Karyomorphological Studies on *Goodyera* and its Allied Genera in Orchidaceae*

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ラン科シュスラン属およびその近縁属の核形態学的研究*

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Introduction

The genus *Goodyera*, the Orchidaceae, consists of approximately 40 species which are mainly terrestrial and rarely epiphytic, and is widely distributed from the subarctic area of the Northern Hemisphere to the tropical Asia (*e.g.*, Satomi 1982). Approximately 13 species of *Goodyera* are reported in Japan (Satomi 1982).

Goodyera and its allied about 36 genera were placed all together in a common group by Dressler (1981). Since this group includes many rare species which would not supply enough complete herbarium specimen masses, taxonomical treatments of the genera and the species could be highly imperfect and confused (Schlechter 1926, Holttum 1964, Brieger 1974-1975, Dressler 1981 etc.). Dressler and Dodson (1960), Maekawa (1971, 1978), Seidenfaden (1978), and so on suggested that more examinations must be necessary to clarify these taxonomic treatments.

On the other hand, most of the taxa of this group grow in primary forests with high humidity and are often associated with dominant forest-trees. Thus, speciation of *Goodyera* might be correlated with certain associated forest-trees (Tanaka 1965a). These facts suggest that the interrelationships among the *Goodyera* species and their allied genera could be further complicated.

Chromosomes of *Goodyera* and its allied genera have been observed by many authors (Miduno 1939, Tanaka 1965b, 1976, Mehra and Bawa 1970, and so on). These reports documented chromosome numbers but lack of any chromosome morphology.

In the present paper, 27 taxa of *Goodyera* and its allied seven genera are dealt with the karyomorphological studies to speculate their speciation and interrelationships.

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* A dissertation submitted in partial fulfilment of the requirement for the degree of Doctor of Science of the Hiroshima University.
Contribution from the Hiroshima Botanical Garden No. 42.

** The Hiroshima Botanical Garden

Bulletin of the Hiroshima Botanical Garden, No. 12 : 71-144, 1990.

Materials and Methods

Localities and source and number of plants studied were listed in Table 1. Taxonomical treatments of the materials followed mostly Ohwi and Kitagawa (1983) and some Garay and Sweet (1974), Hatusima (1975), Luer (1975) and Seidenfaden (1978). The voucher specimens and the cytological data of the plants studied were deposited in the Herbarium of the Hiroshima Botanical Garden.

Somatic chromosomes were stained and observed by the aceto-orcein squash method as follows: Growing root tips were cut into small pieces 1 − 2 mm long and immersed in 0.002M 8-hydroxyquinoline for four hours at 16℃. Then, they were fixed in 45% acetic acid for 15 minutes at 5℃ and were macerated in a mixture of one part of 45% acetic acid and two parts of 1N hydrochloric acid for 20 seconds at 60℃ before they were stained with 1% aceto-orcein for about 15 minutes and squashed softly.

Growing shoot apices in *Hetaeria sikokiana*, two taxa of *Myrmechis* and *Vexillabium yakushimense*, which did not have any usual root, were cut into small pieces 2−3 mm long and were pretreated in 0.002M 8-hydroxyquinoline for four hours at 16℃. Then, they were first fixed in a modified Carnoy's solution (99% ethanol : chloroform : glacial acetic acid = 2 : 1 : 1) for two hours at 5℃ and transferred to 45% acetic acid for five minutes at 5℃, before they were stained with 1% aceto-orcein, squashed and observed.

Chromosomes at resting stage were studied morphologically by their condensed features and shapes and numbers of chromatin blocks. At mitotic prophase, localities of early condensed segments and their features of successional differentiation to late condensed segments were recorded. Chromosomes at mitotic metaphase were measured by length of their long and short arms. Arm ratio and average chromosome length were calculated by long arm length / short arm length and total chromosome length / chromosome number (2n), respectively. Arm ratios were expressed by the value of arm ratio from 1.0 to 1.7 as "median" (m), 1.8 to 3.0 as "submedian" (sm), 3.1 to 7.0 as "subterminal" (st) and over 7.1 as "terminal" (t) according to Levan *et al.* (1964). Variation of chromosome length in a chromosome set was studied. The results of the observations in the resting nuclei and somatic prophase chromosomes and the karyotype formulas at mitotic metaphase were described and classified according to Tanaka (1980). The chromosomes were basically aligned in descending order from the longest to the shortest chromosomes and were given numbers 1, 2, 3,... respectively.

Observations

The results of observations in 27 taxa were described as follows.

Table 1. Locality and source, chromosome number and number of plants studied

Species	Locality and source	Somatic chromosome number (2n)	No. of plants
Anoectochilus formosanus Hayata	Mt. Omotoyama, Ishigaki C. Okinawa Pref.	40	1
Goodyera foliosa (Lindl.) Benth. var. *commelinoides* (Fukuyama) F. Maekawa	Yaku-cho, Yakushima Isl. Kagoshima Pref.	56	2
		56+2B	2
	Mt. Omotoyama, Ishigaki C. Okinawa Pref.	56	1
G. foliosa (Lindl.) Benth. var. *laevis* Finet	Nopporo, Sapporo C., Hokkaido Dist.	28	2
	Mt. Hayasemori, Owani-cho, Aomori Pref.	28	2
	Mt. Iwatesan, Morioka C., Iwate Pref.	28	1
	Mt. Tateyama, Toyama Pref.	28	1
	Mt. Togakushiyama, Nagano Pref.	28	3
	Ishiyama, Otsu C., Shiga Pref.	56	2
	Mt. Mikawayama, Kazumi-cho, Hyogo Pref.	56	1
	Mt. Oginosen, Onsen-cho, Hyogo Pref.	28	3
	Hongu-cho, Wakayama Pref.	56	1
	Kozagawa-cho, Wakayama Pref.	56	1
	Ashizu, Chizu-cho, Tottori Pref.	28	3
	Mt. Daisen, Tottori Pref.	28	5
	Mt. Kamihirusen, Yatsuka-mura, Okayama Pref.	28	3
	Mt. Sanbesan, Oda C., Shimane Pref.	56	9
	Mt. Tateeboshiyama, Saijo-cho, Hiroshima Pref.	28	14
	Mt. Oyorogiyama, Takano-cho, Hiroshima Pref.	28	7
	Mt. Garyuzan, Geihoku-cho, Hiroshima Pref.	56	3
	Mt. Jipposan, Yoshiwa-mura, Hiroshima Pref.	56	4
	Mt. Kanmuriyama, Yoshiwa-mura, Hiroshima Pref.	56	12
	Ugakyo, Asa-cho, Hiroshima Pref.	56	5
	Mt. Togosan, Yuki-cho, Hiroshima Pref.	56	4
	Nukui, Kake-cho, Hiroshima Pref.	56	5
	Nebutani, Tsutsuga-mura, Hiroshima Pref.	56	1
	Tanoshiri, Tsutsuga-mura, Hiroshima Pref.	56	3
	Mt. Jakuchisan, Nishiki-cho, Yamaguchi Pref.	56	2
	Deai, Tokuji-cho, Yamaguchi Pref.	56	5
	Rokkenjaya, Yamaguchi C. Yamaguchi Pref.	56	4

Table 1. continued

	Otoshi, Niihama C., Ehime Pref.	56	4
	Mt. Yokogurayama, Ochi-cho, Kochi Pref.	56	2
	Shimonanokawa, Agawa-mura Kochi Pref.	56	2
G. hachijoensis Yatabe var. *hachijoensis*	Hachijojima Isl., Tokyo, Metrop.	28	1
G. hachijoensis Yatabe var. *leuconeura* (F. Maekawa) Ohwi	Yaku-cho, Yakushima Isl., Kagoshima Pref.	28	4
G. hachijoensis Yatabe var. *matsumurana* (Schltr.) Ohwi	Okinoerabujima Isl., Kagoshima Pref.	28	1
	Iriomotejima Isl., Okinawa Pref.	28	1
G. hachijoensis Yatabe var. *yakushimensis* (Nakai) Ohwi	Kamikoshikijima Isl. Kagoshima Pref.	28	1
	Yaku-cho, Yakushima Isl., Kagoshima Pref.	28	7
G. macrantha Maxim.	Mt.Takagoyama Kimitsu C., Chiba Pref.	28	1
		28+1B	3
		28+2B	2
		28+3B	3
		28+4B	1
	Kozagawa-cho, Wakayama Pref.	28+3B	1
	Yamano, Fukuyama C., Hiroshima Pref.	28	1
		28+1B	7
		28+2B	7
		28+3B	1
		28+4B	1
	Mt. Koshosan, Kaho-cho, Fukuoka Pref.	28+2B	2
	Sotaro, Ume-cho, Oita Pref.	28	3
		28+2B	1
	Mt. Osuzuyama, Tsuno-cho, Miyazaki Pref.	28+2B	1
		28+5B	1
G. oblongifolia Raf.	North America (commercial source)	30	2
G. pendula Maxim.	Sandankyo, Togochi-cho, Hiroshima Pref.	30	1
	Mt. Inugadake, Tsuiki-cho, Fukuoka Pref.	30	1
	Yaku-cho, Yakushima Isl., Kagoshima Pref.	30	3
G. procera (Ker-Gawl.) Hook.	Mt. Komidake, Iriomote Isl. Okinawa Pref.	42	2
G. pubescens (Willd.) R.Br.	North America, (commercial source)	26	2
G. repens (Linn.) R.Br.	Mt. Fuji, Narusawa-mura, Yamanashi Pref.	30	2

Table 1. continued

G. schlechtendaliana Reichb.f.	Mt. Hayasemori, Owani-cho, Aomori Pref.	30	1
	Mt. Kiyosumiyama, Amatsuko-minato-cho, Chiba Pref.	30	1
	Mt. Fuji, Narusawa-mura, Yamanashi Pref.	30	2
	Mt. Hieizan, Otsu C., Shiga Pref.	30	1
	Mt. Mikawayama, Kazumi-cho, Hyogo Pref.	30	1
	Oto-mura, Wakayama Pref.	30	1
		60	1
	Yodo, Saji-mura, Tottori Pref.	30	2
	Chizu-cho, Tottori Pref.	30	1
	Mt. Daisen, Tottori Pref.	30	1
	Mt. Sanbesan, Oda. C., Shimane Pref.	30	2
	Yamano, Fukuyama C., Hiroshima Pref.	30	1
	Sandankyo, Togochi-cho, Hiroshima Pref.	30	1
	Asaminami-ku, Hiroshima C., Hiroshima Pref.	30	1
	Mt. Arataniyama, Hiroshima C., Hiroshima Pref.	60	2
	Mt. Kanmuriyama, Yoshiwa-mura, Hiroshima Pref.	30	1
	Miyajima Isl., Hiroshima Pref.	30	1
	Shuho-cho, Yamaguchi Pref.	30	2
	Nomura-cho, Ehime Pref.	60	1
	Umaji-mura, Kochi Pref.	30	1
	Tagawa-cho, Fukuoka Pref.	30	2
	Mt. Koshosan, Kaho-cho, Fukuoka Pref.	60	1
	Izuhara-cho, Tsushima Isl., Nagasaki Pref.	30	1
	Sotome-cho, Nagasaki Pref.	30	1
	Kamikoshikijima Isl., Kagoshima Pref.	30	2
	Kamiyaku-cho, Yakushima Isl. Kagoshima Pref.	30	1
G. velutina Maxim.	Mt. Kiyosumiyama, Amatsuko-minato-cho, Chiba Pref.	28	1
	Mt. Kasugayama, Nara C., Nara Pref.	56	1
	Sukumo C., Kochi Pref.	28	2
		56	1
	Mt. Inugadake, Tsuiki-cho, Fukuoka Pref.	28	3
	Mt. Koshosan, Kaho-cho, Fukuoka Pref.	56	3
	Mt. Taterayama, Tsushima Isl., Nagasaki Pref.	56	2
	Yaku-cho, Yakushima Isl., Kagoshima Pref.	28	2
G. viridiflora (Bl.) Bl.	Kamiyaku-cho, Yakushima Isl., Kagoshima Pref.	22	1

Table 1. continued

	Yaku-cho, Yakushima Isl., Kagoshima Pref.	22	3
Hetaeria rubens (Lindl.) Benth.	Commercial source	24	1
H. sikokiana (Makino et F. Maekawa) Tuyama	Sandankyo, Togochi-cho, Hiroshima Pref.	42	2
H. yakusimensis Masamune	Kamiyaku-cho, Yakushima Isl., Kagoshima Pref.	42	3
	Yaku-cho, Yakushima Isl., Kagoshima Pref.	42	1
Macodes petola (Bl.) Lindl.	Mt. Gozadake, Iriomote-jima Isl., Okinawa Pref.	42	2
Myrmechis japonica (Reichb.f.) Rolfe	Mt. Kurohimeyama, Shinano-cho, Nagano Pref	56	1
	Mt. Fuji, Narusawa-mura, Yamanashi Pref.	56	1
M. tsukusiana Masamune	Mt. Kuromidake, Yakushima Isl., Kagoshima Pref.	28	2
Odontochilus inabai Hayata	Mt. Marun, Taichun Pref., Taiwan, China	28	1
Vexillabium yakushimense (Yamamoto) F. Maekawa	Yaku-cho, Yakushima Isl., Kagoshima Pref.	26	4
Zeuxine agyokuana Fukuyama	Kamiyaku-cho, Yakushima Isl., Kagoshima Pref.	20	2
	Yaku-cho, Yakushima Isl., Kagoshima Pref.	20	2
Z. leucochila Schltr.	Yaku-cho, Yakushima Isl., Kagoshima Sref.	20	2
Z. odorata Fukuyama	Mitsuishi, Kubera, Yonaguni, Okinawa Pref.	40	1

I. *Anoectochilus*

1. *Anoectochilus formosanus* Hayata, 2n = 40, Japanese Name: Kibana-shusu-ran, Tables 1 and 2, Fig. 1.

Observations were made in a plant collected in Okinawa Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plant were similar to those of this species described by Hatusima (1975).

The chromosome number of the plant was 2n = 40 at mitotic prophase and metaphase which confirmed the previous report on this taxon treated previously as *Anoectochilus tetsuoi* (Tanaka 1965b) but was different from the previous count of n = 12 reported by Hsu (1971).

The chromosomes at resting stage were observed as numerous chromomeric granules, fibrous threads scattered throughout the nucleus and conspicuous chromatin blocks. The chromatin blocks varied in diameter of the long axis from 0.5−3.0 μm and round-, rod- and string-shaped with smooth or rough surface. The chromatin blocks showed a slight variability in size, shape and number among the nuclei. The most common type of the nucleus showed about 20 chromocentric bodies. Thus, the chromosome feature at resting stage was of the chromocenter type in a large sense and were regarded as the intermediate type between the simple chromocenter type and the complex chromocenter type according to the definition proposed by Tanaka (1971). At mitotic prophase, among the 40 chromosomes of

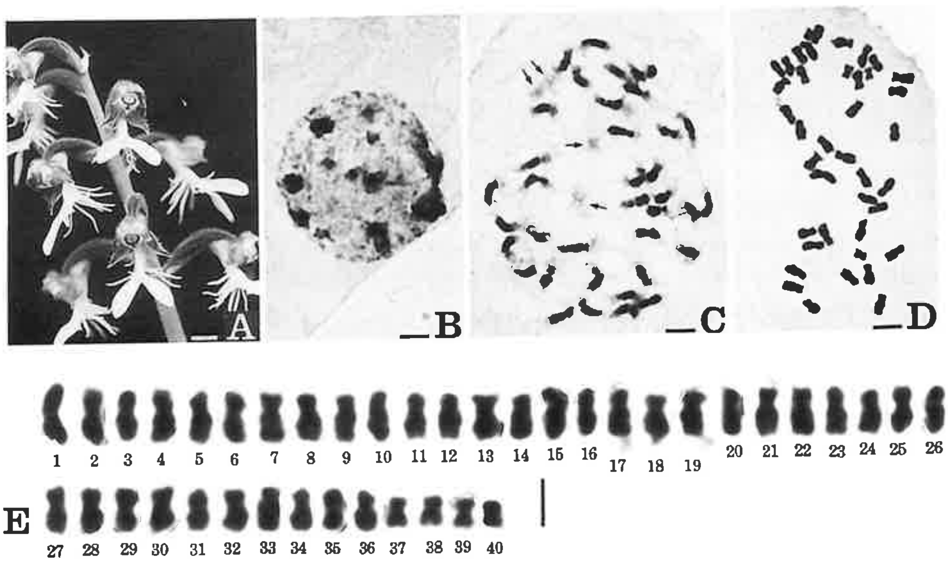

Fig. 1. *Anoectochilus formosanus*, 2n = 40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Arrows indicate the deheterochromatinized chromosomes. Bars indicate 4 mm in A and 2.0μm in B-E.

the complement, 36 chromosomes had early condensed segments in the proximal regions of both arms and differentiated clearly to late condensed segments. The other four chromosomes were slightly shorter than the former 36 chromosomes and had no early condensed segments (Fig. 1. C).

The 2n=40 chromosome set at mitotic metaphase consisted of 36 chromosomes which showed a degradation in length from the longest (2.4 μm) to the shortest (1.4 μm) chromosomes in length and four slightly smaller chromosomes which varied in length from 1.1−1.0 μm. These small chromosomes seemed to correspond to those without early condensed segments at prophase and were known to be morphologically identical to the deheterochromatinized chromosomes in *Spiranthes sinensis* reported by Tanaka (1969). The average chromosome length was 1.7 μm. Among the 40 chromosomes of the complement, 13 were median centromeric with arm ratios varying between 1.0 and 1.5. The other 27 chromosomes were submedian centromeric with arm ratios between 1.8 and 2.6. Three chromosomes (Nos. 17, 18, 19) had lightly stained satellites at the terminal regions of their long arms.

The 2n=40 chromosome complement at mitotic metaphase showed a gradual karyotype due to the gradual decrease of the chromosome length from the longest to the shortest chromosomes and a symmetric karyotype due to arm ratio.

II. *Goodyera*

1. *Goodyera foliosa* (Lindl.) Benth. var. *commelinoides* (Fukuyama) F. Maekawa, 2n=56 and 2n=56+2B, Japanese Name: Tsuyukusa-shusu-ran, Tables 1, 3 and 4, Figs. 2 and 3.

Observations were made in four plants collected in Kagoshima Prefecture and a plant collected in Okinawa Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this variety described by Ohwi and Kitagawa (1983).

The chromosome numbers observed at mitotic prophase and metaphase were 2n=56 in two plants from Kagoshima Prefecture and one from Okinawa and 2n=58 in the other two from Kagoshima Prefecture. These chromosome numbers were determined here for this variety for the first time.

(1) The plants with 2n=56 chromosomes. Tables 1 and 3, Fig. 2.

The chromosomes at resting stage were observed as numerous chromomeric granules, fibrous threads scattered throughout the nucleus and conspicuous chromatin blocks. The chromatin blocks varied in diameter of the long axis from 0.5−1.5 μm and round- and rod-shaped with smooth surface. The chromatin blocks showed slight variability in size, shape and number among the nuclei. The most common type of the nucleus showed about 50 prochromosomal bodies. Thus, the chromosome feature at resting stage was of the prochromosome type according to the definition proposed by Tanaka (1971).

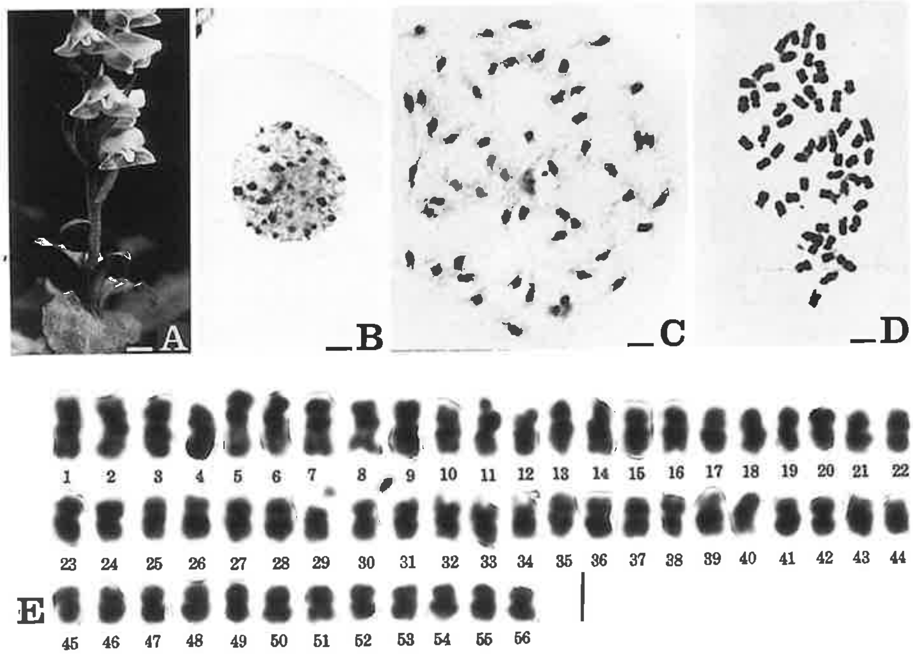

Fig. 2. *Goodyera foliosa* var. *commelinoides*, 2n=56. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 5 mm in A and 2 μm in B-E.

At mitotic prophase, all of the 56 chromosomes had early condensed segments. The early condensed segments were located in the proximal regions and differentiated clearly to late condensed segments.

The 2n=56 chromosome set at mitotic metaphase showed a gradual decrease in length from the longest (2.4 μm) to the shortest (1.1 μm) chromosomes. The average chromosome length was 1.5 μm. Among the 56 chromosomes of the complement, 39 were median centromeric with arm ratios varying between 1.0 and 1.7 and 15 were submedian centromeric with arm ratios between 1.8 and 2.8. The other two chromosomes were subterminal centromeric with the arm ratios of 3.2 and 4.0. Four chromosomes (Nos. 5, 6, 7, 8) had secondary constrictions at the interstitial regions of their long arms and another four (Nos. 11, 12, 29, 30) had satellites at the terminal regions of their short arms, respectively.

Thus, the 2n=56 chromosome complement at mitotic metaphase formed a gradual and symmetric karyotype.

(2) The plants with 2n=58 chromosomes. Tables 1 and 4, Fig. 3.

The chromosome morphology at resting stage and mitotic prophase were similar to those of the 2n=56 plants. Two out of the 58 chromosomes at prophase morphologically similar to one another were condensed earlier than the others and were seemed to be made

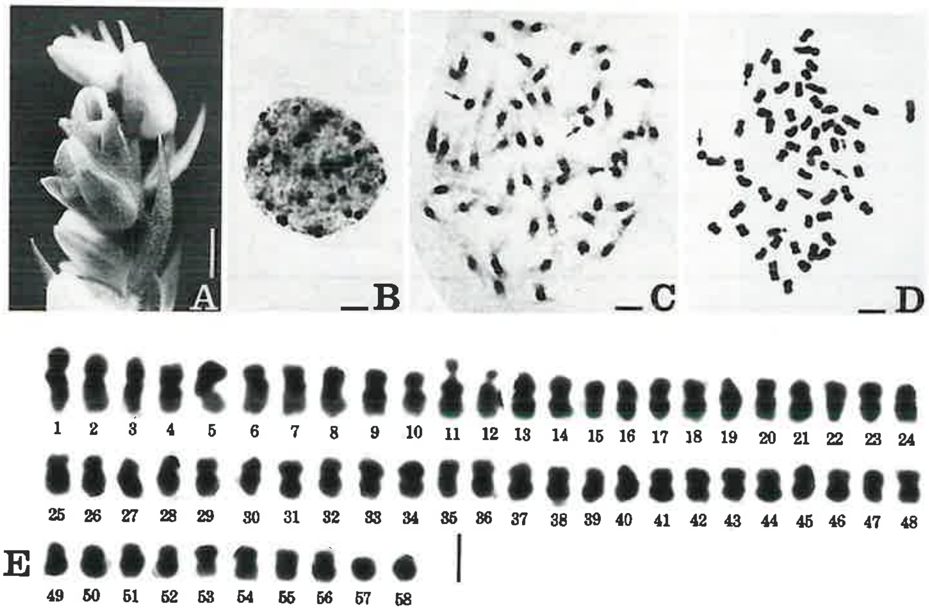

Fig. 3. *Goodyera foliosa* var. *commelinoides*, 2n = 56 + 2B. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Arrows indicate B-chromosomes. Bars indicate 4 mm in A and 2μm in B-E.

of heterochromatin.

The 2n=58 chromosome complement at mitotic metaphase exhibited a gradual decrease in length from the longest (2.3 μm) to the shortest (0.9 μm) chromosomes. The average chromosome length was 1.4 μm. Among the 2n=58 chromosomes of the complement, 37 were median centromeric with arm ratios varying between 1.0 and 1.6, and 18 were submedian centromeric with arm ratios between 1.8 and 2.8. The other one was subterminal centromeric with the arm ratio of 3.2. Two chromosomes (Nos. 57 and 58) were smaller than the other 56 chromosomes and had no constriction. Two small chromosomes observed in these plants could be regarded as B-chromosome based on their morphology at mitotic prophase and metaphase. Four chromosomes (Nos. 5, 6, 7, 8) had secondary constrictions at the interstitial regions of their long arms, and another two (Nos. 11 and 12) had satellites at the terminal regions of their short arms. Thus, the 2n=58 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

2. *Goodyera foliosa* (Lindl.) Benth. var. *laevis* Finet, 2n = 28 and 2n = 56, Japanese Name: Akebono-shusu-ran, Tables 1, 5 and 6, Figs. 4 and 5.

Observations were made in 114 plants collected in Hokkaido and other 29 localities in Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this variety described by Ohwi and Kitagawa (1983).

The chromosome numbers observed at mitotic prophase and metaphase were 2n=28 in 44 plants from 11 localities and 2n=56 in 70 plants from 19 localities. This result confirmed the previous reports in this taxon treated previously as *G. maximowicziana* Makino (Mutsuura 1959, Mutsuura and Nakahira 1959, Tanaka 1965a), but was different from the previous count of 2n=42 reported by Miduno (1939).

(1) The plants with 2n=28 chromosomes. Tables 1 and 5, Fig. 4.

The chromosome morphology at resting stage and mitotic prophase were similar to those of *G. foliosa* var. *commelinoides* (2n=56).

The 2n = 28 chromosome complement at mitotic metaphase performed a gradual decrease in length from the longest (3.1 μm) to the shortest (1.5 μm) chromosomes. The average chromosome length was 2.1 μm. Among the 28 chromosomes in the complement, 18 were median centromeric with arm ratios varying between 1.0 and 1.6, while the other ten were submedian centromeric with arm ratios between 1.8 and 2.7. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions of their long arms and two (Nos. 5 and 6) had satellites at the terminal regions of their short arms.

Thus, the 2n=28 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

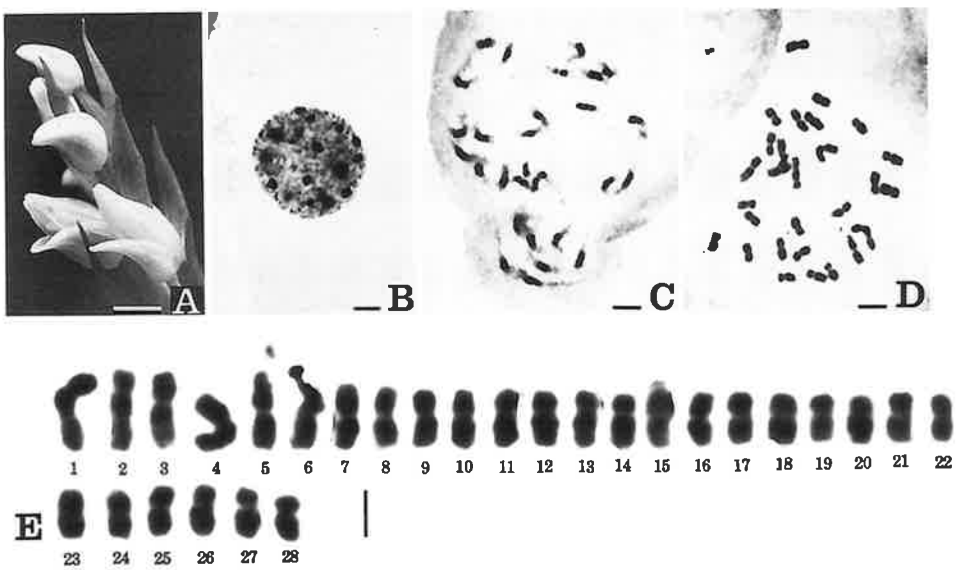

Fig. 4. *Goodyera foliosa* var. *laevis*, 2n=28. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 4 mm in A and 2 μm in B-E.

