鹿児島県屋久島産高等植物の細胞分類学的研究 . 矮小化した分類群

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Nobuko Yamamoto[1], Hiroshi Ikeda[2] and Takuji Hoshino[1] : **Cytotaxonomical studies of flowering plants in Yakushima Island, Kagoshima Prefecture, Japan Part I : dwarf taxa**

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Abstract

Chromosome counts of 33 taxa of dwarf plants collected from Yakushima Island are reported. Chromosome counts for the following 23 taxa are published for the first time : *Coptis ramosa* (2n=18), *Sarothra laxa* f. *hananoegoensis* (2n=16), *Astilbe glaberrima* var. *saxatilis* (2n=14), *Parnassia palustris* var. *yakusimensis* (2n=18), *Saxifraga fortunei* var. *minima* (2n=22), *Viola boissieuana* var. *pseudoselkirki* (2n=24), *V. verecunda* var. *yakusimana* (2n=24), *Circaea alpina* f. *minima* (2n=22), *Angelica longiradiata* var. *yakushimensis* (2n=22), *Tripterospermum japonicum* var. *tenue* (2n=46), *Galium pogonanthum* var. *yakumontanum* (2n=22), *Mitchella undulata* var. *minor* (2n=22), *Neanotis hirsuta* var. *yakusimensis* (2n=24), *Clinopodium multicaule* var. *yakusimense* (2n=20), *Scutellaria kuromidakensis* (2n=26), *Melampyrum laxum* var. *yakusimense* (2n=18), *Cirsium yakushimense* (2n=68), *Heloniopsis breviscapa* var. *yakusimensis* (2n=34), *Metanarthecium luteo-viride* f. *yakusimense* (2n=52+1 B), *Smilax biflora* var. *biflora* (2n=30), *Tofieldia yoshiiana* (2n=30), *Luzula campestris* var. *yakusimensis* (2n=12), *Pseudosasa owatarii* (2n=48). Chromosome counts for a further ten taxa agree with those already published : *Ranunculus yakushimensis* (2n=14), *Hypericum kiusianum* var. *yakusimense* (2n=32), *Mitella doiana* (2n=28), *Fragaria nipponica* var. *yakusimensis* (2n=14), *Sanicula lamelligera* (2n=16), *Lysimachia japonica* var. *minutissima* (2n=20), *Plantago asiatica* var. *yakusimensis* (2n=24), *Cacalia yakusimensis* (2n=60), *Solidago minutissima* (2n=18), *Paris tetraphylla* var. *yakusimensis* (2n=10). No differences were found when comparing these chromosome numbers of dwarf plants with those of closely related non-dwarf taxa.

Key words : chromosome number, cytotaxonomy, dwarf taxa, endemism, Yakushima Island.

Yakushima Island is located about 60 km to the south of the mainland of Kyushu. Masamune (1934) enumerated 861 species of vascular plants in his floristic study of Yakushima Island. Flora of Yakushima Island is characterized by high rate of endemism, and Yahara et al. (1987) listed 72 endemic taxa. Another characteristic of the flora is that many dwarf forms grow on the upper part of the island, and Sugimoto (1957) listed 101 taxa on the island which exhibited dwarfisms. Such endemic or dwarf taxa might be differentiated on the island as a result of restriction of gene flow by isolation from the mainland.

Cytological variation, such as polyploidy or aneuploidy, is one cause of speciation in higher plants (Grant 1981). Therefore, it is possible that cytological variations might play an important role for differentiation on endemic or dwarf taxa in Yakushima Island. Although cytological studies on plants in Yakushima Island have been undertaken for several genera, such as *Mitella* (Wakabayashi 1973 a), *Oxalis* (Terao 1979), *Solidago* (Huziwara 1965) and *Cacalia* (Koyama 1968), there are not enough data to reveal the cytological characteristics of the plants of Yakushima Island.

This is a series of papers reporting cytological characteristics of flowering plants found on Yakushima Island. This first part is concerned with the chromosome numbers for the dwarf taxa.

Materials and methods

Thirty three taxa in 32 genera and 17 families

were collected from across Yakushima Island (Table 1). Root tips or shoot apices were pretreated with 2 mM 8-hydroxyquinoline solution for 4–5 hours at room temperature, or one hour at room temperature and then kept 15 hours at 4℃. Following this they were fixed with Newcomer's fluid (Sharma and Sharma 1980). Thick materials were hydrated by soaking in a 1 N HCl solution for ten minutes at 60℃, before transfer into Schiff's reagent at room temperature for one hour. Materials were macerated with a mixture of 2% cellulase and 2% pectinase for 0.5–1 hour at 37℃, and then washed in distilled water. Slender materials were hydrated and macerated with 1 N HCl for ten minutes at 60℃ and washed in distilled water. After maceration, the meristematic tissues were placed on slide glasses and squashed with an 2% lactopropionic orcein. Chromosomes were observed using a Nikon Eclipse E-600 microscope.

Voucher specimens are deposited in the Herbarium of Okayama University of Science (OKAY).

Results and discussion

Chromosome numbers of 33 taxa in 32 genera in 17 families of flowering plants on Yakushima Island were counted and presented in Appendix. The chromosomes observed in a somatic cell of each taxon are shown in Figs. 1–4. Observed taxa with their chromosome numbers and notes are described below. Families are ordered following Melchior (1964).

Ranunculaceae

1. *Coptis ramosa* (Makino) Tamura : (Fig. 1 A).

Coptis ramosa is endemic to Yakushima Island and grows on mossy tree trunk or rocks under *Cryptomeria japonica* forest. The chromosome number for this species, 2n=18, is reported here for the first time. The same chromosome number, 2n=18, has been reported for other Japanese species of *Coptis* : *C*. *japonica* (Thunb.) Makino (Nakajima 1933 ; Matsuura and Suto 1935), *C*. *japonica* var. *dissecta* (Yatabe) Nakai, *C*. *trifolia* (L.) Solisb. and *C*. *quinquefolia* Miq. (Kurita 1956).

2. *Ranunculus yakushimensis* (Makino) Masam. : (Fig. 1 B).

Ranunculus yakushimensis is endemic to Yakushima Island and grows in wet places at higher elevations. The chromosome number observed for this species, 2n=14, is consistent with the count by Kurita (1955). Kurita (1955) reported that there was no karyological difference between *R*. *yakushimensis* and *R*. *japonicus* Thunb.

Guttiferae

3. *Hypericum kiusianum* Koidz. var. *yakusimense* (Koidz.) T.Kato : (Fig. 1 C).

Hypericum kiusianum var. *yakusimense* is endemic to Yakushima Island and grows on wet places or moist banks besides forestry trails at higher elevations. It was originally described at a specific rank (Koidzumi 1929), but Kimura (1951) reduced it to a variety of *H. pseudopetiolatum* R. Keller.

