

Ecology and Life History of Early Spring Woodland Flowers in Hokkaido

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As warmth replaces cold and days lengthen in spring, forests and fields start to turn from brown to green. The forest floor in particular, is brightened as scores of wild flowers, "the spring ephemerals", bloom. These flowers open and leaves unfurl over a period of just few days. During the short period before canopy closure, the spring ephemerals show us many unique and different ecological features. Here I introduce the ecology and life history of representative woodland perennial flowers in Hokkaido.

Symplocarpus foetidus var. *latissimus* (Zazen-sou, ザゼンソウ) [Plate 1] and *Lysichiton camtschaticense* (Mizu-bashou, ミズバシヨウ) [Plate 2]

Both *Symplocarpus foetidus* Nutt. var. *latissimus* (Makino) Hara and *Lysichiton camtschaticense* (L.) Schott are species in the Araceae. Although most of the species in the Araceae are common in tropic regions, these two genera are adapted to cool temperate regions, having very unique life forms.

Symplocarpus foetidus var. *latissimus* can be found on the mesic forest floor of northern summer-green forests. The North American relative, *S. foetidus* var. *foetidus*, is known as "skunk cabbage" because of the unpleasant odor which emanates from all parts of the plants. In early April, one side of the purplish spathe of the Japanese skunk cabbage, *S. foetidus* var. *latissimus*, begins to open and the spadix can be seen. The flowers start blooming at the top of the spadix before the leaves emerge, and they mature their female parts first (female phase). By the time the lowest flowers have matured their female parts, the top ones are in the male stage and

shedding large amounts of pollen (bisexual phase). Subsequently, the whole spadix becomes male phase in the late flowering.

In the flowering season, and especially during the female and bisexual phases, the spadix produces heat raising the temperature and are 3-15°C higher than air temperature (Uemura et al. 1993; as *Symplocarpus renifolius*). The heat is produced by respiration of the plant and is enough to melt snow around them. The spathe may act as an insulator for the flower. This heating mechanism may have several functions. It has been suggested, for example, that pollinators active in cold weather may take advantage of the warmth produced by the spathe before flying on to the next flower. Infrequent pollinator visitations (rove beetles and mosquitos) may explain low seed set of Japanese skunk cabbage under natural conditions (Uemura et al. 1993).

Once the flowers are pollinated, the spathe disintegrates and the spadix bends down. At about this same time the leaves begin to grow. The seeds are matured inside the spadix and are grouped together into what is called a compound fruit. The genus name for skunk cabbage refers to this fruit; symplorce means "connection" and carpos means "fruit". The seeds are removed by the Japanese wood mouse in late summer. The mice eat many of these seeds immediately, but some of them are hoarded beneath the litter layer (Wada and Uemura 1994; as *Symplocarpus renifolius*). The leaves die back in autumn; new leaf buds and flower buds are produced in late summer, and they are the form in which the plant will overwinter.

Lysichiton camtschatcense is similar in gross morphology to *S. foetidus* var. *latissimus*. The flowers of *L. camtschatcense*, however, are arranged on an upright spadix surrounded by a showy white spathe; the leaves are huge. *L. camtschatcense* thrives in slow-moving woodland stream or swamps, and one can often encounter very large populations along muddy streamsides where light is able to penetrate. Life history of *L. camtschatcense* is outlined by Fujita and Ejima (1997) in the following paper. There are only two species in this genus in the world. The other species, *L. americanum*, is distributed in western North America, and it has bright yellow spathe.

L. americanum is sometimes called western or yellow skunk cabbage.

Erythronium japonicum (Katakuri, カタクリ) [Plate 3]

Erythronium japonicum Decne. is one of the representative spring woodland perennials of Japan. The large showy pinkish flower has attracted not only flower lovers, but also many scientists, and the life history and demographic characteristics of this species have been intensively studied (Kawano 1982; Kawano et al. 1982, 1987; Kawano and Nagai 1982).

This species flowers in early May in Hokkaido. Juvenile plants of this species grow among the flowering adults. Seedlings can be easily recognized because of the lanceolate leaf. Older, vegetative (non-flowering) individuals are characterized by ovate leaves with a round base. The leaf size and biomass of individuals increases gradually every year. Individual plants reach sexual maturity in six to seven years. Once a certain critical size in biomass is reached, the plant produces two basal leaves, and a single scape and flower. *E. japonicum* is a typical polycarpic perennial, and its life span extends over 20 years (Kawano et al. 1987).

Erythronium japonicum propagates primarily by seeds and vegetative reproduction is rare (Kawano 1982). This species is outbreeding and no inbreeding occurs (Kawano and Nagai 1982). The flowers have high UV absorbent perianth and very large nectary in the auricles at the base of the inner perianth (Utech and Kawano 1975). Carpenter bees (*Xylocopa appendiculata circumvolans*), bumblebees, and butterfly (*Luehdorifa japonica*) are important pollinators.

The capsules mature in June and the average number of seeds per capsule is 16-27. Each seed is about 4-5mm long and bears a relatively large elaiosome. The elaiosome is attractive to the ant, *Myrmica kotokui* who disperses the seeds after the seeds have fallen from the plant. This secondary seed dispersal may reduce crowding of seedlings (Ohkawara et al. 1996). Furthermore, seeds from *E. japonicum* plants drop over several days. This seed-fall pattern may be effective in raising the frequency of seed removal by ants and reducing seed predation by some arthropods.

Gagea lutea (Kibanano-amana, キバナノアマナ) [Plate 4]

Another liliaceous spring herb is *Gagea lutea* (L.) Ker-Gawler. Large populations of this plant can be seen on the main campus and the Botanic Garden of Hokkaido University. Ecological studies in the Botanic Garden have showed wide ecological preference of this species, from lawn to forest floor, and the species thrives despite frequent human disturbances such as weeding and stamping (Takahashi and Tani 1997).

This species normally reproduces by seed, although vegetative reproduction by bulbils may occur rarely (Harasawa 1968). Multiple flowers are produced per plant depending on its growth stage, and each flower produces about 11 seeds on the average (Takahashi and Tani 1997). Seed set varies widely among flowers possibly due to variation in pollinator activities.

Adonis ramosa (Fukuju-sou, フクジュソウ) [Plate 5]

Adonis is a genus of Ranunculaceae and one of the most popular ornamental wild herbs in Japan. However, this group has recently been endangered and threatened by development and human activities. The genus *Adonis* in Japan is divided into three species; *A. amurensis* Regel et Radde, *A. multiflora* Nishikawa et Ko. Ito and *A. ramosa* Franchet (Nishikawa and Ito 1978, 1979; Nishikawa 1988) on the basis of morphology and chromosome number. *A. amurensis* has $2n=16$ chromosomes and bears only a single flower per stem. It is distributed in eastern Hokkaido. *A. multiflora* has $2n=16$ chromosomes and bears 3-8 flowers per stem. It occurs from northern Honshu to Kyushu in Japan. *A. ramosa* has $2n=32$ chromosomes and bears mostly one, sometimes several flowers per stem. This species is endemic to Japan and is distributed in Hokkaido, Honshu, and Shikoku. Two species of the genus *Adonis* are distributed in Hokkaido, and we commonly encounter *A. ramosa* in the field. *A. ramosa* has golden parabolically shaped flowers and flowers in early April in Hokkaido. Each flower is composed of 5-10 sepals and 9-19 petals, and sepals are nearly as long as petals.

The parabolic flowers of *A. ramosa* show track the sun's path across the sky helping to maintain a high floral temperature. This

heliotropism in *A. ramosa* affects seed set by promoting pollinator (mostly dipteran insects) attraction and pollen tube growth, and by increasing mean individual seed weight through improvement of thermal conditions for seed development (Kudo 1995).

Anemone flaccida (Ni-rin-sou, ニリンソウ) [Plate 6], *Anemone pseudo-altaica* (Kikuzaki-ichige, キクザキイチゲ) [Plate 7] and *Anemone raddeana* (Azuma-ichige, アズマイチゲ) [Plate 8]

Anemone is also a genus in the Ranunculaceae and about 150 species are known in the world. They can be recognized by their deeply cut leaves. The name anemone comes from the Greek word for "wind", anemos.

A Japanese anemone, *Anemone nikoensis* Maxim. has only one white flower (only sepals and no petals) per ramet as its Japanese common name, ichi-rin-sou, suggests. On the other hand, the common name for *Anemone flaccida* Fr. Schm., which also has white flowers, ni-rin-sou, means two flowers. Although the majority of plants in this species produce two flowers, flower number ranges from one to four per ramet. In the multiple flower ramets, flowering occurs sequentially, and anthesis accordingly becomes longer with flower number. Among flowers within a ramet, early-blooming flowers show large number of pistils and stamens, higher seed production and heavier seeds (Nishikawa and Kudo 1995) than late blooming flowers. *A. flaccida* is self-incompatible and syrphid flies and flies are major pollinators in belying the English common name for *Anemone*, wind-flower. Production of the other late flowers compensate the failure in seed production under the condition of unpredictable pollinator activities (Nishikawa and Kudo 1995).

Anemone pseudo-altaica Hara and *A. raddeana* Regel are also representative spring anemones in Hokkaido. Both these species have relatively big flowers, 3-4 cm in diameter. The color of the flower (sepal) in the former species varies from light-purple to white, and in the latter white with pale purple beneath.

