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## Systematic relationships within the *Genista sylvestris* group (*Genisteae*, *Fabaceae*) on the basis of karyological and biometrical data

### Abstract

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Within the *Genista sylvestris* group, *G. sylvestris* s. str. ( $2n = 88$ ), *G. dalmatica* ( $2n = 88$ ) and *G. michelii* ( $2n = 132$ ) appear to have the same basic chromosome number ( $x = 11$  or  $22$ ), whereas *G. aristata* ( $2n = 48$ ) has a different one ( $x = 6$  or  $12$ ). Seeds measurements, which are correlated with the level of ploidy confirm that *G. aristata* is the most isolated taxon of the group. A combination of karyological, morphological and chorological data lends support to the assumption that the three first-named taxa are closely related and have a common origin, whereas *G. aristata* may be more directly linked with some other species such as *G. cupanii* or *G. hirsuta*.

### Introduction

The *Genista sylvestris* group, of *Genista* subg. *Phyllobotrys* Spach sect. *Voglera* (P. Gaertner & al.) Spach, is here defined to include *G. sylvestris* Scop., *G. dalmatica* Bartl., *G. michelii* Spach and *G. aristata* C. Presl (Fiori 1923-1925, Pignatti 1982).

*Genista sylvestris* and *G. dalmatica* are present in the north-western part of the Balkan Peninsula, from the Karst region of Trieste and Gorizia to northern Albania (Fig. 1). *G. sylvestris* is found mainly in the northern part of this range, *G. dalmatica* in its southern part but extending to Cres in the Dalmatian Islands (Visiani 1850-1851, Gams 1923-1924, Hayek 1924-1927, Horvatić 1934). *G. michelii* is only known from two disjunct areas in Italy, on the Gargano mountains (Puglia) and on the S. Vicino chain (Marche) (Fiori 1923-1925, Brilli-Cattarini 1969, Fenaroli 1970, Pignatti 1982). *G. aristata* is a Sicilian endemic of the Madonie and Nebrodi mountains. (Fiori 1923-1925, Pignatti 1982).

In the north-west of the Balkan Peninsula, *Genista sylvestris* grows on calcareous rocks, generally facing-south, in more or less xerophytic herbaceous communities. It is considered by Horvatić (1975) as a characteristic species of the order *Koelerietalia splendentis* which comprises dry sub-mediterranean meadows. *G. dalmatica* appears to be the more thermophilous of the two Balkan taxa.

Earlier systematic treatments were based on morphological characters. Visiani (1850-1851) subdivided *Cytisus sylvestris* (Scop.) Vis. into var. *innocua* Vis. (= *Genista sylvestris* s. str.) and var. *pungens* Vis. (= *G. dalmatica*); Gams (1923-1924) considered the two Balkan taxa as varieties of *G. sylvestris*: var. *innocua* (Vis.) Ascherson & Graebner and var. *dalmatica* (Bartl.) Tommasini. Fiori (1923-1925) lumped all four taxa, including