Kato (1985, 1986, 1987) made a series of taxonomical studies of *H*. *pseudopetiolatum* complex. In 1987 he reported the chromosome numbers of *H*. *kiusianum* with var. *yakusimense* as 2n=32, and our study confirms this report. Kogi (1984) reported counts of 2n=16, 18, 24 and 32 chromosomes from eight Japanese taxa of *Hypericum*, and mentioned that the taxa with 2 n=16, 24 and 32 were diploid, triploid, and tetraploid, respectively. According to our result and those of previous reports, *H*. *kiusianum* var. *yakusimense* is probably a tetraploid with basic chromosome number x=8.

4. *Sarothra laxa* (Blume) Y.Kimura f. *hananoegoensis* (Masam.) Y.Kimura : (Fig. 1 D).

Sarothra laxa f. *hananoegoensis* is endemic to Yakushima Island and grows on moors at higher elevations. Chromosome number for this form, 2 n=16, was counted for the first time, and is the first reported for the genus.

The genus *Sarothra* is closely related to *Hypericum* (Kimura 1951). *Sarothra laxa* f. *hananoegoensis* might be diploid, because the basic chromosome number of *Hypericum* was reported x=8 (Kogi 1984).

Saxifragaceae

5. *Astilbe glaberrima* Nakai var. *saxatilis* (Nakai) H.Ohba : (Fig. 1 E).

Astilbe glaberrima was described from a speci-

Table 1. Localities (all in Yakushima Island) and voucher specimens of materials examined (all vouchers at OKAY)

Family	Taxon	Locality and voucher specimen
Ranunculaceae	*Coptis ramosa*	Yodogawa Tozan–guchi –– Yodogawa hut, 1,380 m alt. (Ikeda et al. 04042305)
	Ranunculus yakushimensis	Hanano–ego Moor –– Nageshi–daira Col, 1,660 m alt. (Ikeda & Yamamoto 05060921)
Guttiferae	*Hypericum kiusianum* var. *yakusimense*	Near Hanano–ego Moor, 1,630 m alt. (Yamamoto 06012003)
	Sarothra laxa f. *hananoegoensis*	Near Yodogawa Tozan–guchi, 1,360 m alt. (Ikeda et al. 05091902)
Saxifragaceae	*Astilbe glaberrima* var. *saxatilis*	Hanano–ego Moor –– Nageshi–daira Col, 1,690 m alt. (Yamamoto 06012011)
	Mitella doiana	Near Arakawa Dam, 610 m alt. (Yamamoto 06012012)
	Parnassia palustris var. *yakusimensis*	Near Shikano–sawa hut, 1,560 m alt. (Ikeda et al. 05092199)
	Saxifraga fortunei var. *minima*	Near Shikano–sawa hut, 1,560 m alt. (Ikeda et al. 05092101)
Rosaceae	*Fragaria nipponica* var. *yakusimensis*	Hanano–ego Moor –– Nageshi–daira Col, 1,660 m alt. (Yamamoto 06012010)
Violaceae	*Viola boissieuana* var. *pseudoselkirkii*	Near Yodogawa Tozan–guchi, 1,320 m alt. (Ikeda et al. 04042224)
	V. verecunda var. *yakusimana*	Near Hanano–ego Moor, 1,650 m alt. (Ikeda & Yamamoto 05060901)
Onagraceae	*Circaea alpina* f. *minima*	Near the summit of Mt. Miyanoura, 1,920 m alt. (Ikeda et al. 05092203)
Umbelliferae	*Angelica longiradiata* var. *yakushimensis*	Shikano–sawa hut –– Mt. Nagata, 1,790 m alt. (Ikeda et al. 05092114)
	Sanicula lamelligera	Near Arakawa Dam, 610 m alt. (Ikeda et al. 04042210)
Primulaceae	*Lysimachia japonica* var. *minutissima*	Hanano–ego Moor –– Nageshi–daira Col, 1,670 m alt. (Ikeda et al. 04042899)
Gentianaceae	*Tripterospermum japonicum* var. *tenue*	Shikano–sawa hut –– Mt. Nagata, 1,790 m alt. (Ikeda et al. 05092111)
Rubiaceae	*Galium pogonanthum* var. *yakumontanum*	Hanano–ego Moor –– Nageishi–daira Col, 1,680 m alt. (Ikeda & Yamamoto 05060903)
	Mitchella undulata var. *minor*	Shiratani–unsuikyo Gorge, 850 m alt. (Ikeda et al. 04102315)
	Neanotis hirsuta var. *yakusimensis*	Yodogawa, near Kigen–sugi (an old *Cryptomeria*), 1,220 m alt. (Ikeda et al. 05091906)
Labiatae	*Clinopodium multicaule* var. *yakusimense*	Yodogawa hut –– Hanano–ego Moor, 1,570 m alt. (Yamamoto 06012004)
	Scutellaria kuromidakensis	Yodogawa hut –– Hanano–ego Moor, 1,370––1,620 m alt. (Ikeda & Yamamoto 05060823)
Scrophulariaceae	*Melampyrum laxum* var. *yakusimense*	Yodogawa hut –– Hanano–ego Moor, 1,620 m alt. (Ikeda & Yamamoto 05060807)
Plantaginaceae	*Plantago asiatica* var. *yakusimensis*	At the top of Mt. Miyanoura, 1,935 m alt. (Yamamoto 06012009)
Compositae	*Cacalia yakusimensis*	Nageshi–daira Col –– summit of Mt. Miyanoura, 1,720 m alt. (Ikeda et al. 04102308)
	Cirsium yakusimense	Yodogawa Tozan–guchi, 1,360 m alt. (Ikeda et al. 05091901)
	Solidago minutissima	Near Nageshi–daira Col, 1,700 m alt. (Yamamoto 06012001)
Liliaceae	*Heloniopsis breviscapa* var. *yakusimensis*	Nageshi–daira Col –– summit of Mt. Miyanoura, 1,710 m alt. (Yamamoto 06012005)
	Metanarthecium luteo-viride f. *yakusimense*	Near Shikano–sawa hut, 1,560 m alt. (Yamamoto 05092100)
	Paris tetraphylla var. *yakusimensis*	Hanano–ego Moor –– Nageshi–daira Col, 1,680 m alt. (Ikeda & Yamamoto 05060911)
	Smilax biflora var. *biflora*	Hanano–ego Moor –– Nageshi–daira Col, 1,670 m alt. (Ikeda & Yamamoto 05060914)
	Tofieldia yoshiiana	Near Shikano–sawa hut, 1,560 m alt. (Ikeda et al. 05092102)
Juncaceae	*Luzula campestris* var. *yakusimensis*	Hanano–ego Moor –– Nageshi–daira Col, 1,660 m alt. (Ikeda & Yamamoto 05060906)
Gramineae	*Pseudosasa owatarii*	Mt. Nagata –– Mt. Miyanoura, 1,810 m alt. (Ikeda et al. 05092202)

