

UDC 581.526.2  
AGRIS F70

https://doi.org/10.33619/2414-2948/84/06

**PHYTOCENOLOGICAL STRUCTURE AND BIOLOGICAL RESERVES  
OF *Helichrysum aurantiacum* Boiss. & A. Huet  
IN GAZAKH-TOVUZ ECONOMIC REGION (AZERBAIJAN)**

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**ФИТОЦЕНОЛОГИЧЕСКАЯ СТРУКТУРА И БИОЛОГИЧЕСКИЕ ЗАПАСЫ  
*Helichrysum aurantiacum* Boiss. & A. Huet В КАЗАХ-ТОВУЗСКОМ  
ЭКОНОМИЧЕСКОМ РАЙОНЕ (АЗЕРБАЙДЖАН)**

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*Abstract.* The article presents the phytocenological and bioecological analyzes of *Helichrysum aurantiacum* Boiss. et Huet., an endemic species of the Asteraceae family and assessments in plant coenopopulations of the plant. The studies were carried out in 3 districts of Gazakh-Tovuz Economic Region of Azerbaijan. Ten natural populations where *H. aurantiacum* species are distributed were selected. In the selected populations, the integral characteristics of the demographic structure of the plant, age and efficiency indices were studied. The formations and associations were determined, the project cover of the areas was calculated, and the abundance was determined. In the *H. aurantiacum* species, the highest indicator is observed in the generative development stages (225-243 individuals were counted in the  $g_1$ - $g_3$  period). The efficiency coefficient of *H. aurantiacum* species in mature populations was  $\omega=0.52-0.76$ . The high value of the efficiency coefficient in CP 7, 6 and 10 is related to the high number dynamics of plants belonging to the juvenile and immature phases before the generative development phases, and the small number of individuals belonging to the aging (s, ss) phases. The resource potential of the plant was determined and the biological reserve in the districts was 1241.1 centners, and the annual supply was 498.6 centners. This allows the supply of *H. aurantiacum* species in Tovuz, Agstafa and Gazakh districts located in the north-east of the Lesser Caucasus.

*Аннотация.* В статье представлен фитоценологический и биоэкологический анализ *Helichrysum aurantiacum* Boiss. et Huet., эндемичного вида семейства Asteraceae, и оценки в растительных ценопопуляциях растения. Исследования проводились в 3 административных районах Казах-Товузского экономического района Азербайджана. Выделено десять природных популяций, в которых распространен *H. aurantiacum*. В выделенных популяциях изучены интегральные характеристики демографической структуры растений, возраст и показатели продуктивности. Определены формации и ассоциации, рассчитано проектное покрытие площадей, определена численность. У *H. aurantiacum* наибольший показатель наблюдается на генеративных стадиях развития (в период  $g_1$ - $g_3$  насчитано 225–243 особи). Коэффициент продуктивности видов *H. aurantiacum* в половозрелых популяциях составил  $\omega=0,52-0,76$ . Высокое значение коэффициента продуктивности в ЦП 7, 6 и 10 связано с высокой динамикой численности растений ювенильной и иматурной фаз перед генеративными фазами развития и малой численностью особей стареющих (s, ss) фазы. Определен ресурсный потенциал растения и биологический запас по районам составил

1241,1 ц, а годовой запас — 498,6 ц. Это позволяет завозить *H. aurantiacum* в Товузский, Агстафинский и Казахский районы, расположенные на северо-востоке Малого Кавказа.

*Keywords:* nature reserves, plant communities.

*Ключевые слова:* природоохранные территории, растительные сообщества.

The representatives of the Asteraceae, which have a special place in the vegetation of Azerbaijan, play a fundamental role in pasture, hayfield and grazing areas, desert-semi-desert, subalpine-meadow, forest-meadow, xerophilous, phryganoid, primitive rock-scrub vegetation types. The *Helichrysum aurantiacum* Boiss. et Huet., one of the endemic plants of Azerbaijan belonging to the family, is a medicinal plant. In the regions, it is called as “sandy everlast, immortelle, yellow cat's foot, cat's foot, golden shade, golden sun”. The plant's organs of use are the flowers. It has a weak aromatic smell and a dark-bitter taste [1]. It spreads in dry sandy, even stony soils, sometimes in black soil and clayey places. Lateral flowers of the plant are collected during the period of fresh flowering. The decoction and dry extract of the flower of *Helichrysum aurantiacum* plant is widely used as a choleric medicine in the treatment of gallstones, chronic cholecystitis, hepatitis and biliary dyskinesia, and at the same time, the granules of its flowers are widely used [2].