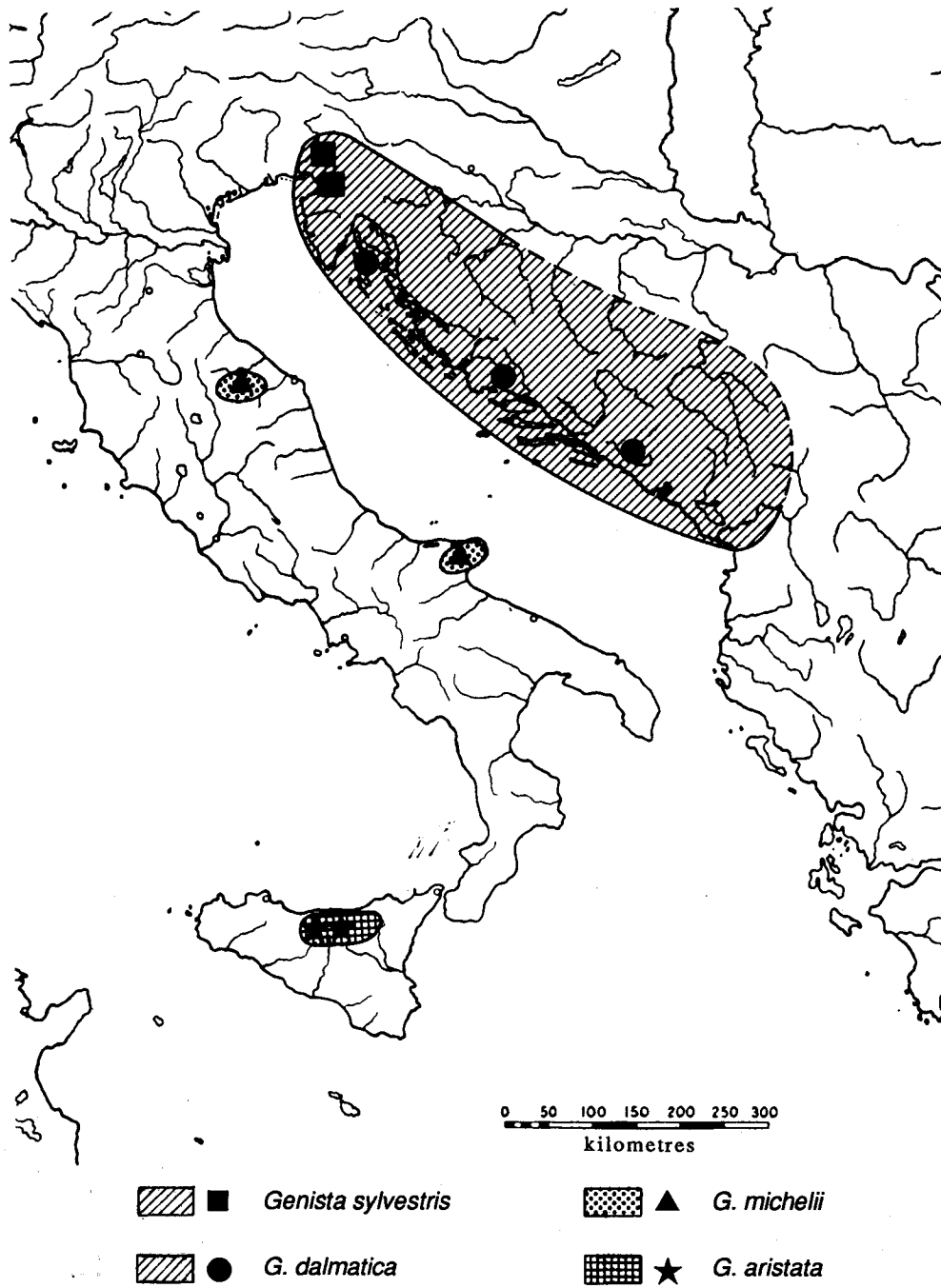


Fig. 1. Geographical distribution of the taxa of *G. sylvestris* group, and origin of the studied populations.

*G. aristata*, as varieties under *G. sylvestris*. Horvatic (1934) referred to the Balkan taxa as subspecies of *G. sylvestris*: subsp. *innocua* (Vis.) Hayek and subsp. *dalmatica* (Bartl.) H. Lindb. Gibbs (1966) treated *G. dalmatica* and *G. michelii* as synonyms of *G. sylvestris*, retaining *G. aristata* as a distinct species. Pignatti (1982) accepted two species: *G. aristata* and *G. sylvestris*, the latter with subsp. *sylvestris* and subsp. *dalmatica* (including *G. michelii*).

