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Morphometrical studies on *Gymnospermium scipetarum* and *G. maloi* (Berberidaceae)

Zoltán Barina, Balázs Pintér & Dániel Pifkó

Summary: Morphometrical studies on three populations of two closely related taxa of *Gymnospermium*, *G. scipetarum* and *G. maloi*, have been carried out. Altogether 10 morphometric characters of 21 distinguishing characters listed in the description of *G. maloi* have been studied and the significance of 3 additional characters are discussed. In 4 cases, no significant differences in the average values of the studied characters have been found between the populations of *G. scipetarum* and *G. maloi*. In 8 cases, the average values of the characters differed significantly, but the characters were not suitable for distinction of the taxa because the averages are too close and their ranges overlap completely. The evaluation of the studied characters showed insignificant differences between populations of the two taxa and a large range of characters within a population and between populations of the same taxon in different habitats. As the description of *G. maloi* didn't provide clear distinguishing characters from *G. scipetarum* and the previously proposed characters proved to be unsuitable, we propose to treat *G. maloi* as a heterotypic synonym of *G. scipetarum*.

Keywords: *Gymnospermium scipetarum*, *G. maloi*, distinction, distribution, morphometrics, taxonomy

The genus *Gymnospermium* includes c. 11 species distributed from East Asia to South Europe. In Europe the genus is restricted to some areas of the continent and its taxa are threatened in all countries. Around 20 populations are known in S Ukraine scattered over an area of c. 20 000 km^2, with a decreasing number of specimens (Didukha 2009). In SE Romania the genus is restricted to a territory of c. 30 km^2 with 5 known localities (Doroftei & Mierlă 2007). In the Balkans, one locality is known from Montenegro where the occurring species is vulnerable (Petrović et al. 2008). Only two occurrences are reported from Central Albania and treated as endangered by Vanjgeli et al. (1995). In 2005 Barina & Pifkó (2009) found one population in South Albania and Tan et al. (2011) another one within a distance of c. 20 km. In Greece the genus is present on 6 localities (Tan et al. 2007, 2009), while it's apparently missing from Bulgaria, Serbia and Macedonia.

The European populations have been variously treated taxonomically. Tan & Mullaj (2001a) regarded all Balkan populations as subspecies of *G. altaicum*. Doroftei & Mierlă (2007) treated the Romanian populations as *G. altaicum* subsp. *odessanum*. Paparisto & Qosja (1976) described the Albanian populations as *G. shqipëtarum*, however, without denoting the holotype. Mayer & Pulević (Mayer 1983) made a valid description for the taxon referring to the diagnosis of Paparisto & Qosja (1976) and gave it the new name *G. scipetarum*, while Tan & Mullaj (2001b) created a new combination on subspecific level regarding it as infraspecific taxon of the wide-ranging *G. altaicum*. Phitos (2002) distinguished the Greek populations regarded previously as *G. altaicum* subsp. *odessanum*, on subspecific level as *G. altaicum* subsp. *peloponnesiacum* Phitos and Karl & Strid (2009) raised them to species level as *G. peloponnesiacum* (Phitos) Strid.

Tan et al. (2011) placed the 8 known Balkan populations into 3 species, *G. peloponnesiacum* from Greece, *G. scipetarum* from North Albania and Montenegro and outlined *G. maloi* as a new species from South Albania. The distinguishing characters between *G. scipetarum* and *G. maloi* are all overlapping quantitative characters of the vegetative parts of the tuberous plant and partly of the reproductive organs with only a few subjective characters (e.g. thickness of the leaf). Tan et al. (2011) carried out morphometric studies on *G. maloi* in the locus classicus, and presumably compared these data with herbarium specimens and published records of the other two taxa with undefined methods of comparison. The details of measuring the quantitative parameters of leaves and stems also remained unclear. According to the authors, only a few ('some') tubers were studied and cultivated. The reported differences of *G. maloi* and *G. scipetarum* in both tuber size and number of stems per tubers require confirmation.

Due to their distribution, Tan et al. (2011) treat all *Gymnospermium* populations in S Albania as *G. maloi* and those in N Albania and in Montenegro as *G. scipetarum*, regardless of their morphological characters. They even regarded *G. maloi* as closely related to *G. scipetarum* and emphasized the unique chromosome number (2n = 14) of *G. maloi*. However, the chromosome number of *G. scipetarum* is unknown.

The obscurity of the studied material and methods used during the separation of *G. maloi* from *G. scipetarum* and the hardly interpretable distinguishing characters suggest the need for detailed comparative studies on the two taxa.

