

S.A. Mamyrova^{1*}, M.Yu. Ishmuratova²¹*Al-Farabi Kazakh National University, Almaty, Kazakhstan;*²*Karaganda University of the name of academician E.A. Buketov, Karaganda, Kazakhstan***Corresponding author: mamyrova.saule@gmail.com*

The genus *Rhaponticum* in Kazakhstan: species diversity, distribution and prospects for practical use. Review

The article presents information on the species composition and distribution of plants of the genus *Rhaponticum* in Kazakhstan based on literary sources and analysis of herbarium materials. The data of more than 300 samples of the herbarium collections were analyzed, including those from the Institute of Botany and Phytointroduction of the Republic of Kazakhstan, the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan, Moscow State University, IRPH "Phytochemistry", the Institute of Biology and Soil of the National Academy of Sciences of the Republic of Kyrgyzstan. More than 30 literary sources were analyzed as well. 6 species of the genus *Rhaponticum* were identified within the territory of Kazakhstan, which can be classified according to the following ecological and high-altitude groups. The groups include species growing in the subalpine and alpine meadows of Altai such as *Rhaponticum carthamoides* (Wüld.) Iljin; plain species such as *Rh. serratuloides* (Georgi) Bobr., *Rh. nitidum* Fisch.; plants growing on rocky and gravelly slopes of the Western Tien Shan such as *Rh. karatavicum* Regel et Schmalh., *Rh. aulieatense* Iljin, *Rh. namanganicum* (Iljin) Dittrich. Medicinal species *Rh. carthamoides*, *Rh. serratuloides* and *Rh. karatavicum* were analyzed to research future prospects of their usage. The perspectives of plants having adaptogenic, psychostimulant, tonic, immunostimulating, anabolic, antibacterial, antioxidant, hemorheological, antiviral, cytotoxic, antiprotozoal properties have been noted and discussed to be used in the medicine, food industry, fodder production, landscape design, beekeeping areas.

Keywords: genus *Rhaponticum*, species composition, distribution, *Rhaponticum carthamoides*, *Rh. serratuloides*, *Rh. nitidum*, *Rh. karatavicum*, *Rh. aulieatense*, *Rh. namanganicum*, usage perspectives.

Introduction

Genus *Rhaponticum* Ludw. (family *Asteraceae*) includes 25 species, which are distributed mainly in the temperate latitudes of Europe and Asia. In Kazakhstan, until recently [1], only 5 species of this genus were found: *Rhaponticum carthamoides* (Wüld.) Iljin, *Rh. serratuloides* (Georgi) Bobr., *Rh. nitidum* Fisch., *Rh. karatavicum* Regel et Schmalh., *Rh. aulieatense* Iljin. At the end of the last century, *Rh. namanganicum* Iljin was found on the territory of Kazakhstan, it is an endemic of the Western Tien Shan, previously known to be present only on the territory of Uzbekistan and Kyrgyzstan [2].

The issues of protection, distribution and phytocenology of almost all representatives of this genus are still poorly understood. Significant part of the species needs protection, for example, 3 species are included into the Red Book of the Republic of Kazakhstan [3]. They are *Rh. karatavicum*, *Rh. aulieatense* and *Rh. carthamoides*. The latter one is a famous medicinal plant, which is constantly being depleted due to illegal and uncontrolled harvesting. The last two species to mention were considered endemic to the Republic of Kazakhstan, however, as it turned out later, *Rh. aulieatense* is also found in Kyrgyzstan. Another species, *Rh. namanganicum*, being a narrowly localized endemic of the Western Tien Shan, also needs special protection and inclusion into the Red Book of the Republic of Kazakhstan.

The purpose of this work is to clarify species diversity and distribution of genus *Rhaponticum* representatives on the territory of Kazakhstan, as well as to assess their practical significance.

The obtained data contribute to the study of plants of this genus, which allows planning effective measures for their protection and conservation of the biological diversity of Kazakhstan.

