Karyomorphological Studies in *Calanthe*, Orchidaceae*

Genjiro Ishida**

ラン科エビネ属の核形態学的研究*

石田源次郎**

Introduction

The genus *Calanthe*, the Orchidaceae, which consists of 80 to 100 species (Garay and Sweet 1974, Teuscher 1978), is widely distributed in Asia from Japan to India and down to Indonesia, Africa, Madagascar, Oceania from the South Sea Islands to Australia, and the West Indies. This genus is important as one of the ornamentally cultivated orchids. Numerous interspecific hybrids among the deciduous species of *Calanthe* occurred in South East Asia have been made by artificial hybridization for horticultural purposes.

Since *Calanthe* is highly variable in external morphology and growth habit, several taxonomic treatments of the genus have been made with some technical difficulties by various workers including Lindley (1833, 1854), Hooker (1890), Schlechter (1912), Steiner (1953), Seidenfaden and Smitinand (1961), Holttum (1964), Backer and Van Den Brink (1968), Ito and Karasawa (1969), Maekawa (1971), Garay and Sweet (1974), Seidenfaden (1975), Saigusa and Nagano (1975), Lin (1976, 1977), Hatusima and Amano (1977), Ohwi (1978), Liu and Su (1978), Pradhan (1979), Comber (1981) and Valmayor (1984).

Much general information regarding the chromosome numbers of *Calanthe* has been made Hoffmann (1929, 1930), Miduno (1940), Mutsuura and Nakahira (1958), Nakasone and Moromizato (1964), Tanaka (1965, 1974), Pancho (1965), Larsen (1966), Arora (1960, 1968), Sharma (1970), Mehra (1970, 1982), Mehra and Bawa (1970), Hsu (1971, 1972), Roy and Sharma (1972), Mehra and Sehgal (1974, 1976), Vij *et al.* (1976), Hsu (1976), Teoh and Lim (1978), Mehra and Kashyap(1979, 1984), Teoh (1980, 1984), Tanaka *et al.* (1981), Yang and Zhu (1984) and Lim (1985). Karyomorphological studies in somatic chromosomes in *Calanthe* species, however, have been poorly made in these references, excepting Tanaka *et al.* (1981) have examined and described karyomorphological details in 22 taxa of the genus occurred in Japan.

---

* A dissertation submitted in partial fulfilment of the requirements for the degree of Doctor of Science of the Hiroshima University.
Contribution from the Hiroshima Botanical Garden No. 41.

** The Hiroshima Botanical Garden

Bulletin of the Hiroshima Botanical Garden, No. 12 : 1-69, 1990.

Chromosome morphology is studied here in 33 taxa of *Calanthe* mostly occurred in East Asia. Then, the observations were described and discussed together with the previous observations (Tanaka *et al.* 1981) to make the final conclusion on the karyomorphology of the genus *Calanthe*.

Materials and Methods

Thirty-three species in *Calanthe* studied were tabulated in Table 1. They were cultivated in the Hiroshima Botanical Garden, Hiroshima City, Japan. Taxonomic treatments of the species followed mostly Seidenfaden (1975), Lin (1976, 1977) and partly Perrier De La Bathie (1939), Liu and Su (1978), Pradhan (1979), Wood (1981), Tang and Cheng (1981) and Valmayor (1984).

Cytological observations were made in somatic chromosomes of root tip cells and in meiotic chromosomes of pollen mother cells (PMC's). Somatic chromosomes were stained and observed by the aceto-orcein squash method of Tanaka (1959) with a slight modification: Growing root tips were cut into small pieces 0.5–1.0 mm long and pretreated in 0.002M 8-hydroxyquinoline for about 8 hours at 5°C; They were fixed in 45% acetic acid for about 10 minutes at 10°C; They were macerated in the mixture of one part of 45% acetic acid and two parts of 1N hydrochloric acid for about 30 seconds at 60°C; Then, they were stained and squashed in 1% aceto-orcein.

For preliminary observation of meiotic chromosomes small piece (0.5–1.0 mm) of PMC block cut from young anther was smeared in the aceto-orcein solution to determine the right stages of PMC's. When those PMC's were placed at the right stage, whole blocks of the PMC's were fixed in acetic alcohol (1:3) for one or more hours at 10°C, and then were stained and smeared in 1% aceto-orcein.

The chromosomes at resting stage were studied morphologically with respect to their condensation figures and were classified into the types categorized and defined by Tanaka (1971, 1980). During the course of investigation, spherical or rod-shaped condensed bodies over 1 μm diameter were counted and expressed as the chromocentric bodies.

The chromosomes of the mitotic metaphase set in each taxon were arranged in descending order in length and the numbers, 1, 2, 3, etc. represented the chromosomes, graded from the longest to the shortest chromosomes. Arm ratio was calculated by long arm length / short arm length. Position of centromere was expressed by arm ratio; 1.0 to 1.7 for median centromere, 1.8 to 3.0 for submedian centromere, and 3.1 to 7.0 for subterminal centromere according to Levan *et al.* (1964).

Table 1. Sources, number of plants and chromosme numbers of the species of *Calanthe* studied

Species	Source	No. of plants observed	Chromosome number (2n) present count	Chromosome number (2n) previous[1)] count
Subgenus Eu-Calanthe				
Section Calothyrsus				
C. argenteo-striata C.Z. Tang and S.J. Cheng	China, Yunnan	1	45	
C. arisanensis Hayata	China, Taiwan	5	40	40
C. aristulifera Reichb. f.	China, Taiwan	2	40	40
C. caudatilabella Hayata	China, Taiwan	2	38	40
C. conspicua Lindl.	Philippines	1	40	
C. cremeo-viridis J.J. Wood	Papua New Guinea	1	46	
C. graciliflora Hayata	China, Taiwan	5	40	40
C. hamata Hand.-Mazz.	China, Guizhou	3	40	40
C. hancockii Rolfe	China, Yunnan	2	40	
C. herbacea Lindl.	India	1	40	40
C. mannii Hook.f.	India	3	40	40
C. masuca (D.Don) Lindl.	China, Taiwan	3	40	40
	India	2	40	40
C. matsudai Hayata	China, Taiwan	3	40	40
C. plantaginea Lindl.	India	2	40	40
C. reflexa Maxim.	China, Taiwan	3	40	40
	China, Sichuan	1	40	
C. sieboldii Decne.	China, Taiwan	3	40	40
C. sylvatica Lindl.	Madagascar	1	40	40
C. tricarinata Lindl.	China, Taiwan	1	40	40
C. triplicata (Willem.) Ames	China, Taiwan	3	40	40
	Philippines	1	40	
Section Styloglossum				
C. clavata Lindl.	China,Guangdong	1	40	40
C. densiflora Lindl.	China, Taiwan	2	40	40
C. formosana Rolfe	China, Taiwan	2	40	40
C. lyroglossa Reichb. f.	China, Taiwan	2	40	40
Section Aceratochilus				
C. kooshunensis Fukuyama	China, Taiwan	2	40	
C. gracilis Lindl.	China, Taiwan	3	40	40
Subgenus Preptanthe				
Section Eu-Preptanthe				
C. cardioglossa Schltr.	Thailand	2	46	c44
C. elmeri Ames	Philippines	1	44	
C. hennisii Loher	Philippines	3	42	
C. hirsuta Seidenfaden	Thailand	2	46	
C. rosea (Lindl.) Benth.	Thailand	1	44	
C. rubens Ridley	Thailand	3	42	44, 42
C. succedanea Gagnep.	Thailand	2	44	
C. vestita Lindl.	Thailand	2	42	40
	Burma	1	42	

1): See the descriptions of the taxa in the text for the literatures.

Observations

Observations on chromosome morphology were made in chromosomes at resting stage and at mitotic prophase and metaphase stages in all the taxa studied. Meiotic chromosomes at metaphase I were observed in one taxon.

Systematic arrangement of 33 taxa representing four sections in two subgenera in *Calanthe* followed Schlechter (1912), however, *C. kooshunensis* Fukuyama and *C. gracilis* Lindl. were, for convenience, treated here to be placed in section Aceratochilus, *Calanthe*.

The results of the observations in 33 taxa in *Calanthe* were described as follows:

I. Subgenus Eu-Calanthe

1. Section Calothyrsus

1) *Calanthe argenteo-striata* C.Z. Tang and S.J. Cheng, 2n=45, Tables 1 and 2, Fig. 1.

A plant was obtained from China, Yunnan. External characteristics of the plant were in accord with the descriptions of the species by Tang and Cheng (1981).

The chromosome number at mitotic metaphase of the plant was 2n=45, which was reported here for the first time.

The chromosomes at resting stage were observed as chromomeric granules, fibrous threads and chromatin blocks scattered throughout the nucleus. The chromatin blocks were round-, rod- and string-shaped and varied in diameter from 1.0–4.0 μm. Their surface sculpture showed numerous irregular depressions. Among the chromocentric bodies appeared in the nucleus average 20 were 1.0 μm or more diameter, larger than the others.

The chromosome features at resting stage were of the complex chromocenter type according to Tanaka's classification (1971).

The chromosomes at mitotic prophase formed several early condensed segments located in the proximal and interstitial regions of both arms. Late condensed segments were observed in the distal regions of the chromosomes. The early condensed segments situated between the condensed segments were observed transforming gradually to the late condensed segments.

The karyotype at mitotic prophase was found to be the interstital type as proposed by Tanaka (1977).

The chromosomes at metaphase varied in length from 4.6–2.3 μm. In the chromosome complement 44 chromosomes showed a gradual decrease in length but the last shortest chromosome was remarkably small. Among the 45 chromosomes of the complement, 31 varied in arm ratio from 1.1–1.6 had their centromeres at the median regions. Twelve chromosomes (Nos. 17–18, 27–30, 35–38, 43–44) varied in arm ratio from 1.8–2.7 had their centromeres at the submedian regions. The other two chromosomes (Nos. 41–42) with arm

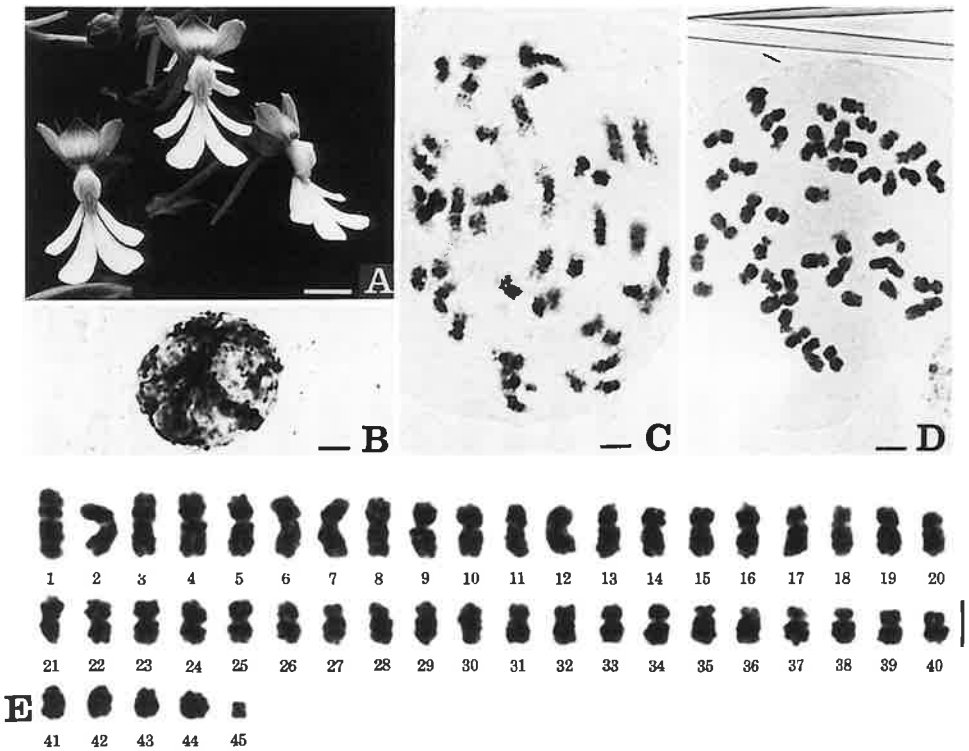

Fig. 1. *Calanthe argenteo-striata*, 2n = 45. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 3 μm in B-E.

ratio of 3.4 had their centromeres at the subterminal regions.

No remarkably early condensed block was found at resting stage and prophase, and the 45th chromosome was conspicuously smaller than the other chromosomes. Thus, the smallest chromosome might be a supernumerary chromosome.

Thus, according to the defintion of the karyotype proposed by Tanaka (1980), this species showed a homogeneous, gradual and symmetric karyotype.

2) *Calanthe arisanensis* Hayata, 2n=40, Tables 1 and 3, Fig.2.

Five plants were obtained from China, Taiwan. External characteristics of the five plants were in accord with the descriptions of the species by Lin (1976).

The chromosome number of the five plants at mitotic metaphase was 2n=40, which confirmed Hsu (1976).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were

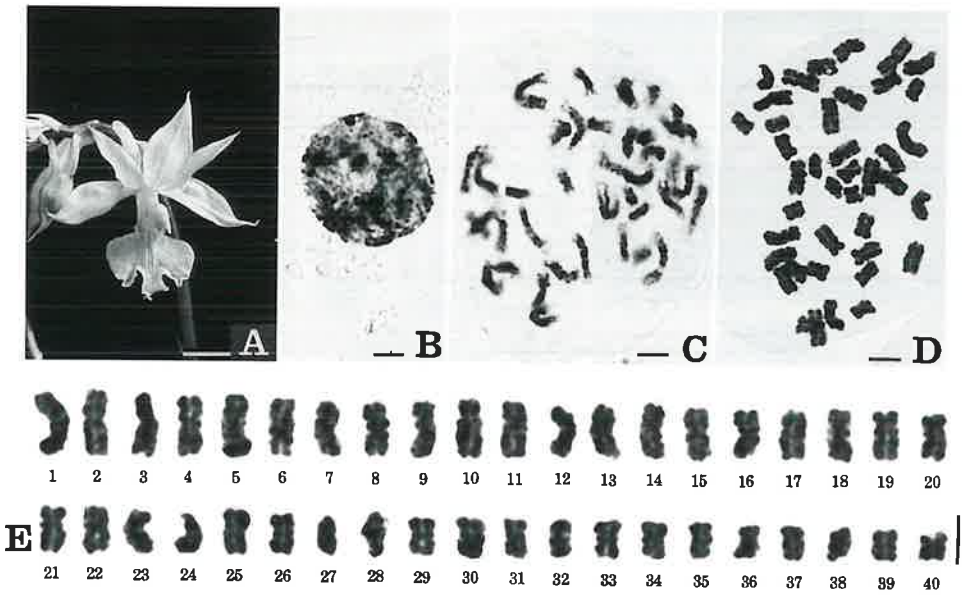

Fig. 2. *Calanthe arisanensis*, 2n=40. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 3 μm in B-E.

of the complex chromocenter type.

The 2n = 40 chromosome complement at mitotic metaphase showed a gradual decrease in length from the longest (4.3 μm) to the shortest (2.0 μm) chromosomes. Among the 40 chromosomes in the complement, 24 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, while the other 16 (Nos. 7–10, 19–22, 25–28, 37–40) varied in arm ratio from 1.8 to 2.5 had their centromeres at the submedian regions.

The majority of the chromosomes at metaphase exhibited small secondary constrictions in the proximal regions of their long arms. No satellite was observed.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

3) *Calanthe aristulifera* Reichb.f., 2n=40, Tables 1 and 4 , Fig. 3.

Two plants were obtained from China, Taiwan. External characteristics of the two plants were in accord with the descriptions of the species by Maekawa (1971).

The chromosome number of the two plants at mitotic metaphase was 2n=40, which confirmed Tanaka *et al.* (1981), and Hsu (1976) for this species as the synonym of *C. elliptica*.

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The 2n = 40 chromosome set at mitotic metaphase showed a gradual decrease in length

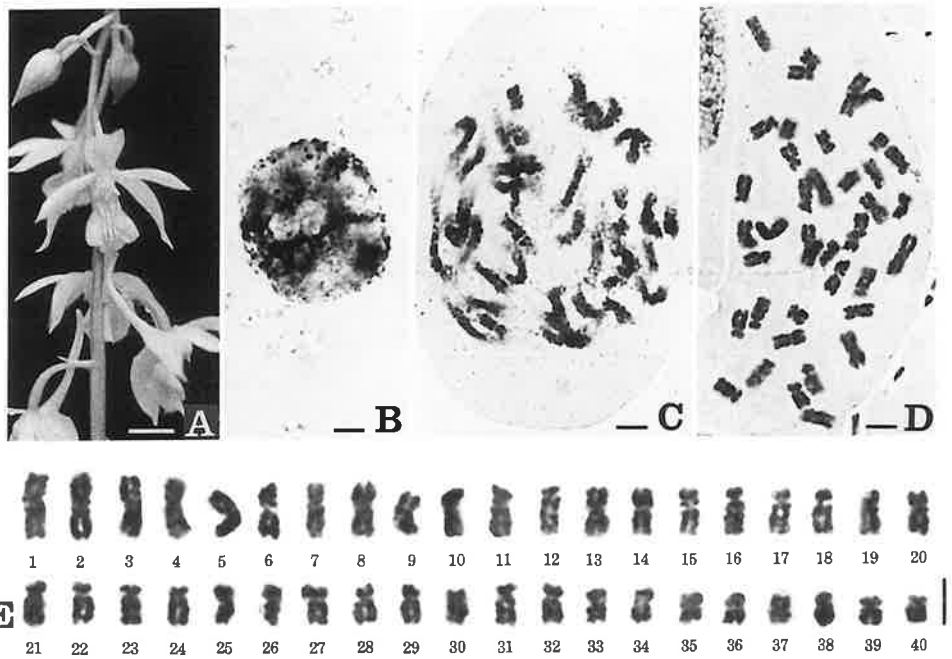

Fig. 3. *Calanthe aristulifera*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 12 mm in A and 3 μm in B-E.

from the longest (4.4 μm) to the shortest (1.9 μm) chromosomes. Among the 40 chromosomes in the complement, 20 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, while the other 20 (Nos. 9–12, 15–24, 27–32) varied in arm ratio from 1.8–2.8 had their centromeres at the submedian regions. No satellite was observed.

This species showed a homogeneous, gradual and symmetric karyotype.

4) *Calanthe caudatilabella* Hayata, 2n=38, Tables 1 and 5, Fig. 4.

Two plants were obtained from China, Taiwan. External characteristics of the two plants were in accord with the descriptions of the species by Lin (1976).

The chromosome number of the two plants at mitotic metaphase was 2n=38, which was different from 2n=40 reported by Hsu (1976). The chromosomes at resting stage were morphologically similar to those of *C. argenteo-striata* described above, but the chromocentric bodies performed more loose aggregations than those of *C. argenteo-striata*. The chromosome features at resting stage were of the loosely aggregated complex chromocenter type. The chromosomes at mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above.

The chromosomes of 2n=38 at mitotic metaphase showed a gradual decrease in length

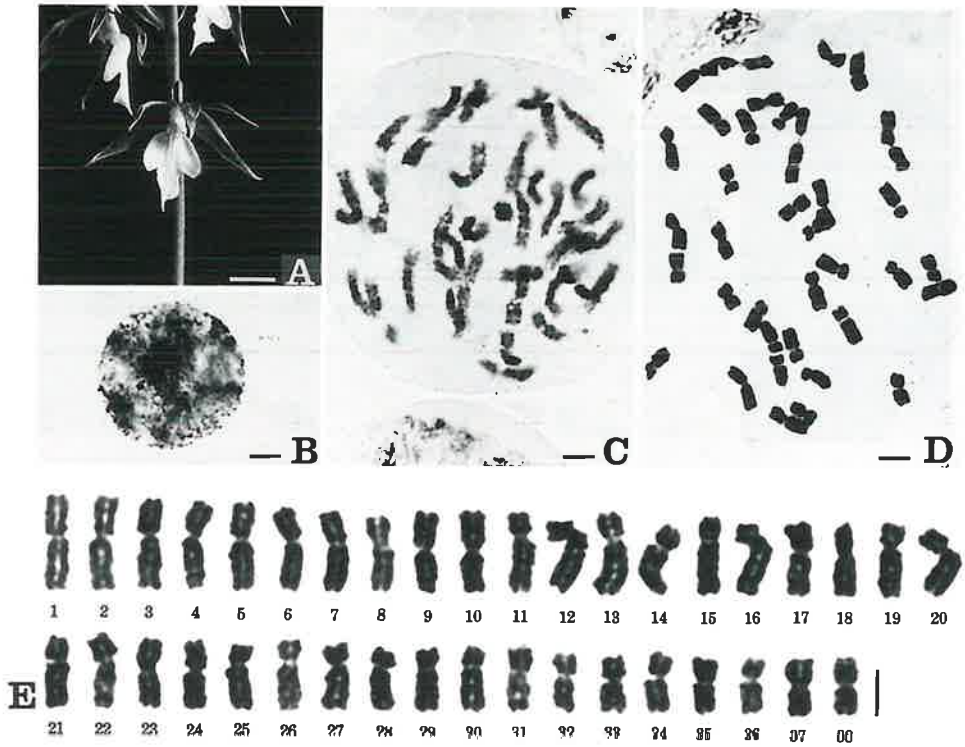

Fig. 4. *Calanthe caudatilabella*, 2n=38. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 8 mm in A and 3 μm in B-E.

from the longest (6.5 μm) to the shortest (3.7 μm) chromosomes. Among the 38 chromosomes in the complement, 22 varied in arm ratio from 1.0–1.6 had their centromeres at the median regions, while the other 16 (Nos. 11–16, 19–22, 25–30) varied in arm ratio from 1.9–2.4 had their centromeres at the submedian regions. No satellite was observed.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

5) *Calanthe conspicua* Lindl., 2n=40, Tables 1 and 6, Fig. 5.

A plant was obtained from the Philippines. External characteristics of the plant were in accord with the descriptions of the species by Valmayor (1984).

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

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

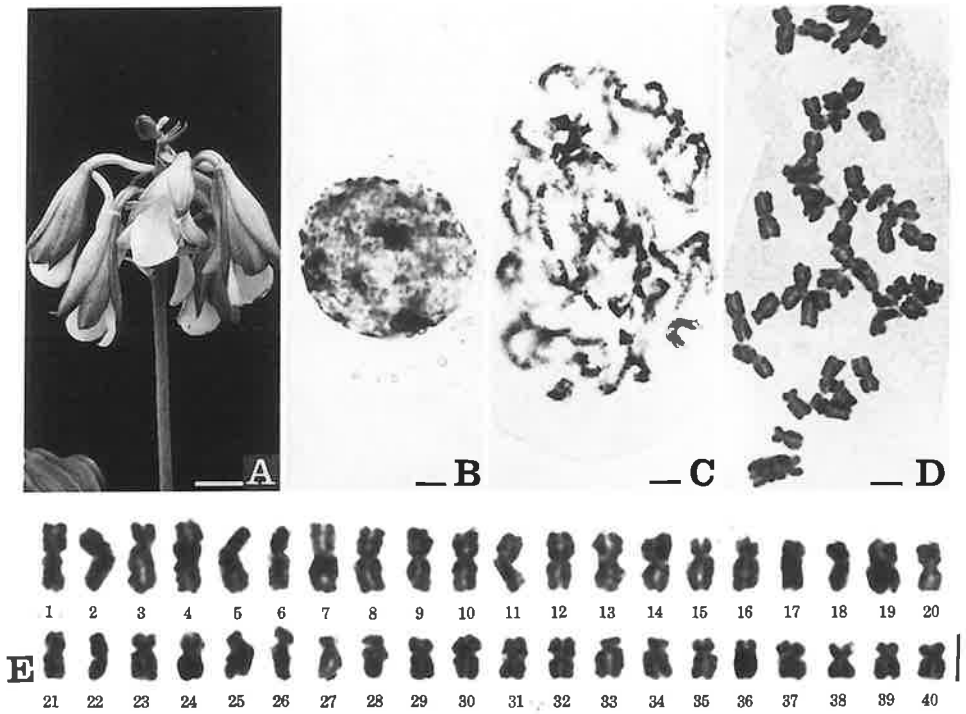

Fig. 5. *Calanthe conspicua*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 13 mm in A and 3 μm in B-E.

The chromosomes of 2n=40 at mitotic metaphase showed a gradual decrease in length from the longest (4.5 μm) to the shortest (2.2 μm) chromosomes. Among the 40 chromosomes in the complement, 26 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, while the other 14 (Nos. 3–4, 15–18, 25–28, 33–36) varied from 1.8–2.8 had their centromeres at the submedian regions. No satellite was observed.

This species showed a homogeneous, gradual and symmetric karyotype.

6) *Calanthe cremeo-viridis* J.J. Wood, 2n=46, Tables 1 and 7, Fig. 6.

A plant was obtained from Papua New Guinea. External characteristics of the plant were in accord with the descriptions of the species by Wood (1981).

The chromosome number of the plant was 2n=46 at mitotic metaphase, which was reported here for the first time for this species.

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=46 complement at mitotic metaphase showed a gradual de-

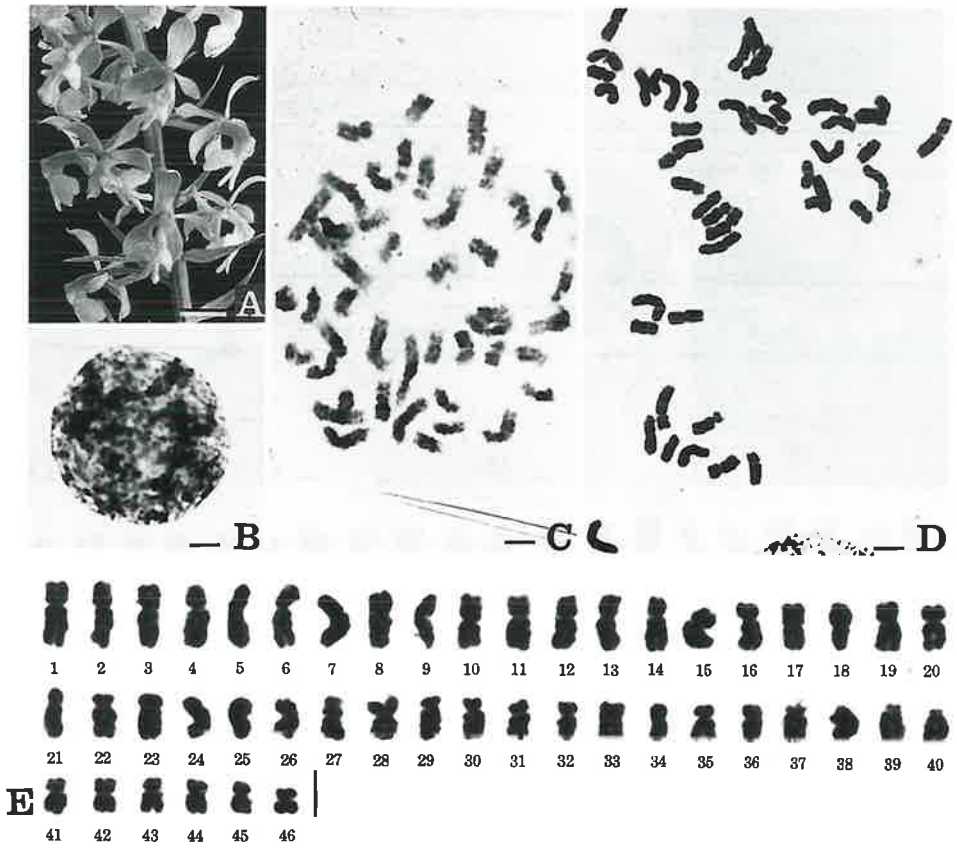

Fig. 6. *Calanthe cremeo-viridis*, 2n=46. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

crease in length from the longest (4.3 μm) to the shortest (1.8 μm) chromosomes. Among the 46 chromosomes in the complement, 34 varied in arm ratio from 1.0–1.6 had their centromeres at the median regions, while the other 12 (Nos. 21–24, 29–32, 37–40) varied in arm ratio from 1.8–3.0 had their centromeres at the submedian regions. No satellite was observed.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

7) *Calanthe graciliflora* Hayata, 2n=40, Tables 1 and 8, Fig. 7.

