ORIGINAL PAPER

PHARMACO-BOTANICAL MAPPING AND EVALUATION OF THE MEDICINAL FLORA – POTENCIAL ALONG THE NIRAJ AND TÂRNAVA MICĂ RIVERS

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Abstract: This study offers the partial results of the botanical studies, botanical cartography, and the evaluation of the medicinal flora potential in the ROSCI0297 Natura 2000 area (Dealurile Târnavei Mici – Bicheș). From March 4th, 2016 to March 3th, 2017, in a 1000 ha sample area and a 34 days long fieldwork the specific location of 101 officially applied medicinal plant species was identified and mapping was achieved. Simultaneously, 26 medicinal plant analogues, 300 other valuable taxa (e. g. plants under protection, rare orchids etc.), and the cartography of invasive plants were documented. Another important result of the first year is the identification, listing and analysis of the reshaping, influential and impairing factors of the vegetation and habitats.

Keywords: medicinal plants, spontaneous flora, botanical cartography, potential, Niraj and Târnava Mică rivers

1. Introduction

Publicated studies (Csűrös 1963; Oroian and Giurgiu, 2003; Kovács, 2008; Domokos, 2015; Oroian et al., 2016; Arany et al., 2017; Nagy, 2017; Nagy 2017a; Nagy 2017b; Nagy 2017c; Nagy, 2018; Nagy 2018a) and studies in form of manuscript (Molnár, 1997; Veress, 2002; Jenei, 2005; Fazakas, 2007; Nagy, 2017d) about the vegetation along the Niraj and Târnava Mică rivers have been carried out by a few researchers.

Many of the ecosystem services of medicinal plants in Transylvania are still untapped. The studied area still has the capacity to provide these species: a recent study proves that 300 tons of mushrooms and medicinal plants can be legally harvested annually (Arany et al., 2017). Nonetheless, the areas' flora is not nearly exploited enough botanically and/or pharmaco-botanically. The fact that most of the medicinal plants still come from the spontaneous flora also contributed to this research. Moreover, the improvement and selection of medicinal plants is also based on spontaneous flora.

The subject of this work is the botanical study, the pharmaco-botanical mapping, and the evaluation of the (semi-)spontaneous flora potential in the territory between the Târnava Mică and Niraj rivers.

The aim was to carry out a comprehensive six-year study that can lay the foundation of a sustainable development in the territory.

2. Materials and Methods

2.1 What do we define by the notion of medicinal plant?

The first problem confronted at the beginning of the research: what do we define by the notion of medicinal plant? A definition for medicinal plants was created: first the unjustified knowledge belonging to popular medicine and those studied by ethno-pharmaco-botany were excluded. Only scientifically proven knowledge was considered (**Fig. 1**). Only those species were considered medicinal plants that are beneficial for medicinal purposes based on the active substance they contain. The circle of medicinal plants was restricted by studying only Vascular plants (Tracheophyta), because since their appearance in the (semi) spontaneous flora of the Carpathian Basin there has been reliable information published on them. Moreover, their effects or drugs/drug preparations can be found in at least one scientific description (pharmacopoeia, monographs, standards, etc.). Several specialized publications were synthesized from the group of those mentioned above since they offer limited information (for example, „Farmacopeea Română Xth edition" contains only 25 species of spontaneous medicinal plants).

With these relatively objective methods, it was possible to compile a database containing 300 species of medicinal plants which can be found in the (semi)spontaneous flora of the Carpathian Basin. These 300 species have the potential to offer 336 drugs and drug preparations. This number is considered as the total number of medicinal plants, which was compared with the medicinal flora of the studied area, observing their differences as well.

The enumeration provides a complete and detailed synthesis of the Carpathian Basin spontaneous medicinal flora as well as the drugs and drug preparations obtained from them: it synthesizes the data of three pharmacopoeias (Ph.Hg. VIII., 2010; Ph.Eur. IX., 2017; Ph.Ro X., 1993), three monographs (ESCOP–European Scientific Cooperative on Phytotherapy, EMA–European Medicines Agency, WHO–World Health Organization) and two drug standards (Hungarian–www.mszt.hu and Romanian–www.asro.ro), as well as two specialized books (Bernáth, 2000; Muntean, 2007).

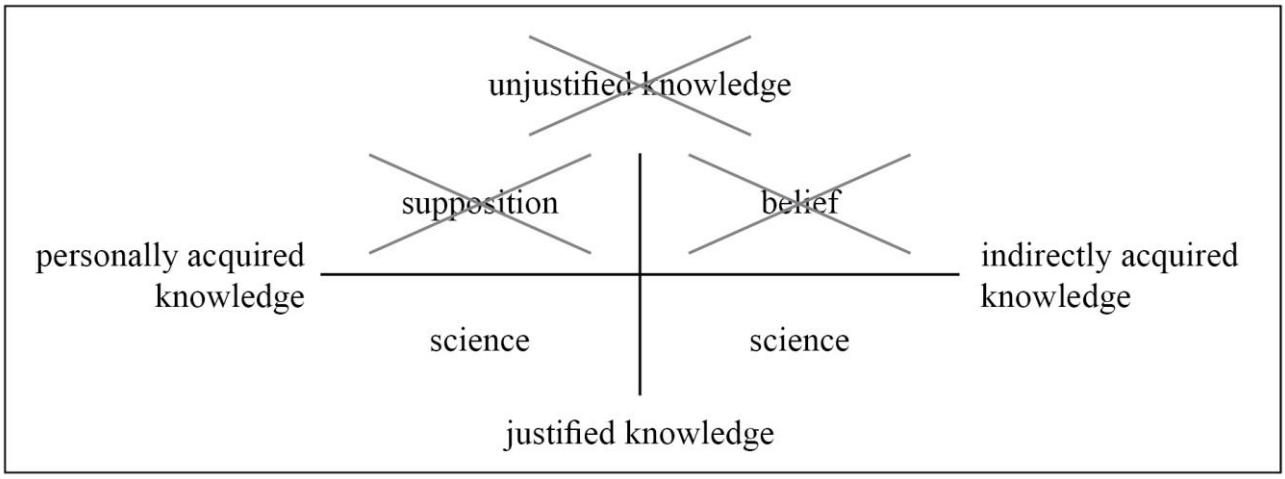

Fig. 1. Delimitation and diminution of the notion of medicinal plants, based on the type of knowledge regarding their efficacy

The nomenclature of the taxa was made on the basis of the Catalogue of Life, which is the most comprehensive and authoritative global index of species currently available (www.catalogueoflife.org). Regarding the endangered plant species, different studies were used to identify them (Simon, 2000; Dihoru and Negrean, 2009; Bartha, 2012).

2.2 Delimitation of the researched area

In the delimitation of the researched area the following criteria was considered: the vast majority of habitat types found in this territory (forests, meadows, etc.), but also urban areas, as well as secondary habitats and agricultural lands, in order to document the medicinal plants that are becoming wild or are resistant to human activities.

For the exact delimitation of the researched area a GPS device was used (Garmin GPSmap 64s), as well as satellite imagery and aerial images. An area of 1000 ha was delimited which was divided into 37 cartographic files, that was further divided into 1000 units of 1 ha (**Fig. 2**).

