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Further Cytological Investigations in Indian Compositae

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In an earlier communication (Gupta 1969), results of cytological investigations in 21 taxa belonging to 16 genera and 17 species from the family Compositae were reported. These studies were continued at Gorakhpur (Eastern Uttar Pradesh). However, since July, 1969, when the senior author moved to Meerut, these studies were extended to the Compositae of this region (Western Uttar Pradesh). Both wild and cultivated taxa were studied. As earlier pointed out (Gupta 1969), the only comprehensive study on Indian Compositae was undertaken by Mehra and his co-workers (Mehra *et al.* 1965). No extensive cytological survey of the Compositae of this vast province of Uttar Pradesh was ever undertaken. Our work, of which this paper is a part, is aimed to collect cytological information about the Compositae of this province. The present report, therefore, is a supplement to the earlier communication. Results of 33 collections belonging to 28 species from ten different tribes of the family Compositae are reported in this paper.

Material and methods

Flower buds were collected from the fields, from public parks or from the gardens at institutions and residences. The buds were fixed in Carnoy's fluid (6: 3: 1). Fixation was always done in the forenoon. Squash preparations were made from anthers and meiosis was studied in temporary preparations. The temporary preparations could be retained by adding a drop of a mixture of glycerine and 45% acetic acid (1: 10) through the edge of the cover glass. Camera lucida drawings were made from the temporary preparations. Wherever possible, slides were made permanent following schedule earlier outlined by Gupta and Srivastava (1969).

Identifications were mainly done by Dr. V. Singh, Meerut College, Meerut. Voucher specimens were retained in the personal collection of the senior author at Meerut University. The tribes, genera and species were arranged in an alphabetic order for the sake of convenience. In earlier report (Gupta 1969), Hooker's Flora of British India (Vol. 3, 1883) was followed. However, this was not convenient for those having no training in taxonomy.

Retsults and discussion

The gametic chromosome number as worked out at meiosis are listed in Table

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1. Results of only those collections, which showed relatively irregular meiosis, are presented in Table 2. The morphological variations among different cytotypes are presented in Table 3. For the purpose of morphology, data on stomata and flowers only could be presented, since only few plants in the form of herbarium specimens were available for study.

The observations and discussion which follow will be restricted to only those species which either gave new chromosome counts or else exhibited other interesting features. Of the 33 collections belonging to 28 species, there were only 14 collections from 13 species which had this feature, and only these will be described in detail. The remaining collections confirmed the earlier reports and the information regarding these can be found in Table 1.

The Table 1 suggested that there was considerable numerical diversity in the chromosome numbers in this family. In order to explain numerical diversity in this family both at the diploid and the polyploid levels, two view points are available. While Stebbins (1966) assumed parallel polyploidy from diploids and the lower polyploids with different base numbers, Raven and Khyos (1965) suggested dysploid changes at the same ploidy level. Ehrendorfer *et al.* (1968) discussed new and important evidence in favour of the former view point. They also discussed the possibility of x=7 as the only primitive base number in Angiosperms. They believed that the descending dysploidy would be more common both at the diploid and the polyploid levels. This is understandable from the cytogenetical view point also, because reduction in chromosome number can be brought about by translocations etc., while increase in chromosome number would require fragmentation of the existing chromosomes particularly through the misdivision of the centromere. Keeping these criteria in mind, the numerical diversity will be discussed in the following discussion.

Abarboa ramosa

Abarboa ramosa, also known as *Volutarella divaricata* was found as a weed, common during the later part of winter season. Under the name *V. divaricata,* Mehra *et al.* (1969) gave two chromosome counts viz. n=8 and n=14. The present material collected from Meerut showed formation of 18 bivalents at metaphase I (Fig. 1). This added another chromosome number and another base number for this species and the genus. If x=7 was the original base number, x=8 and x=9 could be derived by ascending dysploidy.

