Cytogeographical study of Centaurea L. sect. Acrocentron (Cass.) DC. (Asteraceae) in Greece

Bot. Helv. 109 (1999): 139–151
0253-1453/99/020139-13 $ 1.50+0.20/0

Botanica Helvetica

Cytogeographical study of *Centaurea* L. sect. *Acrocentron* (Cass.) DC. (Asteraceae) in Greece

E. Routsi and Th. Georgiadis

Botanical Institute, Division of Plant Biology, Department of Biology, University of Patras, GR 265 00, Patras, Greece

Manuscript accepted October 20, 1998

Abstract

Routsi E. and Georgiadis Th., 1998. Cytogeographical study of *Centaurea* L. sect. *Acrocentron* (Cass.) DC. (Asteraceae) in Greece. Bot. Helv. 109: 139–151.

The cytology, cytogeography, morphology and systematics of *Centaurea* sect. *Acrocentron* in Greece are discussed. The species of this section are divided into groups of related taxa according to their morphology, cytology and geographical distribution. The chromosome numbers of 13 taxa are given for the first time and the numbers of 13 taxa are confirmed.

Key words: Asteraceae, *Centaurea*, *Acrocentron* – Cytogeography, Systematics.

Resumé

Etude cytologique, cytogéographique et systématique du genre *Centaurea* de la section *Acrocentron* en Grèce. Les espèces de cette section sont classifiées dans trois subsections en relation avec leur morphologie, cytologie et distribution géographique. Les nombres chromosomiques pour 13 taxa sont confirmés; les nombres d'autres 13 taxa sont nouveaux. La section *Acrocentron* possède deux nombres chromosomiques de base x=10 et x=11. Selon les données cytogéographiques et systématiques le nombre de base x=11 est probablement le plus ancien. L' etude cytogéographique a démontré une origine du Nord de la Gréce ou orientale de quelques espèces; mais la majorité des taxons sont endémiques de la Gréce.

Introduction

The genus *Centaurea* is represented in Greece by c.150 taxa (species and subspecies) which belong to 12 sections (Wagenitz 1986).

Centaurea sect. *Acrocentron* and *C.* sect. *Acrolophus* (Cass.) DC. are the two largest sections of the genus, and include a great number of Greek endemics. Together they represent more than 50% of the Greek *Centaurea* species. Following the biosystematic study of *Centaurea* sect. *Acrolophus* in Greece (Georgiadis 1980), the biosystematic study of *C.* sect. *Acrocentron* (in Greece) was undertaken, and the results of its cytogeographical and morphological study are presented in this paper.

The systematic problems of *C.* sect. *Acrocentron*, outlined by Gardou (1974), concern the taxonomic status of many taxa and the number of taxa belonging to the section. Twenty-six taxa (including varieties) were reported by Halácsy (1902) to be found in Greece, while Hayek (1931) reported 29 taxa (including varieties). In Flora Europaea (1976), Dostál classified these 29 taxa in five sections: *Acrocentron*, *Orientales*, *Carduiformes*, *Lopholoma*, *Rhizanthae*, and mentions only 6 taxa of *C.* sect. *Acrocentron* from the Greek region. According to Wagenitz & Gamal-Eldin (1985), *C.* sect. *Acrocentron* in Greece includes 31 taxa. Cytological studies by various authors – Guinochet & Foissac (1962); Gardou (1969, 1972, 1974); Damboldt & Matthäs (1975, 1979); Georgiadis (1980, 1983) – have shown that the genus *Centaurea* appears to have many basic chromosome numbers: x=8, 9, 10, 11, 12, 13, 14, 15, 16.

Centaurea sect. *Acrocentron* is characterized by 2n=2x=20, 2n=3x=30, 2n=4x=40, 2n=10x=100 and 2n=11x=110 (Runemark 1967, Gardou 1969, Phitos 1970, 1971, Damboldt & Matthäs 1975, Routsi & Georgiadis 1988), as well as 2n=2x=22 (Runemark 1967, Georgiadis & Christodoulakis 1984). Thus, *C.* sect. *Acrocentron* has two basic chromosome numbers: x=10 and x=11.

The appearance of two basic chromosome numbers and a great variety of morphological features show that *C.* sect. *Acrocentron* is neither cytologically nor morphologically homogeneous. A biosystematic study was therefore necessary to establish a comprehensible phylogenetic classification of this section.

Cytology

Cytological investigations were carried out on root tips of plants raised from achenes collected in the wild. These were pretreated with 8-hydroxycinoline/colchine (3:1), fixed in Carnoy solution (3:1) and hydrolyzed with 1M HCl. They were later stained with Feulgen stain of the 31 taxa of the section, 26 taxa, belonging to 50 populations, were studied cytologically. The following five chromosome numbers were listed for the first time as new reports in Routsi & Georgiadis (1988) as follows:

1) *C. redempta* subsp. *cytherea* 2n=20
2) *C. ebenoides* 2n=20
3) *C. macedonica* 2n=20
4) C. *lactucifolia* 2n=20
5) *C. psilacantha* 2n=20

A further 8 chromosome numbers are also listed as new reports in this paper:

6) *C. rupestris* subsp. *athoa* 2n=20
7) *C. rupestris* subsp. *parnonia* 2n=20
8) *C. rupestris* subsp. *kozanii* 2n=40
9) *C. grbavacensis* 2n=20
10) *C. laconica* subsp. *laconica* 2n=20
11) *C. rupestris* subsp. *finazzeri* 2n=20

This number has also been reported from the former Yugoslavia (Siljak-Yakovlev 1985) and Bulgaria (Kuzmanov et al. 1983).

12) *C. salonitana* 2n=20.

Diploid populations of *C. salonitana* have been found for the first time in Greece. Until now only tetraploid populations were known. For this taxon, the number 2n=20 has also been reported from Romania (Lungeanu 1975) and Bulgaria (Kuzmanov et al. 1979).

