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Contribution to the cytotaxonomical knowledge of *Gagea* Salisb. (Liliaceae) sect. Foliatae A. Terracc. and synthesis of karyological data

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Abstract - Four taxa belonging to the sectio Foliatae A. Terracc. (= Didymobolbos C. Koch) of the genus *Gagea* Salisb. are karyologically and morphologically investigated: *G. chrysantha* (Jan) J. A. Schultes and J. H. Schultes (= G. *amblyopetala* Boiss. and Heldr.; 2*n* = 36), *G. foliosa* (J. and C. Presl) J.A. and J.H. Schultes (2*n* = 36), *G. bohemica* (Zauschner) J.A. and J.H. Schultes var. *saxatilis* (Mert. and Koch.) Fiori (2*n* = 48), *G. granatellii* (Parl.) Parl. (2*n* = 36). All the studied populations come from Northern Calabria. Karyotype analysis is carried out for *G. chrysantha* and *G. foliosa* (both studied for the first time) and for *G. bohemica*. Karyological and morphological features of the four species are presented and discussed. An updated checklist of karyological data of the genus is presented and briefly discussed.

Key words: Chromosome numbers, *Gagea*, Italian flora, taxonomy, karyotypes.

INTRODUCTION

Gagea Salisb. (Liliaceae) is an Eurasiatic genus, occurring in Northern Africa too, which comprehends between 70 and 120 species depending on the opinion of the authors (MABBERLEY 1997; STROH 1936, respectively). It is traditionally considered as composed of two subgenera (TERRACCIANO 1905; STROH 1936; HEYN and DAFNI 1971): subg. Gagea (= Eugagea Pascher), characterized by globose to pyriform seeds, and subg. Hornungia (Bern.) Pascher, characterized by flat, triangular seeds.

Recently a new taxonomic setting of infrageneric taxa was carried out by LEVICHEV (1990).

16 species occur in Italy (RICHARDSON 1980; PIGNATTI 1982), of which 9 belong to sectio Foliatae A. Terracc. (= Didymobolbos C. Koch): *G. bohemica* (Zauschner) J.A. and J.H. Schultes s.l., *G. chrysantha* (Jan) J.A. and J.H. Schultes (=*G. amblyopetala* Boiss. and Heldr.), *G. foliosa* (J. and C. Presl) J.A. and J.H. Schultes, *G. granatellii* (Parl.) Parl. (see also GAVIOLI 1948; ANZALONE and BAZZICHELLI 1959, BALLELLI 1987), *G. lacaitae* A. Terracc., *G. mauritanica* Durieu, *G. ramulosa* A. Terracc., *G. soleirolii* Schultz, *G. villosa* (M. Bieb.) Sweet; 3 to sectio Minimae (Pascher) Davlianidze (= Monophyllos Pascher): *G. fragifera* (Vill.) E. Bayer and G. López, *G. minima* (L.) Ker-Gawler (see also PROSSER 1992; ARCIONI 1993; MINUTILLO 1994), *G. spathacea* (Hayne) Salisb.; 2 to sectio Gagea (= Holobolbos C. Koch): *G. lutea* (L.) Ker-Gawler (see also LUCCHESE and MORALDO, 1983; CONTI and PIRONE, 1988), *G. pusilla* (F. W. Schmidt) Sweet (see also SELVI, 2001); 1 to sectio Tribolbos Boiss.: *G. pratensis* (Pers.) Dumort (see also ABBÀ 1981; MORALDO 1983; BALLELLI 1987). All of these taxa are part of the type subgenus, while only one Italian species belongs to subg. Hornungia, sectio Platyspermum Boiss. (*Gagea trinervia* (Viv.) W. Greuter, which is considered by some authors as belonging to the genus *Lloydia,* see FIORI 1923; PIGNATTI 1982).

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Gagea is notoriously a most critical genus from a taxonomical point of view, because herbarium specimens are often useless, and diagnostic morphological features are few and quite variable (HEYN and DAFNI 1971).

The four taxa studied here are Calabrian members of sectio Foliatae, which includes the species with two bulbs in a common tunic (TERRACCIANO 1905a).

G. fragifera and *G. villosa* will be object of a forthcoming study dedicated to other Italian species.

No karyological data was previously available for *G. chrysantha* and *G. foliosa. G. bohemica* s.l. and *G. granatellii* were investigated only on non-Italian material.

MATERIALS AND METHODS

Plant material

Living plants of the following taxa were collected: *G. chrysantha* - Calabria, Montalto Uffugo (Cosenza), loc. Salerno, under *Erica arborea* L., together with *Romulea columnae* Seb. et Mauri, 26/II/2002, Puntillo et Peruzzi (cult. Hort. Bot. Calabria University, accession number 455); *G. foliosa* - Calabria, Montalto Uffugo (Cosenza), loc. Salerno, seasonally damp lawn, in proximity of *Erica arborea* L., together with *Isoëtes* sp. and *Ophioglossum lusitanicum* L., 26/II/2002, Puntillo et Peruzzi (cult. Hort. Bot. Calabria University, accession number 456); *G. bohemica* - Calabria, Pollino massif, Campotenese, North to Colle del Fago, little mountain between the Statal road n. 106 and the motorway A3, 11/III/2002, Peruzzi and Gargano (cult. Hort. Bot. Calabria University, accession number 722); *G. granatellii* - Calabria, Sila, Rose (Cosenza), 1 Km Est in proximity to Statal Road n. 276, ca. 650 m a.s.l. loc. Giancorella, 16/III/2002, Puntillo (cult. Hort. Bot. Calabria University, accession number 255).

Voucher specimens of the plants used for karyological analyses are kept in CLU.

Chromosome analysis

Squash preparations were made from young ovules of plants collected in situ, according to the following schedule: pretreatment in 0,5% colchicine solution for 4 hours; Carnoy fixing for at least 1 hour; hydrolysis in HCl 1 N for 7 minutes at 60°C; staining with leuco-basic fucsin for 3 hours. Karyotype formulas and terminology are according to LEVAN *et al.* (1964). At least five plates were measured in order to build the idiograms.

Determination of the taxa object of this study was carried out by means of the most recent floras and revisions (FIORI 1923; RICHARDSON 1980; PIGNATTI 1982; ANDERSSON 1991; TISON 1996, 1998, 1998a). The monographs by TERRACCIANO (1906), PASCHER (1906, 1907), PARLATORE (1857) were also consulted. For the morphological descriptions we did not take into account features of the anthers, because they are very variable in the genus *Gagea*, even in the same populations or individuals (TISON 1996). For what concerns the leaves, we maintained the traditional and most familiar terms "basal leaves", "cauline leaves" and "bracts". We have to underline however that in reality these plants have a very brief scape, therefore those that we call cauline leaves are in reality the primary bracts of the inflorescence, and the only true leaves are those basal (TISON 1998).

