Aneuploidy and karyotypic polymorphism of *Lysimachia mauritiana* (Primulaceae) distributed in northern and middle parts in the Ryukyu Archipelago belonging to Kagoshima Prefecture, Japan

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ABSTRACT. Karyotype change of *Lysimachia mauritiana* was cytologically analyzed in 76 individuals collected in the northern and middle parts of the Ryukyu Archipelago in Kagoshima Prefecture, Japan. Sixteen cytotypes were recognized in the areas. At least, four long median- and six terminal-centromeric chromosomes were included in the chromosome complements of the individuals observed. Remarkable chromosomal polymorphism or karyotype variation was shown in the Ryukyu Archipelago, especially the Amami group.

KEYWORDS: Aneuploid, Chromosomal polymorphism, Karyotype variation, *Lysimachia mauritiana*

The biennial *Lysimachia mauritiana* L. (Primulaceae) has wide distribution in the temperate and subtropical zones of both hemispheres (Iwatsuki *et al.* 1996). The populations of the species in Japan can be frequently seen on rocky place in seacoasts from the north to the south in the Archipelago. Chromosome counts in this species have been mainly reported by using of the plant materials in East Asia, especially Korea, Japan, and Taiwan (Jinno 1956; Chuang *et al.* 1962; Carr 1978; Tanaka and Hizume 1978; Ko *et al.* 1986; Oginuma *et al.* 2004a, b).

Earlier reports in last century documented the chromosome number of $2n=20$ or $n=10$ (Jinno 1956; Chuang *et al.* 1962; Carr 1978; Tanaka and Hizume 1978; Ko *et al.* 1986), and three different but two kinds of karyotypes (Jinno 1956; Tanaka and Hizume 1978; Ko *et al.* 1986). The precise report with chromosome measurements by Tanaka and Hizume (1978) in Japanese plants of the species showed the karyotype of $2n=20=4m+2sm+4st+10t$, while the karyomorphological report in the plants collected in the Orchid Island, Taiwan showed another karyotype of $2n=20=4m+4sm+2st+10t$ (Oginuma *et al.* 2004b).

Current research in chromosomes in *Lysimachia mauritiana* in the Yonagunijima Island, Japan showed the chromosome number of $2n=16$ with karyotypic variations including one aneuploidal formula (Oginuma *et al.*

2004a). This led to three new karyotypes of $2n=16=8m+2sm+6t$, $2n=16=7m+2sm+1st+6t$ and $2n=16=6m+2sm+2st+6t$.

Karyotype change in 76 individuals of *Lysimachia mauritiana* collected in the northern to the middle parts of the Ryukyu Archipelago, Kagoshima Pref., Japan was studied here, and wide-range of aneuploids and their karyotypic polymorphism was detected.

MATERIALS AND METHODS

Seventy-six individuals of *Lysimachia mauritiana* collected in the sites in the Ryukyu Archipelago in Kagoshima Prefecture, Kyushu District, Japan were listed in Table 1. They were cultivated in the greenhouse of Kochi Women's University and their somatic chromosomes were examined on the basis of three good, mitotic metaphase cells per individual. The method procedure of pretreatment, fixation and staining for chromosome observation were described elsewhere (Oginuma and Nakata 1988). The relative length of chromosome was calculated by (length of each chromosome) / (total length of all chromosomes of the complement) x 100. Categories and identification of chromosome morphology followed Levan *et al.* (1964).