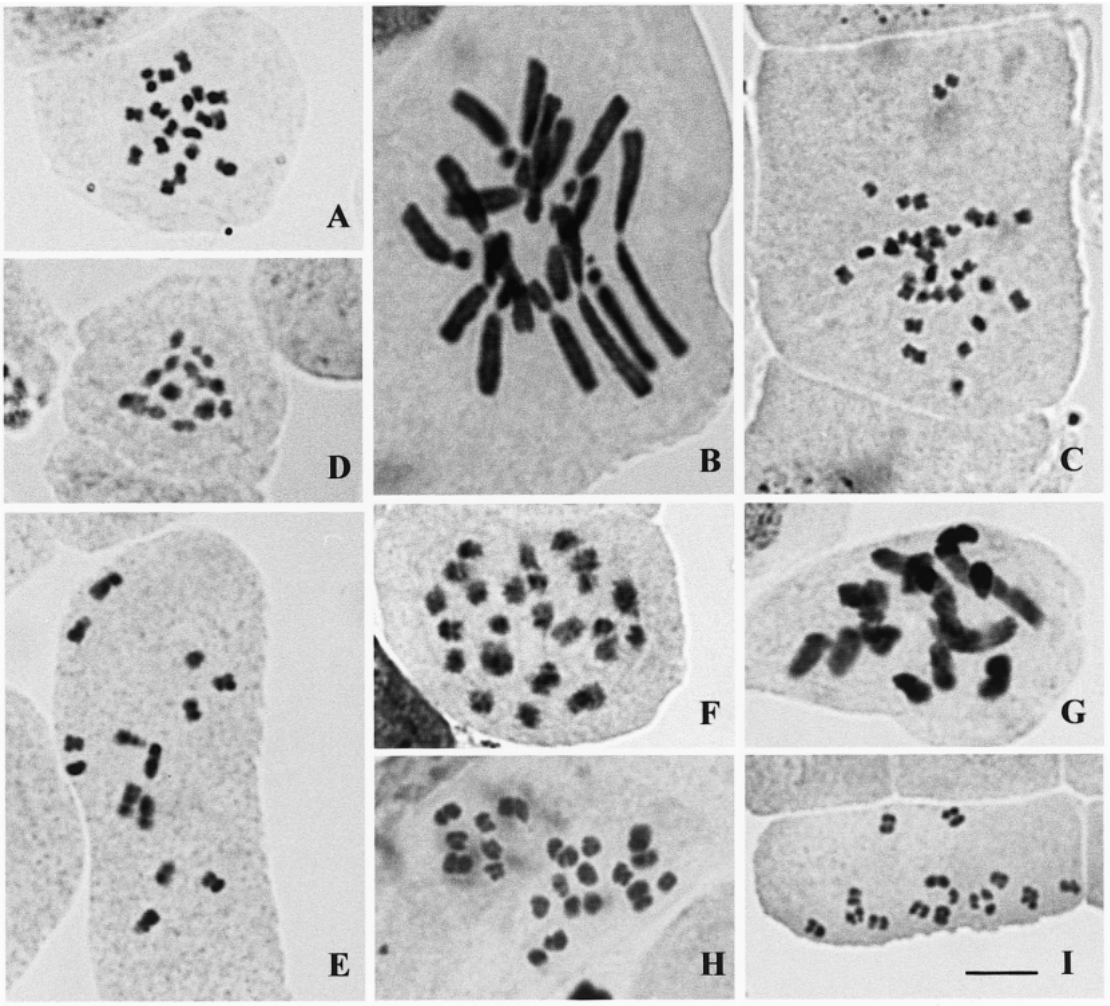

Fig. 1. Mitotic metaphase chromosomes of dwarf plants in Yakushima Island (1). A : *Coptis ramosa* (2n=18). B : *Ranunculus yakushimensis* (2n=14). C : *Hypericum kiusianum* var. *yakusimense* (2n=32). D : *Sarothra laxa* f. *hananoegoensis* (2n=16). E : *Astilbe glaberrima* var. *saxatilis* (2n=14). F : *Mitella doiana* (2n=28). G : *Parnassia palustris* var. *yakusimensis* (2n=18). H : *Saxifraga fortunei* var. *minima* (2n=22). I : *Fragaria nipponica* var. *yakusimensis* (2n=14). Bar =5 μm.

men collected in Yakushima Island by Nakai (1922). He recognized two types in this species, a larger one ("lusus *terrestris*") and a smaller one ("lusus *saxatilis*"). We examined the small-sized individuals (var. *saxatilis*) on wet mossy rocks at 1,690 m above sea level, and report a chromosome number of 2n=14, the first count for this species. Nishikawa (1996) reported the same chromosome number of 2n=14 for the allied species, *A. thunbergii* (Siebold et Zucc.) Miq. var. *congesta* H.Boissieu.

6. *Mitella doiana* Ohwi : (Fig. 1 F).

Mitella doiana is endemic to Yakushima Island and grows moist places at the edges of broad-leaved forest. Wakabayashi (1973 a) revised the taxonomy of the genus *Mitella* and found a polyploid series of 2n=14, 28 and 42. He reported the chromosome number of *M. doiana* as 2n=28 and the present study confirms this. Wakabayashi (1973 a) discussed *Mitella* in Japan and speculated that *M. doiana* was close related to *M. furusei* Ohwi, *M. leiopetala* Ohwi et Okuyama (=*M. furusei* var. *subramosa* Wakab.), *M. makinoi* H.Hara and *M. stylosa* H.Boissieu which all possessed 2n=28 chromosomes.

7. *Parnassia palustris* L. var. *yakusimensis*

(Masam.) H.Ohba : (Fig. 1 G).

Parnassia palustris var. *yakusimensis* is endemic to Yakushima Island and grows on wet places at higher elevations. The chromosome number for this taxon, 2n=18, has been counted for the first time, and agrees with the number for the typical variety that was reported by Nishikawa (1985).

8. *Saxifraga fortunei* Hook.f. var. *minima* Nakai : (Fig. 1 H).

Saxifraga fortunei var. *minima* is endemic to Yakushima Island and grows on wet rocks at higher elevations. The chromosome number for this taxon, 2n=22, is reported for the first time, and agrees with the chromosome numbers for other infraspecific taxa : *S. fortunei* varr. *incisolobata* (Engl. et Irmsch.) Nakai and *obtusocuneata* (Makino) Nakai (Wakabayashi 1973 b).

Rosaceae

9. *Fragaria nipponica* Makino var. *yakusimensis* (Masam.) Masam. : (Fig. 1 I).

