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New chromosome number records of South African *Oxalis* species

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Chromosome numbers of only 49 *Oxalis* L. taxa have been published to date, of which just 23 represent southern African taxa. Chromosome counts for the following southern African taxa are recorded here for the first time: *O. bifida* Thunb., *O. hirta* L. var. *tubiflora* Salter and *O. semiloba* Sond. A third record for *O. truncatula* Jacq. is also presented here. Two previous counts for this species have been published, one revealing a tetraploid and the other a hexaploid condition. All four taxa included here have a basic chromosome number of x = 7. *O. bifida* and *O. truncatula* are both diploid, whereas *O. hirta* var. *tubiflora* and *O. semiloba* were both found to be tetraploid. The diploid form of *O. truncatula* found here completes a polyploid series (2x, 4x and 6x) in this species. It is concluded that karyological data can greatly aid our understanding of the massive diversification and speciation of *Oxalis* in southern Africa. Further cytological studies are recommended.

Keywords: Oxalidaceae, *Oxalis*, basic chromosome number, polyploidy.

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Oxalis L. is the largest genus in the Oxalidaceae, including about 800 species. The genus displays two centers of diversity, one in south-central America and the other in southern Africa (Marks 1956). Salter (1944) completed the most recent alpha-taxonomic revision of the southern African members of the genus. He recognized 208 species, including several varieties, which he arranged into 11 sections. A total of 270 taxa are currently recognized within southern Africa (Dreyer 1993). Cytological studies, for the genus in general and the southern African species in particular, have been very limited. Heitz (1927) listed chromosome numbers for 26 species, including eight southern African taxa. Chromosome counts for three more southern African taxa are given by Yamashita (1935) and one more by Warburg (1938). Marks (1956) completed the most comprehensive cytological study for the genus to date. He published chromosome numbers for 24 additional species of which 16 are South African. His work brought the total number of known chromosome numbers for southern African taxa to 23, representing a mere 8.5% of all the taxa in the region. He identified a basic chromosome number of x = 7 as the most common condition in the genus. Basic numbers of x = 5, 6, 7, 9 and 11 have, however, also been reported (Heitz 1927; Nakajima 1936; Wulff 1937; Warburg 1938; Rutland 1941; Marks 1956). Marks (1956) found that the southern African species display limited variation in basic chromosome number and size, but a fairly high occurrence of polyploidy (Table 1). In contrast, the American species are variable in terms of basic chromosome number and chromosome size, but display less polyploidy.

The aim of the present study was to expand on the cytological knowledge of southern African *Oxalis* taxa, concentrating on taxa from the Stellenbosch area. Chromosome numbers for the following three taxa were determined: *O. bifida* Thunb., *O. semiloba* Sond. and *O. hirta* L. var. *tubiflora* Salter. Additionally, a third count for *O. truncatula* Jacq. was also undertaken.

Mitotic chromosome counts were performed by studying actively dividing cells in young root tips. Suitable roots were cultivated by growing plants in Standard Long Ashton nutrient medium (Hewitt 1966) at pH 6 in 20 liter hydroponics tanks aerated with CO_2. Root tips were harvested after 7–10 days in hydroponics and were pre-treated in 0.002 M 8-hydroxyquinoline for 4 hours. Roots were then fixed in a 3:1 ethanol and acetic acid mixture for 24 hours. This was followed by standard aceto-carmine stain and squash techniques, as described by Snow (1963). Five specimens of each species were studied and counts were obtained from at least 10 cells per specimen. Chromosome numbers are given in Table 1.

Oxalis semiloba (section *Cernuae*, subsection *Purpuratae*) was found to be tetraploid (2n = 4x = 28), with a basic chromosome number of x = 7. This is in accordance with the basic chromosome number reported for *O. bowiei* Lindl. and *O. purpurata* Jacq., two species of the same subsection (Table 1). *O. purpurata* is also tetraploid, whereas *O. bowiei* includes both tetraploid and hexaploid forms.

Oxalis truncatula (section *Oppositae*, subsection *Subintegrae*) was found to be diploid with a basic chromosome number of x = 7. This is interesting, as previous counts for the same species revealed tetraploid (Marks 1956) and hexaploid (Heitz 1927) forms. *O. truncatula* thus displays a polyploid series, including 2x, 4x and 6x forms. Cytologically, subsection *Subintegrae* appears to be very heterogeneous. *O. incarnata* L. is diploid with a basic chromosome number of x = 7, whereas *O. imbricata* Eckl. & Zeyh. is either tetraploid or octaploid with a basic chromosome number of either x = 5 or x = 10 (Marks 1956). Salter (1944) based the delimitation of subsection *Oppositae* on the occurrence of two opposite bracts at the upper or second articulation of the peduncle. Bayer (pers. comm.) doubts the systematic significance of this character, and regards this subsection as one of the most unnatural taxa delimited by Salter (1944). Cytological studies may, therefore, prove highly significant in the re-evaluation of subsection *Oppositae*. The karyological differences are, however, not reflected in the very uniform palynology of the subsection (Dreyer 1996). All the included taxa have micro-reticulate to reticulate pollen grains, with or without intraluminary bacules.

We found *O. bifida* (section *Oppositae*, subsection *Bifurcatae*) to be diploid (2n = 2x = 14), also with a basic chromosome number of x = 7. This conforms exactly to the karyology of *O. smithiana* Eckl. & Zeyh., the only other species within the subsection for which chromosome counts are available (Table 1).

