

中国チベット高原南東部プマユムツォ湖周辺のフロ ラ調査

著者	Minami Motoyasu, Tezuka Takafumi, Zhu Liping, Nishimura Mitsugu
著者別表示	南 基泰, 手塚 修文, 朱 立平, 西村 弥垂
journal or publication title	The journal of phytogeography and taxonomy
volume	58
number	1
page range	50-56
year	2010-12-30
URL	http://doi.org/10.24517/00053433



Motoyasu Minami¹, Takafumi Tezuka^{2,3}, Liping Zhu⁴ and Mitsugu Nishimura⁵:
**Survey of vascular flora around Lake Pumayum Co, an alpine lake located
 in the southeastern Tibetan plateau in China**

南 基泰¹・手塚修文^{2,3}・朱 立平⁴・西村弥亜⁵: 中国チベット高原南東部プマユムツォ湖周辺のフロラ調査

Lake Pumayum Co (28° 34' N, 90° 24' E), located at an altitude of 5,030 m above sea level (a.s.l.), is a typical alpine lake formed by fault action in an intermountain basin of the Sino-Himalayan range in the southeastern Tibetan Plateau in China. With surface area of approximately 208 km², Lake Pumayum Co has the largest area of any alpine lake located at over 5,000 m a.s.l. (Mitamura et al. 2004). Three islands were formed in the lake by tectonic activity, and we refer to these islands as Large Island, Middle Island, and Small Island in this manuscript, as they are unnamed on local maps of the area.

Because the lake is located at over 5,000 m a.s.l. and is surrounded by high mountains, unique vegetation closely reflecting such an extreme environment is believed to exist there. However, limited information is available on the flora found around the lake area owing to restricted access for foreigners by the military. Furthermore, difficulties also arise when conducting research at an altitude of ca. 5,000 m a.s.l., where oxygen concentration is approximately half of that at sea level.

In 2006, we surveyed flora around the lake as well as on Middle Island to obtain baseline data that describes the lakeshore vegetation and aids future systematic ecological surveys of the lake.

Field survey

A field survey of horizontal and vertical distributions of vascular plant species was conducted at 15 survey sites (ca. 10,000–50,000 m²/site) along the lakeshore and on Middle Island during August 12–21, 2006. After tentative classification of the vegetation by physiognomy, we collected specimens from the vascular plant species growing at the 15 survey sites (Fig. 1) and identified them based on classifications of Wu (1983, 1985a, b, 1986, 1987), the Institute of Tibetan Plateau Research (1988) and Yoshida (2005). The local geographic characteristics are summarized below for each of the 15 survey sites around the lake and on Middle Island:

- (1) Northern lakeshore : N1-1, floating sandy or peaty soil at riparian zone along the lake shoreline (5,020–5,021 m a.s.l.) ; N1-2, gentle slope primarily consisting of coarse sandy soil and broken rock (5,021–5,128 m a.s.l.) ; N1-3, lake terrace with accumulated peaty soil (5,128–5,193 m a.s.l.).
- (2) The river mouth of the outflow river on the eastern lakeshore : E1-1, riverbank that had accumu-