13) *C. immanuelis-loewii* 2n=20.

The chromosome number of this species in Greece is given here for the first time. Prior to this study it was only known from Bulgaria (Kuzmanov et al. 1979, 1985).

The mitotic metaphases of the taxa mentioned above are represented in Figure 1. In addition, the chromosome numbers of 13 taxa (Fig. 2) of *C.* sect. *Acrocentron* have been confirmed after studying various populations as listed in Table 1.

The remaining 5 taxa have either not been studied cytologically or their chromosome numbers have been given by previous authors:

- The numbers of *C. raphanina* subsp. *raphanina*, *C. urvillei* subsp. *armata* and *C. laconica* subsp. *lineariloba* are known and are presented in Table 1.
- The population of *C. scabiosa* subsp. *fritschii* from Rhodopi the only location of *C. scabiosa* in Greece) has not yet been studied cytologically. The number 2n=20 has been reported from the former Yugoslavia (Lovka et al. 1971), Germany (Damboldt & Matthäs 1975) and Spain (Valdés-Bermejo 1983). The numbers 2n=20, 30, 40 have also been reported from France (Gardou 1969).
- The cytology of *C. tuntasia* has not been studied previously. This species was lost found in 1912 by Tuntas [W], and despite persistent attempts to relocate it, remains undiscovered. It seems possible that it was a rare, random and sterile hybrid between *C. salonitana* and *C. achaia*, as indicated by its intermediate morphological characters. It is possible that the taxon was found only in very limited areas and has become extinct due to because of urban and rural development and tourism activities in the region Attica where it was first found.

The cytological study of *Centaurea* sect. *Acrocentron* in Greece showed the existence of two basic chromosome numbers: x=10 and x=11. With x=10, diploids, tetraploids, decaploids and endecaploids are found, while with x=11 only diploids appear. All known chromosome numbers of the taxa belonging to *C.* sect. *Acrocentron* in Greece are presented in Table 1.

Morphology and systematics

Morphological studies were carried out on fresh material and herbarium specimens. All voucher specimens. All voucher specimens are deposited in UPA.

The morphological study of *C.* sect. *Acrocentron*, combined with the existence of the two basic chromosome numbers, led us to divide the section into three subsections (Routsi & Georgiadis 1994b): *C.* sect. *Acrocentron* subsect. *Graecae* Routsi & Georgiadis with x=10, *C.* sect. *Acrocentron* subsect. *Atropurpureae* Routsi and Georgiadis with x=11, and *C.* sect. *Acrocentron* subsect. *Achaiae* Routsi & Georgiadis with x=11. The two groups with x=11, although possessing the same basic chromosome number, are distinctly different as their different morphology shows.

Five groups of related taxa, with similar morphological features, were distinguished within *C.* sect. *Acrocentron* subsect. *Graecae*, taking into account their distinct morphological differences, as well as their different geographical distributions and origins (Table 1).

