PRELIMINARY CHROMOSOME STUDIES ON THE VASCULAR PLANTS OF TAIWAN (IV)
COUNTS AND SYSTEMATIC NOTES ON SOME MONOCOTYLEDONS[2]

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Abstract: This is a fourth paper on the chromosome studies of the vascular plants of Taiwan. The chromosome counts of 36 taxa belonging to 32 genera and 11 families of the monocotyledonous plants are reported together with some taxonomical notes in this paper.

Of these chromosome observations, a total of 15 taxa are reported here for the first time and are not be found in the previous records.

The basic number of the orchid genera *Anoectochilus* and *Gastrodia* is proposed to be X=12, and that of *Peliosanthes* (Liliaceae) is suggested to have the basic number of X=17.

INTRODUCTION

Considerable cytological data has been gathered on several groups of Taiwan plants during the course of our chromosome studies. A part of the chromosome counts were presented in the previous papers[3,4,5] and this is the fourth paper in a series on this work. One of the most natural, easily recognizable group of plants is the monocotyledonae, and this is the group now being investigated.

No comprehensive taxonomic study of the Taiwan monocotyledons has been made thus far. Only fragmentary works have been published by some Japanese authors, such as by Honda (1930) on the grasses, Satake (1938, '40) on the Juncaceae and Eriocaulaceae; Ohwi on the sedges (1936, '44) and grasses (1941, '41a, '41b, '41c, '42); Koyama (1961, '62) on the sedges and the genus *Smilax* (1960), and Fukuyama on the orchids.

In recent years Hsu (1962, '63, '63a, '65) reported on the genus *Panicum* and the tribe paniceae (Gramineae). Liu & Huang (1963) enumerated the Araceae. And all bamboo species were reviewed by Lin (1961).

Chen & Hsu (1960, '62) listed the chromosome counts of 82 grass species. A total of 12 taxa of the monocots were reported by Chuang *et al.* (1962) in their study of vascular plants of Taiwan. Hsu (1967) recorded 22 taxa of monocoty-

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(3, 4, 5) Preliminary chromosome Studies on the Vascular Plants of Taiwan. (I) Taiwania **13**: 117-130, 1967. (II) ibid. **14**: 11-27, 1968. (III) ibid. the aster family Compositae **15**: 17-29, 1970.

ledoneous plants. Of the 951 species and 104 infraspecific taxa belonging to 28 families of monocotyledons listed by Masamune (1936), only about one hundred taxa have been studied cytologically.

This is an extension of our former chromosome studies. A lot of living plants have been collected and fixed in the field, some of them were then transported back to Taipei for further studies. Table 2 shows the location of the localities where the collections were made, date of collections and the collection numbers.

MATERIALS AND METHODS

Materials treated and the techniques applied were the same as followed in the previous papers. All material was identified and a complete set of the voucher specimens was deposited in the Herbarium of the National Taiwan University (TAI).

RESULTS AND DISCUSSIONS

Table 1 is a brief summary of the results of the present chromosome counts on the Taiwan monocotyledons. The families are arranged according to the Hutchinson system (1959), and the genera following each family are listed alphabetically. An asterisk (*) indicates the first time a count has been reported as far as is known.

Commelinaceae

Aneilema sinicum Lindle

This is a shade-loving species growing gregariously on the dykes between paddy fields and along the irrigation ditches. The color of the flowers are deep blue at first and with much reduced color just before the perianths are shed. This is a tetraploid with chromosome number of $n=20$, the number agrees with that of Chuang *et al.* (1962 reported as *A. angustifolium*). The voucher sheet shows it seems to be identical with *A. sinica.*

Commelina nudiflora Linn.

Several kinds of chromosome counts have been made by various authors. The present count made on the root tips shows $2n=28$, the same number as reported by Sharma & Sharma (1958).

Commelina obliqua Ham.

The chromosome count of $n=30$ was obtained in material collected from the southern part of Taiwan. It is a tetraploid and differs from the basic number of that of *C. nudiflora.* It seems there is more than one basic number in this genus.

Zingiberaceae

Alpinia shimadai Hay.

