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# Coenocomplex and ecological area of *Atragene speciosa* Weinm. in the Altai-Sayan mountain region

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**Abstract.** *Atragene speciosa* Weinm. is a valuable nootropic medicinal plant, but not abundant in nature. The coenocomplex of *Atragene speciosa* consists mainly of dark coniferous taiga forest. The species composition of this coenocomplex includes 324 species, 74 of which are constant. According to humidity of habitats, this species is in the mesophyte group, and, according to the abundance and salinity or nutrient status of soil, it refers to the mesotrophic group. Cattle grazing is very little or absent in the sites of its vegetation.

## 1. Introduction

The outstanding effect of nootropic medications is their positive effect on learning process and memory, and evident anti-hypoxic effect. Moreover, nootropic medications are used to treat Alzheimer’s disease and attention deficit hyperactivity disorder [1, 2]. Nootropic medications are in demand on the medication market. Nevertheless, it is recognized that their status as medication is contentious. Extract of the aboveground part of *Atragene speciosa* Weinm. (Ranunculaceae) is one of these products. It shows nootropic, adaptogenic and antioxidant potency. Experiment with animals has shown that *Atragene speciosa* brings about an increase in working capacity, which is considered adaptation to physical exercise [1]. Special ecological and biological research of this species has not been carried out yet. This paper aims to study ecological coenotic features of *Atragene speciosa* in the Altai-Sayan mountain region for using the natural population to gather medicinal products and to elaborate recommendations for commercial planting. Accordingly, we have put forward the following goals:

- to research the coenocomplex of this species;
- to determine the ecological area and the best possible habitats;
- to estimate natural reserves of *Atragene speciosa* in the Altai-Sayan mountain region.

## 2. Materials and methods

Ecological-coenotic the approach to studying resources of wild-growing herbs is based on revealing coenocomplex for each raw species. Pharmacology studies have shown nootropic, adaptogenic and antioxidant potency of the extract of the *Atragene speciosa* aboveground part. The use of this plant is widespread in the traditional medicine of Siberia. Tinctures and decoctions of *Atragene speciosa* (the aboveground part, leaves and flowers) are much used in the Siberian traditional medicine as a restorative, bracing and provoking cardiac function. *Atragene speciosa* medicines are believed to have



beneficial effect in curing inter al headaches, vertigo, pulmonary tuberculosis, influenza, diarrhoea, oedema, dropsy, gynaecological conditions, and as a wound-healing agent [3].

The aboveground part of *Atragene speciosa* contains simple phenols, flavonoids, coumarins, organic acids, tanning materials, triterpene saponosides, sterols, alkaloids, polysaccharides, and carotenoids. The butanol fraction of medicinal *Atragene speciosa*, having phenol and triterpenoid compounds, shows the most significant nootropic effect [1].

Analysis of 108 geobotanical descriptions made in the period from 1975 to 2015 in different parts of the Altai-Sayan mountain region has identified the coenocomplex of *Atragene speciosa*. A coenocomplex is a complex of phytocenoses with the species under study [4, 5]. Researchers have identified the peculiarities of belt-zone allocation of this species, occurrence, coenotic confinedness and abundance in various coenoses within the Altai-Sayan region. Belt-zone allocation of *A. speciosa* was identified in terms of abundance in different belts. Occurrence (frequency index – FI) is the number of descriptions with *Atragene speciosa* (108) of the total number of descriptions made on the territory of the Altai-Sayan mountain region (1200). Coenotic confinedness of the species was estimated as the occurrence in different phytocoenoses: in dark coniferous taiga (40 out of 108 descriptions), taiga (20), mixed forests (20), birch and larch forests (10) and in bushes of forest (10) and high-mountain (8) belts, on the fringes of forests, boulder streams, and cobble substrates. Geobotanical descriptions allowed approximating the abundance using percentage of the projective cover. Abundance of the species was calculated in the associations of coenocomplex (arithmetic mean and limits). The confinedness of phytocoenoses with *Atragene speciosa* in certain associations was identified on the basis of the dominant classification [6, 7, 8] given forest associations marked for Kuznetskyi Alatau according to the classification by J. Braun-Blanke [9].

