A Study on the Environment of Teshio Primrose (*Primula takedana* TATEWAKI)

By

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テシオコザクラの環境に関する一考察

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ABSTRACT

The present paper deals with relationship between Teshio primrose (*Primula takedana* TATEWAKI) and its environmental conditions, from the points of view of erosion control engineering (sabôlogy) and ecology. The conclusion is as follows:

1. *Primula takedana* has its habitat on the area of serpentinite in northern Hokkaido, and is found on the half-shaded surface of rupture where forms a northeast slope in topography.
2. The surface soils, which are consisted of serpentine rocks partly weathered into clay, are locally denuded with the rotation of 3–10 years or more. There are, however, some stable parts within the whole surface for several years.
3. *Primula takedana* can invade on the comparatively stable ground and develop its cluster rapidly with its rhizome. If the ground is stable much longer, such plants of *Sasa* and *Carex* as the taller and robuster perennials invade there and drive the primrose by the shade-effect, but the topographic changes halt the development of them, because of rotational denudation of surface soils.
4. It is supposed that *Primula takedana* is an indicator plant on the comparatively stable—but erosive—ground of serpentinite.

In the appendix of this paper, moreover, the morphology of *Primula takedana* observed is described in datail.

CONTENTS

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INTRODUCTION

According to the original description,[9] *Primula takedana* TATEWAKI, Teshio primrose*, grows at "subalpine meadows or rocky places along the valley in the Nupuromapporo, a branch of the Teshio River, Prov. Teshio, Hokkaido. The present species allied to *P. jesoana* MIQ., but it differs from the latter by the shape, colour, size and paucity of the flowers, as well as by the shape of the subcoriaceous leaves at maturity. Flowers from the end of May to June, fruits maturing in July." KITAMURA et al.[5] state that "the species grows on the moist ground of serpentine rocks, or serpentinite, partly weathered into clay, and that it has an affinity to *P. jesoana* subsp. *pubescens*, and the former is supposed as a serpentine type of the latter, in the characteristics of small habit, thickened and parted leaves." As is known from the description or statements cited above, it is said generally that the present primrose is limited in its occurrence on the area of serpentine rocks in Teshio district of Hokkaido.

Plants which are living in on erosive grounds must adapt themselves on there by some means of living. Some species which lives in a special condition is, therefore, important as the plant indicator. The Teshio primrose seems to be the indicator on the denuded slope of the serpentine rocks partly weathered into clay, since this primrose is nearly always, according to my observations, found at denuded slopes with soil-slides on this area under examination. It is interest to study this matter in greater datail.

From the point of view of erosion control engineering, it has been considered that the plant indicator is an important factor. Some plants suggest us the history of the ground with the past erosion, because the influence of the erosion on the vegetation is greater and sharper than that of the climate in a short duration, and because there is a vegetation comparable to the erosion.[2] The history and present conditions suggest us a coming erosion on the ground and cause us to take measures to meet the disaster. Thus, our knowledges of the history of the ground and the present conditions are available to the works for erosion control (sabô-works). These knowledges are reflected on, ecologically, the concept of the plant indicator. Some plant indicators in relation with erosion and deposition have been studied by HIGASHI[3),4] and ARAYA[1] in Hokkaido: some species of *Salix*, *Populus* and *Alnus* on the bed load in torrential rivers, and of *Abies* and *Larix* on the landslide slopes. In spite of the urgent need in our practical works, there are little data on the plant indicator.

The investigation was carried out on June 1st to 2nd and August 4th, 1968.

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* *Teshio-kozakura* in Japanese.

INVESTIGATED SITE

(a) Outlines of the whole area of this study

The site under investigation is situated at the Nupporomapporo-sawa, a branch of Toikambetsu River, where is a part of Hokkaido University Teshio experiment forest-area. That is 130–110 meter above the sea level and about 7 kilometer northeast of Toikambetsu National Railway station (Fig. 1).

Climographs of Horonobe (21 kilometer west of the site, 10 meter above the sea level) and Naka-tombetsu (16 kilometer east, 30 meter above) are shown in Fig. 2.[8] Because the site investigated lies on the higher position in altitude, the average air temperature, especially the temperature during growing season, at the site will be lower than those on both localities; and the growing season a little shorter. Snow falls from late October to late April, and snow depth is 1 to 2 meter every winter.