This is a diploid species similar to that of *A. intermedia* (Hsu, 1967). *A. formosana* is distinguished from these two species by being a taller plant and

Table 1. Chromosome Counts on Some Taiwan Monocots

Fig.	Taxon	Voucher	*n*	2*n*	Locality	Previous counts & authority
	COMMELINACEAE 358(34)					
1.	*Aneilema* X=10 *sinicum* Lendl.	3139	20		Yangmingshan	*n*=20, Chuang *et al.* (1962). (Reported as *A. angustifolium*)
	Commelina X=11, 12?, 15? *nudiflora* Linn.	3254		28	Shihting	2*n*=56, Anderson & S. (1936). 2*n*=28, 56, Sharma & S. (1958). *n*=30, Malik (1961). 2*n*=c. 90, Borgmann (1964).
2.	*obliqua* Ham.	4041	30		Chihpen	2*n*=45, 60, Sharma & S. (1958).
	ZINGIBERACEAE 369(47)					
3.	*Alpinia* X=12 *shimadai* Hay.	3218		24	Chihsingshan	*
	LILIACEAE 372(39)					
4.	*Aletris* X=13 *spicata* Fr.	3992	26		Yushanchienshan	*
5.	*Asparagus* X=10 *cochinchinensis* Merr.	4362	10		Tanshui	*
6.	*Aspidistra* X=18 *daibuensis* Hay.	3425		36	Chushuipo	*
7.	*Disporum* X=6, 8, 9, 11 *kawakamii* Hay.	3362		32	Kueihu	*n*=8, Chuang *et al.* (1962). 2*n*=16, Chao *et al.* (1963).
8.	*Heloniopsis* X=17 *umbellata* Bak.	3187		34	Chihsingshan	*n*=17, Chuang *et al.* (1962).
	umbellata Bak.	3360		34	Kueihu	
9.	*Liriope* X=18 *laxispicata* Hay.	3352		36	Kueihu	*
	laxispicata Hay.	3440	18		Chushuipo	
10.	*Ophiopogon* X=18 *japonicum* Ker.	3365		72	Kueihu	2*n*=36, 72, Sato (1942). 2*n*=72, Oinuma (1944, '46, '49); Sharma & Chand. (1964). 2*n*=65, 66, 67, 68, Nagamatsu & Noda (1964, '67).
	planiscapus Nakai	3167		36	Chihsingshan	*n*=28, 2*n*=72, Sato (1943).
11.	*planiscapus* Nakai	3423	18		Chushuipo	2*n*=36, 72, Oinuma (1944, '46, '49).
	planiscapus Nakai	4111	18		Kenting	
12.	*Peliosanthes* X=17 *kaoi* Ohwi	3349	17	34	Kueihu	*
13.	*Polygonatum* X=9, 10, 11 *arisanense* Hay.	3361		44	Kueihu	*
14.	*Tricyrtis* X=13 *formosana* Bak.	3273	26		Kueihu	2*n*=25, 26, 52, Sato (1942).
15.	*Veratrum* X=8, 11 *formosanum* Loes.	3194		16	Chihsingshan	*n*=8, Chuang *et al.* (1962).
	TRILLIACEAE 374(39')					
16.	*Paris* X=5 *formosana* Hay.	3351		10+2B	Kueihu	2*n*=10+2B, Gotoh & K. (1937).
	SMILACACEAE 376(39')					
17.	*Smilax* X=13, 14, 15, 16 *china* Linn.	3226		30	Chutzuhu	2*n*=60, Nakajima (1939). 2*n*=30, Hsu (1967).
	ARACEAE 381(24)					
	Alocasia X=14(13?) *macrorrhiza* Schott.	3083		28	Chinankung	2*n*=26, Matsuura & Sato (1935). 2*n*=28, Kurakubo (1940); Ito (1942); Pfitzer (1957).