Five plants were obtained from China, Taiwan. External characteristics of the plants were in accord with the descriptions of the species by Lin (1976).

The chromosome number of the five plants at mitotic metaphase was 2n=40, which confirmed Hsu (1976).

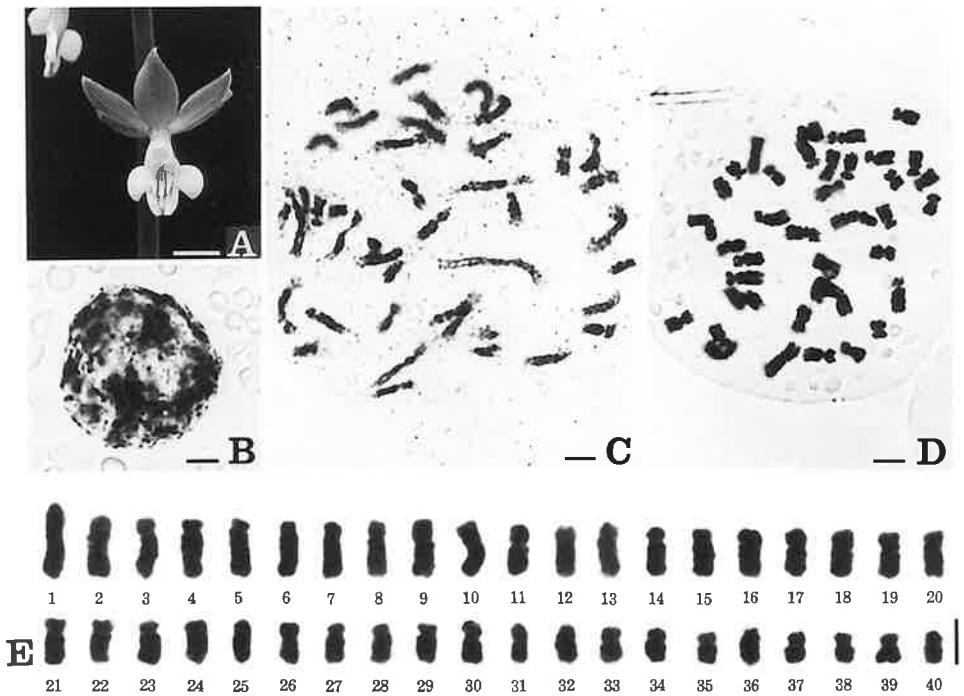

Fig. 7. *Calanthe graciliflora*, 2n=40. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (4.8 μm) to the shortest (2.0 μm) chromosomes. Among the 40 chromosomes in the complement, 18 varied in arm ratio from 1.0–1.6 had their centromeres at the median regions, 20 (Nos. 3–6, 13–16, 21–30, 35–36) varied in arm ratio from 1.8–2.7 had their centromeres at the submedian regions, and other two chromosomes (Nos. 7, 8) with the arm ratio of 4.2 had their centromeres at the subterminal regions. No satellite was observed.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

8) *Calanthe hamata* Hand.-Mazz., 2n=40, Tables 1 and 9, Fig. 8.

Three plants were obtained from China, Guizhou. External characteristics of the plants were in accord with the descriptions of the species by Institute Botany, Academia Sinica (1980).

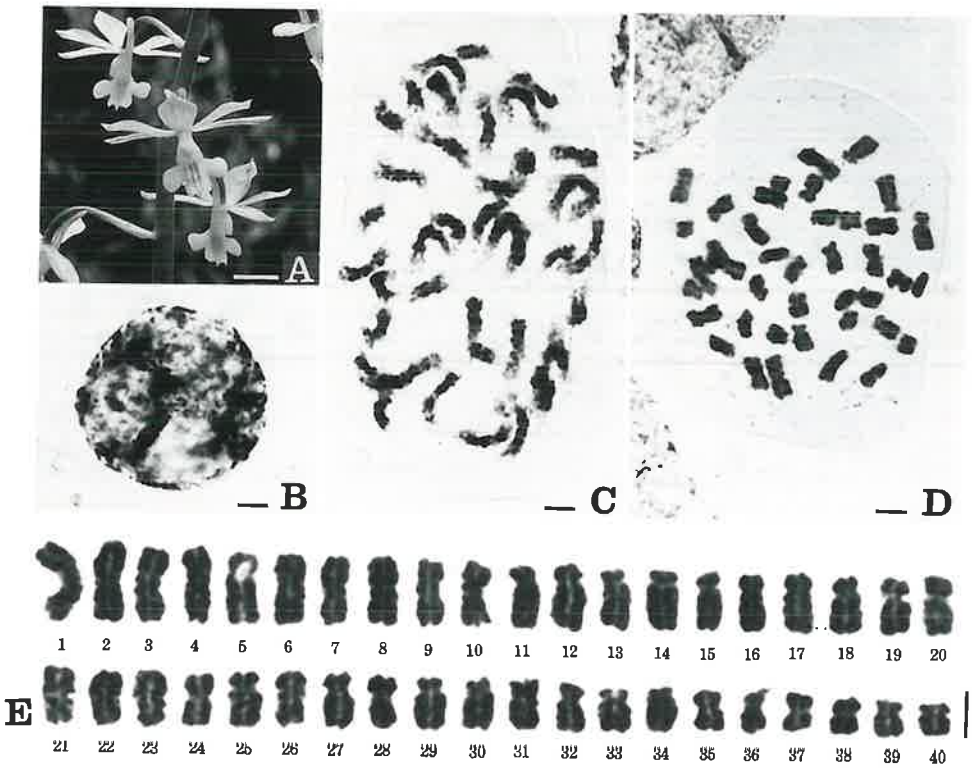

Fig. 8. *Calanthe hamata*, 2n = 40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

The chromosome number of the three plants at mitotic metaphase was 2n = 40, which confirmed Yang and Zhu (1984).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n = 40 complement at mitotic metaphase displayed a gradual decrease in length from the longest (5.6 μm) to the shortest (2.2 μm) chromosomes. Among the 40 chromosomes in the complement, 20 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, 16 (Nos. 5–6, 9–12, 17–18, 25–30, 33–34) varied in arm ratio from 1.8–2.6 had their centromeres at the submedian regions, and four (Nos.13–16) with the arm ratio of 3.3 had their centromeres at the subterminal regions. Two chromosomes (Nos. 34, 36) formed small satellites.

This species showed a homogeneous, gradual and symmetric karyotype.

9) *Calanthe hancockii* Rolfe, 2n=40, Tables 1 and 10, Fig. 9.

Two plants were obtained from China, Yunnan. External characteristics of the two

plants were in accord with the descriptions of the species by Institute of Botany, Academia Sinica (1980), except for their brown-colored sepals and petals.

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

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* 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 (5.3 μm) to the shortest (2.3 μm) chromosomes. Among the 40 chromosomes in the complement, 24 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, the other 16 (Nos. 5–6, 11–20, 27–28, 35–36) varied in arm ratio from 1.8–2.5 had their centromeres at the submedian regions. One chromosome (No. 9) formed a small satellite.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

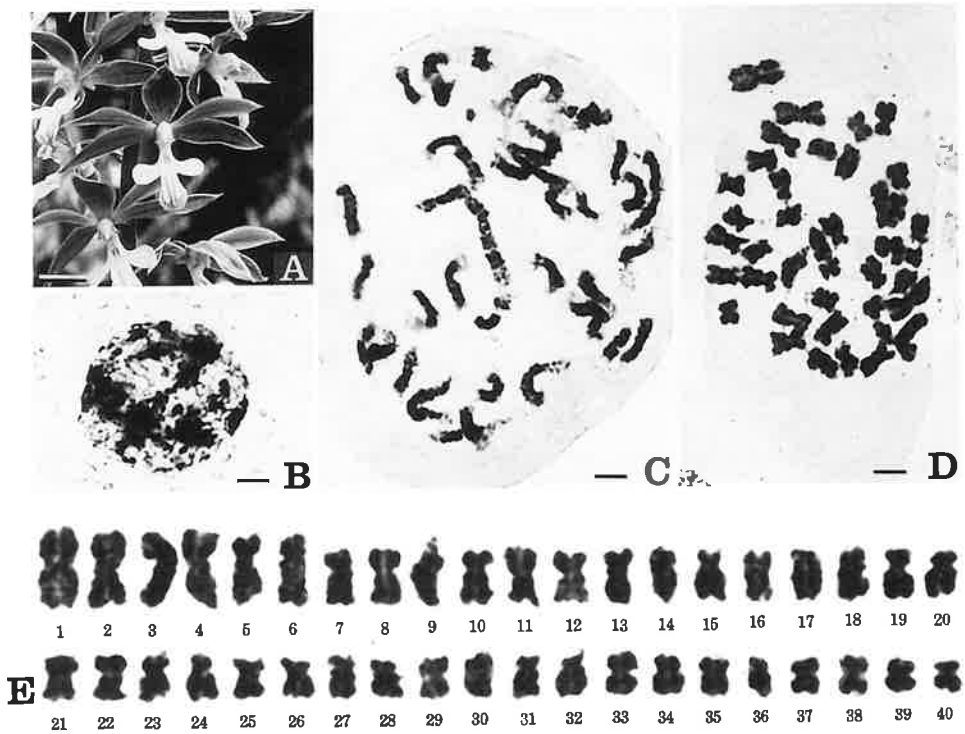

Fig. 9. *Calanthe hancockii*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 3 μm in B-E.

10) *Calanthe herbacea* Lindl., 2n=40, Tables 1 and 11, Fig. 10.

A plant was obtained from India. External characteristics of the plant were in accord with the descriptions of the species by Pradhan (1979).

The chromosome number of the plant at mitotic metaphase was 2n = 40, which confirmed Mehra and Vij (1970), Mehra and Sehgal (1976).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase performed a gradual decrease in length from the longest (5.3 μm) to the shortest (2.4 μm) chromosomes. Among the 40 chromosomes in the complement, 32 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, while the other eight (Nos. 29–36) varied in arm ratio from 1.8–2.6 had their centromeres at the submedian regions. One chromosome (No. 27) formed a satellite in the long arm.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

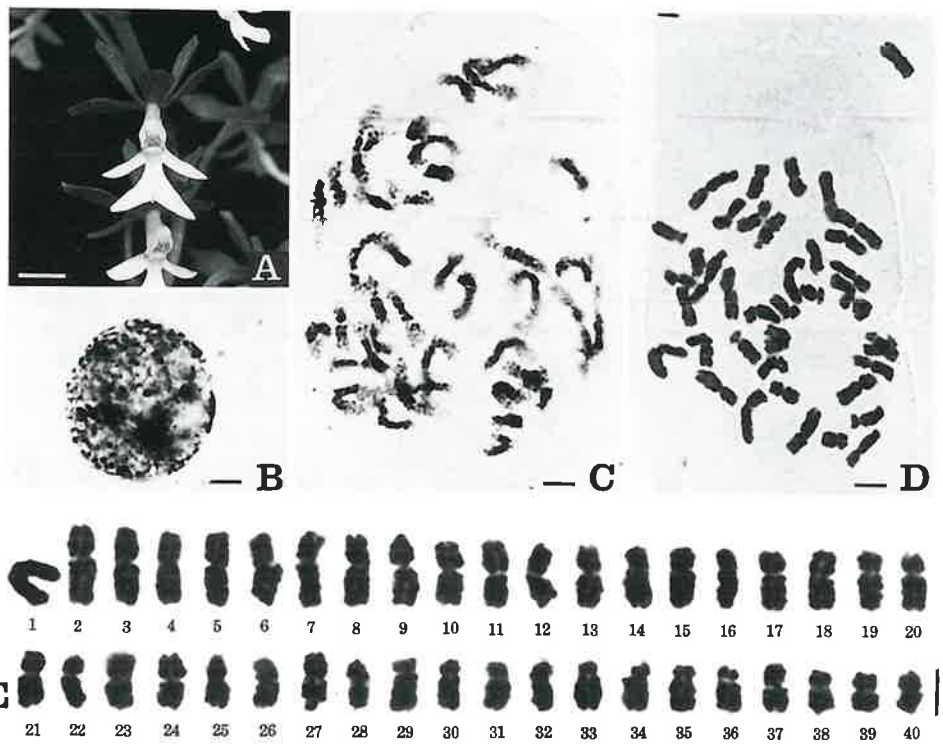

Fig. 10. *Calanthe herbacea*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

11) *Calanthe mannii* Hook.f., 2n=40, Tables 1 and 12, Fig. 11.

Three plants were obtained from India. External characteristics of the plants were in accord with the descriptions of the species by Pradhan (1979).

The chromosome number of the plants at mitotic metaphase was 2n = 40, which confirmed Mehra and Sehgal (1976), Vij *et al.* (1976).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (4.4 μm) to the shortest (1.7 μm) chromosomes. Among the 40 chromosomes in the complement, 20 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, 18 (Nos. 5–8, 11–12, 15–16, 23–24, 29–36) varied in arm ratio from 1.8 to 2.8 had their centromeres at the submedian regions, and two (Nos. 17, 18) with the arm ratio of 3.2 had their centromeres at the subterminal regions. No satellite was observed.

This species showed a homogeneous, gradual and symmetric karyotype.

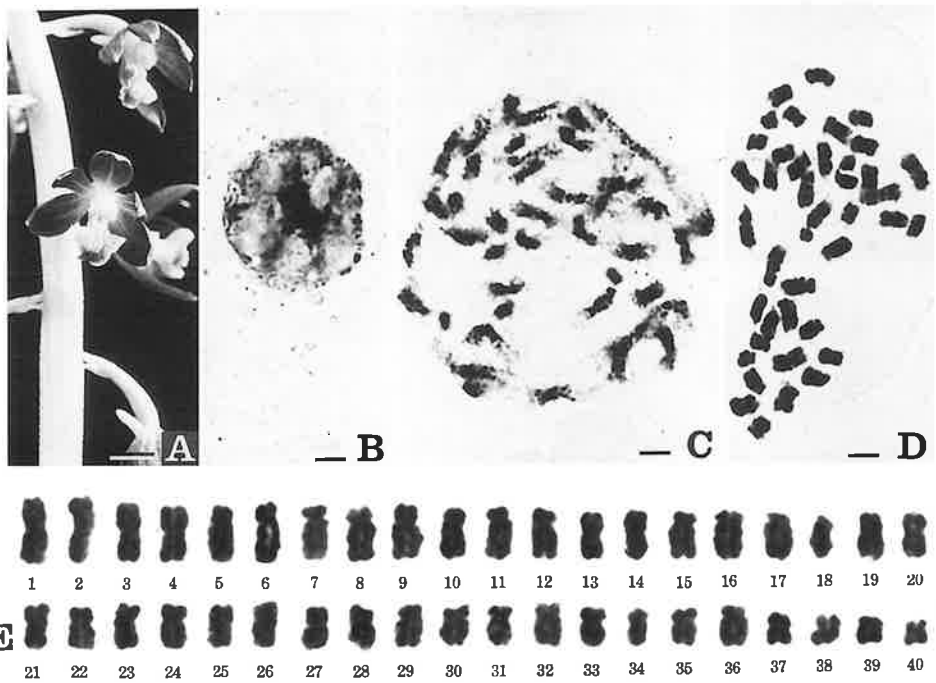

Fig. 11. *Calanthe mannii*, 2n = 40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metahase. Bars indicate 5 mm in A and 3 μm in B-E.

12) *Calanthe masuca* (D.Don) Lindl., 2n=40, Tables 1 and 13, Fig. 12.

Three plants were obtained from China, Taiwan, and two plants were obtained from India. External characteristics of the five plants were in accord with the descriptions of the species by Lin (1976) and Pradhan (1979).

The chromosome number of the five plants at mitotic metaphase was 2n=40, which confirmed Mehra and Vij (1970), Tanaka *et al.* (1981).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase exhibited a gradual decrease in length from the longest (4.9 μm) to the shortest (2.6 μm) chromosomes. Among the 40 chromosomes in the complement, 24 varied in arm ratio from 1.0–1.6 had their centromeres at the median regions, while the other 16 (Nos. 15–20, 27–32, 35–38) varied from 1.8–2.8 had their centromeres at the submedian regions. No satellite was observed.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

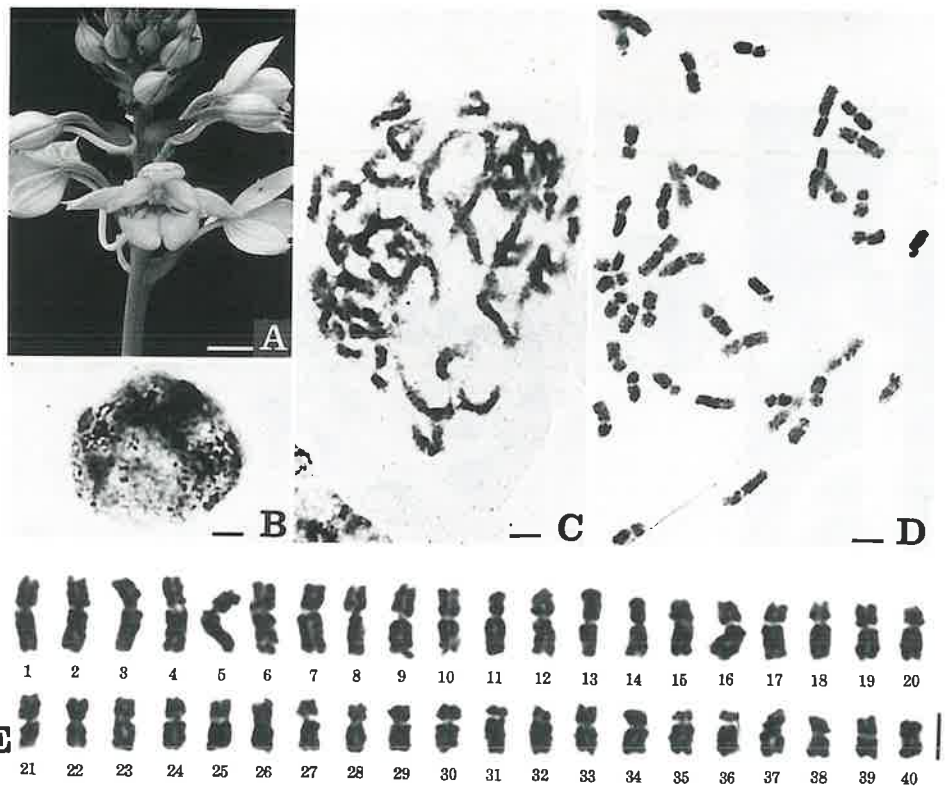

Fig. 12. *Calanthe masuca*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 13 mm in A and 3 μm in B-E.

13) *Calanthe matsudai* Hayata, 2n=40, Tables 1 and 14, Fig. 13.

Three plants were obtained from China, Taiwan. External characteristics of the three plants were in accord with the descriptions of the species by Lin (1976).

The chromosome number of the plants at mitotic metaphase was 2n = 40 and verified one of the Hsu's results, 2n=40 and 42 for this species (1976).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (5.7 μm) to the shortest (2.2 μm) chromosomes. Among the 40 chromosomes in the complement, 22 varied in arm ratio from 1.2–1.7 had their centromeres at the median regions, 16 (Nos. 3–6, 15–16, 19–26, 33–34) varied in arm ratio from 1.8–2.8 had their centromeres at the submedian regions, and the other two (Nos. 17, 18) with the arm ratio of 4.1 had their centromeres at the subterminal regions. No satellite was observed.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

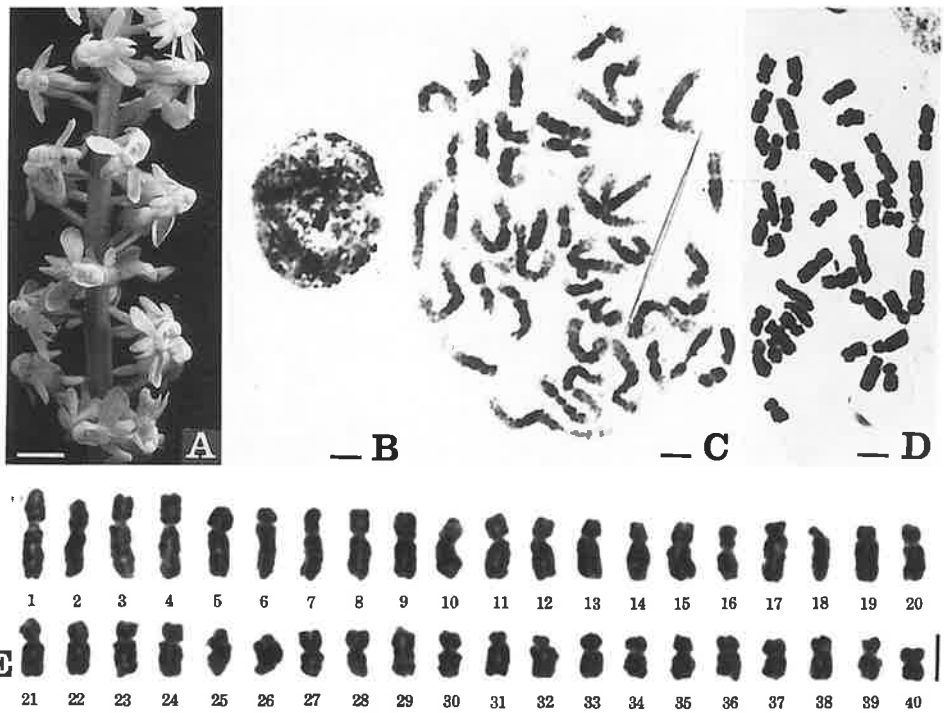

Fig. 13. *Calanthe matsudai*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

14) *Calanthe plantaginea* Lindl., 2n=40, Tables 1 and 15, Fig. 14.

Two plants were obtained from India. External characteristics of the two plants were in accord with the descriptions of the species by Pradhan (1979).

The chromosome number of the plants at mitotic metaphase was 2n=40 and confirmed Arora (1968).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (4.3 μm) to the shortest (2.1 μm) chromosomes. Among the 40 chromosomes in the complement, 16 varied in arm ratio from 1.1–1.6 had their centromeres at the median regions, 18 (Nos. 9–10, 15–26, 29–32) varied in arm ratio from 1.8–2.8 had their centromeres at the submedian regions, and the other six (Nos. 3–8) varied in arm ratio from 3.1–3.6 had their centromeres at the subterminal regions. No satellite was

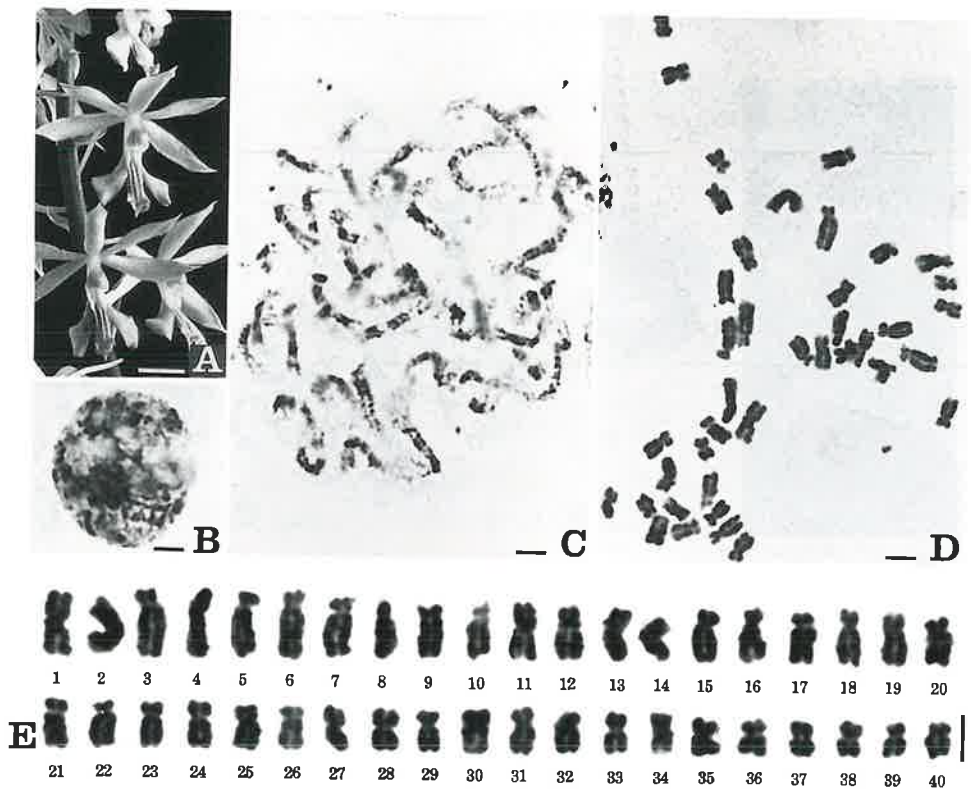

Fig. 14. *Calanthe plantaginea*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

observed.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

15) *Calanthe reflexa* Maxim., 2n=40, Tables 1 and 16, Fig. 15.

Three plants were obtained from China, Taiwan and one plant was obtained from China, Sichuan. External characteristics of the four plants were in accord with the descriptions of the species by Lin (1976).

The chromosome number of the plants at mitotic metaphase was 2n=40 and confirmed Miduno (1940), Tanaka (1965), Hsu (1976), Tanaka *et al.* (1981).

The chromosomes at resting stage were morphologically similar to those of *C. argenteo-striata* described above, but their chromocentric bodies were showed more loose aggregations than those of *C. argenteo-striata*. The chromosomes at mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

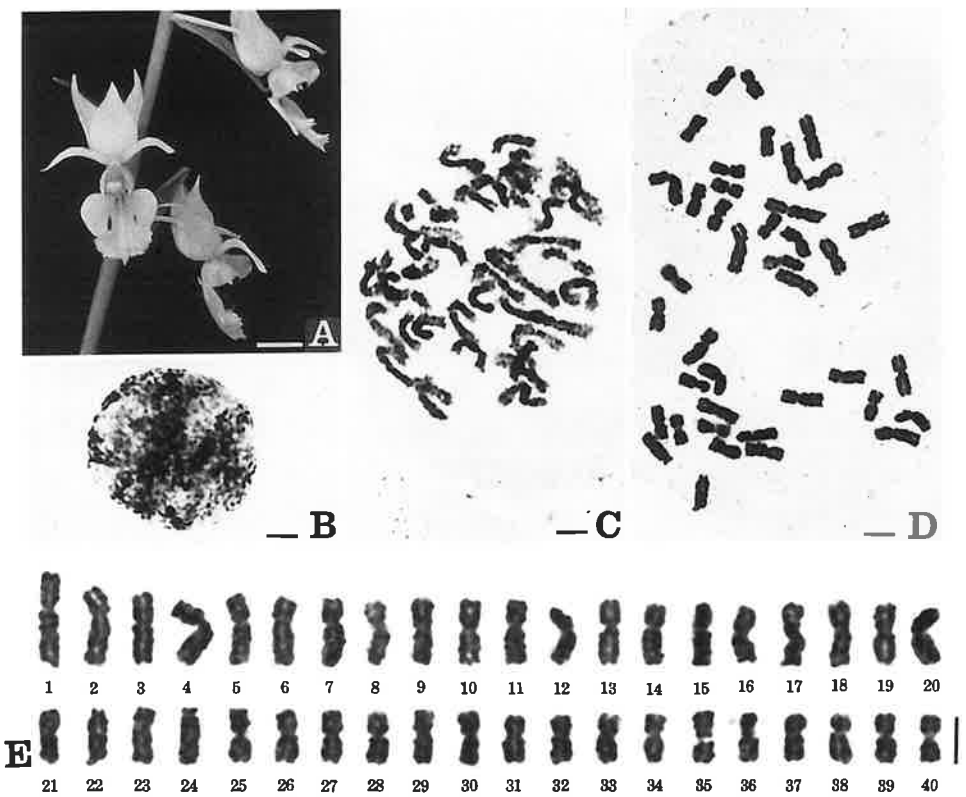

Fig. 15. *Calanthe reflexa*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 8 mm in A and 3 μm in B-E.

