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ANTHOXANTHUM ALPINUM (*POACEAE – AVENEAE*) IN THE MOUNTAINS FROM CROATIA TO MACEDONIA

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The present paper makes a contribution to knowledge of the distribution of *Anthoxanthum alpinum* in Croatia, Bosnia and Herzegovina, Montenegro, Serbia and Macedonia. The data from literature, the investigation of herbarium material and the results of field research reveal that *A. alpinum* is present in the area of the Dinaric mountain chain as part of alpine grassland vegetation at altitudes of 1400 m a.s.l. and above. The ecological optimum for the species in Croatia is in the stands dominated by *Nardus stricta*, but it has also been recorded in the *Festucetum pungentis* association and in mountain communities with *Deschampsia caespitosa*.

Key words: *Anthoxanthum odoratum agg.*, distribution map, Croatia, Bosnia and Herzegovina, Montenegro, Serbia, Macedonia

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Ovim radom daje se doprinos poznavanju rasprostranjenosti vrste *Anthoxanthum alpinum* u Hrvatskoj, Bosni i Hercegovini, Crnoj Gori, Srbiji i Makedoniji. Podaci iz literature, pregled herbarskog materijala i rezultati terenskih istraživanja pokazuju da je vrsta *A. alpinum* prisutna na Dinarskim planinama u sastavu planinske vegetacije travnjaka na nadmorskoj visini od 1400 m i više. Čini se da je ekološki optimum vrste u Hrvatskoj u sastojinama vrste *Nardus stricta*. Vrsta je također zabilježena u ass. *Festucetum pungentis* i u planinskim sastojinama vrste *Deschampsia caespitosa*.

Ključne riječi: *Anthoxanthum odoratum* agg., karta rasprostranjenosti, Hrvatska, Bosna i Hercegovina, Crna Gora, Srbija, Makedonija

INTRODUCTION

In this paper a closer look is taken at the distribution of *Anthoxanthum alpinum* Å. Löve et D. Löve in the Dinaride region of Southeast Europe.

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The area of *A. alpinum* is in the boreal, arctic and mountainous regions of Eurasia. The species has been noted in Greenland, and in many countries of Europe: Iceland, Great Britain, Norway, Sweden, Poland, Germany, Switzerland, France, Russia, the Czech Republic, Austria, Italy, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Macedonia, Bulgaria, Albania, Greece (ADLER *et al.*, 1994; BOGENRIEDER & STIETENCRON, 1985; CONERT, 1985; HEDBERG, 1967, 1986; HEß *et al.*, 1972; JOGAN, 2001; LAUBER & WAGNER, 1998; MARTINČIČ *et al.*, 1999; MELZER, 1986; OBERDORFER, 1994, 2001; ÖSTERGREN, 1942; PIGNATTI, 1982; ROTHMALER, 1994; ROZMUS, 1958; STRID & FRANZÉN, 1981; STRID & TAN, 1991; TEPPNER, 1969, 1970; TUTIN, 1980; VOGGESBERGER, 1998). Further east, the species has been noted in the region of Baikal Lake, Siberia, Iran, Mongolia, Manchuria, Korea and Japan (CONERT, 1985, 2000).

Anthoxanthum alpinum is an arctic-alpine plant. In Central and Southeast Europe it grows in the mountainous regions of the Alps, and in the Carpathians and the Dinarides.

According to WISSKIRCHEN & HAEUPLER (1998), *A. alpinum* has been found in literature under the following synonyms: *A. odoratum* var. *alpinum* Uechtritz 1822, *A. odoratum* var. *glaberrimum* Schur 1866, *A. odoratum* var. *glabrescens* Čelakovský 1867, *A. odoratum* subsp. *alpinum* (Å. Löve & D. Löve) Hultén 1958, *A. odoratum* subsp. *alpinum* (Å. Löve & D. Löve) B. Jones et Melderis 1964, *A. nipponicum* Hook. TEPPNER (1969) and MARTINČIČ *et al.* (1999) mentioned the same species under the synonym *Anthoxanthum nipponicum* Honda.

Due to the genetic relationship, WISSKIRCHEN & HAEUPLER (1998) categorised the species *A. alpinum* and *A. odoratum* s. str. within the broader species *Anthoxanthum odoratum* agg.