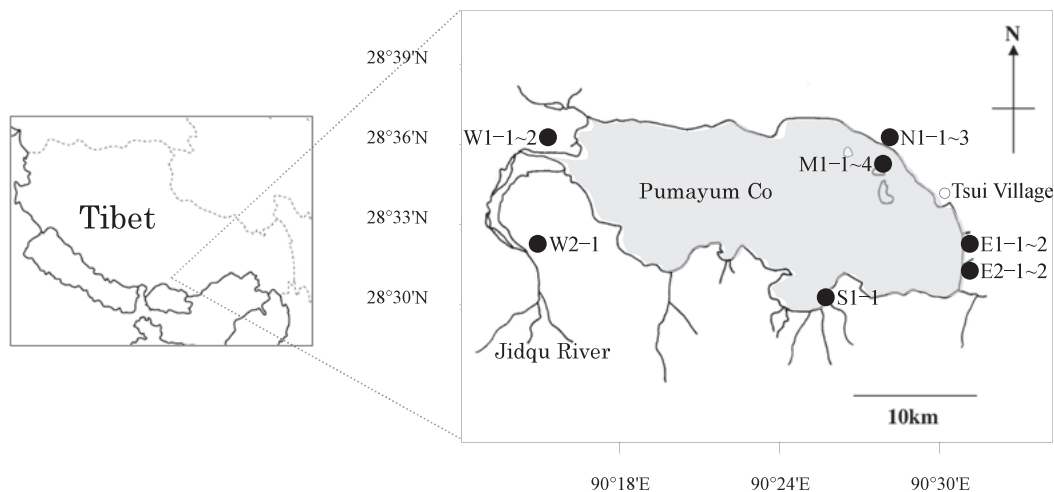


Fig. 1. Sketch map of the Lake Pumayum Co (28° 34' N, 90° 24' E, alt. 5,030 m above sea level). Letters in the sketch map refer to each survey sites.

Table 1. List of vascular plants around lakeshore and the Middle Island on Lake Pumayum Co

Species \ Survey sites ¹⁾	N1-1	N1-2	N1-3	E1-1	E1-2	E2-1	E2-2	W1-1	W1-2	W2-1	S1-1	M1-1	M1-2	M1-3	M1-4
Amaranthaceae <i>Amaranthus</i> sp.		●	●					●	●						
Boraginaceae <i>Lasiacaryum munroi</i>		●	●												
<i>Microula tibetica</i>									●		●				
Brassicaceae <i>Aphragmus oxycarpus</i>					●										
<i>Dimorphostemon pinnatus</i>														●	
<i>Draba oreades</i>											●				
<i>Pegaeophyton scapiflorum</i>									●						
unidentified				●		●									
Caryophyllaceae <i>Arenaria bryophylla</i>		●	●		●	●	●	●		●				●	●
<i>Silene</i> sp.										●					
Chenopodiaceae <i>Chenopodium</i> sp.					●			●	●			●			
Compositae <i>Artemisia brevifolia</i>													●	●	●
<i>Erigeron multiradiatus</i>		●	●					●	●		●				
<i>Leontopodium jacotianum</i>															
var. <i>paradoxum</i>										●					
<i>L. longifolium</i>		●	●		●			●			●				
<i>L. nanum</i>															●
<i>Leontopodium</i> sp.							●								
<i>Saussurea andryaloides</i>								●						●	
<i>S. kingii</i>		●	●							●	●		●	●	
<i>Taraxacum maurocarpum</i>			●							●					
<i>T. sikkimense</i>							●								
<i>Vladimiria berardioidea</i>			●												
Crassulaceae <i>Rhodiola bupleuroides</i>															●
<i>R. crenulata</i>															●
<i>Sedum henrici-roberti</i>											●				
<i>S. multicaule</i>					●					●					
Cyperaceae <i>Carex aridula</i>		●	●		●		●	●		●					●
<i>C. moorcroftii</i>													●		
<i>Eleocharis palustris</i>	●	●	●					●							
<i>E. pauciflora</i>			●												
<i>Kobresia humilis</i>		●	●											●	●
<i>K. macrantha</i>		●	●	●	●						●			●	
<i>K. pratti</i>			●												
<i>K. pygmaea</i>		●	●		●			●	●	●	●				
Gentianaceae <i>Gentiana crassuloides</i>		●	●		●						●				
<i>G. leucomelaena</i>		●						●							
<i>G. micans</i>		●	●					●	●		●				
<i>G. pedicellata</i>		●			●										
<i>Swertia hispidicalyx</i>		●				●		●							
Labiatae <i>Dracocephalum heterophyllum</i>			●											●	●
<i>Phlomis rotata</i>		●	●		●		●	●		●	●				
Leguminosae <i>Astragalus lasaensis</i>		●					●								
<i>A. monticolus</i>		●	●				●								
<i>A. strictus</i>													●	●	
<i>Oxytropis lapponica</i>										●				●	
Liliaceae <i>Allium sikkimense</i>								●	●						
Morinaceae <i>Cryptothladia polyphylla</i>														●	
Nyctagynaceae <i>Urtica hyperborea</i>			●		●										
Papaveraceae <i>Corydalis hookeri</i>													●		●
<i>Hypecoum leptocarpum</i>													●		
Parnassiaceae <i>Parnassia chinensis</i>								●							
<i>P. pusilla</i>									●						
Poaceae <i>Deyeuxia tibetica</i>							●								●
<i>Elymus nutans</i>			●										●	●	●
<i>Poa poophagorum</i>			●				●							●	●
<i>Stipa bungeana</i>		●												●	
<i>S. purpurea</i>															●
unidentified				●	●	●				●					
Polygonaceae <i>Bistorta perpusilla</i>			●				●	●							
<i>Polygonum sibiricum</i>	●				●	●					●	●			
Nyctagynaceae <i>Androsace tapete</i>		●	●		●		●	●		●	●				
<i>Lysimachia</i> sp.			●												
Ranunculaceae <i>Delphinium caeruleum</i>														●	●
<i>Halerpestes tricuspis</i>	●		●	●		●		●	●	●	●				
<i>Ranunculus nephelogenes</i>								●	●						
Rosaceae <i>Potentilla anserina</i>	●	●													
<i>P. biflora</i>					●										
<i>P. saundersiana</i>					●								●		●
<i>Sibbaldia purpurea</i>			●							●					