Corydalis ambigua (Ezo-engosaku, エゾエンゴサク) [Plate 9]

Corydalis ambigua Cham. et Schlecht. is in the Papaveraceae. The

plant generally produces from one to three inflorescences per plant. The flowers are strongly zygomorphic, light blue (white form flowers sometimes can be seen in the field) with a deep blue palate, arranged in racemose inflorescences of 1 to about 15 flowers. Each flower has a spur in which nectar collects. The plants flower from the end of April to early May. Each flower remains in anthesis for 3-4 days.

Corydalis ambigua is self-incompatible, and seed production is significantly affected by the behavior of the pollinators (Ohara and Higashi 1994). During its short flowering period, this plant is exclusively visited by overwintering queens of the bumblebee (*Bombus hypocrita sapporensis*). As mentioned above, each flower has a spur in which nectar collects. Many bumblebees, however, frequently collect nectar directly through the spurs using perforations made by themselves or predecessors. We can observe many holes on the spurs in the field (Sakagami 1951). This behavior is commonly called as 'nectar robbing' and has been considered detrimental to plants because it damages and robs the flowers without contributing directly to pollination. Close observation has confirmed, however, that the nectar robbers open the inner petals enclosing the anthers and stigma frequently while visiting the front of the flowers before robbing, while walking about on the flowers or while collecting nectar through the perforated spurs. This behavior more appropriately is called robber-like pollination (Higashi et al. 1988).

Corydalis ambigua plants with larger numbers of flowers receive more visits from bumblebee queens and show higher seed production than plants with fewer flowers (Ohara and Higashi 1994). This phenomenon is observed in other plant species as well. The duration of visitation (foraging time) rather than the frequency of visitation (number of visits) was critical for higher fecundity. While they are searching for flowers with nectar, perforating the spurs and absorbing the nectar, the bumblebees open the inner petals that enclose the anthers and stigma. Bumblebees that stay longer at flowers should deposit more pollen grains, as a result of the increased chance of a stigma touching a polleniferous area of the bumblebee's body. Accordingly, in *C. ambigua* longer visits are very

important and increase the chances that the pollinators will open more flowers and touch the stigma and anthers. Inflorescences with many flowers, which provide more nectar rewards, receive longer visits and more pollen grains, thus, have higher seed production.

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Outline of Life History of *Lysichiton camtschatcense* (Araceae)

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There are only two species in the world recognized as members of the genus *Lysichiton*, large perennial herbs of the Araceae. *L. camtschatcense* which has a white spathe is distributed widely in Japan, Kurile Islands, Kamchatka, Sakhalin and Ussuri. *L. americanum* which has a yellow spathe is distributed in western North America. In Japan, *L. camtschatcense* can be found from Hyogo Prefecture and north of Chubu district to Hokkaido; it grows in swampy places, on pond shores or stream banks. In Honshu it is usually found in mountain areas, and in Hokkaido it is widespread from lowland to alpine areas. In early spring, just after snow melt, this species begins to bloom with a large conspicuous white spathe, and it is one of the most common spring flowers. Though it is a popular spring flower in Japan, there are few reports about the life history or ecology of this species. Hiratsuka et al. (1994) described the size structure and seedling recruitment of a *L. camtschatcense* population at Yoshinotaira in Honshu. Hoshi and Ohashi (1993) described morphological features of this species. Fujita and Tachikawa (1994) showed the relationship between the growth of *L. camtschatcense* seedlings and light conditions.

We have been investigating the life history of *L. camtschatcense* since 1991 at our main site, Ishikari Oyafuru, and at the sub sites of Niseko and Souashibetu (Hokkaido Development Association, 1991, 1993, 1994, 1995a, 1995b, 1996). In this paper, we will outline the life history of *L. camtschatcense*.

Habitat of *Lysichiton camtschatcense*

Lysichiton camtschatcense is distributed in mountain areas on the Japan Sea side of northeastern to central Honshu Island (Horikawa 1992). It sometimes appears in lowland areas north of Honshu and is commonly found in the swampy places of Hokkaido from lowland to mountain areas. In wooded areas, large populations of *L. camtschatcense* can be found in the *Alnus japonica* or *Alnus japonica*–*Fraxinus mandshurica* var. *japonica* swamp forest. Our study site, Ishikari Oyafuru (43° 13' N, 141° 22' E), is near the estuary of the Ishikari River. The vegetation of this site is *Alnus japonica* swamp forest, *Salix* forest, hygrophYTE grassland dominated by *Phragmites australis*, *Calamagrostis langsdorffii* and *Carex pseudocuraica*. The distribution area of *L. camtschatcense* is almost coincident with that of *Alnus japonica* forest. The latter is arcuately distributed on the swampy places parallel to the old Ishikari River flows. Therefore the site factors of *L. camtschatcense* population seem to be the same as those of *A. japonica* forest. Table 1 shows the floristic composition of the hygrophYTE grassland and *Alnus* swamp forest of Oyafuru using the dominance and sociability indices of Braun-Blanquet (1964). The dominance value of *L. camtschatcense* is high under the *Alnus* forest yet in the hygrophYTE grassland it is very low. The tree layer of *Alnus japonica* – *Lysichiton camtschatcense* community is composed primarily of *A. japonica* (10-11 m high) and is often mixed with *Fraxinus mandshurica* var. *japonica*. The sub-tree and shrub layers are sparse. In the herbaceous layer *L. camtschatcense* dominates. The coverages of *Carex rhynchophysa*, *Phragmites australis* and *Cicuta virosa* are also high.

According to the Hokkaido Development Association (1995), in April, during the snow melting season, the ground water level of the *Alnus japonica*–*Lysichiton camtschatcense* community in Oyafuru is usually about 20 cm above ground level. The level fluctuates approximately 0.5-0.6 cm a day, and the water level slowly falls during the summer season. By the middle of June the water level drops below ground level and reaches its lowest for the year (–40-50 cm) during July and the middle of August. The level rises up

Table 1. Floristic composition of the hugrophyte grassland and swamp vegetation of Ishikari Oyafuru

A. *Alnus japonica* — *Lysichiton camtschatcense* community
B. *Phragmites australis* - *Calamagrostis langsdorffii* community

Community types	A		B									
Quadrat number	1	2	5	6	3	4	7	8	9	10	11	12
Quadrat area(m ²)	100	100	4	4	4	4	4	4	4	4	4	4
Vegetation height (m) H	10	11	2	1.9	2	1.8	2.2	2	2.3	2.3	2	2
Vegetation cover (%) T	75	80										
Vegetation cover (%) H	80	95	100	100	100	100	100	100	100	100	100	100
Number of species	14	10	13	11	13	12	11	12	10	10	11	10
Tree layer												
<i>Alnus japonica</i>	3.4	4.4										
<i>Fraxinus mandshurica</i> var. <i>japonica</i>	1.2											
Herbaceous layer												
<i>Lysichiton camtschatcense</i>	3.3	2.2	+	+								
<i>Alnus japonica</i>	+	+2				+						
<i>Calamagrostis langsdorffii</i>	1.2		4.5	4.4	3.3	4.4	3.3	3.4	3.3	2.2	2.3	4.3
<i>Carex pseudocuraica</i>			1.2	2.3	2.3	2.3	2.2	3.4	3.3	3.3	3.3	+
<i>Scutellaria dependens</i>			+	+	+	1.2	+				+	+
<i>Lycopus lucidus</i>			2.2	+	+	+		2.2			1.1	
<i>Carex lyngbyei</i>			3.3	2.3				+	1.2			
<i>Lysimachia vulgaris</i> var. <i>davurica</i>			2.2	2.3	1.2	1.2						+
<i>Rubia jesoensis</i>			+	+		+						1.1
<i>Lathyrus palustris</i> var. <i>pilosus</i>						+	1.2	+	+2	2.2	2.2	
<i>Lysimachia thyriflora</i>							+	+	+2	+	3.3	
<i>Phragmites australis</i>	1.2	3.3	5.5	3.4	5.5	4.4	5.5	4.4	5.5	5.5	3.3	4.3
<i>Persicaria thunbergii</i>	+	+2				+	2.3	1.2	+2	3.3		+
<i>Cicuta virosa</i>	3.3	2.2			+2			+	+	+	2.2	
<i>Carex rhynchophysa</i>	2.2	4.4					1.2	+2	2.2			+
<i>Equisetum fluviatile</i>	+		+	+	+					+		
<i>Hosta sieboldii</i> var. <i>rectifolia</i>	+		+		1.2							2.2
<i>Carex</i> sp.			+		2.2	1.1		+				
<i>Solanum megacarpum</i>		+						+		2.2		
<i>Iris setosa</i>			+		1.2							1.1
<i>Lythrum salicaria</i>				+			+					+
<i>Galium trifidum</i> var. <i>brevipedunculatum</i>					+		+2			+2		
<i>Stellaria radians</i>	+	+										
<i>Sium suave</i> var. <i>nipponicum</i>	+	+										
<i>Stachys riederi</i> var. <i>villosa</i>		+				+						
<i>Stachys riederi</i> var. <i>intermedia</i>						+			+			
<i>Potentilla palustris</i>											1.1	2.2
<i>Carex vesicaria</i>	2.2											
<i>Fraxinus mandshurica</i> var. <i>japonica</i>	+											
<i>Ligustrum obtusifolium</i>	+											
<i>Salix sachalinensis</i>							+					

to ground level or above due to precipitation and low evapotranspiration and stabilizes during autumn and winter seasons.