Then the most important features of the files and delimitated subunits (coordinates, dimensions, surface, altitude, level difference, exposure, and occasionally soil type, erosion degree) were recorded.

In the first year of the research, the fieldwork took place between 4 March 2016 and 3 March 2017 and required 34 active days of fieldwork.

Fig. 2. The location of the research area (control test site) and sample area (mapping location)

3. Results and disscusions

In the points to follow, the partial results will be presented obtained in the first year regarding the (semi)spontaneous medicinal flora of the Carpathian Basin and the territory between the Târnava Mică and Niraj rivers.

3.1 Results regarding the total (semi) spontaneous flora of the Carpathian Basin

The 300 medicinal plants listed in the database represent the total number of medicinal plants in the Carpathian Basin, while the 336 drugs/drug preparations represent the total number of drugs/drug preparations in this territory. All these medicinal plants are classified as follows: 5 classes (Equisetopsida – 0.33%;Gnetopsida – 0.33%; Liliopsida – 2.99%; Magnoliopsida – 94.68%; Pinopsida – 1.66%), 32 orders, 64 families (**Table 1** – in the Supplementary Material 2) and 159 genera. Regarding the number of the medicinal plants, the richest class is represented by angiosperms (Magnoliopsida), the richest order by Rosales, the richest family by Rosaceae and the richest genus by *Rosa*.

Regarding the geographical spreading (Simon, 2000), the documented medicinal plants of the Carpathian Basin can be classified in 24 different groups. 24.82% of these (101 species) belong to the Eurasian flora (**Fig. 3**).

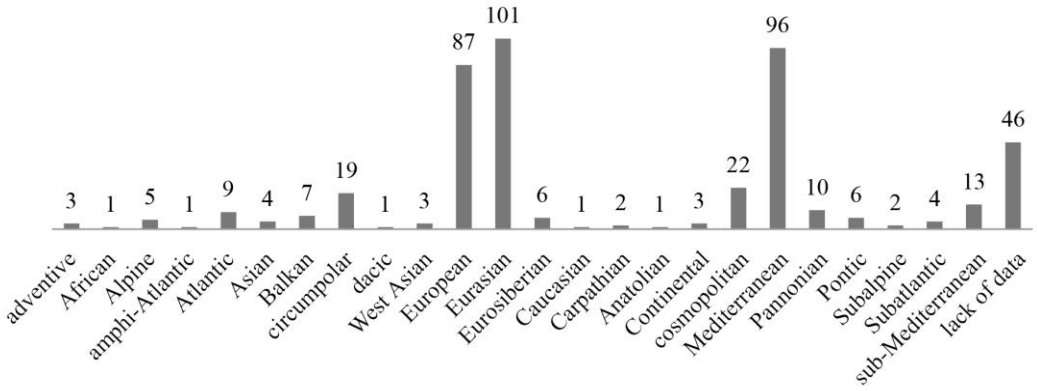

Fig. 3. The number of medicinal plant species from the Carpathian Basin with reference to the geographical spreading

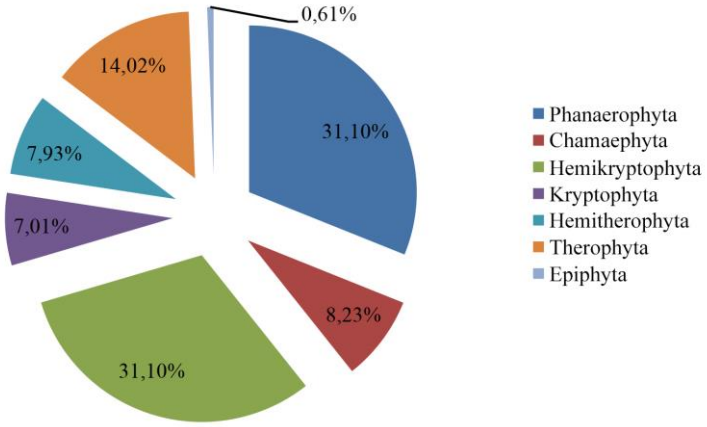

Fig. 4. The status of medicinal plant species from the Carpathian Basin with reference to the biological group aspect

Based on a biological group aspect (Raunkiaer, 1907; Raunkiaer, 1934; Ujvárosi, 1952; Hunyadi, 2011), the medicinal plants of the Carpathian Basin are mostly woody plants from the phanerophytes and herbaceous and perennial plants from the hemicryptophytes, both groups comprising of 102 species with a proportion of 31.10% (**Fig. 4**).

3.2 Results regarding the total (semi-) spontaneous flora of the territory between Târnava Mică and Niraj rivers

During the first year, in the studied area 101 species of (semi)spontaneous medicinal plants were documented, which number constitutes as the 33.66% of the medicinal plants flora of the Carpathian Basin (**Fig. 5**).

These medicinal plants are classified as follows: 4 classes (Equisetopsida – 0.99%; Liliopsida – 3.96%; Magnoliopsida – 94.05%; Pinopsida – 0.99%), 26 orders, 44 families (**Table 1** – in the Supplementary Material) and 88 genera. Regarding the number of the medicinal plants, the richest class is made up of the Magnoliopsida, the richest order of the Asterales, the richest family of the Asteraceae and the richest genus of the *Galium*, *Plantago* and *Quercus*. The percentage division of the (semi)spontaneous flora of the studied territory according to order, reveals that the *Fabales* represent themselves with 7 medicinal taxa, which constitutes the 6,93% of the medicinal plants in the studied territory, and 77.77% of the medicinal plants that belong to the *Fabales* order in the Carpathian Basin (a total of 9). This points out that the area is very rich in medicinal plants belonging to the *Fabeles* order.

In terms of geographical spreading, the documented medicinal plants in the studied area can be classified in 16 different groups. The highest percentage (30.43%) is made of Eurasian flora, meaning 49 species **Fig. 6**).

In terms of bioform, the majority of the (semi)spontaneous medicinal flora in the studied area are herbaceous and perennial hemikryptophytes (53 species – 41.09%) (**Fig. 7**).

In the studied area, medicinal plants were found in the following proportions: 48,51% natural condition; 48,51% disturbed/degraded condition and 2,97% lack of data. 14.29% of the medicinal plants (7 taxa: *Arnica montana* L.; *Menyanthes trifoliata* L.; *Valeriana officinalis* L.; *Adonis vernalis* L.; *Helleborus purpurascens* Waldst. & Kit.; *Hepatica nobilis* Schreb.; *Hippophae rhamnoides* L.) found in their natural condition are endangered species protected by local, regional, national or international laws. If we classify these 101 plants according to Social Behavior Types (Borhidi 1995), we notice that the number of those species found in their natural conditions is 39.81% (**Fig. 8**). This fact shows that the habitat's risk factors (erosion, environmental pollution, and deforestation) are in fact only transformative factors concerning the number and abundance of the medicinal plants. In regard to medicinal flora, the area has a 1.33 degree of degradation, since the species that indicate the degradation are definetely in majority. In terms of relative „temperature figures" (T value/index), the majority (48 species – 47.52%) are species characteristic of the montane mesophilous broad-leaved forest belt (**Fig. 9**).