(2) The plants with 2n=56 chromosomes. Tables 1 and 6, Fig. 5.

The chromosome morphology at resting stage and mitotic prophase were similar to those of the 2n = 28 plants. The 2n = 56 chromosome complement at mitotic metaphase showed a gradual decrease in length from the longest (2.3 μm) to the shortest (1.1 μm) chromosomes. The average chromosome length was 2.1 μm. Among the 56 chromosomes in the complement, 40 were median centromeric with arm ratios varying between 1.0 and 1.7, while 16 were submedian centromeric with arm ratios between 1.8 and 3.0. Four chromosomes (Nos. 1, 2, 3, 4) had secondary constrictions at the interstitial regions of their long arms and another four (Nos, 13, 14, 15, 16) had satellites at the terminal regions of their short arms.

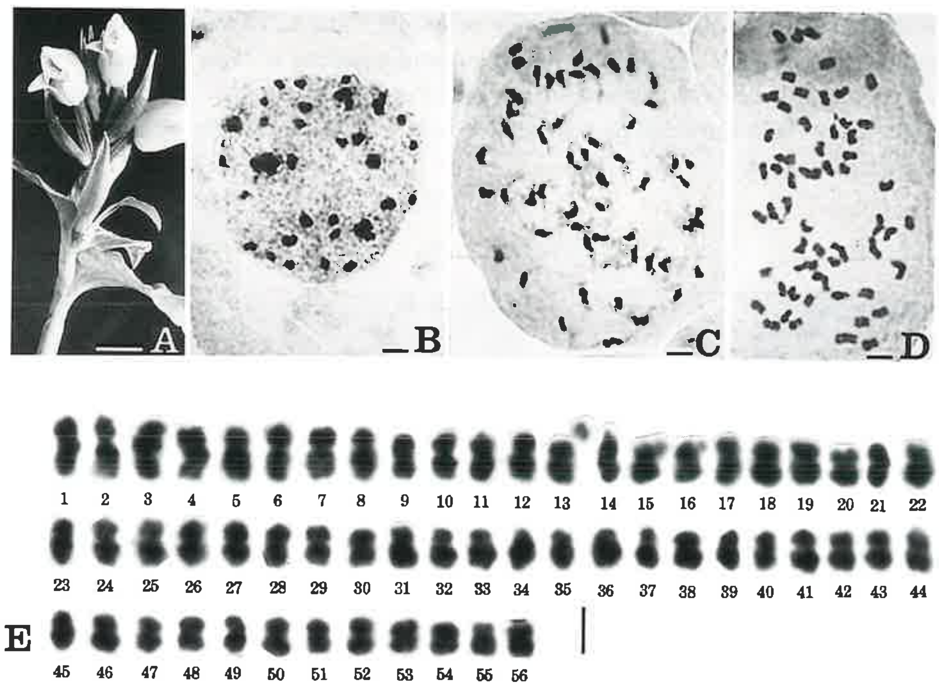

Fig. 5. *Goodyera foliosa* var. *laevis*, 2n=56. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 7 mm in A and 2 μm in B-E.

Thus, the 2n=56 chromosome complement at mitotic metaphase formed a gradual and symmetric karyotype.

3. *Goodyera hachijoensis* Yatabe var. *hachijoensis*, 2n = 28, Japanese Name: Hachijo-shusu-ran, Tables 1 and 7, Fig. 6.

Observations were made in a plant collected in Tokyo, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plant were similar to those of this type variety described by Ohwi and Kitagawa (1983).

The chromosome number of the plant was 2n = 28 at mitotic prophase and metaphase which confirmed the previous reports (Miduno 1939, Tanaka 1965b).

The chromosomes at resting stage were quite similar in morphology to those of *G. foliosa* var. *commelinoides* (2n = 56) excepting this taxon showed numerous small chromatin blocks and darkly stained chromomeric granules and fibrous threads.

The chromosome morphology at mitotic prophase was quite similar to those of *G. foliosa* var. *commelinoides* (2n = 56) excepting early condensed segments were observed at the proximal and terminal regions of several chromosomes in the complement in this taxon.

The 2n = 28 chromosome complement at mitotic metaphase showed a gradual decrease in length from the longest (3.1 μm) to the shortest (1.5 μm) chromosomes. The average chromosome length was 2.1 μm. Among the 28 chromosomes of the complement, 21 were median centromeric with arm ratios between 1.0 and 1.7, six were submedian centromeric with arm ratios between 1.8 and 2.8, and the other one was subterminal centromeric with the arm ratio of 3.2. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the

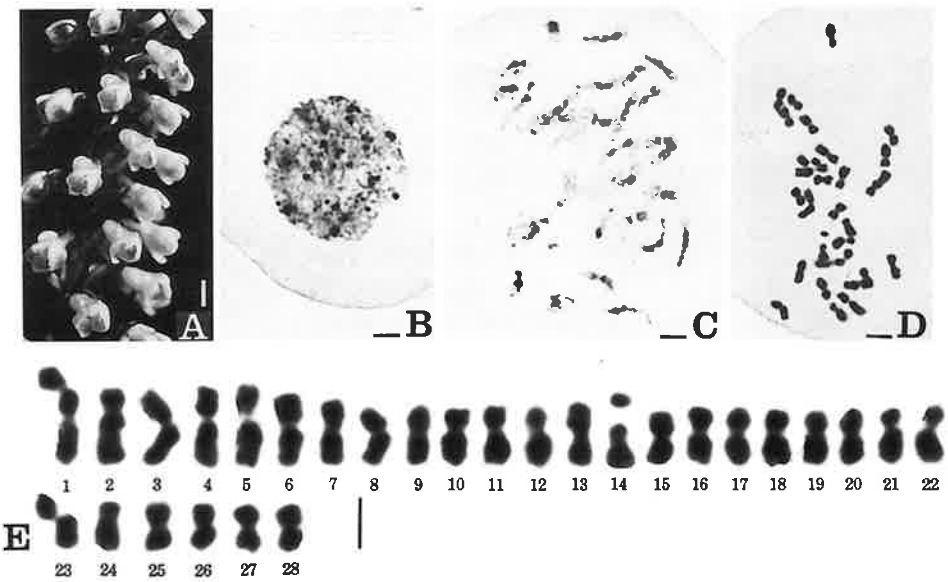

Fig. 6. *Goodyera hachijoensis* var. *hachijoensis*, 2n = 28. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 7 mm in A and 2 μm in B-E.

interstitial regions of their long arms, while two chromosomes (Nos. 13 and 14) had satellites at the terminal regions of their short arms.

Thus, the 2n=28 chromosome complement at mitotic metaphase formed a gradual and symmetric karyotype.

4. ***Goodyera hachijoensis*** **Yatabe var.** ***leuconeura*** **(F. Maekawa) Ohwi, 2n=28, Japanese Name: Shiraito-shusu-ran, Tables 1 and 8, Fig. 7.**

Observations were made in four plants collected in Kagoshima Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this variety described by Ohwi and Kitagawa (1983).

The chromosome number of the plants was 2n=28 at mitotic prophase and metaphase which confirmed Tanaka (1965b).

The chromosome morphology at resting stage and mitotic prophase were similar to those of the type variety of this species described above.

The 2n=28 chromosome complement at mitotic metaphase displayed a gradual decrease in length from the longest (3.5 μm) to the shortest (1.6 μm) chromosomes. The average chromosome length was 2.2 μm. Among the 28 chromosomes of the complement, 20 were median centromeric with arm ratios between 1.0 and 1.7 and the other eight were submedian centromeric with arm ratios between 2.0 and 2.5. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions of their long arms, while another two

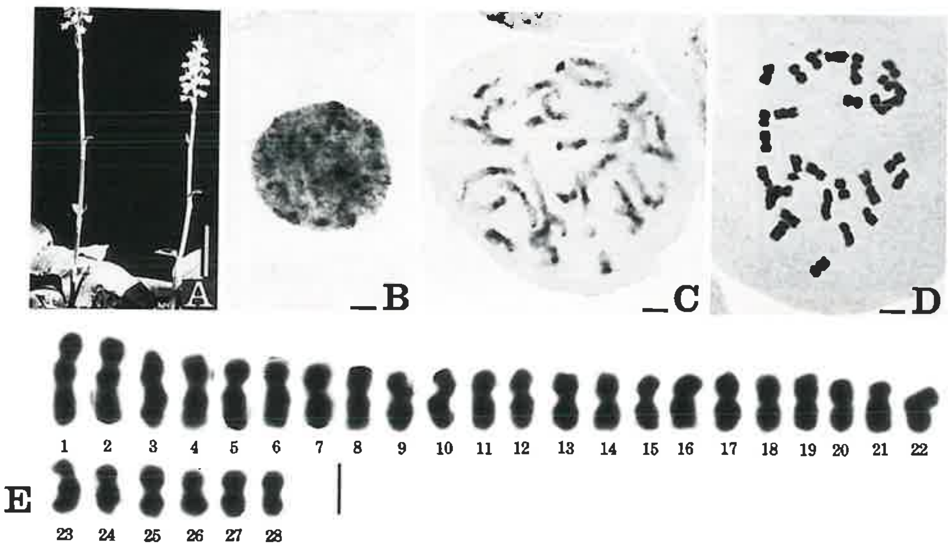

Fig. 7. *Goodyera hachijoensis* var. *leuconeura*, 2n=28. A, plants. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 30 mm in A and 2 μm in B-E.

(Nos. 9 and 10) had satellites at the terminal regions of their short arms.

Thus, the 2n=28 chromosome complement at mitotic metaphase formed a gradual and symmetric karyotype.

5. *Goodyera hachijoensis* Yatabe var. *matsumurana* (Schltr.) Ohwi, 2n = 28, Japanese Name: Kagome-ran, Tables 1 and 9, Fig. 8.

Observations were made in two plants collected in Kagoshima and Okinawa Prefectures, Japan. Morphological features of leaves, shoots, rhizomes and flowers of these plants were similar to those of this variety described by Ohwi and Kitagawa (1983).

The chromosome number of these plants was 2n=28 which confirmed previous reports on this taxon treated previously as *G. matsumurana* Schltr. (Miduno 1939, Tanaka 1965b).

The chromosome morphology at resting stage and mitotic metaphase were similar to those of the type variety of this species described above.

The 2n = 28 chromosome complement at mitotic metaphase performed a gradual decrease in length from the longest (2.9 μm) to the shortest (1.4 μm) chromosomes. The average chromosome length was 2.0 μm. Among the 28 chromosomes of the complement, 21 were median centromeric with arm ratios between 1.0 and 1.7, six were submedian centromeric with arm ratios between 1.8 and 3.0 and the other one was subterminal centromeric with the arm ratio of 3.1. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions of their long arms while another two (Nos. 11 and 12) had satellites at the terminal regions of their short arms.

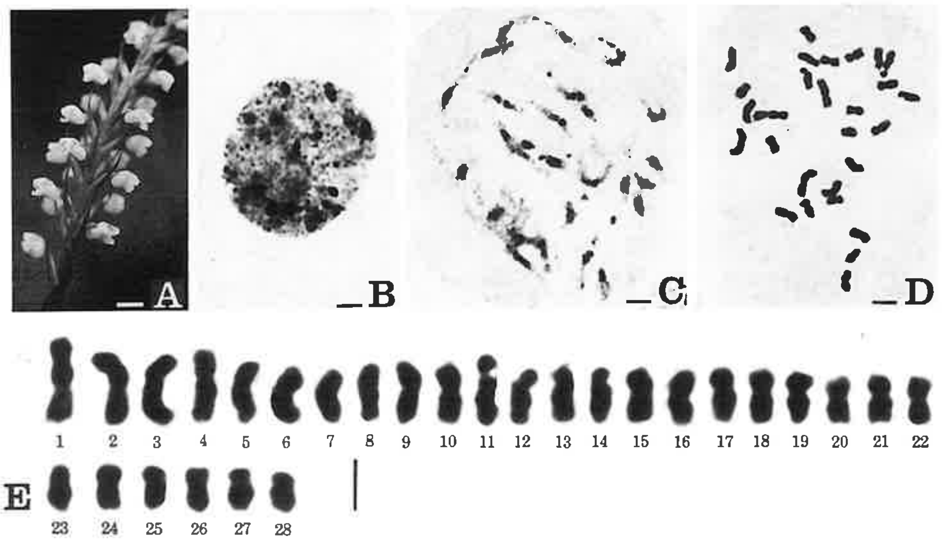

Fig. 8. *Goodyera hachijoensis* var. *matsumurana*, 2n=28. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 6 mm in A and 2 μm in B-E.

Thus, the 2n=28 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

6. *Goodyera hachijoensis* Yatabe var. *yakushimensis* (Nakai) Ohwi, 2n = 28, Japanese Name: Yakushima-shusu-ran, Tables 1 and 10, Fig. 9.

Observations were made in eight plants collected in Kagoshima Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this variety described by Ohwi and Kitagawa (1983).

The chromosome number of these plants was 2n=28 at mitotic prophase and metaphase which confirmed Tanaka (1965b).

The chromosome morphology at resting stage and mitotic prophase were similar to those of the type variety of this species described above.

The 2n=28 chromosome complement at mitotic metaphase showed a gradual decrease in length from the longest (3.8 μm) to the shortest (1.6 μm) chromosomes. The average chromosome length was 2.4 μm. Among the 28 chromosomes of the complement, 20 were median centromeric with arm ratios between 1.0 and 1.6, seven were submedian centromeric with arm ratios between 1.8 and 3.0 and the other one was subterminal centromeric with the arm ratio of 3.2.

Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions

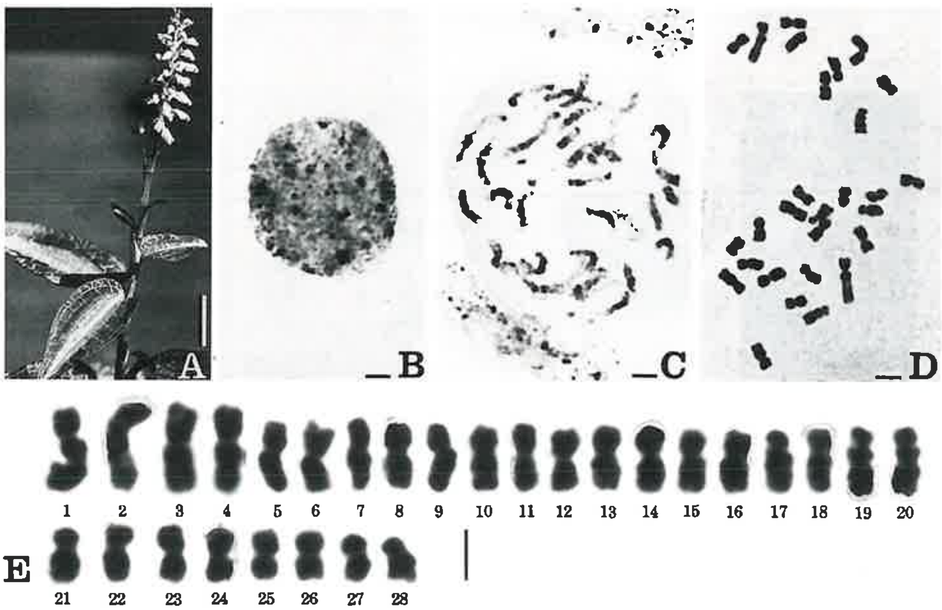

Fig. 9. *Goodyera hachijoensis* var. *yakushimensis*, 2n=28. A, plant. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 13 mm in A and 2 μm in B-E.

of their long arms and another two (Nos. 19 and 20) had satellites at the terminal regions of their short arms.

Thus, the 2n=28 chromosome complement at mitotic metaphase formed a gradual and symmetric karyotype.

7. *Goodyera macrantha* Maxim., 2n = 28 + (0-5B), Japanese Name: Beni-shusu-ran, Tables 1 and 11, Figs. 10 and 11.

Observations were made in 36 plants collected in a locality in Chiba Prefecture and five localities in Prefectures other than Chiba Prefecture. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome numbers observed at mitotic prophase and metaphase were 2n=28 in five plants from three localities, 2n=29 in ten plants from two localities, 2n=30 in 13 plants from five localities, 2n=31 in five plants from three localities, 2n=32 in two plants from two localities and 2n=33 in a plant from a locality. Among these chromosome numbers 2n=30 supported the previous reports (Miduno 1939, Mutsuura and Nakahira 1958, Tanaka 1965b), but the other chromosome numbers were reported here for the first time.

(1) The plants with 2n=28 chromosomes. Tables 1 and 11, Fig. 10.

The chromosome morphology at resting stage and mitotic prophase were similar to those of *G. foliosa* var. *commelinoides* (2n=56).

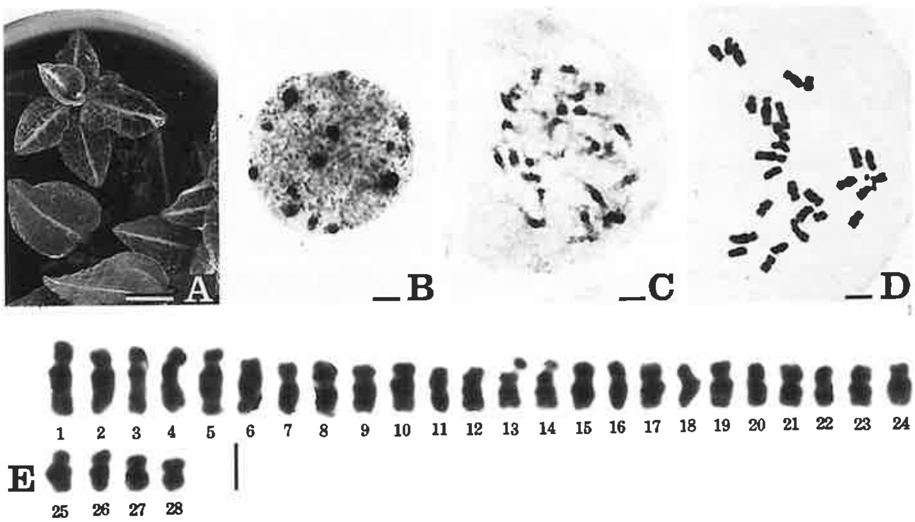

Fig. 10. *Goodyera macrantha*, 2n=28. A, plants. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 15 mm in A and 2 μm in B-E.

The $2n=28$ chromosome complement at mitotic metaphase showed a gradual decrease in length from the longest (2.9 μm) to the shortest (1.4 μm) chromosomes. The average chromosome length was 1.9 μm. Among the 28 chromosomes of the complement, 14 were median centromeric with arm ratios between 1.0 and 1.7, 13 were submedian centromeric with arm ratios between 1.8 and 2.8 and the other one was subterminal centromeric with the arm ratio of 3.6. Four chromosomes (Nos. 1, 2, 3, 4) had secondary constrictions at the interstitial regions of their long arms and another two (Nos. 13 and 14) had satellites at the terminal regions of their short arms.

Thus, the $2n=28$ chromosome set at mitotic metaphase performed a gradual and symmetric karyotype.

(2) The plants with $2n=29$, 30, 31, 32, 33 chromosomes. Table 1, Fig. 11.

The chromosomes at resting stage were similar in morphology to those of *G. foliosa* var. *commelinoides* ($2n=56$) and the chromatin blocks seemed to get larger in proportion to the increase of chromosome numbers (Fig. 11., A, D, G, J, M).

At mitotic prophase the 28 chromosomes of the complement had early condensed segments at the proximal regions. One chromosome in the $2n=29$ plants ($2n=28+1$), two chromosomes in the $2n=30$ plants ($2n=28+2$), three chromosomes in the $2n=31$ plants ($2n=28+3$), four chromosomes in the $2n=32$ plants ($2n=28+4$) and five chromosomes in the $2n=33$ plant ($2n=28+5$) got condensed earlier, respectively (Fig. 11. B, E, H, K, N). These chromosomes were similar in morphology to B-chromosomes in *Tainia laxiflora* reported by Tanaka and Matsuda (1972) and Matsuda and Tanaka (1977). Therefore, the formula of the chromosome number of this species was regarded as $2n=28+$ (0-5B).

8. *Goodyera oblongifolia* Raf., 2n=30, Tables 1 and 12, Fig. 12.

This species is distributed in North America.

Observations were made in two plants propagated commercially. Morphological features of leaves, shoots, rhizomes of the plants were similar to those of this species described by Luer (1975).

The chromosome number of the plants was $2n=30$ which confirmed Kallunki (1981) and supported $n=15$ reported by Taylor and Mulligan (1968) and Pojar (1973), but differed from the previous count of $2n=22$ reported by Löve and Simon (1968).

The chromosome morphology at resting stage and mitotic prophase were similar to those of *G. foliosa* var. *commelinoides* ($2n=56$).

The $2n=30$ chromosome complement at mitotic metaphase exhibited a gradual decrease in length from the longest (2.9 μm) to the shortest (1.4 μm) chromosomes. The average chromosome length was 2.1 μm. Among the 30 chromosomes of the mitotic metaphase complement, 11 were median centromeric with arm ratios between 1.0 and 1.6, 18 were submedian centromeric with arm ratios between 1.8 and 2.8 and the other one was subterminal centromeric with the arm ratio of 3.6. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions of their long arms.

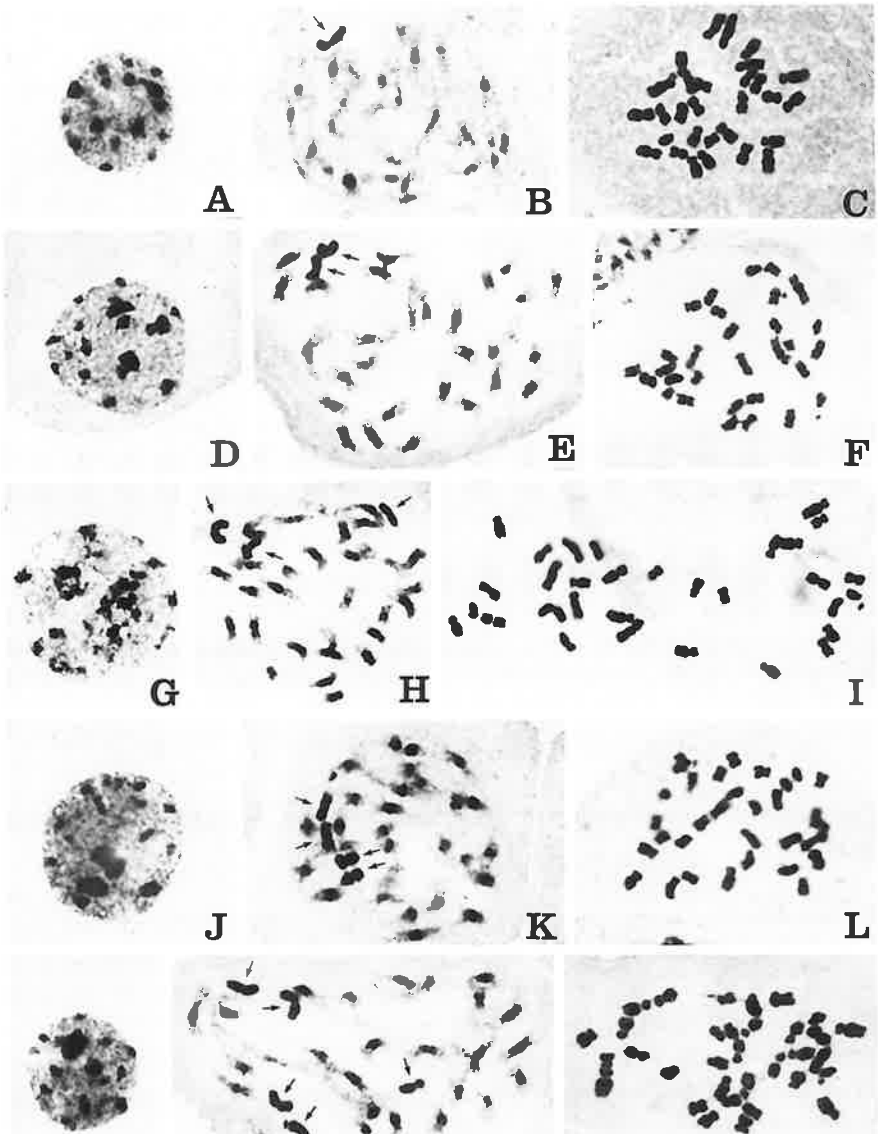

Fig. 11. *Goodyera macrantha*, 2n=28+(1-5B). A-C, 2n=28+1B. D-F, 2n=28+2B. G-I, 2n=28+3B. J-L, 2n=28+4B. M-O, 2n=28+5B. A,D,G,J,M; chromosomes at resting stage. B,E,H,K,N; chromosomes at mitotic prophase. C,F,I,L,O; chromosomes at mitotic metaphase. Arrows indicate B-chromosomes. Bar indicates 2 μm.

Thus, the 2n=30 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

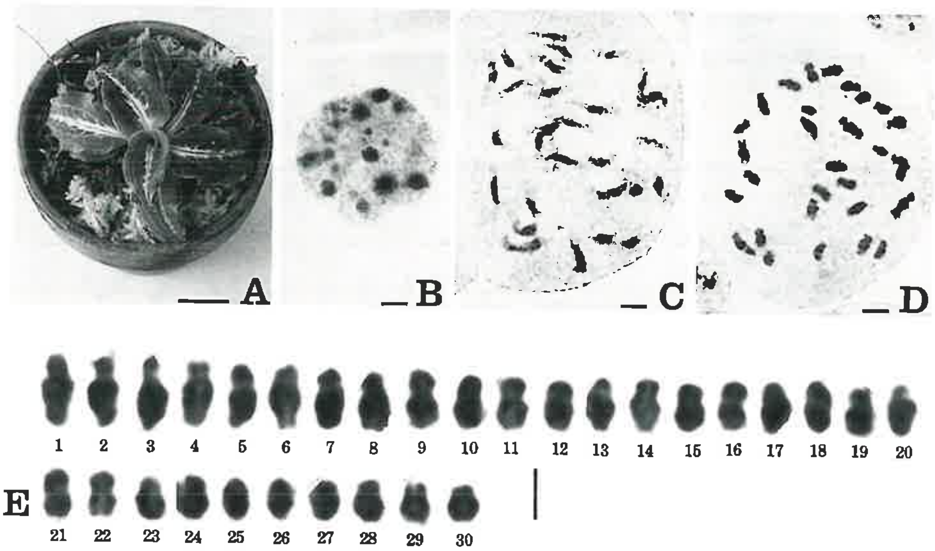

Fig. 12. *Goodyera oblongifolia*, 2n=30. A, plant. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 25 mm in A and 2 μm in B-E.

9. *Goodyera pendula* Maxim., 2n = 30, Japanese Name: Tsuri-shusu-ran, Tables 1 and 13, Fig. 13.

