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Karyomorphological studies on two species of *Paphiopedilum**

Kohji Karasawa** and Mikio Aoyama**

ま え が き

パフィオペディルム属の詳細な核形態学的研究は Karasawa (1979) により，53種５亜種１変種１品種について報告された。その後，Karasawa & Aoyama (1980), Karasawa (1982,1986) により新しく見出された種あるいは変種について順次核型が明らかにされている。

今回新たに染色体数が未報告な２種について核形態学的研究を行ったのでその結果を報告する。

染色体の観察は Karasawa (1979) に準じて行った。体細胞分裂中期染色体の動原体の位置による分類，およびその表現は Levan *et al.* (1964) に従った。静止期染色体および分裂期染色体の特徴を核型として表現する場合は Tanaka (1971, 1977) の定義に従った。

観 察 結 果

今回観察した２種の静止期染色体はいずれも多数の染色体小粒とともに10～15個の濃染する形や大きさが不揃いな凝縮塊を形成した。この静止期染色体の形態は Tanaka (1971) の分類による複雑染色中央粒型に該当し、本属の他の種と異なるところはなかった (cf. Karasawa 1979).

体細胞分裂前期染色体は一様に濃染され従来の観察と同じ結果であった。

中期染色体はそれぞれ特有の核型を示した。その観察結果は以下のとおりであった。

１．*Paphiopedilum barbigerum* Tang et Wang, 2n＝26, Table 1, Fig. 1.

本種は中国南西部に産し，1940年に C.W.Wang らにより記載された。

本種はパフィオペディルム亜属に属し，*P. insigne* に似るが，より小型である。葉は数枚つき，線形から線状倒披針形，長さ10～20cm，革質，緑色。花茎は直立し，１花をつける。花は径約５cm。上萼片は広卵形，基部から中部が濃褐色で褐色の筋がはいり，周辺は白色。花弁は帯状で褐色，縁は波状。唇弁は褐色，開口部は広く耳がある。

本種の染色体数は１個体で2n＝26を算定した。分裂期中期染色体について長さと動原体の位置を測定し，その結果を Table 1 に示した。

2n＝26個の中期染色体は，長さが15.2

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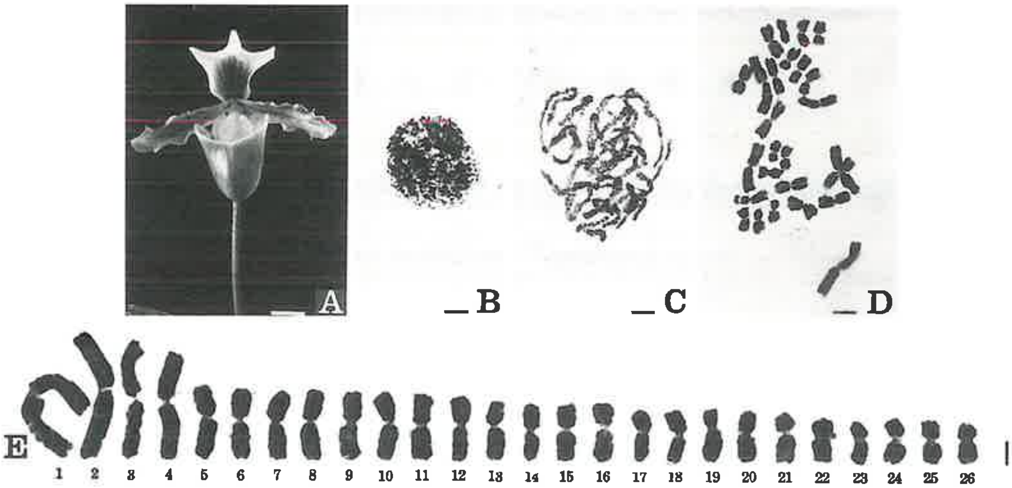

Fig. 1. *Paphiopedilum barbigerum* 2n=26. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 10 mm for A, 5 μm for B-D, 2.5 μm for E.

μm から11.7 μm までの範囲で変移する 4 個の大型染色体と長さが7.8 μm から4.2 μm までの範囲で勾配的に小さくなっている22個の小型染色体とから構成される二相的核型を示した。4 個の大型染色体は腕比が1.0〜1.2の範囲にあり中部動原体型であった。22個の小型染色体は腕比が1.0〜1.7の範囲にあり中部動原体型であった。第13，14番目の 2 個の染色体は短腕の介在部に二次狭窄を持ち，その付随体の長さはいずれも1.1 μm であった。

以上のように本種の核型は，2n=26個の染色体の動原体がすべて中部に位置すること，第13，14番目の染色体が明瞭な付随体を持つことから，*P. insigne* の核型に類似している。

2．*Paphiopedilum henryanum* Braem, 2n=26, Table 2, Fig. 2.

本種は中国とベトナムの国境地域に産し，1987年に Henry Azadehdel により発見され，同年に G.J.Braem が記載した新しい種である。

本種はパフィオペディルム亜属に属し，*P. insigne* に似る。

葉は 3 枚つき，線状披針形，長さ17cm，革質，緑色。花茎は湾曲し，1 花をつける。花は径約 5 cm。上萼片は広卵形，淡黄色に濃紫褐色の不規則な形の粗い斑紋がはいる。花弁は帯状で暗紫色，縁はゆるく波状。唇弁は紫赤色，開口部は広く耳がある。

本種の染色体数は 1 個体で2n=26を算定した。分裂期中期染色体について長さと動原体の位置を測定し，その結果を Table 2 に示した。

2n=26個の中期染色体は，長さが13.0 μm から12.1 μm までの範囲で変移する 4 個の大型染色体と長さが9.0 μm から3.9 μm までの範囲で勾配的に小さくなっている22個の小型染色体とから構成される二相的核型を示した。4 個の大型染色体は腕比がいずれも1.0で中部動原体型であった。22個の小型染色体は腕比が1.0〜1.4の範囲にあり中部動原体型であった。第13，14番

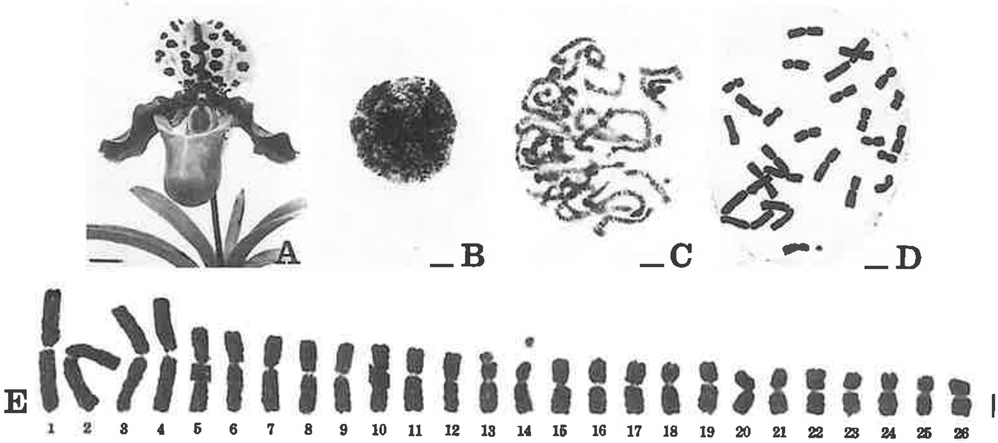

Fig. 2. *Paphiopedilum henryanum* 2n=26. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 10 mm for A, 5 μm for B-D and 2.5 μm for E.

目の2個の染色体は短腕の介在部に二次狭窄を持ち，その付随体の長さはそれぞれ1.1μmと1.0μmであった。

以上のように本種の核型は，2n=26個の染色体の動原体がすべて中部に位置すること，第13，14番目の染色体が明瞭な付随体を持つことから，*P. barbigerum* と同様に *P. insigne* の核型に類似している。

要　約

1．パフィオペディルム属2種の核形態学的研究を行い，新たに *P. barbigerum* 2n=26, *P. henryanum* 2n=26 の染色体数を算定した。

2．*P. barbigerum* の核型は，すべて中部動原体型染色体で，付随体染色体が第13，14番目に位置することから *P. insigne* の核型に類似する。

3．*P. henryanum* の核型は，*barbigerum* と同様に *P. insigne* の核型に類似する。

Summary

1. The chromosome numbers of two species of the genus *Paphiopedilum, P. barbigerum* 2n=26 and *P. henryanum* 2n=26, were recorded for the first time.

2. The chromosome complement of *P. barbigerum* was found to be composed of 26 metacentric chromosomes. Two chromosomes (Nos. 13 and 14) had large satellites. Thus, the karyotype of this species was closely similar to that of *P.insigne*.

3. The Karyotype of *P.henryanum* was also closely similar to that of *P.insigne*.

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Tanaka, R. 1971. Types of resting nuclei in Orchidaceae. Bot. Mag. Tokyo 84:118-122.

Tanaka, R. 1977. Recent karyotype studies. *In* K. Ogawa, *et al.* (eds.), Plant cytology, pp. 293-326. Asakura Book Co., Tokyo.

Table 1. Measurements of somatic chromosomes of *Paphiopedilum barbigerum*, 2n=26 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	7.5+7.7=15.2	8.2	1.0	m
2	6.5+7.8=14.3	7.7	1.2	m
3	6.1+6.3=12.4	6.7	1.0	m
4	5.4+6.3=11.7	6.3	1.1	m
5	3.5+4.3= 7.8	4.2	1.2	m
6	3.3+4.3= 7.6	4.1	1.3	m
7	3.5+4.0= 7.5	4.0	1.1	m
8	3.5+4.0= 7.5	4.0	1.1	m
9	3.4+4.0= 7.4	4.0	1.1	m
10	3.3+3.9= 7.2	3.9	1.1	m
11	3.4+3.5= 6.9	3.7	1.0	m
12	3.2+3.7= 6.9	3.7	1.1	m
13	1.1+1.6+3.5= 6.2*	3.3	1.2	m
14	1.1+1.7+3.2= 6.0*	3.2	1.1	m
15	2.6+3.2= 5.8	3.1	1.2	m
16	2.2+3.5= 5.7	3.1	1.5	m
17	2.6+3.1= 5.7	3.1	1.1	m
18	2.7+3.0= 5.7	3.1	1.1	m
19	2.1+3.5= 5.6	3.0	1.7	m
20	2.6+2.9= 5.5	3.0	1.1	m
21	2.0+3.0= 5.0	2.7	1.5	m
22	2.2+2.6= 4.8	2.6	1.1	m
23	2.1+2.5= 4.6	2.5	1.1	m
24	2.1+2.4= 4.5	2.4	1.1	m
25	2.2+2.3= 4.5	2.4	1.0	m
26	1.9+2.3= 4.2	2.3	1.2	m

* Chromosome with secondary constriction

Table 2. Measurements of somatic chromosomes of *Paphiopedilum henryanum*, 2n=26 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	6.2+6.8=13.0	7.0	1.0	m
2	6.3+6.4=12.7	6.9	1.0	m
3	6.0+6.5=12.5	6.7	1.0	m
4	5.9+6.2=12.1	6.5	1.0	m
5	4.0+5.0= 9.0	4.9	1.2	m
6	3.6+5.2= 8.8	4.7	1.4	m
7	3.5+4.7= 8.2	4.4	1.3	m
8	3.5+4.2= 7.7	4.2	1.2	m
9	3.4+4.1= 7.5	4.0	1.2	m
10	3.0+4.3= 7.3	3.9	1.4	m
11	2.8+3.8= 6.6	3.6	1.3	m
12	3.0+3.4= 6.4	3.5	1.1	m
13	1.1+1.9+3.4= 6.4*	3.5	1.1	m
14	1.0+2.0+3.4= 6.4*	3.5	1.1	m
15	2.9+3.1= 6.0	3.2	1.0	m
16	2.8+3.0= 5.8	3.1	1.0	m
17	2.6+3.1= 5.7	3.1	1.1	m
18	2.3+3.2− 5.5	3.0	1.3	m
19	2.3+3.1= 5.4	2.9	1.3	m
20	2.5+2.9= 5.4	2.9	1.1	m
21	2.3+2.6= 4.9	2.6	1.1	m
22	2.4+2.5= 4.9	2.6	1.0	m
23	2.0+2.5= 4.5	2.4	1.2	m
24	1.9+2.6= 4.5	2.4	1.3	m
25	1.8+2.4= 4.2	2.3	1.3	m
26	1.8+2.1= 3.9	2.1	1.1	m

* Chromosome with secondary constriction

Karyomorphological studies on *Lycaste*, Orchidaceae*

Mikio Aoyama** and Kohji Karasawa**

ラン科リカステ属の核形態学的研究*

青　山　幹　男**・唐　澤　耕　司**

Introduction

The genus *Lycaste*, Orchidaceae, which consists of approximately 30 species (Fowlie 1970), is widely distributed in central and south America. Its pseudobulbs were flatened fusiform and had two or three large leaves near the apex.

One to many inflorescences with a solitaly showy flower had arisen from the base of pseudobulbs.

It has been cultivated by orchid lovers for many years, and a large number of interspecific hybrids within the genus have been produced by artificial hybridization for horticultural purposes. Moreover, intergeneric hybrids between the genus *Lycaste* and the genera *Anguloa*, *Bifrenaria* or *Cymbidium* have been reported (Sander's list of orchid hybrids 1987, Kojima *et al.* 1987). However, some species have failed to synthesize any interspecific hybrids.

The chromosome numbers of *Lycaste* were reported in two species, n=20 in *L. aromatica* (Hoffmann 1929, 1930) and 2n=40 in *L. virginalis* (Kojima *et al.* 1987), however the detail of the chromosome analysis has not yet been made.

In the present investigation the morphology of chromosomes was studied in 16 species of *Lycaste* in order to elucidate interrelationships among them.

Materials and Methods

The species, the sources and number of materials studied are listed in Table 1. These materials were grown in the Hiroshima Botanical Garden, Hiroshima City, Japan. Taxonomic treatments of the materials followed mostly Fowlie (1970) and partly Hawkes (1965). Systematic arrangement followed Fowlie (1970).

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Table 1. Sources, number of clones and chromosme number of the species of *Lycaste* studied

Species	Source	No. of clones	Chromosome number (2n)
Section DECIDUOSAE			
brevispatha (Klotz.) Lindl.	Panama	1	40
tricolor (Klotz.) Rchb. f.	Panama	2	40
deppei (Lodd.) Lindl.	Mexico	1	40
cruenta (Lindl.) Lindl.	Mexico	1	40
campbellii C. Schweinf.	Panama	1	40
aromatica (Graham ex Hook.) Lindl.	Mexico	2	40*
bradeorum Schltr.	Costa Rica	1	40
Section MACROPHYLLAE			
dowiana Endres et Rchb. f.	Costa Rica	1	40
virginalis (Scheid) Linden	Guatemala	2	40*
macrophylla (Poepping et Endlicher) Lindl.	Costa Rica	2	40
Section FIMBRIATAE			
linguella Rchb. f.	Peru	1	48
locusta Rchb. f.	Peru	1	48
denningiana Rchb. f.	Peru	2	50
barringtoniae (Smith) Lindl.	Jamaica	1	44
ciliata (Ruiz et Pavon) Lindl. ex Rchb. f.	Peru	1	44
dyeriana Sander ex Rolfe	Peru	1	48

* confirmed the previous reports

Somatic chromosomes were observed in meristematic cells of root tips in the species studied. Somatic chromosomes were stained and observed by the aceto-orcein squash method of Tanaka (1959) with slight modifications: Growing root tips were cut into small pieces 1–2mm long and immersed in 0.002M 8–hydroxyquinoline for five hours at 18°C. They were then fixed in 45% acetic acid for ten minutes at 5°C. The fixed materials were hydrolyzed in a 2:1 mixture of 1N hydrochloric acid and 45% acetic acid for a minute at 60°C, and were stained in 1% aceto-orcein by the usual squash method.

Karyotype analysis was made on the chromosomes at resting stage, mitotic prophase and metaphase. The position of centromere was expressed by the terms of median, submedian, subterminal and terminal according to Levan *et al.* (1964). The karyotype formulas were based on the condensed segments at prophase and the chromosome lengths and positions of centromeres at metaphase according to Tanaka's classifications (1971, 1980).

Observations

I. Section DECIDUOSAE

1. *Lycaste brevispatha* (Klotz.) Lindl., 2n=40, Tables 1 and 2, Fig. 1.

One plant was obtained from Panama. Flowers were 4 cm wide across. Sepals were green. Petals were light pink. Lips were white with purple spots.

The chromosome number of the plant was 2n=40 at mitotic metaphase, which was reported here for this species for the first time.

The chromosomes at resting stage contained numerous chromomeric granules, fibrous threads and chromatin blocks scattered throughout the nucleus. The chromatin blocks which varied in number from 15 to 20 per nucleus were irregular in size and form and varied from 1.0–2.5 μm in diameter. The chromosome features at resting stage were of the complex chromocenter type according to Tanaka's classification (1971).

The chromosomes at mitotic prophase formed early condensed segments located in the interstitial regions of both arms. The segregated condensed-segments of each chromosome were later joined to each other following the progress of cell division. Late condensed segments were observed in the proximal and distal regions of the chromosomes.

The 2n = 40 chromosomes at mitotic metaphase showed a gradual decrease in length from the longest (2.05 μm) to the shortest (0.70 μm) chromosomes. Among the 40 chromosomes in the complement, 34 were median in centromeric position with arm ratios from 1.0 to 1.7. The other six chromosomes (Nos. 23–24, 33–36) were submedian with arm ratios between 2.0 and 2.5.

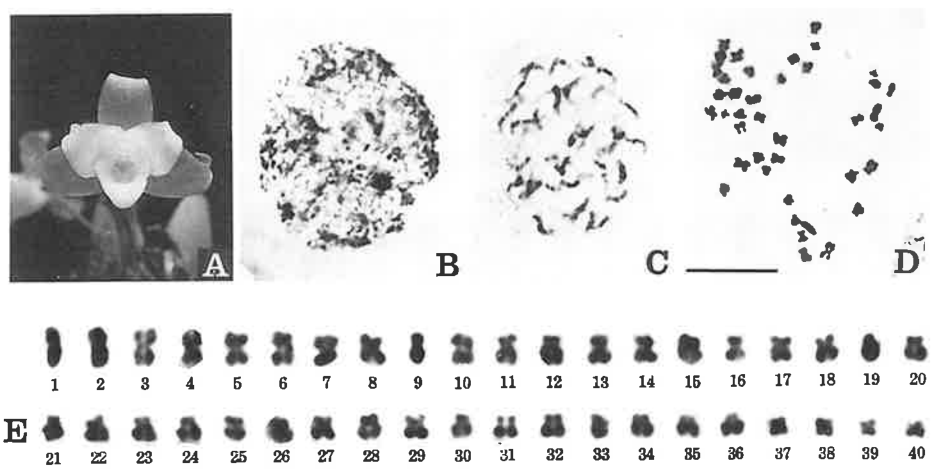

Fig. 1. *Lycaste brevispatha*, 2n=40. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 27 mm for A, 10 μm for B–D and 5 μm for E.

According to the definition of the karyotype proposed by Tanaka (1980), the karyotype of this species was homogeneous and gradual due to the gradual decrease of the chromosome lengths and symmetric due to the low arm ratios.

2. *Lycaste tricolor* (Klotz.) Rchb.f., 2n=40, Tables 1 and 3, Fig. 2.

Two plants were obtained from Panama. Flowers were 6 cm wide across. Petals were yellowish pink in color. Sepals and lips were pink.

The chromosome number of two plants of this species was 2n=40 at mitotic metaphase, which was recorded here for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

In the 2n=40 chromosomes at mitotic metaphase a gradual decrease in length from the longest (2.35 μm) to the shortest (1.00 μm) chromosomes was observed. Among the 40 chromosomes, 24 were median with arm ratios between 1.0 and 1.7, and 14 (Nos. 2, 9–12, 18, 25–29, 33–34, 40) were submedian with arm ratios between 1.8 and 3.0. The other two chromosomes (Nos. 15–16) were subterminal with the arm ratio of 3.8.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

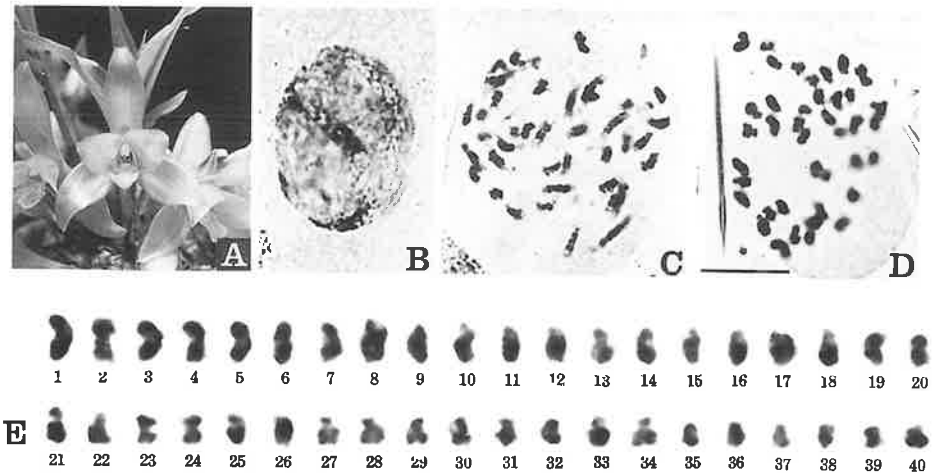

Fig. 2. *Lycaste tricolor*, 2n=40. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 31 mm for A, 10 μm for B–D and 5 μm for E.

3. *Lycaste deppei* (Lodd.) Lindl., 2n=40, Tables 1 and 4, Fig. 3.

One plant was obtained from Mexico. Flowers were 7 cm wide across. Sepals were yellowish green in color with maroon spots. Petals were creamy white. Lips were yellow with red spots.

The chromosome number of the plant was 2n=40 at mitotic metaphase, which was reported here for this species for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

A gradual decrease in length was observed from the longest (2.75 μm) to the shortest (1.20 μm) chromosomes in the 2n = 40 chromosomes at mitotic metaphase. Among 40 chromosomes, 29 were median with arm ratios between 1.0 and 1.7. Another eight chromosomes (Nos. 14–15, 17–20, 31–32) were submedian with arm ratios between 1.8 and 2.4, while the other three chromosomes (Nos. 16, 29–30) were subterminal with the arm ratios of 3.1 and 3.2.

The karyotype of this species was homogeneous and gradual in size and symmetric in form.

