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A revision of chromosome number in some hybrids of *Paphiopedilum**

Kohji Karasawa**

パフィオペディラム属における染色体数の再検討

唐　澤　耕　司

Paphiopedilum is horticulturally valuable genus in Orchidaceae and includes many cultivars. There are several papers on the chromosome number of the cultivars (Francini 1934, Mehlquist 1947, 1949, Duncan 1947, Duncan & MacLeod 1948, Lenz 1960). Among these papers, Lenz has reported that some cultivars of hybrid origin in white Paphiopedilum have B-chromosomes, and he has presumed that the B-chromosomes of these cultivars derive from the autosomes of *P. spicerianum*.

On the other hand, in the most of the natural species of *Paphiopedilum* the chromosome number has been reported (Duncan 1947, Mehlquist 1947, Duncan & MacLeod 1948, 1949, 1950, Kamemoto *et al.* 1963, Tanaka 1964, 1965, Tanaka & Aoyama 1974, Karasawa 1978, 1979, 1980), while the B-chromosome has not been observed.

In the present investigation cultivars of white Paphiopedilum in which B-chromosomes were reported by Lenz (1960) and their parental species were karyomorphologically examined.

Material and Method

Six cultivars of white Paphiopedilum and their parental species investigated are shown in Table 1 and Fig. 4. All cultivars were the same clones with those which were used by Lenz (1960). In addition, all materials and one of the lineages of them were shown in Fig. 1 and 2, and all parental species of cultivars in Table 2.

The observation of somatic chromosomes were carried out according to the previous report (Karasawa 1979).

Observation and Discussion

Chromosomes of parental species

Somatic chromosomes at metaphase of parental species were shown in Fig. 1. All of the parental species, except for *P. spicerianum* and *P. druryi* with 2n=30, had the chro-

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mosome number of 2n=26. No extra chromosomes were observed as same as the all previous reports (cf. Karasawa 1979).

The metaphase chromosomes of the 2n=26 species, except for *P. insigne* var. *sanderae*, were divided into two quantitative groups; the one consisted of four large chromosomes and the other 22 small chromosomes decreasing gradually in size. The position of their centromeres were all median. The 13th and 14th chromosomes of *P. insigne* and the 15th and 16th chromosomes of *P. villosum* had an obvious satellite respectively, which was

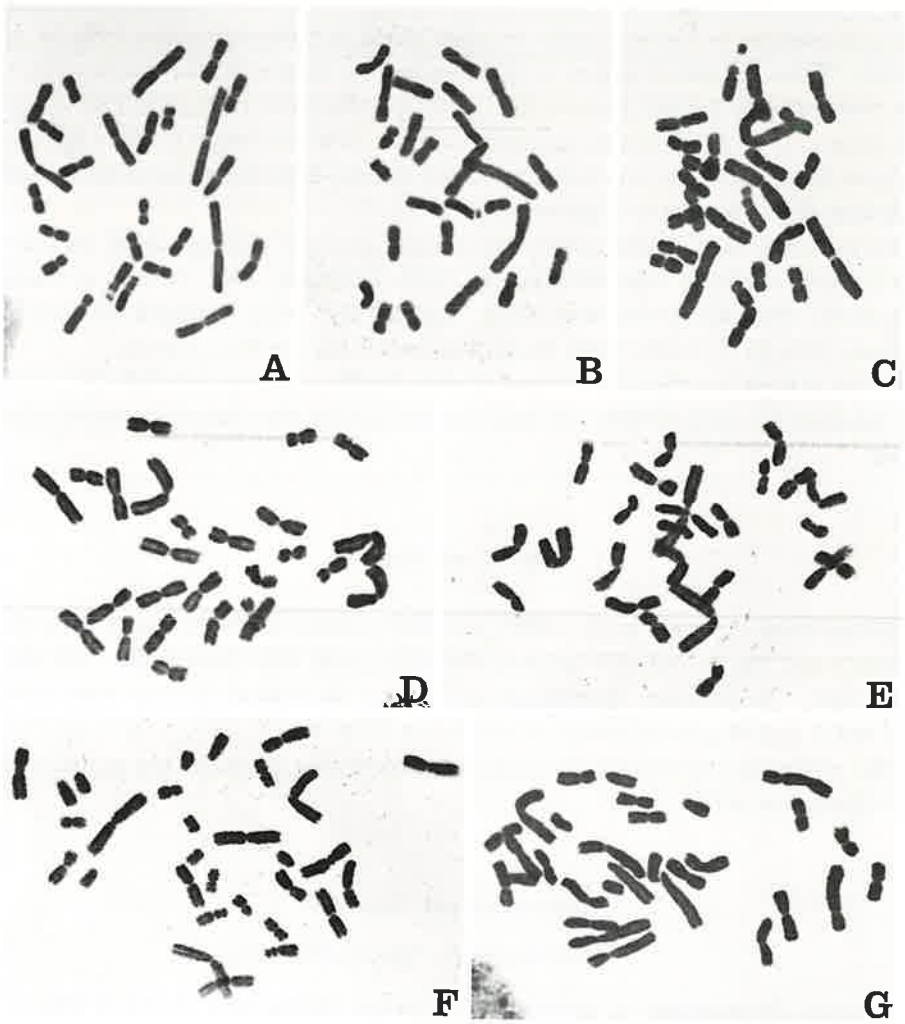


Fig. 1. Photomicrographs of the somatic chromosomes of *Paphiopedilum*.
A, *P. insigne* 2n=26. B, *P. insigne* var. *sanderae* 2n=26. C, *P. villosum* 2n=26. D, *P. niveum* 2n=26. E, *P. bellatulum* 2n=26. F, *P. spicerianum* 2n=30. G, *P. druryi* 2n=30. × 1000.

often separated from the short arm by squash technique.

The karyotype of *P. insigne* var. *sanderae* was different from that of *P. insigne* on the position of centromeres of 4th and 10th chromosome: The position of centromeres of both 4th and 10th chromosomes in *P. insigne* were median, while that in var. *sanderae* were submedian (cf. Karasawa 1978).

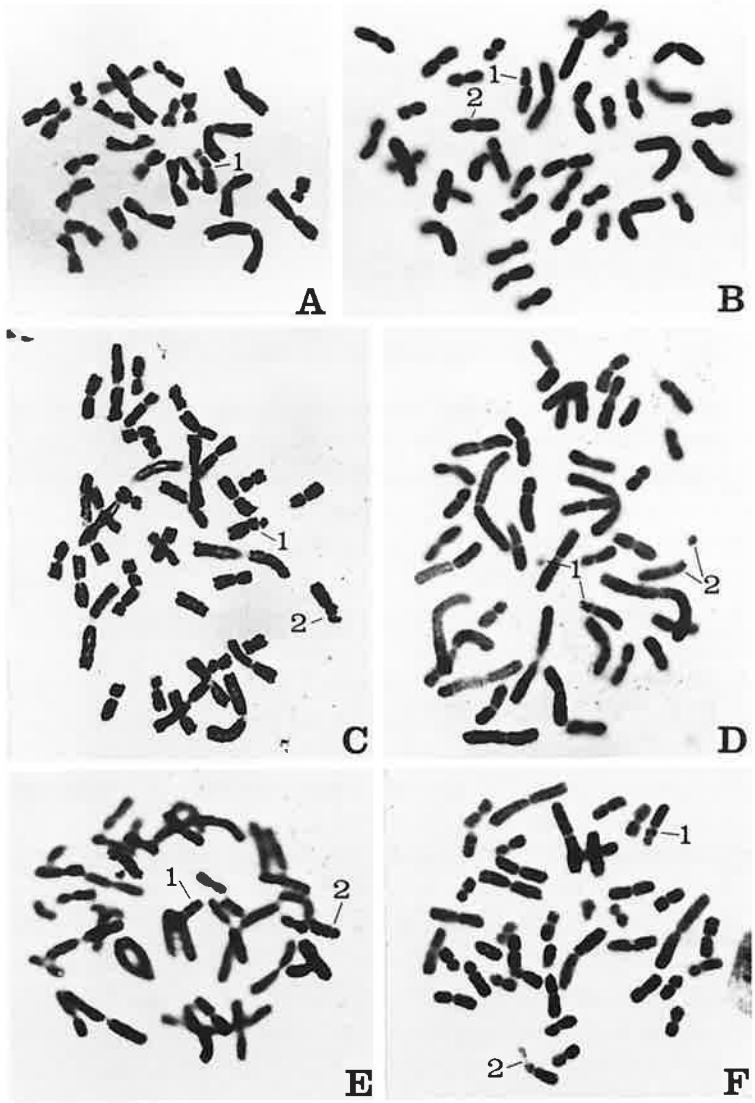


Fig. 2. Photomicrographs of the somatic chromosomes of *Paphiopedilum*.
A, *P.* Boltonii FCC/RHS 2n=26. B, *P.* Albion FCC/RHS 2n=39. C, *P.* Sumurum 'Pearl' 2n=39. D, *P.* Astarte 2n=40. E, *P.* Rosy Dawn AM/RHS 2n=40. F, *P.* F.C. Puddle FCC/RHS 2n=41. × 1000.

Table 1. Chromosome number of white Paphiopedilum

Cultivars	Chromosome number	
	Present report (2n)	Previous report (2n)
P. Boltonii FCC/RHS	26	26+1−2B
P. Albion FCC/RHS	39	39
P. Sumurum 'Pearl'	39	39+1B
P. Astarte	40	40−41+2B
P. Rosy Dawn AM/RHS	40	40+2B
P. F. C. Puddle FCC/RHS	41	Ca. 41+1−2B

Two species with the chromosome number of 2n=30, *P. spicerianum* and *P. druryi*, had 22 metacentric and 8 telocentric chromosomes. The chromosomes of *P spicerianum* had small constriction in the interstitial region of short and/or long arm.

Chromosomes of cultivars

In *P.* Boltonii FCC/RHS, a diploid cultivar, the 2n=26 chromosomes were counted (Fig. 2A). Lenz (1960) has reported that the chromosome number of this cultivar is 2n= 26+1−2B, while no extra chromosomes were found in the present investigation.

The 2n=26 chromosomes of this cultivar consisted of four large and 22 small chromosomes decreasing gradually in size. The position of centromeres of these 26 chromosomes were all median, and submetacentric chromosomes found in *P. insigne* var *sanderae* were not observed. Farthermore, the 13th chromosome had an obvious satellite which was often separated from its short arm (Fig. 3).

According to Sander's List (1945), *P.* Boltonii has been treated as a form of *P.* Muriel Hollington which had been produced by *P. insigne* and *P. niveum.*

By the karyomorphological facts described above, it is suggested that the 2n=26 chromosomes of this cultivar might be consisted of a half set of the complement of *P. insigne* and a half set of the complement of *P. niveum.*

The chromosome numbers of the other five cultivars were counted as follows: *P.* Albion FCC/RHS was 2n=39, *P.* Sumulum 'Pearl' was 2n=39, *P.* Astarte was 2n=40, *P.* Rosy Dawn AM/RHS was 2n=40 and *P.* F. C. Puddle FCC/RHS was 2n=41 (Fig. 2). All of these five cultivars did not have any extra chromosomes, while had two obvious satellites in their chromosome complements respectively, which were often separated from the short arm of their own chromosomes (arrows in Fig. 2). In mitotic prophase no chromosome showing heteropycnosis was observed. There are many parental species which have been used for the artificial hybridization in the breeding of the cultivars of white Paphiopedilum. According to the karyomorphological observations in the parental species (Karasawa 1979), only *P. insigne* and *P. villosum* were found to have satellite chromosomes. Therefore, the satellite chromosomes occurred in the five cultivars shown in Table 1 are considered to be the chromosomes of the two species. By the shape of the short

Fig. 3. Metaphase chromosomes of *Paphiopedilum*. A, *P. insigne* 2n=26. B, *P. niveum* 2n=26. C, *P.* Boltonii FCC/RHS 2n=26. × 1200.

arm of the satellite chromosomes, the four cultivars, *i.e. P.* Albion FCC/RHS, *P.* Sumulum 'Pearl', *P.* Astarte and *P.* F.C. Puddle FCC/RHS, can be presumed to have the satellite chromosome of *P. insigne* or *P. insigne* var. *sanderae*, and the cultivar, *P.* Rosy Dawn AM/RHS, to have the satellite chromosome of *P. insigne*, *P. insigne* var. *sanderae*, or *P. villosum*.

By the present karyomorphological investigations, it is clear that the small fragments in the cultivars of white Paphiopedilum are not B-chromosomes reported by Lenz (1960) but the satellites derived from *P. insigne* or *P. villosum* being their parental species.

I would like to acknowledge the continuing gaidance and encouragement of Professor Dr. Ryuso Tanaka of Hiroshima University.

Summary

1. Karyomorphological investigations were carried out in the six cultivars of white Paphiopedilum in which Lenz (1960) reported B-chromosomes. The chromosome numbers of these six cultivars were counted as follows; 2n=26 in *P.* Boltonii FCC/RHS, 2n=39 in *P.* Albion FCC/RHS and *P.* Sumulum 'Pearl', 2n=40 in *P.* Astarte and *P.* Rosy Dawn AM/RHS, 2n=41 in *P.* F.C. Puddle FCC/RHS.
2. No B-chromosome was observed in the six cultivars, while one obvious satellite was observed in the diploid cultivar and two obvious satellites in the triploid cultivars. It is assumed that they derived from the *P. insigne* or *P. villosum*.
3. It was confirmed that *P.* Boltonii was a hybrid between *P. insigne* and *P. niveum*.

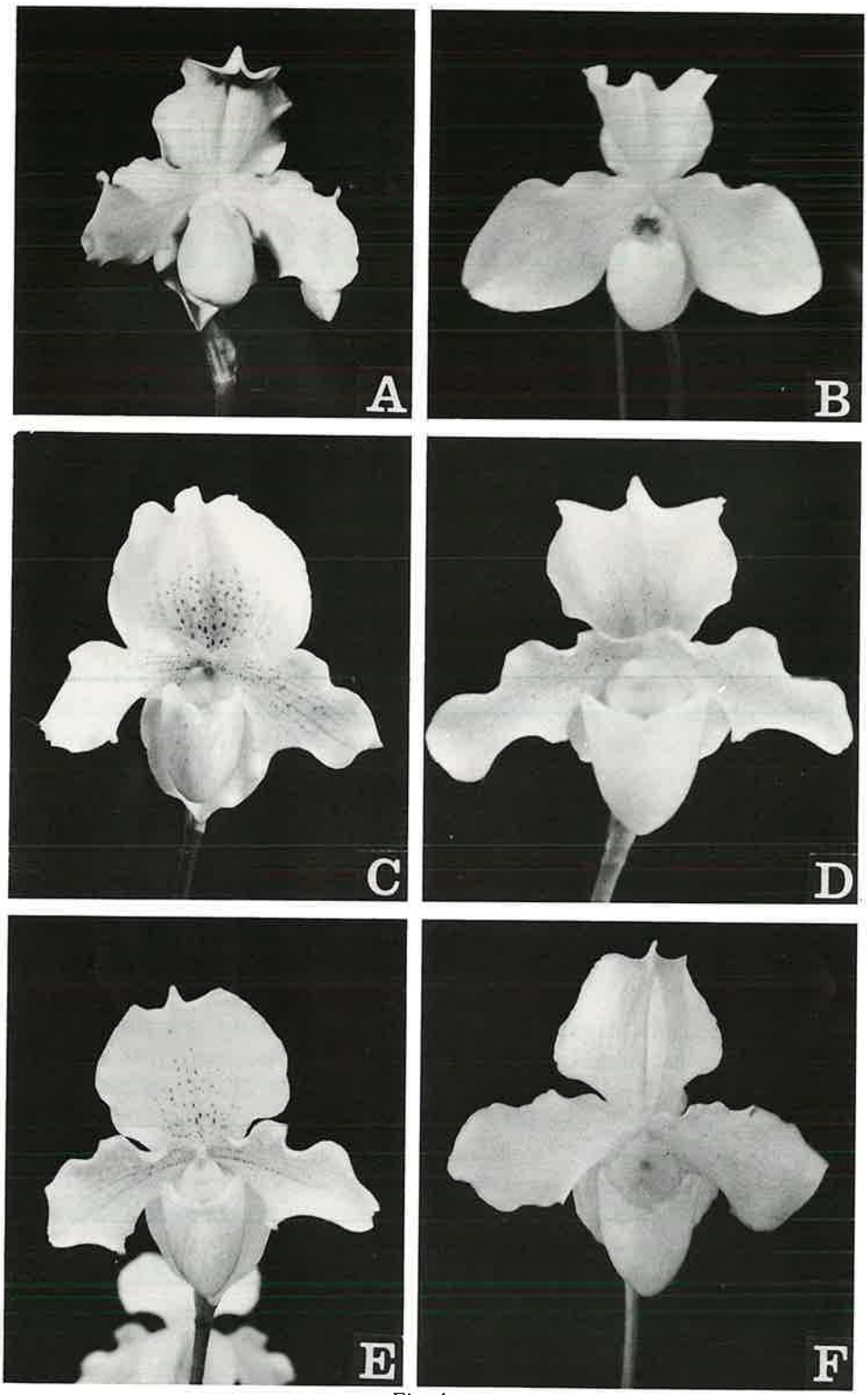
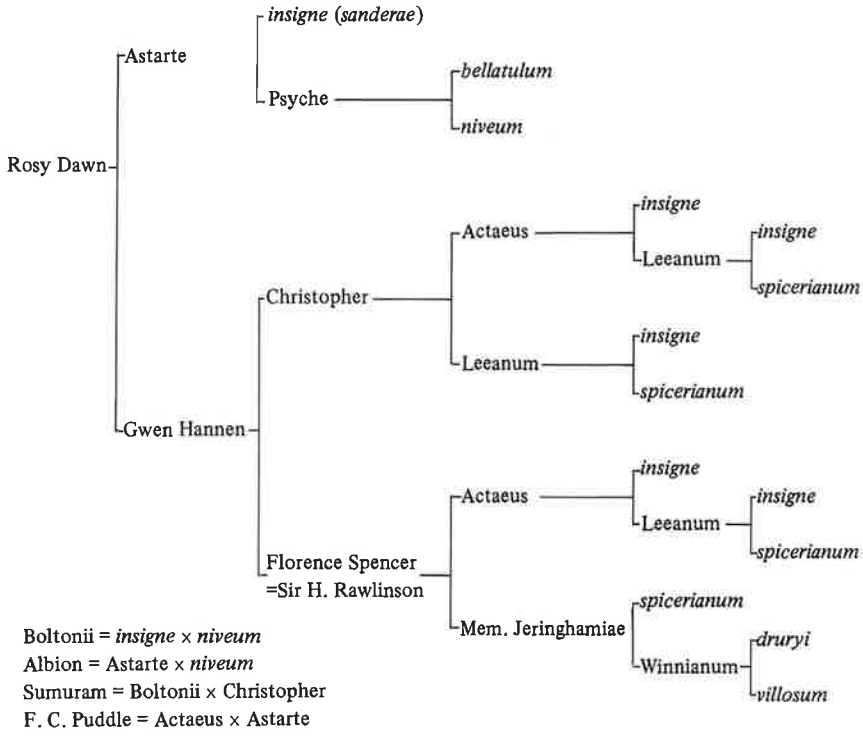


Fig. 4.

Table 2. Parental species of white Paphiopedilum



Literature Cited

Duncan, R. E. 1947. The hybrid lady slipper. Orchid Digest, Sept.-Oct.: 199–207.

_____ & MacLeod, R. A. 1948. Chromosomes of the insigne complex of lady slippers. Am. Orchid Soc. Bull. 17 : 424–429.

_____ & _____. 1949. The chromosomes of the continental species of *Paphiopedilum* with solid green leaves. Am. Orchid Soc. Bull. 18 : 84–89.

_____ & _____. 1949. The chromosomes of some of the polyantha. Am. Orchid Soc. Bull. 18 : 159–163.

_____ & _____. 1949. The chromosomes of the species of Cochlopetalum Hallier. Am. Orchid Soc. Bull. 18 : 573–576.

_____ & _____. 1950. The chromosomes of Eremantha Tesselata. Am. Orchid Soc. Bull. 19 : 137–142.

Francini, E. 1934. Ibridazione interspecifica nel genera *Paphiopedilum.* Nuovo Giornale Bot. Ital. 41 : 189–237.

Fig. 4. Flowers of white Paphiopedilum. A, *P.* Boltonii FCC/RHS. B, *P.* Albion FCC/RHS. C, *P,* Sumurum 'Pearl'. D, *P.* Astarte. E, *P.* Rosy Dawn AM/RHS. F, *P.* F.C. Puddle FCC/RHS. x 0. 5.

Kamemoto, H. H., Sagarik, R. & Dieutrakul, S. 1963. Karyotypes of *Paphiopedilum* species of Thailand. The Kasetsart Jour. 3(2) : 69–78.

Karasawa, K. 1978. Karyomorphological studies on the intraspecific variation of *Paphiopedilum insigne*. La Kromosomo. II–9 : 233–255.

_____. 1979. Karyomorphological studies in *Paphiopedilum*, Orchidaceae. Hiroshima Bot. Garden Bull. 2 : 1–149.

_____. & Aoyama, M. 1980. Karyomorphological studies on three species of *Paphiopedilum*. Hiroshima Bot. Garden Bull. 3 : 67–74. (in Japanese).

Lenz, L. W. 1960. The cytology of the white *Cypripedium*. Am. Orchid Soc. Bull. 29 : 187–191.

Mehlquist, G. A. L. 1947. Polyploidy in the genus *Paphiopedilum* Pfitz. (*Cypripedium* Hort.) and its implications. Mo. Bot. Gard. Bull. 35 : 211–228.

_____. 1949. The importance of chromosome numbers in Orchid breeding. Am. Orchid Soc. Bull. 18 : 284–293.

Tanaka, R. 1964. Chromosome count of Orchids in Japan II. Jap. Orchid Soc. Bull. 10 : 1–5. (in Japanese).

_____. 1965. Chromosome numbers some species of Orchidaceae from Japan and its neighbouring areas. Jour. Jap. Bot. 40 : 65–77.

_____. & Aoyama, M. 1974. Karyological studies on some species of *Paphiopedilum*. Jap. Orchid Soc. Bull. 20 : 3–8. (in Japanese).

_____. & Kamemoto, H. H. 1974. List of chromosome numbers in species of the Orchidaceae. The Orchid (ed. Withner). John Willy & Sons. N. Y.: 411–483.

Karyomorphological observations on *Calanthe* of Japan*

Ryuso Tanaka**, Kohji Karasawa*** and Genjiro Ishida***

日本産エビネ属の核形態学的観察

田中 隆荘・唐澤 耕司・石田 源次郎

Introduction

In the genus *Calanthe*, Orchidaceae, about 150 species are known in the world. Most of the species occur in Asian countries. In Japan about 19 species have been reported (Ohwi 1978, Maekawa 1971). Most of the Japanese species are known to be uniform and morphologically well distinguished, while some of them are morphologically complexed and highly variable (Ito and Karasawa 1969).

The present paper deals with the karyomorphological observations on the Japanese species. According to the list of Tanaka and Kamemoto (1982), the chromosome number of the species of *Calanthe* was reported to be homogeneously 2n=40, while some of them to be 2n=28, 38, 42, 44, 52 and 58. The chromosome number of the Japanese *Calanthe* was also reported to be 2n=40 in most species and 2n=38, 42, or 44 in few species. In contrast to the chromosome number very few observations have been reported on the morphology of the chromosomes of the species of *Calanthe*. Tanaka (1968) reported the results of morphological analysis in some Japanese species of *Calanthe* and presented that there was clear difference in karyotype between *Calanthe discolor* and *Calanthe rubens*, a South East Asian and deciduous species, and between *Calanthe discolor* and *Phaius minor*, an allied genus. He also reported that there was high genetic homology between the chromosomes of *Calanthe triplicata* (as *Calanthe furcata*) and those of *Calanthe sieboldii* (as *Calanthe striata* var. *sieboldii*) (Tanaka 1973). Recently Teoh and Lim (1978) and Teoh (1980) reported the morphology of the chromosomes of four Malaysian species.

According to the previous studies of Tanaka (1968, 1971a, 1971b), in Orchidaceae the morphology of chromosomes at resting stage was found to relate highly to the nature of the variability of species and to the wide-crossability between species. In the present paper the results of morphological observations of chromosomes at resting and mitotic stages are reported.

Material and Method

Taxa and the clones studied in the present investigation were shown in Table 1.

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*** The Hiroshima Botanical Garden
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Table 1. Sources, number of clones and chromosome number of the species of *Calanthe* studied

Taxon	Japanese name	Locality	Source	No. of clone	Chromosome number(2n)
Calanthe aristulifera Reichb. fil.	Kirishimaebine	Mikurajima Island, Tokyo Metropolis	Nakagawa, H.	1	40
		Izumi, Kagoshima Prefecture	Suzuki, K.	1	40
		Mt. Kaimondake, "	Ishida, G.	2	40
Cal. × *bicolor* (Lindl.) Makino	Takane	Nagato, Yamaguchi Prefecture	Tanaka, R.	1	40
		Kitamatsuura, Nagasaki Prefecture	Kumashiro, M.	1	40
		Kitamatsuura, "	Jinno, S.	1	40
		Kitamatsuura, "	Matsuse, J.	1	40
		Fukuejima Island, "	Toyohara, G.	1	40
		Mt. Otsu, Kumamoto Prefecture	Kumashiro, M.	1	40
		Nankan, "	Kumashiro, M.	3	40
		Kyushu District	Suzuki, K.	1	40
Cal. bungoana Ohwi	Taganeran	Tsukumi, Oita Prefecture	Kawamura, K.	1	42*
Cal. densiflora Lindl.	Tamazakiebine	Khasia Hills, India	Hiroshima Bot. Gard. (H.B.G.)	1	40*
Cal. discolor Lindl.	Ebine	Kashiwazaki, Niigata Prefecture	Karasawa, K.	1	40
		Yokohama, Kanagawa Prefecture	Suzuki, K.	1	40
		Otake, Hiroshima Prefecture	Tanaka, R.	1	40
		Yuki, "	Tanaka, R.	1	40
		Hiroshima, "	Sugiyama, H.	1	40
		Hiroshima, "	Enomoto, K.	1	40
		Itsukaichi, "	Suda, Y.	1	40
		Kagawa Prefecture	Hasegawa, A.	1	40
		Mt. Tara, Saga Prefecture	Kumashiro, M.	1	40
		Izumi, Kagoshima Prefecture	Kumashiro, M.	1	40
		Nishinoomote, Tanegashima Island, "	Kumashiro, M.	1	40
Cal. discolor Lindl. var. *amamiana* (Fukuyama) Masamune	Amamiebine	Mt. Yuwandake, Amami-oshima Island, Kagoshima Prefecture	Nishino, T.	1	40*
		Mt. Yuwandake, Amami-oshima Island, "	H. B. G.	2	40*
		Yamato, Amami-oshima Island, "	H. B. G.	1	60*
Cal. discolor Lindl. var. *kanashiroi* Fukuyama	Katsuudakeebine	Mt. Katsuudake, Okinawa Prefecture	Amano, T.	1	40
		Mt. Katsuudake, "	Uchihara, E.	2	40
Cal. discolor Lindl. var. *tokunoshimensis* (Hatu. and Ida) Hatusima	Tokunoshimaebine	Tokunoshima Island, Kagoshima Prefecture	Nomoto, H.	2	40*
Cal. gracilis Lindl. var. *venusta* (Schltr.) F. Maek.	Tokusaran	Tanegashima Island, Kagoshima Prefecture	Maki, T.	1	40
		Yakushima Island, "	Suzuki, K.	1	40
		Mt. Mottyomu, "	Isobe, M.	3	40
		Haro, "	Uesugi, Y.	1	40
		Haro, "	Takahashi, Y.	1	40
		Tainokawa, "	Hayashi, K.	1	40
		Tainokawa, "	Nehira, K.	1	40
		Mt. Yonahadake, Okinawa Prefecture	Amano, T.	1	40
Cal. hattorii Schltr.	Asahiebine	Anijima Island, Tokyo Metropolis	Sakanishi, Y.	1	40
Cal. izu-insularis (Satomi) Ohwi et Satomi	Nioiebine	Mikurajima Island, Tokyo Metropolis	Ishida, G.	2	40*
Cal. japonica Blume	Hirohanokaran	Tashiro, Kagoshima Prefecture	Kumashiro, M.	1	40
		Hekka, "	Kumashiro, M.	1	40
		Amami-oshima Island, "	H. B. G.	2	40
Cal. lyroglossa Reichb. fil.	Suzufuriebine	Amami-oshima Island, Kagoshima Prefecture	Nagano, M.	1	40
		Amami-oshima Island, "	Ito, I.	1	40
		Amami-oshima Island, "	Nakagawa, H.	2	40
		Mt. Yuwandake, "	Nehira, K.	1	40
		Mt. Inokawadake, Tokunoshima Island, "	Ishida, G.	1	40
		Mt. Yonahadake, Okinawa Prefecture	Amano, T.	1	40

Table 1. (continued)

Taxon	Japanese name	Locality	Source	No. of clone	Chromosome number(2n)
Cal. musca (D. Don) Lindl.	Onagaebine	Amami-oshima Island, Kagoshima Prefecture	H. B. G.	2	40
		Mt. Yonahadake, Okinawa Prefecture	Amano, T.	1	40
Cal. nipponica Makino	Kinseiran	Mt. Hayachine, Iwate Prefecture	Tanaka, R.	1	38
		Gunma Prefecture	H. B. G.	3	38
		Mt. Yatsugatake, Nagano Prefecture	Suzuki, K.	1	38
		Mt. Saragadake, Ehime Prefecture	Karasawa, K.	1	38
		Omogo, "	Hatakeyama, H.	1	38
Cal. oblanceolata Ohwi et T. Koyama	Sakurajimaebine	Fukuejima Island, Nagasaki Prefecture	Nakagawa, H.	1	40*
		Koshikijima Island, Kagoshima Prefecture	Inoue, Y.	1	40*
Cal. okinawaensis Hayata	Ryukyuebine	Setouchi, Amami-oshima Island, Kagoshima Prefecture	Minami, T.	1	40*
Cal. reflexa Maxim.	Natsuebine	Mt. Nokogiri, Chiba Prefecture	Suzuki, K.	1	40
		Sandankyo, Hiroshima Prefecture	Kimura, H.	1	40
		Sandankyo, "	Tanaka, R.	1	40
		Sandankyo, "	Enomoto, K.	1	40
		Yoshiwa, "	Suda, Y.	1	40
		Oasa, "	Suda, Y.	1	40
		Mt. Tenzyo, "	Aoyama, M.	1	40
		Mt. Togo, "	Matsuda, T.	1	40
		Hiroshima, "	Ishida, G.	1	40
		Yanai, Yamaguchi Prefecture	Hayashi, K.	1	40
		Mt. Takanawa, Ehime Prefecture	Kotani, M.	3	40
		Sakihama, Kochi Prefecture	Takeshita, H.	2	40
		Ebino, Miyazaki Prefecture	Nishino, T.	1	40
		Mt. Osuzu, "	Hatakeyama, H.	1	40
		Hokugo, "	Ono, K.	1	40
		Izumi, Kagoshima Prefecture	Kumashiro, M.	1	40
		Mt. Kaimondake, "	Ishida, G.	6	40
Cal. schlechteri Hara	Kisoebine	Mt. Fuji, Yamanashi Prefecture	H. B. G.	1	42*
		Gifu Prefecture	H. B. G.	1	42*
Cal. sieboldii Decne.	Kiebine	Tsubaki, Wakayama Prefecture	Ito, I.	1	40
		Nichihara, Shimane Prefecture	Horikawa, Y.	1	40
		Tawarayama, Yamaguchi Prefecture	Tanaka, R.	3	40
		Hagi, "	Isobe, M.	1	40
		Hagi, "	Ishida, G.	1	40
		Shimonoseki, "	Nishino, T.	1	40
		Mt. Kunimi, Nagasaki Prefecture	Jinno, S.	1	40
		Yoshii, "	Matsuse, J.	1	40
		Nankan, Kumamoto Prefecture	Kumashiro, M.	1	40
		Mt. Shibi, Kagoshima Prefecture	Kumashiro, M.	1	40
		Miyanojyo, "	Kumashiro, M.	1	40
Cal. tricarinata Lindl.	Sarumenebine	Mt. Amagi, Shizuoka Prefecture	Suzuki, K.	1	40
		Sandankyo, Hiroshima Prefecture	Kimura, H.	1	40
		Mt. Rakan, "	Tanaka, R.	1	40
		Yoshiwa, "	Katsutani, N.	1	40
		Yoshiwa, "	Ishida, G.	2	40
		Yoshiwa, "	Karasawa, K.	1	60
Cal. triplicata (Willem.) Ames	Tsururan	Tanegashima Island, Kagoshima Prefecture	Maki, T.	1	40
		Yakushima Island, "	Suzuki, K.	1	40
		Yakushima Island, "	Hayashi, K.	2	40
		Tainokawa, Yakushima Island, "	Hayashi, K.	1	40
		Tainokawa, Yakushima Island, "	Nehira, K.	1	40
		Oseda, Yakushima Island, "	Seki, T.	1	40
		Mt. Mottyomu, Yakushima Island, "	Isobe, M.	2	40
		Anbo, Yakushima Island, "	Isobe, M.	1	40
		Mt. Yuwandake, Amami-oshima Island "	Nehira, K.	1	40
		Mt. Inokawadake, Tokunoshima Island, "	Nehira, K.	1	40
		Okinawa Prefecture	Seki, T.	1	40
		Mt. Yonahadake, "	Seki, T.	1	40

* first time record

The clones were collected in natural stands by the present authors and by the collectors shown in Table 1. The present authors express sincere thanks to these collectors for their kindness. The scientific names of the taxa were mainly followed according to Ohwi (1978) and Maekawa (1971), and some were followed according to Garay and Sweet (1974) and Hatusima and Amano (1977).