The chromosome lengths at mitotic metaphase varied from the longest one of 5.6 μm to the shortest one of 3.0 μm. The first chromosome was larger than the others which showed a gradual decrease in length from the longest to the shortest chromosomes. Among the 40 chromosomes in the complement, 35 varied in arm ratio from 1.0–1.6 had their centromeres at the median regions, four (Nos. 5–6, 15–16) varied in arm ratio from 1.8–1.9 had their centromeres at the submedian regions, and the rest one (No. 24) with the arm ratio of 6.0 had its centromere at the subterminal region. A pair of the small chromosomes with the median centromeres formed a large secondary constriction in a proximal region of the long arm. At mitotic prophase the secondary constricted chromosomes appeared attached to a nucleolus through its secondary constricted region. These results in this species verified the previous report (Tanaka et al. 1981).

Thus, this species showed a partially heterogeneous, gradual, and highly symmetric karyotype.

16) *Calanthe sieboldii* Decne., 2n=40, Tables 1 and 17, Fig. 16.

Three plants were obtained from China, Taiwan. External characteristics of the three

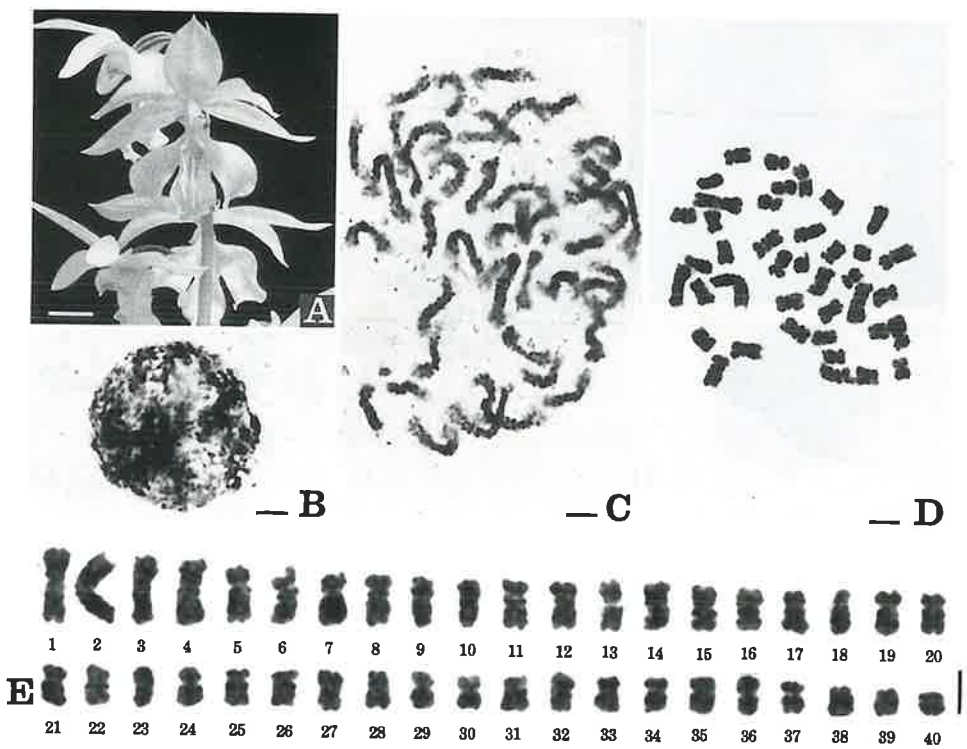

Fig. 16. *Calanthe sieboldii*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 3 μm in B-E.

plants were in accord with the descriptions of the species by Lin (1976).

The chromosome number of the three plants at mitotic metaphase was 2n=40 and confirmed Miduno (1940), Mutsuura and Nakahira (1965), Tanaka (1965, 1974), Hsu (1976), Tanaka *et al.* (1981).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type. The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (4.8 μm) to the shortest (1.5 μm) chromosomes. Among the 40 chromosomes in the complement, 26 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, while the other 14 (Nos. 5–8, 11–12, 17–20, 25–26, 31–32) varied in arm ratio from 1.8–2.4 had their centromeres at the submedian regions. Many chromosomes at metaphase exhibited small constrictions in the proximal regions of long arms.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

17) *Calanthe sylvatica* Lindl., 2n=40, Tables 1 and 18, Fig. 17.

A plant was obtained from Madagascar. External characteristics of the plant were in

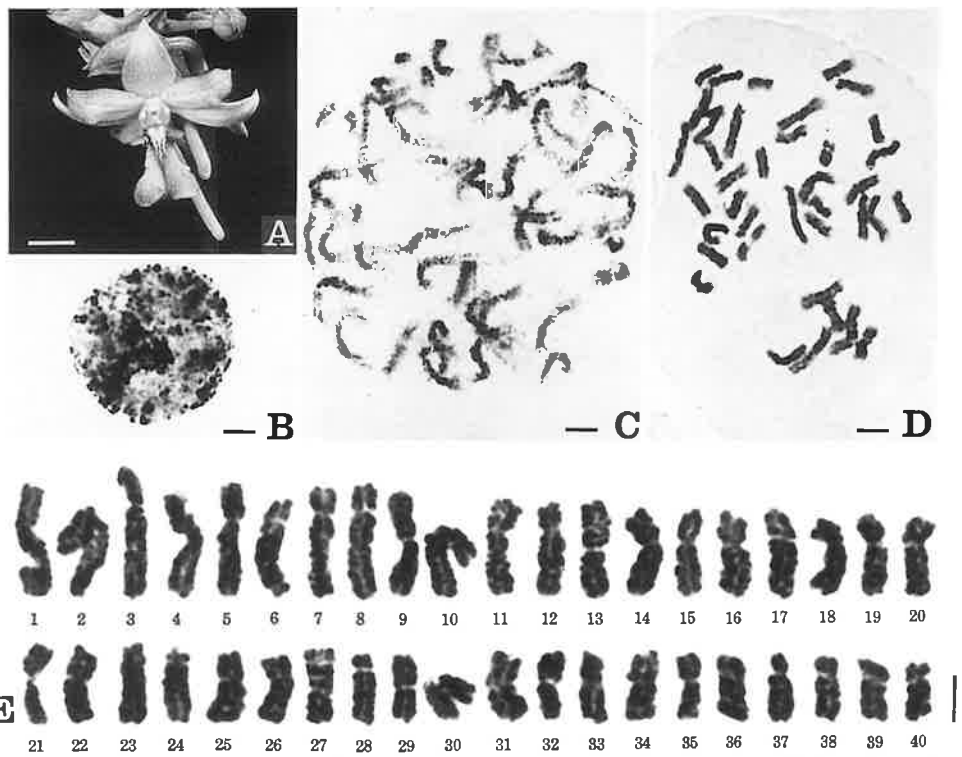

Fig. 17. *Calanthe sylvatica*, 2n=40. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

accord with the descriptions of the species by Perrier De La Bathie (1939). The chromosome number of the plant at mitotic metaphase was 2n=40 and confirmed Chardard (1963).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (8.2 μm) to the shortest (3.9 μm) chromosomes. Among the 40 chromosomes in the complement, 16 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, 14 (Nos. 1–6, 11–12, 17–20, 37–40) varied in arm ratio from 1.9–2.5 had their centromeres at the submedian regions, and the other six (Nos. 7–8, 23–24, 27–28) were varied in arm ratio from 3.1–5.2 had their centromeres at the subterminal regions.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

18) *Calanthe tricarinata* Lindl., 2n=40, Tables 1 and 19, Fig. 18.

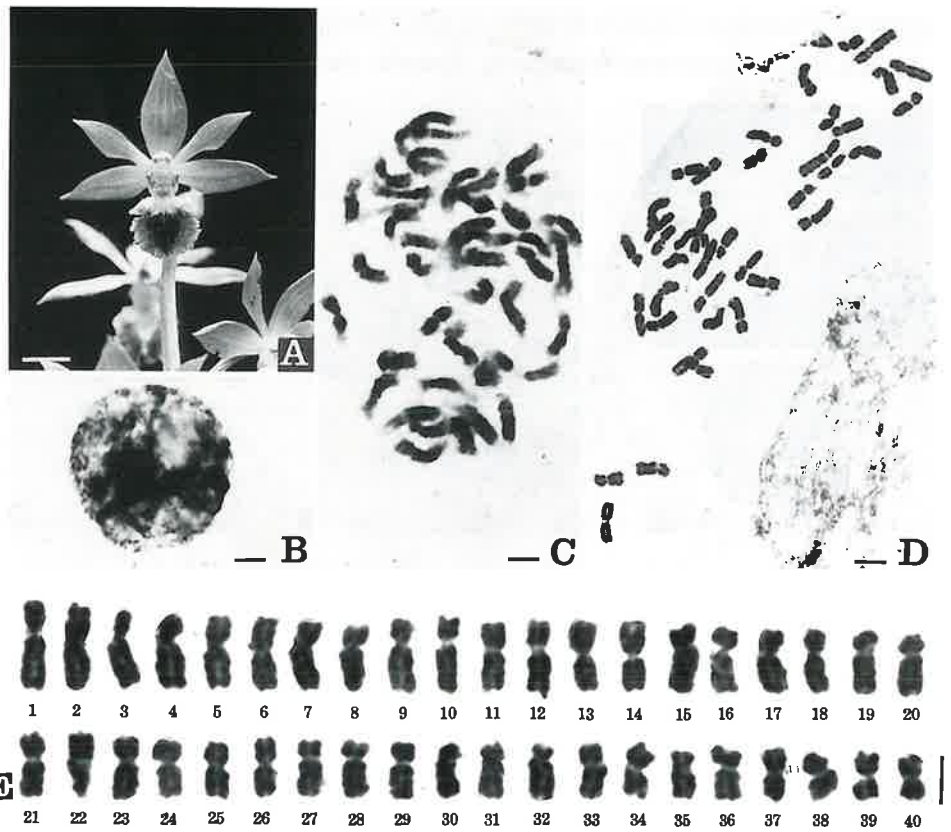

Fig. 18. *Calanthe tricarinata*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 3 μm in B-E.

A plant was obtained from China, Taiwan. External characteristics of the plant were in accord with descriptions of the species by Lin (1976).

The chromosome number of the plant at mitotic metaphase was 2n=40 and confirmed Mutsuura and Nakahira (1958), Mehra and Bawa (1962), Tanaka (1965), Hsu (1976), Tanaka *et al.*(1981).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase displayed a gradual decrease in length from the longest (5.6 μm) to the shortest (2.7 μm) chromosomes. Among the 40 chromosomes in the complement, 26 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, 12 (Nos. 9–10, 15–16, 27–30, 35–36) varied in arm ratio from 1.9–2.3 had their centromeres at the submedian regions, and the other two (Nos. 31, 32) with the arm ratio of 3.1 had their centromeres at the subterminal regions.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

19) *Calanthe triplicata* (Willem.) Ames, 2n=40, Tables 1 and 20, Fig. 19.

Three plants were obtained from China, Taiwan and one plant was obtained from the

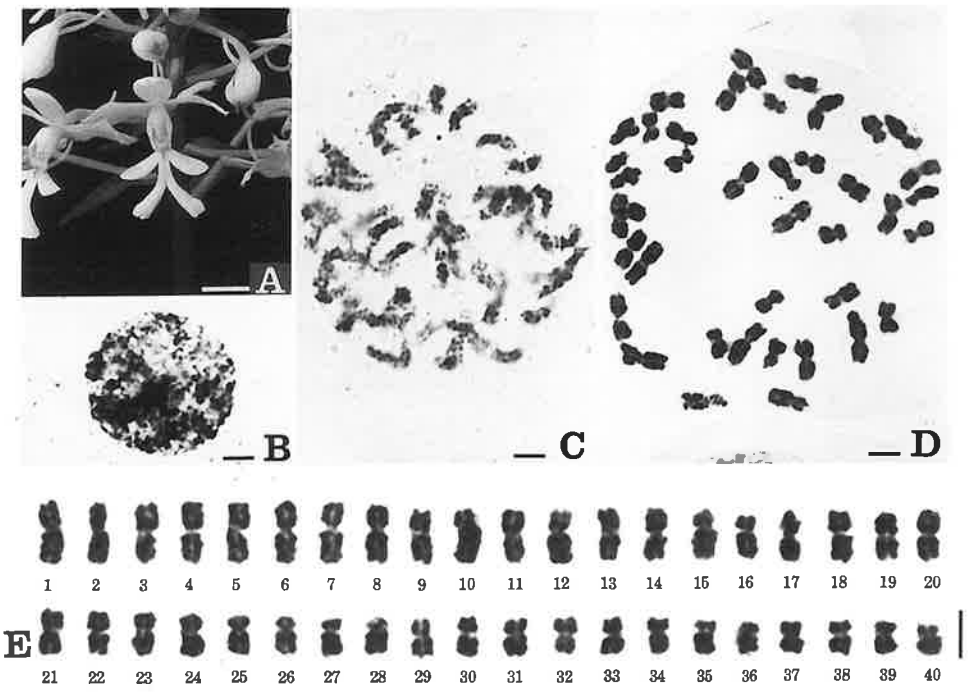

Fig. 19. *Calanthe triplicata*, 2n=40. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

Philippines. External characteristics of the four plants were in accord with descriptions of the species by Lin (1976).

The chromosome number of the plants at mitotic metaphase was 2n=40 and confirmed Arora (1960), Pancho (1965), Tanaka (1965), Larsen (1966), Hsu (1976), Tanaka *et al.* (1981).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. argenteo-striata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (4.0 μm) to the shortest (2.0 μm) chromosomes. Among the 40 chromosomes in the complement, 30 varied in arm ratio from 1.0–1.3 had their centromeres at the median regions, and the other 10 (Nos. 15–16, 25–29, 35–36, 39–40) varied in arm ratio from 1.8 to 2.1 had their centromeres at the submedian regions.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

2. Section Styloglossum

1) *Calanthe clavata* Lindl., Tables 1 and 21, Fig. 20.

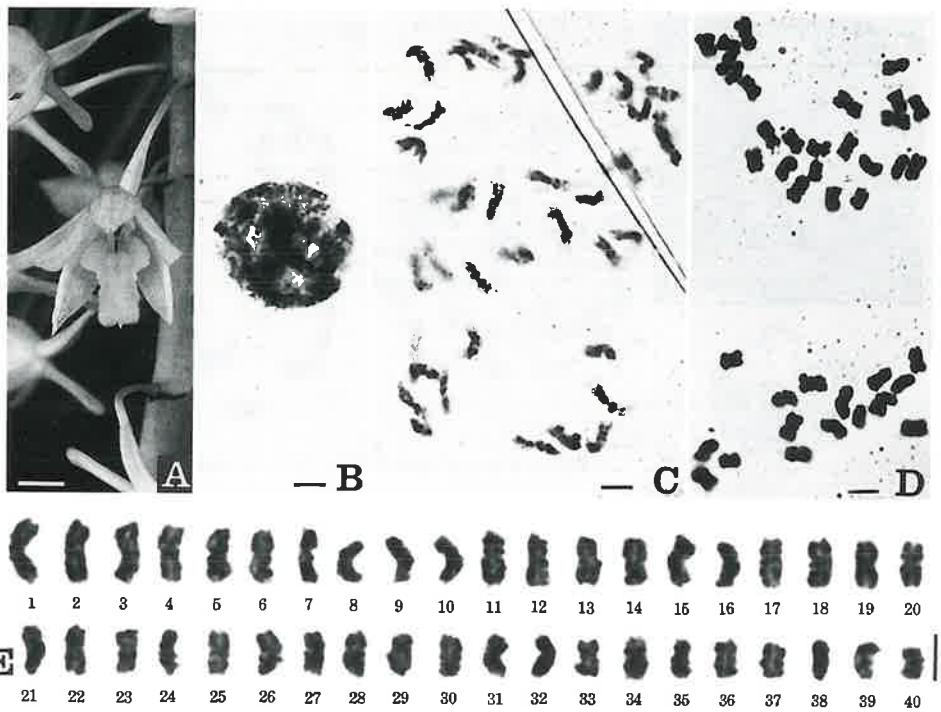

Fig. 20. *Calanthe clavata*, 2n=40. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 7 mm in A and 3 μm in B-E.

A plant was obtained from China, Guangdong. External characteristics of the plant were in accord with descriptions of the species by Seidenfaden (1975).

The chromosome number of the plant at mitotic metaphase was $2n = 40$, which confirmed Mehra (1982).

The chromosomes at resting stage were morphologically similar to those of *C. argenteo-striata* described above but formed larger and stronger condensed blocks. Approximately ten chromocentric bodies were counted in each nucleus. The chromosomes at mitotic prophase were morphologically similar to those of *C. argenteo-striata*. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the $2n=40$ complement at mitotic metaphase showed a gradual decrease in length from the longest (4.5 μm) to the shortest (2.4 μm) chromosomes. Among the 40 chromosomes in the complement, 36 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, and the other four (Nos. 9–10, 35–36) varied in arm ratio from 1.8–2.0 had their centromeres at the submedian regions.

Thus, this species showed a homogeneous, gradual and highly symmetric karyotype.

2) *Calanthe densiflora* Lindl., Tables 1 and 22, Fig.21.

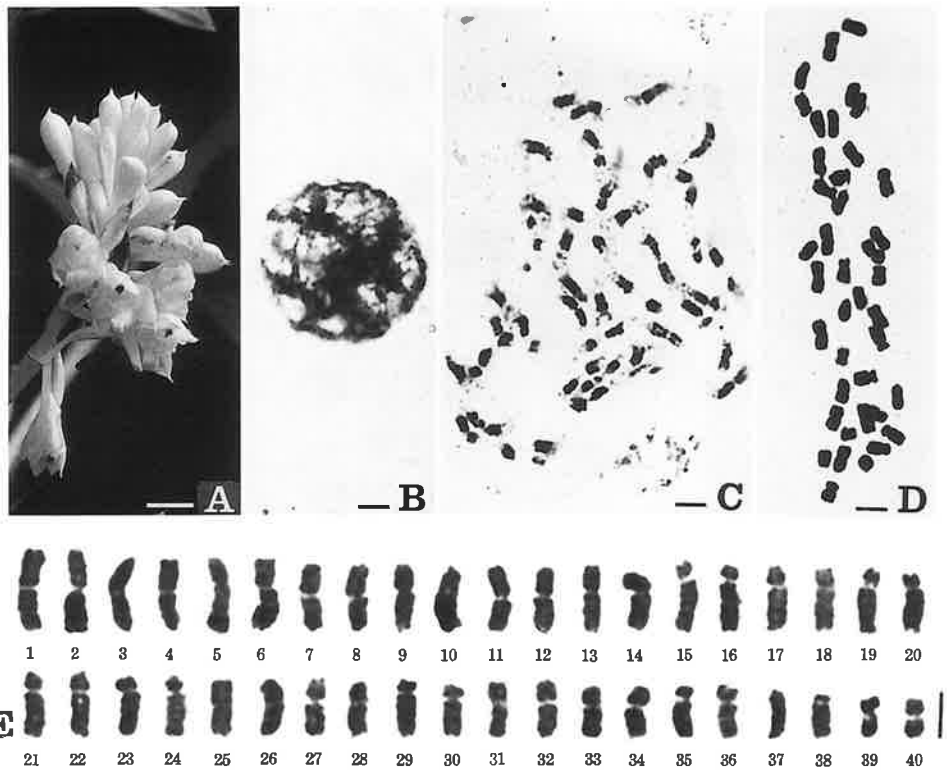

Fig. 21. *Calanthe densiflora*, $2n=40$. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 3 μm in B-E.

Two plants were obtained from China, Taiwan. External characteristics of the plants were in accord with the descriptions of the species by Lin (1977).

The chromosome number of the plants at mitotic metaphase was 2n=40 and confirmed Hsu (1976), Tanaka *et al.* (1981), Vij and Shekhar (1983).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. clavata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (5.1 μm) to the shortest (2.4 μm) chromosomes. Among the 40 chromosomes in the complement, 24 varied in arm ratio from 1.1–1.7 had their centromeres at the median regions, 12 (Nos. 15–18, 21–24, 35–38) varied in arm ratio from 2.4–2.8 had their centromeres at the submedian regions and the other four (Nos. 19–20, 31–32) varied in arm ratio from 3.1–3.2 had their centromeres at the subterminal regions.

Thus, this species showed a homogeneous, gradual and highly symmetric karyotype.

3) *Calanthe formosana* Rolfe, 2n=40, Tables 1 and 23, Fig. 22.

Two plants were obtained from China, Taiwan. External characteristics of the plants

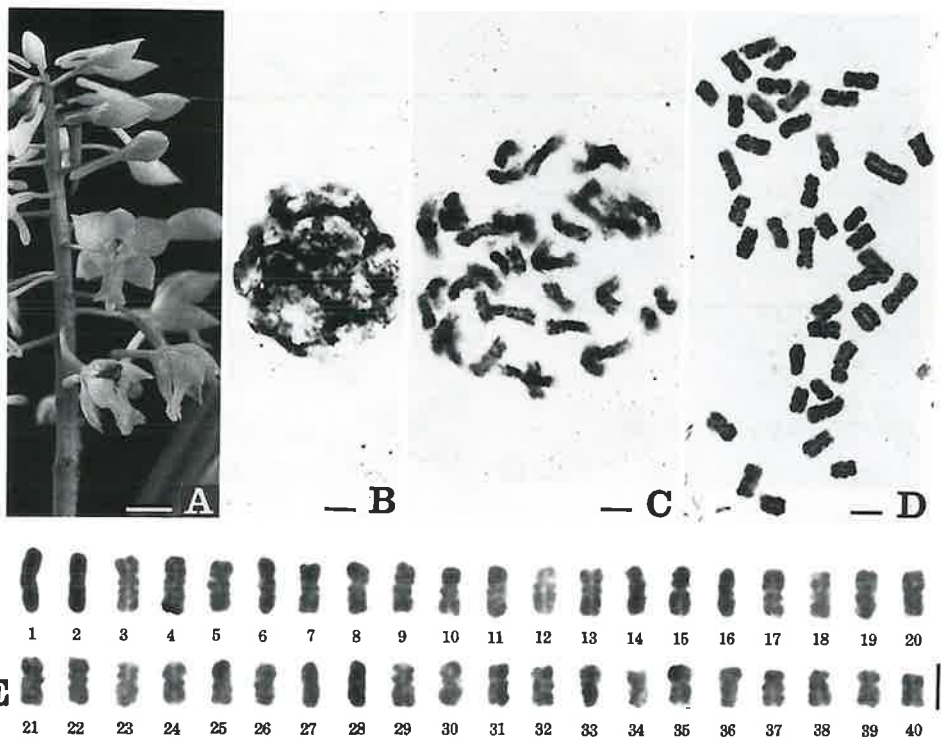

Fig. 22. *Calanthe formosana*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 11 mm in A and 3 μm in B-E.

were in accord with the descriptions of the species by Lin (1976).

The chromosome number of the plants at mitotic metaphase was 2n = 40, which confirmed Hsu (1976).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. clavata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The 2n = 40 chromosomes of the mitotic metaphase complement showed a gradual decrease in length from the longest (4.1 μm) to the shortest (2.4 μm) chromosomes. Among the 40 chromosomes in the complement, 34 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, while the other six (Nos. 5–6, 13–14, 37–38) varied in arm ratio from 1.9–2.1 had their centromeres at the submedian regions.

This species showed a homogeneous, gradual and highly symmetric karyotype.

4) *Calanthe lyroglossa* Reichb.f., 2n=40, Tables 1 and 24, Fig. 23.

Two plants were obtained from China, Taiwan. External characteristics of the plants were in accord with the descriptions of the species by Lin (1976).

The chromosome number of the plants at mitotic metaphase was 2n=40 and confirmed

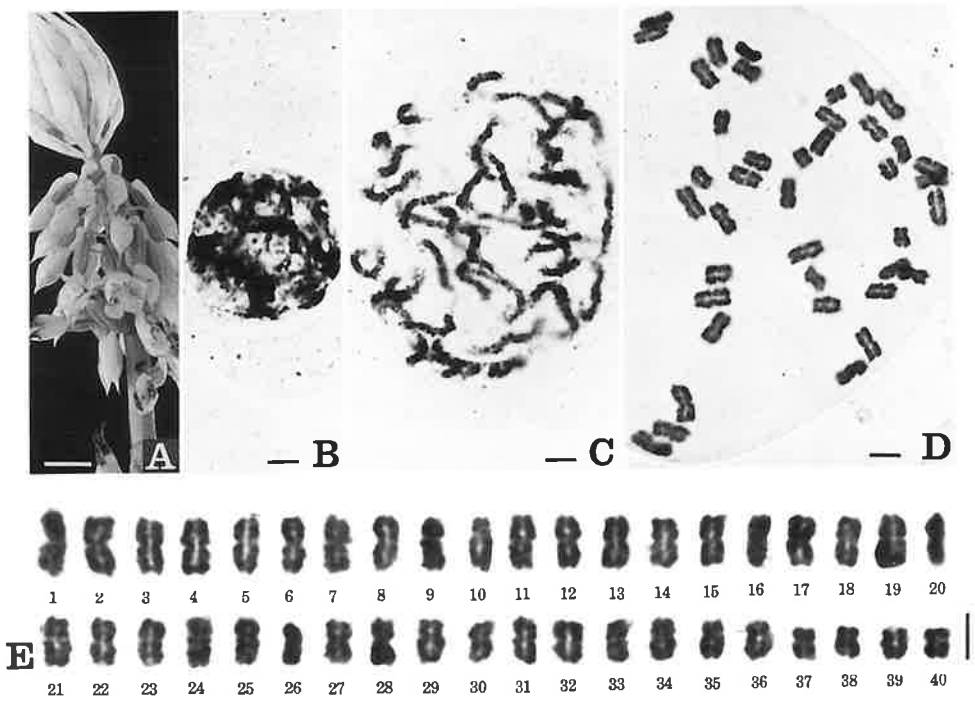

Fig. 23. *Calanthe lyroglossa*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 13 mm in A and 3 μm in B-E.

Hsu (1976), Tanaka *et al.* (1981).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. clavata* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosome complement of 2n = 40 at mitotic metaphase exhibited a gradual decrease in length from the longest (4.3 μm) to the shortest (2.0 μm) chromosomes. Among the 40 chromosomes in the complement, 36 varied in arm ratio from 1.0–1.6 had their centromeres at the median regions, while the other four (Nos. 9–10, 35–36) varied in arm ratio from 1.8–2.0 had their centromeres at the submedian regions.

Thus, this species showed a homogeneous, gradual and highly symmetric karyotype.

3. Section Aceratochilus

1) *Calanthe kooshunensis* Fukuyama, 2n=40, Tables 1 and 25, Fig. 24.

Two plants were obtained from China, Taiwan. Lin (1976) treated this species into a

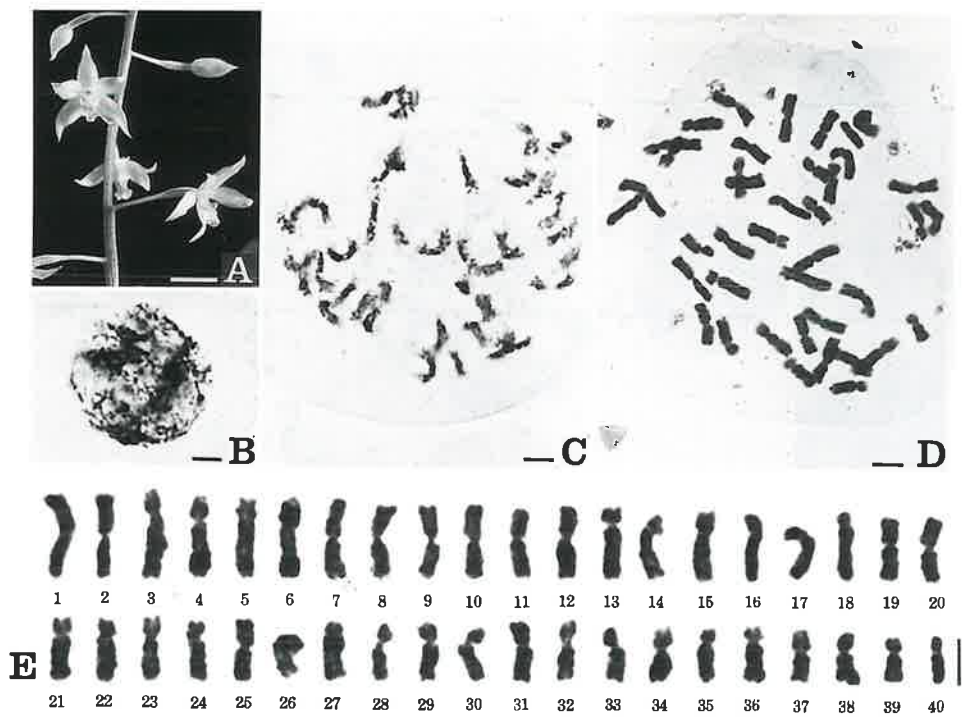

Fig. 24. *Calanthe kooshunensis*, 2n=40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

synonym of *Phaius longipes* (Hook. f.) Holtt. var. *calantheoides* (Ames) Lin, and Valmayor (1984) treated this species into a synonym of *Cephalantheropsis calantheoides* (Ames) Liu and Su. External characteristics of the plants were in accord with the descriptions by Lin (1976) and Valmayor (1984).