Materials and methods

In order to study the species composition and species distribution of the genus *Rhaponticum* in Kazakhstan, literature data from the Scopus, Pubmed.ncbi, e-library, and research databases were studied out during 60-year period, and an herbarium material was reviewed as well. The herbarium samples reviewed were stored and taken from the Herbarium Fund of the Institute of Botany and Phytointroduction of the Republic of Kazakhstan, the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan, Moscow

State University, the International Research and Production Holding “Phytochemistry”, the Institute of Biology and Soil of the National Academy of Sciences of the Republic of Kyrgyzstan.

More than 300 herbarium specimens of genus *Rhaponticum* species were reviewed, including 6 Kazakh species. Herbarium samples were collected from different places of the Republic of Kazakhstan and from neighboring regions of other countries, dated by 1898-2020 years.

Results and Discussion

The genus *Rhaponticum* is interesting from a systematic point of view. Thus, the taxonomy of the genus *Rhaponticum* is quite confusing. There are many systematic biologists who interpreted taxonomy differently. It was meticulously characterized by R.V. Kamelin [4], who confirmed the division of this genus into four independent ones: *Rhaponticum* Ludwig., *Stemmacantha* Cass., *Leuzea* DC. And *Fornicium* Cass, basing it on the developments done by Western European botanists. He classified 5 species to belong to genus *Fornicium* Cass, including 2 Kazakh species *Fornicium serratuloides* (Georgi) R. Kam. and *F. carthamoides* (Georgi) R. Kam. He sufficiently substantiated the isolation of these species, formerly belonging to the genera *Rhaponticum*, *Leuzea* and *Fornicium* Cass.

J. Holub [5] assigns all species to the genus *Leuzea* DC., then he divided the genus into 7 subgenera and assigned *Rh. carthamoides* and *Rh. serratuloides* to subgenus *Fornicium*; and other Kazakhstani representatives as *Rh. nitidum*, *Rh. karatavicum*, *Rh. aulieatense*, *Rh. namanganicum* to subgenus *Rhaponticella*.

M. Dittrich [6] classified most of the species, including *Rh. nitidum*, to belong to genus *Stemmacantha*. A.N. Kupriyanov [7] does not agree with him: he believes that *Rh. nitidum* should retain the generic name of *Rhaponticum*.

O. Hidalgo et al. [8], who studied Kazakhstani species (apart from *Rh. namanganicum*), believed that this genus should be divided into 2 groups, as intra generic classification proposed by J. Holub [5] and molecular phylogeny show numerous inconsistencies. Only two of the seven described subgenera are natural groups: the subgenus *Rhaponticella*(Soskov) Holub and subgenus *Leuzea* DC. The authors considered it more appropriate for the genus *Rhaponticum* to be divided into only two subgenera according to genetic characters, which then correspond to the eastern and occidental clades.

However, the authors failed to find a single feature that defines a group by morphological features. The clade *Rhaponticum oriental*, which includes Kazakhstani representatives of this genus, consists mainly of Central Asian species, but also includes species from Central and East Asia, Australia and Eastern Europe. All of them have relatively limited distribution areas, with the exception of two groups of taxa with wider ranges.

One of these groups includes the object of our study *Rh. serratuloides*. In this work, we use the more familiar, accepted in the Kazakhstani taxonomy, extensive interpretation of the genus [1].

As a result of listed materials processing, a map (Fig. 1) was constructed that clearly demonstrates the distribution species from studied genus in the territory of Kazakhstan.

Characteristics of the species composition and distribution of the genus *Rhaponticum*

1. *Rhaponticum carthamoides* (Wiild.) Iljin (= *Leuzea carthamoides* (Wiild.) Iljin), maral root, saflor tärizdesaiudarı (in Kazakh). It is an herbaceous, perennial plant that reaches a height of up to 180-200 cm; it is a mesophyte [3]. Main districts of distribution are within Western and Eastern Siberia, northeast of Middle Asia. It grows in the mountains of Western and Southern Altai, Tarbagatai and Dzungarian Alatau in Kazakhstan [1, 3].