In terms of relative „moisture figures" (W value/index), the majority consist of plants of semi-humid habitats, under intermediate conditions (31 species – 30.10%) (**Fig. 10**). In terms of relative soil „reaction figures" (R value/index), the majority is species characteristic of mostly neutral soils but also in acid basic ones generally widely tolerant, more or less indifferent plants (38 species – 38.00%) (**Fig. 11**).

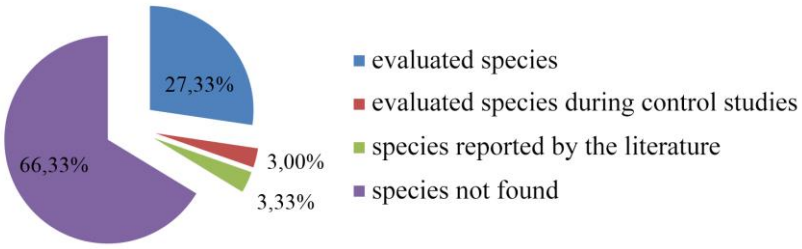

Fig. 5. The status of the medicinal plants from the studied area with reference to the Carpathian Basin medicinal flora

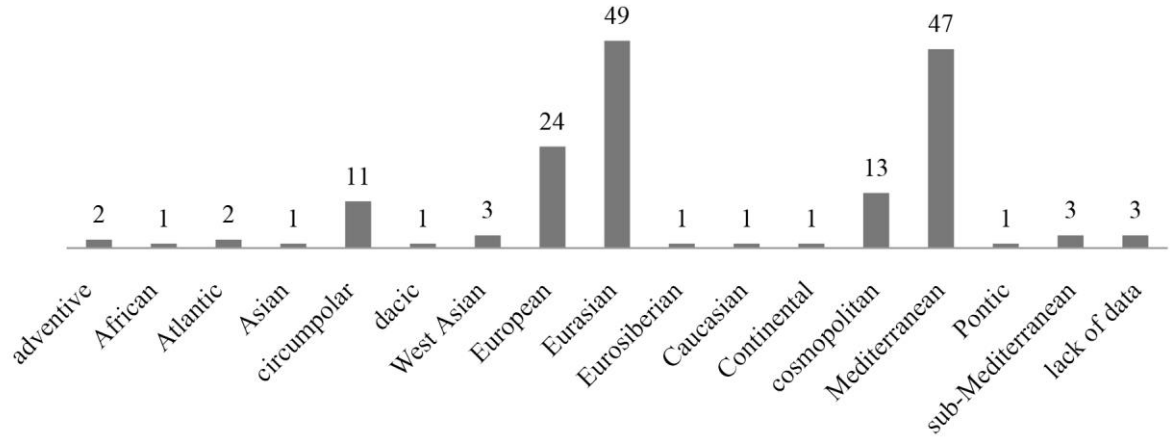

Fig. 6. The number of medicinal plant species from the studied area with reference to the geographical spreading

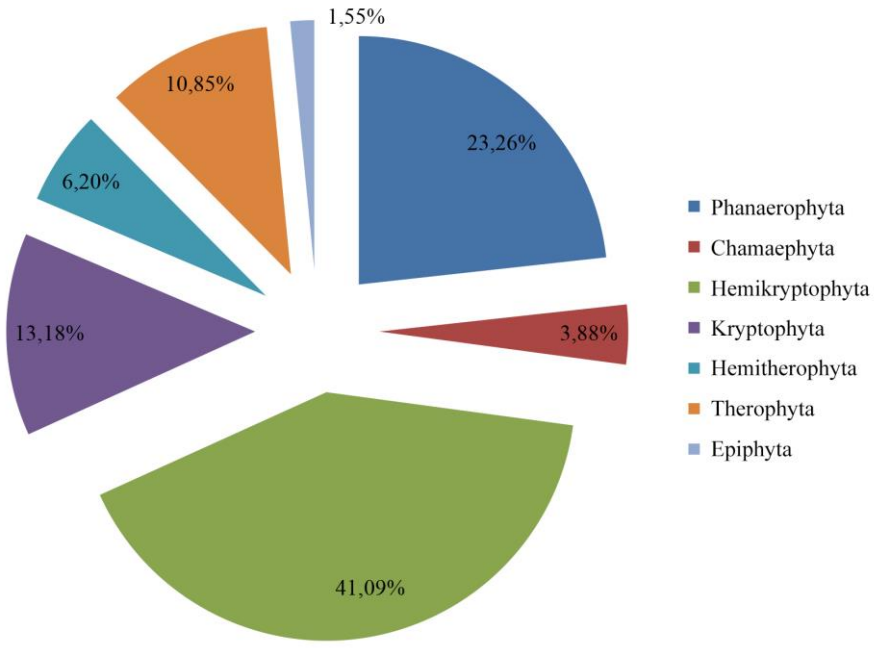

Fig. 7. The status of medicinal plant species from the studied area with reference to the biological group aspect

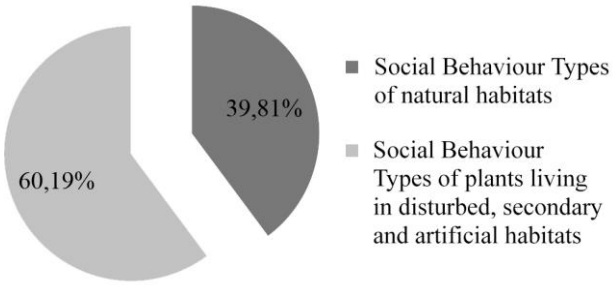

Fig. 8. The status of medicinal plant species from the studied area with reference to the social behavior types

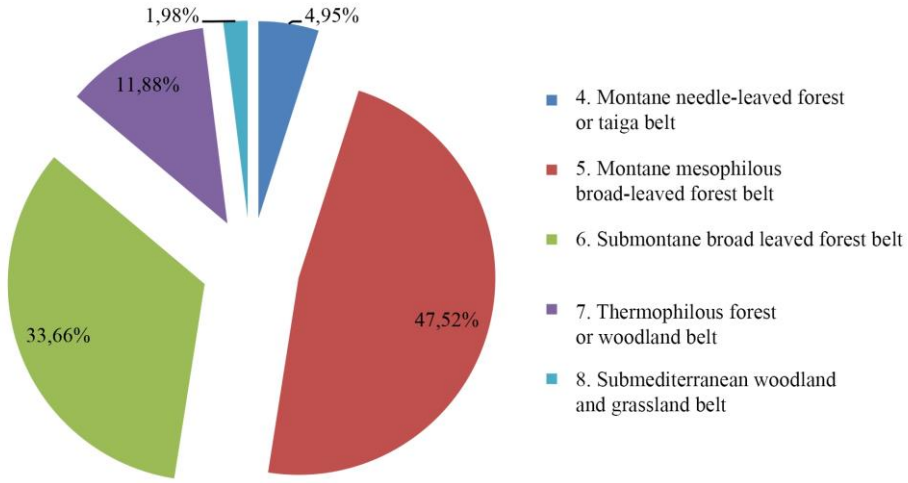

Fig. 9. The status of medicinal plant species from the studied area with reference to the terms of relative „temperature figures"

