PRELIMINARY CHROMOSOME STUDIES ON THE VASCULAR PLANTS OF TAIWAN (I)

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Cytology has greatly influenced systematic botany and has suggested a new direction for research in phylogenetic relationships. Additional evidece based on microscopical studies confirms conclusions reached through gross morphological characters. Application of these new approaches has provided for a better understanding of certain taxa and offers keys to clarification of the interrelationships among the groups concerned.

This part of systematics is based on the living plant. It is a means of relating the field to the vast numbers of herbarium sheets deposited in the ordinary herbarium. The object of the present series is to fill gaps in the chromosome counts of species occurring in temperate countries by similar studies on individuals destributed in the subtropics and tropics. Many regions of these zones offer opportunities for intensive investigation. In this connection, the island of Taiwan is in a key position in Asia. It is situated about halfway between the Kuriles in the north and the Indo-Malayan Archipelagos in the south.

Additionary, Formosa is close to the Asiatic mainland. It has a luxuriant vegetation and interesting flora, with temperate and tropical plants, relatively occupying nitches from the teperate rugged peaks up to 3,997 m. (Yushan) down to the sunny tropical seashore. According to Masmune (1936), there are 537 species of Pteridophytes and 3,304 species of Spermatophytes. Endemic species are comparatively numerous, amounting to nearly 40 per cent.

Relatively extensive taxonomical studies have been made on the woody plants in recent years by Liu (1960, 1962) and Li (1963). Even in these rather well treated woody groups, only a limited number of indigenous species have been examined cytologically. Chen and Hsu (1961, 1962) recorded the chromosome counts of 82 Formosan grass species. The chromosome numbers of about 23 species of Formosan Umbelliferae were reported on by Liu, Chao and Chuang (1961). Counts on about 98 species of Formosan vascular plants have been listed by Chuang, Chao, Hu and Kwan (1962). Recently Feng (1965) examined the chromosomes of five *Viscum* species which are belong to the family Loranthaceae. However, further cytological survey of the flora of Formosa is badly needed not only for a better understanding of its nature, but also to provide valuable information for applied fields such as plant industry, foresty, horticulture, and plant breeding.

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MATERIALS AND METHODS

All materials from which flower buds and root tips were collected in the field. Some specimens were planted in the greenhouse or nursery. Seeds were sometimes germinated on filter paper in Petri dishes to get root tips. The bud or root tip collections were made strictly from one individual plant of a population. Complete sets of voucher specimens were prepared and deposited in the Herbarium of National Taiwan University (TAI). Some living plants were teansplanted here for further investigations.

The flower buds and root tips were fixed in the standard 3:1 alcohol-glacial acetic acid solution for at least 24 hours, then transfered in 70% alcohol and storange in a 5°C. refrigerator. The anthers were dissected out from the buds, stained and smeared with aceto-carmine. The root tips were treated with 1N HCl and then aceto-orcein smear technique was followed. Most observations were made at the magnification of 1,500X with a Nikon STR-Ke binocular microscope, and all drawings were made with the aid of camera lucida. A 100X oil immersion objective and a 15X compensating eyepiece were used except where the chromosomes

