**CARYOLOGIA** Vol. 62, no. 2: 102-113, 2009

# Karyomorphology and systematics of the eastern taxa of *Genista* sect. *Spartioides* and *G. pulchella* (Genisteae-Fabaceae).

Cusma Velari[1*] Tiziana, Laura Feoli Chiapella and Vera Kosovel

[1] Dipartimento di Scienze della Vita, Università degli Studi di Trieste, via Licio Giorgieri 10, I-34127 Trieste, Italy.

**Abstract** — A karyological analysis of some taxa of *Genista* sect. *Spartioides,* distributed in the eastern part of the Mediterranean region, was carried out. The three subspecies of *Genista pulchella*: ssp. *pulchella* (western Balkan Peninsula), ssp. *aquilana* (central Apennines) and ssp. *villarsiana* (southern France) all present the chromosome number $2n = 18 + (0 - 4B)$. The taxa of *G. albida* aggr., *G. albida* (eastern Mediterranean) and *G. involucrata* (Anatolian), both have $2n = 18 + (0 - 2B)$; $2n = 36 + (0 - 3B)$ being rarely found in the latter species. As regards the taxa endemic to the Balkan Peninsula, *G. halacsyi* and *G. subcapitata* show $2n = 18 + (0 – 2B)$, *G. sakellariadis* and *G. millii* $2n = 36 + 2B$. All these numbers may be traced back to the basic number $x = 9$. *G. pulchella* has the most symmetric karyotype, while *G. albida* and *G. involucrata* result more asymmetric; the four Balkan endemics (*G. halacsyi*, *G. sakellariadis*, *G. subcapitata* and *G. millii*) present the highest grade of asymmetry. A comparison with karyological data already available for all the taxa of sect. *Spartioides* was also made.

**Key words**: asymmetry, cytotaxonomy, ideograms, karyotype, level of ploidy, Mediterranean region, mitosis.

## INTRODUCTION

*Genista* L. sect. *Spartioides* Spach (= sect. *Chamaesparton* Griseb. *apud* Talavera 1999), of the subgenus *Genista*, includes non-spiny shrubs with alternate branching, simple leaves with pulvinules sometimes prominent and three vascular traces, broadly ovate standard, usually with sericeous hairs, pubescent keel, a narrowly oblong and several-seeded legume, with sericeous to lanate hairs (Gibbs 1966).

The species of this section occur mostly in the Mediterranean region. Two main distribution centres may be singled out: an eastern (Balkan Peninsula and Anatolia) and a western one (southern Spain and north-western Africa); only *Genista pilosa* L. is widely distributed in western and central Europe, extending to southern Sweden, central Italy and Macedonia (Gibbs 1966).

This paper presents a karyological study on the eastern Mediterranean taxa of the section and on *Genista pulchella* Vis.

* Corresponding author: phone: +39 040 5583871; fax: +39 040 568855; e-mail: cusma@univ.trieste.it

The eastern species of the section are: *Genista sericea* Wulfen, *G. subcapitata* Pančić, *G. halacsyi* Heldr., *G. sakellariadis* Boiss. & Orph., *G. millii* Boiss., *G. albida* Willd., *G. involucrata* Spach. *G. pulchella* Vis. is distributed both in the eastern and in the western part of the Mediterranean region (Greuter *et al.* 1989).

*Genista sericea*, a northern Illyrian amphiadriatic species, ranges from north-eastern Italy (south-eastern Alps of Trentino, Veneto, Friuli) to Albania, with a disjunct distributional area on Pollino Massif (Calabria, Basilicata) (Pampanini 1912; Pignatti 1982; Feoli Chiapella and Rizzi Longo 1987; Conti *et al.* 2005).

*Genista subcapitata* is distributed in Serbia, in Albania and in the neighbouring regions of western Bulgaria and north-eastern Greece (Gibbs 1966; Strid 1986; Greuter *et al.* 1989). It was included by Pampanini (1912) in *G. sericea* as f. *subcapitata*; currently, it is considered as a distinct species (Gibbs 1966, 1968; Strid 1986; Greuter *et al.* 1989).

*Genista halacsyi* grows in few localities of Peloponnisos (Gibbs 1966; Strid 1986); according to Gibbs (1966), it is questionable whether to consider it a distinct taxon or to refer it to *G. sericea*.

*Genista sakellariadis* is present only on Mt. Olimbos (Gibbs 1966; Strid 1986). Pampanini (1912) included *G. sakellariadis* and *G. halacsyi* in *G. sericea* as forms of var. *tomentosa*; according to Strid (1986), *G. sakellariadis* and *G. halacsyi* are taxa of doubtful status, belonging to the *G. sericea* complex.

*Genista millii* is recognized as a distinct species by Gibbs (1966: 47), who, however, regards it as "perhaps conspecific with *G. sericea*". According to Strid (1986: 456) too, the species is "probably related to *G. sericea s. l.*, but appearing distinct". The taxon is found only in Euboea Island and in the neighbouring continental Greek region (Strid 1986).

The *Genista albida* aggr. includes *G. albida* Willd. (= *G. armeniaca* Spach, *G. godetii* Spach, *G. montbretii* Spach), distributed in Anatolia, Caucasia, Syria, Krym, Romania, and *G. involucrata* Spach, endemic to southern and central Anatolia (Săvulescu 1957; Gibbs 1966, 1970; Mouterde 1978-84; Greuter *et al.* 1989).

*Genista pulchella* Vis. (= *G. villarsii* Clementi), a species with a disjunct distribution in southern France, central Apennines and the eastern Adriatic coast, was included by Gibbs (1966) in sect. *Spartioides*. Uribe-Echebarría and Urrutia (1988, 1994) place the species in sect. *Erinacoides* Spach, together with the allied taxon *G. eliassennenii* Uribe-Ech. & Urrutia, endemic to northern Spain. Talavera (1999) accepts this sectional arrangement, but includes *G. eliassennenii* in *G. pulchella.* Conti (2007) subdivides *G. pulchella* into three subspecies: ssp. *pulchella*, distributed in western part of Balkan Peninsula (Croatia, Bosnia and Hercegovina, Montenegro and Albania), ssp. *villarsiana* (Jord.) F. Conti, endemic to southern France, and the new described ssp. *aquilana* F. Conti & Manzi, endemic to a small zone of central Apennines (National Park of Gran Sasso-Monti della Laga) (Hayek 1924/27; Gibbs 1966, 1968; Greuter *et al.* 1989; Rameau *et al.* 1993; Conti 2007).

This paper presents new karyological data on the eastern taxa of the sect. *Spartioides* and on *Genista pulchella*, as well as all the previous references; moreover gives an overall karyological survey of the whole section.

## MATERIAL AND METHODS

Karyological investigations were carried out on seeds collected in the field (localities given in Table 1). Voucher specimens are deposited in the Herbarium of the Department of Biology, University of Trieste (TSB).

Mitoses were observed on root tips of seedlings, pretreated with 8-hydroxiquinoline and stained using the routine Feulgen method. For each population, 5 to 25 metaphase plates were examined.

Unlike the previously examined taxa of *Genista*, where only chromosome numbers could be given due to the small size of the chromosomes (among others, Cusma Velari and Feoli Chiapella 1991; Cusma Velari *et al.* 1999, 2003), in this research the karyotype could be identified by measuring the chromosome complement of the taxa, thanks to the higher chromosome size (1.40-5.69 µm and 0.50-0.92 µm for B chromosomes).