Materials and methods

Three populations of *Gymnospermium* have been studied: one population belongs to *G. maloi* (according to Tan et al. (2011)) and two others to *G. scipetarum*. Instead of studying the loci classici of these taxa, we chose three easily accessible populations clearly distinguished by Tan et al. (2011) based on the locality. Avoiding possible influences of weather conditions of different years or of different phenophases, the measurements were done almost at the same time of the same year (Tab. 1).

At the time of measurement, all populations were at the end of flowering with only few flowers observable. All characters were measured or counted on 50 healthy specimens in all studied populations independently, i.e. one character was ascertained by one person and other characters were studied subsequently or parallel by another person. The height of the plant was measured from the soil surface to the top of the stem along the length of the stem. The diameter of stem was measured by caliper with an accuracy of 0.1 mm in halfway between the soil surface and the node of leaves. Length and width of the middle leaflet of the cauline leaf and length and width of the middle leaflet of the basal leaf were measured with an accuracy of 0.5 mm. Number of flowers was counted considering all pedicels with flowers, fruits or fallen flowers – thus avoiding the miscount in young racemes with crowded flowers. Length of the lower pedicel was measured on specimens with mature fruits unbending the pedicel. Length of the raceme was measured from the base of the uppermost cauline leaf to the top of the unbent raceme.

The diameter of tuber was measured by taking the largest width of the tuber of flowering specimens in mm and all tubers were photo documented. Only five tubers from Skënderbeut population, 6 from Çajup population and 4 from Shmil population were used because tubers are situated 20–50 cm below the ground level and hidden in the cavities of limestone rocks. Thus, the collection of more tubers could remarkably destroy the habitat of populations and cause

Table 1. Localities of *Gymnospermium* populations used for morphometric investigations.

Short name of locality	Locality	Date	Herbarium voucher number
Çajup (*G. maloi*)	Albania; District of Gjirokastër (Rrethi i Gjirokastrës); western slope of Mount Çajup above village Erind; in *Ostrya* scrubland, on limestone; 40.20078 N, 20.16222 E	27.04.2012	20257
Mali i Skënderbeut (*G. scipetarum*)	Albania; District of Kurbin (Rrethi i Kurbinit); Mali i Skënderbeut, above village Gallatë; in young *Quercus-Ostrya* forest, on limestone; 41.64477 N, 19.80897 E	25.04.2012	20196
Shmil (*G. scipetarum*)	Albania; District of Elbasan (Rrethi i Elbasanit); c. 1 km east of village Guri i Zi (Orpen); at the edge of oak forest; 41.21067 N, 20.13558 E	29.04.2012	20293

disadvantageous changes in population structure. Seed size was measured on dried seeds collected in Çajup (coll. no. 22196) and Shmil (coll. no. 22287) including the elaiosome into the length and using the largest width in the middle.

The type of leaf apex was measured and standardised by the length of the leaves, then categorised in three groups: emarginate, rounded or truncate and mucronate. The studied leaves were also photo documented. Voucher specimens are deposited in BP (Hungarian Natural History Museum).

The decision on the leaf texture ('thick, glaucous on both surfaces' vs. 'thin, less glaucous') was not objective enough to include into the investigation. Number of flowering stems and basal leaves can be studied only by digging out statistically enough plants and even then there would be a high failure rate because of the densely growing specimens with easily removeable leaves and stems. Thus, these characters were also not studied. Similarly, all floral characters were omitted because Tan et al. (2011) gave practically the same values for both taxa (e.g. petal length 3.5–4.5 mm for both taxa).

For the comparison of data set averages the u-test was used with a significance threshold of 0.05.

For characterising the habitats of *Gymnospermium* populations the dominant species of the habitats were listed instead of coenological relevés, because all the populations were crossed by roads.

Results

Morphometrical results

The height of the stem varies between 20 and 43 cm in Çajup population, between 20 and 40 cm in Skënderbeut population and between 24 and 43 cm in Shmil population. There is only a slight difference between the averages (28.98 cm, 28.8 cm and 30.72 cm) and even the average height is statistically the same in Çajup and Skënderbeut populations (Fig. 1).

The length of raceme varies between 9.0 and 25.0 cm in Shmil population, between 9.0 and 20.0 cm in Skënderbeut population and between 10.0 and 20.5 cm in Çajup population with averages 13.66 cm, 13.28 cm and 13.34 cm, without significant differences.

