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Polemonium in Hokkaido, the Kuriles and Sakhalin

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北海道・千島・樺太産ハナシノブ植物

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Introduction

The genus Polemonium is a small genus which contains 23 species (Melchior 1964) in the Polemoniaceae. The distribution pattern of species of this genus is American-Circumboreal (*cf.* Good 1974), and the main distribution ranges are the montane areas in the western and eastern parts of N. America. Some species occur from Alaska to Eurasia. (*cf.* Hultén 1971).

In monographs published in the past, Brand (1907) and Davidson (1950) described 18 species and 20 species in both hemispheres respectively. Vassiljev (1953 a) recognized 10 species, containing 3 new species in the Euro-Siberian region. Klokov (1955) described 13 species in the Eurasia Continent only, of which 10 species were newly named. The taxonomical treatment adopted by Brand and Davidson is remarkably different from that by Vassiljev and Klokov. According to the Brand-Davidson's taxonomical treatment, Eurasian plants of the genus Polemonium belong to at best 2 or 3 species; according to the Klokov-Vassiljev's treatment, Eurasian plants are divided into at least 10 species. Most of the species recognized by these Russian taxonomists are "not separate species, but well-defined geographical patterns of morphological variation." (Pigott 1958).

Difficulties of classification of these plants result from the following fact: "when specimens from the extremes of the range are compared, they may appear dissimilar, but there is a transition or gradient from one form to the other, and intergrading expressions of any character or group of characters appear at apparently uncorrelated points throughout the broad range of the species." (Davidson 1950; *cf.* Hara 1956, and Dawson 1936). Thus, in the classification of these complicated

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groups it is more essential to have the defined species concept as well as to be skilful in the taxonomical techniques. In this sense, I am of the same opinion as Davidson's. He (1950) stated : "if all the diagnostic characters of a supposed species are present in the surrounding populations, either singly or in various combinations, such a species has been reduced to synonymy in the present treatment." Consequently, 4 Japanese species recognized by the senior authors (Miyabe & Kudo 1913 ; Kitamura 1941), *Polemonium yezoense, Pol. laxiflorum, Pol. nipponicum* and *Pol. racemosum,* should be included in one collective species, *Pol. caeruleum* Linn., because differences between those species are not so profound as those between *Pol. caeruleum* and other American species recognized by Davidson. Our species mentioned above may fall into a single category, in which the corolla limb exceeds the tube and leaves are prominently basal. From this point of view, in the areas under consideration only 2 species are found. One is *Pol. boreale* Adams, and the other is *Pol. caeruleum* Linn.

Of the infraspecific units, I accepted the subspecies as a unit which expresses geographically-morphologically differential patterns and habitats in global scale.

Other infraspecific taxa are the variety and the form. The variety is a unit which expresses a local variation pattern of any characteristics or ecological habitats within a locality. It is seldom found that we have two or more varieties in the similar habitat, although at the present we have often more varieties in a locality owing to the unproper taxonomical treatment of a local flora. The form is a unit with minor or trifle variations of a given character, such as albication of colored petals, more gigantic or slender habit, etc. This minor unit is often neglected but should be kept in mind in some cases, as Böcher (1967) pointed out. It is not uncommon that we have two or more forms within a locality.

Artificial key to the taxa treated

A. Leaves pubescent on both sides, but corolla lobes glabrous. Seeds viscid-gelatinous when wet. Plants usually branched from the base.
. . . . . 1. *Pol. boreale* Adams

Leaves glabrous on both sides, but corolla lobes ciliolate on the margin. Seeds not viscid-gelatinous when wet. Plants not branched from the base.
. . . . . B

B. Corolla lobes triangular-ovate, acute or acutish at apex. Calyx lobes about 1/2 of the entire, broadly deltoid in outline.
. . . . . 2. *Pol. careuleum* ssp. *campanulatum* Th. Fries

Corolla lobes not triagnular-ovate, usually elliptic to spathulate, obtuse or emarginate or mucronate at apex. Calyx lobes 1/2 to 3/4 of the entire. C

C. Corolla lobes elliptic to broadly ovate, not spathulate, emarginate or mucronate at apex. Calyx deeply parted. Floral disk undulate, sometimes 5-teethed.
. . . . . 4. *Pol. caeruleum* ssp. *yezoense* Hara

Corolla lobes variable in shape, obtuse at apex. Calyx clefted. Floral disk entire or shallowly undulate.

. . . . . 3. *Pol. caeruleum* ssp. *laxiflorum* Ko. Ito

Morphological variations of some characters used in the traditional classification

In the gross morphology of the Polemonium, individual plants are more or less similar to each other in appearance, and it is very often difficult to determine which characteristics are not only decided in the classification of species but also in the determination of generic boundaries (Dawson, l. c.). It is the best way for the future taxonomy that recognition, identification and systematics of a species are obtained from the synthetic evaluation on individual characters as seen in the numerical evaluation in the Numerical Taxonomy. I, however, observed morphological variation of the characteristics which are selected in the present taxonomy, although the selection is not necessarily objective but has been traditionally weighted.

i. General habit : All species under consideration are perennial and extends their habitats vigorously by means of horizontally developing rhizomes. Stem-branching is sometimes useful to separate one species from the very similar species. Although in boreal wind-swept habitats, ssp. *campanulatum* becomes very similar to *Pol. boreale* in appearance, but can be easily distinguished the caespitose and non-branching spp. *campanulatum* from the caespitose and branching *Pol. boreale.*

ii. Corolla : The form of corolla, i. e. rotate or campanulate in this case, is available to the classification, although the distinction is not always absolute. The corolla form of our Polemonium species is rotate in principle in favorable, sunny sites but is apt to be campanulate in shaded sites as seen in ssp. *yezoense.*

Corolla size and the shape of the corolla lobes are important. Shape of the lobes varies from narrowly oblong or oblong to broadly ovate or rounded, and the apex of the lobe varies to varying extent from roundish, obtuse to acutish, or sometimes to emarginate (Fig. 1). Variations of lobe-margins are observable as well. The margins vary from entire to minutely serrate in outline. Generally, the obtuse lobes are characteristic of var. *laxiflorum,* acutish lobes are characteristic of ssp. *campanulatum,* and the emarginate lobes are of ssp. *yezoense.* Miyabe and Kudo (1913) stressed in the diagnosis of their var. *yezoense* that it has emarginate or erosed lobes. The tendency that lobes become erosed at apex is found more or less in other taxa such as ssp. *laxiflorum* in the areas under consideration and ssp. *villosum* in the extra-areas (cf. Davidson, l. c.). It should be noted that among the individuals of ssp. *yezoense* growing in shaded habitats corollas with obtuse or acutish apex are found instead of those with emarginate apex.

iii. Pubescence in corolla : On the nature of hairs (especially leaf-hairs) found in the Polemoniaceae, Metcalfe & Chalk (1957) said as follows : "Mostly of the following uniseriate kinds, vary rarely with lateral protrusions ; (i) short conical hairs placed obliquely to the leaf ; (ii) longer, curved or straight, stiff hairs ; (iii) wormlike (arachnoid) wooly hairs. Walls of the uniseriate hairs varying in thickness,

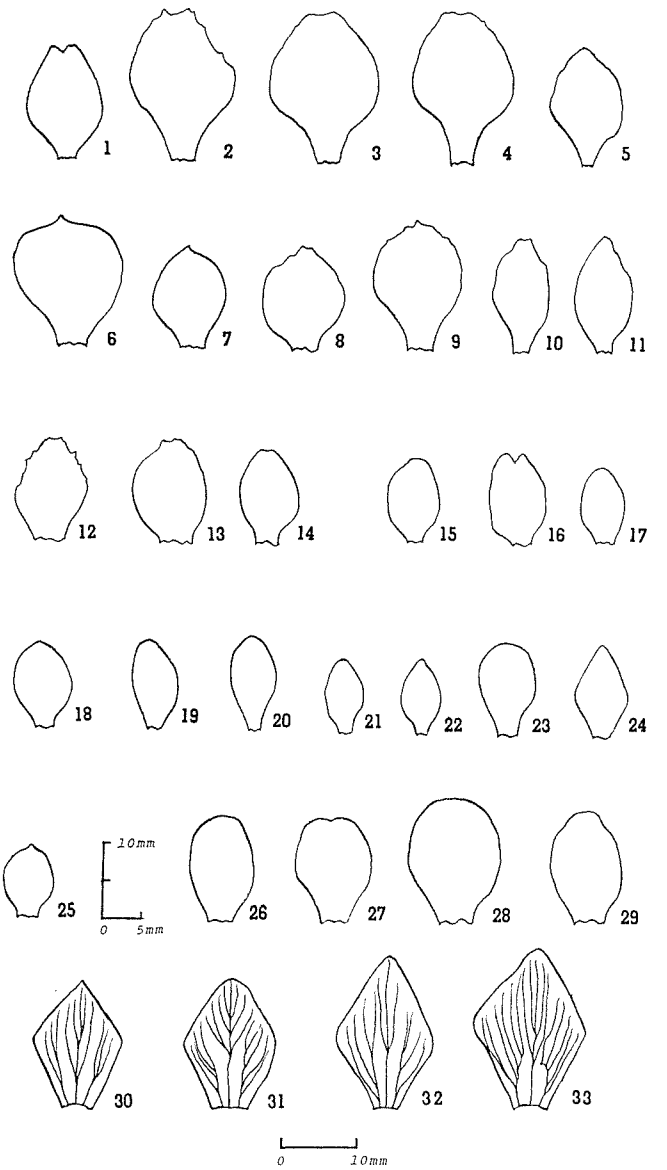

Fig. 1. Variation of shape of corolla-lobes in *Polemonium* species.

1–5: *Pol. caeruleum* ssp. *yezoense*. 1; Mt. Jyozankei Tengu, Jyozankei, 2; Sapporo, 3–5; Hoheikyo, Jyozankei.

6–14: *Pol. caeruleum* ssp. *yezoense* var. *nipponicum*. 6; form. *hidakanum*, Horoman, Hidaka, 7 & 8; form. *nipponicum*, Asagiri Pass, Soeushinai, 9; idem, Fuyushima Hidaka, 10 & 11; Mt. Ohira, Shimamaki, 12–14; Mt. Kita, C. Honshu (TI).

15–25: *Pol. caeruleum* ssp. *laxiflorum* form. *paludosum*. 15 & 16; Kiritappu, Hamanaka, 17; Hamanaka, 18; Toyokoro-Chirukoro, S. Sakhalin, 19 & 23; Chirukoro, S. Sakhalin, 20, 21 & 25; Sikka (Poronaisk), S. Sakhalin, 22; Parukata Tundra, N. Sakhalin, 24; Kashipo, S. Sakhalin.

26–29: *Pol. caeruleum* ssp. *laxiflorum* form. *laxiflorum*. 26; Tofutsu (Cholmsk), S. Sakhalin, 27; Kenshidai, Kashipo, S. Sakhalin, 28; Menabetsu, Notoro Pen., S. Sakhalin, 29; Tokotan (Cholmsk), S. Sakhalin.

30–33: *Pol. caerulem* ssp. *campanulatum*. 30; Nome, Alaska, 31; St. Lorenz Bay, St. Lawrence I., 32; Anadyr, E. Siberia, 33; Bering Strait-E. Cape.

occasionally slightly silicified. Glandular hairs, each with a uniseriate stalk of variable length and a unicellular or multicellular head, occur in species of Bondplandia, Cantua, Collomia, Gillia, Loeselia, Phlox, Polemonium. The more detailed structure of the glandular hairs is valuable in the identification of species." The hair found commonly in our taxa is the second type mentioned by Metcalfe and Chalk. It may be sure that characteristics of the hairs, viz. longer or shorter, unicellular or multicellular or at times straight or curved, are applicable to this classification. It is more effective to use the hair characteristics combined with the absence or

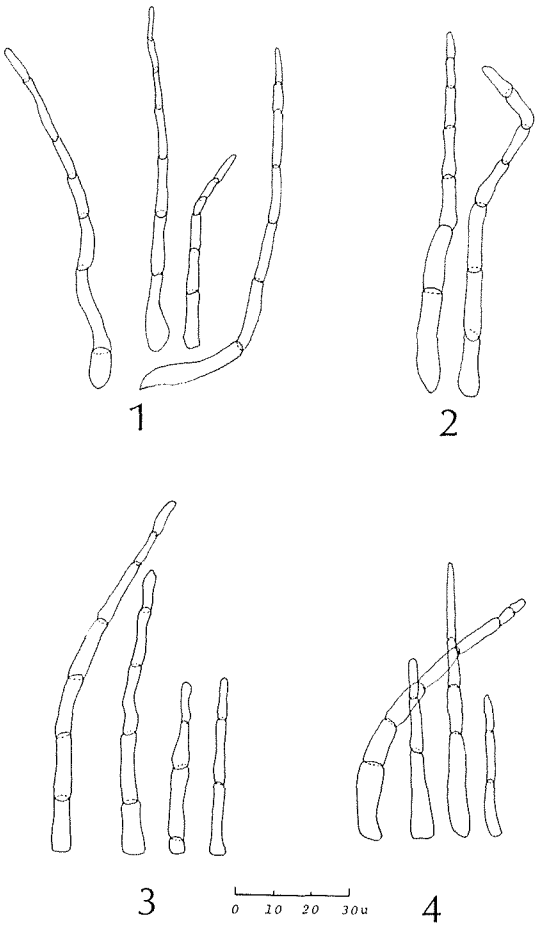

Fig. 2. Hairs found on the inside of corolla and of filaments in *Polemonium* species.

1: *Pol. caeruleum* ssp. *yezoense*; hairs 50 to 100 μ in length, usually 6-9-celled, rarely 4-5-celled, straight or curved.

2: *Pol. caeruleum* ssp. *yezoense* var. *nipponicum* form. *hidakanum*; hairs 75-100 μ in length, 6-9-celled, usually curved more than straight.

3: *Pol. caeruleum* ssp. *laxiflorum*; hairs 50 to 100 μ in length, usually 4-6-celled, rarely 3- or 7-celled, straight more than curved.