2. *Rh. aulieatense* Iljin (= *Stemmacantha aulieatensis* (Iljin) M. Dittrich, *Centaurea aulieatensis* Iljin, *Leuzea aulieatensis* (Iljin) Holub), aulieataayu dārisiin, in Kazakh). It is a perennial plant, 15-40 cm high. Basal and lower stem leaves are petiolate, and others are sessile. Corolla is pink-purple. The tuft of seeds is white, three-rowed, with a light orange ring. A form with gray felt pubescence is also known and may be found. Environmental group is mesoxerophyte.

Its distribution area is Kirghiz and Talas Alatau, Karatau, Ichkeletau, Aktash Mountain ridges. It grows on stony, rubbly and limestone slopes in the middle belt of mountains, mainly in the belt of juniper forest and xerophytic shrubs. It blossoms in May-June, bears fruits in July [9].

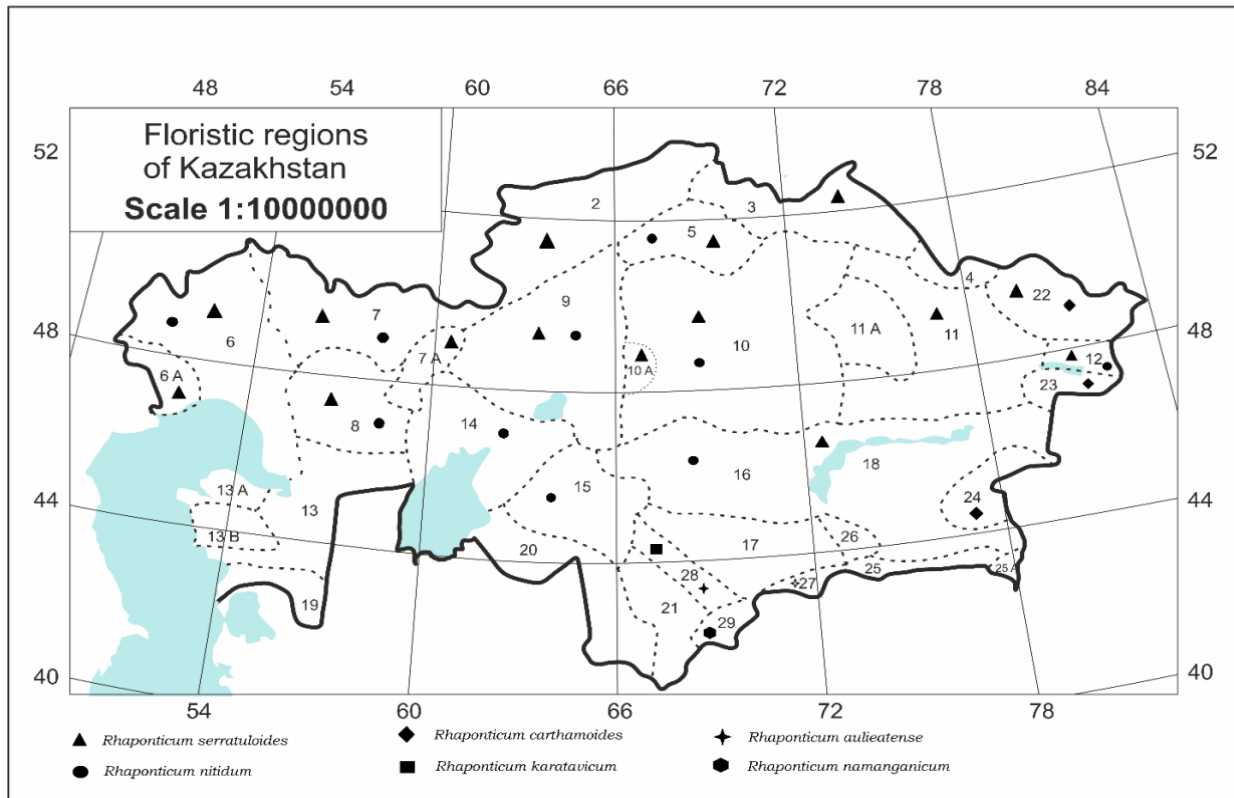


Figure 1. Distribution of species of the genus *Rhaponticum* in Kazakhstan

3. *Rh. karatavicum* Regel et Schmalh., (= *Centaurea karatavica* (Regel & Schmalh.) B. Fedtsch, *Leuzea karatavica* (Regel & Schmalh.) Holub, *Stemmacantha karatavica* (Regel & Schmalh.) Dittrich), karatauyu darisi (in Kazakh). It is a perennial plant, which is 6-12 cm of height. It is distinguished from *Rh. aulieatensis* Iljin by the virtual absence of a stem, by leaves that are curly along the edge, with cartilaginous teeth along the edge [10]. It is a xerophyte. Area of distribution is Karatau, and spurs of the Talas Alatau: Mashat-tau, Daubaba [9].

4. *Rhaponticum namanganicum* (= *Centaurea namanganica* Iljin, *Leuzea namanganica* (Iljin) Holub, *Stemmacantha namanganica* (Iljin) Dittrich). *Rh. namanganicum* is a perennial herbaceous plant with almost stemless growth, as it has very short stems of 3-5 cm in height, with a rosette of basal leaves. It is a xerophyte. According to N.A. Sennikov and G.A. Lazkov [11], these species grow on the southern side of the Chatkal Range in the middle part of the slopes, within rare juniper forest. It can also be found on the northern side of the Chatkal Range and in the Pskem Range [9, 12].

