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Studies on intraspecific polyploids of the fern *Lepisorus thunbergianus* (1) Their distributional patterns in Kanto districts and the occurrence of new cytotypes

中藤成実*・益山樹生**・三井邦男***: ノキシノブの種内倍数体の研究 (1) 関東地方における分布と新サイトタイプ

A number of cytological studies have been carried out for Japanese pteridophytes (cf. Mitui 1975, 1980), and about 80 species have so far been reported to be composed of intraspecific polyploids (Hirabayashi 1981). Some workers (Mitui 1965, 1966a, b, 1968, 1971a, b; Hirabayashi 1969, 1974; Takei 1974, 1978; Nakato 1976, 1981; Nakato & Mitui 1979; Masuyama 1979; Takamiya & Tanaka 1982) have carried out comparative studies on the characteristics of intraspecific polyploids of some species. However, topics in each of these studies were not comprehensive but concerned with only a part of certain features of intraspecific polyploids, such as their external morphology, their distributional patterns, their breeding systems and so on. The intent of this series of studies is to treat as comprehensively as possible on intraspecific polyploids of a fern and thereby to contribute to the better understanding of the significance of polyploidization in pteridophytes.

Lepisorus thunbergianus (Kaulf.) Ching was chosen for the study. This species is an epiphytic fern, which is widely distributed from Okinawa in south to Hokkaido in north. A certain amount of information has been obtained for the intraspecific polyploids of this species. By some cytological studies (Mitui 1965, 1966a, b, 1968; Takei 1974, 1978), four cytotypes were detected in this species: diploids (2n=50), triploids (2n=75), tetraploids (2n=100) and hyper-tetraploids (2n=102). Morphological studies were carried out to show certain

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differences in such micromorphological characters as stomata, scales and spores between the diploids and the tetraploids (Mitui 1966b, 1968, 1971a, b). Cyto-ecological studies were also made for this species and dissimilar distributional patterns were reported for the diploids and the tetraploids (Takei 1974, 1978).

This paper deals with the last topic mentioned above, the dissimilar distributional patterns of intraspecific polyploids. As for this topic, two features of the diploids and the tetraploids are worthy of note. First, it was suggested by Mitui (1968) that the diploids occur more frequently in the coastal regions than in the inland regions, while the reverse is the case with the tetraploids. Takei (1974, 1978) confirmed this with the materials in Hiroshima Pref. and Oita Pref. Second, it was reported by Takei (1978) for the materials in Oita Pref. that diploids were often found at sunny and dried sites, while tetraploids at shady and humid sites, even when they occurred together in the same place. In this paper, more substantial data on these two features will be given and the occurrence of new cytotypes will be reported on the basis of the materials covering over a wide area, Kanto districts.

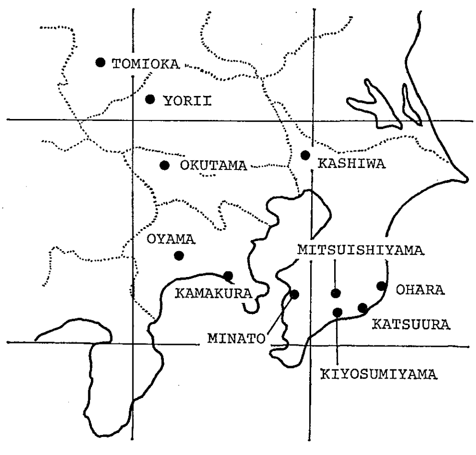

Fig. 1. Map showing the localities of materials in Kanto districts.