The ideograms have been produced using an original program which arranges the homologous chromosome pairs according to decreasing values of total length (c), long arm length (l), short arm length (s) and arm ratio (r). The terminology introduced by White (1973) to describe chromosome morphology is followed, while Levan *et al.* (1964) is followed for the chromosome formula.

Karyotype asymmetry of taxa has been estimated according to Stebbins' classification (1971) and using the intrachromosomal ($A_1$) and interchromosomal ($A_2$) asymmetry index of Romero Zarco (1986).

The nomenclature of the taxa follows Greuter *et al.* (1989) and Conti (2007).

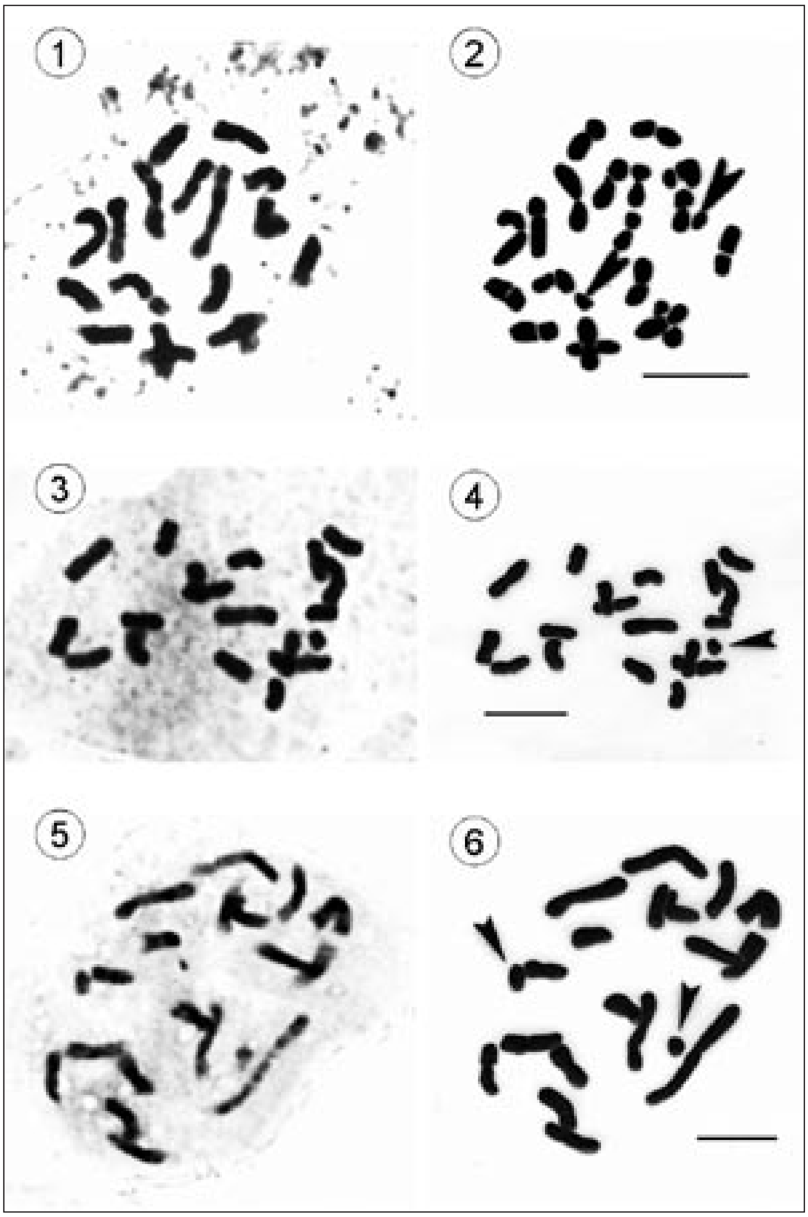
## RESULTS

Chromosome numbers of the eastern taxa of *Genista* sect. *Spartioides* (except *G. sericea*) and of *G. pulchella*, both obtained in this research and resulting from previous references, are presented in Table 1.

Among the three subspecies of *Genista pulchella*, ssp. *pulchella* (Figs. 1, 2, 20A) presents $2n$ = 18 + (0 - 2B) (size range 2.56 - 4.87 µm), while ssp. *aquilana* (Figs. 5, 6, 20C) and ssp. *villarsiana* (Figs. 3, 4, 20B) have $2n$ = 18 + 0 - 4B) (size ranges respectively from 1.68 to 4.03 µm and from 1.56 to 3.19 µm). The number $2n$ = 24 + 2B was exceptionally releved in ssp. *villarsiana*. No previous karyological data are known for *G. pulchella* ssp. *pulchella*; regarding ssp. *aquilana,* preliminary data by Cusma Velari and Feoli Chiapella are presented in Conti (2007). Forissier (1975) counted $n$ = 9, Verlaque (1988) $2n$ = 18, 36, while Seidenbinder and Verlaque (1985) found $2n$ = 24 for ssp. *villarsiana* (sub *G. pulchella*).

TABLE 1 — Chromosome numbers of the eastern taxa of *Genista* sect. *Spartioides* with bibliographic references, geographical origin and collector of the examined populations.