Blumea laciniata

Blumea laciniata, was earlier studied for the first time by Gupta (1969). He studied the material collected from Gorakhpur and gave a chromasome count of n=10. In the present study the material was collected from Meerut. At meiosis, nine bivalents were observed (Fig. 2). This represented a new chromosome count and a new base number for the species and the genus. Earlier reports on this genus included n=11 for *B. lacera* (Mehra *et al.* 1965) and *B. membranacea* (Mehra *et al.* 1965). However, reports of 2n=11 for *B. lacera* (Gupta 1969) and n=10 and n=9 for *B. laciniata* (Gupta 1969 and the present report) suggested that there may be

Table 1. Chromosome numbers in some Indian compositae

Taxa	x	n	Nature of meiosis	Coll no.	Previous reports n	Previous reports 2n	Previous reports
Anthemideae							
Chrysanthemum coronarium L.	9	9	Regular	269		18	*Shimotomai and Hujiwara., 1935; *Löve and Löve, 1948; Blixt in Lamprecht, 1966; Gadella and Kliphuis, 1966;
=*Matricaria chamomella* L.					9		Gupta, 1969.
Chrysanthemum parthenium Pers.	9	9	Irregular	432		18	*Harling, 1951a; *Dowrick, 1952b
					9		Turner *et al.*, 1962
Cotula hemispherica Wall.	10	10	Regular	461	10	20	Mehra *et al.*, 1965
Astereae							
Aster Amellus L.	9	9	Regular	297		18	*Annen, 1945, Chatterji, 1962
						36	Chauksanova *et al.*, 1968a
						66	Annen, 1945
						76	Annen, 1945
					27		Mehra *et al.*, 1965
Erigeron bonariensis L.	9	27	Regular	448		54	*Holmgren, 1919; Huziwara, 1958
Calenduleae							
Calendula officinalis L.	8	16	Regular	470		28	*Negodi, 1936a;
						32	*Weddle, 1941; Janaki Ammal, 1962a
							Meusel and Ohle, 1966
					16		Mehra *et al.*, 1965; Gupta, 1969
Dimorphotheca annua Less.	9	9	Regular	270			
Cichorieae							
Launaea fallex =*L. nudicaulis* Less	9	9	Regular	434		18	*Stebbins *et al.*, 1953
	9	9	Regular	456			
					9		Mehra *et al.*, 1965; Shetty, 1967; Gupta, 1969

Table 1. (Continued)

Taxa	x	n	Nature of meiosis	Coll no.	Previous reports n	Previous reports 2n	Previous reports
Sonchus arvensis L.	16	16	Regular	417		18	Sorsa, 1962, 1963a; Mehra *et al.*, 1965
	9	18	Regular	474		54	**Alva *et al.*, 1956, 1957; **Löve and Löve, 1956, 1961 Mulligan, 1957; Gadella and Kliphuis, 1963, 1967a, 1968a; Curran, 1968
	9	9	Regular	479			
	9	9	Regular	480			
						64	Wulff, 1937b.
					9		Sorsa, 1962, 1963a; Mehra *et al.*, 1965.
Sonchus asper (L) Hill	9	9	Regular	478		18	*Stebbins *et al.*, 1953; Mulligan, 1957; Nisioka, 1958; Koul, 1964a; Mehra *et al.*, 1965; Gadella and Kliphuis, 1966; Curran, 1968
					9		Koul, 1964a, Subramenyam and Kamble, 1967 Taylor and Mulligan, 1968
Youngia japonica D.C. =*Crepis japonica*	9	9	Regular	752		16	*Babcock *et al.*, 1937
					8		Chuang *et al.*, 1963, Mehra *et al.*, 1965; Shetty, 1967; Hsu, 1968; Jones, 1968a
Cynureae							
Abarboa ramosa (Roxb) =*Volutarella divaricata* Benth.	9	18	Regular	457	14		Mehra *et al.*, 1965
					8		Mehra *et al.*, 1965
Carthamus oxycantha Bieb	6	12	Irregular	512		24	*Kishore, 1951; Tonjan, 1968a
					12		Mehra *et al.*, 1965; Srivastava and Gupta, 1970
Centaurae cyanus L.	6	12	Regular	285		24	*Fritsch, 1935; **Löve and Löve, 1956; Guinochet, 1957; Guinochet and Foissac, 1962; Dey and Sharma, 1967; Tonjan, 1968b
						20	Dey and Sharma, 1967
					12		Mehra *et al.*, 1965
Cirsium arvense Bieb =*Cnicus arvensis* Hoffm.	9	18	Regular	481		34	*Ehrenberg, 1945
					17		Mehra *et al.*, 1965
Eupatorieae							
Ageratum conyzoides L.	10	10	Regular	472		20	*Ishikawa, 1916; Koul, 1964a; Hsu, 1968
						40	*Mitra, 1947; Harvey, 1966a
					10		Turner and King, 1964; Turner and L., 1965; Coleman, 1968; Gupta, 1969