Materials and methods

Materials were collected at 84 sites of 11 localities in Kanto districts (Fig. 1) in the winter months of 1981 and 1982. Following environmental conditions of habitats were checked for all materials: the altitude of habitat, the sort of substratum, the inclinatory angle and the exposure of the surface of substratum, the humidity of substratum, and the natural light requirement of material. The degree of the humidity of substratum was judged by the eye-measurement. The degree of the light requirement of material was estimated by the following expedient: a hemispherical picture was taken by the camera with fish-eye lens, which was set on the substratum, and the percentage of

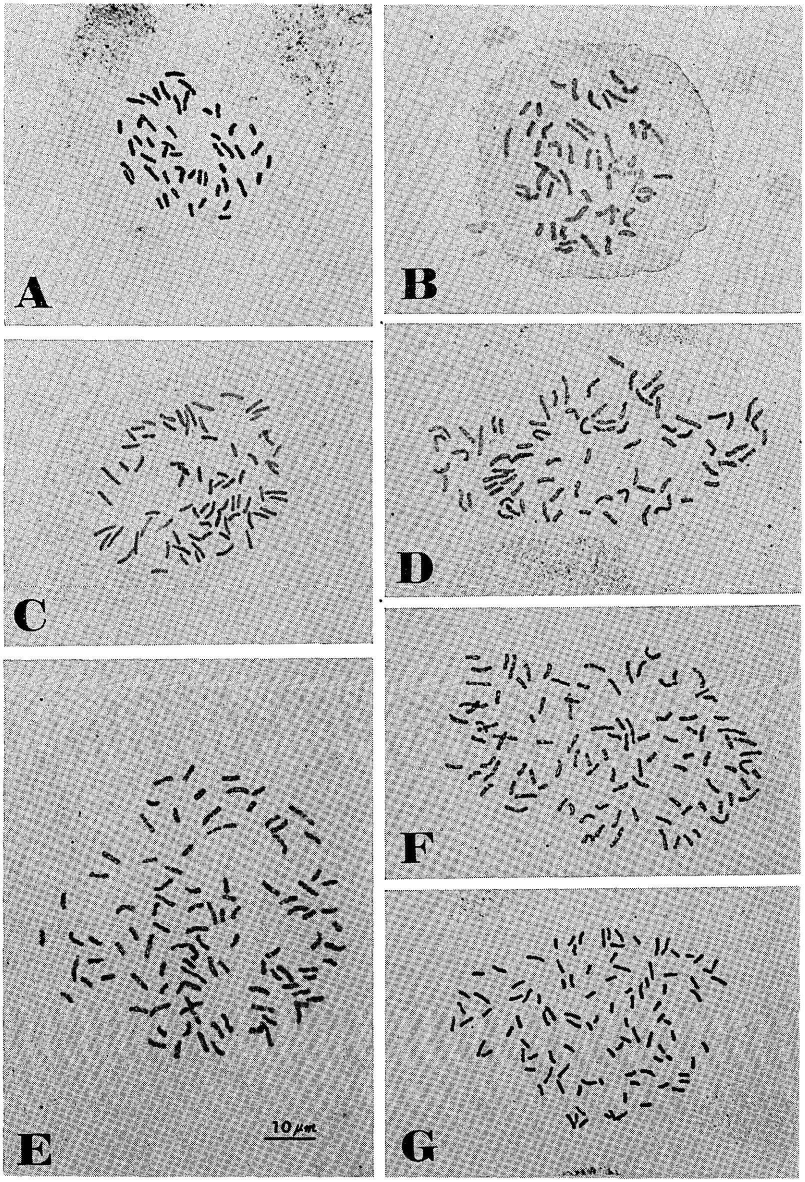

Fig. 2. Somatic chromosomes of seven cytotypes. A. $2n=50$. B. $2n=51$. C. $2n=75$. D. $2n=76$. E. $2n=100$. F. $2n=101$. G. $2n=102$.

Tab. 1. Localities, chromosome numbers and some ecological aspects of materials.

