DOI: 10.3195/ejejfs.903472

Research Paper – Araştırma Makalesi

Eurasian Journal of Forest Science

2021 9(2): 54-62

http://dergipark.org.tr/tr/pub/ejejfs

Glechoma hederacea (Lamiaceae): Key features in its native range, habitats, cultural significance, impacts and sustainability status

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Abstract

The existence and sustainability of the ethnobotanical plant species are among the most important resources for the world, especially considering hunger and economic contribution. Moreover, the use of wild plant species for medical purposes for human and animal health increases the value of these plants. Therefore, social awareness is important for the effective and sustainable use of the relevant species. The main reason for this study is the warnings of local community who have this social awareness. Here, we worked on *Glechoma hederacea* L., which we recorded for the first time in Düzce in 2019, due to the environmental and socioeconomic impacts reported to us by the local community. This study aimed to determine *G. hederacea*'s presence in native range, its habitats, some morphological and phenological data and Cultural Food Importance Index value. In addition, the use of the plant in the local area, the parts used and the impacts of ethnobotanical use on the sustainability of its natural spread are presented. For this purpose, the plant was followed in Düzce central district between July 2019 and May 2020. As a result, it was determined that *G. hederacea* started flowering in March in Düzce and the flowering continued until the end of November. In Düzce, which is built on a plain, it has been determined that *G. hederacea* was widespread primarily in pastures, natural open areas, roadsides, open woodlands, tree edges, agricultural and urban habitats. Moreover, for the sustainability of the plant, it has been determined that local community take some sub-regional measures against vegetation removal and even carry out small activities for plant propagation. However, the ratio between harvesting rate and planting is not sufficient. Considering this situation, awareness activities for *G. hederacea* as well as other plant species with ethnobotanical use and, when necessary, encouraging the production of the relevant native species for medical purposes will be useful.

Keywords: Anthropogenic factors, native**,** phenology, wild plant, index value

Introduction

In recent years, concerns in agricultural production gathered under some basic factors. Such as anthropogenic agents (migration, unemployment, ever-increasing globalization, urbanization, privatization, improper agricultural practices, harvesting of wild populations, land degradation, pollution of soil, exclusion and restoration of terrestrial and aquatic habitats, intensification or abandonment, climate change produced by anthropogenic carbon emissions, etc.), overuse of organisms, invasive species, climate change and natural disasters. These factors could be the main cause to reduce self-sufficiency in agricultural production of all countries (Díaz et al., 2015; IPBES, 2018, 2019). These

situations also directly contribute to the reduction of plant and animal products required for human life to survive. For this reason, people have started to turn to produce commodities that will meet their medical needs, especially nutrition (IPBES, 2018, 2019). The increase in the use of wild plants has been particularly noticeable in the last two decades (Yazlık, 2019). However, since the sustainability of these wild plants used for ethnobotanical purposes is also important, there is a need for data on determination of regional or sub regional wild plant forms, research of usage patterns and sustainability (Yazlık, 2019; Yazlık & Duran, 2019; Phumthum, 2020). Information from local habitats of plant species also provides valuable information for the introduction of plants in different areas (Kendir & Güvenç 2010; Yazlık, 2019; Phumthum 2020). As a matter of fact, there is serious evidence that many plants around the world can be dispersed to different areas with anthropogenic factors (Sipek et al., 2020; Applequist et al., 2020). It has been reported that plants with particularly high phenotypic plasticity and rapid growth exhibit a wide distribution and a successful spread in the introduced range and cause high invasion (Pyšek et al., 2020; Sipek et al., 2020). Therefore, the information obtained from the local habitats of the plants in this direction is critically needed to investigate the causes of plant invasion and to develop control measures (Guo, 2006; Yazlık, 2019; Pyšek et al., 2020). One of the plants displaying these properties is *Glechoma hederacea* L. from Lamiaceae, one of the most used families for ethnobotanical purposes (Benaiche et al., 2019). *Glechoma hederacea* is a low-growing perennial plant in parts of Europe and Asia (Hutchings & Price, 1999; CABI, 2020). It tends to spread rapidly in its habitats with its ability to reproduce both seeds and multiple monopodial stolons and its ability to adapt rapidly to environmental conditions. Moreover, anthropogenic factors arising from its use as an ornamental and / or medicinal plant in terms of ethnobotanical play an important role in introducing the plant to different geographies (Hutchings & Price, 1999; Sipek et al., 2020). In addition, it is one of the most common weeds in many places (Southeast Asia, South Australia, New Zealand, America, Argentina, Brazil, Chile and Canada) outside its natural range, and has been defined as an invasive alien plant in these regions (Sipek et al., 2020).

