Artemisia of Inner Asia: species diversity, essential oils’ composition and practical use

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Abstract. Genus Artemisia is one of the large multispecies genera of the Asteraceae family in the Siberian flora. In the arid and subarid zones of the Holarctic, wormwoods are often the dominant plant community. On the territory of Buryatia there are 47 species of Artemisia, on the territory of Mongolia – 102, and on the Qinghai territory – 54. The genus Artemisia L., growing in Buryatia, Mongolia and Qinghai belongs to three subgenera, of which the subgenus Artemisia is the most widely widespread. The subgenus Seriphidium is more prevalent in Mongolia (16 species), rather than in Buryatia or Qinghai (2 species in each territory). The territories of Buryatia, Mongolia and Qinghai have 13 common species of Artemisia. Among the plants belonging to the genus Artemisia, 40 species grow in both Buryatia and Mongolia at the same time, 22 – in Mongolia and Qinghai, 14 – in Buryatia and Qinghai. The component composition of essential oils is formed as a result of the influence of abiotic and biotic factors of the environment on the plant during its growth. It ensures the best adaptation of the plant to the conditions of particular location. Many species of wormwoods have an important practical value, with a potential to be used in medicine, functional nutrition, food industry, and also as fodder, technical and decorative plants.

1. Introduction
The global flora of wormwoods includes about 500 species [1-3]. In terms of the number of species, the genus Artemisia L. genus is among the ten largest genera in most floras of the Northern Hemisphere. Artemisia L. genus is one of the most extensive multispecies genera of the Asteraceae family in the Siberian flora [4]. In the arid and subarid zones wormwoods often dominates plant communities. Our research was conducted on the territory of Russia (the republic of Buryatia), Mongolia, and China (the Qinghai province).

In the Siberian flora genus Artemisia is represented by 84 species [5]. In Buryatia, according to “Flora of Siberia” [5] there are 43 species, according to “Keys to Plants of Buryatia” [6] – 46. The authors note three more species: Artemisia latifolia Ledeb., Artemisia nitrosa Web. ex Stechm. and Artemisia pectinata Pall., which agrees with data of G Peshkova (1979) [7]. The last-mentioned species listed in “Flora of Siberia” [5] is included in the multispecies genus Neopallasia Poljak. The separation of Artemisia pectinata from the genus Artemisia is supported by a number of authors, including [3]. New data on the distribution of new for the Siberian flora species – Artemisia xanthochroa Krasch., as well as a forgotten species – A. xylorhiza Krasch. ex Filatova are given for the territory of Buryatia [8]. Thus, there are 47 species of Artemisia L in Buryatia.
Genus *Artemisia* L. in the Chinese flora comprises 186 species, including 82 endemic ones [3]. At the same time, the species of the subgenus *Seriphidium* (Bess.) Rouy are distinguished into a separate genus *Seriphidium* (Bess.) Poljak., with 29 species, including 5 endemic ones. There are 52 species of the *Artemisia* L. genus (subgenus *Artemisia* and *Dracunculus*), 2 species of the genus *Seriphidium* [9]. As such, 54 species of *Artemisia* occur in Qinghai.

According to I Gubanov [10], 104 species and subspecies of wormwood are found in the flora of Outer Mongolia. A later paper [11] lists 105 wormwood species, including 3 subspecies: *A. vulgaris* L. subsp. *inundata* Darjima, *A. feddei* subsp. *arschantica* (Darjima) Gubanov et R. Kam. and *A. desertorum* Spreng, subsp. *pseudojaponica* Darjima (belongs to subgenus *Dracunculus*). The list of *Artemisia* species of both authors is the same, the difference being in the identification of subspecies. Thus, without the subspecies in the flora of Outer Mongolia, there are 102 species.

### 2. Models and Methods

Plant samples were collected on the territory of Russia (Buryatia), Mongolia, and China (the Qinghai province). Plant materials were air dried and grinded. Voucher specimens were deposited in Baikal Institute of Nature Management, Siberian Branch, Russian Academy of Sciences and the Northwest Institute of Plateau Biology, Chinese Academy of Sciences.