In geobotany, mass abundance of species in a phytocoenosis begins from 8% of projective cover and more [10]. These phytocoenoses and habitats are considered ideal for gathering medicinal material. Some other authors have studied ecological and coenotic features of *Atragene speciosa* in their research, and the characteristics of this species appear in general lists and summaries [8, 11, 12, 13]. The ecological area is viewed as the allocation of coenopopulations within the space of ecological actors, showing the unity of a particular species as the main taxonomic unit [14]. As we see it [15] the ecological area reflects ecological connections of the cenocomplex of a species, which is close to the first definition and corresponds to the ideas of many botanists [16]; it is also close to the notion of ecological niche as defined by a number of Russian and other scientists [10]. The ecological area was calculated using the value of ecological factors: humidity of habitats (H), abundance and salinity or nutrient status of soils (S), pasture degradation (PD), all of which were given in relative units (grades).

To calculate in IBIS [17] we used the scales of I A Tsatsenkin et al [18]. The analysis of ecological scales was conducted using the system IBIS v.7.1. [17]. To characterize the ecological area, we calculated average values of the studied ecological factors: H and S. We also found their limits and plotted the graphs of the ecological area depending on ecological factors (table 1, figure 1). *Atragene speciosa* is not found in coenoses with human impact as PD in all the studied coenoses is less than 3. Detection of the best group of phytocoenoses in the coenocomplex and best part of the ecological area for *Atragene speciosa* is complicated, since this species is found scattered with the abundance from tenths of a percent to 3 (rarely 5%). The best possible group of coenoses was detected according to the highest occurrence in different coenoses and was calculated according to the highest concentration of habitats in the ecological field H-S (table 2, figure 1).

The evaluation of natural resources was carried out using the scale of reserves assessment in relative values (in categories) [4, 5].

### 3. Results and discussion

*Atragene speciosa* grows in taiga in Eurasia. In the Altai-Sayan mountain region, this species is in the forest belt, shifting to the high-mountain belt and then descending to the forest-steppe zone. The coenocomplex is widespread and diverse in humid regions of Altai-Sayan (North Altai, Kuznetskyi Alatau, northern spurs of West Sayan). In semiarid regions (Central Altai, axial parts of West and East

Sayan) its allocation is restricted mainly by a strip of dark coniferous forests. *Atragene speciosa* is not typical for arid and adjacent regions (South-East Altai, crests Tannu-Ola, Sangilen). The defined frequency index of *Atragene speciosa* in Altai-Sayan is 9%.

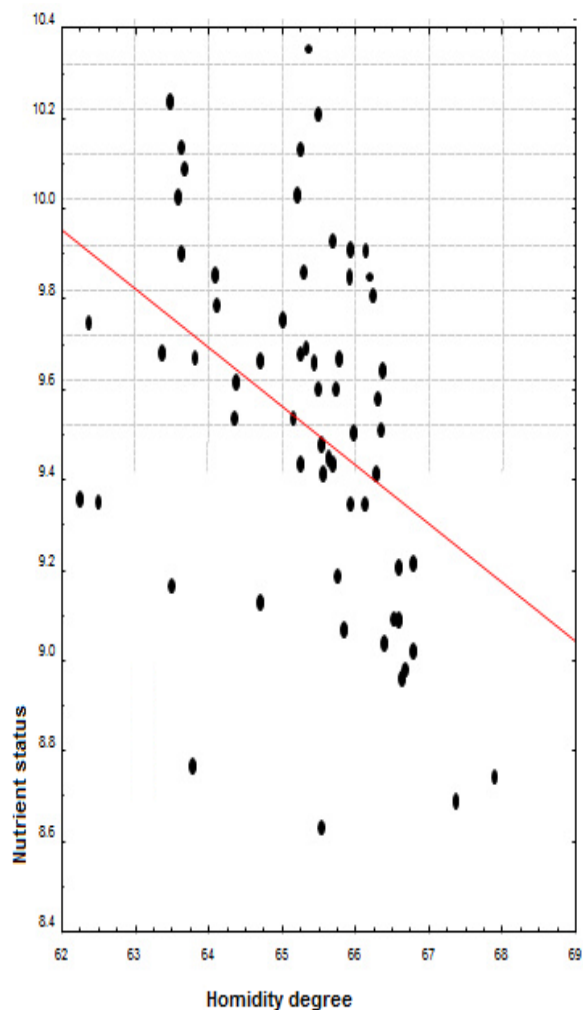
*Atragene speciosa* is widespread in the forest belt where its coenocomplex is most widely represented by phytocoenoses of dark coniferous taiga (FI within the coenocomplex is 37.0%) of *Pinus sibirica* Du Tour, *Abies sibirica* Ledeb., *Picea obovata* Ledeb., mixed forests represented by dark coniferous species including *Betula pendula* Roth, *Larix sibirica* Ledeb. (18.5 %), and taiga (18.5%). Moreover, the coenocomplex includes sub-taiga light coniferous and small-leaved forests of *Pinus sylvestris* L., *Larix sibirica*, *Betula pendula*, *Populus tremula* L. (FI - 9.3 %). This species has also been found in bushes in the high-mountain belt in the coenosis of *Salix sp.*, *Betula rotundifolia* Spach. (FI - 7.4 %), in forest and sub-taiga belts (*Caragana arborescens* Lam., *Cotoneaster melanocarpus* Fisch. ex Blytt, *Grossularia acicularis* (Sm.) Spach, *Lonicera altaica* Pall. ex DC., *Rubus idaeus* L., *Spiraea chamaedryfolia* L.) (FI - 9.3 %). Sometimes it grows higher in subalpine or goltsy (bare rocks) sparse forest, on the fringes of forests, boulder streams, and cobble substrates. In all phytocoenoses of the coenocomplex the abundance of *A. speciosa* is negligible, about 1% and only in dark coniferous taiga does it sometimes reach 5% (table 2).

