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## The Balkan endemic *Centaurea grbavacensis* (Asteraceae) — New evidence on variation, typification, and distribution, with karyological studies

### Abstract

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*Centaurea grbavacensis*, a Balkan endemic species of North Macedonia and N and C Greece, has been thoroughly studied throughout its distribution, based on living, photographic and herbarium material as well as literature. It was found that all forms of the species grow in both Greece and North Macedonia. We studied the variation of the main morphological features, especially for the Mt. Olympos (Greece) subpopulations. It was found that spine length of the involucre phyllaries varies significantly within individuals and subpopulations, irrespective of flower colour (the typical colour is dark brownish purple, whereas in *C. grbavacensis* f. *lutea* it is yellow). Therefore, *C. grbavacensis* f. *spinescens* cannot be maintained as a separate taxon. A karyological study of the two colour forms was performed, and karyotype photos are provided for the first time. The chromosome number,  $2n = 2x = 22$ , was confirmed and the karyotype morphology is mentioned.

*Key words:* *Centaurea*, endemism, taxonomy, variation, distribution, karyology.

### Introduction

Rohlena (1935) was first to recognize *Centaurea grbavacensis* (Rohlena) Stoj. & Acht. as a new taxon, initially described it as a variety of *Centaurea immanuelis-loewii* Degen, which also had been based on plants from southern former Yugoslavia, known today as North Macedonia.

*Centaurea grbavacensis* belongs to *C.* sect. *Acrocentron* (Cass.) DC., a section of c. 100 species mainly found in the Mediterranean region (Font & al. 2002, 2009). Micevski (1975), in his relevant publication on some species of the section, treated the variation of *C. grbavacensis* by formally recognising three formae: f. *grbavacensis* (Fig. 1), f. *spinescens* Rohlena (Fig. 2) and f. *lutea* Micevski (Figs 3 and 4). The said variation is not surprising in view of the relatively wide distribution of the species.

*Centaurea grbavacensis* is a characteristic and attractive Balkan endemic. The most noticeable and interesting feature of its variation is flower colour. *C. grbavacensis* was



Fig. 1. The lectotype (PRC 452963) of *Centaurea grbavacensis* f. *grbavacensis*, designated here.



Fig. 2. The holotype specimen (PRC 452966) of *Centaurea grbavacensis* "f. *spinescens*" Rohlena.

considered endemic to North Macedonia until 1976 (Dostál 1976). It has been well studied throughout its scattered distribution in North Macedonia and all its forms (as recognized by Micevski 1975) have often been found to coexist in the same local population (Map 1, Appendix 1). The yellow flower colour, first informally referred to as *Centaurea immanuelis-loewii* "fl[ore] luteo" by Soška (1938: 230), was known, so far, only in the northernmost distribution area of the species (Map 1, Figs 3 and 4), where it grows side by side with the typical colour form (Map 1, Fig. 5).

*Centaurea grbavacensis* is also found in central and northern Greece (close to the border with North Macedonia). The oldest herbarium specimen of the species from Greece, collected on 18.6.1930 by Erik Wall at "Kleinovo (Kapeo)", [South Pindos, locality located 35 km SW of Kalambaka] (Lundberg 2022; specimen [S No S10-6204] currently unavailable for study). In 1976, Voliotis, while studying the flora of Mt. Voras, collected *C. grbavacensis* on 15.6.1976 (*Voliotis 1186*: Voliotis 1979: 214); Greuter, in 1976, found it on Mt. Tzena (*Greuter 14108*, 30.7.1976) and Strid & Kjellson, again in the same year 1976, on the north-eastern foothills of Mt. Olympos (Strid 1980).

Several additional records were later added from Mt. Tzena (Strid & Papanikolaou 1981; Strid & Andersson 1985; Wagenitz & Gamal-Eldin 1985; Gamal-Eldin & Wagenitz 1991; Chasapis & al. 2016, 2020; Chasapis 2017) and from Mt. Olympos (Gamal-Eldin & Wagenitz 1991; Routsis 1993; Routsis & Georgiadis 1999; Pappas 2020).



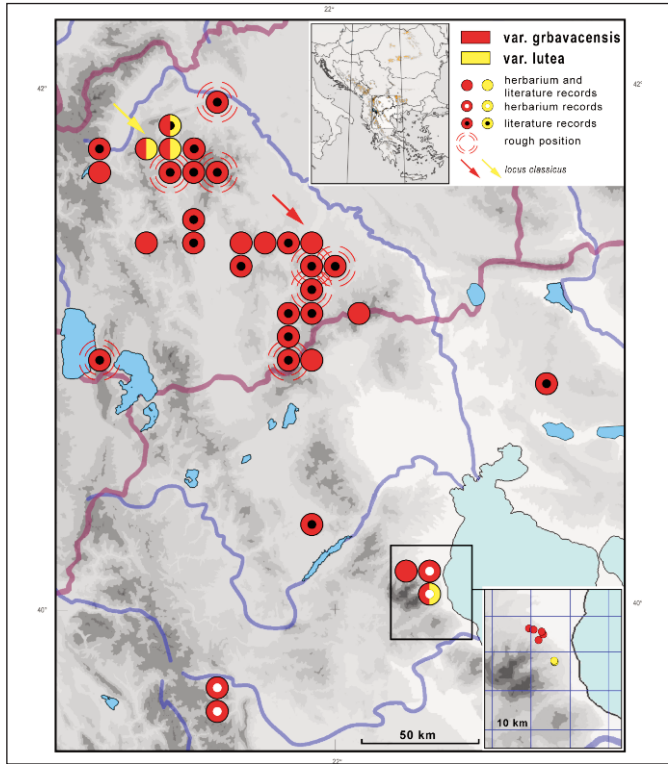
Fig. 3. The herbarium sheet (BEOU 37322) of *Centaurea grbavacensis* f. *lutea* collected by N. Košanin (label written by T. Soška), only 2.5 km from Kapina (cited in Soška 1938, as “*Centaurea grbavacensis* fl[ore] flavo”).