It is widely used for medicinal purposes in all regions of Azerbaijan [5]. The reserve of this plant in the study areas is satisfactory and it is collected by people and sold in the markets. Taking this into account, the study of the phytocenology of the plant populations and its natural resources has been set as a goal.

#### *Material and Methods*

The research work was carried out at the biology department of the Azerbaijan State Agricultural University. Every year, trips were made to the territories of Tovuz, Agstafa and Gazakh districts, ethnobotanical, floristic and methodical expeditions were carried out [10]. The territory of Gazakh-Tovuz Economic Region is very favorable due to its economic and geographical position. A number of methods were used in the phytocenological studies conducted on the *Helichrysum aurantiacum* species and in the assessment of the coenopopulation [6, 7]. Using A. A. Uranov's [6] concept of discrete description of ontogenesis, developmental stages in plant individuals were characterized. Phytocenological studies were based on generally accepted methods [4]. The following population indicators were used to determine the integral characteristics of the demographic structure of the plant:

Age index. 
$$\Delta = - \frac{\sum k_i \times n_i}{N}$$

here  $k_i$  — “value” of ontogenetic state,  $n_i$  — number of individuals,  $i$  — the state of the population,  $N$  — the total number of individuals in the population.

Efficiency index: 
$$\omega = \frac{\sum n_i \times e_i}{\sum N_i}$$

here  $n_i$  — number of plants,  $i$  — state,  $e_i$  — plant effectiveness.

Accepted methods were used to study the state of populations and conduct assessments: writing plant communities and naming the phytocenotic complex is based on B. A. Yurseva [7]. Calculations were made using generally accepted evaluation scales of ontogeny, plant age and

efficiency indices were calculated, thus the developmental stages of plant individuals were fully determined.

Using A. A. Uranov's [6] concept of discrete description of ontogenesis, developmental stages in plant individuals were characterized. The description of ontogenesis is shown based on the forms of the ontogenetic state. Plants were registered in immature (im), virginil (v), young generative (g<sub>1</sub>), middle age period (g<sub>2</sub>), old generative (g<sub>3</sub>), subsenile (ss) and senile (s) periods. The obtained results were analyzed by  $\chi^2$  comparison criterion [1].

Plant productivity was studied based on generally accepted methods [3, 8]. The conducted route and semi-stationary studies were accurate, the population structure of the studied species, their role in formation and associations, their abundance and the number of individuals belonging to all phases of ontogenesis were studied. The state of the vegetation cover was assessed, and reserves were calculated [9, 10].

In order to achieve the goal, short-term expeditions were made to the area on 25 routes in the spring, summer and autumn seasons of 2016-2018, and more than 50 herbarium materials were collected. Studies were conducted in semi-stationary and stationary conditions, more than 20 geobotanical notes on the structure of phytocenoses were taken, and photos of species and formations were taken separately.

### Result and Discussion

10 natural populations were selected, in which the species *Helichrysum aurantiacum* was distributed. Here, it was observed that mainly 3 vegetation types — steppe, semi-desert and mountain-xerophyte phytocenoses are distributed in the first tier, sometimes in the form of glades, and sometimes singly. The formations and associations were identified, the project cover of the areas was calculated, the abundance was determined (Drude, 5-point scale) and the obtained data is reflected in Table 1. The area of the coenopopulations selected for the study of the productivity of *Helichrysum aurantiacum* species was not less than 5 hectares. In the specific areas where the species is spread, special plots were marked and model samples were selected for stock determination. In addition, 15-20 model plants — *Helichrysum aurantiacum* from each population were taken and weighed to calculate the plant's raw material reserve.

