

Research Article

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Status of populations and resource reserves of *Bupleurum multinerve* DC. in various conditions of the Kazakh Altai

The results of population and resource studies of *Bupleurum multinerve* in the Kazakh Altai are presented for the Southern and Southwestern Altai, including the Sarymsakty Ridge, Southern Altai Tarbagatai, Naryn, and Ivanovsky areas. The aim of the study was to conduct population and resource investigations of *Bupleurum multinerve* under natural growing conditions in the Kazakh Altai. The floristic composition, morphometric parameters, age structure, and resource reserves of the populations were studied. The upper altitudinal limit of the species was established at 1300–2015 m above sea level, where it occurs in mountain-steppe, foothill-shrub, mountain-forest, and subalpine plant communities. Under mountain-steppe conditions in the Southern Altai, the species is a dominant component of the vegetation, with a density of up to 70.0%. The vegetation cover of the studied communities reaches 100%, with herbaceous species forming its basis. The studied populations of *B. multinerve* in the Southern and Southwestern Altai are normal and incomplete, with an age spectrum showing a tendency toward left-sided asymmetry. The species is characterized by relatively stable generative shoot height (coefficient of variation, 13.35–18.65%), high variability in the number of generative individuals per unit area (25.0–36.9%), and the capacity for seed-based regeneration, as indicated by variation in the number of generative shoots (15.1–37.2%). The highest population densities were recorded in mountain-steppe habitats on the Sarymsakty Ridge (75 individuals/m²) and in the Naryn area (50.0 individuals/m²). The commercial reserves of aboveground *B. multinerve* biomass in air-dry condition were estimated at 72.02 tons on the Sarymsakty Ridge and 61.46 tons in the Naryn area, with potential harvest volumes of 43.21 and 36.87 tons, respectively.

Keywords: *Bupleurum multinerve*, Southern Altai, Southwest Altai, association, population, species diversity, abundance, age structure, resources.

Introduction

The problem of studying, using, and conserving biological resources under the modern conditions of a changing world is not only a regional but also a geopolitical issue. At present, the relevance of comprehensive research is increasing, based on the integration of various methods and approaches aimed at developing a strategy for the sustainable use of plant resources. Such strategies should take into account not only the demand for already harvested medicinal plant species, but also for new plant species, the harvesting volumes of which are increasing or may increase in the coming years [1].

Among the promising wild medicinal plants in the flora of the Kazakh Altai from the Apiaceae family is *Bupleurum multinerve* (many-nerved hare's ear), a Pleistocene rock and steppe relict of East Siberian origin [2]. The distribution range of this species is quite wide; A.V. Kuminova [3] assigns it to the Asian (North Asian) group of ranges, while G.A. Peshkova [4] classifies it as a Eurasian type. The species occurs in the mountains of Central Asia, Kazakhstan, Mongolia, and China [5].

B. multinerve is a perennial polycarpic taproot caudex herbaceous plant reproducing by seed. It combines features of mesophytes and xerophytes and, due to its dual ecological nature, has broad ecological adaptability to various growth conditions. It is known that species with such dual ecological characteristics are distinguished by a wide range of variability and high productivity; therefore, *B. multinerve* is abundant in many plant associations [6].

In the Kazakh Altai, the coenocomplex of *B. multinerve* is included in groups of meadow-steppe vegetation associations, less frequently in shrub and forest phytocoenoses. The species often extends above the upper forest boundary, where it occurs on rocky slopes among subalpine steppe-like meadows and on fine-stony screes more or less stabilized by vegetation [7].

Interest in studying *B. multinerve* is associated with the possibility of using its raw material in the parapharmaceutical industry due to the accumulation of biologically active substances (BAS) in the vegetative mass, as well as with assessing the prospects for harvesting medicinal raw materials in natural communities, taking into account sustainability and the population's capacity for self-renewal.

B. multinerve is a source of flavonols. The presence of a multi-enzyme system responsible for the breakdown of native flavonols into simple phenolic compounds and the subsequent degradation of aromatic rings were demonstrated by V.G. Minaeva and M.N. Zaprometov [8]. It has been established that the flavonoid-degrading complex includes glycosidases, peroxidases, O-methyltransferases, hydroxylases, and other enzymes [9].

Due to the content of various biologically active compounds—flavonoids, carbohydrates, aliphatic alcohols, vitamins, triterpene saponins, essential oils, and tannins—it is used in official, traditional, and experimental medicine as a capillary-strengthening, anti-inflammatory, anthelmintic, wound-healing, and choleric agent [10, 11].

Based on the total flavonoids of *B. multinerve*, the preparation “Buplerin” has been developed, containing a flavonol complex composed of quercetin, isorhamnetin, rutin, isoquercetin, and isoquercetin-3-rutinoside. The preparation is recommended for use in hemorrhagic diathesis, bleeding gums and nosebleeds, and edema of vascular origin in hypertension accompanied by increased vascular permeability. The essential oil of *B. multinerve* exhibits antimicrobial and antioxidant activity [12, 13].

Considering the significant role of *B. multinerve* as a medicinal plant, population and resource studies of the species in the flora of the Kazakh Altai have been conducted.

The aim of this work was to carry out population and resource studies of *B. multinerve* under natural growth conditions in the territory of the Southern and Southwestern Altai of the Kazakh Altai.

To achieve this goal, the floristic composition of the communities was studied, the abundance of species forming the phytocoenoses was determined, morphometric and demographic parameters were assessed to identify population responses to growth conditions, and the resource potential of the species in the surveyed communities was established.

Experimental

The research was focused on *B. multinerve* in the phytobiota of the Kazakh Altai (Fig. 1).