The plant species *A. alpinum* and *A. odoratum* differ in the degree of ploidy. *Anthoxanthum alpinum* is in most cases a diploid 2n=10, while *A. odoratum* is a tetraploid 2n=20 (HEDBERG, 1967; BOGERIEDER & STIETENCRON, 1985). There are also exceptions. Very rare autotetraploids of *A. alpinum* were also found in the French Alps (TEPPNER, 1970) and in Switzerland (HEDBERG, 1986), and diploids of *A. odoratum* were found in the Mediterranean and sub-Mediterranean regions of South Europe, as well as in Croatia (TEPPNER, 1970). Detailed taxonomic research in Sweden (HEDBERG, 1967) detected specimens of spontaneous triploids within *Anthoxanthum odoratum* agg.

Unlike the species *A. odoratum*, which is well-known and seems the most widely distributed species of the genus *Anthoxanthum* in Europe, *A. alpinum* was indicated by its different ploidy level for the first time only in 1942 (ÖSTERGREN, 1942), which was followed by a number of studies on its morphology, distribution, ecology, etc. Because of their great morphological likeness, *A. alpinum* has often been, and continues to be, confused with *Anthoxanthum odoratum* s. str., which makes the distribution of *A. alpinum* still insufficiently known.

Taxonomic research has indicated several morphological differences between *Anthoxanthum alpinum* and *A. odoratum* s. str. (Tab. 1) (HEDBERG, 1967; TEPPNER, 1969; BOGENRIEDER & STIETENCRON, 1985; BOGENRIEDER *et al.*, 1993). The most important

features for plant recognition are the fertile glume pubescence and leaf colour. The other features are not reliable as a means of determination: they are not sufficiently apparent, they overlap, and are only useful statistically as average values (TEPPNER, 1969).

Tab. 1. The morphological differences of *Anthoxanthum alpinum* and *A. odoratum* s. str.

	Anthoxanthum alpinum	*Anthoxanthum odoratum* s. str.
Glume pubescence	Alps (TEPPNER, 1969): the glume of the upper fertile flower is covered with short, rigid, patent hairs (scabridulae). The intensity of the glume pubescence can vary considerably. In some specimens the glumes are largely covered with hairs, while in others the hairs are found only in the glume tips. This property is visible only under magnification and is very reliable for correct species determination.	Alps (TEPPNER, 1969): the glume of the upper fertile flower is glabrous, i.e. never has short, rigid hairs. On the upper dorsal part of the glume, longer, tender ciliate hairs can occur similar to those of the two lateral sterile flowers. The occurrence of ciliate hairs is recorded in both species.
Length of awns	Alps (TEPPNER, 1969): the awn of the upper sterile lemma protrudes considerable over the tip of the spikelet.	Alps (TEPPNER, 1969): the awn of the upper sterile lemma is equal to, or, rarely, only slightly exceeds the tip of the spikelet.
Panicle length	Germany (BOGENRIEDER *et al.*, 1993): the panicle (inflorescence) length is 3.32 cm ± 0.54.	Germany (BOGENRIEDER *et al.*, 1993): the panicle (inflorescence) length is 4.42 cm ± 1.02.
Plant height	Germany (BOGENRIEDER *et al.*, 1993): the average height is 39.8 cm ± 5.6. Sweden (HEDBERG, 1967): the plant height ranges between 10 and 36 cm, with the maximum frequency at 22 cm.	Germany (BOGENRIEDER *et al.*, 1993): the average height is 55.2 cm ± 9.8. Sweden (HEDBERG, 1967): the plant height ranges between 12 and 38 (52) cm, with the maximum frequency at 28 cm.
Leaf colour	Alps (TEPPNER, 1969): the leaf is mat grey-green on the upper side, and shiny green-yellow on the lower side. However the difference in leaf colouration is not equally pronounced in different developmental stages.	Alps (TEPPNER, 1969): the leaves are matte grey-green on the both sides. This property is reliable for the determination of fresh plants.
Leaf convolution	Alps (TEPPNER, 1969): in developed plants the edges of the leaves convolute upwards. This phenomenon is most pronounced in dry and sunny weather. It also occurs with the torn-off leaves of younger plants whose laminae convolute within minutes of being removed from the plant.	Alps (TEPPNER, 1969): leaf convolution is not found in either the living specimens or the dried herbarium material.