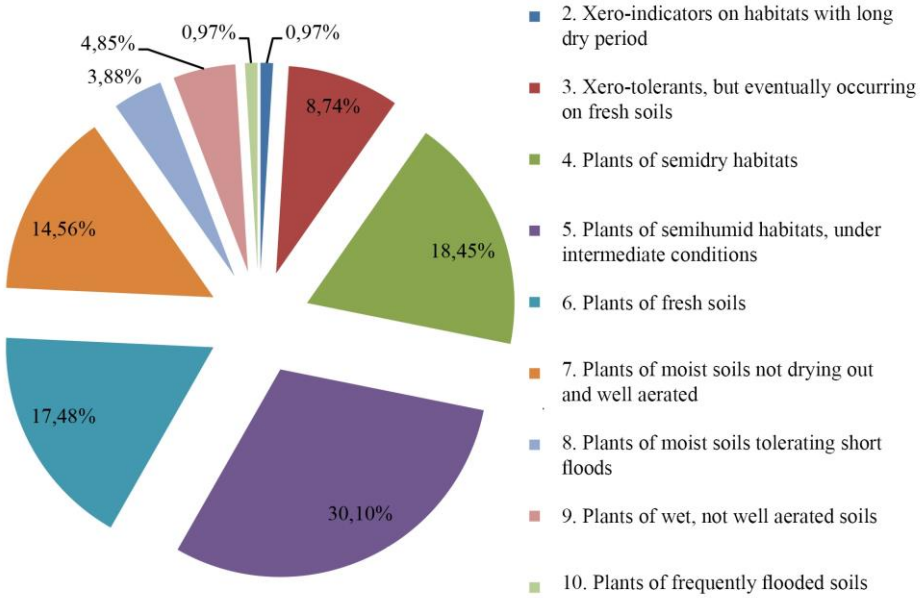

Fig. 10. The status of medicinal plant species from the studied area with reference to the terms of relative „moisture figures"

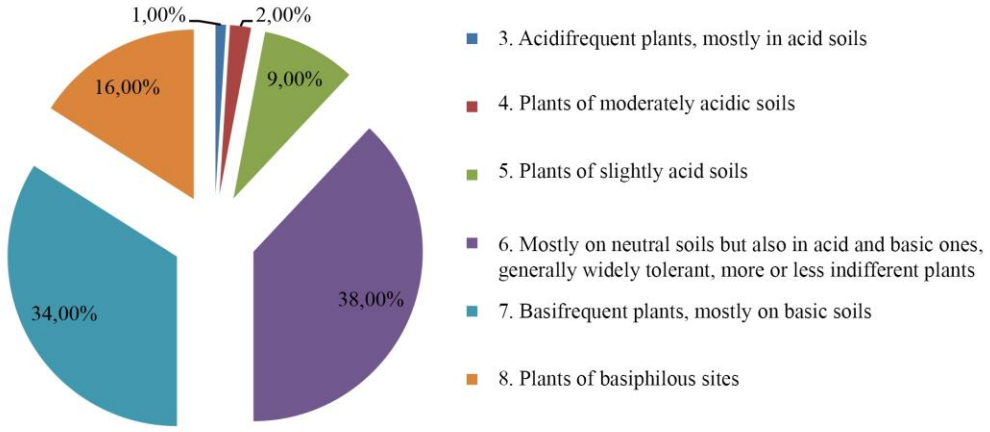

Fig. 11. The status of medicinal plant species from the studied area with reference to the terms of relative soil „reaction figures"

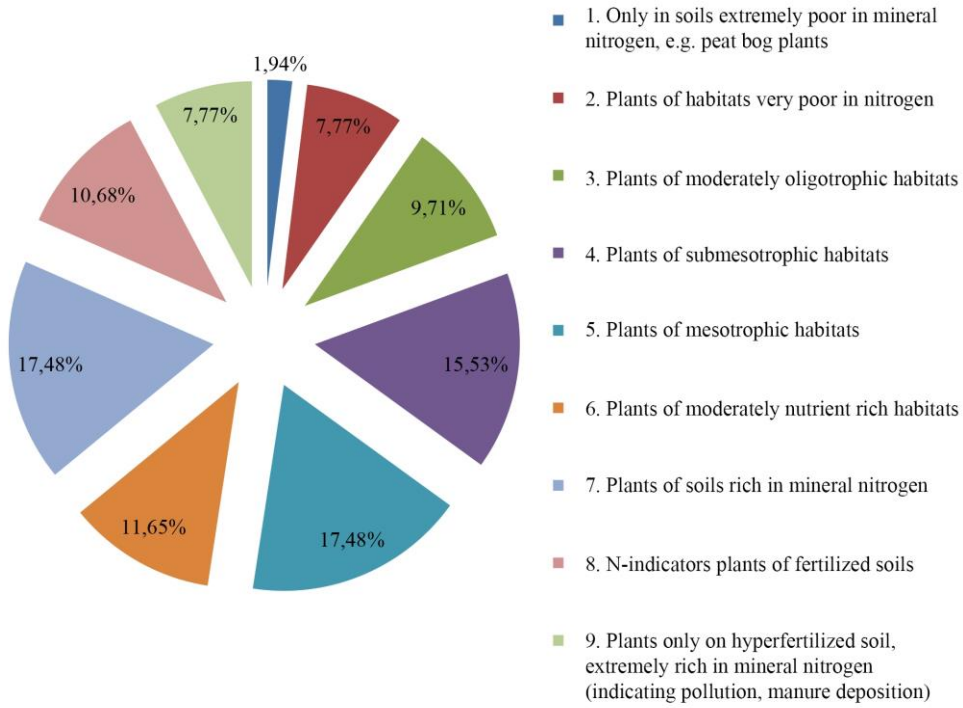

Fig. 12. The status of medicinal plant species from the studied area with reference to the terms of relative „nitrogen figures"

In terms of relative „nitrogen figures" (N value/index), the majority is plants of mesotrophic habitats (18 species – 17.48%), and plants of soils rich in mineral nitrogen (18 species – 17.48%) (**Fig. 12**).

The classification of the (semi)spontaneous medicinal plants in the area according to the relative „light figures" (L value/index) shows that in case of deforestation the number of medicinal taxa would increase spectacularly. Hence in the underbrush of dense forests there are only a few or no species of medicinal plants at all. The so-called half-light plants that live in mostly full light but are also shadow tolerants are in majority in the area's flora (40 species – 39.60%) (**Fig. 13**).