Table 1. (continued)

Species \ Survey sites ^{b)}	N1-1	N1-2	N1-3	E1-1	E1-2	E2-1	E2-2	W1-1	W1-2	W2-1	S1-1	M1-1	M1-2	M1-3	M1-4
Saxifragaceae <i>Saxifraga isophylla</i>			●					●							
Scrophulariaceae <i>Lancea tibetica</i>		●				●									
<i>Pedicularis cheilanthifolia</i>										●					
<i>P. diffusa</i>					●										
<i>P. globifera</i>			●												●
<i>P. longiflora</i> subsp. <i>tubiformis</i>			●												
<i>P. microcalyx</i>			●												
<i>P. rhinanthoides</i> subsp. <i>labellata</i>									●						
<i>Veronica lasiocarpa</i>			●							●					
Umbelliferae <i>Pachypleurum nyalamense</i>								●	●		●				

1) Suvey sites shown in Fig. 1.

lated an alluvial substrate and was always saturated (5,014–5,021 m a.s.l.) ; E1-2, several river terraces along the riverbanks, consisting of gravel and shattered rock or peaty soil (5,021–5,029 m a.s.l.).

(3) The river mouth of an unnamed inflow river on the eastern lakeshore : E2-1, sandy soil near the river mouth (5,021 m a.s.l.) ; E2-2, sandy soil and pebbles around the river mouth (5,022 m a.s.l.).

(4) The Jidqu River delta on the western lakeshore : W1-1, hummocky terrain in a marsh (5,090 m a.s.l.) ; W1-2, peaty soil outside the marsh (5,090 m a.s.l.).

(5) River terrace of the Jidqu River on the western lakeshore: W2-1, at 10 km upward from the river mouth (5,090 m a.s.l.) ; this region is conditions almost identical to W1-2.

(6) Southern lakeshore : S1-1, poorly drained, hydric areas with saturated peaty soils (5,030 m a.s.l.).

(7) Middle Island : M1-1, pebbles from the weathering of the cliff face scattered along the lakeshore, preventing the accumulation of organic matter and peaty soil (5,024 m a.s.l.) ; M1-2, dry and firm, with an occasionally exposed matrix. Steep slope (5,024–5,029 m a.s.l.) ; M1-3, dry and firm with exposed matrix. Gentle slope (5,029–5,074 m a.s.l.) ; M1-4 (in close vicinity of the summit), well-drained xeric habitat located on a scree slope with a ground surface consisting primarily of gravel and shattered rocks (5,074–5,080 m a.s.l.).