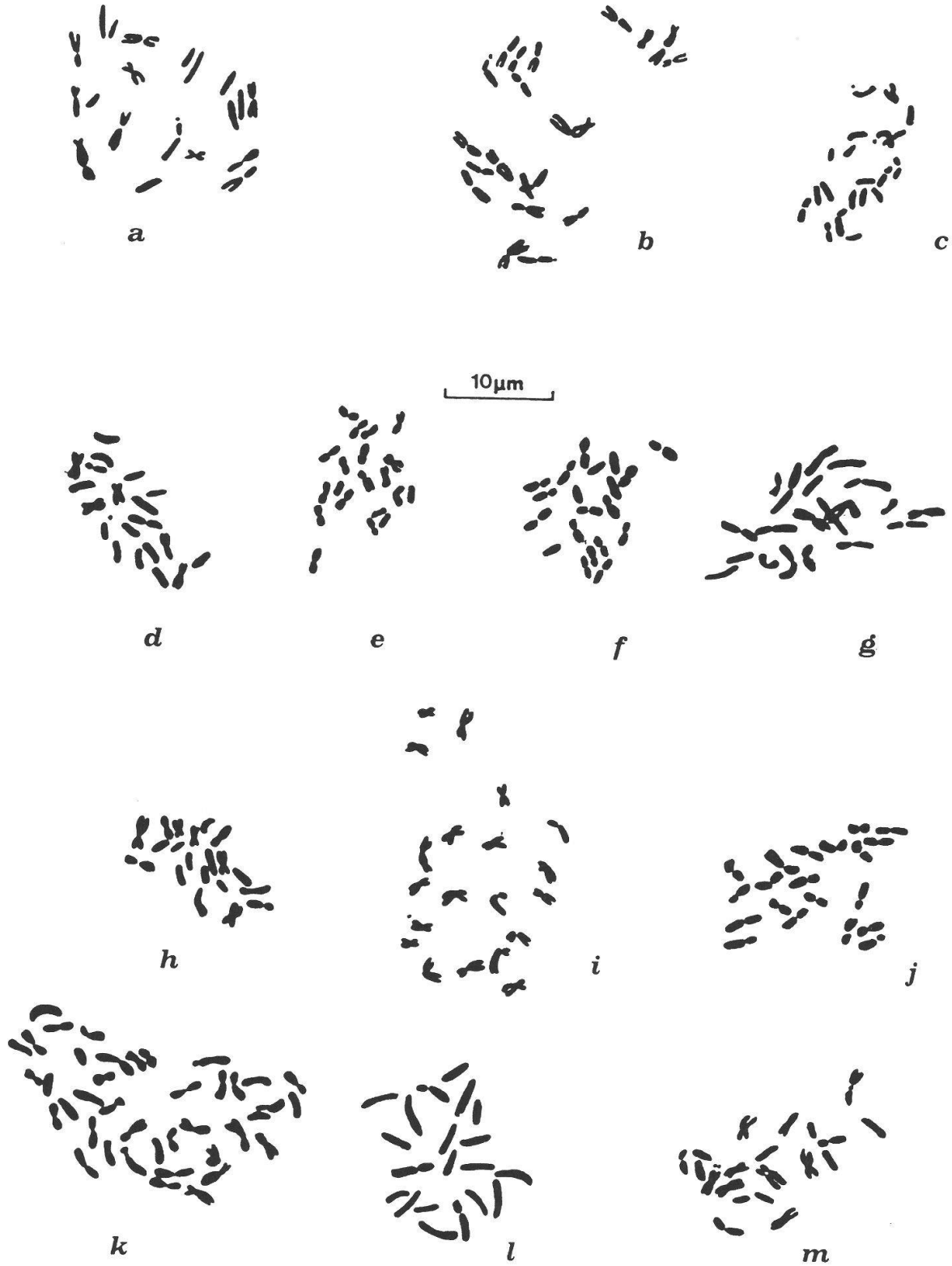

Fig. 1. Mitotic metaphases of: **a** *Centaurea lactucifolia,* **b** *C. redempta* subsp. *cytherea*, **c** *C. ebenoides*, **d** *C. immanuelis-loewii*, **e** *C. grbavacensis*, **f** *C. psilacantha*, **g** *C. macedonica,* **h** *C. rupestris* subsp. *athoa*, **i** *C. rupestris* subsp. *finazzeri,* **j** *C. rupestris* subsp. *parnonia*, **k** *C. rupestris* subsp. *kozanii*, **l** *C. laconica*, **m** *C. salonitana*

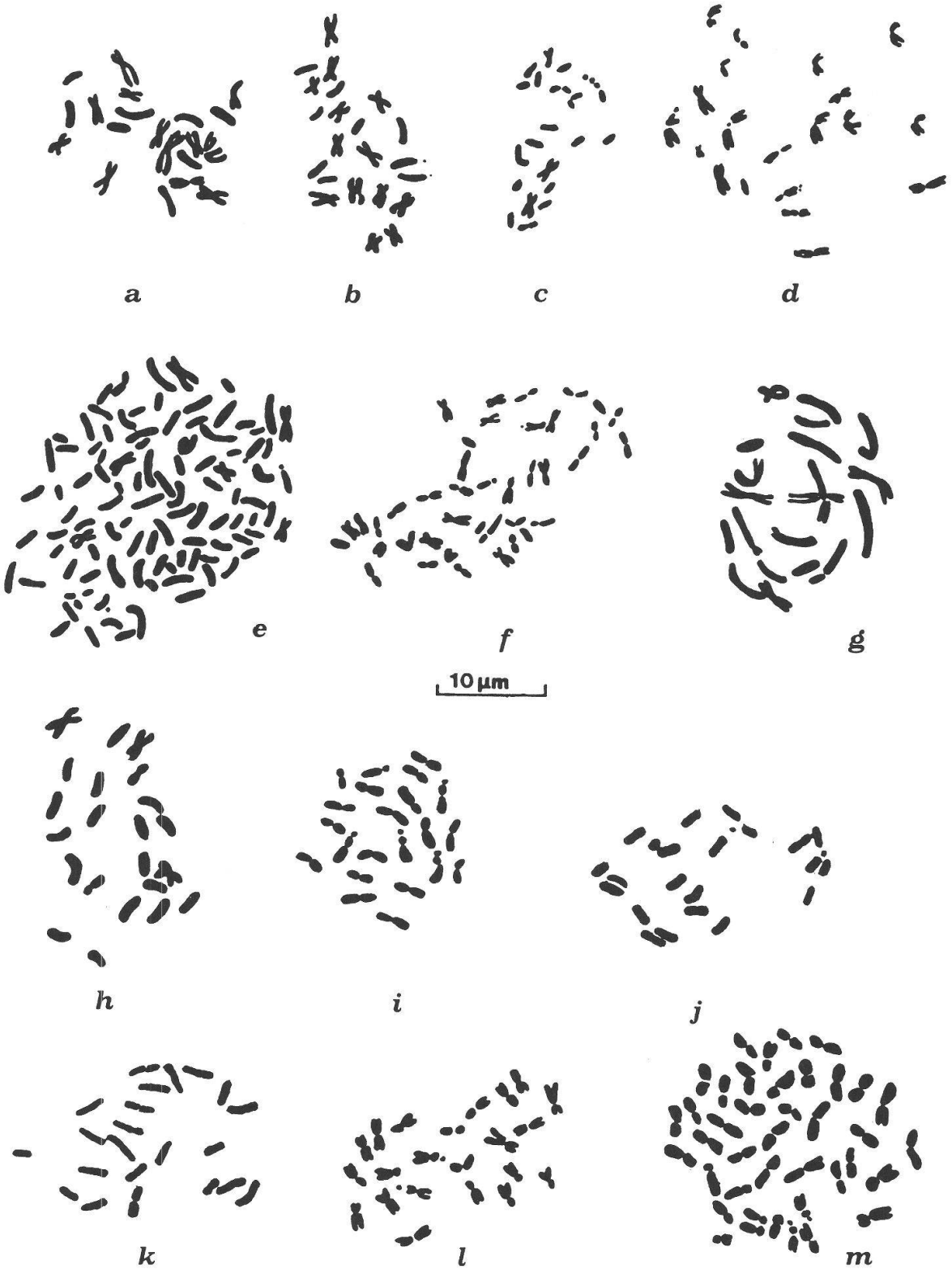

Fig. 2. Mitotic metaphases of: **a** *Centaurea graeca,* **b** *C. atropurpurea,* **c** *C. redempta* subsp. *redempta,* **d** *C. raphanina* subsp. *mixta,* **e** *C. spruneri,* **f** *C. salonitana,* **g** *C. acicularis,* **h** *C. aetolica,* **i** *C. achaia,* **j** *C. euboica* subsp. *euboica,* **k** *C. korinthiaca,* **l** *C. rechingeri,* **m** *C. urvillei* subsp. *urvillei.*

Table 1. Species, subspecies, varieties and chromosome numbers of *Centaurea* sect. *Acrocentron* in Greece.