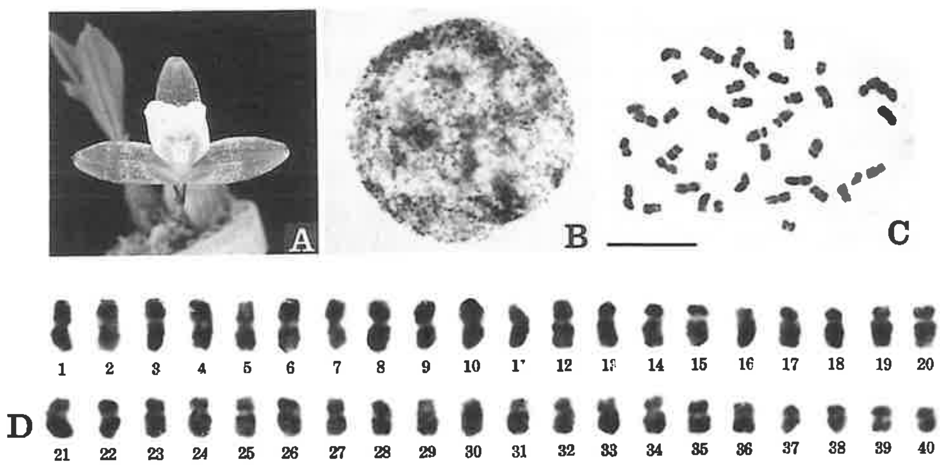

Fig. 3. *Lycaste deppei*, 2n=40. A, a flower. B, chromosomes at resting stage. C and D, chromosomes at mitotic metaphase. Bar indicates 38 mm for A, 10 μm for B–C and 5 μm for D.

4. *Lycaste cruenta* (Lindl.) Lindl., 2n=40, Tables 1 and 5, Fig. 4

One plant was obtained from Mexico. Flowers were 6 cm wide across. Petals were yellowish green in color. Sepals and lips were yellow with red spots near the bases.

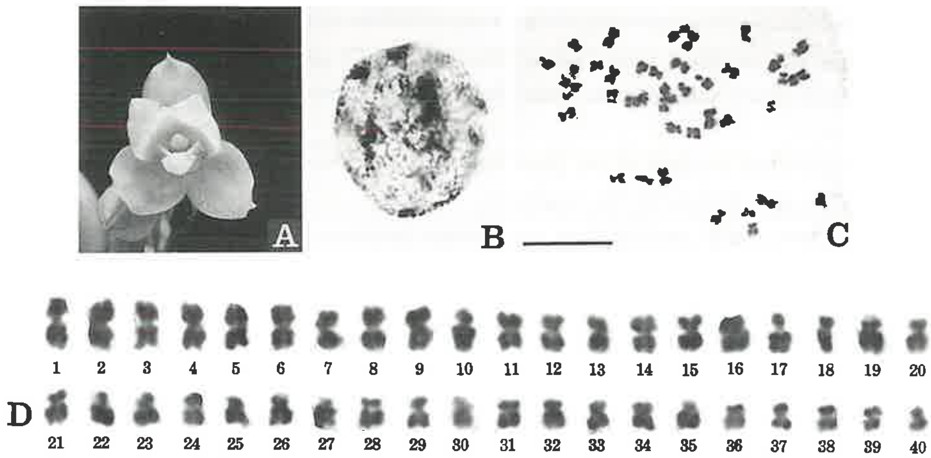

Fig. 4. *Lycaste cruenta*, 2n=40. A, a flower. B, chromosomes at resting stage. C and D, chromosomes at mitotic metaphase. Bar indicates 24 mm for A, 10 μm for B–C and 5 μm for D.

The chromosome number of the plant was 2n=40 at mitotic metaphase, which was reported here for this species for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

A gradual decrease in length was observed from the longest (2.65 μm) to the shortest (1.10 μm) chromosomes in the 2n = 40 chromosomes at mitotic metaphase. Among 40 chromosomes, 28 were median with arm ratios between 1.0 and 1.7. The other 12 chromosomes (Nos. 19, 21–22, 25–28, 30–32, 35–36) were submedian with arm ratios between 1.8 and 2.2.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

5. *Lycaste campbellii* C. Schweinf., 2n=40, Tables 1 and 6, Fig. 5.

One plant was obtained from Panama. Flowers were 4 cm wide across. Petals were pale green in color. Sepals and lips were yellow.

The chromosome number of the plant was 2n=40 at mitotic metaphase, which was reported here for this species for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

The 2n=40 chromosomes at mitotic metaphase showed a degradation in length from the longest (4.25 μm) to the shortest (1.85 μm) chromosomes. Among the 40 chromosomes, 31

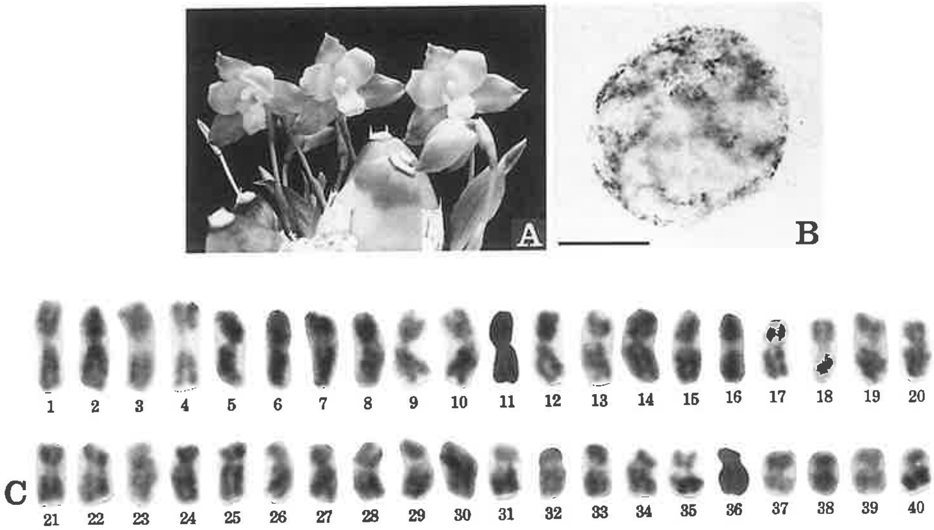

Fig. 5. *Lycaste campbellii*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic metaphase. Bar indicates 27 mm for A, 10 μm for B and 5 μm for C.

were median with arm ratios between 1.1 and 1.6, and nine (Nos. 7, 23–27, 31–32, 34) were submedian with arm ratios between 1.8 and 3.0.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

6. *Lycaste aromatica* (Graham ex Hook.) Lindl., 2n=40, Tables 1 and 7, Fig. 6.

Two plants were obtained from Mexico. Flowers were 6 cm wide across. Sepals were orange in color. Petals and lips were yellow.

The chromosome number of two plants was 2n=40 at mitotic metaphase and confirmed the meiotic chromosome number of n=20 reported by Hoffmann (1929, 1930).

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

A gradual decrease in length was observed from the longest (3.40 μm) to the shortest (1.20 μm) chromosomes in the 2n = 40 chromosomes at mitotic metaphase. Among 40 chromosomes, 27 were median with arm ratios between 1.0 and 1.7. Another nine chromosomes (Nos. 13, 19–26) were submedian with arm ratios between 2.3 and 3.0, while the other four chromosomes (Nos. 14, 18, 35–36) were subterminal with the arm ratios between 3.3 and 4.1. Two chromosomes (Nos. 13–14) had a secondary constriction on the distal region of their short arms, and formed small satellites.

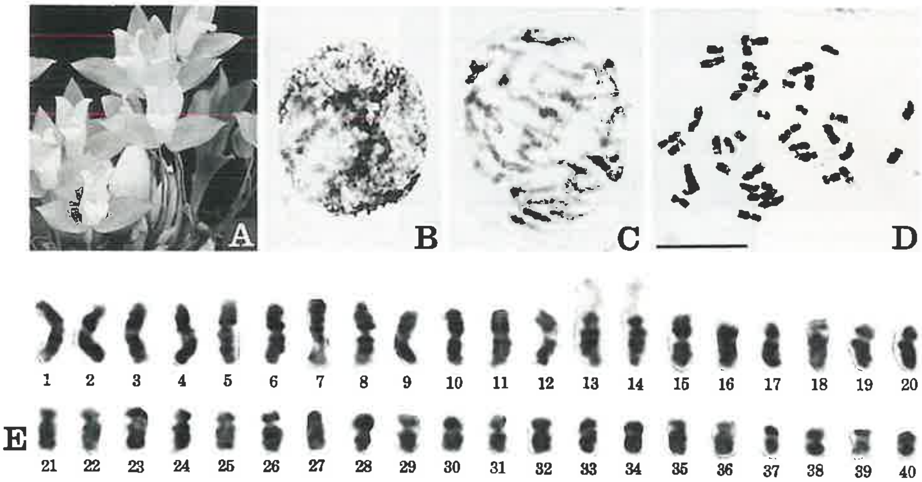

Fig. 6. *Lycaste aromatica*, 2n = 40. A, flowers. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 35 mm for A, 10 μm for B–D and 5 μm for E.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

7. *Lycaste bradeorum* Schltr., 2n=40, Tables 1 and 8, Fig. 7

One plant was obtained from Costa Rica. Flowers were 5 cm wide across. Petals were yellow in color. Sepals and lips were yellowish orange.

The chromosome number of the plant was 2n = 40 at mitotic metaphase, which was reported here for this species for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

A gradual decrease in length was observed from the longest (2.80 μm) to the shortest (1.10 μm) chromosomes in the 2n = 40 chromosomes at mitotic metaphase. Among the 40 chromosomes, 28 were median with arm ratios between 1.0 and 1.7. The other 12 chromosomes (Nos. 5–6, 10–12, 19, 23–24, 33–34, 37–38) were submedian with arm ratios between 1.8 and 2.7.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

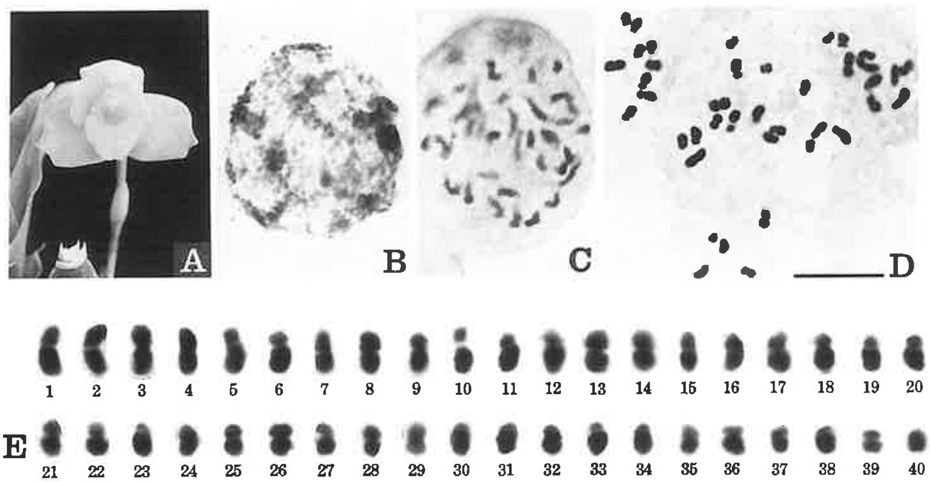

Fig. 7. *Lycaste bradeorum*, 2n=40. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 20 mm for A, 10 μm for B–D and 5 μm for E.

II. Section MACROPHYLLAE

8. *Lycaste dowiana* Endres et Rchb.f., 2n=40, Tables 1 and 9, Fig. 8.

One plant was obtained from Costa Rica. Flowers were 6 cm wide across. Sepals were brownish green. Petals and lips were creamy white.

The chromosome number of the plant was 2n=40 at mitotic metaphase, which was reported here for this species for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of 2n=40 at mitotic metaphase showed a gradual decrease in length from the longest (3.45 μm) to the shortest (1.50 μm) chromosomes. Among the 40 chromosomes in the complement, 23 were median with arm ratios between 1.0 and 1.7. The other 17 chromosomes (Nos. 5–6, 9–12, 14, 19–20, 22, 26–29, 34, 37–38) were submedian with arm ratios between 1.8 and 2.3.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

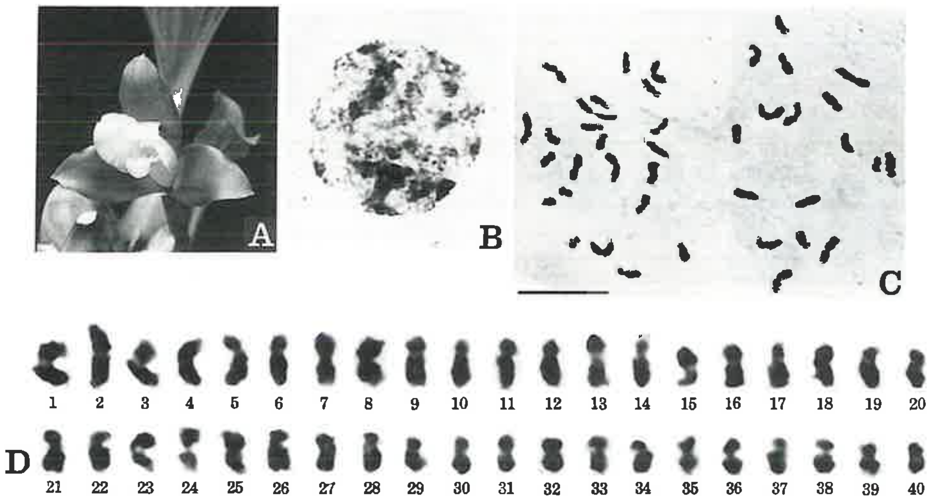

Fig. 8. *Lycaste dowiana*, 2n = 40. A, a flower. B, chromosomes at resting stage. C and D, chromosomes at mitotic metaphase. Bar indicates 28 mm for A, 10 μm for B–C and 5 μm for D.

9. *Lycaste virginalis* (Scheid.) Linden, 2n=40, Tables 1 and 10, Fig. 9.

Two plants were obtained from Guatemala. Flowers were 12 cm wide across. Petals and sepals were pale pink in color. Lips were pinkish purple.

The chromosome number of two plants of this species was 2n=40 at mitotic metaphase, and confirmed the previous report of Kojima *et al.* (1987).

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

In the 2n=40 chromosomes at mitotic metaphase a gradual decrease in length from the longest (2.70 μm) to the shortest (1.05 μm) chromosomes was observed. Among the 40 chromosomes, 26 were median with arm ratios between 1.0 and 1.6, and ten (Nos. 11–12, 21–22, 25–26, 29, 33, 36–37) were submedian with arm ratios between 1.8 and 2.8. The other four chromosomes (Nos. 19–20, 31–32) were subterminal with arm ratios between 3.1 and 6.6.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

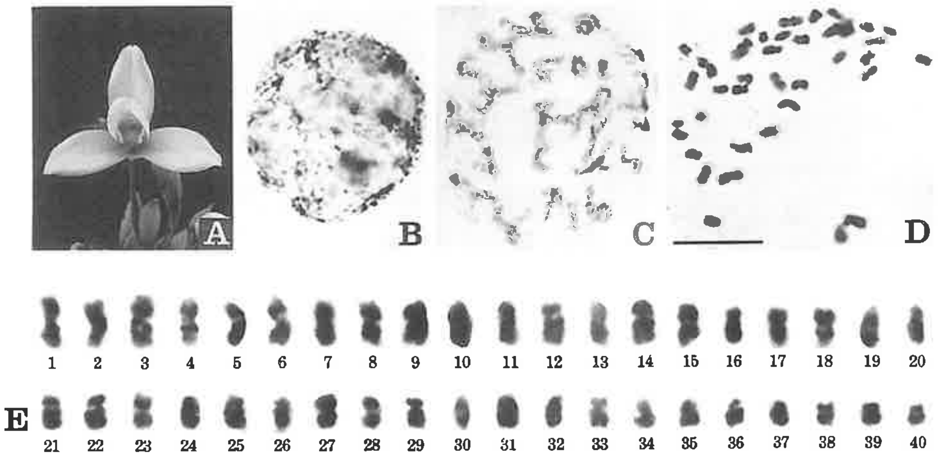

Fig. 9. *Lycaste virginalis*, 2n=40. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 70 mm for A, 10 μm for B–D and 5 μm for E.

10. *Lycaste macrophylla* (Poepping et Endlicher) Lindl., 2n=40, Tables 1 and 11, Fig. 10.

Two plants were obtained from Costa Rica. Flowers were 8 cm wide across. Petals were coppery brown in color. Sepals were creamy white. Lips were creamy white with reddish purple spots.

The chromosome number of two plants of this species was 2n=40 at mitotic metaphase, which was recorded here for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

The length of 2n=40 chromosomes at mitotic metaphase gradually decreased from the longest (2.45 μm) to the shortest (1.00 μm) chromosomes. Among the 40 chromosomes, 27 were median with arm ratios between 1.0 and 1.7. The other 13 chromosomes (Nos. 1–2, 11–12, 15–16, 22–26, 31–32) were submedian with arm ratios between 1.8 and 3.0.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

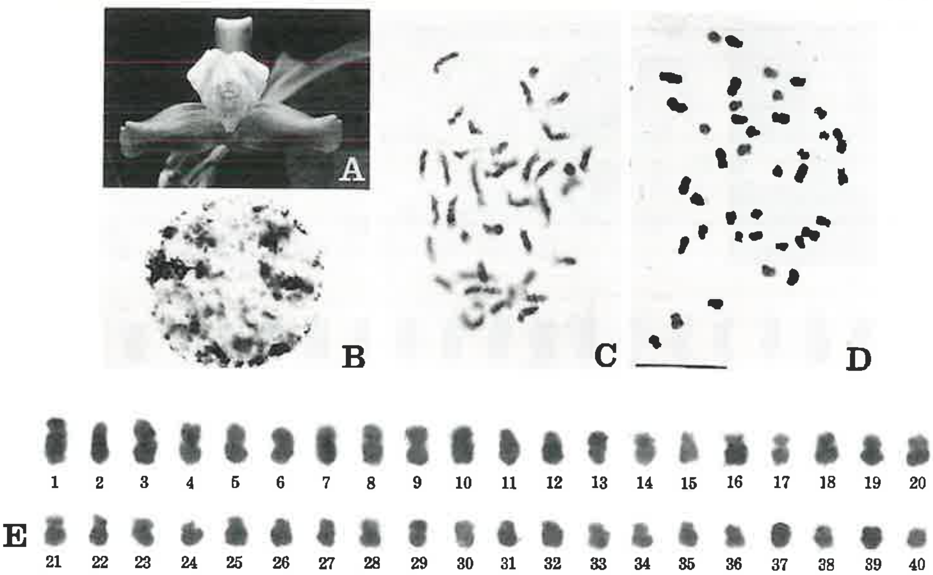

Fig. 10. *Lycaste macrophylla*, 2n=40. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 36 mm for A, 10 μm for B–D and 5 μm for E.

III. Section FIMBRIATAE

11. *Lycaste linguella* Rchb.f., 2n=48, Tables 1 and 12, Fig. 11.

One plant was obtained from Peru. Flowers were 5 cm wide across. Petals were pale green in color. Sepals and lips were creamy white. Lips had a broad callus.

The chromosome number of the plant of this species was 2n=48 at mitotic metaphase, which was recorded here for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

The 2n=48 chromosome complement at mitotic metaphase in this species consisted of two groups of chromosomes; two large chromosomes of 4.75 μm and 4.35 μm and 46 small chromosomes which showed a gradual decrease in chromosome length from 3.15 to 1.50 μm. Among the 48 chromosomes, 14 were median with arm ratios between 1.1 and 1.6, 29 submedian with arm ratios between 1.8 and 2.9, and three (Nos. 4, 25–26) subterminal with arm ratios between 3.3 and 6.6. The centromeres of rest two chromosomes were not observed. Two chromosomes (Nos. 33–34) had a secondary constriction on their short arms, and formed small satellites.

The karyotype of this species was heterogeneous and bimodal in length and symmetric in arm ratio.

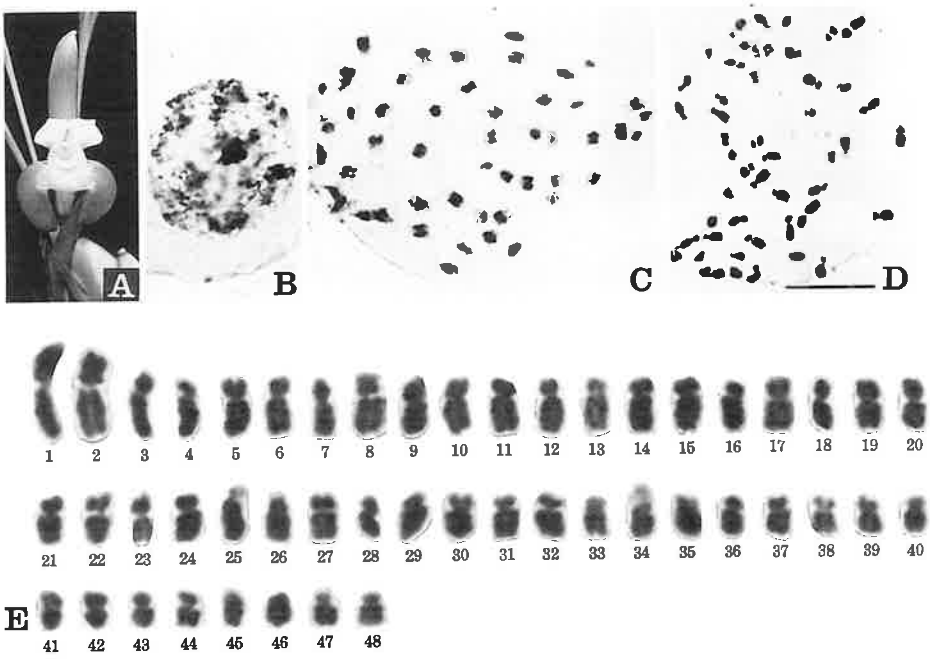

Fig. 11. *Lycaste linguella*, 2n=48. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 31 mm for A, 10 μm for B–D and 5 μm for E.

12. *Lycaste locusta* Rchb. f., 2n=48, Tables 1 and 13, Fig. 12.

One plant was obtained from Peru. Flowers were 8 cm wide across. Petals and sepals were pale green in color. Lips were dark green with a white bearded margin.