Although some data in the form in which this taxon was recorded almost all in Europe except Turkey (Hutchings & Price, 1999), *G. hederacea* has registered since 1982 in Flora of Turkey (Mill, 1982). On the other hand, the distribution of *G. hederacea* in the national data sets (TUBIVES - http://www.tubives.com/ and Bizim Bitkiler - https://www.bizimbitkiler.org.tr) of Turkey are not included the Düzce province (Figure 1). However, the only record that the plant was found in the relevant area was recently given by Aksan & Yazlık (2021 - *in press*). Considering all these situations, this study addressed the present existence of *G. hederacea*, its habitats, some morphology - phenology data and the impact of the ethnobotanical use of the plant on its sustainability in native range.

Material and Method

Study area

Glechoma hederacea data was taken from Düzce central district boundaries (between 40°37 'and 41°07' north latitudes and 30° 49'and 31°50' east longitudes) in Turkey's western Black Sea region. The climate is temperate in the region. The annual average temperature is 13.0 C °, the average annual precipitation is 823.7 kg / m², the average relative humidity is 75%. (Table 1 - Düzce climate data weather station, period from 1959 to 2019 - (https://www.mgm.gov.tr/). Although a favorable rainfall regime prevails, there may be drought during the summer months. In addition, the height of Düzce central district is 146 m above sea level. The total area of Düzce province is 259.300 hectares (Figure 1). In terms of plant geography, forest vegetation covers a large area in Düzce province, which is located in the Öksin sub-flora of the European-Siberian flora area. In addition, most of the agricultural potential of the province surrounded by mountains is in Düzce plain, which is 36.000 hectares wide.

Table 1. Düzce climate data weather station, period from 1959 to 2019

Measurement Period (1959 - 2019)	**Yearly**
Average Temperature (° C)	13.0
Average High Temperature (° C)	19.3
Average Lowest Temperature (° C)	8.5
Average Sunbathing Time (hours)	60.9
Average Rainy Days	133.5
Average Monthly Total Rainfall (mm)	831.0
Highest Temperature (° C)	42.4 (in July 2000)
Lowest Temperature (° C)	-20.5 (in January 1967)