EXPLANATION OF PLATE FIGURES

Plate I

Fig. 1. *Rubus parvifolius*, somatic metaphase with 14 chromosmes.
Fig. 2. R. *glandulos-calycinus*, somatic late prophase with 14 chromosomes.
Fig. 3. *Cassia occidentalis*, diakinesis with 14 bivalents.
Fig. 4. *Acasia confusa*, diakinesis with 13 bivalents.
Fig. 5. *Itea parviflora*, diakinesis with 11 bivalents.
Fig. 6. *Ebulus formosana*, somatic metaphase with 36 chromosomes.
Fig. 7. *Trema orientalis*, late diakinesis with 20 bivalents.
Fig. 8. *Broussonetia papyrifera*, early diakinesis with 13 bivalents.
Fig. 9. *Ficus stipulosa*, somatic early metaphase with 13 chromosomes.
Fig. 10. *Boehmeria zollingeriana*, diakinesis with 13 bivalents.
Fig. 11. *Polygala japonica* var. *angustifolia*, diakinesis with 7 bivalents.
Fig. 12. *Begonia laciniata* var. *formosana*, diakinesis with 13 bivalents.
Fig. 13. *Urena lobata* var. *tomentosa*, somatic metaphase with 14 chromosomes.
Fig. 14. *Euphorbia thymifolia*, somatic late prophase with 12 chromosomes.
Fig. 15. *Mallotus japonicus*, somatic late metaphase with 18 chromosomes.
Fig. 16. *Phyllanthus niruri*, somatic anaphase showing 14:14 distribution of chromosomes.
Fig. 17. *Ternstroemia gymnanthera*, diakinesis with 20 bivalents.
Fig. 18. *Elaeagnus thunbergii*, diakinesis with 14 bivalents.
Fig. 19. *Diospyros eriantha*, diakinesis with 15 bivalents.
Fig. 20. *Murraya paniculata*, somatic metaphase with 18 chromosomes.
Fig. 21. *Ligustrum japonicum*, diakinesis with 23 bivalents.
Fig. 22. *Tabernaemontana divaricata*, diakinesis with 14 bivalents.
Fig. 23. *Hoya carnosa*, somatic anaphase showing 22:22 distribution of chromsomes.
Fig. 24. *Psychotria rubra*, diakinesis with 11 bivalents.
Fig. 25. *Wendlandia formosana*, diakinesis with 11 bivalents.
Fig. 26. *Duranta repens*, diakinesis with 8 bivalents.


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were large enough to observe with the eye field. In the latter case, a 40X objective was used.