Table 1  
 PHYTOCENOLOGICAL STRUCTURE OF *Helichrysum aurantiacum* species

| Areas where populations are recorded                               | Type of vegetation and composition of associations (in all associations the species <i>Helichrysum aurantiacum</i> is typical, with the main species indicated)                  | project coverage % | abundance        |
|--|--|--------------------|------------------|
| 2018   |  |                    |                  |
| Kazakh district Gushchu-Arim                                       | Shrub vegetation<br>1. sp: <i>Rosa arvensis</i> + <i>Doronicum macrophyllum</i> + <i>Rumex alpinus</i> + <i>Filipendula ulmaria</i> + <i>Trifolium pratense</i> + <i>Herbosa</i> | 70                 | Soc              |
| The foothills of Goyazan mountain<br>The foot of Kazanchi mountain | 2. sp: <i>Juniperus foetidissima</i> + <i>Juniperus oblonga</i> + <i>Prunus divaricata</i> + <i>Herbosa</i>  | 60                 | Soc              |
| Kazakh district Kosalar village                                    | Mountain xerophytic vegetation<br>3. sp: <i>Cotoneaster integerrimus</i> + <i>Crataegus sp.</i> + <i>Dactylis glomerata</i> + <i>Cynodon dactylon</i> + <i>Herbosa</i>           | 30                 | Cop <sub>3</sub> |
| The foothills of Goyazan mountain                                  | 4. sp: <i>Thymus collinus</i> + <i>Acantholimon karelinii</i> + <i>Herbosum</i>  | 40                 | Cop <sub>2</sub> |

| Areas where populations are recorded                      | Type of vegetation and composition of associations (in all associations the species <i>Helichrysum aurantiacum</i> is typical, with the main species indicated)   | project coverage % | abundance                            |
|---|---|--------------------|--------------------------------------|
|   | 5. sp: <i>Alhagi pseudalhagi</i> + <i>Paliurus spina-christi</i> + <i>Herbosa</i>   | 70                 | Soc                                  |
| 2019  |   |                    |                                      |
| Agstafa district<br>Mughanli village<br>Pirili village    | Steppe vegetation<br>6. sp: <i>Arctium lappa</i> + <i>Inula helenium</i> + <i>Festuca valesiaca</i> + <i>Stipa capillata</i> + <i>Stachys inflata</i> + <i>Geranium molle</i><br>7. sp: <i>Astragalus caspicus</i> + <i>Kochia prostrata</i> + <i>Stipa capillata</i> + <i>Herbosum</i> | 30<br>40           | Cop <sub>3</sub><br>Cop <sub>2</sub> |
| Tovuz district<br>Mountainous areas                       | Mountain xerophytic vegetation<br>8. sp: <i>Achillea millefolium</i> + <i>Rhamnus pallasii</i> + <i>Herbosum</i><br>9. sp: <i>Artemisia absinthium</i> + <i>Thymus collinus</i> + <i>Senecio othonnae</i> + <i>Cirsium hygrophilum</i> + <i>Cephalaria gigantea</i>                     | 40<br>50           | Cop <sub>2</sub><br>Soc              |
| Tovuz district<br>Esrik forest surroundings and clearings | Meadow vegetation<br>10. sp: <i>Hordeum violaceum</i> + <i>Carex dacica</i> + <i>Carex vesicaria</i> + <i>Anthemis rigescens</i> + <i>Cerastium arvense</i> + <i>Herbosum</i>   | 40                 | Cop <sub>2</sub>                     |

The description of the ontogeny of the *Helichrysum aurantiacum* species is shown based on the forms of the ontogenetic state. Registrations were made in all ontogenetic periods of the plant and individuals were counted. During the study, plots or transects were established according to the methods in the phytocenoses where the plant was distributed. The dynamics of individuals corresponding to different phases of ontogenesis in 10 selected populations was studied and reflected in the diagram (Figure).

Table 1 shows the number of individuals distributed in each population for all phases. As can be seen from the table and diagram, there are more individuals belonging to the generative development phase. This shows that the plant is in continuous development.

The results of the calculations prove that the highest rate in *Helichrysum aurantiacum* species is observed in the generative development stages (225-243 pieces). When we look at the diagram, we see that during the description of ontogeny, the stages of development in plant individuals are also determined. The comparison criterion is indicated by taking notes in the im, v, g<sub>1</sub>, g<sub>2</sub>, g<sub>3</sub>, ss and s periods of the plants.