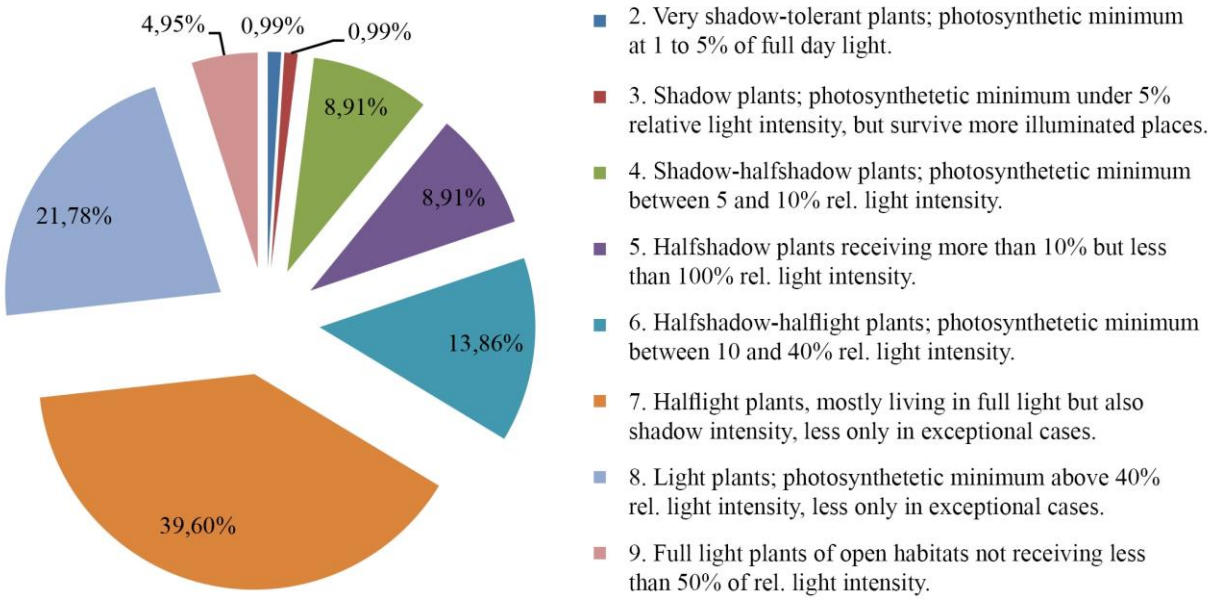

Fig. 13. The status of medicinal plant species from the studied area with reference to the terms of relative „light figures"

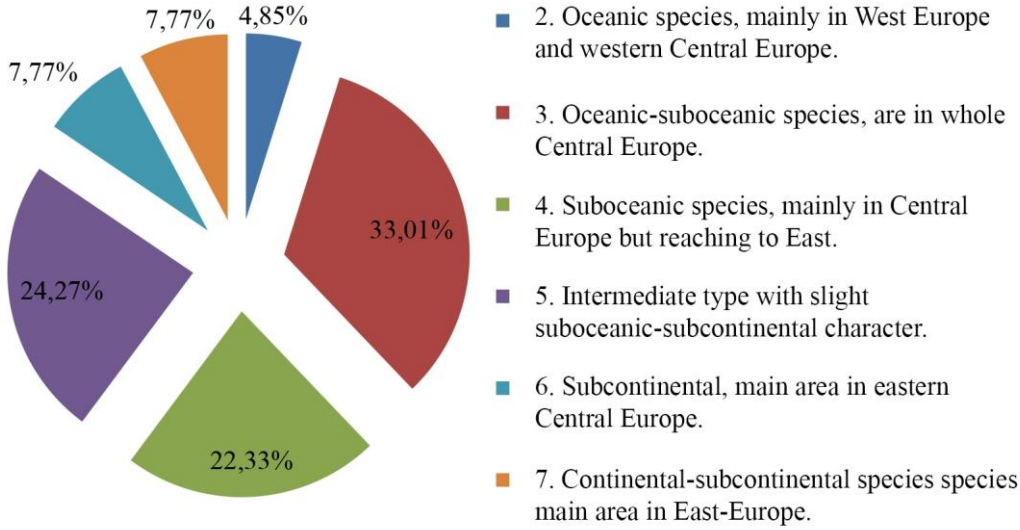

Fig. 14. The status of medicinal plant species from the studied area with reference to the terms of „continentality figures"

In terms of tolerance towards climate change or climate extremes („continentality figures" – C value/index), the majority of the species resulted to be oceanic–suboceanic species, which can be found in whole Central Europe (34 species – 33.01%) (**Fig. 14**).

The resistance of the (semi)spontaneous medicinal plants to salt is limited. According to the salt resistance index („salt figures" – S value/index) 90 species (88.24%) are halophob, not occuring in salty or alkalic soils (**Fig. 15**).

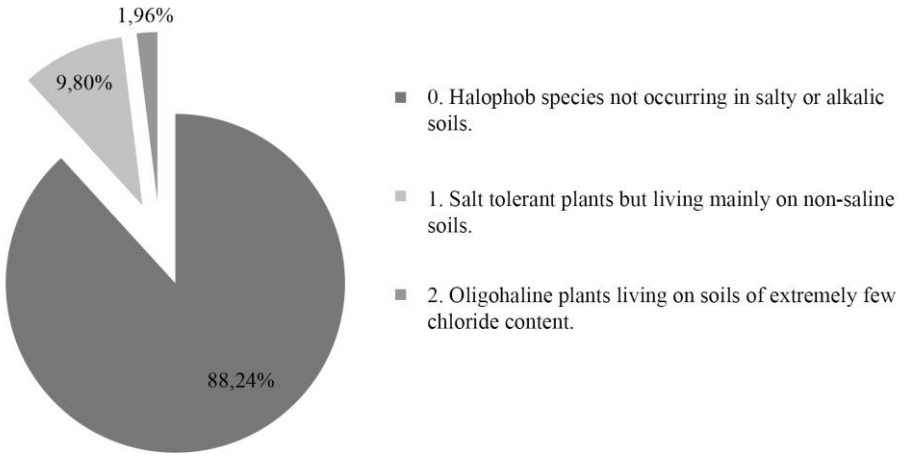

Fig. 15. The status of medicinal plant species from the studied area with reference to the terms of „salt figures"

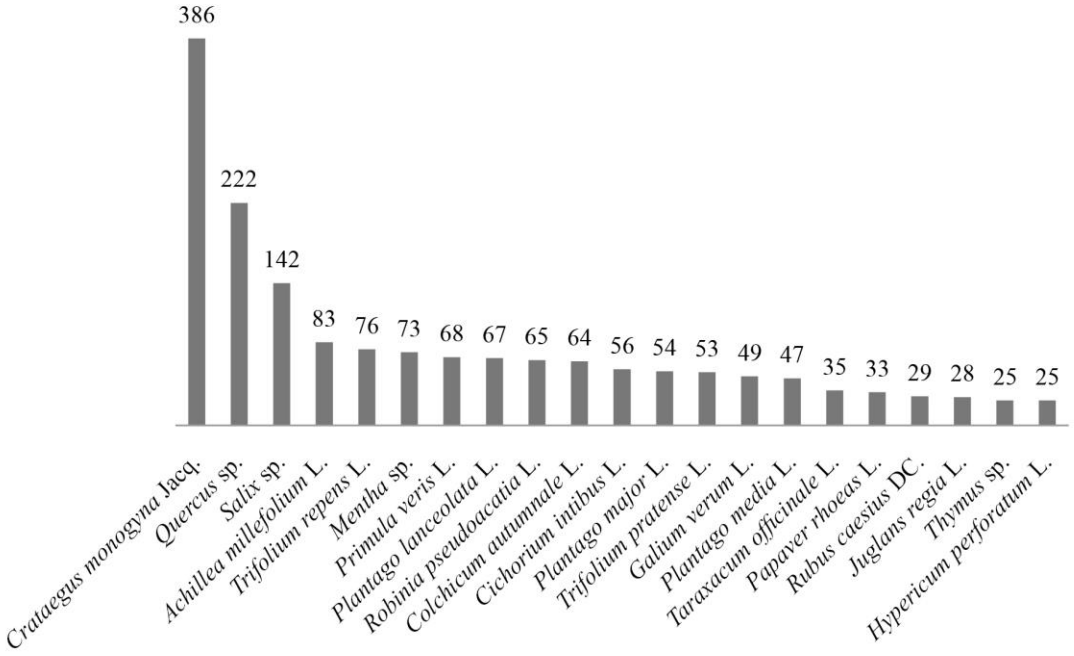

Fig. 16. The size of the area (ha) of the twenty most widespread taxa in the studied territory