It was firstly found in Kazakhstan by A.A. Ivashchenko [2] on the territory of the Sairam-Ugamsky National Park and the Aksu-Zhabagly Reserve within the Ugamsky Range on the gravel slopes of the subalpine belt (2300-2400 m above sea level).

5. *Rhaponticum serratuloides* (= *Leuzea altaica* Link., *Rhaponticum salinum* Less., *Fornicium serratuloides* (Georgi) R. Kam., *Stemmacantha serratuloides* (Georgi) Dittrich), tuymebas maral tamyр (in Kazakh) (Fig. 2). It is a perennial herbaceous plant, which is 50-100 cm tall, grows on salt marshes, salty soils and salt marsh meadows. It is a mesoxerophyte, halophyte [13]. It is one of the most widespread representatives of the genus not only in Kazakhstan, but also beyond its borders. This is a typical steppe species within the Pontic — Kazakhstan — Altai range, having a distribution area from Eastern Europe (Romania, Hungary) to Western Siberia [1, 4].

Rh. serratuloides is found on a vast territory in 15 floristic regions of Kazakhstan: on the spurs of Common Syrt, Mugodzhary, Eastern and Western small hills, Ulutau, Altai, as well as in Tobolsk-Ishim, Irtysh, Kokchetau, Caspian, Bukeev, Aktobe, Embensky, Zaisan and Balkhash-Alakul regions [1, 14].



Figure 2. Flowering plant of *Rhaponticum serratuloides*

6. *Rhaponticum nitidum* Fisch. (= *Centaurea nitiida* (Fisch.) B. Fedtsch., *Leuzea nitida* (Fisch.) Holub, *Rhaponticum caspium* Kar., *Stemmacantha nitida* (Fisch. ex DC.) Dittrich), shay-zhaprak (in Kazakh). It takes second place on dissemination and distribution after *Rh. serratuloides* in Kazakhstan. It is found in 10 floristic regions: Betpakdala, Aral, Western Uplands, Aktobe, Emba, Kzyl-Orda, Zaisan, Kyzylkum, Balhash-Alakul, and Western Tien Shan region. It grows in clayey and sandy steppes, along the slopes of remnants, along rocky banks and dry riverbeds on the plains. It is a mesoxerophyte [13] and early growing fodder plant [15].