The average length of middle cauline leaves doesn't differ significantly between Çajup and Skënderbeut populations (3.88 cm viz. 3.84 cm) and it is only slightly longer in Shmil population (4.03 cm). The values vary between 2.6 cm and 5.6 cm in Çajup population, between 2.8 cm

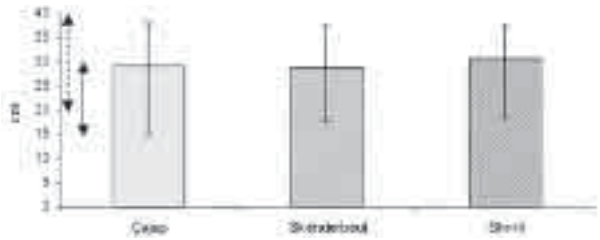

Figure 1. Average height of the stem in the studied *Gymnospermium* populations. Population belonging to *G. maloi* according to Tan et al. (2011) is plain while those belonging to *G. scipetarum* are striped. Lines show the minimum and maximum values in populations. Arrows on the left show the ranges given by Tan et al. (2011) for *G. maloi* (dashed line) and *G. scipetarum* (solid line).

and 5.0 cm in Skënderbeut population and between 2.75 cm and 6.0 cm in Shmil population. Similarly, the average width of the middle leaflet of cauline leaves doesn't differ significantly between Çajup and Skënderbeut populations (2.11 cm viz. 2.07 cm) while it is somewhat narrower (1.84 cm) in Shmil population. Also, the average width of middle basal leaflet doesn't show any significant difference between Çajup (2.38 cm) and Skënderbeut (2.37 cm) populations and the width ranges from 1.1 cm to 3.8 cm in Çajup population, 1.5 cm to 3.3 cm in Skënderbeut and 1.75 cm to 3.55 cm Shmil populations.

The average of the length of the middle leaflet of basal leaves (4.08 cm at Çajup, 4.48 cm at Skënderbeut and 4.61 cm at Shmil) differs significantly; however, the ranges of the three populations completely overlap (Fig. 2).

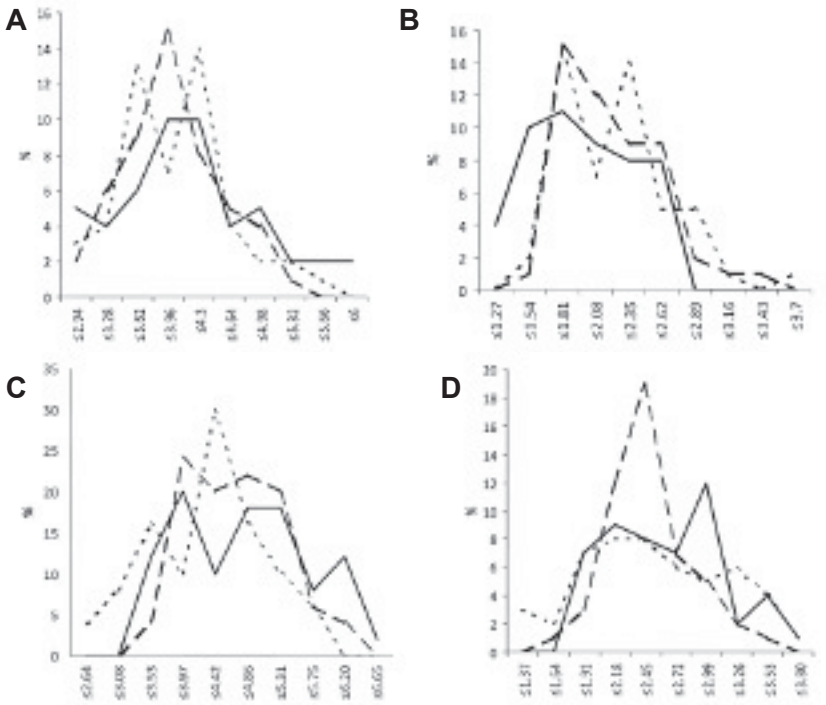

Figure 2. Leaf parameters of the studied populations. A – length of middle cauline leaflet (cm); B – width of middle cauline leaflet (mm); C – length of middle basal leaflet (cm); D – width of middle basal leaflet (mm). Solid line: Shmil population, short-dashed line: Çajup population, long-dashed line: Skënderbeut population.