Certain chromosomes were quite distinct and easily recognized as markers of the metaphase complements, median-centromeric, submedian-centromeric and

Table 1. Chromosome numbers, karyotypes and their collection data of *Lysimachia mauritiana* distributed in the northern and middle parts belonging to Kagoshima Prefecture, Ryukyu Archipelago, Japan

Karyotype ¹⁾	Group name of Islands	Locality	Individual number
$2n=20=5\mathbf{m}+2\mathbf{sm}+1\mathbf{st}+12\mathbf{t}$	Amami group	Tokunoshima Is., Isen-cho, Isen	THIs-0017
$2n=20=4\mathbf{m}+4\mathbf{sm}+12\mathbf{t}$	Amami group	Tokunoshima Is., Isen-cho, Kinen	TIKi-0201
$2n=20=4\mathbf{m}+2\mathbf{sm}+4\mathbf{st}+10\mathbf{t}$	Osumi group	Tanegashima Is., Nishinoomote-shi, Anno	TNAn-0001, 0002, 0003, 0004, 0013
	Osumi group	Yakushima Is., Kamiyaku-cho, Issou	YKaIs-0001, 0002, 0003, 0004, 0012
	Tokara group	Kuchinoshima Is., Toshima-son	KuTo 2-0001, 0002, 0003, 0004, 0011
	Tokara group	Nakanoshima Is., Toshima-son	NaTo 4-0001, 0002, 0003, 0004, 0005
	Tokara group	Suwanosejima Is., Toshima-son	SuTo 3-0001, 0002, 0003, 0004, 0007
	Tokara group	Akusekijima Is., Toshima-son	AkTo 1-0001, 0002, 0003, 0004, 0005
	Tokara group	Kodakarajima Is., Toshima-son	KoTo 1-0101, 0102, 0107, 0108, 0204
$2n=19=6\mathbf{m}+2\mathbf{st}+11\mathbf{t}$	Amami group	Okinoerabujima Is., China-cho, Kuronuki	OCK-0108
$2n=19=5\mathbf{m}+2\mathbf{sm}+1\mathbf{st}+11\mathbf{t}$	Amami group	Tokunoshima Is., Isen-cho, Isen	THIs-0014
$2n=18=6\mathbf{m}+2\mathbf{sm}+10\mathbf{t}$	Tokara group	Takarajima Is., Toshima-son, Sengo	TaTo5-0103
$2n=18=5\mathbf{m}+1\mathbf{m}+2\mathbf{sm}+10\mathbf{t}$	Tokara group	Takarajima Is., Toshima-son, Sengo	TaTo5-0235
$2n=18=4\mathbf{m}+2\mathbf{m}+2\mathbf{sm}+10\mathbf{t}$	Tokara group	Takarajima Is., Toshima-son, Oma	TaTo7-0112
	Amami group	Kikaijima Is., Kikai-cho, Araki	KiKA-0101, 0204, 0209, 0210, 0211
	Amami group	Yoronto Is., Yoron-cho, Hurusato	YYH-0001, 0002, 0003, 0004, 0005
	Amami group	Okinoerabujima Is., Wadamari-cho, Kunigami	OWKu-0105, 0107, 0201, 0202
$2n=17=7\mathbf{m}+2\mathbf{sm}+8\mathbf{t}$	Tokara group	Takarajima Is., Toshima-son, Sengo	TaTo6-0108
	Amami group	Okinoerabujima Is., Wadamari-cho, Kunigami	OWKu-0208
$2n=17=6\mathbf{m}+1\mathbf{m}+1\mathbf{sm}+1\mathbf{st}+8\mathbf{t}$	Tokara group	Takarajima Is., Toshima-son, Oma	TaTo7-0110
$2n=17=5\mathbf{m}+2\mathbf{m}+2\mathbf{sm}+8\mathbf{t}$	Tokara group	Takarajima Is., Toshima-son, Kiyamajiri	TaTo1-0222
$2n=17=4\mathbf{m}+1\mathbf{m}+2\mathbf{sm}+2\mathbf{st}+8\mathbf{t}$	Amami group	Amamioshima Is., Setouchi-cho, Sokaru	ASS-0204
$2n=16=8\mathbf{m}+2\mathbf{sm}+6\mathbf{t}$	Tokara group	Takarajima Is., Toshima-son, Sengo	TaTo6-0110
	Amami group	Tokunoshima Is., Amagi-cho, Nishiagina	TAN-0204, 0213
	Amami group	Kakeromajima Is., Setouchi-cho, Kanya	KaSK-0003, 0005, 0008, 0009
$2n=16=7\mathbf{m}+2\mathbf{sm}+1\mathbf{st}+6\mathbf{t}$	Tokara group	Takarajima Is., Toshima-son, Sengo	TaTo5-0220
	Amami group	Amamioshima Is., Setouchi-cho, Sokaru	ASS-0305
$2n=16=6\mathbf{m}+2\mathbf{m}+2\mathbf{sm}+6\mathbf{t}$	Tokara group	Takarajima Is., Toshima-son, Sengo	TaTo6-0218
	Amami group	Amamioshima Is., Yamato-son, Toen	AYT-0007, 0009, 0010, 0014
$2n=16=5\mathbf{m}+2\mathbf{sm}+3\mathbf{st}+6\mathbf{t}$	Amami group	Kakeromajima Is., Setouchi-cho, Saneku	KaSSa-0105