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

The chromosomes at resting stage were morphologically similar to those of *C. argenteostriata* described above. Approximately ten chromocentric bodies were counted in each nucleus. The chromosome features at resting stage were of the complex chromocenter type. The chromosomes at mitotic prophase were morphologically similar to those of *C. argenteostriata*.

The chromosome complement of 2n=40 at mitotic metaphase exhibited a gradual decrease in length from the longest (5.6 μm) to the shortest (3.2 μm) chromosomes. Among the 40 chromosomes in the complement, 18 varied in arm ratio from 1.0–1.5 had their centromeres at the median regions, 18 (Nos. 3–6, 13–14, 21–24, 27–30, 35–36, 39–40) varied in arm ratio from 1.9–2.5 had their centromeres at the submedian regions, and the other four (Nos. 15–18) varied in arm ratio from 3.3–3.8 had their centromeres at the subterminal regions.

Thus, this species showed a homogeneous, gradual and highly symmetric karyotype.

2) *Calanthe gracilis* Lindl., 2n=40, Tables 1 and 26, Fig. 25.

Three plants were obtained from China, Taiwan. Lin (1976) treated this species into a synonym of *Phaius longipes* (Hook. f.) Holtt. and Valmayor (1984) treated this species into a synonym of *Cephalantheropsis gracilis* (Lindl.) S. Y. Hu. External characteristics of the plants were in accord with the descriptions by Lin (1976) and Valmayor (1984).

The chromosome number of the plants at mitotic metaphase was 2n=40 and confirmed the Tanaka's report (1965) after a treatment of this species into a synonym of *C. venusta* Schltr., and Tanaka, Karasawa and Ishida's report (1981) after another treatment of this species into a synonym of *C. gracilis* Lindl. var. *venusta* (Schltr.) F. Maekawa.

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. kooshunensis* described above. Approximately 12 chromocentric bodies were counted in each nucleus. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (4.3 μm) to the shortest (2.1 μm) chromosomes. Among the 40 chromosomes in the complement, 22 varied in arm ratio from 1.1–1.7 had their centromeres at the median regions, while the other 18 (Nos. 5–10, 15–16, 21–22, 27–32, 37–38) varied in arm ratio from 1.8–2.5 had their centromeres at the submedian regions. Thus, this species showed a homogeneous, gradual and symmetric karyotype.

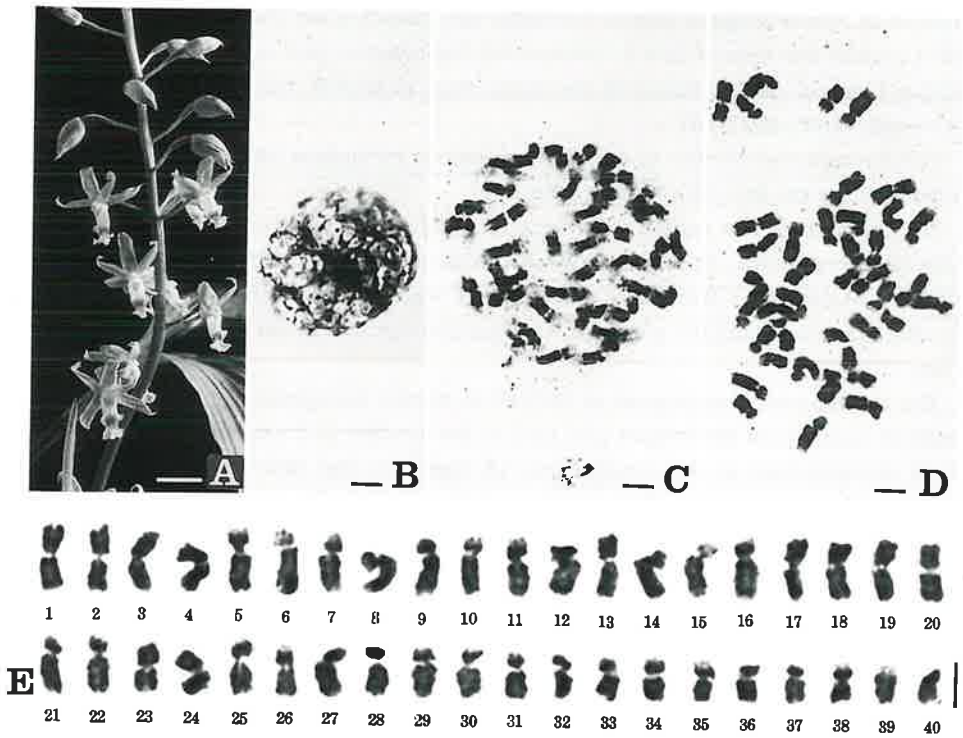

Fig. 25. *Calanthe gracilis*, 2n = 40. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 9 mm in A and 3 μm in B-E.

II. Subgenus Preptanthe

1. Section Eu-Preptanthe

1) *Calanthe cardioglossa* Schltr., 2n=46, Tables 1 and 27, Fig. 26.

Two plants were obtained from Thailand. External characteristics of the plants were in accord with the descriptions of the species by Seidenfaden (1975).

The chromosome number of the plants at mitotic metaphase was 2n = 46, which was different from 2n=c44 reported by Larsen (1966).

The chromosomes at resting stage were morphologically similar to those of *C. argenteo-striata* described above, but formed larger and stronger condensed blocks. Approximately 25 chromocentric bodies were counted in each nucleus. The chromosomes at mitotic prophase were morphologically similar to those of *C. argenteo-striata*. The chromosome features at resting stage were of the complex chromocenter type.

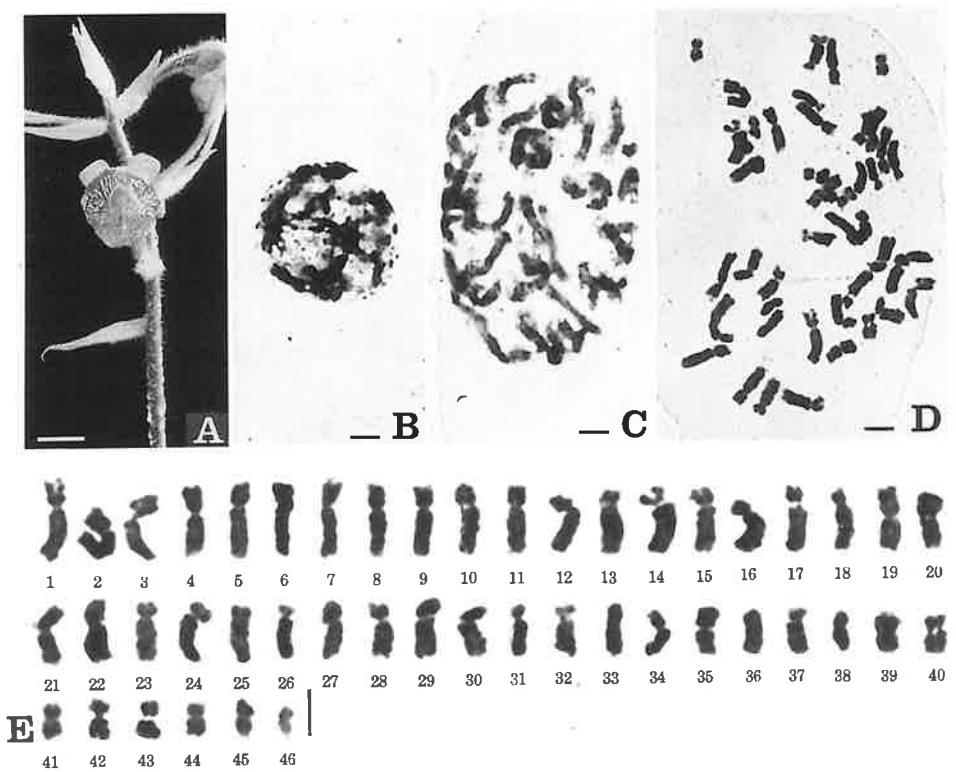

Fig. 26. *Calanthe cardioglossa*, 2n=46. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 14 mm in A and 3 μm in B-E.

The chromosomes of the 2n=40 complement at mitotic metaphase showed a gradual decrease in length from the longest (4.9 μm) to the shortest (1.9 μm) chromosomes. Among the 40 chromosomes in the complement, 20 varied in arm ratio from 1.0–1.6 had their centromeres at the median regions, 18 (Nos. 1–2, 5–12, 15–18, 27–28, 37–38) varied in arm ratio from 2.0–3.0 had their centromeres at the submedian regions, and the other eight (Nos. 13–14, 23–26, 31–32) varied in arm ratio from 3.1–3.8 had their centromeres at the subterminal regions.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

2) *Calanthe elmeri* Ames, 2n=44, Tables 1 and 28, Fig. 27

A plant was obtained from the Pilippines. External characteristics of the plant were in accord with the descriptions of the species by Valmayor (1984).

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

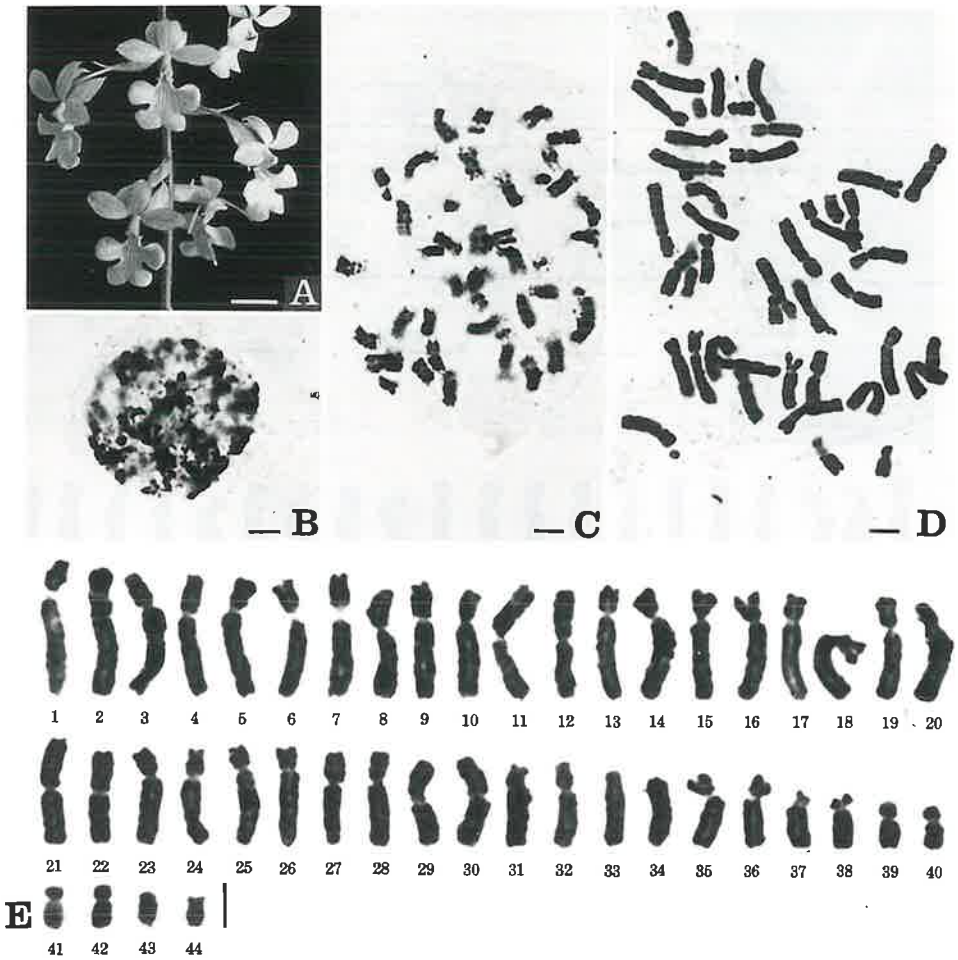

Fig. 27. *Calanthe elmeri*, 2n = 44. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 11 mm in A and 3 μm in B-E.

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. cardioglossa* described above. The chromosome features at resting stage were of the complex chromocenter type.

The 2n = 44 chromosome complement at mitotic metaphase showed a group of bimodality with 36 chromosomes exhibiting a gradual decrease in length from 8.2 to 4.6 μm and the other group of eight chromosomes exhibiting another gradual decrease in length from 3.3 to 1.9 μm. Among the 44 chromosomes in the complement, eight varied in arm ratio from 1.0–1.3 had their centromeres at the median regions, 30 (Nos.3–10, 13–20, 23–24, 27–28, 31–32, 35–36, 39–44) varied in arm ratio from 1.8–2.9 had their centromeres at the subme-

dian regions, and the other six (Nos.1–2, 25–26, 37–38) varied in arm ratio from 3.1–3.7 had their centromeres at the subterminal regions.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

3) *Calanthe hennisii* Loher, 2n=42, Tables 1 and 29, Fig. 28.

Three plants were obtained from the Philippines. External characteristics of these plants were in accord with the descriptions of the species by Valmayor (1984).

The chromosome number of the plants at mitotic metaphase was 2n=42, which was reported here for the first time for this species.

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. cardioglossa* described above. The chromosome features at resting stage were of the complex chromocenter type.

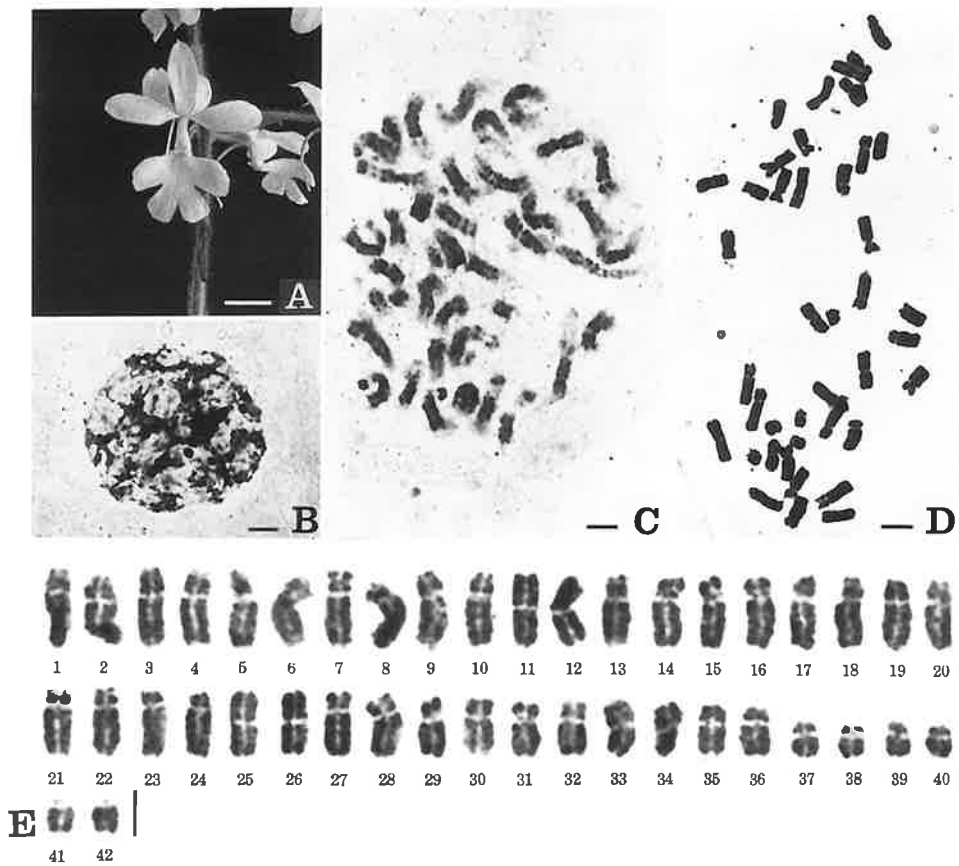

Fig. 28. *Calanthe hennisii*, 2n=42. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 15 mm in A and 3 μm in B-E.

The chromosomes of the 2n=42 complement at mitotic metaphase displayed a bimodality with 36 chromosomes performing a gradual decrease in length from 5.0 to 3.0 μm and six small-sized chromosomes varying in length from 2.1 to 2.0 μm. Among the 42 chromosomes in the complement, ten varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, 30 (Nos. 1–4, 7–10, 3–10, 13–24, 27–30, 35–40) varied in arm ratio from 1.8–2.9 had their centromeres at the submedian regions, and the other two (Nos. 41, 42) with in arm ratio of 5.6 had their centromeres at the subterminal regions.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

4) *Calanthe hirsuta* Seidenfaden, 2n=46, Tables 1 and 30, Fig. 29.

Two plants were obtained from Thailand. External characteristics of these plants were in accord with the descriptions of the species by Seidenfaden (1975).

The chromosome number of the plants at mitotic metaphase was 2n=46, which was re-

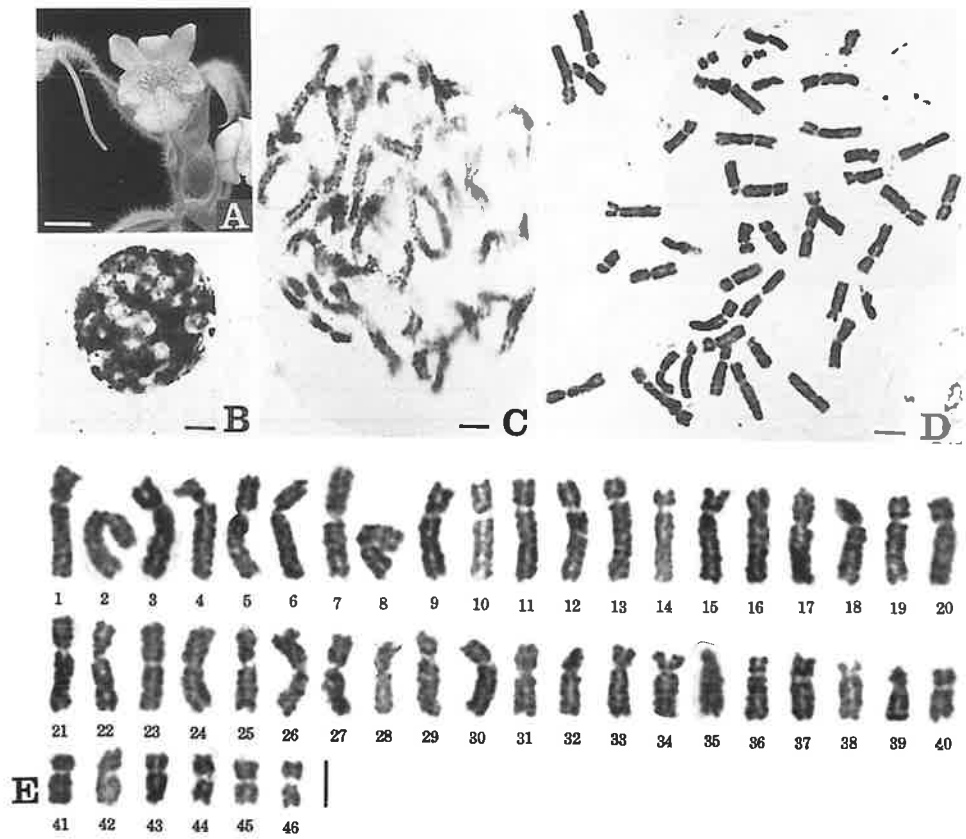

Fig. 29. *Calanthe hirusta*, 2n=46. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 8 mm in A and 3 μm in B-E.

ported here for the first time for this species.

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. cardioglossa* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosome complement of $2n = 46$ at mitotic metaphase showed a gradual decrease in length the longest (6.7 μm) to the shortest (2.6 μm) chromosomes. Among the 46 chromosomes in the complement, 16 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, 28 (Nos. 1–6, 9–12, 15–20, 29–30, 33–42) varied in arm ratio from 1.9–3.0 had their centromeres at the submedian regions, the other two (Nos. 13 ,14) with the arm ratio of 4.0 had their centromeres at the subterminal regions.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

5) *Calanthe rosea* (Lindl.) Benth., 2n=44, Tables 1 and 31, Fig. 30.

A plant was obtained from Thailand. External characteristics of the plant were in accord with the descriptions of the species by Seidenfaden (1975).

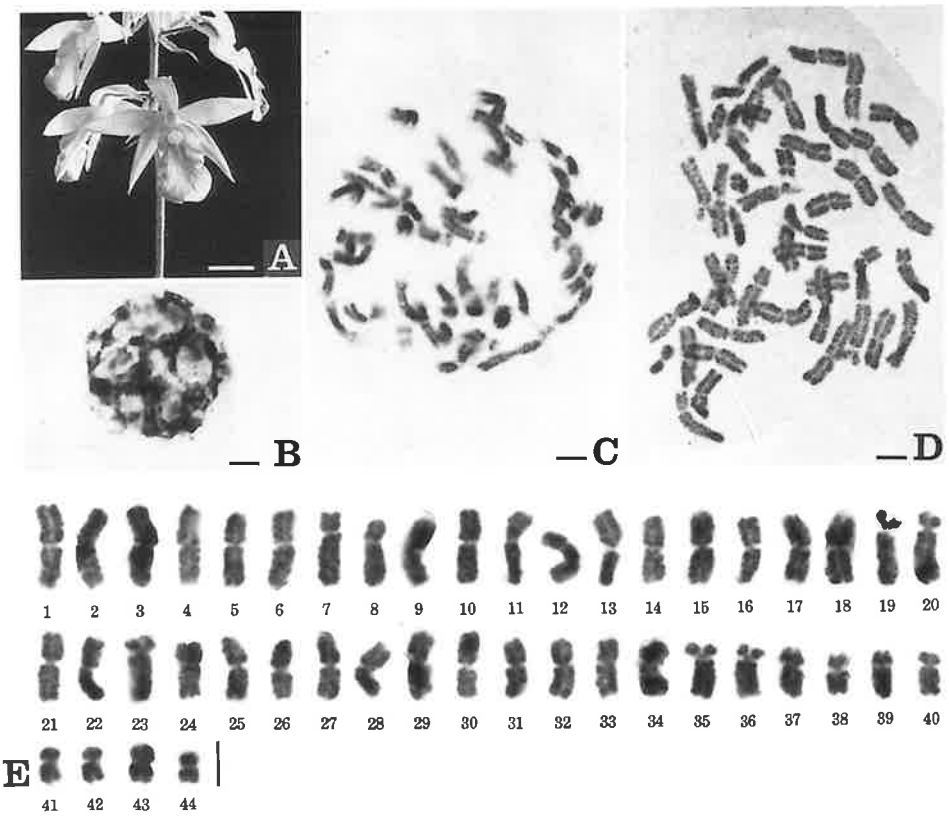

Fig. 30. *Calanthe rosea*, $2n = 44$. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 3 μm in B-E.

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

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. cardioglossa* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=44 complement at mitotic metaphase showed a bimodality with 36 chromosomes exhibiting a gradual decrease in length from 5.0 to 3.0 μm and eight small-sized chromosomes varying in length from 3.0 to 2.1 μm. Among the 44 chromosomes in the complement, 34 varied in arm ratio from 1.0–1.5 had their centromeres at the median regions, eight (Nos. 7–8, 23–24, 35–36, 39–40) varied in arm ratio from 2.2–2.5, were submedian and the other two (Nos. 19, 20) with the arm ratio of 3.3 had their centromeres at the subterminal regions.

This species showed a heterogeneous, bimodal and symmetric karyotype.

6) *Calanthe rubens* Ridley, 2n=42, Tables 1 and 32, Fig. 31.

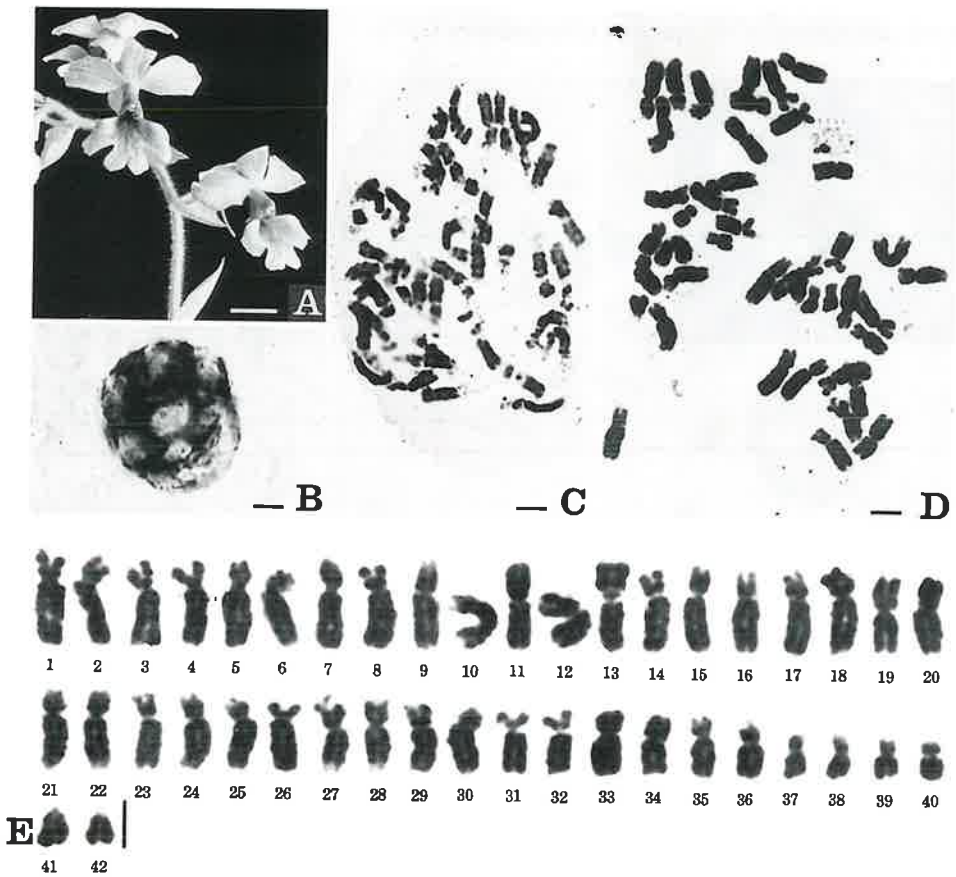

Fig. 31. *Calanthe rubens*, 2n=42. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 3 μm in B-E.

Three plants were obtained from Thailand. External characteristics of the plants were in accord with the descriptions of the species by Seidenfaden (1975).

The chromosome number of the plants at mitotic metaphase was $2n = 42$, which confirmed Teoh and Lim (1978), but was different from $2n = 44$ counted by Tanaka (1965).