All of the clones investigated were grown in the experimental garden of the Botanical Institute of Hiroshima University or in the Hiroshima Botanical Garden, Hiroshima City. The clones were cultivated in the ground or in pots filled with fertilized soil for about one month before cytological investigation. Cytological investigation was carried out in somatic chromosomes of root tip cells and in meiotic chromosomes of pollen mother cells (P.M.Cs.).

Chromosomes were observed by orcein-staining method previously reported (Tanaka 1959) with a slight modification: Root tips cut into small pieces of 0.5–1.0 mm were pretreated with 0.002M 8-hydroxyquinoline for about 18 hours at about 5°C; they were fixed in 45% acetic acid for about 10 minutes at 10° C; they were macerated in the mixture of 1 part of 45% acetic acid and 2 parts of 1N HCl for about 30 seconds at 60°C; then, they were stained with 1% aceto-orcein and squashed. For the observation of meiotic chromosomes a small piece (about 0.5mm) of P.M.Cs. block was cut from young anther for a preliminary observation. By the observation of the aceto-orcein stainings, the stages of P.M.Cs. in young anther were determined. When the P.M.Cs. were in the desirable stage, whole P.M.Cs. blocks in the young anther were treated as follows: Fixed in acetic alcohol (1:3) for over one hour at 10°C, and stained and squashed in 1% aceto-orcein.

The chromosomes at mitotic metaphase were measured by the length of long and short arms. Arm ratio was estimated by the length of long arm / the length of short arm, and expressed by the value of arm ratio 1.0 to 1.7 as "median", 1.8 to 3.0 as "submedian", and 3.1 to 7.0 as "subterminal" according to Levan *et al.* (1964). The chromosomes were aligned in descending order and were given numbers 1, 2, 3, -----.

Observation

Many mitotic cell divisions were observed in the root tips. Observations on the morphology of chromosomes were made in the chromosomes at resting stage, interphase and mitotic stages. Results of the observations in each taxon were as follows.

1. *Calanthe aristulifera* Reichb. fil., (Japanese name: Kirishimaebine), 2n=40, Tables 1 and 2, Fig.1.

Clones of this species were collected from three localities shown in Table 1. Four clones were studied cytologically. Chromosomes were counted to be 2n=40 in all of the four clones and it confirmed the previous reports (cf. Tanaka and Kamemoto 1982).

The chromosomes at interphase formed several darkly stained chromatin blocks.

The blocks varied in shape from round to irregular concave. Some of the chromatin formed chromomeric small granules and the others formed chromomeric fibrous threads. The morphology of chromosomes at interphase was categorized to be the complex chromocenter type as reported by Tanaka (1971a).

The morphology of chromosomes at resting stage in the cells of root cap and young velamen was observed to be similar to that of interphase chromosomes, except the condensed chromocentral blocks at resting stage which condensed more strongly than those at interphase.

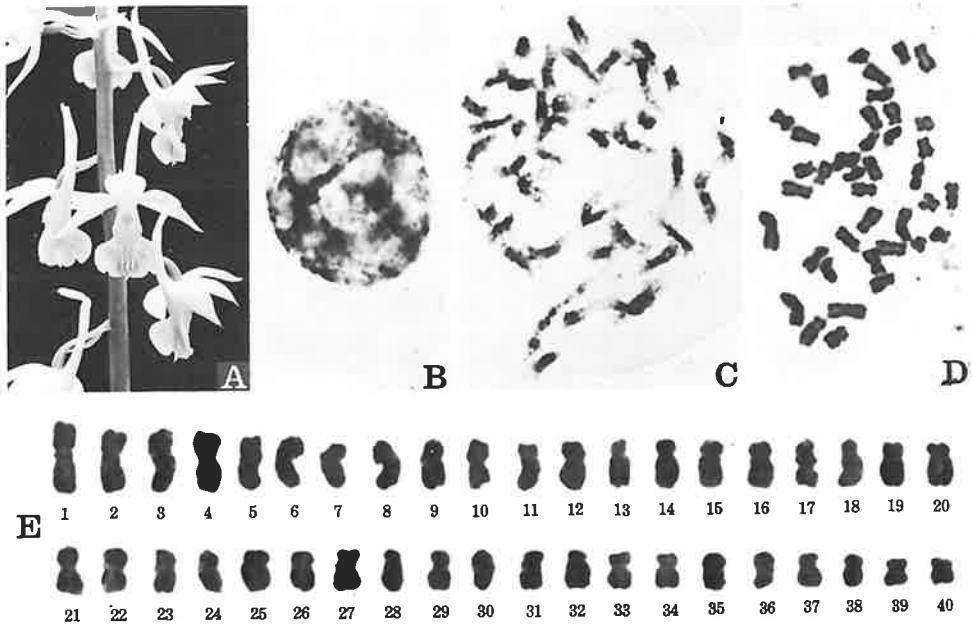

Fig. 1. Photomicrographs of the somatic chromosomes of *Calanthe aristulifera* collected from Mt. Kaimondake. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, × 0.6. B–D, ×1200, E, × 1800.

Chromosomes at mitotic prophase formed several early condensed segments located mostly in proximal regions and some in interstitial regions. Distal regions of the chromosomes were observed to be extended showing a small rounded telomeric block at terminal end. The extended regions condensed later at late prophase. Gradual change of condensation was observed between the early condensed segments and the late condensed segments. Chromosomes at mitotic metaphase varied in length and ranged from about 4.9 μm to 2.1 μm showing gradual change in length. They were observed to be homogeneous type in length. The chromosomes had the centromere located in median and submedian regions. About half of the chromosomes were median centromeric, and the remainings were sub-

median. The longest chromosome of the complement was median centromeric, and four of the long chromosomes were found to be similar in shape to the longest one. Four of the second longest chromosomes were submedian centromeric and had a small constriction situated proximally in long arm. Four of the smallest chromosomes had the centromere in median region. Satellites were not seen.

2. *Calanthe* ×*bicolor* (Lindl.) Makino, (Japanese name: Takane), 2n=40, Table 1, Fig.2.

Eleven clones collected from Yamaguchi, Nagasaki, Kumamoto, and Kagoshima Prefectures, were studied cytologically. Most of the clones were found growing in the natural population of *Calanthe sieboldii,* while very few were in the natural population of

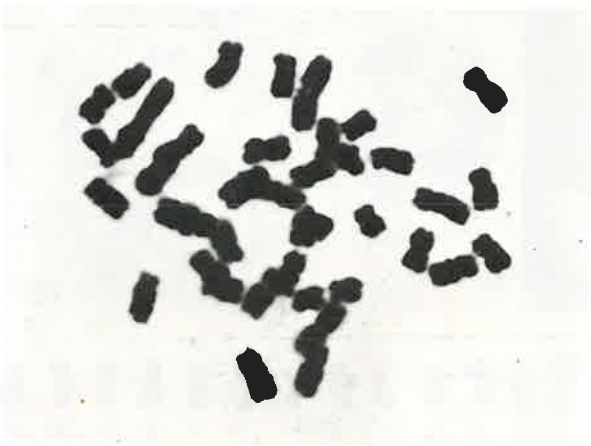

Fig. 2. Photomicrographs of the somatic chromosomes at mitotic metaphase of *Calanthe* × *bicolor* collected from Izumi, Kagoshima Prefecture. ×1800.

Calanthe discolor. These clones showed very high variations in the characteristics of flowers indicating the natural hybridity between *Calanthe sieboldii* and *Calanthe discolor.* In contrast to the morphological variations the chromosome number of the clones was found to be 2n=40 constantly. Morphology of the chromosomes of the clones was observed to be similar to those of *Calanthe sieboldii* and *Calanthe discolor* in resting stage and mitotic stage.

3. *Calanthe bungoana* Ohwi, (Japanese name: Taganeran), 2n=42, Tables 1 and 3, Fig.3.

One clone collected from Oita Prefecture was studied cytologically. In all of the five figures observed in root tip cells 2n=42 chromosomes, a new count, were counted. Chromosomes at resting stage formed many chromocentral chromatin blocks aggregated into the complications of condensed blocks (Fig. 3, B). Some of the chromatin formed small chromomeric granules and threads. Chromosomes at mitotic prophase had early condensed

large segments in proximal regions, late condensed segments in distal regions, and gradually condensed segments in interstitial regions between the two segments described above.

Chromosomes at mitotic metaphase were observed to be relatively longer than those of *Calanthe discolor* described in later paragraph (No. 5). The longest chromosome of the complement was about 5.7 μm in length and had centromere located in median position. The longest chromosome group was found to be composed of two chromosomes. The second longest chromosome was about 5.6 μm and subterminally centromeric. The second

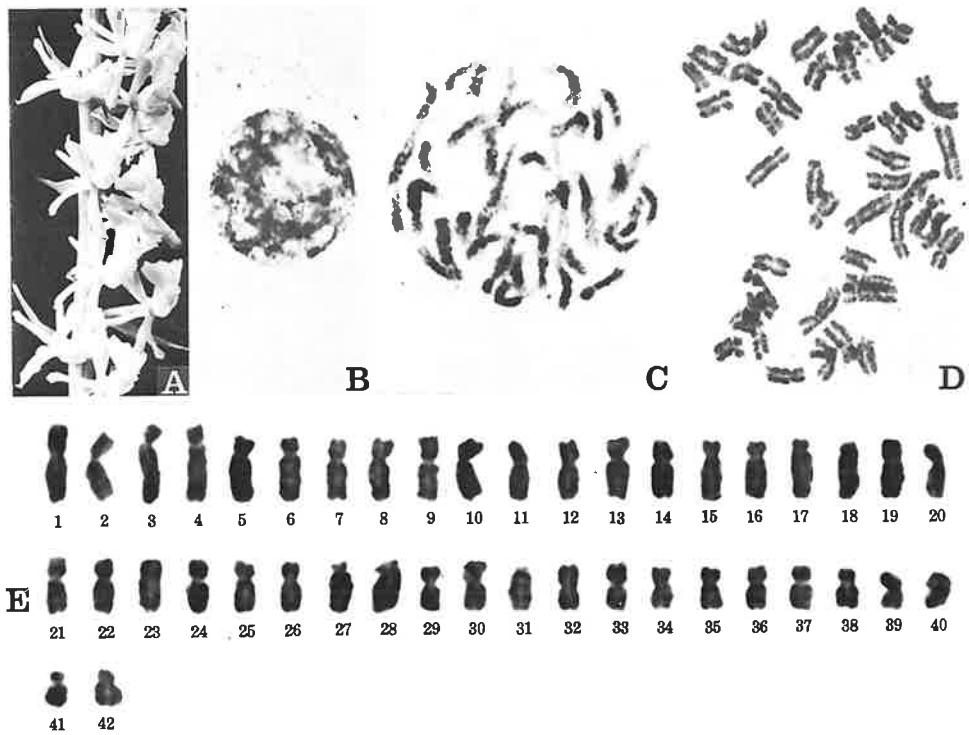

Fig. 3. Photomicrographs of the somatic chromosomes of *Calanthe bungoana* collected from Tsukumi, Oita Prefecture. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n= 42. E, individual chromosomes at mitotic metaphase.
A, x 0.6. B–D, x 1200. E, x 1800.

longest group was also composed of two chromosomes. The third longest chromosome was about 4.8 μm and had submedian constriction. It showed clear differences in length compared to the second longest one. The third longest group was found to be composed of four members. The length of remaining chromosomes from the third longest one reduced gradually showing successive variation in length, thus constituting a partially heterogeneous karyotype. The shortest chromosome was about 2.6 μm and had submedian centromere. The shortest chromosome group was composed of two chromosomes. Of the

42 chromosomes about 22 chromosomes were submedianly or subterminally centromeric, while about 20 were medianly centromeric. Thus, the shape of chromosomes of the complement was categorized to be the partially asymmetric karyotype in arm ratio. No chromosome with satellite or secondary NOR constriction was observed.

4. *Calanthe densiflora* Lindl., (Japanese name: Tamazakiebine), 2n=40, Tables 1 and 4, Fig. 4.

The occurrence of this species was reported from Tokunoshima Island and Okinawa Island by several collectors. In the present observation the clone of this species was obtained from Himalaya, in India, since the clone from Japan could not be obtained. Following are the results observed in the Himalayan clone, which showed typical characteristics in flowers and leaves. Chromosomes were counted to be 2n=40, a new count. The chromosomes formed many chromocentric bodies with irregular surface at resting stage showing the complex chromocentric karyotype similar to those of the Japanese species. Chro-

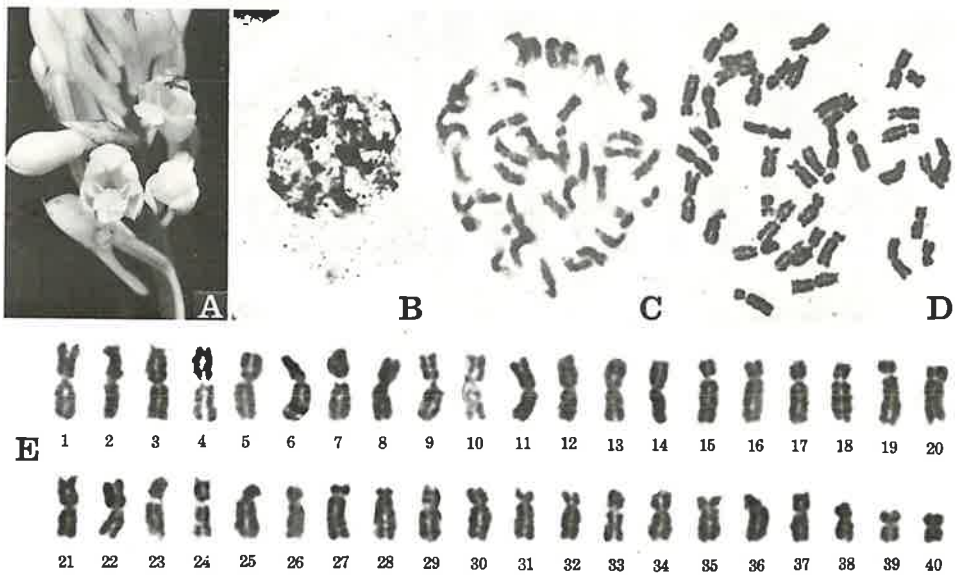

Fig. 4. Photomicrographs of the somatic chromosomes of *Calanthe densiflora* collected from India. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase. A, x 0.8. B–D, x 1200. E, x 1800.

mosomes at mitotic metaphase varied in length gradually and ranged from about 5.7 μm to 2.3 μm showing the homogeneous karyotype in length. The longest chromosome group had median centromere and was composed of four members. A pair of the smallest chromosomes (Fig. 4, E 39, 40) had median centromere and was found to be particularly small compared with the second smallest one. Of the 2n=40 chromosomes about 24 were observed to be median centromeric and about 12 to be submedian and about four to be subterminal. The chromosomes were categorized to be the symmetric karyotype in arm ratio.

5. *Calanthe discolor* Lindl., (Japanese name: Ebine), 2n=40, Tables 1 and 5, Fig. 5.

Clones of this species were collected from 10 localities of Japan. The clones varied in external morphology in leaves, flowers on spikes, and particularly in the color of petals. Most of the clones had pale brown petals, while some had creamy white, pale green, pink, or dark red.

All of the 11 clones investigated cytologically were found to have the same chromosome number 2n=40 confirming that of previous reports (cf. Tanaka and Kamemoto 1982).

Chromosomes at resting stage formed fibrous threads and many chromomeric granules were found scattered in nuclear space. Several chromocentral blocks were observed in resting nuclei. The chromocentral blocks showed loosely aggregated fibrous structure.

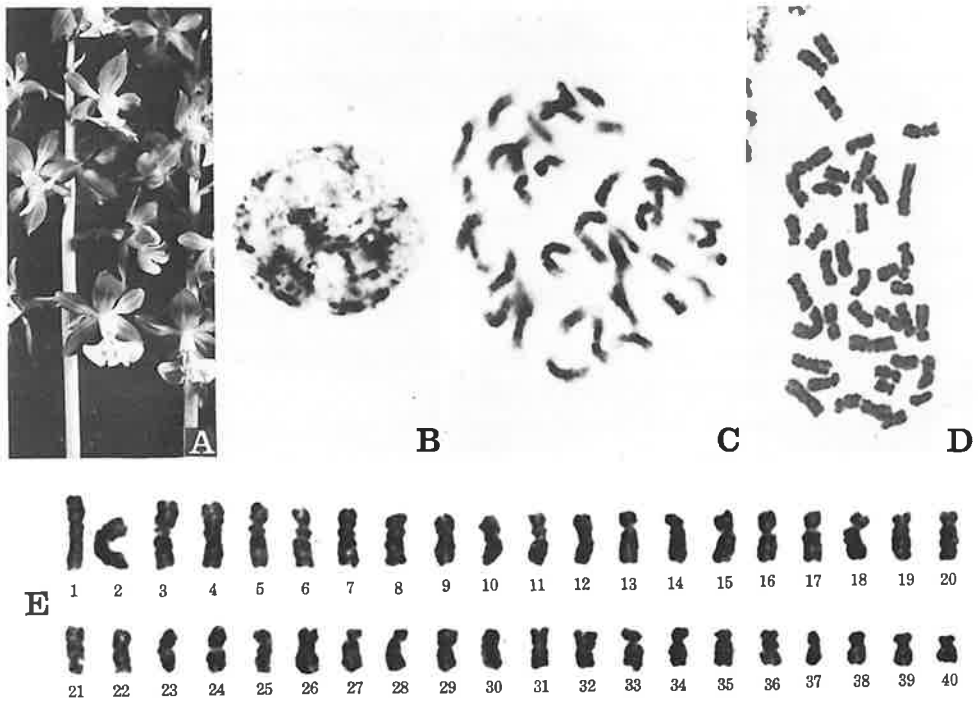

Fig. 5. Photomicrographs of the somatic chromosomes of *Calanthe discolor* collected from Itsukaichi, Hiroshima Prefecture. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, x 0.5. B–D, x 1200. E, x 1800.

They varied in size from about 1.0 μm to 10.0 μm in diameter and showed irregular shape with rough surface. They also varied in number from about 10 to 20 per nucleus. Some of the medium-sized chromocentral blocks were found attached to nucleolus. The morphology of chromosomes at resting stage was categorized to be the loosely aggregated complex chromocenter type as reported by Tanaka (1971a).

Chromosomes at mitotic prophase formed early condensed segments located in proximal and interstitial regions. One or two medium-sized chromosomes were observed

attached to nucleolus by the interstitial segments. In some chromosomes early condensed small segments were additionally found in distal regions. The early condensed segments situated between the condensed segments were observed transforming gradually to the late condensed segments. The karyotype of prophase chromosomes was found to be the interstitial type as proposed by Tanaka (1977).

Chromosomes at metaphase varied in length gradually and ranged from about 5.3 μm to 1.9 μm. The longest chromosome had the centromere in median region and a small constriction in the proximal region of long arm. Four of the longer chromosomes were found to have shape similar to the longest one. The second longest chromosome was observed to have submedian centromere and the small constriction in a proximal region of long arm. The second longest chromosome group was composed of four members. The smallest chromosome of the complement had the centromere in submedian region. Four chromosomes having the same shape with the smallest one were found in 2n=40 complement. Most of the other chromosomes of the complement had the centromere located in median or submedian position, while about two medium chromosomes had subterminal centromere. Small constrictions were observed in many chromosomes at metaphase. No satellite was observed.

The metaphase chromosomes were found to come under the category of the partially heterogeneous and gradual karyotype in length and under the category of the symmetric karyotype in arm ratio.

6. *Calanthe discolor* Lindl. var. *armarilaria* (Fukuyama) Masamune, (Japanese name: Amamiebine), 2n=40 and 2n=60, Tables 1 and 6, Fig. 6.

Four clones collected from Amami-oshima Island, type locality, were studied cytologically. Of the four clones three were found to have 2n=40, a new count, and one to be 2n=60, triploid also a new count. The karyomorphological characteristics of the clones with 2n=40 were found to be similar to those of *Calanthe discolor* described in previous paragraph (No. 5), with the exception of the shape of chromatin blocks at resting stage and in some chromosomes at mitotic stage. That is, the chromosomes at resting stage formed threads with many chromomeric granules scattered in nuclear space and the chromocentric aggregations showing highly irregular roughness on their surface. The number of the aggregations varied from about 10 to 25 per nucleus. The resting chromosome was categorized to be the complex chromocenter type reported by Tanaka (1971a).

At mitotic prophase 2n=40 chromosomes, a new count, were counted. The chromosomes formed early condensed segments located in proximal regions, while some of them had the early condensed segments in interstitial and distal regions. One or two of the condensed segments occurred in the interstitial regions of one or two chromosomes were observed attached to nucleolus. A gradual change in the pattern of condensation was observed between the early condensed segments and the late condensed segments.

Chromosomes at mitotic metaphase were counted to be 2n=40 in all of the root tip

cells observed. The chromosomes varied in length from about 4.8 μm to 1.9 μm showing the gradual change categorized to be the homogeneous karyotype. The longest chromosomes of the complement were found composing a group of four members with median centromere. The second longest chromosome group was composed of four submedian centromeric members. The shortest chromosome group was also composed of four members with median centromere.

Many of the chromosomes of the complement of 2n=40 had median centromeres, while about 16 medium-sized chromosomes had submedian centromeres. Thus, the chromosome complement was categorized to be the symmetric karyotype in arm ratio.

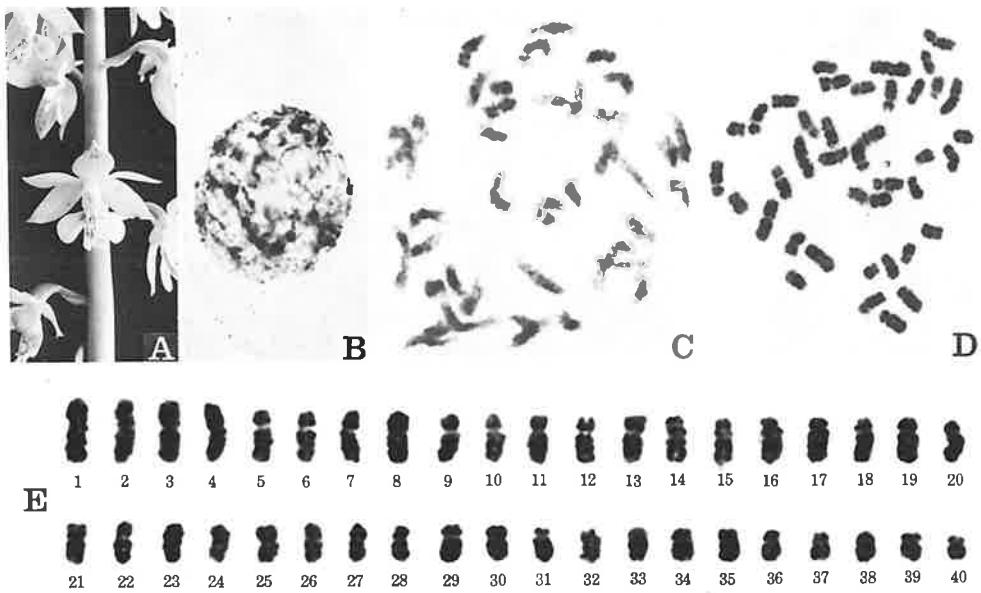

Fig. 6. Photomicrographs of the somatic chromosomes of *Calanthe discolor* var. *amamiana* collected from Mt. Yuwandake. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40, diploid clone. E, individual chromosomes at mitotic metaphase. A, × 0.6. B–D, × 1200. E, × 1800.

Satellites were not observed. Small constrictions were frequently observed on several chromosomes, while these were not specified as the secondary NOR constrictions.

Further report on the triploid clone with 2n=60 will be made in near future.

7. *Calanthe discolor* Lindl. var. *kanashiroi* Fukuyama, (Japanese name: Katsuudakeebine), 2n=40, Tables 1 and 7, Fig. 7.

Three clones collected from Mt. Katsuudake, type locality, were studied cytologically. Somatic chromosomes were counted to be 2n=40 in all of the well spread metaphase

figures, confirming previous count (cf. Tanaka and Kamemoto 1982). Morphological features of resting chromosomes and those of mitotic chromosomes were found to be similar to those of *Calanthe discolor* described in previous paragraph (No. 5). That is, the karyotypes of chromosomes were the complex chromocenter type at resting stage, the interstitial type at mitotic prophase, the partially heterogeneous and gradual type in chromosome length, and the symmetric type in arm ratio. A pair of the longest chromosome of the complement was median centromeric and about 1.2 times longer than the second longest pair which was also median centromeric. The shortest chromosome pair was submedian centromeric and about 4/5 in length of the second shortest pair which was median centromeric. In comparison with *Calanthe discolor,* the chromosome complement of this species was found to be composed of relatively few members with submedian centromeric chromosomes.

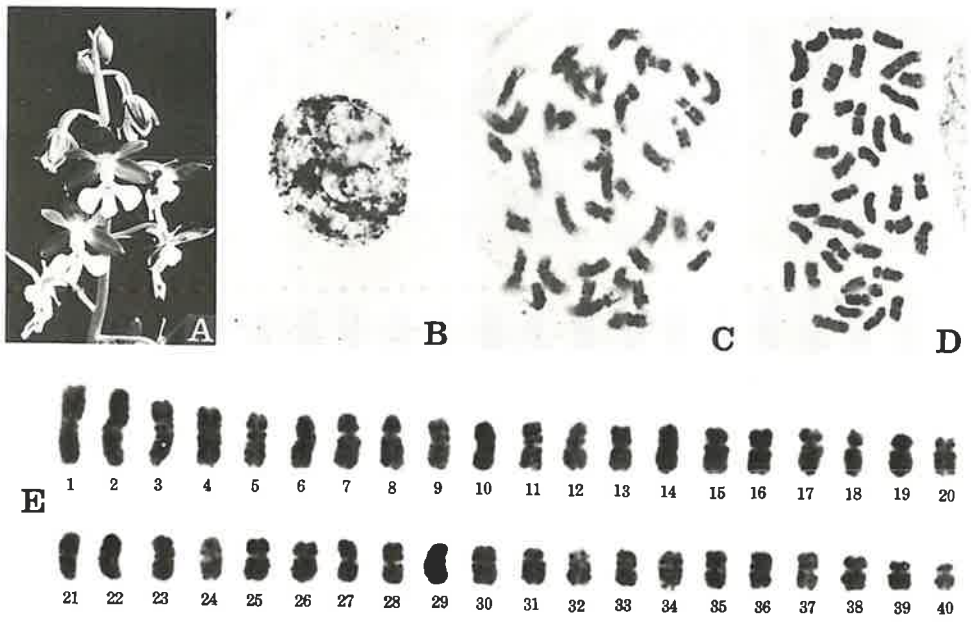

Fig. 7. Photomicrographs of the somatic chromosomes of *Calanthe discolor* var. *kanashiroi* collected from Mt. Katsuudake. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, × 0.4. B–D, × 1200. E, × 1800.

8. *Calanthe discolor* Lindl. var. *tokunoshimensis* (Hatu. and Ida) Hatusima, (Japanese name: Tokunoshimaebine), 2n=40, Tables 1 and 8, Fig. 8.

Two clones of this species were obtained from Tokunoshima Island, type locality. The clones gave sweet orange-like fragrance softly. Somatic chromosome number was counted to be 2n=40, a new count, in all of the well spread metaphase plates investigated.

The karyological features were found to be similar to those of *Calanthe discolor* as described in the previous paragraph (No. 5). That is, the karyotypes were the complex chromocenter type at resting stage, the interstitial type at mitotic prophase, the partially heterogeneous and gradual type in chromosome length, and the symmetric type in arm ratio.

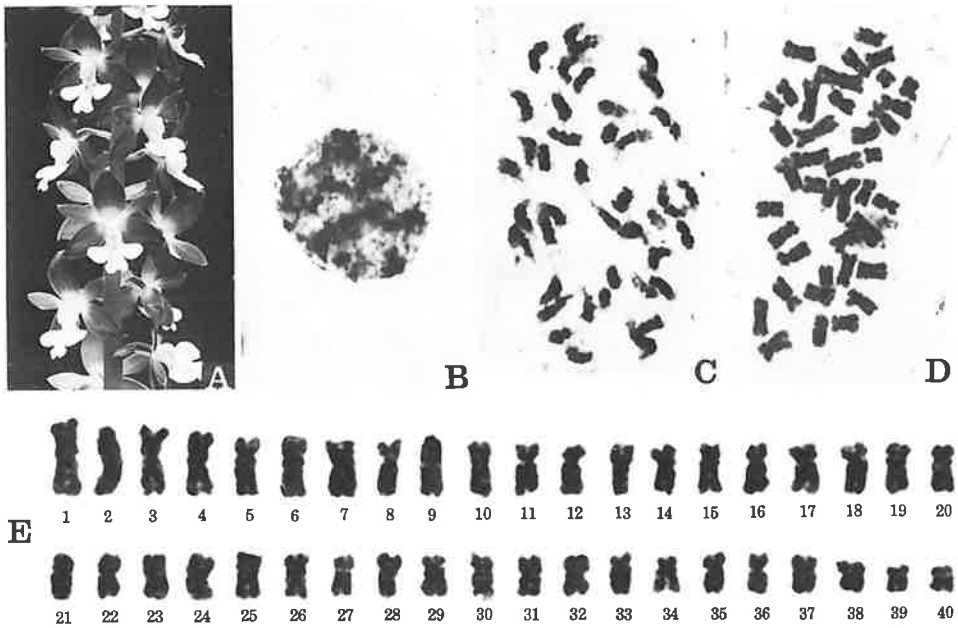

Fig. 8. Photomicrographs of the somatic chromosomes of *Calanthe discolor* var. *tokunoshimensis* collected from Tokunoshima Island. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase. A, x 0.4. B–D, x 1200. E, x 1800.

9. *Calanthe gracilis* Lindl. var. *venusta* (Schltr.) F. Maek., (Japanese name: Tokusaran), 2n=40, Tables 1 and 9, Fig. 9.

According to Ohwi (1978) this species occurs in southern Kyushu District including Yakushima Island and Ryukyu Islands.

Ten clones collected from the following three localities, *i.e.*, Yakushima, Tanegashima and Okinawa Islands, were observed cytologically. All of the ten clones showed the same chromosome number 2n=40 confirming previous reports (cf. Tanaka and Kamemoto 1982). Chromosomes in resting stage formed many strongly condensed chromocentric chromatin blocks. Very few chromatin blocks showing further aggregation into larger blocks were observed. The remaining chromatin formed grains and threads which were observed faintly stained in comparison with those of *Calanthe discolor* (cf. paragraph No. 5) which

showed common features of chromatin at resting stage in the present material. Chromosomes at mitotic prophase formed early condensed segments located in proximal region. The distal segments in each chromosome showed late condensation. The early condensed segments occurred in all chromosomes of the complement, while their size was smaller than those of the common ones found in *Calanthe discolor*.

Chromosomes at mitotic metaphase varied gradually in length from about 5.7 μm

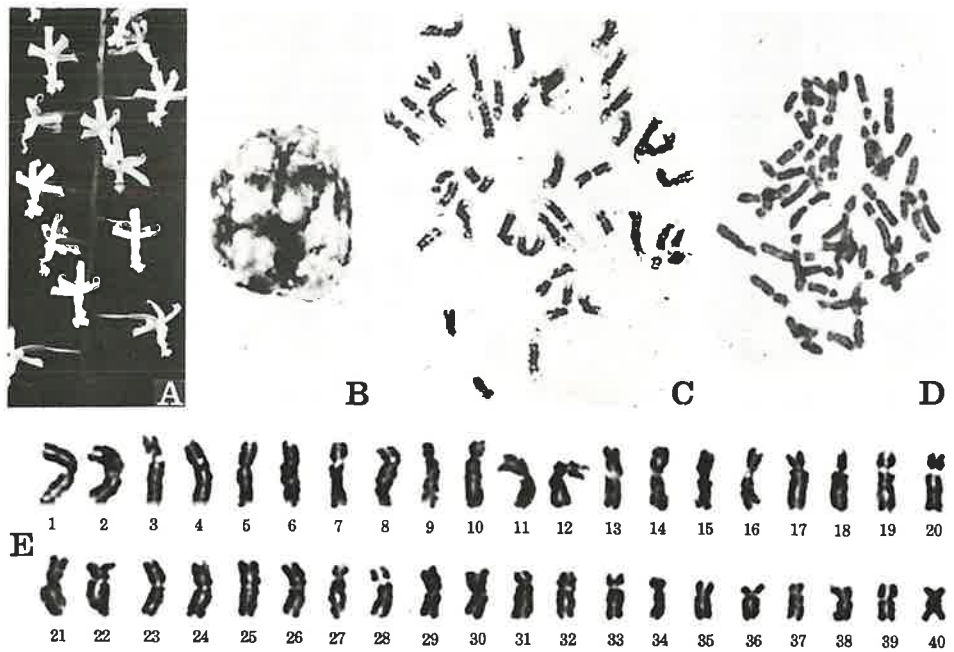

Fig. 9. Photomicrographs of the somatic chromosomes of *Calanthe gracilis* var. *venusta* collected from Mt. Mottyomu. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, x 0.4. B–D, x 1200. E, x 1800.

to 2.6 μm showing a homogeneous karyotype. Of the 2n=40 chromosomes about 18 were observed to be submedian centromeric, and the other 22 to be median centromeric. According to the position of centromere the karyotype of this species was found to be partially heterogeneous.

The longest chromosome group had median centromeres and composed of two members, while the shortest one also had a median centromere and was composed of two members. No secondary constriction showing the localization of NOR was observed.

10. *Calanthe hattorii* Schltr., (Japanese name: Asahiebine), 2n=40, Tables 1 and 10, Fig. 10.

One clone of this species was collected from Anijima Island. The somatic chromosome number was counted to be 2n=40. Karyotypes of this species were found to be similar to those of *Calnthe triplicata* described in later paragraph (No. 22). The karyotypes were as follows. Resting stage: Complex chromocenter type. Mitotic prophase: Interstitial type. Mitotic metaphase: Highly homogeneous and gradual type in chromosome length and symmetric type in arm ratio.