4: *Pol. caeruleum* ssp. *caeruleum*; haris 25 to 50 μ in length, usually 3-4-celled, rarely 5-6-7-celled, straight hairs prevailing.

presence of glandular hairs. In the present classification, I paied special attention to the pubescence found on the inside base of the corolla lobes and of the filaments. Hairiness of the leaf seems not to be available to the classification so far as our taxa are concerned.

As seen in Fig. 2, the hairs found on the inside base of the corolla lobes and of the filaments are multicellular but are recognized some differences among taxa. In ssp. *yezoense*, they are 50 to 100 μ in length and the longest among the four taxa compared, consisted of usually 6 to 9 cells, rarely 4 to 5 cells. In ssp. *caeruleum*, they are 25 to 50 μ in length and the shortest, consisted usually of 3 to 4 cells, rarely 5 to 7 cells. In ssp. *yezoense* var. *nipponicum*, the characteristics of them are almost similar to var. *yezoense*. In ssp. *laxiflorum*, they are mostly 75 μ, rarely 50 to 100 μ in length, consisted of usually 4 to 6 cells, rarely 3 to 7. In ssp. *yezoense*, curved hairs are common; in ssp. *laxiflorum* and *caeruleum*, straight hairs are prevailing.

On the subdivision of northern-boreal species of the Polemonium, pubescence of corolla lobes has been emphasized (Brand l. c.; Kitamura l. c.; Ohwi 1953 & 1965 a & b). In the *Campanulatum* group, corolla lobes are covered with somewhat short hairs and also, are fringed with the same kind of hairs, while in the *Caeruleum* group, they are glabrous overall. As far as I observed, in our taxa belonged to the former group corolla lobes are pubescent, but the pubescence is variable to a large extent. This kind of variation is found on even the plants from the same series of collection.

iv. Floral disk: Kitamura (l. c.) is the first author who applied characteristics of the floral disk to the taxonomy of the Japanese Polemonium species. Foreign authors, as far as I know, may have not made this attempt. In my observation, characteristics of the floral disk serve well for the purpose of separation of ssp. *yezoense* from other taxa under consideration. This characteristic is useful to separate ssp. *yezoense* from ssp. *caeruleum* and *Pol. flavum*, S. American species (Fig. 3).

The floral disks of ssp. *yezoense* are clearly five-lobed in the well-grown individuals as Kitamura described but occasionally become obscure in poorly-grown plants.

v. Hairiness of the stem and the inflorescence: Plants of the Polemonium are usually hairy on the upper parts of the stem and on the inflorescence. There are three kinds of hairs; the first is longer hair, the second is shorter one, and the third is the gland. The longer hairs are 0.5 mm long, usually more or less cury and consist of 6 to 8 cells. The shorter hairs are 0.2 to 0.3 mm long and consist of 3 to 5 cells. The glandular hairs are very short, about 0.1 mm long with globose glands at apex and consist of 1 to 2 cells. All of the species under consideration bear the glands on the upper parts of the stem, the inflorescence and the calyx. The coverage of the rest 2 kinds of hairs differs from species to species but shows a kind of the tendency, in which northern species or individuals are covered with hairs more than southern species or individuals are. The most hairy species is *Pol.*

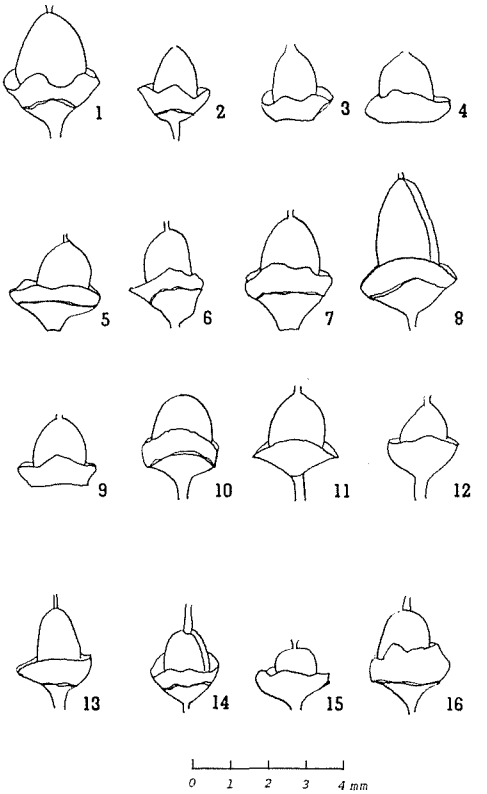

Fig. 3. Variation of floral disks in *Polemonium* species.

1-4: *Pol. caeruleum* ssp. *yezoense*. 1; Hoheikyo, Jyozankei, 2-4; Mt. Jyozankeitengu, Jyozankei.
5-8: *Pol. caeruleum* ssp. *yezoense* var. *nipponicum*. form. *nipponicum*. 5; Mt. Kita, C. Honshu (TI), 6; Nukabira, Hidaka, 7 & 8; Niikappu, Hidaka.
9-10: *Pol. caeruleum* ssp. *laxiflorum* form. *laxiflorum*. 9; Tokotan (Cholmsk), S. Sakhalin, 10; Kamoiwaki.
11-13: *Pol. caeruleum* ssp. *laxiflorum* form. *paludosum*. 11; Chirukoro, S. Sakhlain, 12; Ochiichi, Nemuro, 13; Alexandrovsk-Sachalinskii Tundra, N. Sakhalin.
14: *Pol. caeruleum* ssp. *campanulatum*; Portage Glacia, Alaska.
15 & 16: *Pol. caeruleum* ssp. *caeruleum*; cult. in Sapporo, Bot. Gard. Hokkaido Univ.

boreale, whose calyx is so densely hairy that its surface often looks like silvergrey. Hair disappears in ssp. *yezoense* var. *nipponicum* form. *hidakanum*. In ssp. *yezoense*, however, the stem and inflorescence are covered with either the longer hairs or the shorter hairs as well as the glands but sometimes with only the glands; in ssp. *laxiflorum* those are covered together with both the longer and the shorter hairs, and the glands; in European ssp. *caeruleum* those are with only the short glandular hairs.

vi. Partition of calyx and shape of the lobes: Generally speaking, the partition of calyx is the deepest in ssp. *yezoense* and var. *nipponicum*, in which the partition attains 2/3 to 3/4 of the calyx, but it is the shallowest in European ssp. *caeruleum* and *Pol. racemosum*, in which the partition is at best about 1/2 of the

calyx. The partition commonly varies from 1/2 to 2/3 in ssp. *campanulatum* and ssp. *laxiflorum*. As seen in Fig. 4, the partition is generally significant in the classification of those taxa when it is used in the combination with the shape of the calyx-lobe. The shapes of calyx-lobes vary from broadly deltoid or ovately

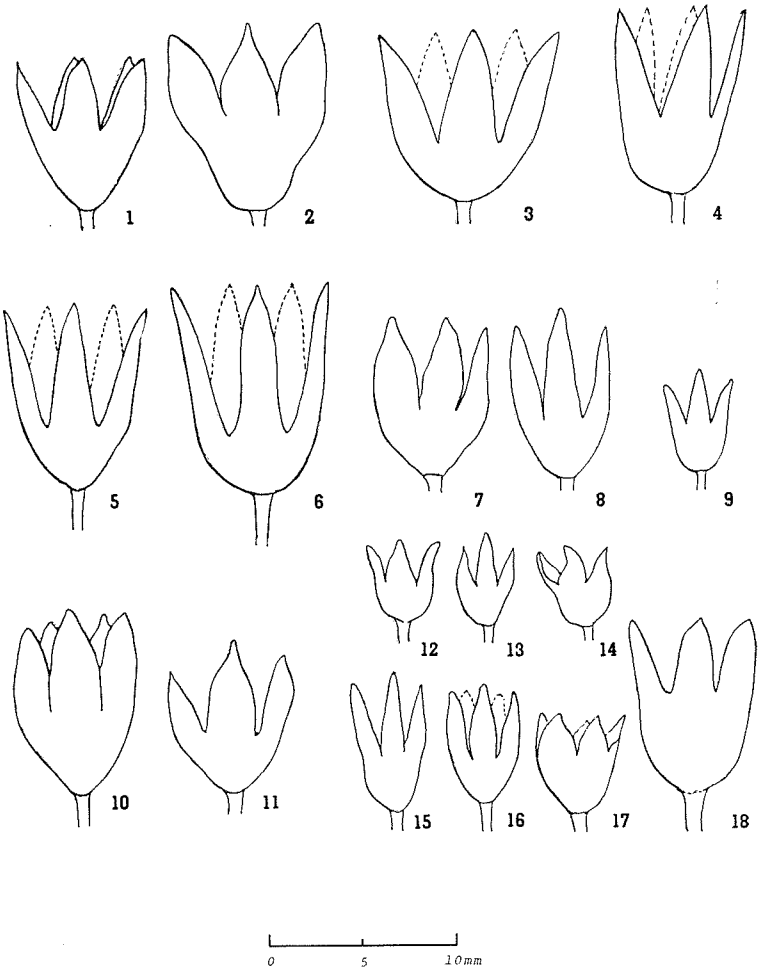

Fig. 4. Partition of calyx and shape of calyx-lobes in *Polemonium* speices.

1-2: *Pol. caeruleum* ssp. *campanulatum*. 1; Nome, Alaska, 2; Paramushir Isl., N. Kuriles.

3-4: *Pol. caeruleum* ssp. *yezoense* var. *nipponicum* form. *nipponicum*; Fuyushima, Hidaka.

5-6: *Pol. caeruleum* ssp. *yezoense*; Hoheikyo, Jyozankei.

7-9: *Pol. caeruleum* ssp. *laxiflorum* form. *laxiflorum*. 7; Mt. Dainan, Moneron Isl., S, Sakhalin, 8 & 9; Nelma, The Maritime Prov.

10 & 11; *Pol. caeruleum* ssp. *laxiflorum* form. *insulare*; Momoiwa, Rebun Isl.

12-16: *Pol. caeruleum* ssp. *laxiflorum* form. *paludosum*. 12; Yamahana-Ikeda, Poronaisk, S. Sakhalin, 13 & 14; Oromotoe, Poronaisk, S. Sakhalin, 15; Sechuri, Kushiro, 16; Kiritappu, Hamanaka.

17 & 18: *Pol. caeruleum* ssp. *caeruleum*; cult. in Bot. Gard., Hokkaido Univ.

deltoid to lanceolate or narrowly lanceolate, and are somewhat different from taxa to taxa. Variabilities of the partition correspond more or less to those of the shapes. In ssp. *yezoense* with the deepest partition, the lobes are narrowly lanceolate to lanceolate in shape, but in European ssp. *caeruleum* with a rather shallower partition, they are often broadly deltoid or ovately deltoid.

vii. Inflorescence: The inflorescence of the taxa under consideration belongs to the definite type in the inflorescence classification. The basic pattern may be

Fig. 5-1. Inflorescence forms (1): racemose-like corymbose-cymes.

1, 2, 3 & 5; racemose types, and 4: a flat topped type. 1; Asagiri Pass, Soeushinai, 2 & 3; a polyanthum type, Momoiwa Rebun Isl., 5; an oligoanthus type, Momoiwa, Rebun Isl., 4; a flat topped type, Momoiwa, Rebun Isl. (solid; flowering, open; fruiting, and cross; buds)

the paniculate-cyme in these taxa, but it is often readily modified to the corymbose-cyme under certain conditions. In habitats where plant individuals are moderately crowded, rachis and branches of the inflorescence are elongated, and the flowers are seldom found overlapping. In habitiats, however, where plant individuals are fairly crowded and particularly when they grow under wind-swept conditions, the inflorescences are compact and usually flowers are found overlapping each other. From the facts mentioned above, it may be said that the inflorescence pattern is not advantageous to the classification of our taxa, with a few exception such as form *insulare*, in which the compact inflorescence is more or less fixed and can be maintained under cultivation (Fig. 5-2).

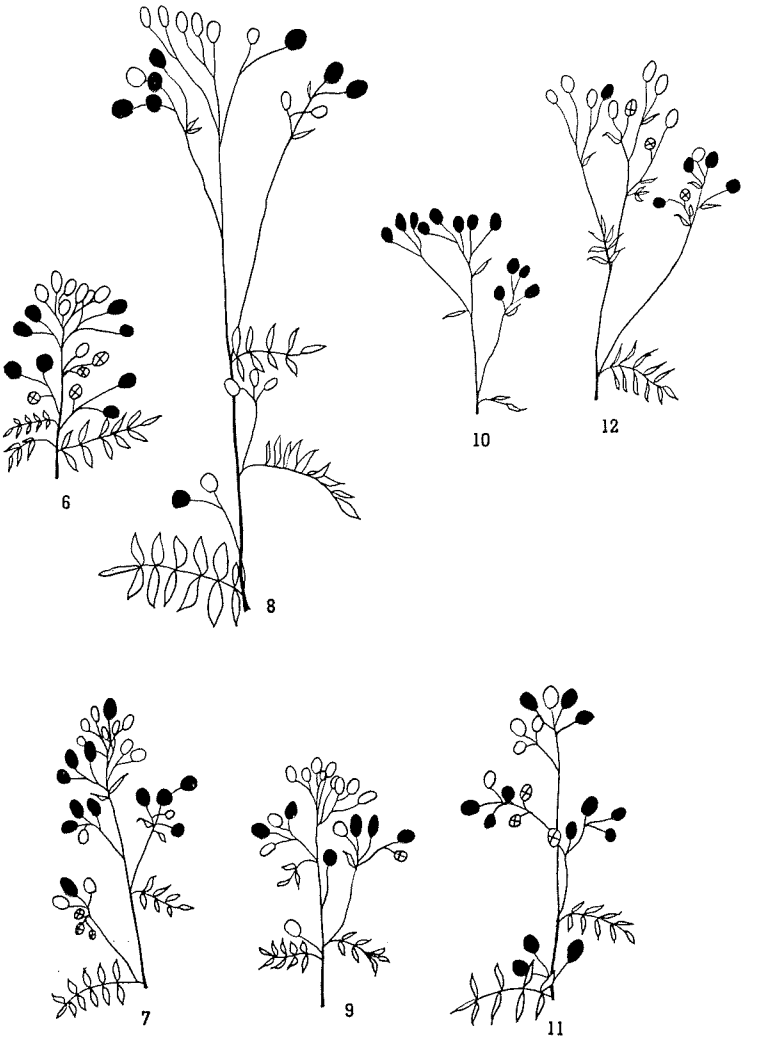

Fig. 5-2. Inflorescence forms (2): corymbose-cymes.
6, 7, 9 and 11; the most shortened inflorescence types; Momoiwa, Rebun Isl., 10 & 12; shortened and flat topped inflorescences grown in shady habitats, Asagiri Pass, Soeushinai, 8; an intermediate type between the elongated and the shortened inflorescence.

viii. Pollengrains: Recently most taxonomists have emphasized that pollen is one of the important keys in classification.