Fragaria nipponica var. *yakusimensis* is endemic to Yakushima Island and grows on grassy places at higher elevations. The chromosome number for this taxon, 2n=14, is consistent with the previous report by Iwatsubo and Naruhashi (1989). Iwatsubo and Naruhashi (1989) examined chromosome numbers of three species of Japanese *Fragaria*, and found the same chromosome number of 2n=14.

Violaceae

10. *Viola boissieuana* Makino var. *pseudoselkirki* (Nakai) Yahara : (Fig. 2 A).

Viola boissieuana var. *pseudoselkirki* is endemic to Yakushima Island and grows on moist banks along forestry trails between the upper montane zone and higher elevations. The chromosome number of this taxon, 2n=24, has been counted for the first time, and is the same as that of the typical variety reported by Miyaji (1929).

11. *Viola verecunda* A. Gray var. *yakusimana* (Nakai) Ohwi : (Fig. 2 B).

Viola verecunda var. *yakusimana* is endemic to Yakushima Island and grows on moors at higher elevations. The chromosome number for this taxon, 2n=24, was counted for the first time, and is the same as that for the typical variety reported by Miyaji (1929).

Onagraceae

12. *Circaea alpina* L. f. *minima* Mitsuta (nom. nud.) : (Fig. 2 C).

Circaea alpina f. *minima* is a dwarf form of *C. alpina* and grows on moist places near the summits of mountains. Mitsuta gave the name without description (Mitsuta and Nagamasu 1984), and so it awaits formal publication. Tanaka et al. (1988) reported the chromosome number of *C. alpina* as 2n=22, the same number as the present study.

Umbelliferae

13. *Angelica longiradiata* (Maxim.) Kitag. var. *yakushimensis* (Masam. et Ohwi) Kitag. : (Fig. 2 D).

Angelica longiradiata var. *yakushimensis* is endemic to Yakushima Island and grows on sunny wet mossy rocks. The chromosome number for this taxon, 2n=22, was counted for the first time, and is the same as that for the typical variety reported by Okazaki and Sakata (1995).

14. *Sanicula lamelligera* Hance : (Fig. 2 E).

Sanicula lamelligera is distributed in Yakushima Island and the Ryukyu Islands, central to south China and Taiwan. In Yakushima Island this species grows on moist ground under coniferous forest in the montane zone. In the present study the chromosome number for this species was counted as 2n=16. Chuang et al. (1963) reported the gametophytic chromosome number for this species as n=8, which is the same as the somatic chromosome number reported here.

Primulaceae

15. *Lysimachia japonica* Thunb. var. *minutissima* Masam. : (Fig. 2 F).

Lysimachia japonica var. *minutissima* is endemic to Yakushima Island and grows on moist banks beside forestry trails at higher elevations. The chromosome number for this taxon, 2n=20, is consistent with the earlier count by Kurosawa and Hara (1960). Different chromosome numbers have been reported for *L. japonica* : 2n=18 for

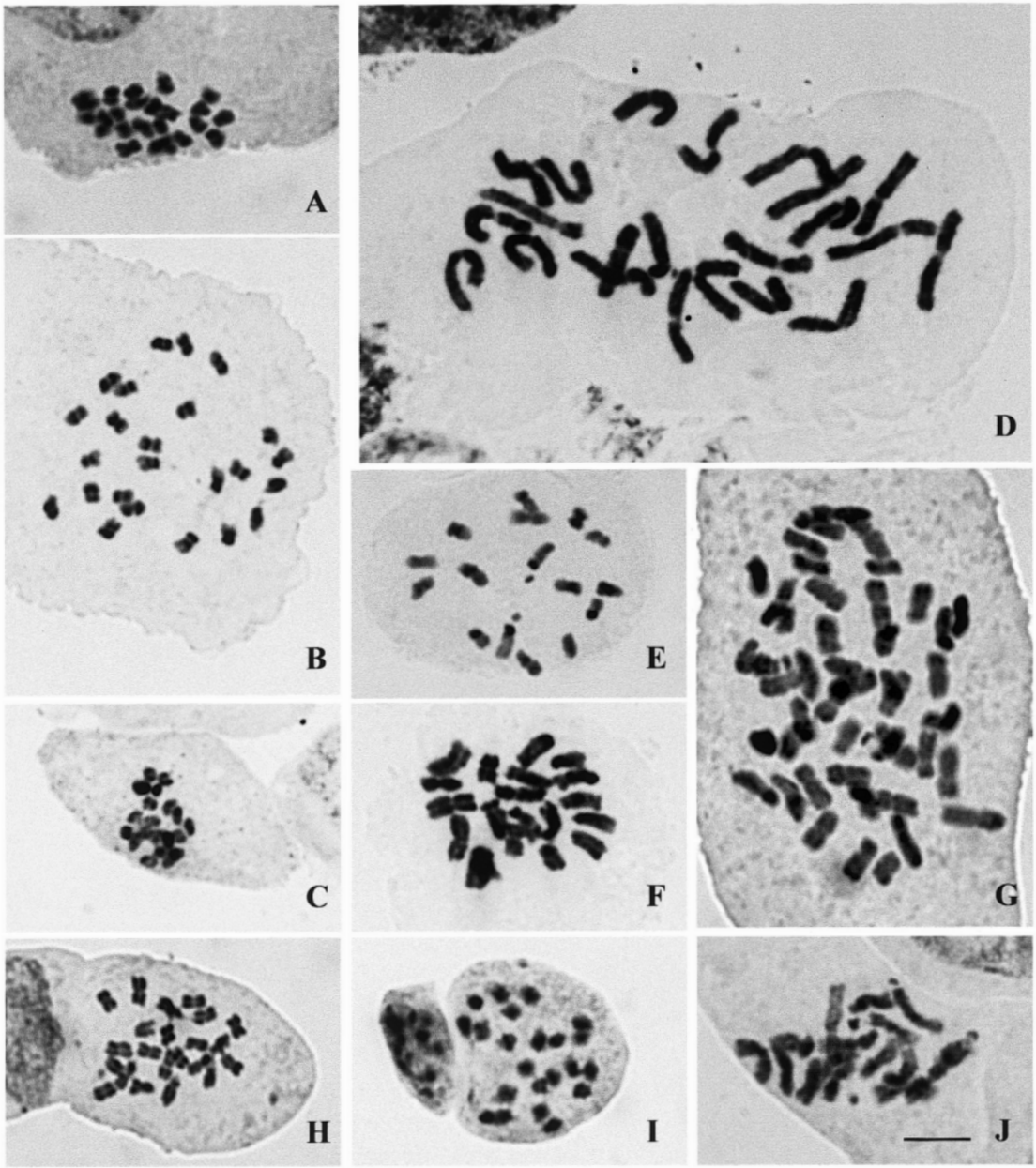

Fig. 2. Mitotic metaphase chromosomes of dwarf plants in Yakushima Island (2). A : *Viola boissieuana* var. *pseudoselkirki* (2n=24). B : *V. verecunda* var. *yakusimana* (2n=24). C : *Circaea alpina* f. *minima* (2n=22). D : *Angelica longiradiata* var. *yakushimensis* (2n=22). E : *Sanicula lamelligera* (2n=16). F : *Lysimachia japonica* var. *minutissima* (2n=20). G : *Tripterospermum japonicum* var. *tenue* (2n=46). H : *Galium pogonanthum* var. *yakumontanum* (2n=22). I : *Mitchella undulata* var. *minor* (2n=22). J : *Neanotis hirsuta* var. *yakusimensis* (2n=24). Bar =5 μm.

materials from eastern Himalaya (Sarker 1988), 2n=20 for materials from Tokyo (Hara and Kurosawa 1959), and 2n=22 for materials from Hokkaido (Nishikawa 1989). From the chromosome number and geographical distribution, var. *minutissima* might be differentiated from the ancestral plants distributed in western Japan with the chromosome number 2n=20.