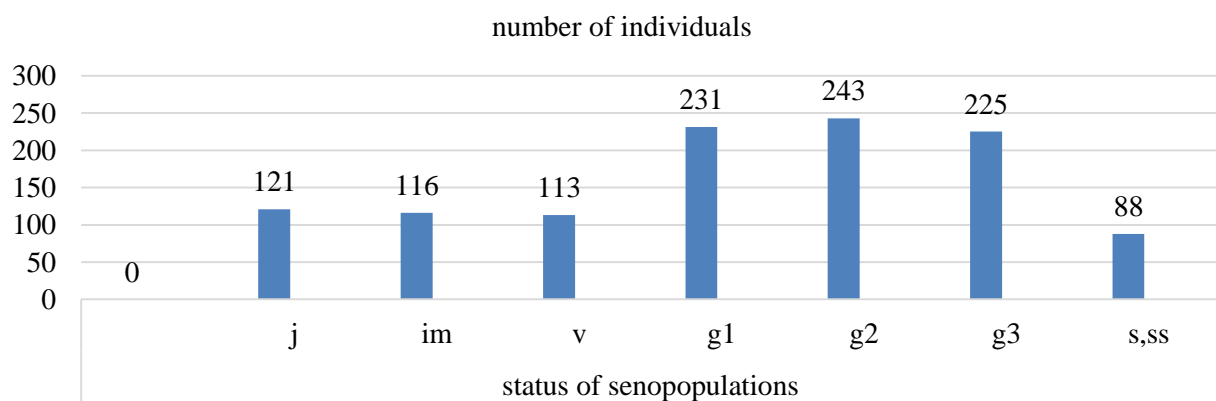


Figure. Dynamics of ontogeny of *Helichrysum aurantiacum* species

Table 2

AGE (GROWTH) STRUCTURE OF *Helichrysum aurantiacum* COENOPOPULATION

| SP № | CP type      | Growth phases of ontogeny (in %) |      |      |                |                |                |       | Indexes |      |
|------|--------------|----------------------------------|------|------|----------------|----------------|----------------|-------|---------|------|
|      |              | j                                | im   | v    | g <sub>1</sub> | g <sub>2</sub> | g <sub>3</sub> | ss, s | Δ       | ω    |
| 3    | Young        | 8.40                             | 60   | 6.70 | 27.2           | 26             | 19             | 7.7   | 0.09    | 0.21 |
| 8    |              | 41.1                             | 24.6 | 20.1 | 4.5            | 6              | 2.2            | 1.5   | 0.08    | 0.21 |
| 9    |              | 18.9                             | 64.6 | 0.9  | 4.6            | 7.8            | 3.2            | 0     | 0.09    | 0.23 |
| 2    | Transition   | 6.34                             | 21.7 | 8.45 | 19.9           | 21.9           | 25.8           | 9.4   | 0.08    | 0.32 |
| 4    |              | 25.1                             | 20.9 | 12.1 | 21.2           | 33.1           | 33.3           | 11.4  | 0.27    | 0.46 |
| 5    | Mature       | 4.5                              | 2.9  | 19.1 | 12.7           | 13.6           | 31.8           | 18.2  | 0.53    | 0.63 |
| 1    |              | 6.2                              | 10.4 | 16.7 | 16.7           | 18.8           | 6.2            | 25    | 0.44    | 0.52 |
| 7    | Fully mature | 50.2                             | 20.5 | 11   | 8.6            | 6              | 2.2            | 1.5   | 0.41    | 0.72 |
| 6    |              | 63.8                             | 13.7 | 6.9  | 4.2            | 7.8            | 3.6            | 0     | 0.43    | 0.75 |
| 10   |              | 14.1                             | 10   | 26.2 | 19.0           | 11.7           | 12.1           | 1.9   | 0.58    | 0.76 |

As can be seen from the table, the efficiency coefficient of *Helichrysum aurantiacum* in mature populations was  $\omega=0,52-0,76$ . The high value of the efficiency coefficient in CP 7, 6 and 10 is related to the high number dynamics of plants belonging to the juvenile and immature phases before the generative development phases, and the small number of individuals belonging to the aging (s, ss) phases.