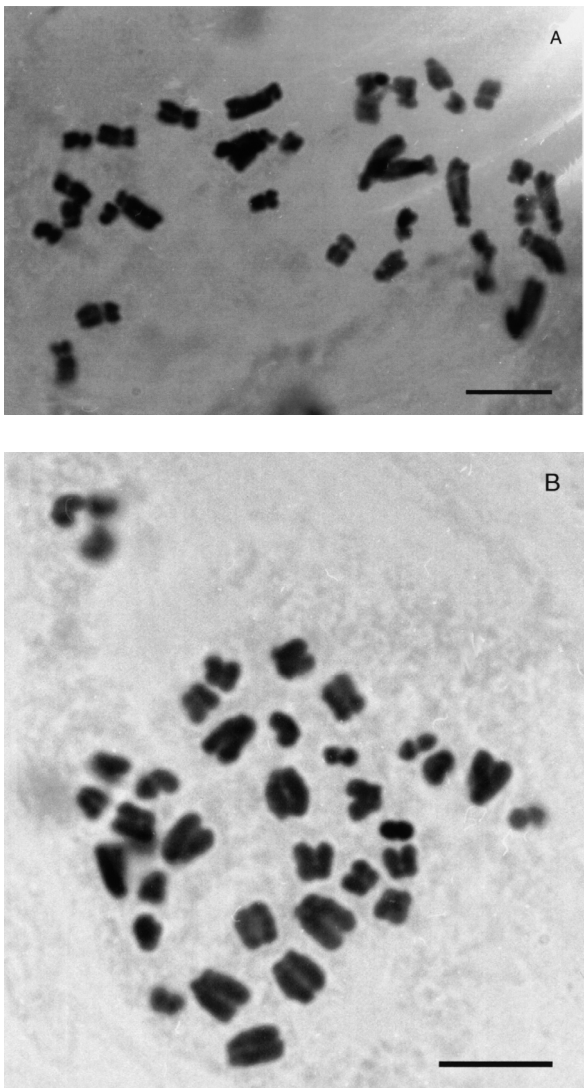

Fig. 1 – Microphotographs of metaphasic plates from young ovules of *Gagea chrysantha*, $2n = 36$, scale bars 5 µm.

Table 1 – Measurements made on 5 metaphasic plates, belonging to five specimens of *Gagea chrysantha* (3x). Data were obtained from microphotographs, then reported in µm.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Long arms (mean lenght of the homologue chromosomes, 3x)												
Plant 1	2,90	2,74	2,57	1,69	1,35	1,56	1,30	1,10	0,95	0,86	0,74	0,61
Plant 2	3,12	2,50	2,48	1,55	1,44	1,32	1,23	1,05	0,94	0,91	0,78	0,57
Plant 3	3,44	2,64	2,23	1,55	1,35	1,11	1,18	1,13	1,06	0,85	0,80	0,52
Plant 4	2,54	2,42	2,18	1,39	1,23	1,10	1,00	1,00	1,03	0,95	0,80	0,56
Plant 5	2,68	2,49	2,09	1,54	1,39	1,23	1,06	0,88	0,91	0,81	0,60	0,51
Mean lenght (L)	2,94	2,56	2,31	1,54	1,35	1,26	1,15	1,03	0,98	0,88	0,74	0,55
Short arms (mean lenght of the homologue chromosomes, 3x)												
Plant 1	0,52	0,53	0,70	0,81	0,86	0,47	0,55	0,68	0,82	0,82	0,59	0,58
Plant 2	0,69	0,54	0,68	0,95	0,73	0,84	0,56	0,83	0,71	0,85	0,71	0,47
Plant 3	0,66	0,52	0,64	0,61	0,69	0,74	0,65	1,02	0,65	0,78	0,54	0,45
Plant 4	0,46	0,54	0,68	0,67	0,68	0,65	0,68	0,55	0,88	0,46	0,58	0,41
Plant 5	0,60	0,59	0,46	0,69	0,84	0,58	0,52	0,52	0,66	0,33	0,42	0,30
Mean lenght (S)	0,59	0,54	0,63	0,75	0,76	0,66	0,59	0,72	0,74	0,65	0,57	0,44
Total lenght (TL)	3,52	3,10	2,94	2,29	2,11	1,92	1,75	1,75	1,72	1,52	1,31	1,00
						24,94						
Ratio Long arm / Short arm (L/S)	5,01	4,70	3,66	2,07	1,78	1,93	1,95	1,43	1,31	1,35	1,31	1,25
Karyotype formula		9st			12sm					15m		

RESULTS

Gagea chrysantha - The chromosome complement of this species has revealed to be triploid $2n = 36$ (Fig. 1).

Karyotype formula can be expressed as follows: $2n = 3x = 9st + 12sm + 15m$ (Table 1, Fig. 2A).

Morphological description of the studied material: plant 6-12 cm high, glabrous. Bulbs globose, small (4-8 mm) with reddish - brown or yellowish tunics. Radical leaves 2, filiform, longer than or equalling the inflorescence (10-16 cm). Thin stem, showing 2 glabrous cauline leaves (3-3, 5 mm wide at the base) altern to subopposite. Bracts 2 with ciliate margins (3-5 mm long, 0,5 mm wide), often 1-2 additional little bracts along the pedicel. Umbel-like inflorescence, with 1-4 flowers. Glabrous pedicels, 1,5-3,5 cm long. Obovate perianth segments, obtuse, 8-9 mm long, 3-4 mm wide, glabrous.

Gagea foliosa - The chromosome complement of this species, investigated for the first time, has revealed to be triploid $2n = 36$ (Fig. 3).

Karyotype formula can be expressed as follows: $2n = 3x = 6st + 3sm + 3m + 3sm + 3m + 3sm + 15m$ (Table 2, Fig. 2B).

Morphological description of the studied material: plant 5-6 cm high, glabrous. Bulbs globose, small (6-7 mm) with brown tunics. Radical leaves 2, linear (1-1,5 mm wide), longer than inflorescence (7-9 cm), usually ruined at flowering. Glabrous stem, showing 2 always subopposite cauline leaves (4-10 mm wide at the base) with subciliate margins, often with subterranean insertion. Bracts 2 with ciliate margins (1 of these up to 2 cm long). Umbel-like inflorescence, with 2-4 flowers. Pedicels 1-2, 5 cm long. Oblong-lanceolate perianth segments, subobtuse, 8-9 mm long, 2-3 mm wide, glabrous.

Gagea bohemica var. saxatilis - The chromosome complement of the studied plants has revealed to be tetraploid, $2n = 48$ (Fig. 4A).