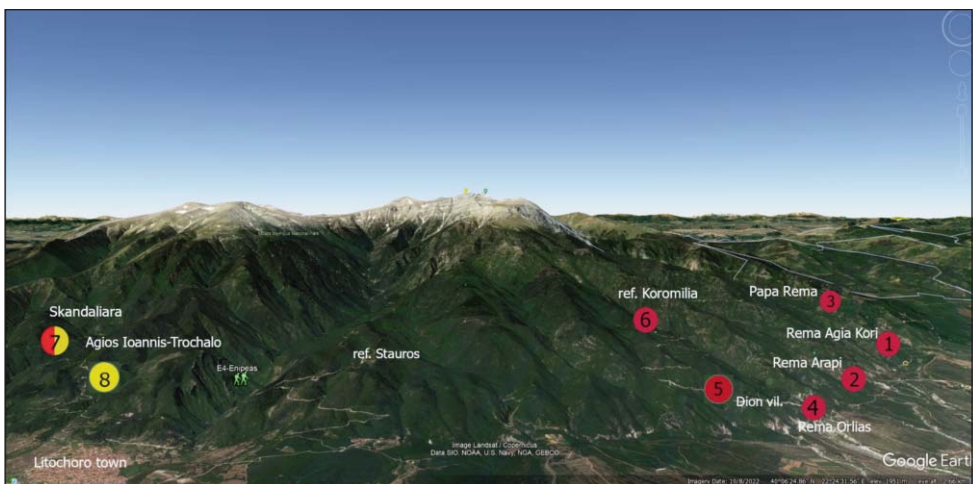
Fig. 4. Holotype specimen of *Centaurea grbavacensis* f. *lutea*, collected by Micevski at Gostivarsko, Suva Gora, Jul. 1968 (MCF).

There is also a reference from Langadá (Symes 2019), close to Kalochori (Prov. Thessalonikis), which, however, we have not yet verified. All the above records are of the typical colour form of *C. grbavacensis*; up to date the spiny form (“f. *spinescens*”) is not recorded to occur in Greece.

In 2015 Ms Themis Nasopoulou, member of the Olympus National Park Management Agency, together with Assist. Prof. G. Fotiadis, found plants of *C. grbavacensis* with yellow flowers on Mt. Olympos, at the place named Skandaliara, Agios Ioannis – Trochalo, (Figs 6a & 6b); this was the first time such plants were observed in Greece. In the same locality, Ms Nasopoulou also found individuals with the typical flower colour (Figs 6c & 6d). Photographs of flower heads from Mt. Olympos, showing both colours together, were posted on the Internet in May 2016 by Vasileiadis (2016). Several more recent photo posts of yellow-flowered *C. grbavacensis* plants from the same locality on Mt. Olympos followed, as Eleftherios Kipopoulos (co-author of this paper) found and studied *C. grbavacensis* in several localities on that mountain (Map 2).



Map 1. Total geographical distribution of *Centaurea grbavacensis*.



Map 2. Distribution of *Centaurea grbavacensis* on Mt. Olympus, Greece: red circles stand for the typical form, yellow circles for f. *lutea*. Locality numbers (see Appendix 1) are shown within the circles.

## Material and Methods

Herbarium material from the whole distribution range in North Macedonia and north and central Greece was used (Maps 1 & 2), kept in the herbaria ATH, ATHU, B, BEO, BEOU, C, EGE, G, GOET, HUTH, K, LD, M, MCF, P, PRC, S, SKO, UPA, WU (abbreviations according to Thiers 2022+) and in the private herbarium “*Phitos & Kamari*” (deposited at UPA). The cited records from living and herbarium material or from literature are listed in Appendix 1. Distribution is mapped using a  $10 \times 10$  km squares grid, based on the Military Grid Reference System (MGRS) of Greece (Lampinen 2001).

Living plants kept in cultivation at the University of Patras, originating from Mt. Olympos, were used for karyological study, which followed is the classical squash technique by Östergren & Heneen (1962), with some small modifications (especially in the pretreatment: 00.03% v/w aqueous 8-hydroxyquinoline, in 5 °C, for 3h). Details of the squash technique and the karyotype morphology have been reported in previous papers (Kamari 1992; Samaropoulou & al. 2013; Bareka & al. 2015).



Fig. 5. Specimen of *Centaurea grbavensis* (in Flora Exsiccata Macedonica) with two individuals belonging to the two colour forms of the species, collected by Teofilovski (30.5.1999) in Suva Gora, North Macedonia.

## Results and Discussion

### Variation

The most noticeable variable features in *Centaurea grbavacensis* are flower colour, size of the apical spines of the involucre bracts (phyllaries) of the capitula (flower heads), especially of the outer middle phyllaries, as well as the segment shape of the basal leaves (simple-intact or sickle-shaped). In particular, the colour of the flowers varies significantly. The typical flowers have dark brownish-purple colour and appear to occur in almost all species subpopulations or populations (Maps 1 & 2, Figs 1, 2, 5, 6c & 6d, 7, 8).

Early literature (Soška 1938: 230) and herbarium material from North Macedonia show that individuals of *Centaurea grbavacensis* with yellow flowers are scattered in three very close localities or subpopulations in the northern part of the species distribution (Map 1). For example, according to Teofilovski (2011) both forms abound in the lower parts of the Treska gorge (Fig. 5), while upstream from the village Zdunje *f. lutea* is prevalent and on the peak Visoka Čuka (Zdunje) that variant no longer exists. On the other hand, in most of the populations or subpopulations scattered in North Macedonia, individuals of otherwise typical *C. grbavacensis* vary in the length of their phyllary spines (Fig. 2, Map 1).