Fig.	Taxon	Voucher	*n*	2*n*	Locality	Previous counts & authority
	IRIDACEAE 386(45)					
18.	*Belmcanda* X=8 *chinensis* (L.) DC.	3882	64		Yehliu	2*n*=32, Nakajima (1936); Roy & Saran (1961).
	ORCHIDACEAE 405(51)					
19.	*Anoectochilus* X=12* *formosanus* Hay.	3441	12		Chushuipo	*
20.	*Calanthe* X=20 sp.	3350		40	Kueihu	
	sp.	3444		40	Chushuipo	
21.	*reflexa* Maxim.	3363		40	Kueihu	2*n*=40, Tanaka (1965).
22.	*Gastrodia* X=12* *elata* Blume	3286	12		Kueihu	*
	Habenaria X=14, 20, 21 *longitentaculata* Hay.	4134		42	Kenting	*
	JUNCACEAE 406(37)					
23.	*Juncus* X=10(8?) *decipiens* Nakai	3174		20	Chihsingshan	*
	decipiens Nakai	3348		20	Kueihu	
	CYPERACEAE 410(21)					
	Carex X=6, 7, 8, 9, 10, 13 *etc.* (chr. polycentric) *filicina* Nees	3185		14	Chihsingshan	*
	GRAMINEAE (POACEAE) 411(20)					
	Agrostis X=7 *sozanensis* Hay.	3206		14	Chihsingshan	*
	Alopecurus X=7 *aequalis* Sibol var. *amurensis* Ohwi	4334	7		Taipei	2*n*=14, Strelkova (1938); Scholovskaya (1946), as *amurensis*. *n*=7, Chen & Hsu (1962). 2*n*=14, Johnsson(1941); Jrgensen *et al.* (1958); Bowden (1960); Sokolovskaya (1963, '65); Löve & L. (1964); Kozuharov & Kuz. (1964), as subsp. *aequalis*; Anderson (1965).
	Brachypodium X=7, 9, 15 *sylvaticum* (Huds.) Beauv. var. *luzoniense* Hara	3336		14	Kueihu	2*n*=18, Avdulov (1928); Tateoka (1956); Hedberg & H. (1961). 2*n*=18, Matsumura *et al.* (1956).
24.	*Eriochloa* X=9 *procera* (Retz.) C.E. Hubb.	4097	9		Fengkang	*n*=18, Ram. *et al.* (1959); Chen & Hsu (1961).
	Ichnanthus X=? *vicinus* (F.M. Bail) Merr.	4055	10		Chihpen	*n*=20, Chen & Hsu (1961).
	Poa X=7 (high polyploids viviparous or apomictic) *acroleuca* Steud.	3951	14		Tunpu	*
25.	*Pseudosasa* X=12 *usawai* Makino et Nem.	3157		48	Chihsingshan	*
	Spirifex X=9 *littoreus* (Burm. f.) Merr.	4190	9		Kenting	2*n*=18, Janaki Ammal (1945); Tateoka (1959).

having much larger fruit, and in addition by having a tetraploid chromosome number $n=24$ (Chuang *et al.*, 1962; Hsu, 1967).

Liliaceae

Aletris spicata Fr.

This is a subalpine herb with haploid number of $n=26$. The tetraploid count is found at much lower elevations in the sulphur spring range of about 700 m. above sea level. The sticky inflorescence easily separates this species from others.

Asparagus cochinchinensis Merr.

This is a diploid species with basic number of X=10. It has small but isomorphic chromosomes. It is one of the common herbs growing on the margins of the secondary thickets.

Aspidistra daibuensis Hay.

One of the related diploid species has a number $2n=38$ as was reported by Larsen (1963) on *A. longifolia*, and a basic number of X=19 was suggested. In our species the diploid number is $2n=36$ and large chromosomes were observed. It supports the basic number X=18, proposed by Darlington & Wylie (1955).

Disporum kawakamii Hay.

Cytological analysis of the karyotypes of two populations have been studied by Chao *et al.* (1963). They showed the meiosis of one population they observed indicated the hybrid nature. Somatic chromosome number of $2n=32$, a tetraploid, is obtained in this study. Some chromosomes are large and some of them have satellates. Another basic number of X=7 was proposed being based on *D. shimadai*, a species growing on the northern coastal regions of the Island. This species grows on humus under thickets in the middle altitudes.

Heloniopsis umbellata Bak.

The somatic chromosome count of this species is $2n=34$. It has short, stout and large sized chromosomes. This species grows on the exposed soils and has yellowish oblong-lanceolate leaves, while *Peliosanthes kaoi* grows in shady thickets and has deep-green, spathe-like broad leaves. The latter species is known only from the type locality, Kueihu, located in the southern part of Taiwan.

Liriope laxispicata Hay.

The key character used for separating *Liriope* from *Ophiopogon* is that the anther of *Liriope* is ovate with the filament as long as the anther, while in the latter it is lanceolate with a very short filament. Two counts, the one haploid $n=18$, the other diploid with $2n=36$ were made from different localities. It seems there is very close relationships between this species and *L. minor*, of which the chromosome count is known as $2n=36$ universally.

Ophiopogon japonicum Kerr.

Several counts have been reported on the somatic cells of this species. A recent

paper by Hasegawa (1968) indicated that all materials collected from both Japan and Korea were uniformly with $2n=72$, and the karyotype was stable. However Nagamatsu *et al.* (1964, '67) reported several counts of hypo-tetraploid. The Taiwan species is in agreement with that of the extensive study of Hasegawa.