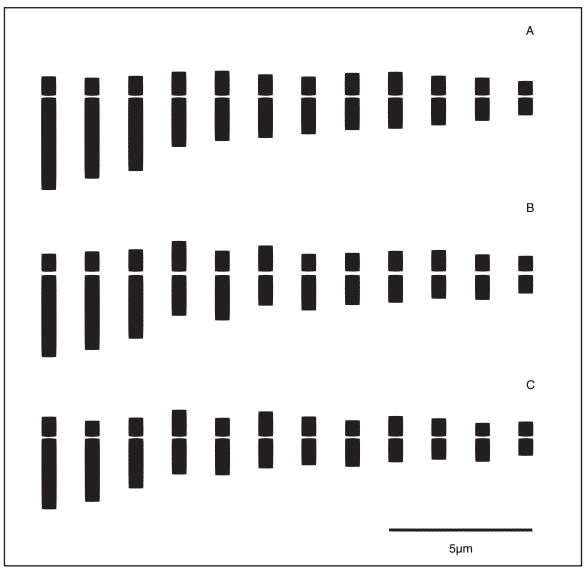

Fig. 2 – Compared haploid idiograms (x = 12) of *Gagea chrysantha*, 3x (A), *Gagea foliosa*, 3x (B), *Gagea bohemica* var. *saxatilis*, 4x (C).

Table 2 – Measurements made on 5 metaphasic plates, belonging to five specimens of *Gagea foliosa* (3x). Data were obtained from microphotographs, then reported in µm.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Long arms (mean lenght of the homologue chromosomes, 3x)												
Plant 1	2,80	2,58	2,36	1,26	1,58	0,98	1,22	1,09	0,96	0,81	0,89	0,55
Plant 2	2,70	2,46	2,22	1,23	1,69	0,98	1,21	0,98	0,91	0,76	0,84	0,53
Plant 3	2,55	2,33	2,03	1,67	1,59	1,01	1,14	0,96	0,93	0,75	0,72	0,47
Plant 4	2,84	2,51	2,32	1,38	1,49	1,25	1,26	1,12	1,06	0,88	0,98	0,85
Plant 5	3,29	3,00	2,09	1,48	1,43	1,03	1,26	0,99	0,89	0,86	0,82	0,77
Mean lenght (L)	2,84	2,58	2,20	1,40	1,56	1,05	1,22	1,03	0,95	0,81	0,85	0,63
Short arms (mean lenght of the homologue chromosomes, 3x)												
Plant 1	0,58	0,79	0,53	1,00	0,59	0,84	0,58	0,62	0,70	0,70	0,51	0,47
Plant 2	0,64	0,68	0,73	0,90	0,51	0,87	0,59	0,52	0,66	0,70	0,63	0,50
Plant 3	0,47	0,47	0,55	1,09	0,76	0,86	0,56	0,66	0,49	0,54	0,45	0,43
Plant 4	0,57	0,86	0,66	1,22	0,80	0,97	0,59	0,60	0,92	0,87	0,62	0,59
Plant 5	0,79	0,63	1,35	1,06	0,90	0,89	0,68	0,73	0,75	0,86	0,71	0,66
Mean lenght (S)	0,61	0,69	0,76	1,05	0,71	0,89	0,60	0,63	0,70	0,73	0,58	0,53
Total lenght (TL)	3,45	3,26	2,97	2,46	2,27	1,94	1,82	1,65	1,65	1,55	1,43	1,16
						25,61						
Ratio Long arm / Short arm (L/S)	4,65	3,76	2,88	1,33	2,19	1,19	2,03	1,64	1,35	1,11	1,46	1,20
Karyotype formula	6st		3sm	3m	3sm	3m	3sm			15m		

Karyotype formula can be expressed as follows: $2n = 4x = 48 = 8st + 4sm + 4m + 4sm + 8m + 4sm + 8m + 4sm + 4m$ (Table 3, Fig. 2C).

Morphological description of the studied material: plant 4-6 cm high, wooly. Globose bulbs, small (7-8 mm) with brown tunics. 2 filiform radical leaves, longer than inflorescence (7-10 cm). Stem densely hairy, showing 2 altern hairy cauline leaves (3-4 mm wide at the base). Bract 1, hairy (7-15 mm long, 1 mm wide). Inflorescence with 1-4 flowers. Pedicels 0,8 cm long. Oblong-lanceolate perianth segments, subobtuse, 10-13 mm long, 3-4 mm wide, pubescent.

Gagea granatellii - The chromosome complement of the studied plants has revealed to be triploid, $2n = 36$ (Fig. 4B).

Because of the average quality of metaphasic plates, we were not able to build the idiogram for this taxon.

Morphological description of the studied material: plant 4-10 cm high, pubescent. Globose bulbs, of medium size (10-12 mm) with reddish - brown tunics, surrounded by recurved roots, often thickened (up to 1 mm). Radical leaves 2, linear (3-5 mm wide), longer than inflorescence (7-20 cm). Pubescent stem, showing 2-

Table 3 – Measurements made on 5 metaphasic plates, belonging to five specimens of *Gagea bohemica* var. *saxatilis* (4x). Data were obtained from microphotographs, then reported in µm.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Long arms (mean lenght of the homologue chromosomes, 4x)												
Plant 1	2,25	2,20	1,88	1,31	1,23	1,00	0,92	1,00	0,82	0,70	0,83	0,58
Plant 2	2,47	2,21	1,38	1,18	1,21	1,00	0,94	1,00	0,83	0,73	0,83	0,59
Plant 3	2,36	2,15	1,58	1,22	1,20	0,98	0,91	0,93	0,83	0,76	0,72	0,54
Plant 4	2,65	2,21	2,08	1,30	1,40	1,14	0,91	1,00	0,83	0,73	0,84	0,63
Plant 5	2,51	2,17	1,71	1,19	1,33	1,04	0,93	0,95	0,80	0,75	0,78	0,60
Mean lenght (L)	2,45	2,19	1,73	1,24	1,27	1,03	0,92	0,98	0,82	0,73	0,80	0,59
Short arms (mean lenght of the homologue chromosomes, 4x												
Plant 1	0,95	0,60	0,69	1,00	0,68	0,97	0,71	0,63	0,70	0,65	0,40	0,52
Plant 2	0,57	0,53	0,61	0,82	0,58	0,80	0,62	0,57	0,75	0,46	0,49	0,46
Plant 3	0,45	0,48	0,65	0,95	0,57	0,85	0,69	0,43	0,70	0,67	0,47	0,50
Plant 4	0,57	0,53	0,62	0,90	0,68	0,80	0,65	0,59	0,65	0,68	0,44	0,49
Plant 5	0,80	0,50	0,64	0,88	0,62	0,85	0,70	0,50	0,63	0,60	0,45	0,51
Mean lenght (S)	0,67	0,53	0,64	0,91	0,63	0,85	0,67	0,54	0,69	0,61	0,45	0,50
Total lenght (TL)	3,12	2,72	2,37	2,15	1,90	1,89	1,60	1,52	1,51	1,35	1,25	1,08
						22,44						
Ratio Long arm / Short arm (L/S)	3,66	4,14	2,69	1,36	2,04	1,21	1,37	1,79	1,20	1,20	1,78	1,19
Karyotype formula	8st		4sm	4m	4sm	8m		4sm	8m		4sm	4m

4 altern to sub-opposite long cauline leaves, not markedly differing in shape from the basals, always showing bulbils in the axils, the lower ones with subterranean insertion. Bracts 1 to several, pubescent. Inflorescence with 3-13 flowers. Pedicels 3-6 cm long, densely wooly. Linear-lanceolate perianth segments, subacute, 10-15 mm long, 3-4 mm wide, sparsely pubescent.

