

Noriaki MURAKAMI\* & Kunio IWATSUKI\*\*: **Observation on the variation of *Asplenium unilaterale* in Japan with special reference to apogamy**

村上哲明\*・岩槻邦男\*\*： ホウビシダの変異と生殖型

When *Asplenium* sect. *Hymenasplenium* was revised by one of us (Iwatsuki 1975), *A. unilaterale* Lam. was treated in the broad sense, as a species including cytological variants. An apogamic form had been recorded from Japan (Momose 1960, Kurita 1960), though plants with a normal life cycle were described from Ceylon (Manton & Sledge 1954). By the current definition of *A. unilaterale*, it has a very wide distribution, covering most of the tropical and subtropical areas of the Old World. As is expected of such a widespread species, it is variable in its phenetic characters. To analyse the variation, we assessed the differences in phenetic characters, and assigned plants to apparently apogamous or sexual cytotypes on the basis of spore counting. Actual cytological evidence will be presented in a further study.

**Materials and methods** To check for the type of life cycle, the number of spores in each sporangium was counted for all the herbarium sheets of *A. unilaterale* in the herbaria of the University of Tokyo (TI) and Kyoto University (KYO). The size and form of the spores was also taken into account with special reference to irregularity. Plants with 32 spores per sporangium were referred to the apogamous type and those with 64 spores to the normal sexual type. Several sporangia were checked for each leaf, or often more sporangia when irregular numbers were counted.

Phenetic features were studied by general taxonomic methods as noted in the section of observations. Living plants, both in the field and in cultivation, were used for observing several important features.

**Observations** Based on identification of the reproductive types, the following observations were made.

1) Distribution. According to observations from herbarium specimens, each

\* Department of Biology, College of General Education, University of Tokyo. 東京大学 教養学部 生物学教室.

\*\* Botanical Gardens, Faculty of Science, University of Tokyo. 東京大学 理学部附属植物園.

population seems to consist of plants with a single reproductive type. In the preliminary check of herbarium specimens, those from Kuki, Owase-shi, Kii Peninsula, had both types of reproduction, but in the field, although apogamous and sexual populations were observed nearby, no particular population consisted of mixed plants of these two types of reproduction. The same situation occurred in Kata as in Kuki, the two localities being some 20 km apart. Except for these two cases, we found only one type of reproduction from one locality.

The cytological difference is constant in some large geographical areas (Fig. 1):

With only sexual type—Africa, Himalayas, Pacific Islands (Polynesia and Melanesia).

With only apogamous type—Western insular Malesia (Sumatra, Borneo, the Philippines).

Areas containing both types—Japan, Taiwan, Indo-China, Thailand and Malaya.

2) Variation in phenetic characters. For analyzing the variation of phenetic characters in connection with the difference in cytotypes, materials were restricted to those from Japan and adjacent areas where a sufficient number of herbarium sheets were available.

a) Sexual and apogamous forms in Japan. Based only on phenetic features, the Japanese plants are easily classified into two groups, which then correlate with reproductive types. The distinct features are (Fig. 2):



Fig. 1. Distribution of the sexual and apogamous types of *Asplenium unilaterale*.  $\Delta$ , apogamous type.  $\bullet$ , sexual type.

Apogamous type—pinnae subquadrangular in outline, with the posterior and anterior edges nearly parallel to each other except close to the moderately acute apex; sori medial, not reaching to less than 2 mm from the pinna-margin.

Sexual type—pinnae falcate, the posterior and anterior edges nearly parallel to each other in the basal half but gradually narrowing in the distal half towards the acute apex; sori supramedial, often nearly reaching the pinna-margin.

The sexual type defined in this way is shown by ● on Fig. 1. It is rather difficult at the moment to compare this form (the sexual type found in the Far East) with the sexual type known in continental Asia, Africa, and the Pacific Islands.