Outline of life History of *Lysichiton camtschatcense*

Figure 1 illustrates the life history of *L. camtschatcense*. Flowering begins from early spring and continues for a month. Spadices are covered with a large white elliptic-ovate spathe. One spadix has 80-1000 florets (hermaphrodite flower). *L. camtschatcense* is entomophilous like *Symplocarpus foetidus* var. *latissimus* (Araceae). The latter blooms in early spring. The spadix of *S. foetidus* var. *latissimus* produces heat, raising its temperature 3-15°C higher than the air temperature (Uemura et al. 1993; as *S. renifolius*). Uemura et al. suggested this heating mechanism may increase pollinator visits. There is no data to confirm that the spathe of *L. camtschatcense* is an organ supporting the pollination by insects.

After flowering, the leaves open sequentially and grow very quickly. In June or in early July the number of green leaves reaches a maximum, the largest size leaf appears and the plant biomass is the largest. From the middle of August leaves with underdeveloped leaf-blades open and in September a conical winter bud appears that is covered with a small hard leaf with underdeveloped leaf-blade.

From the end of July to the middle of August the seeds mature and become covered with a jelly coat. The spadices decay and collapse. The dispersed seeds germinate within the year or after the winter season. Unfortunately we have no data about the span of seed viability. If the seeds are sowed just after gathering, germination is nearly 100%, but if the seeds are stored under dry or low temperature conditions they become dormancy (Hokkaido Development Association 1991, 1993).

A surviving seedling continues growing and it takes about one or two years to become a sterile plant. It reaches a fixed size and begins to bloom as a fertile plant (Fig. 1). Hiratsuka et al. (1994) and Hokkaido Development Association (1993, 1994) report a high positive correlation between plant weight (= plant size) and maximum leaf length. Flowering occurred in the classes that had a maximum leaf length longer than 40 cm at Yoshinodaira, 70 cm at

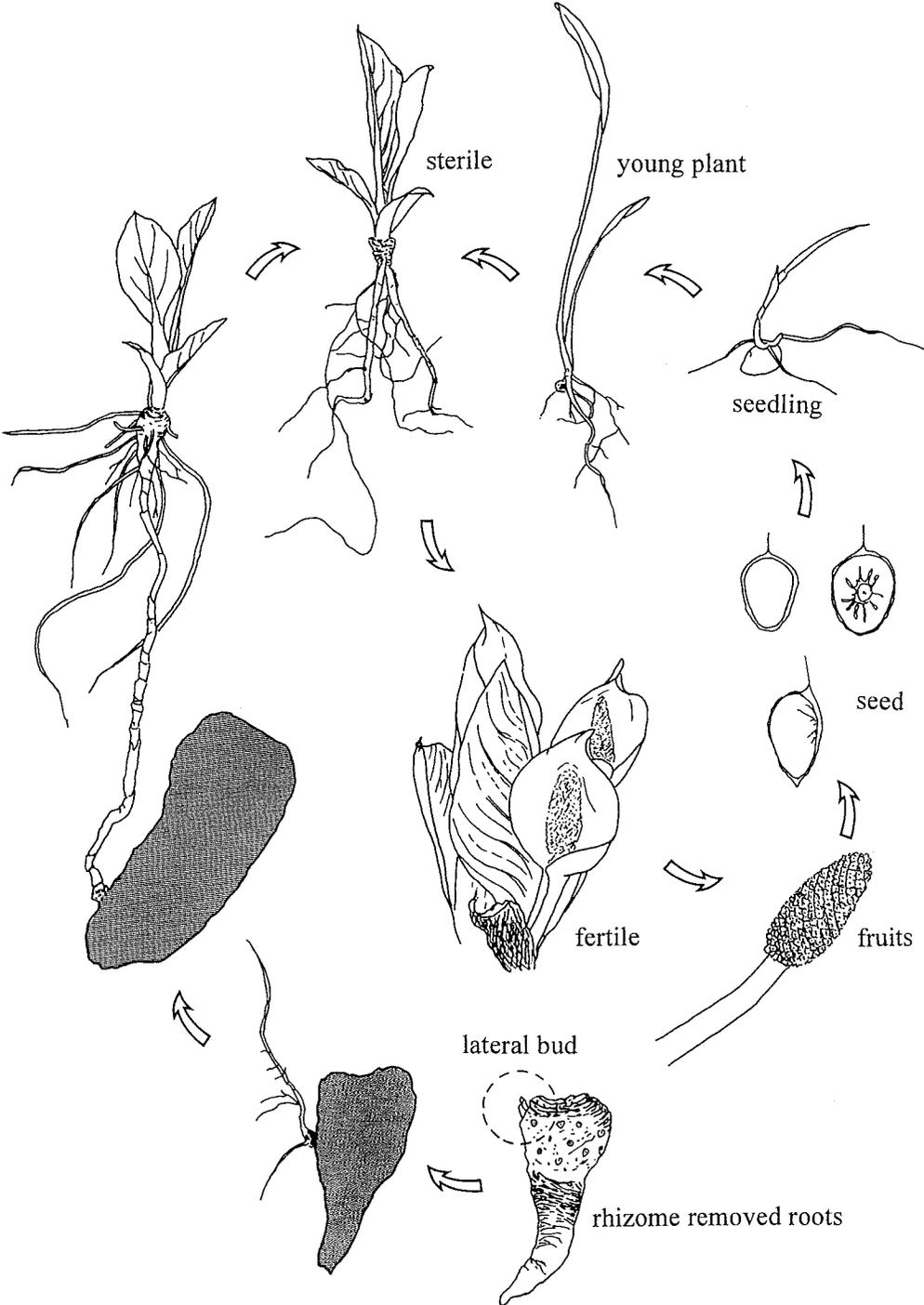


Fig. 1 Life history of *Lysichiton camtschatcense*.

Iahikari Oyafuru and 30 cm at Souashibetsu; the fertile size differs in each population.

As mentioned above, *L. camtschaticense* has a sexual reproduction system, and it also reproduces asexually (Fig.1). *L. camtschaticense* often extends a lateral bud from a rhizome which can develop into a fertile plant. Though *L. camtschaticense* has two reproductive systems, in some populations asexual reproduction is rare (Hokkaido Development Association 1995a, 1995b, 1996).

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BOOKREVIEWS

Flora of Japan vol. IIIb, Angiospermae-Dicotyledoneae: Sympetalae (b). K. Iwatsuki, T. Yamazaki, D. E. Boufford and H. Ohba (eds.), 181pp., Kodansha Ltd., Tokyo. 1995. ISBN4-06-154602-3, ¥25,000.

Following the former fascicle; vol. IIIa in 1993, the last fascicle of volume III containing the Sympetalae was published in February, 1995. In this fascicle on the Asteraceae (Compositae), the majority of the genera are written by H. Koyama and some genera are by other specialists; *Aster* by M. Ito and A. Soejima, *Eupatorium* by T. Yahara, T. Kawahara and K. Watanabe; *Taraxacum* by T. Morita; *Ixeris* by T. Yahara; *Cirsium* by Y. Kadota. Over 50 new names are proposed. In connection with Hokkaido, new dandelion species; *Taraxacum ohirense* S. Watan. et Morita is described. It is endemic to open limestone rubble of Mt. Ohira, southern Hokkaido. We should take notice of the misprint of the specific epithet (as "ohirenses") in the text.

Flora of Japan vol. I, Pteridophyta and Gymnospermae. K. Iwatsuki, T. Yamazaki, D. E. Boufford and H. Ohba (eds.), 302pp., Kodansha Ltd., Tokyo. 1995. ISBN4-06-154603-1, ¥35,000.

Following the former two fascicles; IIIa and IIIb, the volume I on the pteridophytes and gymnosperms was published in November, 1995. The pteridophytes are treated by K. Iwatsuki and M. Kato, and gymnosperms are by T. Yamazaki.

Illustrations of Pteridophytes of Japan, vol. 8. S. Kurata and T. Nakaïke (eds.), 473pp., University of Tokyo Press, Tokyo. 1997. ISBN 4-13-061068-6, ISBN 0-86008-520-1, ¥16,480.

This is the last and supplementary volume of the series of this title which started in 1979. This series includes the illustrations, distribution maps with a full citation of the herbarium specimens for Japanese pteridophytes. This volume contains a supplement to the former distribution maps and a collection of the original description of the species whose type localities are in Japan. This series is written in Japanese, but it should be also useful for the foreign pteridologists.

(Hideki Takahashi)

Life History of the Spring Ephemeral, *Gagea lutea* (Liliaceae) in Sapporo, Hokkaido

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Gagea is a widespread temperate Eurasian genus (70-90 species: Willis 1973; Dahlgren et al. 1985) of bulbous liliaceous perennials which flower in early spring. *Gagea lutea* (L.) Ker-Gawler is a common European species, and in eastern Eurasia it is found in Japan, Sakhalin, Kurils, Korea, China, and Siberia. This species occurs mainly from central Honshu to Hokkaido and is rare in western Honshu and Shikoku in Japan (Satake 1982). It is one of the most common spring ephemerals in Hokkaido, which include *Adonis ramosa*, *Anemone raddeana*, and *Erythronium japonicum*. Plants grow in open secondary grassland and somewhat shady deciduous forest in Hokkaido.

Gagea lutea has one linear-lanceolate basal leaf and 15-25 cm scape with (one- to) several-flowered umbel-like inflorescences. The leaves appear on the ground from the end of March to early April, flowers come out from the middle of April to early May, and aboveground parts disappear in the middle of June after seed dispersal. This timetable is applicable to the Sapporo area, and is affected primarily by year to year variation in snow depth in winter and spring onset.

