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Effect of pollution on the ECO phytocenological assessment of *Thymus caucasicus (Lamiaceae lindl.)* populations in the territory of eastern Azerbaijan, Ardabil

Seyed Shiva Asbaghian Namin*, Eldar Novruzov
Department of Botani, Azerbaijan National Academy of Sciences, Baku, Azerbaijan

*Correspondence author: dr.asbaghiannamin@gmail.com

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Abstract: Ecological and phytocenological assessments of 3 populations of Thymus caucasicus L. species were carried out in Ardabil. Classification of Th.caucasicus phytocenose on ecological groups were developed for the first time. In the result, the associations and their floristic composition and ecology were identified. Age, efficiency, aging indexes were appointed during cenological assessments of the Th.caucasicus formations. 3 natural cenopopulation of Th.caucasicus species were assessed, cenological situation studied in the territory, in 2013-2015 years and it was found that the 1st and 3rd populations were transition, 2nd was mature in 2013, in 2014, 1st was young, 2 nd and 3rd were mature, 1st and 2nd were young in 3rd was mature in 2015. Analysis of the parameters of population illustrated that restoration is higher in the 1st and 2nd cenopopulation in 2015 rather than in 2013 - 2014. Degradation of pasture casued the thymus population distribution to significanly decrease in Ardabil Province.

Keywords: Thymus caucasicus subsp. Grossheimii Jalas., Medicinal plants, phytocenose, edificator, biological and ecological characteristics, cenopopulation

1- Introduction:

Geomorphological structure of the territory of East Azerbaijan is closely connected with its history. These areas are divided into delvual mountainous regions and alvual low-land areas according to its geomorphology. Water resource is provided by numerous rivers in this area. Water regime of vegetation in the area significantly depends on groundwater regime, its depth, and its saltiness, and degree of mineralization. At the same time, water regime is formed through, underground water and rivers filtration in the mountains, rainfall, irrigation water. The following species belonging to thyme genus spread in Ardabil province in eastern Azerbaijan: *Thymus caucasicus* L. Subsp. Grossheimii Jalas.; *Thymus daenensis* Celak. Subsp.daenensis; *Thymus fedeschenkoi* Ronniger; *Thymus kotschyanus* Boiss.et Hohen .; *Thymus migricus* Klokov, DesyShost .; *Thymus persicus* Jalas.; *Thymus transcaucasicus* Ronniger.; *Thymus trautvetteri* Kolov. Desj. Shost., a kind - *Thymus vulgaris* L. is cultivated. Ecological impacts of atmospheric pollution and interactions with climate change in terrestrial ecosystems of the Mediterranean Basin has been reported [Ochoa-Hueso et al., 2017]. The results show that , there was an urgent need to implement coordinated research and experimental platforms along with wider environmental monitoring networks in the region. In particular, a robust deposition monitoring network in conjunction with modelling estimates is crucial, possibly including a set of common biomonitors to help refine pollutant deposition maps. In addition, increased attention must be paid to functional diversity measures in future air pollution and climate change studies to establish the necessary link between biodiversity and the provision of ecosystem services in Mediterranean ecosystems. Through a coordinated effort, the Mediterranean scientific community can fill the above mentioned gaps and reach a greater

understanding of the mechanisms underlying the combined effects of air pollution and climate change in the Mediterranean Basin.

Environmental pollution causes and interacts synergistically with climate change [Alonso et al., 2001, 2014; Bytnerowicz et al., 2007; Sardans and Penuelas, 2013]. Functions that will be synergistically impaired by air pollution and climate change include reductions in crop yield and carbon sequestration [Maracchi et al., 2005; Mills and Harmens, 2011; Shindell et al., 2012; Ferretti et al.,2014]. In addition, a higher fire risk is attributed to higher temperatures and more frequent droughts coupled with an N-driven increase of grass-derived highly flammable fine fuel [Pausas and Fernandez-Munoz, 2012]. The local abiotic (e.g., climate, soil properties) and biotic (e.g.,vegetation type, community attributes, etc.) contexts are known to modulate ecosystem responses to environmental drivers at different temporal and spatial scales [Bardgettet al. ,2013]. The behaviour of terrestrial ecosystems as a global C sink or source under increased N deposition or O3 pollution scenarios is currently a research hot-topic and is of paramount importance for the mitigation of climate change [Felzer et al., 2004; Reich et al., 2006; Pereira et al. ,2007].

3- 4 species belonging to the thyme genus cover a large area in the research plot. 2 of them Thymus kotschyanus and Thymus caucasicus are large populations in Ardabil.