Collection site	Somatic chromosome number (No. of materiels)	Altitude of habitat	Substratum	Inclinatory angle of substratum	Exposure of sub-stratum	Humidity of sub-stratum*	Openness rate of habitat**
Tomioka 1	100(1)	200 m	tree trunk	85°	E	−	<26%
Tomioka 2	100(1)	150 m	tree trunk	90°	N E	−	<18%
Yorii 3	102(1)	180 m	tree trunk	85°	N W	−	23%
Yorii 4	102(1)	180 m	tree trunk	80°	N W	−	<20%
Yorii 5	100(1)	180 m	stone wall	90°	E	±	27%
Yorii 6	102(1)	160 m	stone wall	60°	N W	−	≪30%
Yorii 8	100(1)	120 m	tree trunk	80°	N E	−	≪31%
Okutama 1	50(1)	210 m	tree trunk	90°	S E	−	≪27%
Okutama 2	50(2), 102(1)	220 m	stone wall	90°	E	−	22%
Okutama 3	102(1)	280 m	stone wall	90°	E	−	53%
Okutama 4	102(1)	310 m	rock	45°	N	+	41%
Okutama 5	50(2), 102(2)	290 m	tree trunk	90°	S W	−	<25%
Okutama 6	50(1), 100(1), 102(1)	340 m	stone wall	80°	N E	−	41%
Okutama 7	75(1), 100(3)	340 m	tree trunk	90°	N E	±	<21%
Okutama 8	102(3)	420 m	rock	40°	E	±	17%
Okutama 9	102(2)	420 m	rock	85°	N E	±	17%
Okutama 10	102(3)	440 m	stone wall	75°	S E	−	31%
Okutama 11	101(1)	350 m	tree trunk	80°	W	−	19%
Okutama 12	100(1)	330 m	straw-thatched roof	30°	W	+	<37%
Okutama 13	102(1)	440 m	stone wall	70°	E	−	33%
Kashiwa 1	100(1)	30 m	tree trunk	90°	S E	−	<11%
Kashiwa 2	50(1)	30 m	tree trunk	90°	N	−	≪14%
Kashiwa 3	100(1)	30 m	tree trunk	90°	S W	−	<16%
Oyama 1	100(1)	780 m	rock	80°	N E	−	≪42%
Oyama 3	102(1)	990 m	tree trunk	90°	S	−	12%
Oyama 4	101(1)	840 m	tree trunk	90°	N W	−	<21%

Oyama 5	50(1), 100(1), 102(2)	680 m	stone wall	80°	N	+	≪36%
Oyama 6	50(1)	470 m	tree trunk	75°	E	−	<27%
Oyama 7	50(1)	420 m	tree trunk	90°	S E	−	20%
Oyama 8	51(1)	320 m	tree trunk	95°	S	−	≪51%
Oyama 9	50(1)	320 m	stone wall	70°	S	±	37%
Oyama 10	50(2)	320 m	stone wall	65°	N	±	≪48%
Oyama 11	50(1)	190 m	stone wall	70°	N	−	42%
Oyama 12	50(1)	120 m	stone wall	90°	N W	+	17%
Oyama 13	50(2)	120 m	tree trunk	90°	N E	±	≪34%
Kamakura 1	50(1)	30 m	stone wall	70°	N	±	<14%
Kamakura 2	50(1)	20 m	stone wall	90°	N	−	21%
Kamakura 3	50(2)	20 m	stone wall	70°	N	+	<19%
Kamakura 4	50(1)	30 m	tree trunk	95°	N W	−	<18%
Kamakura 5	50(2)	40 m	tree trunk	80°	N E	−	≪13%
Kamakura 6	50(1)	50 m	stone wall	90°	N	±	<19%
Kamakura 7	76(1)	50 m	stone wall	75°	N	−	≪21%
Kamakura 8	50(2)	50 m	tree trunk	80°	N E	±	<9%
Kamakura 9	100(1)	60 m	stone wall	75°	N W	+	≪31%
Kamakura 10	100(1)	20 m	stone wall	90°	N	±	≪22%
Kamakura 11	50(1)	10 m	tree trunk	90°	S W	−	≪16%
Kamakura 12	100(1)	10 m	stone wall	85°	E	±	<19%
Minato 1	76(1)	10 m	tree trunk	90°	N W	−	≪36%
Minato 2	102(1)	30 m	stone wall	90°	S E	−	<10%
Minato 3	76(1)	30 m	tree trunk	95°	N	−	≪44%
Minato 4	50(1)	30 m	tree trunk	90°	N E	−	≪31%
Minato 5	100(1)	50 m	rock	90°	N	±	24%
Minato 6	50(1)	50 m	stone wall	90°	S E	−	11%
Minato 7	50(1)	30 m	tree trunk	90°	E	±	≪36%
Minato 8	50(1)	30 m	tree trunk	80°	N E	−	≪52%
Mitsuishiyama 9	50(1)	130 m	tree trunk	130°	N	+	<11%
Mitsuishiyama 10	50(2)	100 m	tree trunk	80°	E	+	<18%