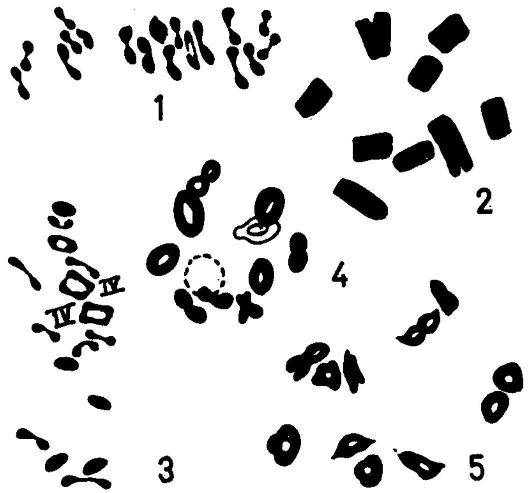
Helenieae							
Tagetes erecta L.	12	24	Regular	275		24	*Eyster, 1939; Towner, 1958; Bolz, 1961
					12		Mehra *et al.*, 1965
Tagetes patula L.	7	7	Regular	271		48	*Eyster, 1939; Towner, 1958; Bolz, 1961; Huziwara, 1968
					24		Mehra *et al.*, 1965
Heliantheae							
Coreopsis basalis Blake	11	11	Regular	288		26	*Gelin, 1934
=*C. drummondii*	10	10	Regular	423	13		Turner, 1960;
					10		Gupta, 1969 (sec text)
Cosmos bipinnatus Cav.	12	12+ 1B	Regular	282		24	*Sugiura, 1936b
					12		Mehra *et al.*, 1965; Melchert, 1968
					11		Rowell and T. 1963
Dahlia variabilis Cav.	8	32	Irregular	290		64	*Lawrence, 1931a
	8	32	Regular	277			
Viguiera helianthoides	17	17	Regular	296			
Zinnia linearis Benth.	12	12	Regular		12		Mehra *et al.*, 1965
Inuleae							
Blumea laciniata D.C.	9	9	Regular	751	10		Gupta, 1969
Helichrysum bracteatum Widd	12	12	Regular	491		28	*Tongiorgi, 1941; Chauksanova *et al.*, 1968
						24	Chatterjee and Sharma, 1968
					12		Chatterjee and Sharma, 1968
					15		Gupta, 1969
Senecioneae							
Emilia sonchifolia DC	8	8	Regular	469		20	Arano, 1962, 1965, 1968
						10	*Baldwin, 1946a; Harvey 1966; Chatterjee and Sharma, 1968
					5		Turner and K., 1964; Mehra *et al.*, 1965: Chatterjee and Sharma, 1968
					10		Arano, 1962; Hsu, 1968
Gamolepis tagetes L.	10	10	Regular	320	10		Mehra *et al.*, 1965
Senecio cruentus DC	10	30	Regular	280	30		Larsen, 1960

* From: Darlington, C.D. and Wylie, A.P. 1955—"*Chromosome Atlas of Flowering Plants*" Allen & Unwin Ltd, London.

** From: Mehra *et al.*, 1965. (see references).

several base numbers in this genus.

This was an interesting case of dysploidy in a single species. However, it was difficult to speculate about the original base number. Nevertheless, since x=9 was one of the most common base numbers in Compositae, this could be a case of ascending dysploidy (9→10→11). These three base numbers could be the primary base numbers or could be the secondarily derived ones. If the whole of Compositae (or Angiosperms) were to have a single base number originally, these three base numbers in this genus have to be derived ones. Ehrendorfer *et al.* (1968) thought that perhaps x=7 was the original base number in primitive Angiosperms. If it is so, 7 could have given rise to 6 and 5 by descending dysploidy. Base number 5 could then give rise to 10 by simple doubling and to 11 by combination with 6. The base number 9 could be derived from 10 directly or from 5 and 4. Such a line of evolution had support from the report of 2n=11 for *B. lacera* (Gupta 1969).