Studies of palynological and serological characters have already been conducted in order to clarify the relationships between the taxa of the group and to establish the most suitable systematic arrangement. In spite of the similarity of pollen characters, Feoli Chiapella (1983) judged the four taxa to be distinct: *Genista aristata* was considered to deserve specific status, the others were tentatively treated at the rank of subspecies under *G. sylvestris*. From a serological point of view, the *G. sylvestris* group proved to be remarkably homogenous (Cristofolini & Feoli Chiapella 1975-1977).

Karyological studies on the *Genista sylvestris* group are scarce. The only published data concern *G. sylvestris* s. str. and *G. dalmatica* (Forissier 1975), and no data were available on *G. michelii* and *G. aristata*. Preliminary results concerning these taxa were presented by Cusma Velari & Feoli Chiapella (1986).

In this paper, the results of a karyological analysis and of a biometric survey of the seeds of the taxa of the *Genista sylvestris* group are presented.

## Materials and methods

Various populations were studied in order to assess the variability of the chromosome numbers. Seeds of *Genista sylvestris* s. str., *G. dalmatica*, *G. michelii* and *G. aristata* were collected in the field. The localities of collection and the names of the collectors are given in Table 1. Voucher specimens are deposited in the herbarium of the Department of Biology, University of Trieste (TSB).

Mitotic studies were carried out on root tips of seedlings. The excised root tips were treated with 8-hydroxyquinoline, fixed in a 1 : 3 solution of glacial acetic acid: absolute ethanol (Carnoy's fluid), hydrolyzed in 1N HCl at 60°C for six minutes and stained using the routine Feulgen method. Slides were prepared using the squash technique. For each population 10 to 50 good metaphase plates were examined in order to reliably establish the chromosome numbers (see Table 1).

Only numbers of chromosomes can be given here, due to the small size of the chromosomes (0.5 - 2.4 µm) and of their high number. In most species of *Genista* it is almost impossible to obtain preparations of a quality sufficient for karyotype analysis (Santos 1945, Sañudo 1979, Cusma Velari & Feoli Chiapella 1987).

The biometric analysis was carried out on seeds from the same populations (Table 1). For each population a sample of 20 seeds was used to measure length and width. The Student t-test was used to assess the significance of the differences between the mean values for the various taxa. The taxa were also compared using classification and ordination methods based on the Gower index (Gower & Ross 1969, Sneath & Sokal 1973).

## Results

*Karyological analysis.* — The results of the karyological analysis are as follows (Fig. 2, Tab. 1):

*Genista sylvestris* s. str.:  $2n = 88$ . The number is twice as high as that one ( $n = 22$ ) reported by Forissier (1975) from Mt. Učka (Hrvatska, Yugoslavia).

*Genista dalmatica*:  $2n = 88$ . This agrees with Forissier (1975), who recorded  $n = 44$  for plants from Sarajevo (Bosna, Yugoslavia).

*Genista michelii*:  $2n = 132$ . There are no earlier published data for this species.

*Genista aristata*:  $2n = 48$  (Fig. 2d, Tab. 1). No previous data are known for this species from the literature.

Table 1. Geographical origin of the examined populations of taxa of the *Genista sylvestris* group, with collectors of the seeds, chromosome numbers, and numbers of metaphase plates studied.

| Taxon                | Localities  | Source             | $2n$ | N° of plates |
|----------------------|---|--------------------|------|--------------|
| <i>G. sylvestris</i> | Trieste, Val Rosandra<br>(Friuli-Venezia Giulia, I) | L. Feoli Chiapella | 88   | 50           |
|                      | M. Caven (Slovenja, YU)                             | L. Feoli Chiapella | 88   | 10           |
| <i>G. dalmatica</i>  | Cres (Hrvatska, YU)                                 | L. Feoli Chiapella | 88   | 20           |
|                      | Omis-Split (Hrvatska, YU)                           | L. Feoli Chiapella | 88   | 10           |
|                      | Brgat, Dubrovnik<br>(Hrvatska, YU)                  | L. Feoli Chiapella | 88   | 10           |
| <i>G. michelii</i>   | Mt.S. Vicino (Marche, I)                            | A. Brill-Cattarini | 132  | 50           |
|                      | Gargano (Puglia, I)                                 | L. Feoli Chiapella | 132  | 10           |
| <i>G. aristata</i>   | M. Madonie (Sicilia, I)                             | F. M. Raimondo     | 48   |              |
|                      | Contrada Mangiarrati<br>(Sicilia, I)                | F. M. Raimondo     | 48   |              |

