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CHROMOSOME NUMBERS IN THE GENUS ANTHURIUM[1]

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ABSTRACT

Chromosome numbers were determined for 63 *Anthurium* species. Thirty-eight of these were newly determined. Generally the present work confirmed existing chromosome counts when these were available for comparison. The most common somatic chromosome number found was 30, but counts ranged from $2n = 20$ to 90. In a few instances conflicting counts were obtained. B chromosomes were found frequently in Sect. *Cardiolonchium* and varied in number from one to three. Four polyploid series were evident from all available counts: 20-40, 24-30-48-84, 28-56 and 30-60-90-ca 124. Most species were part of the polyploid complex based on 30. Although species were not observed with $n = 5$, 6 or 7, movement among the basic numbers was considered to have occurred at this level. The relationship among these basic numbers and $n = 15$ (x_2) is still obscure.

ANTHURIUM SCHOTT with over 500 species is the largest genus of the family Araceae and comprises about one-third of the number of species of the family. This genus extends from central South America to central Mexico and the West Indies, and is easily distinguishable from other related genera. Engler (1905) divided the genus into 18 sections with the primary categorization based upon the number of ovules per locule. Further categorizations of the sections were based on leaf shape and texture, and inflorescence shape, but the characteristic used to separate the majority of the sections was the berry shape.

Chromosome counts of 60–70 different species have been reported to date which includes about 10–15% of the known species. The majority of the counts were recorded by Gaiser (1927), Pfitzer (1957), and Marchant (1973). Gaiser reported counts for 43 species and hybrids. Pfitzer was the first to indicate the presence of B chromosomes in *Anthurium.* Marchant extended the number of species counted, and his report of ca 124 for a species was the highest chromosome number observed in *Anthurium.* The present investigation was initiated to clarify chromosome numbers and species relationships in the genus *Anthurium.*

MATERIALS AND METHODS—The *Anthurium* species studied are a part of the University of Hawaii collection. Most of the species were collected by H. Kamemoto and Y. Sagawa in Panama and neighboring countries in 1968, but others were obtained from private and commerical sources. The identification of the specimens was based principally upon the taxonomic treatments by Standley (1944) and Engler (1905). Voucher specimens were prepared and deposited in the Herbarium of the Botany Department, University of Hawaii.

Chromosome preparations were made from root tips taken between 9:00 a.m. to 12:00 noon, pretreated in 15–20 ppm *o*-isopropyl-N-phenylcarbamate (IPC) for 3–5 hours at 18 C (Sawamura, 1965; Mann and Storey, 1966; Storey and Mann, 1967), fixed in 6:3:1 Carnoy solution (95% ethyl alcohol, chloroform, and glacial acetic acid) for 20 min at 18 C, hydrolyzed in 1N hydrochloric acid for eight minutes at 50 C, rinsed in water, placed in 45% acetic acid for 10 min, and after removing the root caps the tips were squashed in 1% aceto-orcein. Photomicrographs were taken at a magnification of 550×.

RESULTS AND DISCUSSION—In addition to the previous counts, chromosome numbers as determined for 63 species (of which 38 are new counts) are presented in Table 1. The species in the table are presented according to the sections recognized by Engler (1905). Generally where previous counts were available for comparison, the present work confirms these counts. In a few instances conflicting counts were obtained.

Section *Tetraspermium* Schott is the only section with $2n = 24$. Polyploids have also been counted. The counts of $2n = 24$ (Fig. 1) and 30 for *A. trinerve* Miq. and $2n = 84$ for *A. scandens* Engl. (Fig. 3) from Mexico are new. Most of the counts for this section are in agreement with $2n = 24$, or the tetraploid number of $2n = 48$ (Fig. 2). The count of $2n = 30$ may represent a penta-

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TABLE 1. *Chromosome numbers of Anthurium species*

