ユウバリコザクラの花形態と栽培下での授粉実験

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Takahiro Tsukui and Hideki Takahashi : **Floral Morphology of *Primula yuparensis* and Pollination Experiments in Cultivation**

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Primula yuparensis Takeda is an endemic species confined to the serpentine fields of Mt. Yubari (Takeda 1913 ; Tatewaki 1955 ; Toyokuni 1960 ; Brooks 1987 ; Yamazaki 1993). This species is categorized as critically endangered in the latest Japanese Plant Red List (Environment Agency 1997) and is difficult to cultivate for long periods in rock gardens in Hokkaido (Takahashi and Tsukui 1994). Nosaka (1960) considered this a ultrabasicosaxophyte, i. e., a characteristic species that is morphologically recognizable in ultrabasic rock areas, and distinguishable as an independent species (Toyokuni 1955).

Distylous species consisting of two self-incompatible but inter-fertile floral morphs, *pin* and *thrum,* are predominant in the genus *Primula*. However, about 40 species of *Primula* (9 %) are partly or completely long-homostylous (Richards 1993). Descriptions of the flower morphs of *P. yuparensis* are inconsistent. Bruun (1938) first reported the flowers of *P. yuparensis* to be monomorphic. Smith and Fletcher (1943) stated that the flowers of *P. yuparensis* have stamens reaching the corolla throat with the style protruding a little beyond. Recently Hara (1989) reported the long-homostyly with sufficient spatial separation between stigmas and anthers which promote outcrossing. However, Wedderburn and Richards (1992) and Richards (1993) suggested that self-fertile long-homostylous flowers of *Primula* including *P. yuparensis* have the stigma and the anthers together at the flower mouth, and that automatic self-pollination occurs.

In the present study, to clarify the floral traits of *P. yuparensis*, we examined the detailed spatial relationship of stigmas and anthers in the wild and cultivated flowers. In order to determine the degree of self- and cross-compatibility and the possibility of self-pollination, pollination experiments were performed in cultivation.

Materials and Methods

In the wild, flowering extends from June to July. At least two flowers were collected randomly from each plant in mid-June, 1994 and 1995. The flowers were fixed in formalin-acetic acid-alcohol (FAA) mixture. The distance between the top of the stigma and that of the anthers was measured by using a micrometer. Three fully opened flowers used for pollination experiments were selected from each plant and the stigma-anther distance of the flower was also measured by using slide calipers.

The pollination experiments were conducted in the Botanic Garden, Hokkaido University, Sapporo in 1997. The seeds collected from the natural habitat were sowed in 1994 and sixteen plants were pot-grown for experiments. All plants were caged in a finely meshed nylon net (insect-free conditions) before anthesis and the flowers were artificially pollinated at anthesis while caged.

Results and Discussion

Figure 1 shows the typical flower of *P. yuparensis*. In most flowers, the style usually surpasses the anthers both in the wild and in cultivation.

Figure 2 shows the distribution of the stigma-anther distance of *P. yuparensis* flowers. The means of the distance in wild plants were 2.8 mm in 1994 and 2.4 mm in 1995. The mean of the distance in the cultivated plants was 2.1 mm. The anther-stigma distance in wild plants ranged from 0.8 to 5 mm in 1994 and from 0 to

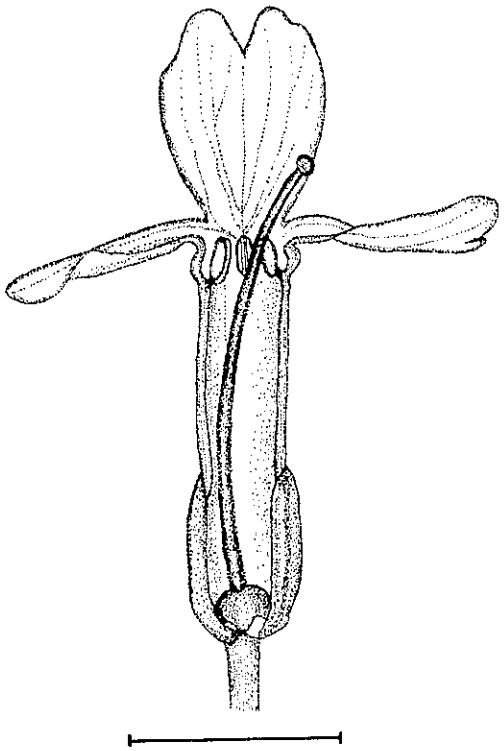

Fig. 1. A typical flower of *Primula yuparensis* . Scale 5 mm.

4.4 mm in 1995. The range of the distances in cultivated plants was 0 to 4.5 mm. These results indicate that the flowers of *P. yuparensis* are not simple monomorphic long-homostylous in which stigma and anthers are at the same level in a flower and there is considerable variation in the distance between stigma and anthers.

The separation of stigma and anther in the same flower has been known as herkogamy (Webb and Lloyd 1986). Considerable variation in herkogamy was observed in *P. watsonii* (Tremayne and Richards 1993). The degree of herkogamy in this species was negatively correlated with the altitude of the habitat. Considerable variation of distances in *P. yuparensis* might be closely related to habitat conditions. Tremayne and Richards (1993) suggested that considerable variation in herkogamy may be associated with the narrow-tubed lepidopterophilous flowers in *P. watsonii*. In connection with this, it is noticeable that the flowers of *P. yuparensis* have one of the narrowest corolla tubes (about 10 mm in length and 2 mm in width, based on cited data of Yamazaki (1993)) as compared with other Japanese *Primula* species.

The results of the pollination experiments are presented in Table 1.

