BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 96, No. 3, pp. 322–328 MAY–JUNE 1969

Chromosome numbers of carnivorous plants[1]

Katsuhiko Kondo
Department of Botany, The University of North Carolina,
Chapel Hill, North Carolina

KONDO, K. (Department of Botany, The University of North Carolina, Chapel Hill, N.C., 27514.) Chromosome numbers of carnivorous plants. Bull. Torrey Bot. Club 96: 322–328. 1969.—The chromosome numbers of the following 7 species of carnivorous plants are here reported for the first time; *Nepenthes rafflesiana* (2n = 78), *Nepenthes thorelii* (2n = 78), *Aldrovanda vesiculosa* (2n = 38), *Drosera burkeana* (2n = 20), *Cephalotus follicularis* (2n = 20), *Pinguicula caudata* (2n = 22), and *Pinguicula colimensis* (2n = 22).

At least 450 species of carnivorous plants representing 26 genera and 5 families are known. Results of research on some of those published previously has included cytological studies most of which were incidental to other work and were not concerned primarily with chromosome numbers. Only 53 species and 5 hybrids have had their chromosome numbers reported, and these are summarized in Table 2.

The chromosome numbers of 17 species are here reported: chromosome counts for 7 species are given for the first time and ten counts verify counts previously reported in the literatures.

Materials and methods. The plants utilized in this study were collected by the author from those cultivated in his green-house in Nagoya, central part of Japan, and in the green-house in the Institute for Breeding Research, Tokyo University of Agriculture. Some of these have been brought from overseas to Japan for horticultural purposes. Consequently, the exact original localities of these cultivated plants are unknown.

Root tips and shoot apices were utilized for the study of somatic chromosomes and were treated with 0.002 mol. 8-oxyquinoline for 2 hours at room temperature before they were fixed in Carnoy's solution; 3:1 of ethanol and glacial acetic acid. Root tips were hydrolysed in N-HCl at 60°C for 5 or 6 minutes and then stained in Feulgen and squashed in aceto-carmine. Chromosome counts of shoot apices were made by the aceto-carmine squash method. Pollen mother-cells of *Drosera peltata* were fixed in Carnoy's solution of 6 parts ethanol, 3 parts chloroform and 1 part of glacial acetic acid. Cytological observations were made by the aceto-carmine squash method.

[1] Contributions from the Institute for Breeding Research, Tokyo University of Agriculture, Setagaya-ku, Tokyo, Japan.

Received for publication September 12, 1968.