According to the data presented by Ermakov, *Atragene speciosa* is confined to the plant association of Cimicifugo foetidae – Abietetum sibiricae, which is part of the alliance Aconito rubicund – Abietion sibiricae, included in the order Piceo obovatae – Pinetalia sibiricae, subclass Piceenea excelsae – obovatae, class Vaccinio – Piceetea [9]. The association develops in well warmed habitats on moderately steep and steep (12-35°) slopes with exposure to the east and west in lower parts of the mountain taiga belt at the altitude of 700-850 m. Tree layer possesses average and high density (0.6-0.7), height of 19-21 m and mixed composition of *Abies sibirica*, *Pinus sibirica*, *Picea obovata*. Shrub layer is always present, however, showing low cover degree (3-8 %); the main species are *Spiraea chamaedryfolia* and *Lonicera altaica*. Field layer has average projective cover of 55-70 %, height of 20-25 cm and does not have a clear sublayer division. It is typical for this layer that among dominant and subdominant species there are moderately thermophilic and moderately hydrophilic south-boreal species: *Carex macroura* Meinsh., *Atragene speciosa* Weinm., *Cimicifuga foetida* L., *Calamagrostis pavlovii* Roshev., *Adenophora lamarckii* Fisch., *Majanthemum bifolium* (L.) F W Schmidt. In Khakassia *Atragene speciosa* is confined to a formation of pine forest with the frequency index of 50 % and to a formation of aspen forest (FI – 80 %) [7]. In Altai this species is among the constant ones of taiga [7]. Within the high-mountain vegetation in the Altai-Sayan mountain region this species has been mentioned in the lichen-crowberry-larch association (FI is over 70 %) [8].

The species composition of the coenocomplex of *Atragene speciosa* in the Altai-Sayan mountain region includes 324 species. There are 74 constant species in this coenocomplex found in 20 % and more of phytocoenoses. The constant species mainly are from the subordinate (50.0 %) and mountainous (47.43 %) groups; the latter mainly consists of species from the subordinate-mountainous subgroup (39.74 %). The constant species of the coenocomplex with *Atragene speciosa* reflect the most ancient coenotic connections of this species and prove that its formation took place in the coenoses of mountain-forest belt and forest zone. Both harvesting and introduction of *Atragene speciosa* will be successful within the abovementioned belt-zone territory.

In the Altai-Sayan mountain region, the coenocomplex of *Atragene speciosa* occupies parts of slopes and river valley bottoms at the height of 700-2300 m above the sea level [11], on the plains of subaerial denudation of different levels. According to humidity of habitats, *Atragene speciosa* is in the mesophyte group growing mainly in humid meadows in the forest zone [18]. According to abundance, salinity or nutrient status of soils in the habitats, this species is mesotrophic. As I A Tsatsenkin has put it [18], mesotrophic plants prefer poor soils (podzolic, sod-podzolic, podzol-gley, peat, etc.) with faintly acid reaction (pH = 5.5-6.5). In its habitat, cattle grazing is negligible or absent in the sites of its vegetation (table 1). The ecological optimum of the species in accordance with the humidity of habitats lies within 65.0-66.5; in accordance with the nutrient status of the soil it is within 9.4-9.9. Using the humidity degree of habitats, we have identified average values for *Atragene speciosa* in Altai and Tuva within the

range of 63.6-63.8, Kuznetskiy Alatau and West Sayan – 66.4-66.6 (table 1). Average nutrient status in Altai and Kuznetskiy Alatau habitats is 8.8-9.0. In West Sayan and Tuva it is 9.5-9.9. The graph of ecological factors demonstrates negative dependence in the habitats of *Atragene speciosa* between humidity and nutrient status of soil (as humidity degree increases, nutrient status of soil decreases) (figure 1).