Taxa	Present counts 2n	Previous counts n	2n	Authority
Sect. 1. *Tetraspermium*				
A. scandens	24, 48, 84	16		Campbell 1905
		ca 24	ca 48	Gaiser 1927
			24	Delay 1947
		24		Pfitzer 1957
			45–47	Marchant 1973
A. trinerve	24, 30			
Sect. II. *Gymnopodium*				
A. gymnopus			ca 30	Gaiser 1927
Sect. III. *Porphyrochitonium*				
A. scherzerianum	30	ca 15	ca 30	Gaiser 1927
		16	32	Haase-Bessel 1928[a]
			30	Kurakubo 1940[b]
		16	32	Malvesin-F[c]
		15		Pfitzer 1957
			32	Tsuchiya & Takeda 1962
Sect. IV. *Pachyneurium*				
A. acaule		15	30	Gaiser 1927
A. boucheanum			56	Mookerjea 1955
A. brownii			ca 30	Gaiser 1927
A. cordatum			ca 30	Gaiser 1927
A. crassinervium		ca 30	ca 60	Gaiser 1927
A. ellipticum	30			
A. glaziovii			34	Mookerjea 1955
			30 + 0–2 f	Sharma & Bhattacharyya 1961
A. grandifolium	30		ca 30	Gaiser 1927
A. hacumense	30		ca 30	Gaiser 1927
A. hookeri	30, 60	ca 15	ca 30	Gaiser 1927
			30	Kurakubo 1940[b]
		15		Pfitzer 1957
A. joseanum	30			
A. maximum		ca 15	ca 30	Gaiser 1927
A. recusatum		ca 15	ca 30	Gaiser 1927
A. seleri	30			
A. tetragonum		15	30	Gaiser 1927
Sect. V. *Polyphyllium*				
A. mexicanum	60			
Sect. VI. *Leptanthurium*				
A. actangulum	30	ca 15	ca 30	Gaiser 1927
A. gracile	30	15	ca 30	Gaiser 1927
			40	Marchant 1973
A. scolopendrinum	20, 40		40	Marchant 1973
Sect. VII. *Oxycarpium*				
A. pittieri	30			
Sect. VIII. *Xialophyllium*				
A. pulchellum			63	Mookerjea 1955
A. subhastatum	30			
A. triangulum	30			
A. tuerckheimii			ca 30	Gaiser 1927
Sect. IX. *Polyneurium*				
A. wallisii?	30 + 2 B		ca 60	Gaiser 1927

[a] In Fedorov 1969.
[b] In Itô 1942.
[c] In Delay 1951.

TABLE 1. *Continued*

Taxa	Present counts 2n	Previous counts n	Previous counts 2n	Previous counts Authority
Sect. X. *Urospadix*				
A. acutum			30	Marchant 1973
A. allenii	30			
A. aureum	30, 31			
A. bellum			56	Mookerjea 1955
A. chiriquense	30			
A. comtum		15	ca 30	Gaiser 1927
A. gladiifolium	30			
A. harrisii			30 + 5 f	Marchant 1973
var. *beyrichianum*		ca 15		Gaiser 1927
A. imperial			30 + 2 f	Marchant 1973
A. littorale	28	15	ca 30	Gaiser 1927
A. lucidum			ca 124	Marchant 1973
A. olfersianum		ca 15	ca 30	Gaiser 1927
A. microphyllum			30 + 1 f	Marchant 1973
A. sellowianum		15		Pfitzer 1957
A. tiranae	28, 29 + 1 B			
A. turrialbense	30			
Sect. XI. *Episeiostenium*				
A. bakeri	30	15	ca 30	Gaiser 1927
			28 + 1 f	Sharma & Bhattacharya 1966
A. consobrinum		15		Pfitzer 1957
A. dominicense		ca 15	ca 30	Gaiser 1927
		15		Nerling 1969
A. guildingii		ca 15	ca 30	Gaiser 1927
A. wendlingerii	30			
Sect. XII. *Digitinervium*				
A. rhodostachyum	28, 29, 30, 31			
Sect. XIII. *Cardiolonchium*				
A. clarinervium	30			
A. crystallinum	30 + 1 B	ca 15	ca 30	Gaiser 1927
			34	Mookerjea 1955
		15 + 0–2 B	30 + 0–2 B	Pfitzer 1957
			30 + 2 f	Marchant 1973
A. forgetii	30	15 + 0–2 B	30 + 0–2 B	Pfitzer 1957
A. grande	30			
A. leuconeurum			35	Mookerjea 1955
A. magnificum	60**	ca 15	ca 30	Gaiser 1927
		16	32	Haase-Bessell 1928[a]
		15 + 0–2 B	30 + 0–2 B	
A. regale	30 + 1 B			
A. splendidum	30 + 2 B			
A. velutinum?	30			
A. venosum?	30			
A. walujewii	30 + 2 B			
A. warocqueanum	30 + 3 B		ca 30	Gaiser 1927
		15		Pfitzer 1957
A. wullschlaegelii	30			
Sect. XIV. *Chamaerepium*				
A. radicans			ca 50	Gaiser 1927
		15		Pfitzer 1957
Sect. XV. *Calomystrium*				
A. hoffmannii	30			
A. lindenianum	30			
A. montanum	30			
A. nymphaeifolium	30		ca 30	Gaiser 1927