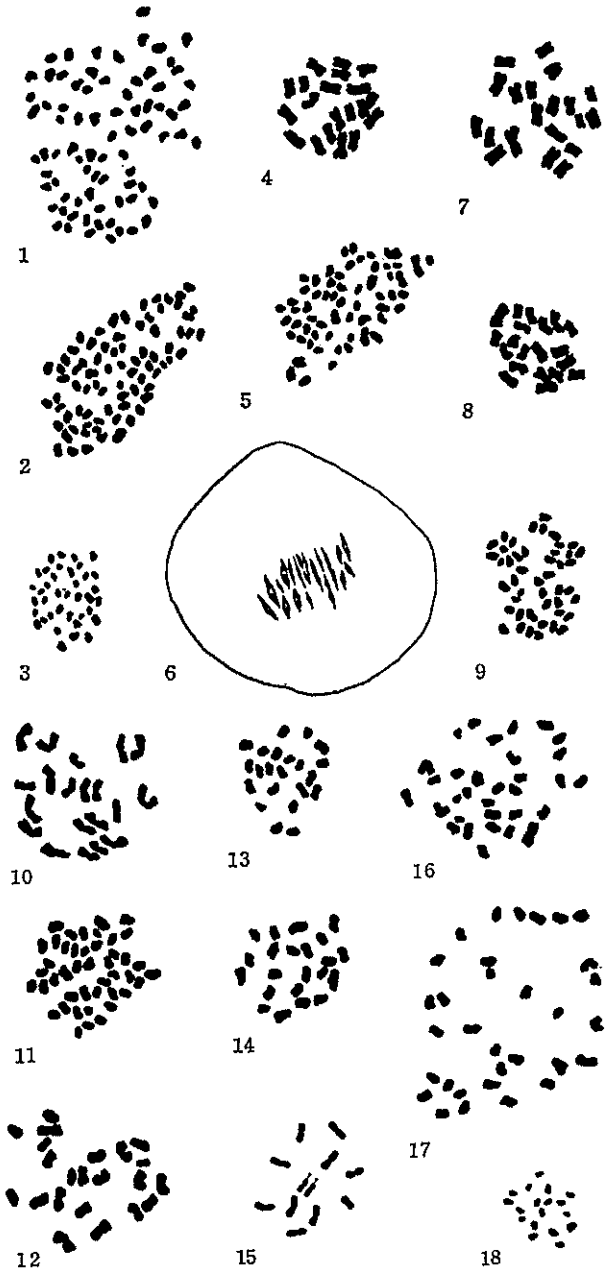

Fig. 1–18. Chromosomes (×1200) in root tip cells of:—Fig. 1. *Nepenthes rafflesiana* Jack. (2n = 78).[1]—Fig. 2. *Nepenthes thorelii* Lecomte (2n = 78).[1]—Fig. 4. *Drosera filiformis Raf.* (2n = 20).—Fig. 5. *Drosera spathulata* Labil. (2n = 60).—Fig. 7. *Drosera capillaris* Poir. (2n = 20).—Fig. 8. *Drosera burkeana* Planch. (2n = 20).[1]—Fig. 9. *Drosera binata* Labil. (2n = 46).—Fig. 10. *Cephalotus follicularis* Labil. (2n = 20).[1]—Fig. 11. *Pinguicula caudata* Schlecht. (2n = 44).—Fig. 12. *Pinguicula caudata* Schlecht. (2n = 22, Loc. Mexico, Tamaulipas).[1]—Fig. 13. *Pinguicula gypsicola* Brandegee (2n = 22).—Fig. 14. *Pinguicula colimensis* McVaugh et Mickel (2n = 22).[1]—Fig. 15. *Pinguicula lusitanica* L. (2n = 12).—Fig. 16. *Pinguicula caerulea* Walt. (2n = 32).—Fig. 17. *Pinguicula lutea* Walt. (2n = 32).—Fig. 17. *Pinguicula lutea* Walt. (2n = 32).—Chromosomes (×1200) in shoot apex cells of:—Fig. 3. *Aldrovanda vesiculosa* L. (2n = 38).[1]—Fig. 18. *Orchyllium alpinum* Barnh. (2n = 18).—Chromosomes (×1200) in Pollen mother-cell of:—Fig. 6. *Drosera peltata* Smith (20 II).

[1] The chromosome counts for 7 species are given for the first time.

Table 1. Results of chromosome studies of carnivorous plants.

Species name	n	2n	Localities
Nepenthaceae			
Nepenthes rafflesiana Jack.		78	Singapore (Singapore Bot. Gard. cult.)
N. thorelli Lecomte		78	Cambodia: Kampot (coll. Osaka City Univ.)
Droseraceae			
Aldrovanda vesiculosa L.		38	Japan (Bot. Gard. Osaka City Univ. cult.)
Drosera filiformis Raf.		20	U.S.A. (cult.)
D. spathulata Labil.		60	Japan. Aichi-ken: Miyoshi
D. peltata Smith	20		Japan. Aichi-ken: Miyoshi
D. capillaris Poir.		20	U.S.A. Louisiana: south of Bogalousa, near junction Hwys. 21 & 41
D. burkeana Planch.		20	South Africa (München Bot. Gard. cult.)
D. binata Labil.		46	Australia (cult.)
Cephalotaceae			
Cephalotus follicularis Labil.		20	Australia. W.A.: between Denmark and Albany, 4 miles from Denmark
Lentibulariaceae			
Pinguicula caudata Schlecht.		44	unknown (cult.)
		22	Mexico. Tamaulipas: Rancho del Cierro; Hidalgo: Hwy. 85 above Jacala, travertine area, alt. 2000 m; Oaxaca: between Ixtlan and Valle Nacional, 71 km from C. Oaxaca
P. gypsicola Brandegee		22	Mexico (München Bot. Gard. cult.)
P. colimensis McVaugh et Mickel		22	Mexico. Oaxaca: between Llano de las Flores and Tuxtepec
P. lusitanica L.		12	Portugal: Coimbra
P. caerulea Walt.		32	U.S.A., N.C. (cult.)
P. lutea Walt.		32	U.S.A., N.C. (cult.)
Orchyllium alpinum Barnh. (*Utricularia alpina* Jacq.)		18	unknown (Bot. Garad. Gothenburg cult.)

Results and discussion. The chromosome numbers of 17 species thus prepared and observed (Fig. 1–18) are listed in Table 1.

