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KARYOLOGICAL STUDIES OF *SPARTOCYTISUS* WEBB & BERTH. (*GENISTEAE - FABACEAE*)

Tiziana CUSMA VELARI and Laura FEOLI CHIAPELLA

Dipartimento di Biologia, Via L. Giorgieri 10, I-34127 Trieste

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Abstract: A karyological analysis of the two species of *Spartocytisus* (*S. filipes* and *S. supranubius*) was carried out. Both species have the same chromosome number 2n=48. *S. nubigenus* shows a number of accessory chromosomes varying from 0 to 4, with a maximum frequency of 2. In addition, a comparison was made with the karyological data already available for the taxa of the *Cytisus*-group and for other intermediate genera of the *Genisteae*.

Introduction

Spartocytisus Webb & Berth. is a small genus endemic to the Canary Islands, which includes *S. filipes* Webb & Berth. and *S. supranubius* (L. f.) Christ ex Kunkel. This interpretation is followed by many authors who have studied the flora of the Canary Islands (Lems 1960; Lid 1967; Santos Guerra 1983; Bramwell & Bramwell 1990; Schöenfelder *et al.*, 1993). On the contrary Polhill (1976), followed by Bisby (1981), suggests to refer *Spartocytisus* to the genus *Cytisus* Desf., within the sect. *Oreosparton* (Webb) Frodin ex Polhill, where it would occupy a position closed to sect. *Trianthocytisus* Griseb. and *Alburnoides* DC., owing to several flower characters (Frodin 1965; Polhill 1976). *Spartocytisus* differs, however, from the former section in the shrubby habitus with many virgate branches, in the small, caducous leaves and in the pink or white (and not yellow) flowers grouped at the nodes of branches without leaves. It mainly differs from the species of the latter section in the terete or angled branches which are not T-shaped in cross-section and in the herbaceous and circumscissilely deciduous calyx.

Spartocytisus filipes (= *Cytisus filipes* Webb & Berth.) is a small shrub of slender appearance which grows between 0 and 800 m in the clearings of sclerophyllous forest and pinewood on the Islands of Tenerife, Gomera, La Palma and Hierro. *S. supranubius* (= *Spartium supranubius* L. f., *Spartocytisus nubigenus* (Willd.) Webb & Berth., *Cytisus supranubius* (L. f.) Kuntze) is also a nanophanerophyte but of larger size and of stouter habitus. It is dominant in the vegetation of the upland and subalpine zones ("pisos supracanario y orocanario" according to Rivas Martínez 1987) of Tenerife and, more rarely, of La Palma (Lems 1960; Lid 1967; Santos Guerra 1983; Bramwell & Bramwell 1990). Its epithet derives from the fact that it grows in the zone above the clouds ("mar de nubes"), typically between 1700 and 3000 m, particularly in Las Cañadas del Teide (Is. Tenerife). The species characterizes the alliance *Spartocytision nubigeni* Oberdorfer ex Esteve 1973 and the association *Spartocytisetum nubigeni* Oberdorfer ex Esteve 1973 (Rivas Martinez *et al.* 1993).

A karyological analysis of both species was carried out in order to increase the systematic knowledge of *Spartocytisus*. No previous karyological data were known for *S. filipes* from the literature.

Materials and methods

The karyological investigations were carried out on seeds, collected in the field, of two populations of *Spartocytisus filipes* and two populations of *S. supranubius* (Fig. 1). The localities of the collection and the names of the collectors are given in Tab. 1. Voucher specimens

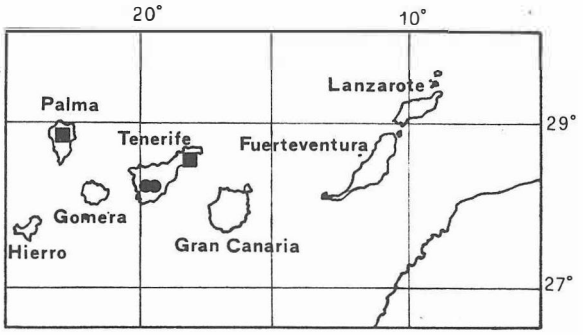

Fig. 1 - Origin of the examined populations of *Spartocytisus filipes* (■) and *S. supranubius* (●).

are deposited in the herbarium of the Department of Biology, University of Trieste (TSB).