Ainu, the aboriginal people of Hokkaido, have eaten bulbs and leaves of this species which is called "Chikap-toma" by them (Chiri 1976). The Japanese plant name "Kibanano-amana" means "Yellow-flowered sweet leaves", and *Gagea lutea* is regarded as an edible wild plant even in recent Japanese guidebooks. But today this custom is not as popular as *Allium victorialis* var. *platyphyllum* and

Smilacina japonica of the same Liliaceae in Hokkaido.

We introduce the life history of *Gagea lutea* in this paper by briefly documenting our preliminary observations on the leaf size class structure and the setting of seed.

Materials and Methods

We analyzed two neighboring populations under different environments in the Botanic Garden of Hokkaido University, Sapporo, from 1994 to 1996; one was a population on open sunny lawn edge, which is the typical habitat of this species, and the other was a population on somewhat shady deciduous forest floor. Grasses including *Gagea lutea* on sunny lawn edge are cut several times a year with a lawn mower. Thus, the open site is under unstable and disturbed conditions; the forest site is under the different conditions of variable light intensity and competition with tall forest-floor plants.

Quadrats for examination were set up on different plots at each site from 1994 to 1996, so the variation of size class structures from 1994 to 1996 (a to c in Figs. 1 and 2) does not reflect the fluctuation from year to year, but from plot to plot at each site.

Population structures were evaluated using the ten size classes and seed numbers (SD) estimated. All plants within the quadrat (0.5 × 0.5 m in 1994; ca. 0.6 m² for open sunny population and 1 × 1 m for forest floor population in 1995; 1 × 1 m in 1996) were harvested at the flowering stage (from the end of April to early May), and each plant was classified into ten size classes which are discriminated based on the basal leaf length as follows: Class 0, <6cm; Class 1, 6-9cm; Class 2, 9-12cm; Class 3, 12-15cm; Class 4, 15-18cm; Class 5, 18-21cm; Class 6, 21-24cm; Class 7, 24-27cm; Class 8, 27-30cm; Class 9, 30- cm. Leaf area is a good indicator of the biomass, reflecting the growth stage in *Trillium* of the Liliaceae (Ohara 1989). Because the leaf shape is linear-lanceolate in *Gagea lutea* and it is difficult to measure the leaf area accurately especially in smaller classes, we regarded the leaf length as a simple indicator of the biomass, which may reflect the growth stage in this species.

The number of seeds produced per quadrat was estimated from the flower numbers per quadrat in each year and average seed numbers per flower calculated in 1996 at each site. In each population ten scapes having young capsules were collected at the end of May, 1996, and the seed numbers were counted. Because most plants of *Gagea lutea* at the open site had been cut before the harvest in 1996, the plants which escaped the cut below shrubs planted on the lawn, were used for the value of the open sunny population.

Results and Discussion

Stage (Size) Class Structures and Flower Numbers

The stage (size) class structures of two neighboring populations, from 1994 to 1996, are illustrated in Figs. 1 (open site) and 2 (forest site). Generally speaking, more plants grow within each quadrat at the open site than those at the forest site (pay attention to the different scales of the vertical axes in the figures). The number of plants per m² varies from 2700 to 5500 at the open site and from 350 to 860 at the forest site. Fluctuation (from 1994 to 1996) of the number of plants per quadrat and stage class structures at each site is predominantly caused by different micro-habitats on different quadrat plots.

Stage class structures are not especially different between open sunny population and forest floor population (Figs. 1 and 2); however, larger stage classes (Classes 8-9) more often occur in the latter population.

The plants at the open site may flower at earlier developmental stages than those at forest site. In the open sunny population, the transition from sterile stage to flowering stage is mostly achieved from class 3 (Fig. 3a); class 1 and 2 plants rarely possess flowers. In the forest floor population, the transition is achieved from class 5 and is never achieved before that class (Fig. 3b). Unstable and disturbed conditions at open site could favor early maturity of this species, and *Gagea lutea* at open site is considered to be adapted as a "ruderal" (Grime 1977; Kudo 1991).

In both populations a higher percentage of flowering individuals

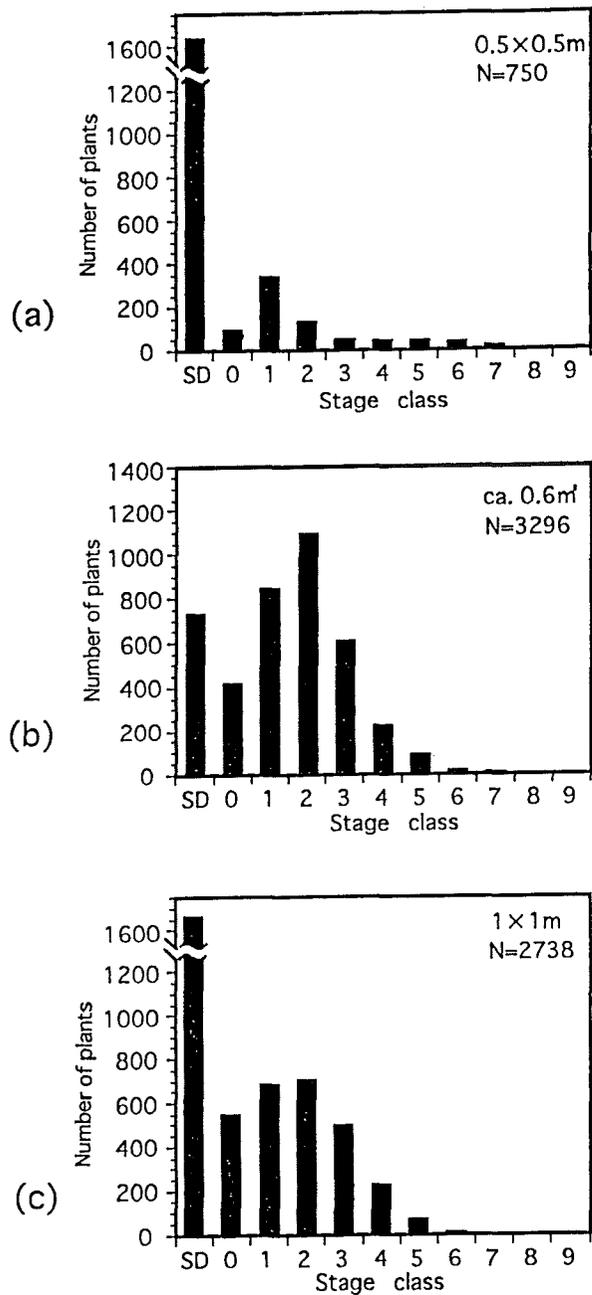


Fig. 1 Stage (size) class structures from open sunny populations of *Gagea lutea* on sunny lawn edge in 1994 (a), 1995 (b), and 1996 (c). The number of seeds produced (SD) was estimated by the number of flowers present in each year \times the mean number of seeds produced per flower in 1996.

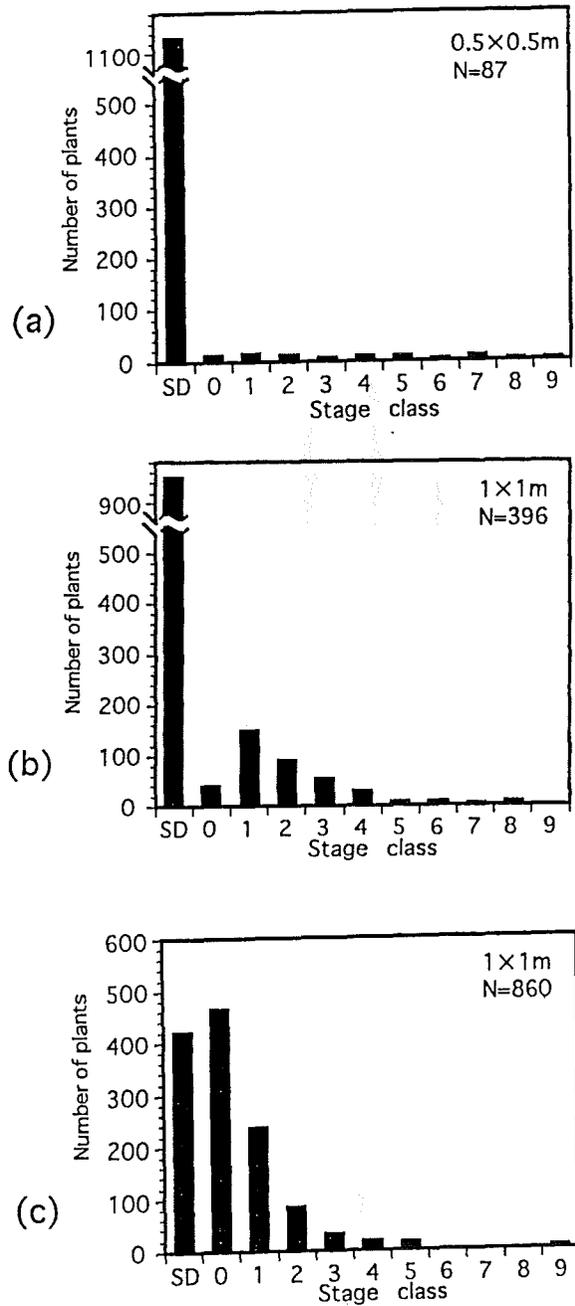


Fig. 2 Stage (size) class structures from forest floor populations of *Gagea lutea* in 1994 (a), 1995 (b), and 1996 (c).