Two species of *Nepenthes, N. rafflesiana* and *N. thorelii,* showed 78 chromosomes in somatic cells. *Nepenthes* is dioecious, and these specimens were found to have male flowers in 1967. The distribution of *N. rafflesiana* is in the region of tropical rain forests of Borneo, Sumatra, and the Malay Peninsula, and that of *N. thorelii* is the savannah region of Cambodia and Vietnam.

Aldrovanda vesiculosa was found to have 2n = 38. Each of these chromosomes is very small and simple; however, it was not possible to make comparisons between this and other genera in the Droseraceae.

The basic chromosome number in most *Drosera* species is 10. Some species showed heteroploidy both in previous reports and in my counts, which suggests that they could furnish good materials for making inferences concerning the origin of various karyotypes (Table 2).

Cephalotus follicularis was observed to have 20 somatic chromosomes, each of which had a simple morphology. Only *C. follicularis,* an isolated species, represents the Cephalotaceae in the southwestern part of Western Australia. Ecological observations made by the author on his 1966 Australia Botanical Research Expedition indicate that it is restricted to habitats of wet, acid soil in *Leptospermum* forests. No morphological variations were observed in this species.

In plants of *Pinguicula caudata* collected by the author in Mexico the 2n number proved to be 22. However, horticultural material shows 44 chromosomes as the 2n number. The count of *P. caudata* (2n = 44) reported by Casper (1962) makes it questionable as to whether this material was a natural polyploid; it could be that of the horticultural race. *Pinguicula*

Table 2. Chromosome numbers of carnivorous plants reviewed.

Species name	n	2n	Workers
Sarraceniaceae			
Sarracenia purpurea L.	12		Shreve, 1906
	13	26	Bell, 1949
		26	Hecht, 1949; Löve & Löve, 1961
S. rubra Walt.	12		Nichols, 1908
	13	26	Bell, 1949
		26	Hecht, 1949
S. minor Walt.	13	26	Bell, 1949
S. variolaris Michx. (*S. minor* Walt.)	12		Nichols, 1908
S. psittacina Michx.		26	Sato, 1947; Hecht, 1949
	13	26	Bell, 1949
S. drummondii Croom	13	26	Bell, 1949
		26	Hecht, 1949
S. flava L.	13	26	Bell, 1949
		26	Hecht, 1949
S. jonesii Wherry (*S. rubra forma jonesii Bell*)		26	Hecht, 1949
S. oreophira Wherry	13	26	Bell, 1949
S. sledgei Macf.	13	26	Bell, 1949
S. drummondii × *flava*		26	Hecht, 1949
2 hybrids (cult.), each		26	Tjio, 1948
Darlingtonia californica Torr.		30	Bell, 1949
Droseraceae			
Drosophyllum lusitanicum Link.		12	Behre, 1929
Dionaea muscipula Ellis	15	30	Smith, 1929
Drosera anglica Huds.		32	Sato, 1947
(*D. longifolia* L.)	20	40	Rosenberg, 1903, 1904, 1909; Simamura, 1941
		40	Rohweder, 1937; Behre, 1929; Soklovskaya, 1961
D. rotundifolia L.	10	20	Rosenberg, 1903, 1904, 1909; Simamura, 1941
		20	Behre, 1929; Löve & Löve, 1956
	10		Wood, 1955; Kondo, 1967
D. obovata Mert. et Koch (*D. longifolia* × *rotundifolia*)	15	30	Rosenberg, 1903, 1904, 1909; Simamura, 1941
D. capensis L.		36	
		– 38	Heitz, 1926
		40	Behre, 1929
D. filiformis Raf.	10		Levine, 1916; Wood, 1955