The mitotic investigation was carried out on root tips of seedlings, pretreated with 8-hydroxiquinoline, fixed in a 1:3 solution of glacial acetic acid: absolute ethanol (Carnoy's fluid), hydrolized in HCl 1N at 60° C for six minutes and stained with Feulgen method. Slides were prepared using the squash technique. For each population 15 to 30 good methaphase plates were examined. Only numbers of chromosomes can be given here, being the somatic chromosomes too small (0.56-1.45 µm) for effective karyotyping.

Results

Spartocytisus filipes shows a high percentage of germination in both populations. The chromosome number 2n = 48 was counted (Tab. 1). The dimensions of the chromosomes fall within an interval of 0.60 and 1.26 µm. No significant variation in size was noted and the chromosome complement appears to be very homogeneous (Fig. 2). The chromosomes are elliptical in shape (after Persson 1971).

Spartocytisus supranubius shows, in both populations, a higher percentage of germination at a lower optimal temperature, probably related to the different ecology (higher altitude) of the plant. The chromosome number 2n = 48+(0-4B) was counted (Tab. 1). The presence and number of accessory chromosomes was variable (2n = 48 in 31.5%, 2n = 48+2B in 57.4% and 2n = 48+4B in 11.4% of the cases examined). Borgen (1969) counted 2n = *c.* 48 in material from Fortalez las Cañadas. The chromosome size ranges between 0.56 and 1.45 µm. Also in this case the complement is homogeneous and the chromosomes are too small to carry out a more thorough examination of the morphology (Fig. 2). The chromosomes are elliptical in shape (after Persson 1971).

Discussion

The karyological analysis showed that both species of the genus *Spartocytisus* have the same somatic number 2n = 48. *S. supranubius* has a number of accessory chromosomes which varies from 0 to 4 with a maximum frequency of 2. The chromosome lenghts of the two species are comparable.

In order to evaluate the karyological condition of *Spartocytisus*, a comparison was made of the known karyological data for the various taxa of the *Cytisus*-group and of the intermediate genera of the *Genisteae* with more primitive characters. The chromosome numbers recorded in the various taxa

Tab. 1 - Geographical origin of the examined populations of *Spartocytisus* species, with collectors of the seeds, chromosome numbers, number of metaphase plates studied, temperature and percentage of germination.

TAXON	LOCALITY	COLLECTOR	DIPLOID No.	No. OF PLATES	GERMINATION TEMPERATURE	% OF GERMINATION
S. filipes	Caldera de Taburiente, Is. La Palma	P. Romero Manrique	48	20	20/21 °C	70
	Valle Guerra, Is. Tenerife	A. Santos Guerra	48	15	20/21 °C	65
S. nubigenus	M. Bermeja, Is. Tenerife	A. Santos Guerra	48 + (0-4B)	30	17/18 °C	85
	Las Cañadas del Teide, Is. Tenerife	G. Junio	48 + (0-4B)	30	17/18 °C	90