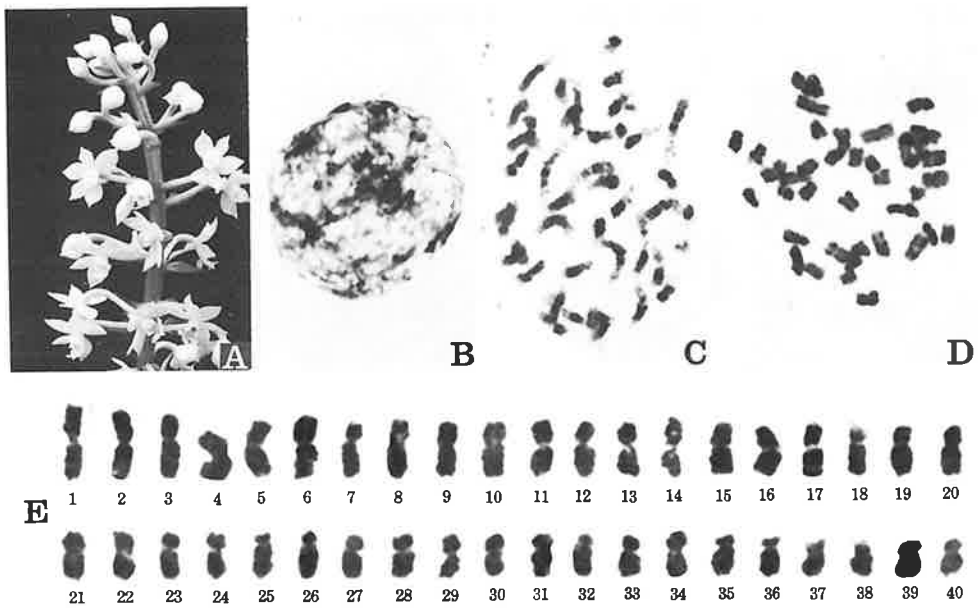

Fig. 10. Photomicrographs of the somatic chromosomes of *Calanthe hattorii* collected from Anijima Island. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, × 0.4. B–D, × 1200. E, × 1800.

11. *Calanthe izu-insularis* (Satomi) Ohwi et Satomi, (Japanese name: Nioiebine), 2n=40, Tables 1 and 11, Fig. 11.

Two clones of this species were obtained from Mikurajima Island. The clones had typical characteristics in leaves and flowers which gave sweet orange-like fragrance strongly. Chromosomes of these clones were counted to be 2n=40, a new count. At resting stage the chromosomes formed many glanular spherules and fibrous threads. Most of the spherules and threads aggregated into several large blocks forming chromocentric bodies which varied in size and number ranging from about 5 to 10. Chromosomes at mitotic prophase formed early condensed long segments located proximally which transformed gradually into late condensed segments situated distally. In some chromosomes of medium length an early condensed small knob was observed distally situated in one of the arm.

Chromosomes at mitotic metaphase varied in length from about 4.8 μm to 2.1 μm showing gradually changed homogeneous karyotype (Fig. 11, E). The longest chromosome of the complement was median centromeric. Four of the long chromosomes were classed together in the longest group. The second longest chromosome group was subterminal centromeric and composed of two members. The third longest chromosome group was submedian centromeric and also had two members. The shortest chromosome was observed to show a particular shape in size. Its centromere was located in median position. The partner chromosome of the shortest chromosome was found to be relatively longer.

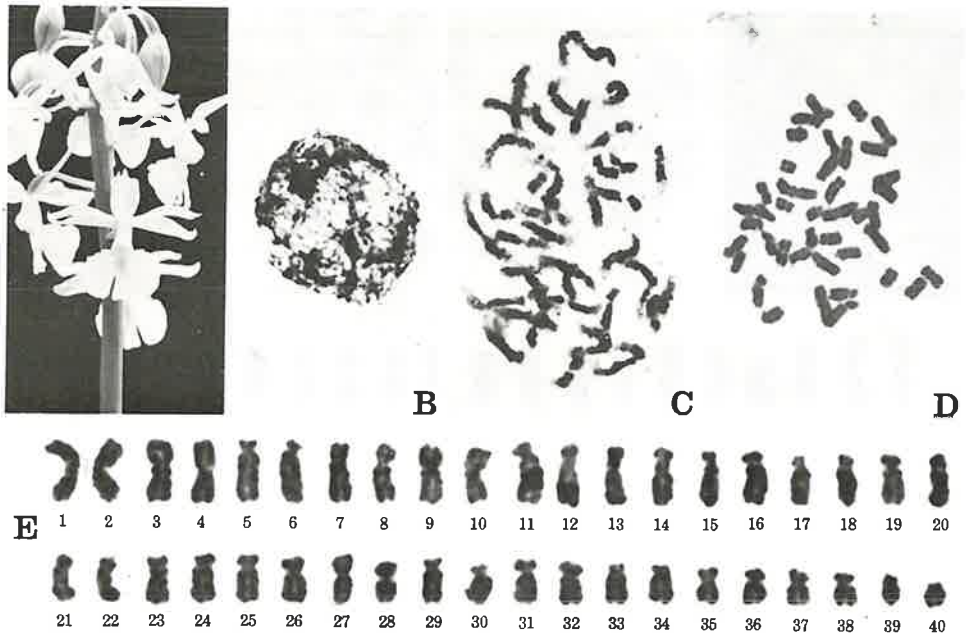

Fig. 11. Photomicrographs of the somatic chromosomes of *Calanthe izu-insularis* collected from Mikurajima Island. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase. A, x 0.6. B–D, x 1200. E, x 1800.

The second longest chromosome group was median centromeric and was composed of four members. Of the 2n=40 chromosomes about 26 were found to be submedian or subterminal centromeric and about 14 to be median centromeric. Thus, the shape of chromosomes was categorized to be partially asymmetric karyotype. Satellites were not found. In addition to the centromeric constriction small constrictions situated proximally were observed in most chromosomes of the complement.

12. *Calanthe japonica* Blume, (Japanese name: Hirohanokaran), 2n=40, Tables 1 and 12, Fig. 12.

Four clones of this species were collected from three localities. Somatic chromosomes were counted to be 2n=40 in all of the four clones confirming previous reports (cf. Tanaka and Kamemoto 1982).

Karyotypes of this species were found to be similar to those of *Calanthe triplicata* described in later paragraph (No. 22) with the exception of the possession of more chromosomes with median centromere. The karyotypes were as follows. Resting stage: Complex chromocenter type. Mitotic prophase: Interstitial type. Mitotic metaphase: Homogeneous and gradual type in chromosome length and highly symmetric type in arm ratio.

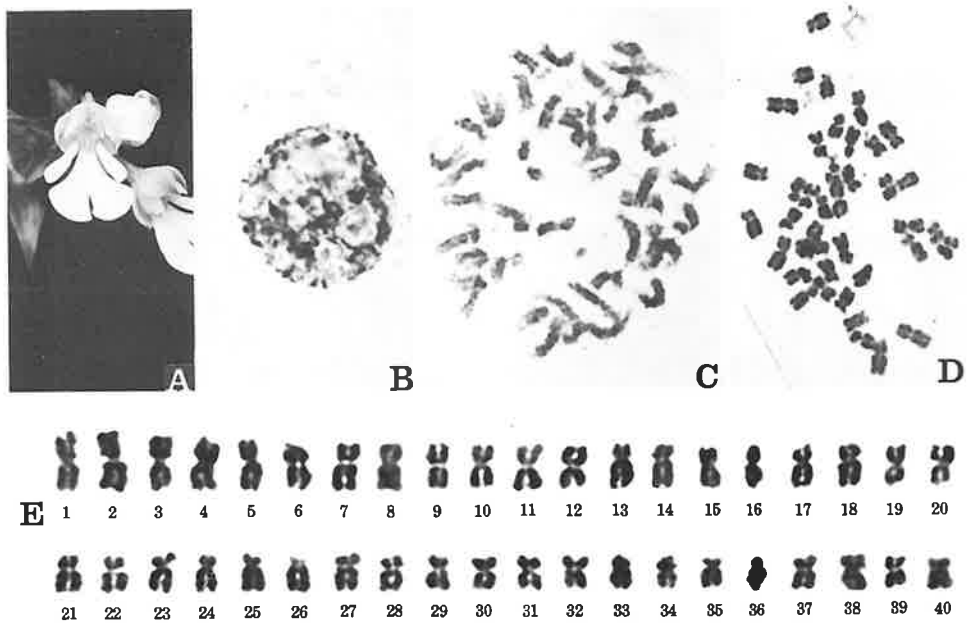

Fig. 12. Photomicrographs of the somatic chromosomes of *Calanthe japonica* collected from Amami-oshima Island. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, x 0.6. B–D, x 1200. E, x 1800.

According to Ohwi (1978) *Calanthe fauriei* Schltr., (Japanese name: Shimaebine) was listed as a species occurring in southern Kyushu District. In the present investigation one clone of this species was collected from Hekka, located in southern-most region of Kyushu District. According to Mr. M. Kumashiro, who is the collector of this clone, this species is considered to be a dwarf form of *Calanthe japonica,* which is described in the above paragraph. Somatic chromosomes were counted to be 2n=40 confirming previous reports (cf. Tanaka and Kamemoto 1982). Karyotypes were observed to be similar to those of *Calanthe japonica,* with the exception of having a smaller chromosome pair with subterminal centromeres.

13. *Calanthe lyroglossa* Reichb. fil., (Japanese name: Suzufuriebine), 2n=40, Tables 1 and 13, Fig. 13.

Seven clones of this species were collected from three localities: Amami-oshima, Tokunoshima and Okinawa Islands. Somatic chromosomes were counted to be 2n=40 which confirmed the previous reports (cf. Tanaka and Kamemoto 1982).

Chromosomes at resting stage formed compactly condensed chromocenters with relatively smooth surface and lightly dispersed granular threads. Chromosomes at mitotic metaphase were relatively smaller than those of *Calanthe discolor* described in paragraph No. 5, a common species of Japanese *Calanthe*. The longest chromosome of the complement was about 4.6 μm and the shortest one was about 2.1 μm. The chromosomes varied

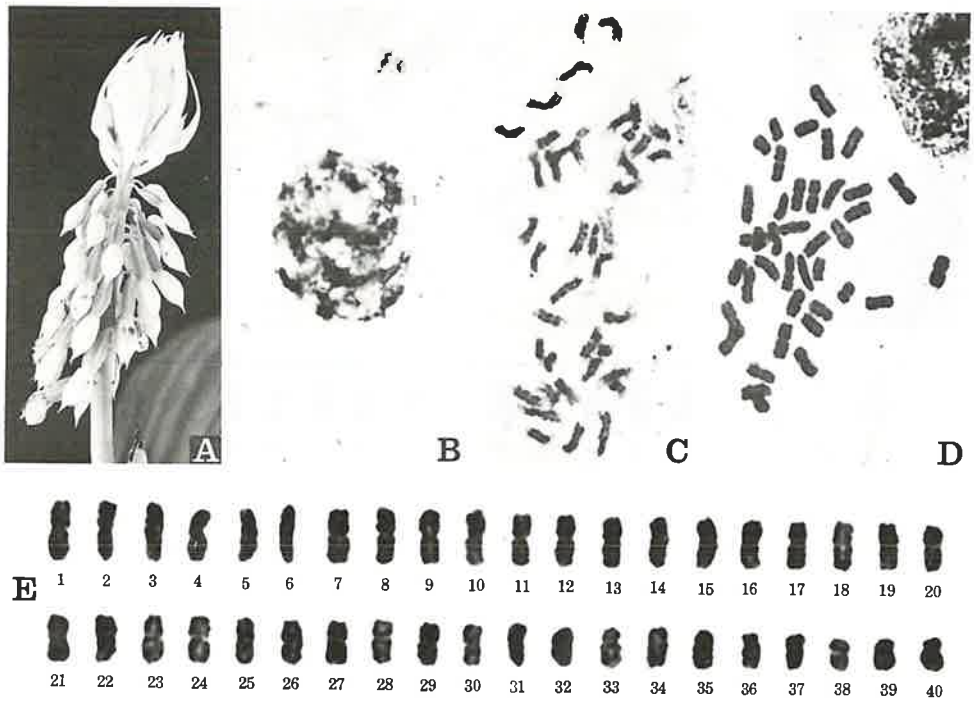

Fig. 13. Photomicrographs of the somatic chromosomes of *Calanthe lyroglossa* collected from Amami-oshima Island. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, ×0.7. B–D, ×1200. E, ×1800.

gradually in length from the longest chromosome to the shortest showing highly homogeneous karyotype. Most of the chromosomes had median centromeres, while only two pairs had submedian centromeres, one of which was a longer chromosome pair (Fig. 13, E5, 6) and the other one was a shorter chromosome pair (Fig. 13, E35, 36). No chromosome with secondary constriction was observed. The shape of the chromosomes was thus categorized to be the highly symmetric karyotype.

14. *Calanthe musca* (D. Don) Lindl., (Japanese name: Onagaebine), 2n=40, Tables 1 and 14, Fig. 14.

Three clones were collected from Amami-oshima and Okinawa Islands. The clones bloomed pale violet flowers. Somatic chromosomes at mitotic metaphase were counted to be 2n=40 in all of the three clones investigated confirming previous reports (cf. Tanaka and Kamemoto 1982).

Chromosomes at resting stage showed extended fibrous structure in addition to several chromocentral blocks compactly and fibrously condensed.

Chromosomes at mitotic prophase had condensed segments in proximal region and extended segments at distal region. A gradual transition was observed between the condensed segments and the extended segments.

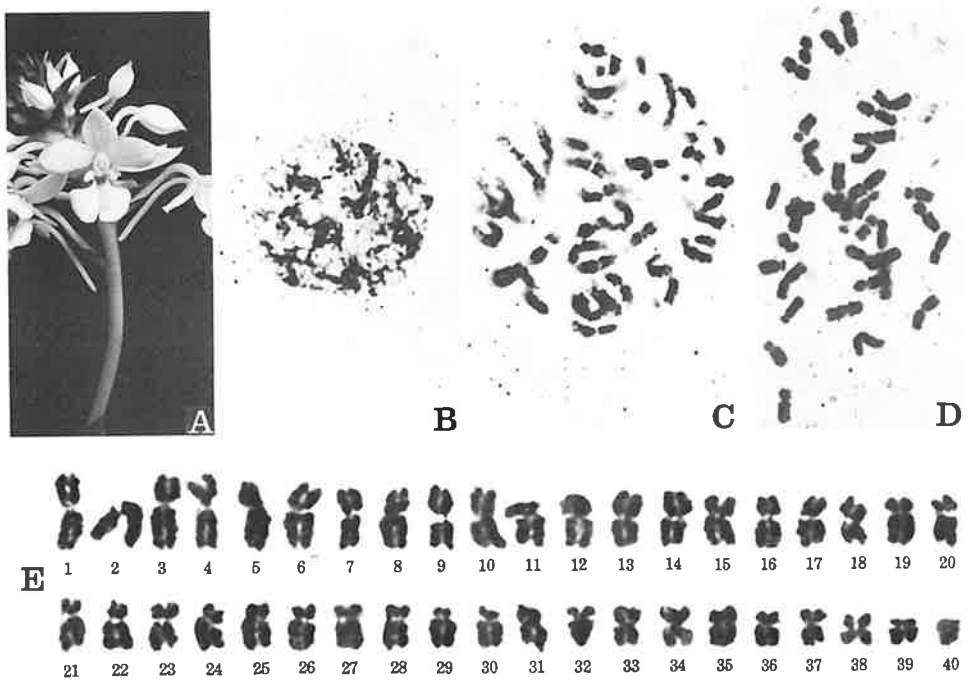

Fig. 14. Photomicrographs of the somatic chromosomes of *Calanthe musca* collected from Amami-oshima Island. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, × 0.7. B–D, × 1200. E, × 1800.

Chromosomes at mitotic metaphase were observed to be highly homogeneous in length. The longest chromosome group had a median centromere and was composed of two members. The second longest chromosome group had a median centromere and was composed of two members. The shortest chromosomes had a submedian centromere and were found to be one pair in 2n=40 chromosomes. The distal regions of the short arms of the shortest chromosomes, sometimes, were observed attached to each other at mitotic prophase.

The karyotypes were categorized as follows. Resting stage: Strongly condensed complex chromocenter type. Mitotic prophase: Gradient type. Mitotic metaphase: Highly homogeneous and gradual type in chromosome length and highly symmetric type in arm ratio.

15. *Calanthe nipponica* Makino, (Japanese name: Kinseiran), 2n=38, Tables 1 and 15, Fig. 15.

Seven clones of this species were collected from five localities. They were observed to be typical in the features of foliage leaves and flowers. In all of the four clones 2n=38 chromosomes were counted in root tip cells at mitotic metaphase confirming the previous report of Tanaka (1965), while the number of 2n=40 reported by Mutsuura and Nakahira

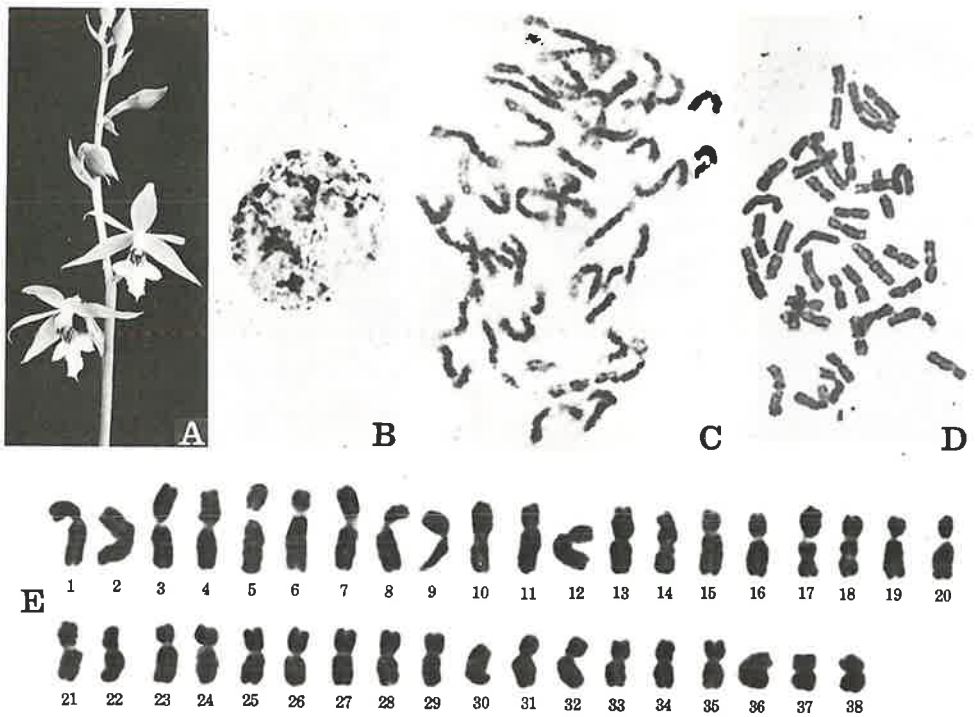

Fig. 15. Photomicrographs of the somatic chromosomes of *Calanthe nipponica* collected from Gunma Prefecture. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=38. E, individual chromosomes at mitotic metaphase.
A, ×0.6. B–D, ×1200. E, ×1800.

(1958) was not confirmed.

Chromosomes at resting stage formed extended fibrous threads and several chromocentral blocks which were fibrous in structure and not strongly condensed.

Chromosomes at mitotic prophase formed early condensed regions located in proximal

regions and transformed gradually into the diffused lately condensed regions located distally.

Chromosomes at mitotic metaphase were observed to be longer, to vary from 6.2 μm to 2.8 μm, and partially heterogeneous in chromosome length. The 2n=38 chromosomes were grouped into 34 median, and 4 submedian chromosomes. They were highly symmetric in arm ratio.

The longest chromosome group of the complement had a centromere in median region and was composed of four chromosomes. The second longest chromosomes, one pair, had a centromere in submedian region. The shortest group had a median centromere and was composed of two chromosomes. A pair of the medium-sized chromosome with median centromere, Fig. 15, E17, 18, showed the small constriction located in interstitial position in long arm. Small constrictions similar to those of this chromosome were observed in two pairs of chromosomes (Fig. 15, E13, 14 and 21, 22).

The karyotypes were categorized as follows. Resting stage: Complex chromocenter type. Mitotic prophase: Gradient type. Mitotic metaphase: Low homogeneous and gradual type in chromosome length and highly symmetric type in arm ratio.

16. *Calanthe oblanceolate* Ohwi et T. Koyama, (Japanese name: Sakurajimaebine), 2n=40, Tables 1 and 16, Fig. 16.

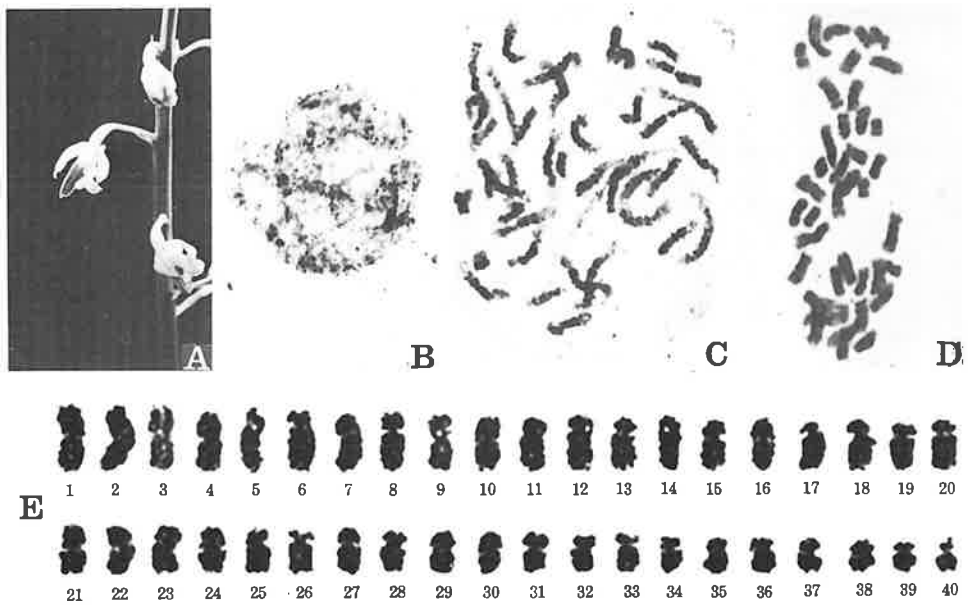

Fig. 16. Photomicrographs of the somatic chromosomes of *Calanthe oblanceolata* collected from Fukuejima Island. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, × 0.4. B–D, × 1200. E, × 1800.

Two clones were collected from two islands located in south-western region of Kyushu District. Somatic chromosomes of these clones were counted to be 2n=40, a new count. Chromosomes at resting stage formed many granular grains of chromatin which aggregated into several irregularly shaped chromocenters. Chromosomes at mitotic prophase had early condensed long segments in proximal regions which gradually transformed to the faintly stained late condensed regions located distally. Chromosomes at mitotic metaphase varied in length gradually ranged from 4.7 μm to 2.0 μm showing a homogeneous karyotype. The longest chromosome group of the complement had median centromere and was observed to be composed of four members. The second longest group had submedian centromere and was composed of four members. The shortest chromosome group had submedian centromere and was composed of two members. About 22 chromosomes of the complement were the median centromeric chromosomes, while the remaining, about 18 chromosomes, were the submedian centromeric ones. The shape of the chromosomes was observed to be categorized as symmetric karyotype. Secondary NOR constriction was not observed in the metaphase chromosomes.

17. *Calanthe okinawaensis* Hayata, (Japanese name: Ryukyuebine), 2n=40, Tables 1 and 17, Fig. 17.

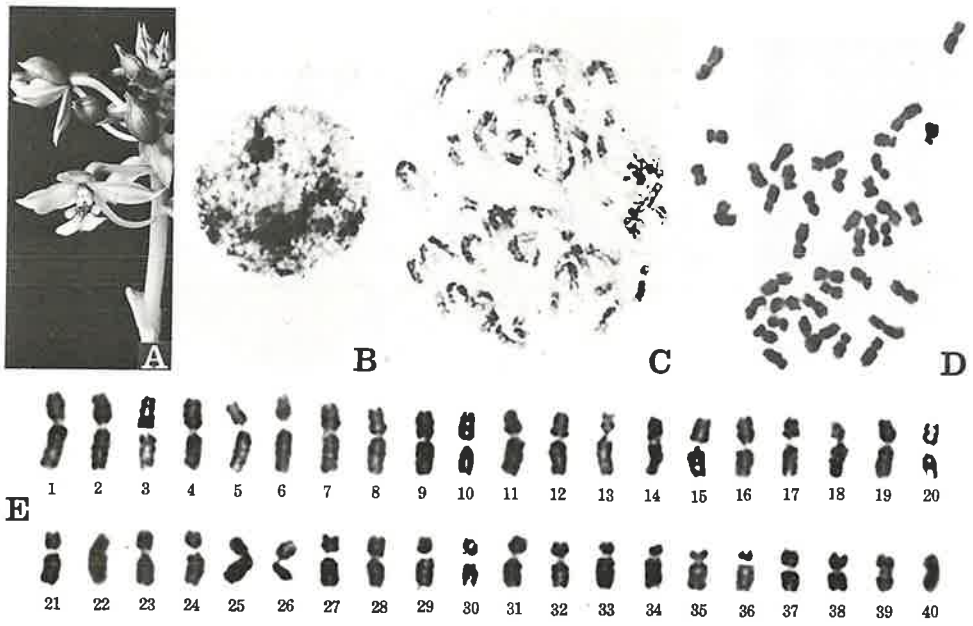

Fig. 17. Photomicrographs of the somatic chromosomes of *Calanthe okinawaensis* collected from Amami-oshima Island. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, ×0.5. B–D, ×1200. E, ×1800.

One clone of this species was collected from Amami-oshima Island. In the clone 2n=40 chromosomes, a new count, were counted. Chromosomes at resting stage formed fine threads and many small compact blocks of chromatin which aggregated forming larger chromocentric parts. Chromosomes at mitotic prophase had early condensed segments at proximal regions which changed gradually into late condensed regions situated distally. The early condensed segments were observed relatively smaller than those of *Calanthe discolor,* a common species of Japanese *Calanthe.* Chromosomes at mitotic metaphase was observed to be relatively smaller than those of *Calanthe discolor.* They were highly homogeneous in length, while the successive gradual variation ranging from 5.3 μm to 2.6 μm was observed. The longest chromosome group of the complement was median centromeric and was composed of two chromosomes. The second longest chromosome group was also median centromeric and was composed of two chromosomes, while long arm was shorter than that of the longest chromosome. The third longest chromosome group was median centromeric and was composed of two members. The shortest chromosome group of the complement was median centromeric and was observed to be composed of four members. The second shortest group was submedian centromeric and was composed of four members. No chromosome with secondary NOR constriction was observed. Metaphase chromosomes of this species were observed highly symmetric in arm ratio. Of the 2n=40 chromosomes only six were found to be submedian centromeric and all of the remaining to be median centromeric.

18. *Calanthe reflexa* Maxim., (Japanese name: Natsuebine), 2n=40, Tables 1 and 18, Fig. 18.

Twenty-five clones collected from 15 widely separated localities were cultivated in flower pots. All of the clones flowered very well and showed typical morphology in foliage leaves and flowers. Therefore, it is considered that this species is a well established uniform species distributed widely in Japan. Somatic chromosomes were counted to be 2n=40 at mitotic metaphase in all of the 25 clones examined and to be 2n=20II (20 bivalents)=40 in P.M.Cs. in some of the clones, which confirmed the previous reports of Miduno (1940), and Tanaka (1965), and not confirmed the report of Mutsuura and Nakahira (1958), who reported 2n=42.

Chromosomes at resting stage formed several chromocentral blocks loosely condensed which were fibrous and formed roughly sticky surface. The morphology of resting chromosomes was observed to be similar to that of *Calanthe schlechteri* described in next paragraph (No. 19).

Chromosomes at mitotic prophase formed early condensed segments located in proximal regions of both arms. The distal regions of both arms were observed to be lately condensed segments. The regions between the early condensed segments and lately condensed ones transformed gradually forming partly condensed fibrous and granular segments.

Chromosomes at mitotic metaphase were observed separated individually on squashed plates showing well spread figures. The chromosomes were relatively larger than those

of *Calanthe discolor* described in paragraph No. 5, and showed gradual variation in their length. The centromeric region in each chromosome appeared clearly.

Most of the chromosomes, about 35, had a median centromere, and four of the remaining five had a submedian centromere. The remaining one was found to be a heterozygous chromosome with a subterminal centromere (Fig. 17, E24 and F24). The hetero-

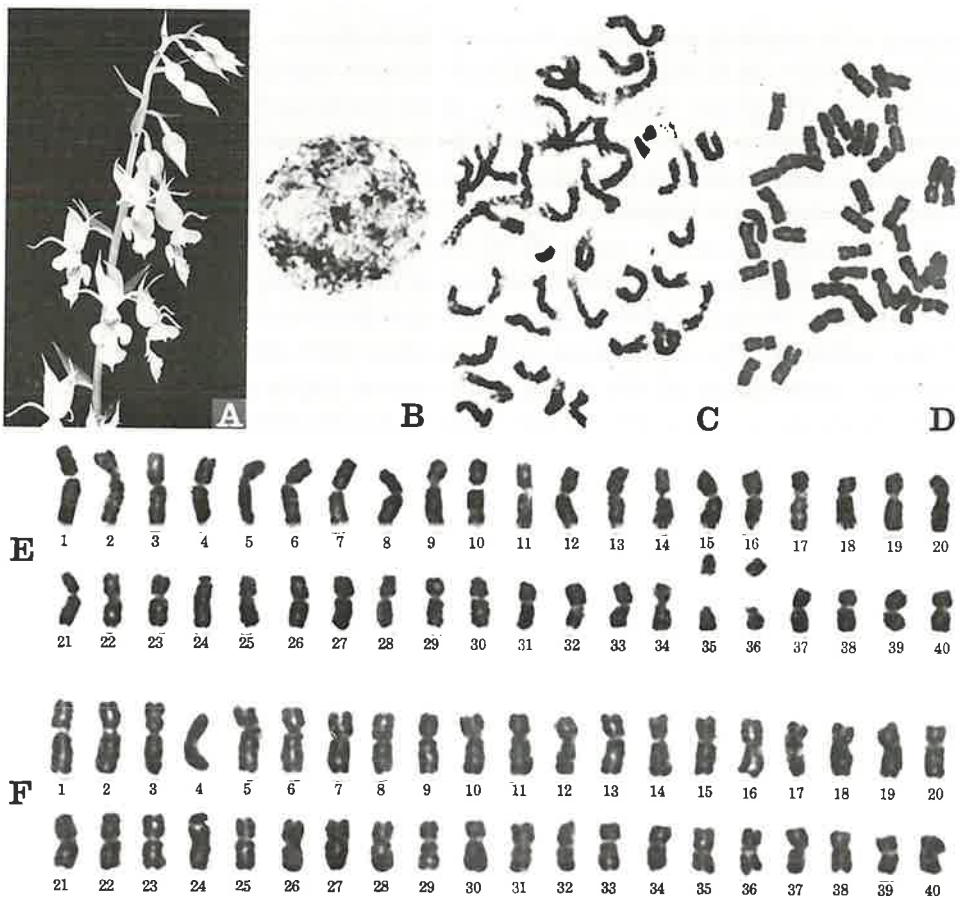

Fig. 18. Photomicrographs of the somatic chromosomes of *Calanthe reflexa* collected from Sakihama, Kochi Prefecture. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, F, individual chromosomes at mitotic metaphase.
A, ×0.5. B–D, ×1200. E,F, ×1800.

zygous chromosome with subterminal centromere was observed in all of the 25 clones investigated.

The longest chromosome of the complement was 5.4 μm in length and had a median centromere. Four chromosomes were morphologically similar to the longest one. The

second longest chromosome group had a submedian centromere, and had two members. The shortest chromosome group had four members with median centromeres and about 2.8 μm in length.

One of the small chromosomes with median centromere formed a large secondary constriction in a proximal region of long arm. At mitotic prophase the secondary constricted chromosomes appeared attached to a nucleolus through its secondary constricted region. During preparation procedure for cytological observation the secondary constricted chromosomes were separated easily through the secondary constriction into two segments. The miss-counting of 2n=40 as 42 (cf. Tanaka and Kamemoto 1982) might be due to the artificially separated segments of these chromosomes.

Meiosis was studied in the two clones from Kochi and Hiroshima Prefectures. The meiotic division was observed at mid-days of summer (July 20–25, 1978). P.M.Cs. in one anther showed variation in stages from pachytene to metaphase I among the pollinia balls. Chromosomes at pachytene stage were observed showing a congregation of fibrous mass resulting difficulty of the differentiation of chromosome individuals. Chromosomes at diakinesis associated by distal ends of both arms and formed bivalents. The association was so weak that the chromosomes were easily separated by the artificial pressure of squash preparation. One bivalent was observed attached to nucleolus through the region of secondary constriction of chromosomes.

Chromosomes at metaphase I formed 20 bivalents. Most of the bivalent chromosomes were ring shaped and had terminal chiasmata showing very weak association, while a few (2 to 3) of them were the rod shaped with an interstitial chiasma. Chromosomes at anaphase I moved toward poles without leaving any lagging chromosomes.

Karyotypes of the present species were categorized as follows: Resting stage: Loosely aggregated complex chromocenter type. Mitotic prophase: Gradient type. Mitotic metaphase: Partially heterogeneous and gradual type in chromosome length and highly symmetric type in arm ratio.

19. *Calanthe schlechteri* Hara, (Japanese name: Kisoebine), 2n=42, Tables 1 and 19, Figs. 19 and 20.