In Greece, the most populations consist of typical plants with dark purplish-brown flowers only. Additionally, on Mt. Olympos, where several scattered subpopulations of *Centaurea grbavacensis* occur (Map 2), we also observed predominance of the typical flower colour (*f. grbavacensis*), but considerable variation in phyllary spine length (Fig. 8). However, on Mt. Olympos, in two subpopulations in the SE part of its range plants with yellow flowers (*f. lutea*) are prevalent (Figs 6a & 6b & 9); in subpop. no 8 (Map 2), not individuals with dark brownish-purple flowers have so far been observed.

It is noteworthy that from the abundant living and photographic material of *Centaurea grbavacensis* studied from Mt. Olympos, we observed that plants with spiny phyllaries (with spines up to 10 mm long, corresponding to "*f. spinescens*") coexist with spineless ones in several localities, irrespective of flower colour (Fig. 6a-b, Fig. 8a-d).

We conclude that, as the length of the phyllary spines varies significantly among the individuals of both colour forms of the species, "*f. spinescens*" cannot be considered as a separate taxon.

With regard to the variation of the segment shape of the basal leaves, our observation on living plants from Mt. Olympos, and of photographs of herbarium specimens (notably the type material of *C. grbavacensis*) and can be summarised as follows: individuals with flowers of brownish-purple colour tend to have basal leaves with simple (entire), falcate or straight segments spreading at a right angle from the leaf rachis. Conversely, individuals with yellow flowers have basal leaves with toothed or deeply lobed segments, but sometimes a few with an undivided lamina (Figs 1 & 2). However, as the mentioned differences in basal leaf shape are not significantly diagnostic for the two different flower colour types.

On Mt. Tzena, *Centaurea grbavacensis* coexists with *C. kotschyana* Heuff., with which it shares the dark brownish-purple flower colour, but which is easily distinguished by a combination of stem and leaf characters: However, *C. kotschyana* has leafy stems and undivided basal leaves, whereas in *C. grbavacensis* the stems are consistently leafless stem and the basally crowded leaves are pinnatisect to bipinnatisect, with numerous linear or linear-lanceolate ultimate segments arranged in different planes.



Fig. 7. Natural habitat (a) and capitula (b and c) of the typical form of *Centaurea grbavacensis*, from Mt. Olympos (Map 2, subpop. no. 6), at the Refuge Koromilia (photos by E. Kipopoulos).

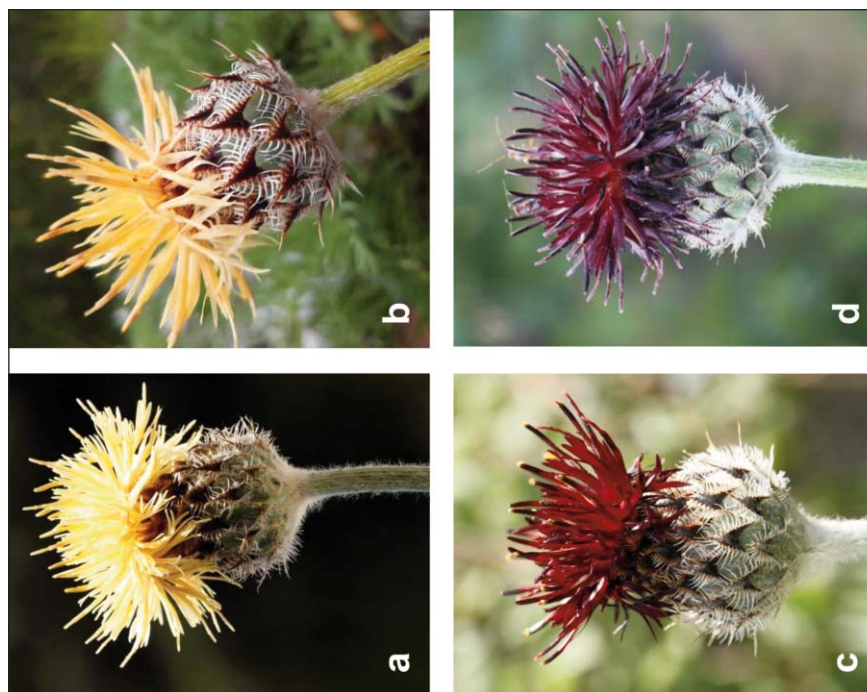


Fig. 6. Capitula of *Centaurea grbavacensis*, individuals from Mt. Olympos (Map 2), at place named Scandaliara (subpop. no. 7): a and b, f. *lutea*; c and d, f. *grbavacensis* (photos by Th. Nasopoulou).



Fig. 9. Plants (**a** and **b**) in their natural habitat and capitulum (**c**) of *Centaurea grbavacensis* f. *lutea*, from Mt. Olympos (Map 2, subpop. no. 8) (photos by E. Kipopoulos).