The chromosome number of the plant of this species was 2n=48 at mitotic metaphase, which was recorded here for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of 2n=48 at mitotic metaphase showed a gradual decrease in length from the longest (1.95 μm) to the shortest (0.95 μm) chromosomes. Among the 48 chromosomes, 27 were median with arm ratios between 1.0 and 1.7, seven (Nos. 1, 4, 7–8, 12, 21, 32) submedian with arm ratios between 1.9 and 2.8, and ten (Nos. 3, 9–11, 19–20, 27–30) subterminal with arm ratios between 3.2 and 5.2. The centromeres of rest four chromosomes were not observed.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

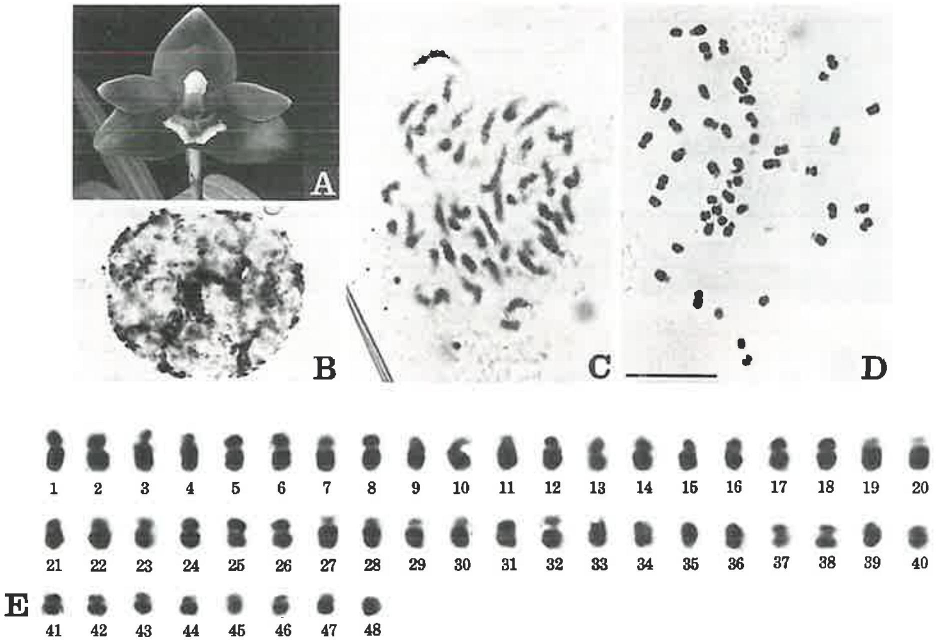

Fig. 12. *Lycaste locusta*, 2n = 48. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 37 mm for A, 10 μm for B–D and 5 μm for E.

13. *Lycaste denningiana* Rchb.f., 2n=50, Tables 1 and 14, Fig. 13.

Two plants were obtained from Peru. The plants have not yet bloomed in our garden.

The chromosome number of two plants of this species was 2n=50 at mitotic metaphase, which was recorded here for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

The 2n = 50 chromosomes at mitotic metaphase gradually decreased in length from the longest (2.60 μm) to the shortest (1.20 μm) chromosomes. Among the 50 chromosomes in the complement, 22 were median with arm ratios between 1.0 and 1.7, nine (Nos. 3–4, 11–12, 15–16, 21, 31–32) submedian with arm ratios between 1.9 and 2.6, and three (Nos. 7–8, 33) subterminal with arm ratios between 3.4 and 3.8. The centromeres of other 16 chromosomes were not observed.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

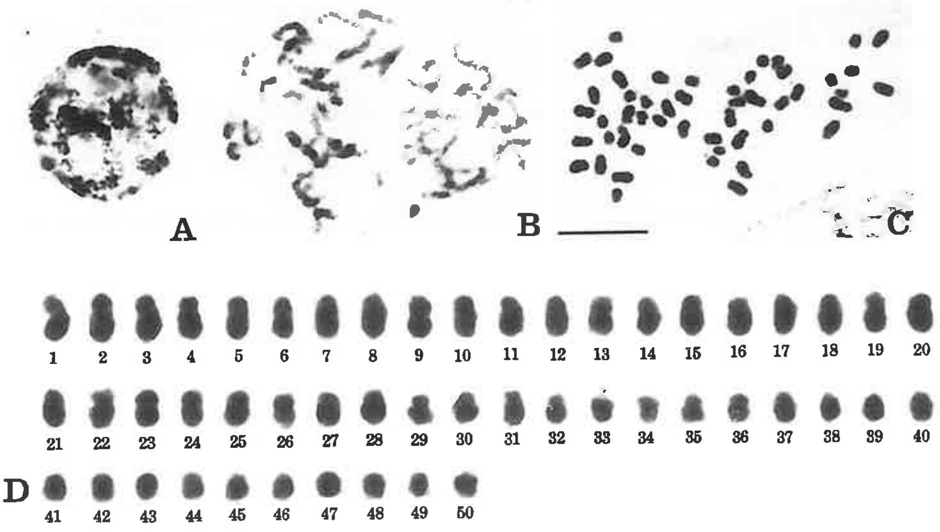

Fig. 13. *Lycaste denningiana*, 2n = 50. A, chromosomes at resting stage. B, chromosomes at mitotic prophase. C and D, chromosomes at mitotic metaphase. Bar indicates 10 μm for A–C and 5 μm for D.

14. ***Lycaste barringtoniae*** **(Smith) Lindl., 2n=44, Tables 1 and 15, Fig. 14.**

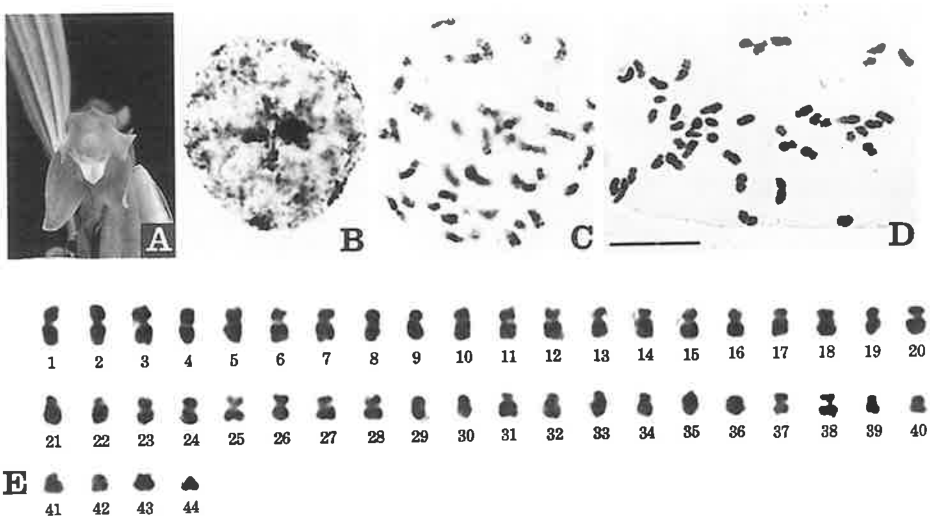

Fig. 14. *Lycaste barringtoniae*, 2n=44. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 26 mm for A, 10 μm for B–D and 5 μm for E.

One plant was obtained from Jamaica. Flowers were 6 cm wide across. Petals and sepals were pale yellowish green in color. Lips were pale brown with bearded margin.

The chromosome number of the plant of this species was 2n = 44 at mitotic metaphase, which was recorded here for the first time.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

The 2n = 44 chromosomes at mitotic metaphase in this species gradually decreased in length from the longest (2.25 μm) to the shortest (0.80 μm) chromosomes. Among the 44 chromosomes, 36 were median with arm ratios between 1.1 and 1.7, and four (Nos. 21–22, 31–32) submedian with arm ratios between 2.1 and 2.6. The centromeres of rest four chromosomes were not observed.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

15. *Lycaste ciliata* (Ruiz et Pavon) Lindl. ex Rchb.f., 2n = 44, Tables 1 and 16, Fig. 15.

One plant was obtained from Peru. Flowers were 7 cm wide across. Petals and sepals were pale brown in color. Bearded lips were creamy white.

The chromosome number of the plant of this species was 2n = 44 at mitotic metaphase, which was recorded here for the first time.

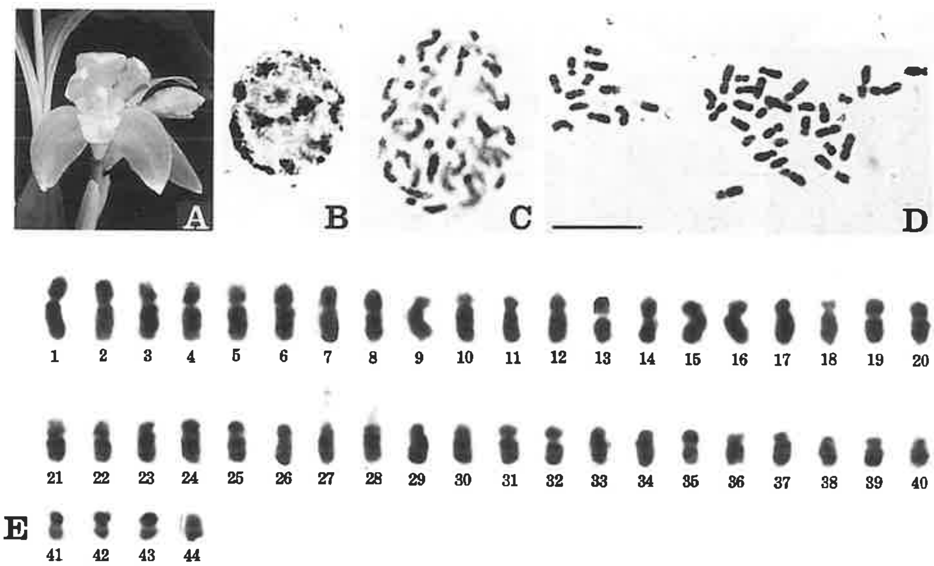

Fig. 15. *Lycaste ciliata*, 2n = 44. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 41 mm for A, 10 μm for B–D and 5 μm for E.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

The 2n = 44 chromosomes at mitotic metaphase gradually decreased in length from the longest (3.40 μm) to the shortest (1.35 μm) chromosomes. Among the 44 chromosomes, 16 were median with arm ratios between 1.0 and 1.7, 19 (Nos. 2–5, 11–12, 15–17, 25–26, 29–31, 33–34, 38–40) submedian with arm ratios between 1.8 and 2.8, and nine (Nos. 9–10, 18, 23–24, 27–28, 36–37) subterminal with arm ratios between 3.2 and 5.0. Two chromosomes (Nos. 27–28) had a secondary constriction on their short arms, and formed small satellites.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

16. *Lycaste dyeriana* Sander ex Rolfe, 2n=48, Tables 1 and 17, Fig. 16.

One plant was obtained from Peru. Flowers were pendulous and 5 cm wide across. Petals and sepals were green in color. Lips were pale green with ciliated margin.

The chromosome number of the plant of this species was 2n = 48 at mitotic metaphase, which was recorded here for the first time.

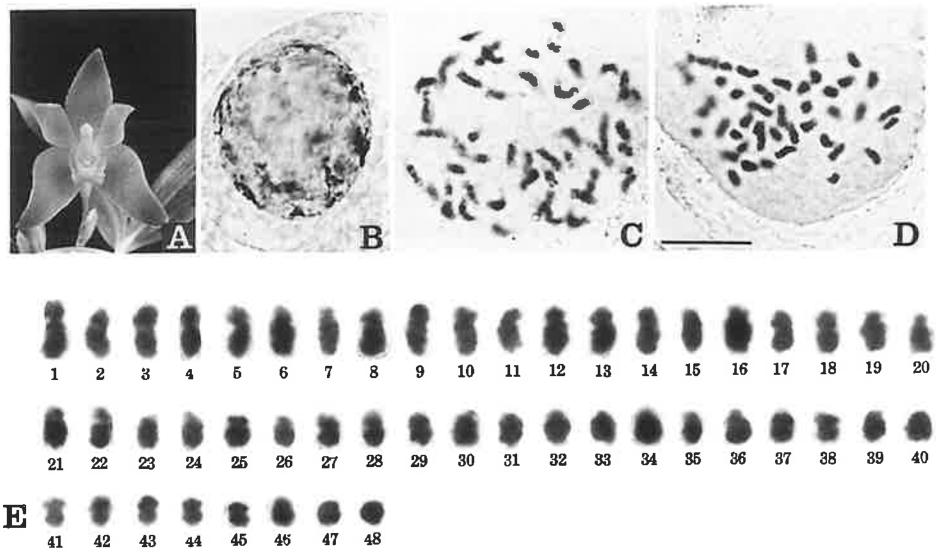

Fig. 16. *Lycaste dyeriana*, 2n = 48. A, a flower. B, chromosomes at resting stage. C. chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 36 mm for A, 10 μm for B–D and 5 μm for E.

The chromosomes at resting stage and mitotic prophase were similar in morphology to those of *L. brevispatha* described above. The chromosome features at resting stage were of the complex chromocenter type.

The 2n=48 chromosomes at mitotic metaphase gradually decreased in length from the longest (3.00 μm) to the shortest (1.20 μm) chromosomes. Among the 48 chromosomes, 17 were median with arm ratios between 1.0 and 1.7, 17 (Nos. 1–2, 6, 9–16, 19–22, 25–26) submedian with arm ratios between 1.8 and 3.0, and seven (Nos. 7–8, 32–36) subterminal with arm ratios between 3.2 and 4.0. The centromeres of rest seven chromosomes were not observed.

The karyotype of this species was homogeneous and gradual in length and symmetric in arm ratio.

Discussion

1. Karyomorphological characteristics of the genus *Lycaste*

In the present observations, resting chromosomes of 16 species of *Lycaste* studied contained chromomeric granules, fibrous threads and chromatin blocks which varied in number from 15 to 20 per nucleus. Those chromosome features at resting stage were of the complex chromocenter type proposed by Tanaka (1971). The chromosomes at mitotic prophase of 16 species formed early condensed segments at the interstitial regions of both arms. The late condensed segments were located in the distal and proximal regions of the chromosomes.

The chromosome numbers of 14 species studied were recorded here for the first time; 2n=40 for *L. brevispatha, L. tricolor, L. deppei, L. cruenta, L. campbellii, L.bradeorum, L. dowiana* and *L. macrophylla*; 2n=44 for *L. barringtoniae* and *L. ciliata*; 2n=48 for *L. linguella, L. locusta* and *L. dyeriana*; 2n=50 for *L. denningiana*, and those of 2n=40 in *L. aromatica* and *L. virginalis* were reexamined.

According to the degrees of condensation of metaphase chromosomes, the average chromosome lengths were varied from 3.0 μm in *L. campbellii* to 1.3 μm in *L. brevispatha*. Among the 16 species studied, only *L. linguella* had two distinguishably large chromosomes and exhibited heterogenous and bimodal karyotype. The other 15 species showed homogeneous and gradual karyotype.

In five species, the centromeres of some chromosomes were not observed. Excepting those chromosomes, the average arm ratios in the complements at mitotic metaphase of *Lycaste* studied was 1.8. The average arm ratios of each species ranged from 2.3 in *L. ciliata* to 1.4 in *L. cruenta*. Thus, the 16 species showed a symmetric karyotype.

Secondary constrictions were observed in three species of *L. aromatica, L. linguella* and *L. ciliata*. They located near the distal regions of short arms, and their satellites were small in size. Light-stained satellites were observed on two prophase chromosomes of *L. dowiana*, however, they were not observed at metaphase. Thus, it is considered that the satellites of *Lycaste* were hardly observed at mitotic metaphase.

2. Cytotaxonomical investigations of the genus *Lycaste*

The genus *Lycaste* has been classified into four sections by Fowlie (1970); Deciduosae, Macrophyllae, Longisepalae and Fimbriatae. Then, he proposed that the former three sections were closely related with the genus *Anguloa*, while section Fimbriatae were more distantly related with *Anguloa* than the other three sections. Moreover, he proposed that *L. dyeriana* should be situated in the genus *Bifrenaria*.

All of the seven species belonging to the section Deciduosae studied had the $2n=40$ chromosome number and their karyotypes were gradual and homogeneous in length and symmetric in arm ratio.

Three species belonging to the section Macrophyllae also had the $2n=40$ chromosomes number and their karyotypes were gradual and homogeneous in length and symmetric in arm ratio.

The chromosome numbers of five species belonging to the section Fimbriatae were difference from those of former two sections. In this studies, the chromosome number of $2n=44$ was observed in *L. barringtoniae* and *L. ciliata*, $2n=48$ in *L.linguella* and *L. locusta* and $2n=50$ in *L. denningiana*. The centromeres of some chromosomes of four species of the section Fimbriatae were not observed. If those chromosomes were terminal in centromeric position, it was seemed that the aneuploidy of this section was caused by the centric fission of median chromosomes. Moreover, the existance of the large chromosomes in *L. linguella* suggested the structural changes of chromosomes.

The chromosome number of $2n=48$ and karyotypes at resting stage, mitotic prophase and metaphase of *L. dyeriana* which was treated as being the genus *Bifrenaria* by Fowlie (1970) were closely similar to those of two species of the section Fimbriatae. The chromosome number of *B. harrisoniae* was reported to be $2n=38$ (Tanaka 1962, Aoyama and Tanaka 1980), and other three species of *Bifrenaria* had same chromosome number of $2n=38$ (Aoyama unpublished). Thus, *L. dyeriana* should be treated as being the section Fimbriatae of the genus *Lycaste*.

The karyomorphological features of 16 species studied were corresponded to the sectional classification by Fowlie (1970), allthougt the section Longisepalae was not observed in the present study. Particularly, the section Fimbriatae was characterized by hyperploidy, and regarded as being monophyletic group differentiated by centric fission and structural changes of chromosomes.

Summary

1. Karyomorphological investigations were carried out in 16 species of the genus *Lycaste*.
2. The chromosome numbers of 14 species were newly reported; $2n=40$ for *L. brevispatha, L. tricolor, L. deppei, L. cruenta, L. campbellii, L. bradeorum, L. dowiana* and *L. macrophylla*; $2n=44$ for *L. barringtoniae* and *L. ciliata*; $2n=48$ for *L. linguella, L. locusta* and *L. dyeriana*; $2n=50$ for *L. denningiana*, and those of $2n=40$ in *L. aromatica* and *L. virginalis* were reexamined.

3. The chromosomes of all species studied at resting stage were the complex chromocenter type (Tanaka 1971).
4. At mitotic metaphase, karyotypes of 15 species were homogeneous and gradual in length and symmetric in arm ratio, while that of *L. linguella* had two large chromosomes and was heterogeneous and bimodal in length and symmetric in arm ratio.
5. Most species with the chromosome numbers of 2n=44, 48 and 50 had some chromosomes of which position of centromere was not determined and considered to be terminal in centromeric position. Therefore, it is seemed that the aneuploidy of *Lycaste* was caused by the centric fission and structural changes of chromosomes.
6. The karyomorphological features of 16 species of *Lycaste* studied corresponded to each sections classified by Fowlie (1970). *L. dyeriana* which was placed in the genus *Bifrenaria* by Fowlie was closely similar to the section Fimbriatae of the genus *Lycaste* karyomorphologically.

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Table 2. Measurements of somatic chromosomes of *Lycaste brevispatha*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.00+1.05=2.05	2.8	1.0	m
2	0.95+1.10=2.05	2.8	1.1	m
3	0.95+1.00=1.95	2.7	1.0	m
4	0.95+0.95=1.90	2.6	1.0	m
5	0.90+0.90=1.80	2.5	1.0	m
6	0.80+0.95=1.75	2.4	1.1	m
7	0.80+0.95=1.75	2.4	1.1	m
8	0.80+0.90=1.70	2.3	1.1	m
9	0.70+0.90=1.60	2.2	1.2	m
10	0.70+0.85=1.55	2.1	1.2	m
11	0.55+0.95=1.50	2.1	1.7	m
12	0.55+0.95=1.50	2.1	1.7	m
13	0.65+0.80=1.45	2.0	1.2	m
14	0.65+0.75=1.40	1.9	1.1	m
15	0.70+0.70=1.40	1.9	1.0	m
16	0.60+0.70=1.30	1.8	1.1	m
17	0.45+0.80=1.25	1.7	1.7	m
18	0.45+0.80=1.25	1.7	1.7	m
19	0.45+0.80=1.25	1.7	1.7	m
20	0.45+0.80=1.25	1.7	1.7	m
21	0.45+0.80=1.25	1.7	1.7	m
22	0.45+0.80=1.25	1.7	1.7	m
23	0.40+0.80=1.20	1.6	2.0	sm
24	0.40+0.80=1.20	1.6	2.0	sm
25	0.50+0.70=1.20	1.6	1.4	m
26	0.50+0.70=1.20	1.6	1.4	m
27	0.50+0.70=1.20	1.6	1.4	m
28	0.50+0.70=1.20	1.6	1.4	m
29	0.45+0.70=1.15	1.6	1.5	m
30	0.45+0.70=1.15	1.6	1.5	m
31	0.40+0.70=1.10	1.5	1.7	m
32	0.40+0.70=1.10	1.5	1.7	m
33	0.35+0.75=1.10	1.5	2.1	sm
34	0.35+0.75=1.10	1.5	2.1	sm
35	0.30+0.75=1.05	1.4	2.5	sm
36	0.30+0.75=1.05	1.4	2.5	sm
37	0.40+0.45=0.85	1.2	1.1	m
38	0.40+0.45=0.85	1.2	1.1	m
39	0.35+0.35=0.70	1.0	1.0	m
40	0.30+0.40=0.70	1.0	1.3	m

Table 3. Measurements of somatic chromosomes of *Lycaste tricolor*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.85+1.50=2.35	3.6	1.7	m
2	0.80+1.45=2.25	3.4	1.8	sm
3	1.05+1.20=2.25	3.4	1.1	m
4	1.00+1.20=2.20	3.4	1.2	m
5	0.95+1.20=2.15	3.3	1.2	m
6	1.00+1.15=2.15	3.3	1.1	m
7	0.80+1.20=2.00	3.1	1.5	m
8	0.80+1.20=2.00	3.1	1.5	m
9	0.60+1.35=1.95	3.0	2.2	sm
10	0.55+1.40=1.95	3.0	2.5	sm
11	0.50+1.30=1.80	2.7	2.6	sm
12	0.45+1.35=1.80	2.7	3.0	sm
13	0.85+0.95=1.80	2.7	1.0	m
14	0.75+1.05=1.80	2.7	1.4	m
15	0.35+1.35=1.70	2.6	3.8	st
16	0.35+1.35=1.70	2.6	3.8	st
17	0.70+1.00=1.70	2.6	1.4	m
18	0.60+1.10=1.70	2.6	1.8	sm
19	0.80+0.90=1.70	2.6	1.1	m
20	0.75+0.90=1.65	2.5	1.2	m
21	0.60+1.05=1.65	2.5	1.7	m
22	0.60+1.00=1.60	2.4	1.6	m
23	0.75+0.75=1.50	2.3	1.0	m
24	0.70+0.80=1.50	2.3	1.1	m
25	0.50+1.00=1.50	2.3	2.0	sm
26	0.45+1.00=1.45	2.2	2.2	sm
27	0.45+0.95=1.40	2.1	2.1	sm
28	0.45+0.95=1.40	2.1	2.1	sm
29	0.50+0.90=1.40	2.1	1.8	sm
30	0.55+0.85=1.40	2.1	1.5	m
31	0.55+0.80=1.35	2.1	1.4	m
32	0.55+0.80=1.35	2.1	1.4	m
33	0.45+0.90=1.35	2.1	2.0	sm
34	0.40+0.95=1.35	2.1	2.3	sm
35	0.55+0.65=1.20	1.8	1.1	m
36	0.55+0.65=1.20	1.8	1.1	m
37	0.50+0.65=1.15	1.8	1.3	m
38	0.50+0.65=1.15	1.8	1.3	m
39	0.45+0.60=1.05	1.6	1.3	m
40	0.35+0.65=1.00	1.5	1.8	sm