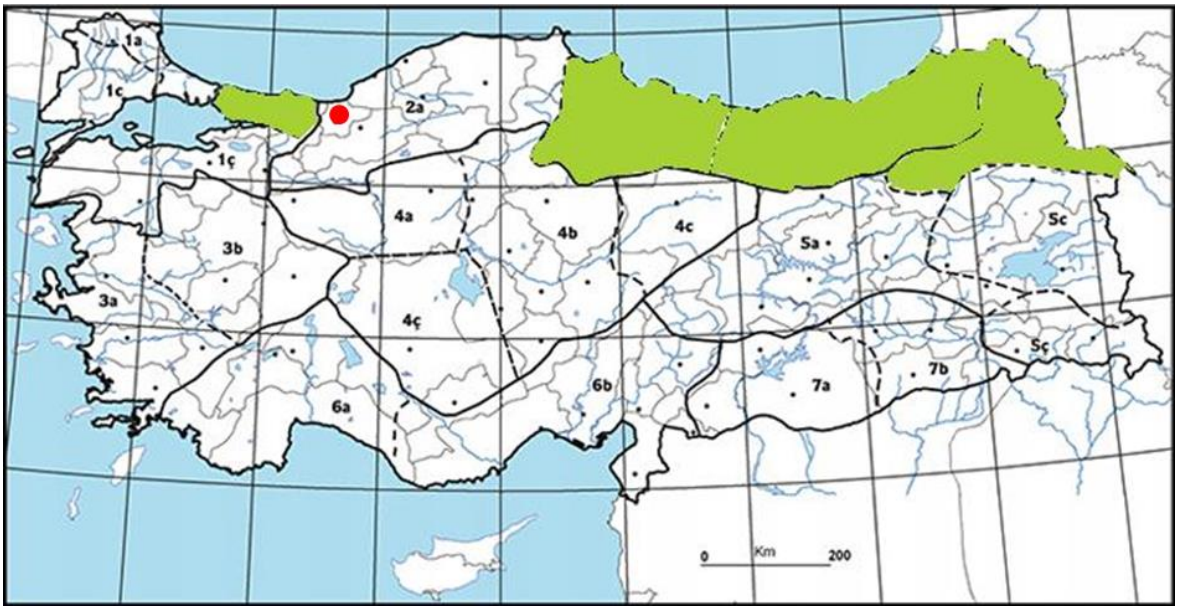

Figure 1. Distribution of *Glechoma hederacea* marked with the green parts on Turkey map (©Bizim Bitkiler, 2020). Düzce study area (A3 grid) marked with a red circle in the Western Black Sea region.

Study species

The native range of *G. hederacea* is Europe to Russian Far East and NW. Reported as China (Hutchings & Price, 1999). Based on Turkey's plant data set (Bizim Bitkiler, 2020 - https://www.bizimbitkiler.org.tr), its Turkish name is *yernanesi*.

It is an evergreen, fragrant perennial plant with lilac, bluish-lilac or purple flowers, and grows up to 50 cm in length. *G. hederacea* has high plant ability due to the fact that is a low-growing perennial herb that spreads by branched horizontal stolons that root at their nodes. Moreover, it is clonal, forms patches or carpet-like mats, adapt to different light intensities, due to leaf area and variable petiole length (Hutchings and Price 1999; Sipek et al., 2020).

Method

Glechoma hederacea was encountered during vegetation studies carried out in pasture areas in Düzce city centre in 2019-2020 (the second author's Master thesis). During this study, the local people reported that were some problems caused by the related plant in the rangelands, such as the deterioration of the

pasture structure and the damage to the animals by the pasture pits. Considering this situation, we interviewed with the headmen (mukhtars), who were the first person authorized to deal with the general problems of the local people, and then the residents. Data on the environmental and socioeconomic impacts of the plant (impact on human welfare, impact on ruminants and pollinator insects) were collected from the interviews with 15 person. In addition, morphological and phenological values of *G. hederacea* (plant height, beginning and end of flowering period) and data on insect and disease factors on the plant were also collected. Finally, the habitats of the relevant plant were determined in Düzce. For this, a total of 12 sample areas (three areas from each direction) were selected, taking into account the directions (East, West, North, South) of the Düzce central district. The sampling number was determined to represent 1% of each sample area and a total of 82 sample points from 12 sample areas were examined. Related areas, area sizes, number of samples according to areas and GPS points were given in Table 2. Data collection and vegetation surveys started on 18 July 2019 and completed on 28 May 2020 (10 months), but the flowering period was monitored all year.

Table 2. Vegetation survey sites, area sizes, number of samples and GPS coordinates in Düzce

No	Survey sites	Location	Area size (acre)	Number of samples	GPS
1	Duraklar	South	60	6	40.790860, 31.123960
2	Hacıahmetler	South	61	6	40.803723, 31.148820
3	Küçükahmetler	South	34	3	40.796578, 31.133358
4	Kadıoğlu	North	121	12	40.877171, 31.122880
5	Sarayyeri	North	69	7	40.873631, 31.135158
6	Çavuşlar	North	27	3	40.871470, 31.172558
7	Ağaköy	West	120	13	40.830237, 31.141866
8	Şaziye	West	44	5	40.843323, 31.052190
9	Karadere Hasanağa	West	144	14	40.840018, 31.067521
10	Yahyalar	East	49	5	40.847168, 31.198928
11	Gündolaması	East	60	6	40.835518, 31.219376
12	Günbaşı	East	20	2	40.848945, 31.241861
		Total	**809**	**82**	