Despite,the structure of the population of some medicinal plants in the Republic of Azerbaijan that is bordered with East Azerbaijan was studied,[Ibadullayeva et al., 2010-2013], we have not carried out such a research work so far for medicinal plants. Taking into account all of these, it was aimed to the study the characteristics of eco-phytocenological properties of Th.caucasicus that is medical plants collected by local communities and creates broad populations in Ardabil.

2- Materials and Methods:

The research work of the Islamic Republic of Iran in 2013-2015 were carried out in the province of Ardabil territory in East Azerbaijan.

In order to assess *Th.caucasicus* populations phytocenologicaly and ecologicaly registrations were conducted by general accepted methods in the geobotanics on the research object and localitets for *Th.caucasicus* were chosen in such a way that the character of its biotope meets several ecological factors. Up to 300 description were carried out in the areas where the associations spread during geobotanical description of *Th.caucasicus* phytocenose. In order to determine the floristic composition, more than 350 herbarium material were collected in the area of research and critical-systematic destination were carried out.

Th.caucasicus semibushes start their vegetation in $+7 - +10^0$ C temperatures and finishes in $+ 4^o - + 60^o$ C temperature. Vegetation period is 140-150 days [Baideman, 1954]. It was used ontegenese discrete description conception of T.A.Rabotnov [1950] and development stages of the individuals have been characterized. Description of ontogenese of *Th.caucasicus* was given according to the forms of ontogenic situation. Registration of plants in immature (im), virginil (v), the young generative (g1), middle age (g2), adult generative (g3), subsenil (ss) and senile (s) periods have been carried out. Obtained results were analyzed by comparing the χ^2 criteria. As the demographic characteristics of the integral structure of the plant has been used the following population indicators: Age Index (Δ) [Uranov, 1975];

$$\Delta = \frac{\sum k_i \text{ x } n_i}{N}$$

i - ontogenic situation, k_i - "mark", n_i- the number of individuals, i- population status, N- the total number of individuals in population.

Restore index [Jukova, 1995] (I_B) was changed by N.V. Glotov [1998] and expressed in relation to the sum of pregenerative individuals and generatives to pregeneratives.

3- Results and Discussion:

Being part of the mountain-xerophyte vegetation spread in Ardabil, *Thymus caucasicus* populations are medicinal plant resource. *Th. caucasicus* phytocenoses have existed in Iran for a few hundred years and they create a wide range of populations, especially in the research area. *Th.caucasicus* formation is zonal in area of research. It starts from foothill to middle mountain, continues until high

mountains. Here occurs the process of changing, succession happens and the cenose is replaced with *Th. caucasicus +Artemisieta absintium + herbosum* phytocenoses.

One of the areas with a high prevalence of *Thymus caucasicus* (fig. 1) groups in Ardabil is Savalan mountain, and Xalxal, everywhere in Ardabil thyme is common in foothill, medium mountain and mountain xerophyte soils. From botanical-geographic point of view, territory covers the rock rubble with mountain - xerophyte vegetation. However, the numerous water bodies in the area and meadow plants are exception. Floristic composition of populations of Th.caucasicus formation is rich. Our research determined that in the mountainous regions of Ardabil *Th.caucasicus* flora consists of more than 70 species of higher plants. The vast majority of them are medicinal plants.

Fig. 1. Thymus caucasicus formation of Ardabil territory

In composition of the permanent associations of Th.caucasicus includes bitter wormwood, thistle, wild grains and so on. In the result of succession *Th.caucasicus* and *Artemisia absintium* accompanied each other in a row in these areas, tend to have the same fullness and grow in the same areas. *Th.caucasic* in foothills first *Thymus caucasicus + Artemisieta absintium,* and then are replaced by clean *Thymus caucasicus*. *Thymus caucasicus* phytocenoses have the similarity in the composition of flora with Astragalueta phytocenose. A number of annual and majority of efemeroids are common in both phytocenoses.

All plants within associations distingushed in *Th. caucasicus* formation consist of 4 groups that each one of them forms a special sinusation. The sinusations are located on stages: Perennial sinusations (shrubs, bushes, semishrubs and semibushes); sinusations of summer and fall annual plants; Ephemeral and ephemeroids sinusations (fugutitives); sinusations of surface primary plants. Sinusation with shrubs, bushes, semishrubs and semibushes is mainly formed by the dominant plant legumes species (Astragalus and Astracantha). As subedifikator with thyme in the sinusation it is found wormwood (*Artemisia absintium),* tarragon (*Tanasetum vulgaris*), St John's wort (*Hypericum perfolatum*), and sometimes hemlock (*Heracleum trchyloma*) around the mountain rivers and others. project Cover varies between 65-70% in *Th.caucasicus* phytocenose.

All semibushes form the upper layer of *Th.caucasicus* phytocenoses. Their height reaches 30-35 cm. It is observed two-level (Milkvetches in the top floor, while others down) in sinusation of Milkvetches, wormwood, eryngo, and so on in the cenose .