No	Taxon	x	2n	Authors	Location
1.	*C. laconica* Boiss. subsp. *laconica*	10	20	Routsi, 1993	Prov. Laconia: Mt. Parnon (1200 m)
2.	*C. laconica* Boiss. subsp. *lineariloba* (Hal. & Doerfler) Gamal-Eldin & Wagenitz	10	20	Runemark, 1967 Phitos, 1970	Prov. Cyclades: Andros, Sifnos Prov. Andros.
3.	*C. redempta* Heldr. subsp. *redempta*	10	20	Runemark, 1967 Phitos & Kamari, 1984 Tzanoudakis, 1986 Routsi & Georg.*, 1988	Kreta: Prov. Chania: Kissamos Kreta: Prov. Rethymno Kreta: Prov. Chania: Topolia Kreta: Prov. Chania: Topolia
4.	*C. redempta* Heldr. subsp. *cytherea* (Rech. f) Routsi & Georgiadis	10	20	Routsi & Georg., 1988	Prov. Pireas Kythira: Kastro
5.	*C. spruneri* Boiss. & Heldr.	10	100	Phitos & Kamari, 1973 Phitos, 1970 Routsi, 1993	Prov. Attica: Sounio Prov. Kefallonia: Kefallonia Prov. Kefallonia: Agon
		10	110	Phitos & Kamari, 1973	Prov. Attiki: Marathonas/ Prov. Aitol/nia: Katouna & Kompoti
				Phitos, 1970 Phitos, 1971	Prov. Achaia: Mt. Chelmos Kreta: Prov. Heraklio: Siva, Moulia
6.	*C. graeca* Griseb.	10	20	Phitos, 1970 Strid & Franzen, 1981 Routsi & Georg., 1988 Routsi, 1993	Prov. Ioannina: Ioannina Prov. Pierria: Mt. Olympos (350 m) Prov. Larissa: Pinios Prov. Kozani: Siatista, Vourinos
7.	*C. psilacantha* Boiss. & Heldr.	10	20	Routsi & Georg., 1988 Routsi, 1993	Prov. Viotia: Äs. Loukas/Prov. Fokida: Delphi Prov. Fokida: Eleonas
8.	*C. raphanina* Sibth. & Sm. subsp. *raphanina*	10	20	Runemark, 1967 Phitos, 1971	Creta: Prov. Lasithi: Sitia Creta: Prov. Rethimno: Mt. Idi (1500 m)
9.	*C. raphanina* Sibth. & Sm. subsp. *mixta* (DC.) Runemark	10	20	Runemark, 1967	Creta: Prov. Attica: Porto Rafti/ Prov. Evia: Akr. Kafireus/Prov. Samos: Ikaria/ Prov. Cyclades: Naxos, Kufonisi
				Phitos, 1971 Routsi & Georg., 1988 Routsi, 1993	Prov. Achaia: Mt. Panachaiko (1200m) Prov. Argolida: Nemea Prov. Cyclades: Serifos/Prov. Attica: Sounio/ Prov. Magnisia: Tsougria/Prov. Korinthia: Mt. Killini (1100 m)
10.	*C. urvillei* DC. subsp. *urvillei*	10	40	Georg. & Christ.*, 1984 Routsi, 1993	Prov. Samos: Samos Prov. Samos: Samos
11.	*C. urvillei* DC. subsp. *armata* Wagenitz Hal.	10	40	Runemark, 1967 Gardou, 1975	Prov. Dodekanissa: Rodos Prov. Dodekanissa: Rodos
12.	*C. acicularis* Sibth. & Smith var. *acicularis*	10	20	Runemark, 1967 Georg. & Christ., 1984 Routsi & Georg., 1988	Prov. Dodekanissa: Simi Prov. Samos: Samos: Kerkis, Ampelos Prov. Samos: Ikaria