Ophiopogon planiscapus Nakai

Hasegawa (1968) showed all Japanese materials she studied were $2n=36$, and the karyotype was stable. The present counts on pollen mother cells strongly support the conspecific relationships between Taiwan taxon and the Japanese plants which are also $n=18$.

Peliosanthes kaoi Ohwi

This is a new species reported recently by Ohwi (1966). The flower buds and root tips were fixed at the type locality and on the type materials. It shows large but different sized chromosomes of $n=17$ in pollen mother cells and the basic number X=17 is thus confirmed by the present count.

Polygonatum arisanense Hay.

This species has large sized chromosomes which in somatic cells has the chromosome number of $2n=44$. The chromosome number of the species is here reported for the first time.

Tricyrtis formosana Bak.

Several chromosome numbers, *i.e.* $2n=25$, 26, 52 were reported by Sato (1942). The material collected at Kueihu is a diploid, $2n=26$ with large chromosomes.

Veratrum formosanum Loes

The somatic chromosomes of this species are large and show the diploid number $2n=16$. The material collected from the Mt. Seven-Star (Chih-sing-shan) supports the results counted on PMC by Chuang *et al.* (1962).

Trilliaceae

Paris formosana Hay.

This species has 10 extremely large chromosomes and two much smaller B chromosomes in the somatic cells. The present study confirms the count of Gothoh & K. (1937). The size of the chromosomes are the largest of any in this study.

Smilacaceae

Smilax china Linn.

The large sized chromosomes of $2n=30$ supports the result of Hsu (1967). This is one of the best species in the genus for cytological investigation as it has very large chromosomes.

Araceae

Alocasia macrorrhiza Schott.

A very common undergrowth at low altitudes throughout the Island. It shows

the diploid number of $2n=28$. The chromosomes are medium sized and the number $2n=28$ agrees with the results reported by Kurakubo (1940), Ito (1942) and Pfitzer (1957). However somatic cells of $2n=26$ were reported by Matsumura & Sato (1935).

Iridaceae

Belmcanda chinensis (Linn.) DC.

This is a littoral plant growing on rocky hillsides near the ocean. It is an octaploid and is not in agreement with the result of Nakajima (1956), who reported it as a diploid having the number $2n=32$. Further study is needed on its cytological nature and the distribution pattern of the species.

Orchidaceae

Anoectochilus formosanum Hay.

This species has medium sized chromosomes which are $n=12$ in meiotic cells. It seems the basic number of the genus is X=12.

Calanthe 3350, 3444

The large sized chromosomes vary considerably in their length and it seems there are B chromosomes in this taxon.

Calanthe reflexa Maxim.

The chromosome morphology of this species varies very much as to its size and shape. No doubt this is one of the materials worthy of further analysis of its karyotype. We need to know more about the relationships among this well defined but terribly species rich genus. The chromosome number $2n=40$ agrees with Tanaka (1965).

Gastrodia elata Blume

A nice slide of the second division in meiosis shows clearly that this non-chlorophyll bearing species has $n=12$ chromosomes. The basic number of the genus is thus proposed to be X=12.

Habenaria longitentaculata Hay.

This is a terrestrial orchid collected from the limestone area in the typical tropical rain forest region. The somatic root tip cells show $2n=42$ chromosomes. It is a first time record on its chromosomes.

Juncaceae

Juncus decipiens Nakai

Two counts from different parts of the Island indicate the same chromosome number $2n=20$ for this swamp-growing species. The chromosomes are small and short.