Indicator species from the 15 survey sites were defined and then classified into vegetation types by two-way indicator species analysis (TWINSPAN) (PC-ORDTM 5, MjM Software Design) (Bruce and James 2002). All plant specimens collected were deposited at the Minami Laboratory, College of Bioscience & Biotechnology, Chubu University, Japan.

Results and discussion

We identified 79 species of seed plants (including seven unidentified species) belonging to 24 families (Table 1, Appendix). Remarkable families represented by a number of species were Compositae (11 spp.), Cyperaceae (8 spp.), Scrophulariaceae (8 spp.), Poaceae (6 spp.), Brassicaceae (5 spp.) and Gentianaceae (5 spp.). The remaining families were represented by less than five species. We found no woody plants or pteridophytes at any of the survey sites.

Across all survey sites, the most common species were *Arenaria bryophylla* Fernald (nine sites), followed by *Halerpestes tricuspis* (Maxim.) Hand.-Mazz. (eight sites) and *Androsace tapete* Maxim., *Carex aridula* V. I. Krecz., *Kobresia pygmaea* (C. B. Clarke) C. B. Clarke and *Phlomis rotata* Benth. ex Hook. f. (seven sites each). According to the Institute of Tibetan Plateau Research (1988), dominant plants around the lake include the genus *Kobresia* (dominant along the northern and eastern lakeshores) and genera *Stipa* and *Artemisia* (dominant along the southern and western lakeshores). However, the results of our survey did not corroborate this information because we were unable to confirm presence of the genus *Artemisia* at the lakeshore. Furthermore, we observed *Stipa bungeana* Trin. only along the northern lakeshore (N1-2) and on Middle Island (M1-3) and *Stipa purpurea* Griseb. (M1-4) and *Artemisia brevifolia* Wall. ex DC. (M1-2, -3 and -4) only on Middle Island.

Nine indicator species were identified in four vegetation groups (A–D) derived from TWINSPAN at level three of sample hierarchy (Fig. 2). The following description characterizes each group in terms of

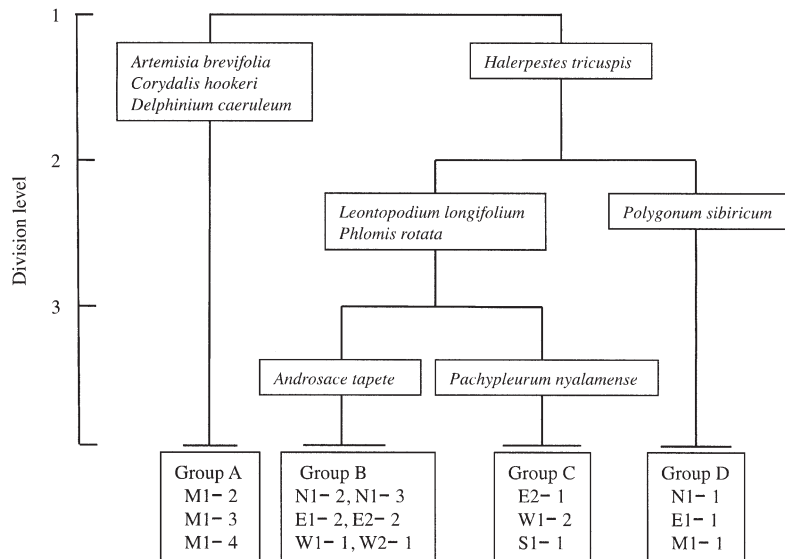


Fig. 2. Two-way indicator species analysis (TWINSpan) dendrogram showing vegetational similarity based on 15 survey sites. Letters refer to each survey site shown in Fig. 1.