The number of the documented factors that change the habitat in the area between Târnava Mică și Niraj rivers is almost 50 (natural disasters – flood, earthfall etc.; environmental pollution; constructions). These factors regarding the medicinal flora are positive, negative, but also positive and negative at the same time, as the examples above illustrate it (erosion, deforestation etc.). In most cases, the factors that endanger the habitat in terms of medicinal flora are only changing it. With reference to the abundance-dominance index, the most common 20 taxa are the most commonly known, most often used, and most often traded nowadays (**Fig. 16** and **Fig. 17**). Therefore, there is huge potential in the production and trade of drugs or drug preparations.

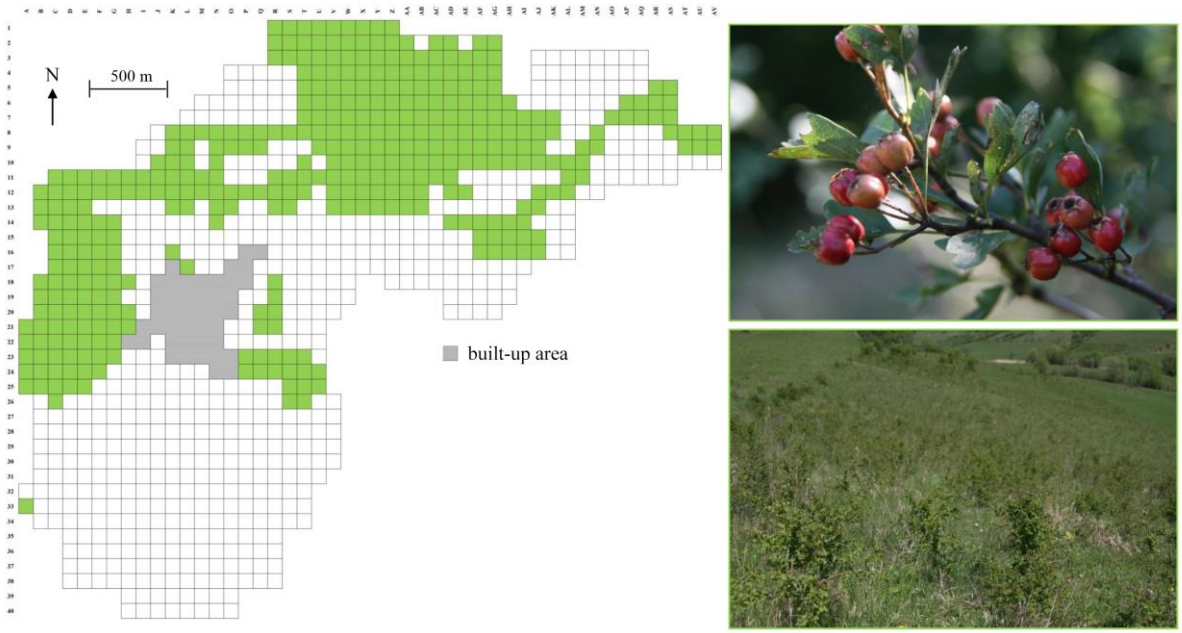

Fig. 17. The most widespread species: the spreading of *Crataegus monogyna* Jacq. in the studied area (original photo)

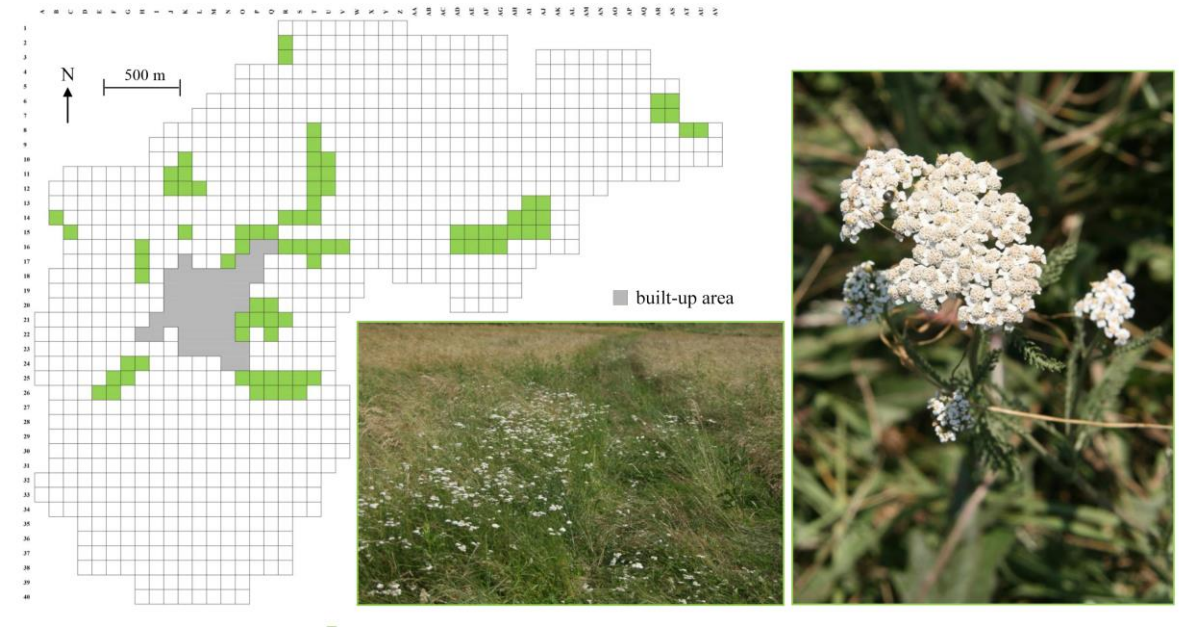

Fig. 18. Example 1 – the spreading of *Achillea millefolium* L. in the studied area (original photo)

The 69 maps show the spreading (area) of the documented medicinal plants (**Fig. 18**). They also reveal which species are tolerant towards human activities and which are trying to avoid the habitats disturbed by human activities. In case of tree species, the maps revealed areas of dense, homogeneous forests. In case of *Salix* and *Populus* genus, the maps show areas of temporal and permanent watercourses or water areas (**Fig. 19**).