Plant frequency (%) was calculated by using the following equations (Odum, 1971): % Frequency = [number of sampling units in which the species occurs (N)] / [total number of sampling units employed for the study (Q)]*100 & F = (N / Q)*100

In addition, we used the Cultural Food Importance Index (CFSI) by Pieroni (2001), a quantitative index that indicates the relative importance value, to obtain another data that may guide the future state of existence of *G. hederacea*. The CFSI was calculated by the following formula.

$$CFSI = QI \times AI \times FUI \times PUI \times MFF \times TSAI \times FMRI \times 10^{-2}$$

The formula takes into account seven index values: (i) Quotation Index (QI): expresses the number of all the positive responses given by the informants about a particular plant. (ii) AI: Availability, (iii) FUI: Frequency of use, (iv) PUI: Plant parts used, (v) MFFI: Multifunctional food use, (vi) TSAI: Taste score appreciation, (vii) FMRI: Food-medicinal role. Categories and index values used in CFSI calculation were given in Table 3.

EPPO code: GLEHE (*Glechoma hederacea* L. - https://gd.eppo.int/taxon/GLEHG)

Table 3. Categories and index values used in the calculation of CFSI

Index of categories	**Availability**	**Index value**
Availability index (AI)	Very common	4.0
	Common	3.0
	Intermediate	2.0
	Rare	1.0
	Localization of the use index value	
	Ubiquitous	=
	Localized	− 0.5
	Very localized	− 0.1
Frequency of use index (FUI)	**Utilization frequency**	**Index value**
	Ordinary year	5.0
	In season	3.0
	Not used during the past 30 years	1.0
Part used index (PUI)	**Part used**	**Index value**
	Aerial parts	3
	Stems and leaves	2
	Roots, bulbs, leaves, fruits	1.5
	Bark, stems, seeds, kernel	1.0
	Flowers, inflorescence, female cone, shoots	0.75
Multifunctional food use index (MFFI)	**Usage**	**Index value**
	Raw, as snacks, cold dishes, dipped in sauce, salted	1.5
	Boiled, steamed, fried	1
	Ingredient for restricted purposes	0.75
	Condiment, grain, oil and fats	0.5
	(Usage in mixtures)	(− 0.5)
Taste score appreciation (TSAI)	**Taste appreciation**	**Index value**
	Best	10
	Good	7.5
	Fair	6.5
	Poor	5.5
	Terrible	4.0
Food-medicinal role index (FMRI)	**Role as food-medicine**	**Index value**
	Important (“that food is a medicine”, with clear specification of the treated affections)	5.0
	Intermediate (“that food is very healthy”)	3.0
	Not recognized	1.0

Results and Discussion

The presence of the *G. hederacea* was determined in 8 areas (Duraklar, Hacıahmetler, Duraklar, Ağaköy, Şaziye, Karadere Hasanağa, Sarayyeri) out of a total of 12 sample areas (Table 2). The highest plant presence was determined in Ağaköy with 80.3% density, while an average of 25% density was determined in other areas. Plant collection rate was also low in areas determined in low rates density. This was considered as the plant collectors preferring to collect the related plant in areas where the plant is denser. As a matter of fact, the most complaints from local community were made in Ağaköy. In addition, the degraded areas were mostly encountered in this village and its surroundings. Moreover, ease of transportation has been evaluated as an important factor in the development of anthropogenic impacts. Therefore, one of the reasons for the problem in this area may be that the distance of this area to the city centre is approximately four kilometres.