Geologically, serpentine rocks exposed are easily weathered into clay in a short

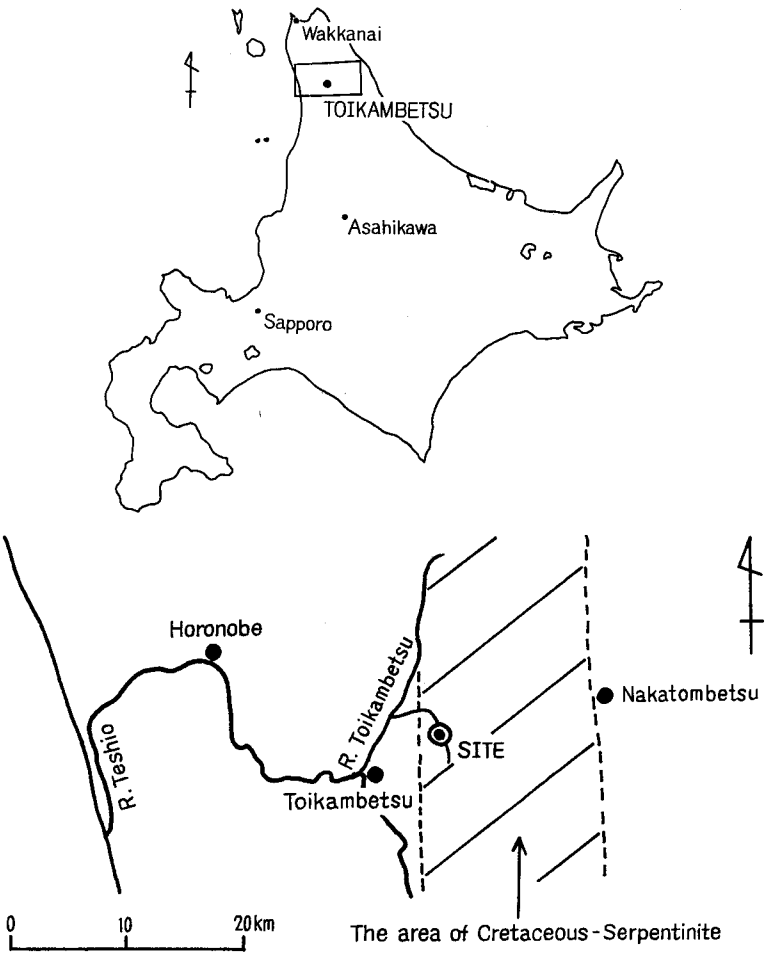

Fig. 1. The site investigated.

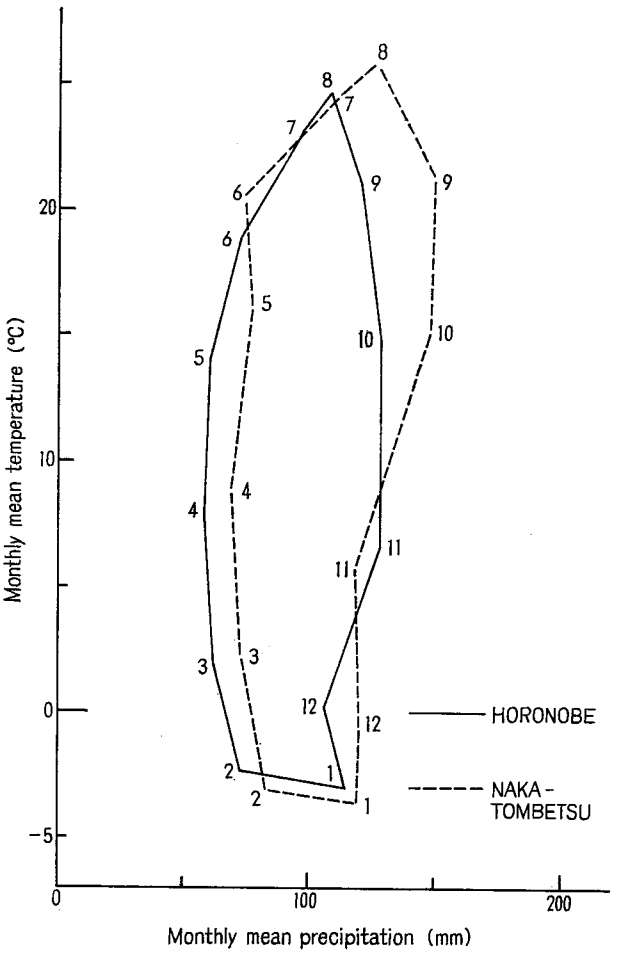

Fig. 2. Climographs in the vicinity of the site.

time. According to MATSUI,[7] "the area around the site consists of schistose serpentinite, which is strongly affected by the secondary deformation and has sliding surfaces within it. In the case where serpentine rocks are weathered into clay at the top part, there exists a remarkably impermeable layer. The very layer causes surface mobile soils on the slope to slide down. There are many sliding surfaces on east slopes with low angles. Erosion caused by scouring water is stronger than by soil-slide on slope. When snow melts or rain falls heavily, erosion increases its power remarkably." Several surfaces of rupture are found on slopes around the site along the stream, according to my observations.