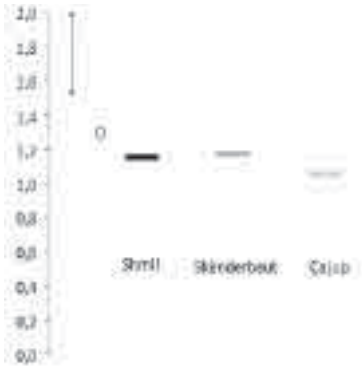

Figure 3. Leaf length : width ratio. Arrow with dashed line on the left show the range given by Tan et al. (2011) for *G. maloi*, while empty circle shows the value given for *G. scipetarum.*

As all leaf parameters were measured independently, an average leaf length : width ratio was calculated for all populations. The average rate is lower in all studied populations than the previously given single number for *G. scipetarum* (1.3) and remarkably less than the range given for *G. maloi* (1.5–2.0) (Fig. 3).

The maximum counted number of flowers was 19 in Shmil population, and 23 in both Çajup and Skënderbeut populations with the minimum number of 8 in all populations (Fig. 4). While the range resulted in Shmil population agrees with the values given by Tan et al. (2011) (8–18), that in Skënderbeut population differs from the values given for *G. scipetarum* and the range of Çajup population largely differs from the published values.

In all three populations leaves with rounded or truncate, emarginate and mucronate apex were found. The most frequent type was the emarginate apex and the less frequent one was the mucronate in Çajup and Skënderbeut populations and the rounded in Shmil population (Fig. 5).

Stem diameter shows a remarkable difference from the previously reported data. The average values for all populations are less than the reported averages for *G. scipetarum* and only 9 specimens from the Shmil population, 5 from the Çajup population and 1 specimen from the Skënderbeut population reached the lowest part of the given range for *G. maloi* and no specimen with a stem diameter falling into the middle or upper part of the range has been found in any population (Fig. 6).

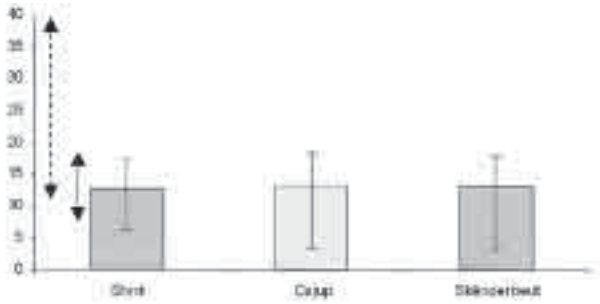

Figure 4. Numbers of flowers per racemes in the studied populations. Population belonging to *G. maloi* according to Tan et al. (2011) is plain while those belonging to *G. scipetarum* are striped. Lines show the minimum and maximum values in populations. Arrows on the left show the ranges given by Tan et al. (2011) for *G. maloi* (dashed line) and *G. scipetarum* (solid line).

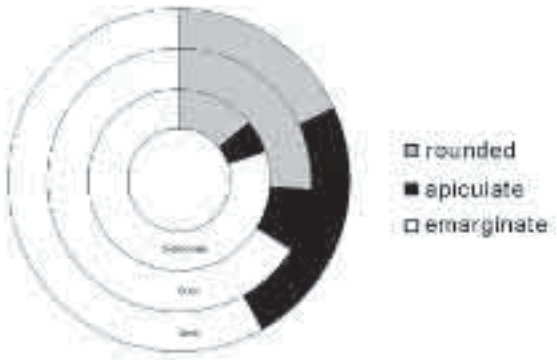

Figure 5. Types of leaf apex in the studied populations. Inner circle: Çajup population, middle circle: Skënderbeut population, outer circle: Shmil population.

The averages of the lower pedicel's length significantly differ in the studied populations. However, no gaps or breaks in the course can be detected. The range of value is wider in Shmil population than given for *G. maloi* and *G. scipetarum* and it is wider in Çajup and Skënderbeut populations than given for *G. scipetarum*. No values near the given lower value for *G. maloi* have been found in these two populations (Fig. 7).

The tuber diameter is significantly lower in Skënderbeut and Shmil populations than in Çajup population. However, the values completely overlap in the three populations and tubers with 4.5–6.9 cm diameter can be found in all populations (Fig. 8).

Seeds are mostly ovate in both Shmil and Çajup populations, but almost rounded seeds can also be found. While the width varies from 2.8 mm to 4.0 mm in Çajup population and from 2.9 mm to 4.2 mm in Shmil population, the length of seeds in Shmil population (5.5–7.5 mm) completely falls into the range of Çajup population, but 24% of the seeds in Çajup population are shorter (Fig. 9).