Basic features: When the data collected for the morphological and phenological of *G. hederacea* in Düzce were evaluated, it was determined that it could be grown up to an average of 20 - 60 cm depending on the habitat type of the plant. Plant height has the highest value (~60 cm) in pastures and open areas, and the lowest value in tree edges (~20 cm). Although it has a high adaptability to different light intensities (Sipek et al., 2020), these different values indicate that it can also vary according to its habitats. The flowering period of *G. hederacea* was observed throughout the year in Düzce, and the flowering period started in March and continued until the end of November.

Habitats: As a result of the vegetation studies, the general habitats of *G. hederacea* were determined as pastures, roadside, tree edges, and open woodland in the natural range. Especially in pastures with high humidity and / or high ground water, the presence of the plant has higher rates. Beside we have also encountered in the road safety zone urban area, some city parks and in hazelnut plantations of Düzce. An additional record was found for the detection of the plant in hazelnut plantations (Koca & Yıldırım, 2008) located in Akçakoca district, which is located on the Black Sea coastline of Düzce.

Impacts: When the general impact conditions are examined, the presence of the plant in pasture areas has a high positive impact on both animal nutrition and the sustainable existence of pollinator insects. However, the clonal uprooting of plants is an important obstacle to the sustainability of this positive effect. In addition, it was determined as negative impacts that the removal of the pasture areas of the related plant caused a serious decrease in the plant density, the injury of animals and the unrest of the local people, due to people other than the local population. Therefore, removing the plant from the environment at a high rate causes negative significant environmental and socioeconomic impacts. In particular, the danger of extinction of the plants in the relevant areas, especially the pasture areas, the injury of animals from the pits opened on the pasture (Figure 3) and the deterioration of human welfare are the main problems of the local people. Indeed, the heavy gathering of native plant species from the relevant areas is one of the most important obstacles to the sustainability of these plants (Guo, 2006; Yazlık, 2019; Yazlık & Duran, 2019).

Usage: The main reason for the collection of the plant is its use in human health. In this context, it has been determined with this study that drugs made from the roots of the plant are used against kidney and urinary tract diseases in Düzce. There is evidence that *G. hederacea* is also used for medicinal purposes in different regions. For example; in traditional European medicine, it is used against eye inflammation, while in traditional Austrian medicine it is used in the treatment of diseases such as liver and bile, respiratory tract, kidney and urinary tract, fever, flu (Hutchings & Price 1999; Sipek et al., 2020). Also at the plant infusion in different regions of Turkey, syrups and liquid extract, cough suppressants, nerve sedative, expectorant, wound healing is used as a tonic and was reported (Birinci, 2008). However, in the current records, it is reported that only the leaves of the plant are used and that the dried leaves are brewed, like tea. It is also emphasized that young leaves are used as an aromatic spice for salads (Baytop 1999; Birinci, 2008). As a result of the evaluations, it has been understood that *G. hederacea* is uprooted only in Düzce. This information is important as the use parts of ethnobotanical plants will provide important evidence in determining the extinction risks of these plants. Therefore, in ethnobotanical studies, determining the usage parts of the plants in addition to the way they are used can provide important data.

According to the Cultural Food Significance Index (CFSI) analysis, the CFSI index value of *G. hederacea* was determined as 590.63. In this high CFSI value of the plant, the frequency of use (FUI), usage parts (PUI), and high food - medicinal role index (FMRI) values of the plant were effective. *G. hederacea*'s detailed CFSI value calculation is given in Table 4.

We believe that the cultural significance index value, which allow quantification of the role played by a particular biological taxon in a particular local culture, provide valuable information about the existence / sustainable use of plant species in relevant local cultures. As a matter of fact, knowing these values provides important information to researchers and decision makers on issues such as determining

the conservation priorities of ethnobotanical plant species, selecting the species to be propagated in place and establishing legal restrictions on collecting. In addition, it also makes it easier to reach a common consensus in ethnobotanical studies that can be done between cultures (Pieroni, 2001).