1) **m**=longer median chromosomes, **m**=median chromosomes, **sm**=longer submedian chromosomes, **sm**=submedian chromosomes, **st**=longer subterminal chromosomes, **st**=subterminal chromosomes, **t**=terminal chromosomes

subterminal-centromeric chromosomes. Additionally, the chromosomes of which relative lengths were more than 5.4 were defined as larger-median, larger-submedian and larger-subterminal chromosomes designated by the bold letters “**m**”, “**sm**” and “**st**” in respective karyotype formula (see Table 1). The chromosome number and number of “**m**” were used as markers to be simplified the karyotypic polymorphism since more than a hundred various karyotypes were observed in this species.

The voucher specimens investigated were deposited in the herbarium of University of the Ryukyus (RYU).

RESULTS AND DISCUSSION

The chromosome numbers of *Lysimachia mauritiana* obtained during the course of investigation were listed in Table 1. The chromosome counts of $2n=17$, 18 and 19

were reported here for the first time. The chromosome numbers of $2n=16$ and 20 obtained verified the previous counts by Jinno (1956), Chuang *et al.* (1962), Carr (1978), Tanaka and Hizume (1978), Ko *et al.* (1986) and Oginuma *et al.* (2004a, b).

The chromosome number of $2n=20$ had been only known for *Lysimachia mauritiana*, until more careful, detailed, intensive study in chromosomes of the species cytogenetic work of *Lysimachia mauritiana* ($2n=16$) in the Yonagunijima Is. was carried out by Oginuma *et al.* (2004a). The present research indicated that the chromosome number of $2n=20$ was frequently found in the area from Tanegashima Is. to Kodakarajima Is. in the Oshumi and Tokara Groups except for Takarajima Is. In contrast, the odd numbers of chromosomes such as $2n=17$ and 19 were found in Takarajima Is., the

southmost island of the Tokara Group and islands of the Amami Group. They were found in the mixed and dense populations with plants of $2n=16$ and 18 (Table 1).

At least, four large median- and six terminal-centromeric chromosomes were included in the chromosome complements of all individuals observed. In the first detailed karyomorphological research using the species with $2n=20=4m+2sm+4st+10t$ was only noted in the paper of Tanaka and Hizume (1978) during the last century. Jinno (1956) and Ko *et al.* (1986), however, mentioned that the chromosome complement of somatic cell in this species displayed median-, submedian- and subterminal-centromeric chromosomes, but not any terminal-centromeric chromosome. Jinno (1956) and Ko *et al.* (1986) used Japanese materials collected from Ehime Prefecture in Shikoku District and Korean materials collected in Hongdo. At least the karyotype of Korean individuals of $2n=20=4m+12sm+4st$ could be misidentification of the chromosome types to establish the karyotype. Judging from the microphotograph of chromosome complement at mitotic metaphase presented by Ko *et al.* (1986), the karyotype of a Korean individual reported could be $2n=20=4m+2sm+4st+10t$, which was quite similar to that of Shikoku District, Japan (Tanaka and Hizume 1978). Additional investigation to re-evaluate the karyotype of the species was performed using 60 individual plants collected from six localities of Kochi Prefecture, Shikoku District and Miyazaki