*Biometric analysis.* — The mean values and standard deviations for the seed dimensions are given in Table 2. The seeds of *Genista sylvestris* and *G. dalmatica* are very similar in size, whilst those of *G. michelii* are larger and those of *G. aristata* are significantly smaller.

The difference between the average seed dimensions of *Genista sylvestris* and *G. dalmatica* is always insignificant; it is always significant between *G. michelii* and *G. sylvestris*, whilst it is significant for the length but not for the width between *G. michelii* and *G. dalmatica*. *G. aristata* is distinct in both characters from the other three taxa of the group with a high level of significance (Tab. 3).

The dendrogram, the ordination and the minimum spanning tree of the taxa of the *Genista sylvestris* group on the basis of their average seed dimensions are presented in

Fig. 3. *G. sylvestris* and *G. dalmatica* have the highest degree of similarity, *G. michelii* is allied to this cluster with a closer similarity to *G. dalmatica*; *G. aristata* is the most isolated taxon of the group, its best affinity being with *G. sylvestris*.

Table 2. Mean values and standard deviations of the length and width (in mm) of seeds of the taxa of the *Genista sylvestris* group.

| Taxon                | Length      | Width       |
|----------------------|-------------|-------------|
| <i>G. sylvestris</i> | 2.94 ± 0.14 | 2.16 ± 0.15 |
| <i>G. dalmatica</i>  | 2.99 ± 0.13 | 2.26 ± 0.19 |
| <i>G. michelii</i>   | 3.26 ± 0.13 | 2.30 ± 0.19 |
| <i>G. aristata</i>   | 1.93 ± 0.12 | 1.64 ± 0.15 |

Table 3. Number of quantitative characters that are discriminant between the taxa of the *Genista sylvestris* group at significant level ( $P < 0.005$ ) according to t-test.

| Taxon                | 1 | 2 | 3 | 4 |
|----------------------|---|---|---|---|
| <i>G. sylvestris</i> | 1 | / | 0 | 2 |
| <i>G. dalmatica</i>  | 2 | / | 1 | 2 |
| <i>G. michelii</i>   | 3 |   | / | 2 |
| <i>G. aristata</i>   | 4 |   |   | / |

## Discussion

*Genista sylvestris* ( $2n = 88$ ), *G. dalmatica* ( $2n = 88$ ) and *G. michelii* ( $2n = 132$ ) appear to have the same basic chromosome number, either  $x = 11$  or  $x = 22$ . These basic numbers were already known in the *Genisteae* (Sañudo 1979). There are sporadic counts of  $2n = 44$  for *G. germanica* L. (Murin in Majovský & al. 1974) and in *G. carinalis* Griseb. (Kruscheva 1975), both also belonging to *G. sect. Voglera*. *G. sylvestris* and *G. dalmatica*, with the same level of ploidy, are tetraploids or octoploids; *G. michelii* hexaploid or dodecaploid.

*Genista aristata* ( $2n = 48$ ) is clearly distinct from the three other taxa by its different basic chromosome number, presumably  $x = 12$ , and would thus be tetraploid. Santos (1945) and Sañudo (1979) also considered the taxa of the *Genisteae* with a chromosome number of  $2n = 48$  to be tetraploid. According to Sañudo (1979), tetraploidy is the most common ploidy level in the *Genisteae*. Recently Verlaque (1988) has suggested that the primitive chromosome number in *Genista* is  $x = 6$ . In that case, *G. aristata* would be an octoploid.