Two clones of this species were collected from Yamanashi and Gifu Prefectures. The two clones showed the chromosome number 2n=42, a new count. Both of the clones had typical characteristic in foliage leaves and flowers (Fig. 18, A). Chromosomes of somatic nuclei at resting stage formed many irregularly condensed chromatin blocks scattered in whole nuclear space and showed fibrous threads of chromatin attached to the chromatin blocks. All of the 2n=42 chromosomes at mitotic prophase had early condensed segments located in proximal region and late condensed segments in distal region. Chromosome segments between the early condensing segments and late condensing segments transformed gradually. A pair of the medium-sized chromosomes had long segments which condensed very lately.

Chromosomes at mitotic metaphase were observed to be larger chromosomes compared to the chromosomes of *Calanthe discolor* described in paragraph No. 5. They varied

in length from about 7.1 μm to 2.1 μm and showed gradual size difference showing a partially heterogeneous karyotype. The longest chromosome of the complement was observed to have a median centromere. Two other chromosomes were found showing the shape similar to the longest one. The second longest chromosome had a median centromere and was found to form two homologous pairs. The smallest chromosome was observed to have a median centromere. Six chromosomes were found to show the shape similar to the smallest one (Fig. 19, E 37–42). The smallest six chromosomes could be seen in

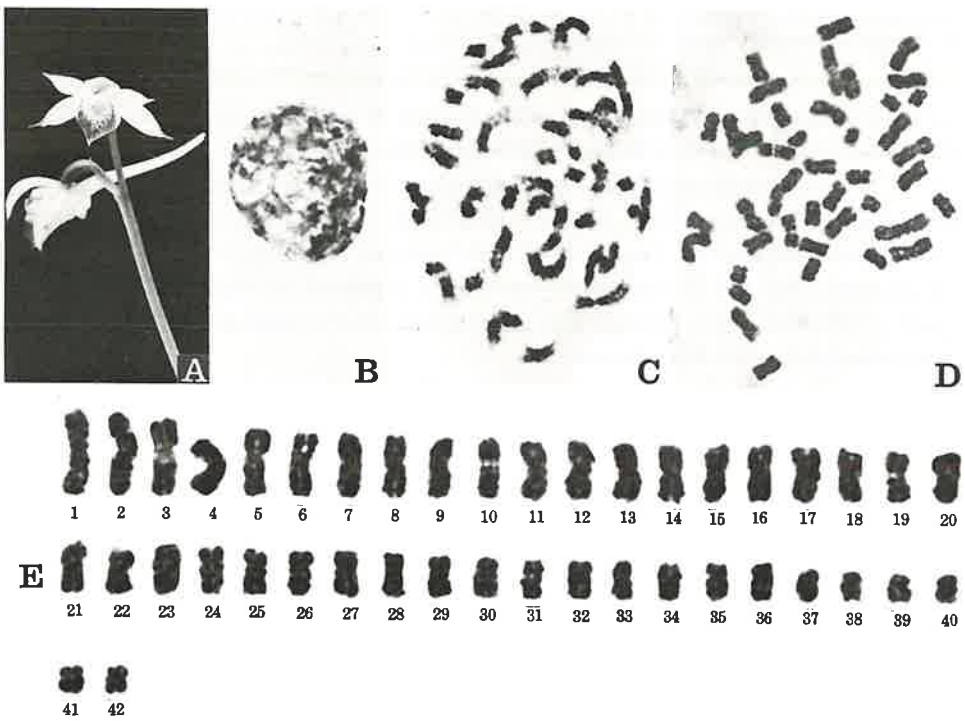

Fig. 19. Photomicrographs of the somatic chromosomes of *Calanthe schlechteri* collected from Gifu Prefecture. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=42. E, individual chromosomes at mitotic metaphase.
A, ×0.4. B–D, ×1200. E, ×1800.

many nuclear plates showing clear difference in size from the next smallest chromosome. All of the other 32 chromosomes had the centromere located in median region with the exception of the medium-sized four chromosomes which had submedian centromere (Fig. 19, E 23–26). No chromosome with subterminal centromere was observed. On the position of centromere the karyotype of this species was found to be highly symmetric. The secondary constriction showing NOR region was not observed in all of the metaphase plates investigated.

One clone of this species was given by Mr. K. Suzuki who obtained it from a collector in Chubu District. This clone had the chromosomes counted to be 2n=40 and reported previously (Tanaka 1965). This clone had only one flower poorly developed, while the spur on the lip developed very long measured about 1.5 cm. The morphology of chromosomes in both resting and mitotic prophase nuclei was observed to be very similar to that of the clones from Yamanashi and Gifu Prefectures described in above paragraph, while the morphology of mitotic metaphase chromosomes was found to differ in the smallest chromosome. Compared to the next smallest chromosomes (37 and 38 in Fig. 20), the smallest chromosome had a submedian centromere and no large difference in size (39 and 40 in Fig. 20). In comparison with the clone from Yamanashi Prefecture the Suzuki's clone showed further difference in having the secondary constricted NOR in a pair of smaller chromosomes which were morphologically similar to the NOR chromosomes of *Calanthe reflexa* described in previous paragraph (No. 18). The NOR in these chromosomes was observed located proximally in long arm. On the basis of variation of the chromosome number in Suzuki's clone we cannot trace further evidence whether this clone was a intraspecific variation or a mutant rarely occurred.

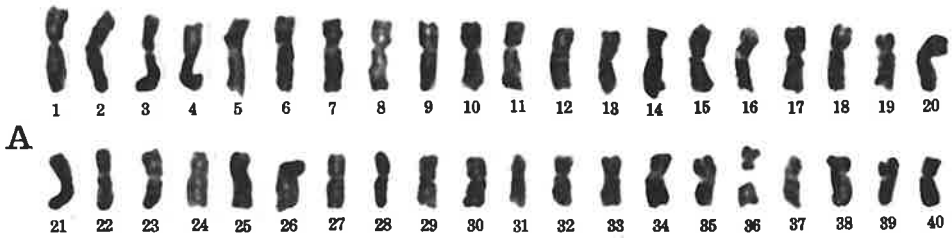

Fig. 20. Photomicrograph of the somatic chromosomes of *Calanthe schlechteri* obtained from Mr. K. Suzuki who collected from Chubu District. A, 2n=40 chromosomes at mitotic metaphase. x 1800.

Mutsuura and Nakahira (1958) reported 2n=44 chromosomes in the present species. According to their report the validated chromosome figures can be observed to be at late prophase in mitotic stage. In our observation some of the smaller chromosomes were separable easily through centromeric contriction by artificial pressure during preparation. It is supposed that the 2n=44 chromosome number might be a miscount on these separated smaller chromosomes at mitotic prophase.

20. *Calanthe sieboldii* Decne., (Japanese name: Kiebine), 2n=40, Tables 1 and 20, Fig. 21.

Twenty-three clones collected from ten localities in Kyushu, Chugoku and Kinki Districts were studied cytologically. All of the clones studied showed the same chromosome number, 2n=40, confirming the previous reports (cf. Tanaka and Kamemoto 1982). Chromosomes at resting stage formed many small blocks of chromatin which aggregated loosely into about 5 to 10 large blocks (Fig. 21, B). Some parts of the chromatin formed

fine fibrous threads scattered in whole nuclear area.

Chromosomes at mitotic prophase formed early condensed large segments situated proximally and late condensed segments situated distally (Fig. 21, C). Gradual transition of the degree of condensation was observed between the early condensed segments and late condensed segments. The early condensed segments in longer chromosomes were larger than those of shorter chromosomes, while the late condensed segments were similar in both longer and shorter chromosomes.

Chromosomes at mitotic metaphase showed variation in length ranged gradually from 5.5 μm to 1.6 μm. The pattern of the variation of the length of chromosomes was cate-

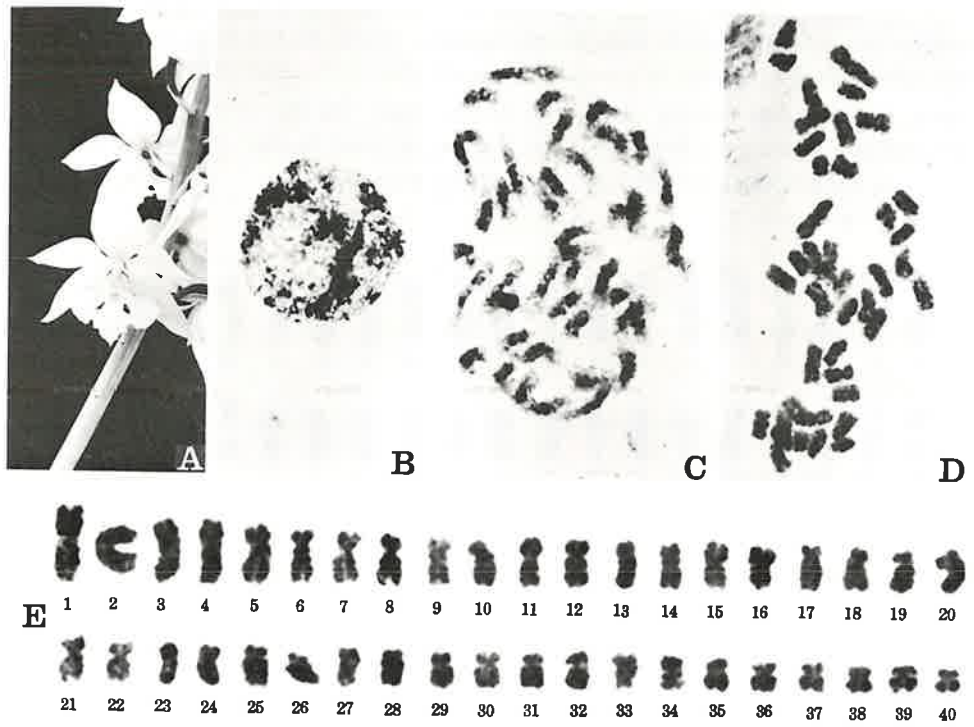

Fig. 21. Photomicrographs of the somatic chromosomes of *Calanthe sieboldii* collected from Shimonoseki, Yamaguchi Prefecture. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase. A, ×0.4. B–D, ×1200. E, ×1800.

gorized to be the homogeneous karyotype. Two of the long chromosomes in the complement were observed to belong to the group of the longest chromosome. The two chromosomes had the centromere located in median position. The second longest group was composed of two median centromeric chromosomes. The third longest group was composed of four submedian centromeric chromosomes. The shortest chromosome group was also composed of six members with median centromere. About 26 chromo-

somes of the 2n=40 chromosomes had median centromere, while the rest of the complement (about 14) were submedian centromeric. The karyotype of this species was categorized to be symmetric in arm ratio.

Satellites revealing NOR were not observed, while in a few chromosomes (2 or 3) small constrictions were observed located in the interstitial region of long arm.

21. *Calanthe tricarinata* Lindl., (Japanese name: Sarumenebine), 2n=40 and 2n=60, Tables 1 and 21, Fig. 22.

Seven clones collected from four localities were studied cytologically. Six of the seven clones had typical characteristics in external morphology as shown in Fig. 22A,

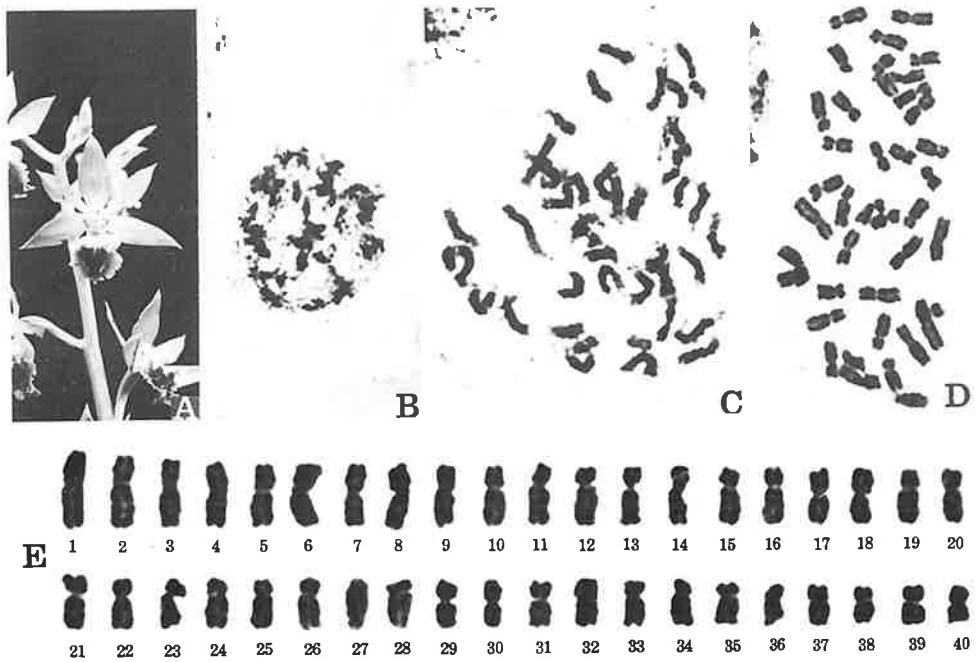

Fig. 22. Photomicrographs of the somatic chromosomes of *Calanthe tricarinata* collected from Yoshiwa, Hiroshima Prefecture. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40, diploid clone. E, individual chromosomes at mitotic metaphase. A, ×0.5. B–D, ×1200. E, ×1800.

while the remaining one showed gigas form in flower texture. This clone was found to be a triploid with 2n=60 which was an additional finding of triploid clone after the previous report (Mutsuura and Nakahira 1958).

Chromosomes at resting stage formed many chromocentric rod aggregations which were remarkably distinguishable from diffused chromatin threads. Most of the chromocentric aggregations associated into larger blocks, while some of the aggregations were observed independent from the blocks.

Chromosomes at mitotic prophase formed early condensed long segments located in proximal and interstitial regions and late condensed short segments located in distal region (Fig. 22, C). In some chromosomes small telomeric knobs were observed. Chromosomes at mitotic metaphase varied gradually in length from about 5.2 μm to about 2.6 μm showing a homogeneous karyotype. The longest chromosome group of the complement had the centromere located in median position and composed of two members (Fig. 22, E 1–4). The second longest group was also composed of two members which had median centromere. The shortest goup had centromeres located in median position and was composed of four members. More than half (about 22) of the members of 2n=40 chromosomes were found to have median centromere, while the remaining (about 16) chromosomes had submedian centromere and only two had subterminal centromere (Fig. 22, E 27, 28). Thus, the arm ratio of the chromosome complement was categorized to be symmetric. No chromosome having NOR secondary constriction was observed.

22. *Calanthe triplicata* (Willem.) Ames, (Japanese name: Tsururan), 2n=40, Tables 1 and 22, Fig. 23.

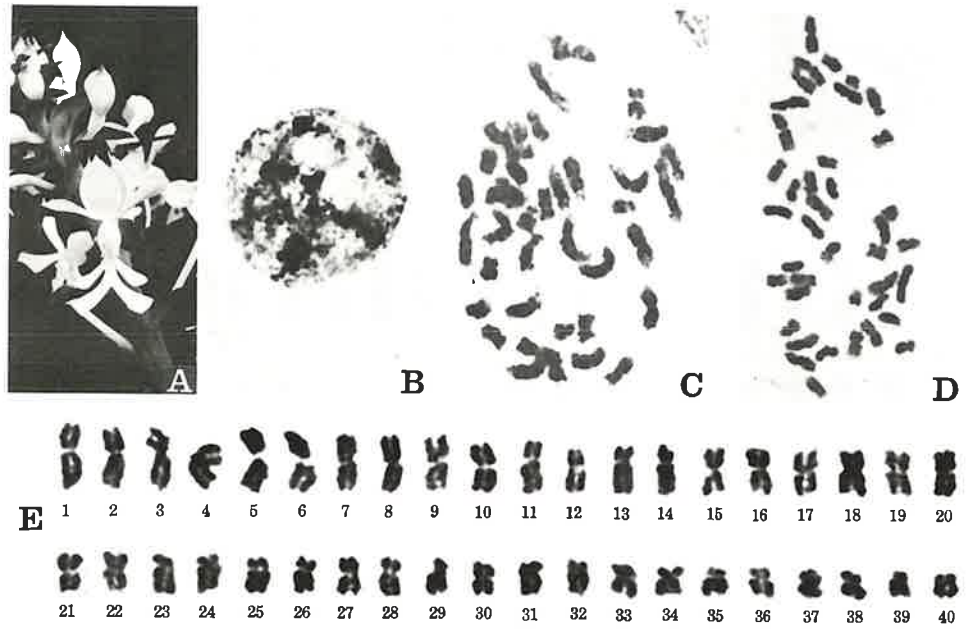

Fig. 23. Photomicrographs of the somatic chromosomes of *Calanthe triplicata* collected from Mt. Mottyomu. A, flowers. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase, 2n=40. E, individual chromosomes at mitotic metaphase.
A, ×0.6. B–D, ×1200. E, ×1800.

Fourteen clones of this species were obtained from five islands: Tanegashima, Yakushima, Amami-oshima, Tokunoshima, and Okinawa. All of these islands belong to the south-western area in Kyushu District. In all of the 13 clones 2n=40 chromosomes were

counted confirming the previous reports (cf. Tanaka and Kamemoto 1982).

Karyomorphological features of this species were found to differ slightly in comparison with those of *Calanthe discolor* described previously in paragraph No. 5. The chromosomes at resting stage formed several compactly condensed round blocks of chromocenters in addition to the loosely aggregated large blocks with irregular surface. At mitotic metaphase the chromosomes were found to be relatively short compared to the chromosomes of *Calanthe discolor.* They varied in length gradually from about 4.8 μm to 1.8 μm showing highly homogeneous karyotype. The longest group of chromosomes was composed of four members. The second longest group of chromosomes had also the median centromere and was also composed of four members. The smallest group of the chromosomes had submedian centromere. In comparison with *Calanthe discolor,* the present species showed more symmetric karyotype in arm ratio. Satellites were not observed.

Concluding Results

1. In the present paper the results of the karyomorphological observations were described in all of the 22 taxa of the *Calanthe* growing wild in Japan.
2. Four kinds of chromosome number, *i.e.,* 2n=38, 2n=40, 2n=42, and 2n=60, were found in the Japanese *Calanthe,* confirming mostly previous reports. 2n=40 was found to be the common chromosome number of the Japanese *Calanthe.* 2n=38 was found only in *Calanthe nipponica,* and 2n=42 in *Calanthe schlechteri* and *Calanthe bungoana.* 2n=60 was found as a spontaneous triploid clone in *Calanthe discolor* var. *amamiana* and in *Calanthe tricarinata.*
3. All of the taxa were found without satellited chromosome with the exception of *Calanthe reflexa* (2n=40).
4. All of them showed homogeneous karyotype in chromosome length at mitotic metaphase, symmetric karyotype in arm ratio, proximally and gradually condensed karyotype at mitotic prophase, and complex chromocentric karyotype at resting stage, while small variations in the karyotype between taxa were also observed.
5. *Calanthe schlechteri* (2n=42), *Calanthe bungoana* (2n=42) and *Calanthe nipponica* (2n=38) were found to have larger chromosomes than the usual Japanese *Calanthe,* and *Calanthe japonica* (2n=40) and *Calanthe lyroglossa* (2n=40) had the smaller chromosomes.
6. On the degree of homogeneity, *Calanthe japonica* (2n=40) and *Calanthe lyroglossa* (2n=40) showed the highest degree and *Calanthe schlechteri* (2n=42) and *Calanthe bungoana* (2n=42) the lowest degree.
7. The highest degree of symmetry in arm ratio was found in *Calanthe schlechteri* (2n=42), *Calanthe reflexa* (2n=40), *Calanthe nipponica* (2n=38), *Calanthe japonica* (2n=40) and *Calanthe lyroglossa* (2n=40). The lowest degree of symmetry was found in *Calanthe bungoana* (2n=42) and *Calanthe izu-insularis* (2n=40). Most of the species with 2n=40 were found showing an average degree of symmetry.

8. Variation in the complex chromocentric karyotype was as follows. In most of the 22 taxa the chromocenters were found forming irregularly shaped chromocentric bodies which varied in number from about 15 to 40 and frequently aggregated to form large blocks which varied in number from about 5 to 10, while in *Calanthe gracilis* var. *venusta* with 2n=40, in *Calanthe tricarinata* with 2n=40, and in *Calanthe lyroglossa* with 2n=40 the chromocentric bodies showed strong and tight aggregations forming small rigid blocks, in *Calanthe nipponica* with 2n=38 and in *Calanthe schlechteri* with 2n=42 the chromocentric bodies formed fewer blocks than the common one, and in *Calanthe reflexa* with 2n=40 the chromocentric bodies were observed showing loose aggregations.
9. By karyomorphological characteristics the Japanese *Calanthe* were grouped into following eight types.

Type A: *Calanthe schlechteri.* Key characters; 2n=42, larger chromosomes, low homogeneous and highly symmetric karyotype, and loosely aggregated chromocentric karyotype.

Type B: *Calanthe nipponica.* Key characters; 2n=38, similar to Type A with the exception of chromosome number.

Type C: *Calanthe reflexa.* Key characters; 2n=40, similar to Type A and Type B in karyomorphological features with the exception of chromosome number, large secondary NOR constriction in a pair of small chromosomes, and a subterminally centromeric chromosome in medium-sized chromosomes.

Type D: *Calanthe bungoana.* Key characters; 2n=42, larger chromosomes, low homogeneous and low symmetric karyotype, and average degree of aggregation in chromocentric karyotype.

Type E: *Calanthe aristulifera, Calanthe* ×*bicolor, Calanthe densiflora, Calanthe discolor, Calanthe discolor* var. *amamiana, Calanthe discolor* var. *kanashiroi, Calanthe discolor* var. *tokunoshimensis, Calanthe izu-insularis, Calanthe oblanceolata, Calanthe sieboldii, Calanthe tricarinata.* Key characters; 2n=40, medium-sized chromosomes, average degree of homogeneity and symmetric karyotype in arm ratio, and average degree of aggregation in chromocentric karyotype; common in Japanese *Calanthe.*

Type F: *Calanthe lyroglossa.* Key characters; 2n=40, smaller chromosomes, highly homogeneous and highly symmetric karyotype in arm ratio, and strongly aggregated chromocentric karyotype.

Type G: *Calanthe japonica, Calanthe okinawaensis, Calanthe hattorii, Calanthe musca, Calanthe triplicata.* Key characters; 2n=40, similar to Type F in karyomorphological features with the exception of the average degree of aggregation in chromocentric karyotype having some chromocenters compactly condensed.

Type H: *Calanthe gracilis* var. *venusta.* Key characters; 2n=40, highly homogeneous karyotype and moderately symmetric karyotype in arm ratio and strongly aggregated chromocentric karyotype.

Literature Cited

Garay, L.A. and Sweet, H.R. 1974. Orchids of Southern Ryukyu Islands. 180pp. Bot. Mus. Harvard Univ. (U.S.A.).

Hatushima, S. and Amano, T. 1977. Flora of the Ryukyus, South of Amami Island. 282pp. Deigo Press Co. (Naha).

Ito, I. and Karasawa, K. 1969. Calanthe in Japan and its Kins. 308pp. Seibundo-Shinkosha (Tokyo).

Levan, A., Fredge, K. and Sandberg, A.A. 1964. Nomenclature for centoromeric position of chromosomes. Hereditas 52: 201–220.

Maekawa, F. 1971. The Wild Orchids of Japan in Colour. 495pp. Seibundo-Shinkosha (Tokyo).

Miduno, T. 1940. Chromosomenstudien an Orchidazeen IV. Cytologia 11: 179–185.

Mutsuura, O. and Nakahira, R. 1958. Chromosome numbers of the family Orchidaceae in Japan (1). Sci. Rep. Saikyo Univ., Nat. Sci. & Liv. Sci., 2, 5: 23–30.

Ohwi, J. 1978. Flora of Japan. 1584pp. Shibundo (Tokyo).

Tanaka, R. 1959. On the speciation and karyotypes in diploid and tetraploid species of *Chrysanthemum* I. Karyotypes in *Chrysanthemum boreale* (2n=18). Jour. Sci. Hiroshima Univ. Ser. B, Div. 2, 9: 1–16.

_____. 1965. Chromosome numbers of some species of Orchidaceae from Japan and its neighbouring areas. Jour. Jap. Bot. 40(3): 65–77.

_____. 1968. Cytology of the Orchidaceae. Seed Formation and Sterile Culture of the Orchids (Ed. Torigata, H.). 1–62. Seibundo-Shinkosha (Tokyo).

_____. 1971a. Types of resting nuclei in Orchidaceae. Bot. Mag. Tokyo 84: 118–122.

_____. 1971b. Cytological studies on the wide-crossing in Orchidaceae. Recent Advances in Breedings 12: 91–112.

_____. 1973. Interspecific hybrid *Calanthe furcata* x *Cal. striata* var. *sieboldii* and its cytogenetic analysis. Japan Orchid Society Bull. 19(1): 3–5.

_____. 1977. Recent karyotype studies. Plant Cytology. (Ed. Ogawa, K. *et al.*). 293–325. Asakura Book Co. (Tokyo).

_____and Kamemoto, H.H. 1982. Updated list of chromosome numbers of orchids. Orchid Biology, 2nd Vol. (Ed. Arditti, J.). Cornell Univ. Press. (in printing).

Teoh, S.B. and Lim S.N. 1978. Cytological studies in Malayan members of the Phaius tribe (Orchidaceae). I. Somatic chromosomes. Malaysian J. Sci. 5(A); 1–11.

_____. 1980. Cytological studies in Malayan members of the Phaius tribe (Orchidaceae). II. Meiotic and B-chromosomes. Caryologia 33: 483–493.

Table 2. Measurements of somatic chromosomes of *Calanthe aristulifera*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	1.9 + 3.0 = 4.9	3.6	1.6	m
2	1.9 + 3.0 = 4.9	3.6	1.6	m
3	1.7 + 2.7 = 4.4	3.3	1.6	m
4	1.7 + 2.7 = 4.4	3.3	1.6	m
5	1.3 + 3.0 = 4.3	3.2	2.3	sm
6	1.3 + 3.0 = 4.3	3.2	2.3	sm
7	1.3 + 2.5 = 3.8	2.8	1.9	sm
8	1.3 + 2.5 = 3.8	2.8	1.9	sm
9	1.7 + 1.9 = 3.6	2.7	1.1	m
10	1.7 + 1.9 = 3.6	2.7	1.1	m
11	1.3 + 2.3 = 3.6	2.7	1.8	sm
12	1.3 + 2.3 = 3.6	2.7	1.8	sm
13	1.2 + 2.4 = 3.6	2.7	2.0	sm
14	1.2 + 2.4 = 3.6	2.7	2.0	sm
15	1.2 + 2.3 = 3.5	2.6	1.9	sm
16	1.2 + 2.3 = 3.5	2.6	1.9	sm
17	1.2 + 2.3 = 3.5	2.6	1.9	sm
18	1.2 + 2.3 = 3.5	2.6	1.9	sm
19	1.2 + 2.1 = 3.3	2.5	1.8	sm
20	1.0 + 2.3 = 3.3	2.5	2.3	sm
21	1.5 + 1.8 = 3.3	2.5	1.2	m
22	1.5 + 1.6 = 3.1	2.3	1.1	m
23	1.3 + 1.8 = 3.1	2.3	1.4	m
24	1.3 + 1.8 = 3.1	2.3	1.4	m
25	1.0 + 2.1 = 3.1	2.3	2.1	sm
26	1.0 + 2.1 = 3.1	2.3	2.1	sm
27	1.0 + 2.1 = 3.1	2.3	2.1	sm
28	1.0 + 2.1 = 3.1	2.3	2.1	sm
29	1.3 + 1.8 = 3.1	2.3	1.4	m
30	1.3 + 1.7 = 3.0	2.2	1.3	m
31	0.9 + 2.0 = 2.9	2.2	2.2	sm
32	0.9 + 2.0 = 2.9	2.2	2.2	sm
33	1.2 + 1.7 = 2.9	2.2	1.4	m
34	1.2 + 1.7 = 2.9	2.2	1.4	m
35	1.3 + 1.5 = 2.8	2.1	1.2	m
36	1.3 + 1.5 = 2.8	2.1	1.2	m
37	1.2 + 1.3 = 2.5	1.9	1.1	m
38	0.9 + 1.5 = 2.4	1.8	1.7	m
39	0.8 + 1.3 = 2.1	1.6	1.6	m
40	0.8 + 1.3 = 2.1	1.6	1.6	m

Table 3. Measurements of somatic chromosomes of *Calanthe bungoana*, 2n=42 at metaphase

Chromosome	Lenght (μm)	Relative length	Arm ratio	Form
1	2.3 + 3.4 = 5.7	3.4	1.5	m
2	2.3 + 3.4 = 5.7	3.4	1.5	m
3	1.3 + 4.3 = 5.6	3.3	3.3	s t
4	1.3 + 4.3 = 5.6	3.3	3.3	s t
5	1.3 + 3.5 = 4.8	2.9	2.7	sm
6	1.3 + 3.5 = 4.8	2.9	2.7	sm
7	1.6 + 3.2 = 4.8	2.9	2.0	sm
8	1.6 + 3.2 + 4.8	2.9	2.0	sm
9	1.7 + 2.9 = 4.6	2.7	1.7	m
10	1.7 + 2.9 = 4.6	2.7	1.7	m
11	1.7 + 2.7 = 4.4	2.6	1.6	m
12	1.7 + 2.7 = 4.4	2.6	1.6	m
13	1.3 + 3.1 = 4.4	2.6	2.4	sm
14	1.3 + 3.1 = 4.4	2.6	2.4	sm
15	1.7 + 2.7 = 4.4	2.6	1.6	m
16	1.7 + 2.7 = 4.4	2.6	1.6	m
17	1.5 + 2.8 = 4.3	2.6	1.9	sm
18	1.5 + 2.8 = 4.3	2.6	1.9	sm
19	0.8 + 3.4 = 4.2	2.5	4.3	s t
20	0.8 + 3.4 = 4.2	2.5	4.3	s t
21	1.3 + 2.5 = 3.8	2.3	1.9	sm
22	1.3 + 2.5 = 3.8	2.3	1.9	sm
23	1.3 + 2.5 = 3.8	2.3	1.9	sm
24	1.3 + 2.5 = 3.8	2.3	1.9	sm
25	1.2 + 2.6 = 3.8	2.3	2.2	sm
26	1.2 + 2.6 = 3.8	2.3	2.2	sm
27	0.7 + 2.7 = 3.4	2.0	3.9	s t
28	0.7 + 2.7 = 3.4	2.0	3.9	s t
29	1.5 + 1.9 = 3.4	2.0	1.3	m
30	1.5 + 1.9 + 3.4	2.0	1.3	m
31	1.6 + 1.8 = 3.4	2.0	1.1	m
32	1.6 + 1.8 = 3.4	2.0	1.1	m
33	1.3 + 1.9 = 3.2	1.9	1.5	m
34	1.3 + 1.9 = 3.2	1.9	1.5	m
35	1.3 + 1.9 = 3.2	1.9	1.5	m
36	1.3 + 1.9 = 3.2	1.9	1.5	m
37	1.3 + 1.9 = 3.2	1.9	1.5	m
38	1.3 + 1.9 = 3.2	1.9	1.5	m
39	1.3 + 1.5 = 2.8	1.7	1.2	m
40	1.3 + 1.5 = 2.8	1.7	1.2	m
41	0.9 + 1.7 = 2.6	1.6	1.9	sm
42	0.9 + 1.7 = 2.6	1.6	1.9	sm

Table 4. Measurements of somatic chromosomes of *Calanthe densiflora*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.7 + 3.0 = 5.7	3.3	1.1	m
2	2.7 + 3.0 = 5.7	3.3	1.1	m
3	2.7 + 2.7 = 5.4	3.2	1.0	m
4	2.7 + 2.7 = 5.4	3.2	1.0	m
5	2.2 + 2.8 = 5.0	2.9	1.3	m
6	2.2 + 2.8 = 5.0	2.9	1.3	m
7	2.0 + 2.8 = 4.8	2.8	1.4	m
8	2.0 + 2.8 = 4.8	2.8	1.4	m
9	2.0 + 2.7 = 4.7	2.8	1.4	m
10	2.0 + 2.7 = 4.7	2.8	1.4	m
11	2.3 + 2.3 = 4.6	2.7	1.0	m
12	2.3 + 2.3 = 4.6	2.7	1.0	m
13	2.1 + 2.5 = 4.6	2.7	1.2	m
14	2.1 + 2.5 = 4.6	2.7	1.2	m
15	1.3 + 3.2 = 4.5	2.6	2.5	sm
16	1.3 + 3.2 = 4.5	2.6	2.5	sm
17	1.3 + 3.2 = 4.5	2.6	2.5	sm
18	1.3 + 3.2 = 4.5	2.6	2.5	sm
19	1.0 + 3.5 = 4.5	2.6	3.5	s t
20	1.0 + 3.5 = 4.5	2.6	3.5	s t
21	2.1 + 2.3 = 4.4	2.6	1.1	m
22	2.1 + 2.3 = 4.4	2.6	1.1	m
23	1.7 + 2.5 = 4.2	2.5	1.5	m
24	1.7 + 2.5 = 4.2	2.5	1.5	m
25	1.2 + 2.8 = 4.1	2.4	2.3	sm
26	1.2 + 2.8 = 4.1	2.4	2.3	sm
27	0.7 + 3.3 = 4.0	2.3	4.7	s t
28	0.7 + 3.3 = 4.0	2.3	4.7	s t
29	1.5 + 2.5 = 4.0	2.3	1.7	m
30	1.5 + 2.5 = 4.0	2.3	1.7	m
31	1.0 + 2.7 = 3.7	2.2	2.7	sm
32	1.0 + 2.7 = 3.7	2.2	2.7	sm
33	1.3 + 2.3 = 3.6	2.1	1.8	sm
34	1.3 + 2.3 = 3.6	2.1	1.8	sm
35	1.1 + 2.4 = 3.5	2.1	2.2	sm
36	1.1 + 2.4 = 3.5	2.1	2.2	sm
37	1.4 + 2.1 = 3.5	2.1	1.5	m
38	1.3 + 1.7 = 3.0	1.8	1.3	m
39	1.0 + 1.3 = 2.3	1.3	1.3	m
40	1.0 + 1.3 = 2.3	1.3	1.3	m