** Indicates that the count is within two chromosomes.

TABLE 1. *Continued*

Taxa	Present counts 2n	Previous counts n	2n	Authority
A. pichinchae	30			
A. ranchoanum	30			
A. roraimense	30			
A. veitchii	30	15	ca 30	Gaiser 1927
		15		Pfitzer 1957
Sect. XVI. *Belolonchium*				
A. andreanum	30	ca 15	ca 30	Gaiser 1927
		16	32	Haase-Bessell 1928[b]
			30	Kurakubo 1940
			30	Simmonds 1954
		15		Pfitzer 1957
			30	Sharma & Bhattachryya 1961
			32	Tsuchiya & Takada 1962
A. concinnatum	30			
A. denudatum	30	ca 15	ca 30	Gaiser 1927
A. flavo-viride?	30			
A. gustavii	30			
A. micromystrium	30			
A. patulum			28 + 1 f	Sharma & Bhattacharya 1966
A. procerum?	30			
A. supianum	ca 90			
Sect. XVII. *Semaeophyllium*				
A. holtonium	30			
A. signatum			34	Mookerjea 1955
A. subsignatum	30		ca 30	Gaiser 1927
			30 + 1 f	Marchant 1973
Sect. XVIII. *Schizoplacium*				
A. aemulum	30, 60			
A. digitatum	30		ca 60	Gaiser 1927
		30		Pfitzer 1957
A. pedato-radiatum		ca 15	ca 30	Gaiser 1927
A. pentaphyllum	60	15		Pfitzer 1957
A. undatum			ca 30	Gaiser 1927
			60 & 60 + 1 B	Marchant 1973
A. variabile		15	ca 30	Gaiser 1927
			60 + 4 f	Sharma & Bhattacharya 1966
Sections Undetermined				
A. baileyi	60			
A. ramonense	30			
A. watermaliense	30			
Anthurium sp.			ca 124	Marchant 1973

ploid, if 6 is considered as the basic number in this section. Campbell's (1905) count of n = 16 for *A. scandens* was presented as an approximation.

As shown in Table 1, previous chromosome counts are available for both Sections *Gymnopodium* Engl. and *Chamaerepium* Schott. However, members of these sections were not available for this study. Gaiser (1927) reported a count of ca 50 for *A. radicans* C. Koch, while Pfitzer (1957) reported 2n = 30. If Pfitzer's count of 2n = 30 is considered as the correct count, then Gaiser's specimen was possibly a tetraploid with 4N = 60.

The distribution of chromosome numbers within the Sections *Porphyrochitonium* Schott and *Belolonchium* Engl. appears similar. Both sections are apparently based on 2n = 30, with a single hexaploid *A. supianum* Engl. being observed in Sect. *Belolonchium.* Five species, *A. concinnatum* Schott, *A. flavo-viride*? Engl., *A. gustavii* Regel., *A. micromystrium* Sodiro, and *A. procerum*? Sodiro, were determined to have 2n = 30. Counts of 2n = 30 and 32 have been recorded for *A. andreanum* Linden and *A. scherzerianum* Schott. The satellites in *Anthurium* species are often loosely attached, and therefore possibly

TABLE 2. *Frequency of chromosome numbers in Anthurium species*

	Chromosome numbers														
	20	24	28	30	32	34	35	40	48	56	60	63	84	90	124
Previous Counts	0	1	2	50	4	3	1	2	1	3	5	1	0	0	2
Present Counts	1	2	2	54	0	0	0	1	1	0	6	0	1	1	0
Composite[a]	1	2	2	87	0	1	1	1	1	3	10	1	1	1	2

[a] Only chromosome numbers thought to be representative of each species are included.

earlier counts of 2n = 32 included the two satellites as separate chromosomes.