The biometric analysis on the seeds does not reveal appreciable differences between *Genista dalmatica* and *G. sylvestris*, whilst *G. michelii* appears to be distinct from both but somewhat closer to *G. dalmatica*. The affinity between *G. dalmatica* and *G. michelii* is underlined by their marked thorny habit that clearly differs from that of the spineless *G. sylvestris*.

The relationships inferred on the basis of our karyological and biometrical data are supported by the results of a palynotaxonomic analysis of the group (Rizzi Longo & Feoli Chiapella 1981, Feoli Chiapella 1983) where by *G. michelii* is clearly distinct by its larger pollen grains from *G. sylvestris* and *G. dalmatica*.

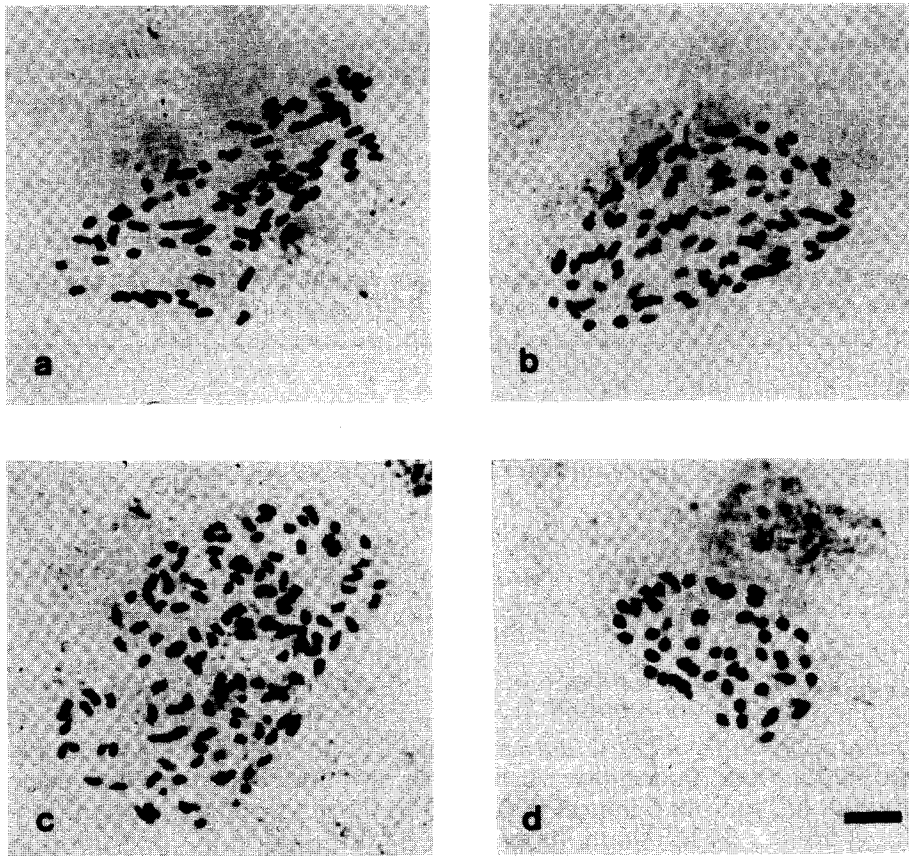


Fig. 2. Somatic metaphase plates. — a, *Genista sylvestris* ( $2n = 88$ ); b, *G. dalmatica* ( $2n = 88$ ); c, *G. michelii* ( $2n = 132$ ); d, *G. aristata* ( $2n = 48$ ). Scale bar = 5  $\mu\text{m}$ .

Our data show that a higher level of ploidy is correlated with an increased seed and pollen grain size. This agrees with results, also concerning *Genista*, of Sañudo (1971, 1972, 1974, 1979) and Cusma Velari & Feoli Chiapella (1987) and lends additional support to the model of a "gigas effect" of polyploidy (Stebbins 1971).