Table 4. Measurements of somatic chromosomes of *Lycaste deppei*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.35+1.40=2.75	3.3	1.0	m
2	1.35+1.40=2.75	3.3	1.0	m
3	1.25+1.50=2.75	3.3	1.2	m
4	1.25+1.35=2.60	3.1	1.0	m
5	1.25+1.35=2.60	3.1	1.0	m
6	1.25+1.35=2.60	3.1	1.0	m
7	1.25+1.35=2.60	3.1	1.0	m
8	1.15+1.45=2.60	3.1	1.2	m
9	1.25+1.30=2.55	3.0	1.0	m
10	1.25+1.30=2.55	3.0	1.0	m
11	1.15+1.35=2.50	3.0	1.1	m
12	1.15+1.35=2.50	3.0	1.1	m
13	0.85+1.50=2.35	2.8	1.7	m
14	0.80+1.50=2.30	2.7	1.8	sm
15	0.55+1.60=2.15	2.6	2.9	sm
16	0.50+1.60=2.10	2.5	3.2	st
17	0.60+1.45=2.05	2.4	2.4	sm
18	0.60+1.45=2.05	2.4	2.4	sm
19	0.60+1.45=2.05	2.4	2.4	sm
20	0.65+1.40=2.05	2.4	2.1	sm
21	0.90+1.15=2.05	2.4	1.2	m
22	0.85+1.20=2.05	2.4	1.4	m
23	0.80+1.20=2.00	2.4	1.5	m
24	0.75+1.25=2.00	2.4	1.6	m
25	0.80+1.20=2.00	2.4	1.5	m
26	0.80+1.15=1.95	2.3	1.4	m
27	0.85+1.05=1.90	2.3	1.2	m
28	0.90+0.95=1.85	2.2	1.0	m
29	0.45+1.40=1.85	2.2	3.1	st
30	0.45+1.40=1.85	2.2	3.1	st
31	0.55+1.30=1.85	2.2	2.3	sm
32	0.55+1.30=1.85	2.2	2.3	sm
33	0.70+1.15=1.85	2.2	1.6	m
34	0.70+1.15=1.85	2.2	1.6	m
35	0.75+0.95=1.70	2.0	1.2	m
36	0.70+0.90=1.60	1.9	1.2	m
37	0.55+0.85=1.40	1.7	1.5	m
38	0.50+0.85=1.35	1.6	1.7	m
39	0.60+0.70=1.30	1.5	1.1	m
40	0.55+0.65=1.20	1.2	1.1	m

Table 5. Measurements of somatic chromosomes of *Lycaste cruenta*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.15+1.50=2.65	3.8	1.3	m
2	1.15+1.45=2.60	3.7	1.2	m
3	1.10+1.35=2.45	3.5	1.2	m
4	1.10+1.30=2.40	3.4	1.1	m
5	1.05+1.30=2.35	3.3	1.2	m
6	1.05+1.25=2.30	3.3	1.1	m
7	1.05+1.15=2.20	3.1	1.0	m
8	1.00+1.15=2.15	3.1	1.1	m
9	1.00+1.15=2.15	3.1	1.1	m
10	0.80+1.35=2.15	3.1	1.6	m
11	0.90+1.10=2.00	2.8	1.2	m
12	0.85+1.05=1.90	2.7	1.2	m
13	0.80+1.05=1.85	2.6	1.3	m
14	0.85+0.95=1.80	2.6	1.1	m
15	0.80+1.00=1.80	2.6	1.2	m
16	0.85+0.95=1.80	2.6	1.1	m
17	0.65+1.15=1.80	2.6	1.7	m
18	0.65+1.15=1.80	2.6	1.7	m
19	0.60+1.10=1.70	2.4	1.8	sm
20	0.65+1.05=1.70	2.4	1.6	m
21	0.60+1.10=1.70	2.4	1.8	sm
22	0.55+1.10=1.65	2.3	2.0	sm
23	0.80+0.85=1.65	2.3	1.0	m
24	0.75+0.85=1.60	2.3	1.1	m
25	0.55+1.00=1.55	2.2	1.8	sm
26	0.55+1.00=1.55	2.2	1.8	sm
27	0.45+1.00=1.45	2.1	2.2	sm
28	0.45+1.00=1.45	2.1	2.2	sm
29	0.55+0.90=1.45	2.1	1.6	m
30	0.50+0.95=1.45	2.1	1.9	sm
31	0.50+0.95=1.45	2.1	1.9	sm
32	0.50+0.95=1.45	2.1	1.9	sm
33	0.60+0.85=1.45	2.1	1.4	m
34	0.60+0.85=1.45	2.1	1.4	m
35	0.50+0.90=1.40	2.0	1.8	sm
36	0.45+0.90=1.35	1.9	2.0	sm
37	0.65+0.65=1.30	1.8	1.0	m
38	0.60+0.65=1.25	1.8	1.0	m
39	0.55+0.60=1.15	1.6	1.0	m
40	0.50+0.60=1.10	1.6	1.2	m

Table 6. Measurements of somatic chromosomes of *Lycaste campbellii*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.75+2.50=4.25	3.5	1.4	m
2	1.80+2.35=4.15	3.4	1.3	m
3	1.75+2.10=3.85	3.2	1.2	m
4	1.70+2.10=3.80	3.2	1.2	m
5	1.65+2.10=3.75	3.1	1.2	m
6	1.70+2.00=3.70	3.1	1.1	m
7	1.25+2.30=3.55	2.9	1.8	sm
8	1.40+2.15=3.55	2.9	1.5	m
9	1.50+2.00=3.50	2.9	1.3	m
10	1.50+2.00=3.50	2.9	1.3	m
11	1.50+2.00=3.50	2.9	1.3	m
12	1.50+2.00=3.50	2.9	1.3	m
13	1.30+2.15=3.45	2.9	1.6	m
14	1.40+2.05=3.45	2.9	1.4	m
15	1.55+1.80=3.35	2.8	1.1	m
16	1.50+1.80=3.30	2.7	1.2	m
17	1.30+1.80=3.10	2.6	1.3	m
18	1.30+1.75=3.05	2.5	1.3	m
19	1.25+1.75=3.00	2.5	1.4	m
20	1.25+1.75=3.00	2.5	1.4	m
21	1.15+1.75=2.90	2.4	1.5	m
22	1.10+1.80=2.90	2.4	1.6	m
23	0.70+2.15=2.85	2.4	3.0	sm
24	0.75+2.10=2.85	2.4	2.8	sm
25	0.70+2.10=2.80	2.3	3.0	sm
26	0.75+2.05=2.80	2.3	2.7	sm
27	0.90+1.85=2.75	2.3	2.0	sm
28	1.15+1.60=2.75	2.3	1.3	m
29	1.05+1.65=2.70	2.2	1.5	m
30	1.05+1.65=2.70	2.2	1.5	m
31	0.85+1.55=2.40	2.0	1.8	sm
32	0.80+1.60=2.40	2.0	2.0	sm
33	0.90+1.50=2.40	2.0	1.6	m
34	0.75+1.60=2.35	2.0	2.1	sm
35	1.50+1.25=2.30	1.9	1.1	m
36	0.85+1.40=2.25	1.9	1.6	m
37	0.85+1.20=2.05	1.7	1.4	m
38	0.85+1.20=2.05	1.7	1.4	m
39	0.85+1.20=2.05	1.7	1.4	m
40	0.75+1.10=1.85	1.5	1.4	m

Table 7. Measurements of somatic chromosomes of *Lycaste aromatica*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.55+1.85=3.40	3.8	1.1	m
2	1.45+1.85=3.30	3.7	1.2	m
3	1.50+1.60=3.10	3.5	1.0	m
4	1.55+1.55=3.10	3.5	1.0	m
5	1.35+1.75=3.10	3.5	1.2	m
6	1.40+1.65=3.05	3.4	1.1	m
7	1.15+1.90=3.05	3.4	1.6	m
8	1.40+1.60=3.00	3.3	1.1	m
9	1.35+1.55=2.90	3.2	1.1	m
10	1.40+1.45=2.85	3.2	1.0	m
11	1.30+1.50=2.80	3.1	1.1	m
12	1.15+1.50=2.65	3.0	1.3	m
13	0.10+0.55+2.00=2.65*	3.0	3.0	sm
14	0.10+0.50+2.00=2.60*	2.9	3.3	st
15	1.25+1.35=2.60	2.9	1.0	m
16	1.00+1.35=2.35	2.6	1.3	m
17	0.85+1.45=2.30	2.6	1.7	m
18	0.45+1.85=2.30	2.6	4.1	st
19	0.65+1.55=2.20	2.5	2.3	sm
20	0.65+1.55=2.20	2.5	2.3	sm
21	0.55+1.55=2.10	2.3	2.8	sm
22	0.60+1.50=2.10	2.3	2.5	sm
23	0.55+1.50=2.05	2.3	2.7	sm
24	0.55+1.50=2.05	2.3	2.7	sm
25	0.55+1.40=1.95	2.2	2.5	sm
26	0.50+1.40=1.90	2.1	2.8	sm
27	0.75+1.15=1.90	2.1	1.5	m
28	0.85+1.00=1.85	2.1	1.1	m
29	0.65+1.10=1.75	2.0	1.6	m
30	0.70+1.00=1.70	1.9	1.4	m
31	0.70+1.00=1.70	1.9	1.4	m
32	0.60+1.05=1.65	1.8	1.7	m
33	0.60+1.05=1.65	1.8	1.7	m
34	0.60+1.00=1.60	1.8	1.6	m
35	0.35+1.25=1.60	1.8	3.5	st
36	0.30+1.20=1.50	1.7	4.0	st
37	0.55+0.80=1.35	1.5	1.4	m
38	0.55+0.75=1.30	1.5	1.3	m
39	0.50+0.75=1.25	1.4	1.5	m
40	0.50+0.70=1.20	1.3	1.4	m

* Chromosome with secondary constriction

Table 8. Measurements of somatic chromosomes of *Lycaste bradeorum*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.15+1.65=2.80	3.8	1.4	m
2	1.25+1.55=2.80	3.8	1.2	m
3	1.25+1.40=2.65	3.6	1.1	m
4	1.25+1.30=2.55	3.5	1.0	m
5	0.80+1.60=2.40	3.3	2.0	sm
6	0.75+1.50=2.25	3.1	2.0	sm
7	1.05+1.10=2.15	3.0	1.0	m
8	1.05+1.10=2.15	3.0	1.0	m
9	0.75+1.20=1.95	2.7	1.6	m
10	0.65+1.30=1.95	2.7	2.0	sm
11	0.65+1.30=1.95	2.7	2.0	sm
12	0.65+1.30=1.95	2.7	2.0	sm
13	0.95+1.00=1.95	2.7	1.0	m
14	0.95+1.00=1.95	2.7	1.0	m
15	0.90+1.00=1.90	2.6	1.1	m
16	0.90+1.00=1.90	2.6	1.1	m
17	0.80+1.10=1.90	2.6	1.3	m
18	0.70+1.15=1.85	2.5	1.6	m
19	0.60+1.20=1.80	2.5	2.0	sm
20	0.65+1.15=1.80	2.5	1.7	m
21	0.70+1.05=1.75	2.4	1.5	m
22	0.70+1.00=1.70	2.3	1.4	m
23	0.45+1.25=1.70	2.3	2.7	sm
24	0.45+1.25=1.70	2.3	2.7	sm
25	0.75+0.90=1.65	2.3	1.2	m
26	0.75+0.90=1.65	2.3	1.2	m
27	0.65+0.95=1.60	2.2	1.4	m
28	0.75+0.80=1.55	2.1	1.0	m
29	0.75+0.80=1.55	2.1	1.0	m
30	0.75+0.80=1.55	2.1	1.0	m
31	0.70+0.80=1.50	2.1	1.1	m
32	0.70+0.80=1.50	2.1	1.1	m
33	0.45+1.05=1.50	2.1	2.3	sm
34	0.40+1.10=1.50	2.1	2.7	sm
35	0.70+0.80=1.50	2.1	1.1	m
36	0.55+0.85=1.40	1.9	1.5	m
37	0.45+0.85=1.30	1.8	1.8	sm
38	0.35+0.95=1.30	1.8	2.7	sm
39	0.50+0.65=1.15	1.6	1.3	m
40	0.50+0.60=1.10	1.5	1.2	m

Table 9. Measurements of somatic chromosomes of *Lycaste dowiana*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.55+1.90=3.45	4.0	1.2	m
2	1.60+1.80=3.40	3.9	1.1	m
3	1.10+1.75=2.85	3.3	1.5	m
4	1.35+1.50=2.85	3.3	1.1	m
5	0.95+1.85=2.80	3.3	1.9	sm
6	0.80+1.80=2.60	3.0	2.2	sm
7	1.25+1.30=2.55	3.0	1.0	m
8	1.25+1.30=2.55	3.0	1.0	m
9	0.85+1.60=2.45	2.8	1.8	sm
10	0.75+1.70=2.45	2.8	2.2	sm
11	0.80+1.65=2.45	2.8	2.0	sm
12	0.75+1.60=2.35	2.7	2.1	sm
13	0.85+1.50=2.35	2.7	1.7	m
14	0.75+1.55=2.30	2.7	2.0	sm
15	1.00+1.25=2.25	2.6	1.2	m
16	0.95+1.25=2.20	2.6	1.3	m
17	0.80+1.40=2.20	2.6	1.7	m
18	0.85+1.25=2.10	2.4	1.4	m
19	0.65+1.40=2.05	2.4	2.1	sm
20	0.65+1.35=2.00	2.3	2.0	sm
21	0.75+1.25=2.00	2.3	1.6	m
22	0.65+1.30=1.95	2.3	2.0	sm
23	0.90+1.05=1.95	2.3	1.1	m
24	0.95+1.00=1.95	2.3	1.0	m
25	0.90+1.05=1.95	2.3	1.1	m
26	0.65+1.30=1.95	2.3	2.0	sm
27	0.65+1.30=1.95	2.3	2.0	sm
28	0.60+1.30=1.90	2.2	2.1	sm
29	0.65+1.20=1.85	2.1	1.8	sm
30	0.80+1.05=1.85	2.1	1.3	m
31	0.80+1.00=1.80	2.1	1.2	m
32	0.75+1.00=1.75	2.0	1.3	m
33	0.70+1.05=1.75	2.0	1.5	m
34	0.55+1.15=1.70	2.0	2.0	sm
35	0.75+0.90=1.65	1.9	1.2	m
36	0.75+0.90=1.65	1.9	1.2	m
37	0.50+1.15=1.65	1.9	2.3	sm
38	0.55+1.05=1.60	1.9	1.9	sm
39	0.65+0.90=1.55	1.8	1.3	m
40	0.65+0.85=1.50	1.7	1.3	m

Table 10. Measurements of somatic chromosomes of *Lycaste virginalis*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.20+1.50=2.70	3.7	1.2	m
2	1.05+1.60=2.65	3.6	1.5	m
3	1.10+1.50=2.60	3.5	1.3	m
4	1.15+1.35=2.50	3.4	1.1	m
5	1.05+1.40=2.45	3.3	1.3	m
6	1.00+1.40=2.40	3.3	1.4	m
7	1.00+1.30=2.30	3.1	1.3	m
8	1.05+1.15=2.20	3.0	1.0	m
9	1.00+1.20=2.20	3.0	1.2	m
10	0.95+1.25=2.20	3.0	1.3	m
11	0.75+1.35=2.10	2.8	1.8	sm
12	0.65+1.40=2.05	2.8	2.1	sm
13	0.75+1.25=2.00	2.7	1.6	m
14	0.75+1.25=2.00	2.7	1.6	m
15	1.00+1.00=2.00	2.7	1.0	m
16	0.75+1.20=1.95	2.6	1.6	m
17	0.90+1.05=1.95	2.6	1.1	m
18	0.90+1.00=1.90	2.6	1.1	m
19	0.25+1.65=1.90	2.6	6.6	st
20	0.45+1.40=1.85	2.5	3.1	st
21	0.60+1.20=1.80	2.4	2.0	sm
22	0.55+1.20=1.75	2.4	2.1	sm
23	0.85+0.90=1.75	2.4	1.0	m
24	0.80+0.90=1.70	2.3	1.1	m
25	0.50+1.15=1.65	2.2	2.3	sm
26	0.50+1.10=1.60	2.2	2.2	sm
27	0.75+0.85=1.60	2.2	1.1	m
28	0.75+0.80=1.55	2.1	1.0	m
29	0.55+1.00=1.55	2.1	1.8	sm
30	0.60+0.95=1.55	2.1	1.5	m
31	0.35+1.20=1.55	2.1	3.4	st
32	0.35+1.20=1.55	2.1	3.4	st
33	0.45+1.05=1.50	2.0	2.3	sm
34	0.55+0.85=1.40	1.9	1.5	m
35	0.55+0.85=1.40	1.9	1.5	m
36	0.35+1.00=1.35	1.8	2.8	sm
37	0.35+0.90=1.25	1.7	2.5	sm
38	0.55+0.65=1.20	1.6	1.1	m
39	0.50+0.60=1.10	1.5	1.2	m
40	0.45+0.60=1.05	1.4	1.3	m

Table 11. Measurements of somatic chromosomes of *Lycaste macrophylla*, 2n=40 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.60+1.85=2.45	3.7	3.0	sm
2	0.55+1.70=2.25	3.4	3.0	sm
3	1.05+1.20=2.25	3.4	1.1	m
4	1.10+1.15=2.25	3.4	1.0	m
5	1.10+1.10=2.20	3.4	1.0	m
6	1.05+1.10=2.15	3.3	1.0	m
7	0.85+1.25=2.10	3.2	1.4	m
8	0.85+1.25=2.10	3.2	1.4	m
9	1.05+1.05=2.10	3.2	1.0	m
10	0.90+1.20=2.10	3.2	1.3	m
11	0.55+1.35=1.90	2.9	2.4	sm
12	0.55+1.25=1.80	2.7	2.2	sm
13	0.65+1.15=1.80	2.7	1.7	m
14	0.65+1.10=1.75	2.7	1.6	m
15	0.50+1.15=1.65	2.5	2.3	sm
16	0.45+1.20=1.65	2.5	2.6	sm
17	0.70+0.90=1.60	2.4	1.2	m
18	0.65+0.90=1.55	2.4	1.3	m
19	0.70+0.85=1.55	2.4	1.2	m
20	0.70+0.85=1.55	2.4	1.2	m
21	0.60+0.95=1.55	2.4	1.5	m
22	0.55+1.00=1.55	2.4	1.8	sm
23	0.55+1.00=1.55	2.4	1.8	sm
24	0.50+1.05=1.55	2.4	2.1	sm
25	0.45+1.05=1.50	2.3	2.3	sm
26	0.45+1.00=1.45	2.2	2.2	sm
27	0.55+0.85=1.40	2.1	1.5	m
28	0.55+0.85=1.40	2.1	1.5	m
29	0.60+0.80=1.40	2.1	1.3	m
30	0.60+0.80=1.40	2.1	1.3	m
31	0.45+0.90=1.35	2.1	2.0	sm
32	0.35+0.95=1.30	2.0	2.7	sm
33	0.50+0.80=1.30	2.0	1.6	m
34	0.60+0.70=1.30	2.0	1.4	m
35	0.50+0.75=1.25	1.9	1.5	m
36	0.50+0.65=1.15	1.8	1.3	m
37	0.50+0.65=1.15	1.8	1.3	m
38	0.50+0.65=1.15	1.8	1.3	m
39	0.45+0.65=1.10	1.7	1.4	m
40	0.45+0.55=1.00	1.5	1.2	m

Table 12. Measurements of somatic chromosomes of *Lycaste linguella*, 2n=48 at mctaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.05+2.70=4.75	2.4	1.3	m
2	1.85+2.50=4.35	2.2	1.3	m
3	0.85+2.30=3.15	1.6	2.7	sm
4	0.65+2.15=2.80	1.4	3.3	st
5	0.85+1.95=2.80	1.4	2.2	sm
6	0.85+1.95=2.80	1.4	2.2	sm
7	1.00+1.80=2.80	1.4	1.8	sm
8	0.90+1.85=2.75	1.4	2.0	sm
9	0.90+1.75=2.65	1.3	1.9	sm
10	0.90+1.75=2.65	1.3	1.9	sm
11	0.70+1.90=2.60	1.3	2.7	sm
12	0.70+1.90=2.60	1.3	2.7	sm
13	0.65+1.85=2.50	1.3	2.8	sm
14	0.65+1.85=2.50	1.3	2.8	sm
15	0.65+1.85=2.50	1.3	2.8	sm
16	0.65+1.80=2.45	1.2	2.7	sm
17	1.00+1.45=2.45	1.2	1.4	m
18	1.05+1.40=2.45	1.2	1.3	m
19	1.05+1.35=2.40	1.2	1.2	m
20	1.10+1.30=2.40	1.2	1.1	m
21	0.80+1.50=2.30	1.2	1.8	sm
22	0.80+1.50=2.30	1.2	1.8	sm
23	0.95+1.35=2.30	1.2	1.4	m
24	0.75+1.55=2.30	1.2	2.0	sm
25	0.30+2.00=2.30	1.2	6.6	st
26	0.35+1.90=2.25	1.1	5.4	st
27	0.70+1.45=2.15	1.1	2.0	sm
28	0.85+1.30=2.15	1.1	1.5	m
29	0.60+1.45=2.05	1.0	2.4	sm
30	0.60+1.45=2.05	1.0	2.4	sm
31	0.55+1.45=2.00	1.0	2.6	sm
32	0.50+1.45=1.95	1.0	2.9	sm
33	0.70+1.15=1.85*	0.9	1.6	m
34	0.70+1.15=1.85*	0.9	1.6	m
35	0.65+1.20=1.85	0.9	1.8	sm
36	0.65+1.20=1.85	0.9	1.8	sm
37	0.55+1.25=1.80	0.9	2.2	sm
38	0.55+1.20=1.75	0.9	2.1	sm
39	0.60+1.15=1.75	0.9	1.9	sm
40	0.60+1.15=1.75	0.9	1.9	sm
41	0.75+1.00=1.75	0.9	1.3	m
42	0.75+1.00=1.75	0.9	1.3	m

Table 12. (continued)

43	0.70+1.00=1.70	0.9	1.4	m
44	0.60+1.00=1.60	0.8	1.6	m
45**	1.60	0.8		
46**	1.60	0.8		
47	0.55+1.00=1.55	0.8	1.8	sm
48	0.50+1.00=1.50	0.8	2.0	sm

* Chromosome with secondary constriction
** The centromere was not observed.