Observations were made in five plants collected in Hiroshima Prefecture and two localities from Prefectures other than Hiroshima Prefecture in Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of these plants was 2n=30 which confirmed the previous report (Tanaka 1965b), but differed from the previous count of 2n=28 reported by Mutsuura and Nakahira (1960).

The chromosome morphology at resting stage and mitotic prophase were similar to those of *G. foliosa* var. *commelinoides* (2n=56).

The 2n = 30 chromosome complement at mitotic metaphase exhibited a bimodality in length with a group of the chromosomes between 4.1 and 4.0 μm and the other group between 3.4 and 1.3 μm. The average chromosome length was 2.1 μm. Among the 30 chromosomes of the mitotic metaphase complement, 21 were median centromeric with arm ratios between 1.0 and 1.7, seven were submedian centromeric with arm ratios between 1.8 and 3.0 and the other two were subterminal centromeric with the arm ratios of 4.0 and 4.1. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions of their

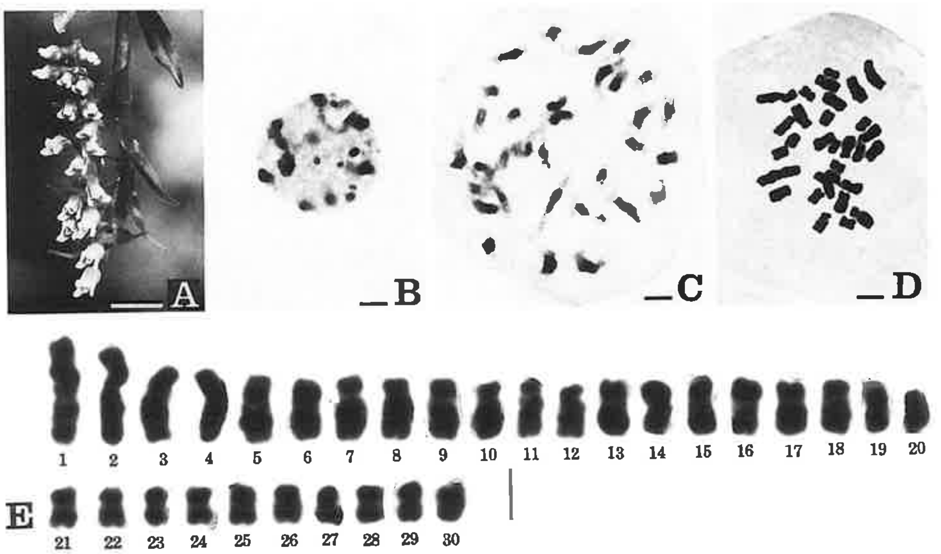

Fig. 13. *Goodyera pendula*, 2n=30. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 6 mm in A and 2 μm in B-E.

long arms, while another two chromosomes (Nos. 11 and 12) had satellites at the terminal regions of their short arms.

Thus, the 2n=30 chromosome complement at mitotic metaphase showed a bimodal and symmetric karyotype.

10. ***Goodyera procera*** **(Ker-Gawl.) Hook., 2n=42, Japanese Name: Kingin-so, Tables 1 and 14, Fig. 14.**

Observations were made in two plants collected in Okinawa Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of the plants was 2n=42 at mitotic prophase and metaphase which confirmed Miduno (1939) and Tanaka (1965b) but was different from the previous count of n=11 reported by Afzelius (1943).

The chromosome morphology at resting stage and mitotic prophase were similar to those of *G. hachijoensis* var. *hachijoensis*.

The 2n=42 chromosome complement at mitotic metaphase showed a gradual decrease in length from the longest (2.1 μm) to the shortest (1.0 μm) chromosomes. The average chromosome length was 1.5 μm. Among the 42 chromosomes of the metaphase complement, 23 were median centromeric with arm ratios between 1.1 and 1.7, 18 were submedian centromeric with arm ratios between 1.8 and 3.0 and the other one was subterminal centromeric with the arm ratio of 3.2.

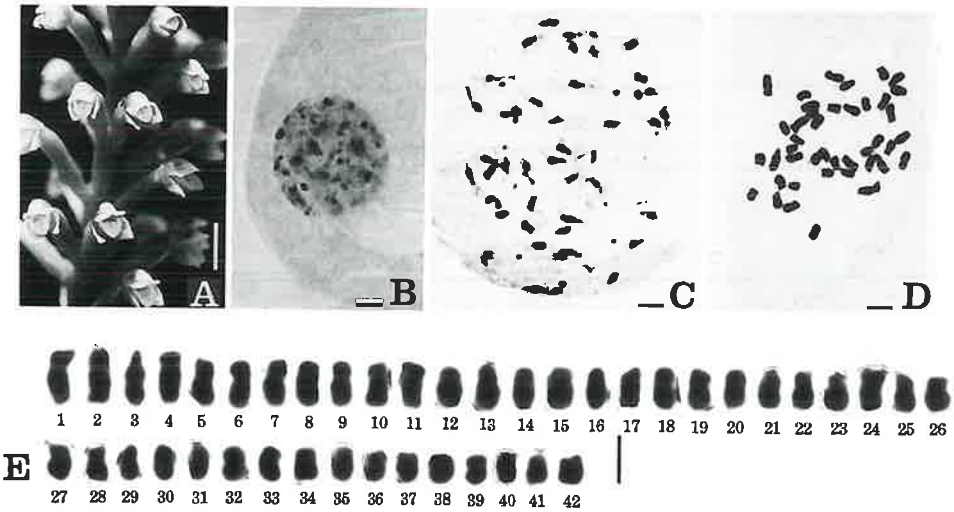

Fig. 14. *Goodyera procera*, 2n=42. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 4 mm in A and 2 μm in B-E.

Thus, the 2n=42 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

11. *Goodyera pubescens* (Willd.) R. Br., 2n=26, Tables 1 and 15, Fig. 15.

This species is distributed in North America.

Observations were made in two plants propagated commercially. Morphological features of leaves, shoots and rhizomes of the plants were similar to those of this species described by Luer (1975).

The chromosome number of the plants was 2n=26 which confirmed Kallunki (1981) and supported the previous count of n=13 reported by Bostick (1965).

The chromosome morphology at resting stage and mitotic prophase were similar to those of *G. foliosa* var. *commelinoides* (2n=56).

The 2n=26 chromosome complement at mitotic metaphase exhibited a gradual decrease in length from the longest (3.1 μm) to the shortest (1.5 μm) chromosomes. The average chromosome length was 2.3 μm. Among the 26 chromosomes of the metaphase complement, 17 were median centromeric with arm ratios between 1.0 and 1.7, eight were submedian centromeric with arm ratios between 1.8 and 2.4 and the other one was subterminal centromeric with the arm ratio of 3.1. Four chromosomes (Nos. 1, 2, 7, 8) had secondary constrictions at the interstitial regions of their long arms and two (Nos. 17 and 18) had satellites at the terminal regions of their long arms.

Thus, the 2n=26 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

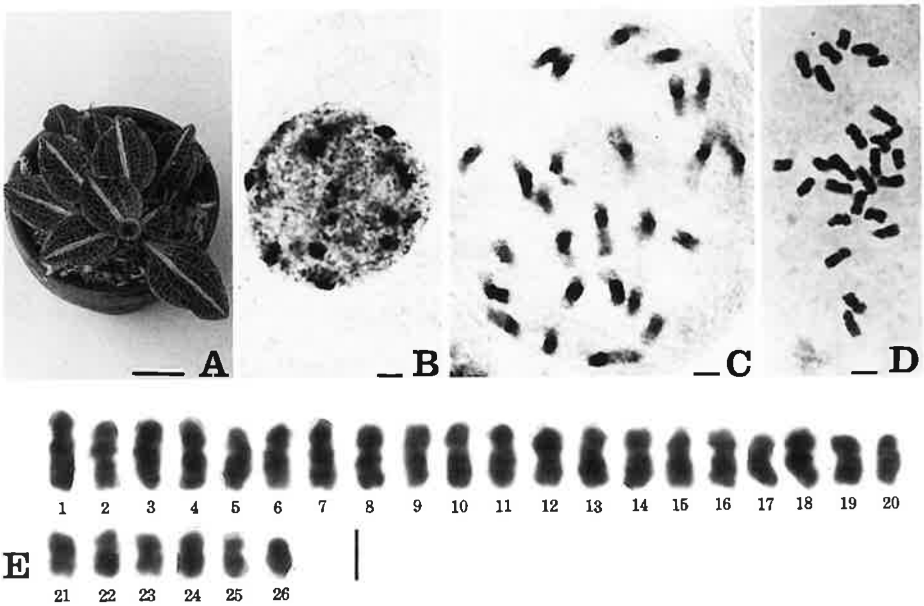

Fig. 15. *Goodyera pubescens*, 2n=26. A, plant. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 25 mm in A and 2 μm in B-E.

12. *Goodyera repens* (Linn.) R. Br., 2n = 30, Japanese Name: Hime-miyama-uzura, Tables 1 and 16, Fig. 16.

Observations were made in two plants collected in Yamanashi Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of the plants was 2n=30 at mitotic prophase and metaphase which confirmed Richardson (1935), Löve and Löve (1944, 1954), Mutsuura and Nakahira (1959), Gadella and Kliphuis (1963), Kliphuis (1963), Vij and Gupta (1975), Mehra and Pandita (1979) and Vij *et al.* (1981) and which supported the previous count of n=15 reported by Richardson (1935), Kliphuis (1963), Mehra and Bawa (1970) and Vij and Gupta (1975), but which was different from the previous counts of 2n=28 and 2n=32 reported by Eftimiu-Heim (1941) and 2n=32 by Tanaka (1965b), Mehra and Bawa (1970) and Schotsman (1970).

The chromosome morphology at resting stage of this species was similar to that of *G. hachijoensis* var. *hachijoensis*.

The chromosomes at mitotic prophase were similar in morphology to those of *G. foliosa* var. *commelinoides* (2n=56).

The 2n=30 chromosome complement at mitotic metaphase performed bimodality with a group of the chromosomes which varied in length from 4.6 to 4.5 μm and the other group

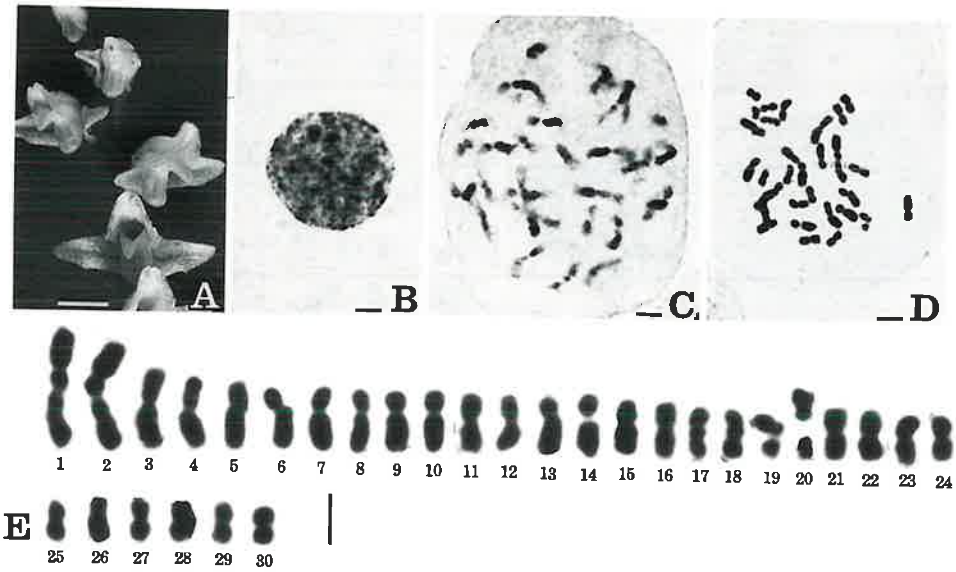

Fig. 16. *Goodyera repens*, 2n = 30. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 4 mm in A and 2 μm in B-E.

of the chromosomes which varied in length from 3.1 to 1.5 μm. The average chromosome length was 2.2 μm. Among the 30 chromosomes of the metaphase complement, 22 were median centromeric with arm ratios between 1.0 and 1.7 and eight were submedian centromeric with arm ratios between 1.8 and 2.2. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions of their long arms, while another two (Nos. 19 and 20) had satellited secondary constrictions in their long arms.

Thus, the 2n = 30 chromosome complement at mitotic metaphase formed a bimodal and symmetric karyotype.

13. *Goodyera schlechtendaliana* Reichb. f., 2n = 30 and 2n = 60, Japanese Name: Miyama-uzura, Tables 1, 17 and 18, Figs. 17 and 18.

Observations were made in 33 plants collected in Aomori Prefecture and 24 localities in other than Aomori Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome numbers observed at mitotic prophase and metaphase were 2n = 30 in 28 plants from 22 localities and 2n = 60 in five plants from four localities. While the former chromosome number of 2n = 30 confirmed the previous reports (Mutsuura and Nakahira 1958, Shoji 1963, Tanaka 1965b), the latter chromosome number of 2n = 60 was reported here for the first time. Thus, the intraspecific polyploidy was found in this species for the first time.

(1) The plants with 2n=30 chromosomes. Tables 1 and 17, Fig. 17.

The chromosome morphology at resting stage and mitotic prophase were quite similar to those of *G. foliosa* var. *commelinoides* (2n = 56) excepting the chromomeric granules and fibrous threads at resting stage were more darkly stained.

The 2n=30 chromosome complement at mitotic metaphase displayed a gradual decrease in length from the longest (3.8 μm) to the shortest (1.6 μm) chromosomes. The average chromosome length was 2.4 μm. Among the 30 chromosomes of the metaphase complement, 21 were median centromeric with arm ratios between 1.0 and 1.6, six were submedian centromeric with arm ratios between 1.8 and 2.8 and the other three were subterminal with arm ratios between 3.2 and 3.6. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions of their long arms and two (Nos. 15 and 16) had lightly stained satellites at the terminal regions of their short arms.

Thus, the 2n=30 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

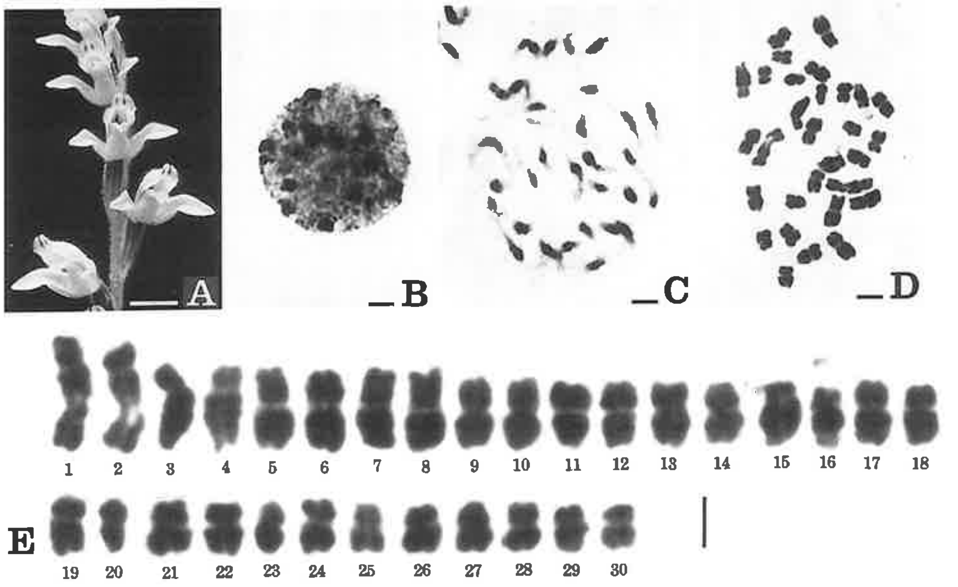

Fig. 17. *Goodyera schlechtendaliana*, 2n=30. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 6 mm in A and 2 μm in B-E.

(2) The plants with 2n=60 chromosomes. Tables 1 and 18, Fig.18.

The reticulate variegation on the leaves were vague and the leaves were thicker than those of the 2n = 30 plants. The chromosome morphology at resting stage and mitotic

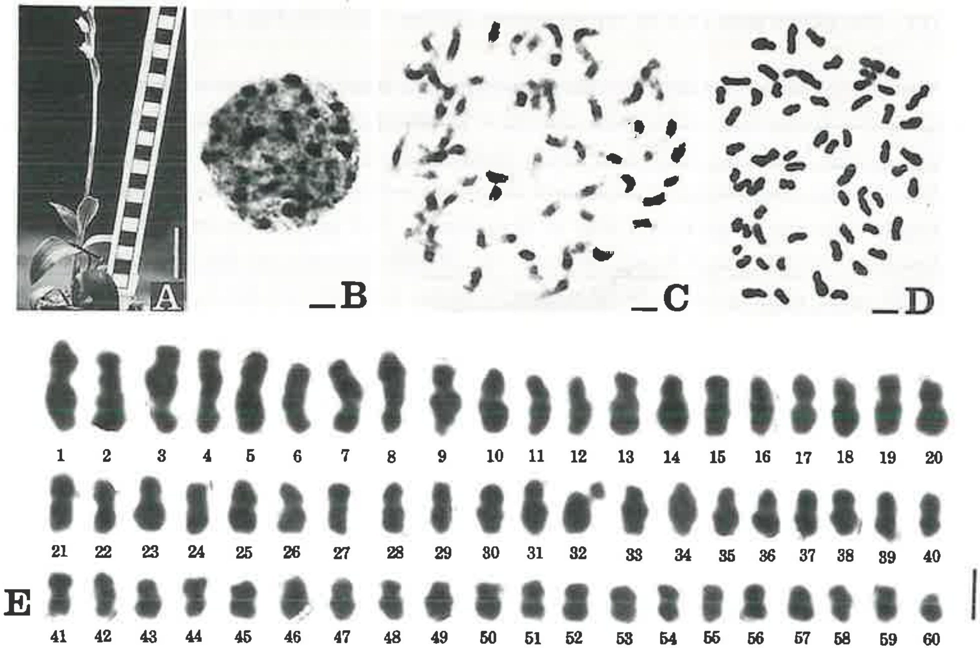

Fig. 18. *Goodyera schlechtendaliana*, 2n=60. A, plant. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 35 mm in A and 2 μm in B-E.

prophase were similar to those of the 2n=30 plants. The 2n=60 chromosome complement at mitotic metaphase performed a gradual decrease in length from the longest (3.4 μm) to the shortest (1.0 μm) chromosomes. The average chromosome length was 1.9 μm. Among the 60 chromosomes of the metaphase complement, 35 were median centromeric with arm ratios between 1.0 and 1.7, 19 were submedian centromeric with arm ratios between 1.8 and 2.8 and six were subterminal with arm ratios between 3.1 and 5.3. Four chromosomes (Nos. 3, 4, 7, 8) had secondary constrictions at the interstitial regions of their long arms.

Thus, the 2n=60 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

The 2n=60 plants seemed to be an autopolyploid of the 2n=30 plants according to the morphology of chromosomes at mitotic metaphase described above.

14. *Goodyera velutina* Maxim., 2n=28 and 2n=56, Japanese Name: Shusu-ran, Tables 1, 19 and 20, Figs. 19 and 20.

Observations were made in 15 plants collected in Chiba Prefecture and another seven localities in Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome numbers observed at mitotic prophase and metaphase were 2n=28 in eight plants from four localities and 2n = 56 in seven plants from four localities. The chromosome number of 2n=28 counted here confirmed the previous reports (Miduno 1939, Mutsuura and Nakahira 1960, Tanaka 1965b), while the chromosome number of 2n = 56 counted here confirmed the previous observation in the plants from Nagasaki Prefecture (Yokota personal communication). It was revealed that the intraspecific polyploidy in this species was observed in various districts in Japan.

(1) The plants with 2n=28 chromosomes. Tables 1 and 19, Fig. 19.

The chromosome morphology at resting stage and mitotic prophase were similar to those of *G. foliosa* var. *commelinoides* (2n=56).

The 2n=28 chromosome complement at mitotic metaphase displayed a gradual decrease in length from the longest (2.2 μm) to the shortest (1.1 μm) chromosomes. The average chromosome length was 1.6 μm. Among the 28 chromosomes of the metaphase complement, 24 were median centromeric with arm ratios between 1.1 and 1.7 and the other four were submedian with arm ratios between 1.8 and 2.6. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions of their long arms and two (Nos. 5 and 6) had satellites at the terminal regions of their short arms.

Thus, the 2n=28 chromosome complement at mitotic metaphase formed a gradual and symmetric karyotype.

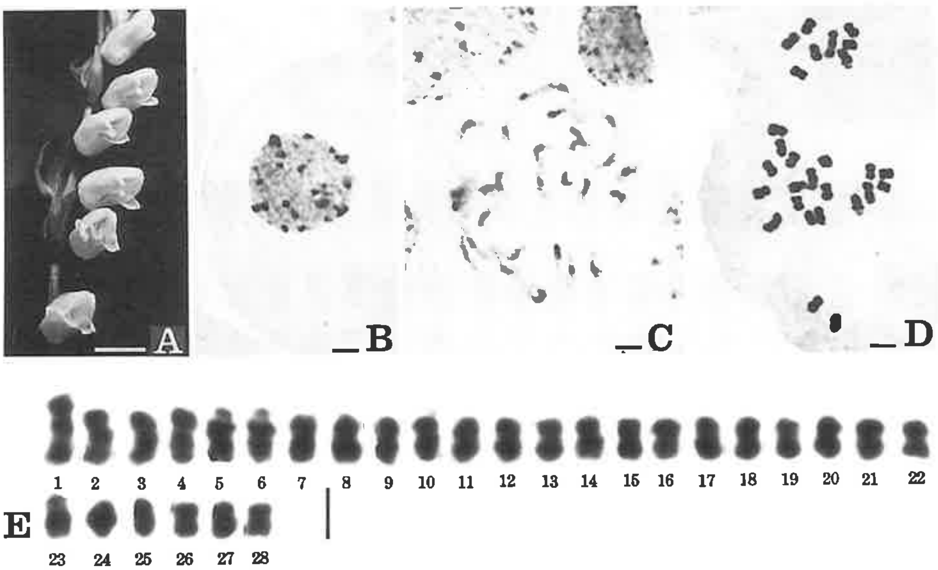

Fig. 19. *Goodyera velutina*, 2n=28. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 2 μm in B-E.

(2) The plants with 2n=56 chromosomes. Tables 1 and 20, Fig. 20.

The chromosome morphology at resting stage and mitotic prophase were similar to those of 2n=28 plants.

The 2n=56 chromosome complement at mitotic metaphase displayed a gradual decrease in length from the longest (2.3 μm) to the shortest (1.1 μm) chromosomes. The average chromosome length was 1.6 μm. Among the 56 chromosomes of the metaphase complement, 42 were median centromeric with arm ratios between 1.0 and 1.7, 12 were submedian centromeric with arm ratios between 1.8 and 2.7 and the rest two were subterminal centromeric with the arm ratio of 3.2. Four chromosomes (Nos. 7, 8, 9, 10) had secondary constrictions at the interstitial regions of their long arms and two (Nos. 11 and 12) had satellites at terminal regions of their short arms.

Thus, the 2n=56 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

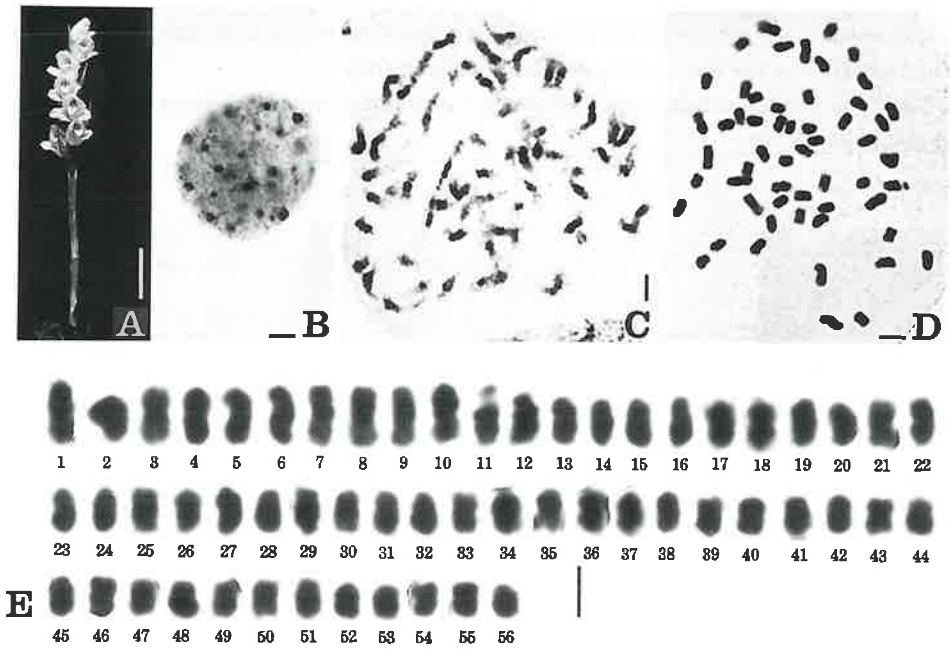

Fig. 20. *Goodyera velutina*, 2n=56. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 15 mm in A and 2 μm in B-E.

The 2n=56 plants seemed to be an autopolyploid of the 2n=28 plants according to the morphology of chromosomes at mitotic metaphase described above.

15. *Goodyera viridiflora* (Bl.) Bl., 2n = 22, Japanese Name: Shima-shusu-ran, Tables 1 and 21, Fig. 21.

Observations were made in four plants collected in Kagoshima Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of the plants was 2n = 22 at mitotic prophase and metaphase which confirmed the previous report on the species treated previously as *G. ogatai* Yamamoto (Tanaka 1965b).

The chromosome morphology at resting stage and mitotic prophase were quite similar to those of *G. foliosa* var. *commelinoides* (2n = 56) excepting most of the large chromatin blocks at resting stage and the early condensed segments at prophase were rod-shaped.

The 2n = 22 chromosome set at mitotic metaphase exhibited a gradual decrease in length from the longest (2.4 μm) to the shortest (1.4 μm) chromosomes. The average chromosome length was 1.9 μm. Among the 22 chromosomes of the metaphase complement, seven were median centromeric with arm ratios between 1.1 and 1.6, nine were submedian centromeric with arm ratios between 1.8 and 2.6 and six were subterminal with arm ratios between 3.3 and 3.6. Four chromosomes (Nos. 3, 4, 5, 6) had secondary constrictions at the interstitial regions of their long arms and two (Nos. 19 and 20) had lightly stained satellites at the terminal regions of their short arms.

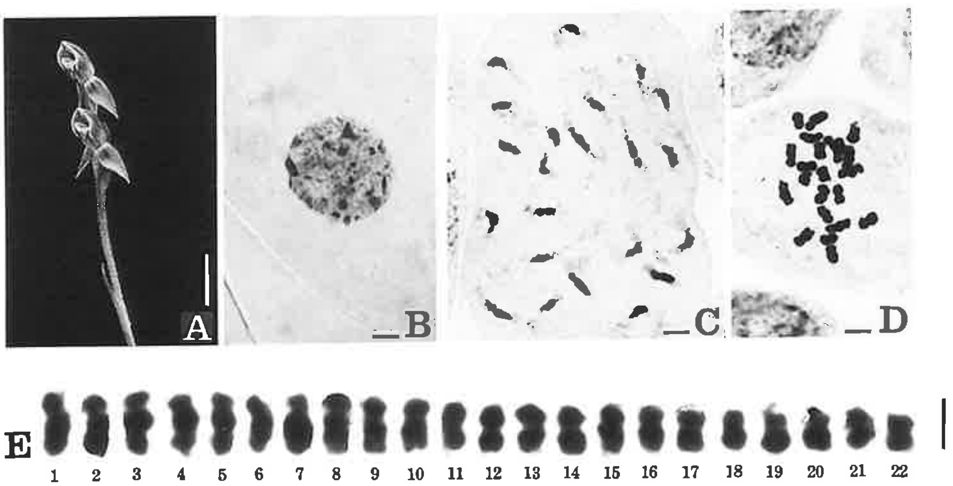

Fig. 21. *Goodyera viridiflora*, 2n = 22. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 2 μm in B-E.