In case of invasive-adventitious species – the group of parcels that could be potential risk factors. In the case of *Viscum album* L. – where are groups of sick and/or old trees (**Fig. 20**) etc.

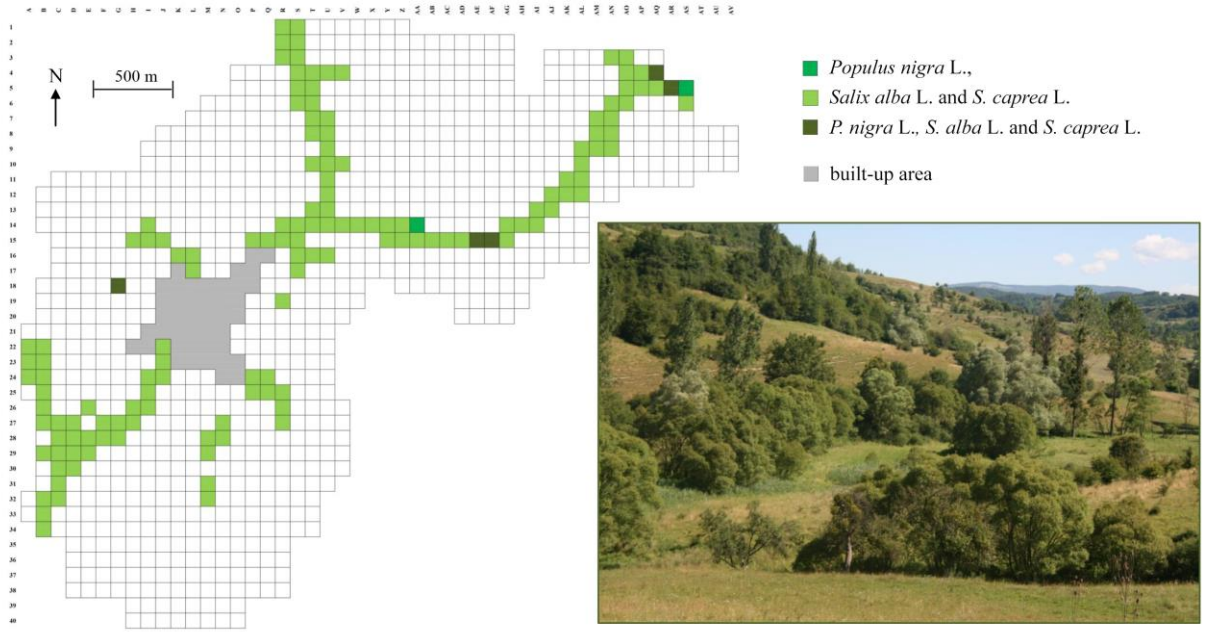

Fig. 19. The spreading of medicinal plants belonging to the *Salicaceae* family in the studied area (original photo)

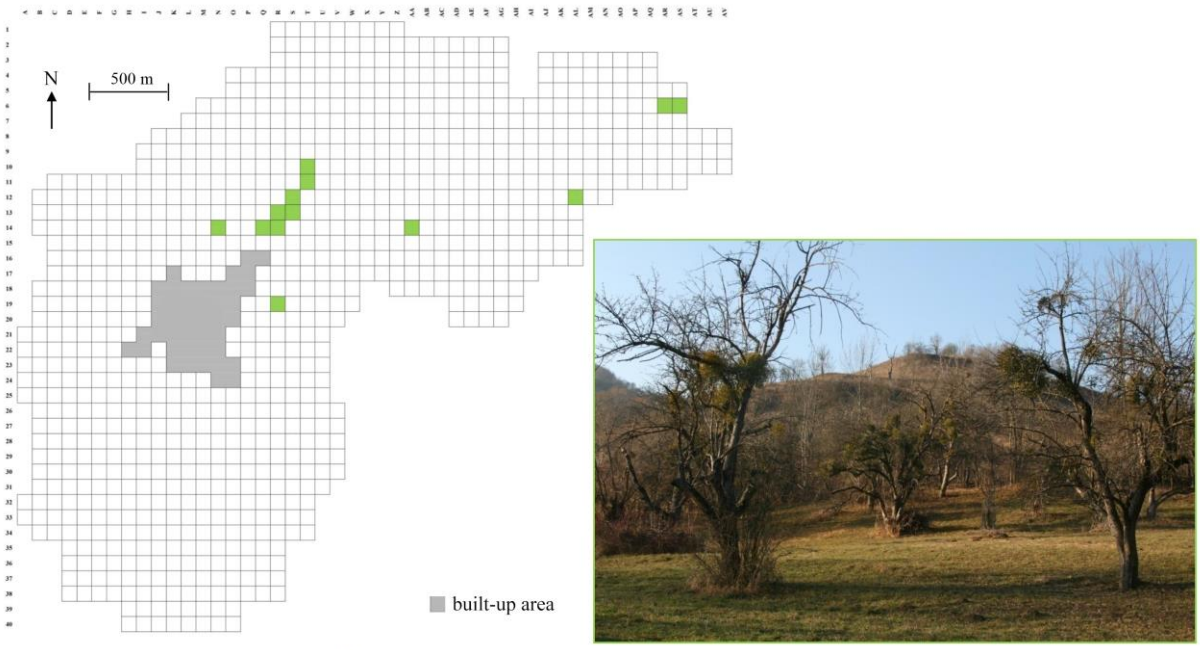

Fig. 20. The spreading of *Viscum album* L. in the studied area (original photo)

The mapping of ineffective or poisonous facsimile (26 species) highlights those parts of the area where there is a possibility to mistake the medicinal plant with the phenotypically similar but unusable species (**Fig. 21**). The 101 documented medicinal plants offer 195 drugs and drug preparations. This number constitutes 58.03% of the total number of the drugs and drug preparations from the (semi)spontaneous medicinal flora potential of the Carpathian Basin.

The number of the obtained drugs from the 101 plants is almost four times higher (79.49%) than the number of drug preparations. These results shows us that in the studied area, not only the harvest of the medicinal plants, but also the processing and marketing of three quarters of the species as a finished product can be accomplished relatively easily with cheap technologies and machinery, since these plants require only primary processing (drying, conditioning) and rudimentary storage. The 155 drugs contain the aerial part of the plants (herba) in highest percentage (32.26%) (**Fig. 22**).