Figure 1. *Bupleurum multinerve* in the flora of the Kazakh Altai

The geographical context of the study included four populations in the Southern Altai and two in the Southwestern Altai (Fig. 2).

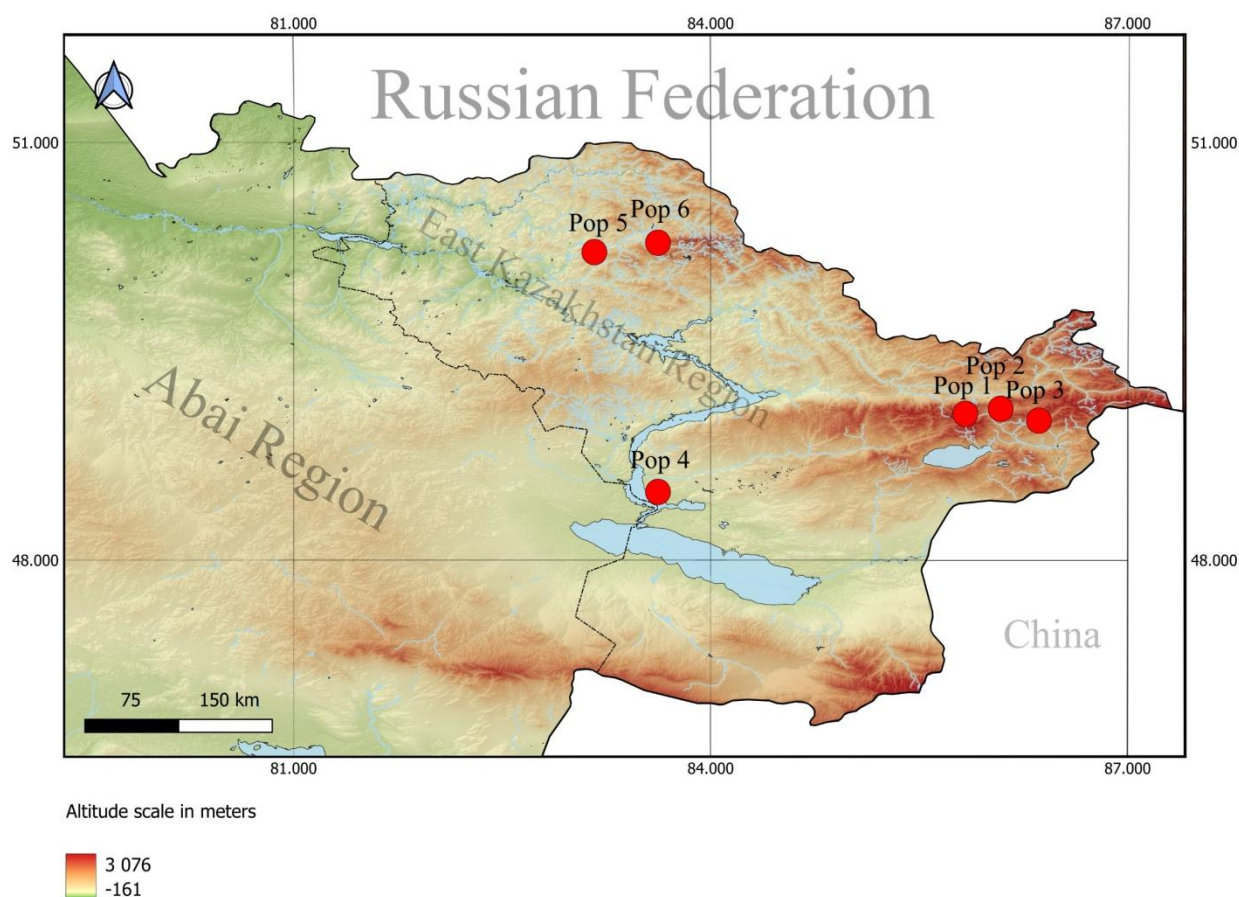


Figure 2. Schematic map of the locations of *Bupleurum multinerve* in the phytobiota of the Kazakh Altai

The mountain system of the Southern Altai, located at the junction of the borders with Russia, Mongolia, and China, has an altitudinal range from 600–700 m above sea level in the western and southwestern foothills to 1500–3400 m in the south and 2000–2500 m in the northeast. The climate is sharply continental, with features determined by altitudinal zonation and the influence of moist northwestern Atlantic air masses, resulting in annual precipitation ranging from 400 mm in the foothills to 800–1000 mm in the mountain forest belt. The Southern Altai is the coldest region within the Kazakh Altai [14].

The Southwestern Altai is characterized by a system of high ridges (1500–2800 m above sea level) and lower mountain and foothill areas (500–700 m above sea level). The climate is sharply continental, with long cold winters, hot summers, significant diurnal and seasonal variations, and pronounced annual fluctuations in air temperature. Annual precipitation ranges from 400–550 mm in the west to 1500 mm in the eastern and northeastern parts of the region [15, 16].

As a result of field studies conducted in the Southern and Southwestern Altai, the floristic composition of plant communities involving *B. multinerve* was examined, including an assessment of species abundance in the Southern Altai. Morphometric and demographic parameters were analyzed, and the resource potential of the species under different growth conditions was determined for six populations, selected based on differences in floristic composition and spatial distribution of the occupied territories.

The coordinates of all populations identified during field research were recorded using a Garmin eTrex 22x GPS navigator. These data were subsequently formatted into an electronic metadata database and uploaded to the Global Biodiversity Information Facility platform (https://gbif.buketov.edu.kz/resourcer=herbarium_abg).