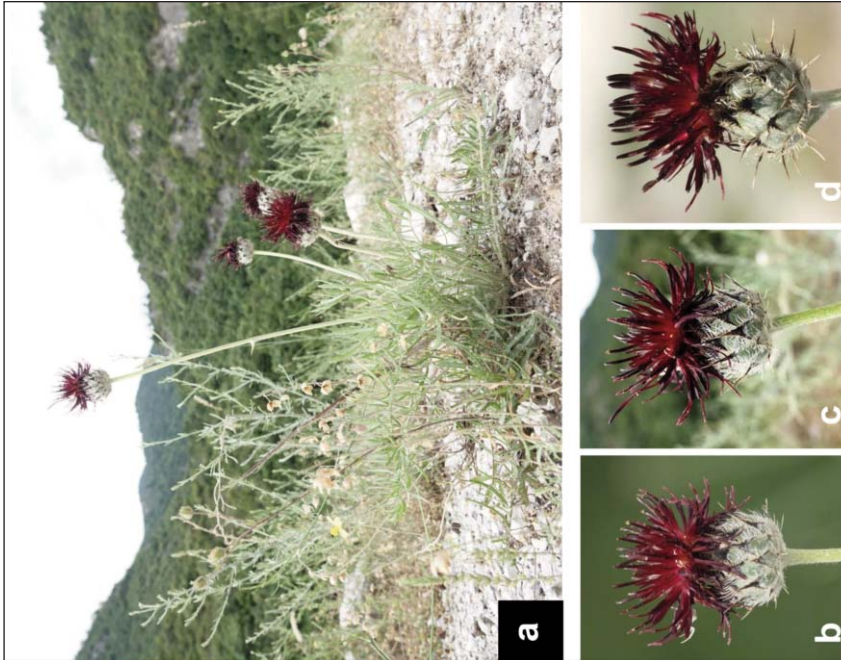


Fig. 8. Natural habitat (**a**) and capitula (**b**, **c**, **d**) of the typical form of *Centaurea grbavacensis*, from Mt. Olympos (Map 2, subpop. no. 2), varying much in the length of phyllary spines (photos by E. Kipopoulos).



According to Micevski (1975), *Centaurea grbavacensis* is also similar to *C. immanuelis-loewii* Degen (both having dark brownish-purple flowers); he regards all Yugoslav (North Macedonian) records of the latter as belonging to the former.

In Greece, the two species *Centaurea grbavacensis* and *C. immanuelis-loewii* never grow together and can be distinguished easily by their stems and habit. *C. immanuelis-loewii* has numerous branched stems with leaves, while *C. grbavacensis*, consistently, has unbranched, leafless stems.

### Typification of *Centaurea grbavacensis*

*Centaurea grbavacensis* (Rohlena) Stoj. & Acht., Stud. Centaur. Bulg.: 39. 1935 ≡ *Centaurea immanuelis-loewii* var. *grbavacensis* Rohlena in Věstn. Král. České Společn. Nauk. Tř. Mat. Přír. 1935(3): 4.1935 ≡ *Colymbada grbavacensis* (Rohlena) Holub in Preslia 46: 228. 1974.

= *Centaurea atropurpurea* var. *soskae* Stoj. & Acht., Stud. Centaur. Bulg.: 40. 1935 ≡ *Centaurea atropurpurea* subsp. *soskae* (Stoj. & Acht.) Dostál in Bot. J. Linn. Soc. 71: 195. 1976.

= *Centaurea immanuelis-loewii* [var. *grbavacensis* Rohlena] f. *spinescens* Rohlena in Věstn. Král. České Společn. Nauk. Tř. Mat. Přír. 2: 4 (1935), **syn. Nov.**

Lectotype: (Designated here by Phitos, Niketić & Kamari): North Macedonia (FYRoM): “Macedonia. In collibus supra Grbavac, pr. Prilep (Brno)”, 23.7.1923, *Vandas* (PRC 452963!). — Fig. 1. ([http://herbarium-prc.natur.cuni.cz/jacq-viewer/viewer.html?rft\\_id=prc\\_452963](http://herbarium-prc.natur.cuni.cz/jacq-viewer/viewer.html?rft_id=prc_452963); Isolectotypes: PRC 452961!, 452964!, 452965!, 452966!).

*Perennial herb. Stems* usually 1–2, rarely many, 20–50 cm tall, erect, rarely with secondary stems, always leafless, woody at the base, usually glabrous above. *Basal leaves* petiolate, pectinate, 8–35 cm long, sparsely arachnoid, with numerous pairs of usually falcate segments (10-)15–55 × (1-)1.5–4.5 mm, subentire or dentate or lobed. *Phyllaries* in several series, 4–8 mm broad, arachnoid, almost completely covered by 3–8 mm long appendages. *Appendages* ± triangular, 5–8–3–6 mm, with a black, ciliate, distinctly decurrent border and ending in a (2-)2.5–6(-10) mm long spinule; *cilia* c. 15–20 on each side, c. 3–5.5 mm long, dark brown at base, with silvery tips. *Flowers* dark brownish-purple or yellowish to yellow, the marginal ones slightly radiating. *Achenes* 4–5 mm long, bearded at base; *pappus* bristles 6–8(-9) mm long, brownish, those of the inner row 1.2–2 mm long.

Two forms are being recognized:

*C. grbavacensis* (Rohlena) Stoj. & Acht. f. *grbavacensis*

— *Flowers* dark brownish-purple.

*C. grbavacensis* f. *lutea* Micevski in Godišen Zborn. Přír.-Mat. Fak. Univ. Skopje, Biol. 27-28: 183. 1975.

Holotype: Gostivarsko, Suva Gora, Jul. 1968, *Micevski* (MCF!). Fig. 4.

— *Flowers* yellowish to yellow.

Micevski (1975: 183) described *Centaurea grbavacensis* f. *lutea* referring to “*C. immanuelis-loewii* fl. luteo” of Soška (1938: 230), which is a descriptive designation, not a validly published name. Even though Micevski failed to use the term “type” referring to the single specimen he cited for his f. *lutea*, thus apparently failing to meet the requirements of valid publication of that time (Turland & al. 2018: Art. 7.11 & 40.1), the name is nevertheless validly published under Art. 40.2. The fact that, in the German summary, two localities are mentioned for f. *lutea* is not tantamount to the inclusion of more than one specimen in the new taxon (see Turland & al. 2018: Art. 40 Note 2).