RESULTS

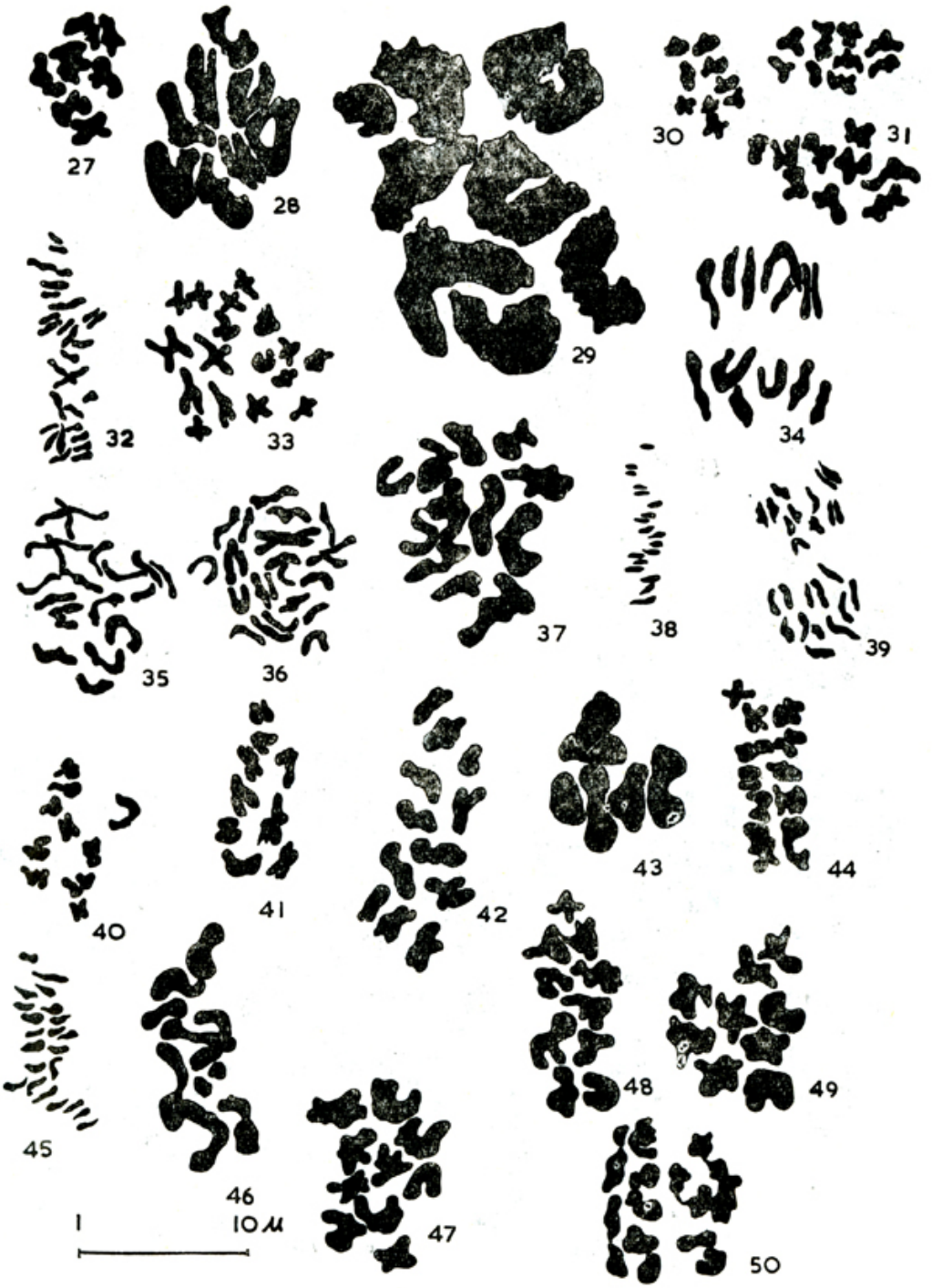
Table 1 shows the results of the present chromosome counts on plants from the vicinity of Taipei. The families are arranged according to Hutchinson's classification system (1959). The theoretical basic chromosme number for a taxon is referred to as "X", somatic "2n", and haploid "n" respectively. References to the previous records of chromosome counts are from Darlington and Wylie (1955), Cave's Index (1958–1965), and Ornduff's Index (1967). An asterisk (*) indicates that the species has not been reported on previously and appears here for the first time. Discussion will be withheld with the end of the complete series of papers. It is too early to settle down to a meaningful conclusion untill sufficient data on the chromosome counts of Taiwan and its neighbouring areas has been accumulated.

SUMMARY

1. This is a part of the systematic study of the plants of Taipei and its vicinity. The chromosome counts of 82 species (including varieties) belonging to 75 genera are reported in this paper.