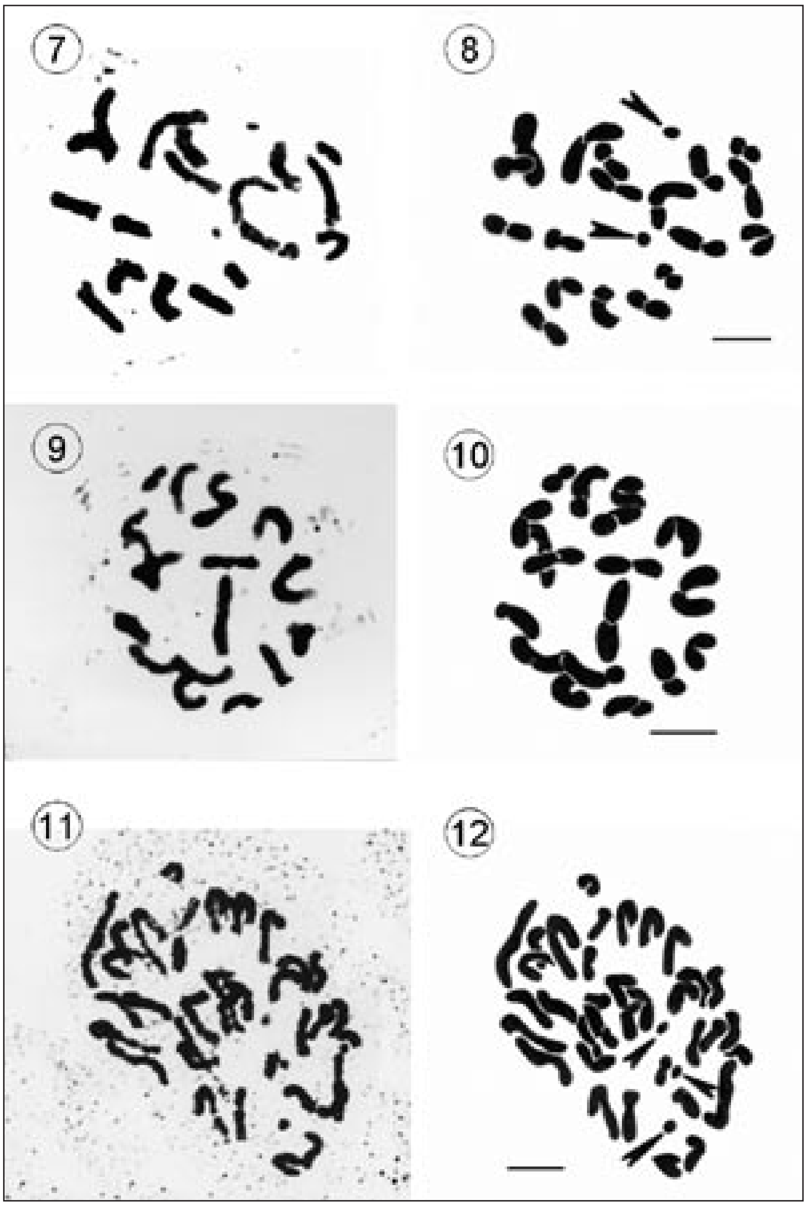
| Taxon | n | 2n | References | Locality | Collector |
|---|---|---|---|---|---|
| *Genista pulchella* ssp. *pulchella* | | 18+(0-2B) | Present paper | Mt. Mosor, Split (Croatia) | Lg. D. Vladović |
| *Genista pulchella* ssp. *aquilana* | | 18+(0-4B), (24+2B) | Present paper | Gran Sasso, Colle delle Macchie, Arischia, L'Aquila (Italy) | Lg. F. Conti |
| *Genista pulchella* ssp. *villarsiana* | | 18+(2-4B) | Present paper | Gorges du Verdon, Provence (France) | Lg. F. Conti |
| | 9 | | Forissier (1975, sub *G. pulchella*) | Aveyron, Causse de Severac, Engayresque (France) | |
| | 9 | | ″ | Col de la Lèque, Alpes-Maritimes (France) | |
| | 9 | 18 | Verlaque (1988, sub *G. pulchella*) | « Sud de la France » | |
| | | 24 | Seidenbinder & Verlaque (1985, sub *G. pulchella*) | Mt. Ventoux, Rocher du Midi, Vaucluse (France) | |
| | | 36 | Verlaque (1988, sub *G. pulchella*) | Alpes de Haute-Provence (France) | |
| | | 36 | ″ | Var (France) | |
| *Genista albida* | | 18+(0-2B) | Present paper | Gulnar-Sarlak (Turkey) | Lg. L. Feoli Chiapella |
| | | 18+(0-2B) | ″ | Gulnar-Aydincik (Turkey) | Lg. L. Feoli Chiapella |
| *Genista involucrata* | | 36 | Present paper | Eğri Dag, Mut-Silifke (Turkey) | Lg. L. Feoli Chiapella |
| | | 18+(0-2B) | Cusma Velari *et al.* (2002) | Nidğe, western Anatolia (Turkey) | |
| *Genista halacsyi* | | 18+2B | Present paper | Mt. Taýgetos, Lakonia (Greece) | Lg. L. Feoli Chiapella |
| *Genista subcapitata* | | 18 | Present paper | Mt. Golo Bardo, Studena, Pernik, Krajste (Bulgaria) | Lg. B. Kuzmanov |
| | | 18 | Kuzmanov *et al.* (1973) | Mt. Golo Bardo (Bulgaria) | |
| | | 18 | Krusheva (1975, sub *G. involucrata* Spach) | Mt. Golo Bardo (Bulgaria) | |
| | | 18 | Kuzmanov (1978) | Mt. Golo Bardo, Krajste (Bulgaria) | |
| | | 18 | Andreev (1981) | Mt. Pirin, Bajuvi dupki, Pareb grob (Bulgaria) | |
| *Genista sakellariadis* | | 36+2B | Present paper | Mt. Ólimbos, Pieria (Greece) | Lg. L. Feoli Chiapella |
| *Genista millii* | | 36+2B | Present paper | Mt. Íti, Fthiotida (Greece) | Lg. L. Feoli Chiapella |




Figs. 1–6 — Photomicrographs (Figs. 1, 3, 5) and drawings (Figs. 2, 4, 6) of a somatic metaphase plate. Figs. 1, 2. *Genista pulchella* ssp. *pulchella* (2*n* = 18 + 2B); Figs. 3, 4. *G. pulchella* ssp. *villarsiana* (2*n* = 18 + 1B); Figs. 5, 6. *G. pulchella* ssp. *aquilana* (2*n* = 18 + 2B). Arrows indicate B chromosomes. Bar: 5 µm.

As concerns the *Genista albida* aggr., we noticed that both *G. albida* (Figs. 7, 8, 20D) and *G. involucrata* (Figs. 9, 10, 20E) have the number 2*n* = 18 + (0 - 2B). The number 2*n* = 36 + (0 - 3B) (Figs. 11, 12) was found as well, although rarely, in one population of *G. involucrata*. Chromosome size ranges respectively from 2.44 to 4.98 µm and 2.03 to 4.12 µm; B chromosomes measure 0.92 and 0.55 µm**.** No previous karyological data are known for *G. albida*.

*Genista halacsyi* presents the chromosome number 2*n* = 18 + 2B (Figs. 13, 14, 21A), with a chromosome size ranging from 2.66 to 5.52 µm and 0.50 µm in B chromosomes. Regarding *G. subcapitata,* the number 2*n* = 18 (Figs. 17, 18, 21C) was counted both by us and several Bulgarian authors (see Table 1); chromosome length ranges from 1.41 to 3.14 µm. *G. sakellariadis* (Figs. 15, 16, 21B) and *G. millii* (Figs. 19, 21D) have 2*n* = 36 + 2B, with a chromosome size ranging respectively from 1.15 to 3.39 µm and 1.98 to 5.69 µm; B chromosomes measure respectively 0.61 and 0.84 µm**.**