Cyperaceae

Carex filicina Nees

Table 2. A List of Collections

Chihpen (知本)—TAITUNG CO.: 22°42′-121°01′.
Oct. 1, 1967—4041, 4055.
Chihsingshan (七星山)—TAIPEI CO.: 25°10′-121°33′, collected from elevation of about 700 m on up to the mountain top, Alt. 1,113 m.
June 17, 1967—3157, 3167, 3174.
July 15, 1967—3185, 3187, 3194, 3206, 5218.
Chinankung (指南宮)—TAIPEI CO.: 24°59′-121°24′, Alt. 230 m.
June 11, 1967—3083.
Chutzuhu (竹子湖)—TAIPEI CO.: 25°12′-121°34′, collected from elevation of about 600 m.
July 15, 1967—3226.
Chushuipo (出水坡)—TAITUNG CO.: 22°23′-120°49′, collected from elevation of about 400 m up to 560 m.
July 31, 1967—3423, 3425, 3440, 3441, 3444.
Fengkang (楓港)—PINGTUNG CO.: 22°12′-120°41′.
Oct. 3, 1967—4097.
Kenting (墾丁)—PINGTUNG CO.: 21°57′-120°47′.
Oct. 3, 1967—4111, 4134.
Oct. 5, 1967—4190.
Kueihu (魁湖)—TAITUNG CO.: ca. 22°46′-120°53′, collected from elevation of about 1,600 m up to 2,000 m.
July 27, 1967—3286, 3273.
July 29, 1967—3336, 3348, 3349, 3350, 3351, 332, 3360, 3361, 3362, 3363, 3365.
Shiting (石碇)—TAIPEI CO.: 25°00′-121°39′, collected from elevation of about 400 m.
July 22, 1967—3254.
Taipei (臺北)—TAIPEI CITY: 25°03′-121°31′, collected from the University campus, NTU.
Apr. 1, 1968—4334.
Tanshui (淡水)—TAIPEI CO.: 25°11′-121°26′, collected from the opposite side of Tanshui, across the Tanshui River.
Apr. 9, 1968—4362.
Tungpu (東埔)—NANTOU CO.: 23°32′-120°53′, collected from elevation of about 2,500 m.
Sept. 29, 1967—3951.
Yangmingshan (陽明山)—TAIPEI CO.: 25°09′-121°33′, collected from elevation of about 400 m.
June 17, 1967—3139.
Yehliu (野柳)—TAIPEI CO.: 25°13′-121°42′, collected from the coastal region.
Sept. 10, 1967—3882.
Yushanchienshan (玉山前山)—CHIAYI CO.: 23°28′-120°54′, Alt. 3,242 m, collected from elevation of about 3,000 m up to 3,200 m.
Sept. 29, 1967—3951, 3992.

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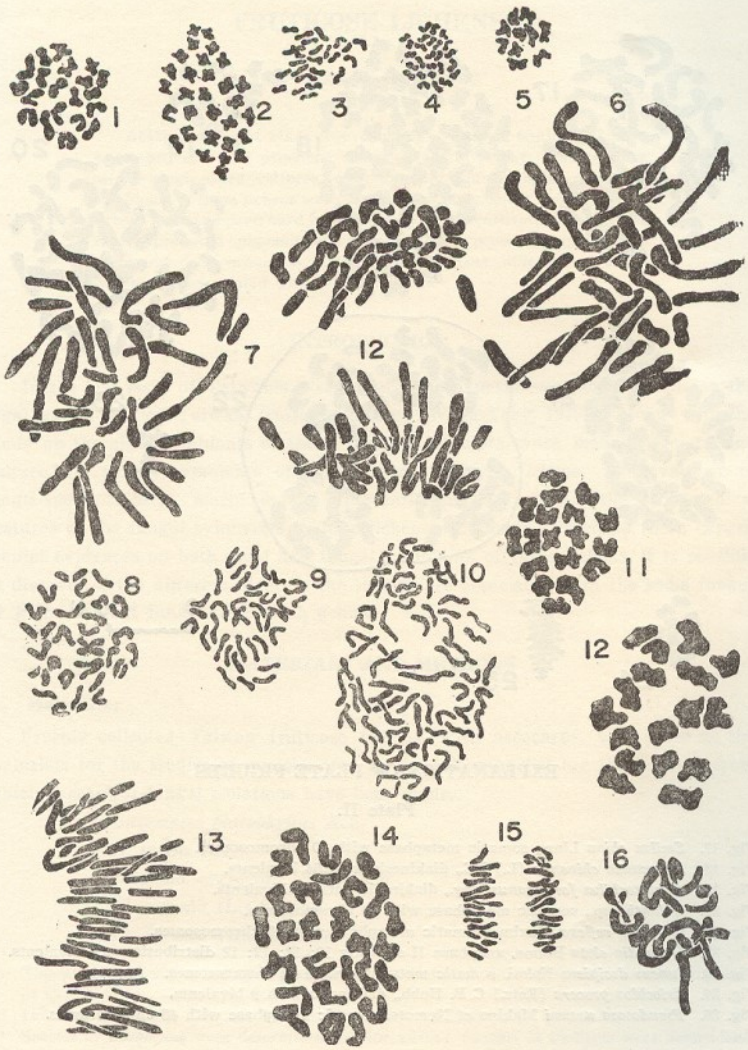
EXPLANATION OF PLATE FIGURES

Plate I.