Thus, the 2n = 22 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

III. *Hetaeria*

1. *Hetaeria rubens* (Lindl.) Benth., 2n=24, Tables 1 and 22, Fig. 22.

This species is distributed in tropical Asia from the Himalayas to Indochina.

Observations were made in a plant propagated commercially. Morphological features of leaves, shoots, rhizomes and flowers of the plant were similar to those of this species described by Seidenfaden (1978).

The chromosome number of the plant was 2n = 24 at mitotic prophase and metaphase which was different from the previous count of 2n = 22 (Mehra and Sehgal 1974, Mehra 1982) and n=21 (Mehra and Bawa 1970, Mehra et al. 1972).

The chromosomes at resting stage were observed as numerous chromomeric granules and fibrous threads scattered more or less unevenly in the nucleus and conspicuous chromatin blocks. The chromatin blocks varied in diameter of the long axis from 0.5 − 3.0 μm and in morphology from round- to rod-shaped with smooth or rough surface. While the chromatin blocks varied slightly in size, shape and number among the nuclei, about 35 chromocentric bodies were constantly counted in every nucleus. Thus, the chromosome feature at resting stage was of the complex chromocenter type according to the definition proposed by Tanaka (1971).

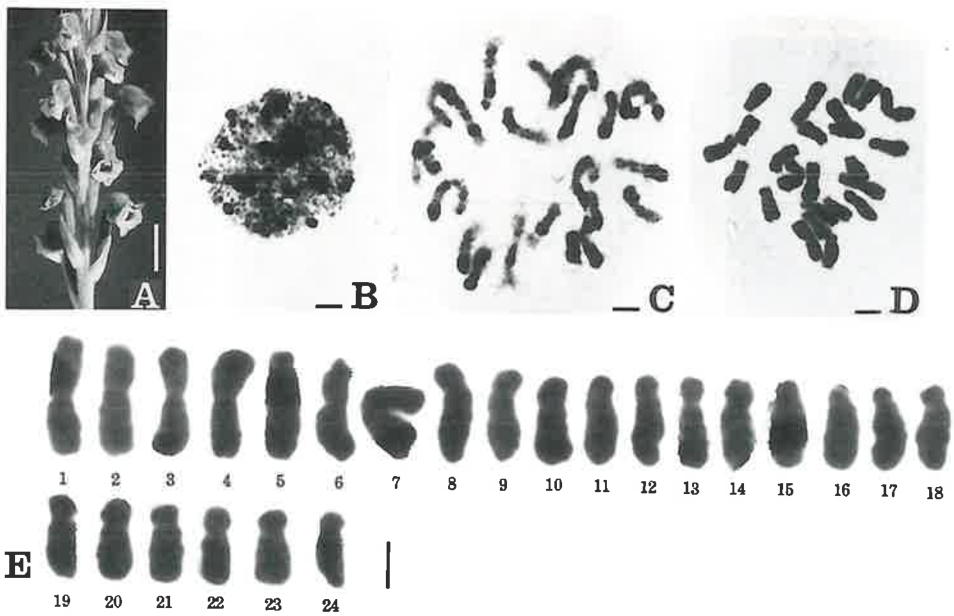

Fig. 22. *Hetaeria rubens*, 2n = 24. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 6 mm in A and 2 μm in B-E.

At mitotic prophase, all of the 2n = 24 chromosomes in the complement had early condensed segments located at the proximal, the interstitial and the terminal regions and less clearing differentiated slightly clearly to late condensed segments.

The 2n = 24 chromosome set at mitotic metaphase performed a gradual decrease in length from the longest (4.6 μm) to the shortest (2.8 μm) chromosomes. The average chromosome length was 3.6 μm. Among the 24 chromosomes of the mitotic metaphase complement, six were median centromeric with arm ratios between 1.0 and 1.4, 12 were submedian centromeric with arm ratios between 2.0 and 3.0 and the other six were subterminal with arm ratios between 3.2 and 5.8.

Thus, the 2n = 24 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

2. *Hetaeria sikokiana* (Makino et F. Maekawa) Tuyama, 2n = 42, Japanese Name: Hime-no-yagara, Tables 1 and 23, Fig. 23.

Observations were made in two plants collected in Hiroshima Prefecture, Japan. Morphological features of shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of the plants was 2n = 42 at mitotic prophase and metaphase

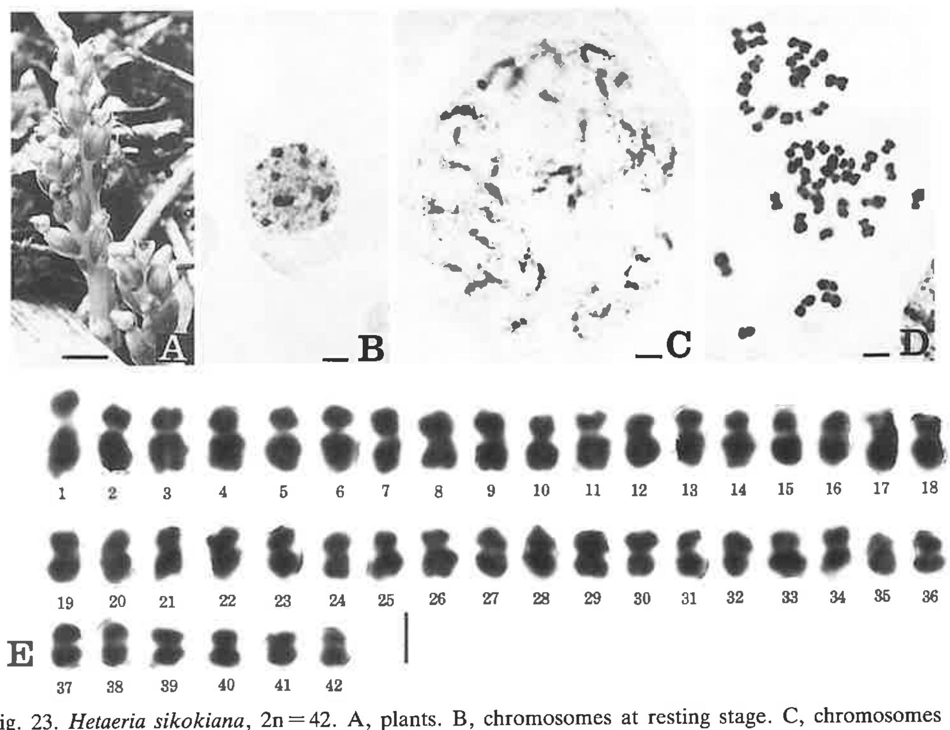

Fig. 23. *Hetaeria sikokiana*, 2n = 42. A, plants. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 6 mm in A and 2 μm in B-E.

which were determined here for the first time.

The chromosome morphology at resting stage was similar to that of *Anoectochilus formosanus*.

The chromosomes at mitotic prophase were similar in morphology to those of *Goodyera hachijoensis* var. *hachijoensis*.

The 2n=42 chromosome set at mitotic metaphase displayed a gradual decrease in length from the longest (2.6 μm) to the shortest (1.1 μm) chromosomes. The average chromosome length was 1.8 μm. Among the 42 chromosomes of the mitotic metaphase complement, 32 were median centromeric with arm ratios between 1.0 and 1.7 and the other ten were submedian centromeric with arm ratios between 1.8 and 2.2. Two chromosomes (Nos. 17 and 18) had satellites at the terminal regions of their short arms.

Thus, the 2n=42 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

3. *Hetaeria yakusimensis* Masamune, 2n = 42, Japanese Name: Yakushima-aka-shusuran, Tables 1 and 24, Fig. 24.

Observations were made in four plants collected in Kagoshima Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of the plants was 2n=42 at mitotic prophase and metaphase

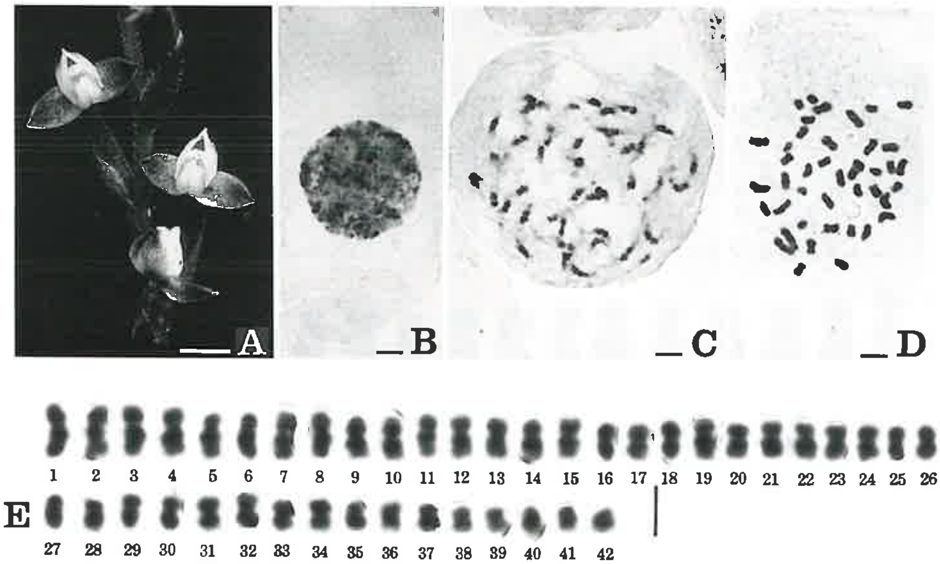

Fig. 24. *Hetaeria yakusimensis*, 2n=42. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 3 mm in A and 2 μm in B-E.

which confirmed Tanaka (1965b).

The chromosome morphology at resting stage and mitotic prophase were similar to those of *Goodyera hachijoensis* var. *hachijoensis*.

The 2n=42 chromosome complement at mitotic metaphase exhibited a gradual decrease in length from the longest (2.0 μm) to the shortest (0.7 μm) chromosomes. The average chromosome length was 1.3 μm. Among the 42 chromosomes of the mitotic metaphase complement, 33 were median centromeric with arm ratios between 1.0 and 1.7 and the other nine were submedian centromeric with arm ratios between 1.8 and 2.2. Two chromosomes (Nos. 1 and 2) had secondary constrictions at the interstitial regions of their long arms.

Thus, the 2n=42 chromosome set at mitotic metaphase showed a gradual and symmetric karyotype.

IV. *Macodes*

1. *Macodes petola* (Bl.) Lindl., 2n=42, Japanese Name: Nanban-kagome-ran, Tables 1 and 25, Fig. 25.

Observations were made in two plants collected in Okinawa Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Holttum (1964).

The chromosome number of the plants was 2n=42 at mitotic prophase and metaphase which was determined here for the first time.

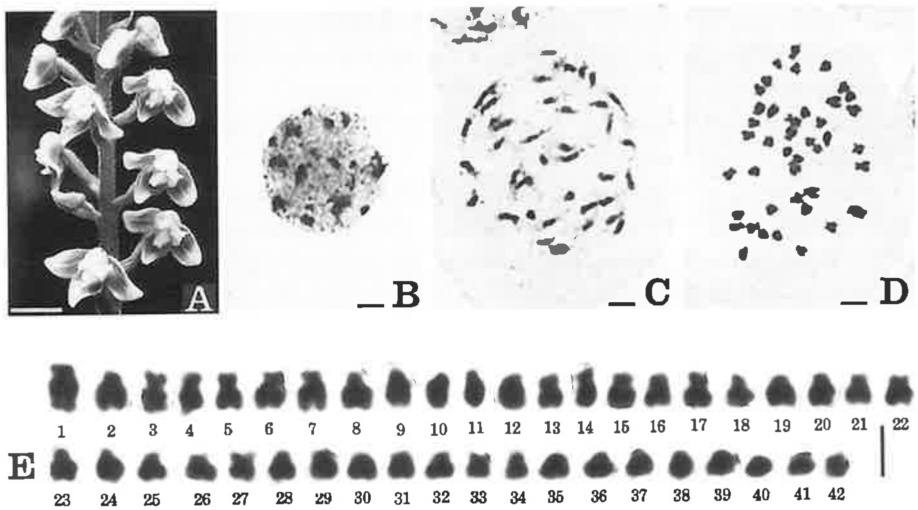

Fig. 25. *Macodes petola*, 2n=42. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 2 μm in B-E.

The chromosome at resting stage were observed as numerous chromomeric granules, fibrous threads scattered throughout the nucleus and conspicuous chromatin blocks. The chromatin blocks varied in diameter of the long axis from 0.5−2.5 μm and in morphology from round-, rod- to string-shaped with smooth or rough surface. While the chromatin blocks varied in size, shape and number among the nuclei, about 20 chromocentric bodies were counted constatly in every nucleus. Thus, the chromosome feature at resting stage was of the intermediate type between simple and complex chromocenter types according to the definition proposed by Tanaka (1971).

At mitotic prophase, early condesed segments located at the proximal regions of all the 2n=42 chromosomes were rod-shaped and were shifted clearly to late condensed segments.

The 2n=42 chromosome complement at mitotic metaphase exhibited a gradual decrease in length from the longest (1.8 μm) to the shortest (0.6 μm) chromosomes. The average chromosome length was 1.1 μm. Among the 42 chromosomes of the mitotic metaphase complement, four were median centromeric with arm ratios between 2.0 and 2.6 ten were subterminal centrometic with arm ratios between 3.5 and 7.0 and the other six were terminal centrometic with arm ratios between 8.0 and 9.0.

Thus, the 2n=42 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

V. *Myrmechis*

1. *Myrmechis japonica* (Reichb. f.) Rolfe, 2n=56, Japanese Name: Aridoshi-ran, Tables 1 and 26, Fig. 26.

Observations were made in two plants collected in Nagano and Yamanashi Prefectures, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of the plants was 2n=56 at mitotic prorhase and metaphase which confirmed Tanaka and Sera (1981).

The chromosomes at resting stage were observed as numerous chromomeric granules, fibrous threads scattered throughout the nucleus and conspicuous chromatin blocks. The chromatin blocks varied in diameter of the long axis from 0.5−1.5 μm and in morphology from round- to rod-shaped with smooth or rough surface. While the chromatin blocks varied slightly in size, shape and number among the nuclei, about 40 prochromosomal bodies were counted constantly in every nucleus. Thus, the chromosome feature at resting stage was of the prochromosome type according to the definition proposed by Tanaka (1971) and it was similar to that of *Goodyera hachijoensis* var. *hachijoensis*.

At mitotic prophase, early condensed segments were located at the proximal regions of all of the 56 chromosomes of the mitotic metaphase complement and at the terminal regions of several chromosomes.

The 2n=56 chromosome complement at mitotic metaphase exhibited a gradual decrease in length from the longest (2.0 μm) to the shortest (1.4 μm) chromosomes. The average

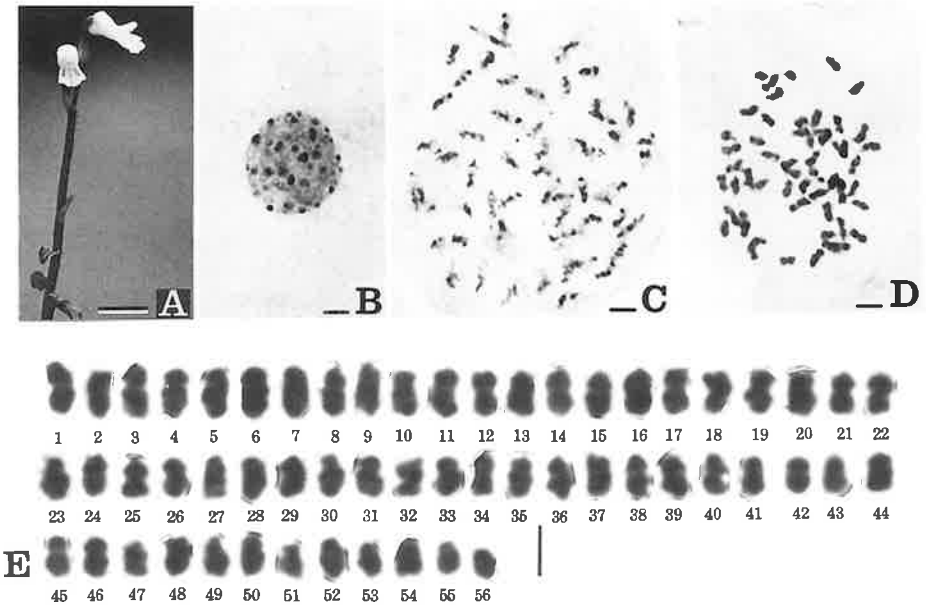

Fig. 26. *Myrmechis japonica*, 2n=56. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 2μm in B-E.

chromosome length was 1.5 μm. Among the 56 chromosomes of the mitotic metaphase complement, 30 were median centromeric with arm ratios between 1.0 and 1.7 and the other 26 were submedian with arm ratios between 1.8 and 2.3

Thus, the 2n=56 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

2. *Myrmechis tsukusiana* Masamune, 2n = 28, Japanese Name: Tsukushi-aridoshi-ran, Tables 1 and 27, Fig. 27.

Observations were made in two plants collected in Kagoshima Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of the plants was 2n=28 at mitotic prophase and metaphase which confirmed the previous report (Tanaka and Sera 1981).

The chromosome morphology at resting stage and mitotic prophase were similar to those of *Goodyera hachijoensis* var. *hachijoensis*.

The 2n=28 chromosome complement at mitotic metaphase displayed a gradual decrease in length from the longest (2.2 μm) to the shortest (1.3 μm) chromosomes. The average chromosome length was 1.7 μm. Among the 28 chromosomes of the mitotic metaphase complement, 22 were median centromeric with arm ratios between 1.0 and 1.6 and the

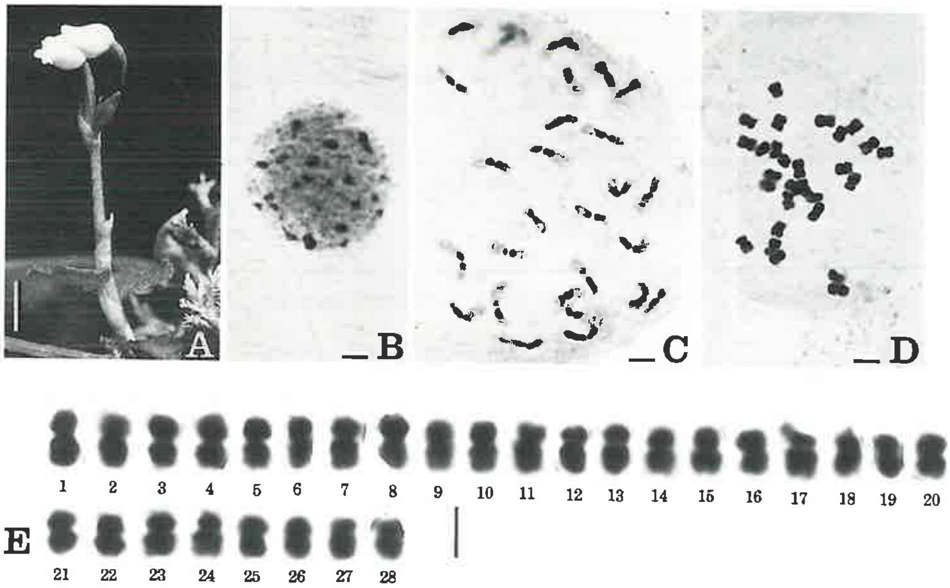

Fig. 27. *Myrmechis tsukusiana*, 2n=28. A, plant. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 5 mm in A and 2μm in B-E.

other six were submedian centromeric with arm ratios between 2.0 and 2.2. Two chromosomes (Nos. 17 and 18) had lightly stained satellites at the terminal regions of their short arms.

Thus, the 2n=28 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

VI. *Odontochilus*

1. *Odontochilus inabai* Hayata, 2n=28, Japanese Name: Inaba-ran, Tables 1 and 28, Fig. 28.

Observations were made in a plant collected in Taichun Prefecture, Taiwan, China. Morphological features of leaves, shoots, rhizomes and flowers of the plant were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of the plant was 2n=28 at mitotic prophase and metaphase which was determined here for the first time.

The chromosomes at resting stage were observed as numerous chromomeric granules, fibrous threads scattered throughout the nucleus and conspicuous chromatin blocks. The chromatin blocks varied in diameter of the long axis from 0.5–2.0 μm and in morphology from round- to rod-shaped with smooth to rough surface. While the chromatin blocks

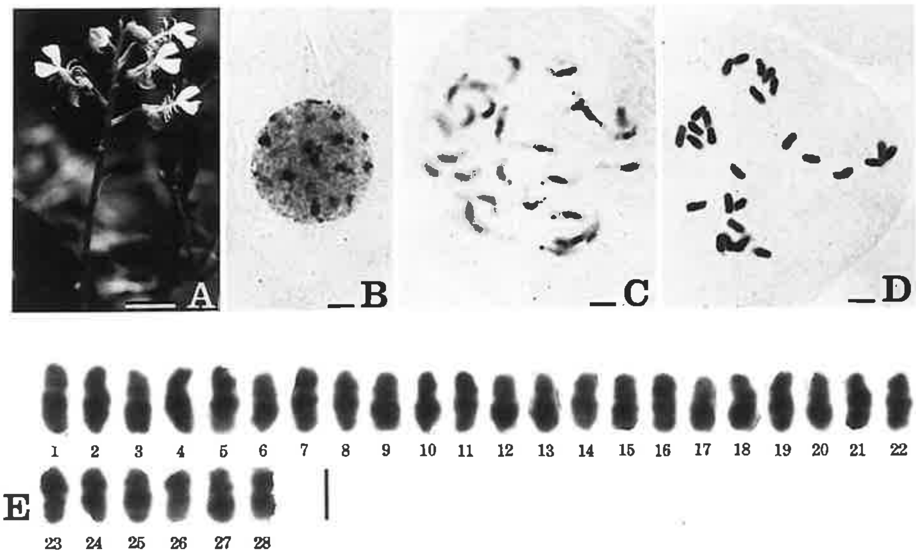

Fig. 28. *Odontochilus inabai*, 2n=28. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 22 mm in A and 2μm in B-E.

varied in size, shape and number among the nuclei, about 25 prochromosomal bodies were counted constantly in every nucleus. Thus, the chromosome feature at resting stage was of the prochromosome type according to the definition proposed by Tanaka (1971) and it was similar to that of *Goodyera foliosa* var. *commelinoides* (2n=56).

At mitotic prophase, early condensed segments were observed at the proximal regions of all of the 28 chromosomes of the complement and at the terminal regions of several chromosomes and were shifted clearly to late condensed segments.

The 2n=28 chromosome complement at mitotic metaphase exhibited a gradual decrease in length from the longest (2.7 μm) to the shortest (1.9 μm) chromosomes. The average chromosome length was 2.3 μm. Among the 28 chromosomes of the mitotic metaphase complement, 22 were median centromeric with arm ratios between 1.0 and 1.7 and the other six were submedian centromeric with arm ratios between 1.8 and 2.1.

Thus, the 2n=28 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

VII. *Vexillabium*

1. *Vexillabium yakushimense* (Yamamoto) F. Maekawa, 2n=26, Japanese Name: Yakushima-hime-aridoshi-ran, Tables 1 and 29, Fig. 29.

Observations were made in four plants collected in Kagoshima Prefecture, Japan. Mor-

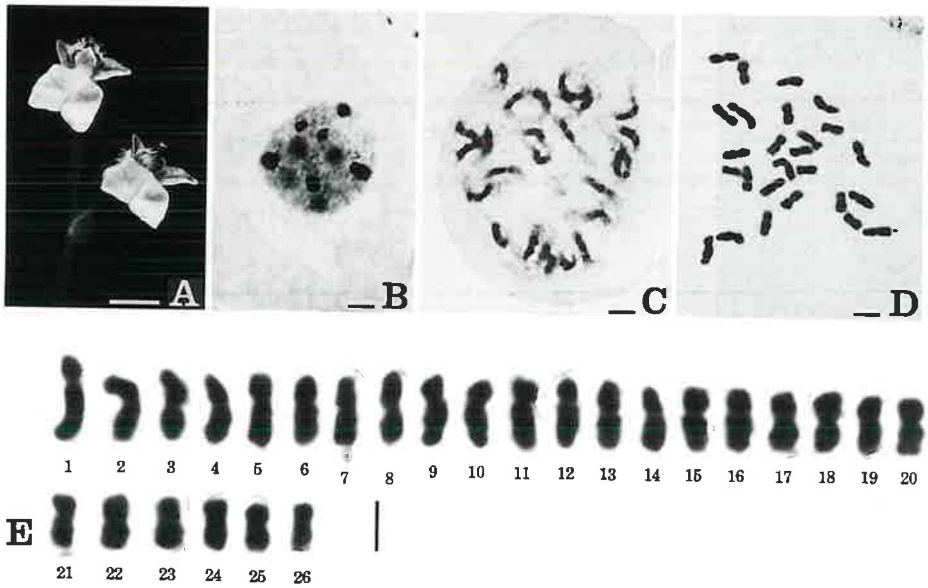

Fig. 29. *Vexillabium yakushimense*, 2n=26 A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 5 mm in A and 2μm in B-E.

phological features of leaves, shoots, rhizomes and flowers of thc plants were similar to those of this species described by Ohwi and Kitagawa (1983).

The chromosome number of the plants was 2n=26 at mitotic prophase and metaphase which confirmed Tanaka (1965b).

The chromosomes at resting stage were observed as numerous chromomeric granules, fibrous threads scattered throughout the nucleus and conspicuous chromatin blocks. The chromatin blocks varied in diameter of the long axis from 0.5−2.0 μm and in morphology from round- to rod-shaped with smooth surface. While the chromatin blocks varied in size, shape and number among the nuclei, about 10 chromocentric bodies were counted constantly in every nucleus. Thus, the chromosome feature at resting stage was of the intermediate type between the simple and complex chromocenter types according to the definition proposed by Tanaka (1971) and it was similar to that of *Anoectochilus formosanus*.

At mitotic prophase, early condensed segments were observed at the proximal regions of all of the 28 chromosomes of complement and the terminal regions of several chromosomes and were shifted clearly to late condensed segments.

The 2n=26 chromosome complement at mitotic metaphase showed a gradual decrease in length from the longest (3.4 μm) to the shortest (1.7 μm) chromosomes. The average chromosome length was 2.5 μm. Among the 26 chromosomes of the mitotic metaphase complement, 19 were median centromeric with arm ratios between 1.0 and 1.7, five were submedian centromeric with arm ratios between 1.8 and 2.3 and the other two were subterminal centromeric with the arm ratios of 3.2 and 3.1. Two chromosomes (Nos. 7 and 8) had lightly stained satellites at the terminal regions of their long arms.

Thus, the 2n = 26 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

VIII. *Zeuxine*

1. *Zeuxine agyokuana* Fukuyama, 2n = 20, Japanese Name: Kagero-ran, Tables 1 and 30, Fig. 30.

Observations were made in four plants collected in Kagoshima Prefecture, Japan. Morphological features of leaves, shoots, rhizomes and flowers of the plants were similar to those of this species described by Garay and Sweet (1974).

The chromosome number of the plants was 2n = 20 at mitotic prophase and metaphase which confirmed the previous report (Tanaka 1965b) on this species treated previously as *Hetaeria xenantha*.