20 g of powdered plant material was hydrodistillated for three hours in Clevenger-type collector. A gas chromatography-mass spectrometry (GC-MS) analysis was carried out to determine the composition of essential oil. GC analyses were performed on Agilent Technologies 6890 instrument equipped with quadrupole mass selective detector HP 5973 MSD and an HP-5ms capillary column (30 m x 0.25 mm x 0.2 μm). Essential oil components were identified by comparing their mass spectra with those from the National Institute of Standards and Technology (NIST, 2007), and by comparing mass spectra and calculated linear retention indices (RI) with literature values [12]. To calculate RIs, co-injection with a mixture of linear hydrocarbons C8–C20 (Sigma, USA) according to [12] was performed. The oil component content was determined as relative amount (%) of the individual oil components and expressed as percentage peak area versus total peak area from GC-MS analyses of the oils.

The composition of the essential oil data was subjected to multivariate statistics using principal component analysis (PCA) which is available in the Sirius 6.0 package [13]. For this purpose, the compounds that were found in all or in most of the samples were used. The relative values (i.e. percentage of the sum) of the compounds were logarithmically transformed, thereby the equation of the quantitative differences among compounds was found.

### 3. Results and Discussion

Wormwoods of Buryatia, Mongolia and Qinghai belong to three subgenera, of which most common is the subgenus *Artemisia*. It should be noted that subgenus *Seriphidium* is more commonly represented in Mongolia (16 species), rather than in the other two territories (2 species each). While in Buryatia and Mongolia species of the subgenus *Abrotanum* Bess. Are the most common – 13 (27.7% species of the genus) and 21 (20.6%) species, in Qinghai these will be species of the subgenus *Absinthium* DC. – 15 species.

In Mongolia, representatives of three sections of the subgenus *Seriphidium* (Bess.) Rouy can be found, including 11 (10.8%) species of the section *Halophilum*, 4 species (3.9%) of section *Sclerophyllum* Filat., and 1 of section *Pycnanthum* Filat. However, there are only 2 species of the *Halophilum* section in Buryatia and Qinghai and they are different.

In Buryatia, Mongolia and Qinghai there are 13 common species of *Artemisia* – *A. vulgaris*, *A. leucophylla*, *A. mongolica*, *A. gmelinii*, *A. phaeolepsis*, *A. annua*, *A. frigida*, *A. rutifolia*, *A. sieversiana*, *A. anethifolia*, *A. dracunculus*, *A. desertorum*, and *A. scoparia*. In addition to these species, 26 more species are common for Buryatia and Mongolia, 9 species are common for Mongolia and Tsinghai, and 1 species – *A. pubescens* – for Buryatia and Qinghai.
Wormwoods have versatile biological activity in relation to the human organism, are popular in folk and traditional medicine and are used to treat a wide range of diseases, as well as for disease prevention as a tonic [14].

Common wormwood *A. vulgaris* L. is widely used in official medicine in many countries as a secretagogue and appetite-increasing agent. In traditional medicine, it is used for epilepsy, tuberculous meningitis and various gynaecological diseases. Wormwood is used for joint pain and neuralgic diseases, for bronchial asthma and colds [15]. Extensive material on the essential oil composition of both wild and cultivated *Artemisia vulgaris* plants has been accumulated in the literature. Analysis of our own and published data on the group composition of the components of essential oils of wormwood shows that there are three chemotypes of essential oils corresponding to the macroregion climate types – humid, semi-arid, arid [16].

Another species, *A. annua* L. is included in the State Pharmacopoeia of Viet Nam and China. Interest in *A. annua* is associated with the isolation in the 1970s by Chinese scientists of a highly effective antimalarial compound, artemisinin. In Russia, particularly in Buryatia, wormwood is a common plant for fallow phytocenoses and constitutes a significant phytomass.