Table 1 Known chromosome numbers of the southern African members of *Oxalis*. Chromosome numbers determined in the present study are indicated in bold type face. See end of table for an explanation of symbols

Section	Subsection	Taxon	Locality	2n	x	Level of ploidy	Reference
Cernuae	*Eu-cernuae*	*O. cernua* Tunb.	unknown	35	7	5x	Yamashita (1935)
		O. pes-carprae L.	Bishopscourt, WCP	28	7	4x	Marks (1956)
	Lividae	*O. dentata* Jacq.	Wynberg Hill, WCP	14	7	2x	Marks (1956)
	Purpuratae	*O. bowiei* Lindl.	Kew Botanic Garden	28	7	4x	Marks (1956)
		O. bowiei Lindl.	Grahamstown, ECP	42	7	6x	Marks (1956)
		O. purpurata Jacq.	unknown	28	7	4x	Heitz (1927)
		***O. semiloba* Sond.**	**Cape Town, WCP**	**28**	**7**	**4x**	**Dreyer & Johnson**
	Stellatae	*O. caprina* L.	unknown	20	5(10)	4x(2x)	Heitz (1927)
		O. tragopoda Salter	Grahamstown, ECP	14	7	2x	Marks (1956)
Oppositae	*Subintegrae*	*O. imbricata* Eckl. & Zeyh.	Knysna, WCP	40	5(10)	8x(4x)	Marks (1956)
		O. incarnata L.	Cambridge Botanic Garden	14	7	2x	Marks (1956)
		O. truncatula Jacq.	unknown	28	7	4x	Marks (1956)
		O. truncatula Jacq.	unknown	42	7	6x	Heitz (1927)
		***O. truncatula* Jacq.**	**Cape Town, WCP**	**14**	**7**	**2x**	**Dreyer & Johnson**
	Bifurcatae	***O. bifida* Thunb.**	**Stellenbosch, WCP**	**14**	**7**	**2x**	**Dreyer & Johnson**
		O. smithiana Eckl. & Zeyh.	unknown	14	7	2x	Heitz (1927)
Strictophyllae		*O. purpurea* L.	Wynberg Hill, WCP	42	7	5	Marks (1956)
Crassulae		*O. cathera* Salter	Garies, Namaqualand, NCP	14	7	2	Marks (1956)
		O. fabaefolia Jacq. form B	unknown	28	7	4x	Warburg (1938)
		O. namaquana Salter	Kamieskroon, NCP	28	7	4x	Marks (1956)
Angustatae	*Pardales*	*O. massoniana* Salter	Van Rhyn's Pass, NCP	14	7	2x	Marks (1956)
		O. pardalis Sond.	Worcester, WCP	14	7	2x	Marks (1956)
	Sessilifoliatae	*O. hirta* L. form F	Kirstenbosch, WCP	30	6	5x	Marks (1956)
		O. hirta L.	unknown	30	6	5x	Yamashita (1935)
		***O. hirta* L. var. *tubiflora* Salter**	**Stellenbosch, WCP**	**28**	**7**	**4x**	**Dreyer & Johnson**
		O. tenuifolia Jacq.	unknown	28	7	4x	Heitz (1927)
	Linearis	*O. ciliaris* Jacq. form C	Montagu, WCP	40	5(10)	8x(4x)	Marks (1956)
		O. cuneata Jacq.	Bitterfontein, WCP	12	6	2x	Marks (1956)
		O. polyphylla Jacq. var. *pentaphylla* (Sims) Salter	unknown	30	5	6	Heitz (1927)
		O. versicolor L.	unknown	14	7	2x	Heitz (1927)
		O. versicolor L.	unknown	30	5	6x	Yamashita (1935)
		O. versicolor L.	Bishopscourt, WCP	30	5	6x	Marks (1956)

2n = somatic chromosome number, x = basic chromosome number, WCP = Western Cape Province, ECP = Eastern Cape Province, NCP = Northern Cape Province

Two chromosome counts are available for the typical variety of *O. hirta* (section *Angustatae*, subsection *Sessilifoliatae*). Marks (1956) studied *O. hirta* form E (Salter 1944) and found it to be hexaploid with a basic chromosome number of x = 5. This agreed with earlier counts of an unspecified form of the same taxon (Yamashita 1935). We found 28 chromosomes in *O. hirta* var. *tubiflora*, which suggests a different base number of x = 7 and a tetraploid condition for this variety. The presence of two different basic chromosome numbers within the same species questions the integrity of the species as such. A thorough cytological evaluation of all the varieties included under *O. hirta* seems necessary. Palynological studies (Dreyer 1996) also revealed an unique pollen type in *O. hirta* var. *tubiflora*, quite different to the pollen of the typical variety.

Two of the four taxa we studied were found to be tetraploid, while counts of *O. truncatula* revealed a diploid condition in a taxon already known to include tetraploid and hexaploid forms. These results further extend the suspected high occurrence of polyploidy among the southern African members of *Oxalis*. The difference in basic chromosome number between the two varieties of *O. hirta* may indicate that base number variations are more common than previously thought. Results from this study suggest that karyology can be instrumental in our understanding of the massive diversification and speciation among the southern African members of the *Oxalis*. Further cytological work is strongly recommended.

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