Due to the extensive and topographically complex nature of the study areas, fieldwork was carried out using a route-reconnaissance method [17]. Topographic maps and forest inventory materials were used in planning field routes. A geobotanical method was applied to describe plant communities involving *B. multinerve* [18]. The nomenclature of genera and species of vascular plants in the communities was verified using the Plants of the World Online database [19]. The condition of coenopopulations was assessed using organismal and population-level traits [20]. The resource potential of *B. multinerve* was determined according to the “Methodology for Assessing Reserves of Medicinal Plants” [21]. To estimate raw material re-

serves in specific stands, sample plots of 1 m² were established, with their number varying from 5 to 10 depending on the area of the stand and the uniformity of species distribution within the community [22].

For morphometric measurements, a sample of 15–20 flowering plants of *B. multinerve* was selected in each population, recording the height of generative shoots, the number of generative shoots, and the number of individuals per 1 m². The age states of individuals were determined according to the classification of O.V. Smirnova et al. [23], developed based on the generally accepted scheme of T.A. Rabotnov [24]. Statistical processing was carried out using Microsoft Excel 2010.

Results and Discussion

Our research revealed that the habitats of *B. multinerve* in the Southern Altai are primarily associated with northwestern (Sarymsakty Ridge), southeastern (South Altai Tarbagatai Ridge), and northeastern (Narym Ridge) exposures, with a vertical distribution range from 1300 to 2015 m above sea level. In the Southwestern Altai, both populations were recorded on the southeastern slope of the Ivanovsky Ridge (Prokhodnoy Belok) with a vertical distribution range of 1450–1990 m above sea level.

In the Southern Altai, the species was found in subalpine, mountain-forest, and mountain-steppe associations; in the Southwestern Altai, it occurs in subalpine low-herb and foothill-shrub associations. Surveys showed that *B. multinerve* is widely distributed in mountain-steppe associations, contributing to the formation of meadow-steppe type vegetation, and to a lesser extent, shrub and forest phytocoenoses (Tab. 1).

Table 1

Characteristics of the habitats of the studied *Bupleurum multinerve* populations in the phytobiota of the Kazakh Altai

Popula- tion	Location	Coordinates of the main points			The area occupied by the view, ha	Name of the association
		width	longitude	height above sea level.		
	Southern Altai					
Pop 1	Sarimsakty Range, northwestern slope, near the Burkhat Pass	49.1333	86.0103	2015	12,0	Subalpine iris-borage
Pop 2	Sarimsakty Range, northwestern slope, near the Burkhat Pass	49.1586	86.0239	1300	200,0	Mountain-steppe mixed-grass- volodushkovaya
Pop 3	South Altai Tarbagatai Range, southeastern slope, foothill ter- race	49.0953	86.2006	1890	15	Mountainous forest grassy-cereal-grassland
Pop 4	Narym Range, northeastern slope	48.5864	83.5764	1380	172	Mountain-steppe mixed-grass- volodushkovaya
	Southwest Altai					
Pop 5	Ivanovsky Range, southeastern slope, (Passing Squirrel)	50.2661	83.5456	1990	25	Subalpine low-grass violet-blue
Pop 6	Ivanovsky Range, southeastern slope, (Passing Squirrel)	50.3211	83.8807	1450	12	Foothill-shrub-grass- and-forb-grass

In the Southern Altai, under subalpine conditions in the iris–*Bupleurum* association (Pop. 1), the area occupied by the species is 12 ha on eroded rocky slopes of the Sarymsakty Ridge, with a total projective cover of 100 %, of which *B. multinerve* contributes 25.8 % to the community. In the mountain-steppe habitats on the Sarymsakty Ridge (Pop. 2) and Narym Ridge (Pop. 4), *B. multinerve* acts as a landscape-forming species, forming independent stands over areas of 200 ha and 172 ha, respectively, with a total projective cover of 100 %, where the occurrence of *B. multinerve* reaches up to 70.0 %. In the mountain-forest association, *B. multinerve* (Pop. 3) on the South Altai Tarbagatai Ridge occupies a small area of 15 ha at the upper limit of cedar park forests; total projective cover is 100 %, and the species' participation in the phytobiota is 19.8 %.

In the Southwestern Altai, on the Ivanovsky Ridge (Pop. 5) under subalpine conditions, a *Bupleurum* association is established within a sparse larch–cedar forest over an area of 25 ha, where the shrub layer is absent. The herbaceous layer is well-developed, with a projective cover of 100 %, and *B. multinerve* contrib-

utes 13.9 % to the phytocoenosis. The foothill-shrub *Bupleurum-mixed-herb-grass* association (Pop. 6) occurs among a sparse shrub layer with canopy closure of 0.2–0.3, occupying an area of 12 ha. Total projective cover is 100 %, with *B. multinerve* accounting for 15.8 %.

When studying species diversity in communities with *B. multinerve* in the Southern Altai, it was found that the floristic complex consists of 78 species of flowering plants. The floristic composition is mainly represented by mountain-steppe mesoxerophytic herbaceous species. Differences in species richness among the described communities are minor. By species abundance, the mountain-forest mixed-herb–grass–*Bupleurum* association on the South Altai Tarbagatai Ridge at 1890 m a.s.l. (Pop. 3) stands out with 46 species. The lowest contribution to species number comes from the iris–*Bupleurum* population (Pop. 1) under subalpine conditions on the Sarymsakty Ridge at 2015 m a.s.l., with 35 species (Tab. 2).