Habitats of studied populations

The Skënderbeut population is located in an altitude of c. 820 m, in oak forest zone, on limestone, where *Fraxinus ornus* L., *Ostrya carpinifolia* Scop. and *Acer obtusatum* Waldst. & Kit. are dominant

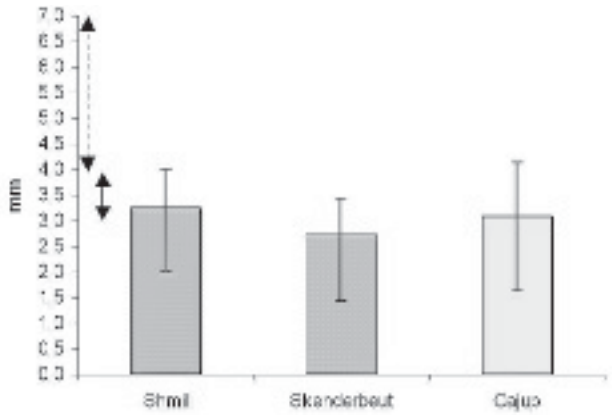

Figure 6. Stem diameter in the studied populations. Population belonging to *G. maloi* according to Tan et al. (2011) is plain while those belonging to *G. scipetarum* are striped. Lines show minimum and maximum values in populations. Arrows on the left show the ranges given by Tan et al. (2011) for *G. maloi* (dashed line) and *G. scipetarum* (solid line).

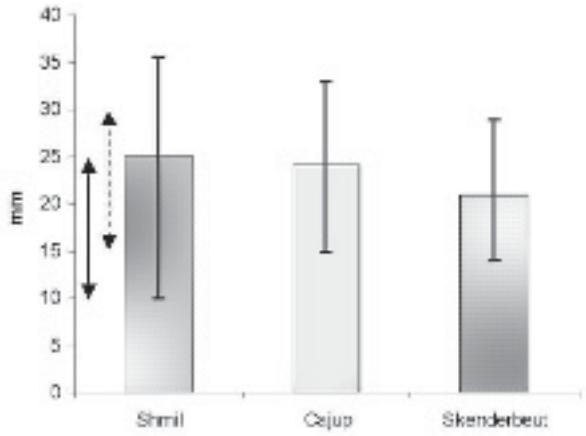

Figure 7. Length of lower pedicel in the studied populations. Population belonging to *G. maloi* according to Tan et al. (2011) is plain while those belonging to *G. scipetarum* are striped. Lines show minimum and maximum values in populations. Arrows on the left show the ranges given by Tan et al. (2011) for *G. maloi* (dashed line) and *G. scipetarum* (solid line).

trees and constitute an open association of c. 10–15 m height and c. 50% tree layer with *Ramonda serbica* Pančić, *Veratrum nigrum* L., *Doronicum columnae* Ten., *Mercurialis perennis* L., *Veronica chamaedrys* L., *Glechoma hirsuta* Waldst. & Kit., *Helleborus odorus* Waldst. & Kit., *Carex distachya* Desf. and *Hesperis laciniata* All. in the herb layer beyond *Gymnospermium*.

The vegetation of Çajup population on dolomitic limestone in an altitude of c. 1200 m (also in oak forest zone) is similar and presumably drier with very scattered small trees of *Fraxinus ornus* L., *Ostrya carpinifolia* Scop. and *Cornus mas* L. and a number of herbaceous plants like *Symphytum bulbosum* K.F. Schimp., *Anemone apennina* L., *Corydalis pumila* (Host.) Rchb., *Ranunculus ficaria* L., *Corydalis cava* (L.) Schweigg. & Körte, *Galanthus nivalis* L., *Saxifraga rotundifolia* L., *Euphorbia amygdaloides* L., *Asplenium ceterach* L., *Doronicum columnae* Ten., *Hedera helix* L., *Ajuga orientalis* L., *Mercurialis ovata* Sternb. & Hoppe and *Lamium garganicum* L. in the shady parts. In the population on Mt Frashri the plant occurs in a similar, but mainly closed woodland dominated by *Ostrya carpinifolia* Scop., *Acer obtusatum* Waldst. & Kit. and *Fraxinus ornus* L.