Figs. 1–5 1, *Abarboa ramosa*, mentaphase I showing 18 bivalents. 2, *Blumea laciniata*, diakinesis showing 9 bivalents. 3, *Cirsium arvense*, metaphase I showing 14 bivalents, and 2 quadrivalents (IV). 4, 5, *Coreopsis basalis*; 4, collection no. 423, diakinesis showing 10 bivalents. 5, collection no. 288 diakinesis showing 11 bivalents.

Carthamus oxyacantha

This was found as a weed in the cultivated fields after wheat was harvested. Material collected from Meerut gave a count of n=12, which confirmed the earlier reports. However the material studied showed considerable asyndesis. The number of univalents in a PMC ranged from none to 16 with a mean of 2.40 univalents per PMC. Normal PMCs having 12 bivalents were only 19.63%. Restitution formation was observed in 14.58% of the PMCs studied. Laggards were observed in 67.31% of the PMCs at anaphase I and in 84.09% of the PMCs at anaphase II. Micronuclei were observed in 78.79% of the PMCs at anaphase II. Micronuclei were observed in 78.79% of PMCs at the dyad stage and in 80.00% of PMCs at the quartet stage. Polyads were observed in 80.23% of PMCs. Pollen size varied from 18.00 μ to 54.00 μ giving a mean value of 31.8 μ.

Since the phenomenon of asyndesis was observed only in one plant, the other plants showing the normal meiotic behaviour, it was concluded that perhaps asyndesis was genetically controlled. The details of meiosis in this collection are being published elsewhere (Srivastava and Gupta 1970).

Cirsium arvense

Cirsium arvense, also known as *Cnicus arvensis* was found as a weed, common at the end of the winter season. The material collected from Meerut was studied and 18 bivalents were observed at metaphase I. Quadrivalent formation was occasionally observed (Fig. 3). This could be due to translocation heterozygosity or due to segmental polyploidy. The present report differed from the earlier report of $2n=34$ (Table 1) and $n=17$ (Mehra *et al.* 1965). It is possible that in this species, the original base number was $x=9$ or 18 and that 17 was secondarily derived one. In any case the present report suggested an additional base number in this species.

Coreopsis basalis

Two collections for this species from Meerut were studied cytologycally. The two collections represented two different chromosome races with $n=10$ (Fig. 4) and $n=11$ (Fig. 5). Earlier reports on this species included the study of two different varieties viz. *Coreopsis basalis* var. *basalis* and *C. basalis* var. *wrightii* (Turner 1960). Both these varieties had $n=13$. The herbarium specimen of collection number 129, which was earlier studied by Gupta (1969), was identified by Central National Herbarium, Howrah as *Coreopsis coronata* and was so reported in our earlier report. The specimen was re-examined by Dr. V. Singh, who identified it as *C. basalis.* If this identification was correct, as we believed, then $n=10$ reported earlier for *C. coronata* was actually a new count for *C. basalis.* The present report added another chromosome number for the species ($n=11$). This makes three chromosome counts representing three base numbers in the species ($n=x=10$, 11 and 13).

Thus *Coreopsis basalis* represented an interesting case of interspecific dysploidy. The three base numbers could result either from $x=10$ as a result of ascending dysploidy or possibly from $x_2=14$ as a result of descending dysploidy. $x_2=14$ must have been derived from the original primitive base number $x=7$ (Ehrendorfer *et al.* 1968). If the second alternative was accepted, which looked more plausible, the present case of dysploidy in *Coreopsis basalis* will support the view of Raven and Khyos (1965), who believed that the dysploid changes take place at the same ploidy level.