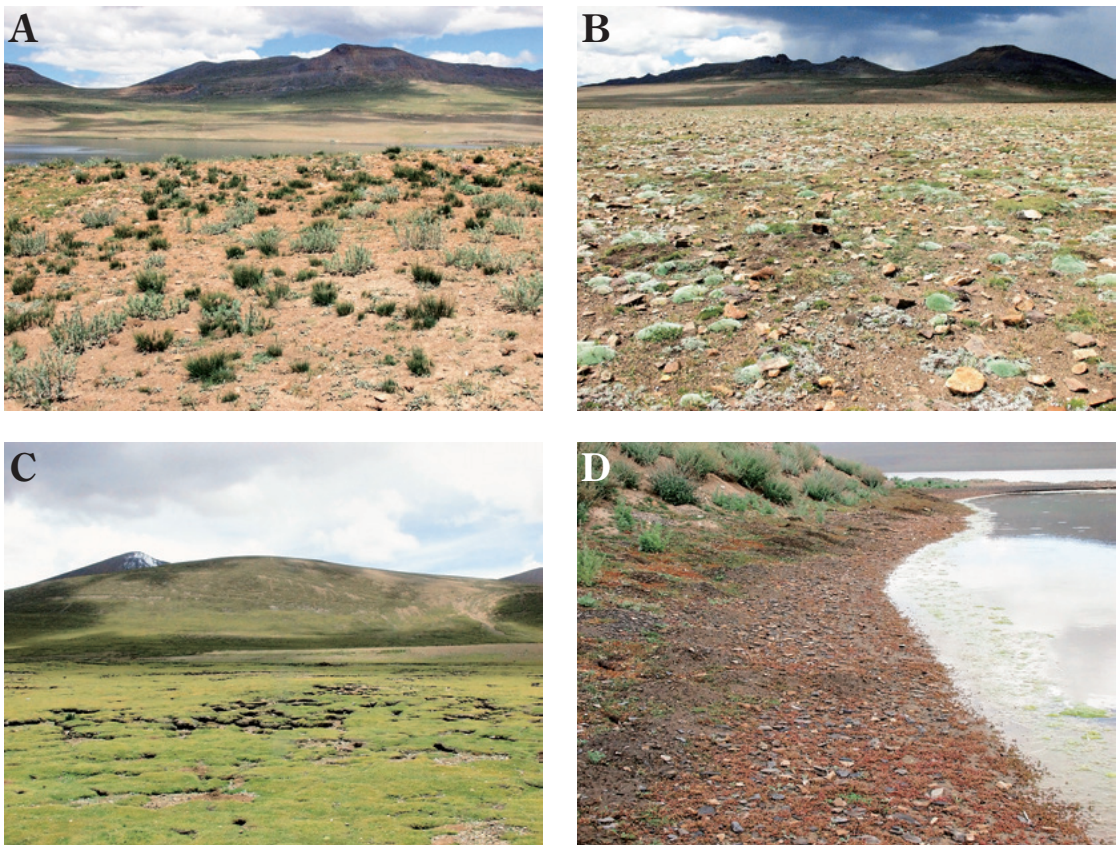


Fig. 3. Typical views of the four vegetation types. A : Alpine desert steppe (M1-3 : 28° 35' N, 90° 28' E, 5,034 m above sea level (a.s.l.)). B : Alpine steppe (N1-2 : 28° 35' N, 90° 29' E, alt. 5,032 m a.s.l.). C : Alpine meadow (S1-1 : 28° 29' N, 90° 25' E, alt. 5,030 m a.s.l.). D : Marsh meadow (M1-1 : 28° 35' N, 90° 28' E, alt. 5,024 m a.s.l.). Letters refer to each survey site shown in Fig. 1.

their indicator species and vegetation types. Group A (M1-2, -3 and -4) (Fig. 3A) is characterized by xerophytes *Artemisia brevifolia*, *Corydalis hookeri* Prain and *Delphinium caeruleum* Jacquem. ex Cambess. The vegetation comprising this group was observed on the entire slope and summit of Middle Island, except the lakeshore; this region was defined as the alpine desert steppe. Group B (N1-2, N1-3, E1-2, E2-2, W1-1 and W2-1) (Fig. 3B) is characterized by *Androsace tapete*, dominating the relatively dry soil lacking peat in the alpine steppe extending widely around the lakeshore. Group C (E2-1, W1-2 and S1-1) (Fig. 3C) is characterized by *Pachypleurum nyalamense* H. T. Chang et R. H. Shan in the alpine meadow, which consisted of peaty soil. Group D (N1-1, E1-1 and M1-1) (Fig. 3D) is characterized by the hygrophyte *Polygonum sibiricum* Laxm. in the marsh meadow, mainly inhabiting the saturated riparian zone along the shoreline.