Table 4. The CFSI value of *Glechoma hederacea*

	Values of the partial indexes	**Details calculation**	**CFSI value**
G. hederacea	**QI**: 12.00 **AI:** Common, ubiquitary **FUI:** Ordinary year **PUI:** Stems and leaves, roots **MFFI:** Boiled, steamed, fried, salted **TSAI:** Good **FMRI:** Important	12.00 x 3.00 x 5.00 x 3.50 x 2.50 x 7.50 x 5.00 x 10^{-2} =	590.63

Finally, it should be noted that although it is not presented here, two insect species (*Liriomyza* sp. and *Frankliniella* sp.) that open galleries on the leaves and also a powdery mildew disease (*Erysiphe* sp.) were also found on *G. hederacea* in Düzce. It will also be beneficial to monitor these agents in the future and to take the necessary measures.

Conclusion

Glechoma hederacea general habitats, morphological - phenological features and ethnobotanical usage have dealt with for the first time with this study in Turkey. In addition, only one plant species could lead to socio-economic impacts in different directions (human welfare and animal nutrition, health) cases have been reported, and could finally occur with the risk of extinction of the plant has emphasized the loss of biodiversity. Considering that all these situations may arise from a single plant species, it is absolutely necessary to develop and disseminate precautionary studies for the protection of ethnobotanical plants. For this, the sustainability of native plants that are used ethnobotanically should be taken into consideration. Particularly ethnobotanical plant usage parts provide important data for the sustainability of the plants' existence. The use of perennial multiple monopodial stolons such as here poses a great risk in removing all of the plant's reproductive material. In other words, the ethnobotanical use of seeds or stem parts alone does not increase the risk value for this perennial plant sustainability, but uprooting the plant in Düzce may cause a serious impact on the extinction risk level. For this reason, against the risk of extinction of ethnobotanical plants, plants should be evaluated according to their "using parts" and necessary awareness studies should be carried out in this regard. In addition, considering the cultural importance of *G. hederacea* discussed here and its contribution to human health; training activities on sustainability, informing local administrators about the priority of conservation of *G. hederacea*, and encouraging local cultivation of the plant by taking into account root use can be suggested. On the other hand, legal restrictions on plant collection for ethnobotanical purposes are also an important factor in the sustainable use of plants. For instance, the collection of ethnobotanical plants from their natural environment and sales are restricted by law in Turkey (Republic of Turkey Ministry of Agriculture and Forestry General Directorate of Forestry: 1983 - 2003 notification 286; 2003 - 2016 notification 297 and since 2016 notification 302). In this context, permission is obtained from the relevant authorities and only limited collection of plants is allowed. However, despite these limitations and inspections, it cannot be prevented that the plants are collected illegally or unconsciously. Therefore, when necessary, the scope of the sanctions of decision-makers and legal restrictions and protection activities should be expanded. Beside these, Cultural Food Significance Index (CFSI) value of *G. hederacea* plant collected and consumed in Düzce was determined for the first time in Turkey with this

study. *G. hederacea* 's this value can be used in consensus that can be established in cross-cultural ethnobotanical studies. In addition, this assessment method provides an additional assessment to determine the importance level of plants listed in ethnobotanical studies. For this reason, we emphasize the determination of importance index values in studies to be carried out within the scope of ethnobotany.

The contribution of native plants to biological diversity is an undeniable fact. In addition, considering the contribution of these plants to biodiversity and ecosystem functions, it is important to protect and sustain the plants in the local ranges of the countries. For this, local information on the relevant species, data on morphological and physiological development processes provide valuable information. Moreover, the continuity of ethnobotanical studies is important for the preservation of local knowledge. Beside, when the subject is considered for the world, the conservation of native plants within their local range makes valuable contributions not only to the regions where they are located, but also to the sustainability of the world. Considering all these situations, the protection of plant production areas, especially pasture areas, which are considered as natural heritage areas for all countries, and the continuity of ethnobotanical studies providing local information should be ensured. Finally, we argue that the most important precaution that can be taken in the issue of preventing excessive collection of ethnobotanical plants depends on the dissemination of awareness studies that will provide understanding of the importance and sustainability of these plants at the local scale.

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Submitted: 25.03.2021 Accepted: 23.06.2021