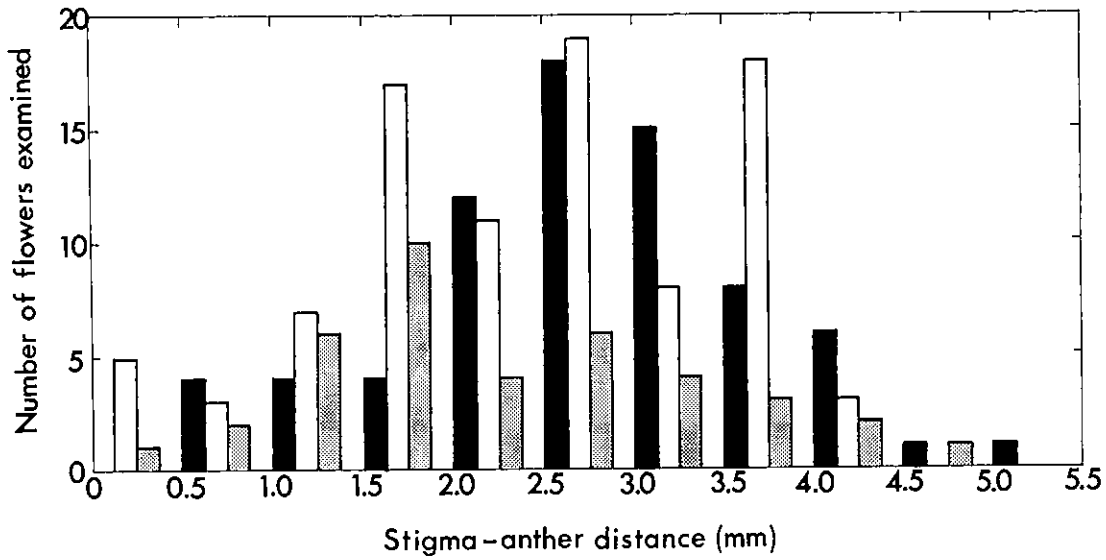

Fig. 2. Variations in stigma-anther distance (mm) of *Primula yuparensis* flowers in three different samples. Black bars indicate those of the wild population in 1994, white bars, of the wild population in 1995, and mesh bars, of the population in cultivation.

Artificial self- and cross-pollination resulted in 100% fruit set. This result shows the flowers of *P. yuparensis* are fully self-compatible. Only 6.9 % of the flowers grown under insect-free conditions bore fruits spontaneously. This restricted self-pollination should result from the spatial separation between stigma and anthers in most flowers of *P. yuparensis* (Fig. 2). As in the majority of *Primula* species, the seed set in most flowers of *P. yuparensis* may depend on the outcrossing by pollinators in the wild.

Table 2 shows the comparison of stigma-anther distance between fertilized and unfertilized flowers under insect-free conditions in *P. yuparensis*. Stigma-anther distances of the fertilized flowers were about a half of those of unfertilized ones. Mean distances of the fertilized flowers differed significantly from those of the unfertilized ones (t-Student $P<0.001$). This result suggests that the close proximity of stigma and anthers in these flowers might cause the spontaneous fruit set by self-pollination because the flowers show full self-compatibility. Stigma-anther distances less than about 1.5 mm promote physical contact between the stigma and anthers, and a possible self-pollination in *P. watsonii* and *P. concholoba* (Tremayne and Richards 1993). Flowers in which stigma-anther distances did not exceed 1.5 mm comprised over 10% of *P. yuparensis* flowers (11.0% in 1994, 16.5% in 1995 and 23.1% in cultivation: Fig. 2). It is assumed that the flower having the close proximity of stigma and anthers might cause self-pollination in the absence of pollinators under wild conditions.

Considerable variation in the distance between stigma and anthers of *P. yuparensis* flowers can affect the pollination efficiency and the amount of crossing and selfing in wild populations. Actual observations on the breeding system, seed production, pollen flow, and insect activity need to be made in the wild.

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Table 1. Fruit setting rates (%) by various pollination treatments under insect-free (caged) conditions in *Primula yuparensis*

	Caged cross-hand pollination	Caged self-hand pollination	Caged
Fruit setting rate	100 (35)	100 (15)	6.9 (217)

( ) Numbers of sample flowers.

Table 2. Comparison of stigma-anther distance (mean±SD) between fertilized and unfertilized flowers under insect-free conditions in *Primula yuparensis*

	Fertilized	Unfertilized
Stigma-anther distance (mm)	1.3±0.7 (12)	2.5±1.0 (27)

( ) Numbers of sample flowers.

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津久井孝博・高橋英樹：ユウバリコザクラの花形態と栽培下での授粉実験

ユウバリコザクラ *Primula yuparensis* は夕張岳の蛇紋岩崩壊地にのみ見られる固有種で絶滅危惧種である。本種の花形態は多くのサクラソウ属植物が2型性を示すのに対し、単型であるとされてきた。しかしその解釈についてはこれまで、1) 葯と柱頭の位置が充分離れた外交配型の long-homostyly と呼ばれる単型花、と 2) 葯と柱頭の位置が同じ位置にある long-homostyly, とがあった。今回の観察で、ユウバリコザクラの葯と柱頭の位置は通常離れているが、その距離は花により 0–5.0 ミリの大きな変異があることが分かった。さらに授粉実験により自家、他家授粉ともに和合性があることが確認された。訪花昆虫を除いた状態でも自然結実する花が少数（6.9%）ありこのような花では柱頭ー葯間距離が短い傾向があった。これは他家授粉とともに機械的な自家授粉が低頻度ながらおこっている可能性を示唆する。今後自生状態での繁殖様式の研究が必要である。

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