		20	Sato, 1947; Behre, 1929
D. intermedia Hayne		20	Behre, 1929; Gadella & Klip, 1963
	10		Wood, 1955
D. spathulata Labil.		ca. 72	Heitz, 1926
		80	Behre, 1929
		20	Rattenbury, 1957
	30		Kondo, 1967
D. burmanii Vahl.		20	Venkatasubban, 1950
D. cistiflora L.		60	Behre, 1929
D. capillaris Poir.	10		Wood, 1955
D. brevifolia Pursh	10	20	Wood, 1955
D. linearis Goldie	10		Wood, 1955
D. linearis × *rotundifolia*		20	Wood, 1955
D. pygmaea Lehm.		20	
		– (22)	Heitz, 1926
	32		Behre, 1929
D. indica L.		28	Venkatasubban, 1950
	14	28	Kondo, 1967
D. binata Labil.		32	Behre, 1929
D. pedata Pers.			
(*D. binata* Labil.)		46	Sato, 1947
D. regia Stephens		34	Behre, 1929
D. peltata Smith		40	Venkatasubban, 1950
Lentibulariaceae			
Pinguicula pumila Michx.		22	Godfrey & Stripling, 1961; Casper, 1963
P. leptoceras Rchb.		22	Casper, 1963
P. ionantha Godfrey		22	Casper, 1963
P. caudata Schlecht.		44	Casper, 1962
P. moranensis H.B.K.			
(*P. caudata* Schlecht.)		44	Casper, 1962
P. gypsicola Brandegee	22		Casper, 1962
		22	Casper, 1963
P. lutea Walt.		32	Godfrey & Stripling, 1961; Casper, 1963
P. caerulea Walt.	16		Godfrey & Stripling, 1961
		32	Casper, 1963
P. lusitanica L.		12	Casper, 1963
P. hirtiflora Ten.	8	16	Honsell, 1959; Casper, 1962
P. alpina L.	16	32	Löve & Löve, 1944; Doulat, 1947; Skalinska, 1959; Sokolovskaja & Strelkova, 1960; Casper, 1962
P. villosa L.		16	Knaben, 1950; Doulat, 1947; Casper, 1963
P. grandiflora Lam.		32	Löve & Löve, 1944; Doulat, 1947; Casper, 1963
P. longifolia Ram. et Dc.		32	Doulat, 1947; Casper, 1963
P. vulgaris L.		64	Löve & Löve, 1944, 1956; Westergaard, 1958; Doulat, 1947; Skalinska, 1959; Zurzycki, 1953; Sokolovskaja & Strelkova, 1960; Casper, 1962
P. primuliflora Wood et Godfrey		32	Godfrey & Stripling, 1961; Casper, 1963
P. crenatiloba Dc.		16	Casper, 1963
P. corsica Bern. et Gren.		16	Casper, 1963
Utricularia minor L.	(18)	36	
	20	– 40	Reese, 1951
		ca. 40	Löve & Löve, 1956
U. vulgaris L.	(18)		
	20		Reese, 1951
U. ochroleuca Hart.		ca. 40	Reese, 1951
U. neglecta	(18)		
	20		Reese, 1951

U. coerulea L.	20		Kausik, 1938
U. inflata Walt.	9	18	Lewis & al., 1962
		36	Lewis & al., 1962
Orchyllium alpinum Barnh. (*Utricularia alpina* Jacq.)	9	18	Kondo, 1967

shows heteroploidy. The basic chromosome numbers are 6, 8 and 11. Material of *P. lusitanica* showed the lowest chromosome number known in *Pinguicula,* 2n = 12; and each of its chromosomes are bigger than those of any other species observed. However, it seems probable that the basic number 6 might be primitive and that 8 originated from it, as did the allopolyploid condition of 11, where 2n = 22 arose by doubling and addition $(8 \times 2 + 6)$.

In *Utricularia,* the author believes that the basic number is 9. But since some morphological variations can be correlated with differences in habitats, additional material should be examined for possible evidence of heteroploidy.

Acknowledgments. The author wishes to express sincere appreciation to Prof. N. Kondo, The Institute for Breeding Research, Tokyo University of Agriculture, Prof. A. J. Sharp, Department of Botany, The University of Tennessee, and Dr. Z. Iwatsuki, Hattori Botanical Laboratory, for their suggestions in determination of some specimens. The author is also indebted to Mr. M. Kamanoi and Mr. M. Amano, The Institute for Breeding Research, Tokyo University of Agriculture, for their interest and helpful suggestions during the course of this investigation.

Literature Cited

BEHRE, K. 1929. Physiologische und zytologische Untersuchungen über *Drosera.* Planta. 7: 208–306.

BELL, C. R. 1949. A cytotaxonomic study of the Sarraceniaceae of North America. Journ. Elis. Mit. Sci. Soc. 65: 137–166.

CASPER, S. J. 1962. Revision der Gattung *Pinguicula* in Eurasien. Feddes Rep. Spec. nov. 66: 1–148.

————. 1963. Gedanken zur Gliderung der Gattung *Pinguicula* L. Bot. Jahrb. 82(3): 321–335.

————. 1963. "Systematisch massgebende" Merkmale für die Einordnung der Lentibulariaceen in das System. Öst. Bot. Zeit. 110: 108–131.

DOULAT, M. 1947. Recherches caryologiques sur quelques *Pinguicula.* Compt. Rend. Academie des Sciences. 225: 354–356.