DISCUSSION

Gagea chrysantha (Jan) J.A. and J.H. Schultes, Syst. Veg. 7: 545 (1829).

Bas: *Ornithogalum chrysanthum* Jan, Elench. Pl.: 5, ex Guss., Fl. Sic. Prod. suppl.: 100 (1832-1843).

Typus: Sicily, "prope Ficuzza", Jan (B, designated by STROH, 1936).

Syn.: *Gagea amblyopetala* Boiss. and Heldr., in Boiss., Diagn. Pl. Or. Nov. 1(7): 107 (1846).

Available iconography: Pignatti, Fl. Ital. 3: 354 (1982), both the *G. chrysantha* and *G. amblyopetala* drawings.

Distribution: South - Eastern Europe, from Southern Italy and some Southern parts of Balkan peninsula to Krym (TERRACCIANO 1906; RICHARDSON 1980; PIGNATTI 1982).

In Italy this species rarely occurs only in few places in Apulia (ANZALONE 1991), Basilicata, Calabria, Sicily and Sardinia (Tison, pers. comm.).

The chromosome number $2n = 36$ is the first report for this species.

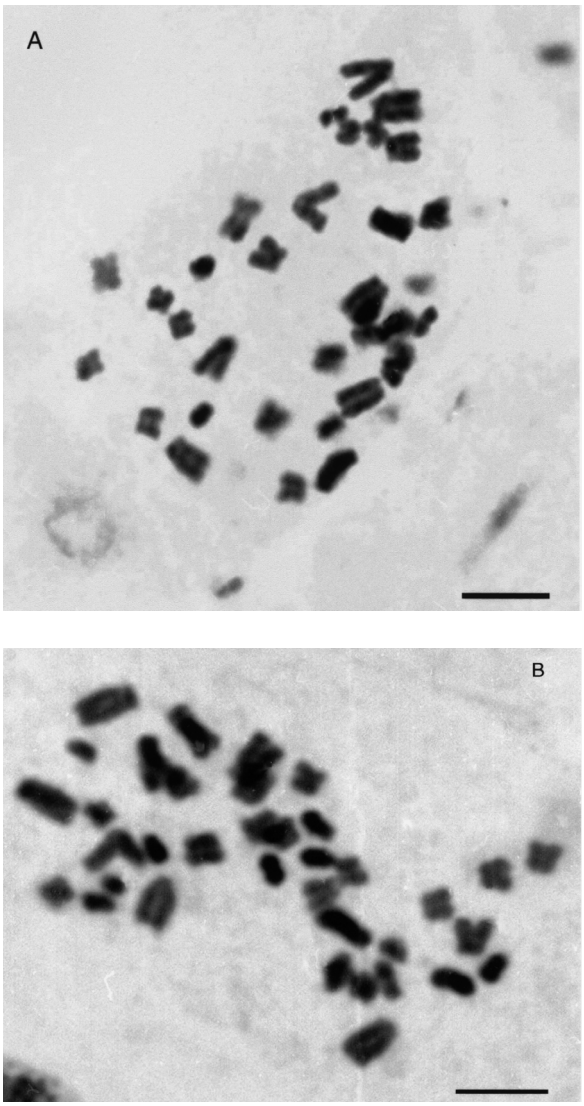

Fig. 3 – Microphotographs of metaphasic plates from young ovules of *Gagea foliosa*, $2n = 36$, scale bars 5 µm.

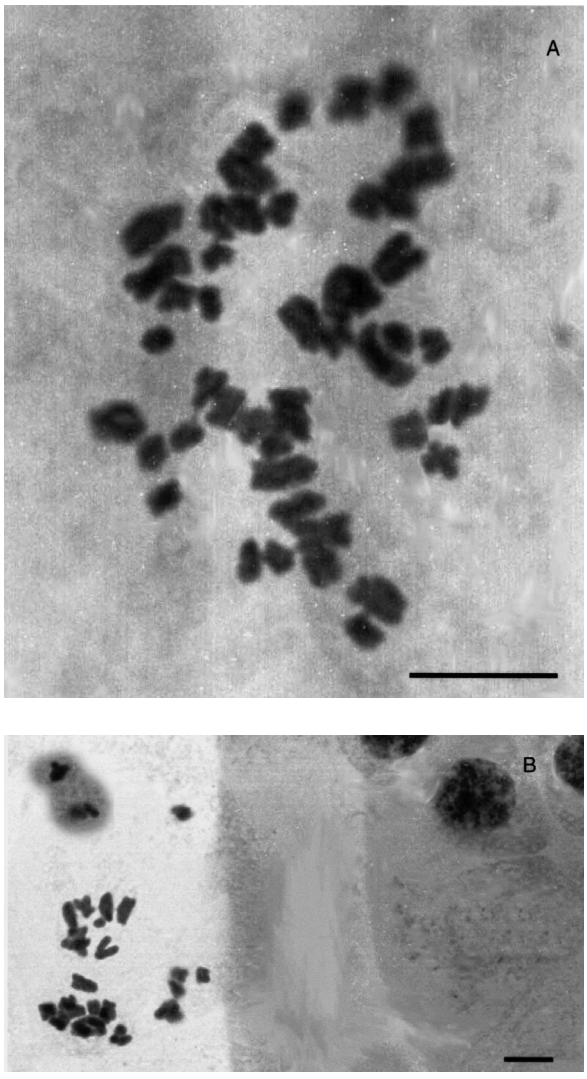

Fig. 4 – Microphotographs of metaphasic plates from young ovules of *Gagea bohemica* var. *saxatilis*, $2n = 48$ (A) and *G. granatellii*, $2n = 36$ (B), scale bars 5 µm.