Cosmos bipinnatus

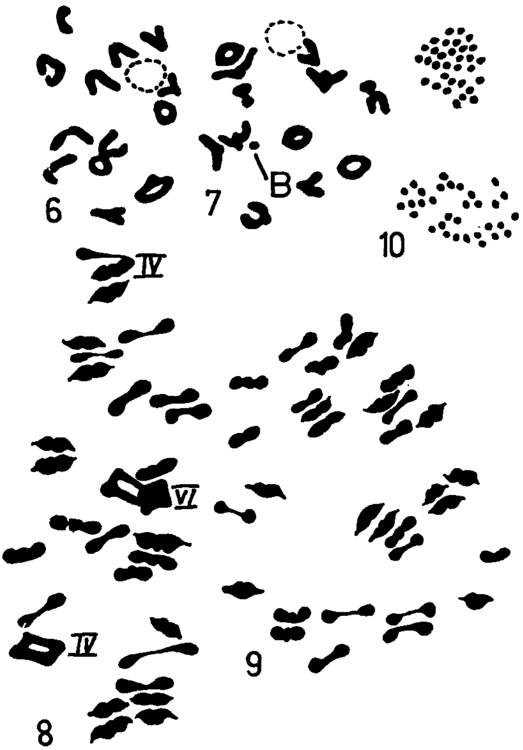
This was a cultivated species and was collected at Meerut. The chromosome count confirmed the earlier report of $n=12$ (Table 1, Fig. 6). However in the material studied, one B chromosome was found to be present in certain PMCs (Fig. 7). B-chromosome in this species is reported for the first time. However, in the genus *Cosmos,* $x=12$ was an established base number and there was no evidence of intraspecific dysploidy.

Dahlia variabilis

This species was studied for the first time in 1931 (Table 1). In the present study, two cultivars from the Botanic Gardens, Gorakhpur University, were cytologically

Table 2. Chromosome associations in species showing irregular meiosis

Species	Chromosome associations				
		I	II	IV	VI
Dahlia variabilis ($n=32$)	Range	—	24–32	0–4	0–1
	Mean	—	29.73	1.00	.09
Chrysanthemum parthenium ($n=9$)	Range	0–2	3–7	1–3	—
	Mean	0.11	4.95	2.00	—
Carthamus oxyacantha ($n=12$)	Range	0–16	4–12	—	—
	Mean	2.40	10.80	—	—



Figs. 6–10. 6, 7, *Cosmos bipinnatus*. 6, diakinesis showing 12 bivalents. 7, diakinesis showing 12 bivalents and one B chromosome. 8–10, *Dahlia variabilis*; 8, collection no. 290, metaphase I showing 25 bivalents, 2 quadrivalents (IV) and 1 hexavalent (VI). 9, 10 collection no. 277; 9, metaphase I showing 32 bivalents exhibiting secondary association. 10, anaphase I, showing 32 chromosomes at each pole.

analysed. Both collections confirmed the earlier report of n=32. Multivalent formation was observed (Fig. 8) in one of the two collections studied (Table 2), suggesting that it was not a pure allopolyploid. Associations of more than six chromosomes were never observed. In the other collection, where multivalent formation was not observed, secondary association was observed among the bivalents. The bivalents were found to be associated in eight groups, suggesting that it could be an octaploid (Fig. 9). At anaphase I, there was normal disjunction of 32 chromosomes to each pole (Fig. 10).

In the genus *Dahlia,* perhaps two different base numbers are commonly found, viz. x=8 and x=18 (Darlington and Wylie 1955). x=18 could be derived from x=9 which may or may not exist now.

Dimorphotheca annua

This species was studied by the authors for the first time. An analysis of meiosis showed 9 bivalents (Fig. 11). Subsequent stages of meiosis were normal.

These observations were in agreement with earlier reports of n=9 in other species of the genus. Therefore, x=9 could be the main base number in the genus. However, there were reports of x=10 also (Darlington and Wylie 1955).

Emilia sonchifolia

The material for this species was collected from Hastinapur. Eight bivalents were observed at metaphase I (Fig. 12). This was a new count for the species. The earlier report of x=n=5 and n=10 are listed in Table 1. Since the only earlier known base number was x=5, the present study added another base number to the species and the genus. The base number x=8 being reported here must have been derived from x_2=10 due to descending dysploidy.

Figs. 11–18. 11, *Dimorphotheca annua*, metaphase I showing 9 bivalents. 12, *Emilia sonchifolia*, metaphase I shwing 8 bivalents. 13–15, *Sonchus arvensis*; 13, collection no. 480, metaphase I showing 9 bivalents. 14, collection no. 417, metaphase I showing 16 bivalents (one bivalent disjoined). 15, collection no. 474, metaphase I showing 18 bivalents. 16, *Tagetes patula*, metaphase I showing 7 bivalents. 17, *Viguieria helianthoides*, diakinesis showing 17 bivalents. 18, *Youngia japonica*, anaphase I showing 9 chromosomes at each pole.