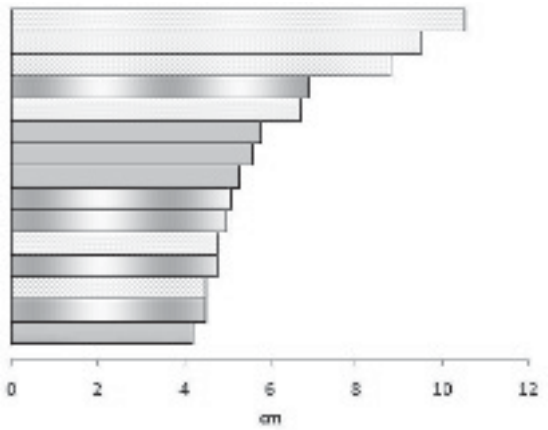

Figure 8. Diameter of tuber in the studied populations. Plain columns: Shmil population; dotted columns: Çajup population; striped columns: Skënderbeut population.

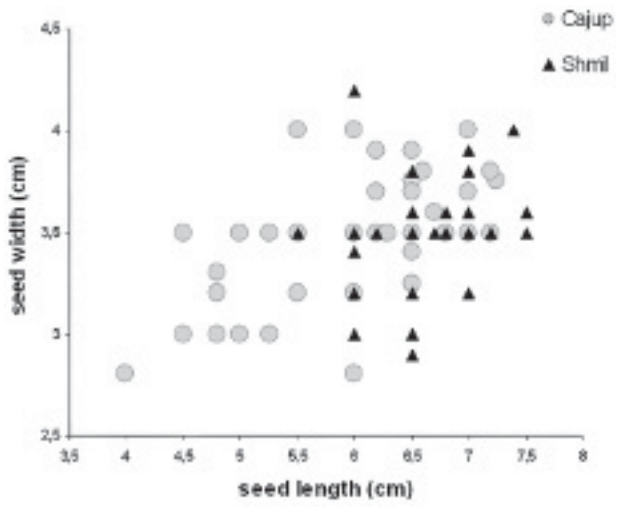

Figure 9. Seed size in the studied populations.

with a number of forest geophytes in the herb layer, like *Fritillaria graeca* Boiss. & Spruner, *Ornithogalum montanum* Cirillo, *Corydalis cava* (L.) Schweigg. & Körte, *Gagea minima* (L.) Ker-Gawl., *Gagea lutea* (L.) Ker-Gawl., *Corydalis solida* (L.) Clairv., *Galanthus nivalis* L., *Corydalis pumila* (Host.) Rchb., *Lilium martagon* L. and *Neotinea lactea* (Poir.) R.M.Bateman, Pridgeon & M.W. Chase together with *Lathraea squamaria* L., *Neottia nidus-avis* (L.) Rich., *Lamium garganicum* L. and *Luzula forsteri* (Sm.) DC.

The population at Shmil has an extent of c. 2.5 ha in an altitude of 1100 m, in beech forest zone, where in the closed forest *Fagus sylvatica* L. and *Acer obtusatum* Waldst. & Kit. are dominant with scattered specimens of *Prunus avium* (L.) L. and *Abies alba* Mill. The herb layer is rich in mesophilous forest species like *Anemone nemorosa* L., *Cardamine bulbifera* (L.) Crantz, *Mercurialis perennis* L., *Galanthus nivalis* L., *Scilla bifolia* L., *Primula vulgaris* Huds., *Erythronium dens-canis* L. and *Stellaria holostea* L. together with plants of drier habitats like *Doronicum columnae* Ten., *Potentilla micrantha* Ram. ex DC., *Melittis melissophyllum* L., *Geum urbanum* L. and *Helleborus odorus* Waldst. & Kit. A number of *Gymnospermium* specimens also occur in forest edges and clearings, where *Asphodelus albus* Mill., *Inula oculus-christi* L., *Carex hallerana* Asso and *Artemisia alba* Turra are dominant herbs.

Chorological records of *Gymnospermium scipetarum* and *G. maloi*

Until now, 8 localities of *Gymnospermium* are known from Montenegro and Albania (Fig. 10). However, the localities are listed under various names what causes confusion.