Gentianaceae

16. *Tripterospermum japonicum* (Siebold et Zucc.) Maxim. var. *tenue* (Masam.) Honda : (Fig. 2 G).

Tripterospermum japonicum var. *tenue* is endemic to Yakushima Island and grows on moist banks beside forestry trails at higher elevations. The chromosome number for this taxon, 2n=46, is counted here for the first time and is the same as for the typical variety reported by Nishikawa (1981) and Shigenobu (1984).

Rubiaceae

17. *Galium pogonanthum* Franch. et Sav. var. *yakumontanum* T.Yamaz. : (Fig. 2 H).

Galium pogonanthum var. *yakumontanum* is endemic to Yakushima Island and grows on moist banks beside forestry trails. The chromosome number for this taxon, 2n=22, was counted for the first time.

18. *Mitchella undulata* Siebold et Zucc. var. *minor* Masam. : (Fig. 2 I).

Mitchella undulata var. *minor* is endemic to Yakushima Island and grows on mossy tree trunks or rocks in coniferous forests. The chromosome number for this taxon, 2n=22, is reported here for the first time. Chromosome number for the typical var. *undulata* was reported the same number, 2n=22, by Robbrecht et al. (1991).

Yokoyama et al. (2003) examined morphological and genetical variation in *M. undulata*, and they could not find any genetic difference between varr. *undulata* and *minor*.

19. *Neanotis hirsuta* (L. f.) W. H. Lewis var. *yakusimensis* (Masam.) W. H. Lewis : (Fig. 2 J).

Neanotis hirsuta var. *yakusimensis* is endemic to Yakushima Island and grows in moist places in the montane zone. The chromosome number for this taxon, 2n=24, was counted for the first time.

Labiatae

20. *Clinopodium multicaule* (Maxim.) Kuntze var. *yakusimense* (Masam.) Yahara : (Fig. 3 A).

Clinopodium multicaule var. *yakusimense* was originally described from materials collected in Yakushima Island (Masamune 1930), and has now also been reported from Mt. Kasuga in Nara Prefecture (Murata 1981), Awaji Island in Hyogo Prefecture (Kobayashi 1992). The chromosome number for this taxon, 2n=20, is reported here for the first time.

21. *Scutellaria kuromidakensis* (Yahara) T.Yamaz. : (Fig. 3 B).

Scutellaria kuromidakensis is endemic to Yakushima Island and grows beside forestry trails or between rocks at higher elevations. Yahara et al. (1987) recognized two taxa, *S. rubropunctata* var. *yakusimensis* and *S. kiusiana* var. *kuromidakensis* at higher elevations in the island. Murata and Yamazaki (1993) treated these two as conspecific and named *S. kuromidakensis*. The chromosome number for this taxon, 2n=26, has been counted for the first time. Sawanomukai et al. (2003) reported chromosome numbers of 16 species and two varieties of Japanese *Scutellaria* and reported 2n=26, 28 and 30. They reported 2n=26 chromosomes for nine species and two varieties in ser. *Indicae*, and found no numerical variation in the series. Morphologically, *S. kuromidakensis* belongs to ser. *Indicae* (Murata and Yamazaki 1993), and we similarly found no chromosomal variation in this species as Sawanomukai et al. (2003) noted.

Scrophulariaceae

22. *Melampyrum laxum* Miq. var. *yakusimense* (Tuyama) Kitam. : (Fig. 3 C).

Melampyrum laxum var. *yakusimense* is endemic to Yakushima Island and grows on grassland or in forest margins at higher elevations. The chromosome number of 2n=18, is here reported for the first time.

Plantaginaceae

23. *Plantago asiatica* L. var. *yakusimensis* (Masam.) Ohwi : (Fig. 3 D).

Plantago asiatica var. *yakusimensis* is a dwarf form of *P. asiatica*, described from materials collected from Yakushima Island (Masamune 1930). This taxon has since been reported from Izu islands, Tokyo Prefecture, southern Korea (Ohwi 1953) and in Miyajima Island, Hiroshima Prefecture (Seki et al. 1975). The chromosome number we observed for this taxon, 2n=24, was the same as previous reports (Matsuo and Noguchi 1989 ; Ishikawa et al. 2006).