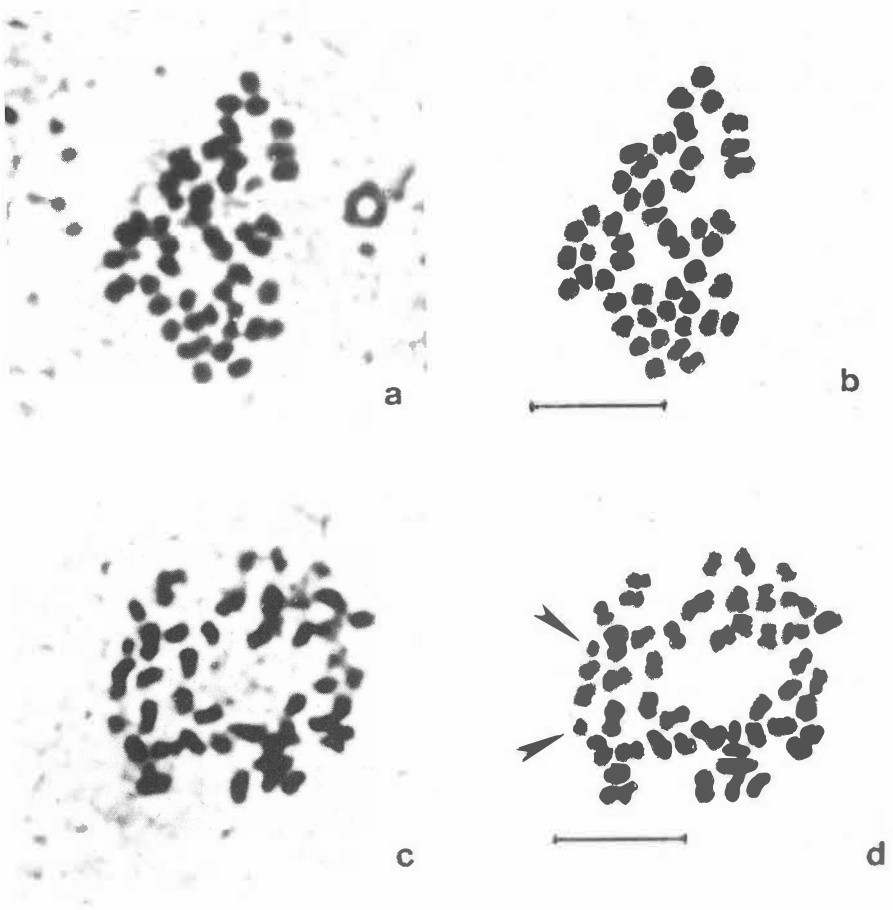

Fig. 2 - Somatic metaphase plates. - a, b, photo and drawing of *Spartocytisus filipes* (2n = 48); c, d, photo and drawing of *S. supranubius* (2n = 48+2B). B-chromosomes are arrowed. Scale bar = 5µm.

of all the sections of *Cytisus* s.l., including *Chamaecytisus* Link, *Chronanthus* (DC.) C. Koch, *Lembotropis* Griseb., *Corothamnus* (Koch) C. Presl and *Sarothamnus* Wimm., are shown in Tab. 2. The nomenclature of sections follows Polhill (1976), that of species follows Greuter *et al.* (1989) with the exception of the species of the sect. *Tubocytisus* DC., which is in accordance with Cristofolini (1991). The attribution of the species to the sections of *Cytisus* is taken from Frodin & Heywood (1968). *C. ingramii* was kept separate from *C. commutatus* and *C. patens* from *C. striatus*, as in Frodin & Heywood (1968), whereas Horjales (1978) and Greuter *et al.* (1989) consider these taxa, whose taxonomic status is still not entirely clear, to be synonymous.

The chromosome number 2n = 48 is, therefore, by far the most common in the various sections of *Cytisus* s.l., even if sometimes 2n = 24, 46, 50, 96, 100 and, more rarely, 22, 44, 52 and 54 were counted. These were interpreted as cases of hypoaneuploidy and hyperaneuploidy by Sañudo (1979) and Verlaque (1988). It can be assumed that the most probable basic chromosome number would be, both for *Spartocytisus* and for the other taxa included in *Cytisus*-group, x = 12 (Sañudo 1979) or perhaps x = 6, as proposed by Verlaque (1988). In particular, among the different sections of *Cytisus*, sect. *Corothamnus*, *Spartopsis* and *Lembotropis* show chromosome numbers which can be interpreted as examples of hypoaneuploidy, whereas sect. *Trianthocytisus* and *Chronanthus* can be considered as cases of hyperaneuploidy. Sect. *Alburnoides* shows, in addition to more frequent cases of hypoaneuploidy, rarer cases of hyperaneuploidy. Sect. *Tubocytisus* is, on the other hand, more heterogeneous, with two (rarely three) ploidy levels clearly represented, frequent cases of

Tab. 2 - Chromosome numbers of the species of *Cytisus* s.l. with the bibliographic references and the origin of the seeds [the abbreviations of the territories follow Flora Europaea, except for Slovenija (Sl), Hrvatska (Hr), Ceská Republika (CR) and Slovenská Republika (SR)]. When horticultural material was used, the conventional acronym according to the Index Herbariorum is reported when possible; otherwise the Botanical Garden is indicated.