1. Albania, Rrethi i Krujës, Mali i Skënderbeut (Paparisto & Qosja 1976: 98). The studied 'Skënderbeut' population. Recorded coordinates: 41.64479 N, 19.80976 E; 41.64479 N, 19.80976 E; 41.64477 N, 19.80897 E; 41.64477 N, 19.80897 E. (*G. scipetarum*)

2. Albania, Mali i Shalqinit (Cëruje) (Paparisto & Qosja 1976: 98). The studied 'Shmil' population. Recorded coordinates: 41.21067 N, 20.13558 E; 41.21166 N, 20.13627 E; 41.21148 N, 20.13664 E; 41.21006 N, 20.13696 E. (*G. scipetarum*)

3. Albania, Kruja district, Mt. Sari Salltek. Tan et al. (2011: 9) gave coordinates: 41°31' N, 19°48' E and described the habitat as 'in clearings of open woodland'. In 2012 we attempted

unsuccessfully to find the population. The coordinates show a road with young beech forest on its sides and the attempts also remained unsuccessful in the opposite hillside with open woodland. (*G. scipetarum*)

4. Montenegro (Crna Gora), "in declivitate septentrionali montis Rumija supra pagum Virpazar, 850 m s.m." (Mayer 1984). Type locality of *G. scipetarum*.

5. Albania, District of Tepelenë (Rrethi i Tepelenës), Griba Mts (Mali i Gribes): on the west side of the ridge between the peaks maja e Trushnices (1815.2 m) and Komtiri (1224 m), above village Zlezi; 40.297280 N, 19.906210 E, 1190 m (Barina & Pifkó 2009: *G. scipetarum*.). This locality was erroneously cited by Tan et al. (2011) as 'Mt. Kendervica' and revised for *G. maloi* without seeing any living or herbarium specimen.

6. Albania, Mt. Picari, 40°12' N, 20°02' E (Tan et al. 2011: 8). Type locality of *G. maloi*.

7. Albania, District of Gjirokastër (Rrethi i Gjirokastrës), Mts Mali i Gjerë, eastern slope of maja e Frashrit (1789 m). Many subpopulations from *Ostrya carpinifolia* woodlands to rocky grasslands. 40.09268 N, 20.09539 E; 40.09172 N, 20.09355 E; 40.09132 N, 20.09267 E; 40.08823 N, 20.07718 E; 40.09122 N, 20.06948 E; 40.09147 N, 20.07642 E.

8. Albania, District of Gjirokastër (Rrethi i Gjirokastrës), western slope of Mount Çajup above village Erind. In *Ostrya* scrubland, on limestone; 40,20078 N, 20,16222 E. The studied 'Çajup' population.

Discussion

The investigation of 13 morphometrical characters of two *Gymnospermium* taxa resulted in a remarkable difference between formerly published records and newly recorded data for the ratio of length and width of the middle basal leaflet, for the number of flowers and for the stem

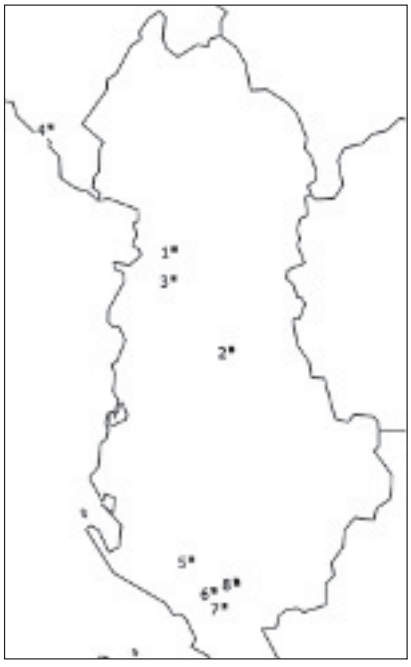

Figure 10. Known localities of *Gymnospermium* from the Western Balkan Peninsula.

diameter. The measured values of these characters are out of the range given by Tan et al. (2011) for *G. maloi* and *G. scipetarum*.

Average values of stem height, length and width of middle leaflet of cauline leaves, width of middle basal leaflet and the length of raceme don't show statistically significant differences in the studied Çajup and Skënderbeut populations and their ranges completely overlap. Leaf size of spring geophytes can largely depend on the age of the individuum (Rees 1969, Werger & Huber 2006), on weather condition (Yoshie & Fukuda 1994), on light condition of the plot. The time of study also greatly affects the measured values even of the same individuum studied in sprouting, mature or decaying state (Lapointe 2001). Thus, the apparent distinction between populations found by Tan et al. (2011) may have resulted from different weather conditions (material was collected from 1974–2010), from different dates of collections and thus different developmental stages of the specimens collected as well as from the comparison of specimens from natural habitats or garden cultivation with dried herbarium specimens.