Fig. 1. *Aneilema sinicum* Lendl., diakinesis with 20 bivalents.
Fig. 2. *Commelina obliqua* Ham., diakinesis with 30 bivalents.
Fig. 3. *Alpinia shimadai* Hay., somatic early metaphase with 24 chromosomes.
Fig. 4. *Aletris spicata* Fr., diakinesis with 26 bivalents.
Fig. 5. *Asparagus cochinchinensis* Merr., diakinesis with 10 bivalents.
Fig. 6. *Aspidistra dzibuensis* Hay., somatic metaphase with 36 chromosomes.
Fig. 7. *Disporum kawakamii* Hay., somatic metaphase with 32 chromosomes.
Fig. 8. *Heloniopsis umbellata* Bak., somatic metaphase with 34 chromosomes.
Fig. 9. *Liriope luxispicata* Hay., somatic metaphase with 36 chromosomes.
Fig. 10. *Ophiopogon japonicum* Ker., somatic metaphase with 72 chromosomes.
Fig. 11. *Ophiopogon planiscapus* Nakai, diakinesis with 18 bivalents.
Fig. 12. *Peliosanthes kaoi* Ohwi, diakinesis with 17 bivalents.
Fig. 13. *Polygonatum crisanense* Hay., somatic anaphase, showing one side with 44 chromosomes.
Fig. 14. *Tricyrtis formosana* Bak., diakinesis with 26 bivalents.
Fig. 15. *Veratrum formosanum* Loes., somatic anaphase, showing 16: 16 distribution of chromosomes.
Fig. 16. *Paris formosana* Hay., somatic early metaphase with 10 chromosomes and two B-chromosomes; magnification reduced to 2/5.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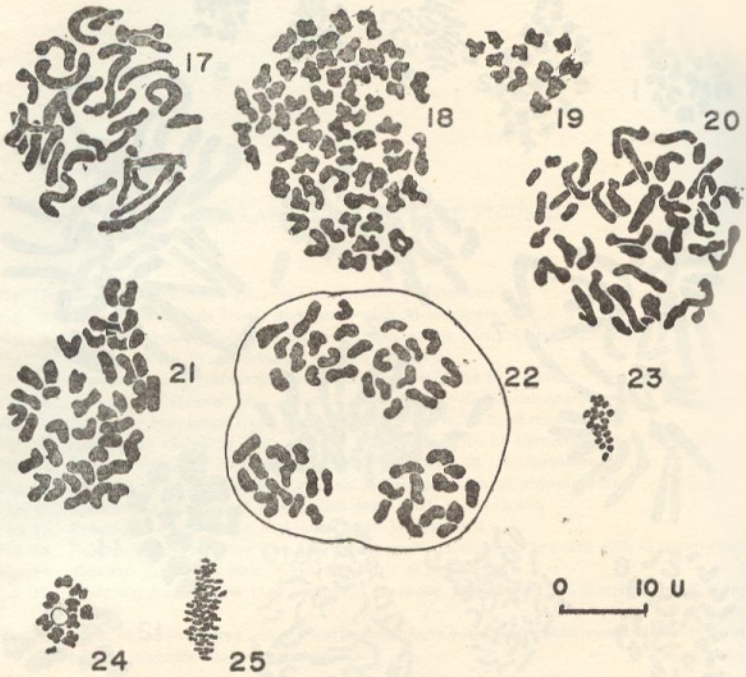

EXPLANATION OF PLATE FIGURES

Plate II.

Fig. 17. *Smilax china* Linn., somatic metaphase with 30 chromosomes.
Fig. 18. *Belmcanda chinensis* (L.) DC., diakinesis with 64 bivalents.
Fig. 19. *Anoectochilus formosanus* Hay., diakinesis with 12 bivalents.
Fig. 20. *Calanthe* sp., somatic metaphase with 40 chromosomes.
Fig. 21. *Calanthe reflexa* Maxim., somatic metaphase with 40 chromosomes.
Fig. 22. *Gastrodia elata* Blume, anaphase II showing 12: 12; 12: 12 distribution of univalents.
Fig. 23. *Juncus decipiens* Nakai, somatic metaphase with 20 chromosomes.
Fig. 24. *Eriochloa procera* (Retz.) C. E. Hubb., diakinesis with 9 bivalents.
Fig. 25. *Pseudosasa usawai* Makino et Nemoto, somatic metaphase with 48 chromosomes.