13.	*C. lactucifolia* Boiss.	10	20	Routsi & Georg., 1988	Prov. Dodekanissa: Halki
				Routsi, 1993	Prov. Rodos: Siana
14.	*C. immanuelis-loewii* Degen	10	20	Routsi, 1993	Prov. Chalkidiki: Palaiochora
15.	*C. grbavacensis* (Rohlena) Stojanoff & Achtaroff	10	20	Routsi, 1993	Prov. Pella: Mt. Voras: Pozar
16.	*C. ebenoides* Heldr. ex S. Moore	10	20	Routsi & Georg., 1988	Prov. Evia: Mt. Kandili
				Routsi, 1993	Prov. Evia: Mt. Kandili: Limni
				Phitos et al., 1989	Prov. Evia: Mt. Kandili
17.	*C. rupestris* L. subsp. *parnonia* (Hal.) Routsi & Georgiadis	10	20	Routsi, 1993	Mt. Parnon (1850m), Prov. Laconia: Mt. Taygetos (1200m)
18.	*C. rupestris* L. subsp. *athoa* (DC.) Gugler	10	20	Routsi, 1993	Athos Peninsula: Mt. Athos
19.	*C. rupestris* L. subsp. *finazzeri* (Adam.) Hayek	10	20	Routsi, 1993	Prov. Pella: Mt. Voras: A. Garefi
20.	*C. rupestris* L. subsp. *kozanii* Routsi & Georgiadis	10	40	Routsi, 1993	Prov. Kozani: Kozani, Grevena
21.	*C. macedonica* Boiss.	10	20	Routsi & Georg., 1988	Prov. Thessaloniki: Mt. Chortiatis: Asvestohori
				Routsi, 1993	Prov. Serres: Proti to Serres
22.	*C. salonitana* Vis.	10	20	Routsi, 1993	Prov. Rodopi: Mt. Iasmos/ Prov. Chalikidiki: Marathousa
		10	40	Phitos, 1970	Prov. Kozani: Kozani
				Routsi, 1993	Prov. Imathia: Veria/Prov. Thessaloniki: Mt. Chortiatis/Prov. Pella: Edessa/ Prov. Ioannina: Aristi/Prov. Kozani: Kozani/Prov. Phthiotida: Bralos, Domokos
23.	*C. scabiosa* L. subsp. *fritschii* (Hayek) Hayek	10	–	–	Mt. Rhodopi
24.	*C. cuntasia* Heldr ex Hal.	–	–	–	Attica
25.	*C. rechingeri* Phitos	11	22	Runemark, 1967	Prov. Evia: Skyros
				Georg. & Christ., 1984	Prov. Samos: Samos
				Routsi, 1993	Prov. Samos: Samos
26.	*C. atropurpurea* Olivier	11	22	Runemark, 1967	Prov. Cyclades: Naxos, Amorgos
				Tzanoudakis, 1986	Prov. Cyclades: Amorgos
				Routsi & Georg., 1988	Prov. Cyclades: Amorgos
27.	*C. corinthiaca* Boiss. & Heldr.	11	22	Phitos & Georg., 1981	Prov. Korinthia: Loutraki
				Routsi, 1993	Prov. Korinthia: Isthmos to Lutraki
28.	*C. euboica* Rech. f. subsp. *euboica*	11	22	Phitos & Georg., 1981	Prov. Evia: Mt. Kandili
				Routsi, 1993	Prov. Evia: Mt. Kandili
29.	*C. euboica* Rech. f. subsp. *intermedia* Phitos & Georgiadis	11	22	Phitos & Georg., 1981	Prov. Evia: Papades
				Routsi, 1993	Prov. Evia: Papades
30.	*C. achaia* Boiss. & Heldr.	11	22	Damboldt & Mat.*, 1975	Prov. Arcadia: Tripo
				Routsi, 1993	Prov. Achaia: Mt. Helmos: Peristera/Prov. Attika: Vilia/Prov Fthiotida: Logitsi, Nat. road Lamia to Larissa
31.	*C. aetolica* Phitos & Georgiadis	11	22	Phitos & Georg., 1981	Prov. Aitol/nia: Mt. Paliovouna, Mesologi, Aitoliko
				Routsi, 1993	Prov. Aitol/nia: Mt. Paliovouna, Mesologi, Aitoliko

* Georg. = Georgiadis, Christ. = Christodoulakis, Mat. = Matthäs. The chromosome numbers given for a) *C. psilacantha* 2n=22, (Moore 1968, Taxon 17: 421) and b) *C. grbavacensis* 2n=22 (Strid 1980) appear to be incorrect.

Key to the subsections and groups of *Centaurea* sect. *Acrocentron*

1 Appendages narrowly semi-lunate, very small (1/8–1/7 of the bract), dark brown. Florets brown-red .

subsect. *Atropurpureae* (basic chromosome number x=11)

1* Appendages semi-lunate, broader, (1/3–3 times longer than the bract), triangular or convex.

2 Appendages convex, stramineous, covering the bracts (70%–100%), with stout terminal spines. Florets whitish to light purple. Leaves pinnatisect(-pinnate), with linear lanceolate segments.

subsect. *Achaiae* (basic chromosome number x=11)

2* Appendages semi-lunate to triangular, usually not covering the bracts, straw-coloured to dark brown. Florets yellow, purple, browned. Leaves usually lyrate, pinnatilobed to pinnatisect(-pinnate), with ovate to linear segments.

subsect. *Graecae* (basic chromosome number x=10)

3 Florets pale yellow or yellow.

4 Appendages covering the bracts (90%–100%), slightly convex. Florets pale yellow. Leaves glabrous, pinnatilobed, with big, rounded segments.

***C. lactucifolia* group**

4* Appendages not covering the bracts. Florets yellow.

5 Short plants, almost without stems. Appendages triangular, usually with 3–5 spinules, straw-coloured. Leaves lyrate, pinnatisect, tomentose, with ovate segments.

***C. acicularis* group**

5* Tall plants, 30(–100) cm, rarely short. Appendages semi-lunate, with 6–12 cilia, straw coloured or dark brown. Leaves arachnoid, pinnatisect(-pinnate), with oblong segments.

***C. rupestris* group**

3* Florets purple or brown-red.

6 Appendages not covering the bracts, semi-lunate, usually with a stout terminal spine, straw-coloured or sometimes dark brown. Florets usually purple, rarely dark red. Leaves lyrate, pinnatisect, with ovate segments.

***C. laconica* group**

6* Appendages usually covering the bracts (15%–50%), broadly triangular, decurrent, dark brown with 10–15 cilia. Florets brown-red, rarely red. Leaves pinnatisect(-pinnate), with lanceolate or linear segments, rarely lyrate.

***C. scabiosa* group**

Cytogeography

The cytology and morphology of the species of *C.* sect. *Acrocentron* seem to be closely linked to their geographical distribution. Thus, examining the groups and subgroups of this section, the following were observed:

– ***C.* sect. *Acrocentron* subsect. *Atropurpureae* (x=11).** This subsection includes *C. rechingeri* (2n=22) and *C. atropurpurea* (2n=22) which are endemic to the Aegean islands and are found on Samos the Sporades and the Cyclades. These isolated species are probably two of the most ancient species of *C.* sect. *Acrocentron,* as the absence of polyploidy,

higher basic chromosome number, morphological speciality, less developed floral characters and their geographical distribution suggest. This group was distributed in the region of Aegaeis and the dislocation of this land during the Miocene isolated these species into small populations on the Aegean islands.