Plate II

Fig. 27. *Verbena officinalis*, diakinesis with 7 bivalents.
Fig. 28. *Clematis taiwaniana*, diakinesis with 8 bivalents.
Fig. 29. *Clematis taiwaniana*, diakinesis with 8 bivalents.
Fig. 30. *Mollugo pentaphylla*, diakinesis with 9 bivalents.
Fig. 31. *Phytolacca americana*, AI showing 9:9 distribution of chromosomes.
Fig. 32. *Alternanthera philoxeoroides*, somatic metaphase with 28 chromosomes.
Fig. 33. *Amaranthus spinosus*, diskinesis with 17 bivalents.
Fig. 34. *Plantago formosana*, AI showing 6:6 distribution of chromosomes.
Fig. 35. *Centella asiatica*, somatic early metaphase with 18 chromosomes.
Fig. 36. *Hydrocotyle sibthorpoides*, somatic early metaphase with 24 chromosomes.
Fig. 37. *Oenanthe javanica*, late diakinesis with 10 bivalents and 2 univalents.
Fig. 38. *Wahlenbergia gracilis*, somatic metaphase with 18 chromosomes.
Fig. 39. *Pratia nummularia*, somatic anaphase showing 12:12 distribution of chromosomes.
Fig. 40. *Ageratum houstoniaum*, diakinesis with 10 bivalents.
Fig. 41. *Aster indicus*, diakinesis with 9 bivalents.
Fig. 42. *Bidens pilosa* var. *radiata*, late diakinesis with 12 bivalents.
Fig. 43. *Dicrocephala bicolor*, late diakinesis with 6 bivalents.
Fig. 44. *Eclipta prostrata*, diakinesis with 11 bivalents.
Fig. 45. *Elephantopus tomentosus*, somatic metaphase with 22 chromosomes.
Fig. 46. *Emilia sonchifolia*, late diakinesis with 10 bivalents.
Fig. 47. *Erechtites valerianaefolia*, diakinesis with 10 bivalents.
Fig. 48. *Erigeron canadensis*, diakinesis with 9 bivalents.
Fig. 49. *Lactuca indica*, diakinesis with 9 bivalents.
Fig. 50. *Siegesbeckia orientalis*, diakinesis with 15 bivalents.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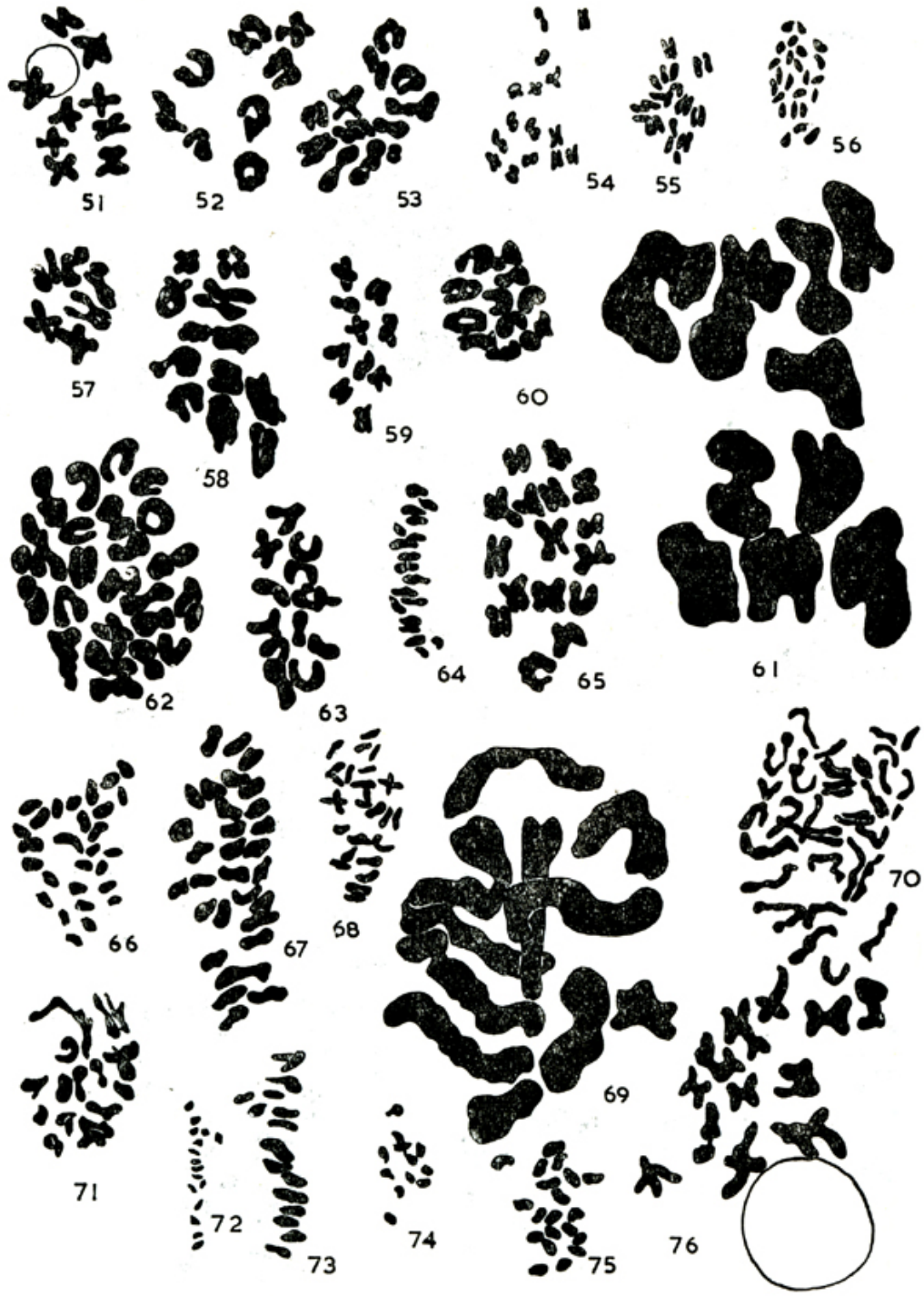
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Table 1. Chromosome Counts in Some Taiwan Vascular Plants.