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. cardioglossa* described above. The chromosome features at resting stage were of the complex chromocenter type. The chromosomes of the $2n = 42$ complement at mitotic metaphase formed a bimodality with 36 chromosomes exhibiting a gradual decrease in length from 5.7 to 3.5 μm and six small-sized chromosomes varying in length from 2.8 to 2.3 μm. Among the 42 chromosomes in the complement, 14 varied in arm ratio from 1.3–1.7 had their centromeres at the median regions, 14 (Nos. 1–10, 13–18, 21–26, 29–32) varied in arm ratio from 1.8–2.4 had their centromeres at the submedian regions, and the other two (Nos.41, 42) with the arm ratio of 6.6 had their centromeres at the subterminal regions.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

7) ***Calanthe succedanea*** **Gagnep., 2n=44, Tables 1 and 33, Fig. 32.**

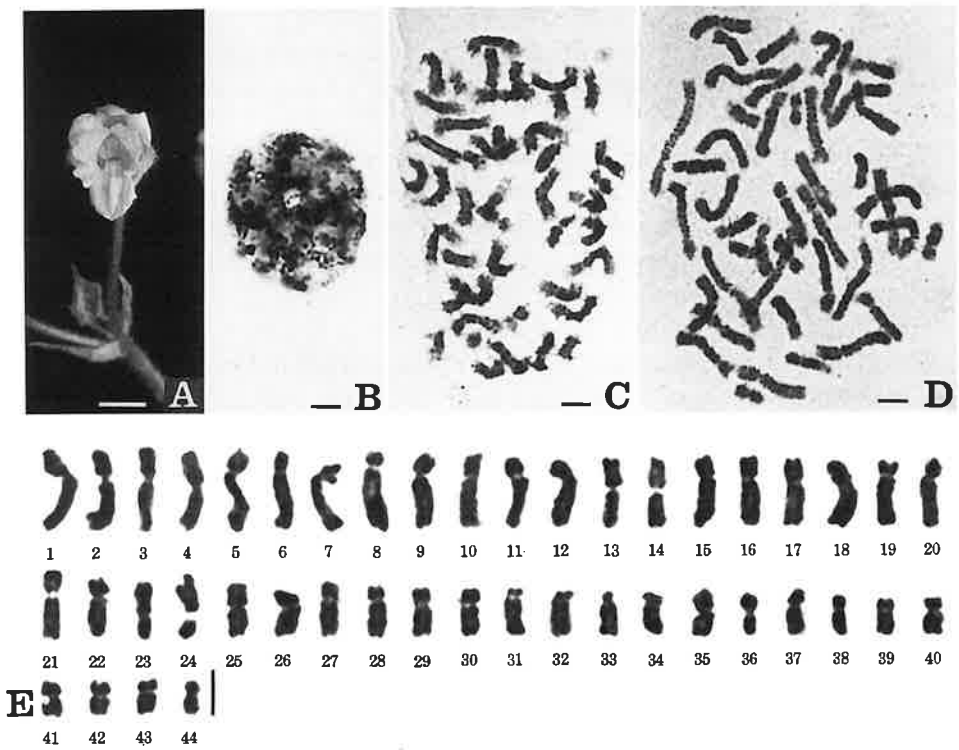

Fig. 32. *Calanthe succedanea*, $2n = 44$. A, a flower. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 7 mm in A and 3 μm in B-E.

Two plants were obtained from Thailand. External characteristics of these plants were in accord with the descriptions of the species by Seidenfaden (1975).

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

The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. cardioglossa* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosome complement at mitotic metaphase displayed a gradual decrease in length from the longest (5.4 μm) to the shortest (2.1 μm) chromosomes. Among the 44 chromosomes in the complement, 16 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, 22 (Nos. 1–2, 5–6, 9–12, 15–18, 21–22, 27–30, 35–36, 39–40) varied in arm ratio from 1.8–2.8 had their centromeres at the submedian regions, and the other six (Nos. 7–8, 19–20, 31–32) varied in arm ratio from 3.1–3.8 had their centromeres at the subterminal regions. One of the medium-sized chromosomes with median centromere at mitotic metaphase formed a large secondary constriction in the proximal region of the long arm.

Thus, this species showed a homogeneous, gradual and symmetric karyotype.

8) *Calanthe vestita* Lindl., 2n=42, Tables 1 and 34, Fig. 33.

Two plants were obtained from Thailand and one plant was obtained from Burma. External characteristics of the plants were in accord with the descriptions of the species by Seidenfaden (1975).

The chromosome number of the plants at mitotic metaphase was 2n = 42, which was different from 2n = 40 counted in *C. vestita* var. *regnieri* by Hoffmann (1929, 1930). The chromosomes at resting stage and mitotic prophase were morphologically similar to those of *C. cardioglossa* described above. The chromosome features at resting stage were of the complex chromocenter type.

The chromosomes of the 2n=42 complement at mitotic metaphase indicated a bimodality with 36 chromosomes exhibiting a gradual decrease in length from 5.7–3.7 μm and six small-sized chromosomes varying in length from 2.4–2.1 μm. Among the 42 chromosomes in the complement, 12 varied in arm ratio from 1.0–1.7 had their centromeres at the median regions, 14 (Nos. 1–4, 7–10, 13–18, 21–26, 31–38) varied in arm ratio from 1.8–3.0 had their centromeres at the submedian regions and the other two (Nos. 41, 42) with the arm ratio of 6.0 had their centromeres at the subterminal regions.

Meiosis was studied in the clone from Burma. The chromosomes in each PMC at metaphase I formed 21 bivalents. Most of the bivalent chromosomes were ring shaped and had terminal chiasmata showing very weak assosiation, while a few of them were rod shaped with an interstitial chiasma. The chromosomes at anaphase I moved normally toward the two poles without any lagging chromosomes.

Thus, this species showed a heterogeneous, bimodal and symmetric karyotype.

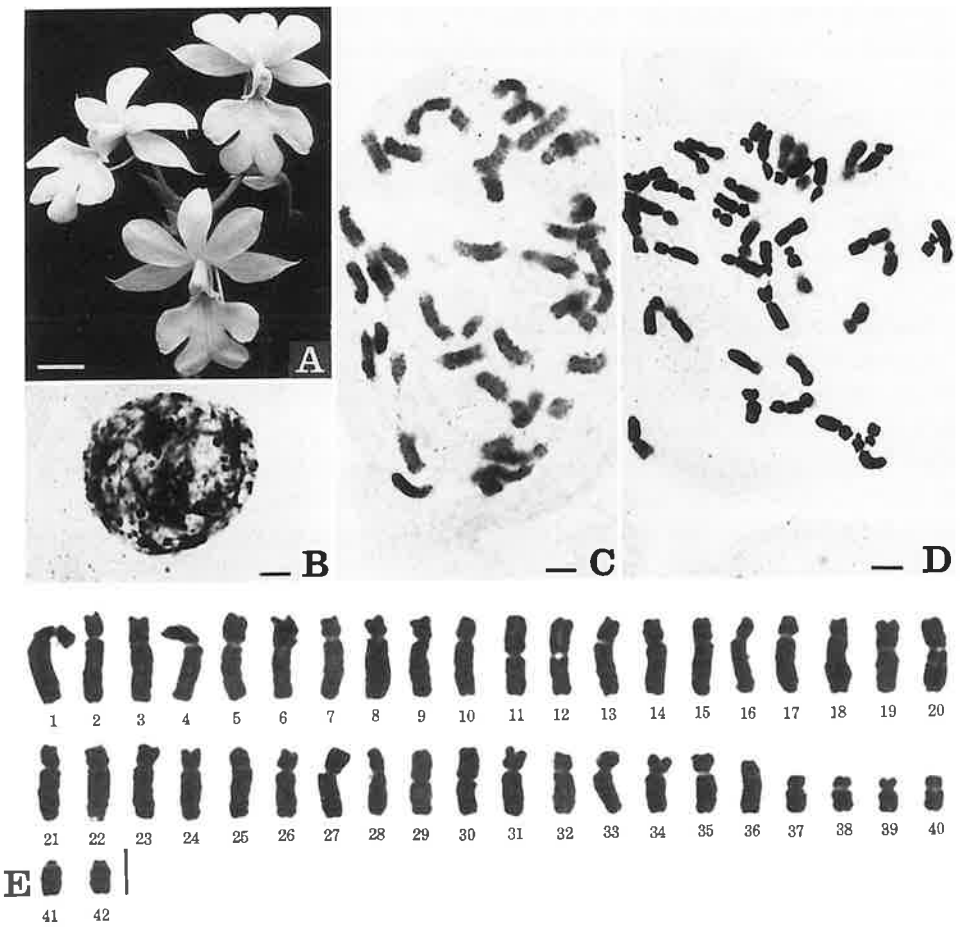

Fig. 33. *Calanthe vestita*, 2n = 42. A, flowers. B, chromosomes at resting stage. C, chromosomes at mitotic prophase. D and E, chromosomes at mitotic metaphase. Bars indicate 10 mm in A and 3 μm in B-E.

Discussion

I. Karyomorphological characteristics

1. Chromosome number

The chromosome numbers of 33 taxa in four sections in two subgenera in *Calanthe* studied were shown in Table 1. Ten taxa shown their chromosome numbers for the first time were listed as follows: *C. argenteo-striata* 2n=45, *C. conspicua* 2n=40, *C. cremeo-viridis* 2n =46, *C. hancockii* 2n=40, *C. kooshunensis* 2n=40, *C. elmeri* 2n=44, *C. hennisii* 2n=42,

C. hirsuta 2n=46, *C. rosea* 2n=44, *C. succedanea* 2n=44. Three taxa shown the chromosome numbers different from the previous counts were listed as follows: *C. caudatilabella* 2n =38, *C. cardioglossa* 2n=46, *C. vestita* 2n=42. The chromosome numbers of the other 20 taxa confirmed the previous reports.

Thus, the 33 taxa in *Calanthe* exhibited an aneuploid series with the chromosome numbers of 2n=38, 40, 42, 44, 45 and 46. The chromosome number of 2n=38 was found in one taxon, 2n=40 in 22 taxa, 2n=42 in three taxa, 2n=44 in three taxa, 2n=45 in one taxon and 2n=46 in three taxa. The chromosome complement of 2n=45 in *C. argenteo-striata* could be composed of 2n=44 chromosomes and one supernumerary chromosome. Thus, the basic chromosome numbers of *Calanthe* were x=19, 20, 21, 22 and 23.

Among the seven sections described by Schlechter (1912), four were studied to determine whether or not they could be correlated with their basic chromosome numbers. The results were listed as follows: x=19 in section Calothyrsus (one taxon), x=20 in section Calothyrsus (16 taxa), Styloglossum (four taxa) and Aceratochilus (two taxa), x=21 in section Eu-Preptanthe (three taxa), x=22 in section Calothyrsus (one taxon) and Eu-Preptanthe (three taxa), and x=23 in section Calothyrsus (one taxon) and Eu-Preptanthe (two taxa). Thus, two groups of sections were categorized; the sections with single basic chromosome number and the sections with multiple basic chromosome numbers. These examinations of the chromosome numbers can be valid to clarify the phylogenetic classification and species relationships in *Calanthe*.

2. Chromosome morphology at resting stage

The chromosomes at resting stage throughout the taxa studied were observed as chromomeric granules, fibrous threads and chromatin blocks. The heterochromatic segments aggregated into large blocks as the chromocentral aggregations.

All of the 33 taxa studied showed commonly their chromosomes of the complex chromocenter type at resting stage according to Tanaka (1971), while each of them showed distinct variation of chromocentral aggregation. Degrees of aggregation of chromocenters could be categorized into three groups; the first group was characterized by loose degree of aggregation found in section Calothyrsus (two taxa), the second group was characterized by strong degree of aggregation found in sections Styloglossum (four taxa) and Eu-Preptanthe (eight taxa), and the third group was characterized by moderate degree of aggregation found in section Calothyrsus (17 taxa) and Aceratochilus (two taxa).

These results suggest that the examination of the resting nuclei is valid for clarification of the phylogenetic classification and species relationships in *Calanthe*.

3. Chromosome morphology at mitotic prophase

Numerous early condensed segments at mitotic prophase were observed at the proximal and interstitial regions of both chromosome arms. These condensed segments got joined with each other during the progress of cell division. The distal regions of the chromosomes showed mostly delayed condensations.

4. Chromosome morphology at mitotic metaphase

Among 33 taxa in four sections studied, 27 performed gradual and homogeneous karyotype, accoring to alignment of chromosome length. Five taxa in section Eu-Preptanthe were showed bimodal and heterogeneous karyotype, and one taxon in section Calothyrsus showed the partially heterogeneous karyotype. Thus, the gradual karyotypes were observed in 18 taxa in section Calothyrsus, four taxa in section Styloglossum, two taxa in section Aceratochilus and three taxa in section Eu-Preptanthe. The bimodal karyotypes were observed in five taxa in section Eu-Preptanthe. The taxa showing bimodal karyotype in *Calanthe* were documented here for the first time. In contrast, the Japanese 22 taxa studied by Tanaka et al.(1981) had the gradual karyotypes.

In all of the 33 taxa in four sections, the average chromosome length was 3.8 μm. The average chromosome length in the sections Aceratochilus and Eu-Preptanthe were both 4.4 μm, longer than those in sections Calothyrsus and Styloglossum, 3.5 μm and 3.6 μm respectively. The longest average-chromosome-length was 5.5 μm measured in *C. elmeri*, while the shortest one was 2.8 μm measured in *C. sieboldii*.

The average arm ratio of all of the taxa studied was 1.8. The highest average arm ratio was 2.2 counted in *C. elmeri* and *C. vestita*, while the lowest one was 1.2 in *C. lyroglossa*. According to the sectional comparison in average arm ratio, section Eu-Preptanthe indicated the highest of the average arm ratio of 2.0, section Aceratochilus indicated the second highest of the average arm ratio of 1.8, section Calothyrsus indicated the third of the average arm ratio of 1.7, and section Styloglossum indicated the fourth of the average arm ratio of 1.5.

Although the 33 taxa studied showed the symmetric karyotype, variation of symmetry was observed. According to degree of symmetry, three groups were categorized: the first group was characterized by higher symmetry found in three taxa in section Styloglossum, 12 taxa in section Calothyrsus and one taxon in section Eu-Preptanthe, the second group was characterized by lower symmetry found in two taxa in section Aceratochilus and seven taxa in section Eu-Preptanthe, and the third group was characterized by moderate symmetry found in seven taxa in section Calothyrsus and one taxon in section Styloglossum.

5. Karyomorphological types

On the basis of the chromosome morphology at resting stage and the lengths and the arm ratios of the chromosomes at mitotic metaphase, the 33 taxa studied could be grouped into 15 types as follows:

Type A. $2n=38$; the complex chromocenter type at resting stage, karyotype of loosely aggregated chromocenters; gradual, moderately homogeneous and moderately symmetric karyotype; large-sized chromosome; and represented by *C. caudatilabella*.

Type B. $2n=40$; moderately homogeneous and highly symmetric karyotype; medium-sized chromosome; large secondary constriction in a pair of small chromosomes and a medium-sized chromosome with the centromere at the subterminal region; the other characters similar to Type A; and represented by *C. reflexa*.

Type C. 2n=40; the complex chromocenter type at resting stage, karyotype with moderate aggregation of chromocenters; gradual, moderately homogeneous and moderately symmetric karyotype; small-sized chromosome; and represented by *C. arisanensis, C. aristulifera, C. graciliflora, C. hamata, C. hancockii, C. mannii, C. matsudai, C. plantaginea, C. sieboldii*, and *C. tricarinata*.

Type D. 2n = 40; highly homogeneous and highly symmetric karyotype; medium-sized chromosome; the other characters similar to Type C; and represented by *C. conspicua, C. herbacea, C. masuca*, and *C. triplicata*.

Type E. 2n = 46; karyomorphological features similar to Type D with exception of chromosome number and small-sized chromosome; and represented by *C. cremeo-viridis*.

Type F. 2n=44; gradual, moderately homogeneous karyotype; small-sized chromosome; the other characters similar to Type D; and represented by *C. argenteo-striata*.

Type G. 2n=40; low homogeneous and low symmetric karyotype; large-sized chromosome; the other characters similar to Type D; and represented by *C. sylvatica*.

Type H. 2n=40; the complex chromocenter type; karyotype with strong aggregation of chromocenters; gradual, highly homogeneous and highly symmetric karyotype; medium-sized chromosome; and represented by *C. clavata, C. formosana*, and *C. lyroglossa*.

Type I. 2n = 40; moderately homogeneous and moderately symmetric karyotype; the other characters similar to Type H; and represented by *C. densiflora*.

Type J. 2n = 40; highly homogeneous karyotype; large-sized chromosome; the other characters similar to Type C; and represented by *C. kooshunensis*, and *C. gracilis*.

Type K. 2n = 42; the complex chromocenter type; karyotype with strong aggregation chromocenters; bimodal, heterogeneous and low symmetric karyotype; large-sized chromosome; and represented by *C. hennisii, C. rubens*, and *C. vestita*.

Type L. 2n = 44; karyomorphological features similar to Type K with exception of chromosome number; and represented by *C. elmeri*.

Type M. 2n=44; gradual, highly homogeneous karyotype; medium-sized chromosome; the other characters similar to Type K; and represented by *C. rosea*.

Type N. 2n = 44; gradual, low homogeneous and low symmetric karyotype; medium-sized chromosome; large secondary constriction in one of medium-sized chromosome; the other characters similar to Type K; and represented by *C. succedanea*.

Type O. 2n = 46; karyomorphological features similar to Type N with exception of chromosome number; and represeted by *C. cardioglossa*, and *C. hirsuta*.

II. Cytotaxonomical investigation in *Calanthe*

Lindley (1845) first studied the systematic classification of *Calanthe*, and divided this genus into two sections. Schlechter (1912) studied New Guinean species of *Calanthe* and classified this genus into seven sections and two subgenera. Saigusa and Nagano (1975) revised *Calanthe* taxonomy divided the genus into five subgenera. Among them Schlechter's system has been strongly supported by numerous workers.

A few taxa in *Calanthe* were placed in *Phaius* or *Cephalantheropsis* due to certain dis-

tinct characteristics such as the lip without a claw and base of lip shortly adnating to base of column (Holtt. 1947, Hu 1974, Lin 1976, Valmayor 1984). However, the *Calanthe* classification has been still insufficient.

Since *Calanthe* is known to have high variation in morphology and ecology, it is necessary to clarify taxonomical treatment and relationships between *Calanthe* and its allied genera.

The karyomorphological relationships among the 33 taxa in four sections followed Schlechter's system were discussed as follow:

1. Subgenus Eu-Calanthe

(1) Section Calothyrsus

Among 19 taxa, 16 showed the chromosome numbers of 2n=40 and the other three taxa showed the chromosome numbers of 2n=38, 2n=45 and 2n=46, respectively. The chromosomes at resting stage shown in all taxa were of the complex chromocentric karyotype, while the chromosomes at mitotic metaphase showed a gradual and homogeneous karyotype due to the chromosome lengths and a symmetric kayotype due to the arm ratios with an exception of a partially heterogeneous karyotype displayed in *C. reflexa*.

Since section Calothyrsus had karyomorphologically different taxa, it is necessary to clarify whether or not these taxa should be placed within a section.

(2) Section Styloglossum

All of the four taxa in section Styloglossum showed the chromosome number of 2n=40. Their chromosomes at resting stage performed the complex chromocentric karyotype, and they chromosmoes at mitotic metaphase showed a gradual, homogeneous and symmetric karyotype. Three taxa, *C. clavata, C. formosana*, and *C. lyroglossa* were similar to each other with respect to chromosome length, arm ratio, and especially high frequency (85–90%) of chromosomes with centromeres at the median regions. Thus, these three taxa could be quite close resembled to each others.

(3) Section Aceratochilus

All of the two taxa in section Aceratochilus had the chromosome number of 2n = 40. They showed the complex chromocentric karyotype at resting stage and a gradual, homogeneous and symmetric karyotype at mitotic metaphase. Among the 22 taxa which have the chromosome number of 2n = 40, these two taxa displayed the longest moderate-chromosome length of 4.2 μm or more.

2. Subgenus Preptanthe

(1) Section Eu-Preptanthe

Eight taxa studied showed the chromosome numbers of 2n=42, 44 and 46. Three taxa with the chromosome number of 2n=42 showed a bimodal, heterogeneous and symmetric karyotype. Among the three taxa with the chromosome number of 2n=44, two, *C. elmeri* and *C. rosea*, showed a bimodal, heterogeneous and symmetric karyotype and one, *C. succedanea*, showed a gradual, homogeneous and symmetric karyotype. The other two taxa with the chromosome number of 2n=46 showed a gradual, homogeneous and symmetric karyotype. No taxa in this section showed the chromosome number of 2n=40. The taxa in this section exhibited strongly condesed chromocentric aggregations at resting stage and gradual and bimodal karyotypes mixed.

Since this section includes the taxa with karyomorphological differences, it is necessary to clarify biosystematically whether or not these taxa must be placed within the single section.

Summary

1. The chromosome numbers of the 33 taxa in *Calanthe*, were clearly documented and their karyomorphologies at resting stage, mitotic prophase and metaphase were well described with the microphotographs and measurements of somatic metaphase chromosomes.

2. The chromosome numbers of the 33 taxa showed an aneuploid series; 2n=38 in one taxon, 2n=40 in 22 taxa, 2n=42 in three taxa, 2n=44 in three taxa, 2n=45 in one taxon and 2n=46 in three taxa.

3. The chromosome numbers of ten taxa were reported here for the first time; 2n=45 for *C. argenteo-striata*, 2n=40 for *C. conspicua*, 2n=46 for *C. cremeo-viridis*, 2n=40 for *C. hancockii*, 2n=40 for *C. kooshunensis*, 2n=44 for *C. elmeri*, 2n=42 for *C. hennisii*, 2n=46 for *C. hirsuta*, 2n=44 for *C. rosea*, and 2n=44 for *C. succedanea*. The chromosome numbers of three taxa, 2n=38 of *C. caudatilabella*, 2n=46 of *C. cardioglossa*, and 2n=42 of *C. vestita*, reported here were different from the previous counts. The chromosome numbers of the other 20 taxa confirmed the previous reports.

4. All of the 33 taxa studied showed the chromosomes of the complex chromocenter type at resting stage. According to degree of chromocentric aggregation at resting stage, three groups were categorized; the first group was characterized by loose degree of chromocentric aggregation found in two taxa, the second group was characterized by the strong aggregation found in 12 taxa and the third group characterized by the moderate aggregation found in 19 taxa.

5. The chromosomes at mitotic prophase in all of the 33 taxa formed early condensed segments in the proximal and interstitial regions of both chromosome arms.

6. Among the 33 taxa, 28 showed homogeneous and gradual karyotypes. According to degree of homogeneity at mitotic metaphase, three groups were categorized; the first group was characterized by high degree of homogeneity found in ten taxa, the second group was characterized by low homogeneity found in four taxa and the third group was characterized by average degree of homogeneity found in 14 taxa. The other five taxa, *C. elmeri, C. hennisii, C. rosea, C. rubens* and *C. vestita*, had the heterogeneous and bimodal karyotypes.

7. All of the 33 taxa studied indicated symmetric karyotype. According to degree of symmetry, three groups were categorized as follows; the first group was characterized by high degree of symmetry found in 11 taxa, the second group was characterized by low symmetry found in eight taxa and the third group was characterized by average symmetry found in 14 taxa.

8. The average chromosome length in all of taxa at mitotic metaphase was 3.8 μm. The longest one of the average chromosome lengths was 5.8 μm in *C. elmeri*, while the shortest one was 2.8 μm in *C. sieboldii*.

9. The 33 taxa studied could be grouped into 15 types described as follows:

Type A. $2n = 38$; the complex chromocenter type at resting stage, loosely aggregated chromocentric karyotype; gradual, moderately homogeneous and moderately symmetric karyotype; large-sized chromosome; and represented by *C. caudatilabella*.

Type B. $2n = 40$; moderately homogeneous and highly symmetric karyotype; medium-sized chromosome; large secondary constriction in a pair of small chromosomes and one medium-sized chromosome with the centromere at the subterminal region; the other characters similar to Type A; and represented by *C. reflexa*.

Type C. $2n = 40$; the complex chromocenter type at resting stage, karyotype with moderately aggregated chromocenters; gradual, moderately homogeneous and moderately symmetric karyotype; small-sized chromosome; and represented by *C. arisanensis, C. aristulifera, C. graciliflora, C. hamata, C. hancockii, C. mannii, C. matsudai, C. plantaginea, C. sieboldii*, and *C. tricarinata*.

Type D. $2n = 40$; highly homogeneous and highly symmetric karyotype; medium-sized chromosome; the other characters similar to Type C; and represented by *C. conspicua, C. herbacea, C. masuca*, and *C. triplicata*.

Type E. $2n = 46$; karyomorphological features similar to Type D with exception of chromosome number and small-sized chromosome; and represented by *C. cremeo-viridis*.

Type F. $2n = 44$; gradual, moderately homogeneous karyotype; small-sized chromosome; the other characters similar to Type D; and represented by *C. argenteo-striata*.

Type G. $2n = 40$; low homogeneous and low symmetric karyotype; large-sized chromosome; the other characters similar to Type D; and represented by *C. sylvatica*.

Type H. $2n = 40$; the complex chromocenter type; karyotype with strong aggregation of

chromocenters; gradual, highly homogeneous and highly symmetric karyotype; medium-sized chromosome; and represented by *C. clavata, C. formosana*, and *C. lyroglossa*.

Type I. 2n = 40; moderately homogeneous and moderately symmetric karyotype; the other characters similar to Type H; and represented by *C. densiflora*.

Type J. 2n=40; high degree of homogeneity; large-sized chromosome; the other characters similar to Type C; and represented by *C. kooshunensis*, and *C. gracilis*.

Type K. 2n=42; the complex chromocenter type; karyotype with strong aggregation of chromocenters; heterogeneous, bimodal and low symmetric karyotype; large-sized chromosome; and represented by *C. hennisii, C. rubens*, and *C. vestita*.

Type L. 2n = 44; karyomorphological features similar to Type K with exception of chromosome number; and represented by *C. elmeri*.

Type M. 2n=44; gradual, highly homogeneous karyotype; medium-sized chromosome; the other characters similar to Type K; and represented by *C. rosea*.

Type N. 2n = 44; gradual, low homogeneous and low symmetric karyotype; medium-sized chromosome; large secondary constriction in one medium-sized chromosome; the other characters similar to Type K; and represented by *C. succedanea*.

Type O. 2n = 46; karyomorphological features similar to Type N with exception of chromosome number; and represented by *C. cardioglossa*, and *C. hirsuta*.

10. The karyomorphological comparisons in the 15 groups described above supported strongly Schlechter's system. However, his two sections, Calothyrsus included the karyomorphological multi-types of A, B, C, D, E, F and G and Eu-Preptanthe included the karyomorphological multi-types of K, L, M, N and O, are needed for reexamination to justify Schlechter's system.

11. The deciduous species of the genus of Southeast Asia were commonly found to show higher bimodal and less symmetry karyotypes and higher chromosome numbers than the other species. Discussing karyomorphologically these differences, it was concluded and evidently proved here for the first time that the Southeast Asian species of *Calanthe*, especially the deciduous species, could be phylogenetically more advanced than the other species and that *Calanthe* speciation might be occurred in a northen distribution and progressed toward the south in Asia.

Acknowledgements

The author wishes to express his sincerest gratitude to Professor Dr. Ryuso Tanaka, Hiroshima University, who directed this study. Cordial thanks are extended to Dr. Katsuhiko Kondo, Associate Professor of Faculty of Integrated Arts and Sciences, Hiroshima University, for reading the manuscript and his interest. The author also would like to express his heartfelt thanks to Dr. Kohji Karasawa, Director of The Hiroshima Botanical Garden, for his valuable suggestions and plant identifications. The hospitality and encouragement by the staffs of The Hiroshima Botanical Garden, is acknowledged with great pleasure.

Literature Cited

Arora, C.M. 1960. New chromosome report. Bull. Bot. Surv. India 2: 305.

Arora, C.M. 1968. *In* IOPB chromosome number reports XVI. Taxon 17: 199–204.

Backer, C.A. and R.C. Bakhuisen Van Den Brink 1968. Flora of Java, Vol. 3. Wolters-Noordhoff, Groningen. 761 pp.

Chardard, R. 1963. Contribution à l'étude cyto-taxonomique des Orchidees. Rev. Cytol. et Biol. Veg. 26, 1: 1–58.

Comber, J.B. 1981. The genus *Calanthe* in Java. Orchid Digest 45: 124–130.

Garay, L. and H.R. Sweet 1974. Orchids of Southern Ryukyu Islands. Bot. Museum, Harvard Univ. Press, Mass. 180 pp.

Hatusima, S. and T. Amano 1977. Flora of the Ryukyus, south of Amami Island. Deigo Press Co., Naha. 282 pp. (In Japanese).

Holttum, R.E. 1964. A revised flora of Malaya, Vol. I, 3rd ed. Goverment Printing Office, Singapore. 759 pp.

Hooker, J.D. 1890. The flora of the British India, Vol. 5: 667–864. L. Reeve, Ashford, Kent, UK.

Hoffmann, K.M. 1929. Cytologische Studien bei den Orchidaceen. Ber. Deutsch. Bot. Ges. 47: 321–326.

Hoffmann, K.M. 1930. Beiträge zur Cytologie der Orchidaceen. Planta 10: 523–595.