Mitsuishiyama 11	50(3), 76(1)	90 m	tree trunk	60°	NW	±	≪34%
Mitsuishiyama 12	50(1)	90 m	tree trunk	60°	NE	±	≪33%
Mitsuishiyama 13	76(2)	170 m	tree trunk	90°	N	−	≪36%
Mitsuishiyama 14	50(1)	270 m	tree trunk	70°	SE	±	<22%
Mitsuishiyama 15	50(1)	280 m	stone wall	90°	E	−	27%
Mitsuishiyama 16	50(1)	100 m	tree trunk	90°	S	−	<29%
Kiyosumiyama 17	50(1)	30 m	stone wall	70°	NE	±	≪41%
Kiyosumiyama 18	50(1)	50 m	tree trunk	135°	SE	−	<16%
Kiyosumiyama 19	50(1)	100 m	stone wall	80°	SW	−	14%
Kiyosumiyama 20	50(1)	100 m	tree trunk	70°	N	−	<23%
Kiyosumiyama 21	50(2)	220 m	tree trunk	130°	NW	−	≪27%
Kiyosumiyama 22	50(1)	220 m	tree trunk	85°	E	−	14%
Kiyosumiyama 23	50(2)	220 m	tree trunk	85°	NE	−	15%
Kiyosumiyama 24	50(1)	220 m	stone wall	60°	SE	−	18%
Kiyosumiyama 25	50(1)	280 m	tree trunk	90°	N	−	≪35%
Kiyosumiyama 26	50(1)	280 m	rock	90°	SE	−	31%
Katsuura 1	50(1)	120 m	tree trunk	90°	NE	−	≪36%
Katsuura 2	50(1)	10 m	straw-thatched roof	30°	NW	+	51%
Katsuura 3	50(1)	40 m	tree trunk	85°	W	±	20%
Katsuura 4	50(1)	20 m	stone wall	25°	W	±	28%
Ohara 5	50(1)	10 m	tree trunk	95°	NE	±	19%
Ohara 6	50(1)	10 m	tree trunk	90°	S	−	21%
Ohara 27	50(1)	20 m	tree trunk	120°	N	−	31%
Ohara 28	50(1)	20 m	concrete wall	90°	E	±	29%
Ohara 29	50(1)	20 m	stone wall	90°	E	−	≪29%
Ohara 30	50(1)	20 m	tree trunk	80°	SE	−	15%
Ohara 31	50(1)	50 m	tree trunk	90°	W	−	12%

* The symbols +, ± and − represent humid, moderate and dried condition, respectively.

** The sign of inequality < or ≪ is given for the case where deciduous trees covered the habitat to a certain degree or to a great degree, respectively.

the white part representing the sky to the whole of the picture (hereafter referred to as 'openness rate', a tentative term) was calculated basing on the enlarged picture. For the determination of somatic chromosome numbers of materials, root tips were pretreated with 0.002 M 8-hydroxyquinoline solution for about 3 hours, and fixed in 45% acetic acid for about 20 minutes. The fixed root tips were macerated with 1N HCl at 60°C for about one minute and squashed in 2% aceto-orcein.