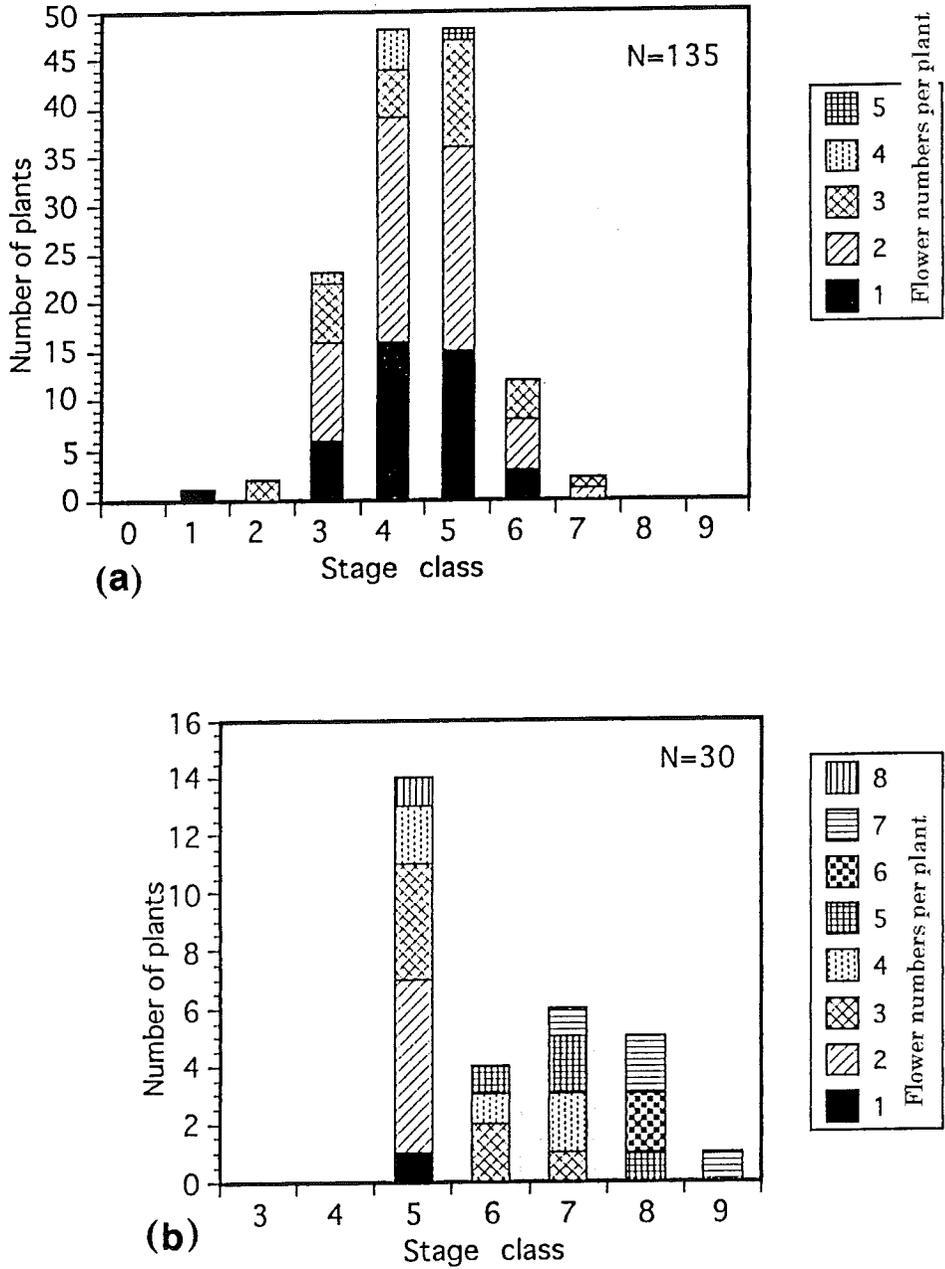


Fig. 3 Stage (size) class structures of flowering plants and the number of flowers per plant from open sunny population (a) and forest floor population (b). Total value of 1995 and 1996.

occurs in the larger stage classes. The flowering plant possesses more flowers at forest site (up to eight flowers) than that at open site (up to five flowers) (Fig. 3), which partly reflects the larger size class plants in the forest floor population. But if we compare the flower numbers per plant in the same stage class between the two populations (e. g., classes 5, 6, and 7 between Figs. 3a and 3b), the same class plants tend to possess more flowers at the forest site than at the open site. Biomass and resource allocation comparisons need to be done between both the sites.

Occasional vegetative reproduction by bulbils in the genus *Gagea* has been reported, but constant vegetative reproduction in *Gagea lutea* has not been stated (Grossgeim 1935; Richardson 1980) except for a brief positive description by Harasawa (1968). Possibility and frequency of vegetative reproduction in this species should be confirmed.

Seed Set

The number of flowers and seeds produced per 1 m² quadrat is very variable depending on the quadrat plots in each year. It is usually larger, however, at the open site than at the forest site (Table 1). This is mainly caused by the presence of more flowering plants within the quadrat at the open site than at the forest site.

There are no distinct differences in the number of seeds and seed setting rate per "normal" flower between the two populations; on the

Table 1. Flower numbers and estimated seed numbers per quadrat at open site and forest site in *Gagea lutea*

	Open	Forest
1994	191-1662/0.25 (764-6648)*	100 -1140/0.25 (400-4560)
1995	84- 731/0.6 (140-1218)	85-969/1 (85-969)
1996	189-1644/1 (189-1644)	37-422/1 (37-422)

* Flower numbers - estimated seed numbers / quadrat size (m²) and (Flower numbers - estimated seed numbers per 1 × 1m quadrat).

average 11.1 seeds and 31.5% in the open sunny population vs. 11.4 seeds and 30.8% in the forest floor population (Table 2). But among 47 total flowers collected and examined in the open sunny population, there occurred ten "non-ovule" flowers in which no recognizable ovules were contained; i. e., 37 "normal" flowers and ten "non-ovule" flowers at open site. These "non-ovule" flowers without seed-setting function occurred only in open sunny population, and their ecological significance has not been clarified yet. If we include them as a total flower number the average number of seeds produced per flower at open site becomes lower (8.7) than that (11.4) at forest site.

The low seed set per "normal" flower at both the sites; 31.5 % and 30.8 %, and wide variation of the seed setting rate between flowers within a plant in both two populations (Tables 2 and 3) may be influenced by unstable climate and unreliable activity of pollinators in early spring of Hokkaido. More seeds and ovules are produced per plant at the forest site than at the open site (Table 2), which is caused by the plant possessing more flowers at the forest site. The

Table 2. Reproductive characteristics (mean number of seeds and ovules per flower and plant, and seed setting rate) in the open sunny population and the forest floor population of *Gagea lutea* in 1996

	N	No of seeds per flower	No of ovules per flower	Seed setting rate per flower (%)
Open	37(47)*	11.1(8.7)**	34.5(27.2)	31.5
Forest	52	11.4	31.8	30.8

	N	No of seeds per plant	No of ovules per plant	Seed setting rate per plant (%)
Open	10	41.00	127.8	31.9
Forest	10	59.20	184.0	34.3

*Among 47 total flowers at open site, 10 flowers were "non-ovule" one which do not contain recognizable ovules without any seed-setting function and other 37 flowers were regarded as "normal" ones.

**Mean in 37 "normal" flowers (mean in 47 total flowers including "non-ovule" flowers).

Table 3. Variation of seed setting rate per flower in each plant growing at open site and forest site in *Gagea lutea*

Plants	Seed setting rate (%)	
	Open	Forest
1	0.0, 34.4, 51.5 (3)	ND, ND, 0.0 (3)
2	6.2, 27.6, 60.9 (3)	0.0, 29.0, 70.7 (3)
3	0.0, 0.0, 0.0, 42.4 (4)	25.0, 32.1, 46.7 (3)
4	0*, 0*, 0.0, 51.5 (4)	ND, 12.5, 35.3, 50.0 (4)
5	0*, 33.3, 56.2, 72.7 (4)	19.0, 20.6, 65.8, 80.5 (4)
6	0*, 0*, 29.73 - 32.35 (5)	0.0, 12.5, 22.9, 55.6, 91.9 (5)
7	0.0, 25.0, 27.3, 51.4, 70.6 (5)	0.0, 2.4, 18.4, 42.1, 55.2 (5)
8	0*, 0*, 21.4, 21.7, 43.2, 45.7 (6)	0.0, 44.4, 51.1, 51.5, 64.0, 71.1, 81.8 (7)
9	16.3, 18.6, 33.3, 39.0, 50.0, 65.2 (6)	0.0, 0.0, 0.0, 5.3, 10.5, 34.2, 60.6 (7)
10	0*, 0*, 0.0, 24.4, 28.9, 40.6, 43.6 (7)	0.0, 0.0, 3.6, 10.0, 10.3, 16.3 16.7, 25.0, 36.7, 62.8, 63.6 (11)

0*, "non-ovule" flowers; ND, not determined.

Numbers in parentheses indicate flower numbers per plant.

first cut with lawn mower at the open site usually occurs during May, but this cutting time is not necessarily stable, and it may be delayed until the end of June in some years. Although the accurate phenology of the seed setting and dispersal at both the sites have not been clarified yet, the time of the first cut and frequency of cuttings may critically effect the life history strategy of *Gagea lutea* at the open site. Cutting during flowering period or before full seed set may result in the extermination of new seedlings in next year. On the other hand, the cutting with lawn mower after seed set may favour seed dispersal onto the lawn.