Table 13. Measurements of somatic chromosomes of *Lycaste locusta*, 2n=48 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	0.65+1.30=1.95	2.8	2.0	sm
2	0.80+1.10=1.90	2.7	1.3	m
3	0.45+1.45=1.90	2.7	3.2	st
4	0.50+1.40=1.90	2.7	2.8	sm
5	0.70+1.15=1.85	2.6	1.6	m
6	0.75+1.10=1.85	2.6	1.4	m
7	0.55+1.20=1.75	2.5	2.1	sm
8	0.60+1.15=1.75	2.5	1.9	sm
9	0.35+1.40=1.75	2.5	4.0	st
10	0.35+1.40=1.75	2.5	4.0	st
11	0.35+1.40=1.75	2.5	4.0	st
12	0.50+1.20=1.70	2.4	2.4	sm
13	0.75+0.90=1.65	2.3	1.2	m
14	0.70+0.90=1.60	2.3	1.2	m
15	0.60+0.95=1.55	2.2	1.5	m
16	0.65+0.90=1.55	2.2	1.3	m
17	0.65+0.90=1.55	2.2	1.3	m
18	0.60+0.95=1.55	2.2	1.5	m
19	0.25+1.30=1.55	2.2	5.2	st
20	0.25+1.25=1.50	2.1	5.0	st
21	0.50+1.00=1.50	2.1	2.0	sm
22	0.55+0.95=1.50	2.1	1.7	m
23	0.55+0.95=1.50	2.1	1.7	m
24	0.65+0.85=1.50	2.1	1.3	m
25	0.70+0.80=1.50	2.1	1.1	m
26	0.65+0.85=1.50	2.1	1.3	m
27	0.30+1.20=1.50	2.1	4.0	st

Table 13. (continued)

28	0.30+1.20=1.50	2.1	4.0	st
29	0.35+1.15=1.50	2.1	3.2	st
30	0.30+1.15=1.45	2.1	3.8	st
31	0.65+0.75=1.40	2.0	1.1	m
32	0.40+1.00=1.40	2.0	2.5	sm
33	0.55+0.75=1.30	1.8	1.3	m
34	0.55+0.75=1.30	1.8	1.3	m
35*	1.25	1.8		
36*	1.25	1.8		
37	0.60+0.65=1.25	1.8	1.0	m
38	0.55+0.70=1.25	1.8	1.2	m
39	0.55+0.70=1.25	1.8	1.2	m
40	0.55+0.65=1.20	1.7	1.1	m
41	0.55+0.60=1.15	1.6	1.0	m
42	0.50+0.60=1.10	1.6	1.2	m
43	0.50+0.60=1.10	1.6	1.2	m
44	0.45+0.60=1.05	1.5	1.3	m
45	0.40+0.60=1.00	1.4	1.5	m
46	0.40+0.60=1.00	1.4	1.5	m
47*	1.00	1.4		
48*	0.95	1.3		

* The centromere was not observed.

Table 14. Measurements of somatic chromosomes of *Lycaste denningiana*, 2n=50 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.00+1.60=2.60	2.9	1.6	m
2	0.95+1.65=2.60	2.9	1.7	m
3	0.75+1.65=2.40	2.7	2.2	sm
4	0.75+1.55=2.30	2.6	2.0	sm
5	0.85+1.35=2.20	2.5	1.5	m
6	1.00+1.20=2.20	2.5	1.2	m
7	0.50+1.70=2.20	2.5	3.4	st
8	0.50+1.70=2.20	2.5	3.4	st
9	1.05+1.15=2.20	2.5	1.0	m
10	0.95+1.20=2.15	2.4	1.2	m
11	0.65+1.45=2.10	2.4	2.2	sm
12	0.70+1.35=2.05	2.3	1.9	sm
13	0.95+1.10=2.05	2.3	1.1	m
14	0.90+1.15=2.05	2.3	1.2	m

Table 14. (continued)

15	0.70+1.35=2.05	2.3	1.9	sm
16	0.55+1.45=2.00	2.3	2.6	sm
17*	2.00	2.3		
18*	2.00	2.3		
19	0.85+1.15=2.00	2.3	1.3	m
20	0.80+1.20=2.00	2.3	1.5	m
21	0.65+1.30=1.95	2.2	2.0	sm
22	0.70+1.25=1.95	2.2	1.7	m
23	0.90+1.05=1.95	2.2	1.1	m
24	0.85+1.05=1.90	2.1	1.2	m
25	0.85+1.00=1.85	2.1	1.1	m
26	0.85+0.90=1.75	2.0	1.0	m
27	0.75+0.95=1.70	1.9	1.2	m
28	0.70+1.00=1.70	1.9	1.4	m
29	0.70+0.95=1.65	1.9	1.3	m
30	0.65+0.95=1.60	1.8	1.4	m
31	0.55+1.05=1.60	1.8	1.9	sm
32	0.50+1.00=1.50	1.7	2.0	sm
33	0.30+1.15=1.45	1.6	3.8	st
34	0.60+0.80=1.40	1.6	1.3	m
35	0.60+0.80=1.40	1.6	1.3	m
36	0.60+0.80=1.40	1.6	1.3	m
37*	1.40	1.6		
38*	1.40	1.6		
39*	1.40	1.6		
40*	1.40	1.6		
41*	1.35	1.5		
42*	1.35	1.5		
43*	1.35	1.5		
44*	1.30	1.5		
45*	1.30	1.5		
46*	1.30	1.5		
47*	1.25	1.4		
48*	1.25	1.4		
49*	1.20	1.6		
50*	1.20	1.6		

* The centromere was not observed.

Table 15. Measurements of somatic chromosomes of *Lycaste barringtoniae*, 2n=44 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.00+1.25=2.25	3.6	1.2	m
2	0.95+1.20=2.15	3.5	1.2	m
3	0.85+1.10=1.95	3.2	1.2	m
4	0.90+1.00=1.90	3.1	1.1	m
5	0.70+1.10=1.80	2.9	1.5	m
6	0.65+1.05=1.70	2.8	1.6	m
7	0.65+1.05=1.70	2.8	1.6	m
8	0.70+1.00=1.70	2.8	1.4	m
9	0.65+1.00=1.65	2.7	1.5	m
10	0.65+1.00=1.65	2.7	1.5	m
11	0.60+0.95=1.55	2.5	1.5	m
12	0.60+0.95=1.55	2.5	1.5	m
13	0.55+0.95=1.50	2.4	1.7	m
14	0.55+0.95=1.50	2.4	1.7	m
15	0.60+0.90=1.50	2.4	1.5	m
16	0.65+0.85=1.50	2.4	1.3	m
17	0.55+0.95=1.50	2.4	1.7	m
18	0.55+0.95=1.50	2.4	1.7	m
19	0.60+0.85=1.45	2.3	1.4	m
20	0.55+0.90=1.45	2.3	1.6	m
21	0.45+1.00=1.45	2.3	2.2	sm
22	0.40+1.05=1.45	2.3	2.6	sm
23	0.65+0.80=1.45	2.3	1.2	m
24	0.60+0.80=1.40	2.3	1.3	m
25	0.60+0.80=1.40	2.3	1.3	m
26	0.55+0.80=1.35	2.2	1.4	m
27	0.55+0.75=1.30	2.1	1.3	m
28	0.50+0.75=1.25	2.0	1.5	m
29	0.55+0.70=1.25	2.0	1.2	m
30	0.55+0.70=1.25	2.0	1.2	m
31	0.40+0.85=1.25	2.0	2.1	sm
32	0.40+0.85=1.25	2.0	2.1	sm
33	0.45+0.80=1.25	2.0	1.7	m
34	0.45+0.75=1.20	1.9	1.6	m
35*	1.15	1.9		
36*	1.10	1.8		
37	0.50+0.55=1.05	1.7	1.1	m
38	0.50+0.55=1.05	1.7	1.1	m
39	0.45+0.50=0.95	1.5	1.1	m
40	0.45+0.50=0.95	1.5	1.1	m
41	0.45+0.50=0.95	1.5	1.1	m
42	0.45+0.50=0.95	1.5	1.1	m

Table 15. (continued)

43*	0.85	1.4
44*	0.80	1.3

* The centromere was not observed.

Table 16. Measurements of somatic chromosomes of *Lycaste ciliata*, 2n=44 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.25+2.15=3.40	3.5	1.7	m
2	1.15+2.15=3.30	3.4	1.8	sm
3	1.05+1.90=2.95	3.0	1.8	sm
4	1.05+1.90=2.95	3.0	1.8	sm
5	1.00+1.90=2.90	3.0	1.9	sm
6	1.05+1.85=2.90	3.0	1.7	m
7	1.15+1.75=2.90	3.0	1.5	m
8	1.15+1.65=2.80	2.9	1.4	m
9	0.50+2.10=2.60	2.7	4.2	st
10	0.50+2.10=2.60	2.7	4.2	st
11	0.70+1.80=2.50	2.6	2.5	sm
12	0.75+1.75=2.50	2.6	2.3	sm
13	1.00+1.40=2.40	2.5	1.4	m
14	1.05+1.35=2.40	2.5	1.2	m
15	0.75+1.65=2.40	2.5	2.2	sm
16	0.75+1.65=2.40	2.5	2.2	sm
17	0.65+1.70=2.35	2.4	2.6	sm
18	0.55+1.80=2.35	2.4	3.2	st
19	0.90+1.40=2.30	2.4	1.5	m
20	0.90+1.40=2.30	2.4	1.5	m
21	0.90+1.35=2.25	2.3	1.5	m
22	0.90+1.35=2.25	2.3	1.5	m
23	0.50+1.70=2.20	2.2	3.4	st
24	0.50+1.70=2.20	2.2	3.4	st
25	0.65+1.50=2.15	2.2	2.3	sm
26	0.65+1.50=2.15	2.2	2.3	sm
27	0.10+0.25+1.75=2.10*	2.1	5.0	st
28	0.10+0.25+1.75=2.10*	2.1	5.0	st
29	0.55+1.55=2.10	2.1	2.8	sm
30	0.60+1.40=2.00	2.0	2.3	sm
31	0.65+1.35=2.00	2.0	2.0	sm
32	0.75+1.25=2.00	2.0	1.6	m

Table 16. (continued)

33	0.55+1.40=1.95	2.0	2.5	sm
34	0.50+1.40=1.90	1.9	2.8	sm
35	0.85+1.00=1.85	1.9	1.1	m
36	0.40+1.35=1.75	1.8	3.3	st
37	0.40+1.35=1.75	1.8	3.3	st
38	0.40+1.15=1.55	1.6	2.8	sm
39	0.45+1.05=1.50	1.5	2.3	sm
40	0.45+1.00=1.45	1.5	2.2	sm
41	0.70+0.75=1.45	1.5	1.0	m
42	0.65+0.75=1.40	1.4	1.1	m
43	0.70+0.70=1.40	1.4	1.0	m
44	0.60+0.75=1.35	1.4	1.2	m

* Chromosome with secondary constriction

Table 17. Measurements of somatic chromosomes of *Lycaste dyeriana*, 2n=48 at metaphase.

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.00+2.00=3.00	3.3	2.0	sm
2	1.00+1.80=2.80	3.1	1.8	sm
3	1.20+1.55=2.75	3.0	1.2	m
4	1.05+1.65=2.70	3.0	1.5	m
5	0.95+1.70=2.65	2.9	1.7	m
6	0.80+1.75=2.55	2.8	2.1	sm
7	0.50+2.00=2.50	2.7	4.0	st
8	0.55+1.95=2.50	2.7	3.5	st
9	0.75+1.75=2.50	2.7	2.3	sm
10	0.65+1.80=2.45	2.7	2.7	sm
11	0.60+1.80=2.40	2.6	3.0	sm
12	0.60+1.80=2.40	2.6	3.0	sm
13	0.75+1.65=2.40	2.6	2.2	sm
14	0.70+1.70=2.40	2.6	2.4	sm
15	0.60+1.65=2.25	2.5	2.7	sm
16	0.55+1.70=2.25	2.5	3.0	sm
17	0.90+1.25=2.15	2.4	1.3	m
18	1.00+1.15=2.15	2.4	1.1	m
19	0.50+1.50=2.00	2.2	3.0	sm
20	0.50+1.50=2.00	2.2	3.0	sm

Table 17. (continued)

21	0.55+1.45=2.00	2.2	2.6	sm
22	0.60+1.30=1.90	2.1	2.1	sm
23*	1.80	2.0		
24*	1.80	2.0		
25	0.60+1.15=1.75	1.9	1.9	sm
26	0.55+1.15=1.70	1.9	2.0	sm
27	0.70+0.95=1.65	1.8	1.3	m
28	0.65+1.00=1.65	1.8	1.5	m
29	0.65+0.90=1.55	1.7	1.3	m
30	0.65+0.85=1.50	1.6	1.3	m
31	0.65+0.85=1.50	1.6	1.3	m
32	0.35+1.15=1.50	1.6	3.2	st
33	0.35+1.15=1.50	1.6	3.2	st
34	0.35+1.15=1.50	1.6	3.2	st
35	0.35+1.15=1.50	1.6	3.2	st
36	0.30+1.20=1.50	1.6	4.0	st
37	0.65+0.80=1.45	1.6	1.2	m
38	0.60+0.80=1.40	1.5	1.3	m
39*	1.40	1.5		
40*	1.40	1.5		
41	0.55+0.85=1.40	1.5	1.5	m
42	0.60+0.80=1.40	1.5	1.3	m
43	0.65+0.75=1.40	1.5	1.1	m
44	0.65+0.70=1.35	1.5	1.0	m
45	0.65+0.65=1.30	1.4	1.0	m
46*	1.30	1.4		
47*	1.25	1.4		
48*	1.20	1.3		

* The centromere was not observed.

Karyomorphological observations on *Phragmipedium besseae* Dodson & Khun, Orchidaceae*

Kohji Karasawa**

フラグミペディウム　ベセアエの核形態学的観察*

唐　澤　耕　司**

An exact karyomorphological studies on *Phragmipedium*, a genus including about 20 species native to tropical America, have been made for 14 species and one variety by Karasawa (1980). He (1980) reported that the increase in chromosome number resulted from Robertsonian centromeric fission and the subsequent structural changes of chromosomes have occurred same as in the genus *Paphiopedilum*, an Asian genus closely allied to *Phragmipedium*.

Phragmipedium besseae was discovered by Mrs. E. Besse in northern part of Peru, and described by C.H. Dodson & J. Khun (1981), and subsequently found also in Ecuador. In this paper, karyomorphological observations on *Phrag. besseae*, which have not yet been made, were reported.

Material and Method

For observation of chromosomes one plant (obtained from Peru) was used. Method for observation of chromosomes and terminology for description of karyotype followed Karasawa (1980).

Observations

External morphology: medium to large plants with several distichous leaves. Leaves conduplicate at the base, oblong, 8–22 cm long, coriaceous, acute at the apex. Inflorescence terminal, erect, 15–20 cm long, carrying several flowers. Flowers (Fig. 1A) opening one by one, 6–7.5 cm in diameter, vermilion to blownish red, velvety. Dorsal sepal oblong. Lateral sepals united into a synsepal. Petals oblong-lanceolate, well opening, 3–3.5 cm long. Lip calceolate, ovoid, incurved along the margin. Staminodes transversely elliptic-cordate.

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The chromosome number of 2n=26 was counted in cells at mitotic metaphase, which is the first time record for the present species. The measurements of metaphase chromosomes are shown in Table 1.

Resting chromosomes (Fig. 1B) formed chromonemata and chromomeres, which were scattered in the nuclear space, and also many chromocenters, which were darkly stained. Chromocenters varied in size and shape, and most of them were aggregated and united. Morphology of resting chromosomes of the present species was referable as the complex chromocenter type of Tanaka (1971), being the same category as the other species of the genus reported by Karasawa (1980).

Mitotic prophase chromosomes (Fig. 1C) contained both early and late condensed segments. Early condensed segments were located at the proximal regions of both arms, and made a sudden transition to late condensed segments which were situated at the distal regions of arms.

At mitotic metaphase (Fig. 1D,E), 2n=26 chromosomes ranged 4.9–1.9 μm and varied gradully their length from the longest to the shortest chromosomes. Of 2n = 26 chromosomes, eight (nos. 1–4, 7, 8, 11, 12) were metacentric with the arm ratio from 1.0 to 1.5, two (nos. 5, 6) were submetacentric with the arm ratio of 3.0 and 1.8, respectively, and the other 16 were telocentric with centromere situated at the terminal region of the arm. Two chromosomes (nos. 9, 10) possessed secondary constriction at the terminal region of the long arm, and the length of satellites were 0.6 and 0.5 μm long, respectively. Thus, the karyotype of the present species were monomodal and gradual in length, and composed of both symmetrical and asymmetrical members.

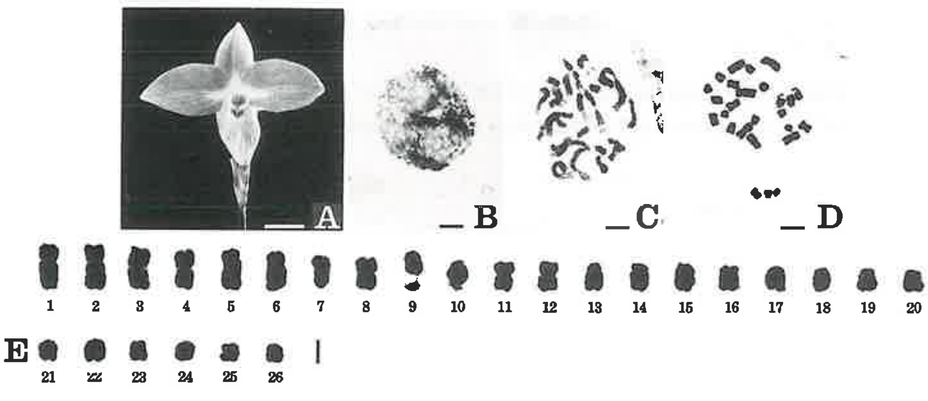

Fig. 1. *Phragmipedium besseae* 2n=26. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 15 mm for A, 5 μm for B-D and 2.5 μm for E.

Discussion

In the genus *Phragmipedium*, a series of chromosome numbers of 2n = 18, 20, 21, 22, 23, 28, 30, 40 has been counted and the variation in chromosome number (except for the cases of 2n = 21, 23 and 40) has been considered to be derived from Robertsonian centromeric fission on the increase by Karasawa (1980).

When the chromosomes with two and one arms are designated as V-and I-shaped, respectively, the basic form of 2n = 18 = 18V and the derivative forms of 2n = 20 = 16V + 4I, 2n = 22 = 14V + 8I, 2n = 28 = 8V + 20I and 2n = 30 = 6V + 24I are recognized in the genus. The chromosome number of 2n = 26 of the present species is newly recorded in the genus, however, it can be designated as 2n = 26 = 10V + 16I, being consistent with the other species in total number of arms within the complements. The present species can be regarded as being derived from ancestral species with 2n = 18V via Robertsonian centromeric fission same as the other species of the genus *Phragmipedium*.

Summary

1. Karyomorphological observation of *Phragmipedium besseae* showed that resting chromosomes were the complex chromocenter type, mitotic metaphase chromosomes were monomodal and gradual in length, and composed of both symmetrical and asymmetrical members.
2. The chromosome number of 2n = 26 was reported for the species for the first time. The chromosome complements comprised 2n = 26 = 10V + 16I = 18V. The present species was regarded as being derived from ancestral stock with 2n = 18 = 18V via Robertsonian centromeric fission same as the other species of the genus *Phragmipedium* which have already been reported by Karasawa (1980).

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Table 1. Measurements of somatic chromosomes of *Phragmipedium besseae,* 2n=26 at metaphase

chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.9+3.0=4.9	6.1	1.5	m
2	1.9+2.9=4.8	6.0	1.5	m
3	2.2+2.3=4.5	5.6	1.0	m
4	2.1+2.2=4.3	5.3	1.0	m
5	1.1+3.3=4.4	5.5	3.0	sm
6	1.5+2.8=4.3	5.3	1.8	sm
7	1.4+2.1=3.5	4.3	1.5	m
8	1.6+1.8=3.4	4.2	1.1	m
9	d +2.6+0.6=3.2*	4.0	–	t
10	d +2.6+0.5=3.1*	3.8	–	t
11	1.5+1.6=3.1	3.8	1.0	m
12	1.5+1.6=3.1	3.8	1.0	m
13	d +2.9=2.9	3.6	–	t
14	d +2.9=2.9	3.6	–	t
15	d +2.9=2.9	3.6	–	t
16	d +2.8=2.8	3.5	–	t
17	d +2.7=2.7	3.3	–	t
18	d +2.6=2.6	3.2	–	t
19	d +2.5=2.5	3.1	–	t
20	d +2.4=2.4	3.0	–	t
21	d +2.2=2.2	2.7	–	t
22	d +2.2=2.2	2.7	–	t
23	d +2.1=2.1	2.6	–	t
24	d +2.0=2.0	2.5	–	t
25	d +1.9=1.9	2.4	–	t
26	d +1.9=1.9	2.4	–	t

* Chromosome with secondary constriction
d: dot

Chromosome count in *Dendrobium* Ⅲ. 43 species*

Kiyoshi Hashimoto**

デンドロビウム属の染色体数　Ⅲ. 43種*

橋　本　清　美**

In Series I and Ⅱ of the present paper (Hashimoto 1981, 1982), the chromosome numbers of 117 species of the genus *Dendrobium* were studied. The chromosome numbers of 50 species of them were recorded for the first time and those of 18 species were re-documented. On the other hand, karyomorphological observations in 82 taxa of the genus *Dendrobium* were studied and those taxa were grouped into 14 karyomorphological types according to chromosome numbers and characteristics of resting nuclei, prophase and metaphase chromosomes (Hashimoto 1987). The present paper, continued from the previous papers, was undertaken to expand the chromosome number and karyomorphological determination of 43 taxa in 13 sections of the genus *Dendrobium*.

Materials and Methods

Validating specimens and cytological data of the plants were deposited in the Hiroshima Botanical Garden. The taxonomy of the materials was mainly followed to Schlechter (1912).

The methods for the observation of the chromosomes were the same as those described in Series I and Ⅱ.

Karyomorphological types of each taxa studied were determined by the category of the definition of the karyomorphological types in *Dendrobium* proposed by Hashimoto (1987).

Results and Discussion

The somatic chromosomes observed in the present investigation were shown in Fig. 1-43. Results of the chromosome numbers and karyomorphological types of the species in the genus *Dendrobium* investigated were listed in alphabetical orders in each sections in Table 1. In Table 1 the previous counts appeared in the present paper were also listed.