In the microscopic observation, pollen sizes are to a centain extent different: the largest is ssp. *campanulatum*; the medium are ssp. *yezoense* var. *nipponicum*, and ssp. *laxiflorum*; the smallest *Pol. flavum*, a S. American species as seen in Table 1. The sexine of pollengrains is generally shown by the striato-fine reticulate with apertures from 2.4 to 3 μ in diameter. The sexine is thicker than the nexin in ssp. *campanulatum*, and var. *nipponicum*, although in other taxa given, the sexine is thinner than the nexin. From these microscopic observations, pollengrains seem to be advantageous to the classification, but they were not accepted as a key character here. Dr. Takahashi (Personal communication 1981) suggested me that it was difficult to distinguish *Pol. caeruleum* ssp. *laxiflorum*, and var. *hidakanum* from each other by pollensculpture patterns based on the SE as shown in Photos 1 and 2.

Table 1. Pollen diametre of the Polemonia in Hokkaido, the Kuriles and Sakhalin with European *Pol. caeruleum* and S. American *Pol. flavum*.

Pollen diametre (μ) / Taxa		Range	Average
Pol. boreale	n=10	(45.0-) 47.5-50.0 (-62.5)	52.0±2.04
Pol. caeruleum ssp. *caeruleum**	n=30	(45.0-) 52.5 (-67.5)	51.9±2.96
Pol. caeruleum ssp. *campanulatum*	n=5	47.5-60.0-80.0	63.5
Pol. caeruleum ssp. *yezoense*	n=32	(45.0-) 47.5-52.5 (-62.5)	52.2±10.02
Pol. caeruleum ssp. *yezoense* var. *nipponicum*	n=60	(45.0-) 50.0-52.5 (-57.5)	53.25±9.55
Pol. caeruleum ssp. *laxiflorum***	(n=20**)	Not measured	
Pol. caeruleum ssp. *laxiflorum* f. *paludosum*	n=28	45.0-50.0 (-57.5)	48.38±6.39
f. *insulare*	n=40	(42.5-) 45.0-47.5 (-50.0)	47.67±2.13
Pol. flavum	n=40	40.0-47.5	45.5±2.06

* Erdtman, G. (1952); the diametre of pollengrains is ca. 45 μ.
** Yamazaki, T. (1933); the diametre of pollengrains is 60-53 μ.

ix. Other characters: Kitamura (l. c.) used the anther size in separating *Pol. nipponicum* from *Pol. acutiflorum*, but in the present paper the anther size was not used. In Polemonium species anther size varies considerably in accordance with its growth stage in flowers. At the bud stage, anthers are very small but abruptly increase in size as well as in volume, and release pollengrains thereafter. After releasing the pollengrains the sheded anther becomes small again. Thus, it is considerably difficult to determine the appropriate time to estimate the anther size.

Cauline leaves-their shape and size, and the number of the leaflets associated with size- are rarely useful in the classification since *Pol. boreale* and ssp. *laxiflorum* f. *paludosum* are distinguished from other taxa by them, but generally they are less important and less useful in the classification of our taxa.

Apart from my observation of morphological variations, Ostenfeld (1923) stated several variations obtained from cultivated materials of Polemonium species: (1) pinnate (or more correctly pinnatifid) and bipinnate (or bipinnatifid) leaves, (2) blue and white color of corolla, (3) well developed large (normal) corolla and very small corolla, and (4) perfect (hermaphrodite) flowers with long filaments and well developed anthers and female flowers with short and barren (rudimentary) stamens.

Description

1. *Polemonium boreale* Adams: Davidson, Polemonium 241. 1951.

A dwarf perennial herb with horizontally running rhizomes. Plants 10 to 20 cm tall, usually branching from the base, covered with multicellular haris and short glands. Leaves small, consisting of 7- to 11-paired leaflets; the leaflets ovate or ovate-elliptic in shape, acute at apex, 3 to 10 mm long, 3 to 5 mm wide, more or less fleshy or succulent, densely to thinly pubescent on both sides; hairs 0.2–0.5 cm in length. Inflorescences corymbose-cyme, the pedicels generally shorter than the calyx. Calyx lanate, 5 to 7 mm in length; the sepals 2.5 to 4 mm long, as long as or a little longer than the campanulate tube. Corolla small, 13 to 18 mm long; the lobes ovate in shape, rounded or truncate at apex, somewhat gnawed on the margin. Stamens not exserted; anthers broadly elliptic 1.1 to 1.3 mm long, yellow in color. Pollengrains polyforate, usually (47.5)–50 μ- to 52 μ in size. Fruit globose, 2 to 4 mm long and wide. Seeds reddish-brown, 2 mm long, 1 mm wide, with tiny wing at the terminal ends. Fl. VII–VIII. Fr. –IX.

Nom. Jap. Hime-Hanashinobu (Yokoyama 1893).
Type locality: "Mouth of the Lena River." Collector unknown.
Icon.: Gmelin (1769, Fl. Sib. IV. tab. 50), Hultén (1930 & 1968), Davidson (1950), J. Lid & D. T. Lid (1952), Vassiljev (1953 a), Porsild (1957), Polunin (1959), Klokov (1966), Böcher *et al.* (1968).
Range: Alaska-Yukon, Canadian Western Arctic, Kamchatka, N. Kuriles, and E. & N. Siberia (Chukotskiy Pen., Lehna, Taymyr Pen., Pol Yamal, etc.), the Baikal (Judkan distr.), Novaya Zemlya, Naryam Mar, Kanin Nos, to Murmansk and N. Norway (Arctic circle), NE Greenland.
Map: Davidson (1950), Vassiljev (1953 a), Porsild (1957), Klokov (1966), Malyshev (1972 fig. 269-1), Tzvelev (1980), Ito (1981, and 1983 Fig. 6-2).

The present species is characterized by a dwarf, caespitose and wholly pubescent habit with somewhat fruticose stems. Although Hultén (1930), Vassiljev (1953) and Woroschilov (1966) distinguished *Pol. hultenii* (=*Pol. humile*) from *Pol. boreale* by taller and more branched stems with several cauline leaves and smaller corollas, it is concluded in the present studies that *Pol. hultenii* is conspecific with *Pol. boreale* as Davidson (1950) considered. Individual plants of this species often bear resemblance to dwarf plants of *Pol. caeruleum* ssp. *campanulatum* in appearence, but the latter are distinguishable from the former by having glabrous leaves and simple stems.

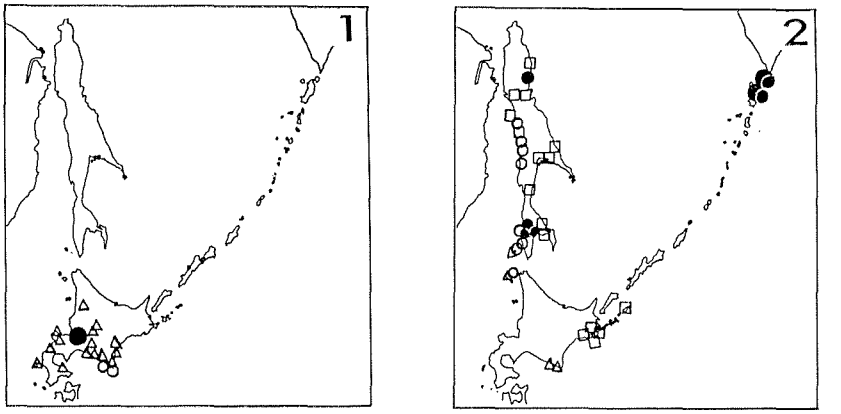

Fig. 6. Distribution maps of *Polemonia* in Hokkaido, the Kuriles and Sakhalin.

1: *Pol. caeruleum* ssp. *yezoense* var. *yezoense*. (large solid circles), var. *nipponicum* form. *nipponicum* (open small triangles), and form. *hidakanum* (open small circles).
2: *Pol. boreale* (large solid circles), *Pol. caeruleum* ssp. *campanulatum* (small solid circles), *Pol. caeruleum* ssp. *laxiflorum* form. *laxiflorum* (open small circles), form. *insulare* (open small triangles), and f. *paludosum* (open small squares).

From the description and herbarium specimens of LE, the Euro-Asiatic species which were published as new species by Vassiljev (1953) and Klokov (1955) are not independent species but phenotypical variations of *Pol. boreale*. They are: *Pol. pseudopulchellum* Vassil., *Pol. onegense* Klok., *Pol. lapponicum* Klok., and *Pol. nudipedum* Klok. (*cf.* Tzvelev 1980).

2. *Polemonium caeruleum* Linn. subsp. *campanulatum* Th. Fries in Bot. Notis. No. 12, 190. 1858.

Perennial, rhizome creeping. Stem erect or ascending, simple, (15-) 20 to 40 (-60) cm high, not solid, usually glabrous except for the upper parts, smooth, 2 to 3 mm across at base. Leaves oddly-pinnately divided; the radical leaves faded or alive in anthesis. Cauline leaves narrowly elliptic with short petioles which are dilated at base and somewhat ciliated on the margin, 6 to 10 cm long, 2.5 to 5 cm wide, reduced toward the inflorescence in size, glabrous, dark green above and pale green beneath; the laeflets 9- to 11-paired, ovately lanceolate or narrowly ovate, acute to obtuse at apex, obliquely roundish to obtuse at base, sessile, usually conspicuously 3-nerved, envire 10 to 22 mm long, 5 to 7 mm wide. Inflorescences commonly compact cyme, rarely corymbose-cyme, with 4-7 flowers; the main axis and the branches usually densely pilose with multicellular viscid hairs of 2 mm in length, mixed with short galnds. Calyx (5-) 7 to 8 (-10) mm long in flowering, densely to sparsely pilose with more or less yellowish shaggy viscid hairs; the lobes as long as or a little longer than the tube, broadly triangular or ovately deltoid in shape, usually the length 1.5 to 2.5 times as long as the breadth, obtuse at apex (Fig. 4, 1-2), often tinted with reddish purple in age. Corolla campanulate to rotate, 15 to 20 mm across and long; the lobes triangular-ovate in shape, usually

acute or often obtuse or rarely mucronate at apex, entire or often irregularly incised-undulate, pubescent on both sides and densely ciliolate in the margin (Fig. 1. 30-33). Stamens shorter than the corolla, ca. 2/3 as long as the corolla, anthers elliptic, yellow; pollengrains yellow, 47.5 to 80.0 μ in size, the sexine striatofine reticulate with apperatures of 2.4 to 3 μ in diameter and thicker than the nexin. Styles not exserted from the corolla. Disk undulate (Fig. 3. 14). Fl. -VIII. Fr. -VIII.

Nom. Jap. Kyokuchi-Hanashinobu (Miyabe & Kudo 1913).

Specim. exam.: ***N. Kuriles***: Paramushir Isl.; Kamogawazaki (12 Jul. 1920—Y. Kudo! bud). Shumshu Isl; Magarikawa (13 Jul. 1920—Y. Kudo bud & fl.), Jyogasaki (20 Aug. 1926—K. Doi! fl.). ***N. Sakhalin***: Chaibo, N. E. part (about 52°N. L., 143°E. L.) (3 May. 1925—Y. Kusano! fl.). ***S. Sakhalin***: Sekiguchi-toge, S. part, between Cholmsk and Yuzhno-Sakhalinsk (30 June 1906—T. Miyake! fl.), Osaka, S. part, between Cholmsk and Yuzhno-Sakhalinsk (1 Jul. 1906—T. Miyake! fl.); Takinosawa (29 June 1906—T. Miyake! fl.).

Typus: Unknown.

Icon.: Kitamura (1941), Vassiljev (1953 a & b), Klokov (1955 & 1966), Hultén (1968).

Range: Alaska-Yukon and Kamchatka, N. Kuriles, Sakhalin, Ochotsk, Maritime Porv. and NW territories of Canada, Bering Isl., E. & N. Siberia, (Chukatskiy Pen., Lehna, Taymyr Pen., Poli Yamal, etc.) to European Russia, Finland and Norway (Arctic circle).

Map: Davidson (1950), Vassiljev (1953 a), Klokov (1966), Hultén (1968), Tzvelev (1980), and Ito (1983 Fig. 6-2).

The present subspecies is a northern boreal type of *Pol. caeruleum* and is generally characterized by having acute and ciliolate corolla lobes, and densely pilose inflorescences and pedicels. The characteristics mentioned above are clear in the arcto-boreal individuals but become obscure in the southern individuals which are found in the areas intermingled with other types such as the European ssp. *caeruleum* and the asiatic ssp. *laxiflorum*.

Of the species described by Vassiljev (1953 a & b), *Pol. acutiflorum*, *Pol. villosum* and *Pol. pacificum* are closely related to this subspecies. According to him, *Pol. acutiflorum* has the widest range among the three species, and it ranges over Eurasian Cont., namely Lappland, Cola Pen., Novaya Zemlya, Ural, Taymyr Pen., Siberia and Kamchatka. The range area is lowland from 60°N. to 75°N. and completely overlaps with that of *Pol. boreale*. *Pol. villosum* distributes in two areas; one is from Tazouskii Pen. to Taymyr Pen., and the other is along the Ochotsk sea coast and around the Baykal Basins, from Kamchatka, Anadyr, Ochotsk to Ussuri and Angara-Sayan south down to 50°N. *Pol. pacificum* is limited to Sakhalin, Kamchatka and Comandorskiye Isl., and its type locality is in Comandorskiye Isl.

Being based upon the key given by Vassiljev (1953 b), the specimens preserved

in SAPT as *Pol. acutiflorum* and *villosum* (not Vassiljev) are arranged as follows:

(1) the *acutiflorum* type: habitats of the specimes examined are in Anadyr, Bering Strait-East Cape, St. Lorenz Bay, Nome (Alaska).