Results and discussion

Cytotypes As listed in Tab. 1, 114 plants were examined for their somatic chromosome numbers and the following seven cytotypes were detected in this study (Fig. 2) : 2n=50 (65 plants), 2n=51 (1), 2n=75(1), 2n=76 (6), 2n=100 (17), 2n=101 (2), and 2n=102 (22).

As readily seen in the results, the main cytotypes in Kanto districts are those of 2n=50, 2n=100 and 2n=102. It may be notable that the cytotype of 2n=102 occurs rather frequently in Kanto districts. According to the data presented by Takei (1974, 1978), the occurrence frequency of this cytotype in all the tetraploids was about 31% (17 plants out of 54) in Hiroshima Pref. and about 26% (16 out of 61) in Oita Pref. However, it attained to 54% (22 out of 41) in Kanto districts. Considering the fact that spores of this cytotype were all normal in shape (Fig. 3D), it seems probable that the cytotype of 2n=102 constitutes stable strains in Kanto districts as well as the cytotypes of 2n=50 and 2n=100.

Of the seven cytotypes detected in this study, the aneuploid cytotypes with 2n=51, 2n=76 and 2n=101 are recorded here for the first time. As seen in Fig. 3A, B and C, the spores of the plants of 2n=76 and those of 2n=101 were entirely and partially abortive, respectively, though the spores of that of 2n=51 were almost normal in shape. A further study is necessary to account for the origin of these cytotypes.

Distributions Data for the environmental conditions of habitat are given in Tab. 1. The study by Takei (1978) on *L. thunbergianus* of Oita Pref. showed that the diploids with 2n=50 occurred frequently at sunny and dried sites, while the tetraploids with 2n=100 and 2n=102 at shady and humid sites. Such habitat preferences, however, were not observed in the materials of Kanto districts. As indicated by the data for the humidity of substratum (Tab. 1), the diploids with 2n=50 were not always found at dried sites, and also the tetraploids with

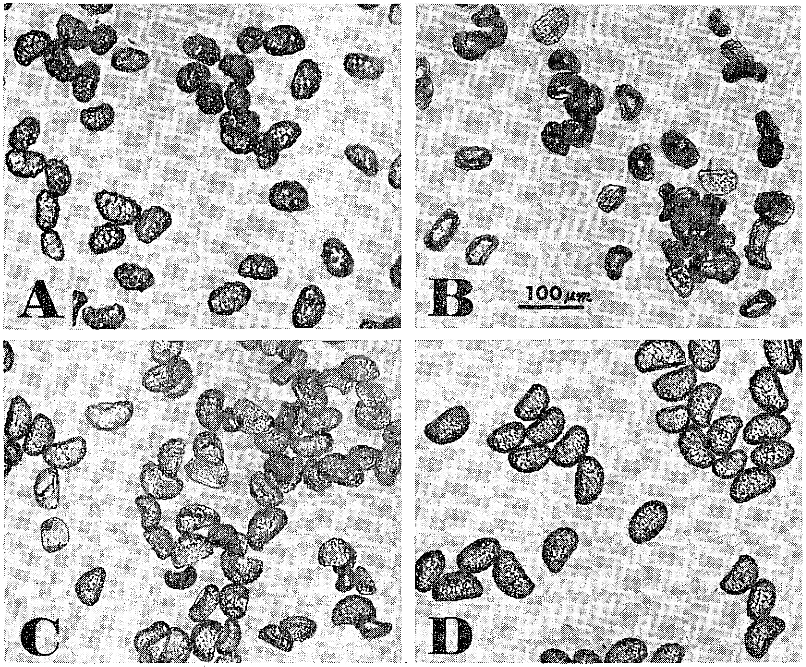

Fig. 3. Spores of four cytotypes. A. 2n=51. B. 2n=76. C. 2n=101. D. 2n=102.