According to the previous records, the leaf apex seemed to be an important distinguishing character between *G. scipetarum* and *G. maloi*. We found that all emarginate, rounded and mucronate apices occur in populations of both taxa and the emarginate apex is clearly the most frequent (58–80%) in all populations. This character is also not appropriate for distinction of *G. scipetarum* and *G. maloi*.

The stem diameter was described by Tan et al. (2011) to be a non-overlapping distinguishing character for the two taxa (3–4 mm for *G. scipetarum* and 4–7 mm for *G. maloi*). The maximum values of our results are remarkably lower or fall into the lower part of the ranges (2.0–4.5 mm). The stem diameter can remarkably change during drying and pressure, thus the comparison of values measured on herbarium specimens and on living specimens may cause an artefact.

We couldn't find clear differences in tuber size between populations (and thus taxa). Though the largest tubers all belong to Çajup (*G. maloi*), the smallest tubers are in both Çajup and Skënderbeut (*G. scipetarum*) populations. The measurement of only 6 tubers of *G. maloi* and 5 of *G. scipetarum* provide only tentative results. However, more samples are unjustified to dig out because of their deeply hidden character. Undoubtedly, size of tuber largely depends on the age of the individuum and is influenced by the structure of limestone base, because tubers are mostly positioned in smaller or larger cavities of limestone 15–50 cm below the ground level. Because of the rocky habitats of all *Gymnospermium* populations in Albania and the effect of garden conditions for plant growing (Tincker 1938, Halevy 1990), the comparison of tubers of wild and cultivated plants, or herbarium specimens (see above) can cause unexpected artefacts.

Similarly to tuber diameter, the number of flowering stems per tuber can only be examined by digging out and destroying the plants. Moreover, during this procedure a number of stems can break off and their origin cannot be determined because of the density of tubers in the soil. Therefore, herbarium specimens surely show less stems than originally attached to the tuber which can cause an underestimation of stems based on herbarium material, while estimation of stems without digging out carefully the whole plant can involve the stems of neighbouring tubers and overestimate the number. Moreover, the number of stems per bulb can be a highly variable character from year to year (Barkham 1980) as well as the size (age) of bulbs (Kim et al. 1998), what makes it an inappropriate character for distinguishing species.

We found a higher diversity of quantitative characters within populations than used for the distinction of the two species and the differences among populations proved to be much less than the ranges within populations.

Tan et al. (2011: 12) identified a difference in habitat type between *G. scipetarum* and *G. maloi*: *G. maloi* is a plant of '*Quercus-Ostrya*' forest and *G. scipetarum* is a plant of beech or hop-hornbeam forests. The southern populations all occur in oak forest zone in woodlands dominated by thermophilous trees and the beech zone (and even beech itself) is missing from these mountains. The northern populations partly also occur in '*Quercus-Ostrya*' woodlands, but these woodlands are connected with beech woodlands, thus the plants can occur solely in '*Quercus-Ostrya*' stands (Krujë), in both '*Quercus-Ostrya*' stands and beech woodlands (Skënderbeut, Rumija) or solely in beech woodlands (Shmil)

A shift to Çajup and Skënderbeut populations can be detected in the Shmil population which has slightly smaller leaves and fewer flowers. This difference may be caused by the different shady habitat of the population in contrast to the open and dry habitat of the other populations.

In our comparative study no clear characters have been found suitable for distinguishing the *Gymnospermium* populations divided by Tan et al. (2011) into two taxa and no clear difference in habitat-preferences of the taxa have been confirmed. Not even minor reliable differences between the described taxa have been found. The characters previously described for the distinction of *G. maloi* are all highly influenced by habitat, weather and light conditions. They showed a larger diversity within a population than that supposed within taxa. Based on the above mentioned reasons and the inadequacy of the method comparing wild populations with cultivated specimens and herbarium specimens of different years used for dividing the *Gymnospermium* populations into two taxa, we propose to treat all known *Gymnospermium* populations from the western part of the Balkan Peninsula within one taxon. Consequently, *G. maloi* should be treated as a heterotypic synonym of *G. scipetarum*.

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Addresses of the authors:

Zoltán Barina (corresponding author)
Dániel Pifkó
Department of Botany
Hungarian Natural History Museum
P. O. Box. 222
1476 Budapest
Hungary
E-mail: barina@bot.nhmus.hu
pifko@bot.nhmus.hu

Balázs Pintér
Laboratory of Molecular Neurobiology
Institute of Experimental Medicine
Hungarian Academy of Sciences
Szigony utca 43
1083 Budapest
Hungary
E-mail: pinyobe@gmail.com