GADELLA, T. W. J., & E. KLIPHUIS. 1963 *in* Index to plant chromosome numbers for 1963. Vol. II (8). (M. S. Cave, Editor) 1964. Univ. North Carol. Press.

GAISER, L. O. 1930. Chromosome numbers in angiosperms II. Biblio. Genet. 6: 171–466.

GODFREY, R. K., & H. L. STRIPLING. 1961. A synopsis of *Pinguicula* (Lentibulariaceae) in the Southeastern United States. Amer. Midl. Nat. 66(2): 395–409.

HECHT, A. 1949. The somatic chromosomes of *Sarracenia.* Bull. Torr. Bot. Club 76(1): 7–9.

HEITZ, E. 1926. Der Nachweiss der Chromosomen. Vergleichende Studien über ihre Zahl Grösse und Form in Pflanzenreich I. Zeits. Bot. 18: 625–681.

HONSELL, E. 1959. Ricerche citotassononiche su *Pinguicula hirtiflora*. Ten. Ann. di. Bot. 26: 177–188.

KAUSIK, S. B. 1958. Pollen development and seed formation in *Utricularia coerulea* L. Beih. Bot. Centralblatt 58 A.

KONDO, K. 1966. Meiosis in PMC of three species of *Drosera*. Chromosome Information Service 7: 23–24.

———. 1966. Notes on the meiosis of PMC of *Orchyllium alpinum* Barnh. Chromosome Information service 7: 25–26.

LEWIS, W. H., & S. A. DAVIS. 1962. Cytological observations of polygala in Eastern North America. Rhodora 64: 102–109.

LÖVE, A., & D. LÖVE. 1956. Cytotaxonomical conspectus of the Icelandic Flora. Acta Hort. Gotob. 20: 65–290.

———. 1961. Chromosome numbers of central and Northwest European plant species. Op. Bot. 5: 1–581.

NICHOLS, M. L. 1908. The development of the pollen of *Sarracenia*. Bot. Gaz. 45: 31–37.

RATTENBURY, J. A. 1957. *in* Index to plant chromosome numbers for 1958. Vol. I (3). (M. S. Cave, Editor) 1959. Univ. North Carol. Press.

REESE, G. 1951. Ergänzende Mitteilungen über die Chromosomenzahlen mitteleuropäischer Gefässpflanzen. I. Ber. Dtsch. Bot. Ges. 64: 240–255.

ROHWEDER, H. 1937. Versuch zur Erfassung der mengenmässigen Bedeckung des Darss und Zingst mit polyploiden Pflanzen. Ein Beitrag zur Bedeutung der Polyploidie bei der Eroberung neuer Lebensräume. Planta 27: 500–549.

ROSENBERG, O. 1903. Das Verhalten der Chromosomen in einer hybriden Pflanze. Ber. Dtsch. Bot. Ges. 21: 110–119.

———. 1904. Über die Tetradenteilung eine *Drosera*-Bastardes. Ber. Dtsch. Bot. Ges. 22: 47–53.

———. 1909. Cytologische und morphologische Studien an *Drosera longifolia* × *rotundifolia*. K. Svenska. Vet. Akad. Handl. N. S. 43: 1–65.

SATO, D. 1948. The karyotype of the insectivorous plants. Oguma Comm. Vol. Cytol. Gen. p. 25–28.

SIMAMURA, T. 1941. Cytological study of *Drosera obovata* Mert. et Koch with special reference to its hybridity. Bot. Mag. Tokyo 55: 553–558.

SHREVE, F. 1906. The development and anatomy of *Sarracenia purpurea* L. Bot. Gaz. 42: 107–126.

SKALINSKA, M., et al. 1959. *in* Index to plant chromosome numbers for 1959 Vol. I (4). (M. S. Cave, Editor). 1960. Univ. North Carol. Press.

SMITH, C. M. 1929. *in* Chromosome atlas of flowering plants. (Darlington, C. D. & A. P. Wylie) 1955. George Allen & Unwin Ltd. London.

SOKOLOVSKAYA, A. P., & O. S. STRELKOVA. 1960. Geographical distribution of the polyploid species of plants in Eurasiatic Arctic. Bot. Zhur. SSSR. 45: 369–381.

TJIO, J. H. 1948. The somatic chromosomes of some tropical plants. Hereditas 34: 135–146.

VENKATASUBBAN, K. R. 1950. *in* Chromosome atlas of flowering plants. (Darlington, C. D. & A. P. Wylie) 1955. George Allen & Unwin Ltd. London.

WOOD, C. E. 1955. Evidence for the hybrid origin of *Drosera anglica*. Rhodora 57: 105–130.