**Figure 1.** Allocation of coenoses with *Atragene speciosa* in the axes of ecological factors of humidity and nutrient status of soil

**Table 1.** Ecological area of *Atragene speciosa* Weinm.

Regions	Average phytoindication statuses of habitats according [18]		
	Humidity	Abundance and salinity (nutrient status)	Pasture degradation
Altai	63.78	8.76	2.58
Tuva	63.61	9.90	2.68
West Sayan	66.38	9.53	2.47
Kuznetskiy Alatau	66.63	8.96	2.41

Note: A is the average value of ecological factor.

We have discovered natural resources of *Atragene speciosa* of category III, which are mainly unexploited, i.e. have a restricted expansion, while the abundance in the optimal part of the coenocomplex does not exceed 1-5% of the projective cover and total exploitable reserves do not exceed approximately ten (sometimes hundreds) kg. Category III species can be used for the needs of local people. Occasionally, in humid areas of the Altai-Sayan mountain region there is *Atragene speciosa* category II sustainable stock which allows harvesting the aboveground part for the regional pharmacy chain. Natural reserves of this species are not a reliable material source for medicine production, which should be based on cultivation in the required amount.

**Table 2.** Abundance and frequency of *Atragene speciosa* in phytocoenoses in the Altai-Sayan mountain region.

Phytocoenoses	Abundance (projective cover, %)	Frequency in the coenocomplex, %
Dark coniferous taiga	1 – 5	37.0
Taiga	1 – 2	18.5
Mixed forest	1	18.5
Birch and larch forest	1	9.3
Bushes of forest and subtaiga zones	1	9.3
Bushes of high-mountain zone	1	7.4

#### 4. Conclusion

*Atragene speciosa* is in the Eurasian area. It is a common species located in the European part of the Russian Federation, it is widespread in West Siberia, and in the Altai-Sayan mountain region, and can be rarely seen in East Siberia. The coenocomplex is relatively widespread and diverse in humid areas of Altai-Sayan (North Altai, Kuznetskiy Alatau, northern spurs of West Sayan). The identified occurrence rate of coenoses with *Atragene speciosa* in Altai-Sayan is 9 %.

The coenocomplex of *Atragene speciosa* is dark coniferous taiga forests (frequency index within the coenocomplex is 37.0 %), mixed (18.5 %), and taiga (18.5 %) and light coniferous subtaiga (9.3 %), subalpine and goltsy (bare rocks) sparse forest, bushes in high-mountain (7.4 %), forest and forest-steppe (9.3 %) belt. According to its zone confinedness, it refers to a subordinate mountainous subgroup of a mountainous group.

The species composition of the coenocomplex is 324 species, of which 74 are constant. The constant species mainly are from the subordinate (50.0 %) and mountainous (47.43 %) groups; the latter mainly consists of species from the subordinate-mountainous subgroup (39.74 %).

In the Altai-Sayan mountain region, the coenocomplex of *Atragene speciosa* is on the slopes and river valley bottoms at the height of 700 to 2300 m above the sea level, on the plains of subaerial denudation of different levels. According to humidity of habitats, this species is in the mesophyte group, and, according to the abundance and salinity or nutrient status of soil, it refers to the mesotrophic group. Cattle grazing is negligible or absent in the sites of its vegetation.

The ecological optimum of the species in accordance with the humidity of habitats lies within 65.0-66.5; in accordance with the nutrient status of the soil it is within 9.4-9.9. We have found negative dependence in the habitats of *Atragene speciosa* between the humidity and nutrient status of soil (as humidity increases, the nutrient status of soil decreases).

The natural reserves of *Atragene speciosa* refer mainly to the unexploited ones (category III) and cannot be a reliable source of material for commercial production of medicinal agents. It is essential to develop the agricultural technique for this species based on its biological features to obtain the material in the amount needed. According to ecological conditions, industrial planting is possible in both mountain-forest belt and forest zone.

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