The apogamous type of reproduction was previously noted by Momose (1960) and Kurita (1960). We made preliminary observations on gametophytes from populations in Kami-tonda, Kii Peninsula, and in Kawazu, Izu Peninsula. Numerous gametophytes were collected, but no gametangia were observed, observations in accordance with those of Momose who cultivated many gametophytes for a couple of years without any development of gametangia. It is not certain whether the absence of gametangia is due to immaturity of the gametophytes or not.

b) Variation in the plants on Yaku-shima Island. This wet island is well populated by ferns and our species is not an exception. Both sexual and apogamous types of *A. unilaterale* occur on this island, though the latter type has been recorded here only once, in Kosugidani. Some peculiar irregularities were observed in size and number of spores per sporangium for the sexual type,

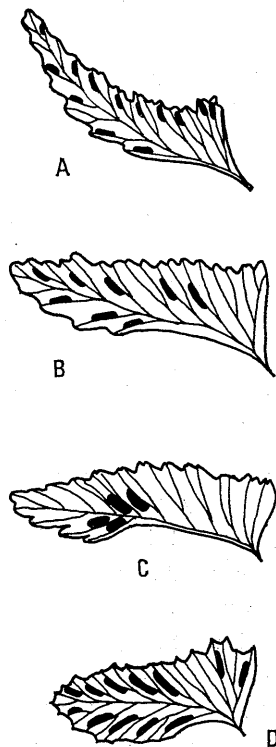


Fig. 2. Pinna morphology of the four forms of *Asplenium unilaterale* in Japan and Taiwan. A, Japanese sexual type. B, Japanese apogamous type. C, Another sexual type with thinner laminae. D, Taiwanese apogamous type.

many individuals of which have sporangia with mostly abortive spores. The occurrence of natural hybridization is strongly suggested by this observation as well as by a comparison of the phenetic features, and a detailed cytological analysis of the populations growing on Yaku-shima island may have interesting results.

c) Japanese and Taiwanese forms of apogamous plants. As apogamous plants directly inherit their characters without any interchange of genetic information with other individuals, variation is usually much less than in plants with normal sexual reproduction. In the case of the apogamous plants of this species found in Japan, they are less variable in phenetic characters than the sexual type, as expected. Moreover, there is a recognizable difference between the apogamous Japanese plants and the apogamous Ryukyu and Taiwan plants, as follows:

Japanese plants—pinnae usually ascending, moderately acute at apex, the margin usually with small and irregular teeth, the base cuneate.

Ryukyu and Taiwan plants—pinnae patent or more or less deflexed, rounded at apex, the margin usually with deep and regular teeth, the base narrowly cuneate.

These two types are geographically segregated except at Yaku-shima Island. Apogamous plants found in northern Thailand are closely similar to the plants in the Ryukyus and Taiwan. *A. subnormale* is similar to the apogamous plants of Taiwan in its pinna morphology, though the former is distinct by its pale-green pinnae with thicker texture, hardly polished petioles, smaller size of plants, and so on. Moreover, all the plants of *A. subnormale* examined are sexual in reproduction.

d) A form with thinner laminae. Another form rather distinct in our area is intermediate between var. *unilaterale* and var. *udum*. In his revision of 1975, Iwatsuki distinguished var. *udum*, with bistratose laminae, as an infraspecific taxon. There are also plants with laminae more than two cells thick and they are larger in size and less transparent in their pagina than in var. *udum*. All the materials of this form examined are sexual in our area, and have laminae with more than three layers of cells, pinna-margins duplo-serrate, with larger and rounded teeth on the posterior side, the pinnae often deflexed, and the sori tending to be close to the costae. This form is found on Yaku-shima Island as well as in the Himalayas and Hawaii. The same type of variant was previously

collected near Owase, Kii Peninsula, though not found in Honshu recently and perhaps now extinct there.

**Discussion** From these preliminary observations, it is concluded that the apogamous forms of *A. unilaterale* seem to have occurred not sporadically but are more or less distinct, even by phenetic characters, from the sexual form found in Japan. The wide-spread *A. unilaterale* is variable in various characters and this variation is correlated at least partly with differences in reproductive methods. The possible occurrence of putative hybrids on Yaku-shima Island may indicate that the various forms of this species are sufficiently differentiated as to warrant taxonomic discrimination.