The chromosomes at resting stage were observed as numerous chromomeric granules, fibrous theads scattered throughout the nucleus and conspicuous chromatin blocks. The chromatin blocks varied in diameter of the long axis from 0.5 − 1.5 μm and in morphology

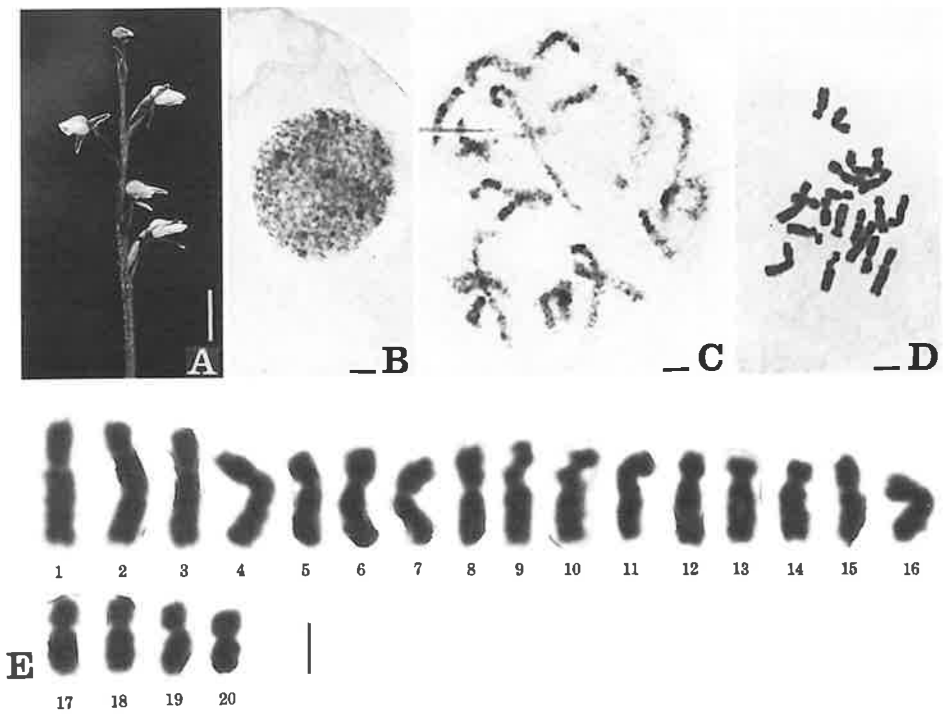

Fig. 30. *Zeuxine agyokuana*, 2n=20. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 2μm in B-E.

from round- to rod-shaped with smooth to rough surface. While the chromatin blocks varied in size, shape and number among the nuclei, about five chromocentric bodies were counted constantly in every nucleus. Thus, the chromosome feature at resting stage was of the simple chromocenter type according to the definition proposed by Tanaka (1971).

At mitotic prophase, early condensed segment were observed at the proximal regions of all of the 2n = 20 chromosomes and the terminal regions beside the interstitial regions of several chromosomes and were shifted more or less gradually to late condensed segments.

The 2n = 20 chromosome complement at mitotic metaphase showed a gradual decrease in legth from the longest (4.9 μm) to the shortest (2.4 μm) chromosomes. The average chromosome length was 3.6 μm. Among the 20 chromosomes of the mitotic metaphase complement, seven were median centromeric with arm ratios between 1.2 and 1.7, 12 were submedian centromeric with arm ratios between 1.8 and 3.0 and the other one was subterminal centromeric with the arm ratio of 3.1. Two chromosomes (Nos. 9 and 10) had satellites at the terminal regions of their short arms.

Thus, the 2n = 20 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

2. *Zeuxine leucochila* Schltr., 2n = 20, Japanese Name: Ishigaki-kinu-ran, Tables 1 and 31, Fig. 31.

Observations were made in two plants collected in Kagoshima Prefecture, Japan. Mor-

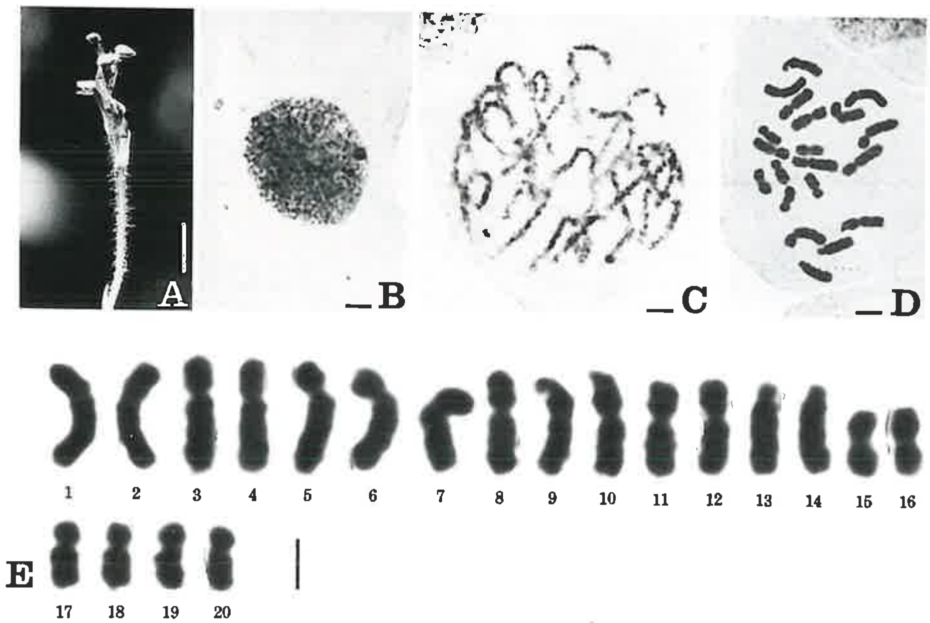

Fig. 31. *Zeuxine leucochila*, 2n = 20. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 8 mm in A and 2 μm in B-E.

phological features of leaves, shoots and rhizomes of the plants were similar to those of this species described by Garay and Sweet (1974). However, their flowers were not typical because the apical parts of the lips were not clearly reniform.

The chromosome number of the plants was 2n = 20 at mitotic prophase and metaphase which was documented here for the first time.

The chromosome morphology at resting stage and mitotic prophase were similar to those of *Z. agyokuana*.

The 2n = 20 chromosomes in the complement at mitotic metaphase formed a bimodality in the chromosome alignment in length with a group of chromosomes ranging from 4.9−3.6 μm and with the other group of chromosomes ranging from 2.7 − 2.5 μm. The average chromosome length was 3.7 μm. Among the 20 chromosomes of the mitotic metaphase complement, eight were median centromeric with arm ratios between 1.0 and 1.7, 10 were submedian centromeric with arm ratios between 2.0 and 3.0 and the other two were subterminal centromeric with the arm ratios of 6.2 and 6.4. Two chromosomes (Nos. 9 and 10) had satellites at the terminal regions of their short arms.

Thus, the 2n = 20 chromosome complement at mitotic metaphase showed a bimodal and symmetric karyotype.

3. *Zeuxine odorata* Fukuyama, 2n = 40, Japanese Name: Jako-kinu-ran, Table 1 and 32, Fig. 32.

Observations were made in a plant collected in Okinawa Prefecture, Japan. Morpholo-

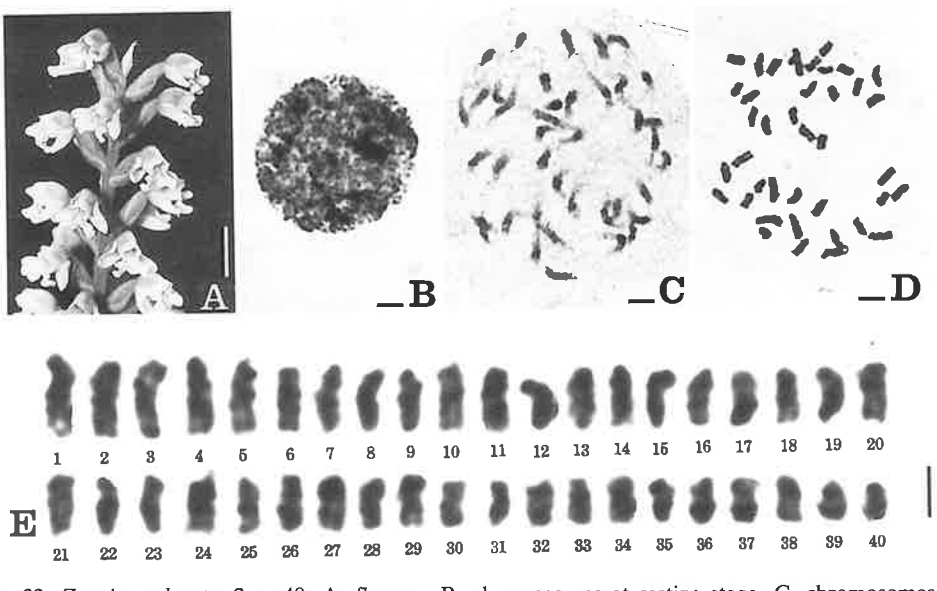

Fig. 32. *Zeuxine odorata*, 2n = 40. A, flowers. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D. and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 2 μm in B-E.

gical features of leaves, shoots, rhizomes and flowers of the plant were similar to those of this species described by Hatusima (1975).

The chromosome number of the plant was 2n = 40 at mitotic prophase and metaphase which was determined here for the first time.

The chromosome morphology at resting stage and mitotic prophase were similar to those of *Hetaeria rubens* excepting the chromocentric bodies were slightly unclear and fewer than those of *H. rubens*.

The 2n = 40 chromosome complement at mitotic metaphase performed a gradual decrease in length from the longest (3.4 μm) to the shortest (1.4 μm) chromosomes. The average chromosome length was 3.7 μm. Among the 40 chromosomes of the complement, 24 were median centromeric with arm ratios between 1.0 and 1.7, 15 were submedian with arm ratios between 1.8 and 2.8 and the other one was subterminal centromeric with the arm ratio of 3.3.

The 2n = 40 chromosome complement at mitotic metaphase showed a gradual and symmetric karyotype.

Discussion

I. Karyomorphological characteristics

1. Chromosome number

The chromosome numbers of 27 taxa investigated were listed in Table 1. The chromosome numbers of 2n = 20, 22, 26, 28, 30, 32, 40, 42, 44 and 56 have previously been reported in *Goodyera* and its certain closely related genera (Tanaka and Kamemoto 1984). Thus, the chromosome numbers of 2n = 24 counted in *Hetaeria rubens*, 2n = 28 + (0-5B) counted in *Goodyera macrantha*, 2n = 56 + 2B counted in G. *foliosa* var. *commelinoides* and 2n = 60 counted in *G. schlechtendaliana* were newly added to the aneuploid series of this group.

Intraspecific polyploidy was observed in three taxa, *Goodyera foliosa* var. *laevis*, *G. schlechtendaliana* and *G. velutina*. The results of the observations in *G. foliosa* var. *laevis* confirmed the previous report (Tanaka 1965a) in correlationships between speciation and natural habitats and between speciation and distributions of certain orchids, while those in *Goodyera schlechtendaliana* and *G. velutina* did not. The polyploids of *G. schlechtendaliana* were localized rather in the southwestern part of their distribution in Japan as seen in *G. foliosa* var. *laevis*.

B-chromosomes have been reported in *Goodyera biflora* (n = 16 + 2B) (Mehra and Kashyap 1979) and *G. secundiflora* n = 15 + (0-1B) (Mehra 1982) among the group members. Thus, B-chromosomes of 2n = 56 + 2B and 2n = 28 + (0-5B) were observed here for the first time in *G. foliosa* var. *commelinoides* and *G. macrantha* , respectively, regarding chromosome morphology and behavior at mitotic prophase and metaphase.

2. Chromosome morphology at resting stage

Each taxon showed distinct features of the chromosome condensation and the shape and the number of chromatin blocks at resting stage. Thus, the resting nuclei could be morphologically grouped into four types according to Tanaka (1971) as follows:

(Ⅰ) The prochromosome type was observed in all taxa of *Goodyera*, *Hetaeria yakusimensis*, *Myrmechis japonica*, *Myr. tsukusiana* and *Odontochilus inabai* . The resting nuclei of the prochromosome type in *G. hachijoensis sensu lato*,*G. procera*, *G. repens*, *H. yakusimensis*, *Myr. japonica* and *Myr. tsukusiana* had rather darkly stained chromomeric granules and many small chromatin blocks. Most of the chromatin blocks in the resting nuclei of *G. viridiflora* were rod-shaped.

(Ⅱ) The simple chromocenter type was observed in *Zeuxine agyokuana* and *Z. leucochila*.

(Ⅲ) The complex chromocenter type was observed in *Hetaeria rubens* and *Zeuxine odorata*. The resting nucleus of *Z. odorata* showed the chromosomes condensed more loosely than that of *H. rubens*.

(Ⅳ) The intermediate type between the simple and the complex chromocenter types, characterized by the chromocentric bodies of which number was 1/2 ~ 1/3 the number of chromosomes with early condensed segments at mitotic prophase. This type was observed in *Anoectochilus formosanus*, *Hetaeria sikokiana*, *Macodes petola* and *Vexillabium yakushimense*. The chromocentric bodies in *H. sikokiana* and *V. yakushimense* showed nearly prochromosome features with smooth surface.

3. Chromosome morphology at mitotic prophase

Early condensed segments were observed in all of the chromosomes in the mitotic prophase complements of the 26 taxa except for *Anoectochilus formosanus*. *A. formosanus* exhibited no early condensed segment in four of the 40 chromosomes at mitotic prophase. The early condensed segments were located at the proximal, interstitial and terminal regions of all of the chromosomes at mitotic prophase in *Hetaeria rubens*, most of the chromosomes at mitotic prophase in *Zeuxine odorata* and several chromosomes at mitotic prophase in *Z. agyokuana* and *Z. leucochila*. Thus, the other chromosomes in *Z. odorata*, *Z. agyokuana* and *Z. leucochila* and all chromosomes in the other 23 taxa were basically belonged to the proximal type of the chromosome morphology at mitotic prophase (Tanaka 1980). On the other hand, the early condensed segments were observed not only at the proximal regions but at the terminal regions of several chromosomes in the mitotic prophase complements of *Goodyera hachijoensis sensu lato*, *G. procera*, *Hetaeria sikokiana*, *H. yakusimensis, Myrmechis japonica, Myr. tsukusiana, Odontochilus inabai* and *Vexillabium yakushimense*.

4. Chromosome morphology at mitotic metaphase

The length of the chromosome of the 27 taxa investigated at mitotic metaphase ranged

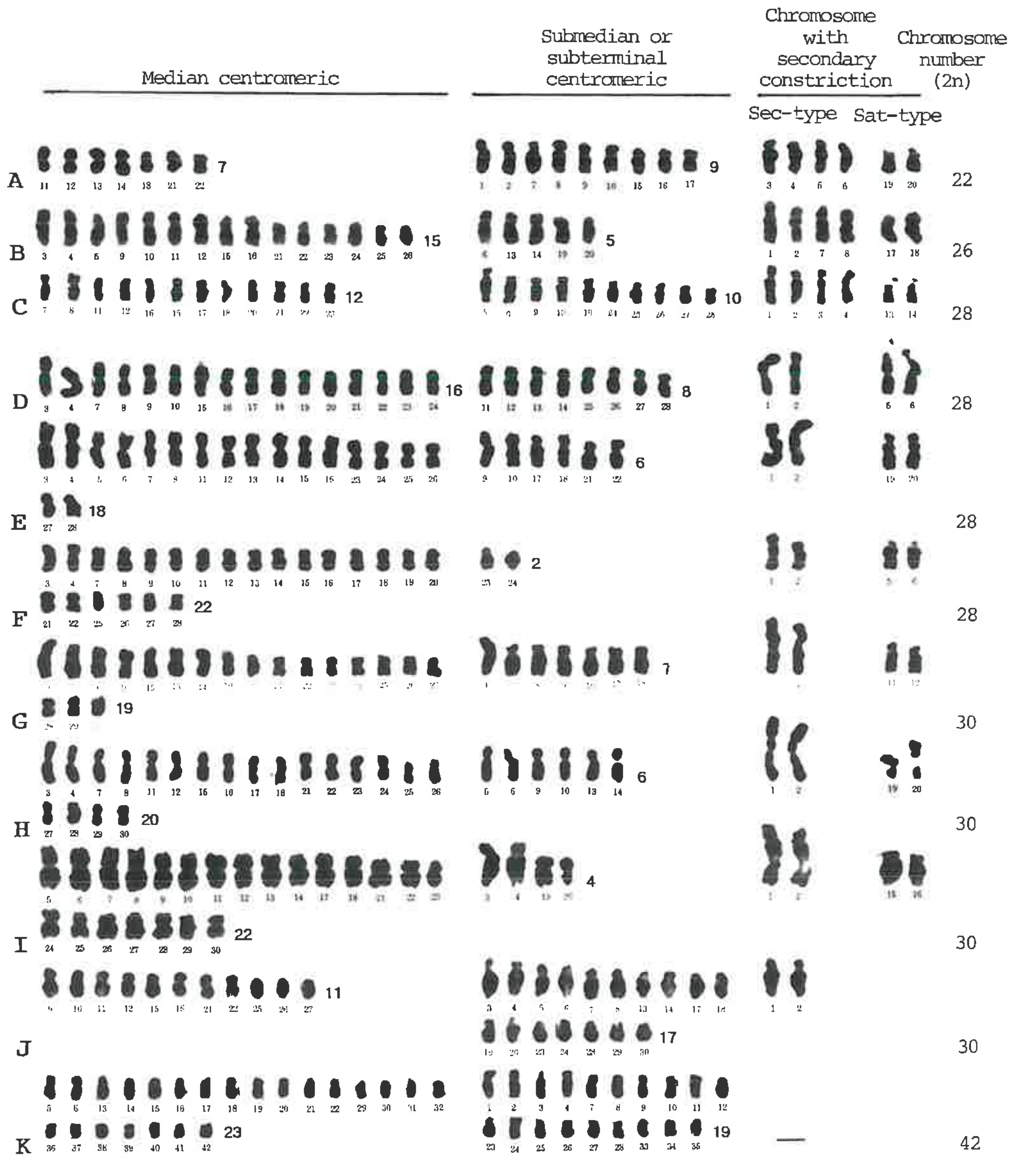

Fig. 33. Photomicrographs of chromosomes at mitotic metaphase in 11 species of *Goodyera*. A, *G. viridiflora*. B, *G. pubescens*. C, *G. macrantha*. D, *G. foliosa* var. *laevis*. E, *G. hachijoensis* var. *yakushimensis*. F, *G. velutina*. G, *G. pendula*. H, *G. repens*. I, *G. schlechtendaliana*. J, *G. oblongifolia*. K, *G. procera*. Bar idicates 2 μm. The Sec-type and the Sat-type are of the marker chromosomes described in the text. The number just below each chromosome is the identification number. The bold-faced number on the right of the chromosome alignment is number of chromosomes belonged to each centromeric type.

Fig. 34. Photomicrographs of chromosomes at mitotic metaphase in 12 species of seven genera allied to *Goodyera*. A, *Zeuxine agyokuana*. B, *Z. leucochila*. C, *Myrmechis tsukusiana*. D, *Hetaeria sikokiana*. E, *H. yakusimensis*. F, *Vexillabium yakushimense*. G, *Anoectochilus formosanus*. H, *H. rubens*. I, *Odontochilus inabai*. J, *Z. odorata*. K, *Macodes petola*. L, *Myr. japonica*. Bar indicates 2 μm."SIM", "PRO", "INT", and "COM" designate simple chromocenter type, prochromosome type, intermediate type between simple and complex chromocenter types, and complex chromocenter type, respectively. Chromosomes with secondary constriction of A,B,C,E,F are Sat-type and those of D are Sec-type. See Fig. 33 for the other explanation.

between 4.9 and 0.6 μm. The mean chromosome lengths in the mitotic metaphase complements of the taxa varied from 3.7 μm in *Zeuxine leucochila* to 1.1 μm in*Macodes petola*. The chromosome complements of the 27 taxa at mitotic metaphase could be divided into two types on the basis of the chromosome length; the large type with the average chromosome lengths of 3.7 or 3.6 μm (three taxa) and the small type with the average chromosome lengths varied from 2.5 -1.1 μm (24 taxa).

The chromosome lengths of the mitotic metaphase complements in 24 taxa showed commonly gradual decrease from the longest to the shortest chromosomes, while those in the other three taxa, *Goodyera pendula*, *G. repens* and *Zeuxine leucochila* showed bimodality of their chromosome lengths.

The 27 taxa showed symmetric karyotype with respect to their arm ratios. Appearance frequencies of the chromosomes with median centromeres in the mitotic metaphase complements in the taxa varied between 86 (*Goodyera velutina*) and 10% (*Macodes petola*).

Figs. 33 and 34 show the chromosome alignments at mitotic metaphase of 11 species of *Goodyera* and 12 species of seven genera allied to *Goodyera*. These figures display that the majority of these 23 species has two or four chromosomes with the secondary constrictions. These chromosomes could be classified into two types regarding their size and the position of the secondary constrictions. One is called "Sec-type", abbreviation of "secondary constriction type". This type is of the large chromosomes with the secondary constrictions at the interstitial regions of their long arms in respective complement. The other one is called "Sat-type", abbreviation of "satellite type". This type is of mostly medium and rarely large chromosomes with satellited secondary constrictions in respective complement. Based on these two types of the chromosomes as the marker chromosomes, the 23 species could be divided into five groups as follows:

A) It is characterized by four chromosomes of the "Sec-type" and two chromosomes of the "Sat-type" and includes *Goodyera viridiflora* (2n=22), *G. pubescens* (2n=26) and *G. macrantha* (2n=28).

B) It is characterized by two chromosomes of the "Sec-type" and two chromosomes of the "Sat-type" and includes *Goodyera foliosa* var. *laevis* (2n=28), *G. hachijoensis sensu lato* (2n=28), *G. velutina* (2n=28), *G. pendula* (2n=30), *G. repens* (2n=30) and *G. schlechtendaliana* (2n=30).

C) It is characterized by two chromosomes of the "Sec-type" and includes *Goodyera oblongifolia* (2n=30) and *Hetaeria yakusimensis* (2n=42).

D) It is characterized by two chromosomes of the "Sat-type" and includes *Zeuxine agyokuana* (2n = 20), *Z. leucochila* (2n = 20), *Vexillabium yakushimense* (2n = 26), *Myrmechis tsukusiana* (2n=28), *Anoectochilus formosanus* (2n=40) and *Hetaeria sikokiana* (2n=42).

E) It is characterized by the absence of any marker chromosomes and includes *Hetaeria rubens* (2n = 24), *Odontochilus inabai* (2n = 28), *Zeuxine odorata* (2n = 40), *Goodyera procera* (2n=42), *Macodes petola* (2n=42) and *Myrmechis japonica* (2n=56).

The chromosomes of "Sat-type" in *Vexillabium yakushimense* and *Anoectochilus formosanus* had slightly stained satellites at their long arms, which were not observed in the other species (Fig. 34 F and G).

II. Relationships among the taxa

1. The genus *Goodyera*

It was confirmed that intraspecific polyploidy with 2n=28 and 2n=56 was observed in *Goodyera foliosa* var. *laevis* and that the tetraploids (2n=56) were distributed more south than the diploids (2n = 28). Furthermore, *G. foliosa* var. *commelinoides* containing the chromosome number of 2n=56 occurred more south than *G. foliosa* var. *laevis* (Ohwi and Kitagawa 1983). These facts suggested that *G. foliosa* var. *commelinoides* might be derived from a tetraploid of *G. foliosa* var. *laevis*. It is speculated that this species might have been diversified and differentiated by polyploidization to progress and expand its distribution more south in East Asia.

It was found karyomorphologically that all of the 11 species were very much closely related with each other regarding the common resting stage of the prochromosome type and the small mitotic metaphase chromosomes exhibiting the symmetric karyotypes. However, these species showed different chromosome numbers of 2n=22, 26, 28, 30 and 42 for the aneuploid series. Tanaka (1976) hypothesized that this aneuploid series might be caused by polyploidization of the basic number x = 7 followed by aneuploidization. In contrast, Maekawa (1978) speculated that the aneuploid series might be caused by polyploidization of the basic number x=5 followed by aneuploidization.

The present observation of four chromosomes of "Sec-type" and two chromosomes of "Sat-type" in *Goodyera viridiflora* (2n=22), *G. pubescens* (2n=26), and *G. macrantha* (2n=28) (Fig. 33) made it possible to hypothesize that the chromosome numbers of 2n=22, 26 and 28 might be in the tetraploid level and those of 2n=22 and 2n=26 might be derived from 2n=28 by elimination of certain chromosomes without any secondary constriction. On the other hand, two of the four chromosomes of the "Sec-type" might have lost the secondary constrictions in the chromosome complement of 2n = 28 (*G. foliosa* var. *laevis*, *G. hachijoensis sensu lato*, and *G. velutina*). Moreover, the 2n=30 chromosomes complements in *G. pendula*, *G. repens* and *G. schlechtendaliana* might have been occurred by addition and increase of the median chromosomes and loss of the secondary constrictions.

Goodyera procera (2n=42) did not show any marker chromosome but showed shorter chromosomes and more gradual decrease in chromosome length than those of the other species of *Goodyera*. These karyomorphological characteristics seemed to indicate that *G. procera* could be distantly related to the other species of the genus.

As mentioned above, the results given here supported Tanaka's hypothesis (1976) that explained evolution of the chromosome numbers in *Goodyera*. Moreover, the results made it possible to make another hypothesis that speciation in *Goodyera* has been taken place firstly by polyploidization of the basic genome and secondly by elimination of certain chromosomes without any secondary constriction and disappearance of the secondary constrictions followed by addition of the chromosomes.

2. The genera allied to *Goodyera*

Zeuxine leucochila (2n=20) was very similar to *Z. agyokuana* (2n=20) with respect to the morphology of the mitotic metaphase chromosomes. However, the former species possessed a pair of medium-sized subterminal chromosomes of which arm ratios were higher than those of the latter species (Fig. 31, E. Nos. 13 and 14) and performed bimodality of the chromosome lengths which was not observed in the latter species. Thus, these observations suggested that *Z. leucochila* coud be closely related to *Z. agyokuana* which might be later differentiated by terminalization of centromeres of a pair of chromosomes in a complement.

Zeuxine agyokuana Fukuyama has been treated taxonomically as *Hetaeria agyokuana* (Fukuyama) K. Nackejima by Nackejima (1971), supported by Hatusima (1975). On the other hand, *Z. agyokuana* was distinct from *Hetaeria yakusimensis* (2n=42) regarding the chromosome number, the chromosome size, the marker chromosomes and the chromosomes of the simple chromocenter type at resting stage. Therefore, the taxonomical treatment of *Z. agyokuana* which was placed in the group separated from *H. yakusimensis* could be supported by the present karyomorphological evidences.

Among the three species of *Zeuxine*, *Z. odorata* Fukuyama did not have any marker chromosome, while the other two species had a pair of chromosomes of the "Sat-type". Moreover, *Z. odorata* was different from the two species since it exhibited the chromosomes of the complex chromocenter type at resting stage while the latter two species did not. Hashimoto (1986) changed taxonomically the generic combination of *Z. odorata* into *Hetaerozeuxine* Hashimoto and completely separated it from *Z. agyokuana* and *Z. leucochila*. Thus, the result given here supported the taxonomical treatment that *Z. odorata* was belonged to the group distinct from that of the other two species.

Vexillabium yakushimense and *Anoectochilus formosanus* are considered to be closely related to each other, since they showed commonly the intermediate type between the simple and the complex chromocenter types at resting stage. Moreover, they possessed singular chromosomes of the "Sat-type" which carried lightly stained satellites on the terminal regions of their long arms, which were not observed in the other species.