The Sections *Pachyneurium* Schott, *Semaeophyllium* Schott, and *Schizoplacium* Schott apparently are composed of mostly diploids with 2n = 30 and a few tetraploids. Several species, *A. aemulum* Schott (Fig. 4), *A. digitatum* (Jacq.) G. Don, *A. hookeri* Kunth, *A. pentaphyllum* G. Don (Fig. 5), *A. undatum* Schott, and *A. variabile* Kunth, have both diploid and tetraploid representatives within the same species, and *A. undatum* and *A. variabile* apparently have B chromosomes or fragments. Three species, *A. glazorii* Hook. f., *A. signatum* C. Koch and Mathieu, and *A. subsignatum* Schott were reported to be diploids with B chromosomes present in varying numbers, but B chromosomes in these species were not observed by the present authors. *Anthurium ellipticum* (Fig. 6), *A. hacumense*, and *A. holtonianum* also have 2n = 30. *Anthurium pulchellum* Engl. reported as having 2n = 63 by Mookerjea (1955) is probably a tetraploid with B chromosomes. The count of 56 for *A. boucheanum* C. Koch (Mookerjea, 1955) cannot easily be explained.

Section *Polyphyllium* Engl. has only a single species, *A. mexicanum* Engl., with 2n = 60 a tetraploid number. This is the only species where a related diploid was not found.

Sect. *Leptanthurium* Schott is a small section of only six species with apparent taxonomic confusion between *A. gracile* and *A. scolopendrinum*. Using Standley's (1944) concept of the species *A. gracile* (Rudge) Lindl. and *A. scolopendrinum* Kunth, both are quite distinct.

The chromosome numbers of three species of Sect. *Leptanthurium* were determined. Unlike the two species *A. acutangulum* and *A. gracile* with 2n = 30, *A. scolopendrinum* Kunth had 2n = 20 (Fig. 7) and 40. Based on the previous count of 40 by Marchant (1973) and the present counts, tetraploids appear to be at least as common as the diploids, if not more prevalent, in this section. The diploid 2n = 20 is the lowest chromosome number observed in the genus. Marchant's count of 40 for *A. gracile* evidently reflects a specimen that Standley would refer to as *A. scolopendrinum*.

The chromosome number of only a single species of Sect. *Polynerium* Engl. was determined. The description *of A. wallisii*? Mast. is however somewhat brief. Since neither Gaiser's specimen (1927) nor that of the present authors was apparently compared with the type, two different species actually may have been counted. If both specimens are considered as representatives of the same species, then the counts would seem to indicate that both the diploid and the tetraploid forms are present. B chromosomes were also seen in the species.

Generally the Sect. *Urospadix* Engl. is characterized by 2n = 30. Six species which were newly counted include *A. allenii* Standl., 2n = 30 (Fig. 8); *A. aureum* Engl., 2n = 30, and 2n = 31; *A. chiriquense* Standl., 2n = 30; *A. gladiifolium* Schott, 2n = 30; *A. trianae* Engl., 2n = 28, and 2n = 29 + 1B; and *A. turrialbense* Engl., 2n = 30. Polyploidy is evident from the counts of 56 (*A. bellum* Schott) by Mookerjea (1955) and ca 124 (*A. lucidum* Kunth) by Marchant (1973), and B chromosomes are also present. In this group aneuploidy apparently also is evident in at least two species, *A. aureum* (2n = 30, 31) and *A. trianae* (2n = 28, 29 + 1B), but the aneuploid number does not appear to be the common number for these species. Evidently for *A. littorale* Engl. the discrepant counts of 2n = 28 (Fig. 9) and 30 (Gaiser, 1927) are due to different species being examined. Unfortunately Gaiser's (1927) specimen was identified by Standley through a leaf specimen alone. The author's specimen (2n = 28) was not compared with the type specimen of the species.

The three Sections *Episeiostenium* Schott, *Calmystrium* Schott, and *Oxycarpium* Schott are also characterized by 2n = 30. Eight new chromosome counts of 2n = 30 have been determined in these groups including *A. hoffmannii* Schott, *A. lindenianum* C. Koch and Augustin (Fig. 10), *A. montanum* Hemsl., *A. pichinchae* Engl., *A. pittieri* Engl., *A. roraimense* N. E. Brown, and *A. wendlingerii* Barroso (Fig. 11). The counts of 2n = 30 for *A. nymphaeifolium* C. Koch and Bouche and *A. veitchii* Mast. confirmed previous counts for these two species. *Anthurium bakeri* Hook. f. was counted by Sharma and Bhattacharya (1966) as 2n = 28 + 1f, but they also observed cells with 20 and 30 chromosomes.