The zonation pattern of vegetation around Lake Pumayum Co and on Middle Island most probably correlates with a gradient of edaphic factors, especially soil moisture. In addition to these soil variables, the 150 inhabitants of Tsui Village located on the slope of a peninsula on the east of the lakeshore (5,050 m a.s.l.) (Fig. 1) have used the entire lakeshore to graze animals. This grazing pressure has resulted in the marked degradation of most of the survey sites. A possible reason for disparity in flora could be soil moisture and grazing pressure.

We thank Mr. Hideo Kihara of NHK in Japan for valuable information about Lake Pumayum Co and Dr. Tetuo Murakami of Nagoya Women's University for providing us with a map of Lake Pumayum Co.

References

- Bruce, McC. and James, B. G. 2002. Analysis of ecological communities. 300 pp. MjM Software Design, Gleneden Beach.
- Institute of Tibetan Plateau Research. 1988. Vegetation of Xizang (Tibet). 589 pp. Science Press, Beijing. (in Chinese)
- Mitamura, O., Seike, Y., Kondo, K., Goto, N., Anbutsu, K., Akatsuka, T., Kihira, M., Qiong, T. and Nishimura, M. 2004. Basic limnological study in an alpine lake Puma Yum Co, the pre-Himalayas, China. Rep. Res. Edu. Ctr. Inlandwat. Environ. 2 : 83-90.
- Wu, C.-Y. 1983. Flora Xizangica Vol. 1. 790 pp. Science Press, Beijing. (in Chinese)
- Wu, C.-Y. 1985a. Flora Xizangica Vol. 2. 956 pp. Science Press, Beijing. (in Chinese)
- Wu, C.-Y. 1985b. Flora Xizangica Vol. 4. 1021 pp. Science Press, Beijing. (in Chinese)
- Wu, C.-Y. 1986. Flora Xizangica Vol. 3. 1047 pp. Science Press, Beijing. (in Chinese)
- Wu, C.-Y. 1987. Flora Xizangica Vol. 5. 955 pp. Science Press, Beijing. (in Chinese)
- Yoshida, T. 2005. Himalayan plants illustrated. 799 pp. Yama-Kei, Tokyo. (in Japanese)

摘要

ブマムツォ湖は、中国・チベット高原南東部の北緯28°34′、東経90°24′、標高5,030 mに位置する淡水湖で、標高5,000m以上にある湖としては世界最大規模である。この湖は非常に高所にあり、軍事制限地域になっているため、これまでに湖周辺のフロラについての詳細な調査はされてこなかった。2006年本湖周辺15ヶ所でフロラ調査を行なった結果、24科79種(7種が未同定)が確認され、そのうちキク科(11種)、カヤツリグサ科(8種)、ゴマノハグサ科(8種)、イネ科(6種)、アブラナ科(5種)及びび Lindow 科(5種)が多数の種を含む主要な科で、残りの科はいずれも4種以下であった。

フロラ調査を行なった15ヶ所について二元指標種分析(TWINSPAN)を行なった結果、指標種と植生の相違から以下の4グループに分割できた。グループAは湖の島の湖岸を除く砂礫斜面全域と頂上のみで、乾生植物の *Artemisia brevifolia*, *Corydalis hookeri* 及び *Delphinium caeruleum* が指標種となる高山荒原であった。グループBは湖周辺に広く分布する腐食質が堆積しない比較的乾燥した場所に成立し、*Androsace tapete* が指標種となる高山ステップであった。グループCは未腐食質が堆積し、*Pachypleurum nyalamense* が指標種となる高山草原であった。グループDは湖畔の土壤水分が飽和した湖岸で、湿生植物の *Polygonum sibiricum* が指標種となる湿地草原であった。このような湖周辺の植生の違いは、土壤水分の違いと放牧によ