TAXON	APLOID No.	DIPLOID No.	REFERENCES	LOCALITY
sect. Trianthocytisus Griseb.				
C. aeolicus Lindley		2n= 48	Fralm-Leliveld 1957	Bot. Gard., Antibes
		2n= 52	Bartolo et al. 1977	Vulcano, Isole Eolie (It)
C. villosus Pourret	n= 25		Forissier 1975b	Bosco di Ficuzza (It)
		2n= 48	Sañudo 1973b	Los Barrios, Cadiz (Hs)
C. emeriflorus Reichenb.	n= 25		Favarger 1969	Grigna Meridionale (It)
			Forissier 1973a	Grigna Meridionale (It)
sect. Alburnoides DC.				
C. balansae (Boiss.) Ball subsp. europaeus	n= 23		Sañudo 1973b	Somosierra, Madrid (Hs)
(G. López & Jarvis) Muñoz Garmendia			Forissier 1975b	Cévennes & Lauteret (Ga)
(= C. purgans sensu Tutin & al.)		2n= ± 46	Castro 1949	COI
C. multiflorus (L'Hér.) Sweet	n= 23		Sañudo 1973b	Avila (Hs)
			Forissier 1975b	Coimbra (Lu)
		2n= 46	Gilot 1965	COI
		2n= 48	Fernandes & Santos 1971	Penedones (Lu)
			Fernandes et al. 1977	Ternas de Caldelas (Lu)
			Fernandes & Queiros 1978	Coimbra (Lu)
		2n= 54	Horjales 1974	Vila Franca, Coimbra (Lu)
		2n= ± 96	Castro 1949	L
C. ardoinoi E. Fourn.	n= 25		Forissier 1975b	Plateau de Caussols, Alpes Maritimes (Ga)
sect. Corothamnus (Koch) Nyman (= Corothamnus (Koch) C. Presl)				
C. procumbens (Willd.) Sprengel		2n= 22	Castro 1949	E
		2n= 44	Hindáková1974	Juhoslovensky kras; Tripeniazky above Jelsava (SIR) (SR)
		2n= 48	Dvorák & Dadákova 1976b	Boleradice, Kurdejov (CR)
			Dvorák 1977	Boleradice, Kurdejov (CR)
C. decumbens (Durande) Spach	n= 23		Forissier 1973a	W
		2n= 48	Sañudo 1973b	Oncala, Soria (Hs)
sect. Spartopsis Dumort. (= Sarothamnus Wimm., Cytisus sect. Sarothamnus (Wimm.) Benth.)				
C. ingramii Blakelock		2n= c. 92	Horjales 1978	Mañón-Coruña (Hs)
		2n= 96	Sañudo 1973b	Lugo (Hs)
C. commutatus (Willk.) Briq.	n= 23-24		Sañudo in Lainz et al. 1976	Santander (Hs)
	n= 48		Sañudo 1973b	Mañaria, Vizcaya (Hs)
C. arboreus (Desf.) DC.				
subsp. baeticus (Webb) Maire	n= 24		Sañudo 1973b	Cádiz (Hs)
subsp. malacitanus (Boiss.) Malagarriga	n= 24		Sañudo 1973b	Orgiva, Granada (Hs)
C. striatus (Hill) Rothm.	n= 23		Forissier 1975a	Coimbra (Lu)
		2n= 46	Sañudo 1973b	Lugo (Hs)
			Horjales 1975	Isla de Ons, Pontevedrea (Hs)
		2n= 46,48	Horjales 1974	Coimbra (Lu)
			Horjales 1975	La Barquera, Coruña (Hs)
		2n= 48	Fernandes & Santos 1971	San Pedro da Cova, Gondomar (Lu)
			Fernandes et al. 1977	Guarda, Braga (Lu)
C. grandiflorus (Brot.) DC.	n= 24		Sañudo 1973b	Santa Elena, Jaén (Hs)
		2n= 24	Fernandes & Santos 1971	Coimbra (Lu)
		2n= 46	Gilot 1965	COI, Chelsea Physic Gard.
		2n= 48	Horjales 1975	S. Paulo de Frades, Coimbra (Lu)
			Fernandes et al. 1977	Caldelas, Vila Nova de Gaia (Lu)
			Fernandes & Queiros 1978	Guarda (Lu)
C. scoparius (L.) Link	n= 23		Forissier 1973a	Corrèze (Ga)
			Sañudo 1973b	Santa Elena, Jaén (Hs)
		2n= 24	Berger et al. 1958 (after Sañudo 1979)	
		2n= 46	Gilot 1965	G, Bot. Gard. Delft
			Gill & Walker 1971	various localities (Br)
			Zielinski 1975	Blazejewka (Po)
		2n= 46, 48	Horjales 1975	Sigueiro, Trasmonte-Sedeira, Coruña (Hs)
			Heiser & Witaker 1948	California (introduced)
		2n= 48	Morton 1955	Longtown, Cumberland (Br)
			Böcher & Larsen 1955	various localities (Ge, Ho, Br, Ga, Hs)
			Horjales 1975	La Barquera, Coruña (Hs)
			Fernandes et al. 1977	Penedones (Lu)
			Fernandes & Queiros 1978	Minho (Lu)