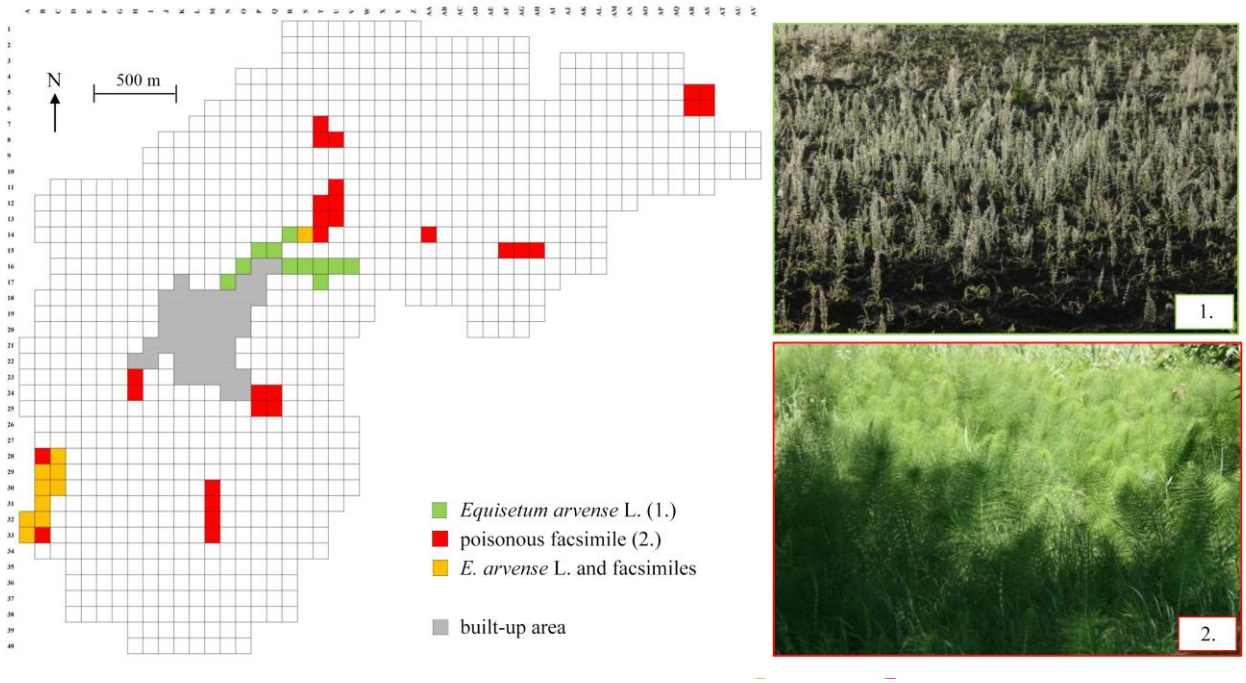

Fig. 21. Example 2 – the spreading of medicinal plants belonging to the *Equisetum* genus and its facsimiles in the studied area (original photo)

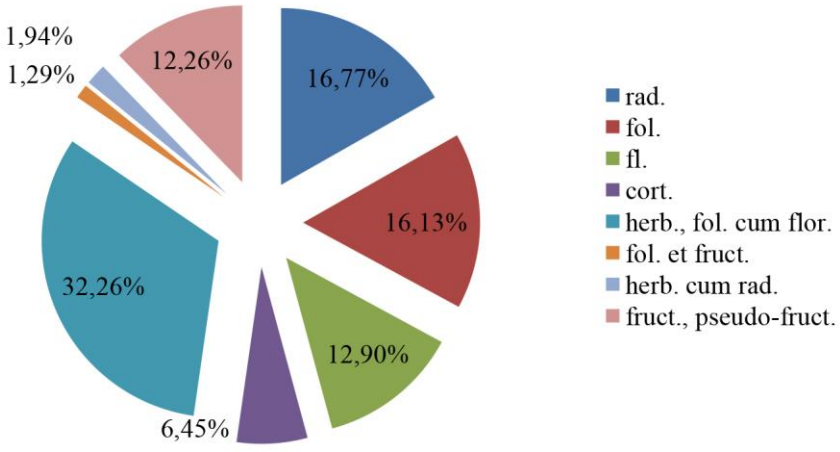

Fig. 22. Morphological grouping of drugs provided by the medicinal plants and the percentage distribution of groups (abbreviations: rad.–radix; fol.–folium; fl.–flos; cort.–cortex; herb., fol. cum flor.–herba, folium cum flore; fol. et fruct.–folium et fructus; herb. cum rad.–herba cum radicae; fruct., pseudo-fruct.-fructus, pseudofructus)

The 40 drug preparations mostly (11) and in highest percentage (27.50%) contain extracts (extractum) obtained by various method (**Fig. 23**).

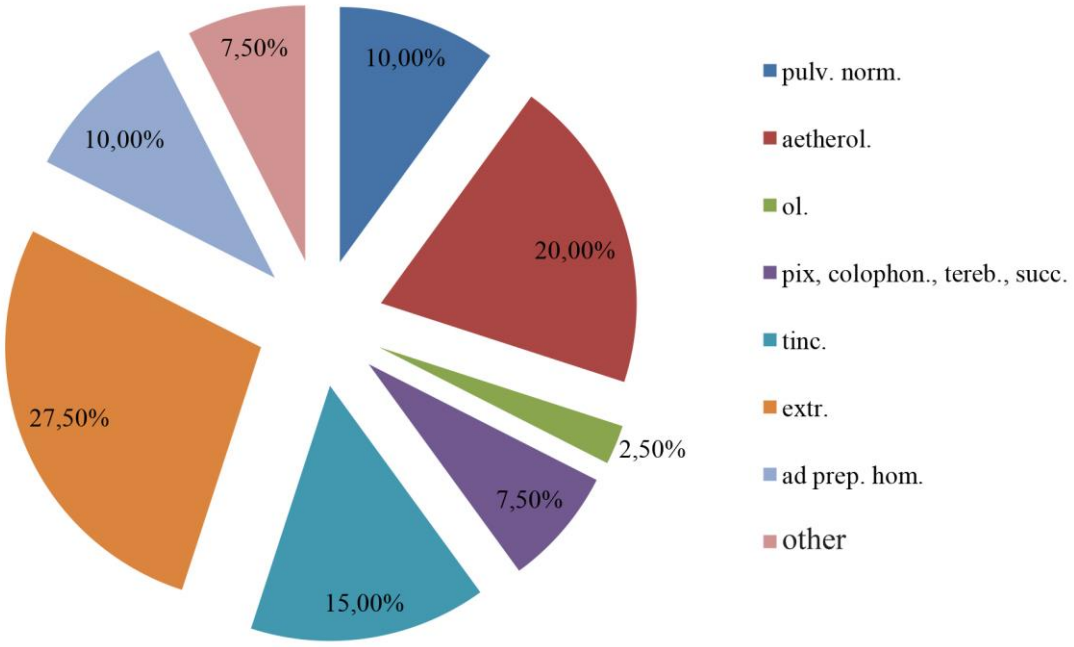

Fig. 23. Type grouping of drug preparations provided by the medicinal plants and the percentage distribution of groups (abbreviations: pulv. norm.–pulvis normatus; aetherol.–aetheroleum; ol.–oleum; pix, colophon., tereb., succ.–pix, colophonium, terebinthia, succus; tinc.–tinctura; extr.–extractum; ad prep. hom.–ad preparations homeopathicas)

Conclusions

The botanical inventory and the pharmaco-botanical mapping of the area is wished to be continued until 2020, based on the 6-year plan. The second year of mapping was started on 4th March 2017. The second year's partial results also indicate the presence of new medicinal plant species in the studied area. The processing of statistical data and the preparation of specimens for the herbarium is currently ongoing.

It is believed that this study based on the researches carried out will effectively contribute to the rational and sustainable valorization of the potential of the (semi)spontaneous vegetation of the studied area in order to create alternative rural development opportunities in the territory that provide a better living for the local society.

Conflict of Interest

The author 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.

Acknowledgments

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