**Conclusions**

*Genista aristata*, a Sicilian endemic, is clearly distinct from *G. sylvestris*, *G. dalmatica* and *G. michelii* both in morphology (floral characters, type of pilosity, seed dimensions) and basic chromosome numbers.

*Genista michelii* can be distinguished by its higher ploidy level and by greater seed and pollen grain size. *G. sylvestris* and *G. dalmatica*, both with an Illyrian distribution, have

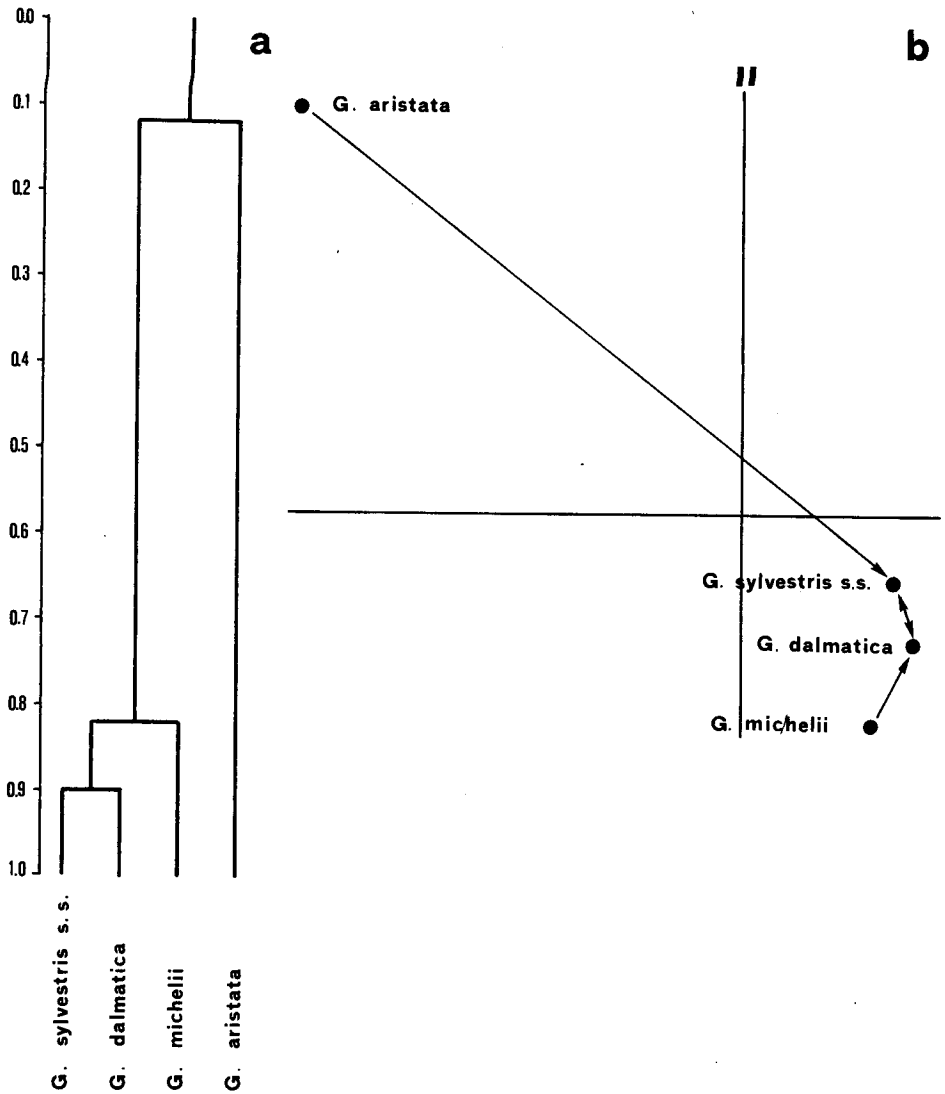


Fig. 3. Dendrogram (a), ordination and MST (b) of the taxa of the *Genista sylvestris* group, based on seed characters (Gower index).

the same ploidy level and very similar seed and pollen grain size. These three taxa presumably had a common origin in the past, when the two shores of the Adriatic were still connected, a hypothesis which is also supported by their notable serological affinity (Cristofolini & Feoli Chiapella 1975, 1977). *G. michelii*, an Italian endemic with a disjunct distribution on the peninsula, appears to have become isolated early from its Illyrian counterparts, with subsequent karyological and palynological differentiation.