Odontochilus inabai Hayata (*e. g.*, Lin 1976, Lin and Hsu 1976, Ohwi and Kitagawa 1983) has been sometimes treated as *Anoectochilus inabai* Hayata (*e. g.*, Garay and Sweet 1974, Maekawa 1978) or a synonym of *Pristiglottis tashiroi* (Maxim.) Crez *et* J.J.Sm (Hatusima 1975). In this study, *O. inabai* showed no chromosome of the "Sat-type"as seen in *A. formosanus*. Moreover, *O. inabai* showed the chromosomes of the prochromosome type at resting stage while *A. formosanus* showed the chromosomes of the intermediate typc between the simple and the complex chromocenter types. These results supported the taxonomical treatment that *O. inabai* was placed in the taxonomic group different from that of *A. formosanus*.

Myrmechis tsukusiana (2n=28) and *Hetaeria yakusimensis* (2n=42) had the marker chromosomes of the "Sat-type" similar to those observed in *Goodyera*, and showed the prochromosome type at resting stage as seen in *Goodyera*. Therefore, it is speculated that these two species might be closely related to *Goodyera* and originated from the progress of speciation by the polyploidization with the basic chromosome number of x=7 as similarly speculated in *Goodyera*.

Similarly, the marker chromosomes of the "Sat-type" were observed in *Zeuxine agyokuana* (2n = 20), *Z. leucochila* (2n = 20) and *Hetaeria sikokiana* (2n = 42). However, these three species showed the chromosomes of the simple chromocenter type or the intermediate type between the simple and the complex chromocenter types at resting stage, which were different from those of certain species of *Goodyera*. The similarity of the chromosome sizes at mitotic metaphase indicates a close relationship of *Z. agyokuana*, *Z. leucochila* and *Hetaeria rubens* (2n = 24). On the other hand, *H. rubens* was similar to *Odontochilus inabai* (2n = 28), *Z. odorata* (2n = 40), *Goodyera procera* (2n = 42), *Macodes petola* (2n = 42) and *Myrmechis japonica* (2n = 56) with respect to lack of the marker chromosomes. However, these species showed the different types of the chromosomes at resting stage and the arm ratios of the mitotic metaphase chromosomes (Figs. 33 and 34). Thus, it suggested that the species without any marker chromosome might be distantly related to each other and might have certain relationships with respective taxon with the marker chromosomes. Further karyomorphological examination in many more species is necessary to clarify the relationships among those species.

Goodyera and its allied genera were divided into two groups according to the number of stigmas by Schlechter (1926, 1927), Brieger (1974-1975), Dressler (1981), and so on; *Goodyera* and *Macodes* were placed in Haplostigmata, and the other six genera were placed in Diplostigmata. However, these two groups could not be separated clearly by the chromosome morphology as discussed above. Thus, the results indicates that two taxonomic groups divided on the basis of the number of stigmas are not supported by the karyomorphological relationships among these genera or species.

Summary

1. The morphological observations in somatic chromosomes at resting, mitotic prophase and metaphase stages were made in 27 taxa of *Goodyera* and its seven allied genera.

2. The chromosome numbers counted in the 27 taxa were listed as follows: 2n = 20 (two taxa), 2n = 22 (one taxon), 2n = 24 (one taxon), 2n = 26 (two taxa), 2n = 28 (six taxa), 2n = 28 + (0-5B) (one taxon), 2n = 28 and 2n = 56 (two taxa), 2n = 30 (three taxa), 2n = 30 and 2n = 60 (one taxon), 2n = 40 (two taxa), 2n = 42 (four taxa), 2n = 56 (one taxon), 2n = 56 and 2n = 56 + 2B (one taxon).

3. The chromosome numbers of six taxa were determined in this study for the first time; 2n = 56 and 2n = 56 + 2B of *Goodyera foliosa* var. *commelinoides*, 2n = 42 of *Hetaeria sikokiana*, 2n = 42 of *Macodes petola*, 2n = 28 of *Odontochilus inabai*, 2n = 20 of *Zeuxine leucochila*, and 2n = 40 of *Z. odoata*. The chromosome numbers in three taxa were different from the previous counts; 2n = 28 + (0-5B) in *G. macrantha* (previously 2n = 30), 2n = 30 and 60 in *G. schlechtendaliana* (previously 2n = 30), and 2n = 24 in *Hetaeria rubens* (previously 2n = 22).

4. Intraspecific polyploidy with 2n=30 and 2n=60 was found in *Goodyera schlechtendaliana* for the first time. On the other hand, it was newly reported that intraspecific polyploidy with 2n=28 and 2n=56 was observed in *G. velutina* in various localities throughout in Japan. B-chromosomes were observed for the first time in *G. foliosa* var. *commelinoides* (2n=56+2B) and in *G. macrantha* 2n=28+(0-5B).

5. The chromosome morphology at resting stage given in the taxa studied were classified into four types; the prochromosome type in 19 taxa, the simple chromocenter type in two taxa, the complex chromocenter type in two taxa and the intermediate type between the simple and the complex chromocenter types in four taxa.

6. Early condensed segments found at mitotic prophase were located in the proximal regions of the chromosomes in most of the taxa studied, excepting in some cases they were located either in the proximal regions or in the proximal, the interstitial and the terminal regions in some taxa.

7. Among the species studied *Zeuxine leucochila* (2n=20) showed the longest chromosomes at mitotic metaphase varying from 4.9−2.5 μm with mean length of 3.7 μm. In contrast, *Macodes petola* (2n = 42) showed the shortest chromosomes at mitotic metaphase varying from 1.8−0.6 μm with mean length of 1.1 μm. On the basis of the lengths of the mitotic metaphase chromosomes, the 27 taxa were classified into the "large" and the "small" types. The large type had the average chromosome lengths of 3.6 or 3.7 μm while the small type had the average chromosome lengths varying from 1.1 to 2.5 μm.

8. According to the arm ratios of the chromosomes at mitotic metaphase, the 27 taxa showed the symmetric karyotype although appearance frequencies of the median chromosomes in their complements varied between 86 and 10%.

9. Twenty-four out of the 27 taxa studied showed the gradual karyotype and three taxa showed the bimodal karyotype in chromosome length at mitotic metaphase.

10. Twenty-three species representing the 27 taxa studied exhibited two types of the marker chromosomes at mitotic metaphase as follows: One was the "Sec-type" which was characterized by the secondary constriction at the interstitial region of the long arm and the other one was the "Sat-type" which was characterized by the satellited secondary constriction. Based on these marker chromosomes,the 23 species were divided into the following five groups (A∼E):

A group: Characterized by four chromosomes of the "Sec-type" and two chromosomes of the "Sat-type"; represented by *Goodyera viridiflora* (2n=22), *G. pubescens* (2n=26) and *G. macrantha* (2n=28). The same number of marker chromosomes with the three different chromosome numbers indicated that these chromosome numbers could be in tetraploid level and that the chromosome numbers of 2n=22 and 2n=26 might be derived from 2n=

28 by chromosome elimination.

B group: Characterized by two chromosomes of the "Sec-type" and two chromosomes of the "Sat-type"; represented by *Goodyera foliosa* var. *laevis* (2n=28), *G. hachijoensis sensu lato* (2n=28), *G. velutina* (2n=28), *G. pendula* (2n=30), *G. repens* (2n=30) and *G. schlechtendaliana* (2n=30). It is speculated that the chromosome number of 2n=28 might be occurred from 2n=28 of the group A by disappearance of the secondary constrictions in the two chromosomes of the Sec-type and that the chromosome number of 2n=30 might be occurred by increase of median chromosomes following disappearance of the secondary constrictions.

C group: Characterized by two chromosomes of the "Sec-type"; represented by *Goodyera oblongifolia* (2n=30) and *Hetaeria yakusimensis* (2n=42). It is speculated that the chromosome number of 2n=30 might be derived from 2n=30 of the group B by disappearance of the secondary constrictions of the chromosomes of the Sat-type and asymmetrization of the chromosomes.

D group: Characterized by two chromosomes of the "Sat-type"; represented by *Zeuxine agyokuana* (2n=20), *Z. leucochila* (2n=20), *Vexillabium yakushimense* (2n=26), *Myrmechis tsukusiana* (2n=28), *Anoectochilus formosanus* (2n=40) and *Hetaeria sikokiana* (2n=42).

E group: Characterized by no marker chromosome; represented by *Hetaeria rubens* (2n=24), *Odontochilus inabai* (2n=28), *Zeuxine odorata* (2n=40), *Goodyera procera* (2n=42), *Macodes petola* (2n=42) and *Myrmechis japonica* (2n=56).

11. Certain cytotaxonomic and karyomorphological evidences supplied some informations to clarify the interrelationships and the taxonomical treatments among the species and the genera as follows:

1) *Goodyera foliosa* var. *laevis* had the intraspecific polyploidy with 2n=28 and 2n=56. *G. foliosa* var. *commelinoides* distributed more south than the former variety showed the chromosome number 2n=56. These coincidences suggested that *G. foliosa* var. *commelinoides* might be derived from a polyploid of *G. foliosa* var. *laevis* which could be differentiated to expand the distribution toward southwards in East Asia.

2) *Goodyera procera* (2n=42) was different from the other species of the genus since it had no marker chromosome and small-sized chromosomes.

3) The above tenth category of the summary supported that the basic chromosome number of *Goodyera* was x=7 (Tanaka 1976). Thus, it was speculated that the chromosome numbers of 2n=22, 26, 28 and 30 in *Goodyera* might be secondarily derived from 2n=28 or a tetraploid plant with x=7. These different chromosome numbers might be accomplished and accumulated by elimination, addition, asymmetrization of certain chromosomes without any secondary constriction and disappearance of the secondary constrictions.

4) The mitotic metaphase chromosomes of *Zeuxine leucochila* (2n = 20) and *Z.*

agyokuana (2n=20) were karyomorphologically similar to each other excepting the former species had a pair of singular subterminal chromosomes. This result suggested that *Z. leucochila* (2n=20) could be closely related to *Z. agyokuana* (2n=20) and might be later differentiated by terminalization of centromeres.

5) *Zeuxine agyokuana* (2n=20) was different from *Hetaeria yakusimensis* (2n=42) on account of the chromosome number and of the chromosome morphology at resting and mitotic metaphase. This result did not support the taxonomical treatment of these species by Nackejima (1971) and Hatusima (1975).

6) Among three species of *Zeuxine*, *Z. odorata* (2n=40) was distinguished from the other two species by the chromosome morphology of the complex chromocenter type at resting stage and lack of the marker chromosomes of the "Sat-type". This result supported the taxonomical treatment of these species by Hashimoto (1986).

7) It was suggested that *Anoectochilus formosanus* (2n = 40) and *Vexillabium yakushimense* (2n=26) could be closely related with each other because they had commonly the chromosome morphology of the intermediate type between the simple and the complex chromocenter types at resting stage and the marker chromosomes morphologically similar to each other.

8) *Odontochilus inabai* (2n=28) was distinct from *Anoectochilus formosanus* (2n=40) since it had the chromosome morphology of the prochromosome type at resting stage and lack of the marker chromosomes of the "Sat-type". This result supported the taxonomical treatment of these species by Lin (1976) and Ohwi and Kitagawa (1983).

9) *Hetaeria yakusimensis* (2n=42) and *Myrmechis tsukusiana* (2n=28) were similar to the species of *Goodyera* with respect to the type of the marker chromosomes and the chromosome morphology of the prochromosome type at resting stage. Therefore, these two species seemed to be closely related to *Goodyera* and might be differentiated by the similar process as in *Goodyera*.

10) *Goodyera* and *Macodes* which had single stigma, were not karyomorphologically distinct from *Anoectochilus*, *Hetaeria*, *Myrmechis*, *Odontochilus*, *Vexillabium* and *Zeuxine* which had two stigmas. Thus, this phenomenon indicated that the taxonomical treatment based on the number of stigmas and made by Schlechter (1926), Brieger (1974-1975), Dressler (1981) and so on was not supported by the karyomorphological investigation.

Acknowledgments

This study was accomplished under the direction of Professor Dr. Ryuso Tanaka, Faculty of Science, Hiroshima University, to whom the author wishes to express his sincerest gratitude. The author wishes to express his cordial thanks to Dr. Katsuhiko Kondo, Associate Professor, Faculty of Integrated Arts and Sciences, Hiroshima University, and Dr. Kohji Karasawa, Director, the Hiroshima Botanical Garden, for their valuable suggestions during the course of this study.

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Table 2. Measurements of somatic chromosomes of *Anoectochilus formosanus* at mitotic metaphase, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.1+1.3=2.4	3.6	1.1	m
2	0.9+1.1=2.0	3.0	1.2	m
3	0.7+1.3=2.0	3.0	1.8	sm
4	0.7+1.3=2.0	3.0	1.8	sm
5	0.6+1.4=2.0	3.0	2.3	sm
6	0.7+1.3=2.0	3.0	1.8	sm
7	0.6+1.3=1.9	2.8	2.1	sm
8	0.6+1.3=1.9	2.8	2.1	sm
9	0.6+1.3=1.9	2.8	2.1	sm
10	0.6+1.3=1.9	2.8	2.1	sm
11	0.5+1.3=1.8	2.7	2.6	sm
12	0.5+1.3=1.8	2.7	2.6	sm
13	0.5+1.3=1.8	2.7	2.6	sm
14	0.5+1.3=1.8	2.7	2.6	sm
15	0.5+1.3=1.8	2.7	2.6	sm
16	0.6+1.1=1.7	2.5	1.8	sm
17	0.6+1.1+d=1.7*	2.5	1.8	sm
18	0.5+1.1+d=1.6*	2.4	2.2	sm
19	0.5+1.1+d=1.6*	2.4	2.2	sm
20	0.6+1.1=1.7	2.5	1.8	sm
21	0.6+1.1=1.7	2.5	1.8	sm
22	0.5+1.1=1.6	2.4	2.2	sm
23	0.6+1.1=1.7	2.5	1.8	sm
24	0.6+1.1=1.7	2.5	1.8	sm
25	0.6+1.1=1.7	2.5	1.8	sm
26	0.6+1.1=1.7	2.5	1.8	sm
27	0.7+1.0=1.7	2.5	1.4	m
28	0.7+1.0=1.7	2.5	1.4	m
29	0.8+0.9=1.7	2.5	1.1	m
30	0.7+0.9=1.6	2.4	1.2	m
31	0.7+0.9=1.6	2.4	1.2	m
32	0.6+0.9=1.5	2.2	1.5	m
33	0.5+1.0=1.5	2.2	2.0	sm
34	0.5+1.0=1.5	2.2	2.0	sm
35	0.7+0.8=1.5	2.2	1.1	m
36	0.5+0.9=1.4	2.1	1.8	sm
37	0.5+0.6=1.1	1.6	1.2	m
38	0.5+0.6=1.1	1.6	1.2	m
39	0.5+0.5=1.0	1.5	1.0	m
40	0.5+0.5=1.0	1.5	1.0	m

d : lightly stained satellite
*: chromosome with secondary constriction
m: median sm: submedian

Table 3. Measurements of somatic chromosomes of *Goodyera foliosa* var. *commelinoides* at mitotic metaphase, 2n=56

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.9+1.5=2.4	2.8	1.6	m
2	0.8+1.5=2.3	2.7	1.8	sm
3	0.9+1.4=2.3	2.7	1.5	m
4	0.8+1.4=2.2	2.6	1.7	m
5	0.6+0.7+1.0=2.3*	2.7	2.8	sm
6	0.5+0.6+1.0=2.1*	2.4	3.2	st
7	0.6+0.6+0.8=2.0*	2.3	2.3	sm
8	0.4+0.6+1.0=2.0*	2.3	4.0	st
9	0.8+1.3=2.1	2.4	1.6	m
10	0.8+1.1=1.9	2.2	1.3	m
11	0.4+0.6+1.0=2.0*	2.3	1.0	m
12	0.4+0.4+1.1=1.9*	2.2	1.3	m
13	0.8+1.0=1.8	2.1	1.2	sm
14	0.7+1.1=1.8	2.1	1.5	m
15	0.6+1.0=1.6	1.9	1.6	m
16	0.6+1.0=1.6	1.9	1.6	m
17	0.7+0.9=1.6	1.9	1.2	m
18	0.7+0.9=1.6	1.9	1.2	m
19	0.6+1.0=1.6	1.9	1.6	m
20	0.7+0.8=1.5	1.7	1.1	m
21	0.7+0.8=1.5	1.7	1.1	m
22	0.7+0.8=1.5	1.7	1.1	sm
23	0.7+0.8=1.5	1.7	1.1	sm
24	0.6+0.9=1.5	1.7	1.5	m
25	0.6+0.9=1.5	1.7	1.5	m
26	0.6+0.9=1.5	1.7	1.5	m
27	0.6+0.8=1.4	1.6	1.3	m
28	0.7+0.7=1.4	1.6	1.0	m
29	0.2+0.4+0.9=1.5*	1.7	1.5	m
30	0.2+0.3+0.8=1.3*	1.5	1.6	m
31	0.4+1.0=1.4	1.6	2.5	sm
32	0.5+0.9=1.4	1.6	1.8	sm
33	0.4+0.9=1.3	1.5	2.2	sm
34	0.4+0.8=1.2	1.4	2.0	sm
35	0.4+0.8=1.2	1.4	2.0	sm
36	0.6+0.7=1.3	1.5	1.1	m
37	0.5+0.8=1.3	1.5	1.6	m
38	0.5+0.8=1.3	1.5	1.6	m
39	0.6+0.8=1.4	1.6	1.3	m
40	0.5+0.8=1.3	1.5	1.6	m

Table 3. continued

41	0.5+0.8=1.3	1.5	1.6	m
42	0.6+0.7=1.3	1.5	1.1	m
43	0.4+0.9=1.3	1.5	2.2	sm
44	0.4+0.9=1.3	1.5	2.2	sm
45	0.4+0.8=1.2	1.4	2.0	sm
46	0.3+0.8=1.1	1.3	2.6	sm
47	0.6+0.7=1.3	1.5	1.1	m
48	0.6+0.7=1.3	1.5	1.1	m
49	0.6+0.7=1.3	1.5	1.1	m
50	0.6+0.7=1.3	1.5	1.1	m
51	0.6+0.6=1.2	1.4	1.0	m
52	0.5+0.7=1.2	1.4	1.4	m
53	0.5+0.7=1.2	1.4	1.4	m
54	0.5+0.7=1.2	1.4	1.4	m
55	0.5+0.7=1.2	1.4	1.4	m
56	0.5+0.6=1.1	1.3	1.2	m

st: subterminal
See Table 2. for explanation of the other symbols.

Table 4. Measurements of somatic chromosomes of *Goodyera foliosa* var. *commelinoides* at mitotic metaphase, 2n=58

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.9+1.4=2.3	2.8	1.5	m
2	0.8+1.3=2.1	2.6	1.6	m
3	0.8+1.1=1.9	2.3	1.3	m
4	0.8+1.1=1.9	2.3	1.3	m
5	0.6+0.6+0.9=2.1*	2.6	2.5	sm
6	0.5+0.6+0.8=1.9*	2.3	2.8	sm
7	0.4+0.5+0.8=1.7*	2.1	3.2	st
8	0.6+0.5+0.6=1.2*	2.1	1.8	sm
9	0.7+1.0=1.7	2.1	1.4	m
10	0.7+0.9=1.6	2.0	1.2	m
11	0.3+0.5+1.1=1.9*	2.3	1.3	m
12	0.3+0.4+0.9=1.6*	2.0	1.2	m
13	0.6+0.9=1.5	1.8	1.5	m
14	0.7+0.8=1.5	1.8	1.1	m
15	0.7+0.8=1.5	1.8	1.1	m
16	0.7+0.8=1.5	1.8	1.1	m
17	0.7+0.8=1.5	1.8	1.1	m
18	0.7+0.8=1.5	1.8	1.1	m
19	0.5+1.0=1.5	1.8	2.0	sm
20	0.5+1.0=1.5	1.8	2.0	sm
21	0.5+1.0=1.5	1.8	2.0	sm
22	0.5+1.0=1.5	1.8	2.0	sm
23	0.6+0.9=1.5	1.8	1.5	m
24	0.6+0.8=1.4	1.7	1.3	m
25	0.4+1.0=1.4	1.7	2.5	sm
26	0.5+0.9=1.4	1.7	1.8	sm
27	0.5+0.9=1.4	1.7	1.8	sm
28	0.5+0.9=1.4	1.7	1.8	sm
29	0.5+0.9=1.4	1.7	1.8	sm
30	0.5+0.9=1.4	1.7	1.8	sm
31	0.6+0.8=1.4	1.7	1.3	m
32	0.6+0.8=1.4	1.7	1.3	m
33	0.6+0.8=1.4	1.7	1.3	m
34	0.7+0.7=1.4	1.7	1.0	m
35	0.6+0.7=1.3	1.6	1.1	m
36	0.5+0.8=1.3	1.6	1.6	m
37	0.6+0.7=1.3	1.6	1.1	m
38	0.6+0.7=1.3	1.6	1.1	m
39	0.5+0.7=1.2	1.5	1.4	m
40	0.5+0.7=1.2	1.5	1.4	m

Table 4. continued

41	0.5+0.7=1.2	1.5	1.4	m
42	0.6+0.6=1.2	1.5	1.0	m
43	0.5+0.7=1.2	1.5	1.4	m
44	0.5+0.7=1.2	1.5	1.4	m
45	0.4+0.8=1.2	1.5	2.0	sm
46	0.4+0.8=1.2	1.5	2.0	sm
47	0.4+0.8=1.2	1.5	2.0	sm
48	0.5+0.6=1.1	1.3	1.2	m
49	0.5+0.6=1.1	1.3	1.2	m
50	0.5+0.6=1.1	1.3	1.2	m
51	0.5+0.6=1.1	1.3	1.2	m
52	0.4+0.7=1.1	1.3	1.7	m
53	0.5+0.6=1.1	1.3	1.2	m
54	0.5+0.5=1.0	1.2	1.0	m
55	0.3+0.7=1.0	1.2	2.3	sm
56	0.3+0.7=1.0	1.2	2.3	sm
57	−+0.9=0.9	1.1	−	−
58	−+0.9=0.9	1.1	−	−

See Table 3. for explanation of symbols.

Table 5. Measurements of somatic chromosomes of *Goodyera foliosa* var. *laevis* at mitotic metaphase, 2n=28

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.9+0.9+1.3=3.1*	5.2	2.4	sm
2	0.9+0.9+1.3=3.1*	5.1	2.7	sm
3	1.1+1.8=2.9	4.9	1.6	m
4	1.1+1.8=2.9	4.9	1.6	m
5	0.5+0.7+1.5=2.7*	4.6	1.2	m
6	0.4+0.6+1.5=2.5*	4.2	1.5	m
7	1.3+1.4=2.7	4.6	1.0	m
8	1.1+1.3=2.4	4.0	1.1	m
9	0.9+1.4=2.3	3.9	1.5	m
10	0.9+1.3=2.2	3.7	1.4	m
11	0.7+1.4=2.1	3.5	2.0	sm
12	0.7+1.4=2.1	3.5	2.0	sm
13	0.7+1.4=2.1	3.5	2.0	sm
14	0.7+1.3=2.0	3.4	1.8	sm
15	1.0+1.1=2.1	3.5	1.1	m
16	0.9+1.1=2.0	3.4	1.2	m
17	0.9+1.0=1.9	3.2	1.1	m
18	0.8+1.0=1.8	3.0	1.2	m
19	0.7+1.0=1.7	2.9	1.4	m
20	0.6+1.0=1.6	2.7	1.6	m
21	0.8+0.9=1.7	2.9	1.1	m
22	0.8+0.9=1.7	2.9	1.1	m
23	0.8+0.9=1.7	2.9	1.1	m
24	0.8+0.9=1.7	2.9	1.1	m
25	0.6+1.1=1.7	2.9	1.8	sm
26	0.6+1.1=1.7	2.9	1.8	sm
27	0.5+1.0=1.5	2.5	2.0	sm
28	0.5+1.0=1.5	2.5	2.0	sm

See Table 2. for explanation of symbols.

Table 6. Measurements of somatic chromosomes of *Goodyera foliosa* var. *laevis* at mitotic metaphase, 2n=56

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.8+0.6+0.9=2.3*	2.7	1.8	sm
2	0.7+0.7+0.7=2.1*	2.5	2.0	sm
3	0.7+0.7+0.7=2.1*	2.5	2.0	sm
4	0.5+0.7+0.8=2.0*	2.4	3.0	sm
5	0.8+1.2=2.0	2.4	1.5	m
6	0.8+1.1=1.9	2.2	1.3	m
7	0.6+1.1=1.7	2.0	1.8	sm
8	0.6+1.1=1.7	2.0	1.8	sm
9	0.7+1.1=1.8	2.1	1.5	m
10	0.7+1.1=1.8	2.1	1.5	m
11	0.8+0.9=1.7	2.0	1.1	m
12	0.8+0.8=1.6	1.9	1.0	m
13	0.2+0.6+0.9=1.7*	2.0	1.1	m
14	0.2+0.6+0.9=1.7*	2.0	1.1	m
15	0.2+0.5+1.0=1.7*	2.0	1.4	m
16	0.2+0.5+0.9=1.6*	1.9	1.2	m
17	0.6+1.0=1.6	1.9	1.6	m
18	0.6+1.0=1.6	1.9	1.6	m
19	0.6+1.0=1.6	1.9	1.6	m
20	0.5 1.0 1.5	1.8	2.0	sm
21	0.6+0.9=1.5	1.8	1.5	m
22	0.6+0.9=1.5	1.8	1.5	m
23	0.6+0.9=1.5	1.8	1.5	m
24	0.6+0.9=1.5	1.8	1.5	m
25	0.6+0.9=1.5	1.8	1.5	m
26	0.7+0.8=1.5	1.8	1.1	m
27	0.6+0.9=1.5	1.8	1.5	m
28	0.7+0.7=1.4	1.6	1.0	m
29	0.7+0.7=1.4	1.6	1.0	m
30	0.6+1.8=1.4	1.6	1.3	m
31	0.7+0.7=1.4	1.6	1.0	m
32	0.7+0.7=1.4	1.6	1.0	m
33	0.5+1.0=1.5	1.8	2.0	sm
34	0.5+1.0=1.5	1.8	2.0	sm
35	0.6+0.9=1.5	1.8	1.5	m
36	0.5+0.8=1.3	1.5	1.6	m
37	0.5+0.8=1.3	1.5	1.6	m
38	0.5+1.0=1.5	1.8	2.0	sm
39	0.5+0.9=1.4	1.6	1.8	sm
40	0.5+0.9=1.4	1.6	1.8	sm
41	0.6+0.7=1.3	1.5	1.1	m
42	0.6+0.7=1.3	1.5	1.1	m
43	0.5+0.8=1.3	1.5	1.6	m
44	0.5+0.8=1.3	1.5	1.6	m
45	0.5+0.9=1.4	1.6	1.8	sm
46	0.5+1.9=1.4	1.6	1.8	sm
47	0.5+1.9=1.4	1.6	1.8	sm
48	0.4+0.9=1.3	1.5	2.2	sm
49	0.6+0.7=1.3	1.5	1.1	m
50	0.6+0.7=1.3	1.5	1.1	m
51	0.6+0.7=1.3	1.5	1.1	m
52	0.6+0.7=1.3	1.5	1.1	m
53	0.5+0.7=1.2	1.4	1.4	m
54	0.5+0.7=1.2	1.4	1.4	m
55	0.5+1.6=1.1	1.3	1.2	m
56	0.1+0.7=1.1	1.3	1.7	m

See Table 3. for explanation of symbols.