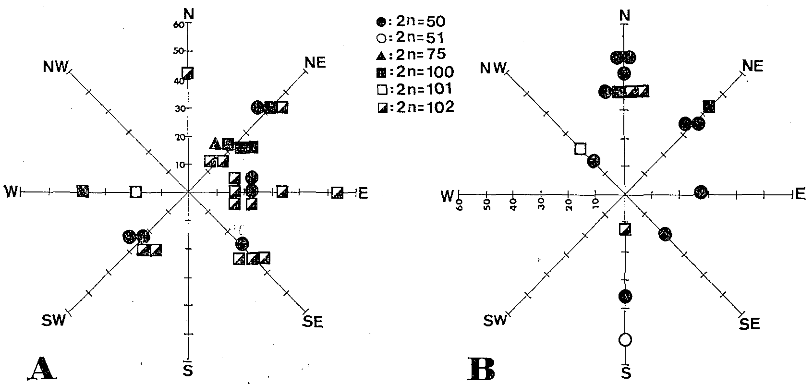

Fig. 4. The openness rates of habitats of the materials in Okutama (A) and Oyama (B). The materials are divided into eight groups according to the exposure of the surface of substratum. Numerals in axes indicate the openness rate (%).

2n=100 and 2n=102 not always at humid sites. The case is similar as to the light requirement of the diploids and the tetraploids. In this study, the light requirement of material was represented expediently by the openness rate of habitat. It is possible to compare two plants for their light requirements in terms of openness rates of their habitats so long as the surfaces of substrata on which they grow are in the same exposure Fig. 4 shows the openness rate of habitat and the exposure of the surface of substratum for the materials collected in Okutama and Oyama. It is indicated by this figure that the diploids and the tetraploids in Kanto districts have no preference in respect to their light requirement, for there is no correlation between the ploidy and the openness rate; in the materials of Okutama, for example, openness rates of diploids are higher than those of tetraploids in NE group, while the reverse is the case in E and SE groups. The diploids and the tetraploids bear no preference also as to the sort of substratum and the inclinatory angle and the exposure of the surface of substratum, as indicated by the data in Tab. 1.

In connection with these features, it is interesting to note that diploids and tetraploids sometimes occurred together even at the same site, as found in Okutama 2, 5 and 6 and Oyama 5 (Tab. 1). Recently, in their study on the populations of polyploid complex of *Lycopodium clavatum*, Takamiya & Tanaka (1982) have observed a successional change of populations and suggested that diploids and other polyploids form at first the mixed type populations, but later they come to separate from each other owing to their habitat preferences and establish the sole type populations at different sites. It seems that such a marked successional change of populations does not take place in *L. thunbergianus* populations in Kanto districts, because habitat preferences were not observed in the diploids and the tetraploids in this area, as mentioned above.

Fig. 5 shows diagramatically the horizontal and vertical distributions of the materials examined. Two major trends are indicated by this figure. First, the diploids occurred dominantly in the coastal regions, as found in the materials of Ohara to Kamakura, while the tetraploids occurred frequently in the inland regions, as seen in the materials of Okutama to Tomioka. Takei (1974, 1978) also observed the same trend in the materials of Hiroshima Pref. and Oita Pref. Second, as seen in the materials of Okutama and Oyama, diploids occurred frequently at the sites of low altitude, while tetraploids at the sites of higher altitude. These trends as to the distributional patterns seem to indicate that,