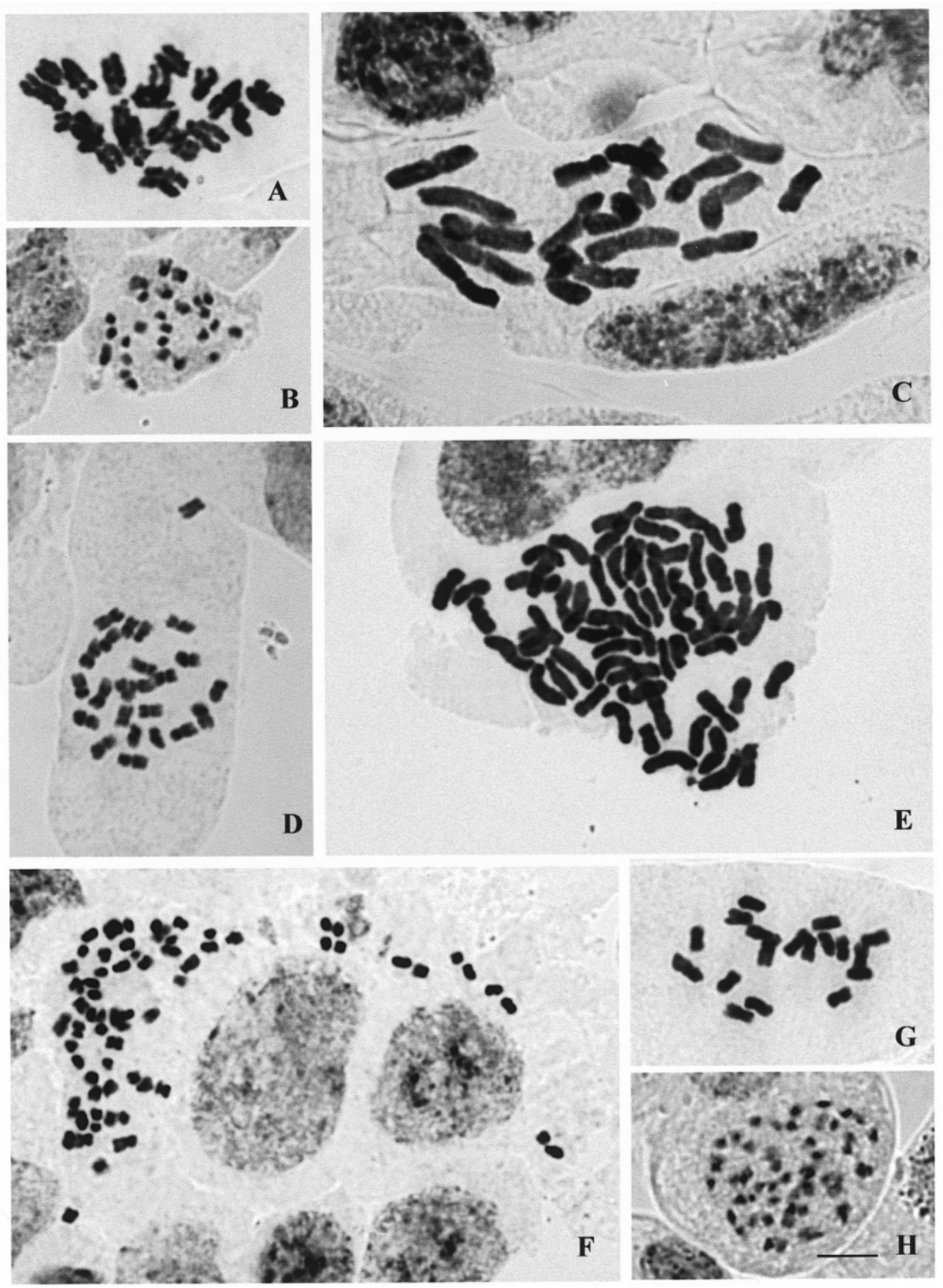

Fig. 3. Mitotic metaphase chromosomes of dwarf plants in Yakushima Island (3). A : *Clinopodium multicaule* var. *yakusimense* (2n=20). B : *Scutellaria kuromidakensis* (2n=26). C : *Melampyrum laxum* var. *yakusimense* (2n=18). D : *Plantago asiatica* var. *yakusimensis* (2n=24). E : *Cacalia yakusimensis* (2n=60). F : *Cirsium yakusimense* (2n=68). G : *Solidago minutissima* (2n=18). H : *Metanarthecium luteo-viride* f. *yakusimense* (2n=52+1 B). Bar =5 μm.

Compositae

24. *Cacalia yakusimensis* Masam. : (Fig. 3 E).

Cacalia yakusimensis is endemic to Yakushima Island and grows on moist ground of rocky places. The chromosome number for this taxon, 2n=60, is consistent with the count by Koyama (1968). Koyama (1961, 1968) reported the chromosome number of *C. hastata*, close related species to *C. yakusimensis*, as the same number 2n =60.

25. *Cirsium yakusimense* Masam. : (Fig. 3 F).

Cirsium yakusimense is endemic to Yakushima Island and grows on open grassland at higher elevations. The chromosome number for this taxon of 2n=68, is here reported for the first time.

26. *Solidago minutissima* (Makino) Kitam. : (Fig. 3 G).

Solidago minutissima is endemic to Yakushima Island and grows on wet mossy rocks at higher elevations. The chromosome number recorded for this taxon, 2n=18, is consistent with that by Huziwara (1965). The chromosome number of the closely related species, *S. virgaurea* L. subsp. *asiatica* Kitam. ex H.Hara, was also reported as 2n=18 (Matsuura and Suto 1935; Huziwara 1962).

Liliaceae

27. *Heloniopsis breviscapa* Maxim. var. *yakusimensis* (Masam.) H. Hara : (Fig. 4 A).

Heloniopsis breviscapa var. *yakusimensis* is endemic to Yakushima Island and grows on moist places at higher elevations. The chromosome number of this taxon, 2n=34, is here reported for the first time. Although *H. breviscapa* is sometimes treated as a variety of *H. orientalis* (Thunb.) Tanaka (Ohwi 1953; Satake 1982), Hara (1947) considers it as an independent species. Chromosome numbers of the typical var. *breviscapa* and allied species, *H. orientalis*, have also been reported as 2n=34 (Suto 1936; Okuyama 1962).

28. *Metanarthecium luteo-viride* Maxim. f. *yakusimense* Masam. : (Fig. 3 H).

Metanarthecium luteo-viride f. *yakusimensis* is endemic to Yakushima Island and grows on moist places at higher elevations. The chromosome number for this taxon, 2n=52+1 B, is here reported for the first time. The chromosome number of 2n=52 for the typical f. *luteo-viride* (Satô 1942) is consistent with our result, except that we report an accessory chromosome.

29. *Paris tetraphylla* A.Gray var. *yakusimensis* Masam. : (Fig. 4 B).

Paris tetraphylla is well known for its considerable morphological variation (Hara 1969; Yamanaka 1970; Kawano et al. 1980). Plants of *P. tetraphylla* in Yakushima Island are characterized in having small leaves and tepals, and are treated as var. *yakusimensis*. These plants grow on moist banks beside forestry trails at higher elevations. The chromosome number of *P. tetraphylla* has been reported as 2n=10 across its whole geographic range (Miyamoto and Kurita 1990; Miyamoto et al. 1991; Miyamoto et al. 1992; Uchino and Wang 1997), and our count is consistent with this.

30. *Smilax biflora* Siebold ex Miq. var. *biflora* : (Fig. 4 C).

Smilax biflora var. *biflora* is distributed in Yakushima and Amami Islands. In Yakushima Island, this species grows on open moist places at higher elevations. The chromosome number for this taxon, 2n=30, is reported here for the first time.

31. *Tofieldia yoshiiana* Makino : (Fig. 4 D).

Tofieldia yoshiiana is endemic to Yakushima Island and grows on wet mossy rocks at higher elevations. The chromosome number for this taxon, 2n=30, is reported here for the first time.

Juncaceae

32. *Luzula campestris* DC. var. *yakusimensis* Masam. : (Fig. 4 E).

Luzula campestris var. *yakusimensis* is endemic to Yakushima Island and grows on grassy banks beside forestry trails. The chromosome number for this taxon, 2n=12, is here reported for the first time. Halkka (1964) reported the gametophytic chromosome number for the typical var. *campestris* as n=6 from the materials collected in Finland. The same in somatic chromosome number was found for the Yakushima Island material counted in this study.