Table 2

Summary of the floristic composition of plant communities involving *Bupleurum multinerve*, indicating species abundance in the Southern Altai

№	Names of plant species	Name of association			
		Subalpine iris– <i>Bupleurum</i> association, 2015 m a.s.l.	Mountain-steppe mixed-herb– <i>Bupleurum</i> association, 1300 m a.s.l.	Mountain-forest mixed-herb– grass– <i>Bupleurum</i> association, 1890 m a.s.l.	Mountain-steppe mixed-herb– <i>Bupleurum</i> association, 1380 m a.s.l.
	Abundance on the Drude scale				
	1	2	3	4	5
1	<i>Spiraea media</i> Schmidt	sp	-	sp	sp
2	<i>Cotoneaster uniflorus</i> Bunge	-	-	un	-
3	<i>Cotoneaster melanocarpus</i> G. Lodd.			sol	sp
4	<i>Sibiraea laevigata</i> (L.) Maxim	un	-	sol	-
5	<i>Pentaphylloides fruticosa</i> (L.)O.Schwarz	un	-	un	-
6	<i>Rosa acicularis</i> Lindl.	un	-	un	-
7	<i>Rosa spinossissima</i> L.	-	un	-	un
8	<i>Lonicera caerulea</i> subsp. <i>altaica</i> (Pall.) Gladkova	-	un	-	-
9	<i>L. microphylla</i> Willd. ex Roem. & Schult.	sp	-	-	-
10	<i>Berberis sibirica</i> Pall.	-	sol	sol	-
11	<i>Caragana pumila</i> Pojark	-	-	-	un
12	<i>Bupleurum multinerve</i> DC.	cop ₁	soc	cop ₁	soc
13	<i>Helictotrichon desertorum</i> (Less.)Pilg.	-	-	sp	sp
14	<i>Helictotrichon pubescens</i> (Huds.) Schult.	-	sp	cop ₂	sp
15	<i>Helictotrichon schellianum</i> (Hack.)Kitag	sp	-	cop ₂	-
16	<i>Elymus uralensis</i> (Nevski) Tzvelev	cop ₁	-	cop ₃	-
17	<i>E. mutabilis</i> (Drobov) Tzvelev	un	un	-	-
18	<i>Artemisia sericea</i> (Besser) Weber ex Stechm.	sp	sp	sp	sp
19	<i>A. kotuchovii</i> Kupr.	-	un	-	-
20	<i>A. viridis</i> Willd. ex DC.	-	-	sp	sp
21	<i>Phleum phleoides</i> (L.) H. Karst	-	-	sol	-
22	<i>Poa attenuata</i> Trin.	-	-	sol	-

Continuation of Table 2

№	Names of plant species	Name of association			
		Subalpine iris– <i>Bupleurum</i> association, 2015 m a.s.l.	Mountain-steppe mixed-herb– <i>Bupleurum</i> association, 1300 m a.s.l.	Mountain-forest mixed-herb– grass– <i>Bupleurum</i> association, 1890 m a.s.l.	Mountain-steppe mixed-herb– <i>Bupleurum</i> association, 1380 m a.s.l.
	Abundance on the Drude scale				
	1	2	3	4	5
23	<i>Festuca valesiaca</i> Schleich. ex Gaudin	-	-	sp	-
24	<i>Pedicularis cystopteridifolia</i> Rydb.	-	-	un	-
25	<i>Pedicularis eriantha</i> (Boiss. & Buhse) T.N. Popova	-	sp	-	-
26	<i>Pedicularis proboscidea</i> Steven	-	-	sp	-
27	<i>Gentiana decumbens</i> L..f.	s	-	sp	-
28	<i>Gentiana macrophylla</i> Pall.	sp	-	un	-
29	<i>Oxytropis ambigua</i> (Pall.) DC.	un	sp	-	un
30	<i>Oxytropis sulphurea</i> Bunge	-	-	sp	-
31	<i>Koenigia alpina</i> (All.) T.M. & Schult. Reveal	sp	un	soc	un
32	<i>Campanula glomerata</i> L.	un	s	sp	un
33	<i>Gypsophila altissima</i> L.	un	sp	un	sp
34	<i>Allium altaicum</i> Pall.	un	-	-	-
35	<i>Allium lineare</i> L.	un	un	un	un
36	<i>Allium nutans</i> L.	-	un	-	s
37	<i>Allium flavidum</i> Ledeb.	sp	sol	-	-
38	<i>Allium rubens</i> Spreng.	-	sol	un	-
39	<i>Thalictrum flavum</i> L.	-	s	un	sp
40	<i>Aconitum anthoroideum</i> DC.	sp	un	sp	-
41	<i>Achillea millefolium</i> L.	-	sp	sp	un
42	<i>Saussurea parviflora</i> (Poir.) DC.	sp	un	un	-
43	<i>Galium cicaezans</i> Michx.	sp	-	-	-
44	<i>Galium verum</i> L.	un	sp	sol	sol
45	<i>Geranium collinum</i> Stephan ex Willd.	-	sp	-	sp
46	<i>G. pseudosibiricum</i> J. Mayer	sp	sol	-	-
47	<i>Phlomoides alpina</i> (Pall.) Adylov, Kamelin & Makhm.	sol	-	sp	-
48	<i>Phlomoides tuberosa</i> (L.) Moench	-	-	-	sp
49	<i>Galatella hauptii</i> (Ledeb.) Lindl. ex DC.	un	sp	-	-
50	<i>Galatella sedifolia</i> subsp. <i>sedifolia</i> (L.) Greuter	-	sol	sp	sp-cop ₃
51	<i>Iris ruthenica</i> Ker Gavl.	cop ₂	cop ₂	cop ₁	cop ₂ -cop ₃
52	<i>Carex macroura</i> Meinsh.	cop ₂	cop ₂ ,	cop ₂	sp
53	<i>Gentianella amarella</i> (L.) Börner	sp	sp	sp	sol
54	<i>Gentianopsis barbata</i> (Froel.) Ma	sol	sol	sp	sp-cop ₁
55	<i>Dracocephalum ruyschiana</i> L.	sp	-	sp	-
56	<i>Dracocephalum discolor</i> Bunge	-	-	sol	sp
57	<i>Aster alpinus</i> L.	sol	sp	sp	-