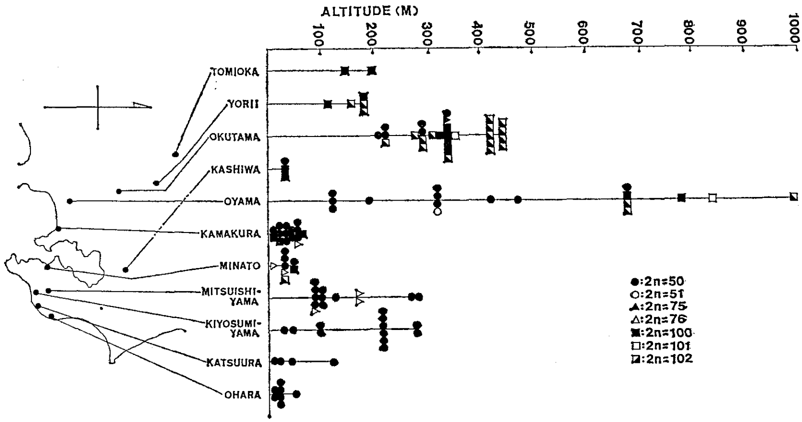

Fig. 5. Horizontal and vertical distributions of materials.

in *L. thunbergianus*, the derived cytotypes, i.e. the tetraploids, have a tendency to occupy the colder climatic regions, while the original cytotypes, i.e. the diploids, the warmer climatic regions. Substantial data for this view will be given in the subsequent papers.

We are indebted to Dr. Hirosi Ito, Emeritus Professor of Tokyo Kyoiku University, for his encouragement in publishing this series of studies.

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ノキシノブには2倍体 (2n=50), 3倍体 (2n=75), 4倍体 (2n=100) が報告されており，さらに高4倍体 (2n=102) の存在も知られている。今回，関東地方においてこれらのサイトタイプがどのように分布しているかを知るため，11産地84ヶ所の114個体について染色体数，生育地の標高，着生している基質の種類，基質の傾斜度，基質の方位，生育地の湿潤の度合，及び生育地の明るさの度合を調査した。

その結果，染色体数については，新たに 2n=51, 76, 101 の異数体がいくつか発見された。また，2n=102 の高4倍体が正4倍体と同様，量的に多く分布していることが明らかになった。各サイトタイプと生育地の基質，傾斜度，方位，湿潤や明るさの度合との間には，特に相関関係は認められなかった。しかし，2倍体群は主として沿岸部あるいは低地に，4倍体群は主として内陸部あるいは高地に分布するという傾向が認められた。

□天野鉄夫：**琉球列島有用樹木誌** 255 pp. 1982. 同誌刊行会，那覇. ¥3,500 (送料300). 園原咲也氏の琉球有用植物誌は1952年に琉球林業試験場集報 No. 2 として出版されたが，戦後多くの種が加えられ，また多少印刷上の誤りもあったのを天野鉄夫氏が改訂して，沖縄県緑化推進委員会の機関誌「みどり」に昭和53年3月から57年1月まで4ヶ年に亘って連載された。本書はこれを一括して書物にしたものである。結局960種の多くが記載されており，琉球が日本南部として意義があるだけに甚だ重要である。モリヘゴに始まりシロゴクラクチョウカに終るまで分類順に排列し，方言名，形質，産地，分布，用途，備考と適切な記載がしてある。ことに方言名は中々微に入り細を穿ってよく拾ってあるので，まことに参考になるが，仮名書であるのが少々惜しい気がする。用途にも新らしい面がずいぶん書き込まれている。 (前川文夫)

□名古屋野生同好会植物サークル(編)，高木典雄(監修)：**愛知の野草図鑑** 314 pp. 1983. 中日新聞本社，名古屋. ¥2,000. 近頃県単位で図鑑の出版されることが多いがこれもその一つ。県単位で珍らしいものとしてカキノハグサ，ウンヌケ，シラタマホシクサ等が挙がっている。各頁を単位として写真と花の時期，草丈，生育場所及びノートを附け，写真もできる限り大きく，花や果実の写真を添えて理解を助けている。春夏秋の三季に分けたのも思い切りがよく，三季毎に五十音順にしてあるが，二三乱れているのはちょっと気になる。オオバウマノスズクサのノートに「昔は馬の首にこんな鈴をぶら下げたのでしょうか」とあるのも少し気にかかる。植物の図鑑は動物と違って葉，花，果実，種子とまるで違うので，小さな図鑑では苦心のいるところであると思う。 (前川文夫)