(2) the *villosum* type: No specimens applicable to Vassiljev's *Pol. villosum* are observed.

(3) the *pacificum* type: habitats of the specimens examined are in Portage Glacia and Nome (Alaska), Bering Isl., Anadyr, Kamchatka, and Paramushir (N. Kuriles). Specimens obtained from the habitats mentioned above are in accordance with the Vassiljev's description and figure.

(4) the *pacificum-acutiflorum* type: specimens from Shumshu Isl. (N. Kuriles) are intermediate between *Pol. pacificum* and *Pol. acutiflorum* sensu Vassiljev.

As seen above, most of the habitats overlap in the range. In fact, the differences between *Pol. pacificum* and *Pol. villosum* are detectable in those of hairiness of inflorescences and calyces, and of the number of the flowers. The differences among Vassiljev's three species, however, are eventually differences between the growth forms. For example, *Pol. acutiflorum* is a type which advances into the northern extremes and becomes the dwarf habit with few flowers, while *Pol. pacificum* is a southern type and its habit becomes stout with many flowers. It is reasonable that Woroschilov considered that these three species are to be conspecific.

3. *Polemonium caeruleum* subsp. *laxiflorum* (Regel) Ko. Ito, stat. nov.: in J. Geobot. **20**: 93. 1972. nom. nud.: Shimizu New Al. Fl. Jap. Color. I: 93. et 313. 1982.

Basion. *Polemonium caeruleum* a. *vulgare* lusus *laxiflorum* Regel Tent. Fl. Ussur. 106. 1862.

A robust or slender plant with creeping rhizomes. Stem erect or ascending, simple, 30 to 60 cm tall, 2 to 6 mm across at base, almost glabrous or puberulous. Leaves oddly-pinnately divided; the radical leaves alive or emarcid in anthesis. Cauline leaves reduced toward the inflorescence in size, dark green above and pale green beneath, glabrous, oblong, 12 to 21 cm long, 2.5 to 5 cm wide with petioles which are dilated at base, confluent to the stem and ciliate on the margin; leaflets 9- to 12-paired, narrowly ovate-lanceolate, ovate-lanceolate or broadly lanceolate, usually 2 to 4 cm long, 3 to 7 mm wide, often attain to 10 mm in width, obliquely roundish or obtuse at base, sessile, acute or acuminate at apex with a point. Inflorescences crowded corymbose or corymbose-cyme with 10 to 25 flowers, or loosely spreading cyme with elongated branches; the rachis and branches usually covered densely with short glands alone, rarely mixed with multicellular pilose hairs. Calyx longer than the pedicels, campanulate, 8 to 10 mm long in anthesis, sparsely to moderately viscid pubescent with multicellular hairs; the lobes as long as or a little longer than the tube, lanceolate to deltoid, obtuse at apex, the length 1.5 to 2.5 times as long as the width (Fig. 4. 7-16). Corolla campanulate, 17 to 20 mm long, purple-blue, rarely white; the lobes vary in shape from broadly elliptic to ovately rotund or broadly spathulate to subrotund, usually obtuse, rarely emarginate at apex, ciliolate on the margin, glabrous beneath (Fig. 1. 15-29). Stamens not

extruding from the corolla, 1/2 to 2/3 of the corolla in length; anthers 3-4 mm long, pollengrains orange yellow or orange, polyforate usually 45.0-47.5 μ ($-50\ \mu$) in size (Plate I, Photo 1). Styles shorter than the corolla, ca. 3/4 of it but rarely extrude from it. Disk more or less undulate, entire or often somewhat 2— or 5— teethed (Fig. 4. 9-13). Seeds reddish brown, 2 to 3 mm long. Fl. VI to VIII. Fr. VI to VIII.

Nom. Jap. Karafuto-Hanashinobu (Miyabe & Kudo 1913).
Typus: Tokotan (Cholmsk), S. Sakhalin. [Lectotypus] (Miyabe & Kudo 1913) in SAPT.
Range: Japan (N. Hokkaido), Sakhalin and Maritime Province.

Key to the infraspecific taxa

A. Plants slender. Stems usually 1.5-3 mm thick at the base. Leaflets 0.5-7 mm wide. Habitats on bogs.
. . . . . c) ssp. *laxiflorum* f. *paludosum* Ko. Ito

Plants stout. Stems usually 3-6 mm thick at the base. Leaflets generally more than 5 mm wide. Habitats in mesic sunny meadows, river banks, forest margins. . . . . B

B. Inflorescences loosely spreading cyme or corymbose-cyme.
. . . . . a) ssp. *laxiflorum* f. *laxiflorum*

Inflorescences compact corymbose. Grown in coastal windy meadows.
. . . . . b) ssp. *laxiflorum* f. *insulare* Ko. Ito

a) form. *laxiflorum*

Plant stout, stem usually 3 to 6 mm across at the base. Leaflets ovate to ovate-lanceolate, usually over 5 mm wide. Inflorescences loosely spreading cyme or corymbose-syme, many-flowered; the rachins and branches are covered densely with short glands. Growing on meadows, river-banks, forest margins, etc. (Fig. 1. 26-29: Fig. 3. 9-10: Fig. 4. 7-9).

Nom. Jap. Karafuto-Hanashinobu (Miyabe & Kudo 1913).

Specim. Exam.: ***N. Sakhalin*:** Alexandrovski (30 Jul. 1905—M. Takamatsu! fr.), Pilewo (13, Aug. 1906—K. Miyabe! veg.). ***S. Sakhalin*:** Kenshindai (Kashipo) (16 Jul. 1932—H. Abumiya *et al.*! fl.), Somayoidake (Kashipe) (20 Jul. 1932—H. Abumiya *et al.*! fl.), Mt. Kashipo (Kashipo) (7 Aug. 1928—N. Hiratsuka! fr.), Makunkotan (Motodomari) (22 Jul. 1906—K. Miyabe & T. Miyake! fr.), Galkinovlaskoe (Juzhno-Sakhalinsk) (11 Jul. 1906—T. Miyake! fl. & Fr.), Meinabetsu, Notoro Pen. (Odomari) (3 Jul. 1908—T. Miyake! fl.), Anbetsu (Nayoshi) (2 Sept. 1929—Y. Tokunaga *et al.*! fl.), Sokorai (Nayoshi) (13 Aug. 1906—K. Miyabe & T. Miyake! fr.), **Tokotan (Cholmsk) (22 June 1907—T. Miyake! "Typus" of *P. coeruleum* ssp. *vulgare* var. *laxiflorum* Miyabe et Kudo! fl.),** Notosan (Cholmsk) (28 June 1970—T. Miyake! fl.), Tofutsu (Cholmsk) (27 June 1907—T. Miyake! fl.).

Kaiba Isl. (O. Moneron); Kotan (24 Jul. 1906—T. Miyake! fl.), Tomarizawa (23 Jul. 1906—T. Miyake! fr.), Shimizudanai (26 Jul. 1906—T. Miyake! fl.), Minami-Kotan (19 Jul. 1931—U. Kimoto *et al.*! fl.).
***Hokkaido*:** Pref. Soya; Funadomari (Rebun Isl.) (7 Aug. 1920—M. Tatew.! fl.), Motozi (Rebun Isl.) (11 Jul. 1933—M. Tatew.! fl.).

Range: Japan (N. Hokkaido), Sakhalin, Amur, Maritime Province, Manchuria and N. Siberia.
Icon.: Komarov & Alisova (1932 t-268), Kitamura (1941 f. 6), Funazaki (1941 f. 22*). Cormophyt. Sin. (1947 f. 5040), Ito (1981), Murata (1982), and Shimizu (1982 Pl. 29. t 92-3)
Map: Ito (1981 and 1983 Fig. 6-2).

i) **subform. *albiflorum* (Tatew.) Ko. Ito,** stat. nov.

Basion. *Pol. coeruleum* ssp. *vulgare* var. *laxiflorum* form. *albiflorum* Tatewaki in Acta Phytotax. Geobot. **2**: 252. 1933. nom. nud.

Flores albi. Cetera ut in typo.
Nom. Jap. Shirobana-Karafutohanashinobu (Tatewaki 1933).
Range: rarely meets with the normal plants with colored corollas.
Specim. exam.: ***S. Sakhalin*: Moneron Isl.: Mt. Dainan (24 Jul. 1931—U. Kimoto *et al.*! fl. —Holotypus in SAPT).**

b) **form. *insulare* Ko. Ito,** form. nov.: Ito l. c. nom. nud.: Shimizu l. c.

A typo recedit planta robustiore, inflorescentiis corymbosis vulgo compactis vel subcompactis, saepe glomeratis. Lobis calycis latioribus anguste deltoidis vel deltoido-lanceolatis.

Planta forma maritima. Caulis inferne glaber, superne breviter glanduloso-puberulus, simplex, basis, 2-7 mm in diametr. Folia inferne usque ad 5-17 cm longa, 3-5 cm lata, petiolata, imparti-pinnata, glabra. Foliola 9-13-jugata, anguste ovato-elliptica vel ovata, apice breviter acuta et apiculata, basi rotunda vel latecuneata, 10-25 mm longa, 4-7 mm lata. Inflorescentia compacto-corymbosa saepe glomerate corymbosa cum vulgo 10-20 floribus; pedicelli brevitores quam calyces sub anthesi vel subaequali, dense breve glanduloso-pilosiusculi saepe cum longioribus pilosis; Calyx sub anthesi 7-10 mm longus dense vel sparse glanduloso-pilosus; lobis 4-5.5 mm longis, lanceolatis vel deltoido-lanceolatis (Fig. 4. 10-11), tubulo paulum longioribus, tubulus calycis longiuscule villosus; corolla campanulata, usque ad 20 mm longa; lobis lanceolatis vel anguste ellipticis, apice obtusis, rotundatis, saepe subacutis, mucronatis, integratis vel obsolute undulatis, ciliolatis, saepissime subtus puberulis vel glabris. Stamina corolla breviora; styli quam corollae subaequilongis. Semina ambitu subfusiformia 2.5-3 mm longa, triquetra, anguste alata, atricinnamomea. Fl: VI. Fr.: VI.

Nom. Jap. Rebun-Hanashinobu (n. n.)

* Zusetsu-Karafuto-no-Shokubutsu.

Specim. exam.: ***Hokkaido*:** Pref. Soya; **Monoiwa, Kabuka V. (Rebun Isl.)**, (2 Jul. 1920—M. Tatew.! fl., 18 June 1928—E. Nirei! fl., 21 June 1929—E. Nirei! fl., Jul. 1933—K. Seki *et al.*! fl., **18 Jul. 1968—Ko. Ito & M. Tohyama ! fl. —Holotypus in SAPT),** Rebun Isl. (cult. in Sapporo) (26 May 1913—K. Miyabe & 31 May 1927—M. Tatew.! fl.). Pref. Hidaka; Aburakoma (7 Jul. 1907—K. Kondo! fl.), Mt. Apoi (12 June 1952—M. Tatew.! bud), Cape Erimo (13 June 1952—M. Tatew.! bud).

Range: Japan (N. Hokkaido).
Icon.: Terazaki (1938 t. 2511*), Ito (1981), and Shimizu (1982 Pl. 29. t 92-3').
Map: Ito (1981, and 1983 Fig. 6-2).

The present new form is considered as a form which developes on coastal meadows under prevailing windy conditions. Under the strong windy conditions, plants become more robust and bear compact corymbose inflorescences. We have similar variations in some taxa, which are found under the same conditions on Rebun Isl.; *Aconitum sachalinense* var. *compactum* Miyabe et Tatewaki, and *Cortusa sachalinensis* var. *congesta* Miyabe et Tatewaki.

c) **form. *paludosum* Ko. Ito,** nom. nov.: Ito l. c. nom. nud. Syn. *Pol. coeruleum* ssp. *vulgare* var. *β. racemosum* Miyabe et Kudo, non Regel.

A typo differt planta graciliore, caule basi 1.5-3 mm in diametr., internodiis plerumque elongatis. Folioliis plerumque angustioribus, lanceolatis vel anguste ovato-ellipticis, vulgo 0.5-7 mm latis.

Planta forma paludosa. Caulis simplex, a basi adsurens, 25-60 cm. alt., inferne glaber, superne glanduloso-puberulus, basis 1.5-3 mm in diametr. Folia inferiora ad 7-20 (−26) cm longa, 2-3 (−5) cm lata, petiolata, imparti-pinnata, glabra, superne viridissima, inferne viridula vel galuco-viridia. Foliola 9-12-jugata, lanceolata, late lanceolata vel anguste ovato-elliptica, apice acuminata vel acuta, plerumque apiculata, basi rotunda vel obtusa, plus minusque asymmetrica, 5-20 (−35) mm longa, 0.5-7 (−10) mm lata. Inflorescentia stricto-racemoso-cyma vel laxe corymboso-cyma cum vulgo 8-16-floribus, rhachibus et ramis vulgo glanduloso-pilosiusculis, saepe cum longioribus pilosis. Calyx 5-7 mm longus sub anthesi, ad usque 10 mm longus post anthesin, dense glanduloso-pilosus, rarissime glaber; lobis lanceolatis vel anguste deltoidis, tubulo aequilongis vel longioribus (Fig. 4. 12-16). Corolla campanulata, (10-) 15-20 mm longa; lobis apice obtusis vel rotundatis, raro emarginatis, margine integratis vel inciso-serratis, plerumque ciliolatis, sed saepe vix ciliolatis (Fig. 1. 15-25). Stamina corolla breviora, antheris 3-4 mm longis, stylis corolla longioribus vel aequilongis. Capsula ellipsoidea vel ovoidea, 6-7 mm longa, 4-5 mm lata, glabra. Semina ambitu subfusiformia, 2-3 mm longa, ca. 1 mm lata, triquetra, anguste alata, cinnamomea. Discus undulatus (Fig. 3. 11-13), raro 5-fidus. Fl. VI-VIII. Fr. VI-VIII.

Nom. Jap. Kushiro-Hanashinobu (Miyabe & Kudo 1913).