(b) Detailed observations of the site investigated

The Teshio primrose grows usually on a denuded slope as mentioned already and forms a small patch. Three patches are found on the foot of northeast mountain-slopes, whose angle is about 35° and whose top is about 150 meter higher than the stream bed. The stream bottom ranges from 110 to 150 meter above the

sea level. This part is the middle of the Nupporomapporo-sawa, where bed load are eroded and deposited alternately.

Direction and angle of a slope, on which is a patch of *Primula takedana* investigated, are N40°E and about 35° respectively. On this slope, the sun shines weakly for short hours a day; a kind of half-shaded place without trees. Scouring waters of the torrential stream have washed out and eroded the foot of the slope. Surface soils above the erosion slide periodically down and fulfill the eroded slope. On a part of the soils, or slide block, keep alive trees and shrubs (Fig. 3 and Photo. 1). Several small slopes bordered by large rocks are observed on the lower part of this mountain-slope.

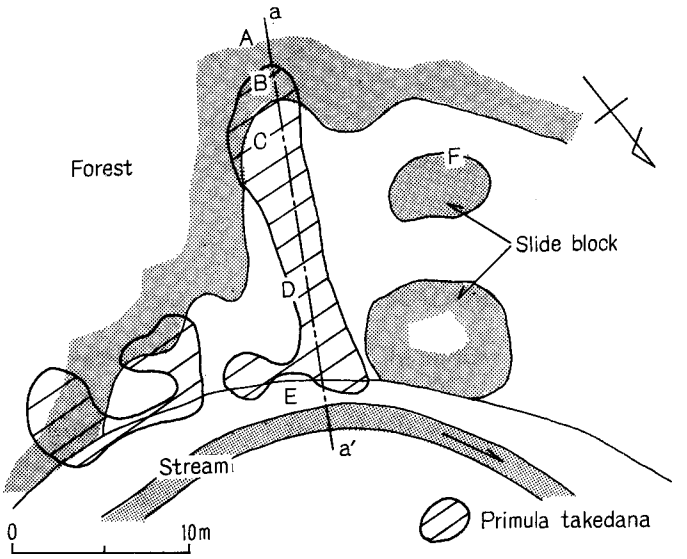

Fig. 3. Sketch of the surface of rupture.

Phytosociologically, forests around the surface of rupture is composed of mainly *Abies sachalinesis*, *Picea glehnii*, *Alnus maximowiczii*, *Prunus* sp., *Sorbus commixta*, and *Magnolia obovata*. The floor is covered with *Sasa paniculata*, *Carex* sp. and other herbs. On the margin of scarps of the slope, however, there is no tree over 3 meter in height.

The slope of serpentine rocks with partially thick carpet of the Teshio primrose is devided into five parts: A) forest without the primrose, B) forest with it, C) scarp, D) weathered soil deposit, and E) stream bed (Fig. 3 and 4).

A) In the marginal forest above the upper border of the surface of rupture, most trees composed of the forest is young in age and sparse in distribution. The angle of this part is about 35°.

B) Trees on the B part is younger than those on the A part. The average angle of this part is 37° and this figure is nearly equal to those of the A part (35°) and the D part (36°). The accumulation of humus is found on both grounds of the A and B parts.