Above-mentioned between-site variation in *Gagea lutea* may be an example of ecological plasticity. Critical comparisons of biomass and resource allocation, phenology, and pollinator activity between the two sites need to be clarified for more accurate understanding of the life history of this species.

This study was carried out as a part of the Biological Experiment for the third-year students in the Faculty of Agriculture of Hokkaido University, from 1994 to 1996. We express our thanks to the students who measured and calculated.

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Plant Portrait and Plant Research in *Anemone amurensis* (Korshinsky) Komarov

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Anemone amurensis (Korshinsky) Komarov is one of the spring ephemerals which previously has not been listed in flora of Japan. This paper sets out to examine the relationship of plant portraits and research history in *A. amurensis*.

Anemone amurensis is a perennial herb of the family Ranunculaceae and is newly recorded in Hokkaido, Japan (Nishikawa et al. 1988). Though this species has not been listed in most Japanese floras yet, it has been included in a recent plant checklist (Ito et al. 1994) and handbook (Samejima et al. 1993) in Hokkaido.

In the survey of literature for *A. amurensis*, plant portraits in the few floras provide intriguing topics, relating taxonomic subjects. The purpose of plant portraits has been associated with that of human usage for pure decoration, illustration on introduced and medicinal plants, and plant research. Most plant portraits show only one figure of plant species without a scenic backdrop in order to clearly illustrate morphological features of each plant. The history and meaning of plant portrait has been widely discussed by Blunt (1986), but this is not my concern in this paper.

Nowadays plant portrait can be defined as the painting and drawing of plants with botanical accuracy. When we strengthen the point of botanical accuracy on the plant figure, we refer to them as botanical illustrations. A large number of plant portraits have been drawn for illustration in the papers of botanical or plant research published until now. There are few papers, however, on portraits in actual botanical studies. This paper attempts to show the role of plant portraits in research history of the newly recorded *A. amurensis*.

The first portrait drawn as *A. amurensis* in flora of Japan

Before showing portraits of *A. amurensis*, it will be useful to describe the general morphology of the species. The description of handbook (Samejima et al. 1993) is given as follows: the plant is 5-15 cm in height and has a creeping rhizome; involucral leaves are stalked, 3 parted and the lateral and central segment is divided; the flower is borne singly with 5-8 petal-like sepals. Plant drawing (Fig. 1) supplements the description. The morphological characters of this species resemble that of *A. pseudo-altaica* Hara, which is distributed from the middle part of Honshu to the central part of Hokkaido (Tamura 1982). Sepals of *A. amurensis* are shorter and wider than those of *A. pseudo-altaica*. Furthermore, compared with *A. pseudo-altaica*, the rhizome in *A. amurensis* is slender and weak.

As for the modern portrait, pencil and water color drawing is predominant, but all portraits of *A. amurensis* have been black and white line drawings. The first plant portrait drawn as *A. amurensis* was found in Flora of Saghalin (Miyabe and Miyake 1915). But Hara (1939) indicated that the species in Flora of Saghalin differed from true *A. amurensis* in morphology of leaf. It seems that the margins of leaf segments in basal and involucral ones are simple lobed, not cleft as for his indication on the portrait. Afterward, the species in this portrait was regarded as *A. soyensis* H. Boiss. (Hara 1976).

The correct portrait of *A. amurensis* in flora of Japan.

The distribution of this species in Japan is confined to the Pacific Ocean side in eastern Hokkaido (Tokachi and Kushiro district) (Nishikawa et al. 1988; Shinsho and Takashima 1989; Shinsho 1990). Nishikawa et al. (1988) stated that *A. pseudo-altaica* did not occur in eastern Hokkaido. Shinsho and Takashima (1989) investigated floral morphology of the *Anemone* species occurring in the Kushiro district. They regarded this *Anemone* species as a hybrid between *A. pseudo-altaica* and *A. nikoensis* Maxim. because cleft leaf segments was derived from *A. pseudo-altaica* and ovoid perianth-segment in solitary flower from *A. nikoensis*. Afterward Shinsho (1990) considered this *Anemone* in Kushiro district as *A. amurensis*.

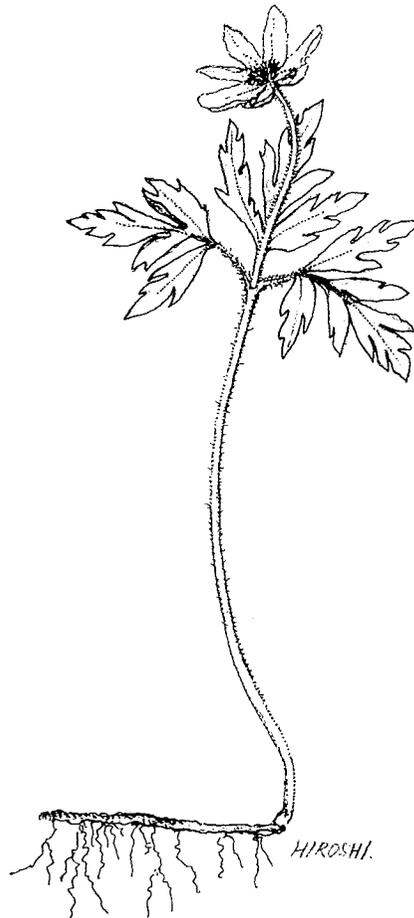


Fig. 1 Line drawing of *Anemone amurensis*. Note the shape of sepals in this portrait and color illustration of *A. pseudo-altaica* at the end of this volume (Plate 7). This figure dose not show the radical leaf. The shape of radical leaf resembles that of involucral one.

The first correct portrait of *A. amurensis* may have been shown by Takita (1987). His portrait was drawn by reference to the plant specimen which was sampled in Kushiro district. Although he illustrated the portrait as *A. pseudo-altaica*, this portrait clearly represented the features of *A. amurensis* ; sepals in the solitary flower were broad and ovoid.

The portrait of *A. amurensis* in flora of China

Since the distribution of *A. amurensis* is the range of northern and eastern China, the portrait of *A. amurensis* is introduced in flora of China. Compared with two portraits in floras above mentioned, the realistic figure of this portraits is due to shading on plant body. Nishikawa et al. (1988) pointed out that the shape of style was characteristic in *A. amurensis* and they cited the plant portrait in Flora of China (Wang 1980). According to Wang's description, this species is characterized by having a hairy ovary and a long hooked style. The morphology of the portrait, however, is different from his description: the style is straight and very short and the stigma is spherical. Interestingly, plant portrait of another flora (Liaoning Sheng Forest and Soil Research Institute 1975) also showed hooked style. It is not evident whether the differences between the portraits in the two floras reveal the intraspecific variation, difference of developmental stage, or just an error.

Conclusion

The plant portraits of floras in *A. amurensis* indicate taxonomic problems of this species in relationship to relative species. In particular, the similarity to *A. pseudo-altaica* may cause the delay in the recognition of *A. amurensis* in Japan.

In conclusion, the author should note that the plant portrait has a role as historical materials rather than as materials for actual research. Because plant portraits reveal how people observe and interpret plant species in each period. The plant portrait can be stated as a pictorial record of botany. In order to increase the evaluation of plant portraits as historical materials, the verification work of the figure and its botanical cognizance in plant portrait in each period should be conducted.

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NEWS

The International Kuril Island Project (IKIP) is an international collaboration of American, Russian, and Japanese scientists to survey the plants, insects, spiders, fresh water and terrestrial mollusks and fish of the Kuril Archipelago. The islands of the Kuril Archipelago form the eastern boundary of the Okhotsk Sea and a bridge between Hokkaido and the Russian peninsula of Kamchatka. Those who are interested in this project can obtain the information from the internet homepage; [<http://artedi.fish.washington.edu/ikip>]. In this home page the following items; project participant, IKIP reports, publications and presentations, IKIP databases, are available.

Internet Homepage [<http://www.cc.hokudai.ac.jp/agricu/exbg>] of the Botanic Garden, Faculty of Agriculture, Hokkaido University is available. You can enjoy the photographs of the Garden landscape throughout the year. Now only Japanese version is available and English version is in preparation.

The preceding volumes of Miyabe are available. Number 1 treats *Trillium* (30 pages and 7 plates) and number 2 *Primula* (27 pages and 9 plates). Please get in touch with the Library of Botanic Garden, Hokkaido University, Sapporo 060, Japan.

The Society for the Support of Botanic Garden, Hokkaido University helps the social and educational activities of the Botanic Garden. The Society publishes postcards of the botanical illustrations in this volume and the poster of alpine plants in Hokkaido.

Errata for No. 2 *Primula* 1994

p. 13 line 6 for *Plimura* read *Primula*

line 8 for *Primura* read *Primula*

p. 24 line 2 and 3 in legend of Fig. 5

for Open bars indicate the thrum's pollen grains and solid ones the pin's grains.

read Open bars indicate the pin's pollen grains and solid ones the thrum's grains.