Continuation of Table 2

№	Names of plant species	Name of association			
		Subalpine iris– <i>Bupleurum</i> association, 2015 m a.s.l.	Mountain-steppe mixed-herb– <i>Bupleurum</i> association, 1300 m a.s.l.	Mountain-forest mixed-herb– grass– <i>Bupleurum</i> association, 1890 m a.s.l.	Mountain-steppe mixed-herb– <i>Bupleurum</i> association, 1380 m a.s.l.
	Abundance on the Drude scale				
	1	2	3	4	5
58	<i>Primula macrocalyx</i> Bunge	un	sol	sol	un
59	<i>Euphrasia altaica</i> Serg.	sol	un	-	-
60	<i>Krascheninnikovia ceratoides</i> (L.) Gueldenst.	sol	-	-	sp
61	<i>Pseudoroegneria gmelinii</i> (Trin. ex Schr.) Sennikov	-	sol	-	un
62	<i>Senecio nemorensis</i> L.	-	sol	-	-
63	<i>Poa attenuata</i> Trin	-	sol	un	sol
64	<i>P. angustifolia</i> L.	-	-	-	sp
65	<i>Viola disjuncta</i> W. Becker	-	sp	-	-
66	<i>Klasea cardunculus</i> (Pall.) Holub	-	un	-	-
67	<i>Scutellaria altaica</i> Ledeb. ex Sweet	-	sol	-	-
68	<i>Orostachys spinosa</i> (L.) Sweet	-	sol	un	-
69	<i>Thymus serpyllum</i> L.	-	cop ₂	-	sp
70	<i>Phedimus stoloniferus</i> (S.G. Gmel.) 't Hart	-	sp	-	-
71	<i>Dianthus chinensis</i> L.	-	un	un	un
72	<i>Sanguisorba officinalis</i> L.	-	-	sol	-
73	<i>Scabiosa ochroleuca</i> L.	-	-	-	sol
74	<i>Stipa krylovii</i> Roshev.	-	-	-	sp
75	<i>Medicago falcata</i> L.	-	-	-	sol
76	<i>Fragaria viridis</i> Weston	-	-	-	sp-cop ₂ ,
77	<i>Crepis lyrata</i> (L.) Froel.	-	-	-	un
78	<i>Seseli buchtormense</i> (Fisch.) W.D.J. Koch	-	-	-	un
	TOTAL	35	43	46	39

Analysis using the Drude scale showed that shrubs do not play a significant role in the composition of the vegetation cover. In all studied populations, *B. multinerve* acts as the edicator, with an abundance of soc under mountain-steppe conditions in the Sarymsakty and Narym Ranges (Fig. 3-4), and with an abundance of cop1 under.



Figure 3. Thickets of *Bupleurum multinerve* in the Narym Range



Figure 4. Thickets of *Bupleurum multinerve* in the Sarymsakty Range

The dominants in the herbaceous layer of the communities are *Carex periformis* var. *macrooura* — cop2, *Elymus uralensis* — cop1, *Fragaria viridis* — sp-cop2, *Galatella sedifolia* subsp. *sedifolia* — sp-cop3, *Gentianopsis barbata* — sp-cop1, *Helictotrichon pubescens* — cop2, *H. schellianum* — cop2, *Iris ruthenica* — cop2, *Koenigia alpina* — soc, *Thymus serpyllum* — cop2; other species are considered accompanying.

Considering the potential significance of *Bupleurum multinerve* as a source of plant raw material for the production of parapharmaceutical products, a resource assessment of the above-ground biomass was conducted in the studied populations in the Southern and Southwestern Altai (Tab. 3).

Table 3

Resource assessment of the potential above-ground biomass productivity of *Bupleurum multinerve* in the studied populations of the Kazakh Altai

Population	Location of the population	The area occupied by the view, ha	Yield, kg/ha (air-dry weight)	Operating stock of air-dry raw materials, t	Operating stock of air-dry raw materials, t Volume of possible preparation of air-dry raw materials, t
Southern Altai					
Pop1	Sarimsakty Range, north-western slope, near Burkhat Pass, 2015 m a.s.l.	12.0	178.85	2.15	1.29
Pop 2	Sarimsakty Range, north-western slope, near Burkhat Pass, 1300 m a.s.l.	200.0	360.10	72.02	43.21
Pop3	South Altai Tarbagatai Range, southeastern slope, foothill terrace, 1890 m a.s.l.	15.0	211.90	3.18	1.91
Pop 4	Narym Range, northeastern slope, 1380 m a.s.l.	172.0	357.32	61.46	36.87
Southwest Altai					
Pop 5	Ivanovsky Range, south-eastern slope, (Passing Squirrel), 1990 m a.s.l.	25.0	199.8	4.99	2.99
Pop 6	Ivanovsky Range, south-eastern slope, (Passing Squirrel), 1450m a.s.l.	22.0	221.3	4.87	2.92

In the territory of the Southern Altai, the industrial exploitable reserves of air-dried above-ground biomass of *Bupleurum multinerve* were determined under mountain-steppe conditions in the Sarymsakty (Pop 2)

and Narym (Pop 4) Ranges, amounting to 72.02 t and 61.46 t, respectively, with a possible harvest volume of 43.21 t and 36.87 t. This is due to the extensive areas occupied by the species combined with a high density of individuals per unit area. The obtained data allow these populations to be recommended for industrial harvesting of above-ground biomass.