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** The Hiroshima Botanical Garden

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Table 1. Chromosome numbers and karyomorphological types of the species of *Dendrobium* studied

Species	Chromosome number: Present count 2n	Previous count 2n	Previous count n	Karyomorphological type	Reference
Section Bolbidium					
Dendrobium pachyphyllum (Krzl.) Bakh. f.	38			C	
Section Rhizobium					
D. lichenastrum (F. Muell) Krzl. var. *prenticei* Dockr.	38	38		E	Jones *et al.* 1982
D. racemosum (Nich.) Clemesha et Dockr.	76			H	
D. toressae Dockr.	38	38		E	Jones *et al.* 1982
		Ca.36			Lim 1983
Section Dendrocoryne					
D. adae F. M. Bail.	38	38		C	Lim 1983
D. × *delicatum* F. M. Bail.	57	C.57		C	Jones 1963
		38			Lim 1983
D. falcorostrum Fitz.	38			C	
D. fleckeri Rupp. et C. T. White	38	38		C	Lim 1983
D. kingianum var. *silcockii* F. M. Bail.	76	C. 76		C	Jones 1963
D. speciosum var. *hillii* F. M. Bail.	38	38		C	Jones 1963
Section Latourea					
D. aberans Schltr.	40			N	
D. atroviolaceum Rolfe	38	38		G	Wilfret & Kamemoto 1971
		38			Lim 1983
D. johnsoniae F. Muell.	38	38		G	Lim 1983
Section Callista					
D. capillipes Rchb. f.	40	38		I	Jones 1963
D. griffithianum Lindl.	40	40		I	Jones *et al.* 1982
		40			Kamemoto *et al.* 1987
Section Eugenanthe					
D. arachnites Rchb. f.	38	38		C	Pancho 1965
		38			Wilfret & Kamemoto 1971
		38			Singh 1981
D. bensoniae Rchb. f.	38			B	
D. chrysanthum Wall.	38	38	19	C	Vajrabhaya & Randolph 1960
		38			Kosakai & Kamemoto 1961
		38			Jones 1963
		38			Kamemoto & Sagarik 1967
		38			Vij *et al.* 1976
			20		Mehra & Sehgal 1976
		40			Sharma 1970
		40			Mehra & Kashyap 1978
		40	20		Sau & Sharma 1983
		38			Sau & Sharma 1983
D. clavatum Lindl. et Wall var. *aurantiacum* Tang et Wang	38			B	

Table.1 (continued)

D. crepidatum Lindl.	38	38		B	Jones 1963
		38			Kamemoto & Sagarik 1967
		38			Hedge & Boraiah 1973
		38			Lim 1983
D. devonianum Paxt.	38		19	B	Chardard 1963
		38			Banerji & Chaudhuri 1972
D. hercoglossum Rchb. f.	38	38		C	Jones *et al.* 1982
D. hildebrandii Rolfe	38	38		C	Kosaki 1958
		38+1f			Kosaki 1958
		38			Kosaki & Kamemoto 1961
		38+1f			Kosaki & Kamemoto 1961
		38			Jones 1963
		38			Kamemoto & Sagarik 1967
		38			Lim 1983
D. linawianum Rchb. f.	38			C	
D. lohohense Tang et Wang	38			D	
D. okinawense Hatusima et Ida	38			C	
D. primulinum Lindl. var. *giganteum* Veitch.	38			H	
D. transparens Wall.	38	38		B	Jones 1963
		40	20		Sharma & Chatterji 1966
			20		Mehra & Vij 1970
			20		Sharma 1970
			20		Roy & Sharma 1972
			19		Mehra & Sehgal 1980
		38	19		Sau & Sharma 1983
Section Pedilonum					
D. chrysoglossum Schltr.	38			B	
D. dichaeioides Schltr.	38	38		B	Lim 1983
D. hughii Rchb. f.	40			N	
D. leucayanum T. M. Reeve	38	38		C	Lim 1983
D. parcum Rchb. f.	40			L	
Section Oxyglossum					
D. coerulescens Schltr.	38			B	
Section Stachyobium					
D. eriaeflorum Griff.	80			I	
Section Ceratobium					
D. antennatum Lindl.	38	38		D	Jones *et al.* 1982
D. cincinnatum F. Muell.	38			D	
D. discolor Lindl.	38	38		D	Kamemoto *et al.* 1987
D. lineale Rolfe	38	38		D	Jones *et al.* 1982
Section Oxygenianthe					
D. schuetzei Rolfe	40	40	20	J	Shindo & Kamemoto 1967
D. virgineum Rchb. f.	40			J	
Section Rhopalanthe					
D. linearifolium Teijsm et Binn.	38			G	
Section Aporum					
D. anceps Sw.	38		19+(0+2B)	G	Mehra 1970

Among the 43 taxa in 13 sections in the genus *Dendrobium*, 32 were 2n=38. 7 were 2n =40 and the rest were other numbers such as 2n=57 in *D. delicatum*, 2n=76 in *D. racemosum* and *D. kingianum* var. *silcockii* and 2n=80 in *D. eriaeflorum*.

The chromosome numbers of 18 taxa, *D. pachyphyllum* 2n=38, *D. racemosum* 2n=76, *D. falcorostrum* 2n=38, *D. aberans* 2n=40, *D. bensoniae* 2n=38, *D. clavatum* var. *aurantiacum* 2n=38, *D. linawianum* 2n=38, *D. lohohense* 2n=38, *D.okinawense* 2n=38, *D. primulinum* var. *giganteum* 2n=38, *D. chrysoglossum* 2n=38, *D. hughii* 2n=40, *D. parcum* 2n=40, *D. coerulescens* 2n=38, *D. eriaeflorum* 2n=80, *D. cincinnatum* 2n=38, *D. virgineum* 2n=40, and *D. linearifolium* 2n=38, were recorded here for the first time. The chromosome numbers of the rest 25 taxa were re-confirmed.

Chromosomes in the resting nuclei of 43 taxa shown in Figures B of each plates showed the different four karyotypes according to Tanaka's classification (1971): The simple chromocenter type, the complex chromocenter type, the intermediate type between those two types and the prochromosome type.

Morphological characteristics of the prophase chromosomes were found to be corresponded to those of resting nuclei.

The metaphase chromosomes of 43 taxa in 13 sections studied showed the two different karyotype according to chromosome length: 29 taxa in nine sections showed the gradual karyotype, the other 14 taxa in eight sections showed the bimodal karyotype.

The major-sized chromosome, which have been noted several authors (Vajrabhaya & Randolph 1960, Jones 1963, Wilfret & Kamemoto 1971, Jones *et al*. 1982) were observed in *D. parcum* in section Pedilonum (Fig. 33-D).

Thus, 43 taxa studied could be grouped into ten karyomorphological types according to the category of the definition of previous paper (Hashimoto 1987): *D. bensoniae, D. clavatum* var. *aurantiacum, D. crepidatum, D. devonianum* and *D. transparens* in sect. Eugenanthe, *D. chrysoglossum* and *D. dichaeioides* in sect. Pedilonum and *D. coerulescens* in sect. Oxyglossum for Type B, *D. pachyphyllum* in sect. Bolbidium, *D. adae, D.* × *delicatum, D. falcorostrum, D. fleckeri, D. kingianum* var. *silcockii* and *D.speciosum* var. *hillii* in sect. Dendrocoryne, *D. arachnites, D. chrysanthum, D. hercoglossum, D. hildebrandii, D. linawianum* and *D. okinawense* in sect. Eugenanthe, *D. leucayanum* in sect. Pedilonum for Type C, *D. lohohense* in sect. Eugenanthe, *D. antennatum, D. cincinnatum, D. discolor* and *D. lineale* in sect. Ceratobium for Type D, *D. lichenastrum* var. *prenticei* and *D. toressae* in sect. Rhizobium for Type E, *D. atroviolaceum* and *D. johnsoniae* in sect. Latourea, *D. linearifolium* in sect. Rhopalathe and *D. anceps* in sect. Aporum for Type G, *D. racemosum* in sect. Rhizobium and *D. primulinum* var. *giganteum* in sect. Eugenanthe for Type H, *D. capillipes* and *D. griffithianum* in sect. Callista and *D. eriaeflorum* in sect. Stachyobium for Type I, *D. schuetzei* and *D. virgineum* in sect. Oxygenianthe for Type J, *D. parcum* in sect. Pedilonum for Type L and *D. aberans* in sect. Latourea and *D. hughii* in sect. Pedilonum for Type N.

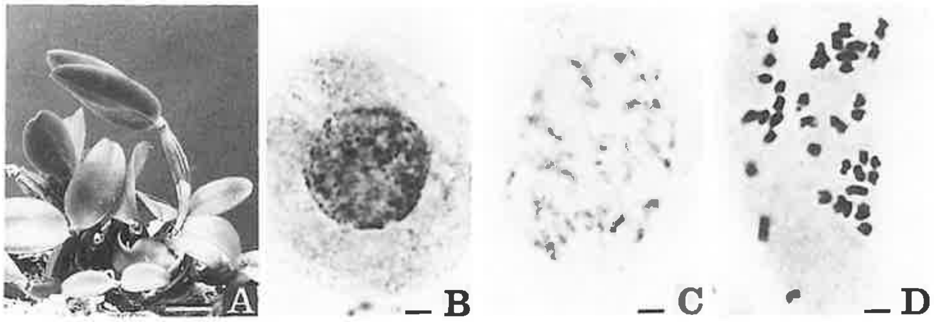

Fig.1. *Dendrobium pachyphyllum*, 2n = 38. A, a specimen. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.0 cm in A and 2.0 μm in B-D.

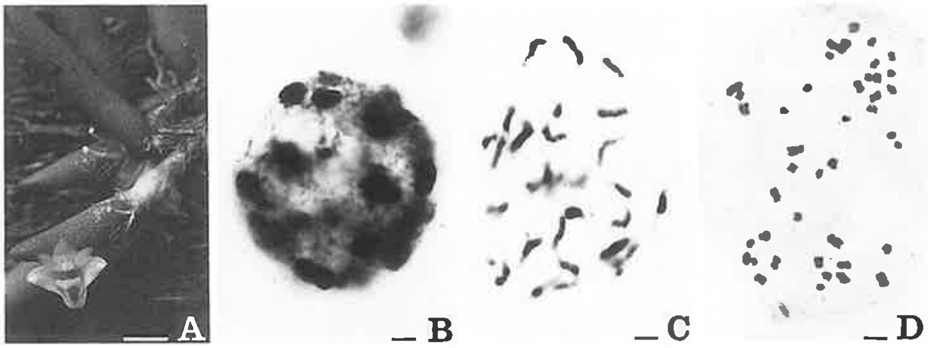

Fig.2. *Dendrobium lichenastrum* var. *prenticei*, 2n=38. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.3 cm in A and 2.0 μm in B-D.

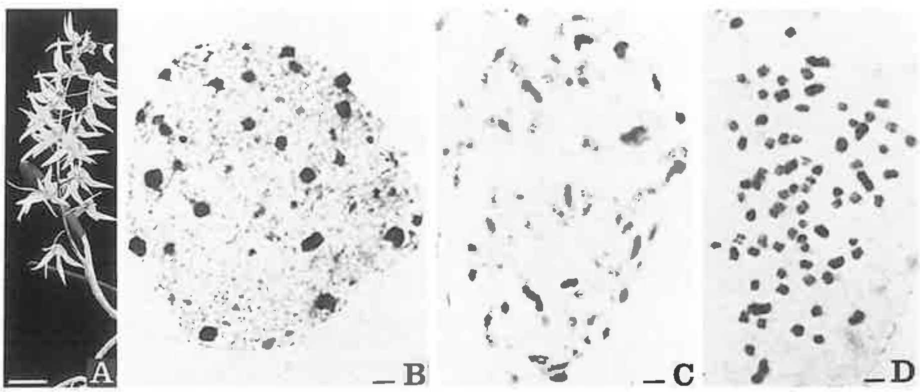

Fig.3. *Dendrobium racemosum*, 2n=76. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.5 cm in A and 2.0 μm in B-D.

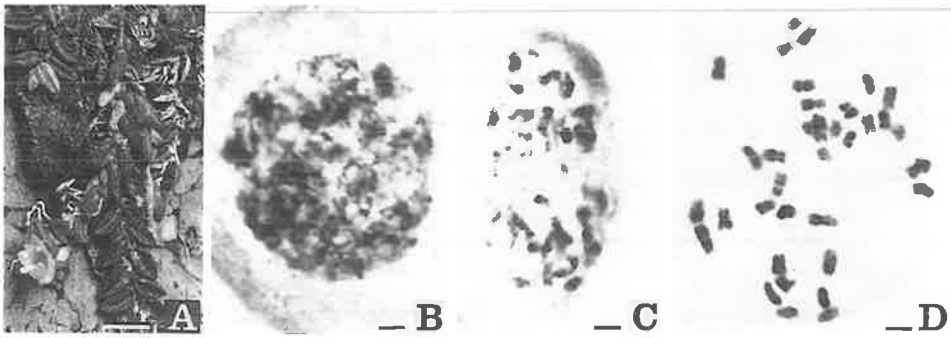

Fig.4. *Dendrobium toressae*, 2n = 38. A, a specimen. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.9 cm in A and 2.0 μm in B-D.

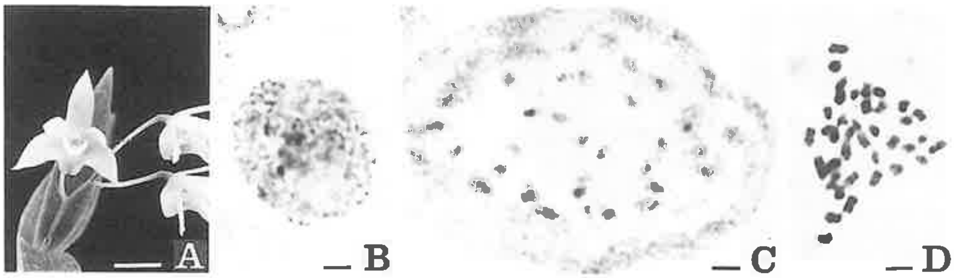

Fig.5. *Dendrobium adae*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.9 cm in A and 2.0 μm in B-D.

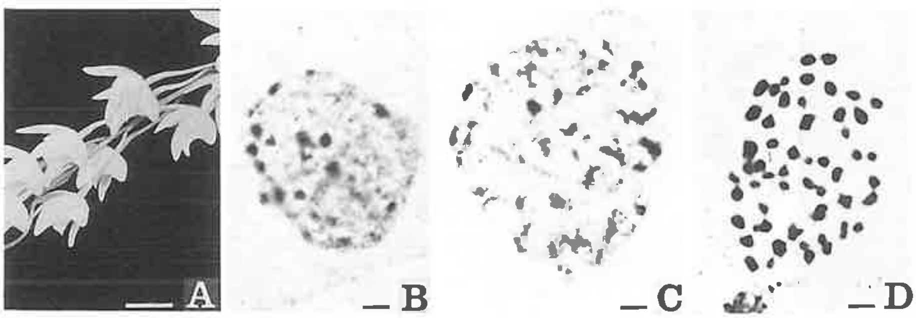

Fig.6. *Dendrobium* × *delicatum*, 2n = 57. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.8 cm in A and 2.0 μm in B-D.

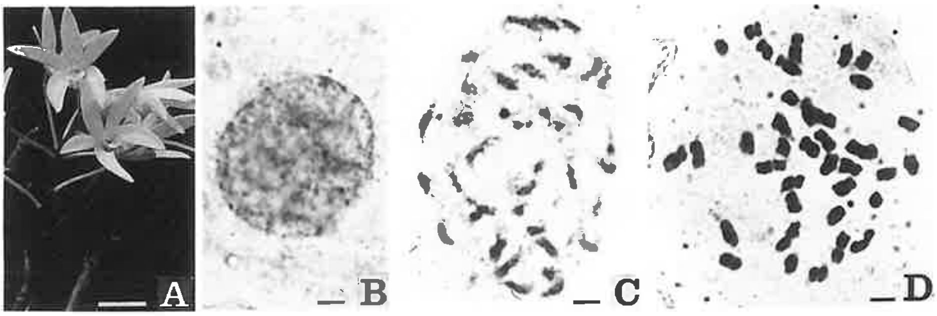

Fig.7. *Dendrobium falcorostrum*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.3 cm in A and 2.0 µm in B-D.

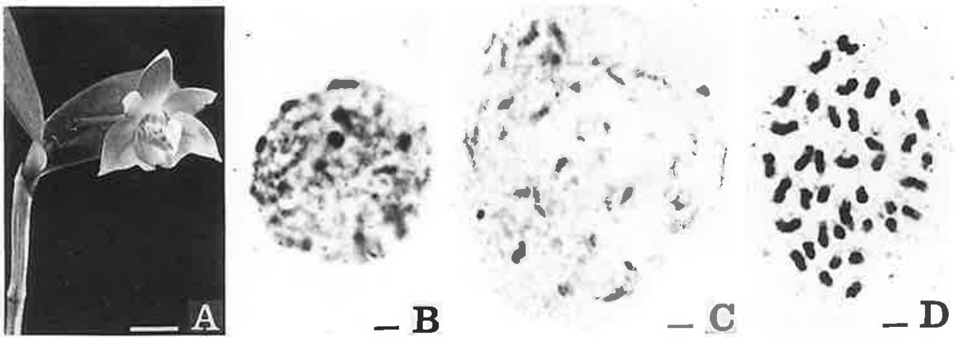

Fig.8. *Dendrobium fleckeri*, 2n=38. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.1 cm in A and 2.0 µm in B-D.

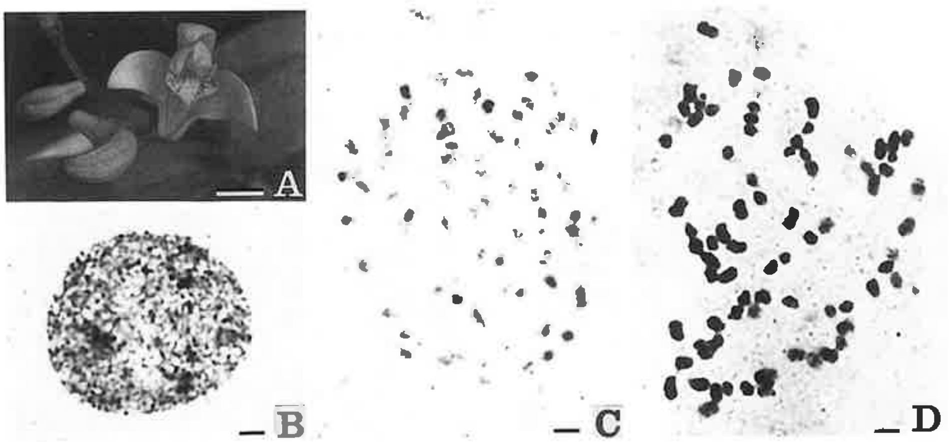

Fig.9. *Dendrobium kingianum* var. *silcockii*, 2n=76. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.6 cm in A and 2.0 µm in B-D.

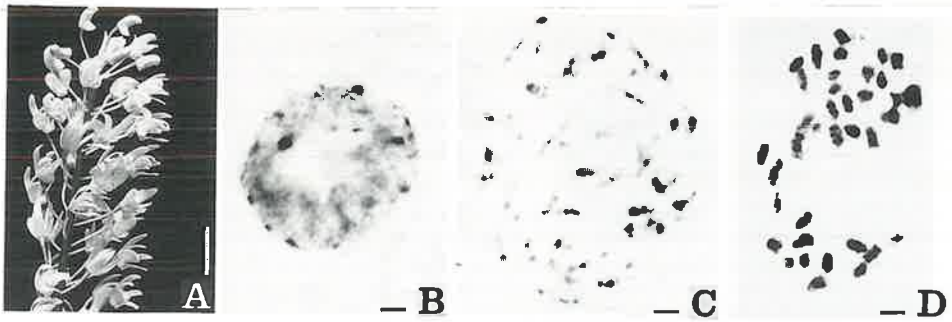

Fig.10. *Dendrobium speciosum* var. *hillii*, 2n=38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 2.3 cm in A and 2.0 μm in B-D.

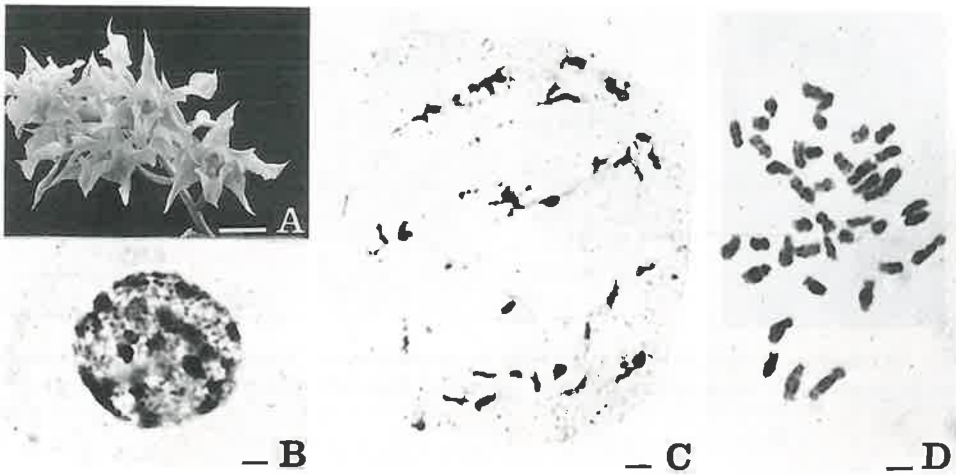

Fig.11. *Dendrobium aberans*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.8 cm in A and 2.0 μm in B-D.

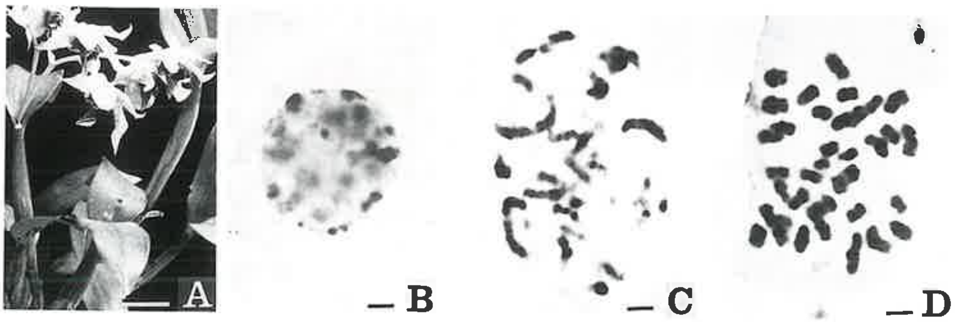

Fig.12. *Dendrobium atroviolaceum*, 2n=38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 2.3 cm in A and 2.0 μm in B-D.

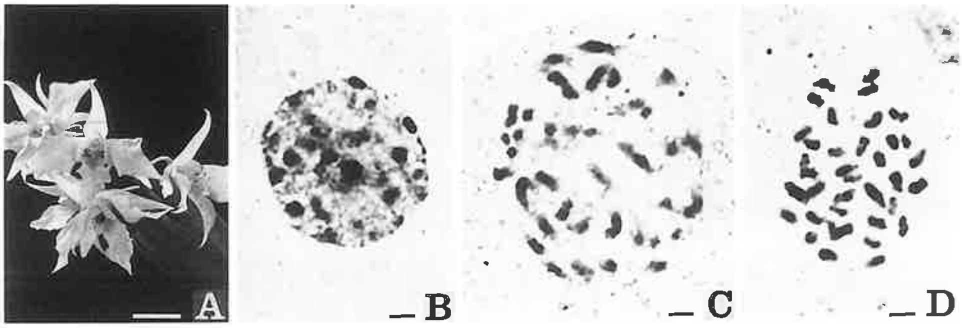

Fig.13. *Dendrobium johnsoniae*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.8 cm in A and 2.0 μm in B-D.