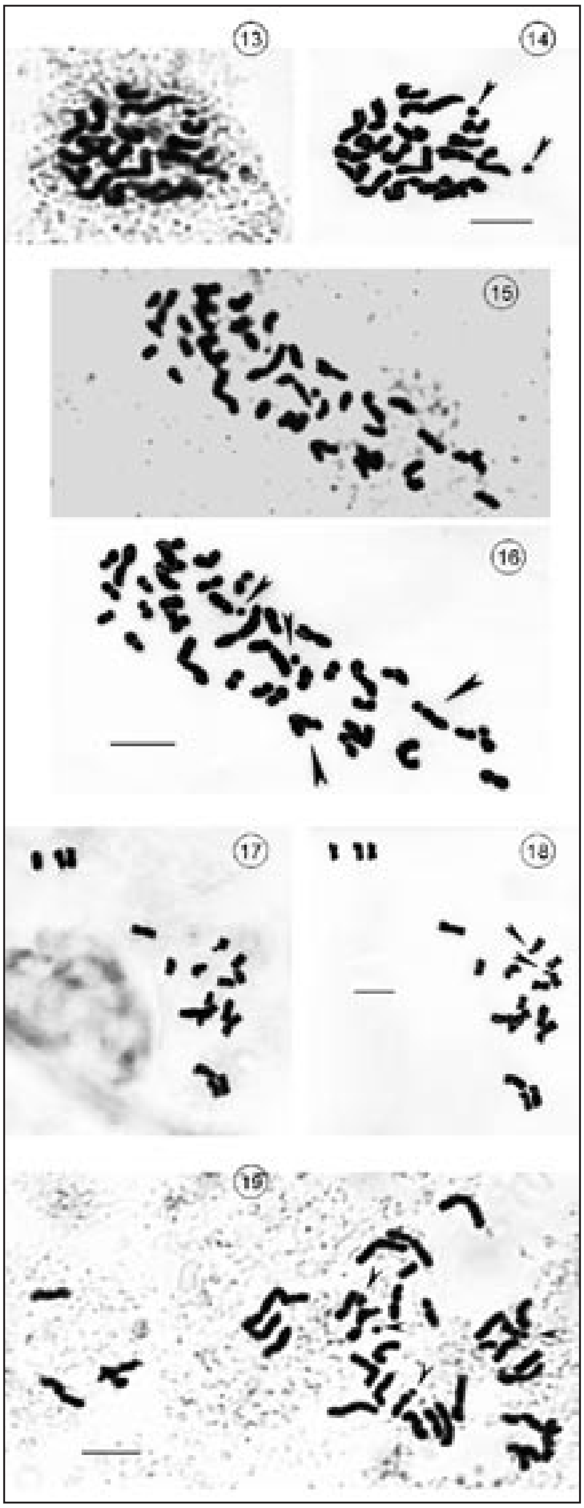



Figs. 7–12 — Photomicrographs (Figs. 7, 9, 11) and drawings (Figs. 8, 10, 12) of a somatic metaphase plate. Figs. 7, 8. *Genista albida* ($2n = 18 + 2B$); Figs. 9, 10. *G. involucrata* ($2n = 18$); Figs. 11, 12. *G. involucrata* ($2n = 36 + 3B$). Arrows indicate B chromosomes. Bar: 5 µm.

*Genista sericea*, an Illyrian amphiadriatic species with $2n = 48$, and the above mentioned taxa endemic to the Balkan Peninsula, were the subject of a preliminary note presenting only their chromosome numbers (CUSMA VELARI *et al.* 1996).

Table 2 summarizes the karyotype features of the eastern-centered taxa of sect. *Spartioides* and of *G. pulchella*. Most taxa present the chromosome number $2n = 18$, while *G. sakellariadis, G. millii* and sometimes *G. involucrata* have $2n = 36$; B chromosomes are present in the complement of all the taxa, except for *G. subcapitata*.

Analyzing the chromosome formula, we can notice that the three subspecies of *G. pulchella*, *G. albida* and *G. involucrata* have exclusively m chromosomes (M only in *G. pulchella* ssp. *pulchella*). The Balkan endemics *G. halacsyi*, *G. sakellariadis, G. millii* and *G. subcapitata* present m and sm, the last species also M and st chromosomes. Satellites were found only in *G. subcapi-*




Figs. 13–19 — Photomicrographs (Figs. 13, 15, 17, 19) and drawings (Figs. 14, 16, 18) of a somatic metaphase plate. Figs. 13, 14. *Genista halacsyi* (2*n* = 18 + 2B); Figs. 15, 16. *G. sakellariadis* (2*n* = 36 + 2B); Figs. 17, 18. *G. subcapitata* (2*n* = 18); Fig. 19. *G. millii* (2*n* = 36 + 2B). Arrows indicate B chromosomes and satellites. Bar: 5 µm.

*tata, G. sakellariadis* and *G. millii*, in m chromosomes.

The total chromosome length (TCL) varies from 41.14 µm (in *G. pulchella* ssp. *pulchella*) to 132.12 µm (in *G. millii*).

As regards the karyotype asymmetry following Stebbins's classification, *G. subcapitata* belongs to category 3A; *G. sakellariadis* and *G. millii* to 3B; *Genista pulchella* ssp. *pulchella,* ssp. *aquilana* and ssp. *villarsiana, G. albida*, *G. involucrata* and *G. halacsyi* to 4B (Table 2).

Given the slight differences in karyotype asimmetry among some taxa, the method of Romero Zarco (1986) was used too, which considers two numerical parameters: the intrachromosomal asymmetry index $A_1$ (due to ratio between arm length) and the interchromosomal asymmetry index $A_2$ (due to variation in chromosome total length) (Table 2). The index $A_1$ presents the lowest values in the three subspecies of *Genista pulchella,* intermediate values in *G. albida* and *G. involucrata*, higher values in the Balkan endemic species, where it varies from 0.29 to 0.40, with the highest value in *G. millii*. The index $A_2$ shows slight differences among the examined taxa: a high variation in chromosome length is found particularly in *G. sakellariadis,* while *G. subcapitata* shows the lowest variation among the other species.

Fig. 22 shows the dispersion diagram representing the karyotype asymmetry of the taxa. The three subspecies of *Genista pulchella* have the most symmetrical karyotype, while the Balkan endemic species present a more asymmetrical karyotype (particularly *G. millii* and, though at a lesser extent, *G. subcapitata*); the species of *G. albida* aggr. present an intermediate asymmetry.

## DISCUSSION

The numbers found in the taxa endemic to the Balkan Peninsula may be traced back to the basic number $x = 9$: *Genista halacsyi* and *G. subcapitata* are diploid; *G. sakellariadis* and *G. millii* tetraploid.

The taxa of *Genista albida* aggr. (*G. albida* and *G. involucrata*) and the three subspecies of *G. pulchella* have the same basic number $x = 9$, with mostly diploid populations; tetraploid numbers were counted only in *G. involucrata* and *G. pulchella* ssp. *villarsiana*.

The secondary basic number $x = 9$, found in the eastern taxa of sect. *Spartioides*, may be interpreted as derived by descending aneuploidy from