Simultaneously with the assessment of resource potential, certain morphometric parameters of generative individuals were evaluated, with statistically significant differences at $P \leq 0.05$ (Fig. 5). The study revealed that the phenotypes of *Bupleurum multinerve* differ in height depending on their habitat.

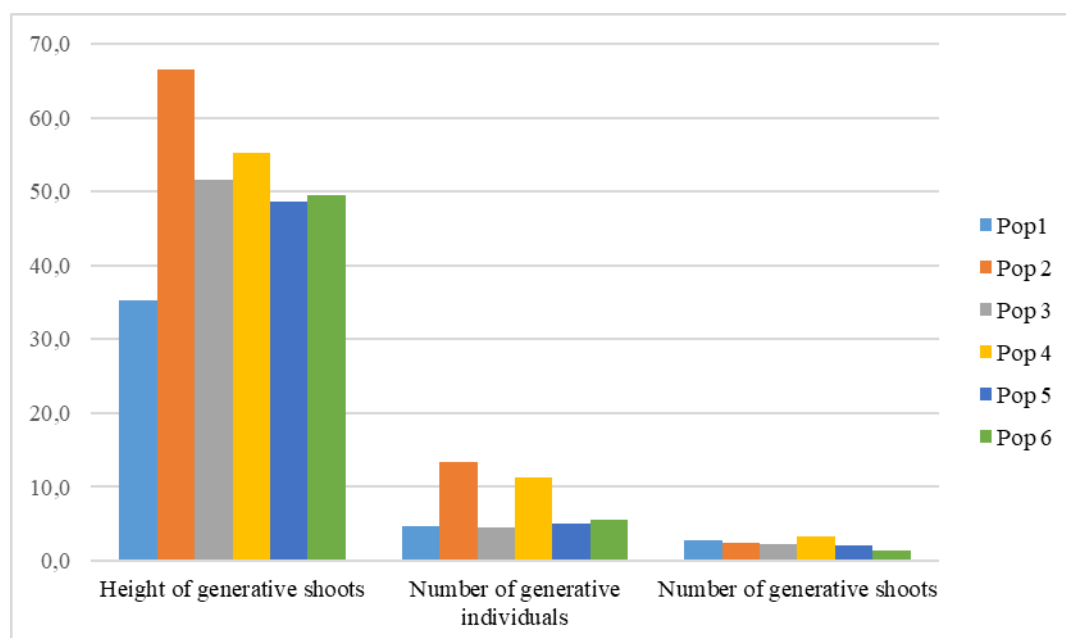


Figure 5. Selected morphometric parameters of above-ground organs of *Bupleurum multinerve* in the studied populations of the Southern and Southwestern Altai

Based on morphometric measurements, the tallest generative individuals were recorded under mountain-steppe conditions in the Southern Altai, in populations Pop2 (Sarymsakty Range) and Pop4 (Narym Range), measuring 66.5 ± 1.93 cm and 55.3 ± 6.23 cm, respectively. The minimum height was observed in the population under subalpine conditions in Pop1 (Sarymsakty Range) at 35.2 ± 1.13 cm. The maximum number of generative individuals per 1 m² was recorded under mountain-steppe conditions in Pop2 (Sarymsakty Range) and Pop4 (Narym Range), with values of 13.37 ± 2.06 and 11.23 ± 3.23 individuals/m², respectively. In natural conditions of the Southern and Southwestern Altai, generative individuals were characterized by a low number of generative shoots, ranging from 1.48 ± 0.26 to 3.39 ± 0.86 shoots per individual.

Based on morphometric data, the populations under mountain-steppe conditions in the Sarymsakty and Narym Ranges can be considered promising for seed collection for introduction and inclusion in a seed gene bank.

According to statistical guidelines, when the coefficient of variation is less than 12 %, the trait variability is considered low; from 13 % to 20 % — medium; from 21 % to 40 % — high; and above 40 % — very high [25]. In our study, the height of generative plants in all populations varied at a medium level of variability, ranging from 13.35 % to 18.65 %, indicating the stability of this trait in individuals of the species in the surveyed ranges of the Kazakh Altai. Traits with high variability in *B. multinerve* included the number of individuals per unit area, varying from 25.0 % to 36.9 %, while the variability of generative shoot number ranged from medium to high, from 15.1 % to 37.2 %, demonstrating high plasticity and the species' ability to self-renew under natural conditions in the Southern and Southwestern Altai.

Bupleurum multinerve is a rhizome-taproot perennial with a monocyclic, oligocarpic, or polycarpic biomorph type [26]. According to E.L. Nukhimovskij [27], individuals of different biomorphs of *B. multinerve* may occur within the same cenotic population, undergoing a complete ontogenetic cycle, the duration of which is directly dependent on growth conditions. Considering the ontogenetic development characteristics of *B. multinerve* [28], a single individual was used as the counting unit in the study of the age

structure of populations. Counts were conducted across four age groups: juvenile (j), immature (im), virginal (v), and generative (g) individuals, as senescent and dying plants were not observed (Fig. 6).