Tab. 1. continued

	Anthoxanthum alpinum	*Anthoxanthum odoratum* s. str.
Uppermost leaf angle	Germany (BOGENRIEDER *et al.*, 1993): the uppermost leaf on the panicle-carrying stem lies at an angle of ca. 20°.	Germany (BOGENRIEDER *et al.*, 1993): the uppermost leaf on the panicle-carrying stem makes an angle of ca. 30°.
Sheath colouration	Germany (BOGENRIEDER *et al.*, 1993): in fully developed plants the basal sheaths are red in colour and rigid.	Germany (BOGENRIEDER *et al.*, 1993): the leaf sheaths mostly remain soft and green-yellow in colour.

THE DISTRIBUTION OF *ANTHOXANTHUM ALPINUM* IN THE MOUNTAINS FROM CROATIA TO MACEDONIA

During field research into Snježnik and Zavižan in Croatia in June 2001, *A. alpinum* was found in grassland vegetation. It was determined from literature that this species had already been found in Croatia by the Austrian botanist TEPPNER (1970), even though until this paper this find had not been recorded by Croatian botanists (DOMAC, 1984, 1994; ILIJANIĆ & TOPIĆ, 2000). The plant *A. alpinum* was also noted by TEPPNER (1969, 1970) in Bosnia and Herzegovina, Montenegro and Macedonia, which is also not listed in the available literature from these countries. The finding of the species in the field and in literature data provided a motive to review the herbarium specimens of *A. odoratum* agg. from the collections of the Botanical Institute of the Faculty of Science in Zagreb (Herbarium Croaticum recorded under ZA, and the Herbarium of Marija and Ivo Horvat recorded under ZAHO).

It is worth noting that the herbarium specimen collected by Stjepan Gjurašin on the peak of Visočica on Mount Velebit in 1899 is entitled *A. odoratum* L. var. *glabrescens* Čelak. subv. *montanum* Luschen. et Grabner, which is a synonym for the current name of *A. alpinum*. Thus, as early as the 19th century, this Croatian botanist had noticed that the mountain plants of the *Anthoxanthum* genus in Croatia looked somewhat different from the widespread *A. odoratum* s. str.

The presence of *A. alpinum* in Croatia does not come as a surprise, since the species was already noted in neighbouring Italy (PIGNATTI, 1982), Slovenia (MARTINČIČ *et al.*, 1999; JOGAN, 2001) and Austria (TEPPNER, 1969; MELZER, 1986; ADLER *et al.*, 1994), while the Hungarian Flora (TIBOR, 2000) and the Flora of Serbia (JOSIFOVIĆ, 1976) do not mention it.

Based on literature data (TEPPNER, 1969, 1970), the herbarium material and the results of field research, *A. alpinum* is recorded in eight localities in Croatia, three localities in Bosnia and Herzegovina, two localities in Montenegro, two localities in Serbia and eight localities in Macedonia. The list of the localities follows, and all the findings are also shown on the map (Fig. 1).