The origin of *Genista aristata* was probably independent. This species is perhaps more closely related to western Mediterranean taxa of *G. sect. Voglera* in which the chromosome number is based on  $x = 12$ . The number  $2n = 48$  has also been found in *G. cupanii* Guss. (Bartolo & al. 1977), a Sicilian endemic, and in *G. hirsuta* Vahl (Sañudo 1972) that occurs in the southern part of the Iberian Peninsula and in northern Morocco. The existence of links between S European and N African taxa has been reported i.a. by Küpfer (1986).

If a common origin is postulated for *Genista aristata* and *G. sylvestris*, as by Gibbs (1966), this must then have predated the differentiation of *G. sylvestris*, *G. dalmatica* and *G. michelii*, whose common basic chromosome number,  $x = 11$  or  $x = 22$ , could have developed through dysploidy from taxa of *G. sect. Voglera* with a more ancient basic number,  $x = 12$  (Sañudo 1979) or  $x = 6$  (Verlaque 1988), wide-spread among the taxa of this section (Sañudo 1979).

With respect to the systematic treatment of the group, it would be more appropriate to consider *Genista sylvestris* s. str., *G. dalmatica* and *G. michelii* as subspecies of *G. sylvestris*, as has already been informally proposed by Feoli Chiapella (1983), while *G. aristata* could be maintained as a distinct species, in accordance with Gibbs (1966, 1968).

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#### References

- Bartolo, G., Brullo, S., Maiorana, G. & Pavone, P. 1977: Numeri cromosomici per la flora italiana: 315-328. — *Inform. Bot. Ital.* **9**: 71-87.
- Brillì-Cattarini, A. 1969: Segnalazione di piante nuove, inedite o notevoli per la regione marchigiana. I. — *Giorn. Bot. Ital.* **103**: 367-384.
- Cusma Velari, T. & Feoli Chiapella, L. 1986: Osservazioni cariologiche sul gruppo di *Genista sylvestris*. — *Giorn. Bot. Ital.* **120**, Suppl. **2**: 173.
- & — 1987: Analisi cariologica e citogeografica di *Genista radiata*. — *Biogeographia* **13**: 421-427.
- Cristofolini, G. & Feoli Chiapella, L. 1975: Serological systematics of *Genisteae*. — *Giorn. Bot. Ital.* **109**: 292-294.
- & — 1977: Serological systematics of the tribe *Genisteae* (*Fabaceae*). — *Taxon* **26**: 43-56.
- Fenaroli, L. 1970: *Florae garganicae prodromus. Pars altera*. — *Webbia* **24**: 435-578.
- Feoli Chiapella, L. 1983: Palynotaxonomic studies on *Genisteae*. I. *Genista germanica* L. and the group of *G. sylvestris*. — *Boll. Soc. Adriat. Sci.* **67**: 25-40.
- Fiori, A. 1923-1925: *Nuova flora analitica d'Italia*. **1**. — Firenze.
- Forissier, R. 1975: Reports. [In Löve, Å. (ed.): *IOPB chromosome number reports XLVII.*] — *Taxon* **24**: 144.