Fig.	Species	Voucher	n	2n	Locality	Previous count & authority
	ROSACEAE					
	Rubus X = 7 (Polyploids often apomictic)					
1	parvifolius	3092		14	Chihnankung	2n=14 Bammi (1965)
2	glandulos-calycinus	3204		14	Mt. Seven-star	*
	CAESALPINIACEAE					
	Cassia X=6, 7, 8; X_2=13 (6+7)					
3	occidentalis	3512	14	28	Wulai	2n=26, Muto (1929); 2n=28, Pantulu (1940)
	MIMOSACEAE					
	Acasia X=13					
4	confusa	3011	13		Yangmingshan	2n=26, Atchison (1948)
	ESCALLONIACEAE "SAXIFRAGACEAE"					
	Itea X=11					
5	parviflora	3007	11		Yangmingshan	*
	CAPRIFOFOLIACEAE					
	Ebulus (Sambucus) X=(9), 18, 19.					
6	formosana	3087		36	Chihnankung	n=18, Chuang et al. (1962)
	ULMACEAE					
	Trema X=10*					
7	orientalis	3013	20		Yangmingshan	*
	MORACEAE					
	Broussonetia X=13					
8	papyrifera	3237	13		Shihting	2n=26, Bowden (1940)
	Ficus X=13					
9	stipulosa	3133		26	Taipei	*
	URTICACEAE					
	Boehmeria X=7, 13					
10	zollingeriana	3234	13		Shihting	*
	POLYGALACEAE					
	Polygala X=7*					
11	japonica var. angustifolia	3057	7		Taipei	2n=42 (P. japonica) Suzuka (1950)
	BEGONIACEAE					
	Begonia X=6, 7, 9 X_2=13 (6+7)					
12	laciniata var. formosana	3233	13		Shihting	*
	MALVACEAE					
	Urena X=7					
13	lobata var. tomentosa	3086		14	Chihnankung	2n=28, 56 (U. lobata) Skovsted (1941)
	lobata var. tomentosa	3235		14	Shihting	
	EUPHORBIACEAE					
	Euphorbia X=6, 7, 8, 9, 10 (Apomixis)					
14	thymifolia	3030		19	Taipei	*
15	Mallotus X=9 japonicus	3219		18	Mt. Seven-star	*
16	Phyllanthus X=7 niruri	3120		14	Taipei	n=13 Chuang et al. (1962) 2n=26 Raghavan (1957)

2. Of these chromosome counts, of 34 species are presented here for the first time.
3. The basic number in *Trema*, *Polygala*, *Pratia*, *Dicrocephala*, *Dysophylla*, and *Forrestia* is considered to be X=10, X=7, X=6, X=6, and X=10 respectively.