Only a single species *A. rhodostachyum* Sodiro of Sect. *Digitinervium* Sodiro was investigated, but each specimen examined had a different chromosome number. If 2n = 30, which is the common diploid number in *Anthurium*, is considered as the diploid number for this species, then an aneuploid series 28, 29 (Fig. 12), and 31 occurs. This is the only species which has exhibited an aneuploid series. *A. rhodostachyum* has a very

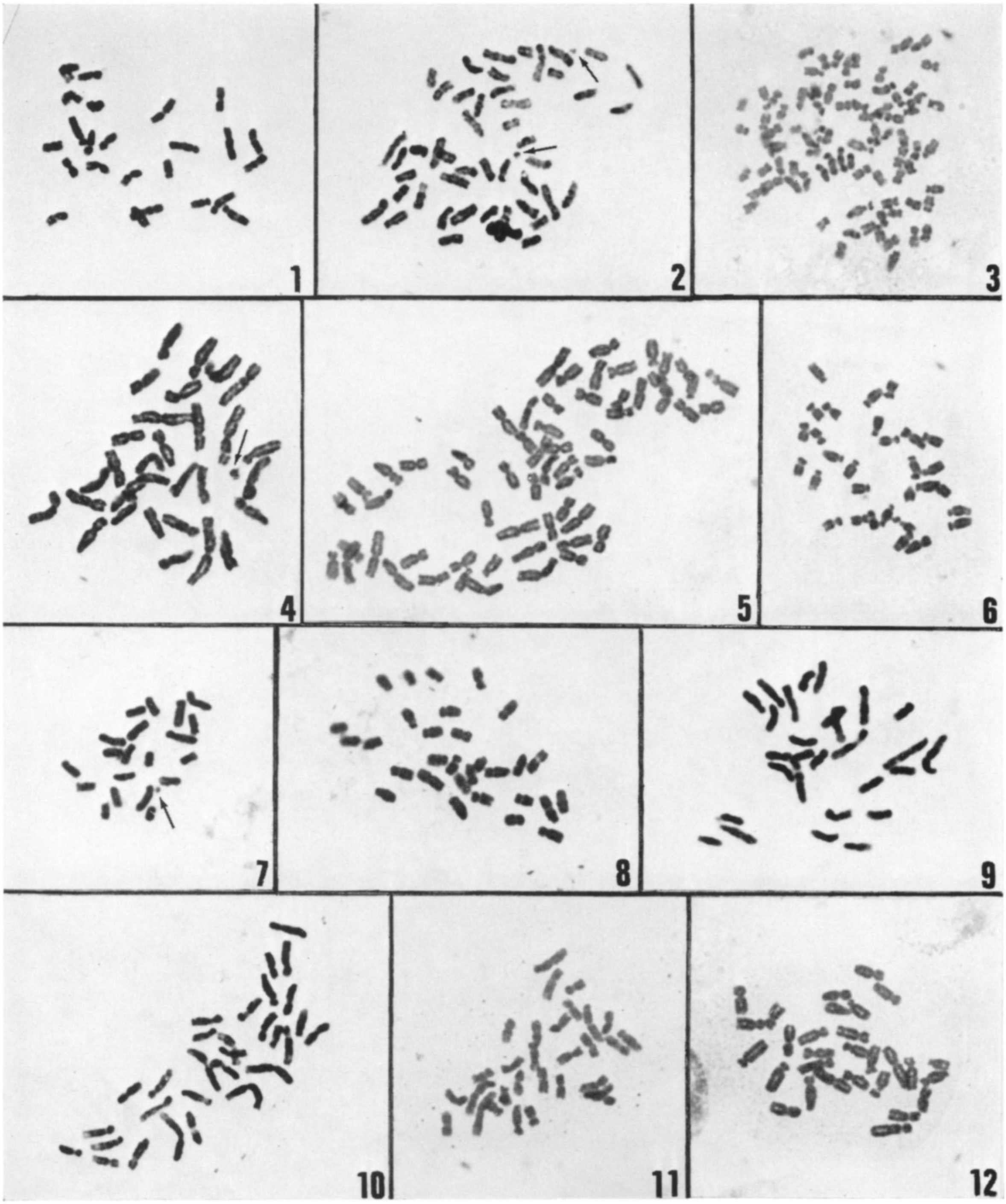

Fig. 1–12. Somatic chromosomes of *Anthurium* species, arrows indicate loosely held satellites. × 1100. **1.** *A. trinerve*, 2n = 24. **2.** *A. scandens*, 4N, 2n = 48. **3.** *A. scandens*, 7N, 2n = 84. **4.** *A. aemulum*, 2N, 2n = 30. **5.** *A. pentaphyllum*, 2n = 60. **6.** *A. ellipticum*, 2n = 30. **7.** *A. scolopendrinum*, 2N, 2n = 20. **8.** *A. allenii*, 2n = 30. **9.** *A. littorale*, 2n = 28. **10.** *A. lindenianum*, 2n = 30. **11.** *A. wendlingerii*, 2n = 30. **12.** *A. rhodostachyum*, 2n = 29.