Gazakh-Tovuz, the 14th Economic Region of Azerbaijan, is located in the north-east of the Lesser Caucasus and is represented by 3 districts: Tovuz, Aghstafa and Gazakh. In 2015-2020, research works devoted to the study of biological reserves of useful plants were carried out in the area. However, due to the large number of species, plants that have a wide distribution area and are used in many ways due to their usefulness have been studied. Assessments of resource potential were mainly carried out on *Tussilago farfara*, *Helichrysum aurantiacum*, *Arctium lappa*, *Inula helenium*, *Centaurea cyanus*, *Cichorium intybus*, *Achillea millefolium* species from the Asteraceae family. The present article provides information on the species *Helichrysum aurantiacum*.

The route-recognostic method was used to study the reserve of useful plants. The size of the recorded areas was taken as 10×10 m. In order to determine the stock and density of plants, experimental plots were selected in the studied vegetation types in 3 replicates, first 1 m<sup>2</sup> each, then 5 and 10 m<sup>2</sup>. The structure, composition of the vegetation, the number of species there, edificator and dominants, in a word, the floristic-geobotanical indicators of the areas were studied and the richness of the flora was noted by Druden's 5-point scale.

Medicinal plants are found in Tovuz, Aghstafa and Gazakh districts, especially in mountainous areas in meadow-shrub formations. The studied *Helichrysum aurantiacum* differ from meadows according to their phytocenological structure, but according to their biological characteristics, they are close to meadow plants that follow the forest. It is abundant in poorly collected, hard to reach tiers, sometimes in xerophytic steppes, and sometimes in stony-rocky belts. From an ecological point of view, *Helichrysum aurantiacum* is mainly found on stony and gravelly hills, slopes, between forests and bushes, in ravines, in dry valleys. They grow better in good aerobic conditions, in soils rich in minerals. The following plant species are also found in *Helichrysum aurantiacum* associations: *Doronicum macrophyllum* Fisch. ex Hornem., *Rumex alpinus* L., *Dactylis glomerata* L., *Elytrigia repens* (L.) Nevski, *Mentha longifolia* (L.) L., *Pyrethrum roseum* M. Bieb., *Lamium album* L., *Nepeta grandiflora* M. Bieb., *Senecio othonnae* M. Bieb., *Cirsium hygrophilum* Boiss., *Rosa arvensis* Huds., *Haplophyllum ciscaucasicum* (Rupr.) Grossh. & Vved., *Ranunculus elegans* C. Koch etc.

*Helichrysum aurantiacum* is typical for all groupings in a number of meadow associations in a small area in the Esrik valleys: *Hordeum violaceum* Boiss. & Hohen., *Carex dacica* Heuff.,



*C. vesicaria* L., *Anthemis rigescens* Willd., *Cerastium arvense* L., *Bromopsis variegata* (M. Bieb.) Holub, *Onobrychis transcaucasica* Grossh. and etc. In this area, *Helichrysum aurantiacum* dominates.

A part of the meadows around the forest, where *Helichrysum aurantiacum* coenoses are found, is sometimes mixed with elements of subalpine meadows and forms mountain-meadow plants. Its average height is 170 cm, the length of the leaf is 8-13 cm, the number of leaves is up to 4-5. The abundance of the plant in the area is 1-2 points. These meadows are prominent in the high mountain belts in 1 area. The plant is widely used as medicine.

The grooved covers occupying the foothill belt have led to the formation of a xerophytic landscape. *Helichrysum aurantiacum* and *Rumex confertus* (Asiatic dock) dominate this zone in different seasons. It is also found together with *Capsella bursa-pastoris*, *Lamium album*, *Urtica dioica* species in lower mountain belt forests.