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Plate III

Fig. 51. *Vernonia cinerea*, diakinesis with 9 bivalents.
Fig. 52. *Youngia japonica*, diakinesis with 8 bivalents.
Fig. 53. *Solanum nigrum*, diakinesis with 12 bivalents.
Fig. 54. *Ipomoea carica*, diakinesis with 15 bivalents.
Fig. 55. *Dichondra repens*, somatic early metaphase with 24 chromosomes.
Fig. 56. *Mazus pumilus*, somatic early metaphase with 24 chromosomes.
Fig. 57. *Dysophylla auricularia*, diakinesis with 6 bivalents.
Fig. 58. *Sagittaria trifolia*, diakinesis with 11 bivalents.
Fig. 59. *Aneilema sinicum*, diakinesis with 10 bivalents.
Fig. 60. *Commelina communis*, diakinesis with 11 bivalents.
Fig. 61. *Forrestia chinensis*, diakinesis with 10 bivalents.
Fig. 62. *Alpinia formosana*, late diakinesis with 24 bivalents.
Fig. 63. *Alpinia intermedia*, diakinesis with 12 bivalents.
Fig. 64. *Hedychium coronarium*, somatic metaphase with 18 chromosomes.
Fig. 65. *Dianella ensifolia*, diakinesis with 16 bivalents.
Fig. 66. *Monochoria vaginalis*, early metaphase with 28 chromosomes.
Fig. 67. *Smilax china*, somatic early metaphase with 30 chromosomes.
Fig. 68. *Typhonium divaricatum*, somatic late prophase with 26 chromosomes.
Fig. 69. *Crinum asiatica* var. *sinicum*, late diakinesis with 11 bivalents.
Fig. 70. *Phoenix hanceana* var. *formosana*, somatic late prophase with 36 chromosomes.
Fig. 71. *Curculigo recurvata*, somatic early metaphase with 18 chromosomes.
Fig. 72. *Cyperus iria*, somatic metaphase with 16 chromosomes.
Fig. 73. *Cyperus pilosa*, somatic metaphase with 16 chromosomes.
Fig. 74. *Fimbristylis dichotoma*, somatic early prophase with 12 chromosomes.
Fig. 75. *Isachne debilis*, somatic early metaphase with 20 chromosomes.
Fig. 76. *Phyllostachys makinoi*, diakinesis with 12 bivalents.

Fig.	Species	Voucher	n	2n	Locality	Previous count & authority
	THEACEAE "TERNSTROEMIACEAE"					
	Ternstroemia X=?					
17	gymnanthera	3021	20		Taipei	*
	ELAEGNACEAE					
	Elaeagnus X=14					
18	thunbergii	3208	14		Mt. Seven-star	*
	EBENACEAE					
	Diospyros X=15					
19	eriantha	3137	15		Taipei, cult.	*
	RUTACEAE					
	Murraya X=9					
20	paniculata	3131		18	Taipei, cult	2n=18 Toxogens (1933)
	OLEACEAE					
	Ligustrum X=23					
21	japonicum	3119	23		Taipei, cult.	2n=46 Taylor (1945)
	APOCYNACEAE					
	Tabernaomontana X=?					
22	divaricata	3183	14		Taipei, cult.	*
	ASCLEPIADACEAE					
	Hoya X=11					
23	carnosa	3510		22	Wulai	2n=22 Pardi (1934)
	RUBIACEAE					
	Psychotria X=11					
24	rubra	3134	11		Taipei	*
	rubra	3068		22	Taipei	
	rubra	3071	11		Taipei	
	rubra	3134	11		Taipei	
	Wendlandia X=11*					
25	formosana	3135	11		Taipei	n=11 Chuang et al. (1962)
	VERBENACEAE					
	Duranta X=?					
26	repens	3246	8		Shihting	2n=36 Patermann, T. (1938)
	Verbena X=5, 7					
27	officinalis	3242	7		Shihting	2n=14 Dermen (1936)
	RANUNCULACEAE					
	Clematis X=8					
28	taiwaniana	3248	8		Shihting	2n=8 Chuang et al. (1962) as C. gouriana
29	taiwaniana	3480	8		Kankou	
	FICOIDACEAE "AIZOACEAE"					
	Mollugo X=9					
30	pentapylla	3509	9		Wulai	2n=18 Sugiura (1936) 2n=36 Raghavan (1940)
	PHYTOLACCACEAE					
	Phytolacca X=9					
31	americana	3232	9		Shihting	n=18 Bostick (1965)
	AMARANTHACEAE					
	Alternanthera X=?					
32	philoxeroides	3136		28	Taipei	*
	Amaranthus x=8, 17					
33	spinosus	3506	17	34	Wulai	2n=34 Takagi (1933) n=17 Sharma & B. (1965)
	spinosus	3243	17		Shihting	