PCA-analysis (in PC1-PC2 coordinate system) showed that essential oils of *A. annua* can be conditionally divided into “Asian” and “European” ones. “Asian” essential oils are characterized by the predominance of β-selinene, caryophyllene and caryophyllene oxide, and the accumulation of artemisia ketone, germacrene D, α-copaena. At the same time, the “European” essential oils are characterized by high camphor and 1,8-cineole content, as well as the accumulation of artemisia alcohol.

We have shown the anti-radical activity of essential oils of the whole aerial part and a mixture of inflorescences and leaves of wormwood, using 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical method. Our results show better antioxidant potential than previous works for the essential oils of *A. annua* cultivated in Bosnia, Portugal as well as for the wild plant from Serbia. The high activity of essential oils of wormwood of the annual flora of Buryatia can be explained by the oil composition [17].

The search for non-toxic compounds of natural origin with anti-inflammatory, bactericidal, regenerating effects is an urgent task for medicine, perfumery and cosmetology, as well as the pharmaceutical industry. It is known that the substance that determines such properties of many medicinal plants is chamazulene. The traditional chamazulene-containing medicinal plant material is chamomile (*Matricaria chamomilla* L., *Asteraceae*). In the flora of Buryatia, a promising source of chamazulene-containing essential oil is *A. sieversiana* [18]. This species of wormwoods is widespread in Buryatia and forms a significant phytomass, which opens up prospects for its practical use. Other species of practical importance due to the high content of chamazulene are *A. macrocephala* [19] and *A. jacutica* [20]. *A. jacutica* is an East Siberian endemic with a very limited range. On the territory of Buryatia, one habitat is known, in the Yeravinsky district. *A. macrocephala* is more common in Mongolia. homogeneous finely dispersed emulsions based on essential oil of *A. sieversiana* have been obtained. Emulsion based compositions can be used in various fields of medicine, perfumery and cosmetology, as well as in the pharmaceutical industry as drugs with anti-inflammatory and antioxidant properties [21].

Most species of wormwoods are excellent fodder and are readily eaten by sheep. They are particularly valued as fodder (fattening feed). *A. marschalliana, A. pontica, A. frigida, A. scoparia, A. austriaca, A. sieversiana, and A. vulgaris* have fodder value among Siberian species [15]. Various species of wormwood are used in seasonings throughout the world. Dried leaves of tarragon (*A. dracunculus*) are used as a spicy aromatic additive to various dishes: salads, soups, when preserving vegetables, when making cheese [22]. Wormwoods are used as ornamental plants. A large number of species are planted in pots or in the ground. Ornamental species are in most cases mountainous, alpine, and less often steppe, which are distinguished with dense pubescence of a silvery-green shade and graceful inflorescences: *A. lagopus, A. samoiedorum, A. remotiloba, A. furcata, A. depauperata, A. jacutica and A. frigida* [15].

*A. frigida* and *A. adamsii* can serve as indicators of pasture degradation [23]. We have shown that the macrocomponents of essential oil of both species from different regions and countries are 1,8-cineole, camphor, borneol, which have allelopathic properties [24, 25].
4. Conclusion

Thus, the component composition of essential oils is the result of the action of abiotic and biotic environmental factors on the plant during its development and ensures the best adaptation of plants to the conditions of a particular growing area. Many species are of great practical importance, and can be used in medicine, functional nutrition, food industry and as fodder, technical and ornamental plants.