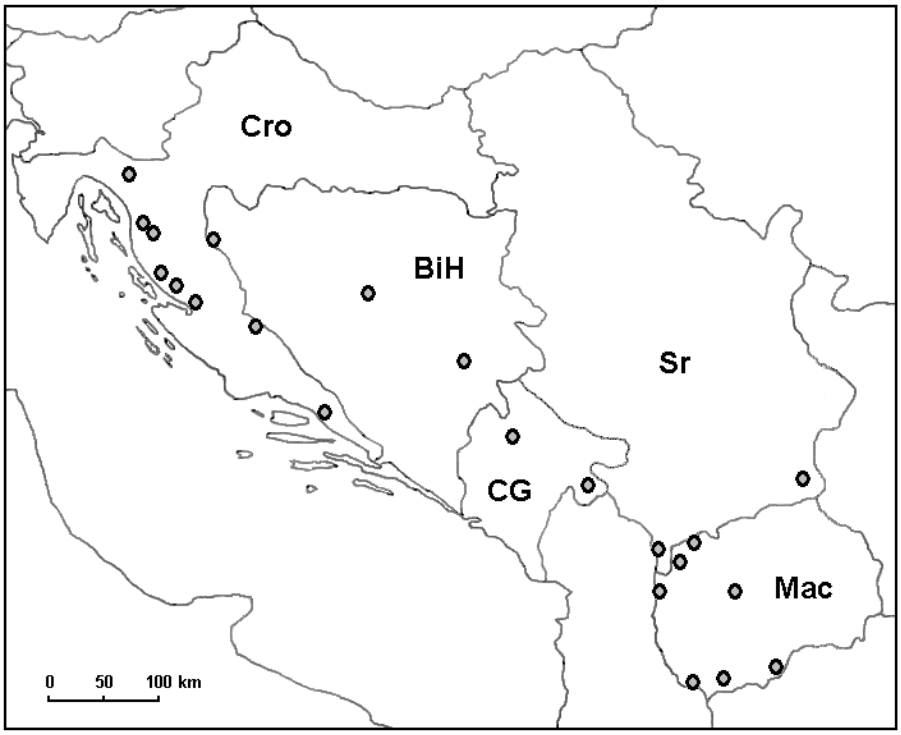

Fig. 1. The map of the distribution of *Anthoxanthum alpinum* in Croatia (Cro), Bosnia and Herzegovina (BiH), Montenegro (CG), Serbia (Sr) and Macedonia (Mac).

Localities in Croatia:

- Gorski kotar, Snježnik, southwest slopes, on the grassland, above the limestone, altitude 1400–1480 m a.s.l., 15/08/1969, TEPPNER (1970); the finding has recently been confirmed on the Snježnik grassland, altitude ca. 1490 m a.s.l., June 2001, Herbarium Z. Stančić, S. Essert, N. Zubović, ZA.
- North Velebit, Modrić Dolac near Veliki Zavižan, altitude 1477 m a.s.l., within the *Nardetum strictae* association, seed collected in 1969, TEPPNER (1970); the finding has recently been confirmed on the Zavižan grassland, altitude ca. 1500 m a.s.l., June 2001, Herbarium Z. Stančić, N. Zubović, S. Essert, ZA.
- North Velebit, Rajinac, altitude ca. 1600 m a.s.l., 16/07/1929, Herbarium of M. and I. Horvat, ZAHO.
- South Velebit, Veliki Stolac near Šugarska Duliba, altitude ca. 1400 m a.s.l., 05/07/1929 and 13/07/1929, with moss from the *Polytrichum* genus, Herbarium M. and I. Horvat, ZAHO.

– Velebit, peak of Visočica, altitude ca. 1600 m a.s.l., 03/06/1899, the species is recorded under the name *A. odoratum* L. var. *glabrescens* Čelak. subv. *montanum* Luschen. et Grabner, Herbarium Stjepan Gjurašin, ZA.
– South Velebit, Dušice under Sveto Brdo, altitude ca. 1700 m a.s.l., 01/07/1928, Herbarium M. and I. Horvat, ZAHO.
– The south easternmost part of Dinara, in doline, 18/07/1930, Herbarium M. and I. Horvat, ZAHO.
– Biokovo, Troglav Hill, south of St. Jure, grassland in the beech forest region, altitude ca. 1520 m a.s.l., 20/08/1969, TEPPNER (1970).

Localities in Bosnia and Herzegovina:

– Lička Plješevica, Dejanovića Bay near Zavalje, 13/06/1926, Herbarium M. and I. Horvat, ZAHO.
– Mount Vlašić, Devečani, plateau with experimental fields surrounded by peaks, 28/07/1956, Herbarium M. and I. Horvat, ZAHO.
– Jahorina, on the hill south of the Šator Hotel, meadow with *Nardus stricta*, north to northeastern exposure, altitude 1760–1800 m a.s.l., 25/08/1969, TEPPNER (1970).

Localities in Montenegro:

– Durmitor, Škrka, the *A. alpinum* species grows together with *Festuca pungens*, 08/08/1933, Herbarium M. and I. Horvat, ZAHO.
– Čakor, altitude ca. 2000 m a.s.l., Ehrendorfer and Burri 2111b and 2181g., TEPPNER (1969).

Localities in Serbia:

– Koritnik, 02/08/1936, Herbarium M. and I. Horvat, ZAHO.
– Besna Kobila, subalpine meadows, under the name *A. odoratum* L. var. *montanum* A. G., 14/07/1977, Herbarium N. Ranđelović, ZA.