Table 4 – Updated synthesis of karyological data for the genus *Gagea* Salisb. (Liliaceae).

species	infraspecific taxa	chromosome number 2*n*	source of material	References
1	*G. aberrans* Levichev	24	Central Asia	Davlianidze and Levichev, 1987
2	*G. aipetriensis* Levichev	24	Krym	Zemskova and Levichev, 1998
3	*G. alexeenkoana* Miscz.	24	Soviet Union	Davlianidze, 1969
			Caucasus	Davlianidze, 1976
4	*G. anisanthos* C. Koch	48	Caucasus	Davlianidze, 1976
5	*G. artemczukii* A. Krasnova	24	Ukraine	Zemskova and Levichev, 1998
6	*G. bohemica* (Zauschner) J. A. and J. H. Schultes	24	Israel	Heyn and Dafni, 1977
			Western France	Guerlesquin, 1985
		36	France	Tison, 1996
		48	Macedonia	Sopova *et al.*, 1984
			Macedonia	Sopova *et al.*, 1984a
		60	Czech Republic	Měsíček and Hrouda, 1974
			Galles	Slater, 1990
	var. *saxatilis* (Mert. and Koch.) Fiori	24	France	Tison, 1996
		36	France	Tison, 1998a
		48	Spain	Lopez Gonzalez, 1990
			Calabria (Italy)	present study
	var. *corsica* (Jord. and Fourr.) Rouy	36	Corsica	Contandriopoulos, 1962
7	*G. brevistolonifera* Levichev	24	Central Asia	Zemskova and Levichev, 1998
		48	Central Asia	Zemskova and Levichev, 1998
8	*G. bulbifera* (Pall.) Salisb.	24	Caucasus	Davlianidze, 1976
		36	Kazakistan	Zakirova and Nafanailova, 1988
9	*G. caelestis* Levichev var. *exinata* Levichev	24	Central Asia	Davlianidze and Levichev, 1987
10	*G. calantha* Levichev	24	Central Asia	Davlianidze and Levichev, 1987
11	*G. calyptrifolia* Levichev	48	Central Asia	Davlianidze and Levichev, 1987
12	*G. capusii* A. Terracc.	24	Turkestan	Zemskova and Levichev, 1998
13	*G. carinata* Levichev	18	Central Asia	Davlianidze and Levichev, 1987
14	*G. caroly-kochii* Grossh.	24	Soviet Union	Davlianidze, 1969
			Caucasus	Davlianidze, 1976
15	*G. chanae* Grossh.	48	Soviet Union	Davlianidze, 1969
16	*G. charadzeae* Davl.	48	Caucasus	Davlianidze, 1976
17	*G. chlorantha* (Bieb.) J. A. and J. H. Schultes	24	Soviet Union	Davlianidze, 1969
			Israel	Heyn and Dafni, 1971
			Caucasus	Davlianidze, 1976
		25	Israel	Heyn and Dafni, 1971
18	*G. chomutovae* Pascher	18	Central Asia	Davlianidze and Levichev, 1987
19	*G. chrysantha* (Jan) J. A. and J. H. Schultes (= *G. amblyopetala* Boiss. and Heldr.)	36	Calabria (Italy)	present study
20	*G. commutata* C. Koch	24	Caucasus	Davlianidze, 1976
	var. *commutata*	24	Israel	Heyn and Dafni, 1971
	var. *procera* (Mouterde) Heyn and Dafni	36	Israel	Heyn and Dafni, 1971
21	*G. confusa* A. Terracc.	36	Soviet Union	Davlianidze, 1969
			Caucasus	Davlianidze, 1976
22	*G. davlianidzeae* Levichev	24	Central Asia	Davlianidze and Levichev, 1987
		48	Central Asia	Zemskova and Levichev, 1998
23	*G. dayana* Chodat and Beauv. var. *dayana*	24	Israel	Heyn and Dafni, 1971
	var. *conjungens* (Pascher) Heyn and Dafni	24	Israel	Heyn and Dafni, 1971
24	*G. dubia* A. Terracc.	24	Soviet Union	Davlianidze, 1969
			Asia	Zemskova and Levichev, 1998
		48	Soviet Union	Davlianidze, 1969
			Caucasus	Davlianidze, 1976
			Asia	Zemskova and Levichev, 1998
25	*G. durieui* Parl.	24	Spain	Ruiz Rejon, 1978
		36	Spain	Ruiz Rejon, 1978
	fo. *vestita* Faure and Maire	36	Marocco	Corsi *et al.*, 1996
26	*G. elegans* Wall. ex Royle	96	Himalaya	Jee *et al.*, 1985
			Himalaya	Jee *et al.*, 1989
27	*G. erubescens* (Bess.) J. A. and J. H Schultes	24	Asia	Zemskova and Levichev, 1998
28	*G. fedschenkoana* Pascher	18	Asia	Zemskova and Levichev, 1998
29	*G. ferganica* Levichev	18	Central Asia	Davlianidze and Levichev, 1987
30	*G. fibrosa* (Desf.) J. A. and J. H. Schultes	24	Israel	Heyn and Dafni, 1971
31	*G. foliosa* (J. and C. Presl) J. A. and J. H. Schultes	36	Calabria (Italy)	present study
32	*G. fragifera* (Vill.) E. Bayer and G. Lopez (= *G. fistulosa* (Ram.) Ker-Gawler, see note 1)	48	Macedonia	Sopova *et al.*, 1984
			Macedonia	Sopova *et al.*, 1984a
		60	Asia	Zemskova and Levichev, 1998
		ca. 80	Sweden	Bianchi, 1946
33	*G. germainae* Grossh.	24	Asia	Zemskova and Levichev, 1998
		48	Soviet Union	Davlianidze, 1969
			Caucasus	Davlianidze, 1976