Table 5. Measurements of somatic chromosomes of *Calanthe discolor*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.0 + 3.3 = 5.3	3.7	1.7	m
2	2.0 + 3.3 = 5.3	3.7	1.7	m
3	2.0 + 3.2 = 5.2	3.6	1.6	m
4	2.0 + 3.2 = 5.2	3.6	1.6	m
5	1.5 + 3.2 = 4.7	3.2	2.1	sm
6	1.5 + 3.2 = 4.7	3.2	2.1	sm
7	1.6 + 3.0 = 4.6	3.2	1.9	sm
8	1.5 + 3.0 = 4.5	3.1	2.0	sm
9	1.6 + 2.4 = 4.0	2.8	1.5	m
10	1.6 + 2.4 = 4.0	2.8	1.5	m
11	1.1 + 2.9 = 4.0	2.8	2.6	sm
12	1.1 + 2.9 = 4.0	2.8	2.6	sm
13	1.3 + 2.6 = 3.9	2.7	2.0	sm
14	1.3 + 2.6 = 3.9	2.7	2.0	sm
15	1.5 + 2.4 = 3.9	2.7	1.6	m
16	1.5 + 2.4 = 3.9	2.7	1.6	m
17	1.3 + 2.5 = 3.8	2.6	1.9	sm
18	1.3 + 2.5 = 3.8	2.6	1.9	sm
19	1.0 + 2.7 = 3.7	2.6	2.7	sm
20	1.0 + 2.7 = 3.7	2.6	2.7	sm
21	1.3 + 2.2 = 3.5	2.4	1.7	m
22	1.6 + 1.7 = 3.3	2.3	1.7	m
23	1.5 + 1.8 = 3.3	2.3	1.2	m
24	1.5 + 1.8 = 3.3	2.3	1.2	m
25	1.1 + 2.1 = 3.2	2.2	1.9	sm
26	1.1 + 2.1 = 3.2	2.2	1.9	sm
27	0.7 + 2.5 = 3.2	2.2	3.6	s t
28	0.7 + 2.5 = 3.2	2.2	3.6	s t
29	1.4 + 1.8 = 3.2	2.2	1.3	m
30	1.4 + 1.8 = 3.2	2.2	1.3	m
31	1.4 + 1.6 = 3.0	2.1	1.1	m
32	1.4 + 1.6 = 3.0	2.1	1.4	m
33	1.0 + 1.9 = 2.9	2.0	1.9	sm
34	1.0 + 1.9 = 2.9	2.0	1.9	sm
35	0.7 + 1.9 = 2.6	1.8	2.7	sm
36	0.7 + 1.9 = 2.6	1.8	2.7	sm
37	1.0 + 1.5 = 2.5	1.7	1.5	m
38	1.0 + 1.5 = 2.5	1.7	1.5	m
39	0.7 + 1.5 = 2.2	1.5	2.1	sm
40	0.6 + 1.3 = 1.9	1.3	2.2	sm

Table 6. Measurements of somatic chromosomes of *Calanthe discolor* var. *amamiana*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.1 + 2.7 = 4.8	3.7	1.3	m
2	2.1 + 2.7 = 4.8	3.7	1.3	m
3	1.8 + 2.8 = 4.6	3.6	1.6	m
4	1.8 + 2.8 = 4.6	3.6	1.6	m
5	1.4 + 2.5 = 3.9	3.0	1.8	sm
6	1.4 + 2.5 = 3.9	3.0	1.8	sm
7	1.3 + 2.4 = 3.7	2.9	1.8	sm
8	1.3 + 2.4 = 3.7	2.9	1.8	sm
9	1.4 + 2.2 = 3.6	2.8	1.6	m
10	1.4 + 2.2 = 3.6	2.8	1.6	m
11	1.2 + 2.4 = 3.6	2.8	2.0	sm
12	1.2 + 2.4 = 3.6	2.8	2.0	sm
13	1.3 + 2.3 = 3.6	2.8	1.8	sm
14	1.3 + 2.3 = 3.6	2.8	1.8	sm
15	1.5 + 2.0 = 3.5	2.7	1.3	m
16	1.5 + 2.0 = 3.5	2.7	1.3	m
17	1.1 + 2.3 = 3.4	2.6	2.1	sm
18	1.1 + 2.3 = 3.4	2.6	2.1	sm
19	0.9 + 2.4 = 3.3	2.6	2.7	sm
20	0.9 + 2.4 = 3.3	2.6	2.7	sm
21	1.2 + 1.9 = 3.1	2.4	1.6	m
22	1.2 + 1.9 = 3.1	2.4	1.6	m
23	1.3 + 1.6 = 2.9	2.3	1.2	m
24	1.3 + 1.6 = 2.9	2.3	1.2	m
25	1.3 + 1.5 = 2.8	2.2	1.2	m
26	1.3 + 1.5 = 2.8	2.2	1.2	m
27	1.1 + 1.7 = 2.8	2.2	1.5	m
28	1.1 + 1.7 = 2.8	2.2	1.5	m
29	1.0 + 1.8 = 2.8	2.2	1.8	sm
30	1.0 + 1.8 = 2.8	2.2	1.8	sm
31	0.7 + 1.9 = 2.6	2.0	2.7	sm
32	0.7 + 1.9 = 2.6	2.0	2.7	sm
33	0.9 + 1.5 = 2.4	1.9	1.7	m
34	1.0 + 1.4 = 2.4	1.9	1.4	m
35	1.0 + 1.4 = 2.4	1.9	1.4	m
36	1.0 + 1.3 = 2.3	1.8	1.3	m
37	1.0 + 1.4 = 2.4	1.9	1.4	m
38	0.9 + 1.4 = 2.3	1.8	1.6	m
39	0.8 + 1.3 = 2.2	1.7	1.6	m
40	0.7 + 1.2 = 1.9	1.5	1.7	m

Table 7. Measurements of somatic chromosomes of *Calanthe discolor* var. *kanashiroi*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.4 + 2.8 = 5.2	4.2	1.2	m
2	2.4 + 2.8 = 5.2	4.2	1.2	m
3	1.6 + 2.7 = 4.3	3.3	1.7	m
4	1.6 + 2.5 = 4.1	3.3	1.6	m
5	1.4 + 2.6 = 4.0	3.2	1.9	sm
6	1.4 + 2.6 = 4.0	3.2	1.9	sm
7	1.4 + 2.5 = 3.9	3.1	1.8	sm
8	1.4 + 2.5 = 3.9	3.1	1.8	sm
9	1.6 + 2.1 = 3.7	3.0	1.3	m
10	1.6 + 1.9 = 3.5	2.8	1.2	m
11	1.2 + 2.1 = 3.3	2.6	1.8	sm
12	1.2 + 2.1 = 3.3	2.6	1.8	sm
13	1.4 + 1.8 = 3.2	2.6	1.3	m
14	1.4 + 1.8 = 3.2	2.6	1.3	m
15	1.2 + 1.9 = 3.1	2.5	1.6	m
16	1.2 + 1.9 = 3.1	2.5	1.6	m
17	1.0 + 2.0 = 3.0	2.4	2.0	sm
18	1.0 + 2.0 = 3.0	2.4	2.0	sm
19	1.0 + 1.9 = 2.9	2.3	1.9	sm
20	1.0 + 1.9 = 2.9	2.3	1.9	sm
21	1.4 + 1.5 = 2.9	2.3	1.1	m
22	1.4 + 1.5 = 2.9	2.3	1.1	m
23	1.1 + 1.8 = 2.9	2.3	1.6	m
24	1.1 + 1.8 = 2.9	2.3	1.6	m
25	1.0 + 1.8 = 2.8	2.2	1.8	sm
26	1.0 + 1.8 = 2.8	2.2	1.8	sm
27	1.2 + 1.6 = 2.8	2.2	1.3	m
28	1.2 + 1.6 = 2.8	2.2	1.3	m
29	1.3 + 1.5 = 2.8	2.2	1.2	m
30	1.3 + 1.5 = 2.8	2.2	1.2	m
31	0.7 + 1.9 = 2.6	2.1	2.7	sm
32	0.7 + 1.9 = 2.6	2.1	2.7	sm
33	1.2 + 1.4 = 2.6	2.1	1.2	m
34	1.2 + 1.4 = 2.6	2.1	1.2	m
35	0.9 + 1.4 = 2.3	1.8	1.6	m
36	0.9 + 1.4 = 2.3	1.8	1.6	m
37	1.1 + 1.2 = 2.3	1.8	1.1	m
38	1.1 + 1.2 = 2.3	1.8	1.1	m
39	0.7 + 1.3 = 2.0	1.6	1.9	sm
40	0.6 + 1.3 = 1.9	1.5	2.2	sm

Table 8. Measurements of somatic chromosomes of *Calanthe discolor* var. *tokunoshimensis*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.7 + 2.7 = 5.4	3.8	1.0	m
2	2.7 + 2.7 = 5.4	3.8	1.0	m
3	2.3 + 2.9 = 5.2	3.7	1.3	m
4	2.3 + 2.9 = 5.2	3.7	1.3	m
5	1.3 + 3.0 = 4.3	3.1	2.3	sm
6	1.3 + 3.0 = 4.3	3.1	2.3	sm
7	1.4 + 2.9 = 4.3	3.1	2.1	sm
8	1.4 + 2.9 = 4.3	3.1	2.1	sm
9	2.0 + 2.2 = 4.2	3.0	1.1	m
10	2.0 + 2.2 = 4.2	3.0	1.1	m
11	1.3 + 2.4 = 3.7	2.6	1.8	sm
12	1.3 + 2.4 = 3.7	2.6	1.8	sm
13	1.5 + 2.1 = 3.6	2.6	1.4	m
14	1.5 + 2.1 = 3.6	2.6	1.4	m
15	1.1 + 2.4 = 3.5	2.5	2.2	sm
16	1.2 + 2.3 = 3.5	2.5	1.9	sm
17	1.2 + 2.3 = 3.5	2.5	1.9	sm
18	1.2 + 2.3 = 3.5	2.5	1.9	sm
19	1.0 + 2.3 = 3.3	2.3	2.3	sm
20	1.0 + 2.3 = 3.3	2.3	2.3	sm
21	1.5 + 1.8 = 3.3	2.3	1.2	m
22	1.6 + 1.7 = 3.3	2.3	1.1	m
23	1.5 + 1.8 = 3.3	2.3	1.2	m
24	1.5 + 1.8 = 3.3	2.3	1.2	m
25	0.8 + 2.5 = 3.3	2.3	3.1	sm
26	1.0 + 2.3 = 3.3	2.3	2.3	sm
27	1.3 + 1.9 = 3.2	2.3	1.5	m
28	1.3 + 1.9 = 3.2	2.3	1.5	m
29	0.9 + 2.3 = 3.2	2.3	2.6	sm
30	1.1 + 2.1 = 3.2	2.3	1.9	sm
31	1.4 + 1.6 = 3.0	2.1	1.1	m
32	1.3 + 1.6 = 2.9	2.1	1.2	m
33	0.8 + 2.1 = 2.9	2.1	2.6	sm
34	0.8 + 1.9 = 2.7	1.9	2.4	sm
35	1.1 + 1.7 = 2.8	2.0	1.5	m
36	1.1 + 1.7 = 2.8	2.0	1.3	m
37	1.2 + 1.6 = 2.8	2.0	1.3	m
38	1.0 + 1.1 = 2.1	1.5	1.1	m
39	0.7 + 1.3 = 2.0	1.4	1.9	sm
40	0.7 + 1.3 = 2.0	1.4	1.9	sm

Table 9. Measurements of somatic chromosomes of *Calanthe gracilis* var. *venusta*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.7 + 3.0 = 5.7	3.5	1.1	m
2	2.7 + 3.0 = 5.7	3.5	1.1	m
3	1.8 + 3.0 = 4.8	3.0	1.7	m
4	1.8 + 3.0 = 4.8	3.0	1.7	m
5	1.4 + 3.3 = 4.7	2.9	2.4	sm
6	1.4 + 3.3 = 4.7	2.9	2.4	sm
7	1.3 + 3.3 = 4.6	2.8	2.5	sm
8	1.3 + 3.3 = 4.6	2.8	2.5	sm
9	1.5 + 3.1 = 4.6	2.8	2.1	sm
10	1.5 + 3.1 = 4.6	2.8	2.1	sm
11	1.7 + 2.7 = 4.4	2.7	1.6	m
12	1.7 + 2.7 = 4.4	2.7	1.6	m
13	1.3 + 3.1 = 4.4	2.7	2.4	sm
14	1.3 + 3.1 = 4.4	2.7	2.4	sm
15	2.0 + 2.3 = 4.3	2.7	1.2	m
16	2.0 + 2.3 = 4.3	2.7	1.2	m
17	2.0 + 2.3 = 4.3	2.7	1.2	m
18	2.0 + 2.3 = 4.3	2.7	1.2	m
19	2.0 + 2.3 = 4.3	2.7	1.2	m
20	2.0 + 2.3 = 4.3	2.7	1.2	m
21	1.3 + 2.9 = 4.2	2.6	2.2	sm
22	1.3 + 2.9 = 4.2	2.6	2.2	sm
23	1.9 + 2.3 = 4.2	2.6	1.2	m
24	1.9 + 2.3 = 4.2	2.6	1.2	m
25	1.7 + 2.3 = 4.0	2.5	1.4	m
26	1.7 + 2.3 = 4.0	2.5	1.4	m
27	1.2 + 2.7 = 3.9	2.4	2.3	sm
28	1.2 + 2.7 = 3.9	2.4	2.3	sm
29	1.3 + 2.3 = 3.6	2.2	1.8	sm
30	1.3 + 2.3 = 3.6	2.2	1.8	sm
31	1.0 + 2.5 = 3.5	2.2	2.5	sm
32	1.0 + 2.5 = 3.5	2.2	2.5	sm
33	1.7 + 1.8 = 3.5	2.2	1.1	m
34	1.7 + 1.8 = 3.5	2.2	1.1	m
35	1.1 + 1.8 = 2.9	1.8	1.6	m
36	1.1 + 1.8 = 2.9	1.8	1.6	m
37	0.8 + 1.8 = 2.6	1.6	2.3	sm
38	0.8 + 1.8 = 2.6	1.6	2.3	sm
39	1.1 + 1.5 = 2.6	1.6	1.4	m
40	1.1 + 1.5 = 2.6	1.6	1.4	m

Table 10. Measurements of somatic chromosomes of *Calanthe hattorii*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.3 + 3.3 = 5.6	3.9	1.4	m
2	2.3 + 2.7 = 5.0	3.4	1.2	m
3	1.9 + 2.9 = 4.8	3.3	1.5	m
4	1.9 + 2.8 = 4.7	3.2	1.5	m
5	2.0 + 2.5 = 4.5	3.1	1.3	m
6	2.0 + 2.5 = 4.5	3.1	1.3	m
7	1.4 + 2.7 = 4.1	2.8	1.9	sm
8	1.4 + 2.7 = 4.1	2.8	1.9	sm
9	1.8 + 2.2 = 4.0	2.8	1.2	m
10	1.8 + 2.2 = 4.0	2.8	1.2	m
11	1.7 + 2.3 = 4.0	2.8	1.4	m
12	1.7 + 2.3 = 4.0	2.8	1.4	m
13	1.7 + 2.3 = 4.0	2.8	1.4	m
14	1.7 + 2.3 = 4.0	2.8	1.4	m
15	1.8 + 2.0 = 3.8	2.6	1.1	m
16	1.8 + 2.0 = 3.8	2.6	1.1	m
17	1.8 + 2.0 = 3.8	2.6	1.1	m
18	1.6 + 2.2 = 3.8	2.6	1.6	m
19	1.4 + 2.3 = 3.7	2.5	1.6	m
20	1.4 + 2.3 = 3.7	2.5	1.6	m
21	1.4 + 1.9 = 3.3	2.3	1.4	m
22	1.4 + 1.9 = 3.3	2.3	1.4	m
23	1.2 + 2.1 = 3.3	2.3	1.8	sm
24	1.2 + 2.1 = 3.3	2.3	1.8	sm
25	0.8 + 2.5 = 3.3	2.3	3.1	sm
26	0.8 + 2.4 = 3.2	2.2	3.0	sm
27	1.2 + 2.0 = 3.2	2.2	1.7	m
28	1.2 + 2.0 = 3.2	2.2	1.7	m
29	1.3 + 1.8 = 3.1	2.1	1.4	m
30	1.3 + 1.8 = 3.1	2.1	1.4	m
31	1.0 + 2.1 = 3.1	2.1	2.1	sm
32	1.0 + 2.1 = 3.1	2.1	2.1	sm
33	1.1 + 2.0 = 3.1	2.1	1.8	sm
34	1.1 + 2.0 = 3.1	2.1	1.8	sm
35	0.9 + 2.1 = 3.0	2.1	2.3	sm
36	0.9 + 2.1 = 3.0	2.1	2.3	sm
37	1.0 + 1.7 = 2.7	1.9	1.7	m
38	1.0 + 1.7 = 2.7	1.9	1.7	m
39	1.0 + 1.7 = 2.7	1.9	1.7	m
40	1.0 + 1.7 = 2.7	1.9	1.7	m

Table 11. Measurements of somatic chromosomes of *Calanthe izu-insularis*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.0 + 2.8 = 4.8	3.2	1.4	m
2	2.0 + 2.8 = 4.8	3.2	1.4	m
3	2.0 + 2.7 = 4.7	3.2	1.4	m
4	2.0 + 2.7 = 4.7	3.2	1.4	m
5	0.9 + 3.7 = 4.6	3.1	4.1	s t
6	0.9 + 3.7 = 4.6	3.1	4.1	s t
7	1.5 + 3.0 = 4.5	3.0	2.0	sm
8	1.5 + 3.0 = 4.5	3.0	2.0	sm
9	1.7 + 2.6 = 4.3	2.9	1.5	m
10	1.7 + 2.6 = 4.3	2.9	1.5	m
11	1.0 + 3.3 = 4.3	2.9	3.3	s t
12	1.0 + 3.3 = 4.3	2.9	3.3	s t
13	1.0 + 3.3 = 4.3	2.9	3.3	s t
14	1.0 + 3.3 = 4.3	2.9	3.3	s t
15	1.0 + 3.1 = 4.1	2.8	3.1	s t
16	1.0 + 3.1 = 4.1	2.8	3.1	s t
17	1.0 + 2.8 = 3.8	2.6	2.8	sm
18	1.0 + 2.8 = 3.8	2.6	2.8	sm
19	1.1 + 2.7 = 3.8	2.6	2.5	sm
20	1.1 + 2.7 = 3.8	2.6	2.5	sm
21	1.1 + 2.7 = 3.8	2.6	2.5	sm
22	1.1 + 2.7 = 3.8	2.6	2.5	sm
23	1.0 + 2.7 = 3.7	2.5	2.7	sm
24	1.0 + 2.7 = 3.7	2.5	2.7	sm
25	1.2 + 2.3 = 3.5	2.4	1.9	sm
26	1.2 + 2.3 = 3.5	2.4	1.9	sm
27	1.3 + 2.0 = 3.3	2.2	1.5	m
28	1.3 + 1.8 = 3.1	2.1	1.4	m
29	0.8 + 2.4 = 3.2	2.2	3.0	sm
30	0.8 + 2.4 = 3.2	2.2	3.0	sm
31	1.1 + 2.1 = 3.2	2.2	1.9	sm
32	1.1 + 2.1 = 3.2	2.2	1.9	sm
33	0.7 + 2.2 = 2.9	2.0	3.1	s t
34	0.7 + 2.2 = 2.9	2.0	3.1	s t
35	1.1 + 1.7 = 2.8	1.9	1.5	m
36	1.1 + 1.7 = 2.8	1.9	1.5	m
37	1.0 + 1.7 = 2.7	1.8	1.7	m
38	1.0 + 1.7 = 2.7	1.8	1.7	m
39	0.9 + 1.3 = 2.2	1.5	1.4	m
40	0.9 + 1.2 = 2.1	1.4	1.3	m

Table 12. Measurements of somatic chromosomes of *Calanthe japonica*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	1.8 + 2.2 = 4.0	3.4	1.2	m
2	1.8 + 2.2 = 4.0	3.4	1.2	m
3	1.7 + 2.1 = 3.8	3.2	1.2	m
4	1.7 + 2.1 = 3.8	3.2	1.2	m
5	1.6 + 2.1 = 3.7	3.1	1.3	m
6	1.6 + 2.1 = 3.7	3.1	1.3	m
7	1.4 + 1.9 = 3.3	2.8	1.4	m
8	1.4 + 1.9 = 3.3	2.8	1.4	m
9	1.6 + 1.7 = 3.3	2.8	1.1	m
10	1.6 + 1.7 = 3.3	2.8	1.1	m
11	1.4 + 1.8 = 3.2	2.7	1.3	m
12	1.4 + 1.8 = 3.2	2.7	1.3	m
13	1.3 + 1.9 = 3.2	2.7	1.5	m
14	1.3 + 1.9 = 3.2	2.7	1.5	m
15	1.3 + 1.8 = 3.1	2.6	1.4	m
16	1.3 + 1.8 = 3.1	2.6	1.4	m
17	1.2 + 1.8 = 3.0	2.5	1.5	m
18	1.2 + 1.8 = 3.0	2.5	1.5	m
19	1.3 + 1.7 = 3.0	2.5	1.3	m
20	1.3 + 1.7 = 3.0	2.5	1.3	m
21	1.2 + 1.7 = 2.9	2.5	1.4	m
22	1.2 + 1.7 = 2.9	2.5	1.4	m
23	1.0 + 1.9 = 2.9	2.5	1.9	sm
24	1.0 + 1.9 = 2.9	2.5	1.9	sm
25	0.9 + 1.9 = 2.8	2.4	2.1	sm
26	0.9 + 1.9 = 2.8	2.4	2.1	sm
27	1.0 + 1.7 = 2.7	2.3	1.7	m
28	1.0 + 1.7 = 2.7	2.3	1.7	m
29	1.0 + 1.5 = 2.5	2.1	1.5	m
30	1.0 + 1.5 = 2.5	2.1	1.5	m
31	1.0 + 1.4 = 2.4	2.0	1.4	m
32	1.0 + 1.4 = 2.4	2.0	1.4	m
33	1.0 + 1.4 = 2.4	2.0	1.4	m
34	1.0 + 1.4 = 2.4	2.0	1.4	m
35	0.8 + 1.6 = 2.4	2.0	2.0	sm
36	0.8 + 1.6 = 2.4	2.0	2.0	sm
37	1.0 + 1.3 = 2.3	1.9	1.3	m
38	1.0 + 1.3 = 2.3	1.9	1.3	m
39	1.0 + 1.2 = 2.2	1.9	1.2	m
40	1.0 + 1.2 = 2.2	1.9	1.2	m

Table 13. Measurements of somatic chromosomes of *Calanthe lyroglossa*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.2 + 2.4 = 4.6	3.4	1.1	m
2	2.2 + 2.4 = 4.6	3.4	1.1	m
3	1.7 + 2.6 = 4.3	3.1	1.5	m
4	1.7 + 2.6 = 4.3	3.1	1.5	m
5	1.4 + 2.8 = 4.2	3.1	2.0	sm
6	1.4 + 2.8 = 4.2	3.1	2.0	sm
7	2.0 + 2.0 = 4.0	2.9	1.0	m
8	2.0 + 2.0 = 4.0	2.9	1.0	m
9	1.7 + 2.1 = 3.8	2.8	1.2	m
10	1.7 + 2.1 = 3.8	2.8	1.2	m
11	1.8 + 1.9 = 3.7	2.7	1.1	m
12	1.8 + 1.9 = 3.7	2.7	1.1	m
13	1.8 + 1.9 = 3.7	2.7	1.1	m
14	1.8 + 1.9 = 3.7	2.7	1.1	m
15	1.7 + 2.0 = 3.7	2.7	1.2	m
16	1.7 + 2.0 = 3.7	2.7	1.2	m
17	1.7 + 1.9 = 3.6	2.6	1.1	m
18	1.7 + 1.9 = 3.6	2.6	1.1	m
19	1.5 + 2.0 = 3.5	2.6	1.3	m
20	1.5 + 2.0 = 3.5	2.6	1.3	m
21	1.4 + 2.1 = 3.5	2.6	1.5	m
22	1.4 + 2.1 = 3.5	2.6	1.5	m
23	1.6 + 1.9 = 3.5	2.6	1.2	m
24	1.6 + 1.9 = 3.5	2.6	1.2	m
25	1.6 + 1.7 = 3.3	2.4	1.1	m
26	1.6 + 1.7 = 3.3	2.4	1 1	m
27	1.4 + 1.8 = 3.2	2.3	1.3	m
28	1.4 + 1.8 = 3.2	2.3	1.3	m
29	1.3 + 1.8 = 3.1	2.3	1.4	m
30	1.3 + 1.8 = 3.1	2.3	1.4	m
31	1.2 + 1.6 = 2.8	2.0	1 3	m
32	1.2 + 1.6 = 2.8	2.0	1.3	m
33	1.1 + 1.6 = 2.7	2.0	1.5	m
34	1.1 + 1.6 = 2.7	2.0	1.5	m
35	0.9 + 1.8 = 2.7	2.0	2.0	sm
36	0.9 + 1.8 = 2.7	2.0	2.0	sm
37	1.0 + 1.5 = 2.5	1.8	1.5	m
38	1.0 + 1.5 = 2.5	1.8	1.5	m
39	0.8 + 1.3 = 2.1	1.5	1.6	m
40	0.8 + 1.3 = 2.1	1.5	1.6	m

Table 14. Measurements of somatic chromosomes of *Calanthe musca*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.6 + 3.3 = 5.9	4.5	1.3	m
2	2.6 + 3.3 = 5.9	4.5	1.3	m
3	2.0 + 2.9 = 4.9	3.7	1.5	m
4	2.0 + 2.9 = 4.9	3.7	1.5	m
5	1.9 + 2.4 = 4.3	3.3	1.3	m
6	1.9 + 2.4 = 4.3	3.3	1.3	m
7	1.7 + 2.3 = 4.0	3.0	1.4	m
8	1.7 + 2.3 = 4.0	3.0	1.4	m
9	1.8 + 2.2 = 4.0	3.0	1.2	m
10	1.8 + 2.2 = 4.0	3.0	1.2	m
11	1.8 + 2.0 = 3.8	2.9	1.1	m
12	1.8 + 2.0 = 3.8	2.9	1.1	m
13	1.8 + 2.0 = 3.8	2.9	1.1	m
14	1.8 + 2.0 = 3.8	2.9	1.1	m
15	1.3 + 2.1 = 3.4	2.6	1.6	m
16	1.3 + 2.1 = 3.4	2.6	1.6	m
17	1.5 + 1.7 = 3.2	2.4	1.1	m
18	1.5 + 1.7 = 3.2	2.4	1.1	m
19	1.0 + 2.0 = 3.0	2.3	2.0	sm
20	1.0 + 2.0 = 3.0	2.3	2.0	sm
21	1.0 + 2.0 = 3.0	2.3	2.0	sm
22	1.0 + 2.0 = 3.0	2.3	2.0	sm
23	1.0 + 2.0 = 3.0	2.3	2.0	sm
24	1.0 + 2.0 = 3.0	2.3	2.0	sm
25	1.0 + 1.9 = 2.9	2.2	1.9	sm
26	1.0 + 1.9 = 2.9	2.2	1.9	sm
27	1.3 + 1.5 = 2.8	2.1	1.2	m
28	1.3 + 1.5 = 2.8	2.1	1.2	m
29	0.9 + 1.8 = 2.7	2.0	2.0	sm
30	0.9 + 1.8 = 2.7	2.0	2.0	sm
31	0.8 + 1.8 = 2.6	2.0	2.3	sm
32	0.8 + 1.8 = 2.6	2.0	2.3	sm
33	0.9 + 1.7 = 2.6	2.0	1.9	sm
34	0.9 + 1.7 = 2.6	2.0	1.9	sm
35	0.9 + 1.5 = 2.4	1.8	1.7	m
36	0.9 + 1.5 = 2.4	1.8	1.7	m
37	0.9 + 1.2 = 2.1	1.6	1.3	m
38	0.9 + 1.2 = 2.1	1.6	1.3	m
39	0.5 + 1.0 = 1.5	1.1	2.0	sm
40	0.5 + 1.0 = 1.5	1.1	2.0	sm

Table 15. Measurements of somatic chromosomes of *Calanthe nipponica*, 2n=38 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.9 + 3.3 = 6.2	3.7	1.1	m
2	2.9 + 3.3 = 6.2	3.7	1.1	m
3	2.6 + 2.9 = 5.5	3.3	1.1	m
4	2.6 + 2.9 = 5.5	3.3	1.1	m
5	1.5 + 3.9 = 5.4	3.2	2.6	sm
6	1.5 + 3.9 = 5.4	3.2	2.6	sm
7	2.3 + 3.1 = 5.4	3.2	1.3	m
8	2.0 + 3.1 = 5.1	3.0	1.6	m
9	2.2 + 2.9 = 5.1	3.0	1.3	m
10	2.2 + 2.9 = 5.1	3.0	1.3	m
11	1.9 + 3.0 = 4.9	2.9	1.6	m
12	1.9 + 3.0 = 4.9	2.9	1.6	m
13	2.3 + 2.4 = 4.7	2.8	1.0	m
14	2.3 + 2.3 = 4.6	2.7	1.0	m
15	1.7 + 2.7 = 4.4	2.6	1.6	m
16	1.7 + 2.7 = 4.4	2.6	1.6	m
17	2.0 + 2.4 = 4.4	2.6	1.2	m
18	1.5 + 2.6 = 4.1	2.4	1.7	m
19	1.6 + 2.7 = 4.3	2.5	1.7	m
20	1.6 + 2.7 = 4.3	2.5	1.7	m
21	1.9 + 2.3 = 4.2	2.5	1.2	m
22	1.9 + 2.3 = 4.2	2.5	1.2	m
23	1.4 + 2.8 = 4.2	2.5	2.0	sm
24	1.4 + 2.8 = 4.2	2.5	2.0	sm
25	1.9 + 2.3 = 4.2	2.5	1.2	m
26	1.9 + 2.3 = 4.2	2.5	1.2	m
27	1.9 + 2.2 = 4.1	2.4	1.2	m
28	1.9 + 2.2 = 4.1	2.4	1.2	m
29	1.6 + 2.3 = 3.9	2.3	1.4	m
30	1.6 + 2.2 = 3.8	2.3	1.4	m
31	1.4 + 2.4 = 3.8	2.2	1.7	m
32	1.4 + 2.4 = 3.8	2.2	1.7	m
33	1.8 + 1.9 = 3.7	2.2	1.1	m
34	1.8 + 1.9 = 3.7	2.2	1.1	m
35	1.6 + 2.0 = 3.6	2.1	1.3	m
36	1.6 + 2.0 = 3.6	2.1	1.3	m
37	1.4 + 1.4 = 2.8	1.7	1.0	m
38	1.4 + 1.4 = 2.8	1.7	1.0	m

Table 16. Measurements of somatic chromosomes of *Calanthe oblanceolata*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.2 + 2.5 = 4.7	3.6	1.1	m
2	2.2 + 2.5 = 4.7	3.6	1.1	m
3	2.0 + 2.6 = 4.6	3.5	1.3	m
4	2.0 + 2.6 = 4.6	3.5	1.3	m
5	1.2 + 3.2 = 4.4	3.4	2.7	sm
6	1.2 + 3.2 = 4.4	3.4	2.7	sm
7	1.3 + 2.5 = 3.8	2.9	1.9	sm
8	1.3 + 2.5 = 3.8	2.9	1.9	sm
9	1.8 + 2.0 = 3.8	2.9	1.1	m
10	1.8 + 2.0 = 3.8	2.9	1.1	m
11	1.3 + 2.3 = 3.6	2.8	1.8	sm
12	1.3 + 2.3 = 3.6	2.8	1.8	sm
13	1.0 + 2.6 + 3.6	2.8	2.6	sm
14	1.0 + 2.6 = 3.6	2.8	2.6	sm
15	1.3 + 2.2 = 3.5	2.7	1.7	m
16	1.3 + 2.2 = 3.5	2.7	1.7	m
17	0.9 + 2.4 = 3.3	2.5	2.7	sm
18	0.9 + 2.4 = 3.3	2.5	2.7	sm
19	0.9 + 2.3 = 3.2	2.4	2.6	sm
20	0.9 + 2.3 = 3.2	2.4	2.6	sm
21	1.6 + 1.6 = 3.2	2.4	1.0	m
22	1.6 + 1.6 = 3.2	2.4	1.0	m
23	1.5 + 1.6 = 3.1	2.4	1.1	m
24	1.5 + 1.6 = 3.1	2.4	1.1	m
25	1.0 + 2.0 = 3.0	2.3	2.0	sm
26	1.0 + 2.0 = 3.0	2.3	2.0	sm
27	1.0 + 1.7 = 2.7	2.1	1.7	m
28	1.0 + 1.7 = 2.7	2.1	1.7	m
29	1.1 + 1.6 = 2.7	2.1	1.5	m
30	1.1 + 1.6 = 2.7	2.1	1.5	m
31	1.0 + 1.7 = 2.7	2.1	1.7	m
32	1.0 + 1.7 = 2.7	2.1	1.7	m
33	0.9 + 1.8 = 2.7	2.1	2.0	sm
34	0.9 + 1.7 = 2.6	2.0	1.9	sm
35	1.0 + 1.7 = 2.7	2.1	1.7	m
36	1.0 + 1.7 = 2.7	2.1	1.7	m
37	1.0 + 1.2 = 2.2	1.7	1.2	m
38	1.0 + 1.2 = 2.2	1.7	1.2	m
39	0.7 + 1.3 = 2.0	1.5	1.9	sm
40	0.7 + 1.3 = 2.0	1.5	1.9	sm