る採食圧の違いによるものと推測された。

¹College of Bioscience & Biotechnology, Chubu University, 1200, Matsumoto-cho, Kasugai, Aichi 487-8501, Japan ; ²Division of Life Sciences, Graduate School of Science, Nagoya University, Chikusa-ku, Nagoya 464-8601, Japan ; ³School of Health and Human Life, Nagoya Bunri University, Inazawa-cho, Inazawa 492-8520, Japan ; ⁴Institute of Tibetan Plateau Research, Chinese Academy of Sciences, No.18 Shuangqing Road, Beijing 100085, China ; ⁵Graduate School of Marine Science and Technology, Tokai University, 3-20-1, Orido, Shimizu, Shizuoka 424-0902, Japan ¹ 〒 487-8501 愛知県春日井市松本町 1200 中部大学応用生物学部 ; ² 〒 464-8601 愛知県名古屋市千種区 名古屋大学大学院理学研究科生命理学専攻 ; ³ 〒 492-8520 愛知県稲沢市稲沢町 名古屋文理大学健康生活学部 ; ⁴ 〒 100085 中国北京市双清路 18 号 中国科学院青藏高原研究所 ; ⁵ 〒 424-8610 静岡県清水市折戸 3-20-1 東海大学海洋学部

(Received July 24, 2010 ; accepted November 6, 2010)

Appendix

All specimens collected around Lake Pumayum Co, except *Amaranthus* sp., *Rhodiola crenulata* (Hook. f. & Thomson) H. Ohba and *Urtica hyperborea* Jacq. ex Wedd., were deposited at the Minami Laboratory in the College of Bioscience & Biotechnology, Chubu University, Japan. The above three plants were not collected for specimens, because we identified three plants locally. Therefore three specimens are not included in the list of following specimens.

Monocotyledoneae

Cyperaceae : *Carex aridula* V. I. Krecz. (CH060674) ; *C. moorcroftii* Falc. ex Boott (CH060601) ; *Eleocharis palustris* (L.) Roem. et Schult. (CH060670) ; *E. pauciflora* (Lightf.) Link (CH060700) ; *Kobresia humilis* (C. A. Mey. ex Trautv.) Serg. (CH060672) ; *K. macrantha* Boeck. (CH060588) ; *K. pratti* C. B. Clarke (CH060671) ; *K. pygmaea* (C. B. Clarke) C. B. Clarke (CH060621). **Liliaceae** : *Allium sikkimense* Baker (CH060616). **Poaceae** : *Deyeuxia tibetica* Bor (CH060769) ; *Elymus nutans* Griseb. (CH060602) ; *Poa poophagorum* Bor (CH060586) ; *Stipa bungeana* Trin. (CH060592) ; *S. purpurea* Griseb. (CH060699) ; unidentified (CH060730).