Localities in Macedonia:

– Kobilino Polje – Velika Korabska Vrata, 23/07/1935, Herbarium M. and I. Horvat, ZAHO.
– Korab, Herbarium Dimonie, W, WU, TEPPNER (1969).
– Rudoka, Šutman, 26/07/1935, Herbarium M. and I. Horvat, ZAHO.
– Šarplanina, Kobilica, altitude 1800 m a.s.l., *A. alpinum* grows together with *Poa violacea*, 08/08/1934 and 27/07/1938, Herbarium M. and I. Horvat, ZAHO.
– Jakupica, Begovo, *A. alpinum* grows together with *Poa violacea*, 28/07/1934, Herbarium M. and I. Horvat, ZAHO.
– On the Stara Galičica slopes, 09/07/1939, Herbarium M. and I. Horvat, ZAHO.

– Pelister, peak, on rocky slopes, with a species of *Sesleria* genus, in the belt of low trees of *Pinus peuce*, NW exposure, slope 30°, altitude 2210 m a.s.l., 13/08/1937, Herbarium M. and I. Horvat, ZAHO.
– Kajmakčalan, on mountain pastures, altitude 1500 m a.s.l., Herbarium Dimonie, W, WU, TEPPNER (1969).

The determination of *A. alpinum* in multiple localities in Croatia, Bosnia and Herzegovina, Montenegro, Serbia and Macedonia provides a more complete picture of its area in the Southeast European region.

It is certain that the distribution of *A. alpinum* in the Dinaride region is far greater than is indicated by the localities on the map (Fig. 1). It can be seen from the data shown in this paper that this species has a continuous range along the Dinaride massif.

HABITAT

A. alpinum is a perennial and a hemicryptophyte. In the region of Central Europe, according to VOGGESBERGER (1998), it develops on alpine and subalpine grasslands, between dwarf shrubs, and in light forests. This is a plant of light, suited to open habitats. It grows on sites where snow remains for longer periods, and on sites exposed to erosion. It prefers moderately dry to moderately moist soil, and soil which is well aerated and poor to feebly rich in nutrients, with an average humus content. It prefers soil which is poor in calcium carbonate, with an acidic reaction.

The research of BOGENRIEDER *et al.* (1993) has shown that *A. alpinum* also grows on pastures, where grazing by cattle is detrimental to its development, although it prospers under sheep grazing.

The ecological optimum of the species in the Feldberg region of Germany lies within the *Leontodonto-Nardetum* association (BOGENRIEDER *et al.*, 1993). In relevés of this community, this species has a high occurrence frequency, and considerable cover values. In the same region, the species was also noted within the *Bartsio-Caricetum fuscae* association.

OBERDORFER (1994, 2001) records that in the Alps the species develops within the communities of the *Nardion*, *Caricion fuscae* and *Caricion curvulae* alliances, to an upper limit of 2350 m a.s.l.

CONERT (2000) writes that the species belongs phytosociologically to the communities of *Nardion strictae*, *Caricion curvulae* and *Caricion nigrae*.

A. alpinum was found on the grasslands of Zavižan (Velebit) in Croatia within the stands dominated by *Nardus stricta*, on fairly deep leached soil. It seems that the optimum of this species lies in that habitat type, because its abundance is greatest there. The species was also determined in the *Festucetum pungentis* association and in the mountain stands of *Deschampsia caespitosa*.

A relevé of a stand dominated by *Nardus stricta* with *A. alpinum* from Zavižan in Croatia is provided here as an example.

Locality: Zavižan, North Velebit, coordinates 44° 48′ 45′′ N, 14° 58′ 39′′ E; altitude 1498 m a.s.l.; exposure North; inclination 20–30°, date 22/07/2001, relevé area 25 m^2 (5x5 m).
Floristic composition: *Anthoxanthum alpinum* Å. Löve & D. Löve – 2, *Nardus stricta* L. – 5, *Festuca rubra* agg. – 3, *Carex pilulifera* L. – 2, *Potentilla erecta* (L.) Raeusch. – 2, *Campanula scheuchzeri* Vill. – 1, *Luzula campestris* agg. – 1, *Polygonum viviparum* L. – 1, *Crocus vernus* (L.) Hill subsp. *albiflorus* (Kit.) Asch. et Graebn. – +, *Hypericum* sp. – +, *Knautia dinarica* (Murb.) Borbás – +, *Picea abies* (L.) H. Karst. – +, *Ranunculus nemorosus* DC. – +, *Rhinanthus angustifolius* C. C. Gmel. – +, *Vaccinium myrtillus* L. – +, *V. vitis-idaea* L. – +, *Veratrum album* L. – +.