Plants with clearly spiny phyllaries, named “f. *spinescens*” or corresponding to the relevant description, have not been reported from Greece, so far. However, our study of the photographic material collected over the years on Mt. Olympos by E. Kipopoulos, showed

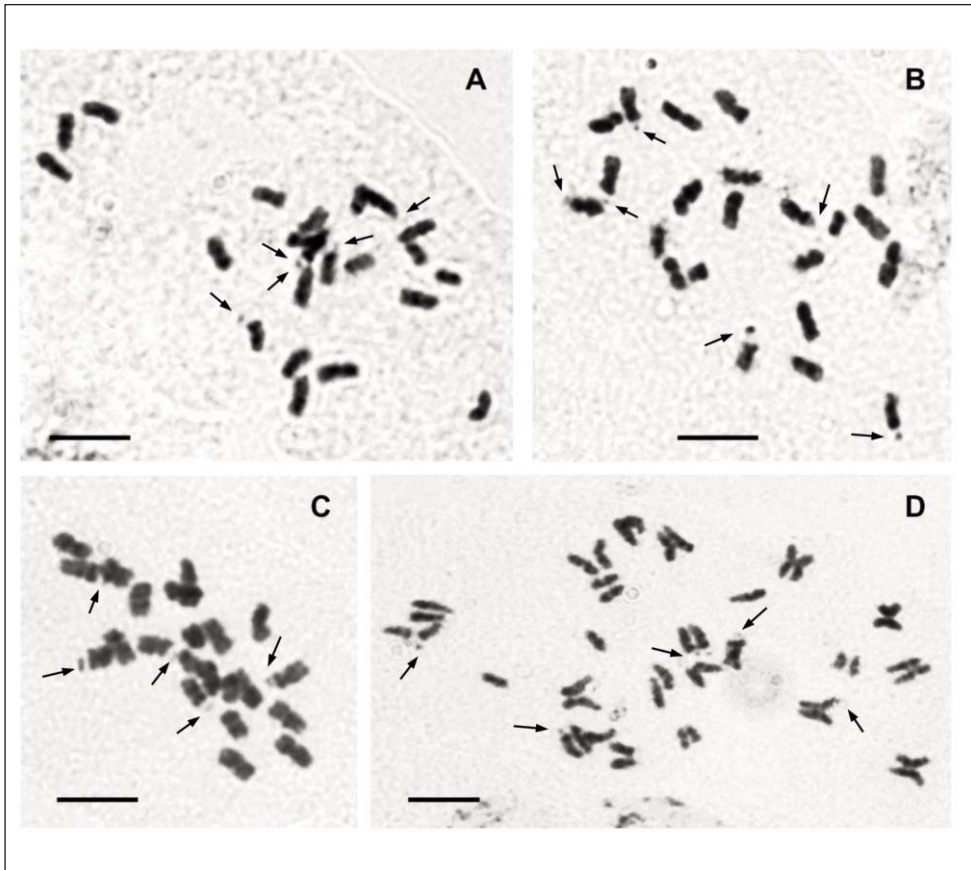


Fig. 10. Karyotypes of *Centaurea grbavacensis*: **a** and **b**, mitotic metaphase plates of the typical form; **c**, mitotic metaphase and **d**, mitotic anaphase plate of f. *lutea*. – Arrows indicate the SAT-chromosomes; Scale bars = 10 μm.

that in the locality Rema Arapi (subpop. no. 2 in Map 2) a majority of otherwise typical plants of *C. grbavacensis* have up to 10 mm long phyllary spines (Fig. 9) and according to Rohlena (1935: 4) correspond to his “*f. spinescens*”.

The same kind of phyllary variation was also observed in several subpopulations of Mt. Olympos.

Additionally, we can here report, for the first time, that the same kind of variation in phyllary spines also exists in yellow-flowered plants (*f. lutea*) in material from subpop. no. 7 (Map 2) on Mt. Olympos (Fig. 6), some of which, based on spine length, would correspond to “*f. spinescens*”. Probably, further study of all subpopulations of *C. grbavacensis* will show that throughout the species distribution the appearance of spiny phyllaries is a variable character, and that spiny plants appear in both colour forms recognized here.

### **Distribution**

*Centaurea grbavacensis* is a Balkan endemic that occurs in North Macedonia, north and central Greece (Map 1, Appendix 1), where it forms small, scattered subpopulations.

In three subpopulations in the northern part of North Macedonia (Map 1), both colour forms of *C. grbavacensis* coexist, and several subpopulations show strong variation in length (up to 10 mm) of the phyllary spines, even on single plants.

In Greece (Map 1) the typical colour form of *C. grbavacensis* predominates. The exception is Mt. Olympos (Map 2), where several scattered subpopulations of typical, dark-purple flowered *C. grbavacensis*, grow on the NE slopes (Figs 7 & 8), but in the two only subpopulations of the SE slopes, also *f. lutea* appears. In subpop. no. 7 (Map 2) some typical, dark-purple flowered plants also exist (Fig. 6), but in the subpop. no. 8 (Map 2), only yellow-flowered plants have been observed, so far (Fig. 9).

Even though the flora of Mt. Tzena and Mt. Voras of N Greece has been well studied, no yellow-flowered plants of *C. grbavacensis* have been reported from there, in spite of the shorter distance separating these mountains from northern North Macedonia.

We conclude that yellow-flowered plants (*f. lutea*) only occur in few localities in the northern and southern the periphery of the total species range (Map. 1).