- Gams, H. 1923-1924: *Leguminosae*.— Pp. 1113-1644 in: Hegi, G. (ed.): *Illustrierte Flora von Mittel-Europa*, 4. — München.
- Gibbs, P. E. 1966: A revision of the genus *Genista* L. — *Notes Roy Bot. Gard. Edinburgh* 27: 11-99.
- 1968: *Genista* L. — Pp. 94-100 in Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M. & Webb, D. A. (ed.): *Flora europaea*, 2. — Cambridge.
- Gower, J. C. & Ross J. S. 1969: Minimum spanning tree single linkage cluster analysis. — *Appl. Statist.* 18: 54-64.
- Hayek, A. von, 1924-1926: *Prodromus florae peninsulae balcanicae*, 1. — *Repert. Spec. Nov. Regni Veg. Beih.* 30(1).
- Horvatić, C. S. 1934: *Flora i vegetacija otoka Paga*. — *Prir. Istraž. Kral. Jugoslavije* 19: 116-374.
- 1975: Neuer Beitrag zur Kenntnis der Syntaxonomie der Trocken-Rasen- und Steintriften-Gesellschaften des ostadriatischen Karstgebietes. — Pp. 300-310 in: Jordanov, D., Bondev, I., Kozuharov, S., Kuzmanov, B., Palamarev, E. & Velcev, V. (ed.): *Problems of Balkan flora and vegetation*. — Sofija.
- Kruscheva, R. N. 1975: Reports. [In Löve, Á. (ed.): *IOPB chromosome number reports L.*] — *Taxon* 24: 676-677.
- Küpfer, P. 1986: Liens génétiques entre les flores orophiles nord-africaines et sud-européennes. — *Giorn. Bot. Ital.* 120, Suppl. 2: 41-44.
- Majovský, J. (ed.) 1974: Index of chromosome numbers of Slovakian flora. — part 4. — *Acta Fac. Rerum Nat. Univ. Comeniane, Bot.* 23: 1-23.
- Pignatti, S. 1982: *Flora d'Italia*, 1. — Bologna.
- Rizzi Longo, L. & Feoli Chiapella, L. 1981: Sistematica palinologica del gruppo di *Genista sylvestris*. — *Giorn. Bot. Ital.* 115: 416.
- Santos, A. C. dos, 1945: Algumas contagens de cromosomas nos generos *Genista* L. e *Cytisus* L. — *Bol. Soc. Brot., ser. 2A*, 19: 519-521.
- Sañudo, A. 1971: Variabilidad cromosómica de las Genisteas de la Flora española en relación con su ecología. I. Número y comportamiento de los cromosomas durante la meiosis. A. Secciones *Erinacoides* Spach *Scorpioides* (L.) DC., y *Asterospartum* Spach del Gen. *Genista*. — *Cuad. Ci. Biol. Univ. Granada* 1: 1-21.
- 1972: Variabilidad cromosómica de las Genisteas de la Flora española en relación con su ecología. I. Número y comportamiento de los cromosomas durante la meiosis. B. Secciones *Genista*, *Spartioides* Spach, *Phyllospartium* Willk. y *Voglera* (G. Gaertner, B. Meyer & Schreb.) Spach del Gen. *Genista*. — *Cuad. Ci. Biol. Univ. Granada* 2: 44-51.
- 1974: Variabilidad cromosómica de las Genisteas de la flora española en relación con su ecología. I. Número y comportamiento de los cromosomas durante la meiosis. F. Géneros: *Chamaespartium* Adanson y *Echinopartium* (Spach) Rothm. — *Anales Inst. Bot. Cavanilles* 31: 165-174.
- 1979: Chromosome variability in the *Genisteeae* (Adans.) Benth. (*Leguminosae*). - *Webbia* 34: 363-408.
- Sneath, P. H. A. & Sokal, R. R. 1973: *Numerical taxonomy. The principles and practice of numerical classification*. — San Francisco.
- Stebbins, G. L. 1971: *Chromosomal evolution in higher plants*. — London.
- Verlaque, R. 1988: Modalités de la spéciation chez les Genisteeae. — Pp. 229-230 in: *Simposi International de Botanica "Pius Font i Quer"* (Lleida, 7-10.IX.1988). *Resums de ponencies i comunicacions*. — Lérida.
- Visiani, R. de 1850-1851: *Flora Dalmatica*, 3. — Leipzig.

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