* Zoku-Nihon-Shokubuts-Zufu.

fr.; Aug. 1895—idem.!), Kiritappu (date-unknown-M. Tanaka! 15 June 1968—Ko. Ito!), **Hamanaka (4 Jul. 1884—K. Miyabe! the "Holotypus" of *Pol. racemosum* Miyabe et Kudo! fl.,** date unknown—U. Tanaka! fl.), Chanai (14 June 1949—M. Tatewaki! fl.). Pref. Nemuro; Ochiishi (17. June 1934—M. Tatewaki! fr., Onneto (Aug. 1933—H. Ito! fl.).

***S. Kuriles*:** Isl. Shakotan; Upper Okkaibetsu (30 June 1934—D. Akaishi! fl.).

***N. Sakhalin*:** (Okhotsk side), Uhruta-Oha (*Oxa*) on peaty lands (1 Sept. 1923—B. Ishida! fr.), Pilewo riverside (24 Aug. 1923—Y. Kudo *et al.*! fr.), Parukata Tundra (10, Aug. 1922—Y. Kudo & M. Tatemwaki! fl.), (Tatarskiy Proliv side), Alexandrovsk-Sachalinskii Tundra (26 Jul. 1922—Y. Kudo & M. Tatewaki! fl.). ***S. Sakhalin*:** (Okhotsk side); Chirukoro (28 June 1936—M. Tatewaki *et al.*! fl.), Toyokoro-Chirukoro (12 Jul. 1935—M. Kawashima! fl.), Tsubugaru (21 Jul. 1935—S. Sugawara! fl.), Yamahana-Ikeda, Sikka (*Poronaisk*) (12 Jul. 1937—B. Yoshimura *et al.*! fl.), Ikeda-Sikka (*Poronaisk*) (12 Jul. 1937—B. Yoshimura *et al.*! fl.), Sikka (*Poronaisk*) (23 Jul. 1906—K. Miyabe & T. Miyake! fr.) (19 Jul. 1930—H. Ohtani *et al.*! fl.), Noboe (*Oemotoe*) (31 Jul. 1935—S. Sugawara! fl. & fr.), Kawase-gareyama-nosawa, Sikka (*Poronaisk*) (19 June 1936—M. Tatewaki *et al.*! veg.), Mirukunai, Sikka (*Poronaisk*) (5 June 1936—M. Tatewaki *et al.*! bud & fl.), Nishiyama Kashipo (4 Aug. 1932—H. Abumiya & Y. Hoshino! fl.). (Central parts); Ikusagawa (*Dalni*) (29 Jul. 1906—T. Miyake! fl.), Vladimirovskae (*Juzhno-Sachalinsk*) (22 Aug. 1906—K. Miyabe & T. Miyake! fr.). (*Tatarskiy Proliv side*), Anbetsu (*Boschnjakovo*) (2 Sept. 1929—K. Kawai & M. Tokunaga! fl. & fr.), Karafuto-Kokkyo (N. 50° Line) (1933—S. Ichikawa! fl.).

Range: Japan (N. & E. Hokkaido), Sakhalin, S. Kuriles, Amur and Ussuri.
Icon.: Klokov (1955 Fig. 9, pro *Pol. schizanthi*), and Ito (1981).
Map: Ito (1981, and 1983, Fig. 6-2).

The present new form is typically represented by the plant with narrower leaves and a few smaller-flowered inflorescences, but in fields plants with broader leaflets and many large-flowered inflorescences are commoner than the former. This form is a form adjusted to the bog environment.

The plants hitherto called as *Pol. laxiflorum* sensu Kitamura have two types. One is the robust or apparently well-developed type, and the other is the slender or ill-developed type, which was called *Pol. laxiflorum* var. *racemosum* Miyabe et Kudo. As a result of my field observation, it was found out that the latter is the same as the former.

Pol. caeruleum lusus *ramosum* Regel is not a form of *Pol. laxiflorum* but a different taxon as Kitamura pointed out. *Pol. racemosum* (Regel) Kitamura is characterized by having many smaller flowers on the raceme with elongated rhachis attaining to 10 to 20 cm in length and calyces with broadly deltoid lobes which are commonly shorter than the tubular part. These characteristics are illustrated correctly by Vassiljev (*cf.* Figs. 1-3, under *Pol. liniflorum* Vassil.)

In 1953, Klokov published a new species, *Pol. schizanthum* Klokov from

Spec. Exam : ***Hokkaido*** : Pref. Kushiro ; Sechuri (June 1895—S. Ito ! fl. & Sakhalin, in which the diagnosis was given : "a *Pol. coeruleo* L. statura graciliore, folioliis minoribus angustioribusque, inflorescentia subcorymbosa, non painculata, laxiore, calyce longiore, calycis tubulo villoso, non puberulo, corolla campanulata, non rotata, majore, lobis eae haud raro apice ciliatiusculis, non semper glabris, capsula majore, seminibus longioribus recedit." (*cf.* p. 316). The description and the specimens of LE reveal that *Pol. schizanthum* is considerably close to ssp. *laxiflorum*. The type locality of *Pol. schizanthum* is in Sakhalin, and the type specimen was collected in "insula Sachalin, distr. Meridionali-Sachalinensis, lacus Sussuj, pratum humidum ad viam inter opp. Juzhno-Sachalinsk et pal. Lugovoje, Copiosum." (Klokov 1. c.).

Reexaminaton of the Sakhalin specimens identified hitherto with *Pol. laxiflorum* Kitam. or *Pol. coeruleum* var. *laxiflorum* Miyabe et Kudo, and *Pol. schizanthum* learns that *Pol. schizanthum* Klok. is conspecific with the present form, although Woroschilov (1966) considered that Klokov's new species is totally synonymous to *Pol. villosum* which has the villose calyx.

4. ***Polemonium caeruleum*** **Linn. subsp.** ***yezoense*** **(Miyabe et Kudo) Hara** in Journ. Fac. Sci. Univ. Tokyo. III. **6** (7) : 364. 1956., excl. syn. "*Pol. nipponico*".

Key to the infraspecific taxa

A. Floral disk 5-teethed. Corolla lobes emarginate. Calyx-lobes narrowly lanceolate. . . . . a) ssp. *yezoense* var. *yezoense*

Floral disk undulate. Corolla lobes mucronate at apex. Calyx-lobes lanceolate. . . . . B and b) ssp. *yezoense* var. *nipponicum* Ko. Ito

B. Stems and inflorescences pubescent. . . . . b 1) var. *nipponicum* f. *nipponicum* Stems and inflorescences glabrous or nearly so. . . . . b 2) var. *nipponicum* f. *hidakanum* Ko. Ito

a) var. *yezoense*

Perennial, rhizome creeping. Stem erect, simple, 40 to 60 cm tall, not solid, usually glabrous except for the upper parts, smooth, (2-) 3 to 5 (-6) mm across at the base. Leaves oddly-pinnately divided ; the radical leaves emarcid in anthesis. Cauline leaves narrowly elliptic, with short petioles which are dilated at the base and more or less ciliate on the margin, 12 to 25 cm long, 5 to 8 cm wide, reduced toward the inflorescence in size, glabrous, dark green above and pale green or glaucous beneath ; leaflets (7—) 9— to 10 (-11)-paired, ovately lanceolate to broadly lanceolate, acuminate or acute, pointed at the apex, roundish or broadly cuneate, more or less oblique at the base, sessile, conspicuously 3-nerved, entire on the margin ; the lowest leaflets usually 1 to 2.5 cm long, 2 to 6 mm wide, often attain from 2

to 3 cm long, from 6 to 9 mm wide, or from 3.5 to 4 cm long, from 12 to 15 mm wide; the terminal ones narrowly elliptic, acuminate at both ends, usually 2 to 3 cm long, 6 to 8 mm wide, often attain 6 cm in length, 12 mm in width.

Bracts pinnate or pinnatifid or simple, entrire, petiolate or sessile, glabrous. Inflorescences strict to open corymbose-cyme with (8-) 10 to 15 (-25) flowers; the rachis and the branches of the inflorescences commonly densely hairy with short stalked glands of 0.2 mm in length together with multicellular white long hairs of 0.5 mm long; the pedicels as long as or a little longer than the calyx in anthesis. Calyx campanulate, 8 to 11 mm long in anthesis, pubescent with multicellular long hairs being 0.5 to 1 mm in length; the lobes usually 2/3 to 3/4 of the calyx in length, narrowly lanceloate to lanceolate, sometimes narrowly ovate-lanceolate, acuminate but truncate to obtuse or rotundate at the apex, reflexed from the base of the calyx at fruit, the length ca. 3 to 6 times as long as the width (Fig. 4. 5-6). Corolla rotate to slightly reflex, blue to purplish-blue, 20 to 25 mm long in full growth, usually emarginate, but often obtuse to rotundate at apex, (in poor growth, corolla companulate, 15 mm long, hardly emerginate) entire, ciliolate on the margin (Fig. 2. 1-5); styles subequal to the corolla in length. Stamens shorter than the corolla, ca. 2/3 of the corolla; anthers elliptic, 2 mm long, 1.3 mm wide *in sicco*, while oblong, ca. 4 mm long *in vivo*. Pollengrains, yellow or orange-yellow, polyforate, mostly 47.5-52.5 μ, rarely to 62.5 μ in size. Capsules ovate-globose, 6 to 8 mm long, 5 to 7 mm wide, glabrous, trilocular. Disk usually distinctly 5-teethed, obscure or undulate (Fig. 4. 5-6). Seeds reddish-black or brown, 2 to 4 mm long, 1 to 1.5 mm wide narrow but conspicuous wings, not mucilagious when wet. Fl. V to VI. Fr. VIII.

Nom. Jap. Yezo-no-Hanashinobu (Miyabe & Kudo 1913).

Specim. exam.: Pref. Ishikari; Jyozankei, Hoheikyo (27 June 1965—Ko. Ito! fl.; 10 Jul. 1967—Ko. Ito! fr.; 12 June, 1968—Ko. Ito! bud & fl.). Jyozankei (6, June 1921—M. Tatewaki! fl.), Mt. Jyozankei-Tengu (5 June 1930—H. Ohtani! fl.; 2 June 1955—S. Kawano! fl.; 17 Jul. 1961—J. Hasegawa! fr.), Shimofujino (17 Sept. 1929—K. Takahashi! veg.), Kataishi-Yama Sando, Ishiyama (June 1889—Y. Tokubuchi! fl.), Makomanai-Nakanoshima, Sapporo C. (7 Sept. 1929—H. Yanagisawa! bud & fl.), Mt. Moiwa (June 1928—Class 1928! fl.), **Sapporo** (June 1878—S. Tanouchi! fl.; May 1880—K. Miyabe! bud & fl.; June, 1883—**K. Miyabe!** fl. — "**Holotypus**"; June 1892—Y. Tokubuchi! fl. & bud), locality unknown (1886—H. Nagaya! fl.).

Typus: "Shady wood et banks of streams" (June 1883—K. Miyabe: fl.) in SAPT.

Range: Endemic to Hokkkaido, Japan (N. Part)

Icon.: Kitamura (1941), Okuyama (1966), Ito (1981), Murata (1982), and Shimizu (1982 Pl. 29. t 92-2).

Map: Ito (1981, and 1983 Fig. 6-1).

The typical variety is characterized by having notched petals, narrower and

longer calyx-lobes and distinctly 5-divided floral disks. These characteristics are most conspicuous in Polemonia grown around Hoheikyo, Sapporo C., and its adjoining areas.

As Kitamura pointed out, this variety is available for the horticultural purpose. In Hokkaido, the plant is often cultivated but sometimes becomes a rather troublesome herb owing to its vital propagative potentiality.

b) **var. *nipponicum* (Kitamura) Ko. Ito,** comb. nov. Ito l. c. nom. nud. : Shimizu l. c.

Basion. *Polemonium nipponicum* Kitamura, l. c. 181. fig. 3.

Perennial, rhizome repens. Stem erect or ascending, simple, 30 to 60 cm tall, not solid, usually glabrous except for the upper parts, smooth, 2-4-5 mm across at the base. Leaves oddly-pinnately divided ; the radical leaves emarcid or alive in anthesis. Cauline leaves narrowly elliptic with short petioles which are dilated at the base and more or less ciliate on the margin, (5-) 10 to 20 cm long with the petioles, (2-) 3 to 6 cm wide, reduced toward the inflorescence in size, glabrous, dark green above and pale green beneath ; leaflets (7—) 9— to 10— (-13)- paired, ovately lanceolate to narrowly ovate-lanceolate, sometimes broadly lanceolate, acute or acuminate but obtuse at apex, roundish or broadly cuneate at base, more or less asymmetric at the base, sessile, conspicuously 3-nerved, entire on the margin ; the lowest leaflets are commonly largest, 5 to 30 mm long, (2-) 5 to 15 mm wide, but often attain 10 to 35 mm in length, 6 to 15 mm in width ; the terminal ones narrowly elliptic to oblong or ovately lanceolate, 1 to 5 cm long, 3 to 7 mm wide, acuminate at both ends. Bracts usually pinnate or pinnately clefted, rarely simple, entire, petiolate or sessile, glabrous. Inflorescences strict to open cyme with (5-) 10-15 (-25-40) flowers ; the rachis and the branches of inflorescences usually densely hairy with short stalked glands, sometimes glabrous ; the hairs mostly ca. 0.2 mm long together with long curled hairs of 0.5 mm in length, white, dirty white or reddish brown in color ; the pedicels as long as or a little shorter than the calyx in anthesis. Calyx campanulate, 8 to 11 mm long in anthesis, usually pubescent with long hairs as well as short glands, rarely glabrous ; the lobes 1/2 to 3/4 of the calyx in length, broadly lanceolate, truncate to obtuse or rotundate at apex (Fig. 4. 3-4), the midribs and lateral nerves prominent *in sicco*, 4 to 7 mm long, the length ca. 1.5 to 3 times as long as the width. Corolla 15 to 27 mm long, or 7 to 10 mm across ; the lobes 10 to 18 mm long, elliptic to broadly ovate, commonly cuspidate at apex, rarely rotundate or shallowly emarginate at apex, entire or serrate-incised (Fig. 1, 6-14), cilliolate on the margin, glabrous or sparsely pilose on the both sides. Stamens ca. 2/3 as long as the corolla ; the anthers ca. 3 mm long *in vivo*, 1.5 mm long *in sicco*. Pollengrains generally (45-) 50-52.5 (-57.5) μ in size. Styles subequal to the corolla in length. Capsules globose to ellipsoid, 5 to 7 mm long and wide, glabrous, trilocular. Disk undulate (Fig. 3. 5-8) or often bluntly 5-teethed. Seeds reddish brown or blackish brown, 2 to 3 mm long, 1 to 1.5 mm wide with, narrower, membranaceous wing, not shining and hardly

mucilaginous when wet. Fl. V. to VIII. Fr. VIII.