Table 17. Measurements of somatic chromosomes of *Calanthe okinawaensis*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.1 + 3.2 = 5.3	3.4	1.5	m
2	2.1 + 3.2 = 5.3	3.4	1.5	m
3	2.4 + 2.7 = 5.1	3.2	1.1	m
4	2.2 + 2.7 = 4.9	3.2	1.2	m
5	1.9 + 3.1 = 5.0	3.2	1.6	m
6	1.9 + 3.1 = 5.0	3.2	1.6	m
7	2.3 + 2.7 = 5.0	3.2	1.2	m
8	2.1 + 2.7 = 4.8	3.1	1.3	m
9	2.2 + 2.4 = 4.6	3.0	1.1	m
10	2.2 + 2.4 = 4.6	3.0	1.1	m
11	1.9 + 2.6 = 4.5	2.9	1.4	m
12	1.9 + 2.6 = 4.5	2.9	1.4	m
13	1.7 + 2.7 = 4.4	2.8	1.6	m
14	1.7 + 2.6 = 4.3	2.8	1.5	m
15	1.8 + 2.3 = 4.1	2.6	1.3	m
16	1.8 + 2.3 = 4.1	2.6	1.3	m
17	1.5 + 2.4 = 3.9	2.5	1.6	m
18	1.5 + 2.4 = 3.9	2.5	1.6	m
19	1.7 + 2.1 = 3.8	2.5	1.2	m
20	1.7 + 2.1 = 3.8	2.5	1.2	m
21	1.4 + 2.4 = 3.8	2.5	1.7	m
22	1.4 + 2.4 = 3.8	2.5	1.7	m
23	1.4 + 2.3 = 3.7	2.4	1 6	m
24	1.4 + 2.3 = 3.7	2.4	1.6	m
25	1.3 + 2.3 = 3.6	2.3	1.8	sm
26	1.3 + 2.3 = 3.6	2.3	1.8	sm
27	1.4 + 2.0 = 3.4	2.2	1.4	m
28	1.4 + 2.0 = 3.4	2.2	1.4	m
29	1.2 + 2.0 = 3.2	2.1	1.7	m
30	1.2 + 1.9 = 3.1	2.0	1.6	m
31	1.2 + 1.9 = 3.1	2.0	1.6	m
32	1.2 + 1.9 = 3.1	2.0	1.6	m
33	0.9 + 2.2 = 3.1	2.0	2.4	sm
34	0.9 + 2.2 = 3.1	2.0	2.4	sm
35	0.9 + 1.9 = 2.8	1.8	2.1	sm
36	0.9 + 1.9 = 2.8	1.8	2.1	sm
37	1.3 + 1.5 = 2.8	1.8	1.2	m
38	1.3 + 1.5 = 2.8	1.8	1.2	m
39	1.0 + 1.6 = 2.6	1.7	1.6	m
40	1.0 + 1.6 = 2.6	1.7	1.6	m

Table 18. Measurements of somatic chromosomes of *Calanthe reflexa*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.2 + 3.2 = 5.4	3.3	1.5	m
2	2.2 + 3.2 = 5.4	3.3	1.5	m
3	2.3 + 3.0 = 5.3	3.2	1.3	m
4	2.3 + 3.0 = 5.3	3.2	1.3	m
5	1.7 + 3.0 = 4.7	2.9	1.8	sm
6	1.7 + 3.0 = 4.7	2.9	1.8	sm
7	2.0 + 2.5 = 4.5	2.7	1.3	m
8	2.0 + 2.5 = 4.5	2.7	1.3	m
9	1.8 + 2.7 = 4.5	2.7	1.5	m
10	1.8 + 2.7 = 4.5	2.7	1.5	m
11	1.7 + 2.8 = 4.5	2.7	1.6	m
12	1.7 + 2.8 = 4.5	2.7	1.6	m
13	1.9 + 2.6 = 4.5	2.7	1.4	m
14	1.9 + 2.6 = 4.5	2.7	1.4	m
15	1.9 + 2.5 = 4.4	2.7	1.3	m
16	1.9 + 2.5 = 4.4	2.7	1.3	m
17	1.2 + 2.8 = 4.0	2.4	2.3	sm
18	1.2 + 2.8 = 4.0	2.4	2.3	sm
19	1.5 + 2.5 = 4.0	2.4	1.7	m
20	1.5 + 2.5 = 4.0	2.4	1.7	m
21	1.9 + 2.1 = 4.0	2.4	1.1	m
22	1.9 + 2.1 = 4.0	2.4	1.1	m
23	1.8 + 2.2 = 4.0	2.4	1.2	m
24	0.8 + 3.2 = 4.0	2.4	4.0	s t
25	1.7 + 2.3 = 4.0	2.4	1.4	m
26	1.7 + 2.3 = 4.0	2.4	1.4	m
27	1.5 + 2.3 = 3.8	2.3	1.5	m
28	1.5 + 2.3 = 3.8	2.3	1.5	m
29	1.7 + 2.1 = 3.8	2.3	1.2	m
30	1.7 + 2.1 = 3.8	2.3	1.2	m
31	1.4 + 2.3 = 3.7	2.3	1.6	m
32	1.4 + 2.3 = 3.7	2.3	1.6	m
33	1.3 + 2.2 = 3.5	2.1	1.7	m
34	1.3 + 2.2 = 3.5	2.1	1.7	m
35	1.6 + 1.8 = 3.4*	2.1	1.1	m
36	1.6 + 1.8 = 3.4*	2.1	1.1	m
37	1.5 + 1.8 = 3.3	2.0	1.2	m
38	1.5 + 1.8 = 3.3	2.0	1.2	m
39	1.3 + 1.5 = 2.8	1.7	1.2	m
40	1.3 + 1.5 = 2.8	1.7	1.2	m

* Chromosome with secondary constriction

Table 19. Measurements of somatic chromosomes of *Calanthe schrechteri*, 2n=42 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	3.5 + 3.6 = 7.1	4.3	1.0	m
2	2.7 + 3.1 = 5.8	3.5	1.1	m
3	2.0 + 3.0 = 5.0	3.1	1.5	m
4	2.0 + 3.0 = 5.0	3.1	1.5	m
5	1.9 + 3.0 = 4.9	3.0	1.6	m
6	1.9 + 3.0 = 4.9	3.0	1.6	m
7	1.9 + 2.9 = 4.8	2.9	1.5	m
8	1.9 + 2.9 = 4.8	2.9	1.5	m
9	2.0 + 2.7 = 4.7	2.9	1.4	m
10	2.0 + 2.7 = 4.7	2.9	1.4	m
11	2.0 + 2.4 = 4.4	2.7	1.2	m
12	2.0 + 2.4 = 4.4	2.7	1.2	m
13	2.1 + 2.3 = 4.4	2.7	1.1	m
14	2.1 + 2.3 = 4.4	2.7	1.1	m
15	2.0 + 2.3 = 4.3	2.6	1.2	m
16	2.0 + 2.3 = 4.3	2.6	1.2	m
17	1.7 + 2.6 = 4.3	2.6	1.5	m
18	1.7 + 2.6 = 4.3	2.6	1.5	m
19	1.7 + 2.4 = 4.1	2.5	1.4	m
20	1.7 + 2.4 = 4.1	2.5	1.4	m
21	1.5 + 2.5 = 4.0	2.4	1.7	m
22	1.5 + 2.5 = 4.0	2.4	1.7	m
23	1.3 + 2.7 = 4.0	2.4	2.1	sm
24	1.3 + 2.7 = 4.0	2.4	2.1	sm
25	1.1 + 2.5 = 3.6	2.2	2.3	sm
26	1.1 + 2.5 = 3.6	2.2	2.3	sm
27	1.4 + 2.2 = 3.6	2.2	1.6	m
28	1.4 + 2.2 = 3.6	2.2	1.6	m
29	1.3 + 2.2 = 3.5	2.1	1.7	m
30	1.3 + 2.2 = 3.5	2.1	1.7	m
31	1.2 + 2.0 = 3.2	2.0	1.7	m
32	1.2 + 2.0 = 3.2	2.0	1.7	m
33	1.3 + 1.7 = 3.0	1.8	1.3	m
34	1.3 + 1.7 = 3.0	1.8	1.3	m
35	1.0 + 1.7 = 2.7	1.6	1.5	m
36	1.0 + 1.7 = 2.7	1.6	1.5	m
37	1.0 + 1.5 = 2.5	1.5	1.5	m
38	1.0 + 1.5 = 2.5	1.5	1.5	m
39	1.0 + 1.5 = 2.5	1.5	1.5	m
40	1.0 + 1.3 = 2.3	1.4	1.3	m
41	1.0 + 1.1 = 2.1	1.3	1.1	m
42	1.0 + 1.1 = 2.1	1.3	1.1	m

Table 20. Measurements of somatic chromosomes of *Calanthe sieboldii*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.3 + 3.2 = 5.5	4.4	1.4	m
2	2.3 + 3.2 = 5.5	4.4	1.4	m
3	1.7 + 2.8 = 4.5	3.6	1.6	m
4	1.7 + 2.8 = 4.5	3.6	1.6	m
5	1.1 + 2.8 = 3.9	3.2	2.5	sm
6	1.1 + 2.8 = 3.9	3.2	2.5	sm
7	1.3 + 2.4 = 3.7	3.0	1.8	sm
8	1.3 + 2.4 = 3.7	3.0	1.8	sm
9	1.8 + 1.8 = 3.6	2.9	1.0	m
10	1.8 + 1.8 = 3.6	2.9	1.0	m
11	1.2 + 2.2 = 3.4	2.7	1.8	sm
12	1.2 + 2.2 = 3.4	2.7	1.8	sm
13	1.5 + 1.8 = 3.3	2.7	1.2	m
14	1.5 + 1.8 = 3.3	2.7	1.2	m
15	1.5 + 1.7 = 3.2	2.6	1.1	m
16	1.5 + 1.7 = 3.2	2.6	1.1	m
17	0.9 + 2.3 = 3.2	2.6	2.6	sm
18	0.9 + 2.3 = 3.2	2.6	2.6	sm
19	1.0 + 2.0 = 3.0	2.4	2.0	sm
20	1.0 + 2.0 = 3.0	2.4	2.0	sm
21	1.1 + 1.9 = 3.0	2.4	1.7	m
22	1.1 + 1.9 = 3.0	2.4	1.7	m
23	1.2 + 1.7 = 2.9	2.3	1.4	m
24	1.2 + 1.7 = 2.9	2.3	1.4	m
25	0.8 + 2.0 = 2.8	2.3	2.5	sm
26	0.8 + 2.0 = 2.8	2.3	2.5	sm
27	1.2 + 1.6 = 2.8	2.3	1.3	m
28	1.2 + 1.5 = 2.7	2.2	1.3	m
29	1.0 + 1.6 = 2.6	2.1	1.6	m
30	1.0 + 1.6 = 2.6	2.1	1.6	m
31	0.8 + 1.6 = 2.4	1.9	2.0	sm
32	0.8 + 1.6 = 2.4	1.9	2.0	sm
33	1.0 + 1.4 = 2.4	1.9	1.4	m
34	1.0 + 1.4 = 2.4	1.9	1.4	m
35	0.8 + 1.3 = 2.1	1.7	1.6	m
36	0.8 + 1.3 = 2.1	1.7	1.6	m
37	0.8 + 1.2 = 2.0	1.6	1.5	m
38	0.8 + 1.1 = 1.9	1.5	1.4	m
39	0.7 + 1.0 = 1.7	1.4	1.4	m
40	0.7 + 0.9 = 1.6	1.3	1.3	m

Table 21. Measurements of somatic chromosomes of *Calanthe tricarinata*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.0 + 3.2 = 5.2	3.5	1.6	m
2	2.0 + 3.2 = 5.2	3.5	1.6	m
3	2.0 + 2.7 = 4.7	3.2	1.4	m
4	2.0 + 2.7 = 4.7	3.2	1.4	m
5	1.7 + 2.7 = 4.4	3.0	1.6	m
6	1.7 + 2.7 = 4.4	3.0	1 6	m
7	1.9 + 2.4 = 4.3	2.9	1.3	m
8	1.9 + 2.4 = 4.3	2.9	1.3	m
9	1.7 + 2.6 = 4.3	2.9	1.5	m
10	1.7 + 2.6 = 4.3	2.9	1.5	m
11	1.4 + 2.8 = 4.2	2.8	2.0	sm
12	1.3 + 2.8 = 4.1	2.8	2.2	sm
13	1.5 + 2.6 = 4.1	2.8	1.7	m
14	1.5 + 2.6 = 4.1	2.8	1.7	m
15	1.3 + 2.7 = 4.0	2.7	2.1	sm
16	1.3 + 2.7 = 4.0	2.7	2.1	sm
17	1.6 + 2.2 = 3.8	2.6	1.4	m
18	1.6 + 2.2 = 3.8	2.6	1.4	m
19	1.2 + 2.4 = 3.6	2.4	2.0	sm
20	1.2 + 2.4 = 3.6	2.4	2.0	sm
21	1.2 + 2.3 = 3.5	2.4	1.9	sm
22	1.2 + 2.3 = 3.5	2.4	1.9	sm
23	1.1 + 2.3 = 3.4	2.3	2.1	sm
24	1.1 + 2.3 = 3.4	2.3	2.1	sm
25	1.2 + 2.1 = 3.3	2.2	1.8	sm
26	1.2 + 2.1 = 3.3	2.2	1.8	sm
27	0.7 + 2.6 = 3.3	2.2	3.7	s t
28	0.7 + 2.5 = 3.2	2.2	3.6	s t
29	1.4 + 1.9 = 3.3	2.2	1.4	m
30	1.4 + 1.9 = 3.3	2.2	1.4	m
31	1.3 + 1.9 = 3.2	2.2	1.5	m
32	1.3 + 1.9 = 3.2	2.2	1.5	m
33	1.0 + 2.2 = 3.2	2.2	2.2	sm
34	1.0 + 2.2 = 3.2	2.2	2.2	sm
35	1.0 + 2.0 = 3.0	2.0	2.0	sm
36	1.0 + 1.9 = 2.9	2.0	1.9	sm
37	1.1 + 1.8 = 2.9	2.0	1.6	m
38	1.1 + 1.7 = 2.8	1.9	1.5	m
39	1.2 + 1.5 = 2.7	1.8	1.3	m
40	1.3 + 1.3 = 2.6	1.8	1.0	m

Table 22. Measurements of somatic chromosomes of *Calanthe triplicata*, 2n=40 at metaphase

Chromosome	Length (μm)	Relative length	Arm ratio	Form
1	2.1 + 2.7 = 4.8	3.9	1.3	m
2	1.9 + 2.7 = 4.6	3.8	1.4	m
3	1.6 + 2.6 = 4.2	3.5	1.6	m
4	1.6 + 2.6 = 4.2	3.5	1.6	m
5	1.8 + 2.3 = 4.1	3.4	1.3	m
6	1.8 + 2.3 = 4.1	3.4	1.3	m
7	2.0 + 2.1 = 4.1	3.4	1.1	m
8	2.0 + 2.1 = 4.1	3.4	1.1	m
9	1.8 + 2.1 = 3.9	3.2	1.2	m
10	1.8 + 1.9 = 3.7	3.0	1.1	m
11	1.4 + 2.3 = 3.7	3.0	1.6	m
12	1.4 + 2.0 = 3.4	2.8	1.7	m
13	1.2 + 2.3 = 3.5	2.9	1.9	sm
14	1.2 + 2.3 = 3.5	2.9	1.9	sm
15	1.4 + 1.9 = 3.3	2.7	1.4	m
16	1.4 + 1.9 = 3.3	2.7	1.4	m
17	1.5 + 1.8 = 3.3	2.7	1.2	m
18	1.5 + 1.8 = 3.3	2.7	1.2	m
19	1.5 + 1.8 = 3.3	2.7	1.2	m
20	1.5 + 1.8 = 3.3	2.7	1.2	m
21	1.4 + 1.4 = 2.8	2.3	1.0	m
22	1.4 + 1.4 = 2.8	2.3	1.0	m
23	0.7 + 2.0 = 2.7	2.2	2.9	sm
24	0.7 + 2.0 = 2.7	2.2	2.9	sm
25	0.9 + 1.7 = 2.6	2.1	1.9	sm
26	0.9 + 1.7 = 2.6	2.1	1.9	sm
27	1.0 + 1.6 = 2.6	2.1	1.6	m
28	1.0 + 1.6 = 2.6	2.1	1.6	m
29	1.1 + 1.5 = 2.6	2.1	1.4	m
30	1.1 + 1.3 = 2.4	2.0	1.2	m
31	0.8 + 1.6 = 2.4	2.0	2.0	sm
32	0.8 + 1.6 = 2.4	2.0	2.0	sm
33	0.8 + 1.3 = 2.1	1.7	1.6	m
34	0.8 + 1.3 = 2.1	1.7	1.6	m
35	0.8 + 1.2 = 2.0	1.6	1.5	m
36	0.8 + 1.2 = 2.0	1.6	1.5	m
37	0.8 + 1.0 = 1.8	1.5	1.3	m
38	0.8 + 1.0 = 1.8	1.5	1.3	m
39	0.6 + 1.2 = 1.8	1.5	2.0	sm
40	0.6 + 1.2 = 1.8	1.5	2.0	sm

Chromosome count in *Dendrobium* I. 87 species*

Kiyoshi Hashimoto**

デンドロビウム属の染色体数Ⅰ．87種

橋 本 清 美

The genus *Dendrobium* comprising over 2,000 species is floriculturally one of the most useful orchid. The species have been subdivided into 41 sections by Schlechter (1912), while taxonomists today placed them in genera *Ephemerantha, Epigenium, Diplocaulobium* and so on (Brieger 1981). In the present paper the taxonomy of the species was followed to Schlechter (1912, 1927).

Chromosome numbers of the genus *Dendrobium* have been recorded by many authors, *e.g.* Hoffmann 1929, 1930, Miduno 1940, Eftimiu-Heim 1941, Ito and Mutsuura 1957, Kosaki 1958, Tanaka 1962, 1964, 1965, Mutsuura and Nakahira 1958, 1959, Vajrabhaya and Randolph 1960, Kamemoto *et al.* 1961, Kosaki and Kamemoto 1961, Dorn and Kamemoto 1962, Jones 1963, Chardard 1963, Shindo and Kamemoto 1963, Pancho 1965, Sharma and Chatterji 1966, Kamemoto and Sagarik 1967, Kamemoto *et al.* 1967, Kamemoto and Tara 1968, Arora 1968, 1971, Mehra and Vij 1970, Sharma 1970, Banerji and Chaudhuri 1972, Hsu 1972, Roy and Sharma 1972, Hedge and Boraiah 1973, Mehra and Sehgal 1975, 1976, Mehra and Kashyap 1976, 1978, Chatterji 1976, Vij *et al.* 1976, Malla *et al.* 1977, 1978, and Sarkar *et al.* 1978.

According to these records the chromosome numbers have been reported in 143 species and 34 varieties. Except the horticultural or irregular variants, 106 taxa of them are 2n=38, 24 are 2n=40, 24 are both 2n=38 and 2n=40, and the rest 23 are various from 2n=30 to 2n=114. The present paper was undertaken to expand the chromosome number determinations of 87 species in the genus *Dendrobium.*

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* Contribution from the Hiroshima Botanical Garden No.17

**The Hiroshima Botanical Garden

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Materials and Methods

All materials identified by the observation of flowers were grown in the Hiroshima Botanical Garden.

Observation of somatic chromosomes was made with the aceto-orcein technique developed by Tanaka and Kamemoto (1960) : Active root tips were immersed in 0.002 M 8-hydroxyquinoline for 4 hours at 16°C. They were then transferred to a modified Carnoy's solution (1:1:2) for 15 minutes at 16°C, hydrolyzed in IN HCl at 60°C for 2 minutes, transferred to 45% acetic acid for 3 minutes, and squashed and stained in 1% aceto-orcein.

For observation of meiosis, bud materials were prepared essentially as above but omitting the pretreatment and maceration.

Results and Discussion

The somatic chromosomes observed in the present investigation were shown in Figs. 1–9. Results of the chromosome counts of all species investigated were listed in alphabetical orders in Table 1. In Table 1 the previous counts appeared in papers were also listed. Among the 87 species in the genus *Dendrobium*, 59 were 2n=38, 21 were 2n=40 and the rest were other numbers such as 2n=36+2f in *D. insigne*, 2n=39 in *D. dicuphum*, 2n=40+1f in *D. densiflorum*, 2n=40+2f in *D. dixanthum*, 2n=43 in *D. longicornu* var. *java*, and 2n=76 in *D. kingianum*. *D. distichum* was both 2n=38 (diploid) and 2n=57 (triploid).

The chromosome numbers of following 36 species were recorded for the first time: *D. acerosum* 2n=38, *D. aemulum* 2n=38, *D. agrostophyllum* 2n=38, *D. amethystoglossum* 2n=40, *D. aphrodite* 2n=40, *D. batanense* 2n=38, *D. beckleri* 2n=38, *D. cucumerinum* 2n=38, *D. cymbidioides* 2n=40, *D. equitans* 2n=38, *D. falconeri* 2n=38, *D. finisterrae* 2n=40, *D. forbesii* 2n=40, *D. guerreroi* 2n=40, *D. insigne* 2n=36+2f, *D. lasianthera* 2n=38, *D. lichenastrum* 2n=40, *D. longicornu* var. *java* 2n=43, *D. ophioglossum* 2n=38, *D. phlox* var. *flava* 2n=38, *D. platygastrium* 2n=40, *D. plicatile* 2n=38, *D. pugioniforme* 2n=38, *D. quinquecostatum* 2n=38, *D. ramosii* 2n=40, *D. rhodopterigium* 2n=38, *D. ruppianum* 2n=38, *D. sanseiense* 2n=40, *D. schneiderae* 2n=38, *D. scopa* 2n=38, *D. stuposum* 2n=38, *D. sulcatum* 2n=40, *D. teretifolium* var. *fassiculatum* 2n=40, *D. terminale* 2n=38, *D. tetragonum* var. *giganteum* 2n=38, and *D. wassellii* 2n=38.

The chromosome number of 14 species were here redocumented as follows: 2n=38 to 2n=40 in *D. delacourii*, *D. densiflorum*, *D. senile*, 2n=40 (n=20) to 2n=38 in *D. crumenatum*, *D. infundibulum*, *D. leonis*, *D. moschatum*, *D. nobile*, *D. parishii*, *D. pierardii*, *D. superbum*, *D. tosaense*, 2n=ca. 80 to 2n=38 in *D. sophronites*, n=20 and 2n=36 to 2n=38 in *D. heterocurpum*. Those appear to be either in error or representing abnormal types of the species.

The chromosome numbers of 2n=38+1f, 40+1f, 40+2f, 43, 57 and 76 investigated,

Table 1. Chromosome numbers of the species of *Dendrobium* studied

Species	Chromosome number: Present count 2n	Present count n	Previous count 2n	Previous count n	References
acerosum Lindl.	38				
aemulum R.Br.	38				
aggregatum Roxb. var. *majus* Rolfe	38		38		Kosaki 1958
agrostophyllum F. Muell.	38				
amethystoglossum Rchb. f.	40	20			
aphrodite Rchb. f.	40				
batanense Ames et Quisumb.	38				
beckleri F. Muell.	38				
bigibbum Lindl. var. *superbum* Hort. subvar. *compactum* Dockr.	38		38, ca. 57		Jones 1963
canaliculatum R.Br.	38	19	2x		Jones 1963
			38		Wilfret & Kamemoto 1971
candidum Wall.	38		38		Jones 1963
capra J.J.Sm		19		19	Malla *et al.* 1977
chrysotoxum Lindl.	38		38		Jones 1963
compactum Rolfe	40	20			
crassinode Benth. & Rchb. f.	38		38		Kamemoto & Sagarik 1967
			2x		Jones 1963
crumenatum Sw.	38		38		Kamemoto & Sagarik 1967
					Wilfret & Kamemoto 1971
			38+1f		Jones 1963
			40		Pancho 1965
cucumerinum Macleay	38				
cymbidioides Lindl.	40				
delacourii Guill.	40	20	38		Kamemoto & Sagarik 1967
					Wilfret & Kamemoto 1971
densiflorum Wall.	40+1f		40+2f		Kosaki 1958
				20+(1–2)	Mehra & Vij 1970
			42		Chatterji 1976
			38		Sharma 1970
				20	Mehra & Sehgal 1976
denudans D. Don	40		40		Jones 1963
				20	Vij *et al.* 1976
dicuphum Muell.	39	19,20	38		Jones 1963
distichum Rchb. f.	57	variable	57		Vajrabhaya & Randolph 1960
	38	19	38		Pancho 1965, Wilfret & Kamemoto 1971

Table 1. (continued)

Species	Chromosome number				References
	Present count		Previous count		
	2n	n	2n	n	
dixanthum Rchb. f.	40+2f		40		Kamemoto & Sagarik 1967
					Wilfret & Kamemoto 1971
				41	Jones 1963
equitans Kränzl.	38				
falconeri Hk.	38		2x		Jones 1963
farmeri Paxt.	40		40		Kamemoto & Sagarik 1967
					Sharma 1970
					Banerji & Chaudhuri 1972
fimbriatum Lindl.					
var. *oculatum* Hk.	38		38		Ito & Mutsuura 1957
					Kosaki & Kamemoto 1961
			38+2B		Vij *et al.* 1976
findlayanum Par. & Rchb. f.	38		38		Jones 1963
					Kamemoto & Sagarik 1967
finisterrae Schltr.	40				
forbesii Ridl.	40				
formosum Roxb.					
var. *giganteum*	38		38		Kosaki & Kamemoto 1961
					Kamemoto & Sagarik 1967
					Wilfret & Kamemoto 1971
friedericksianum Rchb. f.	38		38		Jones 1963, Chardard 1963
					Kamemoto & Sagarik 1967
guerreroi Ames & Quisumb.	40				
heterocarpum Wall.	38		38		Kosaki 1958
					Kosaki & Kamemoto 1961
					Jones 1963, Pancho 1965
					Kamemoto & Sagarik 1967
					Wilfret & Kamemoto 1971
					Banerji & Chaudhuri 1971
			36		Sharma 1970
				20	Mehra & Sehgal 1976
infundibulum Lindl.	38		38		Tanaka 1964
					Kamemoto & Sagarik 1967
			40		Hoffmann 1930
				19	Vij *et al.* 1976
				20	Hoffmann 1929
insigne Rchb. f.	36+2f				
kingianum Bidw.	76		76		Vajrabhaya & Randolph 1961
					Tanaka 1964
			38		Jones 1963
			112–114		Jones 1963
lasianthera J.J.Sm.	38				
leonis Rchb. f.	38	19	40		Wilfret & Kamemoto 1971

Table 1. (continued)

lichenastrum Kränzl.	40				
linguiforme Smith.	38		38		Jones 1963
longicornu Lindl.					
var. *java*	43				
lyonii Ames	40	20	40		Kosaki & Kamemoto 1961
macraei Lindl.	38		38		Vij *et al.* 1976
				19	Mehra & Vij 1970
macrophyllum A. Rich.	38		38		Kosaki 1958
					Kosaki & Kamemoto 1961
miyakei Schltr.	38		38		Hsu 1972
monile Kränzl.	38		38		Miduno 1940
					Ito & Mutsuura 1957
					Mutsuura & Nakahira 1958
					Kosaki & Kamemoto 1961
					Jones 1963, Tanaka 1971
					Hsu 1972
			ca.38		Nakasone & Moromizato 1964
			38+1–3f		Jones 1963
moschatum Sw.	38		38		Chardard 1963
					Kamemoto & Sagarik 1967
					Wilfret & Kamemoto 1971
			39		Kamemoto & Sagarik 1967
			40		Jones 1963, Sharma 1970
				19	Vij *et al.* 1976
nobile Lindl.	38			ca.20	Hoffmann 1929, 1930
			38		Miduno 1940b
					Ito & Mutsuura 1957
					Vajrabhaya & Randolph 1960
					Jones 1963
					Kamemoto & Sagarik 1967
					Sharma 1970, Tanaka 1971
				19	Miduno 1940b
					Ito & Mutsuura 1957
					Vajrabhaya & Randolph 1960
					Chardard 1963
			40		Eftimiu-Heim 1941
			57		Jones 1963
ophioglossum Rchb. f.	38				
parishii Rchb. f.	38		40		Ito & Mutsuura 1957
					Sharma 1970, Chatterji 1976
			38		Jones 1963
					Kamemoto & Sagarik 1967
phalaenopsis Fitzg.	38		38		Kosaki 1958
					Kosaki & Kamemoto 1961
					Wilfret & Kamemoto 1971
				19	Kosaki & Kamemoto 1961

Table 1. (continued)

Species	Chromosome number: Present count 2n	Present count n	Previous count 2n	Previous count n	References
phlox Schltr. var. *flava*	38				
pierardii Roxb. ex. Hook.	38	19	38		Vajrabhaya & Randolph 1960
					Sharma & Chatterji 1966
					Jones 1963
					Kamemoto & Sagarik 1967
					Sarkar *et al.* 1978
				19	Kosaki 1958
					Kosaki & Kamemoto 1961
					Sharma & Chatterji 1966
			40		Sharma 1970
					Roy & Sharma 1972
				19–20	Chardard 1963
			57		Sharma & Chatterji 1966
platygastrium Rchb. f.	40				
plicatile Lindl.	38				
pugioniforme A. Cunn.	38				
quinquecostatum Schltr.	38				
ramosii Ames	40				
revolutum Lindl.	40		40		Kamemoto & Sagarik 1967
rhodopterygium Rchb. f.	38				
ruppianum A.D. Hawkes	38				
sanseiense Hayata	40				
scabrilingue Lindl.	38		38		Kamemoto & Sagarik 1967
schneiderae F.M. Bail.	38				
scopa Lindl.	38				
secundum Lindl.	40	20	40		Jones 1963
					Kamemoto & Sagarik 1967
				20	Chardard 1963
senile Par. & Rchb. f.	40		38		Kamemoto & Sagarik 1967
					Wilfret & Kamemoto 1971
smilliae F.v. Muell.	38		38		Jones 1963
sophronites Schltr.	38		ca.80		Jones 1963
strebloceras Rchb. f.	38		38		Jones 1963
					Wilfret & Kamemoto 1971
stuposum Lindl.	38				
sulcatum Rchb. f.	40				
superbiens Rchb. f.	38		38		Vajrabhaya & Randolph 1960
					Jones 1963
					Vij *et al.* 1976
				19	Vajrabhaya & Randolph 1960
superbum Rchb. f.	38		40		Eftimiu-Heim 1941
					Ito & Mutsuura 1957

Table 1. (continued)

				19	Kosaki 1958
					Vajrabhaya & Randolph 1960
					Kosaki & Kamemoto 1961
sutepense Rolph et Downie	38		2x		Jones 1963
			38		Wilfret & Kamemoto 1961
taurinum Lindl.	38		38		Kosaki 1958
					Kosaki & Kamemoto 1961
teretifolium R.Br.					
var. *fasciculatum* Rupp.	40				
terminale Par. et Rchb. f.	38				
tetragonum A. Cunn.					
var. *giganteum* Gilbert	38				
thyrsiflorum Rchb. f.	40		40		Vajrabhaya & Randolph 1960
					Kosaki & Kamemoto 1961
					Kamemoto & Sagarik 1967
				20	Hoffmann 1929, 1930
topaziacum Ames	38	19	38		Pancho 1965
tortile Lindl.	38		38		Kosaki & Kamemoto 1961
					Jones 1963
					Kamemoto & Sagarik 1967
					Wilfret & Kamemoto 1971
tosaense Makino	38	19	38		Tanaka 1965, 1971
			40		Mutsuura & Nakahira 1959
wardianum Warn.	38		2x		Jones 1963
				19	Mehra & Sehgal 1976
wassellii S.T. Blake	38				

might have been horticultural or natural variants. On the other hand the chromosome number of 2n=39 in *D. dicuphum*, a new count, was found to be hybrid combination since the meiotic configuration was observed to be 19 II + 1I.

Summary

1. Chromosome counts were carried out in 87 species of *Dendrobium*.
2. Among these 87 species, 59 species were 2n=38, 21 were 2n=40, and the rest seven were 2n=36+2f, 2n=39, 2n=40+1f, 2n=40+2f, 2n=43, 2n=76, and 2n=38 and 57, respectively.
3. The chromosome numbers of 36 species were recorded for the first time and those of 14 species were redocumented.

References

Arora, C.M. 1968. IOPB chromosome number reports XVI. Taxon 17 : 199–204.
_____1971. IOPB chromosome number reports XXXIV. Taxon 20 : 785–797.

Banerji, M. & Chaudhuri, M. 1972. Further studies on chromosomes of some Orchidaceae and Iridaceae from the temperate Himalayas. Proc. Indian Sci. Congr. Assoc. 59(3) : 347.

Brieger, F.G. 1981. Die Orchideen. Parey, Berlin. 3 Auflage. 636–753.

Chardard, R. 1963. Contribution á l'étude cyto-taxinomique des Orchidées. Rev. Cyt. et Biol. Vég. 26 : 1–58.

Chatterji, A.K. 1976. Chromosome studies in some orchids. Proc. Indian Sci. Congr. Assoc. 63 : 114.

Dorn, E.C. & Kamemoto, H.H. 1962. Chromosome Transmission of *Dendrobium phalaenopsis* 'Lyons Light No.1'. Amer. Orchid Soc. Bull. 31(12) : 997–1006.

Eftimiu-Heim, P. 1941. Recherches sur le noyaux des Orchidées. Le Botaniste 31 : 65–111.

Hedge, S.N. & Boraiah, G. 1973. Cytotaxonomical studies in the genus *Dendrobium* Sw. Proc. Indian Sci. Congr. Assoc. 60(III) : 309.