species	infraspecific taxa	chromosome number 2*n*	source of material	References
34	*G. glacialis* C. Koch	48	Soviet Union	DAVLIANIDZE, 1969
			Caucasus	DAVLIANIDZE, 1976
			Transcaucasia	POGOSIAN, 1997
35	*G. glaucescens* Levichev	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
36	*G. granatellii* (Parl.) Parl.	24	France	TISON, 1998
		36	Calabria (Italy)	present study
37	*G. granulosa* Turcz.	48	Asia	ZEMSKOVA and LEVICHEV, 1998
		ca. 60	Asia	ZEMSKOVA and LEVICHEV, 1998
38	*G. graminifolia* Vved.	24		ROMANOV, 1936
39	*G. granulosa* Turcz.	24	Krasnoyarsk	STEPANOV and MURATOVA, 1995
		72	Tomsk	MALAKHOVA and MARKOVA, 1994
40	*G. helenae* Grossh.	24	Soviet Union	DAVLIANIDZE, 1969
			Caucasus	DAVLIANIDZE, 1976
41	*G. heteroantha* Levichev	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
42	*G. jailensis* Levichev	24	Asia	ZEMSKOVA and LEVICHEV, 1998
43	*G. joannis* Grossh.	24	Caucasus	DAVLIANIDZE, 1976
44	*G. juniperina* Levichev	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
45	*G. kamelinii* Levichev	36	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
46	*G. longiscapa* Grossh.	ca. 90	Asia	ZEMSKOVA and LEVICHEV, 1998
47	*G. ludmilae* Levichev	48	Central Asia	ZEMSKOVA and LEVICHEV, 1998
48	*G. lutea* (L.) Ker-Gawler (see note 2)	12	Austria	TISCHLER, 1950
		24	Spain	MONTSERRAT MARTI, 1981
			Macedonia	SOPOVA *et al.*, 1984
			Macedonia	SOPOVA *et al.*, 1984a
		48	India	MALIK, 1961
			Czech Republic	MĚSIČEK and HROUDA, 1974
			Himalaya	MEHRA and SACHDEVA, 1976
			Karpat	KRICHOPHALUSHI, 1989
		72	Japan	SAKAMURA and STOW, 1926
			Europe	TISCHLER, 1934
			Japan	MATSUURA and SUTO, 1935
				SATO, 1936
			Denmark	WESTERGAARD, 1936
			Europe	GEITLER, 1949
			Soviet Union	DAVLIANIDZE, 1969
			Austria	LEUTE, 1974
			Poland	SKALINSKA *et al.*, 1976
			Slovakia	VACHOVA and MAJOVSKY, 1978
				VACHOVA, 1980
			Macedonia	SOPOVA *et al.*, 1984
			Macedonia	SOPOVA *et al.*, 1984a
			Austria	WITTMAN *et al.*, 1987
			British Islands	DEMPSEY *et al.*, 1994
49	*G. micrantha* (Boiss.) Pascher	24	Israel	HEYN and DAFNI, 1977
50	*G. minima* (L.) Ker-Gawler	24	Denmark	WESTERGAARD, 1936
			Norway	LAANE, 1971
			Czech Republic	MĚSIČEK and HROUDA, 1974
			Slovakia	MURIN, 1976
			Poland	POGAN *et al.*, 1980
			Finland	AROHONKA, 1982
			Macedonia	SOPOVA *et al.*, 1984
			Macedonia	SOPOVA *et al.*, 1984a
		32	North Europe	STENAR, 1927
			Holland	TISCHLER, 1934
51	*G. minutiflora* Regel	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
52	*G. nakajana* Kitag.	24	Asia	ZEMSKOVA and LEVICHEV, 1998
		48	Russia	RUDYKA, 1995
			Asia	ZEMSKOVA and LEVICHEV, 1998
53	*G. nevadensis* Boiss.	24	Portugal	LOON, 1982
		36	Spain	KÜPFER, 1974
54	*G. ova* Stapf	48	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
55	*G. paczoskii* (Zapal.) Grossh.	48	Slovakia	UHRIKOVA and MAJOVSKY, 1978
			Russia	ZEMSKOVA and LEVICHEV, 1998
56	*G. pamiroalaica* Levichev	48	Asia	ZEMSKOVA and LEVICHEV, 1998
57	*G. paniculata* Levichev	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
58	*G. persica* Boiss. (= *G. gageoides* (Zucc.) Vved.)	48		MEHRA and SACHDEVA, 1971
			Himalaya	MEHRA and SACHDEVA, 1976
59	*G. podolica* J. A. and J. H. Schultes	24	Asia	ZEMSKOVA and LEVICHEV, 1998
60	*G. popovii* Vved.	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
61	*G. praeciosa* Klok.	24	Russia	ZEMSKOVA and LEVICHEV, 1998
62	*G. praemixta* Vved.	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987

species	infraspecific taxa	chromosome number 2*n*	source of material	References
63	*G. pratensis* (Pers.) Dumort (see note 2)	24	Macedonia	SOPOVA *et al.*, 1984
			Macedonia	SOPOVA *et al.*, 1984a
		36	Sweden	WEIMARCK, 1963
			Slovakia	MURIN, 1976
		48	Sweden	WEIMARCK, 1963
			Czech Republic	KUBAT, 1970
			Czech Republic	WITTENBERGER, 1970
			Slovakia	MĚSIČEK and HROUDA, 1974
			Poland	POGAN *et al.,* 1980
			Central Asia	DAVLIANIDZE and LEVICHEV, 1987
			Asia	ZEMSKOVA and LEVICHEV, 1998
		60	Slovakia	MĚSIČEK and HROUDA, 1974
64	*G. protraeta* Levichev	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
65	*G. pusilla* (F. W. Schmidt) Sweet (see note 1)	24	Czech Republic	MĚSIČEK and HROUDA, 1974
			Slovakia	UHRIKOVA and MAJOVSKY, 1980
			Macedonia	SOPOVA *et al.*, 1984
			Macedonia	SOPOVA *et al.*, 1984a
			Austria	KIEHN *et al.*, 1991
			Asia	ZEMSKOVA and LEVICHEV, 1998
		48	Macedonia	SOPOVA *et al.*, 1984
			Macedonia	SOPOVA *et al.*, 1984a
		60	Macedonia	SOPOVA *et al.*, 1984
			Macedonia	SOPOVA *et al.*, 1984a
66	*G. reticulata* J. A. and J. H. Schultes	24		MALIK and SEHGAL, 1959
			Israel	HEYN and DAFNI, 1971
			Himalaya	KOUL *et al.*, 1976b
				KOUL and WAKHLU, 1985
			Caucasus	MAGULAEV, 1992
67	*G. rubicunda* Meinsh.	48	Asia	ZEMSKOVA and LEVICHEV, 1998
68	*G. soleirolii* F. Schultz	36	Sardinia	MARTINOLI, 1950
			Sardinia	MARTINOLI, 1954
69	*G. schachimardanica* Levichev	18	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
70	*G. spathacea* (Hayne) Salisb. (see note 3)	ca. 102		SATO, 1936
				WESTERGAARD, 1936
		106	Slovakia	MĚSIČEK and HROUDA, 1974
71	*G. stipitata* Merckl.	72		KOUL *et al.,* 1976
72	*G. subtilis* Vved.	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
	subsp. carvum Levichev	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
73	*G. sulfurea* Miscz.	72	Caucasus	DAVLIANIDZE, 1976
74	*G. taurica* Stev.	24	Caucasus	DAVLIANIDZE, 1976
		25	Soviet Union	DAVLIANIDZE, 1969
75	*G. tenera* Pascher	36		ROMANOV, 1936
			Central Asia	DAVLIANIDZE and LEVICHEV, 1987
76	*G. tenuifolia* Fom.	24	Soviet Union	DAVLIANIDZE, 1969
			Caucasus	DAVLIANIDZE, 1976
77	*G. terraccianoana* Pascher	24	Asia	ZEMSKOVA and LEVICHEV, 1998
78	*G. testudina* Levichev	48	Asia	ZEMSKOVA and LEVICHEV, 1998
79	*G. transversalis* Stev.	24	Asia	ZEMSKOVA and LEVICHEV, 1998
80	*G. tribulbilla* Levichev	36	Asia	ZEMSKOVA and LEVICHEV, 1998
81	*G. turkestanica* Pascher (= G. capusii A. Terracc.)	24	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
82	*G. vegeta* Vved.	60	Central Asia	DAVLIANIDZE and LEVICHEV, 1987
83	*G. villosa* (M. Bieb.) Sweet (= *G. arvensis* (Pers.) Dumort, see note 1, 4)	48	Soviet Union	MISCENKO, 1908
				TISCHLER, 1938
			Czech Republic	MĚSIČEK and HROUDA, 1974
			Slovakia	UHRIKOVA and MAJOVSKY, 1978
			Slovakia	UHRIKOVA and MAJOVSKY, 1980
			Macedonia	SOPOVA *et al.*, 1984
			Macedonia	SOPOVA *et al.*, 1984a
			France	REYNAUD *et al.*, 1993
		60	Israel	HEYN and DAFNI, 1977
	var. *villosa*	72	Israel	HEYN and DAFNI, 1977
	var. *hermonis* Dafni and Heyn	60	Israel	HEYN and DAFNI, 1977
	subsp. hervieri (Deg.) Löve and Kjellqvist	48	Spain	RUIZ REJON, 1978
			Spain	LÖVE and KJELLQVIST, 1973
84	G. *villosula* Vved.	24		ZAKHARYEVA and MAKUSHENKO, 1969