Gramineae

33. *Pseudosasa owatarii* (Makino) Makino ex

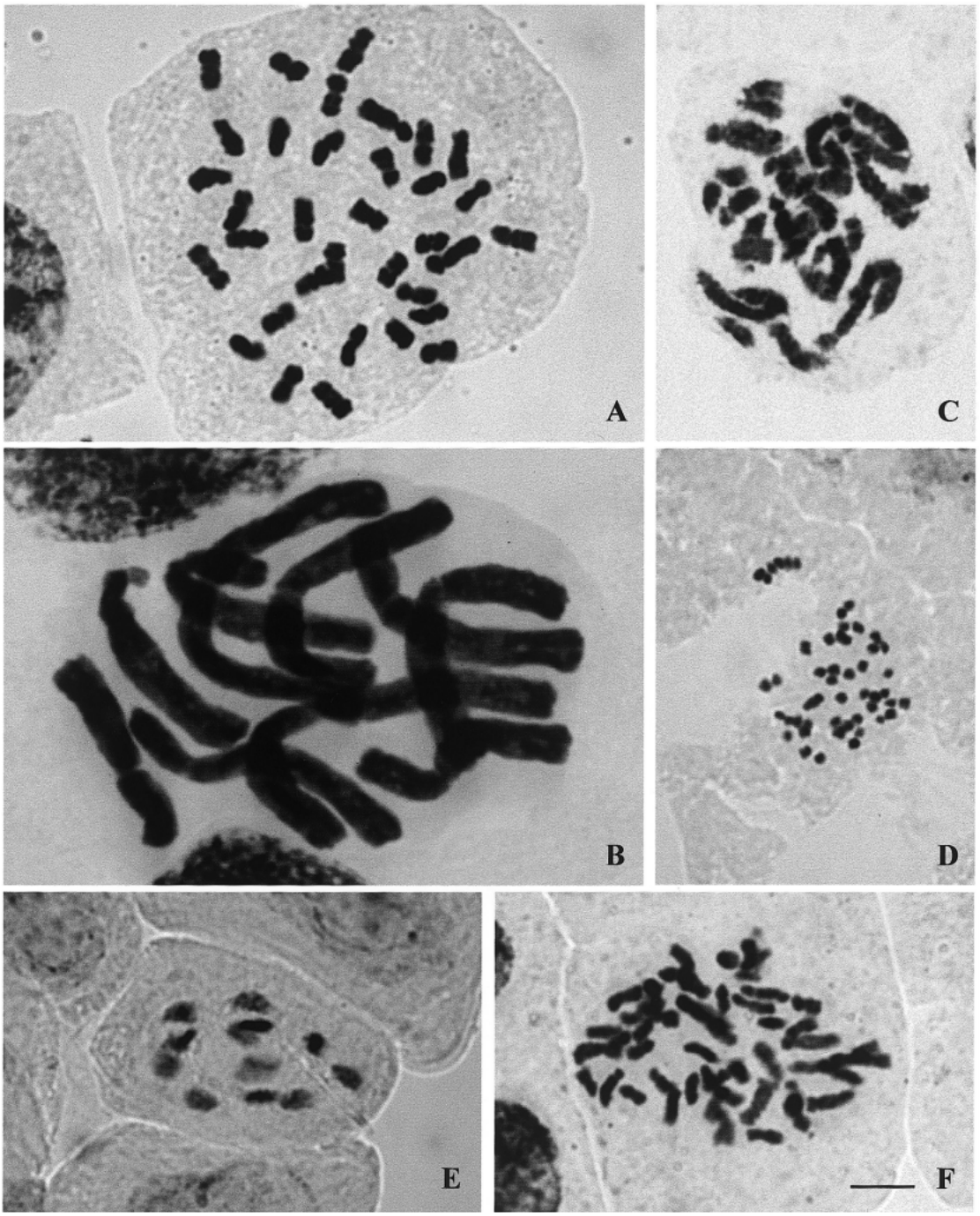

Fig. 4. Mitotic metaphase chromosomes of dwarf plants in Yakushima Island (4). A : *Heloniopsis breviscapa* var. *yakusimensis* (2n=34). B : *Paris tetraphylla* var. *yakusimensis* (2n=10). C : *Smilax biflora* var. *biflora* (2n =30). D : *Tofieldia yoshiiana* (2n=30). E : *Luzula campestris* var. *yakusimensis* (2n=12). F : *Pseudosasa owatarii* (2n=48). Bar =5 μm.

Nakai : (Fig. 4 F).

Pseudosasa owatarii is endemic to Yakushima Island and makes gregarious communities on ridges or near the summit at higher elevations. The chromosome number for this taxon, 2n=48, is reported here for the first time.

We examined chromosome numbers of 33 dwarf taxa. The chromosome numbers of 23 taxa are counted for the first time. In addition, chromosome number of *Sarothra* is the first report for the genus. Chromosome numbers of other 10 taxa agree with earlier reports.

Among the 11 species, 7 endemic species (*Coptis ramosa*, *Ranunculus yakushimense*, *Astilbe glaberrima*, *Mitella doiana*, *Scutellaria kuromidakensis*, *Cacalia yakushimensis* and *Solidago minutissima*) have same chromosome numbers with related species respectively. While among the 22 infraspecific taxa, 15 endemic taxa (*Hypericum kiusiana* var. *yakusimense*, *Parnassia palustris* var. *yakusimensis*, *Saxifraga fortunei* var. *minima*, *Fragaria nipponica* var. *yakusimensis*, *Viola boissieuana* var. *pseudoselkirki*, *V. verecunda* var. *yakusimana*, *Angelica longiradiata* var. *yakusimensis*, *Lysimachia japonica* var. *minutissima*, *Tripterospermum japonicum* var. *tenue*, *Mitchella undulata* var. *minor*, *Plantago asiatica* var. *yakusimensis*, *Heloniopsis breviscapa* var. *yakusimensis*, *Metanarthecium luteoviride* f. *yakusimense*, *Paris tetraphylla* var. *yakusimensis* and *Luzula campestris* var. *yakusimensis*) have same chromosome numbers with their typical taxa.

Yokoyama et al. (2003) examined morphological and molecular variation in *Mitchella undulata*, and they noted that *M. undulata* var. *minor* did not show apparent morphological discontinuity nor unique genetical difference from other populations in Japan. On the other hand, Ishikawa et al. (2006) examined morphological and molecular variation in *Plantago asiatica*, and they found materials collected in Yakushima Island (var. *yakusimensis*) did not show apparent morphological discontinuity from other populations in Japan, but possessed a specific genotype, although the substitution level was low.

Yakushima Island had been connected to Kyushu mainland several times during the ice age, but is isolated at present (Kimura 1996; Kuroda and Ozawa 1996). Our results suggest that the dwarfism for plants in Yakushima Island was established in a relatively short time by environmental factors as well as genetic isolation.