Hoffmann, K. 1929. Zytologishe Studien der Orchidaceen. Ber. Deutschen Bot. Gasell. 47 : 321–326.

_____ 1930. Beiträge zur cytologie der Orchidaceen. Planta 10 : 523–595.

Hsu, C.C. 1972. Preliminary chromosome studies on the vascular plants of Taiwan (V). Taiwania 17 : 48–65.

Ito, I. & Mutsuura, O. 1957. Chromosome numbers in *Dendrobium* species and hybrids. Jap. Orchid Soc. Bull. 3(1) : 1–3.

Jones, K. 1963. The chromosomes of *Dendrobium*. Amer. Orchid Soc. Bull. 5(2) : 1–2.

Kamemoto, H.H., Tanaka, R. & Kosaki, K. 1961. Chromosome number of orchids in Hawaii. Univ. Hawaii Agr. Exp. Sta. Bull. 127 : 1–28.

_____ & Sagarik, R. 1967. Chromosome numbers of *Dendrobium* species of Thailand. Am. Orchid Soc. Bull. 36(10) 889–894.

_____ , Kosaki, K. & Shindo, K. 1967. Chromosome counts of orchids in Hawaii. Na Pua Okika o Hawaii Nei 17(3) : 79–82.

_____ & Tara, M. 1968. Chromosome inheritance in reciprocal crosses of *Dendrobium phalaenopsis* 'Lyons Light No.1'. Proc. Amer. Soc. Hort. Sci. 92 : 665–671.

Kosaki, K. 1958. Preliminary investigations on the cytogenetics of *Dendrobium*. Proc. II World Orc. Conf. Harvard Univ. Press, Cambridge, Mass.: 25–29.

_____ & Kamemoto, H.H. 1961. Chromosomes of some *Dendrobium* species and hybrids. Na Pua Okika o Hawaii Nei. 11(7) : 75–86.

Malla, S.B., Bhattarai, S., Gorkhali, M., Saiju, H. & Singh, P. 1977. IOPB chromosome number reports LVII. Taxon 26 : 443–452.

_____ , _____ , _____ , _____ & Kayastha, N. 1978. IOPB chromosome number reports LXII. Taxon 27 : 519–535.

Maxwell, M.K. 1967. 'A cytological study of Australian orchid genera, the *Dendrobium kingianum* Bidw. ex Lindl. Complex. Aust. Orchid Rev. 22 : 25–30.

Mehra, P.N. & Vij, S.P. 1970. IOPB chromosome number reports XXV. Taxon 19 : 102–113.

_____ & Sehgal, R.N. 1975. IOPB chromosome number reports XLIX, Taxon 24 :

501–516.

_____ & _____ 1976. IOPB chromosome number reports LIV. Taxon 25 : 631–649.

_____ & Kashyap, S.K. 1976. IOPB chromosome number reports LII. Taxon 25 : 483–500.

_____ & _____ 1978. IOPB chromosome number reports LX. Taxon 27 : 223–231.

Miduno, T. 1940. Chromosomenstudien an Orchidazeen IV. Cytologia 11: 179–185.

Mutsuura, O. & Nakahira, R. 1958. Chromosome numbers of the family Orchidaceae in Japan (1). Sci. Rep. Saikyo Univ. 2(5) : 25–30.

_____ & _____ 1959. Chromosome numbers of the family Orchidaceae in Japan (2). Sci. Rep. Kyoto Univ. 3(1) : 27–31.

_____ & _____ 1960. Chromosome numbers of the family Orchidaceae in Japan (3). Sci. Rep. Kyoto Univ. 3(2) : 11–16.

Pancho, J.V. 1965. IOPB chromosome number reports III. Taxon 14(2) : 50–57.

Roy, S.C. & Sharma, A.K. 1972. Cytological studies on Indian Orchids. Proc. Indian Nat. Sci. Acad. Biol. 38 : 72–86.

Sarkar, A.K., Chakraborty, M., Saha, N.C. & Das, S.K. 1978. IOPB chromosome number reports LXIII. Taxon 27 : 519–535.

Schlechter, R. 1912; Die Orchideen von Deutsch New Guinea. Fedde Report. 1. (6) : 440–643.

_____ 1927. Die Orchideen. Parey, Berlin. 2d. ed., 956pp.

Sharma, A.K. 1970. Annual report 1967–1968. Res. Bull. Univ. Calcutta 2 : 1–50.

_____ & Chatterji, K. 1966. Cytological studies on orchids with respect to their evolution and affinities. The Nucleus 9 : 177–203.

Shindo, K. & Kamemoto, H.H. 1963. Chromosome numbers and genome relationships of some species in the Nigrohirsutae section of *Dendrobium*. Cytologia 28 : 68–75.

Tanaka, R. 1962. Chromosome count of orchids in Japan I. Jap. Orchid Soc. Bull. 8(1) : 1–4.

_____ 1964. Chromosome count of orchids in Japan II. Jap. Orchid Soc. Bull. 10(1): 1–5.

_____ 1965. Chromosome numbers of some species of Orchidaceae from Japan and its neighbouring areas. Journ. Jap. Bot. 40(3) : 65–77.

_____ 1971. Types of resting nuclei in Orchidaceae. Bot. Mag. (Tokyo) 84 : 118–122.

_____ & Kamemoto, H.H. 1960. Meiotic chromosome behavior in diploid and polyploid *Vanda* orchid hybrids. Cytologia 25 : 405–418.

Vajrabhaya, T. & Randolph, L.F. 1960. Chromosome studies in *Dendrobium*. Amer. Orchid Soc. Bull. 29 : 507–517.

Vij, S.P. & Gupta, G.C. 1976. IOPB chromosome number reports LIV. Taxon 25 : 631–649.

Wilfret, G.J. & Kamemoto, H.H. 1969. Genome and Karyotype relationship in the genus *Dendrobium* (Orchidaceae). Cytologia 36(4) : 604–613.

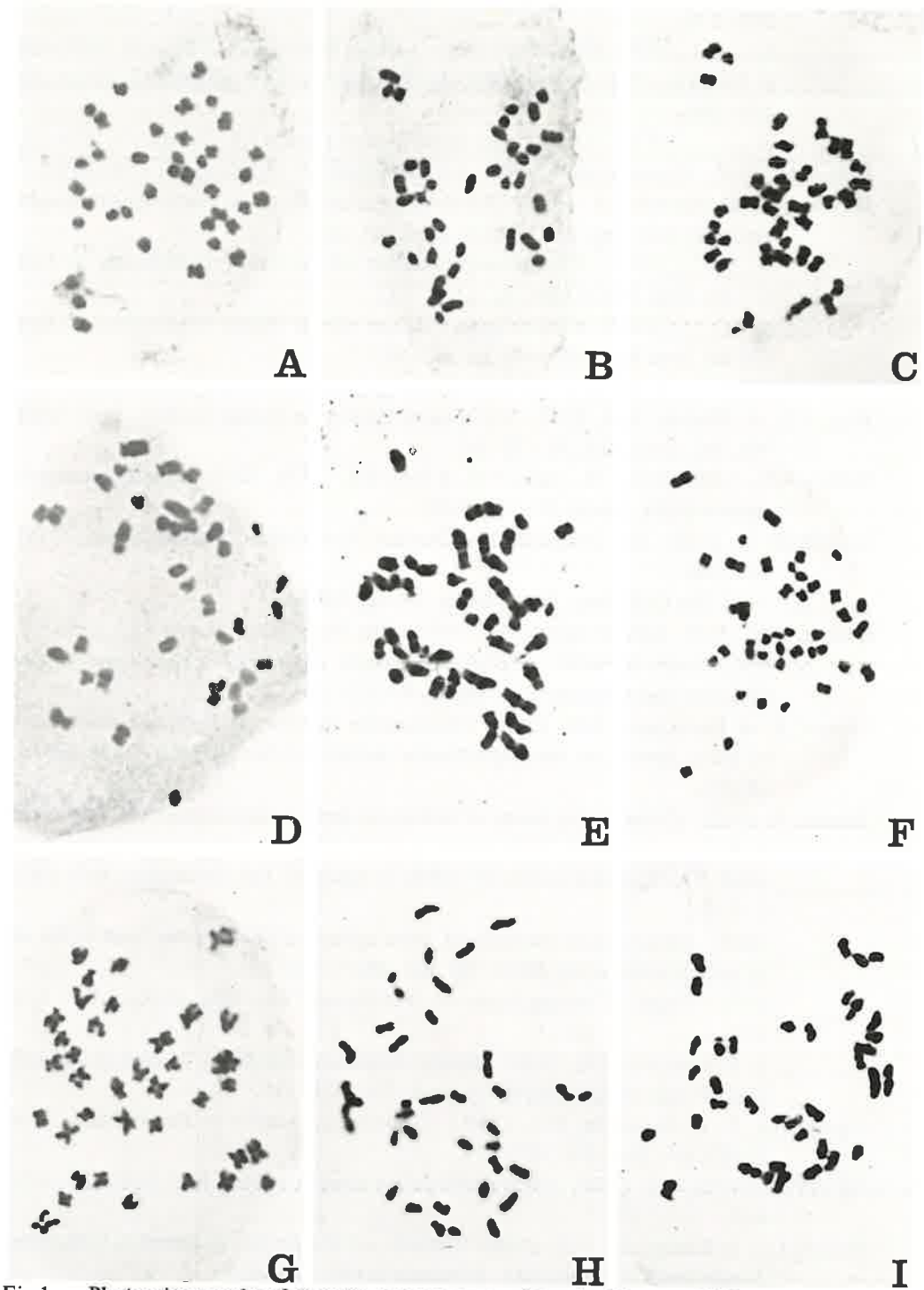


Fig 1. Photomicrographs of somatic chromosomes of *Dendrobium*. × 2000.
A, *D. acerosum* 2n=38. B, *D. aemulum* 2n=38. C, *D. aggregatum* var. *majus* 2n=38. D, *D. agrostophyllum* 2n=38. E, *D. amethystoglossum* 2n=40. F, *D. aphrodite* 2n=40. G, *D. batanense* 2n=38. H, *D. beckleri* 2n=38. I, *D. bigibbum* var. *superbum* subvar. *compactum* 2n=38.

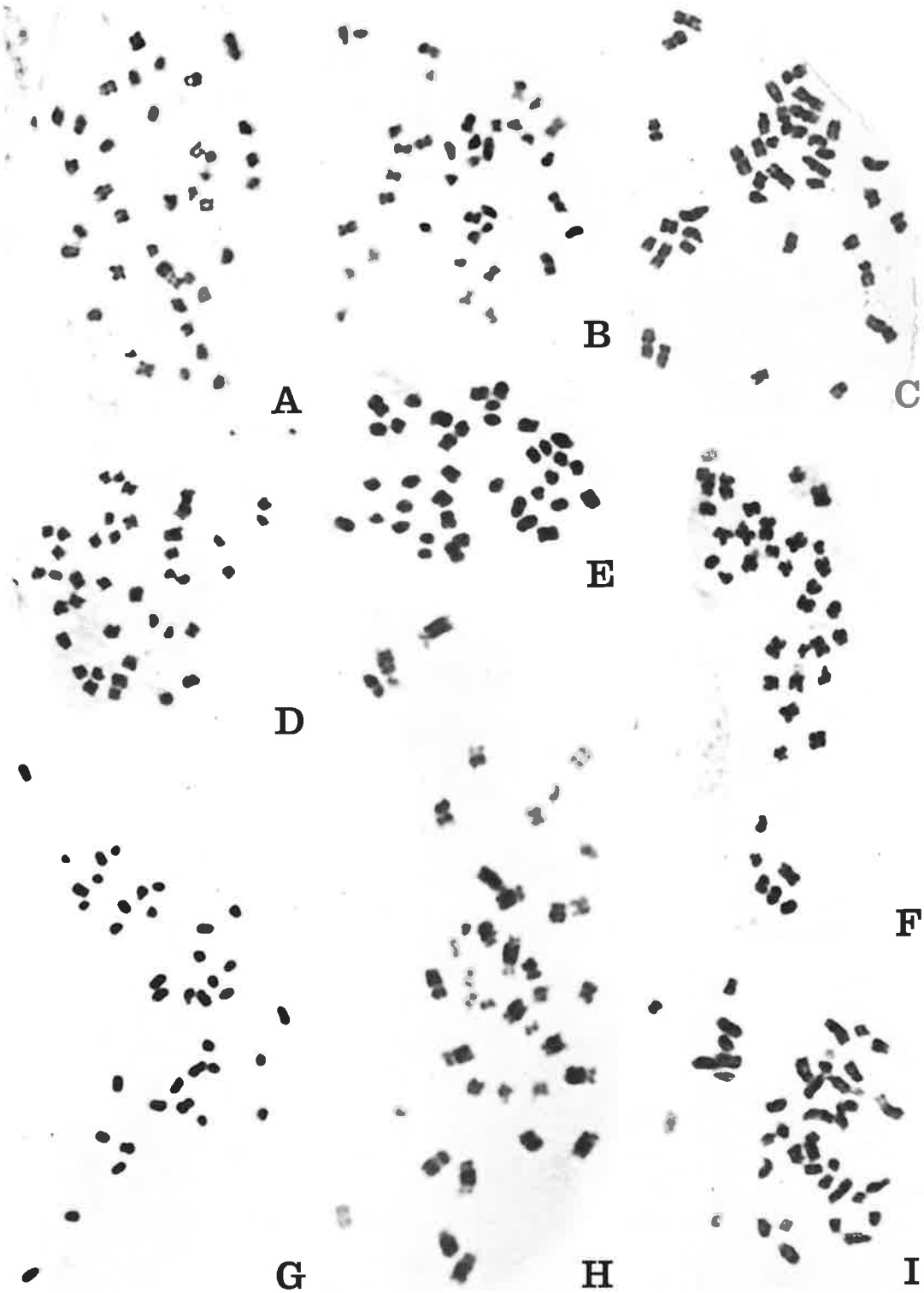


Fig. 2 Photomicrographs of somatic chromosomes of *Dendrobium*. × 2000.
A, *D. canaliculatum* 2n=38. B, *D. candidum* 2n=38. C. *D. chrysotoxum* 2n=38.
D, *D. compactum* 2n=40. E, *D. crassinode* 2n=38. F, *D. crumenatum* 2n=38.
G, *D. cucumerinum* 2n=38. H, *D. cymbidioides* 2n=40. I, *D. delacourii* 2n=40.

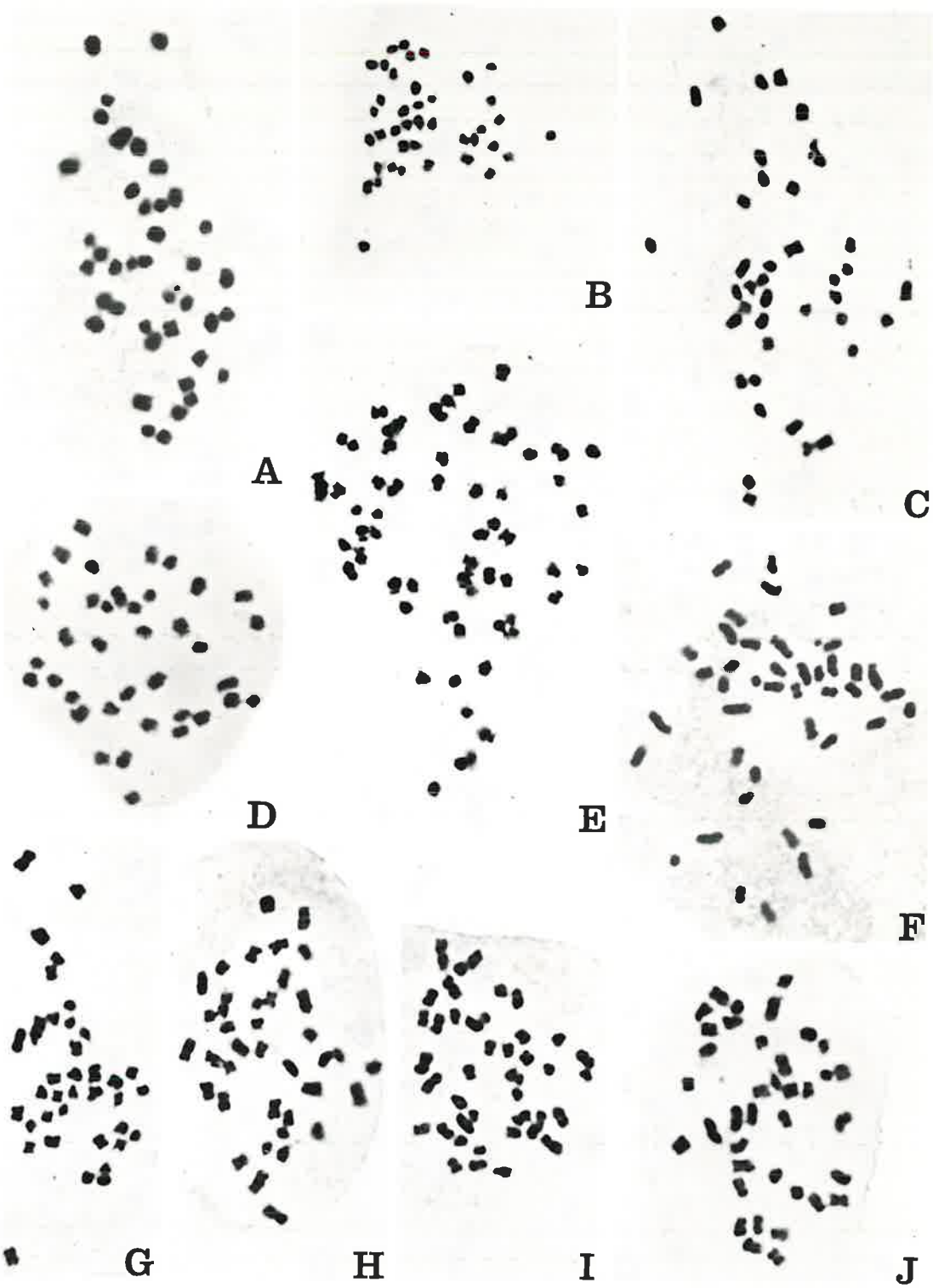


Fig. 3. Photomicrographs of somatic chromosomes of *Dendrobium*. × 2000.
A, *D. densiflorum* 2n=40+1f. B, *D. denudans* 2n=40. C, *D. dicuphum* 2n=39. D, *D. distichum* 2n=38 (diploid). E, *D. distichum* 2n=57 (triploid). F, *D. dixanthum* 2n=40+2f. G, *D. equitans* 2n=38. H, *D. falconeri* 2n=38. I, *D. farmeri* 2n=40. J, *D. findlayanum* 2n=38.

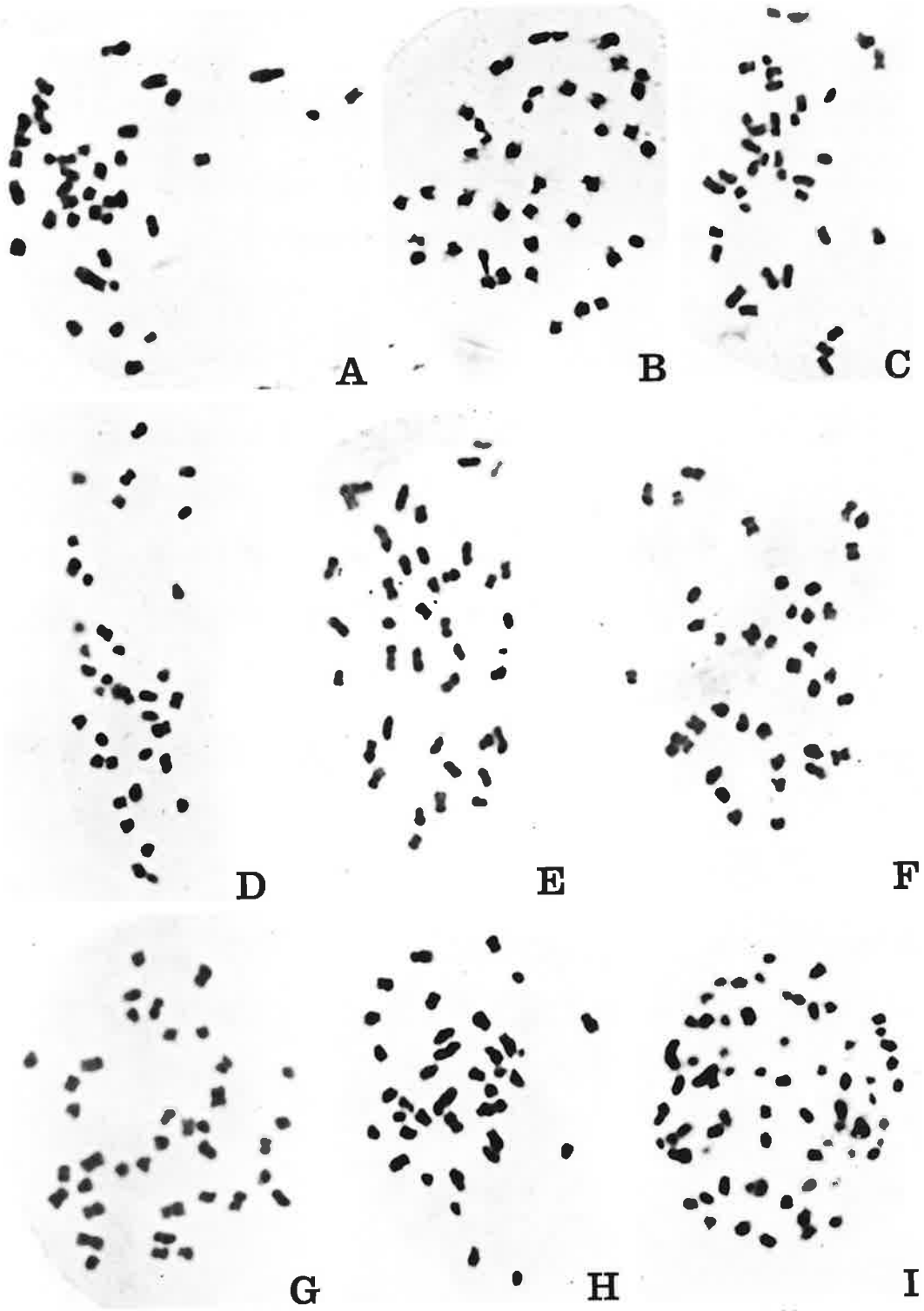


Fig. 4. Photomicrographs of somatic chromosomes of *Dendrobium*. × 2000.
A, *D. finisterrae* 2n=40. B, *D. forbesii* 2n=40. C, *D. formosum* var. *giganteum* 2n=38. D, *D. friedericksianum* 2n=38. E, *D. guerreroi* 2n=40. F, *D. heterocarpum* 2n=38. G, *D. infundibulum* 2n=38. H, *D. insigne* 2n=36+2f. I, *D. kingianum* 2n=76 (tetraploid).

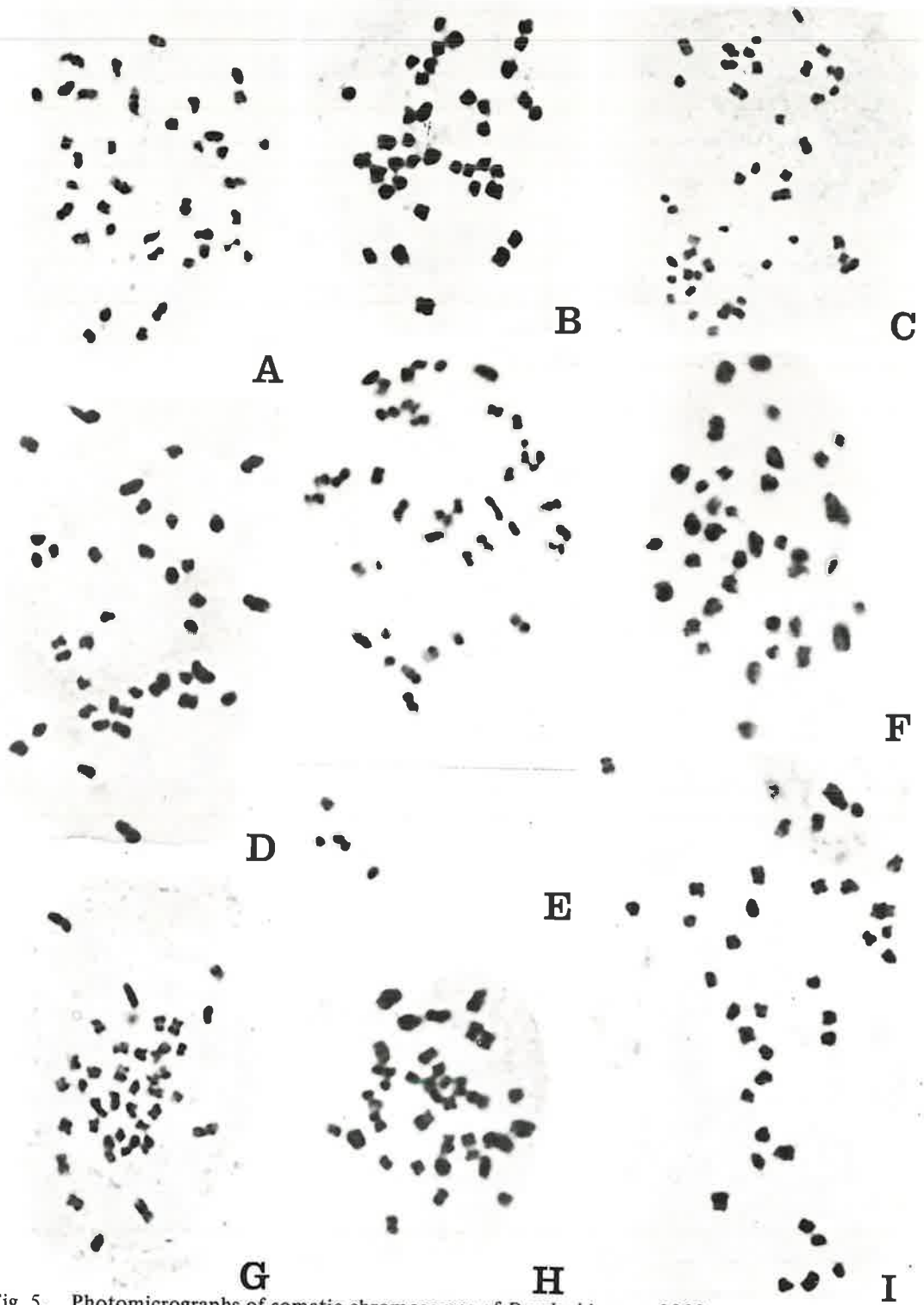


Fig. 5. Photomicrographs of somatic chromosomes of *Dendrobium*. × 2000.
A, *D. lasianthera* 2n=38. B, *D. leonis* 2n=38. C, *D. lichenastrum* 2n=40. D, *D. linguiforme* 2n=38. E, *D. longicornu* var. *java* 2n=43. F, *D. lyonii* 2n=40. G, *D. macraei* 2n=38. H, *D. macrophyllum* 2n=38. I, *D. miyakei* 2n=38.

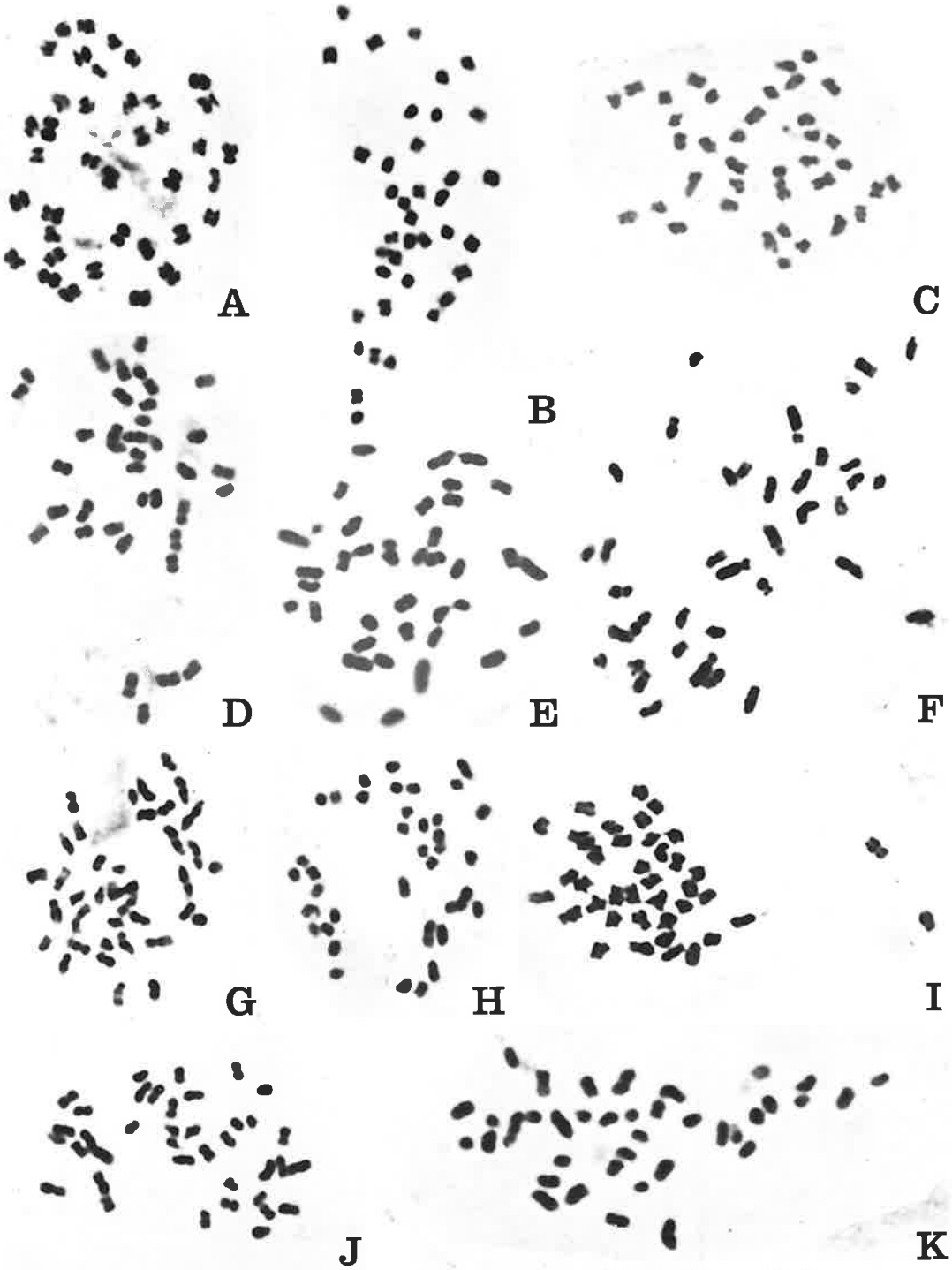


Fig. 6. Photomicrographs of somatic chromosomes of *Dendrobium*. x 2000.
A, *D. monile* 2n=38. B, *D. moschatum* 2n=38. C, *D. nobile* 2n=38. D, *D. ophioglossum* 2n=38. E, *D. parishii* 2n=38. F, *D. phalaenopsis* 2n=38. G, *D. phlox* var. *flava* 2n=38. H, *D. pierardii* 2n=38. I, *D. platygastrium* 2n=40. J, *D. plicatile* 2n=38. K, *D. pugioniforme* 2n=38.

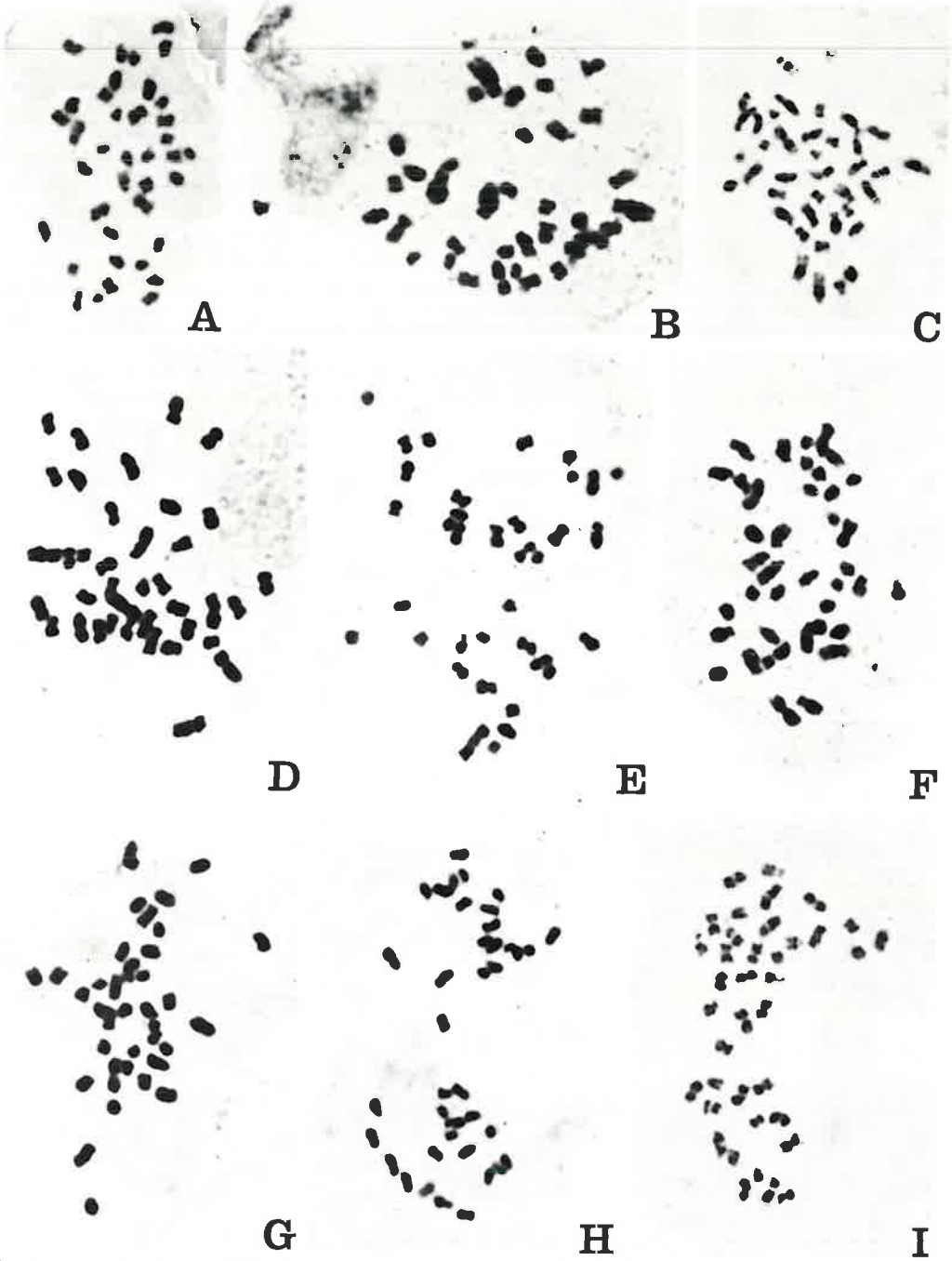


Fig. 7. Photomicrographs of somatic chromosomes of *Dendrobium*. × 2000.
A, *D. quinquecostatum* 2n=38. B, *D. ramosii* 2n=40. C, *D. revolutum* 2n=40.
D, *D. rhodopterygium* 2n=38. E, *D. ruppianum* 2n=38. F, *D. sanseiense* 2n=40.
G, *D. scabrilingue* 2n=38. H, *D. schneiderae* 2n=38. I, *D. scopa* 2n=38.