Sinusation with summer-autumn annual plants is formed by long vegetative period annual plants. Species composition of this sinusation is rich, thickness is significant variable. Annual plants are often found as part of the subedificator in *Th. caucasicus* and cover large areas. In the fall, reaching the upper limit of the development of summer-

autumn annual plants form the second tier. Ephemeral and ephemeroids create sinusation with fugutitives. One of the characteristic features of *Th. caucasicus* phytosenose is participation of grain ephemers in cenose. 2 types of ephemeral-glocophytes and halophytes is found in the composition of *Th.caucasicus.*In Soil with weak Salinity it is often found glicophyte grain ephemers, while with high salinity prevail halophytes ephemera. typical Glicophyte ephemeral and ephemeroids for *Th.caucasicus* phytocenose are: *Bromus yaponicus, Lepidium perfolatum, Anisantha tectorum, Hordeum leporinum, Poa bulbosa* and others. halophytes ephemers - *Eremopyrum orientale, Etriticeum, Spergularia salina, Plantago loeflingii, Hordeum geniculatum etc*. ephemera form 5-15 cm height of clearly visible tier in grass and have a large range of species. There are high *Parentucellia latifolia* (10-20 cm) bulbosa Poa, Hordeum leporinium etc as well as 3-4 cm in height *Filago pyramidata* in fugutitive layer. Five association groups have been identified according to the degree of development of the soil, different life forms and floristic composition, the nature of relief, groundwater depth and mineralization of soil during investigation of the classification and ecology *Th.caucasicus* phytosenose*: Thymus caucasicus* annual grass (trixohydrophytes) association group; *Thymus caucasicus* shrubs, bushes and perennial herbs (freatophytes) association group; semishrubs and semibushes (freatophytes, trixohidrophytes, ombrophytes) association group; *Thymus caucasicus* ephemeral and efemeroids (ombrophytes) association group; *Thymus caucasicus* semibrushes with wormwood and hemlock (ombrophytes) association group.

Each group is characterized for diversity of subedificators and structure of phytocenose according to water supply. Association groups meets complex biotope criterias where they ecologically spread.

Phytocenological and environmental studies conducted on the specie of *Th.caucasicus* individuals in populations from all phases of the ontogenesis assessed, plant age, efficiency, aging and restoration ratios were counted. 3 natural cenopopulation were selected from groups that *Th.caucasicus* spread during research years. The total area of the selected cenopopulation was not less than 100 ha. Ontogenic structure of the *Th.caucasicus* species in different years have been reported in table No 1. The research materials in the study of popopulations different in phytocenoses was collected in accordance with generally accepted methodology. Collection of materials was carried out transects located consistent and scattered methods. Mentioned transects have to pass through the area and should be characterized by a relatively high or low abundance of any selected species. Thus, the studied species were taken out of the area and by determining the ontogenic status, spectrum had been drawn up. comparison of the population parameters of any selected plants within the cenopopulatins carriout out by Student's t-criteria amended by Shidac. In the result, differences in plants ontogenesis in populations was calculated (fig. 2).

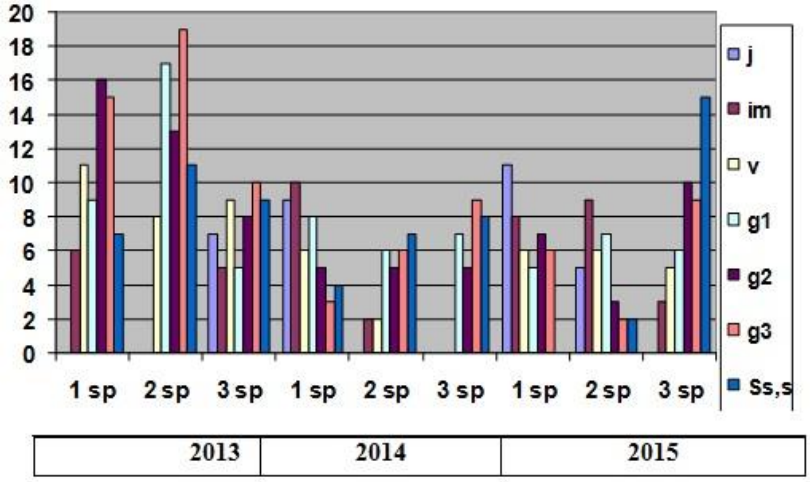


Fig. 2. Ontogenic spectrum of Thymus caucasicus species

Cenopopulation in which widespread *Th.caucasicus species* were evaluated in different years and a decrease was observed in the number of individuals of cenopopulations in the years of 2014-2015 compared with 2013. However, this reduction was restored by the growing number of generative individuals in 2015.