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山本伸子[1]・池田　博[2]・星野卓二[1]：鹿児島県屋久島産高等植物の細胞分類学的研究　I. 矮小化した分類群

鹿児島県屋久島に生育する植物の中には，屋久島を南限・北限とする分類群や屋久島に固有な分類群，あるいは極端に矮小化した分類群が多く知られている。したがって，屋久島に特徴的に分布する分類群は，島嶼環境における植物の分化・多様化を研究する上でよい材料であると考えられる。ここでは，屋久島産高等植物のうち，矮小化した分類群の染色体数を報告する。

矮小化した分類群 17 科 32 属 33 分類群について染色体数を算定した。その結果，23 分類群（オオゴカヨウオウレン（2n=18），ヒメコケオトギリ（2n=16），コヤクシマショウマ（2n=14），ヤクシマウメバチソウ（2n=14），ヤクシマダイモンジソウ（2n=22），ヤクシマミヤマスミレ（2n=24），コケスミレ（2n=24），ヒメミヤマタニタデ（2n=22），ヤクシマツクシゼリ（2n=22），ヤクシマツルリンドウ（2n=46），ヤクシマヤマムグラ（2n=22），ヒメツルアリドオシ（2n=22），ヤクシマハシカグサ（2n=24），コケトウバナ（2n=20），ヤクシマナミキ（2n=26），ヤクシマママコナ（2n=18），ヤクシマアザミ（2n=68），ヤクシマショウジョウバカマ（2n=34），ヤクシマノギラン（2n=52+1 B），ヒメカカラ（2n=30），ヤクシマチャボゼキショウ（2n=30），ヤクシマスズメノヒエ（2n=12），ヤクシマダケ（2n=48））については，今回はじめて染色体数を算定した。特にヒメコケオトギリについては，コケオトギリ属としても初めての染色体数の報告となる。また，10 分類群（ヒメウマノアシガタ（2n=14），ヤクシマコオトギリ（2n=32），ヒメチャルメルソウ（2n=28），ヤクシマシロバナヘビイチゴ（2n=14），ヒメウマノミツバ（2n=16），ヤクシマコナスビ（2n=20），ヤクシマオオバコ（2n=24），ヤクシマコウモリ（2n=60），イッスンキンカ（2n=18），ヤクシマツクバネソウ（2n=10））については，これまでに報告があり，これまでの報告と同じ染色体数が算定された。矮小化した分類群と，母種または最も近縁と考えられる分類群の染色体数を比較したところ，すべて同じ染色体数であった。

今回の研究では，矮小化と細胞学的変異との関連は見出せなかった。これは，屋久島が氷河期に何度も九州本土と陸続きになった時期があり，島として隔離されてからの時間が短いためではないかと考えられる。

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Appendix

Present and previous chromosome counts of examined taxa.

Family	Taxon	Present counts	Previous counts	References
Ranunculaceae	*Coptis ramosa* オオゴカヨウオウレン	2n=18*		
	Ranunculus yakushimensis ヒメウマノアシガタ	2n=14	2n=14	Kurita (1955)
Guttiferae	*Hypericum kiusianum* var. *yakusimense* ヤクシマコオトギリ	2n=32	2n=32	Kato (1987)
	Sarothra laxa f. *hananoegoensis* ヒメコケオトギリ	2n=16*		
Saxifragaceae	*Astilbe glaberrima* var. *saxatilis* コヤクシマショウマ	2n=14*		
	Mitella doiana ヒメチャルメルソウ	2n=28	2n=28	Wakabayashi (1973 a)
	Parnassia palustris var. *yakusimensis* ヤクシマウメバチソウ	2n=18*		
	Saxifraga fortunei var. *minima* ヤクシマダイモンジソウ	2n=22*		
Rosaceae	*Fragaria nipponica* var. *yakusimensis* ヤクシマシロバナヘビイチゴ	2n=14	2n=14	Iwatsubo and Naruhashi (1989)
Violaceae	*Viola boissieuana* var. *pseudoselkirkii* ヤクシマミヤマスミレ	2n=24*		
	V. verecunda var. *yakusimana* コケスミレ	2n=24*		
Onagraceae	*Circaea alpina* f. *minima* ヒメミヤマタニタデ	2n=22*		
Umbelliferae	*Angelica longiradiata* var. *yakushimensis* ヤクシマツクシゼリ	2n=22*		
	Sanicula lamelligera ヒメウマノミツバ	2n=16	n=8	Chuang et al. (1963)
Primulaceae	*Lysimachia japonica* var. *minutissima* ヤクシマコナスビ	2n=20	2n=20	Kurosawa and Hara (1960)
Gentianaceae	*Tripterospermum japonicum* var. *tenue* ヤクシマツルリンドウ	2n=46*		
Rubiaceae	*Galium pogonanthum* var. *yakumontanum* ヤクシマヤマムグラ	2n=22*		
	Mitchella undulata var. *minor* ヒメツルアリドオシ	2n=22*		
	Neanotis hirsuta var. *yakusimensis* ヤクシマハシカグサ	2n=24*		
Labiatae	*Clinopodium multicaule* var. *yakusimense* コケトウバナ	2n=20*		
	Scutellaria kuromidakensis ヤクシマナミキ	2n=26*		
Scrophulariaceae	*Melampyrum laxum* var. *yakusimense* ヤクシマママコナ	2n=18*		
Plantaginaceae	*Plantago asiatica* var. *yakusimensis* ヤクシマオオバコ	2n=24	2n=24	Matsuo and Noguchi (1989) ; Ishikawa et al. (2006)
Compositae	*Cacalia yakusimensis* ヤクシマコウモリ	2n=60	2n=60	Koyama (1968)
	Cirsium yakushimense ヤクシマアザミ	2n=68*		
	Solidago minutissima イッスンキンカ	2n=18	2n=18	Huziwara (1965)
Liliaceae	*Heloniopsis breviscapa* var. *yakusimensis* ヤクシマショウジョウバカマ	2n=34*		
	Metanarthecium luteo-viride f. *yakusimensis* ヤクシマノギラン	2n=52+1B*		
	Paris tetraphylla var. *yakusimensis* ヤクシマツクバネソウ	2n=10	2n=10	Miyamoto and Kurita (1990) ; Miyamoto et al. (1991, 1992)
	Smilax biflora var. *biflora* ヒメカカラ	2n=30*		
	Tofieldia yoshiiana ヤクシマチャボゼキショウ	2n=30*		
Juncaceae	*Luzula campestris* var. *yakusimensis* ヤクシマスズメノヒエ	2n=12*		
Gramineae	*Pseudosasa owatarii* ヤクシマダケ	2n=48*		

* : First record of chromosome numbers.