- ***C.* sect. *Acrocentron* subsect. *Achaiae* (x=11).** This subsection, consisting of *C. achaia*, *C. euboica*, *C. corinthiaca* and *C. aetolica*, is distributed in Attica, Central and North Peloponnese, Sterea Hellas and Evia. It is a Greek endemic group, cytologically homogeneous (2n=22) and characterized by special morphological features, mainly concerning the appendages of the bracts. *C. sibthorpii* is another species of this section and is closely related to *C. achaia*. A detailed study of the populations of these two species using Correspondence Factor Analysis showed that *C. achaia* and *C. sibthorpii* are to the same species.
- ***C.* sect. *Acrocentron* subsect. *Graecae* (x=10).** This subsection includes the following groups and species:

1. *C. lactucifolia* group:

C. lactucifolia (2n=20) is a Greek endemic species, found in small populations on the Eastern Aegean Islands, Rhodos and Chalki. It is a taxonomically isolated species, without any close relatives, "possibly a relict from the Pliocene cliff flora" (Carlström 1986).

2. *C. acicularis* group:

C. acicularis (2n=20) is an Anatolian species, closely related to *C. chrysantha* (Wagenitz 1975b). It is found on the Eastern Aegean Islands and in Western Turkey.

3. *C. laconica* group: (*C. redempta, C. laconica, C. raphanina, C. urvillei, C. spruneri, C. graeca, C. psilacantha*)

The diploid species *C. redempta* and *C. laconica* (2n=20) are closely related and constitute an endemic Greek subgroup. They are located in Crete, Kythira, the Peloponnese and the West Cyclades. As shown by their close morphological similarities, these species must have been members of a subgroup distributed in the once-connected landmass of Crete-Kythira-Peloponnese-Cyclades, and were isolated after the dislocation of this land. This subgroup is related to *C. eryngiodes*, a species found in Lebanon, Syria and Egypt (Wagenitz 1975a). Similarities to Anatolian species and the distribution area of the subgroup indicate a possible Anatolian origin.

C. raphanina: is a Greek endemic and is found on Crete (subsp. *raphanina*), the Aegean Islands and in Eastern Greece (subsp. *mixta*). Both subspecies are diploid (2n=20).

On the Eastern Aegean Islands, *C. urvillei* is found. It is a very distinct taxon, which is closely related to the Anatolian species *C. lydia* (Wagenitz 1975b). Of the 5–6 subspecies described (Wagenitz 1975b), two are found on the Eastern Aegean Islands and they are both tetraploid (2n=40). Diploid populations (2n=20) of these subspecies have been reported from Turkey (Gardou & Tchehrehgocha 1975). The appearance of polyploidy at the western geographical limits of this species, as well as its similarities to Anatolian species confirm, its Asiatic origin.

C. spruneri, a species possessing the highest chromosome number within the section (2n=100, 110), has a relatively wide distribution area. It is found in Crete, Attica, North and Central Peloponnese, Western Greece, the Ionian Islands and Southern Albania.

C. graeca (2n=20), a species distributed in North, Central Greece and the former Yugoslavia, and along with the Greek endemic *C. psilacantha* (2n=20), found in Sterea Hellas, also belong to the *C. laconica* group.

4. *C. rupestris* group: (*C. salonitana, C. macedonica, C. rupestris, C. tuntasia*)

C. salonitana and *C. macedonica*, two closely related species, are distributed in Macedonia and Central Greece. *C. macedonica* (2n=20) is found in Central Macedonia and Central Albania. *C. salonitana*, a species with a wide distribution area (USSR, Turkey, Romania, Bulgaria, Hungary, the former Yugoslavia, Greece), appears in diploid and tetraploid populations. Diploid populations (2n=20) are found in East and Central Macedonia, while the tetraploid (2n=40) are distributed from Macedonia to Attica. The subgroup of *C. rupestris* (Routsi & Georgiadis 1994), which is represented in Greece by 4 subspecies, grows in NW Turkey, Greece (North Greece and Peloponnese), the former Yugoslavia, Bulgaria, Italy and France. The 3 subspecies, subsp. *athoa*, subsp. *finazzeri* and subsp. *parnonia* (a Greek endemic) are diploid (2n=20) and they are found in the mountains of Athos, Voras, Taygetos and Parnon. The fourth subspecies, subsp. *kozanii*, found in the area of Kozani, is also an endemic and is tetraploid (2n=40). The taxa of this subgroup are related to the *C. scabiosa* group, through *C. ebenoides* and *C. immanuelis-loewii*, with which they share many morphological similarities.

The *C. rupestris* subgroup seems to have a Northern origin, as indicated by its geographical distribution, its relationship with the *C. scabiosa* group, the lack of similarities with Anatolian species and the existence of polyploid populations in Greece (in their southern distribution area). The appearance of subsp. *athoa* (*C. athoa* DC.) in NW Turkey does not indicate about a possible Anatolian origin since no similarity with other Anatolian species has been observed (Wagenitz 1975b).

5. *C. scabiosa* group: (*C. scabiosa, C. immanuelis-loewii, C. grbavacensis C. ebenoides*)

C. scabiosa, *C. immanuelis-loewii* and *C. grbavacensis* are the southern members of a group originating from the North and are characterized by special morphological features. In Flora Europaea (1976) these species are classified in the sections *Lopholoma* and *Orientales*, which include Balkan and European species.

C. grbavacensis and *C. immanuelis-loewii*, both diploids (2n=20), are distributed mainly in North Greece and neighbouring former Yugoslavia and Bulgaria. The southern distribution area of this group is Mt. Olympus where *C. grbavacensis* is found. *C. scabiosa* is a species with a wide geographical distribution (USSR-Finland), one subspecies of which (subsp. *fritchii*) is found only in the area of Drama (Rhodopi) in Greece. Other reports from Greece (Pavlidis 1982) possibly concern *C. immanuelis-loewii*.

One species related to this group is *C. ebenoides* (2n=20), a Greek endemic from the Island of Evia. Its appendage morphology and head shape and size are similar to those of *C. immanuelis-loewii*.