According to the ecological and altitudinal confinement of species of the genus *Rhaponticum* on the territory of Kazakhstan, taking into account the zonal characteristics of E.I. Rachkovskaya [16], they are able to be divided into the following classes: 1 species representative of the highlands (*Rh. carthamoides*), growing in the subalpine and alpine meadows of the Altai mountain system in the altitude range of 1300-2000 m above sea level. The representatives growing in the mountains of the Western Tien — Shan and inhabitants of gravelly and rocky slopes of low and middle mountains (500-1500 m above sea level) are *Rh. karatavicum* and *Rh. aulieatense*; the one growing on dry rubbly slopes and variegated upper belt (over 2000 m above sea level) is *Rh. namanganicum*. The remaining 2 species are representatives of the plain habitats of steppe and desert zones, *Rh. serratuloides* and *Rh. nitidum*.

It was noted that plant of this genus in Kazakhstan within natural populations was carried out in insufficient volume. Thus, there are separate publications on the ecological and phytocenotic characteristics and resource assessment of the *Rh. carthamoides* [16, 17] and the floristic composition of plant communities with the participation of the *Rh. serratuloides* [18–20]. Unfortunately, to the current date, the features of the ecological confinement and composition of plant communities with the participation of *Rh. nitidum*, *Rh. karatavicum*, *Rh. aulieatense*, *Rh. namanganicum* in Kazakhstan remain unexplored.

Prospects for the practical use of plants of genus Rhaponticum

An analysis of the available literary sources showed that *Rh. carthamoides* is the most studied and widely used plant of genus *Rhaponticum* in medicine, which is also used as an ornamental, melliferous and fodder plant (Table).

Less studied species in terms of use in medicine are *Rh. karatavicum* and *Rh. serratuloides* [21-33]. The latter one, being the most common species, is of great scientific and practical importance, since it has been established that this species contains ecdysterone and sesquiterpene lactones [30, 34] and also have sufficient biomass, unlike other species of this genus. For this reason, it can replace *Rh. carthamoides* as a raw material in pharmaceutical industry

Practical application of some species of the genus *Rhaponticum* in Kazakhstan

Species name	Practical use	References
<i>Rhaponticum carthamoides</i>	In medicine: adaptogenic, psychostimulant, tonic, immunostimulating, anabolic, antibacterial, antioxidant, hemorheological, antiviral. In the food industry, fodder production, as honey — bearing and decorative plant.	21-29
<i>Rhaponticum serratuloides</i>	In medicine: antiviral, cytotoxic, antiprotozoal	30
<i>Rhaponticum karatavicum</i>	In medicine: adaptogenic, antioxidant, antibacterial	31,32
<i>Rhaponticum nitidum</i>	Fodder plant	15

The second largest species *Rh. nitidum* was identified as an early growing fodder plant. There is no information on the practical use of *Rh. aulieatense* and *Rh. namanganicum* in the literature.

Conclusion

Thus, it was found that 6 species of the genus *Rhaponticum* grow on the territory of Kazakhstan. All of them are perennial herbaceous plants and grow in different ecological zones. *Rh. carthamoides* is a representative of the highlands of alpine and subalpine meadows; common species growing on the plains in the steppe and desert zones are *Rh. serratuloides* and *Rh. nitidum*, and these are inhabitants of rocky and gravelly mountain slopes as well. The habitats of the genus *Rhaponticum* plants in Kazakhstan, their ecological groups and prospects for practical application are determined. There are little information related to *Rh. aulieatense* and *Rh. namanganicum* species.

Directions for the practical use of representatives of the genus *Rhaponticum* have been determined in medicine, in the food industry, as fodder, ornamental and honey-bearing plants.

To develop measures for the conservation of species of the genus *Rhaponticum*, further field studies are required, most importantly, the information on the number and condition of populations, anthropogenic pressure, the potential for practical application and conservation ex situ and in situ should be deeply researched.