Table 7. Measurements of somatic chromosomes of *Goodyera hachijoensis* var. *hachijoensis* at mitotic metaphase, 2n=28

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.8+0.9+1.4=3.1*	5.2	2.8	sm
2	0.7+0.9+1.4=3.0*	5.1	3.2	st
3	1.3+1.8=3.1	5.2	1.3	m
4	1.1+1.7=2.8	4.7	1.5	m
5	0.9+1.7=2.6	4.4	1.8	sm
6	0.9+1.6=2.5	4.2	1.7	m
7	1.0+1.4=2.4	4.0	1.4	m
8	0.9+1.4=2.3	3.9	1.5	m
9	0.9+1.3=2.2	3.7	1.4	m
10	0.8+1.3=2.1	3.5	1.6	m
11	0.8+1.3=2.1	3.5	1.6	m
12	0.8+1.3=2.1	3.5	1.6	m
13	0.5+0.5+1.0=2.0*	3.4	1.0	m
14	0.5+0.5+1.0=2.0*	3.4	1.0	m
15	0.9+1.1=2.0	3.4	1.2	m
16	0.9+1.0=1.9	3.2	1.1	m
17	0.8+1.1=1.9	3.2	1.3	m
18	0.8+1.1=1.9	3.2	1.3	m
19	0.8+1.1=1.9	3.2	1.3	m
20	0.7+1.0=1.7	2.9	1.4	m
21	0.5+1.4=1.9	3.2	2.8	sm
22	0.5+1.4=1.9	3.2	2.8	sm
23	0.6+1.3=1.9	3.2	2.1	sm
24	0.5+1.3=1.8	3.0	2.6	sm
25	0.8+0.8=1.6	2.7	1.0	m
26	0.8+0.8=1.6	2.7	1.0	m
27	0.7+0.8=1.5	2.5	1.1	m
28	0.7+0.8=1.5	2.5	1.1	m

See Table 3. for explanation of symbols.

Table 8. Measurements of somatic chromosomes of *Goodyera hachijoensis* var. *leuconeura* at mitotic metaphase, 2n=28

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.0+1.0+1.5=3.5*	5.6	2.5	sm
2	0.9+0.9+1.4=3.2*	5.1	2.5	sm
3	1.1+1.9=3.0	4.8	1.7	m
4	1.1+1.7=2.8	4.5	1.5	m
5	0.9+1.8=2.7	4.3	2.0	sm
6	0.8+1.7=2.5	4.0	2.1	sm
7	1.0+1.4=2.4	3.8	1.4	m
8	1.0+1.4=2.4	3.8	1.4	m
9	0.5+0.5+1.3=2.3*	3.7	1.3	m
10	0.4+0.6+1.3=2.3*	3.7	1.3	m
11	0.9+1.4=2.3	3.7	1.5	m
12	0.8+1.4=2.2	3.5	1.7	m
13	0.9+1.3=2.2	3.5	1.4	m
14	0.9+1.3=2.2	3.5	1.4	m
15	0.8+1.3=2.1	3.3	1.6	m
16	0.8+1.3=2.1	3.3	1.6	m
17	0.9+1.1=2.0	3.2	1.2	m
18	0.9+1.1=2.0	3.2	1.2	m
19	1.0+1.0=2.0	3.2	1.0	m
20	0.9+0.9=1.8	2.9	1.0	m
21	0.6+1.5=2.1	3.3	2.5	sm
22	0.6+1.4=2.0	3.2	2.3	sm
23	0.3+1.4=2.0	3.2	2.3	sm
24	0.6+0.3=1.9	3.0	2.1	sm
25	0.9+0.9=1.8	2,9	1.0	m
26	0.8+0.9=1.7	2.7	1.1	m
27	0.8+0.8=1.6	2.6	1.0	m
28	0.8+0.8=1.6	2.6	1.0	m

See Table 2. for explanation of symbols.

Table 9. Measurements of somatic chromosomes of *Goodyera hachijoensis* var. *matsumurana* at mitotic metaphase, 2n=28

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.7+0.9+1.3=2.9*	5.1	3.1	st
2	0.7+0.8+1.2=2.7*	4.8	2.8	sm
3	1.3+1.8=3.1	5.5	1.3	m
4	1.0+1.7=2.7	1.8	1.7	m
5	0.9+1.5=2.4	4.2	1.6	m
6	0.8+1.5=2.3	4.1	1.8	sm
7	0.9+1.4=2.3	4.1	1.5	m
8	0.9+1.3=2.2	3.9	1.4	m
9	1.0+1.3=2.3	4.1	1.3	m
10	0.9+1.1=2.0	3.5	1.2	m
11	0.5+0.5+1.1=2.1*	3.7	1.1	m
12	0.5.+0.4+1.1=2.0*	3.5	1.2	m
13	0.6+1.4=2.0	3.5	2.3	sm
14	0.5+1.5=2.0	3.5	3.0	sm
15	0.6+1.1=2.0	3.5	1.2	m
16	0.9+1.0=1.9	3.4	1.1	m
17	0.8+1.1=1.9	3.4	1.3	m
18	0.8+1.1=1.9	3.4	1.3	m
19	0.7+1.1=1.8	3.2	1.5	m
20	0.7+1.0=1.7	3.0	1.4	m
21	0.7+1.0=1.7	3.0	1.4	m
22	0.8+0.8=1.6	2.8	1.0	m
23	0.6+1.0=1.6	2.8	1.6	m
24	0.7+0.9=1.6	2.8	1.2	m
25	0.7+0.9=1.6	2.8	1.2	m
26	0.7+0.8=1.5	2.6	1.1	m
27	0.5+1.0=1.5	2.6	2.0	sm
28	0.4+1.0=1.4	2.5	2.5	sm

See Table 3. for explanation of symbols.

Table 10. Measurements of somatic chromosomes of *Goodyera hachijoensis* var. *yakushimensis* at mitotic metaphase, 2n=28

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.9+0.8+2.1=3.8*	5.6	3.2	st
2	0.9+0.9+1.8=3.6*	5.3	3.0	sm
3	1.4+2.0=3.4	5.0	1.4	m
4	1.4+1.9=3.3	4.8	1.3	m
5	1.3+1.7=3.0	4.4	1.3	m
6	1.3+1.5=2.8	4.1	1.1	m
7	1.1+1.6=2.7	4.0	1.4	m
8	1.1+1.5=2.6	3.8	1.3	m
9	0.9+1.7=2.6	3.8	1.8	sm
10	0.8+1.6=2.4	3.5	2.0	sm
11	1.1+1.3=2.4	3.5	1.1	m
12	1.1+1.3=2.4	3.5	1.1	m
13	0.9+1.5=2.4	3.5	1.6	m
14	0.9+1.5=2.4	3.5	1.6	m
15	1.1+1.3=2.4	3.5	1.1	m
16	1.0+1.3=2.3	3.4	1.3	m
17	0.6+1.8=2.4	3.5	3.0	sm
18	0.6+1.4=2.3	3.4	2.8	sm
19	0.4+0.6+1.1=2.1*	3.1	1.1	m
20	0.5+0.5+1.1=2.1*	3.1	1.1	m
21	0.6+1.5=2.1	3.1	2.5	sm
22	0.6+1.5=2.1	3.1	2.5	sm
23	1.0+1.0=2.0	2.9	1.0	m
24	0.9+1.0=1.9	2.8	1.1	m
25	0.8+0.9=0.7	2.5	1.1	m
26	0.8+0.9=1.7	2.5	1.1	m
27	0.6+1.0=1.6	2.3	1.6	m
28	0.6+1.0=1.6	2.3	1.6	m

See Table 3. for explanation of symbols.

Table 11. Measurements of somatic chromosomes of *Goodyera macrantha* at mitotic metaphase, 2n=28

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.8+1.0+1.1=2.9*	5.4	2.6	sm
2	0.7+1.0+1.0=2.7*	5.0	2.8	sm
3	0.7+1.0+1.0=2.7*	5.0	2.8	sm
4	0.7+1.0+1.0=2.7*	5.0	2.8	sm
5	0.7+1.9=2.6	4.8	2.7	sm
6	0.5+1.8=2.3	4.3	3.6	st
7	0.8+1.3=2.1	3.9	1.6	m
8	0.7+1.2=1.9	3.5	1.7	m
9	0.6+1.3=1.9	3.5	2.1	sm
10	0.6+1.3=1.9	3.5	2.1	sm
11	0.9+0.9=1.8	3.3	1.0	m
12	0.8+1.0=1.8	3.3	1.2	m
13	0.4+0.4+1.0=1.8*	3.3	1.2	m
14	0.4+0.4+1.0=1.8*	3.3	1.2	m
15	0.7+1.1=1.8	3.3	1.5	m
16	0.7+1.1=1.8	3.3	1.5	m
17	0.7+1.1=1.8	3.3	1.5	m
18	0.7+1.1=1.8	3.3	1.5	m
19	0.6+1.2=1.8	3.3	2.0	sm
20	0.7+1.0=1.7	3.1	1.4	m
21	0.7+1.0=1.7	3.1	1.4	m
22	0.8+0.8=1.6	3.0	1.0	m
23	0.3+1.0=1.6	3.0	1.6	m
24	0.5+1.1=1.6	3.0	2.2	sm
25	0.5+1.1=1.6	3.0	2.2	sm
26	0.5+1.0=1.5	2.8	2.0	sm
27	0.5+0.9=1.4	2.6	1.8	sm
28	0.5+0.9=1.4	2.6	1.8	sm

See Table 3. for explanation of symbols.

Table 12. Measurements of somatic chromosomes of *Goodyera oblongifolia* at mitotic metaphase, 2n=30

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.8+1.3+0.8=2.9*	4.6	2.6	sm
2	0.8+1.4+0.6=2.8*	4.4	2.5	sm
3	0.8+2.1=2.9	4.6	2.6	sm
4	0.7+2.0=2.7	4.2	2.8	sm
5	0.8+1.8=2.6	4.1	2.2	sm
6	0.6+1.9=2.5	3.9	3.1	st
7	0.8+1.6=2.4	3.8	2.0	sm
8	0.8+1.6=2.4	3.8	2.0	sm
9	0.9+1.4=2.3	3.6	1.5	m
10	0.9+1.3=2.2	3.5	1.4	m
11	0.9+1.3=2.2	3.5	1.4	m
12	0.8+1.3=2.1	3.3	1.6	m
13	0.7+1.4=2.1	3.3	2.0	sm
14	0.6+1.5=2.1	3.3	2.5	sm
15	0.8+1.2=2.0	3.1	1.5	m
16	0.8+1.2=2.0	3.1	1.5	m
17	0.7+1.3=2.0	3.1	1.8	sm
18	0.7+1.3=2.0	3.1	1.8	sm
19	0.7+1.3=2.0	3.1	1.8	sm
20	0.5+1.0=2.0	3.1	3.0	sm
21	0.9+0.9=1.8	2.8	1.0	m
22	0.7+1.1=1.8	2.8	1.5	m
23	0.6+1.2=1.8	2.8	2.0	sm
24	0.6+1.2=1.8	2.8	2.0	sm
25	0.8+0.9=1.7	2.7	1.1	m
26	0.8+1.9=1.7	2.7	1.1	m
27	0.7+1.0=1.7	2.7	1.4	m
28	0.3+1.1=1.7	2.7	1.9	sm
29	0.6+1.1=1.7	2.7	1.8	sm
30	0.5+0.9=1.4	2.2	1.8	sm

See Table 3. for explanation of symbols.

Table 13. Measurements of somatic chromosomes of *Goodyera pendula* at mitotic metaphase, 2n=30

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.8+0.8+2.5=4.1*	6.5	4.1	st
2	0.8+0.9+2.3=4.0*	6.3	4.0	st
3	1.3+2.1=3.4	5.4	1.6	m
4	1.1+2.0=3.1	4.9	1.8	sm
5	1.1+1.5=2.6	4.1	1.3	m
6	1.1+1.4=2.5	4.0	1.2	m
7	0.7+1.7=2.4	3.8	2.4	sm
8	0.6+1.8=2.4	3.8	3.0	sm
9	0.7+1.6=2.3	3.6	2.2	sm
10	0.6+1.7=2.3	3.6	2.8	sm
11	0.4+0.5+1.4=2.3*	3.6	1.5	m
12	0.4+0.4+1.3=2.1*	3.3	1.6	m
13	0.8+1.4=2.2	3.5	1.4	m
14	0.9+1.3=2.2	3.5	1.4	m
15	0.8+1.3=2.1	3.3	1.6	m
16	0.9+1.1=2.0	3.2	1.2	m
17	0.7+1.4=2.1	3.3	2.0	sm
18	0.7+1.3=2.0	3.2	1.8	sm
19	0.7+0.9=1.6	2.5	1.2	m
20	0.7+0.9=1.6	2.5	1.2	m
21	0.7+0.8=1.5	2.4	1.1	m
22	0.7+0.8=1.5	2.4	1.1	m
23	0.7+0.7=1.4	2.2	1.0	m
24	0.7+0.7=1.4	2.2	1.0	m
25	0.6+0.8=1.4	2.2	1.3	m
26	0.6+0.8=1.4	2.2	1.3	m
27	0.6+0.7=1.3	2.1	1.1	m
28	0.6+0.7=1.3	2.1	1.1	m
29	0.6+0.7=1.3	2.0	1.1	m
30	0.6+0.7=1.3	2.1	1.1	m

See Table 3. for explanation of symbols.

Table 14. Measurements of somatic chromosomes of *Goodyera procera* at mitotic metaphase, 2n=42

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.6+1.5=2.1	3.4	2.5	sm
2	0.6+1.5=2.1	3.4	2.5	sm
3	0.5+1.6=2.1	3.4	3.2	st
4	0.5+1.5=2.0	3.2	3.0	sm
5	0.7+1.0=1.7	2.7	1.4	m
6	0.7+1.0=1.7	2.7	1.4	m
7	0.6+1.3=1.9	3.1	2.1	sm
8	0.5+1.3=1.8	2.9	2.6	sm
9	0.6+1.1=1.7	2.7	1.8	sm
10	0.5+1.1=1.6	2.6	2.2	sm
11	0.5+1.1=1.6	2.6	2.2	sm
12	0.5+1.0=1.5	2.4	2.0	sm
13	0.6+1.0=1.6	2.6	1.6	m
14	0.6+1.0=1.6	2.6	1.6	m
15	0.6+1.0=1.6	2.6	1.6	m
16	0.6+1.0=1.6	2.6	1.6	m
17	0.6+1.0=1.6	2.6	1.6	m
18	0.6+1.0=1.6	2.6	1.6	m
19	0.7+0.9=1.6	2.6	1.2	m
20	0.6+0.9=1.5	2.4	1.5	m
21	0.5+0.8=1.3	2.1	1.6	m
22	0.5+0.8=1.3	2.1	1.6	m
23	0.4+1.0=1.4	2.3	2.5	sm
24	0.4+1.0=1.4	2.3	2.5	sm
25	0.5+0.9=1.4	2.3	1.8	sm
26	0.5+0.9=1.4	2.3	1.8	sm
27	0.5+0.9=1.4	2.3	1.8	sm
28	0.4+0.8=1.2	1.9	2.0	sm
29	0.6+0.8=1.4	2.3	1.3	m
30	0.6+0.8=1.4	2.3	1.3	m
31	0.6+0.8=1.4	2.3	1.3	m
32	0.6+0.7=1.3	2.1	1.1	m
33	0.4+0.9=1.3	2.1	2.2	sm
34	0.4+0.8=1.2	1.9	2.0	sm
35	0.4+0.8=1.2	1.9	2.0	sm
36	0.4+0.7=1.1	1.8	1.7	m
37	0.4+0.7=1.1	1.8	1.7	m
38	0.4+0.7=1.1	1.8	1.7	m
39	0.5+0.6=1.1	1.8	1.2	m
40	0.4+0.6=1.0	1.6	1.5	m
41	0.4+0.6=1.0	1.6	1.5	m
42	0.4+0.6=1.0	1.6	1.5	m

See Table 3. for explanation of symbols.

Table 15. Measurements of somatic chromosomes of *Goodyera pubescens* at mitotic metaphase, 2n=26

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.9+1.1+1.1=3.1*	5.3	2.4	sm
2	0.7+1.1+1.1=2.9*	4.9	3.1	st
3	1.0+1.7=2.7	4.6	1.7	m
4	1.0+1.6=2.6	4.4	1.6	m
5	1.0+1.6=2.6	4.4	1.6	m
6	0.9+1.7=2.6	4.4	1.8	sm
7	0.9+0.8+0.9=2.6*	4.4	1.8	sm
8	1.0+0.7+0.8=2.5*	4.3	1.5	m
9	1.0+1.5=2.5	4.3	1.5	m
10	0.9+1.6=2.5	4.3	1.7	m
11	0.9+1.5=2.4	4.1	1.6	m
12	1.0+1.3=2.3	3.9	1.3	m
13	0.8+1.5=2.3	3.9	1.8	sm
14	0.8+1.5=2.3	3.9	1.8	sm
15	0.8+1.4=2.2	3.8	1.7	m
16	0.8+1.4=2.2	3.8	1.7	m
17	0.8+1.0+0.3=2.1*	3.6	1.6	m
18	0.7+1.0+0.4=2.1*	3.6	2.0	sm
19	0.7+1.3=2.0	3.4	1.8	sm
20	0.7+1.3=2.0	3.4	1.8	sm
21	0.9+0.9=1.8	3.1	1.0	m
22	0.7+1.1=1.8	3.1	1.5	m
23	0.8+0.9=1.7	2.9	1.1	m
24	0.7+1.0=1.7	2.9	1.4	m
25	0.6+1.0=1.6	2.7	1.6	m
26	0.6+0.9=1.5	2.6	1.5	m

See Table 3. for explanation of symbols.

Table 16. Measurements of somatic chromosomes of *Goodyera repens* at mitotic metaphase, 2n=30

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.6+0.7+2.3=4.6*	6.9	1.8	sm
2	1.5+0.7+2.3=4.5*	6.8	2.0	sm
3	1.4+1.7=3.1	4.7	1.2	m
4	1.3+1.6=2.9	4.4	1.2	m
5	0.9+1.7=2.6	3.9	1.8	sm
6	0.9+1.7=2.6	3.9	1.8	sm
7	0.9+1.6=2.5	3.8	1.7	m
8	0.9+1.5=2.4	3.6	1.6	m
9	0.8+1.5=2.3	3.5	1.8	sm
10	0.8+1.5=2.3	3.5	1.8	sm
11	1.0+1.3=2.3	3.5	1.3	m
12	0.7+1.6=2.3	3.5	2.2	sm
13	0.7+1.4=2.1	3.2	2.0	sm
14	0.9+1.3=2.2	3.3	1.4	m
15	0.8+1.3=2.1	3.2	1.6	m
16	0.9+1.1=2.0	3.0	1.2	m
17	0.7+1.2=1.9	2.9	1.7	m
18	0.7+1.1=1.8	2.7	1.5	m
19	0.7+0.5+0.6=1.8*	2.7	1.5	m
20	0.8+0.5+0.6=1.9*	2.9	1.3	m
21	0.9+1.0=1.9	2.9	1.1	m
22	0.9+0.9=1.8	2.7	1.0	m
23	0.9+0.9=1.8	2.7	1.0	m
24	0.8+0.9=1.7	2.6	1.1	m
25	0.7+1.0=1.7	2.6	1.4	m
26	0.7+0.8=1.5	2.3	1.1	m
27	0.7+0.8=1.5	2.3	1.1	m
28	0.7+0.8=1.5	2.3	1.1	m
29	0.7+0.8=1.5	2.3	1.1	m
30	0.7+0.8=1.5	2.3	1.1	m

See Table 2. for explanation of symbols.

Table 17. Measurements of somatic chromosomes of *Goodyera schlechtendaliana* at mitotic metaphase, 2n=30

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.9+1.3+1.6=3.8*	5.2	3.2	st
2	0.8+1.4+1.4=3.6*	4.9	3.5	st
3	1.0+2.3=3.3	4.5	2.3	sm
4	0.9+2.1=3.0	4.1	2.3	sm
5	1.4+1.7=3.1	4.3	1.2	m
6	1.4+1.4=3.1	4.3	1.2	m
7	1.5+1.6=3.1	4.3	1.0	m
8	1.5+1.5=3.0	4.1	1.0	m
9	1.3+1.4=2.7	3.7	1.0	m
10	1.3+1.4=2.7	3.7	1.0	m
11	1.1+1.4=2.5	3.4	1.2	m
12	1.1+1.4=2.5	3.4	1.2	m
13	1.0+1.5=2.5	3.4	1.5	m
14	1.1+1.3=2.4	3.3	1.1	m
15	d+0.5+1.8=2.3*	3.2	3.6	st
16	d+0.5+1.6=2.1*	2.9	3.2	st
17	0.9+1.4=2.3	3.2	1.5	m
18	0.8+1.1=1.9	2.6	1.3	m
19	0.8+1.5=2.3	3.2	1.8	sm
20	0.7+1.3=2.0	2.7	1.8	sm
21	0.8+1.3=2.1	2.9	1.6	m
22	0.8+1.1=1.9	2.6	1.3	m
23	0.9+1.4=2.3	3.2	1.5	m
24	0.9+1.0=1.9	2.6	1.1	m
25	0.8+1.0=1.8	2.5	1.2	m
26	0.8+1.0=1.8	2.5	1.2	m
27	0.9+0.9=1.8	2.5	1.0	m
28	0.7+1.0=1.7	2.3	1.4	m
29	0.6+1.1=1.7	2.3	1.8	sm
30	0.6+1.0=1.6	2.2	1.6	m

See Table 3. for explanation of symbols.

Table 18. Measurements of somatic chromosomes of *Goodyera schlechtendaliana* at mitotic metaphase, 2n=60

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.4+2.0=3.4	2.9	1.4	m
2	1.5+1.9=3.4	2.9	1.2	m
3	0.8+1.5+1.0=3.3*	2.8	3.1	st
4	0.7+1.4+1.1=3.1*	2.7	3.4	st
5	1.3+1.9=3.2	2.8	1.4	m
6	1.0+1.9=2.9	2.5	1.9	sm
7	0.6+1.1+1.3=3.0*	2.6	4.0	st
8	0.8+1.0+0.9=2.7*	2.3	2.3	sm
9	0.8+1.4=2.2	1.9	1.7	m
10	1.0+1.4=2.4	2.1	1.4	m
11	1.0+1.4=2.4	2.1	1.4	m
12	1.0+1.4=2.4	2.1	1.4	m
13	0.6+1.7=2.3	2.0	2.8	sm
14	0.6+1.6=2.2	1.9	2.6	sm
15	0.8+1.5=2.3	2.0	1.8	sm
16	0.8+1.4=2.2	1.9	1.7	m
17	0.9+1.3=2.2	1.9	1.4	m
18	0.9+1.3=2.2	1.9	1.4	m
19	1.0+1.1=2.1	1.8	1.1	m
20	0.8+1.3=2.1	1.8	1.6	m
21	0.6+1.5=2.1	1.8	2.5	sm
22	0.8+1.3=2.1	1.8	1.6	m
23	0.9+1.1=2.0	1.7	1.2	m
24	0.9+1.0=1.9	1.6	1.1	m
25	0.8+1.0=1.8	1.5	1.2	m
26	0.8+1.0=1.8	1.5	1.2	m
27	0.6+1.3=1.9	1.6	2.1	sm
28	0.6+1.3=1.6	1.6	2.1	sm
29	0.7+1.1=1.8	1.5	1.5	m
30	0.7+1.1=1.8	1.5	1.5	m
31	0.6+1.5=2.1	1.8	2.5	sm
32	0.4+1.5=1.9	1.6	3.7	st
33	0.3+1.5=1.8	1.5	5.0	st
34	0.3+1.6=1.9	1.6	5.3	st
35	0.8+1.0=1.8	1.5	1.2	m
36	0.8+1.0=1.8	1.5	1.2	m
37	0.6+1.1=1.7	1.5	1.8	sm
38	0.8+0.9=1.7	1.5	1.1	m
39	0.8+0.9=1.7	1.5	1.1	m
40	0.7+0.8=1.5	1.3	1.1	m

Table 18. continued

41	0.6+1.1=1.7	1.5	1.8	sm
42	0.6+1.0=1.6	1.4	1.6	m
43	0.7+0.8=1.5	1.3	1.1	m
44	0.7+0.8=1.5	1.3	1.1	m
45	0.6+0.8=1.4	1.2	1.3	m
46	0.6+0.8=1.4	1.2	1.3	m
47	0.6+0.8=1.4	1.2	1.3	m
48	0.6+0.8=1.4	1.2	1.3	m
49	0.5+1.0=1.5	1.3	2.0	sm
50	0.5+0.9=1.4	1.2	1.8	sm
51	0.5+0.9=1.4	1.2	1.8	sm
52	0.4+1.0=1.4	1.2	2.5	sm
53	0.4+1.0=1.4	1.2	2.5	sm
54	0.4+0.9=1.3	1.1	2.2	sm
55	0.5+0.8=1.3	1.1	1.6	m
56	0.5+0.7=1.2	1.0	1.4	m
57	0.6+0.6=1.2	1.0	1.0	m
58	0.5+0.6=1.1	0.9	1.2	m
59	0.4+0.8=1.2	1.0	2.0	sm
60	0.3+0.7=1.0	0.9	2.3	sm

See Table 3. for explanation of symbols.

Table 19. Measurements of somatic chromosomes of *Goodyera velutina* at mitotic metaphase, 2n=28

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.6+0.8+0.8=2.2*	4.9	2.6	sm
2	0.6+0.7+0.7=2.0*	4.5	2.3	sm
3	0.8+1.3=2.1	4.7	1.6	m
4	0.8+1.3=2.1	4.7	1.6	m
5	0.3+0.5+1.0=1.8*	4.0	1.2	m
6	0.3+0.4+1.0=1.7*	3.8	1.4	m
7	0.8+1.0=1.8	4.0	1.2	m
8	0.8+1.0=1.8	4.0	1.2	m
9	0.7+1.0=1.7	3.8	1.4	m
10	0.7+1.0=1.7	3.8	1.4	m
11	0.8+0.9=1.7	3.8	1.1	m
12	0.8+0.9=1.7	3.8	1.1	m
13	0.7+0.9=1.6	3.6	1.2	m
14	0.6+1.0=1.6	3.6	1.6	m
15	0.7+0.8=1.5	3.3	1.1	m
16	0.7+0.8=1.5	3.3	1.1	m
17	0.7+0.8=1.5	3.3	1.1	m
18	0.7+0.8=1.5	3.3	1.1	m
19	0.7+0.8=1.5	3.3	1.1	m
20	0.6+0.8=1.4	3.1	1.3	m
21	0.6+0.8=1.4	3.1	1.3	m
22	0.6+0.8=1.4	3.1	1.3	m
23	0.5+0.9=1.4	3.1	1.8	sm
24	0.4+0.9=1.3	2.9	2.3	sm
25	0.6+0.7=1.3	2.9	1.1	m
26	0.6+0.7=1.3	2.9	1.1	m
27	0.5+0.8=1.3	2.9	1.6	m
28	0.4+0.7=1.1	2.4	1.7	m

See Table 2. for explanation of symbols.