subsp. maritimus (Rouy) Heywood		2n= 24	Morton 1955	Lizard, Cornwall (Br)
		2n= 46	Gill & Walker 1971	Dungeness (Br)
		2n= 48	Böcher & Larsen 1955	Grosnez Point, Jersey (Br)
			Adams 1957	Lizard Head, Cornwall (Br)
			Gill & Walker 1971	Cornwall (Br)
subsp. cantabricus (Willk.) Rivas Martinez & al.	n= 24		Sañudo 1973b	Santander (Hs)
subsp. reverchonii (Degen & Hervier)	n= 24		Sañudo 1973b	Alcaraz, Teruel (Hs)
Rivas Goday & Rivas Martinez		2n= ± 46	Castro 1949	E
C. patens L.	n= 24		Sañudo 1973b	Valencia (Hs)
		2n= ± 46	Castro 1949	YALT
C. tribracteolatus Webb	n= 24		Sañudo 1973b	Cádiz (Hs)
sect. Chronanthus DC. (= Chronanthus (DC.) C. Koch)				
C. fontanesii Ball (= Chronanthus biflorus (Desf.)	n= 25		Sañudo 1973a	Zaragoza (Hs); El Fargue, Puerto Lope,
Frodin & Heywood)				Sierra de Lújar, Granada (Hs)
		2n= 24	Castro 1949	E
sect. Lembotropis (Griseb.) Benth. (= Lembotropis Griseb.)				
C. nigricans L. (= Lembotropis nigricans (L.) Griseb)	n= 23		Forissier 1973a	Karpaty (SR), Südlicher Wienerwald (Au)
		2n= 48	Santos 1944-45	SBT
			Hindáková & Cincura 1967	Cernochov (SR)
			Nilsson & Lassen 1971	Novi Vinodolski (Hr)
			Kozuharov et al.1972	Hubavec, Karlovo (Bu)
			Zielinski 1975	Przedborza (Po)
		2n= 96	Castro 1949	POZ
sect. Tubocytisus DC. (= Chamaecytisus Link)				
C. proliferus L. fil.		2n= 46,50	Horjales 1975	ORT
		2n= 48	Castro 1949	Bot. Gard., Orotava
			Borgen 1969	GB
var. angustifolius O. Kuntze		2n= 52	Horjales 1975	ORT
C. spinescens C. Presl	n= 50		Forissier 1973b	Ovindoli (It)
C. purpureus Scop.	n= 25		Forissier 1973b	Monte Baldo (It)
		2n= 48	Strasburger 1905	
			Gilot 1965	Bot. Gard., Oldenburg
C. hirsutus L. (= C. aggregatus Schur,	n= 25		Forissier 1973a	Muntele Suhardul (Rm)
C. ciliatus Wahlenb., C.capitatus Scop.,			Forissier 1973b	Timpa (Rm), Graz (Au)
C. supinus L., C. leucotrichus Schur)	n= 50		Forissier 1973a	Col di Tenda, Lago di Garda (It)
		2n= ± 46	Castro 1949	BAS
		2n= 48	Nilsson & Lassen 1971	Pivka (Slo)
			Zielinski 1975	Sobótki (Po)
		2n= 50	Kuzmanov & Markova 197	by the river Danube (Bu)
		2n= c. 84	Horjales 1975	BIRM
		2n= c. 91	Horjales 1975	DUIS
		2n= 96	Gilot 1965	HAL, DR, MOD
			Kuzmanov et al. 1973	Ruse (Bu)
			Kuzmanov & Markova 197	Belogradcik (Bu)
C. hirsutus L.	n= 25		Forissier 1975a	Certosa di Pesio (It); Pazin (Hr)
subsp. polytrichus (M. Bieb.) Hayek		2n= 46	Strid & Andersson 1985	M. Olympus (Gr)
C. leiocarpus A. Kerner	n= 25		Forissier 1973b	"Romania"
		2n= ± 48	Castro 1949	E
C. triflorus Lam. (= C. elongatus Waldst. & Kit.)		2n= 48	Frahm-Leliveld 1957	Z
C. gallicus A. Kerner (sub "Chamaecytisus				
supinus (L.) Link subsp. capitatus (Scop.)")	n= 50		Forissier 1973a	Quémigny (Ga)
C. lasiosemius Boiss. (= C. frivaldszkyanus Degen)		2n= 48	Kuzmanov 1975	M. Rhodope (Bu)
C. etiocarpus Boiss. subsp. etiocarpus				
(= C. absinthioides Janka)		2n= 96	Kozuharov et al. 1972	Sestrimo, Rila (Bu)
C. austriacus L. subsp. austriacus	n= 50		Forissier 1973a	Hainburg Donau (Au)
		2n= 48	Dvorák & Dadákova 1976a	
			Dvorák 1977	Mutenice, Cejc (CR)
		2n= 96	Castro 1949	K. Bot. Gard. Tabor, Bot. Gard. Moorestown
C. austriacus L. subsp. austriacus		2n= 48	Gilot 1965	STA, POZ
var. rochelii (Wierzb.) Cristof.			Hindáková & Cincura 1967	Cernochov (SR)
		2n= 96	Castro 1949	LISU
C. albus Hacq.		2n= 48	Zielinski 1975	Bugiem (Po)
		2n= 50	Forissier 1973a	Karpaty (SR)
			Kuzmanov et al. 1973	Tarnovo (Bu)
C. ratisbonensis Schaeffer		2n= 24, 48	Zielinski 1975	Przedbórz, Maslowice, Olkusza (Po)
		2n= 48	Dvorák & Dadákova 1976a	
			Dvorák 1977	Boleradice, Kurdejov (CR)
C. ruthenicus Fischer ex Woloszak	n= 25		Forissier 1973a	Bot. Gard., Tiflis (Georgia)
(= C. caucasicus Grossh.) subsp. ruthenicus	n= 50		Forissier 1973a	Riazan, Moskow (Rs)
		2n= 48	Zielinski 1975	various localities (Po)
		2n= 50	Castro 1949	VOR
Incertae sedis				
C. procerus Link	n= 23		Sañudo 1973b	Avila (Hs)