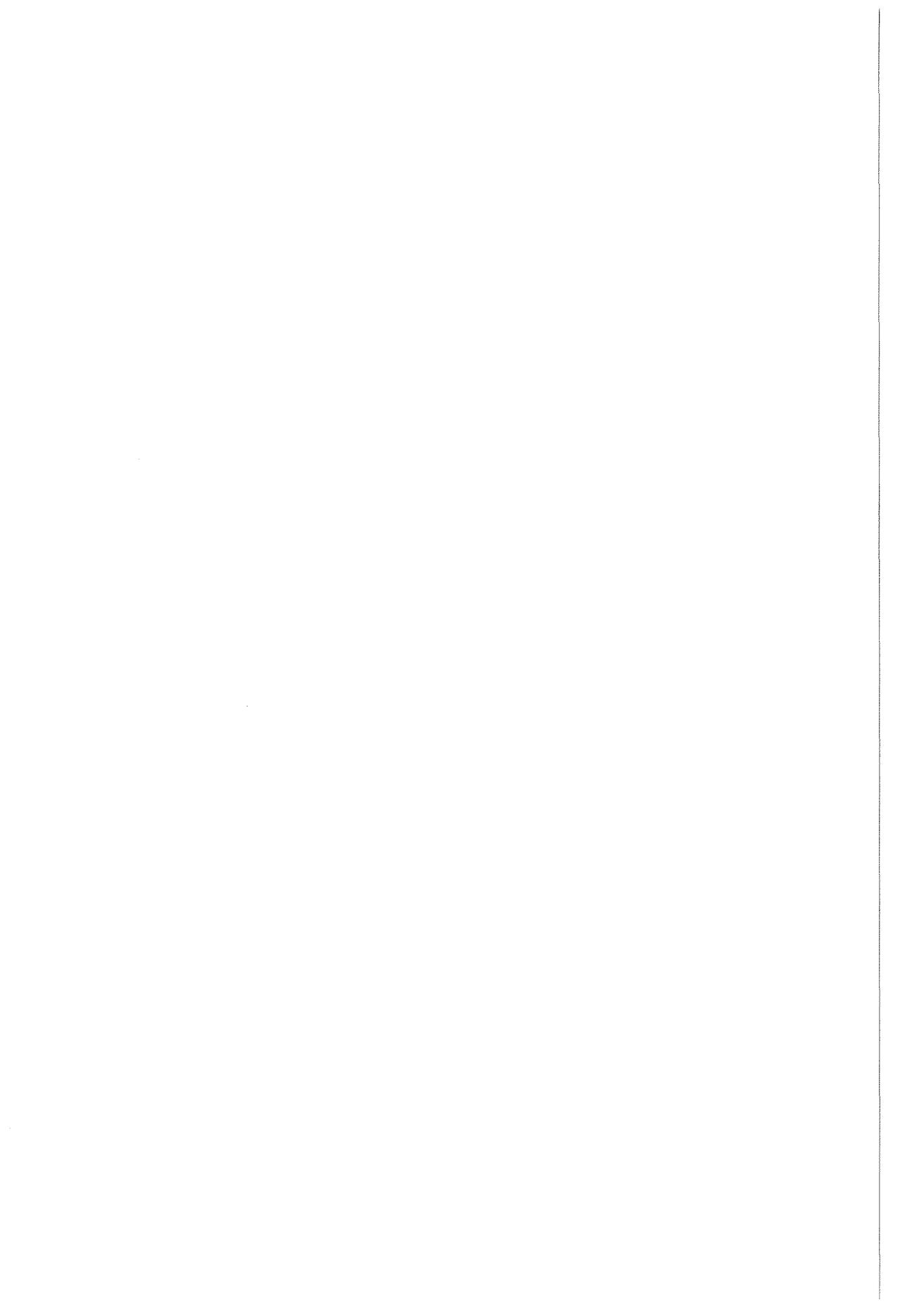
Symplocarpus foetidus var. *latissimus*
ザゼンソウ