Prefecture, Kyushu District, and Prefectures of Fukui, Shizuoka, Shimane and Tottori, Honshu. All of the individuals of these localities studied showed only a single karyotype of $2n=20$ that consisted of four larger median-, two submedian-, four subterminal- and ten terminal-centromeric chromosomes ($2n=20=4m+2sm+4st+10t$; Figure not shown). This karyotype was same as that of Annou, Tanegashima Is., Japan (Fig. 3). Thus, it was suggested that the karyotype of $2n=20=4m+2sm+4st+10t$ was typical for *L. mauritiana* distributed in main islands of Japan.

Sixteen cytotypes recognized in the Ryukyu Archipelago belonging to Kagoshima Prefecture, Kyushu District were listed in Table 1 and Figs. 1-16. Previously, five reports on somatic karyotype descriptions in this species have been known (Jinno 1956; Tanaka and Hizume 1978; Ko *et al.* 1986; Oginuma *et al.* 2004a, b). The present study showed 13 new cytotypes and three cytotypes same to the previous reports such as $2n=20=4m+2sm+4st+10t$ documented in the main islands of Japan (Tanaka and Hizume 1978), $2n=16=8m+2sm+6t$ and $2n=16=7m+2sm+1st+6t$ documented in the Yonagunijima Is. (Oginuma *et al.* 2004a). In contrast, four karyotypes previous reported such as $2n=20=4m+16(m-st)$ from the main islands of Japan (Jinno 1956), $2n=20=4m+12sm+4st$ from Korea (Ko *et al.* 1986), $2n=16=6m+2sm+2st+6t$ from Yonagunijima Is. (Oginuma *et al.* 2004a) and $2n=20=4m+4sm+2st+10t$ from Orchid Is., Taiwan

Figs. 1-5. Chromosome arrangement based on the karyotypic formula in *Lysimachia mauritiana* in Tokunoshima Is., Okinoerabujima Is. and Tanegashima Is. 1. Isen (TIIIs-0017; $2n=20=5m+2sm+1st+12t$). 2. Kinen (TIKI-0201; $2n=20=4m+4sm+12t$). 3. Annou (TNiAn-0013; $2n=20=4m+2sm+4st+10t$). 4. Kuronuki (OCK-0108; $2n=19=6m+2st+11t$). 5. Isen (TIIIs-0014; $2n=19=5m+2sm+1st+11t$). Five individuals were collected from Tokunoshima Is. (1, 2 and 5), Tanegashima Is. (3) and Okinoerabujima Is. (4), respectively. Bar=5 μ m.

Figs. 13-16. Chromosome arrangement based on the karyotypic formula in *Lysimachia mauritiana* in Takarajima Is., Kakeromajima Is. and Tokunoshima Is. 13. Nishiagina (TAN- 0213; $2n=16=8\mathbf{m}+2\mathbf{sm}+6\mathbf{t}$). 14. Toshima-son, Sengo (TaTo5-0220; $2n=16=7\mathbf{m}+1\mathbf{sm}+2\mathbf{st}+6\mathbf{t}$). 15. Toshima-son, Sengo (TaTo6-0218; $2n=16=6\mathbf{m}+2\mathbf{m}+2\mathbf{sm}+6\mathbf{t}$). 16. Saneku (KaSSa-0105; $2n=16=5\mathbf{m}+2\mathbf{sm}+3\mathbf{st}+6\mathbf{t}$). Four individuals were collected from Tokunoshima Is. (13), Takarajima Is. (14 and 15) and Kakeromajima Is. (16), respectively. Bar=5 $\mu\mathbf{m}$.

(Oginuma *et al.* 2004b) were not found during the course of investigation this study. Thus, this result indicated that quite remarkable chromosomal polymorphism or karyotype variation was found by means of 16 cytotypes at least in the Ryukyu Archipelago, especially the Amami Group (Table 1). It suggests that further studies may supply many more new karyotypes in the species in this region.

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