*Centaurea cyanus* and *Helichrysum aurantiacum* dominant species of *Cephalaria gigantea* formation were found locally in the study area. Studies have shown that this type of formation differs from one another with different types of plants. Here, with one or two plants, *Helichrysum aurantiacum* becomes an edificator, and the rest are components. *Lathyrus miniatus* M. Bieb. ex Steven, *Delphinium foetidum* Lomak and etc. can be shown. Vegetation cover of Boyukkislaq village of Tovuz district is 85-95%. In this area, *Helichrysum aurantiacum*, *Arctium lappa* and *Inula helenium* dominates in coenosis, the abundance of the area is 2-3 points. Forb plants (65%), cereals (23%) are the main part and *Helichrysum aurantiacum* makes up 10-15%. 2-3 specimens *Arctium lappa* can be found in every 4 m<sup>2</sup>. The average height of the *Helichrysum aurantiacum* species is 65-85 cm, the number of leaves is up to 12-25, and the wet weight of the aerial part is between 1.0-1.5 kg. The width of the leaf is 1.5-2.0 cm, the length is 5-6 cm. *Helichrysum aurantiacum* is smaller than *Inula helenium* and *Arctium lappa*.

It was determined that compared to the previous years, the exploitation reserve of plants decreased as a result of the influence of anthropogenic factors. Some species (*Helichrysum aurantiacum*, *Urtica dioica*, *Arctium lappa*, *Lamium album*, *Achillea millefolium*, *Capsella bursa-pastoris*, *Cichorium intybus*, *Centaurea cyanus*) are used as medicine and are eagerly eaten by animals. Some (*Asparagus officinalis*, *Urtica dioica*, *Capsella bursa-pastoris*, etc.) are supplied by local communities as valuable food plants.

The biological reserve of *Helichrysum aurantiacum* was calculated (Table 3). As a result of bioecological studies, it was determined that the plant has spread from the lower mountain belt to the highland meadows.

Table 3  
RESERVE OF *Helichrysum aurantiacum* SPECIES IN GAZAKH-TOVUZ ADMINISTRATIVE AREA  
(in 2018-2019)

| The name of the districts | Name of villages by districts               | Area of plant distribution (h) | Reserve density (h/s) | Biological reserve (centner) | Exploitation reserve (centner) |
|---------------------------|---|--------------------------------|-----------------------|------------------------------|--------------------------------|
| Tovuz district            | Esrik valley                                | 150                            | 8.7±1.52              | 375.0±35.68                  | 139.00±17.84                   |
| Gazakh district           | The foothills of                            | 120                            | 8.3±0.51              | 278.0±20.47                  | 109±12.65                      |
|                           | Goyazan mountain                            | 115                            | 6.6±2.33              | 167.0±10.00                  | 84.00±5.02                     |
|                           | The foot of Gazanchi mountain, Guschu-Ayrim | 280                            | 5.9±1.29              | 135.0±9.00                   | 67.50±4.99                     |
| Agstafa                   | Mughanli village                            | 95                             | 4.5±0.88              | 176.10±14.38                 | 51.00±4.72                     |

| The name of the districts | Name of villages by districts | Area of plant distribution (h) | Reserve density (h/s) | Biological reserve (centner) | Exploitation reserve (centner) |
|---------------------------|-------------------------------|--------------------------------|-----------------------|------------------------------|--------------------------------|
| district                  | Pirili village                | 121                            | 5.6±0.91              | 110.0±7.90                   | 48.10±3.64                     |
|                           | Total:                        | 881                            | 5.21±0.78             | 1241.1±79.90                 | 498.6±37.90                    |

Thus, it is possible to annually supply *Helichrysum aurantiacum* in Tovuz, Agstafa and Gazakh districts located in the north-east of the Lesser Caucasus botanical-geographical region of Azerbaijan.

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Работа поступила  
в редакцию 25.09.2022 г.

Принята к публикации  
09.10.2022 г.

Ссылка для цитирования:

Abbasova V. Phytocenological Structure and Biological Reserves of *Helichrysum aurantiacum* Boiss. & A. Huet in Gazakh-Tovuz Economic Region (Azerbaijan) // Бюллетень науки и практики. 2022. Т. 8. №11. С. 48-55. <https://doi.org/10.33619/2414-2948/84/06>

Cite as (APA):

Abbasova, V. (2022). Phytocenological Structure and Biological Reserves of *Helichrysum aurantiacum* Boiss. & A. Huet in Gazakh-Tovuz Economic Region (Azerbaijan). *Bulletin of Science and Practice*, 8(11), 48-55. <https://doi.org/10.33619/2414-2948/84/06>