Lysichiton camtschaticense
ミズバショウ

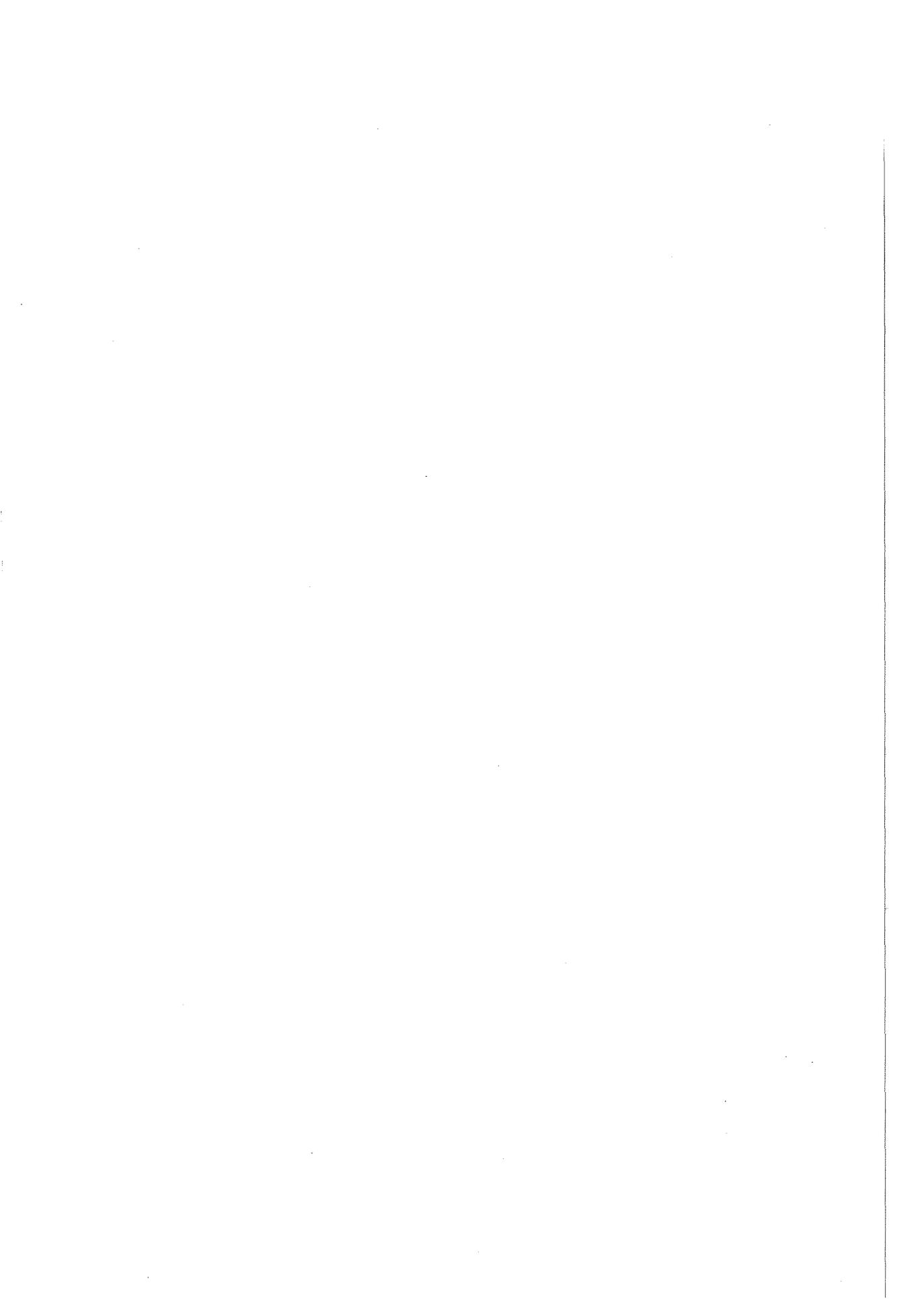


Erythronium japonicum
カタクリ





Gagea lutea
キバナノアマナ

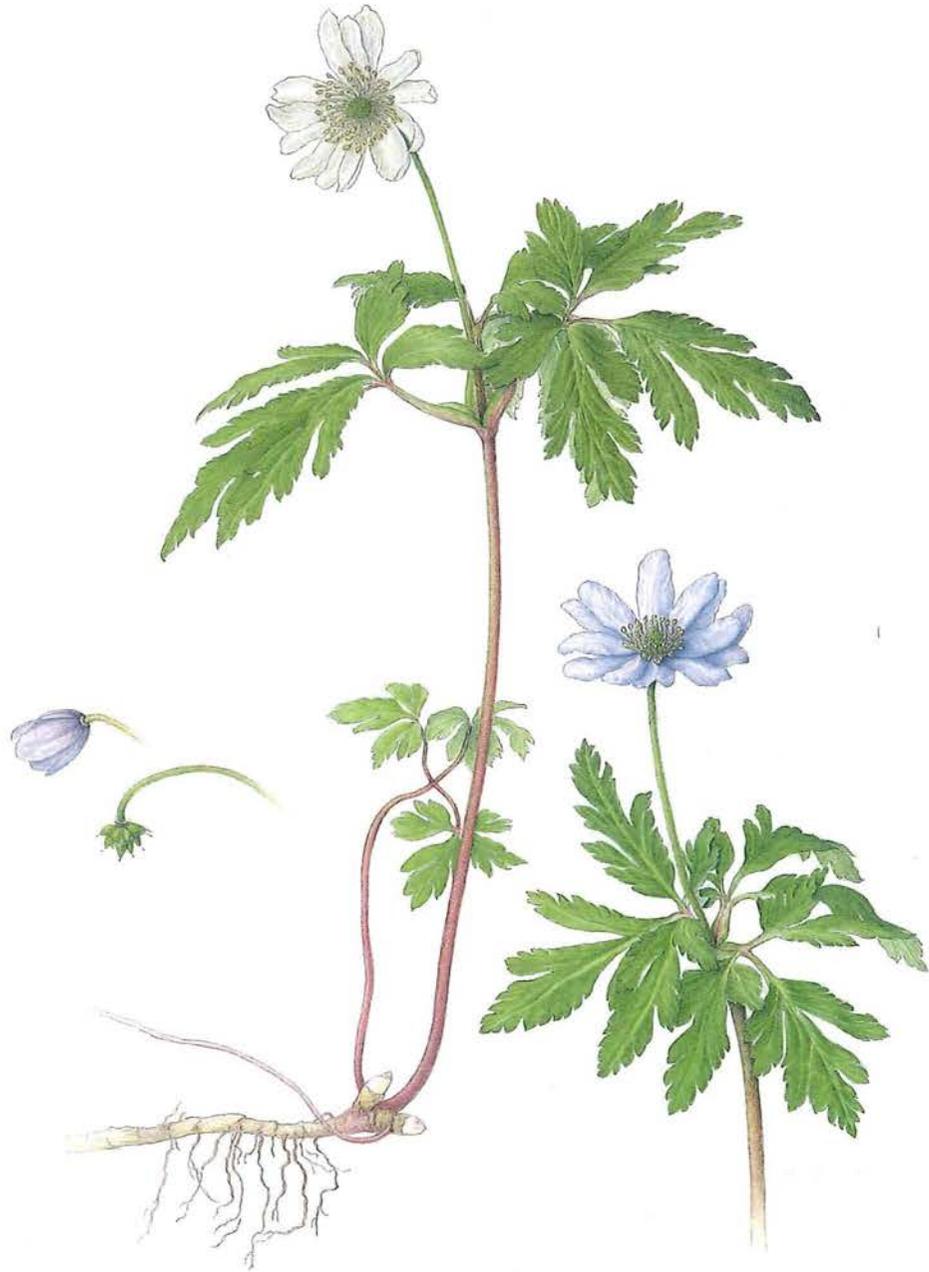




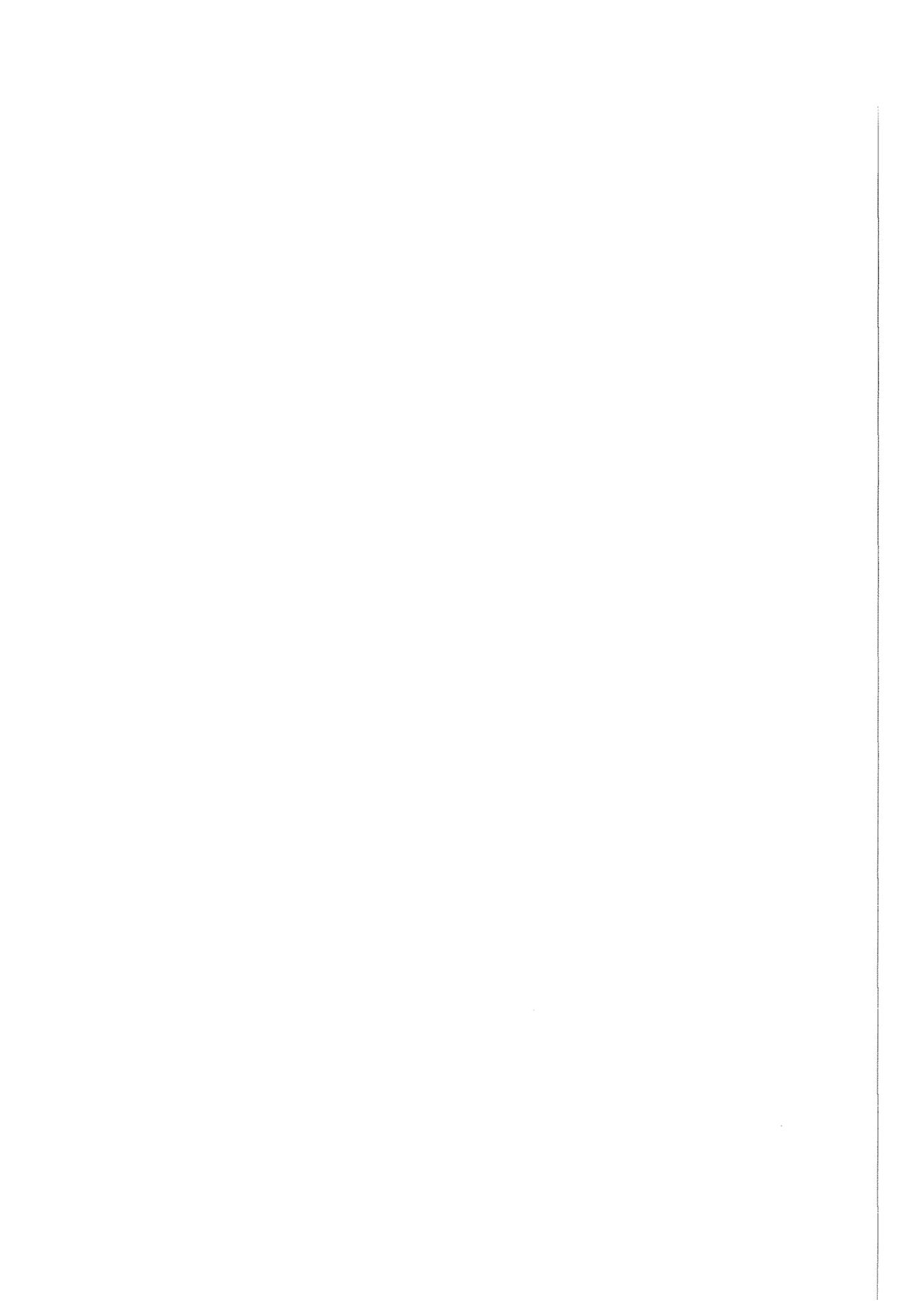
Adonis ramosa
フクジュソウ



Anemone flaccida
ニリンソウ

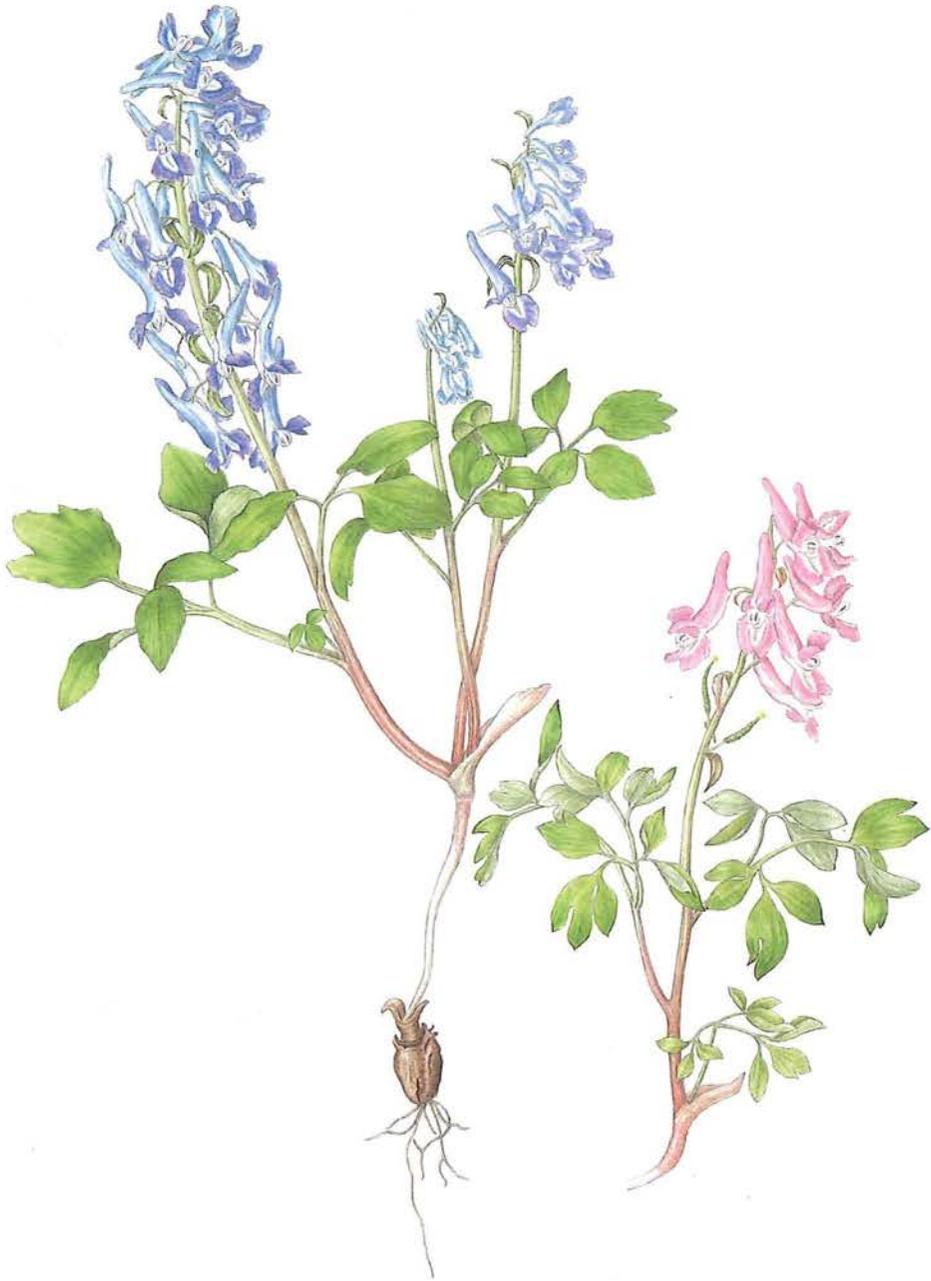


Anemone pseudo-altaica
キクザキイチゲ





Anemone raddeana
アズマイチゲ



Corydalis ambigua
エゾエンゴサク