Fig.	Species	Voucher	n	2n	Locality	Previous count & authority
	PLANTAGINACEAE					
	Plantago X=4, 5, 6 X_2=9 (4+5)					
34	formosana	3059	6		Taipei	3n=36 Masamune ex Tateish (1932)
	formosana	3122		12	Taipei	
	UMBELLIFERAE					
	Centella X=9*					
35	asiatica	3079		18	Chihnankung	n=9 Liu et al. (1961)
	Hydrocotyle X=8, 9, 11, 12*					
36	sibthorpoides	3126		24	Taipei	n=12 Liu et al. (1961)
	Oenanthe X=11					
37	javanica	3024	11	22	Yangmingshan	n=10 Liu et al. (1961)
	CAMPANULACEAE					
	Wahlenbergia X=(8?), 9					
38	gracilis	3508		18	Wulai	*
	LOBELIACEAE					
	Pratia X=6*					
39	nummularia	3111		12	Chihnankung	*
	COMPOSITAE					
	Ageratum X=10					
40	conyzoides	3053		20	Taipei	2n=20 Ishikawa (1916) 2n=40 Mitoa (1947)
	houstonianum	3036	10		Taipei	2n=20 Cooper & M. (1935) n=10 Mehra et al. (1965)
	Aster X=5, 8, 9					
41	indicus	3054	9		Taipei	*
	Bidens X=12					
42	pilosa var. radiata	3028	12	24	Taipei	2n=48 Gelin (1934); Covas & Hs. (1946) n=24 Smith (1965)
	Dicrocephala X=6*					
43	bicolor	3062	6		Taipei	*
	Eclipta X=11					
44	prostrata	3025	11	22	Taipei	n=11, 2n=22 Arano (1962)
	Elephantopus X=11					
45	tomentosus	3080		22	Chihnankung	n=11 Chuang et al. (1962)
	Emilia X=5					
46	sonchifolia	3019	10		Yangmingshan	2n=10 Boldwin (1946); 2n=20 Arane (1965)
	sonchifolia	3490	10		Kankou	n=5 Afzelius (1924) Mehra et al. (1965)
	Erechtites X=10					
47	valerianaefolia	3027	10	20	Taipei	2n=20 Turner & Irwin (1960)
	valerianaefolia	3105	10	20	Chihnankung	
	valerianaefolia	3112			Chihnankung	
	Erigeron X=9, 16 (Polyploids apomictic)					
	annuus	3118		27	Taipei	2n=27 Mehra et al. (1965)
48	canadensis	3029	9		Taipei	2n=18 Arano (1965)
	canadensis	3103		18	Chihnankung	