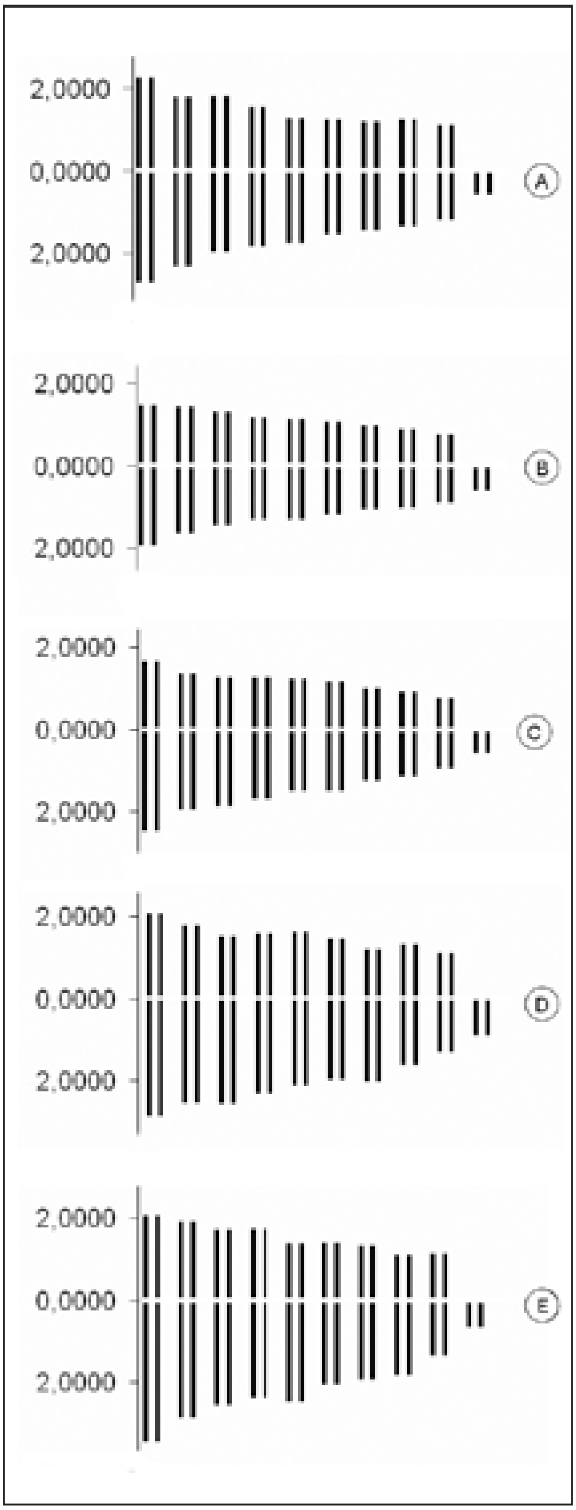



Fig. 20 — Ideograms of the eastern taxa of *Genista* sect. *Spartioides*. A. *G. pulchella* ssp. *pulchella* ($2n$ = 18 + 2B); B. *G. pulchella* ssp. *villarsiana* ($2n$ = 18 + 2B); C. *G. pulchella* ssp. *aquilana* ($2n$ = 18 + 2B); D. *G. albida* ($2n$ = 18 + 2B); E. *G. involucrata* ($2n$ = 18 + 2B). The lenght values on the axes in µm.

$x$ = 12, by far the most common in *Genista* and in the Genisteae in general (see SAÑUDO 1979; GOLDBLATT 1981; CUSMA VELARI *et al.* 2003). The number $x$ = 9 has proved to be more common in *Genista* than previously assumed: it was reported in sect. *Erinacoides* Spach too, where it is the most common basic number (SAÑUDO 1971; TALAVERA 1999), and in sect. *Voglera* (P. Gaertn., B. Mey. & Schreb.) Spach (SAÑUDO 1972; CUSMA VELARI *et al.* 1999).

Among the eastern species of the section, only *Genista sericea* shows the chromosome number $2n$ = 48, with the basic number $x$ = 12; the results of the study of infraspecific taxa of *G. sericea* will be presented in a separate paper.

The three subspecies of *Genista pulchella* recently described by CONTI (2007) present the same number $2n$ = 18 and a similar chromosome formula. From our data, the Illyrian taxon (ssp. *pulchella*), the central-Apenninic endemic (ssp. *aquilana*) and the southern French one (ssp. *villarsiana*) result diploid. The numbers $2n$ = 18, $2n$ = 24 e $2n$ = 36, counted by SEIDENBINDER and VERLAQUE (1985) and by VERLAQUE (1988) in some French populations, are interpreted by VERLAQUE (1988) as ascribable to 'chromosomal races' respectively triploid, tetraploid and hexaploid, traced back by the author to the basic number $x$ = 6. The cytotype with $2n$ = 24 corresponds to *G.* x *martini* Verg. et Soulié, considered by various authors (*e.g.* VERGUIN 1910; GIBBS 1966; GIRERD 1983) as hybrid between *G. pulchella* and *G. scorpius* (L.) DC. Given the uncertain identification of *G.* x *martini* (it is doubtful whether to attribute it to *G. pulchella*), we consider more appropriate to trace back also the chromosome numbers of *G. pulchella* to the basic number $x$ = 9, as for most eastern taxa of the section. Moreover, the hypothesis of VERLAQUE (1988) on the basic number $x$ = 6 has not been sufficiently proved, as no diploid species with $2n$ = 12 has been found in *Genista*.

Among the examined species, *Genista pulchella* presents the most symmetric karyotype: ssp. *villarsiana* is by far the most symmetric, followed by ssp. *pulchella* and ssp. *aquilana.* As regards the karyotype asymmetry, the three subspecies of *G. pulchella* are all distinct; this karyological study may thus endorse the recent subdivision of *G. pulchella* into three subspecific taxa endemic respectively to southern France, central Apennines and the western part of the Balkan Peninsula, proposed by CONTI (2007).

*Genista albida* and *G. involucrata* result very similar as regards the chromosome complement, since they both present the same chromosome formula and grade of asymmetry. Both are