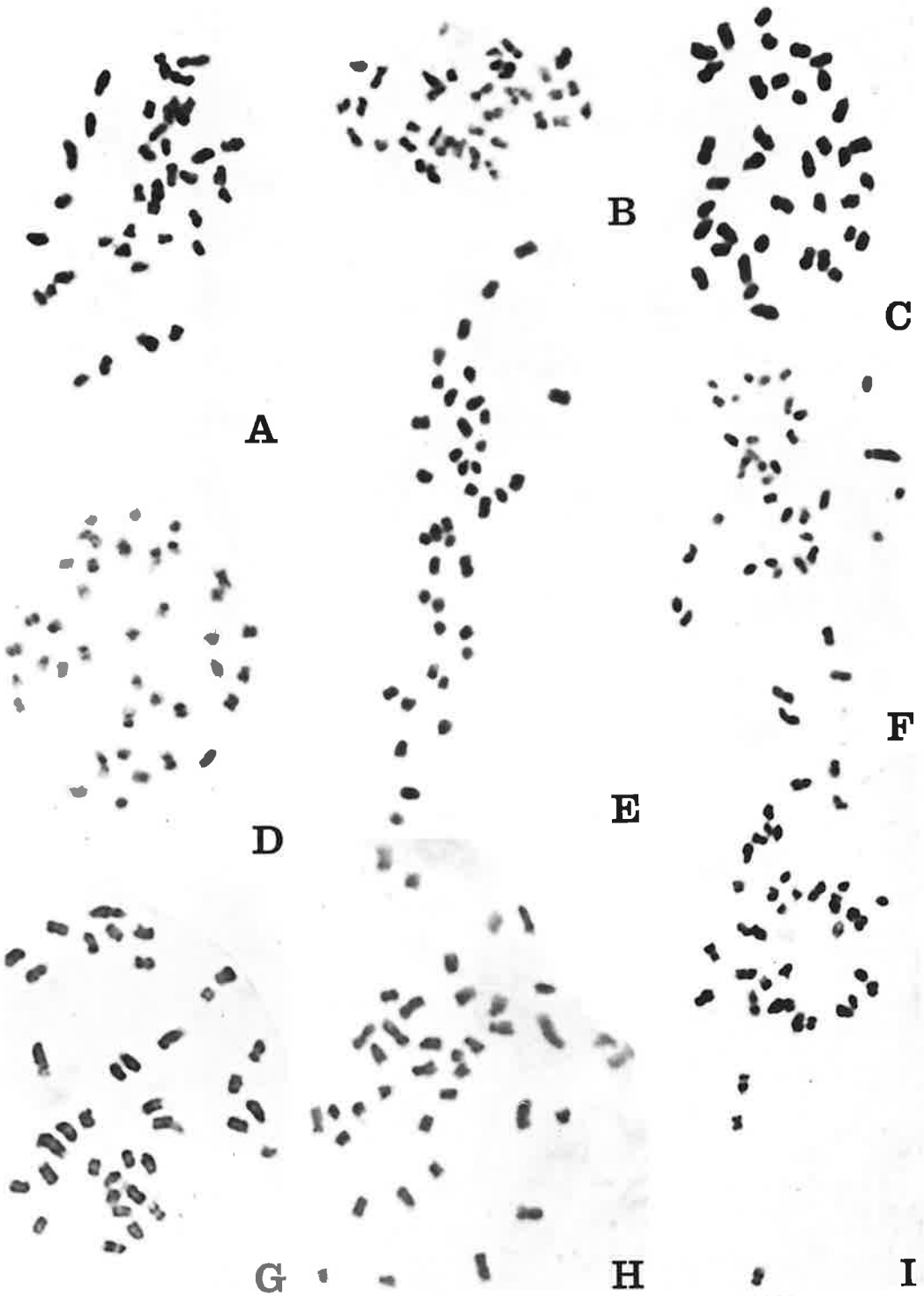


Fig. 8. Photomicrographs of somatic chromosomes of *Dendrobium*. x 2000.
A, *D. senile* 2n=40. B, *D. smilliae* 2n=38. C, *D. sophronites* 2n=38. D, *D. stuposum* 2n=38. E, *D. sulcatum* 2n=40. F, *D. superbiens* 2n=38. G, *D. superbum* 2n=38. H, *D. sutepense* 2n=38. I, *D. taurinum* 2n=38.

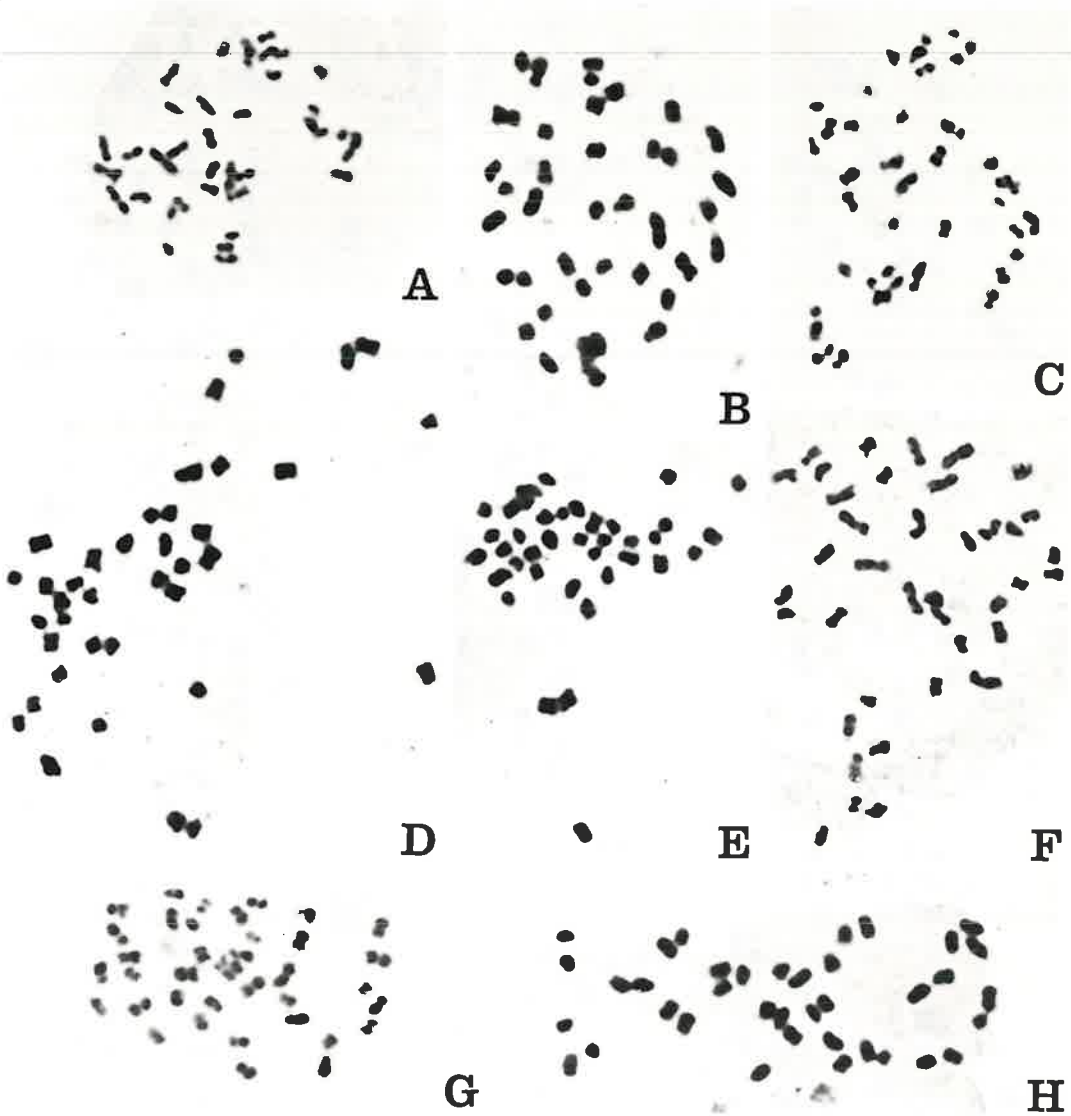


Fig. 9. Photomicrographs of somatic chromosomes of *Dendrobium*. x 2000.
A, *D. teretifolium* var. *fasciculatum* 2n=40. B, *D. terminale* 2n=38. C, *D. tetragonum* var. *giganteum* 2n=38. D, *D. topaziacum* 2n=38. E, *D. tortile* 2n=38. F, *D. tosaense* 2n=38. G, *D. wardianum* 2n=38. H, *D. wassellii* 2n=38.

パフィオペディラム属の葉の形態*

唐澤耕司**・青山幹男**

Morphological studies on leaf of *Paphiopedilum*

Kohji Karasawa and Mikio Aoyama

Paphiopedilum 属の系統と分類を明らかにするうえで，花とともに葉の形態的特徴が重要であることはすでに知られている。しかしながら分類上，葉の形態としては斑紋の有無および葉端の形態が取り上げられているにすぎない(R.J.v.D. 1969)。また，Rosso (1966)は Cypripedioideae 亜科の 4 属をとりあげて各組織の形態を比較したが，属内における比較検討はしていない。

筆者らは本属を分類するうえで上面表皮の厚さ，気孔の大きさおよび数が重要な形質であるとの結論を得たのでここに報告する。

材料および方法

観察に供した種と各部の測定値は表 1 に示した。

使用した株は本園の栽培温室の同一環境の下で栽培しているもので，1 種につき 1 測定値を記録した。

観察には充分に成長した葉を用い，葉の先端から¼の部位の中肋脈と葉縁の中間部分の組織を使用し，プレパラートを作成した。

各部の測定は写真撮影後，引き伸した印画紙上で計測し，葉肉の厚さは葉の厚さと上面表皮の厚さとの差で算出した。

観察結果

1．葉の厚さ

葉の厚さは最大 2.10 ㎜ (*P. parishii*) から最小 0.47㎜ (*P. glaucophyllum*) までの範囲の数値を示した。その比は4.5倍で総平均値は0.89㎜であった。

2．上面表皮の厚さ

上面表皮の厚さは最大 1.27 ㎜ (*P. parishii*) から最小0.05㎜ (*P. purpuratum*) までの範囲の数値を示し，種によって大きな差が見られた。その比は25.4倍に達し，総平均値は 0.35 ㎜であった。

上面表皮における表皮細胞の形はその厚さに応じて，縦長のものや扁平なものが見られた。表皮細胞の外面にはクチクラ層が発達しており，*P. micranthum* では突起状の凹凸が形成されていた。表皮細胞の側面の細胞壁は薄く，*P. concolor* では蛇腹状の小さなしわが観察された(図 1)。

3．葉肉の厚さ

葉肉の厚さは最大 0.83 ㎜ (*P. parishii*) から最小 0.34㎜ (*P. glaucophyllum*) までの範囲の数値を示し，種間の差は小さかった。その比は2.4倍で総平均値は 0.54 ㎜であった。

同化組織は *P. parishii*, *P. insigne* などのように柵状組織と海綿状組織が明瞭に分化している種や，*P. glaucophyllum*, *P. lawrenceanum* などのように不明瞭な種が観察された。葉が斑入となる種では緑葉部分と斑入部分との組織上の差は見られず，葉緑体の数と葉緑素の量の減少によって斑入部分が形成されていた。

* Contribution from the Hiroshima Botanical Garden No. 18
** The Hiroshima Botanical Garden
Bulletin of The Hiroshima Botanical Garden, No. 4 : 81–87, 1981.

Table 1. Plant materials and measurements of tissues in leaf

Species	Thickness of leaf (mm)	Thickness of upper epidermis (mm)	Thickness of mesophill (mm)	Length of guard cell (μm)	Number of stomata (/mm²)
Subgenus BRACHYPETALUM					
bellatulum	1.57	1.03	0.54	49	40.5
concolor	1.37	0.70	0.67	37	46.5
niveum	1.47	1.00	0.47	43	48.0
micranthum	0.86	0.15	0.71	53	27.9
delenatii	0.70	0.20	0.50	58	19.1
Subgenus POLYANTHA					
stonei	0.70	0.11	0.58	52	41.6
rothschildianum	0.93	0.20	0.73	54	37.1
praestans	1.33	0.70	0.63	55	33.0
philippinense	1.33	0.77	0.56	54	28.5
randsii	0.95	0.46	0.48	44	40.1
lowii	0.80	0.28	0.52	42	43.5
haynaldianum	1.07	0.47	0.60	44	40.5
parishii	2.10	1.27	0.83	47	51.0
victoria-mariae	0.70	0.13	0.56	60	31.1
chamberlainianum	0.80	0.23	0.57	50	33.0
c. var. *latifolium*	0.75	0.21	0.53	54	31.5
primulinum	0.76	0.25	0.51	52	39.0
glaucophyllum	0.47	0.13	0.34	53	27.0
Subgenus PAPHYOPEDILUM					
hirsutissimum	0.60	0.22	0.38	43	37.5
exul	1.10	0.60	0.50	49	43.5
villosum	0.70	0.10	0.60	37	40.5
insigne	0.65	0.15	0.50	48	63.0
i. var. *sanderae*	0.68	0.15	0.53	50	73.1
charlesworthii	0.86	0.35	0.51	38	86.6
spicerianum	0.73	0.23	0.50	45	49.5
druryi	1.43	0.73	0.70	48	43.5
Subgenus BARBATA					
fairieanum	0.83	0.43	0.40	44	54.0
bullenianum	0.63	0.20	0.43	57	15.0
appletonianum	0.53	0.10	0.43	63	21.5
tonsum	0.57	0.13	0.44	61	13.5
sukhakulii	0.50	0.10	0.40	60	13.5
lawrenceanum	0.70	0.13	0.57	62	12.0
callosum	0.87	0.22	0.65	65	18.0
venustum	0.80	0.27	0.53	60	15.0
purpuratum	0.57	0.05	0.52	61	15.0
virens	0.67	0.15	0.52	62	21.0
mastersianum	0.77	0.12	0.65	63	13.5
Average	0.89	0.35	0.54	51.8	35.4
Ratio (max./min.)	4.5	25.4	2.4	1.8	7.2

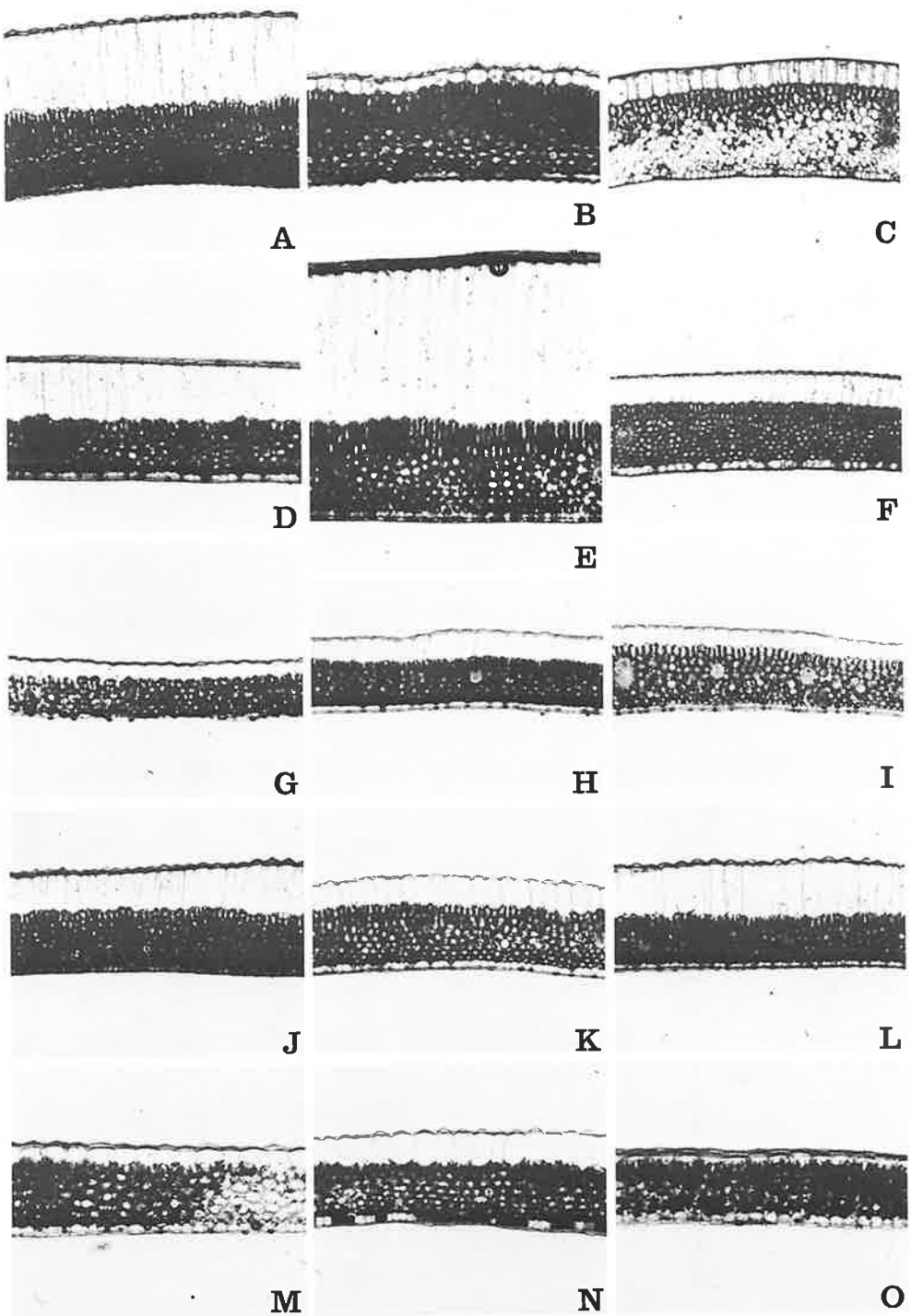


Fig. 1. Cross sections of leaf of *Paphiopedilum*.
A, *P. concolor*. B, *P. micranthum*. C, *P. rothschildianum*. D, *P. randii*. E, *P. parishii*. F, *P. chamberlainianum*. G, *P. glaucophyllum*. H, *P. hirsutissinum*. I, *P. insigne*. J, *P. charlesworthii*. K, *P. spicerianum*. L, *P. fairieanum*. M, *P. lawrenceanum*. N, *P. venustum*. O, *P. purpuratum*. × 18.

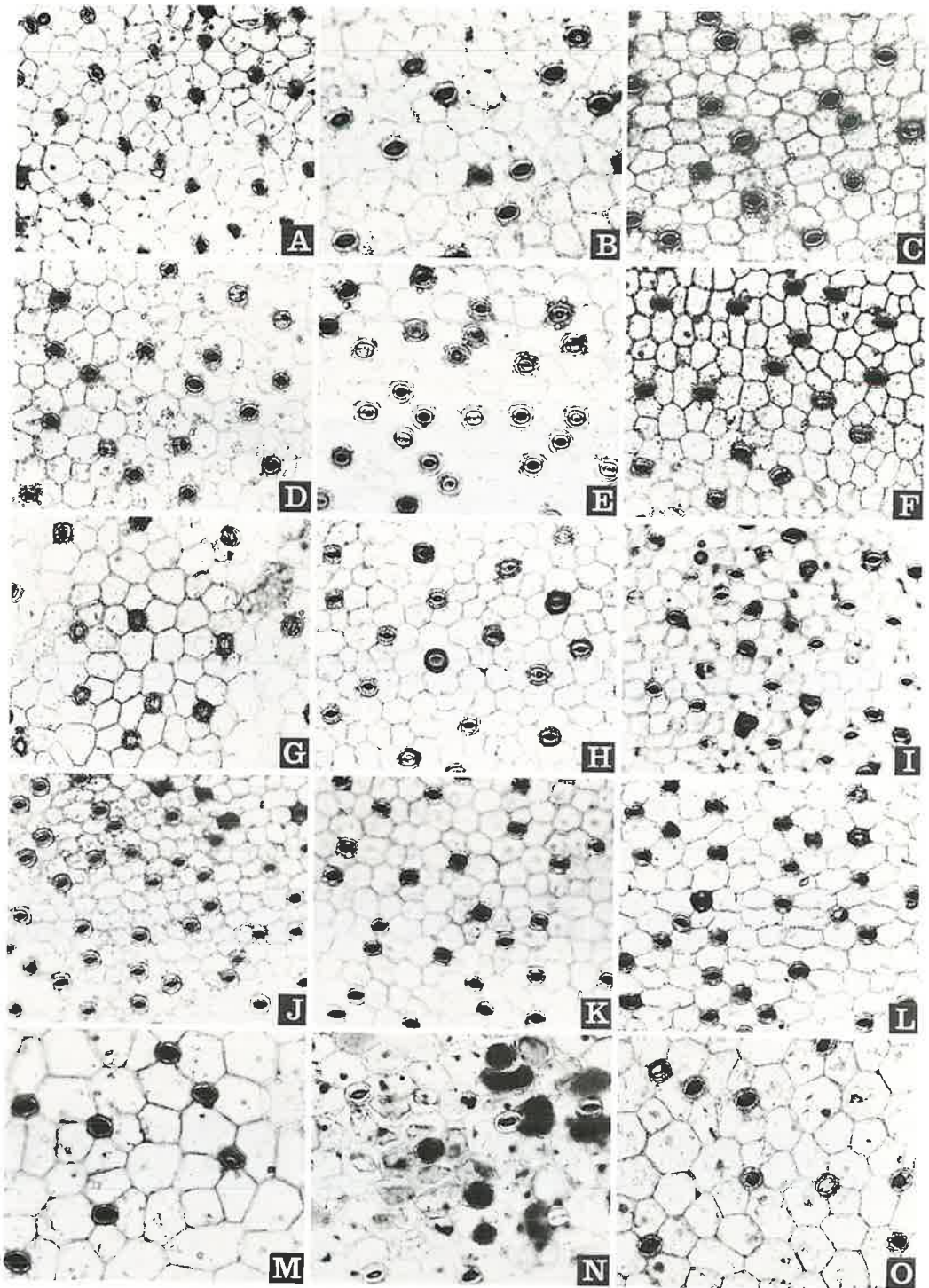


Fig. 2. Stomata in lower epidermis of leaf of *Paphiopedilum*.
A, *P. concolor*. B, *P. micranthum*. C, *P. rothschildianum*. D, *P. randii*. E, *P. parishii*. F, *P. chamberlainianum*. G, *P. glaucophyllum*. H, *P. hirsutissinum*. I, *P. insigne*. J. *P. charlesworthii*. K, *P. spicerianum*. L. *P. fairieanum*. M, *P. lawrenceanum*. N, *P. venustum*. O. *P. purpuratum*. × 60.

下面表皮の厚さは各種ともほぼ同じで上面表皮に見られるような著しい差は生じていなかった。葉の裏面が着色している *P. venustum* では表皮細胞の一部に色素を含んだ細胞が点在していた(図2 N)。

4．気孔の大きさ

下面表皮における孔辺細胞の長径は最大65 μm (*P. callosum*) から最小37 μm (*P. concolor, P. villosum*) までの範囲の数値を示しており，その比は1.8倍で総平均値は51．8 μm であった。

孔辺細胞は他の表皮細胞より小さく，その周囲には特に変形した表皮細胞は見られなかった(図2)。また孔辺細胞の外側にはクチクラ層が発達してできた前腔が形成されていた(図3)。

5．気孔の数

下面表皮における気孔数は最大86.6個/㎟ (*P. charlesworthii*) から最小12.0個/㎟ (*P. lawrenceanum*) までの範囲の数値を示し，種によって大きな差が見られた。その比は7.22倍で総平均値は35.4個/㎟ であった。

考　　察

葉の厚さと上面表皮の厚さとの間には強い相関が見られる。すなわち，厚い葉をもつ種では上面表皮の厚さが増加しており，葉肉組織の厚さは増加していない。一方，気孔長と気孔数との間には明瞭な負の相関が見られる。すなわち，大きな気孔をもつ種では気孔数が少なくなっており，気孔長，気孔数の変動を相互に補っている傾向がみられる。

上面表皮層は *P. parishii, P. concolor, P. druryi* など着生している種や比較的乾燥する所で生育する種では著しく発達しているが，一方，*P. glaucophyllum, P. purpuratum* など林床で生活している種では発達の程度が低い。このように上面表皮の厚さのちがいが生育地の環境の相違にもとづいていることは明らかに認められる。また，上面表皮細胞の側壁が蛇腹状に伸縮することから，本属では貯水組織として主に葉の上面表皮層を利用していることがわかる。

上面表皮の厚さは種間で著しい差を示すが，気孔長，気孔数は従来の分類群 (Brieger 1971) ごとにまとまった数値を示す傾向が見られる。すなわち，上面表皮の厚さが生育地の環境に適応して変化しやすい形質であるのに対して，気孔長，気孔数は近縁の種の間でほぼ一定の数値を示すことから環境の影響を受けにくい安定した形質であると思われる。

Brachypetalum 亜属のうち *P. bellatulum, P. concolor, P. niveum* は上面表皮がよく発達しており，気孔長は平均的に低い数値を示し，気孔数は平均的に高い数値を示す。一方，*P. micranthum, P. deleenatii* は上面表皮の発達の程度が低く，気孔長は平均的に高い数値を示し，気孔数は平均的に低い数値を示す。このように本亜属は各部の測定値から明らかに異なる2群を含んでいる。

Polyantha 亜属の各種は上面表皮の厚さおよび気孔長において種間の差が大きいが，気孔数において比較的近似な数値を示す。本亜属のうち Cochlopetalum 節に属する各種は上面表皮の厚さにおいて

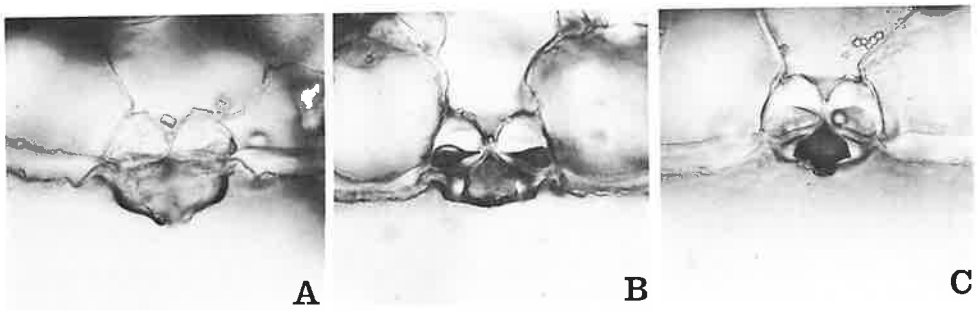
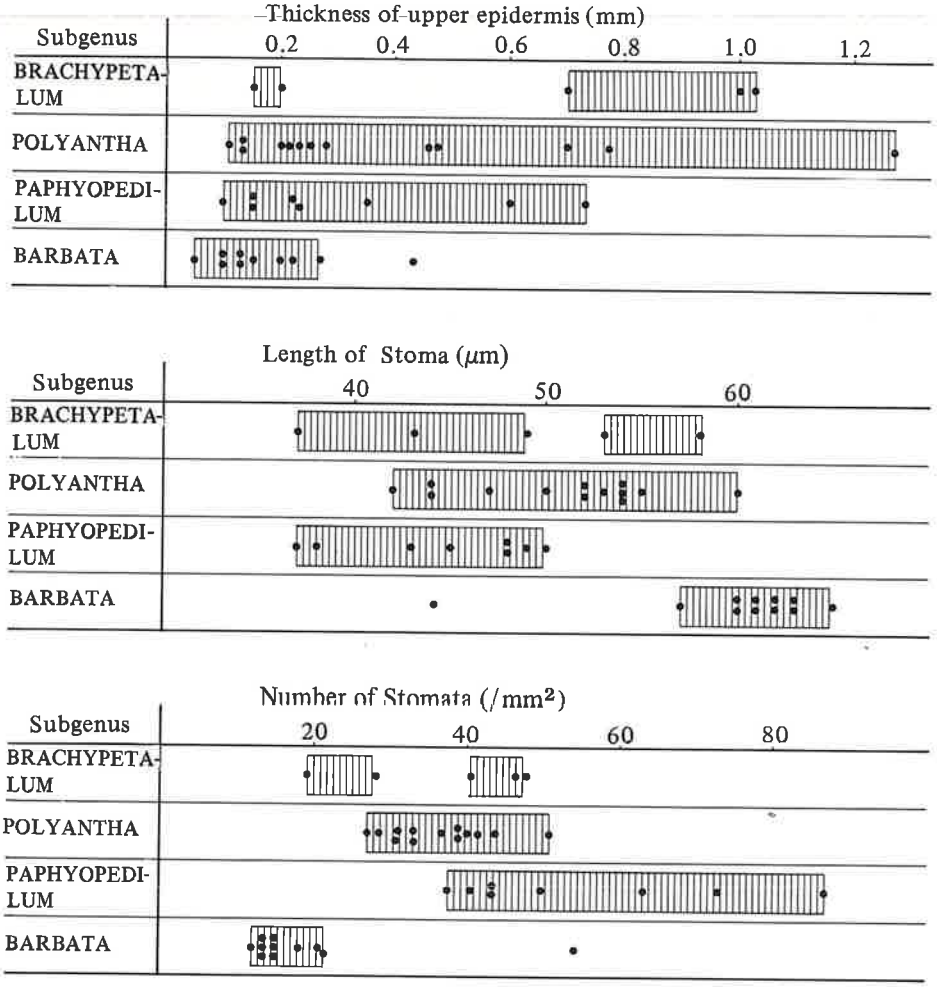


Fig. 3. Cross sections of stoma of *Paphiopedilum*.
A, *P. micranthum*. B, *P. stonei*. C, *P. callosum*. × 300.



種間の差が小さく，比較的類似した分類群として位置づけられる。

Paphiopedilum 亜属は気孔長，気孔数において種間の差が大きいが，他の亜属に比較すると，気孔長において平均的に高い値を示す。

P. fairieanum を除く Barbata 亜属の各種は非常に近似した数値を示す。他の亜属に比較すると気孔長において平均的に高い値を，気孔数において最も低い値を示す。*P. fairieanum* は本亜属の中では例外的な数値を示し，Paphiopedilum 亜属の平均的な値と一致する。

以上のごとく葉の形態をもとに本属の種を比較し，従来の分類を検討すると基本的には Brieger の分類と一致するが，次の点では明らかに異なる結果が得られた。

Brachypetalum 亜属は従来単一の分類群として扱われていたが，葉の各部の形態からは 2 つの異なる形質をもつ集団が含まれていることがわかる。

Barbata 亜属に含まれている *P. fairieanum* は気孔長，気孔数において Paphiopedilum 亜属の数値と一致しており，しかも緑葉であることからも Paphiopedilum 亜属と類似した葉の形態をもっている。

要　　約

1．*Paphiopedilum* 属 36 種の葉の横断面および気孔の観察をおこない各部の測定値を比較した。

2．本属では，上面表皮細胞を貯水組織として利用しており，生態的適応が見られる。

3．裏面表皮における気孔長と気孔数との間には明瞭な負の相関が見られる。

4．葉の形態をもとに Brachypetalum 亜属を 2 群に区分できる。

5．*P. fairieanum* は Paphiopedilum 亜属と共通した葉の形態をもつ。

Summary

1. Morphological investigations of leaf of *Paphiopedilum* were carried out in 36 species.
2. Upper epidermis of leaf were consisted of a single layer of cells that functioned as water storage tissue.
3. The relations between the numbers of stomata and the length of guard cell were elucidated.
4. Morphological structures of the leaf of the species could be divided into two groups distinctly in the subgenus Brachypetalum.
5. *P. fairieanum* belonging to subgenus Barbata was allied to subgenus Paphiopedilum in the maesurements of leaf.

引　用　文　献

Brieger, F.G. 1971. Die Orchideen, Cypripedioideae. Felgentreff & Goebel KG. Berlin: 161–185.

Rosso, S.W. 1966. The vegetative anatomy of the Cypripedioideae (Orchidaceae). Jour. Linn. Soc., Bot. 59: 309–341.

von Delden, R.J. 1969. Notes on a Study of Morphological and Chromatic Characteristics for the Identification of Unflowering Paphiopedilum Plants. Orchid Digest 33: 17–20.

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