Dicotyledoneae

Choripetalae

Brassicaceae : *Aphragmus oxycarpus* (Hook. f. et Thomson) Jafri (CH060710) ; *Dimorphostemon pinnatus* (Pers.) Kitag. (CH060587) ; *Draba oreades* Schrenk (CH060635) ; *Pegaeophyton scapiflorum* (Hook. f. et Thomson) C. Marquand et Airy Shaw (CH060625) ; unidentified (CH060709). **Caryophyllaceae** : *Arenaria bryophylla* Fernald (CH060591) ; *Silene* sp. (CH060609). **Chenopodiaceae** : *Chenopodium* sp. (CH060596). **Crassulaceae** : *Rhodiola bupleuroides* (Wall. ex Hook. f. et Thomson) S. H. Fu (CH060582) ; *Sedum henrici-roberti* Raym.-Hamet (CH060633) ; *S. multicaule* Wall. ex Lindl. (CH060712). **Leguminosae** : *Astragalus lascaensis* C. C. Ni et P. C. Li (CH060767) ; *A. monticolus* P. C. Li et C. C. Ni (CH060679) ; *A. strictus* Graham ex Benth. (CH060585) ; *Oxytropis lapponica* (Wahlenb.) Gay (CH060593). **Papaveraceae** : *Corydalis hookeri* Prain (CH060594) ; *Hypecoum leptocarpum* Hook. f. et Thomson (CH060599). **Parnassiaceae** : *Parnassia chinensis* Franch. (CH060802) ; *P. pusilla* Wall. ex Arn. (CH060617). **Polygonaceae** : *Bistorta perpusilla* (Hook. f.) Greene (CH060765) ; *Polygonum sibiricum* Laxm. (CH060598). **Ranunculaceae** : *Delphinium caeruleum* Jacquem. ex Cambess. (CH060583) ; *Halerpestes tricuspis* (Maxim.) Hand.-Mazz. (CH060639) ; *Ranunculus nephelogenes* Edgew. (CH060622). **Rosaceae** : *Potentilla anserina* L. (CH060542) ; *P. biflora* Willd. ex Schldtl. (CH060715) ; *P. saundersiana* Royle (CH060707) ; *Sibbaldia purpurea* Royle (CH060611). **Saxifragaceae** : *Saxifraga isophylla* Harry Sm. (CH060787). **Umbelliferae** : *Pachypleurum nyalamense* H. T. Chang et R. H. Shan (CH060620).

Sympetalae

Boraginaceae : *Lasiocaryum munroi* (C. B. Clarke) I. M. Johnst. (CH060691) ; *Microula tibetica* Benth. (CH060626). **Compositae** : *Artemisia brevifolia* Wall. ex DC. (CH060584) ; *Erigeron multira-*

diatus (Lindl. ex DC.) Benth. ex C. B. Clarke (CH060619) ; *Leontopodium jacotianum* Beauverd var. *paradoxum* (J. R. Drumm.) Beauverd (CH060606) ; *L. longifolium* Ling (CH060624) ; *L. nanum* (Hook. f. et Thomson) Hand.-Mazz. (CH060697) ; *Leontopodium* sp. (CH060694) ; *Saussurea andryaloides* (DC.) Sch. Bip. (CH060589) ; *S. kingii* C. E. C. Fisch. (CH060600) ; *Taraxacum maurocarpum* Dahlst. (CH060608) ; *T. sikkimense* Hand.-Mazz. (CH060768) ; *Vladimiria berardioidea* (Franch.) Ling (CH060785). **Gentianaceae** : *Gentiana crassuloides* Bureau et Franch. (CH060648) ; *G. leucomelaena* Maxim. ex Kusn. (CH060807) ; *G. micans* C. B. Clarke (CH060618) ; *G. pedicellata* (Wall. ex D. Don) Griseb. (CH060743) ; *Swertia hispidicalyx* Burkill (CH060753). **Labiatae** : *Dracocephalum heterophyllum* Benth. (CH060590) ; *Phlomis rotata* Benth. ex Hook. f. (CH060603). **Morinaceae** : *Cryptothladia polyphylla* (DC.) Cannon (CH060729). **Primulaceae** : *Androsace tapete* Maxim. (CH060636) ; *Lysimachia* sp. (CH060690). **Scrophulariaceae** : *Lancea tibetica* Hook. f. et Thomson (CH060771) ; *Pedicularis cheilanthifolia* Schrenk (CH060607) ; *P. diffusa* Prain (CH060711) ; *P. globifera* Hook. f. (CH060692) ; *P. longiflora* Rudolph subsp. *tubiformis* (Klotzsch) Pennell (CH060786) ; *P. microcalyx* Hook. f. (CH060788) ; *P. rhinanthoides* Schrenk ex Fisch. et C. A. Mey. subsp. *labellata* (Jacquem.) Pennell (CH060623) ; *Veronica lasiocarpa* Pennell (CH060612).