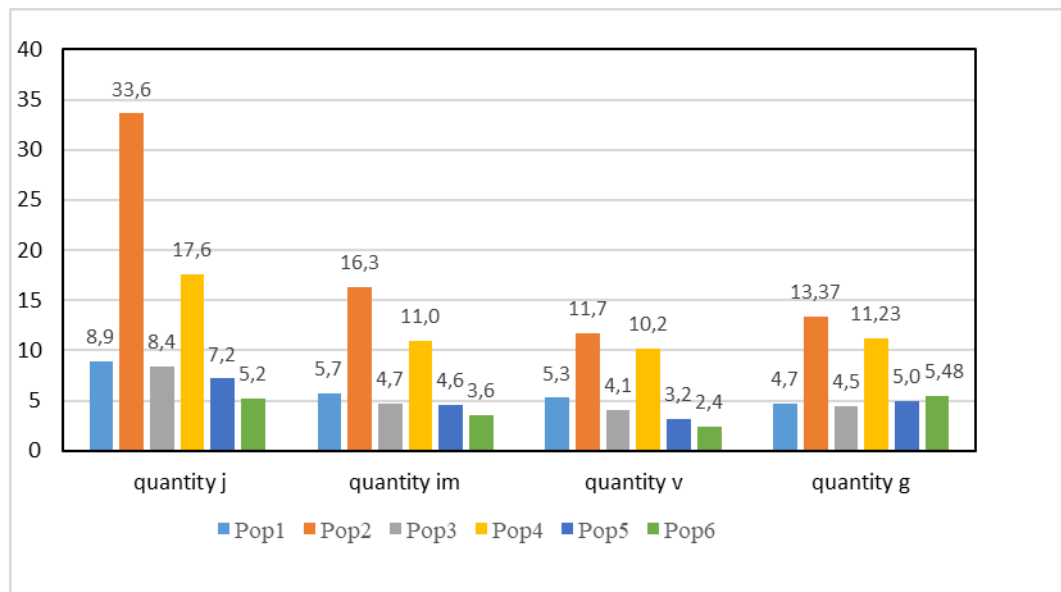


Figure 6. Quantitative composition of age groups in the studied populations of *Bupleurum multinerve* in the Southern and Southwestern Altai

The studied populations of *Bupleurum multinerve* in the Southern and Southwestern Altai, despite inhabiting different geographic locations, are normal and complete, exhibiting an age spectrum with a tendency toward left-skewed asymmetry. In all populations, the young fraction dominates over the adult fraction according to the index $(j + im)/(v + g)$, which confirms that the species maintains its population density primarily through seed reproduction within the associations. At the current stage, minor differences in the ratio of virginal (v) to generative (g) individuals across all populations indicate that the environmental conditions for *B. multinerve* in the studied populations are optimal.

When assessing the economic traits of *B. multinerve*, the density of individuals per unit area is considered a key economic indicator. The results of the study show that, except for populations Pop2 and Pop4, the density of individuals per 1 m² varies slightly despite heterogeneous natural conditions (Fig. 7). Under Southern Altai conditions, this indicator was 24.6 individuals/m² in Ror1 and 21.7 individuals/m² in Pop3; in the Southwestern Altai, it was 20.0 individuals/m² in Pop5 and 18.7 individuals/m² in Pop6. The highest density of individuals was observed in Pop2 (75.0 individuals/m²) and Pop4 (50.0 individuals/m²) under mountain-steppe conditions in the Sarymsakty and Naryn Ranges. Based on these data, it can be inferred that the surveyed populations are currently in a stable state and that the habitat conditions correspond to the species' ecological optimum.

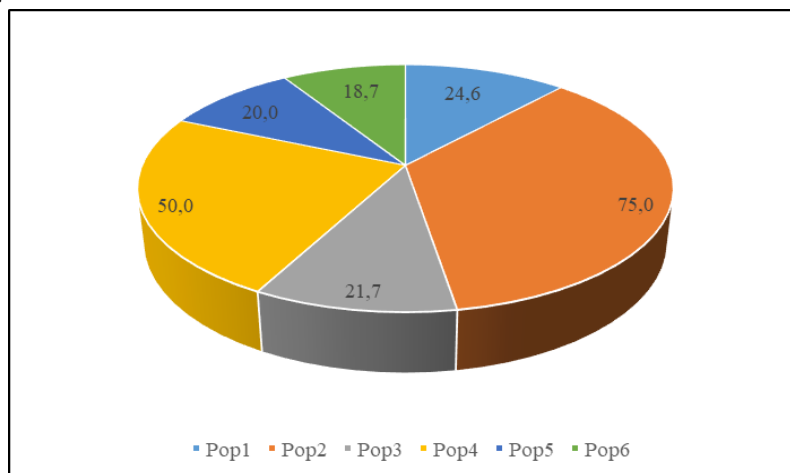


Figure 7. Density of *Bupleurum multinerve* individuals in populations of the Southern and Southwestern Altai, individuals/m²

Thus, the integration of ecological-phytocoenotic and morphometric indicators, along with the assessment of age structure and productivity of *Bupleurum multinerve*, demonstrates the potential for the species' use at the present stage as an unconventional wild medicinal plant in the Kazakh Altai. Future studies, including assessments of genetic diversity, reproductive biology, and modeling of climate resilience, will significantly enhance the prospects for sustainable utilization of the species in the region.

Conclusion

Population and resource studies in the phytobiota of the Kazakh Altai have shown that the Southern and Southwestern Altai regions hold significant potential for the economic use of natural populations of the unconventional wild medicinal plant *B. multinerve*. Habitat analysis demonstrated specific preferences with respect to plant communities; populations were recorded in mountain-steppe, foothill-shrub, mountain-forest, and subalpine associations, with the species in the mountain-steppe conditions of the Southern Altai acting as a landscape-forming element with dominance levels *soc* and *sor1*.

The vertical distribution of the species ranges from 1,300 to 2,015 m a.s.l. The rich species diversity of floristic composition in these associations, combined with a significant level of variation in morphometric parameters—such as the height of generative shoots, the number of generative shoots per individual, and the number of generative individuals per unit area—confirms the stability of populations and the ecological plasticity of *B. multinerve* in the phytobiota of the Kazakh Altai.