*Notes to Table 4

(1) For nomenclatural notes on this taxon, see BAYER and LÒPEZ GONZALEZ (1989)

(2) For recent revisions of *G. lutea* and *G. pratensis* group, see TISON (1997)

(3) The basyonim of this species was recently lectotypified (CUCCUINI and LUCCIOLI 1995)

(4) For nomenclatural notes on this taxon, see SCHWARZ (1949)

Gagea foliosa (J. and C. Presl) J.A. and J.H. Schultes, Syst. Veg. 7: 1703 (1829).

Bas.: *Ornithogalum foliosum* J. and C. Presl, Delic. Prag.: 149 (1822).

Typus: Sicily, "in umbrosis nemorosis ai Polizzi nello bosco dei nucelli, Nebrodum, VI/1817, Presl (PR, designated by PASCHER 1906).

Iconographia selecta: Pascher, Beih. Bot. Centralbl. 20(2): 79 (1906); Tison, Le Monde des Plantes 462: 5 (1998).

Distribution: Central Mediterranean area (Tison, pers. comm.). Up to now this unit was known in Italy for Apulia, Basilicata, Sardinia and Sicily (PIGNATTI 1982). The signalling of this species for Marche [Monti Sibillini: pascoli sassosi e pendici detritico-sassose nel versante Sud del M. Zampa presso il rif. M. Sibilla, 1550-1600 m. s. m., suolo calcareo, 15/V/1985, Brilli Cattarini et Gubellini (FI!)] made by BRILLI-CATTARINI and GUBELLINI (1987) is to refer to *G. villosa*.

This taxon is new for Calabrian flora.

G. chrysantha and *G. foliosa*, considered as very closely related (RICHARDSON 1980) and growing in Calabria near in the same areas, are well karyologically distinct for the features of the idiograms (Fig. 2), such as the occurrence in the first of three chromosomes of terminal type (sensu lato) in more respect to the latter. *G. foliosa* shows a little longer haploid idiogram (25,61 µm instead of 24,94 µm). The two taxa are rather morphologically distinct too, mainly by features of the cauline leaves (generally altern, glabrous in *G. chrysantha*; always sub opposite, larger and subciliate in *G. foliosa*). So, *G. chrysantha* and *G. foliosa* are two triploid units very similar but which deserve to keep separated, both for morphological and karyological reasons.

Gagea bohemica (Zauschner) J.A. and J.H. Schultes, Syst. Veg. 7: 549 (1829).

Bas.: *Ornithogalum bohemicum* Zauschner in Abh. Privatges. Prag. 2: 121 (1776).

Typus: Czech Republic, "Bohemia - Schmidt 336" Herb. Willd. 6590 (B, designated by HEYN and DAFNI, 1977).

Syn.: *O. zauschneri* Pohl, Fl. Bohem. 2: 14 (1815).

Iconographia selecta: Rix and Woods, Watsonia 13: 266 (1981), Tison, Le Monde des Plantes 455: 16 (1996).

Distribution: Europe, Anatolia and Israel (KHINKOVA 1971; RICHARDSON 1980; ROGERS 1980; SLATER 1980; RIX and WOODS 1981; NETIEN 1982; PAGE 1982; FISCHER 1985; DELAIGUE 1991).

PIGNATTI (1982) affirms that in Italy only *G. busambarensis* (Tineo) Parl. would be present, and that *G. bohemica* would be not part of our flora. According to other researchers (MARCENÒ and COLOMBO 1978; ANZALONE 1991; TISON 1996), *G. busambarensis* is a very localized endemic of Rocca Busambra in Sicily, characterized by peculiar features such as 5 basal leaves (instead of 2) and scape completely without leaves (instead of 2-3); in Sardinia and Corsica it is present *G. bohemica* var. *corsica* (Jord. et Fourr.) Rouy, distinct for exiles characteristics; while all the other peninsular stations are to refer to *G. saxatilis* (Mert. et Koch) J.A. and J.H. Schultes.

G. saxatilis, was considered to more resumptions as a good species (RICHARDSON 1980; TISON 1996; REYNAUD and TISON 1997), or subspecies of *G. bohemica* (BAYER and LOPEZ GONZALEZ 1988; ANZALONE 1991; BAYER and LOPEZ GONZALEZ 1991; TISON 1998); according to HEYN and DAFNI (1977), RIX and WOODS (1981) and some recent studies in publication (Tison, pers. comm.) this unit cannot be kept certainly distinguished from *G. bohemica*. We prefer therefore to assign to the specimens from us studied the simple varietale rank, used already at the time of the description of the basionym (MERTENS and KOCH 1826). In Sicily, on the Madonie and Etna (GIARDINA 1999) mounts it is present also *G. nebrodensis* (Tod.) Nym., already synonymized by PARLATORE (1826) with *G. saxatilis*.

– var. saxatilis (Mert. and Koch.) Fiori, Nuova Fl. Anal. It. 1: 254 (1923).

Bas.: *Ornithogalum bohemicum* Zauschner var. *saxatilis* Mert. et Koch in Röhlings, Deutsch. Fl. 2: 545 (1826).

Typus: Western Germany, "m. Donnersberg, Palat", Koch (B, designated by STROH 1936).