Hsu, C.-C. 1971. Preliminary chromosome studies on the vascular plants of Taiwan (IV). Counts and some systematic notes on some monocotyledons. Taiwania 16 :123–136.

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

Hsu, C. 1976. Cytological studies on the economically promising wild orchids found on Taiwan. Proc. Natl. Sci. Concil (Taiwan) 9: 61–78.

Institute of Botany, Academia Sinica (ed.). 1980. Orchidaceae, *Calanthe* pp.716–725, *In* Iconographia Cormophytorum Sinicorum, Vol. 5. Science Press, Beijing.

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

Larsen, K. 1966. Studies in the flora of Thailand, 40. Cytology of vascular plants, II. Dansk. Bot. Ark. 23: 375–399.

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

Lim, K.-Y. 1985. The chromosomes of orchids at Kew 3. Miscellaneous species. Amer. Orchid Soc. Bull. 54: 1234–1235.

Lin, T.P. 1976–1977. Native orchids in Taiwan, Vol. 1–2. Ji-Chyi Wang, Chiayi, Taiwan.

Lindley, J. 1833. (Reprinted 1963). *Calanthe* pp.249–252, *In* The genera and species of Orchidaceous plants. Part 3, Vandaea. London.

Lindley, J. 1854. *Calanthe* pp.1–11, *In* Folia Orchidacea. London.

Liu, T.S. and H.J. Su 1978. Orchidaceae, *Calanthe* pp.904–916, *In* Li, H.L. (ed.), Flora of Taiwan, Vol. 5. Epoch Publishing Co., Taipei.

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

Mehra, P.N. 1982. Cytology of East Indian grasses. P.N. Mehra, Chandigrah.

Mehra, P.N. and K.S. Bawa 1962. Chromosome studies in Orchidaceae. Proc. 49th Session Indian Sci. Congr. Calcutta. (1962): 326–327.

Mehra, P.N. and S.K. Kashyap 1979. *In* IOPB chromosome number reports LXIV. Taxon 28: 406–408.

Mehra, P.N. and S.K. Kashyap 1984. Cytological observation on some West Himalayan orchids tribe: Epidendreae. Cytologia. 47: 583–595.

Mehra, P.N. and R.N. Sehgal 1974. *In* IOPB chromosome number reports XLVI. Taxon 23: 801–812.

Mehra, P.N. and R.N. Sehgal 1976. *In* IOPB chromosome number reports LIV. Taxon 25: 631–649.

Miduno, T. 1940. Chromosomenstudien an Orchidazeen. IV. Chromosomenzahlen einiger Arten und Bastarde bei Orchideen. Cytologia 11: 179–185.

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

Nakasone, H.Y. and S. Moromizato 1964. Chromosome determinations of some Ryukyuan Orchid species. Sci. Bull. Div. Agr. Home Economics and Engineering Univ. Ryukyu 11: 13–18.

Ohwi, J. 1978. Flora of Japan. Shibundo (Tokyo). 1548 pp. (In Japanese).

Pancho, J.V. 1965. *In* IOPB chromosome number reports, III. Taxon 14: 50–57.

Perrier De La Bathie, H. 1939. *Calanthe*, *In* Flore de Madagascar. 49: Vol. 1.

Pradhan, U.C. 1979. Indian Orchids. Vol. 2. Kalimpong, India. 747 pp.

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

Saigusa, T. and M. Nagano 1975. New classification of *Calanthe*. Acta Calanthologica Japonica 5: 7–11. (In Japanese).

Schlechter, R. 1912. Die Orchidaceen von Deutsch Neu Guinea. Fedde Report Beih. 1079 pp.

Seidenfaden, G. 1975. Orchid genera in Thailand I, *Calanthe*. Dansk Bot. Ark. 29 (2): 1–50.

Seidenfaden, G. and T. Smitinand 1961. *Calanthe* pp. 329–339, *In* The orchids of Thailand. Part 3. The Siam Society, Bangkok.

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

Steiner, M.L. 1953. Calanthes of the Philippines. Philippine Orchid Rev. 5: 4–15.

Tanaka, R. 1965. Chromosome numbers of some species of Orchidaceae from Japan and its neighbouring areas. Journ. Jap. Bot. 40: 65–77.

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

Tanaka, R. 1974. Organizational system of meiotic division and the development of reproductive cells in higher plants. The Cell 6: 22–25.

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

Tanaka, R. 1980. The karyotype. *In* Kihara, H. (ed.), Plant genetics 1, pp. 335–358. Shokabo Co., Tokyo. (In Japanese).

Tanaka, R., K. Karasawa and G. Ishida 1981. Karyomorphological observations on *Calanthe* of Japan. Hiroshima Bot. Gard. Bull. 4: 9–62.

Tang, C.Z. and S.J. Cheng 1981. A new orchid from south China. Orchid Review 89: 144–146.

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

Teoh, S.B. 1984. Polyploid spore formation in diploid orchid species. Genetica 63: 53–59.

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

Teuscher, H. 1978. *Calanthe* and *Spathoglottis*. Amer. Orchid Soc. Bull. 47: 336–343.

Valmayor, H.L. 1984. Orchidiana Philippiniana. Vol.1. Eugenio Lopez Foundation. Manila.

Vij, S.P., A. Arora, and U.S. Nanda 1976. *In* IOPB chromosome number reports LIV. Taxon 25: 631–649.

Vij, S.P. and N. Shekhar 1983. *In* IOPB chromosome number reports LXXXI. Taxon 32: 668.

Wood, J.J. 1981. New orchids from Papua New Guinea. Orchid Review 89: 209–213.

Yang, D. and X. Zhu 1984. The chromosome numbers of twelve species in Orchidacea from China. Acta Phytotax. Sin. 22: 252–255.

Table 2. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe argenteo-striata*, 2n=45

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.0+2.6=4.6	3.4	1.3	m
2	2.0+2.6=4.6	3.4	1.3	m
3	1.8+2.5=4.3	3.1	1.3	m
4	1.8+2.5=4.3	3.1	1.3	m
5	1.8+2.3=4.1	3.0	1.2	m
6	1.8+2.3=4.1	3.0	1.2	m
7	1.7+2.2=3.9	2.8	1.2	m
8	1.7+2.2=3.9	2.8	1.2	m
9	1.5+2.1=3.6	2.6	1.4	m
10	1.5+2.1=3.6	2.6	1.4	m
11	1.4+2.2=3.6	2.6	1.5	m
12	1.4+2.2=3.6	2.6	1.5	m
13	1.3+2.1=3.4	2.5	1.6	m
14	1.3+2.1=3.4	2.5	1.6	m
15	1.3+2.0=3.3	2.4	1.5	m
16	1.3+2.0=3.3	2.4	1.5	m
17	1.1+2.1=3.2	2.3	1.9	sm
18	1.1+2.1=3.2	2.3	1.9	sm
19	1.2+1.9=3.1	2.3	1.5	m
20	1.2+1.9=3.1	2.3	1.5	m
21	1.3+1.6=2.9	2.1	1.2	m
22	1.3+1.6=2.9	2.1	1.2	m
23	1.3+1.6=2.9	2.1	1.2	m
24	1.3+1.6=2.9	2.1	1.2	m
25	1.3+1.5=2.8	2.0	1.1	m
26	1.3+1.5=2.8	2.0	1.1	m
27	0.9+1.9=2.8	2.0	2.1	sm
28	0.9+1.9=2.8	2.0	2.1	sm
29	0.8+1.8=2.6	1.9	2.2	sm
30	0.8+1.8=2.6	1.9	2.2	sm
31	1.0+1.6=2.6	1.9	1.6	m
32	1.0+1.6=2.6	1.9	1.6	m
33	1.0+1.6=2.6	1.9	1.6	m
34	1.0+1.6=2.6	1.9	1.6	m
35	0.7+1.9=2.6	1.9	2.7	sm
36	0.7+1.9=2.6	1.9	2.7	sm
37	0.8+1.7=2.5	1.8	2.1	sm
38	0.8+1.7=2.5	1.8	2.1	sm
39	1.0+1.3=2.3	1.7	1.3	m
40	1.0+1.3=2.3	1.7	1.3	m
41	0.5+1.7=2.2	1.6	3.4	st
42	0.5+1.7=2.2	1.6	3.4	st

Table 2. continued

43	0.7+1.3=2.0	1.5	1.8	sm
44	0.7+1.3=2.0	1.5	1.8	sm
45	0.6+0.6=1.2	0.9	1.0	m

Table 3. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe arisanensis*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.9+2.3=4.2	3.4	1.2	m
2	1.9+2.3=4.2	3.4	1.2	m
3	1.7+2.3=4.0	3.3	1.3	m
4	1.7+2.3=4.0	3.3	1.3	m
5	1.7+2.2=3.9	3.2	1.2	m
6	1.7+2.2=3.9	3.2	1.2	m
7	1.2+2.5=3.7	3.0	2.0	sm
8	1.2+2.5=3.7	3.0	2.0	sm
9	1.1+2.5=3.6	2.9	2.2	sm
10	1.1+2.5=3.6	2.9	2.2	sm
11	1.3+2.3=3.6	2.9	1.7	m
12	1.3+2.3=3.6	2.9	1.7	m
13	1.7+1.8=3.5	2.9	1.0	m
14	1.7+1.8=3.5	2.9	1.0	m
15	1.6+1.8=3.4	2.8	1.1	m
16	1.6+1.8=3.4	2.8	1.1	m
17	1.3+2.1=3.4	2.8	1.6	m
18	1.3+2.1=3.4	2.8	1.6	m
19	0.9+2.3=3.2	2.6	2.5	sm
20	0.9+2.3=3.2	2.6	2.5	sm
21	1.0+2.1=3.1	2.5	2.1	sm
22	1.0+2.1=3.1	2.5	2.1	sm
23	1.3+1.7=3.0	2.4	1.3	m
24	1.3+1.7=3.0	2.4	1.3	m
25	0.9+2.0=2.9	2.4	2.2	sm
26	0.9+2.0=2.9	2.4	2.2	sm
27	0.7+1.8=2.5	2.0	2.5	sm
28	0.7+1.8=2.5	2.0	2.5	sm
29	0.9+1.6=2.5	2.0	1.7	m
30	0.9+1.6=2.5	2.0	1.7	m
31	1.0+1.4=2.4	2.0	1.4	m
32	1.0+1.4=2.4	2.0	1.4	m
33	0.8+1.4=2.2	1.8	1.7	m
34	0.8+1.4=2.2	1.8	1.7	m
35	0.8+1.4=2.2	1.8	1.7	m
36	0.8+1.4=2.2	1.8	1.7	m
37	0.7+1.3=2.0	1.6	1.8	sm
38	0.7+1.3=2.0	1.6	1.8	sm
39	0.7+1.3=2.0	1.6	1.8	sm
40	0.7+1.3=2.0	1.6	1.8	sm

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.8+2.6=4.4	3.7	1.4	m
2	1.8+2.6=4.4	3.7	1.4	m
3	1.8+2.5=4.3	3.7	1.3	m
4	1.8+2.5=4.3	3.7	1.3	m
5	1.7+2.2=3.9	3.3	1.2	m
6	1.7+2.2=3.9	3.3	1.2	m
7	1.5+2.1=3.6	3.1	1.4	m
8	1.5+2.1=3.6	3.1	1.4	m
9	1.1+2.2=3.3	2.8	2.0	sm
10	1.1+2.2=3.3	2.8	2.0	sm
11	0.9+2.3=3.2	2.7	2.5	sm
12	0.9+2.3=3.2	2.7	2.5	sm
13	1.3+1.8=3.1	2.6	1.3	m
14	1.3+1.8=3.1	2.6	1.3	m
15	0.8+2.3=3.1	2.6	2.8	sm
16	0.8+2.3=3.1	2.6	2.8	sm
17	0.9+2.1=3.0	2.6	2.3	sm
18	0.9+2.1=3.0	2.6	2.3	sm
19	1.0+1.9=2.9	2.5	1.9	sm
20	1.0+1.9=2.9	2.5	1.9	sm
21	0.9+1.9=2.8	2.4	2.1	sm
22	0.9+1.9=2.8	2.4	2.1	sm
23	0.7+2.0=2.7	2.3	2.8	sm
24	0.7+2.0=2.7	2.3	2.8	sm
25	1.1+1.5=2.6	2.2	1.3	m
26	1.1+1.5=2.6	2.2	1.3	m
27	0.9+1.7=2.6	2.2	1.8	sm
28	0.9+1.7=2.6	2.2	1.8	sm
29	0.9+1.7=2.6	2.2	1.8	sm
30	0.9+1.7=2.6	2.2	1.8	sm
31	0.8+1.7=2.5	2.1	2.1	sm
32	0.8+1.7=2.5	2.1	2.1	sm
33	0.9+1.3=2.2	1.9	1.4	m
34	0.9+1.3=2.2	1.9	1.4	m
35	1.0+1.1=2.1	1.8	1.1	m
36	1.0+1.1=2.1	1.8	1.1	m
37	0.8+1.2=2.0	1.7	1.5	m
38	0.7+1.2=1.9	1.6	1.7	m
39	0.7+1.2=1.9	1.6	1.7	m
40	0.7+1.2=1.9	1.6	1.7	m

Table 5. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe caudatilabella*, 2n=38

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.7+3.8=6.5	3.6	1.4	m
2	2.7+3.8=6.5	3.6	1.4	m
3	2.3+3.5=5.8	3.2	1.5	m
4	2.3+3.5=5.8	3.2	1.5	m
5	2.3+3.2=5.5	3.0	1.3	m
6	2.3+3.2=5.5	3.0	1.3	m
7	2.2+3.1=5.3	2.9	1.4	m
8	2.2+3.1=5.3	2.9	1.4	m
9	2.5+2.7=5.2	2.9	1.0	m
10	2.5+2.7=5.2	2.9	1.0	m
11	1.5+3.7=5.2	2.9	2.4	sm
12	1.5+3.7=5.2	2.9	2.4	sm
13	1.7+3.5=5.2	2.9	2.0	sm
14	1.7+3.5=5.2	2.9	2.0	sm
15	1.5+3.5=5.0	2.8	2.3	sm
16	1.5+3.5=5.0	2.8	2.3	sm
17	2.0+2.8=4.8	2.7	1.4	m
18	2.0+2.8=4.8	2.7	1.4	m
19	1.6+3.1=4.7	2.6	1.9	sm
20	1.6+3.1=4.7	2.6	1.9	sm
21	1.6+3.1=4.7	2.6	1.9	sm
22	1.6+3.1=4.7	2.6	1.9	sm
23	2.2+2.4=4.6	2.5	1.0	m
24	2.2+2.4=4.6	2.5	1.0	m
25	1.3+3.1=4.4	2.4	2.3	sm
26	1.3+3.1=4.4	2.4	2.3	sm
27	1.3+2.9=4.2	2.3	2.2	sm
28	1.3+2.9=4.2	2.3	2.2	sm
29	1.3+2.8=4.1	2.3	2.1	sm
30	1.3+2.8=4.1	2.3	2.1	sm
31	1.5+2.5=4.0	2.2	1.6	m
32	1.5+2.5=4.0	2.2	1.6	m
33	1.6+2.2=3.8	2.1	1.3	m
34	1.6+2.2=3.8	2.1	1.3	m
35	1.7+2.1=3.8	2.1	1.2	m
36	1.7+2.1=3.8	2.1	1.2	m
37	1.7+2.0=3.7	2.0	1.1	m
38	1.7+2.0=3.7	2.0	1.1	m

Table 6. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe conspicua*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.0+2.5=4.5	3.4	1.2	m
2	2.0+2.5=4.5	3.4	1.2	m
3	1.5+3.0=4.5	3.4	2.0	sm
4	1.5+3.0=4.5	3.4	2.0	sm
5	1.8+2.5=4.3	3.2	1.3	m
6	1.8+2.5=4.3	3.2	1.3	m
7	2.0+2.3=4.3	3.2	1.1	m
8	2.0+2.3=4.3	3.2	1.1	m
9	1.9+2.1=4.0	3.0	1.1	m
10	1.9+2.1=4.0	3.0	1.1	m
11	1.9+1.9=3.8	2.9	1.0	m
12	1.9+1.9=3.8	2.9	1.0	m
13	1.8+2.0=3.8	2.9	1.1	m
14	1.8+2.0=3.8	2.9	1.1	m
15	1.2+2.3=3.5	2.6	1.9	sm
16	1.2+2.3=3.5	2.6	1.9	sm
17	1.1+2.1=3.2	2.4	1.9	sm
18	1.1+2.1=3.2	2.4	1.9	sm
19	1.5+1.7=3.2	2.4	1.1	m
20	1.5+1.7=3.2	2.4	1.1	m
21	1.4+1.8=3.2	2.4	1.2	m
22	1.4+1.8=3.2	2.4	1.2	m
23	1.2+1.8=3.0	2.3	1.5	m
24	1.2+1.8=3.0	2.3	1.5	m
25	0.9+2.1=3.0	2.3	2.3	sm
26	0.9+2.1=3.0	2.3	2.3	sm
27	0.9+2.0=2.9	2.2	2.2	sm
28	0.9+2.0=2.9	2.2	2.2	sm
29	1.1+1.7=2.8	2.1	1.5	m
30	1.1+1.7=2.8	2.1	1.5	m
31	1.3+1.4=2.7	2.0	1.0	m
32	1.3+1.4=2.7	2.0	1.0	m
33	0.7+2.0=2.7	2.0	2.8	sm
34	0.7+2.0=2.7	2.0	2.8	sm
35	0.9+1.7=2.6	2.0	1.8	sm
36	0.9+1.7=2.6	2.0	1.8	sm
37	1.0+1.3=2.3	1.7	1.3	m
38	1.0+1.3=2.3	1.7	1.3	m
39	0.8+1.4=2.2	1.7	1.7	m
40	0.8+1.4=2.2	1.7	1.7	m

Table 7. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe cremeo-viridis*, 2n=46

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.6+2.7=4.3	3.0	1.6	m
2	1.6+2.7=4.3	3.0	1.6	m
3	1.7+2.6=4.3	3.0	1.5	m
4	1.7+2.6=4.3	3.0	1.5	m
5	1.7+2.5=4.2	2.9	1.4	m
6	1.7+2.5=4.2	2.9	1.4	m
7	1.7+2.3=4.0	2.8	1.3	m
8	1.7+2.3=4.0	2.8	1.3	m
9	1.7+2.0=3.7	2.6	1.1	m
10	1.7+2.0=3.7	2.6	1.1	m
11	1.5+2.2=3.7	2.6	1.4	m
12	1.5+2.2=3.7	2.6	1.4	m
13	1.4+2.3=3.7	2.6	1.6	m
14	1.4+2.3=3.7	2.6	1.6	m
15	1.3+2.1=3.4	2.4	1.6	m
16	1.3+2.1=3.4	2.4	1.6	m
17	1.6+1.7=3.3	2.3	1.0	m
18	1.6+1.7=3.3	2.3	1.0	m
19	1.3+1.9=3.2	2.2	1.4	m
20	1.3+1.9=3.2	2.2	1.4	m
21	1.0+2.2=3.2	2.2	2.2	sm
22	1.0+2.2=3.2	2.2	2.2	sm
23	1.0+2.1=3.1	2.2	2.1	sm
24	1.0+2.1=3.1	2.2	2.1	sm
25	1.2+1.7=2.9	2.0	1.4	m
26	1.2+1.7=2.9	2.0	1.4	m
27	1.3+1.5=2.8	2.0	1.1	m
28	1.3+1.5=2.8	2.0	1.1	m
29	0.7+1.9=2.6	1.8	2.7	sm
30	0.7+1.9=2.6	1.8	2.7	sm
31	0.9+1.7=2.6	1.8	1.8	sm
32	0.9+1.7=2.6	1.8	1.8	sm
33	1.1+1.5=2.6	1.8	1.3	m
34	1.1+1.5=2.6	1.8	1.3	m
35	1.0+1.6=2.6	1.8	1.6	m
36	1.0+1.6=2.6	1.8	1.6	m
37	0.9+1.7=2.6	1.8	1.8	sm
38	0.9+1.7=2.6	1.8	1.8	sm
39	0.7+1.8=2.5	1.7	2.5	sm
40	0.6+1.8=2.4	1.7	3.0	sm
41	1.0+1.3=2.3	1.6	1.3	m
42	1.0+1.3=2.3	1.6	1.3	m

Table 7. continued

43	0.9+1.3=2.2	1.5	1.4	m
44	0.9+1.3=2.2	1.5	1.4	m
45	0.9+1.2=2.1	1.5	1.3	m
46	0.8+1.0=1.8	1.3	1.2	m

Table 8. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe graciliflora*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.0+2.8=4.8	4.0	1.4	m
2	1.8+2.3=4.1	3.4	1.2	m
3	1.0+3.0=4.0	3.3	3.0	sm
4	1.0+3.0=4.0	3.3	3.0	sm
5	1.1+2.6=3.7	3.1	2.3	sm
6	1.1+2.6=3.7	3.1	2.3	sm
7	0.7+3.0=3.7	3.1	4.2	st
8	0.7+3.0=3.7	3.1	4.2	st
9	1.4+2.3=3.7	3.1	1.6	m
10	1.4+2.3=3.7	3.1	1.6	m
11	1.3+2.0=3.3	2.7	1.5	m
12	1.3+2.0=3.3	2.7	1.5	m
13	1.0+2.3=3.3	2.7	2.3	sm
14	1.0+2.3=3.3	2.7	2.3	sm
15	1.0+2.2=3.2	2.7	2.2	sm
16	1.0+2.2=3.2	2.7	2.2	sm
17	1.3+1.8=3.1	2.6	1.3	m
18	1.3+1.8=3.1	2.6	1.3	m
19	1.2+1.8=3.0	2.5	1.5	m
20	1.2+1.8=3.0	2.5	1.5	m
21	0.8+2.2=3.0	2.5	2.7	sm
22	0.8+2.2=3.0	2.5	2.7	sm
23	0.9+2.0=2.9	2.4	2.2	sm
24	0.9+2.0=2.9	2.4	2.2	sm
25	1.0+1.8=2.8	2.3	1.8	sm
26	1.0+1.8=2.8	2.3	1.8	sm
27	0.8+1.8=2.6	2.2	2.2	sm
28	0.8+1.8=2.6	2.2	2.2	sm
29	0.8+1.7=2.5	2.1	2.1	sm
30	0.8+1.7=2.5	2.1	2.1	sm
31	1.1+1.3=2.4	2.0	1.1	m
32	1.1+1.3=2.4	2.0	1.1	m
33	1.0+1.4=2.4	2.0	1.4	m
34	1.0+1.4=2.4	2.0	1.4	m
35	0.7+1.4=2.1	1.7	2.0	sm
36	0.7+1.4=2.1	1.7	2.0	sm
37	0.9+1.2=2.1	1.7	1.3	m
38	0.9+1.2=2.1	1.7	1.3	m
39	0.9+1.1=2.0	1.7	1.2	m
40	0.9+1.1=2.0	1.7	1.2	m

Table 9. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe hamata*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.1+3.5=5.6	3.8	1.6	m
2	2.1+3.2=5.3	3.5	1.5	m
3	1.9+3.3=5.2	3.5	1.7	m
4	1.9+3.3=5.2	3.5	1.7	m
5	1.7+3.2=4.9	3.3	1.8	sm
6	1.7+3.2=4.9	3.3	1.8	sm
7	1.9+2.7=4.6	3.1	1.4	m
8	1.9+2.7=4.6	3.1	1.4	m
9	1.5+2.9=4.4	2.9	1.9	sm
10	1.5+2.9=4.4	2.9	1.9	sm
11	1.2+2.9=4.1	2.7	2.4	sm
12	1.2+2.9=4.1	2.7	2.4	sm
13	0.9+3.0=3.9	2.6	3.3	st
14	0.9+3.0=3.9	2.6	3.3	st
15	0.9+3.0=3.9	2.6	3.3	st
16	0.9+3.0=3.9	2.6	3.3	st
17	1.1+2.7=3.8	2.5	2.4	sm
18	1.1+2.7=3.8	2.5	2.4	sm
19	1.3+2.3=3.6	2.4	1.7	m
20	1.3+2.3=3.6	2.4	1.7	m
21	1.7+1.8=3.5	2.3	1.0	m
22	1.7+1.8=3.5	2.3	1.0	m
23	1.7+1.8=3.5	2.3	1.0	m
24	1.7+1.8=3.5	2.3	1.0	m
25	1.2+2.3=3.5	2.3	1.9	sm
26	1.2+2.3=3.5	2.3	1.9	sm
27	1.0+2.5=3.5	2.3	2.5	sm
28	1.0+2.5=3.5	2.3	2.5	sm
29	1.2+2.3=3.5	2.3	1.9	sm
30	1.2+2.3=3.5	2.3	1.9	sm
31	1.3+2.0=3.3	2.2	1.5	m
32	1.3+2.0=3.3	2.2	1.5	m
33	0.8+2.1=2.9	1.9	2.6	sm
34	0.2+0.8+2.1=3.1*	2.1	2.1	sm
35	1.0+1.5=2.5	1.7	1.5	m
36	0.3+1.0+1.5=2.8*	1.9	1.2	m
37	1.1+1.3=2.4	1.6	1.1	m
38	1.1+1.3=2.4	1.6	1.1	m
39	0.8+1.4=2.2	1.5	1.7	m
40	0.8+1.4=2.2	1.5	1.7	m

* : Chromosome with secondary constriction

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.6+2.7=5.3	4.0	1.0	m
2	2.6+2.7=5.3	4.0	1.0	m
3	2.3+2.9=5.2	3.9	1.2	m
4	2.3+2.9=5.2	3.9	1.2	m
5	1.5+3.0=4.5	3.4	2.0	sm
6	1.5+3.0=4.5	3.4	2.0	sm
7	1.7+2.1=3.8	2.9	1.2	m
8	1.7+2.1=3.8	2.9	1.2	m
9	0.3+1.4+2.3=4.0*	3.0	1.4	m
10	1.4+2.3=3.7	2.8	1.6	m
11	1.3+2.4=3.7	2.8	1.8	sm
12	1.3+2.4=3.7	2.8	1.8	sm
13	1.1+2.3=3.4	2.6	2.0	sm
14	1.1+2.3=3.4	2.6	2.0	sm
15	1.1+2.3=3.4	2.6	2.0	sm
16	1.1+2.3=3.4	2.6	2.0	sm
17	1.0+2.4=3.4	2.6	2.4	sm
18	1.0+2.4=3.4	2.6	2.4	sm
19	1.0+2.2=3.2	2.4	2.2	sm
20	1.0+2.2=3.2	2.4	2.2	sm
21	1.3+1.8=3.1	2.3	1.3	m
22	1.3+1.8=3.1	2.3	1.3	m
23	1.3+1.7=3.0	2.3	1.3	m
24	1.3+1.7=3.0	2.3	1.3	m
25	1.3+1.5=2.8	2.1	1.1	m
26	1.3+1.5=2.8	2.1	1.1	m
27	0.8+2.0=2.8	2.1	2.5	sm
28	0.8+2.0=2.8	2.1	2.5	sm
29	1.3+1.4=2.7	2.0	1.0	m
30	1.3+1.4=2.7	2.0	1.0	m
31	1.0+1.6=2.6	2.0	1.6	m
32	1.0+1.6=2.6	2.0	1.6	m
33	0.9+1.6=2.5	1.9	1.7	m
34	0.9+1.6=2.5	1.9	1.7	m
35	0.8+1.7=2.5	1.9	2.1	sm
36	0.8+1.7=2.5	1.9	2.1	sm
37	1.1+1.2=2.3	1.7	1.0	m
38	1.1+1.2=2.3	1.7	1.0	m
39	1.0+1.3=2.3	1.7	1.3	m
40	1.0+1.3=2.3	1.7	1.3	m