The dominance of juvenile and immature individuals over virginal and generative individuals in the age structure indicates the effectiveness of seed reproduction and the species' capacity for self-maintenance through seeds. The left-skewed age spectrum reflects population youth and serves as a current indicator of high vitality and the ability to maintain occupied territories.

Resource assessment demonstrated the industrial significance of the species in the Southern Altai under mountain-steppe conditions, where *B. multinerve* formed the most extensive and highly productive industrial stands (ranging from 357.32 kg/ha to 360.10 kg/ha of air-dry weight). The most resource-rich populations should be prioritized when planning the harvest volumes of plant raw materials as a valuable medicinal plant of the Kazakh Altai flora, while also ensuring the conservation of populations in their natural habitats.

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Conflict of interest

The authors declare no conflict of interest.

Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript. CRediT. **Danilova A.N.** — development of relevance, analysis of results, **Kotukhov Y.A.** — field work, development of methodology; **Sumbembayev A.A.** — geobotanical research, analysis, **Anufriyeva O.A.** — field work, conclusion, **Akhmetzhanov A.M.** — study of the age structure of populations, literature sources.

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**Қазақстан Алтайының әртүрлі жағдайларындағы *Bupleurum multinerve* DC.
ресурстық қоры және популяциялар күйі**

Қазақстан Алтайындағы *Bupleurum multinerve* бойынша зерттеулердің нәтижелері ұсынылған. Зерттеудің мақсаты — Қазақстан Алтайындағы табиғи өсу жағдайларында *Bupleurum multinerve* түрінің популяциялық және ресурстық көрсеткіштерін зерттеу. Популяциялардың флористикалық құрамы, морфометриялық параметрлері, жас құрылымы және ресурстық қоры анықталды. Түрдің тік таралу шегі теңіз деңгейінен 1300–2015 м аралығында екені анықталып, ол тау-далалық, тау бөктеріндегі бұталы, тау орманды және субальпілік қауымдастықтар құрамында кездесетіні белгіленді. Оңтүстік Алтайдың тау-далалық жағдайында бұл түр ландшафт түзуші, оның үлесі 70,0 %-ға дейін жетеді. Қауымдастықтардың өсімдік жамылғысы 100 % қалыптасқан, негізін шөптесін өсімдіктер құрайды. Оңтүстік және Оңтүстік-Батыс Алтайдағы зерттелген *B. multinerve* қалыпты, толық құрамды емес, жастық спектрі сол жақты асимметрияға бейім. Түр генеративті өркеннің биіктігі бойынша 13,35 %-дан 18,65 %-ға дейін тұрақтылықпен сипатталады, ал бірлік ауданға шаққандағы генеративті дарактар саны бойынша 25,0–36,9 % аралығында жоғары өзгергіштік көрсетеді. Сонымен қатар генеративті өркендердің 15,1–37,2 % деңгейінде ауытқуы есебінен тұқым арқылы өздігінен жаңару қабілетіне ие. Дарактардың ең жоғары тығыздығы Сарымсақты (75 дана/м²) және Нарым (50,0 дана/м²) жоталарының тау-далалық жағдайларында тіркелген. *B. multinerve* түрінің жерүсті массасының өнеркәсіптік қоры ауа-құрғақ күйде Сарымсақты және Нарым жоталарында сәйкесінше 72,02 т және 61,46 т болып анықталды, ал мүмкін болатын дайындау көлемі — 43,21 т және 36,87 т.

Кілт сөздер: *Bupleurum multinerve*, Оңтүстік Алтай, Оңтүстік-Батыс Алтай, ассоциация, популяция, түрлік әртүрлілік, молшылық, жас құрылымы, ресурстар.

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**Состояние популяций и ресурсные запасы *Bupleurum multinerve* DC.
в различных условиях Казахского Алтая**

Представлены результаты исследований *Bupleurum multinerve* в Казахском Алтае. Цель исследования — популяционные и ресурсные исследования *Bupleurum multinerve* в естественных условиях произрастания в Казахском Алтае. Изучены флористический состав, морфометрические параметры, возрастной состав, ресурсные запасы популяций. Установлен порог вертикального распространения вида — 1300–2015 м н. у. м. в составе горно-степных, предгорно-кустарниковых, горно-лесных и субальпийских ассоциаций. В горно-степных условиях Южного Алтая вид является ландшафтообразующим с плотностью до 70,0 %. Растительный покров ассоциаций сформирован на 100 %, основу составляют травянистые виды растений. Популяции *B. multinerve* на Южном и Юго-Западном Алтае нормальные, неполноценные, возрастной спектр с тенденцией к левосторонней асимметрии. Вид характеризуется стабильностью по высоте генеративного побега от 13,35 % до 18,65 %, высокой вариабельностью по количеству генеративных особей на единице площади от 25,0 до 36,9 %, способностью к самовозобновлению семенным путем за счет варьирования генеративных побегов на уровне от 15,1 до 37,2 %. *Наибольшая плотность особей отмечена в горно-степных условиях произрастания на хр. Сарымсақты (75 шт./м²) и Нарымском (50,0 шт./м²). Промышленные запасы надземной массы *B. multinerve* в воздушно-сухом состоянии установлены в горно-степных условиях на хр. Сарымсақты и Нарымском соответственно — 72,02 и 61,46 т, а объем возможной заготовки — 43,21 и 36,87 т.*

Ключевые слова: *Bupleurum multinerve*, Южный Алтай, Юго-Западный Алтай, ассоциация, популяция, видовое разнообразие, численность, возрастная структура, ресурсы.

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