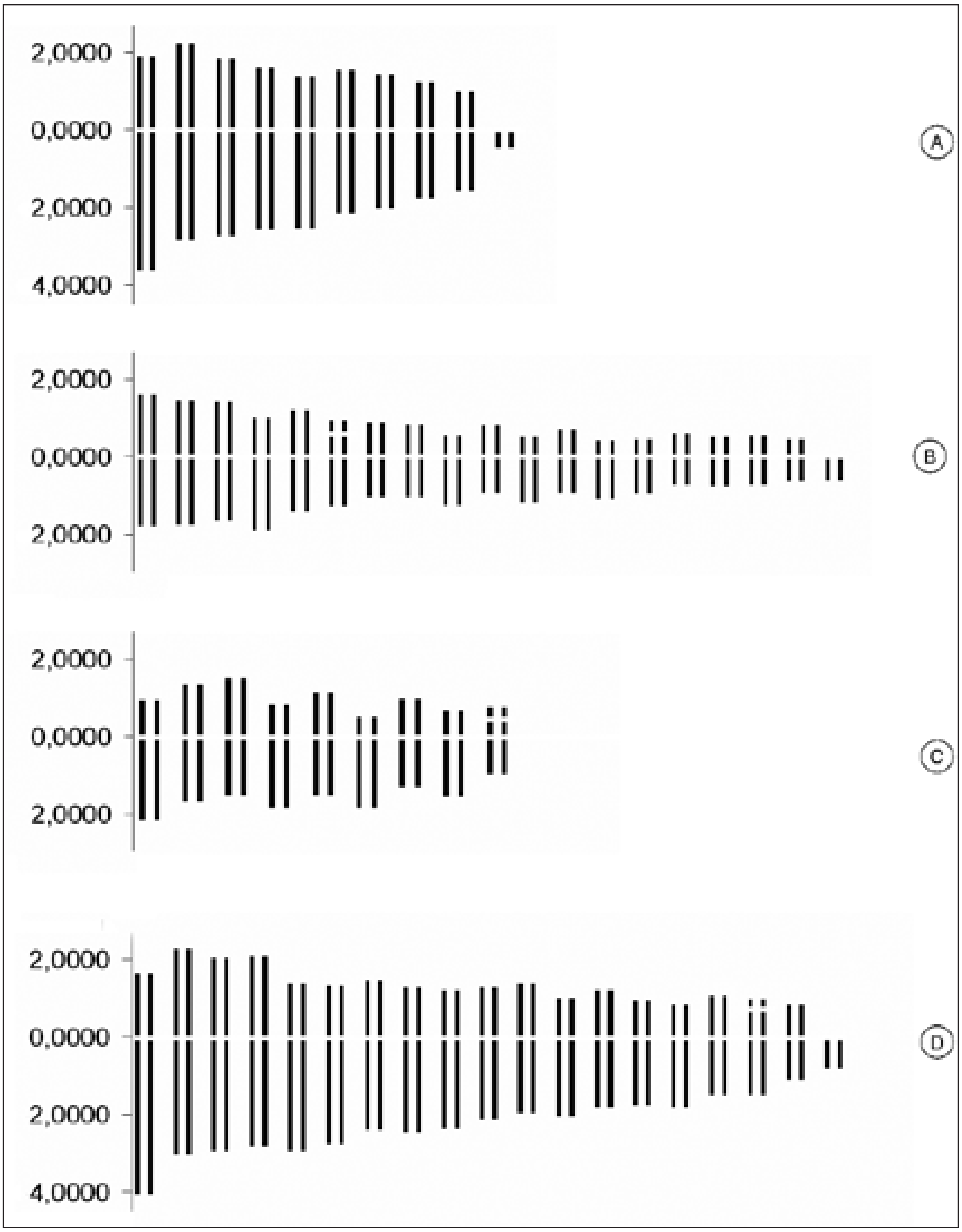



Fig. 21 — Ideograms of the eastern taxa of *Genista* sect. *Spartioides*. A. *G. halacsyi* (2*n* = 18 + 2B); B. *G. sakellariadis* (2*n* = 36 + 2B); C. *G. subcapitata* (2*n* = 18); D. *G. millii* (2*n* = 36 + 2B). The lenght values on the axes in µm.

more asymmetric than the three subspecies of *G. pulchella.* While *G. albida* has an always diploid chromosome number, *G. involucrata* presents a certain tendency towards poliploidy.

The four Balkan endemics *Genista halacsyi*, *G. sakellariadis*, *G. subcapitata* and *G. millii* present the highest grades of asymmetry.

The attribution of specific rank to *Genista ha-*

TABLE 2 — Comparison between the karyotypes of the eastern taxa of *Genista* sect. *Spartioides.* TCL = total chromosome lenght, c = mean chromosome length, σ = standard deviation, Δ = maximum variation of chromosome length, $A_1$ = intrachromosomal asymmetry index, $A_2$ = interchromosomal asymmetry index.

| Taxon | *G. pulchella* ssp. *pulchella* | *G. pulchella* ssp. *villarsiana* | *G. pulchella* ssp. *aquilana* | *G. albida* | *G. involucrata* | *G. halacsyi* | *G. sakellariadis* | *G. subcapitata* | *G. millii* |
|---|---|---|---|---|---|---|---|---|---|
| 2n | 18+(0-2B) | 18+(2-4B) | 18+(0-4B) | 18+(0-2B) | 18+(0-2B) | 18+2B | 36+2B | 18 | 36+2B |
| Chromosome formula | 4M+14m+2B | 18m+2B | 18m+2B | 18m+2B | 18m+2B | 14m+4sm+2B | 24m+2m$^s$+10sm+2B | 2M+6m+2m$^s$+6sm+2st | 16m+2m$^s$+18sm+2B |
| Satellites | | | | | | | pair 6 | pair 9 | pair 17 |
| TCL (µm) | 58.32 | 41.14 | 48.84 | 66.36 | 64.19 | 72.42 | 72.67 | 46.49 | 132.12 |
| c±σ (µm) | 3.24±0.84 | 2.30±0.52 | 2.71±0.72 | 3.69±0.76 | 3.57±0.93 | 4.02±0.94 | 2.01±0.73 | 2.58±0.47 | 3.67±1.05 |
| Δ (µm) | 2.61 | 1.63 | 2.35 | 2.54 | 3.10 | 2.86 | 2.23 | 1.40 | 3.70 |
| Stebbins' karyotype asymmetry categories | 4B | 4B | 4B | 4B | 4B | 4B | 3B | 3A | 3B |
| $A_1$ | 0.14 | 0.11 | 0.20 | 0.27 | 0.28 | 0.33 | 0.29 | 0.37 | 0.40 |
| $A_2$ | 0.26 | 0.23 | 0.27 | 0.20 | 0.26 | 0.23 | 0.37 | 0.18 | 0.29 |

*lacsyi* is endorsed, clearing the doubts of GIBBS (1966) and STRID (1986) on the 'conspecificity' of *G. halacsyi* with *G. sericea*, given the clear karyological differences (different basic numbers), as well as morphological.

Also *Genista sakellariadis* results definitely distinct both from *G. sericea* and *G. halacsyi* for the chromosome complement (respectively for the different basic numbers and the level of ploidy), as well as for the morphological characters. Thus, it appears appropriate to regard *G. sakellariadis* as a distinct species, confirming GIBBS' arrangement (1966, 1968) and clearing the doubts about its rank advanced by STRID (1986).

The specific status of *Genista subcapitata*, already segregated from *G. sericea* by GIBBS (1966, 1968) and STRID (1986), appears confirmed also on the basis of karyological characters (different basic numbers).

*Genista millii* presents the same level of ploidy of *G. sakellariadis*, from which it differs for the karyotype morphology and the grade of asymmetry. It results thus correct to consider it a distinct species, confirming GIBBS' (1966) and STRID's (1986) arrangement.

*Genista halacsyi* and *G. subcapitata* are both diploid, but the former has a more symmetric chromosome complement, the latter more asymmetric. Of the two tetraploid species, *G. sakellariadis* shows a more symmetric karyotype, while *G. millii* results the species of the group with the highest grade of asymmetry. In the past Authors as LEVITSKY (1931) and STEBBINS (1971) considered the most asymmetrical karyotypes as derived. Particularly for Genisteae, SAÑUDO (1979) and VERLAQUE *et al.* (1983) accept this interpretation. Recently, with the advent of molecular phylogenetic studies, the tendency is to be more cautious, because of the occasional contrasting results (see *e.g.* PERUZZI 2005). Only with molecular data on the species of sect. *Spartioides* here examined, it will be possible to advance a reliable interpretation.

The western taxa of sect. *Spartioides* and *Genista pilosa* were karyologically analysed in CUSMA VELARI *et al.* (2003). The secondary basic number $x = 12$ appears to be the most common, with generally euploid species. Most species have the chromosome number $2n = 48$, with level of ploidy $4x$ [*G. ramosissima* (Desf.) Poir. in Lam., *G. cinerea* (Vill.) DC. in Lam. & DC., *G. valentina* (Willd. ex Spreng.) Steud., *G. majorica* Cantó & M. J. Sánchez, *G. jimenezii* Pau, *G. teretifolia* Willk., sometimes *G. obtusiramea* J. Gay ex Spach and *G. florida* L.], while *G. cinerascens* Lange and *G. pilosa* present in most cases the number $2n = 24$