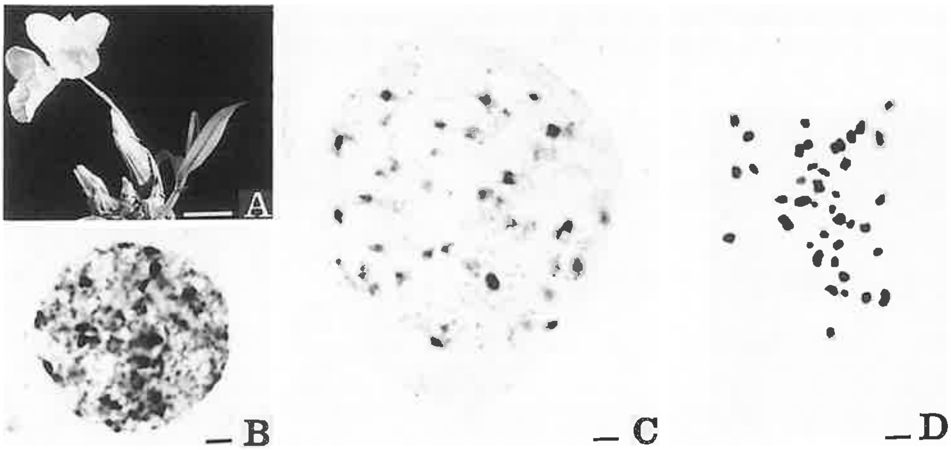

Fig.14. *Dendrobium capillipes*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.5 cm in A and 2.0 μm in B-D.

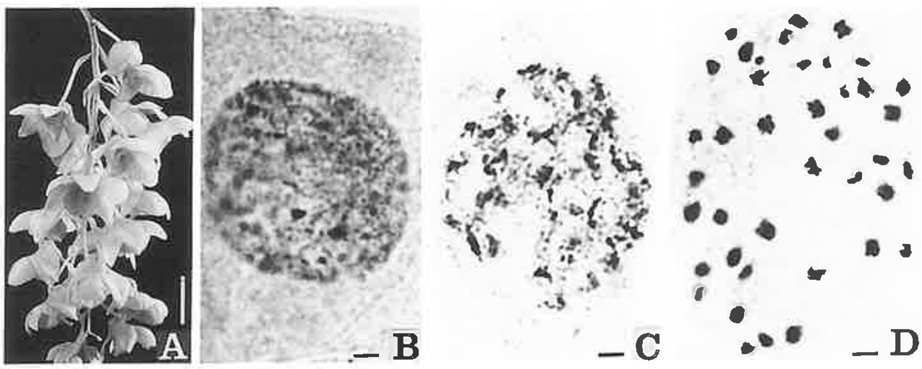

Fig.15. *Dendrobium griffithianum*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.8 cm in A and 2.0 μm in B-D.

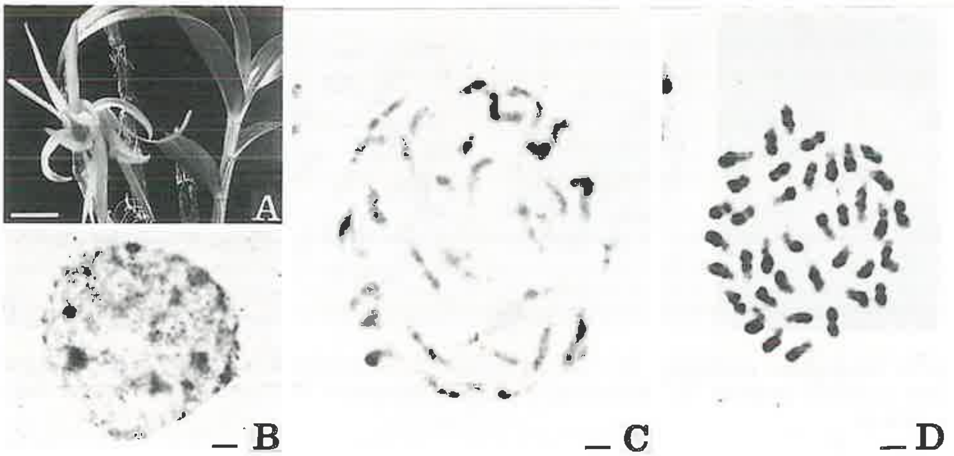

Fig.16. *Dendrobium arachnites*, 2n=38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.3 cm in A and 2.0 μm in B-D.

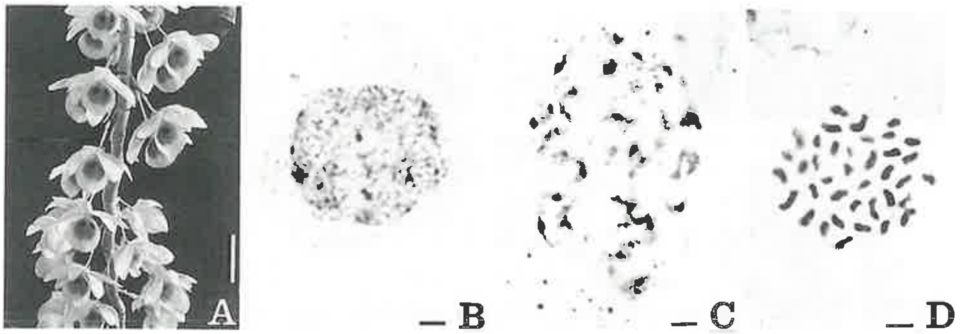

Fig.17. *Dendrobium bensoniae*, 2n=38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 2.3 cm in A and 2.0 μm in B-D.

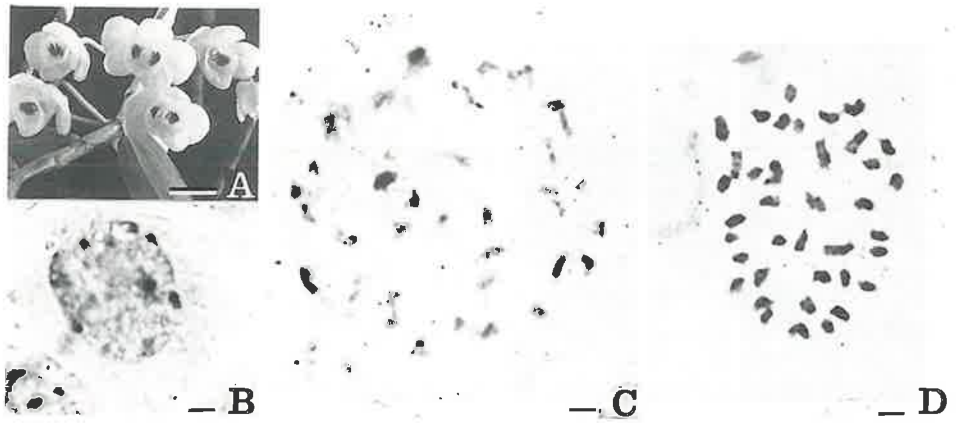

Fig.18. *Dendrobium chrysanthum*, 2n=38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 2.3 cm in A and 2.0 μm in B-D.

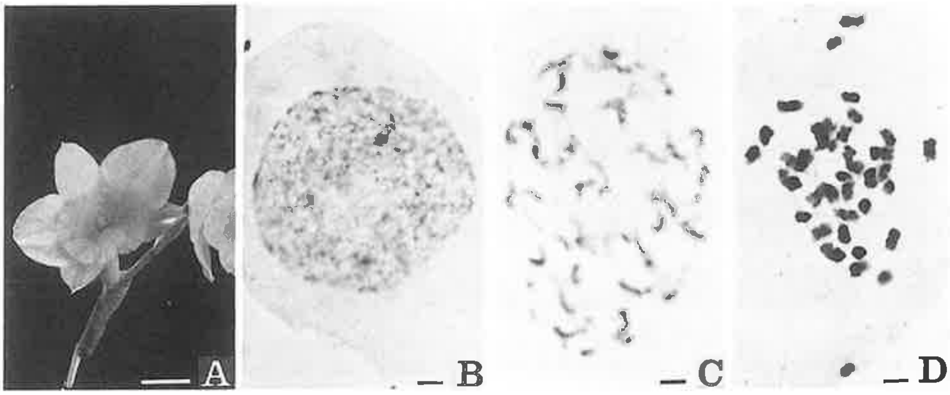

Fig.19. *Dendrobium clavatum* var. *aurantiacum*, 2n=38. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.3 cm in A and 2.0 μm in B-D.

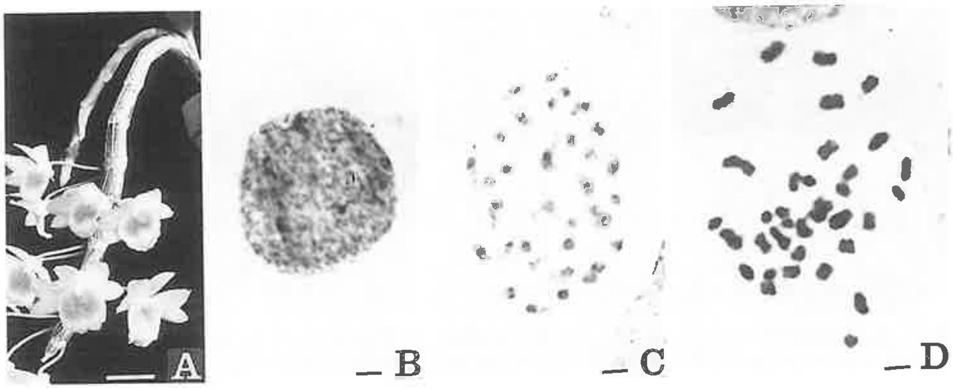

Fig.20. *Dendrobium crepidatum*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 2.3 cm in A and 2.0 μm in B-D.

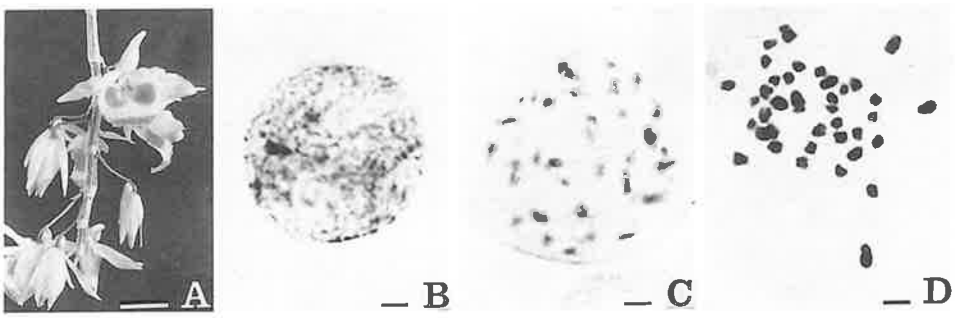

Fig.21. *Dendrobium devonianum*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.8 cm in A and 2.0 μm in B-D.

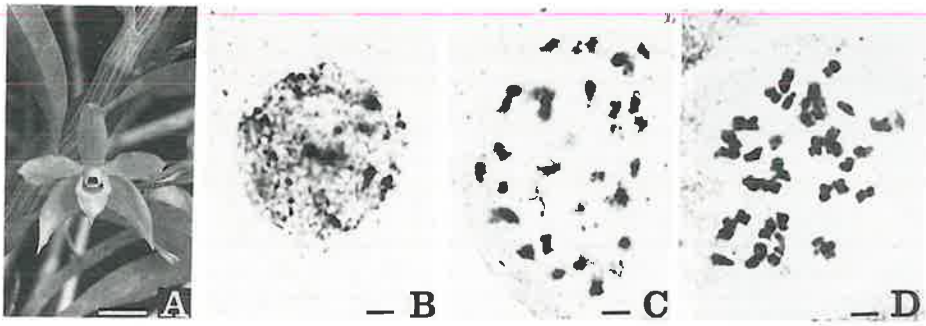

Fig.22. *Dendrobium hercoglossum*, 2n=38. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.8 cm in A and 2.0 μm in B-D.

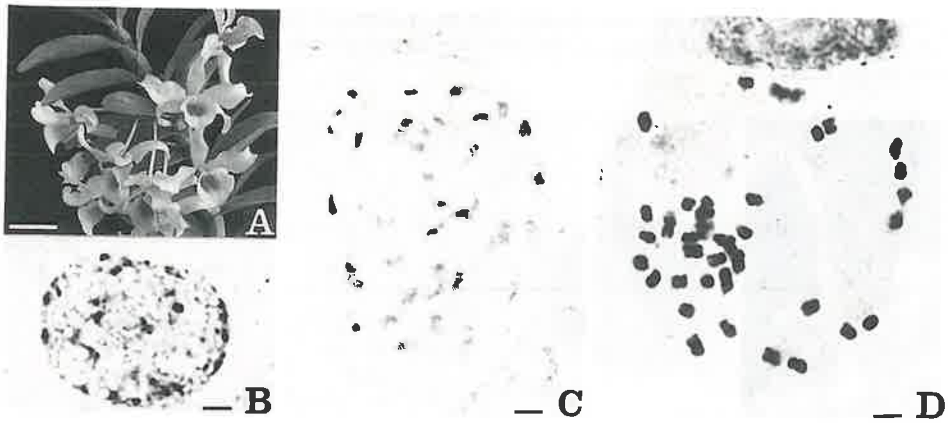

Fig.23. *Dendrobium hildebrandii*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 3.0 cm in A and 2.0 μm in B-D.

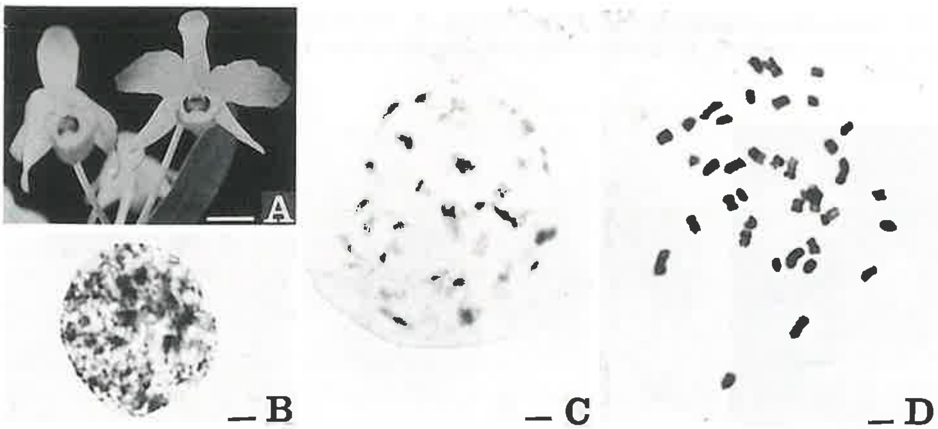

Fig.24. *Dendrobium linawianum*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.1 cm in A and 2.0 μm in B-D.

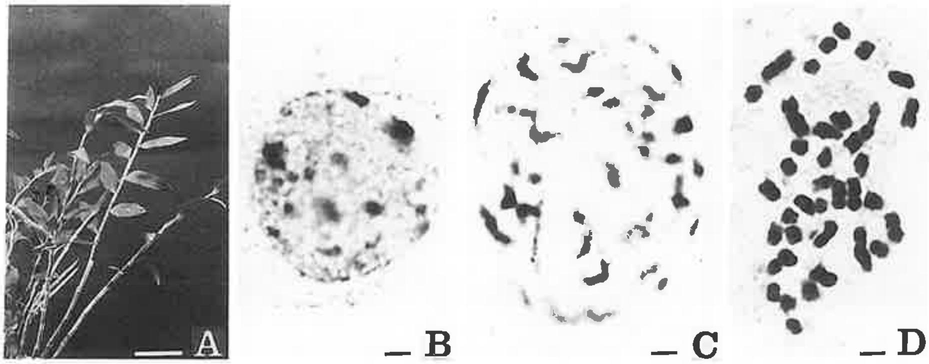

Fig.25. *Dendrobium lohohense*, 2n=38. A, a specimen. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 4.5 cm in A and 2.0 μm in B-D.

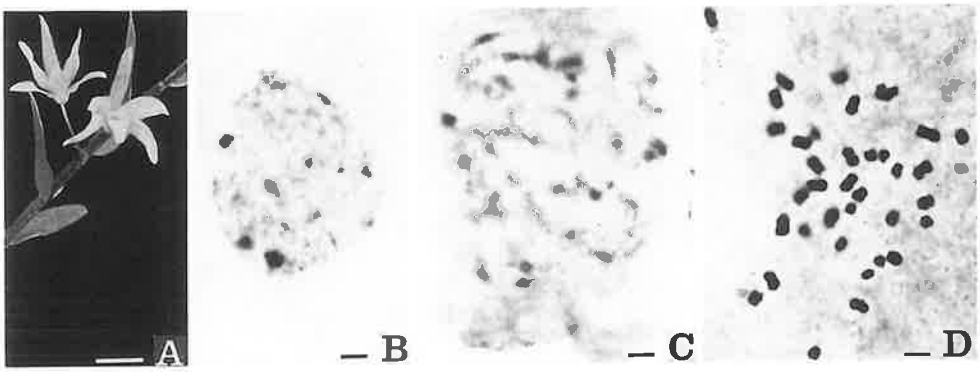

Fig.26. *Dendrobium okinawense*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.3 cm in A and 2.0 μm in B-D.

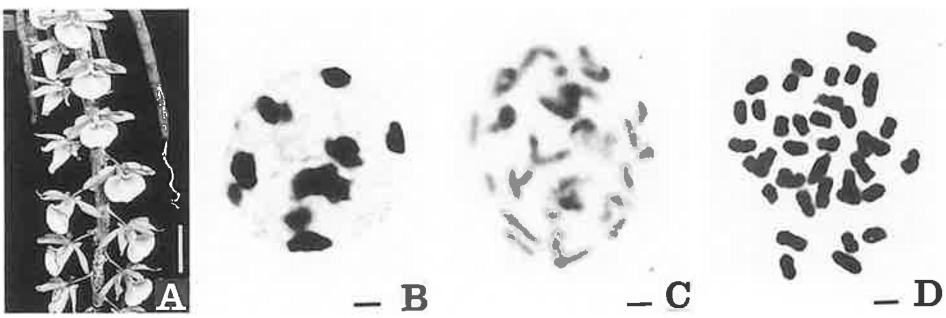

Fig.27. *Dendrobium primulinum* var. *giganteum*, 2n=38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 4.5 cm in A and 2.0 μm in B-D.

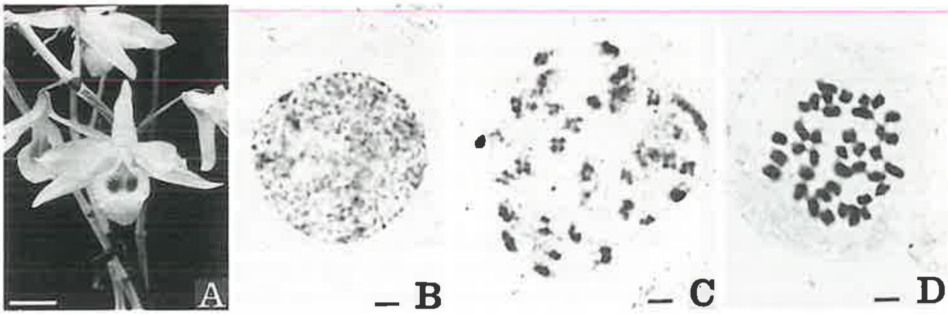

Fig.28. *Dendrobium transparens*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.3 cm in A and 2.0 μm in B-D.

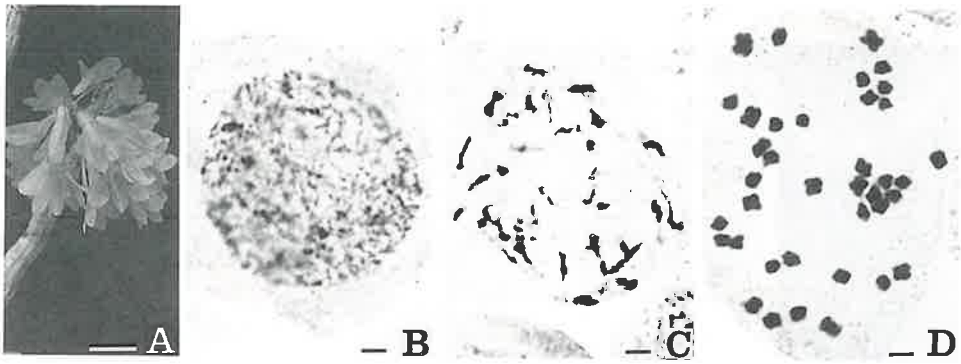

Fig.29. *Dendrobium chrysoglossum*, 2n=38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.8 cm in A and 2.0 μm in B-D.

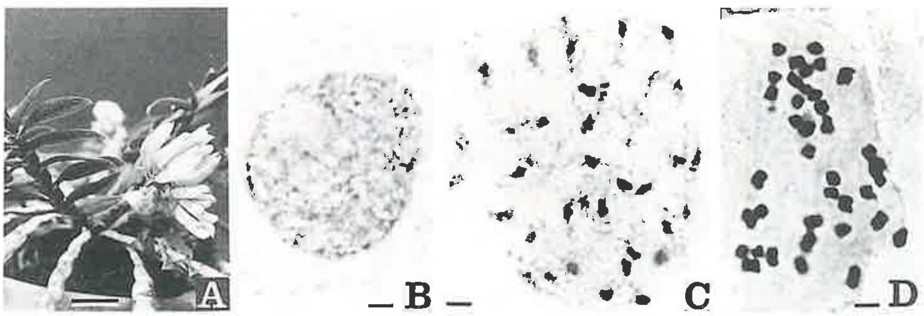

Fig.30. *Dendrobium dichaeioides*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.0 cm in A and 2.0 μm in B-D.

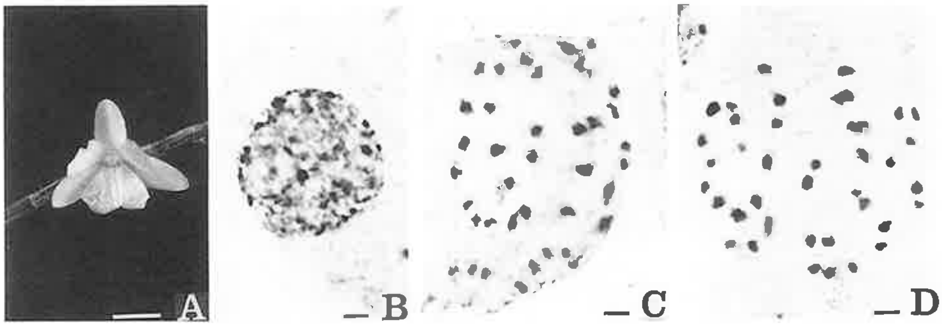

Fig.31. *Dendrobium hughii*, 2n=40. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.9 cm in A and 2.0 μm in B-D.