Sonchus arvensis

This species was found as a common weed in the wheat fields and elsewhere and usually flowered in the later part of the winter season. There was a great morphological polymorphism and this was associated with chromosomal polymorphism. Therefore this species provided interesting material for biosystematic investigation. Four collections from this species were studied, which represented three chromosome races viz. n=9; n=16 and n=18. In all the collections meiosis was normal and 9 bivalents (Fig. 13), 16 bivalents (Fig. 14) and 18 bivalents (Fig. 15) were regularly observed.

The morphological features for the stomata and the flowers in the three chromosome races are represented in Table 3. There was apparently no relationship between the chromosome numbers and the size of the stomata. However, as the size of the stomata decreased the frequency of stomata increased. While in the diploid material the frequency was 5.1, it was 21.5 in the tetraploid material. It was not possible to record other morphological features, since only few herbarium specimens were available for study.

Table 3. Measurements on stomata and flowers in *Coreopsis basalis* and *Sonchus arvensis*

Species	Coll. no.	n	Stomata				Flower** (length in cm)
				length (in μ)	width (in μ)	freq.*	
Coreopsis basalis	288	11	Range	2.9–3.4	2.6–2.9	5–7	.45–.45
			Mean	3.2	2.8	6.1	.45
	423	10	Range	2.9–4.1	2.1–2.9	7–9	.40–.45
			Mean	3.6	2.4	7.9	.44
Sonchus arvensis	417	16	Range	2.1–2.4	1.8–2.1	14–19	9.0–1.00
			Mean	2.2	1.9	15.3	.98
	474	18	Range	2.1–2.5	1.5–1.6	20–24	1.05–1.15
			Mean	2.3	1.52	21.5	1.10
	480	9	Range	2.4–2.8	2.1–2.6	4–7	.85–1.05
			Mean	2.6	2.3	5.1	1.00

* The frequency of stomata is given per unit area=679.14 μ.

** The measurements of flowers were taken from tubular florets only. In the genus *Sonchus*, no ligulate flowers are found.

The earlier studies on the species are listed in Table 1. To the list having 2n=18, 54 and 64, the present study added two more counts i.e. n=16 and n=18. While n=18 could be directly obtained from n=9, n=16 could result from the dysploid changes at the diploid or at the polyploid levels. This then could have given rise to 2n=64. Further biosystematic work of this species will definitely give valuable information.

Targetes patula

This was a cultivated species commonly grown in residential gradens. A single collection belonging to this species was studied and seven bivalents were observed (Fig. 16). The present study, therefore, added a new count for the species, since the only earlier report was 2n=48 (Table 1). The present report also added a new base number for the species.

Viguieria helianthoides

This species was studied by the authors for the first time and 17 bivalents were observed during meiosis (Fig. 17). Meiotic behaviour was completely normal. However, n=17 was known in this genus for other species studied earlier. These species were *V. grammatoglossa, V. hemsleyana, V. trachyphylla, V. cordifolia, V. adenophylla, V. porteri* and *V. sordiroi.* The presence of the same chromosome number in several species suggested that x=17 was fairly well established in this genus. However, the earlier reports on n=18 for *V. deltoides* var. *parishii* (Powell and Turner 1963) and n=8 for *V. longifolia* var. *parishii* (Powell and Turner 1963) and n=17 should be secondarily derived base numbers. The primary base numbers could be x=8, 9. These two base numbers could have easily given rise to x=17.

Youngia japonica

Youngia japonica also known as *Crepis japonica* was commonly found during the winter season. Nine bivalents were observed during meiosis. The bivalents disjoined at anaphase I sending nine chromosomes to each pole (Fig. 18). The earlier reports included a single chromosome count with n=8. The present report, therefore, added another base number viz. x=9 for the species.

Summary

1. Chromosome numbers for 33 collections belonging to 28 species and 25 genera from ten different tribes are reported.
2. Results of cytological study in 13 species were discussed in detail, since these were either studied for the first time or gave new counts or else showed other features of cytological interest.
3. Dysploidy was found to be common feature at the intraspecific level.
4. Polyploidy, as well as ascending and descending dysploidy seemed to have played an important role in evolution of the taxa discussed.

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