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С.А. Мамырова, М.Ю. Ишмуратова

Қазақстандағы *Rhaponticum* туысы: түрлік алуантүрлілігі, таралуы және тәжірибелік қолдану перспективасы Шолу

Мақалада әдеби дереккөздер мен гербарий материалдарын талдау негізінде *Rhaponticum* туысы өсімдіктерінің Қазақстандағы түрлік құрамы мен таралуы туралы мәліметтер берілген. Қазақстан Республикасы Ботаника және фитоинтродукция институтының, Өзбекстан Республикасы Ғылым академиясы Ботаника институтының, Мәскеу мемлекеттік университетінің, «Фитохимия» ХҒӨХ, Қырғыз Республикасы ҰҒА Биологиялық-топырақ институтының гербарий қорларының 300-ден астам үлгілерінің, сондай-ақ 30-дан астам әдеби дереккөздердің деректері талданды. Қазақстан территориясында *Rhaponticum* туысының 6 түрі анықталды, оларды келесі экологиялық-биіктіктік топтар бойынша жіктеуге болады: Алтайдың субальпілік және альпілік шалғындарында өсетін — *Rhaponticum carthamoides* (Willd.) Hjin; жазықтық түрлер — *Rh. serratuloides* (Georgi) Bobr., *Rh. nitidum* Fisch.; Батыс Тянь-Шаньның тасты және қиыршықтасты баурайларында өсетін *Rh. karatavicum* Regel et Schmalh., *Rh. aulieatense* Hjin, *Rh. namanganicum* (Hjin) Dittrich. *Rh. carthamoides*, *Rh. Serratuloides* және *Rh. karatavicum* дәрілік түрлерін пайдалану перспективасы бойынша деректер талданған. Өсімдіктердің адаптогенді, психостимуляциялаушы, сергітетін, иммуностимуляциялаушы, анаболикалық, бактерияға қарсы, гемореологиялық, вирусқа қарсы, цитотоксикалық, антипротозойлық қасиеттерге ие түрлерінің медицинада қолдану потенциалы, сонымен бірге, тағам өнеркәсібінде, мал азығын өндіруде, ландшафтты дизайнда, ара шаруашылығында қолдану мүмкіндігі атап өтілген.

Кілт сөздер: *Rhaponticum* туысы, түрлік құрам, таралу, *Rhaponticum carthamoides*, *Rh. serratuloides*, *Rh. nitidum*, *Rh. karatavicum*, *Rh. aulieatense*, *Rh. namanganicum*, қолдану перспективасы.

С.А. Мамырова, М.Ю. Ишмуратова

Род *Rhaponticum* в Казахстане: видовое разнообразие, распространение и перспектива практического использования Обзор

В статье представлены сведения по видовому составу и характеру распространения растений рода *Rhaponticum* в Казахстане на основании литературных источников и анализа гербарных материалов. Проанализированы данные более 300 образцов гербарных фондов Института ботаники и фитоинтродукции Республики Казахстан, Института ботаники Академии наук Республики Узбекистан, Московского государственного университета, МНПХ «Фитохимия», Биолого-почвенного института НАН Республики Кыргызстан, а также более 30 литературных источников. Выявлено, что в пределах территории Казахстана произрастают 6 видов рода *Rhaponticum*, которые можно классифицировать по следующим эколого-высотным группам: виды, произрастающие на субальпийских и альпийских лугах Алтая, — *Rhaponticum carthamoides* (Willd.) Hjin; равнинные виды — *Rh. serratuloides* (Georgi) Bobr., *Rh. nitidum* Fisch.; растения, произрастающие на каменистых и щебнистых склонах Западного Тянь-Шаня, — *Rh. karatavicum* Regel et Schmalh., *Rh. aulieatense* Hjin, *Rh. namanganicum* (Hjin) Dittrich. Проанализированы данные по перспективе использования лекарственных видов *Rh. carthamoides*, *Rh. Serratuloides* и *Rh. karatavicum*. Отмечен потенциал применения растений в медицине, обладающих адаптогенным, психостимулирующим, тонизирующим, иммуностимулирующим, анаболическим, антибактериальным, антиоксидантным, гемореологическим, противовирусным, цитотоксическим, антипротозойным свойствами; в пищевой отрасли, кормопроизводстве, в ландшафтном дизайне, пчеловодстве.

Ключевые слова: род *Rhaponticum*, видовой состав, распространение, *Rhaponticum carthamoides*, *Rh. serratuloides*, *Rh. nitidum*, *Rh. karatavicum*, *Rh. aulieatense*, *Rh. namanganicum*, перспективы использования.

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