### **Karyology**

In *Centaurea* sect. *Acrocentron* (Cass.) DC., to which *C. grbavacensis* belongs, there are two basic chromosome numbers:  $x = 11$ , that is considered ancestral and is known only from diploid taxa, and  $x = 10$ , found in both diploids and polyploids (up to deca- and endecaploids, with  $2n = 100$  and  $2n = 110$  chromosomes: Phitos 1970, 1971; Phitos & Kamari 1973). Several taxa of *C. sect. Acrocentron* have been studied karyologically (Dittrich 1966; Runemark 1967; Gardou 1969; Phitos 1970, 1971; Phitos & Kamari 1973; Damboldt & Matthäs 1975; Phitos & Georgiadis 1981; Georgiadis & Christodoulakis 1984; Routsis & Georgiadis 1988, 1999; Routsis 1993; Font & al. 2008, 2009; Uysal & al. 2009; Ranjbar & Negaresh 2013; Zografidis & al. 2023).

For *Centaurea grbavacensis* the chromosome number  $2n = 2x = 22$  has been reported by Strid & Andersson (1985: 205) and Wagenitz & Gamal-Eldin (1985), in individuals with dark brownish-purple flowers from the SE summit of Mt. Tzena. Additionally, Routsis (1993) and Routsis & Georgiadis (1999) reported the (presumably erroneous) chromosome number  $2n = 2x = 20$  in material of the same taxon from Mt. Voras (Poazar).

**Karyologically examined material (from Greece: Mt. Olympos)**

- C. grbavacensis* f. *grbavacensis*:** Inter locum Dion et refugion Koromilia, 40° 08' 48.14" N 22° 26' 58.52" E, alt. 435 m, 13.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari* no 29508) (subpop. no. 5, Map 2). — Figs 10a-b.
- C. grbavacensis* f. *lutea*:** Agios Ioannis-Trochalos: ad margines viae sylvaticae inter vicum Litochoro et locum Scandaliara, 40° 04' 46.81" N, 22° 28' 52.18" E, alt. 806 m, 13.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari* no 29507) (subpop. no. 8, Map 2). — Figs 10c-d.

We counted  $2n = 2x = 22$  chromosomes in both colour forms of *Centaurea grbavacensis*, on material from Mt. Olympos (see above). The chromosome number in both forms is diploid, the karyotypes are symmetrical and include metacentric (m) and submetacentric (sm) chromosomes. Two chromosome pairs in the karyotypes of both forms bear satellites. These two pairs of sm-SAT chromosomes bear spherical satellites on their shorter arms and are usually well visible. In some cases, we observed a third pair of small spherical satellites, but these are not always visible (in Figs 10a, 10c & 10d we observed five, and in Fig. 10b, six satellites). The karyotype formula is  $2n = 2x = 8m+8sm + 6sm-SAT = 22$  chromosomes, varying in size from 3.0 to 5.7  $\mu\text{m}$ .

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Appendix 1. Referred and studied specimens of the Balkan endemic *Centaurea grbavacensis* s.l. from its total geographical distribution.

*Centaurea grbavacensis* f. *grbavacensis*

**NORTH MACEDONIA:**

**Kavadarci** (MGRS EL78):

**Grbavec** ["Grbavac"] as *Centaurea immanuelis-loewii* Degen var. *grbavacensis* Rohlena, 1923.07.23, Macedonia: Vrcholy nad Grbavcem, leg. K. Vandas (Brno), no 5084 (PRC 452957; PRC 452958). The original specimen was divided onto following sheets (bar-coded units) in 2010: PRC 452957 (Fig. 2) & PRC 452958); supra Grbavac, leg. K. Vandas (Brno), s.n. (PRC 452959; PRC 452960); in collibus supra Grbavac, 1923.07.23, leg. K. Vandas (Brno), s.n. **Lectotype:** PRC 452963 (Fig. 1). [Isolectotypes: PRC 452961; PRC 452964; PRC 452965; PRC 452966] (B, GB, PRC).

**Drenovo ("Raec") gorge:** Anthyllido-Centauretum *grbavacensis* (Kostadinovski 2014).

**Prilep:**

**Sivec** (MGRS EL48): in saxosis marmoreis montis Sivec, leg. T. Soška (BEO 26622); in saxosis marmoreis montis Sivec (s.n. BEOU); leg. V. Lindtner (26625 BEO); leg. T. Soška (BEO 26623, 26624); leg. T. Soška (BEO 26617) (as "*C. immanuelis-löwii*", revised by K. Micevski); leg. O. & E. Behr (B); (Micevski 1975) ("B, MCF, S"); (Matevski & Konstadinovski 2003); (Matevski & al. 2015).

**Prilep** (MGRS EL47): near to the city (Stojanoff & Achtaroff 1935) (Herb. Prague).

**Pletvar pass** (MGRS EL58): (Matevski & Konstadinovski 2003).

**Mt. Kozjak** (MGRS EL58): stony places on limestone (Micevski 1975) ("MCF"); (Matevski & Konstadinovski 2003).

**Treskavec** (MGRS EL48): (Melovski & al. 2012).

**Trojaci** (MGRS EL68): ad virum, leg. T. Nocolov (B).

**Poreč:**

**Kapina** (MGRS EM12): leg. O. Grebenščikov (BEO 26621) (as "*C. immanuelis-löwii*", revised by K. Micevski); within the distillery in the forest, leg. O. Grebenščikov (BEO 26620) (as "*C. immanuelis-löwii*", revised by K. Micevski); leg. V. Lindtner (BEO 26618); solo dolomitico, alt. ca. 750 m s.m., leg. T. Soška, det. T. Krstić, (BEO 26615) (as "*C. immanuelis-löwii*", revised by K. Micevski); alt. ca 800 m s.m., leg. V. Lindtner (BEO 26614) (as "*C. immanuelis-löwii*", revised by K. Micevski); solo dolomitico, alt. ca 750 m s.m., leg. V. Lindtner, det. T. Krstić (BEO 26612, 26613) (as "*C. immanuelis-löwii*", revised by K. Micevski); (Soška 1938) (as "*C. immanuelis-löwii*"; (Micevski 1975) ("BEO"); (Matevski 2010).