* : Chromosome with secondary constriction

Table 11. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe herbacea*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.1+3.2=5.3	3.5	1.5	m
2	2.1+3.2=5.3	3.5	1.5	m
3	2.2+2.7=4.9	3.3	1.2	m
4	2.2+2.7=4.9	3.3	1.2	m
5	2.1+2.7=4.8	3.2	1.2	m
6	2.1+2.7=4.8	3.2	1.2	m
7	2.0+2.7=4.7	3.1	1.3	m
8	2.0+2.7=4.7	3.1	1.3	m
9	1.8+2.3=4.1	2.7	1.2	m
10	1.8+2.3=4.1	2.7	1.2	m
11	1.9+2.2=4.1	2.7	1.1	m
12	1.9+2.2=4.1	2.7	1.1	m
13	1.7+2.3=4.0	2.7	1.3	m
14	1.7+2.3=4.0	2.7	1.3	m
15	1.5+2.4=3.9	2.6	1.6	m
16	1.5+2.4=3.9	2.6	1.6	m
17	1.5+2.3=3.8	2.5	1.5	m
18	1.5+2.3=3.8	2.5	1.5	m
19	1.3+2.3=3.6	2.4	1.7	m
20	1.3+2.3=3.6	2.4	1.7	m
21	1.3+2.3=3.6	2.4	1.7	m
22	1.3+2.3=3.6	2.4	1.7	m
23	1.7+1.8=3.5	2.3	1.0	m
24	1.7+1.8=3.5	2.3	1.0	m
25	1.4+2.0=3.4	2.3	1.4	m
26	1.3+2.0=3.3	2.2	1.5	m
27	1.7+1.7+0.5=3.9*	2.6	1.2	m
28	1.7+1.7=3.4	2.2	1.0	m
29	0.9+2.4=3.3	2.2	2.6	sm
30	0.9+2.4=3.3	2.2	2.6	sm
31	1.1+2.0=3.1	2.1	1.8	sm
32	1.1+2.0=3.1	2.1	1.8	sm
33	0.9+2.2=3.1	2.1	2.4	sm
34	0.9+2.2=3.1	2.1	2.4	sm
35	0.9+2.1=3.0	2.0	2.3	sm
36	0.9+2.1=3.0	2.0	2.3	sm
37	1.4+1.5=2.9	1.9	1.0	m
38	1.3+1.5=2.8	1.9	1.1	m
39	1.1+1.3=2.4	1.6	1.1	m
40	1.1+1.3=2.4	1.6	1.1	m

* : Chromosome with secondary constriction

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.1+2.3=4.4	3.6	1.0	m
2	2.1+2.3=4.4	3.6	1.0	m
3	1.8+2.0=3.8	3.1	1.1	m
4	1.8+2.0=3.8	3.1	1.1	m
5	1.2+2.6=3.8	3.1	2.1	sm
6	1.2+2.6=3.8	3.1	2.1	sm
7	1.0+2.7=3.7	3.0	2.7	sm
8	1.0+2.7=3.7	3.0	2.7	sm
9	1.3+2.3=3.6	3.0	1.7	m
10	1.3+2.3=3.6	3.0	1.7	m
11	0.9+2.5=3.4	2.8	2.7	sm
12	0.9+2.5=3.4	2.8	2.7	sm
13	1.4+1.8=3.2	2.6	1.2	m
14	1.4+1.8=3.2	2.6	1.2	m
15	0.8+2.3=3.1	2.5	2.8	sm
16	0.8+2.3=3.1	2.5	2.8	sm
17	0.7+2.3=3.0	2.5	3.2	st
18	0.7+2.3=3.0	2.5	3.2	st
19	1.4+1.5=2.9	2.4	1.0	m
20	1.4+1.5=2.9	2.4	1.0	m
21	1.2+1.7=2.9	2.4	1.4	m
22	1.2+1.7=2.9	2.4	1.4	m
23	1.0+1.8=2.8	2.3	1.8	sm
24	1.0+1.8=2.8	2.3	1.8	sm
25	1.2+1.6=2.8	2.3	1.3	m
26	1.2+1.6=2.8	2.3	1.3	m
27	1.2+1.6=2.8	2.3	1.3	m
28	1.2+1.6=2.8	2.3	1.3	m
29	0.8+1.9=2.7	2.2	2.3	sm
30	0.8+1.9=2.7	2.2	2.3	sm
31	0.9+1.8=2.7	2.2	2.0	sm
32	0.9+1.8=2.7	2.2	2.0	sm
33	0.9+1.8=2.7	2.2	2.0	sm
34	0.9+1.8=2.7	2.2	2.0	sm
35	0.8+1.8=2.6	2.1	2.2	sm
36	0.8+1.8=2.6	2.1	2.2	sm
37	1.0+1.3=2.3	1.9	1.3	m
38	1.0+1.3=2.3	1.9	1.3	m
39	0.7+1.0=1.7	1.4	1.4	m
40	0.7+1.0=1.7	1.4	1.4	m

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.2+2.7=4.9	3.4	1.2	m
2	2.2+2.7=4.9	3.4	1.2	m
3	1.9+2.8=4.7	3.2	1.4	m
4	1.9+2.8=4.7	3.2	1.4	m
5	1.7+2.8=4.5	3.1	1.6	m
6	1.7+2.8=4.5	3.1	1.6	m
7	1.7+2.7=4.4	3.0	1.5	m
8	1.7+2.7=4.4	3.0	1.5	m
9	1.9+2.4=4.3	3.0	1.2	m
10	1.9+2.4=4.3	3.0	1.2	m
11	2.0+2.3=4.3	3.0	1.1	m
12	1.9+2.3=4.2	2.9	1.2	m
13	1.7+2.4=4.1	2.8	1.4	m
14	1.7+2.4=4.1	2.8	1.4	m
15	1.3+2.4=3.7	2.5	1.8	sm
16	1.3+2.4=3.7	2.5	1.8	sm
17	1.3+2.4=3.7	2.5	1.8	sm
18	1.3+2.4=3.7	2.5	1.8	sm
19	1.3+2.4=3.7	2.5	1.8	sm
20	1.3+2.4=3.7	2.5	1.8	sm
21	1.7+1.8=3.5	2.4	1.0	m
22	1.7+1.8=3.5	2.4	1.0	m
23	1.3+1.9=3.2	2.2	1.4	m
24	1.3+1.9=3.2	2.2	1.4	m
25	1.2+2.0=3.2	2.2	1.6	m
26	1.2+2.0=3.2	2.2	1.6	m
27	1.1+2.1=3.2	2.2	1.9	sm
28	1.1+2.1=3.2	2.2	1.9	sm
29	1.1+2.0=3.1	2.1	1.8	sm
30	1.1+2.0=3.1	2.1	1.8	sm
31	0.8+2.3=3.1	2.1	2.8	sm
32	0.8+2.3=3.1	2.1	2.8	sm
33	1.2+1.8=3.0	2.1	1.5	m
34	1.2+1.8=3.0	2.1	1.5	m
35	0.8+2.2=3.0	2.1	2.7	sm
36	0.8+2.2=3.0	2.1	2.7	sm
37	0.9+1.7=2.6	1.8	1.8	sm
38	0.9+1.7=2.6	1.8	1.8	sm
39	1.3+1.3=2.6	1.8	1.0	m
40	1.3+1.3=2.6	1.8	1.0	m

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.3+3.4=5.7	4.0	1.4	m
2	2.3+3.1=5.4	3.7	1.3	m
3	1.9+3.5=5.4	3.7	1.8	sm
4	1.9+3.5=5.4	3.7	1.8	sm
5	1.6+3.1=4.7	3.3	1.9	sm
6	1.2+3.4=4.6	3.2	2.8	sm
7	1.7+2.9=4.6	3.2	1.7	m
8	1.7+2.9=4.6	3.2	1.7	m
9	1.7+2.5=4.2	2.9	1.4	m
10	1.7+2.5=4.2	2.9	1.4	m
11	1.5+2.5=4.0	2.8	1.6	m
12	1.5+2.5=4.0	2.8	1.6	m
13	1.2+2.5=3.7	2.6	2.0	m
14	1.2+2.5=3.7	2.6	2.0	m
15	1.6+2.1=3.7	2.6	1.3	sm
16	1.6+2.1=3.7	2.6	1.3	sm
17	0.7+2.9=3.6	2.5	4.1	s t
18	0.7+2.9=3.6	2.5	4.1	s t
19	1.0+2.5=3.5	2.4	2.5	sm
20	1.0+2.5=3.5	2.4	2.5	sm
21	1.2+2.2=3.4	2.4	1.8	sm
22	1.2+2.2=3.4	2.4	1.8	sm
23	1.1+2.3=3.4	2.4	2.0	sm
24	1.1+2.3=3.4	2.4	2.0	sm
25	1.0+2.3=3.3	2.3	2.3	sm
26	0.9+2.2=3.1	2.1	2.4	sm
27	1.3+1.7=3.0	2.1	1.3	m
28	1.3+1.7=3.0	2.1	1.3	m
29	1.3+1.7=3.0	2.1	1.3	m
30	1.3+1.7=3.0	2.1	1.3	m
31	1.1+1.7=2.8	1.9	1.5	m
32	1.1+1.7=2.8	1.9	1.5	m
33	0.8+2.0=2.8	1.9	2.5	sm
34	0.8+2.0=2.8	1.9	2.5	sm
35	1.0+1.7=2.7	1.9	1.7	m
36	1.0+1.7=2.7	1.9	1.7	m
37	1.1+1.5=2.6	1.8	1.3	m
38	1.1+1.5=2.6	1.8	1.3	m
39	0.9+1.5=2.4	1.7	1.6	m
40	1.0+1.2=2.2	1.5	1.2	m

Table 15. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe plantaginea*, 2n=40

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

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.3+3.3=5.6	3.7	1.4	m
2	2.0+3.3=5.3	3.5	1.6	m
3	2.1+2.8=4.9	3.2	1.3	m
4	2.1+2.8=4.9	3.2	1.3	m
5	1.6+2.9=4.5	2.9	1.8	sm
6	1.6+2.9=4.5	2.9	1.8	sm
7	1.7+2.7=4.4	2.9	1.5	m
8	1.7+2.7=4.4	2.9	1.5	m
9	1.8+2.5=4.3	2.8	1.3	m
10	1.8+2.5=4.3	2.8	1.3	m
11	1.9+2.3=4.2	2.7	1.2	m
12	1.9+2.3=4.2	2.7	1.2	m
13	1.7+2.4=4.1	2.7	1.4	m
14	1.7+2.4=4.1	2.7	1.4	m
15	1.4+2.7=4.1	2.7	1.9	sm
16	1.4+2.7=4.1	2.7	1.9	sm
17	1.9+2.0=3.9	2.6	1.0	m
18	1.9+2.0=3.9	2.6	1.0	m
19	1.7+2.2=3.9	2.6	1.2	m
20	1.7+2.2=3.9	2.6	1.2	m
21	1.6+1.9=3.5	2.3	1.1	m
22	1.6+1.9=3.5	2.3	1.1	m
23	1.3+2.2=3.5	2.3	1.6	m
24	0.5+3.0=3.5	2.3	6.0	st
25	1.6+1.8=3.4	2.2	1.1	m
26	1.6+1.8=3.4	2.2	1.1	m
27	1.6+1.8=3.4	2.2	1.1	m
28	1.6+1.8=3.4	2.2	1.1	m
29	1.4+2.0=3.4	2.2	1.4	m
30	1.4+2.0=3.4	2.2	1.4	m
31	1.6+1.7=3.3	2.2	1.0	m
32	1.6+1.7=3.3	2.2	1.0	m
33	1.5+0.5+1.1=3.1*	2.0	1.0	m
34	1.5+0.5+1.1=3.1*	2.0	1.0	m
35	1.4+1.7=3.1	2.0	1.2	m
36	1.4+1.7=3.1	2.0	1.2	m
37	1.3+1.7=3.0	2.0	1.3	m
38	1.3+1.7=3.0	2.0	1.3	m
39	1.3+1.7=3.0	2.0	1.3	m
40	1.3+1.7=3.0	2.0	1.3	m

*: Chromosome with secondary constriction

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.0+2.8=4.8	4.3	1.4	m
2	2.0+2.8=4.8	4.3	1.4	m
3	1.7+2.3=4.0	3.6	1.3	m
4	1.7+2.3=4.0	3.6	1.3	m
5	1.2+2.5=3.7	3.3	2.0	sm
6	1.2+2.5=3.7	3.3	2.0	sm
7	1.0+2.2=3.2	2.9	2.2	sm
8	1.0+2.2=3.2	2.9	2.2	sm
9	1.5+1.7=3.2	2.9	1.1	m
10	1.5+1.7=3.2	2.9	1.1	m
11	1.0+2.2=3.2	2.9	2.2	sm
12	1.0+2.2=3.2	2.9	2.2	sm
13	1.3+1.8=3.1	2.8	1.3	m
14	1.3+1.8=3.1	2.8	1.3	m
15	1.3+1.6=2.9	2.6	1.2	m
16	1.3+1.6=2.9	2.6	1.2	m
17	1.0+1.8=2.8	2.5	1.8	sm
18	1.0+1.8=2.8	2.5	1.8	sm
19	1.0+1.8=2.8	2.5	1.8	sm
20	1.0+1.8=2.8	2.5	1.8	sm
21	1.0+1.7=2.7	2.4	1.7	m
22	1.0+1.7=2.7	2.4	1.7	m
23	1.2+1.3=2.5	2.2	1.0	m
24	1.2+1.3=2.5	2.2	1.0	m
25	0.7+1.7=2.4	2.1	2.4	sm
26	0.7+1.7=2.4	2.1	2.4	sm
27	1.0+1.3=2.3	2.1	1.3	m
28	1.0+1.3=2.3	2.1	1.3	m
29	1.0+1.3=2.3	2.1	1.3	m
30	1.0+1.3=2.3	2.1	1.3	m
31	0.7+1.5=2.2	2.0	2.1	sm
32	0.7+1.5=2.2	2.0	2.1	sm
33	0.9+1.3=2.2	2.0	1.4	m
34	0.9+1.3=2.2	2.0	1.4	m
35	0.8+1.3=2.1	1.9	1.6	m
36	0.8+1.3=2.1	1.9	1.6	m
37	0.8+1.2=2.0	1.8	1.5	m
38	0.8+1.2=2.0	1.8	1.5	m
39	0.7+1.0=1.7	1.5	1.4	m
40	0.6+0.9=1.5	1.3	1.5	m

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.8+5.4=8.2	3.7	1.9	sm
2	2.8+5.4=8.2	3.7	1.9	sm
3	2.5+5.7=8.2	3.7	2.2	sm
4	2.5+5.7=8.2	3.7	2.2	sm
5	2.3+5.0=7.3	3.3	2.1	sm
6	2.0+5.0=7.0	3.2	2.5	sm
7	1.7+5.3=7.0	3.2	3.1	st
8	1.7+5.3=7.0	3.2	3.1	st
9	3.0+3.8=6.8	3.1	1.2	m
10	3.0+3.8=6.8	3.1	1.2	m
11	1.8+4.2=6.0	2.7	2.3	sm
12	1.8+4.2=6.0	2.7	2.3	sm
13	2.8+3.2=6.0	2.7	1.1	m
14	2.6+3.2=5.8	2.6	1.2	m
15	2.1+3.3=5.4	2.4	1.5	m
16	2.1+3.3=5.4	2.4	1.5	m
17	1.8+3.6=5.4	2.4	2.0	sm
18	1.8+3.6=5.4	2.4	2.0	sm
19	2.3+3.0=5.3	2.4	1.3	sm
20	2.3+3.0=5.3	2.4	1.3	sm
21	2.0+3.3=5.3	2.4	1.6	m
22	2.0+3.3=5.3	2.4	1.6	m
23	0.8+4.2=5.0	2.3	5.2	st
24	0.8+4.2=5.0	2.3	5.2	st
25	1.7+3.0=4.7	2.1	1.7	m
26	1.7+3.0=4.7	2.1	1.7	m
27	1.0+3.5=4.5	2.0	3.5	st
28	1.0+3.5=4.5	2.0	3.5	st
29	2.2+2.3=4.5	2.0	1.0	m
30	2.2+2.3=4.5	2.0	1.0	m
31	2.0+2.3=4.3	1.9	1.1	m
32	2.0+2.3=4.3	1.9	1.1	m
33	1.8+2.5=4.3	1.9	1.3	m
34	1.8+2.5=4.3	1.9	1.3	m
35	1.8+2.5=4.3	1.9	1.3	m
36	1.8+2.5=4.3	1.9	1.3	m
37	1.2+3.0=4.2	1.9	2.5	sm
38	1.2+3.0=4.2	1.9	2.5	sm
39	1.2+2.7=3.9	1.8	2.2	sm
40	1.2+2.7=3.9	1.8	2.2	sm

Table 19. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe tricarinata*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.3+3.3=5.6	3.4	1.4	m
2	2.3+3.3=5.6	3.4	1.4	m
3	2.3+3.2=5.5	3.3	1.3	m
4	2.3+3.2=5.5	3.3	1.3	m
5	2.3+2.7=5.0	3.0	1.1	m
6	2.3+2.7=5.0	3.0	1.1	m
7	1.9+2.7=4.6	2.8	1.4	m
8	1.9+2.7=4.6	2.8	1.4	m
9	1.5+3.0=4.5	2.7	2.0	sm
10	1.5+3.0=4.5	2.7	2.0	sm
11	1.7+2.7=4.4	2.7	1.5	m
12	1.7+2.7=4.4	2.7	1.5	m
13	2.0+2.3=4.3	2.6	1.1	m
14	2.0+2.3=4.3	2.6	1.1	m
15	1.3+3.0=4.3	2.6	2.3	sm
16	1.3+3.0=4.3	2.6	2.3	sm
17	1.7+2.6=4.3	2.6	1.5	m
18	1.7+2.6=4.3	2.6	1.5	m
19	1.3+2.8=4.1	2.5	2.1	sm
20	1.3+2.8=4.1	2.5	2.1	sm
21	1.5+2.6=4.1	2.5	1.7	m
22	1.5+2.6=4.1	2.5	1.7	m
23	1.4+2.5=3.9	2.4	1.7	m
24	1.4+2.5=3.9	2.4	1.7	m
25	1.7+2.1=3.8	2.3	1.2	m
26	1.7+2.1=3.8	2.3	1.2	m
27	1.3+2.5=3.8	2.3	1.9	sm
28	1.3+2.5=3.8	2.3	1.9	sm
29	1.3+2.5=3.8	2.3	1.9	sm
30	1.3+2.5=3.8	2.3	1.9	sm
31	0.9+2.8=3.7	2.2	3.1	st
32	0.9+2.8=3.7	2.2	3.1	st
33	1.4+2.3=3.7	2.2	1.6	m
34	1.4+2.3=3.7	2.2	1.6	m
35	1.1+2.3=3.4	2.1	2.0	sm
36	1.1+2.3=3.4	2.1	2.0	sm
37	1.5+1.7=3.2	1.9	1.1	m
38	1.5+1.7=3.2	1.9	1.1	m
39	1.3+1.4=2.7	1.6	1.0	m
40	1.3+1.4=2.7	1.6	1.0	m

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.8+2.2=4.0	3.3	1.2	m
2	1.8+2.2=4.0	3.3	1.2	m
3	1.8+2.0=3.8	3.2	1.1	m
4	1.8+2.0=3.8	3.2	1.1	m
5	1.7+2.1=3.8	3.2	1.2	m
6	1.7+2.1=3.8	3.2	1.2	m
7	1.6+2.2=3.8	3.2	1.3	m
8	1.6+2.2=3.8	3.2	1.3	m
9	1.6+1.9=3.5	2.9	1.1	m
10	1.6+1.9=3.5	2.9	1.1	m
11	1.7+1.8=3.5	2.9	1.0	m
12	1.7+1.8=3.5	2.9	1.0	m
13	1.7+1.7=3.4	2.8	1.0	m
14	1.7+1.7=3.4	2.8	1.0	m
15	1.2+2.2=3.4	2.8	1.8	sm
16	1.1+2.1=3.2	2.7	1.9	sm
17	1.6+1.7=3.3	2.8	1.0	m
18	1.6+1.7=3.3	2.8	1.0	m
19	1.5+1.6=3.1	2.8	1.0	m
20	1.5+1.6=3.1	2.8	1.0	m
21	1.4+1.5=2.9	2.4	1.0	m
22	1.4+1.5=2.9	2.4	1.0	m
23	1.2+1.6=2.8	2.3	1.3	m
24	1.2+1.6=2.8	2.3	1.3	m
25	0.9+1.7=2.6	2.2	1.8	sm
26	0.9+1.7=2.6	2.2	1.8	sm
27	0.8+1.7=2.5	2.1	2.1	sm
28	0.8+1.7=2.5	2.1	2.1	sm
29	1.2+1.3=2.5	2.1	1.0	m
30	1.2+1.3=2.5	2.1	1.0	m
31	1.2+1.3=2.5	2.1	1.0	m
32	1.2+1.3=2.5	2.1	1.0	m
33	1.0+1.3=2.3	1.9	1.3	m
34	1.0+1.3=2.3	1.9	1.3	m
35	0.8+1.5=2.3	1.9	1.8	sm
36	0.8+1.5=2.3	1.9	1.8	sm
37	1.0+1.1=2.1	1.8	1.1	m
38	1.0+1.1=2.1	1.8	1.1	m
39	0.7+1.3=2.0	1.7	1.8	sm
40	0.7+1.3=2.0	1.7	1.8	sm

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.0+2.5=4.5	3.5	1.2	m
2	2.0+2.5=4.5	3.5	1.2	m
3	1.7+2.3=4.0	3.1	1.3	m
4	1.7+2.3=4.0	3.1	1.3	m
5	1.7+2.1=3.8	3.0	1.2	m
6	1.7+2.1=3.8	3.0	1.2	m
7	1.3+2.3=3.6	2.8	1.7	m
8	1.3+2.3=3.6	2.8	1.7	m
9	1.1+2.3=3.4	2.7	2.0	sm
10	1.1+2.3=3.4	2.7	2.0	sm
11	1.5+1.9=3.4	2.7	1.2	m
12	1.5+1.9=3.4	2.7	1.2	m
13	1.6+1.7=3.3	2.6	1.0	m
14	1.6+1.7=3.3	2.6	1.0	m
15	1.3+1.9=3.2	2.5	1.4	m
16	1.3+1.9=3.2	2.5	1.4	m
17	1.3+1.9=3.2	2.5	1.4	m
18	1.3+1.9=3.2	2.5	1.4	m
19	1.5+1.7=3.2	2.5	1.1	m
20	1.5+1.7=3.2	2.5	1.1	m
21	1.3+1.8=3.1	2.4	1.3	m
22	1.3+1.8=3.1	2.4	1.3	m
23	1.3+1.7=3.0	2.4	1.3	m
24	1.3+1.7=3.0	2.4	1.3	m
25	1.3+1.7=3.0	2.4	1.3	m
26	1.3+1.7=3.0	2.4	1.3	m
27	1.3+1.7=3.0	2.4	1.3	m
28	1.3+1.7=3.0	2.4	1.3	m
29	1.3+1.7=3.0	2.4	1.3	m
30	1.3+1.7=3.0	2.4	1.3	m
31	1.3+1.5=2.8	2.2	1.1	m
32	1.3+1.5=2.8	2.2	1.1	m
33	1.0+1.6=2.6	2.0	1.6	m
34	1.0+1.6=2.6	2.0	1.6	m
35	0.9+1.7=2.6	2.0	1.8	sm
36	0.9+1.7=2.6	2.0	1.8	sm
37	1.0+1.4=2.4	1.9	1.4	m
38	1.0+1.4=2.4	1.9	1.4	m
39	0.9+1.5=2.4	1.9	1.6	m
40	0.9+1.5=2.4	1.9	1.6	m

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

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.0+2.5=4.5	3.5	1.2	m
2	2.0+2.5=4.5	3.5	1.2	m
3	1.7+2.3=4.0	3.1	1.3	m
4	1.7+2.3=4.0	3.1	1.3	m
5	1.7+2.1=3.8	3.0	1.2	m
6	1.7+2.1=3.8	3.0	1.2	m
7	1.3+2.3=3.6	2.8	1.7	m
8	1.3+2.3=3.6	2.8	1.7	m
9	1.1+2.3=3.4	2.7	2.0	sm
10	1.1+2.3=3.4	2.7	2.0	sm
11	1.5+1.9=3.4	2.7	1.2	m
12	1.5+1.9=3.4	2.7	1.2	m
13	1.6+1.7=3.3	2.6	1.0	m
14	1.6+1.7=3.3	2.6	1.0	m
15	1.3+1.9=3.2	2.5	1.4	m
16	1.3+1.9=3.2	2.5	1.4	m
17	1.3+1.9=3.2	2.5	1.4	m
18	1.3+1.9=3.2	2.5	1.4	m
19	1.5+1.7=3.2	2.5	1.1	m
20	1.5+1.7=3.2	2.5	1.1	m
21	1.3+1.8=3.1	2.4	1.3	m
22	1.3+1.8=3.1	2.4	1.3	m
23	1.3+1.7=3.0	2.4	1.3	m
24	1.3+1.7=3.0	2.4	1.3	m
25	1.3+1.7=3.0	2.4	1.3	m
26	1.3+1.7=3.0	2.4	1.3	m
27	1.3+1.7=3.0	2.4	1.3	m
28	1.3+1.7=3.0	2.4	1.3	m
29	1.3+1.7=3.0	2.4	1.3	m
30	1.3+1.7=3.0	2.4	1.3	m
31	1.3+1.5=2.8	2.2	1.1	m
32	1.3+1.5=2.8	2.2	1.1	m
33	1.0+1.6=2.6	2.0	1.6	m
34	1.0+1.6=2.6	2.0	1.6	m
35	0.9+1.7=2.6	2.0	1.8	sm
36	0.9+1.7=2.6	2.0	1.8	sm
37	1.0+1.4=2.4	1.9	1.4	m
38	1.0+1.4=2.4	1.9	1.4	m
39	0.9+1.5=2.4	1.9	1.6	m
40	0.9+1.5=2.4	1.9	1.6	m

Table 23. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe formosana*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.8+2.3=4.1	3.3	1.2	m
2	1.7+2.3=4.0	3.2	1.3	m
3	1.3+2.3=3.6	2.9	1.7	m
4	1.3+2.3=3.6	2.9	1.7	m
5	1.2+2.3=3.5	2.8	1.9	sm
6	1.2+2.3=3.5	2.8	1.9	sm
7	1.4+2.0=3.4	2.7	1.4	m
8	1.4+2.0=3.4	2.7	1.4	m
9	1.4+1.9=3.3	2.7	1.3	m
10	1.4+1.9=3.3	2.7	1.3	m
11	1.3+2.0=3.3	2.7	1.5	m
12	1.3+2.0=3.3	2.7	1.5	m
13	1.1+2.2=3.3	2.7	2.0	sm
14	1.1+2.2=3.3	2.7	2.0	sm
15	1.5+1.7=3.2	2.6	1.1	m
16	1.5+1.7=3.2	2.6	1.1	m
17	1.4+1.7=3.1	2.5	1.2	m
18	1.4+1.7=3.1	2.5	1.2	m
19	1.4+1.7=3.1	2.5	1.2	m
20	1.4+1.7=3.1	2.5	1.2	m
21	1.3+1.8=3.1	2.5	1.3	m
22	1.3+1.8=3.1	2.5	1.3	m
23	1.3+1.7=3.0	2.4	1.3	m
24	1.3+1.7=3.0	2.4	1.3	m
25	1.3+1.7=3.0	2.4	1.3	m
26	1.3+1.7=3.0	2.4	1.3	m
27	1.4+1.5=2.9	2.3	1.0	m
28	1.4+1.5=2.9	2.3	1.0	m
29	1.3+1.6=2.9	2.3	1.2	m
30	1.3+1.6=2.9	2.3	1.2	m
31	1.2+1.7=2.9	2.3	1.4	m
32	1.2+1.7=2.9	2.3	1.4	m
33	1.3+1.5=2.8	2.3	1.1	m
34	1.3+1.5=2.8	2.3	1.1	m
35	1.0+1.7=2.7	2.2	1.7	m
36	1.0+1.7=2.7	2.2	1.7	m
37	0.8+1.7=2.5	2.0	2.1	sm
38	0.8+1.7=2.5	2.0	2.1	sm
39	0.9+1.5=2.4	1.9	1.6	m
40	0.9+1.5=2.4	1.9	1.6	m