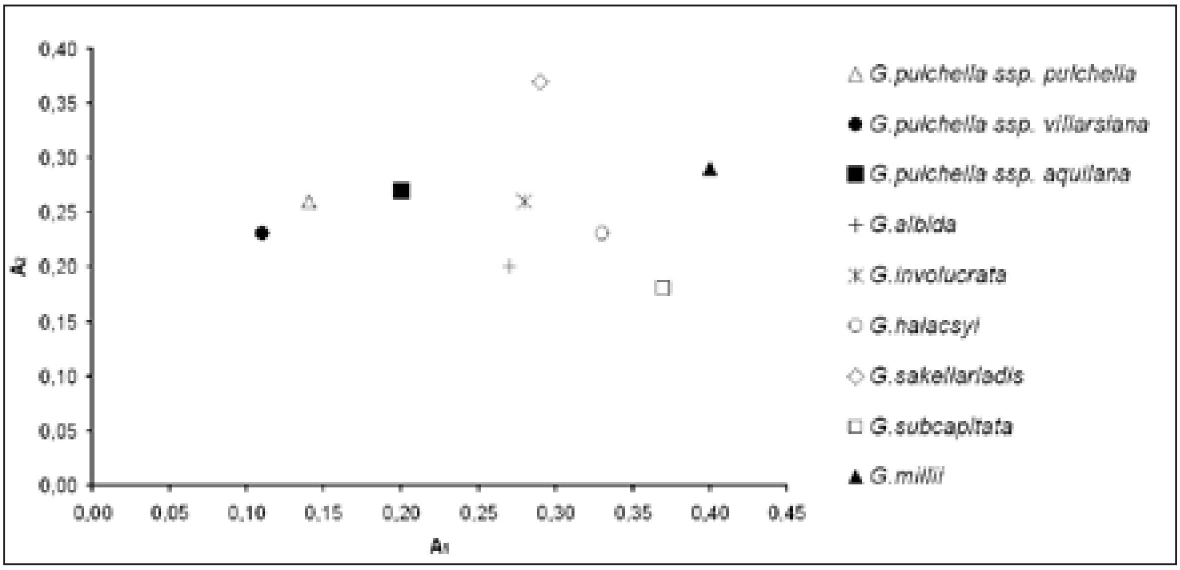



Fig. 22 — Dispersion diagram representing the karyotype asymmetry of the eastern taxa of *Genista* sect. *Spartioides*. $A_1$, intrachromosomal asymmetry index; $A_2$, interchromosomal asymmetry index.

with level of ploidy 2*x*. Higher grades of ploidy (hexaploid, rarely octoploid, cytotypes in *G. cinerascens* and *G. obtusiramea*) were rarely found.

A tendency towards descending aneuploidy was found in *Genista florida* ($2n$ = 46 as well as $2n$ = 48) and in *G. pilosa* ($2n$ = 22, 44 as well as $2n$ = 24); this tendency is not very common in *Genista*, but was often releved in *Teline* Medik. (Sañudo 1973; Cusma Velari *et al.* 2000) and in *Cytisus* Desf. (Cusma Velari and Feoli Chiapella 1994).

Sect. *Spartioides* results thus karyologically heterogeneous, presenting two secondary basic numbers ($x$ = 9 and $x$ = 12). Moreover three (seldom four) levels of ploidy and some cases of aneuploidy were found. The heterogeneity of *Genista*, due to polyploidy, disploidy and aneuploidy is actually well known (Sañudo 1979; Goldblatt 1981; Verlaque 1988). Besides the basic numbers $x$ = 9 and $x$ = 12, chromosome numbers traceable back to $x$ = 10 and $x$ = 11 were also reported in some species of other sections of *Genista* (Sañudo 1971; Cusma Velari and Feoli Chiapella 1991); these numbers presumibly derive from $x$ = 12 as well by descending aneuploidy.

Furthermore, sect. *Spartioides* results morphologically and phytochemically (alkaloids and isoflavonoids) heterogeneous (Cantò *et al.*, 1997). The species of the section do not form a monophyletic group also on the basis of molecular data obtained from the analysis of nrDNA (ITS region) and cpDNA (*trn*L-*trn*F IGS) by Pardo *et al.* (2004); yet, these authors examined almost exclusively taxa distributed in the western Mediterranean region; no eastern species studied in this research was considered; a partial analysis, relative to cpDNA, was carried out only on *Genista sericea*, which clusters with the *G. cinerea* group.

**Acknowledgements —** Financial support by "Ministero dell'Istruzione, dell'Università e della Ricerca" (M.I.U.R., Roma) is gratefully acknowledged. We thank Prof. Fabio Conti (Centro Ricerche Floristiche dell'Appennino, L'Aquila), Prof. Dalibor Vladović (Split) and Prof. Bogdan Kuzmanov † (Sofia) for having supplied us with some seeds. Thanks are due to Lucia Feoli for the English version and Simone Velari for graphics.

## REFERENCES

Andreev N., 1981 — In: Löve Á. (Ed.), *IOPB Chromosome number reports LXX*. Taxon, 30 (1): 74-75.

Cantó P., Rivas-Martínez S., Greinwald R. and van Rensen I., 1997 — *Revisión de Genista L. sect. Spartioides Spach en la Península Ibérica y Baleares.* Lazaroa, 18: 9-44.

Conti F., Abbate G., Alessandrini A. and Blasi C. (Eds), 2005 — *An Annotated Checklist of the Italian Vascular Flora.* Palombi Editori, Roma.

Conti F., 2007 — *Morphometric study and taxonomy of Genista pulchella Vis. s.l. (Fabaceae), a south European species.* Botanical Journal of the Linnean Society, 153: 245-254.

Cusma Velari T. and Feoli Chiapella L., 1991 — *Systematic relationships within the Genista sylvestris* *group (Genisteae, Fabaceae) on the basis of karyological and biometrical data.* Flora Mediterranea, 1: 21–29.

CUSMA VELARI T. and FEOLI CHIAPELLA L., 1994 — *Karyological studies of Spartocytisus Webb & Berth. (Genisteae-Fabaceae).* Studia Geobotanica, 14: 33-39.

CUSMA VELARI T., FEOLI CHIAPELLA L. and KOSOVEL V., 1996 — *Osservazioni cariosistematiche sul gruppo di Genista sericea.* Giornale Botanico Italiano, 130 (1): 369.

CUSMA VELARI T., FEOLI CHIAPELLA L., CRISTIN C. and KOSOVEL V., 1999 — *Karyological systematics of Genista ifniensis A. Caballero, Genista tricuspidata Desf., and related species (Genisteae-Fabaceae).* Studia Geobotanica, 17: 77-83.

CUSMA VELARI T., FEOLI CHIAPELLA L. and BACCHETTA G., 2000 — Reports (1189-1190). In: Kamari G., Felber F., Garbari F. (Eds), *Mediterranean chromosome number reports 10.* Flora Mediterranea, 10: 401-405.

CUSMA VELARI T., FEOLI CHIAPELLA L. and AYTAÇ Z., 2002 — Report (1315). In: Kamari G., Blanché C., Garbari F. (Eds), *Mediterranean chromosome number reports 12.* Flora Mediterranea, 12: 480-482.

CUSMA VELARI T., FEOLI CHIAPELLA L. and KOSOVEL V., 2003 — *Karyological notes on Genista sect. Spartioides Spach with emphasis on western species and G. pilosa L. (Genisteae-Fabaceae).* Studia Geobotanica, 22: 55-64.

FEOLI CHIAPELLA L. and RIZZI LONGO L., 1987 — *Distribuzione ed ecologia del genere Genista L. nel Friuli-Venezia Giulia.* Biogeographia, 13: 119-154.

FORISSIER R., 1975 — In: Löve Á. (Ed.) *IOPB Chromosome number reports L.* Taxon, 24 (5/6): 672.

GIBBS P.E., 1966 — *A revision of the genus Genista L.* Notes from the Royal Botanic Garden Edinburgh, 27 (1): 11-99.