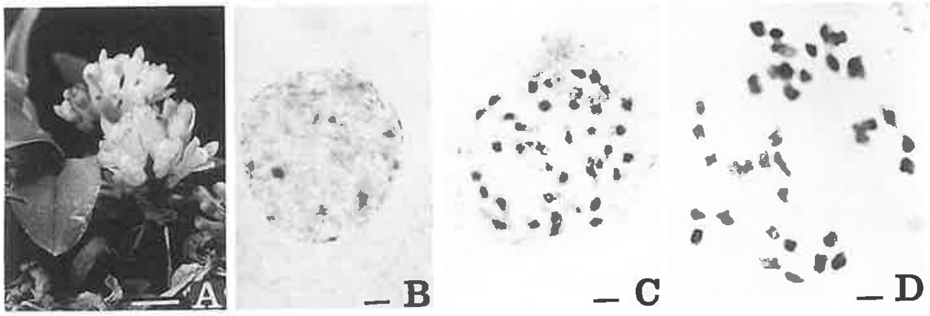

Fig.32. *Dendrobium leucayanum*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.8 cm in A and 2.0 μm in B-D.

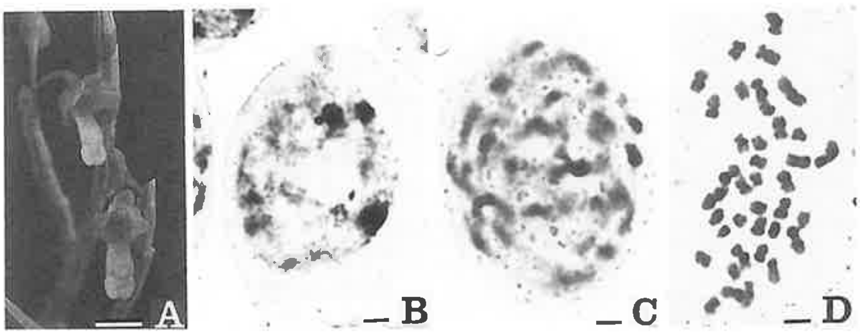

Fig.33. *Dendrobium parcum*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.5 cm in A and 2.0 μm in B-D.

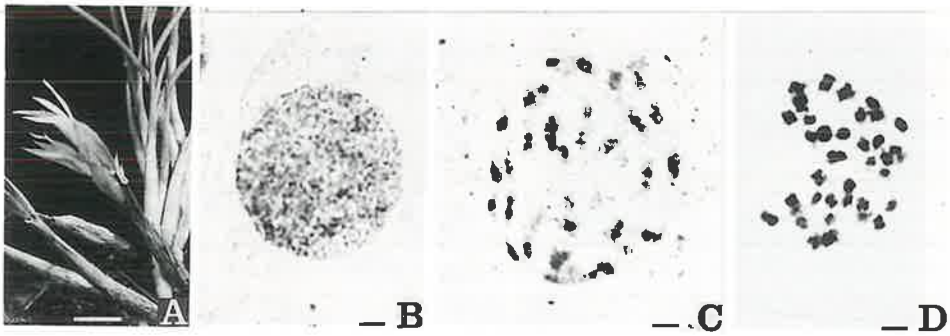

Fig.34. *Dendrobium coerulescens*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.7 cm in A and 2.0 μm in B-D.

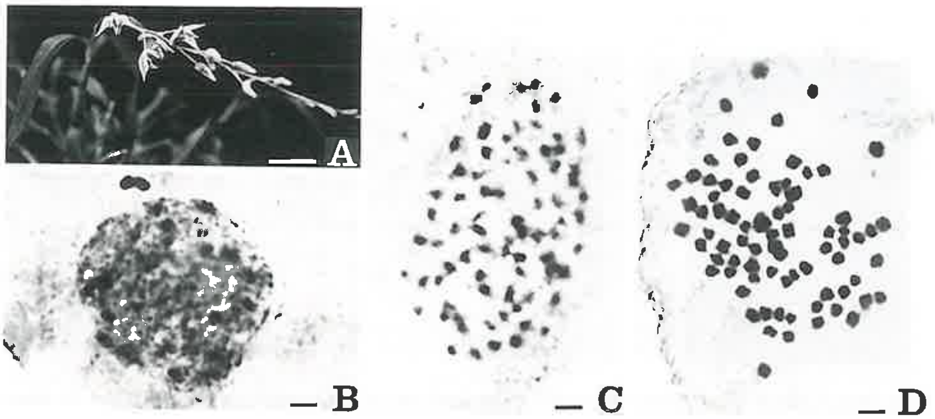

Fig.35. *Dendrobium eriaeflorum*, 2n = 80. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.9 cm in A and 2.0 μm in B-D.

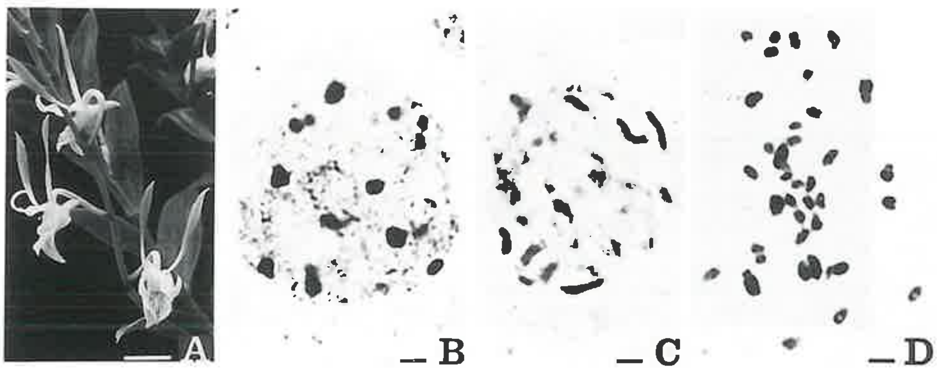

Fig.36. *Dendrobium antennatum*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.5 cm in A and 2.0 μm in B-D.

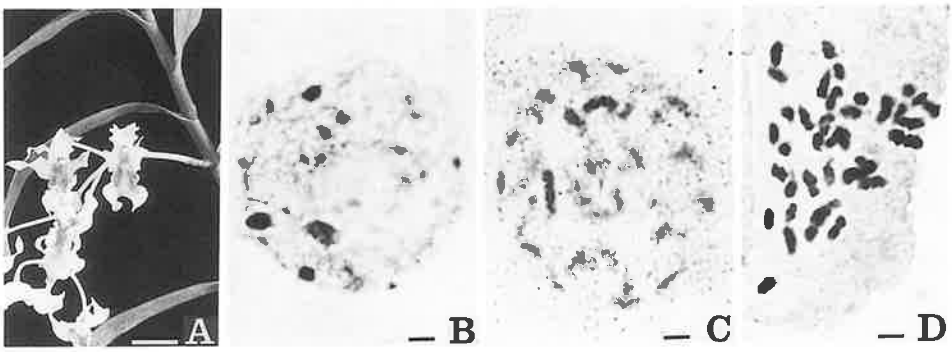

Fig.37. *Dendrobium cincinnatum*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.3 cm in A and 2.0 μm in B-D.

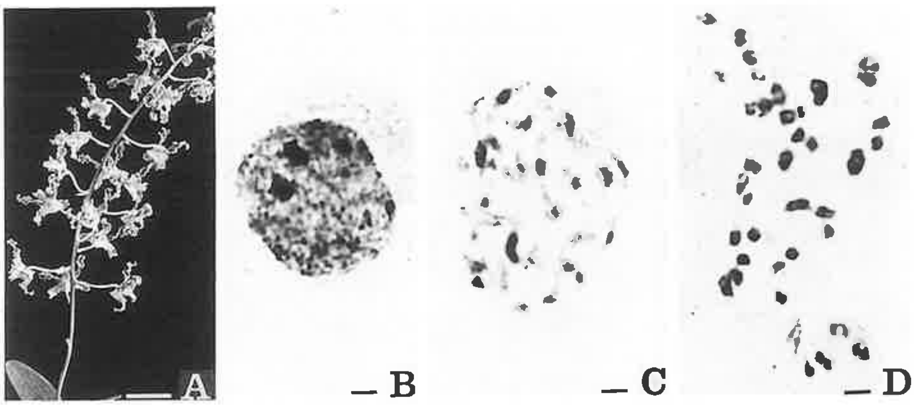

Fig.38. *Dendrobium discolor*, 2n = 38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 4.5 cm in A and 2.0 μm in B-D.

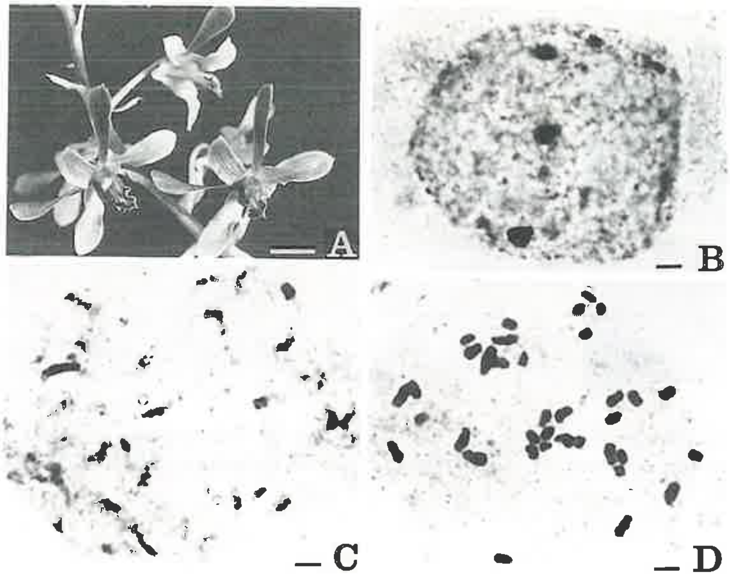

Fig.39. *Dendrobium lineale*, 2n=38. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.0 cm in A and 2.0 μm in B-D.

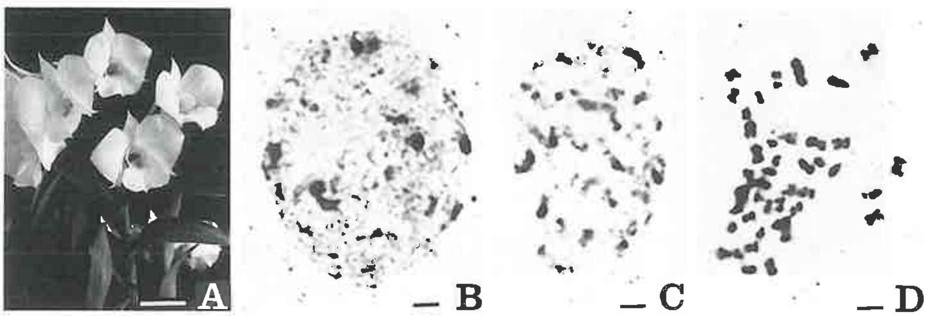

Fig.40. *Dendrobium schuetzei*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 3.0 cm in A and 2.0 μm in B-D.

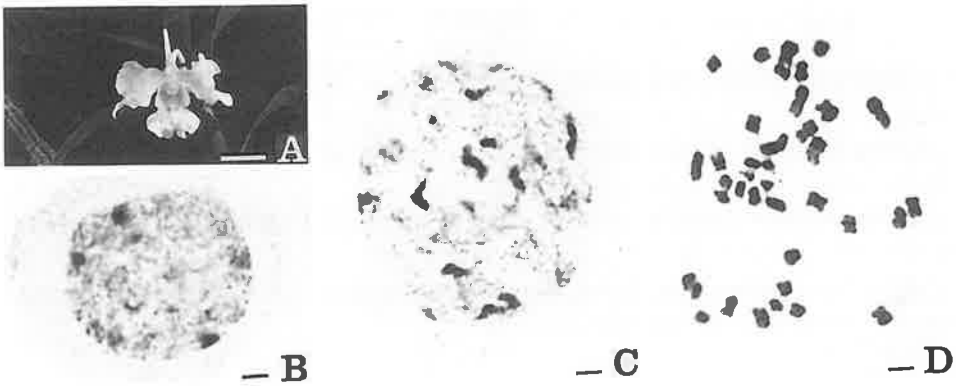

Fig.41. *Dendrobium virgineum*, 2n = 40. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 1.8 cm in A and 2.0 μm in B-D.

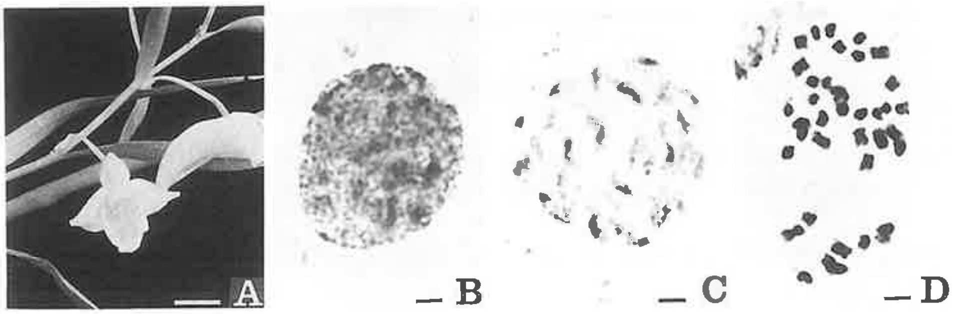

Fig.42. *Dendrobium linearifolium*, 2n=38. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.6 cm in A and 2.0 μm in B-D.

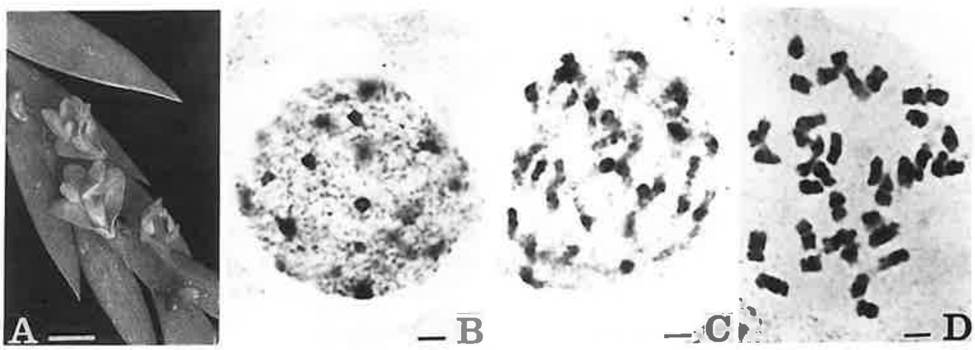

Fig.43. *Dendrobium anceps*, 2n=38. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D, chromosomes at mitotic metaphase. Bar indicates 0.6 cm in A and 2.0 μm in B-D.

Summary

1. Chromosome counts were carried out in 43 taxa in 13 sections of the genus *Dendrobium*.
2. Among 43 species in the genus *Dendrobium*, 32 were 2n=38, 7 were 2n=40, one was 2n=57, 2 were 2n=76 and one was 2n=80.
3. The chromosome numbers of the 18 taxa of the genus *Dendrobium* were recorded for the first time and those of 25 taxa were redocumented.
4. The 43 taxa studied were grouped into ten karyomorphological types according to the category proposed in the previous paper.

Acknowledgments

This work has been carried out under the direction of Professor Dr. Ryuso Tanaka of Hiroshima University, to whom the author wishes to express his sincerest gratitude. I also wish to thank Dr.Kohji Karasawa of Director of the Hiroshima Botanical Garden, to whom the author is indebted for the identification of the materials studied.

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Karyomorphological observations on *Cypripedium kentuckiense* Reed, Orchidaceae*

Kohji Karasawa ** and John T. Atwood ***

ラン科，シプリペジウム　ケンタッキエンセの核形態学的観察*

唐　澤　耕　司**・ジョン T. アトウッド***

Cypripedium is a terrestrial orchid genus widely distributed in temperate regions of the Northern Hemisphere with high concentration in eastern Asia and North America, containing about 38 species (Chen & Xi 1987). The chromosome numbers of the genus have been reported for 19 species, most of them being uniformly n = 10 or 2n = 20 (cf. Tanaka & Kamemoto 1984, Karasawa & Aoyama 1986).

Based on comparative studies on the karyotypes of Japanese and Formosan species, Karasawa & Aoyama (1986) reported that the karyomorphological characteristics are quite consistent with the subgeneric classification of the genus proposed by Brieger (1973).

Cypripedium kentuckiense was recently described from North America (Reed 1981, 1982). In the present paper, we report karyomorphological observations on this species for the first time.

Material and Method

A plant (Fig. 1A) obtained from state of Louisiana, U.S.A. was used in the present study. Method for observation of chromosomes and terminology for description of karyotypes followed Karasawa & Aoyama (1986).

Observations

The chromosome number of 2n = 20 was counted in ten mitotic metaphase cells. Measurements of mitotic metaphase chromosomes are shown in Table 1.

Resting chromosomes (Fig. 1B) contained chromonemata and numerous darkly stained

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chromomeres which were scattered in the nuclear space, and no conspicuous heteropycnotic bodies were observed. The morphology of the resting chromosomes is best described as the densely diffuse type of Tanaka (1971), same as the other species of the genus reported by Karasawa & Aoyama (1986).

At mitotic prophase (Fig. 1C), numerous early condensed segments were equally formed in many parts of chromosomes, which condensed gradually and uniformly.

At mitotic metaphase (Fig. 1E), 2n=20 chromosomes ranged 10.1–23.0 μm in length, and changed their length gradually. Of them, five chromosomes (nos. 13, 14, 16, 17, 20) were submetacentric with arm ratio 1.8–2.9, and the other 15 metacentric with arm ratio 1.0–1.5. Two chromosomes (nos. 5, 6) had secondary constrictions at the proximal region of the short arm, whose satellites were 5.3 and 5.0 μm long, respectively.

Thus, the karyotype of *Cypripedium kentuckiense* is characterized as being monomodal and gradual in length, and symmetrical in arm ratio.

Discussion

Although the chromosome numbers of n=10, 11; 2n=20, 21, 22, 30 (3x) are counted in 22 species out of the genus *Cypripedium* (Tanaka & Kamemoto 1984, Karasawa & Aoyama 1986). Most of the counts are n=10 or 2n=20, while a plant of *C. formosanum* with 2n=30 chromosomes was regarded as a triploid of x=10, and a plant of *C. macranthum* var.

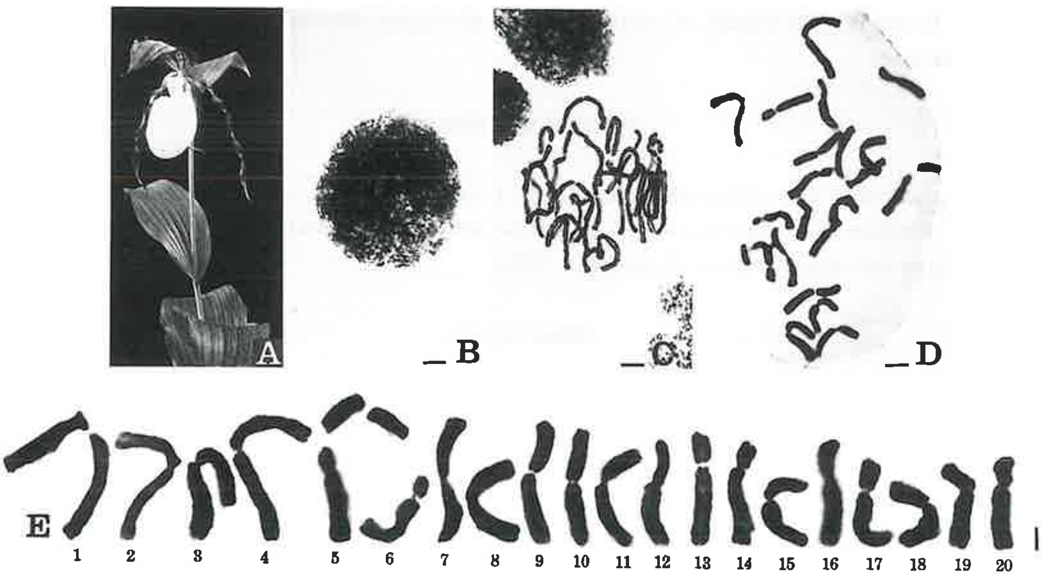

Fig. 1. *Cypripedium kentuckiense* 2n=20. A, a plant. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bar indicates 5 μm for B-D and 2.5 μm for E.

speciosum with 2n=21 chromosomes an aneuploid with structural change of chromosomes (Karasawa & Aoyama 1986). The chromosome number of 2n=20 of the present species is the same as for most published reports. Compared with the results reported by Karasawa & Aoyama (1986), the present species is similar in the morphology of chromosomes at resting stage and mitotic prophase, the size of satellites, the centromeric position of medium-sized and small chromosomes within the complements to the subgenus *Cypripedium*, although the mean arm ratio of the species was lower than the subgenus *Cypripedium*.

Summary

1. Karyomorphological observations on *Cypripedium kentuckiense* are reported. It was found that resting chromosomes were the densely diffuse type, metaphase chromosomes were monomodal and gradual in length, and symmetrical in arm ratio.

2. The chromosome number of 2n=20 in the present species is reported for the first time. The similarity in the morphology of metaphase chromosomes showed a close relationship with other species of the subgenus *Cypripedium*.

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Table 1. Measurements of somatic chromosomes of *Cypripedium kentuckiense* 2n=20 at metaphase

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	10.5+12.5=23.0	8.3	1.1	m
2	10.3+10.5=20.8	7.5	1.0	m
3	8.3+ 9.5=17.8	6.4	1.1	m
4	8.5+ 8.8=17.3	6.2	1.0	m
5	5.3+2.7+ 8.0=16.0*	5.7	1.0	m
6	5.0+2.3+ 8.3=15.6*	5.6	1.1	m
7	7.0+ 7.3=14.3	5.1	1.0	m
8	6.5+ 7.0=13.5	4.8	1.0	m
9	5.5+ 8.0=13.5	4.8	1.4	m
10	5.8+ 7.0=12.8	4.6	1.2	m
11	5.0+ 7.5=12.5	4.5	1.5	m
12	5.0+ 7.3=12.3	4.4	1.4	m
13	3.3+ 8.8=12.1	4.3	2.6	sm
14	3.0+ 8.8=11.8	4.2	2.9	sm
15	5.3+ 6.5=11.8	4.2	1.2	m
16	4.0+ 7.3=11.3	4.1	1.8	sm
17	3.3+ 7.8=11.1	4.0	2.3	sm
18	4.3+ 6.3=10.6	3.8	1.4	m
19	4.0+ 6.3=10.3	3.7	1.5	m
20	3.3+ 6.8=10.1	3.6	2.0	sm

* Chromosome with secondary constriction

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