C) Scarp has the steepest angle of the five parts, i. e. 51°. In this C part,

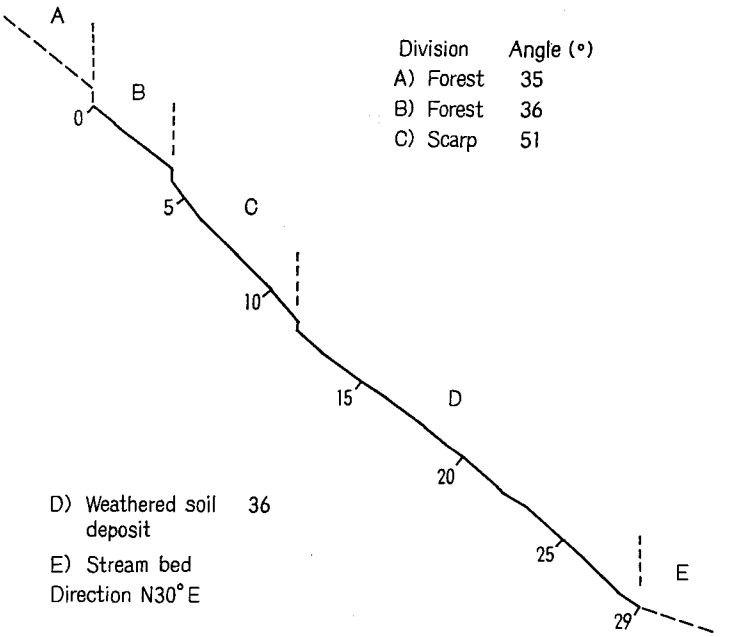

Fig. 4. Longitudinal section of the slope (a–a′ in Fig. 3).

old surface soils which are weathered and softened falls always down, and newly exposed surface is very hard.

D) This part is different from the C part by the following character. Weathered soil in the C part is depositing on the D part, resulting in the average angle of 36°. Soils become soft due to weathering, but it is hard several centimeter beneath the surface. The accumulation of humus is not recognized on surface soils, which are moist by the ground water seepage and are not porous enough for aeration.

E) The overflow bed along the stream is very narrow at the convex side of the curve at its turn and become wider far from it. There are found *Primula* plants on the debris slided down on this bed.

EXPERIMENTS AND RESULTS

(a) The belt-transect

A belt-transect, 1 meter wide by 29 meter long, N30°E in the direction, is set on from the B to D parts. The society of *Primula takedana* is shown in Fig. 5. The species occurs throughout the belt up to down, thicker in cluster at the lower position of the belt, and thinner and smaller at the scarp. Diameters of each cluster range from 10 to 50 centimeter (Photo. 2). On the forest-floor, this primrose manages to live in, tolerating the shade-effect (Photo. 3).

Cover degree and frequency of the plants in the belt-transect are shown in Table 1. Among these plants there are some forest-habitant-species, which they may have fallen from the above forest, not by seeds. As shown in Table 1,

Table 1. Cover degree and frequency of the plants in the belt-transect.

Division	B					C							D																		
Species	Distance (m)																													F.*	C.V.**
	0~1	1~2	2~3	3~4	4~5	5~6	6~7	7~8	8~9	9~10	10~11	11~12	12~13	13~14	14~15	15~16	16~17	17~18	18~19	19~20	20~21	21~22	22~23	23~24	24~25	25~26	26~27	27~28	28~29		
Primula takedana	2	3	2	3	2	2	1	1	3	3	+	+	1	+	+	1	1	2	3	3	4	3	3	3	3	3	4	3	3	V	2466
Carex sp.	4	2	2	4	1	1	2	4	1	+	·	+	·	·	·	·	·	·	+	+	+	+	+	+	·	+	+	·	+	IV	1093
Astilbe thunbergii var. *congesta*	1	1	+	1	1	1	2	2	+	+	·	·	·	+	+	·	·	+	·	1	+	+	+	·	+	+	·	·	+	IV	224
Sanguisorba tenuifolia var. *alba*	+	+	+	·	+	+	+	1	+	+	·	·	+	·	·	·	·	·	·	1	+	+	·	·	+	+	+	·	+	IV	34
Parnassia palustris	·	·	·	·	·	·	·	·	·	·	·	+	+	+	·	·	·	+	1	1	+	·	+	+	+	·	+	+	+	III	34
Petasites japonicus var. *giganteus*	·	·	·	·	·	·	·	·	·	+	·	·	·	+	·	+	·	·	·	·	+	+	1	+	1	+	+	·	·	III	34
Miscanthus sinensis	·	·	·	·	+	·	2	1	·	·	·	·	·	·	·	·	·	·	1	·	+	·	·	+	·	·	+	+	1	III	112
Alnus maximowiczii	·	1	3	1	1	+	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	II	181
Filipendula kamtschatica	1	+	+	+	·	+	+	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	II	78
Picris hieracioides var. *glabrescens*	·	·	·	·	+	+	+	·	+	+	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·	II	
Sasa paniculata	2	1	1	1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I	112
Thalictrum aquilegifolium	·	+	·	·	·	+	+	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I	

Note: Species, less than 15 percent in frequency, are as follows.