GIBBS P.E., 1968 — *Genista* L. In T.G. Tutin, N.A. Burges, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb (Eds), "Flora Europaea", 2: 94-100. Cambridge University Press, Cambridge.

GIBBS P.E., 1970 — *Genista* L. In P.H. Davis (Ed.), "Flora of Turkey and the East Aegean Islands", 3: 24-32. Edinburgh University Press, Edinburgh.

GIRERD B., 1983 — *Recherches sur la Flore de Provence occidentale. L' hybride Genista martinii Verguin et Soulié (G. scorpius x G. pulchella) au Mont Ventoux.* Société Botanique de Vaucluse, 2: 1-8.

GOLDBLATT P., 1981 — *Cytology and Phylogeny of Leguminosae*. In R.M. Polhill and P.H. Raven (Eds), "Advances in Legume Systematics", 2: 427- 463. The Royal Botanic Gardens, Kew.

GREUTER W., BURDET H.M. and LONG G., 1989 — *Med-Checklist,* 4: 91-105. Conservatoire et Jardin botaniques, Genève.

HAYEK A. von., 1924-1927 — *Prodromus florae peninsulae balcanicae*. Published as *Repertorium Specierum novarum Regni vegetabilis.* Beiheft, 30 (1): 907-916.

KRUSHEVA R.M., 1975 — In: Löve Á. (Ed.), *IOPB Chromosome number reports L.* Taxon, 24 (5/6): 676-677.

KUZMANOV B.A., 1978 — *Cytotaxonomic Investigation of Bulgarian Leguminous Plants*. In S.I. Kozuharov and B.A. Kuzmanov (Eds), "Evolution of flowering plants and florogenesis, 1. Fabaceae, Scrophulariaceae, Rubiaceae": 11-71. Bulgarian Academy of Sciences, Sofia.

KUZMANOV B.A., ANCEV M.E. and MARKOVA T.A., 1973 — In: Löve Á. (Ed.), *IOPB Chromosome number reports XLI.* Taxon, 22 (4): 461.

LEVITSKY G.A., 1931 — *The karyotype in systematics*. Bulletin of Applied Botany, of Genetics, and Plant-Breeding, 27: 220-240.

LEVAN A., FREDGA K. and SANDBERG A.A., 1964 — *Nomenclature for centromeric position on chromosomes.* Hereditas, 52: 201-220.

MOUTERDE P., 1978-84 — *Nouvelle Flore du Liban et de la Sirie.* (A. Charpin and W. Greuter Eds). Dar El-Machreq (Imprimerie Catholique), Beyrouth.

PAMPANINI R., 1912 — *La Genista sericea Wulf. e la sua distribuzione in Italia.* Nuovo Giornale Botanico Italiano, 19: 327-348.

PARDO C., CUBAS P. and TAHIRI H., 2004 — *Molecular phylogeny and systematics of Genista (Leguminosae) and related genera based on nucleotide sequences of nrDNA (ITS region) and cpDNA (trnL-trnF intergenic spacer)*. Plant Systematics and Evolution, 244: 93-119.

PERUZZI L. and AQUARO G., 2005 — *Contribution to the cytotaxonomical knowledge of Gagea Salisb.(Liliaceae). II. Further karyological studies on Italian populations*. Candollea, 60(1): 237-253.

PIGNATTI S., 1982 — *Flora d'Italia*, 1: 636-644. Edagricole, Bologna.

RAMEAU J.C., MANSION D. and DUMÉ G., 1993 — *Flore forestière française,* 2: 564-583. Institut pour le développement forestier, Dijon-Quetigny.

ROMERO ZARCO C., 1986 — *A new method for estimating karyotype asymmetry.* Taxon, 35 (3): 526-530.

SAÑUDO A., 1971 — *Variabilidad cromosómica de las Genisteas de la Flora española en relación con su ecología. 1. Número y comportamiento de los cromosomas durante la meiosis. A. Secciones Erinacoides Spach, Scorpioides (L.) DC. y Asterospartum Spach del Gen. Genista L.* Cuadernos de Ciencias Biológicas, Universidad de Granada, 1: 1-21.

SAÑUDO A., 1972 — *Variabilidad cromosómica de las Genisteas de la Flora española en relación con su ecología. 1. Número y comportamiento de los cromosomas durante la meiosis. B. Secciones Genista, Spartioides Spach, Phyllospartum Willk. y Voglera (B. Gaertner, B. Meyer & Schreb.) Spach, del Gen. Genista L.* Cuadernos de Ciencias Biológicas, Universidad de Granada, 2: 43–52.

SAÑUDO A., 1973 — *Variabilidad cromosómica de las Genisteas de la Flora española en relación con su ecología. 1. Número y comportamiento de los cromosomas durante la meiosis. C. Sección Cephalospartum del Gen. Genista L. y géneros Lygos Adan-*

*son, Spartium L., Teline Medicus, Calicotome Link y Argyrolobium Ecklon & Zeyher.* Cuadernos de Ciencias Biológicas, Universidad de Granada, 2 (2): 117-120.

SAÑUDO A., 1979 — *Chromosome variability in the Genisteae (Adans.) Benth. (Leguminosae).* Webbia, 34 (1): 363-408.

SĂVULESCU T., 1957 — *Flora Republicii Populare Romîne,* 5: 53-72. Editura Academiei Republicii Populare Romîne, Bucuresti.

SEIDENBINDER M. and VERLAQUE R., 1985 — In: Löve Á. (Ed.), *IOPB Chromosome number reports LXXXVI.* Taxon, 34 (1): 161.

STEBBINS G.L., 1971 — *Chromosomal Evolution in Higher Plants.* Edward Arnold Ltd, London.

STRID A., 1986. — *Mountain flora of Greece*, 1: 452-459. Cambridge University Press, Cambridge.

TALAVERA S., 1999 — *Genista* L. In S. Talavera, C. Aedo, S. Castroviejo, C. Romero Zarco, L. Sáez, F.J. Salgueiro, M. Velayos (Eds), "Flora Iberica", 7 (1): 45-119. Real Jardín Botánico, CSIC, Madrid.

URIBE-ECHEBARRÍA P.M. and URRUTIA P., 1988 — *Apuntes para el conocimiento de la sección Erinacoides Spach del género Genista L. (Leguminosae)*. Estudios del Instituto Alavés de la Naturaleza, 3: 209-224.

URIBE-ECHEBARRÍA P.M. and URRUTIA P., 1994 — *Distribución de los táxones de la sección Erinacoides Spach del género Genista L., en la península Ibérica.* Estudios Museo de Ciencias Naturals de Alava, 9: 21-34.

VERGUIN L., 1910 — *Un Genêt hybride*. Bulletin de la Société botanique de France, 47: 131-134.

VERLAQUE R., SEIDENBINDER M. and RAYNAUD C., 1983 — *Recherches cytotaxonomiques sur la speciation en région Méditerranéenne III: espèces aneuploides.* Revue de Biologie-Ecologie méditerranéenne, 10: 315-346.

VERLAQUE R., 1988 — *Modalités de la speciation chez les Genisteae.* Actes del Simposi Internacional de Botànica Pius Font i Quer 2: 49-68.

WHITE M.J.D., 1973 — *The Chromosomes*. 6th ed. Chapman and Hall, London.

Received July 8th 2009; accepted February 20th 2009