The var. *nipponicum* in central Honshu is identical in general characteristics with *Pol. yezoense* var. *hidakanum* Ko. Ito. In a strict sense, ssp. *yezoense* should be limited to the vicinity of Sapporo in occurrence. Most plants of *Pol. yezoense* hitherto called in Hokkaido belong to the present variety. Some differences between plants of this variety in Honshu and those in Hokkaido are seen. The former are more slender in habit and have smaller and fewer pinnulae, but the latter are stout and have large and numerous pinnulae. The former grow on the upper parts of the high mountains or sub alpine meadow, while the latter grow on the lower lands.

The present variety is divided into the following 2 forms.

b 1) form. *nipponicum*

Calyx, inflorescences and the upper parts of the stem are glandulous pubescent, rarely mixed with multicellular pilose hairs.

Nom. Jap. Miyama-Hanashinobu (Kitamura 1941)

Specim. exam.: **Hokkaido:** Pref. Oshima; Kakkumi Pass (21 Aug. 1888—Y. Tokubuchi! bud & fl.). Pref. Shiribeshi; Kamoiwaki, Okushiri Isl. (17 Jul. 1935—B. Yoshimura! fl.; 18 Jul. 1935—ibid.! fl. & fr.), Tomarikawa, Shimamaki V. (27 June 1954—T. Misumi & T. Igarashi! fr.), Mt. Ohira, Shimamaki V. (10 Aug. 1938—I. Yamamoto! fl.; 31 Jul. 1954—T. Igarashi & S. Watanabe! fr.), Mt. Raiden, Iwanai T. (11 June 1897—S. Ishikawa! fl.), Inakuraishi, Shakotan Pen. (11, June 1969—Ko. Ito! cult. fl.). Pref. Sorachi; Soeushinai, Uryu Gun (25 June, 1965—M. Tatewaki & M. Tohyama! fl.; 25 June 1966—Ko. Ito & M. Tohyama: fl.), Mt. Kirigishi (23 Aug. 1969—S. Watanabe! fr.; 26 Jul. 1970—M. Tohyama *et al.*! fl. & fr.). Pref. Kamikawa; Mt. Yubari, Kanayama side, south of Mt. Ko-Yubari (7 Jul. 1964—T. Hamaya! fl.). Pref. Hidaka; Pankenushi 135-Rinpan (22 June 1953—T. Shibuya! fl.), Niikappu (4 June 1939—M. Tatewaki! fl.), Mitsuishi (14 June 1965—Y. Takahashi! fl.), Horoman (June 1952—N. Nishimura! fl.; 11 June 1966—M. Tohyama! fl.), Horoman River Karyu (5 June 1952—J. Samejima & Nishimura! fl.), Horoman-Apoi (15 June 1952—T. Kamai! fl.), Fuyushima (13 May 1952—M. Tatewaki! fl.), Nukabira, Upper reaches of Saru R. (Jul. 1951—N. Nishimura! fl.), Mt. Apoi (June 1927—M. Tatewaki! fl.), Samani (31 May 1927—M. Tatewaki! fl.), Shoya (17 Aug. 1892—Y. Tokubuchi! fl.; 26 May 1927—M. Tatewaki! bud). Pref. Tokachi; Puke Stream (18 June 1892—T. Kobanawa! fl.), Toyoni (24 May 1947—M. Tatewaki & F. Sugawara! veg; 31 Jul. 1953—M. Togashi! fl.; 9 June 1969—T. Enoki! fl.), Biroo (20 June 1937—H. Iwamoto! fl.; 13 May 1952—M. Tatewaki! fl.).

Typus: Yetchiu: Mt. Shirouma, Shozudake (29 Aug. 1920—G. Koidzumi)
Range: Endemic to Japan (Central Honshu & Hokkaido).
Icon.: Kitamura (1941), Kitamura *et al.* (1957), Okuyama (1961), Murata (1982), and Shimizu (1982 Pl. 29. t-92).

Map: Okuyama (1961), Ito (1981 and 1983. Fig. 6-1).

b 2) **form. *hidakanum* (Ko. Ito) Ko. Ito,** comb. et stat. nov., et emend.: Ito l. c. nom. nud.: Shimizu l. c.

Basion. *Polemonium yezoense* var. *hidakanum* Ko. Ito in Journ. Geobot. 8: 72. 1960.

A typo recedit calycibus, pedunculis et caulibus superne tote glabris vel glabrisuculis. Calycis lobi angusto-lanceolati, apice truncati. Corollae lobi 15-20 mm longi, acutiusculi vel mucronati (Fig. 1, 6). Discus obsolete 5-lobatus, undulatus raro integer. 2n=18 (Nishikawa, unpublished). (Photo 3. 1 & 2).

Nom. Jap. Hidaka-Hanashinobu (Ko. Ito 1960)

Specim. exam.: Pref. Hidaka, Shibuchari (16 June 1884—K. Miyabe! fl.). Shinsamani (1 Jul. 1951—M. Tatewaki! fl.), **Niikappu** (5 June 1936—M Tatewaki! fl.; **6 June 1939—M. Tatewaki! fl. —Holotypus in SAPT**).

Range: Endemic to Hokkaido (Southern Hokkaido).

Icon.: Ito (1960 and 1981).

Map: Ito (1981, and 1983 Fig. 6-1).

In 1960 I distinguished *P. yezoense* var. *hidakanum* from *P. caeruleum* ssp. *yezoense* by its acutish, not emarginate corolla-lobes. At that time, 2 types were found in var. *hidakanum*; one is a type having pubescent calyx, peduncles and stem; the other is a type which is glabrous or nearly so in them, but I did not note any taxonomical significance in these differences. In the present study, I recognize that var. *hidakanum* characterized by the acutish corolla-lobes is synonymous with Kitamura's *P. nipponicum* described in Honshu. This newly ranked taxon, forma *hidakanum*, however, retains the epithet by amending its contents, in which this taxon is characterized by being glabrous or nearly glabrous calyx, peduncles and stem as the holotype of var. *hidakanum* shows.

Taxonomical treatment

Polemoniaceae Juss.-Polemonioideae Brand-Polemonieae Peter-Polemonium Tourn.

Series 1. Humilia Vassil. (incl. Ser. Parviflora Vassil.)

1. *Polemonium boreale* Adams [in Mem. Soc. Nat. Mosc. **5**: 92. 1817.]: Davidson Polemonium 241. 1950.: J. Lid & D. T. Lid Norsk Fl. 517. 1952: Prosild Ill. Fl. Canad. Artic Archipel. 136. Fig. 60-b & Map. 282. 1957.: Polunin Cricumpol. Arct. Fl. 365. 1959.: Klokov Fl. Murm. Prov. **5**: 58. 1966.: Hultén Fl Alaska 768. 1968. (pro ssp. *borealí*): Böcher *et al.* Fl. Greenland. 157. 1968.: Tzvelev Arct. Fl. URSS. **8**: 220. 1981.

Synonymy: *Pol. humile* Willd., ex Roem. et Schult. Syst. Veget. **4**: 792. 1819. non Salisb.: Peter in Engl. u. Prantl, Pflzfam. IV. 3 a. 52. f. 23. 1891.: Benth. in DC. Prod. **9**: 318. 1845. (*sp. dubiae*): Yabe & Yendo in B. M. T. **18**: (192). 1904.: Miyabe & Kudo in Trans. Sapporo Nat. Hist. Soc. **4**: 102. 1913.: Hultén Fl. Kam. **4**: 73. Pl. 4. fig. c. 1930.: Kudo in Bull. Exper.

For. Kyushu Univ. **1**: 83. 1931.: Makino & Nemoto Fl. Jap. ed. 2. 981. 1931.: Tatew. in Bull. Biogeogr. Jap. **4**: 295. 1934.: Vassil. in Komar. Fl. URSS **19**: 87. 1953.: Malyzhev Alpine Fl. Stanovoye Nag. Upland. 129. 1972.

Pol. pulchellum β. *humile* (Willd.) Ledebour Fl. Ross. **3**: 84 & γ. *macranthum* Ledeb. l. c. 85. 1847.

Pol. coeruleum ε. *humile* Herder in Act. Hort. Petrop. **1**: 484. 1872.

Pol. lanatum Pallas subsp. α. *boreale* (Adams) Brand & var. β. *humile* (Willd.) Brand in Engl. Pfl.-reich. IV-250 Ht. 27. 40. 1907.

Pol. parviflorum Tolm.: Woroschilov l. c. pro syn.

Pol. villosum Rud., ex Georgi [Beschr. Russ. Reich. **III**-4: 777. 1800.] nom. ambig.: Tzvelev l. c., pro syn.

Pol. hultenii Hara Enum. Sperm. Jap. **I**: 169. 1948., nom. nov. based upon *Pol. humile* Willd., ex Roem. et Schult.: Woroschilov Fl. Sov. Far. East. 349. 1966.

Series 2. Caerulea Vassil. (incl. Ser. Villosa Vassil.) s. l.

2. *Polemonium caeruleum* Linn. Sp. Pl. ed. 1. 162. 1753. subsp. *campanulatum* Th. Fries in Bot. Notis. No. 12: 190. 1858.: Lindb. fil. in Sched. operis Pl. Finnl. exs. No. 867. 1916.: Lindman Svensk Fanerogamfl. 457. 1918.: Hara in Journ. Fac. Sci. Univ. Tokyo III. **6** (7): 361. 1958.

Pol. caeruleum **campanulatum* Th. Fries.: Blytt Haamdbog I. Nargens Flora 585, 1905-1906.

Basion. *Pol. campanulatum* Th. Fries in Fries, Herb. Norm. XVI. 17. ex. Nyman, Consp. Fl. Europaea 504., in Notis. Saellsk. Faun. Fl. Fenn. Foerk. **13**: 258. & 262. 1871-1874. [nomina sola]: Tzvelev Fl. Arct. URSS **8**: 217. 1980.

Later homonym: *Pol. campanulatum* (Th. Fries) Lindb. fil. l. c.: Klokov in Bot. mat. Gerb. inst. ANSSSR. **17**: 281. *t. 2.* 1955. & Fl. Murm. Prov. **5**: 54. *t. 7.* 1966.

Syn.: *Pol. acutiflorum* Willd., ex. Syst. Veget. curant. Roem. & Schult. **4**: 792. 1819: ibid. curant. Sprengel **1**: 623. 1825.: Benth. in DC Prod. **9**: 318. 1845. (*sp. dubiae*): Eastwood in Bot. Gazette **33**: 286. 1902.: Hultén Fl. Kamtch. **4**: 72. 1930., Fl. Alaska 767. & fig., Map. p. 767. 1968., & Fl. Alaska & Yuk. **8**: 1320. 1948.: Tatew. in Bull. Biogeo. Jap. **4**: 295. 1934.: Kitamura in Act. Phytotax. Geobot. **10**: 183. fig. 5. 1941.: J. Lid. & D. T. Lid. Norsk Fl. 516. fig. 295-e. 1952. & D. T. Lid. Norsk. Sv. Fl. 556. fig. 333-e. 1963.: Vassil. in Komarov Fl. URSS. **19**: 81. t. 5. f. 2. 1953.: Ohwi Fl. Jap. ed. 1. 977. 1953. & ibid. ed. 2. 1123. 1965.: Polunin Circumpol. Arc. Fl. 364. 1959.: Tutin Fl. Eur. **III**: 74. 1972.: Tzvelev l. c. 218.

Pol. caeruleum var. β. *acutiflorum* (Willd.) et γ. *ovatum* Ledebour Fl. Ross. **3**: 84. 1847.: Trautv. & Mey. Fl. Ochot. 69. 1856. excl. γ.: Regel & Tiling Fl. Ajan. 112. 1858. excl. γ.: Kurtz in Engl. Bot. Jahrb. **19**: 399. 1895. excl. γ.

"*Pol. villosum*" Auctt. fl. bor., non Rudolph, ex Georgi: Miyabe & Miyake Fl. Saghal. 333. 1915.: Kudo Fl. Param. 152. 1922., Contr. N. Saghal. 53. 1923.

& Rep. Veg. N. Saghal. 207.: Vassil. in Komar. Fl. URSS. **19**: 80. 1953.: Popov Fl. Cent. Sib. **2**: 606. 1959.: Woroschilov Fl. Sov. Far East. 350. 1966.: Borobjev Key Pl. Prim. & Priamur 338. 1966. cum var. *linifloro*.

Pol. caeruleum subsp. *villosum* (Rud.) Brand in Engl. Pfl.-reich. IV-250. Hft. 27. 38. 1907.: Miyabe & Kudo in Trans. Sapporo Nat. Hist. Soc. **4**: 101. 1913.: Makino & Nemoto Fl. Jap. ed. 2. 980. 1931: Davidson Polemonium 223. fig. 3. 1950.: Niggins *et al.* Fl. Alaskan Arct. Slope 303. 1962.

Pol. pacificum V. Vassil. in Bot. mat. Gerb. inst. ANSSSR. **15**: 222. 1953. & in Komar. Fl. URSS. **19**: 81. t. 5. f. 3. 1953.: Woroschilov l. c. pro syn.: Hultén op. cit. 767. 1968.

Pol. diminutum Klok. in Bot. mat. Gerb. inst. ANSSSR. **17**: 289. t. 4. 1955.: Woroschilov l. c. pro syn.

Pol. foliolatum Klok. l. c. 284. t. 3.: Woroschilov. l. c. pro syn.

Pol. majus Tolmatchev in Fedde Rep. **23**: 274. 1927., fide Hultén.: Hara Enum. Sperm. Jap. **I**: 169. 1948.

"*Pol. coeruleum* Linn." Koidz. in B. M. T. **25**: 218. 1911.