Four forms have tentatively been recognized for *A. unilaterale* from the Far East in addition to the distinct variety, var. *udum* (Figs. 2, 3). However, it is rather difficult at the moment to identify these four forms with the various names now placed in the synonymy of *A. unilaterale*. Moreover, it is unwarranted to assign these forms to any rank until we can make more detailed studies

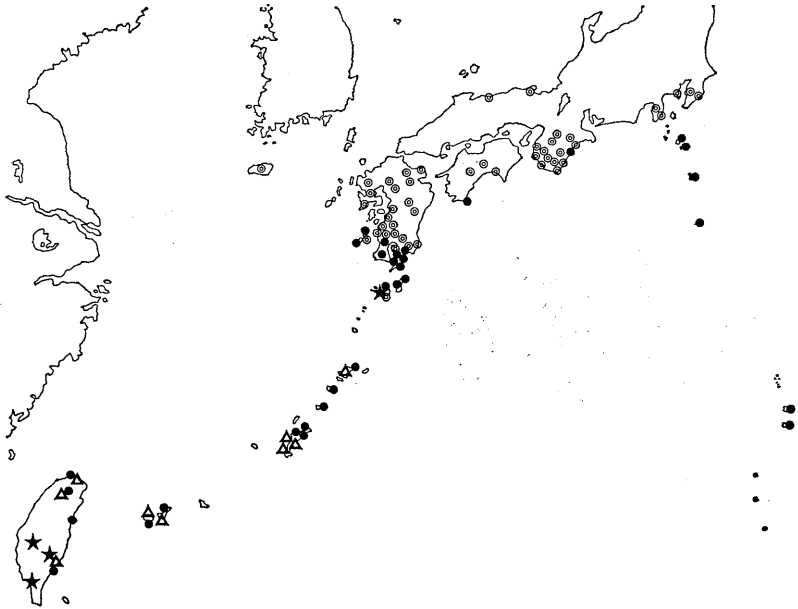


Fig. 3. Distribution of the four forms of *Asplenium unilaterale* in Japan and Taiwan. ○, Japanese apogamous type. ●, Japanese sexual type. △, Taiwanese apogamous type. ★ Another sexual type with thinner laminae.

of this variable species throughout its wide distribution areas. In this study we can only conclude that there are various definable infraspecific taxa in *A. unilaterale*.

In making field studies we were aided by Mr Y. Higuchi and Mr R. Ito; Dr S. Mitsuta supplied us with a variety of interesting materials; the topic was helpfully discussed by members of the Botanical Gardens, University of Tokyo; and the manuscript was checked linguistically by Mr M.G. Price. This study was partly supported by Grant-in-Aid (Special Project, no 57123115) from Ministry of Education, Culture and Science to KI.

#### Literature cited

- Iwatsuki, K. 1975. Taxonomic studies of pteridophyta X. 13. *Asplenium* sect. *Hymenasplenium*. Acta Phytotax. Geobot. 27: 39-54. Kurita, S. 1960. Chromosome numbers of some Japanese ferns. J. Jap. Bot. 35: 269-272 (in Japanese). Momose, S. 1960. The prothallia of Aspleniaceae (3). J. Jap. Bot. 35: 47-54 (in Japanese). Manton, I. & W.A. Sledge. 1954. Observations on the cytology and taxonomy of the pteridophyte flora of Ceylon. Phil. Trans. Roy. Soc. Lond. B. 238: 127-185.

\* \* \* \*

ホウビンダは旧世界の熱帯に広く分布していて変異の大きい種で、日本産のものにもいくつか名前を与えられた型が知られている。ホウビンダには生殖型に正常のものと同アポガミー（無配生殖）を行うものと2型あることが知られていたが、その分布を比較すると Fig. 1 のようになった。生殖型を区別して、地域性も考慮しながら分類形質を比較すると、日本から台湾にかけての地域に4つの型が識別された (Figs. 2, 3)。これらの相互関係を解析するためには、中国や東南アジアの材料を大量に比較する必要がある、日本と台湾のものだけでは命名上の整理もできないので、本報では生殖型の2型が偶発的なものではないということを示唆するにとどめる。