Orchis sp.	14%	*Picea glehnii*	3%	*Chrysosplenium* sp.	3%
Achillea sibirica	10	*Sorbus commixta*	3	*Angelica* sp.	3
Dryopteris sp.	10	*Spiraea butulifolia*	3	*Solidago virga-aurea* var. *leiocarpa*	3
Cirsium sp.	7	*Acer mono*	3		

F.*: Frequency class C.V.**: Coverage value

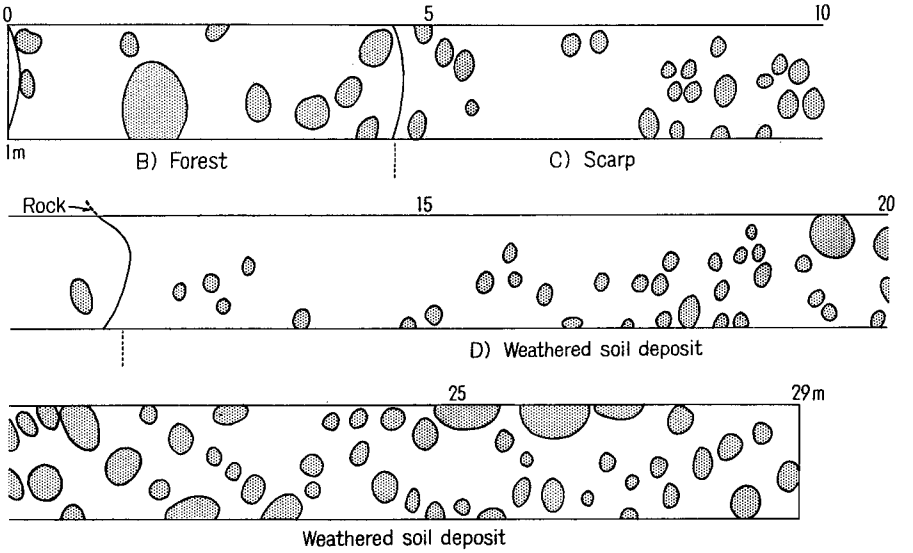

Fig. 5. Belt-transect in *Primula takedana* Soc.

Carex sp. is prevalent on the forest-floor (B) than on the deposit (D). *Alnus*, *Sasa*, *Astilbe*, and *Sanguisolba* are more conspicuous in the forest as well. While, *Parnassia* and *Petasites* (which would be rather small in size) may be prefering the deposited soils which are moist (Photo. 4). On the most moist ground between the belt and slide blocks lives in *Phragmites communus*.

(b) Stem-analyses

Numbers of the annual rings of *Alnus maximowiczii* and *Picea glehnii* are nearly almost measured on the plants grown on the forests (A and B) and on the scarp (C) except one plant on the slide block (F) shown in Fig. 3. They are cut horizontally at the ground surface, on August 4th, 1968. The results are shown in Table 2. *Alnus* and *Picea* plants on the same place show the same age, though tree-heights are remarkably different from each other. Ages of *Alnus* plants on the scarp vary 1 to 4 years. On the upper part of the slope, *Alnus* plants are generally older in age than those on the lower part. There is not found obviously the

Table 2. Ages of plants grown on forests and on slide block

Species	Division	Age	Height (m)	Diameter* (cm)	Numbers of samples	Note
Alnus maximowiczii	A	11	2.1	3.6	1	*Cut at ground surface
	B	8	1.1	2.6	1	
	C	4	0.5	0.6	1	
	C	1–2	—	—	3	
Picea glehnii	A	11	0.5	1.1	1	
	F	21	1.0	2.0	2	With compression wood, 3 years ago

compression wood* in these plants, though they are bending downwards. And in the section of *Picea* plant on the slide block, which is bending upwards, there is found the compression wood before 3 years.

(c) Other observations of *P. takedana*

The other patch of *Primula takedana*, upstream in Fig. 3, is established on the apporoximately same habitat in the environmental conditions. The *Primula* plants grow on the slope which is covered with *Sasa* and *Carex*, and also on the moist bed load with *Parnassia*. *Primula* plants bear thinner leaves and fewer floweres in such shaded places as *Sasa* and *Carex* are dominant.