3. *Polemonium caeruleum* Linn. subsp. *laxiflorum* (Regel) Ko. Ito

Basion. *Polemonium caeruleum* a. *vulgare* lusus *laxiflorum* Regel Tent. Fl. Ussur. 106. 1862.: Herder Pl. Radd. **4** (1): 199. 1873.

Syn. *Pol. coeruleum* subsp. *A. valgare* var. *γ. laxiflorum* (Regel) Miyabe & Kudo in Trans. Sapporo Nat. Hist. Soc. **4**: 100. 1913.: Miyabe & Miyake Fl. Saghal. 333. 1915.: Kudo in Bull. Exper. For. Kyushu Univ. **1**: 83. 1931.: Hara Enum. Sperm. Jap. **I**: 169. 1948.: Murata Wild Fl. Jap. **3**: 56. 1981.

Pol. caeruleum subsp. *campanulatum* var. *laxiflorum* (Regel) Hara in Journ. Fac. Sci. Univ. Tokyo III. **6** (7): 364. 1956.

Pol. acutiflorum var. *laxiflorum* (Regel) Ohwi Fl. Jap. ed. 1. 977. 1953., ibid. ed. 2. 1123. 1965. & ibid. Engl. ed. 755. 1965.

Pol. laxiflorum (Regel) Kitamura in Act. Phytotax. Geobot. **10**: 182. 1941.: Kitamura *et al.* Colour. Ill. Herb. Pl. Jap. **1**: 201. 1957.: Woroschilov Fl. Sov. Far East. 349. 1966.; Icon. Cormophyt. Sin. **3**: 543. 1974.

Pol. schizanthum Klok. in Bot. mat. Gerb. inst. ANSSSR. **17**: 315. fig. 9. 1955. syn. nov.

"*Pol. coeruleum* L.": Fr. Schm. Fl. Sachal. 160. 1868.: Koidz. in Journ. Coll. Sci. Imp. Univ. Tokyo **27** (Art 13): 103. 1910.

"*Pol. coeruleum* var. *villosum* (Rud.) Brand": Komarov & Alis. Key Far East. URSS. **2**: 880. *t. 268*. 1932.

Pol. liniflorum Vassil. in Bot. mat. Gerb. inst. ANSSSR. **15**: 218 1953. excl. fig. *p. p.* & in Komar. Fl. URSS. **19**: 84. 1953. *p. p.*

a) *Polemonium caeruleum* subsp. *laxiflorum* form. *laxiflorum* subform. *albiflorum* (Tatew.) Ko. Ito

Basion. *Pol. coeruleum* subsp. *vulgare* var. *laxiflorum* form. *albiflorum* Tatewaki in Act. Phytotax. Geobot. **2**: 252. 1933. nom. nud.

Syn. *Pol. laxiflorum* form. *albiflorum* (Tatew.) Hara l. c. 170. 1948. cum.

diagn.

b) form. *insulare* Ko. Ito

"*Pol. caeruleum* L." Terazaki Zoku-Shokubutsu-Zufu. t. 2511. 1938.

c) form. *paludosum* Ko. Ito

Syn. *Pol. coeruleum* subsp. *vulgare* var. *β. racemosum* (non Regel) Miyabe & Kudo op. cit. 99. 1913., excl. syn.: Miyabe & Miyake l. c. 332.: Kudo Contr. Fl. Nord. Saghal. 53. 1923. & Rep. Veg. Nord. Saghal. 207. 1924.: Miyabe & Tatew. in Trans. Sapporo Nat. Hist. Soc. **13** (pt. 4): 381. 1934.

"*Pol. laxiflorum*" Auctt. Fl. Jap. *p. min. p.*

Pol. schizanthum Klok. l. c. *p. max. p.*

4. *Polemonium caeruleum* Linn. subsp. *yezoense* (Miyabe et Kudo) Hara in Journ. Fac. Scu. Univ. Tokyo III. **6** (7): 364. 1956., excl. syn. "*Pol. nipponico*". & Hara J. Jap. Bot. **51**: 76. 1976.: Murata Wild Fl. Jap. **3**: 56. 1981. cum *Pol. nipponico.*

Basion. *Polemonium coeruleum* Linn. ssp. *vulgare* (Ledeb.) Brand var. *α. yezoense* Miyabe & Kudo in Trans. Sapporo Nat. Hist. Soc. **4**: 99. 1913. quoad pl. ishikariensis, cum typo.

Syn. *Pol. yezoense* (Miyabe & Kudo) Kitamura in Acta Phytotax. Geobot. **10**: 177. 1941. *p. p.*: Hara Enum. Sperm. Jap. **I**: 170. 1948. *p. p.*: Ohwi Fl. Jap. ed. 1. 977. 1953. *p. p.*, ibid. ed. 2. 1122. 1965. *p. p.* & ibid. Engl. ed. 754. 1965.: Kitamura *et al.* Colour. Ill. Herb. Pl. Jap. **1**: 201. 1957. *p. p.*: Okuyama Colour. Ill. Wild Pl. Jap. **6**: 83. pl. 482-1. 1966.

a. var. *nipponicum* (Kitamura) Ko. Ito

Basion. *Polemonium nipponicum* Kitamura l. c. 181. fig. 3. 1941: Kitamura *et al.* l. c. Pl. 61. fig. 498.

Syn. *Pol. acutiflorum* var. *nipponicum* (Kitamura) Ohwi Fl. Jap. ed. 1. 977. 1953, in Bull. Sci. Mus. Tokyo **33**: 84. 1953. & Fl. Jap. rev. ed. 1123. 1965. & ibid. Engl. ed. 754. 1965.: Okuyana Nihon-Shokubuts-Zufu 47. pl. 83 (a) & (b). 1961.

Pol. yezoense Kitamura vel *Pol. caeruleum* var. *yezoense* Miyabe & Kudo: Auctt. fl. jap. excl. synon. *et* pl. sapporoensis. p. max. p.: Tatew. Veget. Apoi. 107. 1928.: Nakai Veg. Apoi. 66. 1930.: Hara in Bot. Mag. Tokyo **51** (602): 49. 1937.

Pol. caeruelum subsp. *yezoense* Hara l. c. 1956. pro syn. & in Jour. Jap. Bot. **51** (3): 76. 1976. pro syn.

b. form. *hidakanum* (Ko. Ito) Ko. Ito

Basion. *Polemonium yezoense* var. *hidakanum* Ko. Ito in Journ. Geobot. 8: 72. 1960.

Syn. *Pol. coeruleum* var. *yezoense* Miyabe et Kudo, l. c. p. p.

Conclusion

In the Flora URSS vol. 19 (1953) Vassiljev sets forth 4 series in the Sect. Polemonium, and Klokov (1955) arranged the Euro-Asiatic species recognized by him

under the series. Of the 4 series given by Vassiljev, the Villosa and the Caerulea should be unified into a single series in my opinion as seen in the present studies in which I favour the Brand-Davidson's taxonomical treatment. Also the ser. Parviflora is superfluous, if *Pol. parviflorum* Tolm. is conspecific with *Pol. boreale* Adams. (*cf.* Hultén 1930 & Woroschilov 1966). Consequently, I prefer to accept 2 series, if necessary, in the systematics under question. One is the ser. Caerulea (incl. the ser. Villosa) Vassil., and the other is the ser. Humilia Vassil. In the present studies, *Pol. caeruleum* comes under the former series, and *Pol. boreale* comes under the latter series.

Pigott (1959) considered that the distributional boundary line between European ssp. *caeruleum* and the arctic ssp. *campanulatum* lies on Lake Baykal, from where ssp. *caeruleum* predominates westwards-W. Siberia through European Russia to Europe, and ssp. *campanulatum* prevails eastwards-E. Siberia, Kamchatka and to Alaska. Kitamura (1941) has pointed out already that at least the Polemonia found in Asia are not a member of a variant of the European ssp. *caeruleum* or ssp. *vulgare* Brand, but are relatives of the arctic ssp. *campanulatum* or *Pol. acutiflorum*.

In addition, Kitamura mentioned two courses of the phylogenetic differentiation in the Polemonia in Asia. One is a line of *Pol. acutiflorum-Pol. racemosum-Pol. kiushianum*. In this course, at first *Pol. racemosum* in Manchuria and Korea may have been derived from *Pol. acutiflorum* in the Arctic Region, the former having panicles bearing smaller and numerous flowers, and next, *Pol. racemosum* might be a possible ancester of *Pol. kiushianum* in S. W. Japan, in which the colloralobes are characterized by the obtuse lobes in place of the acute lobes and the seed becomes the smallest. The other is a line of *Pol. acutiflorum-Pol. laxiflorum-Pol. nipponicum-Pol. yezoense*. In this case, the differentiation begins within the common ancester, *Pol. acutiflorum*, through *Pol. laxiflorum* in Sakhalin, Manchuria etc., *Pol. nipponicum* in C. Honshu, and terminates to *Pol. yezoense* endemic in Hokkaido. The latest is characterized by expecially larger corollas with emarginate lobes and the 5-teethed disk (Fig. 1. 1-4 : Fig. 3. 1-3). Palynological records (cf. Godwin, 1956 ; Nakamura, 1968) suggested that the differentiation may be affected by the late-glacial and the post-glacial climatic changes in the Quaternary Era.

Davidson (1951) postulated that the present Eurasian polupations of *Pol. caeruleum* and its allies probably originated from the ancestral ones of the Tertiary Polemonia in N. America. According to him, they crossed the Bering "bridge" and migrated to Alaska, to Asia and to Europe. In such migration courses, interbreeding occurred, and ancestral genes scattered to a varying degree among populations. He concluded that the genes present in the American populations are present also in the Eurasian stock, although usually masked by the others. Davidson's view would suggest that the hypothetical phylogenetic differentiation course given by Kitamura is acceptable in outline, and that a great morphological diversities present in the Eurasian Polemonia are due to the gene recombinations occurring suddenly, or randomly. Even in the morphological variations along the geographical gradient

within the range of at least *Pol. caeruleum* and its allies, splitters can recognize and delimit certain independent taxa but at the same time they may be perplexed by the taxanonomical interpretations of local populations which contain plants provided with the characteristics foreign to the population. For example, the erosed corolla-lobes of ssp. *yezoense*, one of the most important characteristics of this subspecies, are often found in others, e. g. in f. *paludosum* of var. *laxiflorum* in which the lobes are typically obtuse to rotund. Moreover, some plants collected on Mt. Kirigishi and on Asagiri Pass identical with var. *nipponicum* in the present studies are phenotypically closely resemble to European ssp. *caeruleum* with special regard to pubescence in which short glandular hairs are prevailing.

If one considers Kitamura's and Davidson's hypothetical conclusion, he will easily understand with regard to the examples given above that there is no necessity to consider those individuals or populations as a new species by a simple reason which is different from the others.

Systematics of Polemonium species suggest us that the analysis of geographical and socio-ecological gradient is essential rather than the morphology, in addition to cytotaxonomical experiments which have scarcely been dealt with (Ostenfeld 1923 & 1929; Clausen 1931). Socio-ecologically Polemonia may be characteristics of peri-glacial communities both in the past and in the present; geographically they are more or less relict, and disjunctively distribute at present. Explanations of the mechanisims on those phenomena and processes are out of the scope of the present paper, and remain in the future.

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References

(excluded from taxonomical literature)

Böcher, W. (1967): Continuous variation and Taxonomy. *Taxon.* **16**: 255–258.

Çlausen, J. (1931): Genetic Studies in Polemonium III. Preliminary account on the cytology of species and specific hybrids. *Hereditas*, **15**: 62–66.

Dawson, M. L. (1936): The floral morphology of the Polemoniaceae. *Amer. J. Bot.* **23**: 501–511.

Erdtman, G. (1952): Pollen Morphology and Plant Taxonomy. Almquist & Wiksells, Stockholm.

Erdtman, G. (1969): Handbook of Palynology. Munksgaard, Copenhagen.

Godwin, H. (1956): The History of the British Flora. Cambridge Univ. Press, London.

Good, R. (1974): The Geography of the Flowering Plants. 4 th ed., Longman, London.

Hultén, E. (1971): The Circumpolar Plants II. Dicotyledons. in Kungl. Svenska Vetenskaps-akademiens Handlingar Fjärde Serien. Band 13 Nr. 1.

Malyshev, L. I. (ed.) (1972): Alpine Flora of The Stanovoye Nagorye Uplands, composition, pecularities and genesis. *Academy of Science of the USSR, Siberian Branch, Siberian Institute of Plant Physiology and Biochemistry.* Nauka, Siberian Branch, Novosibirsk.

Melchior, H. (1964): Polemaniaceae. in A. Engl. Syll. Pflanzenfamil. 12 Aufl. Bd. II. 426–427.

Metcalfe, C. R. and Chalk, L. (1979): Anatomy of the Dicotyledones. 2nd ed. vol. 1. Clarendon Press, Oxford.

Nakamura, J. (1968): Palynological aspects of the Quaternary in Hokkaido. V. Pollen succession and climatic change since the Upper Pleistocene. *Res. Rep. Kochi Univ. Nat. Sci. 3.* **17**: 39–50.

Ostenfeld, C. H. (1923): Genetic studies in Polemonium coeruleum. *Hereditas*, **4**: 17–26.

Ostenfeld, C. H. (1929): Genetic studies in Polemonium coeruleum. II. Experiments with crosses of *P. mexicanum* Cerv. and *P. pauciflorum* Wats. *ibid.* **12**: 33–40.

Peter, A. (1891): Polemoniaceae. in A. Engl. & Prantl Natür. Pflanzenfamil. IV-3a. 40–54.

Piggot, C. D. (1958): Polemonium caeruleum L. *J. Ecol.* **46**: 507–525.

Tikhomirov, B. A. (ed.) (1966): [Vascular Plants of the Siberian North and the Northern Far East.] English translation ed. by Philips, L. (1969). Jerusalem.

Yamazaki, T. (1933): Morphology of pollens and spores collected in the Kyoto Imp. Univ. Exp. Forest of Sakhalin. *Bull. Kyoto Imp. Univ. For.*, No. 5.