**Kula** (MGRS EM13): Soška (1938) (as "*C. immanuelis-löwii*").

**Kula-Kapina** (MGRS EM13): in a mixed pine-oak coppice forest, leg. P. Černjavski (BEO 26616) (as "*C. immanuelis-löwii*", revised by K. Micevski).

**Poreč** (MGRS EM11): Soška (1938) (as "*C. immanuelis-löwii*").

**Gorna Belica ["Belica"]** (MGRS EM21): (Soška 1938) (as "*C. immanuelis-löwii*"; (Micevski 1975) ("MCF").

**Mt. Karadžica** (MGRS EM21, EM22):

**Boro Pole ["Boropolje"]:** (Soška 1938) (as "*C. immanuelis-löwii*").



**Mt. Jakupica** (MGRS EM31): (Melovski & al. 2012).

**Makedonski Brod** (MGRS EL29):

**Barbaros**: stony places on limestone (Micevski 1975) (“SKO”); (Matevski & Konstadinovski 2003); (Melovski & al. 2012); (Matevski & al. 2015).

**Debrešte**: 41° 22' 21.81" N, 21° 39' 21.14" E, Globulario-Centaureetum grbavacensis, Astragalohelianthemetum marmorei (Matevski & al. 2015).

**Mt. Bukovik**:

**Bukovik** (MGRS DM82): in saxosis marmoreis, leg. *T. Soška* (s.n. BEOU) (as “*C. grbavacensis* var. *soškae*”); (Micevski 1975).

**Straža** (MGRS DM81): (Ivanovski 2011); (Melovski & al. 2012).

**Mt. Nidže (= Mt. Voras)** (MGRS EL63): (Melovski & al. 2012).

**Mt. Ljuben** (MGRS EL08): in saxosis marmoreis, leg. *T. Soška* (s.n. BEOU) (as “*C. grbavacensis* var. *soškae*”); (Micevski 1975); (Melovski & al. 2012).

**Nova Breznica [“Pusta Breznica”]**:

**Treska Gorge** (MGRS EM12, EM13): in pratis saxosis ca. 1000 m prope pag., leg. *P. Černjavski* (S 10-6207) [[https://www.gbif.org/occurrence/search?taxon\\_key=3127657](https://www.gbif.org/occurrence/search?taxon_key=3127657)]; (Matevski & Konstadinovski 2003).

**Mt. Kozjak** (MGRS EM13): (Matevski 2010); (Matevski & al. 2015).

**Mariovo**:

**Satoka** (MGRS EL65): (Micevski 1975).

**Crna Reka** (MGRS EL76, EL77): (Micevski 1975).

**Tikveš Lake** (MGRS EL87): (Melovski & al. 2012).

**Toplik** (MGRS EL64): (Matevski 2014); (Matevski & al. 2015).

**Sekulova Tumba** (MGRS EL65): (Matevski 2014); (Matevski & al. 2015).

**Labinica** (MGRS EL64): (Matevski 2014); (Matevski & al. 2015).

**Skopje** (MGRS EM34): (Matevski & al. 2015).

**Mt. Suva Gora**:

**Suva Gora** (MGRS EM02): 41.78902° N, 21.05255° E, leg. *B. Zlatković, A. Teofilovski (40031 BEOU)*; Novaković & al. (2022); (Melovski & al. 2012).

**Zaječec** (MGRS EM13): (Teofilovski 2011).

**Lukovica** (MGRS EM13): (Teofilovski 2011). – Fig. 5.

**Rečište** (MGRS EM13): (Teofilovski 2011).

**Majdans gorge** (MGRS EL75): (Jovanovski & al. 2016).

**Mt. Galičica** (MGRS DL83): (Globulario-Centauretum grbavacensis) (Ćušterevska 2016).

**GREECE:**

**Mt. Voras** (MGRS EL73):

**Loutra Pozar:** Steinige Abhänge der Therma – Schlucht (Loutra Pozar, häufig, 15.6.1976, leg. *D. Voliotis 1186* (Voliotis 1979: 214); **Pozar**, 12.VIII.1987, leg. *Th. Georgiadis 6939* (UPA): Routsis 1993; WNW of **Loutra Arideas**, 40.966667° N, 21.9° E (?); **Schlucht des Nikolaon-Baches**, 4,6 km nordwestlich Loutra Loutrakiou, 40.98655° N, 21.86485° E: Unnamed Rd.; **Pozar** (GBIF 2022).

**Mt. Tzena** (MGRS EL95):

**Dytiki Makedonia.** Macedonia occ. (distr. Almopia), montes **Kožuf**, in letere meridionali verticis Tzena, alt. 1700 m, in fissuris et scanilibus rupium calcareum praeruptarum, flores atropurpurei, 30.7.1976, leg. *W. Greuter no 14108* (B, BEO, C, G, UPA); ibidem: Voliotis (1983); ibidem: Gamal-Eldin & Wagenitz (1991: 493); ibidem: Routsis 1993 (UPA); stony and rocky limestone places with sparse vegetation, alt. 700-1800 m., Font & al. (2002; 2008; 2009); **Nomos Pellas, Mt. Tzena**, 41.151956° N, 22.171624° E, 1930 m.; **E slopes of the SE summit**, c. 1800-2060 m, rocky places in alpine grassland, limestone, 19.8.1979, *A. Strid & K. Papanikolaou 16687* (B, C, EGE, G); Strid & Papanikolaou (1981); ibidem: Strid & Andersson (1985: 205); sparse bunch of thermophyllous deciduous trees, 35.1800 E 45.54700 N, 17.10.2009, alt. 1340 m, leg. *M. Chasapis no 416*; in phryganic ecosystems, 350830 E, 4552590 N, 24.5.2012, alt. 720 m, leg. *M. Chasapis no 1914*; Chasapis (2017: 41); Chasapis & al. (2020: 60).