heavy textured semicordate leaf and appears quite distinct taxonomically from the other *Anthurium* species examined.

Section *Cardiolonchium* Schott also generally has diploids with 2n = 30, but B chromosomes are very common. Eight species of this section were newly counted. These are *A. clarinervium* Matuda, 2n = 30; *A. grande* hort., 2n = 30; *A. regale* Linden, 2n = 30 + 1B; *A. splendidum* hort., 2n = 30 + 2B; *A. velutinum*? Engl., 2n = 30; *A. venosum*? Griseb, 2n = 30; *A. walujewii* Regel, 2n = 30 + 2B; and *A. wullschlaegelii* Engl., 2n = 30. The count of 2n = 30 for *A. forgetii* N. E. Brown confirms the earlier count for this species. Only a single species, *A. magnificum* Linden, is a tetraploid. B chromosomes are more numerous in this section than in any of the other sections examined. The size of the B chromosomes is quite variable, being small in *A. warocqueanum* J. Moore or approaching the size of the smallest A chromosomes in *A. crystallinum* Linden and André (Fig. 12), *A. regale*, *A. splendidum*, and *A. walujewii*. The two counts of 34 (*A. crystallinum*) and 35 (*A. leuconeurum* Lemaire) by Mookerjea may reflect her observance of four or five B chromosomes in her specimens.

Three species of undetermined sectional affiliation have been newly counted. *Anthurium baileyi* Standl. is a tetraploid with 2n = 60. The other two are *A. ramonense* K. Krause and *A. watermaliense* hort. which have 2n = 30. An unidentified species and *A. lucidum* Kunth were both reported by Marchant (1973) to have 2n = ca 124, which is the highest chromosome number observed.

General discussion—Table 2 shows the frequency distribution of chromosome numbers. B chromosomes are not included in the table since generally these can be considered as variants of the usual chromosome numbers for these taxa. Both the previous and present counts indicate a similar distribution with 30 as the most common number. The composite distribution of the chromosome numbers reflects the consideration of both the previous counts and present counts for each taxon, and only chromosome numbers thought to be representative of each taxon are included.

The three chromosome numbers 34, 35 and 63 present a problem. All of these counts were made by a single worker (Mookerjea, 1955), and none of them have been confirmed by other workers. These counts may reflect aneuploidy or the presence of B chromosomes in plants under cultivation. These counts will not, therefore, be considered in establishing a basic number for the genus.

The chromosome numbers reported below 30 are 20, 24 and 28, suggesting basic numbers of 5, 6 and 7. Even though 15 was considered as the basic number of *Anthurium* by Gaiser (1927) and Marchant (1973), 15 is evidently a secondary basic number (x_2). Although no species were observed with chromosome numbers of 2n = 10, 12 and 14, the shift in the basic number is considered to have occurred at this level. If the shift had occurred with basic numbers of 10, 12 and 14 (with 2n = 20, 24 and 28), then one would also expect each of the numbers of 11 and 13 (2n = 22 and 26) to be equally frequent. Species with 2n = 22 and 26 were not observed. The shift among basic numbers therefore probably occurred at the original level indicated. Thus a shift at 5, 6 and 7 with chromosome doubling would give plants with n = 10, 12 and 14 (2n = 20, 24 and 28). These are the observed somatic numbers.

The other chromosome numbers presented in Table 2 form polyploid series of the four previously considered numbers as: 20-40 (2), 24-30-48-84 (5), 28-56? (6) and 30-60-90-ca 124 (100). The number given in parentheses indicates the number of species in the complex (but a few species have been counted twice where both the diploid and tetraploid are present in the same species). Curiously, almost all the counted *Anthurium* species are a part of the polyploid complex of 2n = 30. The relationship between the basic numbers of 5, 6, 7 and 15 (x_2) is obscure and can be perhaps better assessed through correlation with crossability and morphological studies.

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