About 400 meter upstream from the site, a third patch of *Primula takedana* is found on an older surface of rupture of serpentine rocks partly weathered into clay. Direction and angle of the surface, 160 to 150 meter above the sea level, are N40°E and 35° respectively. On the denuded slope is not found any tree or *Sasa* species. There exist mainly 3 species; *Primula takedana* at the moist part, *Carex* sp. at less moist part, and *Veronica schmidtiana* subsp. *senensis* at comparatively dry scarp. Marginal forest above the upper border of the surface of rupture is covered with *Sasa paniculata*, and lacks *Primula* on the forest-floor.

DISCUSSION

According to ARAYA,[1] some trees, such as willow or alder etc., invade on the naked surface of bed load immediately after the appearance of deposit, and their annual rings suggest the very year of deposition. They are a kind of time-recorders with the unit of year concerning the past naked surface, resulted from the bed load movement. That year is determined more accurately from the numbers of annual rings with 1 year or more added, because of the time discrepancy between the depositing season of ground and the invading season of plants.

In some conifers, according to HIGASHI,[4] compression wood is formed in a tree inclined, caused by the movement of land surface. This wood suggest the year of the movement. That year must corrected by adding of 0 or 1 year, according to the season of growing or resting as well.

Alnus and *Picea* plants analysed in this study, therefore, must suggest the years of local soil-slides on the whole slope of weathered serpentinite. Each plant newly established itself on each part shows the numbers of years after its surface soil movement occured in annual rings. And the compression wood also shows the year of block-slide (Table 3). Because of the time discrepancy between denudation and invasion, 1 year (1 growing season) or more is to be added to each age.

From Table 3, it is supposed that the rotation of soil-slides on the slope are 3–10–18 years locally. These various years suggest that the present surface of rupture might not appear at the same year as a whole, as well as in large-scale landslide. Therefore, there may be always locally stable parts on there. On these stable parts, *Primula takedana* can establish itself without shade-effect. The species

* *Ate* in Japanese.

Table 3. Time discrepancies of soil-slides on the slope

Division	F		A		A		B		C	Note
Species	*Picea*		*Picea*		*Alnus*		*Alnus*		*Alnus*	
Age	21 (3*)		11		11		8		1–4	*Compression wood
Discrepancy	18	10		0		3		4		

may be destroyed by the momentary movement of block-slide but is not buried to death by the constant small movement of weathered soil deposition.

Primula takedana invades in the shortly and locally stable ground within the erosive slope by seeds and establishes itself freely and rapidly by its rhizome. The developing speed of the species is faster than those of *Carex*, *Sasa* and other herbs on this ground of serpentinite. If the ground is stable for much longer years, *Primula takedana* is shaded by these species. And if the ground is stable more shortly to be established, the invader can not develop to the regenerational stage. On the hard and periodically soil-falling surface of the scarp, *Primula takedana* and other plants can hardly establish themselves, in spite of strong invasion by sufficient supply of seeds. On the contrary, the weathered soil deposit is very suitable for perennial plants once invaded.

The Teshio primrose grows on weakly sun-shined ground. This condition of half-shaded does not allow light-requiring plants which are found on the light slopes, opposite of the stream, of weathered serpentinite; they are, for example, *Hemerocallis dumortierii* var. *esculenta*, *Heloniopsis orientalis* and *Anaphalis margaritacea*. The shade-effect by the competitors is more severe for the primrose than that by topography, since competitors drive the species above and beneath the soil surface.

Moist soil is also a limited factor. Most plants of this site investigated can not grow on moist soils except the present *Primula*, *Parnassia* and *Phragmites*. There are many perennial plants which have the tolerance of soil deposition, but they prefer porous deposit of coarse soils at other area to less aerated one of serpentine clay at the area; they are, for example, *Petasites japonicus* var. *giganteus*, *Aralia cordata*, and *Polygonum sachalinense*.

A pioneer plant is confined,[2),3)] that it is a xerophytic or hydrophytic, light-requiring species with wide disparsal ability which invades in and establishes itself on the naked ground of poor fertility. *Primula takedana* is insufficient to meet these conditions. However, if a pioneer is supposed to be a species which can grow under unfavourable conditions intolerable for most species, *Primula takedana* is a kind of pioneer plants.

Primula takedana lives in on the ground above-mentioned, where the erosional rotation is suitable, or not shorter, for the species and not suitable for the competitors. Thus the Teshio primrose is always established on the denuded ground of serpentinite with the erosional rotation of 3–10 years or more. There are many species related with the land surface movement, or topographic changes; *Elymus mollis* on sand-dunes, *Petasites japonicus* var. *giganteus* and *Aralia cordata* on

weathered soil deposits, some species of *Salix*, *Populus* and *Alnus* on bed load in torrential rivers,[1] *Abies sachalinensis* on landslide slopes,[3] *Larix leptolepis* on surfaces of rupture at mountain-slopes of volcanoes,[10] though each vegetative rotation is remarkably different in time-scale.