Discussion – Conclusions

Studying the cytology of *Centaurea* sect. *Acrocentron* in Greece, the chromosome numbers of 26 taxa (13 taxa given for the first time) were determined by the study of 50 populations. Two basic chromosome numbers (x=10 and x=11), were found within *C.* sect. *Acrocentron* and diploid, tetraploid, decaploid and endecaploid species appeared. It is worth noting that the only species of *C.* sect. *Acrocentron* possessing the basic chromosome number of x=11 are Greek endemics. The fact that 31 taxa (the highest number in the countries of the Mediterranean area) of *C.* sect. *Acrocentron* are found in Greece, in addition to the existence of great morphological variety and the two basic chromosome numbers, suggest that the re-

gion of Greece played an important role in the differentiation of this section's species and emphasizes the interest of its biosystematic study (Routsi 1993).

Following the new cytological data the 8:12 ratio between the species with x=11 and x=10 as mentioned by Garcia Jacas and Susanna (1992) for the Eastern Mediterranean area, is modified and predominance of the species with x=10 becomes more evident. At the species level, this ratio reaches 6:16 and at the subspecies level reaches a striking 7:23.

In the Eastern Mediterranean, the taxa with x=11 have a distinct morphology, are taxonomically isolated and have restricted geographical distribution. In addition, the taxa with x=11 are diploid as opposed to the Western Mediterranean where only polyploid taxa (paleopolyploid) exist (Garcia Jacas & Susanna 1992). The evolutionary trend from larger to smaller chromosome numbers in the Composites is well known (Babcock 1947, Swanson 1957, Stebbins 1977, Solbrig 1977) and could support the assumption that the basic chromosome number of x=11 is the oldest one.

In the Eastern Mediterranean area, and Greece in particular, speciation in taxa with the basic chromosome number of x=10, seems to be as intensive as that observed in the Western Mediterranean. This could be explained by the existence of more x=10 taxa in the area (23) and also by their higher ploidy level in contrast to the fewer (7), always diploid, taxa with x=11.

The morphological study showed the existence of great variety within this section. Correlation of the cytological and morphological data resulted in *C.* sect. *Acrocentron* being divided into three subsections, one (subsect. *Graecae*) with x=10, and two (subsect. *Atropurpureae* and subsect. *Achaiae*) with x=11, each of them characterized by special morphological features. Within *C.* sect. *Acrocentron* subsect. *Graecae* there is great variety, and further

Tab. 2. Classification of section *Acrocentron* species in Greece according to their geographical distribution and origin.

Taxa with a northern distribution area	Taxa with their main distribution in Greece	Greek endemics	Anatolian species
		C. rechingeri	
		C. atropurpurea	
		C. achaia	
		*C. euboica**	
		C. corinthiaca	
		C. aetolica	
C. scabiosa			
C. grbavacensis			
C. immanuelis-loewii		*C. ebenoides*	
C. rupestris subsp. *finazzeri*		*C. rupestris* subsp. *kozanii*	
	C. rupestris subsp. *athoa*		
	C. macedonica	*C. rupestris* subsp. *parnonia*	
C. salonitana	*C. graeca*		
	C. spruneri	*C. psilacantha*	*C. urvillei**
		*C. raphanina**	
		C. laconica	
		*C. redempta**	*C. acicularis*
		C. lactucifolia	

* The subspecies of these species are not mentioned because they belong to the same category

groups of morphologically related taxa can be distinguished. The groups and subgroups of *C.* sect. *Acrocentron* appear to have both different geographical distribution and origin. Thus, the following four categories can be distinguished: a) species originating from the North, b) species with their main distribution in Greece, c) species with exclusive distribution in Greece (Greek endemics), and d) Anatolian species (Table 2).

The division of *Centaurea* sect. *Acrocentron* into the sections proposed here, was based on a detailed cytological, cytogeographical and morphological study of the section *Acrocentron* in Greece. The above classification could be expanded for the total number of species of this section in the whole Mediterranean area by the creation of new subsections. This, however, demands the same detailed analysis for the remaining unknown species.

References

Babcock E. B. 1947. The genus *Crepis*. Part one. – Univ. Calif. Publ. Bot. 21: 1–197.

Carlström A. 1986. New taxa and notes from the SE Aegean area and SW Turkey. – Willdenowia 16: 73–78.

Damboldt J. & Matthäs U. 1975. Chromosomenzahlen einiger mediterraner und mitteleuropäischer *Centaurea*-Arten (Asteraceae). – Pl. Syst. Evol. 123: 103–115.

Damboldt J. & Matthäs U. 1979. Karyologische Untersuchungen an *Centaurea* (sect. *Phalolepis*) Pawlowskii (Compositae). – Bot. Jahrb. Syst. 100: 406–413.

Dostál J. 1976. In Tutin, T. G. et al. (eds) Flora Europaea 4, pp. 254–301. – Cambridge University Press, Cambridge.

Garcia Jacas, N. & Susanna, A. 1992. Karyological notes on *Centaurea* sect. *Acrocentron* (Asteraceae). – Pl. Syst. Evol. 179: 1–18.

Gardou C. 1969. Caryosystématique des Centaurées de la section *Acrocentron* Cass. – Bull. Soc. Bot. Fr. 116: 29–38.

Gardou C. 1972. Recherches biosystématiques sur la section *Jacea* Cass. et quelques sections voisines du genre *Centaurea* L. en France et dans les régions limitrophes. – Feddes Repert. 83: 311–472.

Gardou C. 1974. Quelques vues synthétiques sur les Centaurées de la section *Acrocentron* (Cass.) O. Hoffm. dans la flore Mediterranéenne. – Colloques internationales du CNRS. Montpellier. – Flora Mediterranea 235: 537–547.

Gardou C. & Tchehrehcocha I. 1975. In IOPB chromosome number reports XLIX. – Taxon 24: 501–516.

Georgiadis Th. 1980. Contribution à l'étude phylogénétique du genre *Centaurea* L. (section *Acrolophus* (Cass.) DC.) en Grèce. – Thèse, Aix Marseille – I.