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References

[1] Polyakov P P 1961 Genus Artemisia Flora of the USSR (Moscow & Leningrad: USSR Academy of Sciences Press) 26 pp 425-631
[2] Korobkov A A 1981 Wormwood of the North-East of the USSR (Leningrad: Nauka) 120 p
[3] Lin Y R, Shi Z, Humphries C J and Gilbert M G 2011 Anthemideae Flora of China (Beijing: Science Press & St. Louis: Missouri Botanical Garden Press) 20-21 pp 653–773
[4] Amelchenko V P 2006 Biosystematics of Siberian wormwood (Kemerovo: “Ibris”) p 238
[5] Krasnoborov I M 1997 Artemisia L. Flora of Siberia (Novosibirsk: SB RAS Press) 13 pp 90-141
[6] Anenkhonov O A, Pykalova T D, Osipov K I, Sekulich I R, Badmaevo N K, Namzalov B B, Krivobokov L V, Munkueva M S, Sutkin A V, Tubshinova D B, et. al. 2001 Keys to plants of Buryatia (Ulan-Ude: Institute of General and Experimental Biology SB RAS) 672 p
[7] Peshkova G A 1979 Genus Artemisia L. Flora of Central Siberia (Novosibirsk: Nauka) 2 pp 841-59
[8] Dulepova N A, Korobkov A A, Korolyuk A Yu and Kotzeruba V V 2012 Turczaninowia 2 55-1
[9] Liu, Sh et al. 1996 Flora Qinghaica (Xining: Qinghai People’s publishing house) 3 pp 375-409
[10] Gubanov I A 1996 Abstract of the flora of Outer Mongolia (vascular plants) (Moscow: “Valang”) 136 p
[11] Dariimaa, Sh. 2002 Asteraceae Dumort. of Mongolia (taxonomic composition, ecology, geography, history of development and economic significance Doctor of Advanced Studies in Biology, Thesis (St. Petersburg) 648 p
[12] Tkachev A V 2008 Investigation of plant volatiles (Novosibirsk: “Ofset”) 969 p
[13] Kvalheim O M and Karstang T V 1987 Chemometrics and Intelligent Laboratory Systems 2 235-7
[14] Kahan M A and Khanina M G 2018 Wormwood of Siberia and the Far East (chemical composition, taxonomy, biological activity) (Orekhovo-Zuevo: Editorial and Publishing Department of GSTU) 246 p
[15] Berezovskaya T P, Amelchenko V P, Krasnoborov I M and Serykh E A 1991 Siberian wormwoods: taxonomy, ecology, chemosystematics, prospects of use (Novosibirsk: Nauka) 125 p
[16] Zhigzhitzhapova S V, Radnaeva L D, Gao Q B, Chen S L and Zhang F Q 2016 Industrial Crops and Products 83 462-9
[17] Zhigzhitzhapova S V, Dylenova E P, Gulaev S M, Randalova T E, Taraskin V V, Tykkeev Zh A and Radnaeva L D 2020 Natural Product Research 34 pp 2668-71
[18] Zhigzhitzhapova S V, Randalova T E, Radnaeva L D, Anenkhonov O A and Zhang F 2015 Journal of Essential Oil Bearing Plants 18(3) 637-41
[19] Zhigzhitzhapova S V, Sambuunyam R., Randalova T E and Radnaeva L D 2019 Plant Chemistry 2 105-12
[20] Dylenova E P, Zhigzhitzhapova S V, Randalova T E and Radnaeva L D 2017 Study of biologically active substances of the species Artemisia jacutica Drob., endemic to the flora of Siberia Proc. of Sci. Conf. “Fundamental problems of ecology in Russia” (Irkutsk: Irkutsk Scientific Centre) p 85
[21] Zhigzhitzhapova S V, Popov D V, Pintaeva E T, Radnaeva L D, Chimittsyrenova L I and Randalova T E 2017 *Pharmaceutical Chemistry Journal* 5 388-90

[22] Kharaim N N 2007 Spicy aromatic plants of the genus *Artemisia* L. *Scientific Notes of V I Vernadsky Crimean Federal University. Ser. “Biology. Chemistry”* 4 pp 109-14

[23] Danzhalova E V 2008 *Pasture degradation of plant communities of steppe ecosystems of Central Mongolia* (Moscow: A N Severtsev Institute of Ecology and Evolution RAS) 27 p

[24] Zhigzhitzhapova S V, Randalova T E, Dylenova E P, Radnaeva L D, Chen Sh and Zhang F 2017 *Acta Biomedica Scientifica* 4 915-26

[25] Randalova T E, Sambuunyam R, Zhigzhitzhapova S V and Radnaeva L D 2017 *Acta Biomedica Scientifica (East Siberian Biomedical Journal)* 2 59-1