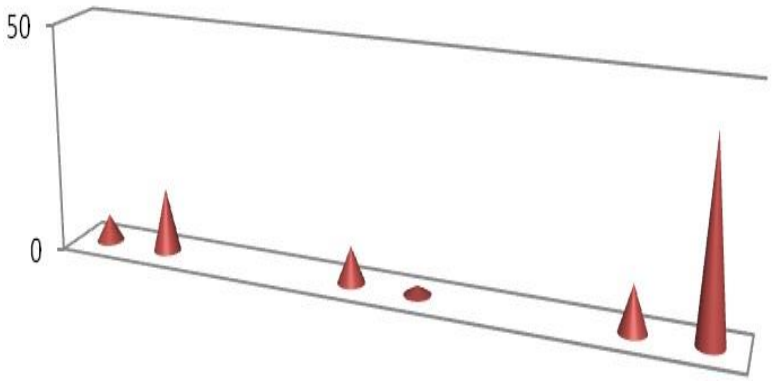
Type of cenopopulations was defined by using A.A. Uranov's absolute maximum criteria and L.A. Jivatovski's delta-omega normal clasification of cenopopulations (Tab.1). Thus, in order to estimate the type of CP in 1 (2014), 1 - 2 (2015) CP young (Δ=0,23 - 0,26; ω =0,27-0,42), 1 (2013) and 3 (2013) SP transition (Δ=0,42 - 0,46; ω =0,42-0,45), 2 (2013), 2 (2014), 3 (2015) and 3 (2015) SP is mature populations (Δ=0,52 - 0,62; ω =0,53-0,72). A variety of ontogenic spectrum and variability in the SP in different years of *Th.caucasicus* is explained by the influence of environmental conditions as well as anthropogenic factors related to the reconstruction and restoration work in the region. The analysis of the parameters illustrated that all the investigated population are recovering well. SP 1 and 2 restoration index was higher in 2015 than in 2013 - 2014.

Table 1: Evaluation of Thymus caucasicus cenopopulations (SP)

№ SP		SP tipi	Grow phases of the ontogenesis, %					Index's			
			j	im	v	g_1- g_3	ss, s	Δ	ω	$İ_b$	$İ_q$
2013	1	Transition	0	9.4	17.2	62.5	11	0.46	0.42	0.43	11
	2	Ripened	0	0	12	72.1	16.2	0.52	0.57	0.16	16.2
	3	Transition	0	9.43	17	43.4	13	0.42	0.45	0.91	17
2014	1	Young	20	22.2	13.3	35.6	9	0.26	0.33	1.56	8.88
	2	Yetişmiş	0	7.14	7.14	61	25	0.54	0.53	0.24	25
	3	Ripened	0	0	0	72.41	28	0.62	0.72	0	27.6
2015	1	Young	26	19	14	42	0	0.24	0.42	1.4	-
	2	Young	15	27	18	35.3	6	0.23	0.27	1.67	-
	3	Ripened	0	6.3	10.42	52.1	31.25	0.57	0.56	0.32	31.25

3 natural cenopopulations of *Th.caucasicus* were estimated in the years of 2013-2015 in the region, cenological situation was studied, it became clear that in 2013 CP 1 and 3 were transition , 2 was mature, in 2014 CP 1 was young, 2, 3 mature, in 20151 and 2 young, 3 was mature. Analysis of the parameters of population illustrated that, restoration of 1 and 2 cenopopulations was higher in 2013 - 2014 than in 2015.

During the study, botanical forms of life groups in *Thymus caucasicus* populations were assigned. The following life forms are inculded into thyme formations (fig. 3): Xerofphytes - perennial and annual plants, wormwood, milkvetch, etc., and mezophytes group include ephemeroids and ephemeral. It seems from diogram that 51% of species composition dominated by the ephemera Thyme formations and also annual semibrushes.



1/ Ephemera's: Short vegetation; Long vegetation
2/ One-year: Short vegetation; Long vegetation
3/ Perennial: Half bushes: Bushes

Fig. 3. Life forms of phytocenosen in the abundance of Thymus caucasicus.

4- Conclusion:

During The investigation of development in phytocenose, it was revealed that, the development cycle of *Th.caucasicus* is almost similar. *Th. caucasicus* begins the vegetation in March and April, the flower buds are formed in June-July. Flowering in August, September crop, destruction is observed in early December.

Layer of the semibushes dominated by *Thymus caucasicus* is permanent. The layer of summer-fall annual plants and ephemers are subject to seasonal changes. seasonal distribution of the rainfall has a major impact on the development dynamics of the Ephemers. Spring and autumn precipitations are very important for the development of xerophyte elements.

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