perju, T. (1995). *Entomologia agricolă componentă a protecţiei integrate a agroecosistemelor*. Bucureşti, RO: Ceres, Vol. II, 289 p.

Pîrvu, C. (2000). *Universul plantelor*. Bucureşti: Enciclopedia. 909 p.

Reinert, S., Hulke, B., & Prasifka, J. (2020). Pest potential of Neotephritis finalis (Loew) on Silphium integrifolium Michx., Silphium perfoliatum L., and interspecific hybrids. *Agron. J., 112*. 1462–1465.

Savin, A. & Gudimova, N. (2019). The influence of mineral fertilizers on the nectar, forage and seed productivity sylphs standardized. In *Modern Problem of Beekeeping and Apitherapy*; Publisher: Rybnoe, Russia; pp. 186–191.

Tălmaciu, M. & Tălmaciu, N. (2014). *Entomologia Agricolă ID*. USAMV "Ion Ionescu De La Brad" Iaşi, 181 p.

Teleuţă, A. & Ţîţei, V. Brevet de soi. Soiul 'Vital' de silfie, *Silphium perfoliatum*. Brevet de soi nr.209/2016.05.31; Publ. BOPI nr.9/16. http://www.agepi.md/sites/default/files/bopi/BOPI_09_2016.pdf#page=33

Ţîţei, V. & Roşca, I. (2021). Good practices for the use of degraded lands in the cultivation of crops with energy biomass potential. Chişinău, 80p. https://www.ucipifad.md/wp content/uploads/2018/12/Bunele-practici-de-utilizare-a-terenurilor-degradate-%C3%AEn-cultivarea-culturilor-cu-poten%C5%A3ial-de-biomas%C4%83-energetic%C4%83.pdf Accessed on July 15, 2021.

Ţîţei, V., Cîrlig, N. & Guţu, A. (2020) Some biological peculiarities and economic value of the cultivation of cup plant, *Silphium perfoliatum* L. *Studia Universitatis Moldaviae. Seria Ştiinţe Reale şi ale Naturii, 6*(136), 79–82.

Бейдеман И. (1974). *Методика изучения фенологии растений и растительных сообществ.* Новосибирск. 161с.

Мамаев Б. (1985). *Школьный атлас – определитель насекомых.* Москва: Просвещение.160 с.

Методические указания по семеноведению интродуцентов. Москва: Наука, 1980.

Плавильщиков, Н. (1994). *Определитель насекомых*. Москва: Топикал, 543 с.

https://meteo.md/