Syn.: *Gagea saxatilis* (Mert. and Koch) J.A. and J.H. Schultes, Syst. Veg. 7: 550 (1829), *Ornithogalum nebrodense* Tod., in Gussone, Syn. Add. 2: 812 (1843); *Gagea nebrodensis* (Tod.) Nym., Syll. Fl. Eur. suppl.: 372 (1854-1855); *Gagea saxatilis* (Mert. and Koch) J.A. and J.H. Schultes subsp. *australis* A. Terracc., Bull. Herb. Boiss. sèr. 2, 6: 112 (1906); *Gagea bohemica* (Zauschner) J.A. and J.H. Schultes subsp. *saxatilis* (Mert. and Koch) Ascherson and Graebner, Synopsis 3: 74-92 (1905-1907); *Gagea bohemica* (Zauschner) J.A. and J.H. Schultes subsp. *nebrodensis* (Tod. ex Guss.) I. B. K. Richardson, Bot. Jour. Linn. Soc. 76: 356 (1978).

Iconographia selecta: Heyn and Dafni, Israel Jour. Bot. 26: 18 (1977), Tison, Le Monde des Plantes 455: 16 (1996).

Distribution: in Italy this species rarely occurs from Central Appennines to Pollino Massif (PIGNATTI 1982; CONTI *et al.* 1998, 1990; ANZALONE 1991) and Sicily.

For *G. bohemica* s.l. the chromosome number $2n = 48$ was already known in plants from Spain and Macedonia, together with $2n = 24$ in material from Israel and France, $2n = 36$ in plants from Corsica and France, $2n = 60$ in specimens from locus classicus of *G. bohemica* s.s. and Galles (Table 4).

Therefore, this species represents a classical example of an euploid series, showing all the levels of ploidy between 2x and 5x.

The haploid idiogram of this species shows a pattern rather close to the one of *G. foliosa* (cfr. Fig. 2), except for some chromosome, which is of median type in the latter and of submedian type in *G. bohemica* var. *saxatilis*, and the shorter total lenght of haploid idiogram of the latter (22,44 µm).

According to MERTENS and KOCH (1826), RICHARDSON (1980), TISON (1996), *G. bohemica* var. *saxatilis* is distinguished from *G. bohemica* s.s. for the small size of flowers, the bigger size of the scape, some features of the ovary (trunked at the apex instead of subcordate).

In the Balkans occurs *G. peduncularis* (J. and C. Presl) Pascher, a species which, on the basis of the basyonim's protologue (PRESL and PRESL 1822) and literature (ANDERSSON 1991) appear to be very similar with *G. bohemica*, distinct by the longer pedicels (more than 2 cm); its chromosome number is still unknown.

Gagea granatellii (Parl.) Parl., Fl. Palerm. 1: 276 (1845).

Bas.: *Ornithogalum granatellii* Parl., Diario l'Occhio 11: 85 (1839).

Typus: Sicily, "*Ornithogalum granatellii* Nob. Nel giorn. L'Occhio. In pascuis montosis et in campis aridis. Panormi al Caputo. Monte Busambra. Floret Martis Aprili", 1840, Parlatore (G, see TISON 1998).

Syn.: *Gagea arvensis* (Pers.) Dumort. subsp. *granatellii* (Parl.) Ascherson and Graebner, Synopsis 3: 74-92 (1905-1907).

Iconographia selecta: Tison, Le Monde des Plantes 462: 3-5 (1998).

Distribution: Steno – Mediterranean region, from Greece (ANDERSSON 1991; with some doubt) and Italy westwards to Marocco and Algerie (TISON 1998).

This species occurs in Italy in the Thyrrenian islands, Apulia and Basilicata (PIGNATTI 1982). The presence of this taxon in Calabria was already reported by TERRACCIANO (1891) for the Pollino area.

For this species was reported until now only the chromosome number $2n = 24$ (Table 4).

G. granatellii is easily distinguished from the similar *G. villosa* by the presence of several cauline leaves, the lower ones with subterranean insertion, the bulb surrounded by recurved roots, the phenology (flowering time anticipated of about 1 month). By a karyological point of view, the first taxon is diploid and triploid, while the latter is always tetra- penta- or hexaploid (Table 4). *G. granatellii* is distinct from *G. foliosa* too by the occurrence of bulbils. *G.* x *luberonensis* Tison, an hybrid between *G. bohemica* and *G. granatellii* was recently indentified (TISON 1996a) and described (TISON 1998a) for France, confirming the complex systematic situation inside the sect. Foliatae.

The checklist presented (Table 4) shows all the species of the genus *Gagea*, which have been karyologically studied, in alphabetical order. There are 204 records referring to 95 taxa (84 species and 11 infraspecific taxa). Total of different chromosome counts (considering two or more cytotypes for some units) is 125. The basic number is x = 12.

55 taxa show 2x complement (57,8%) of which 36 are exclusively diploid ($2n = 24$); 17 taxa show 3x complement (17,9%) of which 10 are exclusively triploid ($2n = 36$); 26 taxa show 4x complement (27,3%) of which 13 are exclusively tetraploid ($2n = 48$); 7 taxa show 5x complement (7,3%) of which 2 are exclusively pentaploid ($2n = 60$); 5 taxa show 6x complement (5,3%) of which 3 are exclusively exaploid ($2n = 72$); 2 taxa (2,1%) are probably 7x ($2n$ = ca. 80, ca. 90); 1 taxon (1%) is 8x ($2n = 96$), 10 taxa show aneuploidy or aploidy (10,5%) of which only 6 are exclusively aneuploid ($2n = 18$; $2n = 102$-106).

37,8% of the considered taxa are diploid, 10.6% triploid, 13,7% tetraploid, 2,2% pentaploid, 3,1% hexaploid, 1% are heptaploid, 1% octoploid, 6,3% aneuploid, 24,3% show two or more cytotypes (representing more or less completely euploid series) or very rare possibility of aneuploidy/aploidy phenomena.

The highest chromosome number occurs in *G. spathacea* (Hayne) Salisb. ($2n = 106$), while the lowest (excluding a probable case of aploidy $2n = 12$ in *G. lutea* (L.) Ker-Gawler) occurs in *G. chomutovae* Pascher, *G. carinata* Levichev, *G. fedschenkoana* Pascher, *G. ferganica* Levichev, *G. schachimardanica* Levichev ($2n = 18$).

Most of the diploid species occur in Central – Western Asia and belong to the subgenus Hornungia (sect. Platyspermum Boiss.), allowing us hypothesize that this taxon is the most primitive.

This study allowed us to definitely establish the basic number of the genus *Gagea* (x = 12), which for some authors (i. e. REYNAUD *et al.* 1993) would be x = 6.

From the analysis of the checklist of karyological data, we assume that almost halves studied taxa are diploid, or show diploid populations, the aneuploidy is rare, while the presence of triploids, tetraploids or more or less partial euploid series is enough frequent.

Both the subgenera Hornungia and Gagea probably originated in Central – Western Asia, and have subsequently colonized, often thanks to massive phenomena of polyploidization, the most western territories of the Eurasiatic continent and Northern Africa.

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