All recorded localities of *A. alpinum* in Croatia, Bosnia and Herzegovina, Montenegro, Serbia and Macedonia lie at altitudes of 1400 m a.s.l. and above. BOGENRIEDER & STIETENCRON (1985) and BOGENRIEDER *et al*. (1993) note that the border in the Feldberg region of Germany is at ca. 1300 m a.s.l., and at ca. 1400 m on the southern slopes. While researching *A. odoratum* and *A. alpinum* in Poland, ROZMUS (1958) determined that a rather sharp altitudinal border lies between their areas at 1200 m a.s.l. HEDBERG (1967) obtained somewhat different results in Sweden, on the basis of the analysis of a large number of specimens of both species. The diploid cytotype (*A. alpinum*) is not restricted only to the mountain region in Sweden, but is also widespread in the northern lowland part of the country. The tetraploid cytotype (*A. odoratum*) on the other hand is distributed in the southern part of the country. The border between these two cytotypes is not sharp, and both cytotypes also occur in each other's areas, even together in some recorded localities. As possible causes, HEDBERG (1967) lists seed distribution by traffic, hay transportation, commercial seed mixtures, and probably also the microclimatic situation in each specific habitat.

The question arises concerning which ecological factors cause the division of the areas of *A. alpinum* and *A. odoratum*, especially since *A. odoratum* is a stronger competitor than *A. alpinum* (BOGENRIEDER *et al*., 1993). The same authors hypothesise that the limiting factor could be the adaptation of *A. alpinum* to the long-lasting snow during winter.

In experimental research in the Czech Republic (FLEGROVÁ & KRAHULEC, 1999), tussocks of *A. alpinum* were transplanted onto an *A. odoratum* habitat and vice versa. The vitality and vegetative and generative reproduction ability of the plants were carefully monitored over two vegetational seasons. The results lead to the conclusion that *A. alpinum* cannot spread to the *A. odoratum* area because of the strong competition with other species. Namely, due to the climatic conditions, *A. alpinum* is evolutionally adapted to high stress, but to a low level of competition. On the other hand, the survival of *A. odoratum* in the *A. alpinum* area is limited by its inability to bloom and form seeds, and it is known that *A. odoratum* reproduces primarily via seed (ANTONOVICS, 1972).

In future research it would be interesting to determine the more precise altitude of the border between the species *A. alpinum* and *A. odoratum* in Southeast Europe, to investigate the precise distribution, and to examine the phytosociological affinity of *A. alpinum* and the ecological features of the habitat in greater detail.

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SAŽETAK

Anthoxanthum alpinum (*Poaceae – Aveneae*) u planinama od Hrvatske do Makedonije

Z. Stančić

Vrste *Anthoxanthum alpinum* i *A. odoratum* s. str., iako morfološki vrlo slične, razlikuju se arealom rasprostranjenosti, fitocenološkom pripadnošću i ekologijom. Vrsta *Anthoxanthum alpinum* je borealno-planinska biljka. U srednjoj i južnoj Europi razvija se samo u planinama, gdje raste na travnjacima i drugim otvorenim staništima. Vrsta *A. odoratum* s. str. je travnjačka vrsta nižih nadmorskih visina i više južnih geografskih širina. Velika morfološka sličnost tih dviju biljaka razlog je što je vrsta *A. alpinum* često određivana kao *A. odoratum* agg. Posljedica toga je nedovoljno poznat areal vrste *A. alpinum*. Ovim radom dat je prilog poznavanju raspros-

tranjenosti vrste *A. alpinum* na području Dinarida. Podaci iz literature, herbarski materijal i rezultati terenskih istraživanja pokazuju da je vrsta *A. alpinum* zabilježena na osam lokaliteta u Hrvatskoj, na tri lokaliteta u Bosni i Hercegovini, na dva lokaliteta u Crnoj Gori, na dva lokaliteta u Srbiji i na osam lokaliteta u Makedoniji. Na svim nalazištima vrsta je zabilježena u sastavu planinske vegetacije travnjaka na nadmorskoj visini od 1400 m i iznad. Ekološki optimum vrste u Hrvatskoj je u sastojinama vrste *Nardus stricta*, a opažena je i u asocijaciji *Festucetum pungentis*, te u planinskim sastojinama vrste *Deschampsia caespitosa*.