Table 20. Measurements of somatic chromosomes of *Goodyera velutina* at mitotic metaphase, 2n=56

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.9+1.4=2.3	2.6	1.5	m
2	0.9+1.4=2.3	2.6	1.5	m
3	1.0+1.3=2.3	2.6	1.3	m
4	0.9+1.3=2.2	2.5	1.4	m
5	0.8+1.4=2.2	2.5	1.7	m
6	0.8+1.4=2.2	2.5	1.7	m
7	0.7+0.7+0.8=2.2*	2.5	2.1	sm
8	0.6+0.7+0.8=2.1*	2.4	2.5	sm
9	0.5+0.8+0.8=2.1*	2.4	3.2	st
10	0.5+0.8+0.8=2.1*	2.4	3.2	st
11	0.3+0.4+1.1=1.8*	2.0	1.5	m
12	0.4+0.4+0.9=1.7*	1.9	1.1	m
13	0.6+1.1=1.7	1.9	1.8	sm
14	0.6+1.1=1.7	1.9	1.8	sm
15	0.8+0.9=1.7	1.9	1.1	m
16	0.8+0.9=1.7	1.9	1.1	m
17	0.7+0.9=1.6	1.8	1.2	m
18	0.7+0.9=1.6	1.8	1.2	m
19	0.6+1.0=1.6	1.8	1.6	m
20	0.6+1.0=1.6	1.8	1.6	m
21	0.6+1.0=1.6	1.8	1.6	m
22	0.6+1.0=1.6	1.8	1.6	m
23	0.8+0.8=1.6	1.8	1.0	m
24	0.7+0.9=1.6	1.8	1.2	m
25	0.8+0.8=1.6	1.8	1.0	m
26	0.8+0.8=1.6	1.8	1.0	m
27	0.6+0.9=1.5	1.7	1.5	m
28	0.5+1.1=1.6	1.8	2.2	sm
29	0.4+1.1=1.5	1.7	2.7	sm
30	0.5+0.9=1.4	1.6	1.8	sm
31	0.7+0.8=1.5	1.7	1.1	m
32	0.7+0.8=1.5	1.7	1.1	m
33	0.7+0.8=1.5	1.7	1.1	m
34	0.7+0.8=1.5	1.7	1.1	m
35	0.7+0.7=1.4	1.6	1.0	m
36	0.5+0.9=1.4	1.6	1.8	sm
37	0.5+0.9=1.4	1.6	1.8	sm
38	0.5+0.9=1.4	1.6	1.8	sm
39	0.6+0.8=1.4	1.6	1.3	m
40	0.6+0.8=1.4	1.6	1.3	m
41	0.5+0.9=1.4	1.6	1.8	sm
42	0.6+0.8=1.4	1.6	1.3	m
43	0.6+0.8=1.4	1.6	1.3	m
44	0.6+0.8=1.4	1.6	1.3	m
45	0.6+0.8=1.4	1.6	1.3	m
46	0.6+0.7=1.3	1.5	1.1	m
47	0.6+0.7=1.3	1.5	1.1	m
48	0.6+0.7=1.3	1.5	1.1	m
49	0.6+0.7=1.3	1.5	1.1	m
50	0.5+0.7=1.2	1.3	1.4	m
51	0.6+0.6=1.2	1.3	1.0	m
52	0.6+0.6=1.2	1.3	1.0	m
53	0.5+0.7=1.2	1.3	1.4	m
54	0.5+0.7=1.2	1.3	1.4	m
55	0.4+0.8=1.2	1.3	2.0	sm
56	0.4+0.7=1.1	1.2	1.7	m

See Table 3. for explanation of symbols.

Table 21. Measurements of somatic chromosomes of *Goodyera viridiflora* at mitotic metaphase, 2n=22

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.7+1.7=2.4	5.8	2.4	sm
2	0.7+1.7=2.4	5.8	2.4	sm
3	0.6+0.9+0.8=2.4*	5.8	3.0	sm
4	0.5+1.0+0.8=2.3*	5.5	3.6	st
5	0.5+0.9+0.9=2.3*	5.5	3.6	st
6	0.5+0.9+0.9=2.3*	5.5	3.6	st
7	0.5+1.8=2.3	5.5	3.6	st
8	0.5+1.7=2.2	5.3	3.4	st
9	0.6+1.6=2.2	5.3	2.6	sm
10	0.6+1.4=2.0	4.8	2.3	sm
11	0.8+1.0=1.8	4.3	1.2	m
12	0.8+0.9=1.7	4.1	1.1	m
13	0.7+1.0=1.7	4.1	1.4	m
14	0.6+1.0=1.6	3.9	1.6	m
15	0.5+1.1=1.6	3.9	2.2	sm
16	0.5+1.1=1.6	3.9	2.2	sm
17	0.5+1.0=1.5	3.6	2.0	sm
18	0.7+0.8=1.5	3.6	1.1	m
19	d+0.5+1.0=1.5*	3.6	2.0	sm
20	d+0.5+0.9=1.4*	3.4	1.8	sm
21	0.6+0.8=1.4	3.4	1.3	m
22	0.6+0.8=1.4	3.4	1.3	m

See Table 3. for explanation of symbols.

Table 22. Measurements of somatic chromosomes of *Hetaeria rubens* at mitotic metaphase, 2n=24

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.3+2.3=4.6	5.4	1.0	m
2	1.8+2.6=4.4	5.1	1.4	m
3	1.9+2.5=4.4	5.1	1.3	m
4	2.1+2.2=4.3	5.0	1.0	m
5	2.0+2.2=4.2	4.9	1.1	m
6	1.7+2.3=4.0	4.7	1.3	m
7	1.3+2.7=4.0	4.7	2.0	sm
8	1.0+2.9=3.9	4.5	2.9	sm
9	1.0+2.7=3.7	4.3	2.7	sm
10	1.0+2.4=3.4	4.0	2.4	sm
11	0.8+2.7=3.5	4.1	3.3	st
12	0.8+2.6=3.4	4.0	3.2	st
13	0.9+2.5=3.4	4.0	2.7	sm
14	0.9+2.4=3.3	3.8	2.6	sm
15	0.6+2.9=3.5	4.1	4.8	st
16	0.5+2.9=3.4	4.0	5.8	st
17	0.6+2.8=3.4	4.0	4.6	st
18	0.7+2.5=3.2	3.7	3.5	st
19	0.8+2.4=3.2	3.7	3.0	sm
20	0.8+2.3=3.1	3.6	2.8	sm
21	0.8+2.3=3.1	3.6	2.8	sm
22	0.8+2.0=2.8	3.3	2.5	sm
23	0.8+2.0=2.8	3.3	2.5	sm
24	0.7+2.1=2.8	3.3	3.0	sm

See Table 3. for explanation of symbols.

Table 23. Measurements of somatic chromosomes of *Hetaeria sikokiana* at mitotic metaphase, 2n=42

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.8+1.8=2.6	3.5	2.2	sm
2	0.8+1.7=2.5	3.4	2.1	sm
3	0.8+1.6=2.4	3.2	2.0	sm
4	0.9+1.5=2.4	3.2	1.6	m
5	0.8+1.4=2.2	3.0	1.7	m
6	0.8+1.4=2.2	3.0	1.7	m
7	1.0+1.1=2.1	2.8	1.1	m
8	1.0+1.1=2.1	2.8	1.1	m
9	0.9+1.1=2.0	2.7	1.2	m
10	0.8+1.1=1.9	2.6	1.3	m
11	0.7+1.3=2.0	2.7	1.8	sm
12	0.7+1.3=2.0	2.7	1.8	sm
13	0.7+1.4=2.1	2.8	2.0	sm
14	0.7+1.3=2.0	2.7	1.8	sm
15	0.8+1.1=1.9	2.6	1.3	m
16	0.8+1.1=1.9	2.6	1.3	m
17	0.2+0.4+1.3=1.9*	2.6	2.1	sm
18	0.2+0.5+1.1=1.8*	2.4	1.5	m
19	0.7+1.1=1.8	2.4	1.5	m
20	0.7+1.1=1.8	2.4	1.5	m
21	0.7+1.1=1.8	2.4	1.5	m
22	0.7+1.0=1.7	2.3	1.4	m
23	0.7+1.0=1.7	2.3	1.4	m
24	0.7+1.0=1.7	2.3	1.4	m
25	0.6+1.1=1.7	2.3	1.8	sm
26	0.5+1.1=1.6	2.2	2.2	sm
27	0.7+0.9=1.6	2.2	1.2	m
28	0.7+0.9=1.6	2.2	1.2	m
29	0.8+0.8=1.6	2.2	1.0	m
30	0.7+0.8=1.5	2.0	1.1	m
31	0.7+0.9=1.6	2.2	1.2	m
32	0.7+0.8=1.5	2.0	1.1	m
33	0.5+1.0=1.5	2.0	2.0	sm
34	0.6+0.8=1.4	1.9	1.3	m
35	0.6+0.8=1.4	1.9	1.3	m
36	0.6+0.8=1.4	1.9	1.3	m
37	0.6+0.7=1.3	1.8	1.1	m
38	0.6+0.7=1.3	1.8	1.1	m
39	0.5+0.7=1.2	1.6	1.4	m
40	0.5+0.7=1.2	1.6	1.4	m
41	0.5+0.7=1.2	1.6	1.4	m
42	0.5+0.6=1.1	1.5	1.2	m

See Table 2. for explanation of symbols.

Table 24. Measurements of somatic chromosomes of *Hetaeria yakusimensis* at mitotic metaphase, 2n=42

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.8+0.7+0.5=2.0*	3.8	1.5	m
2	0.6+0.6+0.6=1.8*	3.4	2.0	sm
3	0.6+1.1=1.7	3.2	1.8	sm
4	0.6+1.0=1.6	3.0	1.6	m
5	0.5+1.0=1.5	2.9	2.0	sm
6	0.5+1.0=1.5	2.9	2.0	sm
7	0.7+0.9=1.6	3.0	1.2	m
8	0.7+0.9=1.6	3.0	1.2	m
9	0.8+0.8=1.6	3.0	1.0	m
10	0.8+0.8=1.6	3.0	1.0	m
11	0.6+0.9=1.5	2.9	1.5	m
12	0.5+0.9=1.4	2.7	1.8	sm
13	0.5+0.9=1.4	2.7	1.8	sm
14	0.5+0.9=1.4	2.7	1.8	sm
15	0.6+0.8=1.4	2.7	1.3	m
16	0.6+0.8=1.4	2.7	1.3	m
17	0.7+0.7=1.4	2.7	1.0	m
18	0.7+0.7=1.4	2.7	1.0	m
19	0.4+0.9=1.3	2.5	2.2	sm
20	0.4+0.8=1.2	2.3	2.0	sm
21	0.5+0.8=1.3	2.5	1.6	m
22	0.5+0.8=1.3	2.5	1.6	m
23	0.5+0.8=1.3	2.5	1.6	m
24	0.5+0.7=1.2	2.3	1.4	m
25	0.6+0.6=1.2	2.3	1.0	m
26	0.6+0.6=1.2	2.3	1.0	m
27	0.4+0.7=1.1	2.1	1.7	m
28	0.4+0.7=1.1	2.1	1.7	m
29	0.5+0.6=1.1	2.1	1.2	m
30	0.5+0.6=1.1	2.1	1.2	m
31	0.5+0.6=1.1	2.1	1.2	m
32	0.5+0.5=1.0	1.9	1.0	m
33	0.5+0.5=1.0	1.9	1.0	m
34	0.5+0.5=1.0	1.9	1.0	m
35	0.4+0.5=0.9	1.7	1.2	m
36	0.3+0.5=0.8	1.5	1.6	m
37	0.3+0.5=0.8	1.5	1.6	m
38	0.4+0.4=0.8	1.5	1.0	m
39	0.4+0.4=0.8	1.5	1.0	m
40	0.3+0.4=0.7	1.3	1.3	m
41	0.3+0.4=0.7	1.3	1.3	m
42	0.3+0.4=0.7	1.3	1.3	m

See Table 2. for explanation of symbols.

Table 25. Measurements of somatic chromosomes of *Macodes petola* at mitotic metaphase, 2n=42

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.4+1.4=1.8	3.8	3.5	st
2	0.3+1.3=1.6	3.4	4.3	st
3	0.5+1.0=1.5	3.1	2.0	sm
4	0.5+1.0=1.5	3.1	2.0	sm
5	0.5+1.0=1.5	3.1	2.0	sm
6	0.5+1.0=1.5	3.1	2.0	sm
7	0.3+1.1=1.4	2.9	3.6	st
8	0.4+1.0=1.4	2.9	2.5	sm
9	0.4+1.0=1.4	2.9	2.5	sm
10	0.4+1.0=1.4	2.9	2.5	sm
11	0.4+0.9=1.3	2.7	2.2	sm
12	0.4+0.9=1.3	2.7	2.2	sm
13	0.4+0.8=1.2	2.5	2.0	sm
14	0.4+0.8=1.2	2.5	2.0	sm
15	0.4+0.8=1.2	2.5	2.0	sm
16	0.4+0.8=1.2	2.5	2.0	sm
17	0.5+0.8=1.3	2.7	1.6	m
18	0.4+0.6=1.0	2.1	1.5	m
19	0.3+0.9=1.2	2.5	3.0	sm
20	0.3+0.9=1.2	2.5	3.0	sm
21	0.3+0.8=1.1	2.3	2.6	sm
22	0.3+0.8=1.1	2.3	2.6	sm
23	0.3+0.8=1.1	2.3	2.6	sm
24	0.3+0.8=1.1	2.3	2.6	sm
25	0.3+0.7=1.0	2.1	2.3	sm
26	0.3+0.7=1.0	2.1	2.3	sm
27	0.4+0.7=1.1	2.3	1.7	m
28	0.4+0.6=1.0	2.1	1.5	m
29	0.1+0.9=1.0	2.1	9.0	t
30	0.1+0.9=1.0	2.1	9.0	t
31	0.2+0.8=1.0	2.1	4.0	st
32	0.2+0.7=0.9	1.9	3.5	st
33	0.2+0.7=0.9	1.9	3.5	st
34	0.3+0.6=0.9	1.9	2.0	sm
35	0.1+0.8=0.9	1.9	8.0	t
36	0.1+0.8=0.9	1.9	8.0	t
37	0.1+0.8=0.9	1.9	8.0	t
38	0.1+0.8=0.9	1.9	8.0	t
39	0.1+0.7=0.8	1.7	7.0	st
40	0.1+0.7=0.8	1.7	7.0	st
41	0.1+0.5=0.6	1.3	5.0	st
42	0.1+0.5=0.6	1.3	5.0	st

t: terminal
See Table 3. for explanation of symbols.

Table 26. Measurements of somatic chromosomes of *Myrmechis japonica* at mitotic metaphase, 2n=56

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.0+1.0=2.0	2.4	1.0	m
2	0.9+0.9=1.8	2.2	1.0	m
3	0.7+1.3=2.0	2.4	1.8	sm
4	0.7+1.3=2.0	2.4	1.8	sm
5	0.7+1.3=2.0	2.4	1.8	sm
6	0.6+1.4=2.0	2.4	2.3	sm
7	0.6+1.3=1.9	2.3	2.1	sm
8	0.6+1.3=1.9	2.3	2.1	sm
9	0.6+1.1=1.7	2.0	1.8	sm
10	0.6+1.1=1.7	2.0	1.8	sm
11	0.6+1.0=1.6	1.8	1.6	m
12	0.7+0.9=1.6	1.9	1.2	m
13	0.6+0.9=1.5	1.8	1.5	m
14	0.7+0.8=1.5	1.8	1.1	m
15	0.6+0.9=1.5	1.8	1.5	m
16	0.6+0.9=1.5	1.8	1.5	m
17	0.6+0.9=1.5	1.8	1.5	m
18	0.7+0.8=1.5	1.8	1.1	m
19	0.6+0.9=1.5	1.8	1.5	m
20	0.6+0.9=1.5	1.8	1.5	m
21	0.7+0.8=1.5	1.8	1.1	m
22	0.6+0.9=1.5	1.8	1.5	m
23	0.6+0.9=1.5	1.8	1.5	m
24	0.6+0.9=1.5	1.8	1.5	m
25	0.7+0.8=1.5	1.8	1.1	m
26	0.7+0.8=1.5	1.8	1.1	m
27	0.5+1.0=1.5	1.8	2.0	sm
28	0.5+1.0=1.5	1.8	2.0	sm
29	0.5+1.0=1.5	1.8	2.0	sm
30	0.5+1.0=1.5	1.8	2.0	sm
31	0.5+1.0=1.5	1.8	2.0	sm
32	0.5+1.0=1.5	1.8	2.0	sm
33	0.5+0.9=1.4	1.7	1.8	sm
34	0.5+0.9=1.4	1.7	1.8	sm
35	0.5+0.9=1.4	1.7	1.8	sm
36	0.5+0.9=1.4	1.7	1.8	sm
37	0.6+0.8=1.4	1.7	1.3	m
38	0.6+0.8=1.4	1.7	1.3	m
39	0.6+0.8=1.4	1.7	1.3	m
40	0.6+0.8=1.4	1.7	1.3	m

Table 26. continued

41	0.5+0.8=1.3	1.6	1.6	m
42	0.5+0.8=1.3	1.6	1.6	m
43	0.5+0.8=1.3	1.6	1.6	m
44	0.5+0.8=1.3	1.6	1.6	m
45	0.5+0.8=1.3	1.6	1.6	m
46	0.5+0.8=1.3	1.6	1.6	m
47	0.4+0.9=1.3	1.6	2.2	sm
48	0.4+0.9=1.3	1.6	2.2	sm
49	0.4+0.9=1.3	1.6	2.2	sm
50	0.4+0.9=1.3	1.6	2.2	sm
51	0.4+0.8=1.2	1.4	2.0	sm
52	0.4+0.8=1.2	1.4	2.0	sm
53	0.4+0.8=1.2	1.4	2.0	sm
54	0.4+0.7=1.1	1.3	1.7	sm
55	0.3+0.7=1.0	1.2	2.6	sm
56	0.3+0.7=1.0	1.3	2.3	sm

See Table 2. for explanation of symbols.

Table 27. Measurements of somatic chromosomes of *Myrmechis tsukusiana* at mitotic metaphase, 2n=28

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.9+1.3=2.2	4.5	1.4	m
2	0.9+1.3=2.2	4.5	1.4	m
3	1.0+1.0=2.0	4.1	1.0	m
4	1.0+1.0=2.0	4.1	1.0	m
5	0.9+1.0=1.9	3.9	1.1	m
6	0.8+1.1=1.9	3.9	1.3	m
7	0.8+1.1=1.9	3.9	1.3	m
8	0.8+1.1=1.9	3.9	1.3	m
9	0.8+1.0=1.8	3.7	1.2	m
10	0.8+1.0=1.8	3.7	1.2	m
11	0.6+1.3=1.9	3.9	2.1	sm
12	0.6+1.3=1.9	3.9	2.1	sm
13	0.7+1.1=1.8	3.7	1.5	m
14	0.8+0.9=1.7	3.5	1.1	m
15	0.8+0.9=1.7	3.5	1.1	m
16	0.7+1.0=1.7	3.5	1.4	m
17	d+0.5+1.1=1.6*	3.3	2.2	sm
18	d+0.5+1.1=1.6*	3.3	2.2	sm
19	0.6+1.0=1.6	3.3	1.6	m
20	0.7+0.9=1.6	3.3	1.2	m
21	0.8+0.8=1.6	3.3	1.0	m
22	0.8+0.8=1.6	3.3	1.0	m
23	0.6+0.9=1.5	3.1	1.5	m
24	0.6+0.9=1.5	3.1	1.5	m
25	0.6+0.9=1.5	3.1	1.5	m
26	0.7+0.8=1.5	3.1	1.1	m
27	0.5+1.0=1.5	3.1	2.0	sm
28	0.4+0.9=1.3	2.7	2.2	sm

See Table 2. for explanation of symbols.

Table 28. Measurements of somatic chromosomes of *Odontochilus inabai* at mitotic metaphase, 2n=28

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.0+1.7=2.7	4.3	1.7	m
2	0.9+1.7=2.6	4.1	1.8	sm
3	1.0+1.5=2.5	4.0	1.5	m
4	0.9+1.3=2.5	4.0	1.7	m
5	0.9+1.6=2.5	4.0	1.7	m
6	1.0+1.4=2.4	3.8	1.4	m
7	0.9+1.5=2.4	3.8	1.6	m
8	0.8+1.6=2.4	3.8	2.0	sm
9	1.0+1.3=2.3	3.7	1.3	m
10	1.0+1.3=2.3	3.7	1.3	m
11	1.0+1.3=2.3	3.7	1.3	m
12	0.9+1.4=2.3	3.7	1.5	m
13	0.9+1.4=2.3	3.7	1.5	m
14	0.9+1.4=2.3	3.7	1.5	m
15	1.1+1.1=2.2	3.5	1.0	m
16	0.9+1.3=2.2	3.5	1.4	m
17	0.9+1.3=2.2	3.5	1.4	m
18	0.9+1.3=2.2	3.5	1.4	m
19	1.0+1.1=2.1	3.3	1.1	m
20	0.8+1.4=2.2	3.5	1.7	m
21	0.7+1.5=2.2	3.5	2.1	sm
22	0.7+1.5=2.2	3.5	2.1	sm
23	1.0+1.0=2.0	3.2	1.0	m
24	0.8+1.1=1.9	3.0	1.3	m
25	0.7+1.3=2.0	3.2	1.8	sm
26	0.7+1.3=2.0	3.2	1.8	sm
27	0.8+1.1=1.9	3.0	1.3	m
28	0.7+1.2=1.9	3.0	1.7	m

See Table 2. for explanation of symbols.

Table 29. Measurements of somatic chromosomes of *Vexillabium yakushimense* at mitotic metaphase, 2n=26

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.8+2.6=3.4	5.3	3.2	st
2	0.8+2.5=3.3	5.1	3.1	st
3	1.4+1.5=2.9	4.5	1.0	m
4	1.3+1.6=2.9	4.5	1.2	m
5	1.0+1.8=2.8	4.3	1.8	sm
6	1.0+1.7=2.7	4.2	1.7	m
7	1.3+1.5+d=2.8*	4.3	1.1	m
8	1.3+1.5+d=2.8*	4.3	1.1	m
9	0.9+1.9=2.8	4.3	2.1	sm
10	0.8+1.9=2.7	4.2	2.3	sm
11	0.9+1.8=2.7	4.2	2.0	sm
12	0.9+1.8=2.7	4.2	2.0	sm
13	1.1+1.6=2.7	4.2	1.4	m
14	1.0+1.5=2.5	3.9	1.5	m
15	0.9+1.6=2.5	3.9	1.7	m
16	0.9+1.5=2.4	3.9	1.6	m
17	0.9+1.3=2.2	3.4	1.4	m
18	1.0+1.1=2.1	3.3	1.1	m
19	1.0+1.1=2.1	3.3	1.1	m
20	0.9+1.2=2.1	3.3	1.3	m
21	0.8+1.3=2.1	3.3	1.6	m
22	0.9+1.1=2.0	3.1	1.2	m
23	0.9+1.0=1.9	3.0	1.1	m
24	0.9+1.0=1.9	3.0	1.1	m
25	0.7+1.0=1.7	2.6	1.4	m
26	0.7+1.0=1.7	2.6	1.4	m

See Table 2. for explanation of symbols.

Table 30. Measurements of somatic chromosomes of *Zeuxine agyokuana* at mitotic metaphase, 2n=20

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.8+3.1=4.9	6.7	1.7	m
2	1.7+3.1=4.8	3.3	1.8	sm
3	1.6+3.1=4.7	6.4	1.9	sm
4	1.5+3.1=4.6	6.3	2.0	sm
5	1.4+2.6=4.0	5.5	1.8	sm
6	1.4+2.6=4.0	5.5	1.8	sm
7	1.7+2.3=4.0	5.5	1.3	m
8	1.7+2.2=3.9	5.3	1.2	m
9	0.6+0,8+2.4=3.8*	5.2	1.7	m
10	0.6+0.8+2.3=3.7*	5.1	1.6	m
11	1.0+2.6=3.6	4.9	2.6	sm
12	1.0+2.6=3.6	4.9	2.6	sm
13	0.8+2.5=3.3	4.5	3.1	st
14	0.8+2.4=3.2	4.4	3.0	sm
15	1.1+2.1=3.2	4.4	1.9	sm
16	1.1+2.1=3.2	4.4	1.9	sm
17	1.1+1.8=2.9	4.0	1.6	m
18	0.9+1.8=2.7	3.7	2.0	sm
19	0.9+1.8=2.7	3.7	2.0	sm
20	0.9+1.8=2.4	3.3	1.6	m

See Table 3. for explanation of symbols.

Table 31. Measurements of somatic chromosomes of *Zeuxine leucochila* at mitotic metaphase, 2n=20

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.6+3.3=4.9	6.6	2.0	sm
2	1.6+3.2=4.8	6.5	2.0	sm
3	1.5+3.2=4.7	6.4	2.1	sm
4	1.5+3.1=4.6	6.2	2.0	sm
5	1.1+3.4=4.5	6.1	3.0	sm
6	1.1+3.3=4.4	6.0	3.0	sm
7	1.5+2.6=4.1	5.6	1.7	m
8	1.5+2.5=4.0	5.4	1.6	m
9	0.4+0.4+2.3=3.8*	5.1	1.5	m
10	0.4+1.1+2.3=3.8*	5.1	1.5	m
11	1.4+2.3=3.7	5.0	1.6	m
12	1.4+2.3=3.7	5.0	1.6	m
13	0.5+3.2=3.7	5.0	6.4	st
14	0.5+3.1=3.6	4.9	6.2	st
15	1.3+1.4=2.7	3.7	1.0	m
16	1.3+1.3=2.6	3.5	1.0	m
17	0.8+1.9=2.7	3.7	2.3	sm
18	0.8+1.7=2.5	3.4	2.1	sm
19	0.8+1.7=2.5	3.4	2.1	sm
20	0.8+1.7=2.5	3.4	2.1	sm

See Table 3. for explanation of symbols.

Table 32. Measurements of somatic chromosomes of *Zeuxine odorata* at mitotic metaphase, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.1+2.3=3.4	3.7	2.0	sm
2	1.2+2.0=3.2	3.5	1.6	m
3	0.9+2.3=3.2	3.5	2.5	sm
4	0.8+2.3=3.1	3.4	2.8	sm
5	0.7+2.1=2.8	3.1	3.0	sm
6	0.7+2.0=2.7	3.0	2.8	sm
7	1.0+1.6=2.6	2.9	1.6	m
8	0.9+1.7=2.6	2.9	1.8	sm
9	0.8+1.8=2.6	2.9	2.2	sm
10	0.6+2.0=2.6	2.9	3.3	st
11	1.1+1.4=2.5	2.7	1.2	m
12	0.9+1.6=2.5	2.7	1.7	m
13	1.1+1.3=2.4	2.6	1.1	m
14	1.0+1.4=2.4	2.6	1.4	m
15	1.0+1.4=2.4	2.6	1.4	m
16	1.0+1.3=2.3	2.5	1.3	m
17	1.0+1.3=2.3	2.5	1.3	m
18	0.8+1.5=2.3	2.5	1.8	sm
19	0.7+1.7=2.4	2.6	2.4	sm
20	0.6+1.7=2.3	2.5	2.8	sm
21	0.7+1.6=2.3	2.5	2.2	sm
22	0.7+1.6=2.3	2.5	2.2	sm
23	0.7+1.5=2.2	2.4	2.1	sm
24	0.8+1.3=2.1	2.3	1.6	m
25	0.8+1.3=2.1	2.3	1.6	m
26	1.0+1.0=2.0	2.2	1.0	m
27	1.0+1.0=2.0	2.2	1.0	m
28	0.9+1.1=2.0	2.2	1.2	m
29	0.7+1.3=2.0	2.2	1.8	sm
30	0.9+1.0=1.9	2.1	1.1	m
31	0.8+1.1=1.9	2.1	1.3	m
32	0.7+1.2=1.9	2.1	1.7	m
33	0.6+1.3=1.9	2.1	2.1	sm
34	0.8+1.0=1.8	2.0	1.2	m
35	0.8+1.0=1.8	2.0	1.2	m
36	0.8+1.0=1.8	2.0	1.2	m
37	0.8+1.0=1.8	2.0	1.2	m
38	0.8+0.9=1.7	1.9	1.1	m
39	0.8+0.8=1.6	1.8	1.0	m
40	0.6+1.8=1.4	1.5	1.3	m

See Table 3. for explanation of symbols.