Suggestions for further research

Here, I would recommend some new or additional work that should be done in matters related directly and indirectly with this research. For example:

1. Other species of *Primula* live in other areas of serpentinite in Hokkaido. And if they will be studied in relation with soil-slide, the relationship between endemic species and their special habitats will be cleared more.
2. In this study, the relations between rotational (or periods of) soil-slides of weathered serpentinite and cycles of heavy precipitation (rain or snow-melting) are not discussed sufficiently. For this studies, it would be convenient to choose experimental sites close to meteorological stations.
3. It seems to me that geologists would study soil-slide and related phenomena in this area and other areas of Hokkaido. This study of soil-slides should be made in cooperation with botanists, ecologists and forestry researchers. In such a way, the study should include, with a time-scale, the broad relations between phytosociology and soil-slides (or topographic changes).

CONCLUSION

Primula takedana is found in northern Hokkaido and endemic on there. The species lives in on the denuded slope of serpentine rocks partly weathered into clay. The surface soil on this site is denuded locally with the rotation of 3–10 years or more. Both the shortly stable ground and the weathered soil deposit are suitable for the Teshio primrose with fast-developing rhizome; both the half-shaded ground and the moist soil with less aeration are not unsuitable for the primrose: these environmental conditions, mainly topographic changes, halt the development of other taller and robuster plants, which drive the primrose by the shade-effect, and leave the primrose alone as a pioneer in such environments. *Primula takedana* is supposed to be an indicator plant growing on the erosive (in a short time) ground of serpentinite, from the points of view of sabôlogy and ecology.

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APPENDIX

MORPHOLOGICAL STUDIES of *Primula takedana* TATEWAKI in detail can be summarized as follows (Fig. 6):

1. There are two kinds of limb-clefting associated with hairiness of plant body. In the first with more hairy leaves and scapes, the limbs are parted, and each lobelet is often emarginate again. While, in the second with less hairy leaves and scapes, the limbs are usually emarginate and each lobelet is not emarginate. In the plants of the area investigated, the correlation of limb-clefting with hairiness of plant body seems to be constant.
2. Roots are fibrous, and are 3–10 in number and 5–10 centimeter long or more, about 1 millimeter in thickness at the base. Buds of the next season are

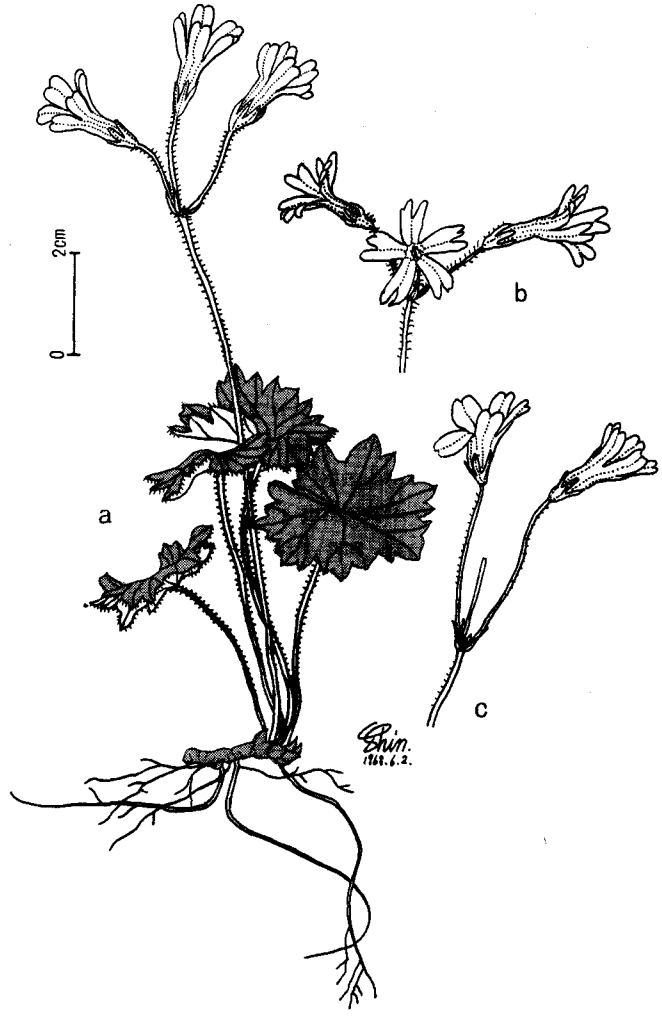

Fig. 6. *Primula takedana* TATEWAKI.
a and **c**, less hairy type
b, more hairy type

formed at leaf-axils by August of the year.