**Prov. Thessakloniki, Langadas** (MGRS FL72):

**Kalochori:** meadows in gentle hills near Dorkada: Symes (2019).

**Mt. Koziakas (Kleinovo)** (MGRS EJ38, EJ39): Kapeo, 18.6.1930, leg. *Erik Wall*, catal. no S10-6204 (S). <https://www.gbif.org/occurrence/1096744876> Klinovos (Kleinovo)

**Kozani (Skopos)** (MGRS EK76): Northern Greece, The Pindhos Mountains: Bennallick & Green (2017).

**Mt. Olympos:**

**Agia Kori** (MGRS FK14): (Map 2, subpop. no 1): 40° 09' 41.02" N 22° 24' 21.52" E, alt. 370 m, 16.06.2019, *E. Kipopoulos* (obs. & photos); limestone, *E. Routsis & E. Karavokyrou 119* (UPA); *Th. Georgiadis & E. Routsis 7346* (UPA): Routsis 1993.

**Rema Arapi** (MGRS FK24): (Map 2, subpop. no 2): 40° 09' 30.03" N 22° 25' 12.60" E, alt. 317 m, 19.06.2019 & 22.06.2019, *E. Kipopoulos* (obs. & photos). – Fig. 8; 40° 9' 23.51" N 22° 25' 23.27" E, alt. 450 m, 26.05.2020, *E. Kipopoulos* (obs. & photos).

**Papa Rema** (MGRS FK14): (Map 2, subpop. no 3). N foothills, along forest road on the E side of Papa Rema ravine, alt. 400-600 m, 18.6.1976, *Strid & Kjellsson 11342 & 11521* (ATH, C); ibidem: Schlucht, 430 m, steiniger Steilhang, *Wagenitz 3608* (GOET): Gamal-Eldin & Wagenitz (1991); ibidem: Routsis 1993 (UPA); ibidem: Pappas (2020).

**Rema Orlias** (MGRS FK24): (Map 2, subpop. no 4): 40° 09' 12.45" N 22° 26' 40.34" E, alt. 235 m, 03.06.2020, *E. Kipopoulos* (obs. & photos).

**Dion to Koromilia** (MGRS FK24): (Map 2, subpop. no 5): Inter locum Dion et refugion Koromilia, 40° 08' 48.14" N 22° 26' 58.52" E, alt. 435 m, 13.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari 29508*); ibidem: alt. 400-600 m, 23.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari 12953*); ibidem: 40° 8' 48.70" N 22° 26' 58.02" E, alt. 445 m, 05.06.2022, *E. Kipopoulos* (obs. & photos).

**Koromilia** (MGRS FK24): (Map 2, subpop. no 6): Refugion Koromilia, 40° 8' 0.33" N 22° 26' 4.43" E, alt. 1012 m, 28.06.2020, *E. Kipopoulos* (obs. & photos). – Fig. 7.

**Agios Ioannis-Trochalo** (MGRS FK23): (Map 2, subpop. no 7), place named Scandaliara: 40° 4' 48.73" N 22° 28' 55.18" E, alt. 785 m, *Th. Nasopoulou* (obs. & photos). – Figs 6c & 6d.

***Centaurea grbavacensis f. lutea*****NORTH MACEDONIA:****Mt. Suva Gora:**

**Suva Gora** (MGRS EM02): Holotype: Gostivarsko, Suva Gora, Jul. 1968, leg. *K. Micevski* (183 MCF). – Fig. 4; ibidem: 41.78902°N, 21.05255°E, leg. *Zlatković & A. Teofilovski 40023* (BEOU); Novaković & al. (2022).

**Zaječec** (MGRS EM13): (Teofilovski 2011).

**Lukovica** (MGRS EM13): (Teofilovski 2011). – Fig. 5.

**Rečište** (MGRS EM13): (Teofilovski 2011).

**Zdunje** (MGRS EM13): Visoka Čuka (Teofilovski 2011).

**Poreč** (MGRS EM12):

**Kapina**: leg. *H. Oehm* (BEO) (as “*C. immanuelis-löwii* fl. lutei”, revised by *K. Micevski*); 2.5 km from Kapina, leg. *N. Košanin* (label written by *T. Soška*) (BEOU); *Soška* (1938).

**Oča [“Onča”] river**: Kozji do, in glareosis, leg. *N. Košanin* (BEOU 37322) (as *C. immanuelis-loewii*). – Fig. 3.

**GREECE:****Mt. Olympos**

**Agios Ioannis-Trochalo, place Scandaliara** (MGRS FK23): (Map 2, subpop. no 7): 40° 04' 48.73" N 22° 28' 55.18" E, alt. 785 m, *Th. Nasopoulou* (obs. & photos). – Figs 6a & 6b.

**Agios Ioannis-Trochalo** (MGRS FK23): (Map 2, subpop. no 8): ad margines viae silvaticae inter vicum Litochoro et locum Scandaliara, 40° 04' 59.66" N 22° 28' 48.08" E, alt. 800 m, 29.05.2020, *E. Kipopoulos* (obs. & photos). – Fig. 9; ibidem: 40° 04' 46.81" N 22° 28' 52.18" E, alt. 806 m, 13.07.2021., *E. Kipopoulos* (Herb. *Phitos & Kamari 29507*); ibidem: 40° 04' 59.66" N 22° 28' 48.08" E, alt. 700-850 m, 23.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari 29512*).