Fig.	Species	Voucher	n	2n	Locality	Previous count & authority
	Lactuca X=8, 9 (Old World); X_2=17 (New World)					
49	chinensis	3494	9	18	Wulai	*
	formosana	3037	9		Taipei	n=9 Chuang et al. (1962)
	formosana	3491	9		Wulai	
	indica	3492	9		Wulai	2n=18 Thompson et al. (1941)
	Siegesbeckia X=10					
50	orientalis	3039	15		Taipei	n=15, 30; 2n=60 Mehra et al. (1965)
	orientalis	3497		20	Wulai	
	Vernonia X=7, 8, 9 X_2=15, 17 X_3=26					
51	cinerea	3088	9		Chihnankung	n=9 Chuang et al. (1962); Turner & L. (1965); Mehra et al. (1965)
	cinerea	3245	9		Shihting	
	cinerea	3511	9		Wulai	
	Ixeris X=5, 6, 7, 8					
	laevigata var. lanceolata	3096		16	Taipei	*
	Youngia X=5, 8					
52	japonica	3026	8		Chihnankung	n=8 Chuang et al. (1962) as Crepis japonica; 2n=16 Babcock et al. (1937)
	SOLANACEAE					
	Solanum X=12, 13					
53	nigrum	3055	12	24	Taipei	n=12 Chuang et al. (1962) 2n=24 Bhaduri (1933)
	CONVOLVULACEAE					
	Ipomoea X=15					
54	carica	3023	15		Taipei	*
	carica	3128		30	Taipei	
	Dichondra X=?					
55	repens	3125		24	Taipei	*
	SCROPHULARIACEAE					
	Mazus X=?					
56	pumilus	3034	12	24	Teipei	*
	LABIATAE					
	Dysophylla X=6*					
57	auricularia	3258	6		Shihting	n=17 Chuang et al. (1962)
	ALISMATACEAE					
	Sagittaria X=11 (10)					
58	trifolia	3042	11	22	Taipei	2n=22 Morinaga & F. (1931)
	COMMELINACEAE					
	Aneilema X=10					
59	sinicum	3052	10	20	Taipei	*
	Commelina X=11, 12?, 15?					
60	communis	3493	11		Wulai	2n=48, 90 Mitsukuri (1947) n=23, 44 Fukumoto (1965)
	Forrestia X=10*					
61	chinensis	3259	10		Shihting	*

Fig.	Species	Voucher	n	2n	Locality	Previous count & authority
	ZINGIBERACEAE					
	Alpinia X=12					
62	formosana	3075	24		Chihnankung	n=24 Chuang et al. (1962)
63	intermedia	3001	12		Yangmingshan	*
	Hedychium X=9, 17, 26					
64	coronarium	3239		18	Shihting	2n=54 Raghavan & V. (1943)
	LILIACEAE					
	Dianella X=8					
65	ensifolia	3015	16		Yangmingshan	n=16 Chuang et al. (1962) 2n=16, 64, 76, 80, 84 Curtis (1952)
	PONTEDERIACEAE					
	Monochoria X=14, 26					
66	vaginalis	3041		28	Taipei	
	vaginalis	3184		28	Taipei	2n=52 Morinaga & F. (1931)
	SMILACACEAE					
	Smila X=13, 14, 15, 16					
67	china	3106		30	Chihnankung	2n=60 Nakajima (1937)
	ARACEAE					
	Typhonium X=13					
68	divaricatum	3070		26	Taipei	2n=52 Ito (1942)
	divaricatum	3116		26	Taipei	
	AMARYLLIDACEAE					
	Crinum X=11					
69	asiatica var. sinicum	3180	11		Taipei	2n=22 Inariyama (1937)
	asiatica var. sinicum	3181	11		Taipei	
	PALMAE					
	Phoenix X=18					
	hanceana					
70	var. formosana	3129		36	Taipei	*
	HYPOXIDACEAE					
	Curculigo X=9					
71	recurvata	3240		18	Shihting	2n=18 Sharma & Ghosh (1954)
	CYPERACEAE					
	Cyperus X=8, 9					
72	iria	3504		16	Wulai	*
73	pilosa	3489		16	Wulai	*
	rotundus	3499		16	Wulai	*
	Fimbristylis X=5, 6, 8, 11					
74	dichotoma	3486		12	Wulai	2n=10 Sharma & Bal (1956)
	GRAMINEAE					
	Isachne X=10					
75	debilis	3212		20	Mt. Seven-star	*
	Oplismenus X=10, 12					
	compositus	3236		72	Shihting	n=36 Chen & Hsu (1961)
	Paspalum X=10, 12					
	conjugatum	3050	10		Taipei	n=10 Chen & Hsu (1961) 2n=40 Tateoka (1965)
	Phyllostachys X=12					
76	makinoi	3252	12		Shihting	*

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