Summary

In the present paper, the taxonomy of Polemonium species in Hokkaido (N. Japan), the Kuriles and Sakhailn was dealt with. The classification was carried out on the basis of traditional morphological characteristics and field observations. Following to the species concept of Davidson's (1950), four species recognized by senior authors reduced to two species; *Polemonium caeruleum* Linne and *Pol. boreale* Adams. Infraspecific units adopted were the subspecies, the variety and the form. The subspecies should be a unit which expresses geographical-morphological differential patterns and habitats in global scale; the variety shows local pattern of variations of any characteristics or ecological habitats within a locality; the form is a simple trifle variation of a given character.

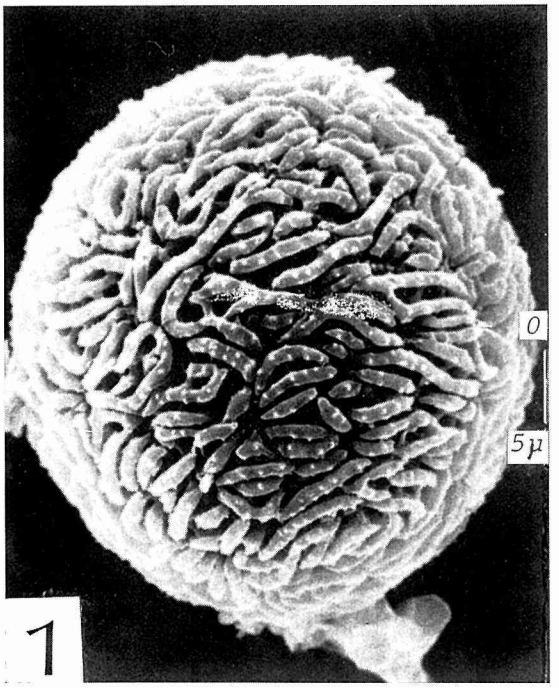
Although the result of the taxonomy was shown in taxonomical treatment in detail, Polemonia found in the areas under consideration were as follows:

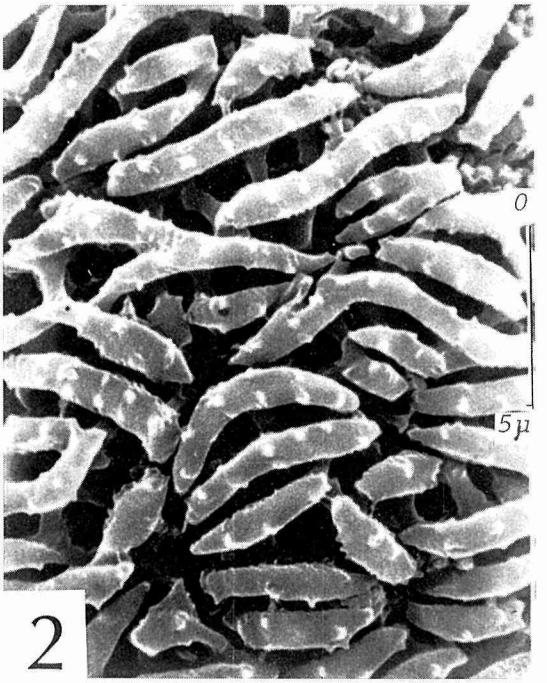
1. *Polemonium boreale* Adams, 2. *Pol. caeruluem* Linn. ssp. *campanulatum* Th. Fries, 3. *Pol. caeruleum* Linn. ssp. *laxiflorum* (Regel) Ko. Ito, and 4. *Pol. caeruleum* Linn. ssp. *yezoense* (Miyabe et Kudo) Hara. Under the latter 2 subspecies, the following varieties and forms were distinguished; ssp. *laxiflorum* f. *insulare* Ko. Ito, ssp. *laxiflorum* f. *paludosum* Ko. Ito, ssp. *yezoense* var. *nipponicum* (Kitamura) Ko. Ito, and var. *nipponicum* f. *hidakanum* (Ko. Ito) Ko. Ito.

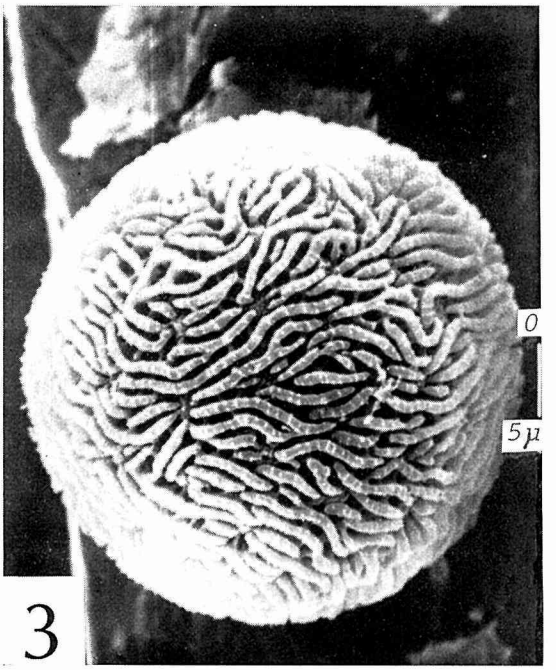
Four series set forth in the Sect. Polemonium by Vassiljev (1953) dissolved into 2 sereis, Ser. Caerulea and Ser. Humilia. *Pol. caeruleum*and its 3 subspecies distinguished were included in Ser. Caerulea, and *Pol. boreale* was in the Ser. Humilia.

In conclusion, the distirbutional route of the present Polemonia was examined, and Kitamura-Davidson's hypothesis was accepted; one route is *Pol. caeruleum* ssp. *campanulatum–Pol. racemosum–Pol. kiushianum*; the other route is *Pol. caeruleum* ssp. *campanulatum–Pol. caeruleum* ssp. *laxiflorum–Pol. caeruelum* ssp. *yezoense*.

The present paper learned that the chromosome number of *Pol. caeruleum* ssp. *yezoense* var. *nipponicum* f. *hidakanum* was published for the first time in Japan; the number is $2n=18$, entirely the same number as that of some Polemonium species shown by foreign authors.







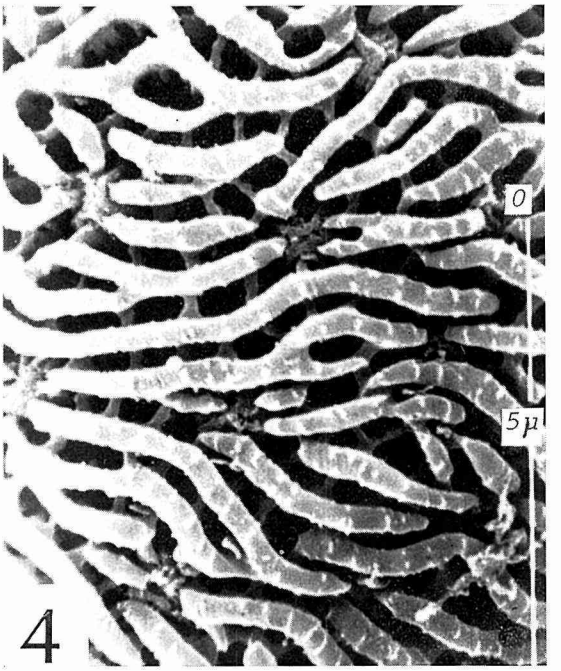


Photo 1. Scanning Electron Mircographs of pollen grains in *Polemonium* species.

1 & 2: *Pol. caeruleum* ssp. *laxiflorum* form. *insulare* (Momoiwa, Rebun Isl. 18 June 1968—Ko. Ito & M. Tohyama).

3 & 4: *Pol. caeruleum* ssp. *yezoense* var. *nipponicum* (Asagiri Pass, Soeushinai, 24 June 1968—Ko. Ito & M. Tohyama).

1 & 3; a pollen grain, 2 & 4; enlarged part of the striato-fine reticulate sexin.

(photos by M. Takahashi)

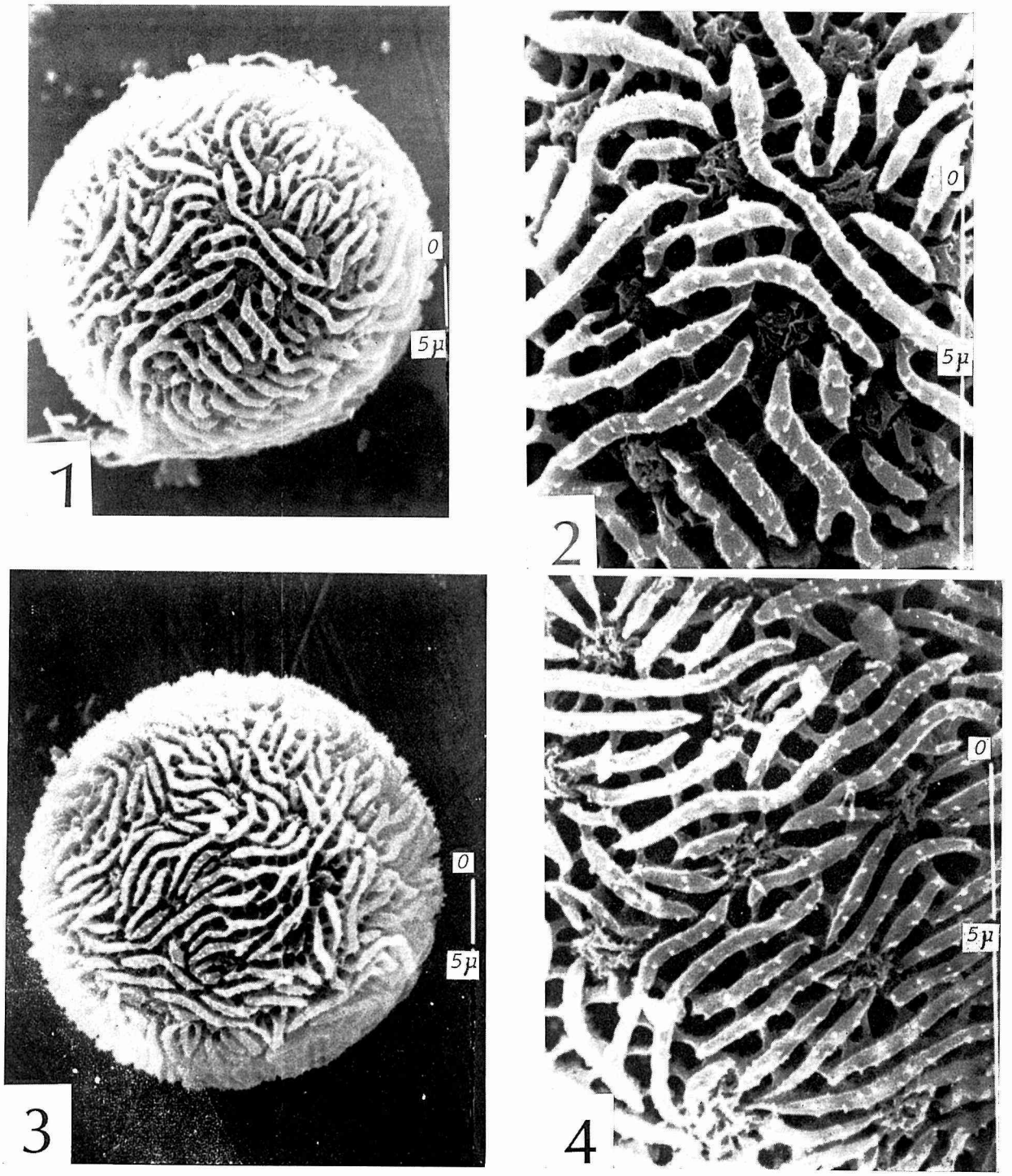


Photo 2. Scanning Electron Micrographs of pollen grains in *Polemonium* species.

1 & 2: *Pol. caeruleum* ssp. *campanulatum* (Nome, Alaska-6 Aug. 1907—N. Yokoyama).

3 & 4: *Pol. caeruleum* ssp. *caeruleum* (Paroecia Solleftea, Fanby, in prato, Prov. Angermanland, Sweden, 5 Jul. 1929– Sten Grapengiesser, ex G. Samuelson (†) Plantae Suecicae Exsiccate Edidit Eric Hutlén).

1 & 3; a pollen grain, 2 & 4; enlarged part of the striato-fine reticulate sexine.

(Photos by M. Takahashi)

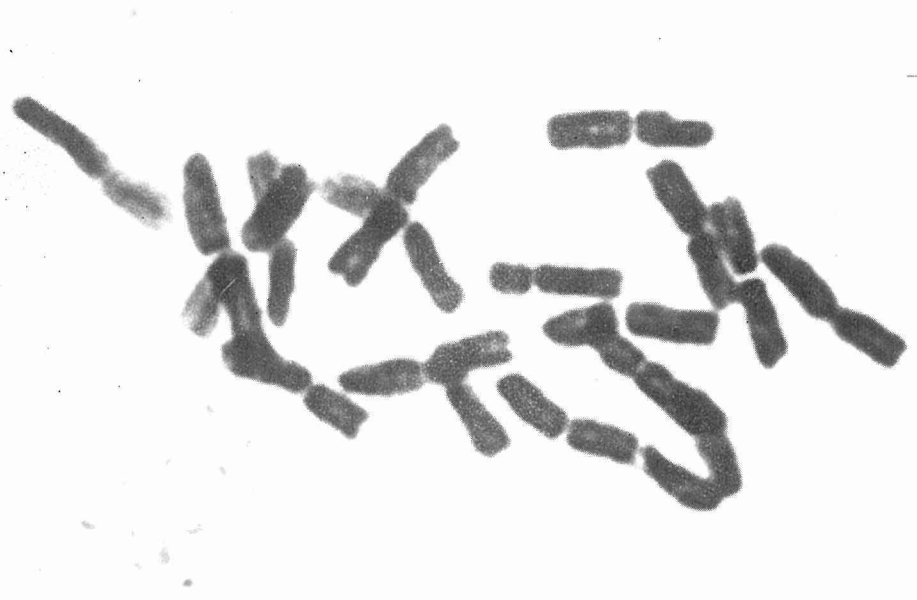


Photo 3. 1 & 2: Somatic chromosomes of *Pol. caeruleum* ssp. *yezoense* var. *nipponicum* form. *hidakanum*. (×ca. 3,600)

(Photos by T. Nishikawa)