3. *Primula takedana* is dispersed by means of seeds, but after having established itself, the individual plant is formed in cluster by means of vegetative propagation.

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要　　約

本稿はテシオコザクラ (*Primula takedana* TATEWAKI) とその生息地の環境諸条件との関係を，砂防工学と生態学の立場から，取り扱う。調査は1968年6月1～2日と8月4日に，北海道大学天塩地方演習林において実施された。そのおもな方法はベルトトランセクト法によるテシオコザクラ基群叢の測定と，樹木年輪による表土崩落周期の推定とである。その結果は次のようである。

1. テシオコザクラは北海道天塩地方の蛇紋岩地帯に生息し，特に崩壊地の裸斜面に見られる。調査地は北東斜面 (N40°E, 35°) にあり，地形的に半陰地である。
2. 斜面の表層には蛇紋岩風化粘土が存在し，それらは局部的に3～10年ないしそれ以上の周期で崩落する。しかし，全体からみると，崩壊地内にはある時間安定な場所もある。上方の若い森林の地面にも古い崩落の痕跡が存在する。滑落面は急傾斜でその表土が堅く，風化土の堆積地 (崖錐) は地下水の浸出によって過湿・通気不良である。
3. テシオコザクラは比較的安定した裸地に種子で侵入し，多年生の根系によって急速に発達する。ある時間より長く表土が安定な場合，ササ・スゲなどの大形で強い植物が侵入し

て，その被陰効果にテシオコザクラは耐えられなくなる。

4. 上述の諸条件，特に地形条件（地表変動），は競争者の発達を妨げ，テシオコザクラをそうした環境の適応種とする。
5. テシオコザクラは短い周期で表土が崩落しやすい蛇紋岩斜面の植物指標と見なされる。

さらに，付録に，テシオコザクラの形態が詳しく観察され記載された。

Photo 1. The surface of rupture.

Photo 2. Clusters of *Primula takedana* in open (June 2nd).

Photo 3. Clusters of *Primula takedana* shaded by *Carex* and *Sasa* (June 2nd).

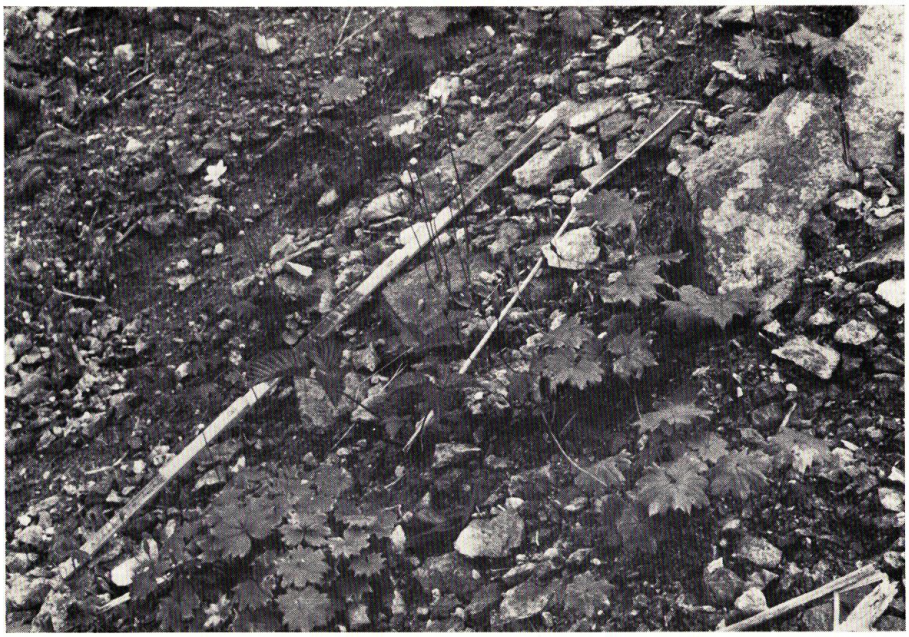

Photo 4. *Primula takedana* with fruits and *Parnassia palustris* in flower (Aug. 4th).