Georgiadis Th. 1983. Contribution à l'étude cytogéographique du genre *Centaurea* L. (section *Acrolophus* (Cass.) DC.) en Grèce. – Candollea 38: 325–340.

Georgiadis Th. & Christodoulakis D. 1984. Contribution à l'étude cytogéographique des Centaurées de l'ile de Samos. – Candollea 39: 307–318.

Guinochet M. & Foissac J. 1962. Sur les caryotypes des quelques espèces du genre *Centaurea* L. et leur signification taxinomique. – Rev. Cytol. Biol.Veget. 25: 373–387.

Halácsy E. 1902. Conspectus Florae Graecae 2. – Lipsiae.

Hayek A. 1931. Prodromus Florae Peninsulae Balkanicae. – Rep. Spec. Nov. Regni Veg. 30: 735–795.

Kuzmanov B., Ninova B. & Georgieva S. 1979. In IOPB chromosome number reports LXIV. –Taxon 28: 391–408.

Kuzmanov B., Ninova B. & Georgieva S. 1983. In IOPB chromosome number reports LXXXI. –Taxon 32: 665.

Kuzmanov B., Ninova B. & Georgieva S. 1985. In IOPB chromosome number reports LXXXVII. – Taxon 34: 346.

Lovka M., Susnik F., Löve A. & Löve D. 1971. In IOPB chromosome number reports XXXIV. – Taxon 20: 791.

Lungeanu I. 1975. Chromosome number reports. – Taxon 24: 504.

Pavlidis G. 1982. Geovotaniki meleti tou Orinou Sigrotimatos Vertiskou. – Thessaloniki.

Phitos D. 1970. Zur Polyploidie in der Gattung *Centaurea* L. Sektion *Acrocentron* (Compositae). – Ber. Deutsch. Bot. Ges. 83: 69–73.
Phitos D. 1971. Cytotaxonomische Studien der griechischen *Centaurea* – Arten, Sektion Acrocentron (Compositae). – Ber. Deutsch. Bot. Ges. 84: 255–259.
Phitos D. & Georgiadis Th. 1981. A propos du groupe de *Centaurea achaia* Boiss. et Heldr. de la section *Acrocentron* (Cass.) DC. – Bot. Chron. 1: 99–114.
Phitos D. & Kamari G. 1973. Cytologische Untersuchungen an einigen griechischen Blütenpflanzen. (*Centaurea*, *Aethionema*). – Biol. Gallo-Hellenica IV: 147–151.
Phitos D. & Kamari G. 1984. Cytotaxonomical contributions on the flora of Crete II. – Candollea 39: 447–451.
Phitos D, Kamari G. & Athanasiou K. 1989. Chromosome numbers of some species of the Greek flora. – Bot. Chron. 9: 41–47.
Routsi E. 1993. Biosystematic study of the section *Acrocentron* (Cass.) DC. of the genus *Centaurea* L. in Greece. – PhD Thesis, Univ. of Patras Greece.
Routsi E. & Georgiadis Th. 1988. In IOPB chromosome number reports XCIX. – Taxon 37: 396–399.
Routsi E. & Georgiadis Th. 1994a. Systematic review of *Centaurea* rupestris L., section *Acrocentron* (Cass.) DC., in Greece. – Candollea 49: 359–368.
Routsi E. & Georgiadis Th. 1994b. Contribution to the systematics of the genus *Centaurea* section *Acrocentron* (*Asteraceae*) in Greece. – Nordic Journal of Botany 14: 369–378.
Runemark H. 1967. Studies in the Aegean Flora XII. Cytologic and morphologic investigations in *Centaurea*. – Bot. Notiser 120: 161–176.
Siljak-Yakovlev S. 1985b. In IOPB chromosome number reports LXXXVIII. – Taxon 34: 548.
Solbrig O. T. 1977. Chromosomal cytology and evolution in the family *Compositae*. In Heywood, V. H., Harborne, J. B. & Turner, B. L. (eds): The Biology and Chemistry of the *Compositae*, pp. 267–281. – London and New York: Academic Press.
Stebbins L. 1977. Developmental and Comparative anatomy of the *Compositae*. – In Heywood, V. H., Harborne, J. B. & Turner, B. L. (eds): The Biology and Chemistry of the *Compositae*, pp. 91–110. – London and New York: Academic Press.
Strid, A. 1980. Wild Flowers of Mount Olympus. – Kifissia: Goulandris Nat. Hist. Museum.
Strid A. & Franzen R. 1981. In IOPB chromosome number reports LXXIII. – Taxon 30: 829–842.
Swanson P. C. 1957. Cytology and Cytogenetics. Englewood cliffs N. J. (USA).
Tzanoudakis D. 1986. Chromosome studies in the Greek flora. I. Karyotypes of some Aegean Angiosperms. – Bot. Helvetica 96: 27 – 36.
Valdés-Bermejo E. & Agudo Mata M. P. 1983. Estudios cariologicos en especies Ibericas del genero *Centaurea* L.(Compositae). I. – Anales del Jardin Botanica de Madrid 40: 119–142.
Wagenitz G. 1975a. Floristic connections between the Balkan peninsula and the near East as exemplified by the genus *Centaurea*. – Problems of Balkan flora and vegetation, pp. 223–228. Sofia.
Wagenitz G. 1975b. *Centaurea*. In Davis, P. H., Flora of Turkey and the East Aegean Islands, 5: 465–585. – University Press, Edinburgh.
Wagenitz G. & Gamal-Eldin E. 1985. Zur Kenntnis der griechischen *Centaurea*-Arten der Sektion *Acrocentron*. – Bot. Jahrb. Syst. 107: 95–127.
Wagenitz G. 1986. *Centaurea* in South-West Asia: patterns of distribution and diversity. – Proceedings of the Royal Society of Edinburgh, 89B, 11–21.