Table 24. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe lyroglossa*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.0+2.3=4.3	3.4	1.1	m
2	2.0+2.3=4.3	3.4	1.1	m
3	1.9+1.9=3.8	3.0	1.0	m
4	1.9+1.9=3.8	3.0	1.0	m
5	1.7+2.0=3.7	2.9	1.1	m
6	1.7+2.0=3.7	2.9	1.1	m
7	1.7+2.0=3.7	2.9	1.1	m
8	1.7+2.0=3.7	2.9	1.1	m
9	1.2+2.5=3.7	2.9	2.0	sm
10	1.2+2.5=3.7	2.9	2.0	sm
11	1.7+1.8=3.5	2.7	1.0	m
12	1.7+1.8=3.5	2.7	1.0	m
13	1.7+1.8=3.5	2.7	1.0	m
14	1.7+1.8=3.5	2.7	1.0	m
15	1.7+1.8=3.5	2.7	1.0	m
16	1.7+1.8=3.5	2.7	1.0	m
17	1.6+1.7=3.3	2.6	1.0	m
18	1.6+1.7=3.3	2.6	1.0	m
19	1.6+1.7=3.3	2.6	1.0	m
20	1.6+1.7=3.3	2.6	1.0	m
21	1.5+1.7=3.2	2.5	1.1	m
22	1.5+1.7=3.2	2.5	1.1	m
23	1.3+1.8=3.1	2.4	1.3	m
24	1.3+1.8=3.1	2.4	1.3	m
25	1.2+1.8=3.0	2.4	1.5	m
26	1.2+1.8=3.0	2.4	1.5	m
27	1.3+1.6=2.9	2.3	1.2	m
28	1.3+1.6=2.9	2.3	1.2	m
29	1.1+1.8=2.9	2.3	1.6	m
30	1.1+1.8=2.9	2.3	1.6	m
31	1.3+1.5=2.8	2.2	1.1	m
32	1.3+1.5=2.8	2.2	1.1	m
33	1.3+1.5=2.8	2.2	1.1	m
34	1.3+1.5=2.8	2.2	1.1	m
35	0.9+1.7=2.6	2.0	1.8	sm
36	0.9+1.7=2.6	2.0	1.8	sm
37	0.9+1.2=2.1	1.6	1.3	m
38	0.9+1.2=2.1	1.6	1.3	m
39	0.9+1.1=2.0	1.6	1.2	m
40	0.9+1.1=2.0	1.6	1.2	m

Table 25. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe kooshunensis*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.7+2.9=5.6	3.3	1.0	m
2	2.7+2.9=5.6	3.3	1.0	m
3	1.6+4.0=5.6	3.3	2.5	sm
4	1.6+3.7=5.3	3.1	2.3	sm
5	1.5+3.6=5.1	3.0	2.4	sm
6	1.5+3.6=5.1	3.0	2.4	sm
7	2.5+2.5=5.0	3.0	1.0	m
8	2.3+2.5=4.8	2.8	1.0	m
9	2.3+2.3=4.6	2.7	1.0	m
10	2.3+2.3=4.6	2.7	1.0	m
11	2.0+2.5=4.5	2.7	1.2	m
12	2.0+2.5=4.5	2.7	1.2	m
13	1.3+3.2=4.5	2.7	2.4	sm
14	1.3+3.2=4.5	2.7	2.4	sm
15	0.9+3.5=4.4	2.6	3.8	s t
16	0.9+3.5=4.4	2.6	3.8	s t
17	1.0+3.3=4.3	2.6	3.3	s t
18	1.0+3.3=4.3	2.6	3.3	s t
19	1.8−2.3=4.1	2.4	1.2	m
20	1.8−2.3=4.1	2.4	1.2	m
21	1.2−2.8=4.0	2.4	2.3	sm
22	1.2−2.8=4.0	2.4	2.3	sm
23	1.2−2.7=3.9	2.3	2.2	sm
24	1.2+2.7=3.9	2.3	2.2	sm
25	1.7+2.2=3.9	2.3	1.2	m
26	1.7+2.2=3.9	2.3	1.2	m
27	1.2+2.7=3.9	2.3	2.2	sm
28	1.2+2.7=3.9	2.3	2.2	sm
29	1.2+2.7=3.9	2.3	2.2	sm
30	1.2+2.7=3.9	2.3	2.2	sm
31	1.5+2.3=3.8	2.3	1.5	m
32	1.5+2.3=3.8	2.3	1.5	m
33	1.4+2.1=3.5	2.1	1.5	m
34	1.4+2.1=3.5	2.1	1.5	m
35	1.0+2.5=3.5	2.1	2.5	sm
36	1.0+2.5=3.5	2.1	2.5	sm
37	1.3+1.9=3.2	1.9	1.4	m
38	1.3+1.9=3.2	1.9	1.4	m
39	1.1+2.1=3.2	1.9	1.9	sm
40	1.1+2.1=3.2	1.9	1.9	sm

Table 26. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe gracilis*, 2n=40

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.0+2.3=4.3	3.1	1.1	m
2	2.0+2.3=4.3	3.1	1.1	m
3	2.0+2.2=4.2	3.0	1.1	m
4	2.0+2.2=4.2	3.0	1.1	m
5	1.5+2.7=4.2	3.0	1.8	sm
6	1.5+2.7=4.2	3.0	1.8	sm
7	1.2+3.0=4.2	3.0	2.5	sm
8	1.2+3.0=4.2	3.0	2.5	sm
9	1.3+2.8=4.1	2.9	2.1	sm
10	1.3+2.8=4.1	2.9	2.1	sm
11	1.6+2.5=4.1	2.9	1.5	m
12	1.6+2.5=4.1	2.9	1.5	m
13	1.5+2.6=4.1	2.9	1.7	m
14	1.5+2.6=4.1	2.9	1.7	m
15	1.3+2.7=4.0	2.8	2.0	sm
16	1.3+2.7=4.0	2.8	2.0	sm
17	1.7+2.3=4.0	2.8	1.3	m
18	1.7+2.3=4.0	2.8	1.3	m
19	1.7+2.1=3.8	2.7	1.2	m
20	1.7+2.1=3.8	2.7	1.2	m
21	1.1+2.5=3.6	2.6	2.2	sm
22	1.1+2.5=3.6	2.6	2.2	sm
23	1.5+1.7=3.2	2.3	1.1	m
24	1.5+1.7=3.2	2.3	1.1	m
25	1.2+2.0=3.2	2.3	1.6	m
26	1.2+2.0=3.2	2.3	1.6	m
27	1.0+2.1=3.1	2.2	2.1	sm
28	1.0+2.1=3.1	2.2	2.1	sm
29	1.0+2.1=3.1	2.2	2.1	sm
30	1.0+2.1=3.1	2.2	2.1	sm
31	1.0+1.9=2.9	2.1	1.9	sm
32	1.0+1.9=2.9	2.1	1.9	sm
33	1.1+1.7=2.8	2.0	1.5	m
34	1.1+1.7=2.8	2.0	1.5	m
35	1.1+1.7=2.8	2.0	1.5	m
36	1.0+1.7=2.7	1.9	1.7	m
37	0.9+1.8=2.7	1.9	2.0	sm
38	0.9+1.7=2.6	1.8	1.8	sm
39	0.9+1.2=2.1	1.5	1.3	m
40	0.9+1.2=2.1	1.5	1.3	m

Table 27. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe cardioglossa*, 2n=46

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.6+3.3=4.9	3.0	2.0	sm
2	1.6+3.3=4.9	3.0	2.0	sm
3	1.9+2.7=4.6	2.9	1.4	m
4	1.9+2.7=4.6	2.9	1.4	m
5	1.3+3.3=4.6	2.9	2.5	sm
6	1.3+3.3=4.6	2.9	2.5	sm
7	1.5+3.0=4.5	2.8	2.0	sm
8	1.5+3.0=4.5	2.8	2.0	sm
9	1.3+3.0=4.3	2.7	2.3	sm
10	1.3+3.0=4.3	2.7	2.3	sm
11	1.3+3.0=4.3	2.7	2.3	sm
12	1.3+3.0=4.3	2.7	2.3	sm
13	1.0+3.1=4.1	2.5	3.1	st
14	1.0+3.1=4.1	2.5	3.1	st
15	1.2+2.8=4.0	2.5	2.3	sm
16	1.2+2.8=4.0	2.5	2.3	sm
17	1.0+3.0=4.0	2.5	3.0	sm
18	1.0+3.0=4.0	2.5	3.0	sm
19	1.8+2.0=3.8	2.4	1.1	m
20	1.8+2.0=3.8	2.4	1.1	m
21	1.7+2.1=3.8	2.4	1.2	m
22	1.7+2.1=3.8	2.4	1.2	m
23	0.8+2.8=3.6	2.2	3.5	st
24	0.8+2.8=3.6	2.2	3.5	st
25	0.7+2.7=3.4	2.1	3.8	st
26	0.7+2.7=3.4	2.1	3.8	st
27	1.1+2.3=3.4	2.1	2.0	sm
28	1.1+2.3=3.4	2.1	2.0	sm
29	1.3+2.1=3.4	2.1	1.6	m
30	1.3+2.1=3.4	2.1	1.6	m
31	0.7+2.2=2.9	1.8	3.1	st
32	0.7+2.2=2.9	1.8	3.1	st
33	1.2+2.0=3.2	2.0	1.6	m
34	1.2+2.0=3.2	2.0	1.6	m
35	1.3+1.6=2.9	1.8	1.2	m
36	1.3+1.6=2.9	1.8	1.2	m
37	0.8+1.8=2.6	1.6	2.2	sm
38	0.8+1.8=2.6	1.6	2.2	sm
39	1.0+1.2=2.2	1.4	1.2	m
40	1.0+1.2=2.2	1.4	1.2	m
41	0.9+1.2=2.1	1.3	1.3	m
42	0.9+1.2=2.1	1.3	1.3	m

Table 27. continued

43	0.9+1.1=2.0	1.2	1.2	m
44	0.9+1.1=2.0	1.2	1.2	m
45	0.9+1.0=1.9	1.2	1.1	m
46	0.9+1.0=1.9	1.2	1.1	m

Table 28. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe elmeri*, 2n=44

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.0+6.2=8.2	3.2	3.1	st
2	2.0+6.2=8.2	3.2	3.1	st
3	2.3+5.3=7.6	3.0	2.3	sm
4	2.3+5.3=7.6	3.0	2.3	sm
5	2.0+5.3=7.3	2.9	2.6	sm
6	2.0+5.3=7.3	2.9	2.6	sm
7	2.5+4.8=7.3	2.9	1.9	sm
8	2.5+4.8=7.3	2.9	1.9	sm
9	2.2+5.0=7.2	2.8	2.2	sm
10	2.2+5.0=7.2	2.8	2.2	sm
11	3.3+3.8=7.1	2.8	1.1	m
12	3.3+3.8=7.1	2.8	1.1	m
13	1.8+5.3=7.1	2.8	2.9	sm
14	1.8+5.3=7.1	2.8	2.9	sm
15	2.0+5.0=7.0	2.7	2.5	sm
16	2.0+5.0=7.0	2.7	2.5	sm
17	1.9+5.0=6.9	2.7	2.6	sm
18	1.7+5.1=6.8	2.7	3.0	sm
19	1.9+4.6=6.5	2.5	2.4	sm
20	1.9+4.6=6.5	2.5	2.4	sm
21	3.2+3.3=6.5	2.5	1.0	m
22	2.9+3.3=6.2	2.4	1.1	m
23	1.9+4.3=6.2	2.4	2.2	sm
24	1.9+4.3=6.2	2.4	2.2	sm
25	1.4+4.8=6.2	2.4	3.4	st
26	1.4+4.8=6.2	2.4	3.4	st
27	2.0+4.0=6.0	2.3	2.0	sm
28	2.0+4.0=6.0	2.3	2.0	sm
29	2.7+3.0=5.7	2.2	1.1	m
30	2.7+3.0=5.7	2.2	1.1	m
31	1.7+3.7=5.4	2.1	2.1	sm
32	1.7+3.7=5.4	2.1	2.1	sm
33	2.0+2.7=4.7	1.8	1.3	m
34	2.0+2.7=4.7	1.8	1.3	m
35	1.4+3.2=4.6	1.8	2.2	sm
36	1.4+3.2=4.6	1.8	2.2	sm
37	0.7+2.6=3.3	1.3	3.7	st
38	0.7+2.6=3.3	1.3	3.7	st
39	1.0+1.8=2.8	1.1	1.8	sm
40	1.0+1.8=2.8	1.1	1.8	sm
41	0.9+1.8=2.7	1.1	2.0	sm
42	0.9+1.8=2.7	1.1	2.0	sm

Table 28. continued

43	0.5+1.4=1.9	0.7	2.8	sm
44	0.5+1.4=1.9	0.7	2.8	sm

Table 29. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe hennisii*, 2n=42

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.5+3.5=5.0	3.1	2.3	sm
2	1.5+3.5=5.0	3.1	2.3	sm
3	1.7+3.1=4.8	3.0	1.8	sm
4	1.7+3.1=4.8	3.0	1.8	sm
5	1.7+2.9=4.6	2.8	1.7	m
6	1.7+2.9=4.6	2.8	1.7	m
7	1.4+3.1=4.5	2.8	2.2	sm
8	1.4+3.1=4.5	2.8	2.2	sm
9	1.3+3.1=4.5	2.8	2.4	sm
10	1.3+3.1=4.5	2.8	2.4	sm
11	2.1+2.3=4.4	2.7	1.0	m
12	2.1+2.3=4.4	2.7	1.0	m
13	1.5+2.9=4.4	2.7	1.9	sm
14	1.5+2.9=4.4	2.7	1.9	sm
15	1.4+3.0=4.4	2.7	2.1	sm
16	1.4+3.0=4.4	2.7	2.1	sm
17	1.4+3.0=4.4	2.7	2.1	sm
18	1.4+3.0=4.4	2.7	2.1	sm
19	1.4+3.0=4.4	2.7	2.1	sm
20	1.4+3.0=4.4	2.7	2.1	sm
21	1.2+3.1=4.3	2.7	2.5	sm
22	1.2+3.1=4.3	2.7	2.5	sm
23	1.1+3.2=4.3	2.7	2.9	sm
24	1.1+3.2=4.3	2.7	2.9	sm
25	1.9+2.0=3.9	2.4	1.0	m
26	1.9+2.0=3.9	2.4	1.0	m
27	1.2+2.3=3.5	2.2	1.9	sm
28	1.2+2.3=3.5	2.2	1.9	sm
29	1.2+2.3=3.5	2.2	1.9	sm
30	1.2+2.3=3.5	2.2	1.9	sm
31	1.3+2.2=3.5	2.2	1.6	m
32	1.3+2.2=3.5	2.2	1.6	m
33	1.5+2.0=3.5	2.2	1.3	m
34	1.5+2.0=3.5	2.2	1.3	m
35	1.0+2.0=3.0	1.9	2.0	sm
36	1.0+2.0=3.0	1.9	2.0	sm
37	0.7+1.4=2.1	1.3	2.0	sm
38	0.7+1.4=2.1	1.3	2.0	sm
39	0.7+1.3=2.0	1.2	1.8	sm
40	0.7+1.3=2.0	1.2	1.8	sm
41	0.3+1.7=2.0	1.2	5.6	st
42	0.3+1.7=2.0	1.2	5.6	st

Table 30. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe hirsuta*, 2n=46

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.2+4.5=6.7	2.9	2.0	sm
2	2.2+4.5=6.7	2.9	2.0	sm
3	1.9+4.7=6.6	2.9	2.4	sm
4	1.9+4.7=6.6	2.9	2.4	sm
5	2.2+4.2=6.4	2.8	1.9	sm
6	2.2+4.2=6.4	2.8	1.9	sm
7	2.8+3.3=6.1	2.7	1.1	m
8	2.8+3.3=6.1	2.7	1.1	m
9	2.1+4.0=6.1	2.7	1.9	sm
10	2.1+4.0=6.1	2.7	1.9	sm
11	1.7+4.3=6.0	2.6	2.5	sm
12	1.7+4.3=6.0	2.6	2.5	sm
13	1.2+4.8=6.0	2.6	4.0	st
14	1.2+4.8=6.0	2.6	4.0	st
15	1.4+4.3=5.7	2.5	3.0	sm
16	1.4+4.3=5.7	2.5	3.0	sm
17	1.9+3.7=5.6	2.4	1.9	sm
18	1.9+3.7=5.6	2.4	1.9	sm
19	1.5+4.0=5.5	2.4	2.6	sm
20	1.5+4.0=5.5	2.4	2.6	sm
21	2.0+3.5=5.5	2.4	1.7	m
22	2.0+3.5=5.5	2.4	1.7	m
23	2.5+2.8=5.3	2.3	1.1	m
24	2.5+2.8=5.3	2.3	1.1	m
25	2.3+2.7=5.0	2.2	1.1	m
26	2.3+2.7=5.0	2.2	1.1	m
27	2.0+3.0=5.0	2.2	1.5	m
28	2.0+3.0=5.0	2.2	1.5	m
29	1.7+3.3=5.0	2.2	1.9	sm
30	1.7+3.3=5.0	2.2	1.9	sm
31	1.7+2.7=4.4	1.9	1.5	m
32	1.7+2.7=4.4	1.9	1.5	m
33	1.3+3.0=4.3	1.9	2.3	sm
34	1.3+3.0=4.3	1.9	2.3	sm
35	1.0+3.0=4.0	1.7	3.0	sm
36	1.0+3.0=4.0	1.7	3.0	sm
37	1.2+2.7=3.9	1.7	2.2	sm
38	1.2+2.7=3.9	1.7	2.2	sm
39	1.1+2.2=3.3	1.4	2.0	sm
40	1.1+2.2=3.3	1.4	2.0	sm
41	1.0+2.0=3.0	1.3	2.0	sm
42	1.0+2.0=3.0	1.3	2.0	sm

Table 30. continued

43	1.1+1.8=2.9	1.3	1.6	m
44	1.1+1.8=2.9	1.3	1.6	m
45	1.3+1.3=2.6	1.1	1.0	m
46	1.3+1.3=2.6	1.1	1.0	m

Table 31. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe rosea*, 2n=44

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	2.5+2.7=5.2	3.0	1.0	m
2	2.5+2.7=5.2	3.0	1.0	m
3	2.5+2.7=5.2	3.0	1.0	m
4	2.5+2.7=5.2	3.0	1.0	m
5	2.0+2.7=4.7	2.7	1.3	m
6	2.0+2.7=4.7	2.7	1.3	m
7	1.3+3.3=4.6	2.6	2.5	sm
8	1.3+3.3=4.6	2.6	2.5	sm
9	2.0+2.5=4.5	2.6	1.2	m
10	2.0+2.5=4.5	2.6	1.2	m
11	1.8+2.7=4.5	2.6	1.5	m
12	1.8+2.7=4.5	2.6	1.5	m
13	2.2+2.3=4.5	2.6	1.0	m
14	2.2+2.3=4.5	2.6	1.0	m
15	2.0+2.3=4.3	2.5	1.1	m
16	2.0+2.3=4.3	2.5	1.1	m
17	2.0+2.3=4.3	2.5	1.1	m
18	2.0+2.3=4.3	2.5	1.1	m
19	1.0+3.3=4.3	2.5	3.3	st
20	1.0+3.3=4.3	2.5	3.3	st
21	1.8+2.3=4.1	2.4	1.2	m
22	1.8+2.3=4.1	2.4	1.2	m
23	1.2+2.8=4.0	2.3	2.3	sm
24	1.2+2.8=4.0	2.3	2.3	sm
25	1.9+2.0=3.9	2.2	1.0	m
26	1.9+2.0=3.9	2.2	1.0	m
27	1.8+2.0=3.8	2.2	1.0	m
28	1.8+2.0=3.8	2.2	1.0	m
29	1.8+2.0=3.8	2.2	1.0	m
30	1.8+2.0=3.8	2.2	1.0	m
31	1.5+2.1=3.6	2.1	1.4	m
32	1.5+2.1=3.6	2.1	1.4	m
33	1.4+2.2=3.6	2.1	1.5	m
34	1.4+2.2=3.6	2.1	1.5	m
35	1.0+2.4=3.4	2.0	2.4	sm
36	1.0+2.4=3.4	2.0	2.4	sm
37	1.2+1.8=3.0	1.7	1.5	m
38	1.2+1.7=2.9	1.7	1.4	m
39	0.9+2.0=2.9	1.7	2.2	sm
40	0.9+2.0=2.9	1.7	2.2	sm
41	1.0+1.5=2.5	1.4	1.5	m
42	1.0+1.5=2.5	1.4	1.5	m
43	1.0+1.3=2.3	1.3	1.3	m
44	0.9+1.2=2.1	1.2	1.3	m

Table 32. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe rubens*, 2n=42

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.7+4.0=5.7	3.0	2.3	sm
2	1.7+4.0=5.7	3.0	2.3	sm
3	1.8+3.7=5.5	2.9	2.0	sm
4	1.8+3.7=5.5	2.9	2.0	sm
5	1.7+3.8=5.5	2.9	2.2	sm
6	1.7+3.8=5.5	2.9	2.2	sm
7	1.7+3.7=5.4	2.8	2.1	sm
8	1.7+3.7=5.4	2.8	2.1	sm
9	1.9+3.5=5.4	2.8	1.8	sm
10	1.9+3.5=5.4	2.8	1.8	sm
11	2.3+3.1=5.4	2.8	1.3	m
12	2.3+3.1=5.4	2.8	1.3	m
13	1.7+3.6=5.3	2.8	2.1	sm
14	1.7+3.6=5.3	2.8	2.1	sm
15	1.7+3.6=5.3	2.8	2.1	sm
16	1.7+3.6=5.3	2.8	2.1	sm
17	1.7+3.5=5.2	2.7	2.0	sm
18	1.7+3.5=5.2	2.7	2.0	sm
19	2.1+2.8=4.9	2.6	1.3	m
20	2.1+2.8=4.9	2.6	1.3	m
21	1.6+3.3=4.9	2.6	2.0	sm
22	1.6+3.3=4.9	2.6	2.0	sm
23	1.6+3.2=4.8	2.5	2.0	sm
24	1.6+3.2=4.8	2.5	2.0	sm
25	1.3+3.2=4.5	2.4	2.4	sm
26	1.3+3.2=4.5	2.4	2.4	sm
27	1.7+2.8=4.5	2.4	1.6	m
28	1.7+2.8=4.5	2.4	1.6	m
29	1.3+2.8=4.1	2.1	2.1	sm
30	1.3+2.8=4.1	2.1	2.1	sm
31	1.3+2.7=4.0	2.1	2.0	sm
32	1.3+2.7=4.0	2.1	2.0	sm
33	1.5+2.5=4.0	2.1	1.6	m
34	1.5+2.3=3.8	2.0	1.5	m
35	1.4+2.4=3.8	2.0	1.7	m
36	1.3+2.2=3.5	1.8	1.6	m
37	1.1+1.7=2.8	1.5	1.5	m
38	1.1+1.7=2.8	1.5	1.5	m
39	1.0+1.5=2.5	1.3	1.5	m
40	0.9+1.5=2.4	1.3	1.6	m
41	0.3+2.0=2.3	1.2	6.6	st
42	0.3+2.0=2.3	1.2	6.6	st

Table 33. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe succedanea*, 2n=44

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.7+3.7=5.4	3.3	2.1	sm
2	1.7+3.7=5.4	3.3	2.1	sm
3	2.2+3.0=5.2	3.2	1.3	m
4	2.2+2.8=5.0	3.1	1.2	m
5	1.3+3.7=5.0	3.1	2.8	sm
6	1.3+3.7=5.0	3.1	2.8	sm
7	1.0+3.8=4.8	3.0	3.8	st
8	1.0+3.8=4.8	3.0	3.8	st
9	1.5+3.2=4.7	2.9	2.1	sm
10	1.5+3.2=4.7	2.9	2.1	sm
11	1.2+3.3=4.5	2.8	2.7	sm
12	1.2+3.3=4.5	2.8	2.7	sm
13	2.2+2.3=4.5	2.8	1.0	m
14	2.2+2.3=4.5	2.8	1.0	m
15	1.3+3.0=4.3	2.7	2.3	sm
16	1.3+3.0=4.3	2.7	2.3	sm
17	1.4+2.7=4.1	2.5	1.9	sm
18	1.4+2.7=4.1	2.5	1.9	sm
19	1.0+3.1=4.1	2.5	3.1	st
20	1.0+3.1=4.1	2.5	3.1	st
21	1.2+2.6=3.8	2.4	2.1	sm
22	1.2+2.6=3.8	2.4	2.1	sm
23	1.5+0.8+1.3=3.7*	2.2	1.4	m
24	1.5+0.8+1.3=3.7*	2.2	1.4	m
25	1.5+1.8=3.3	2.0	1.2	m
26	1.5+1.8=3.3	2.0	1.2	m
27	1.1+2.2=3.3	2.0	2.0	sm
28	1.0+2.2=3.2	2.0	2.2	sm
29	1.0+1.9=2.9	1.8	1.9	sm
30	1.0+1.9=2.9	1.8	1.9	sm
31	0.6+2.3=2.9	1.8	3.8	st
32	0.6+2.3=2.9	1.8	3.8	st
33	0.7+2.0=2.7	1.7	2.8	sm
34	0.7+2.0=2.7	1.7	2.8	sm
35	1.3+1.4=2.7	1.7	1.0	m
36	1.3+1.4=2.7	1.7	1.0	m
37	1.0+1.7=2.7	1.7	1.7	m
38	1.0+1.7=2.7	1.7	1.7	m
39	0.8+1.5=2.3	1.4	1.8	sm
40	0.8+1.5=2.3	1.4	1.8	sm
41	0.9+1.2=2.1	1.3	1.3	m
42	0.9+1.2=2.1	1.3	1.3	m

Table 33. continued

43	0.8+1.3=2.1	1.3	1.6	m
44	0.8+1.3=2.1	1.3	1.6	m

* : Chromosome with secondary constriction

Table 34. Measurements of somatic chromosomes at mitotic metaphase in *Calanthe vestita*, 2n=42

Chromosome	Length(μm)	Relative length	Arm ratio	Form
1	1.5+4.2=5.7	3.0	2.8	sm
2	1.5+4.2=5.7	3.0	2.8	sm
3	1.8+3.7=5.5	2.9	2.0	sm
4	1.8+3.7=5.5	2.9	2.0	sm
5	2.0+3.3=5.3	2.8	1.6	m
6	2.0+3.3=5.3	2.8	1.6	m
7	1.3+4.0=5.3	2.8	3.0	sm
8	1.3+4.0=5.3	2.8	3.0	sm
9	1.6+3.7=5.3	2.8	2.3	sm
10	1.6+3.7=5.3	2.8	2.3	sm
11	2.5+2.7=5.2	2.8	1.0	m
12	2.5+2.7=5.2	2.8	1.0	m
13	1.7+3.4=5.1	2.7	2.0	sm
14	1.7+3.4=5.1	2.7	2.0	sm
15	1.6+3.5=5.1	2.7	2.1	sm
16	1.6+3.5=5.1	2.7	2.1	sm
17	1.3+3.7=5.0	2.7	2.8	sm
18	1.3+3.7=5.0	2.7	2.8	sm
19	2.0+2.8=4.8	2.6	1.4	m
20	2.0+2.8=4.8	2.6	1.4	m
21	1.5+3.3=4.8	2.6	2.2	sm
22	1.5+3.3=4.8	2.6	2.2	sm
23	1.3+3.3=4.6	2.5	2.5	sm
24	1.3+3.3=4.6	2.5	2.5	sm
25	1.3+3.2=4.5	2.4	2.4	sm
26	1.3+3.2=4.5	2.4	2.4	sm
27	1.7+2.8=4.5	2.4	1.6	m
28	1.7+2.8=4.5	2.4	1.6	m
29	2.0+2.3=4.3	2.3	1.1	m
30	2.0+2.3=4.3	2.3	1.1	m
31	1.5+2.8=4.3	2.3	1.8	sm
32	1.3+2.8=4.1	2.2	2.1	sm
33	1.3+2.7=4.0	2.1	2.0	sm
34	1.3+2.7=4.0	2.1	2.0	sm
35	1.2+2.5=3.7	2.0	2.0	sm
36	1.2+2.5=3.7	2.0	2.0	sm
37	0.8+1.6=2.4	1.3	2.0	sm
38	0.8+1.6=2.4	1.3	2.0	sm
39	0.8+1.4=2.2	1.2	1.7	m
40	0.8+1.4=2.2	1.2	1.7	m
41	0.3+1.8=2.1	1.1	6.0	st
42	0.3+1.8=2.1	1.1	6.0	st