hyperaneuploidy and sporadic examples of hypoaneuploidy. It is possible, however, that the counting of 2n = 50, 52, 54, 100 was, at least in some cases, due to the presence of accessory chromosomes, as found in *S. supranubius* (Tab. 1). Furthermore, conflicting chromosome counts could also be due to the presence in the complement of very small and satellited chromosomes, in which the connection between the satellites and the remainder of the chromosome is frequently very tenuous, so that mistaken counts are easily obtained (Gill & Walker 1971).

Intermediate genera of the *Genisteae* with more primitive characters (Polhill 1976, 1979; Cristofolini & Feoli Chiapella 1984), such as *Cytisophyllum* Lang, *Argyrocytisus* (Maire) Raynaud, *Petteria* C. Presl, *Laburnum* Fabr., have only occasionally chromosome number 2n = 48, whereas different numbers such as 2n = 50 and 2n = 52 were counted more often (Tschehow 1931; Castro 1949; Gilot 1965; Forissier 1973b; Sañudo 1973b; Fernandes & Queirós 1978; Verlaque *et al.* 1987). According to Verlaque (1988), this would reveal, in relict genera with a single polyploid level, the presence of a senescent phase in the aneuploidal evolution, characterized by stabilized aneuploidy. On the contrary, *Cytisus* s.l. has three levels of ploidy, still showing characters of expansion or at least of decline. In particular *Chamaecytisus* seems to be, also on the basis of karyological characters, still in an active phase of speciation.

The fact that *Spartocytisus* presents an eupolyploidal complement, even though the presence of accessory chromosomes, suggests to consider it as belonging to the *Cytisus*-group rather than being a relict, systematically more isolated genus. *S. filipes* and *S. supranubius* would therefore constitute a young, karyologically and morphologically homogeneous genus, evolved in the Canary Islands.

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