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Seed mass and germination in an alpine meadow on the eastern Tsinghai–Tibet plateau

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Abstract In this study, we built up a database of 570 species from an alpine meadow on the eastern Tsinghai–Tibet plateau. We examined the correlation of seed mass and germination with phylogeny, habitat and altitude, and the relationship between seed mass and germination. We found that: habitats had no significant effects on seed mass and germinability, which was in accord with the former studies; there was a significant negative correlation between seed mass and altitude, as well as between germinability and altitude, which was opposite to most of the former studies; there was a significant negative correlation between seed mass and germinability, which was in contrast with other studies that have found a positive relationship, and seed mass could explain 24.1% of total variation in germinability; in GLM, family and genus accounted for 43.9% and 83.9% of total variation in seed mass, and 34.1% and 65.4% in germinability, respectively, thus, it was evident that seed mass and germinability were strongly related to phylogeny. We considered that seed mass and germination might be the result of both selective pressures over long-term ecological time and the constraints over long-standing evolutionary history of the taxonomic membership. We suggest that correlates of ecology and phylogeny should be taken into account in comparative studies on seed mass and germination among species.

Keywords Altitude · Ecological constrains · Germination · Habitat · Phylogeny · Seed mass

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Introduction

Seed traits, including seed mass, dormancy, germination, and dispersal, are central components of plant life histories (Harper 1977; Fenner 1983; Thompson 1987), and their importance to plant fitness are widely appreciated (Venable 1985, 1989; Foster 1986; Lord et al. 1995; Venable et al. 1998; Higgins and Richardson 1999).

Seed mass has long been regarded as an important aspect in the reproductive biology of plants. Traditionally, seed mass within a plant species is considered to be a remarkably constant characteristic. However, numerous studies have demonstrated that seed mass within a species or even an individual plant can vary greatly (see Hendrix 1984). Seed mass varies over 10 orders of magnitude among plant species (see Zhang et al. 2004), even within a plant community, species often span a 10^{5-}–10^{6} range of seed mass (Leishman and Westoby 1994). Such variation in seed mass has often been correlated with environmental factors. Both within and among species, a larger seed mass has been associated with less-disturbed habitats (Werner and Platt 1976), with dryness (Schimpf 1977), or with a decrease in altitude (Baker 1972) and an increase in latitude (see Wulff 1986).

Seed germination is one of the most extensively researched areas in plant biology (Olff et al. 1994; Vera 1997). The capacity of seed germination and seedling establishment can partly determine the regeneration of the plant communities of grassland. Thus, an estimate of germination capacity is important to determine sexual reproductive efficiency (Vera 1997). However, geographical related variation in germination response is common among widespread plants (see Lord 1994), and populations in different environments may have experienced different selection pressures on germination behavior (Lord 1994). Altitude is a likely factor to be associated with variation among populations. Variations in germination of different species had been observed in relation to altitude (Miller and Cummins 1987; Vera 1997; Holm 1994).

According to recent studies, it is reasonable to expect that, within a family or a genus, reproductive characters, such as seed mass and germination, could be affected by phylogenetic constraints and developmental allometries that limit segregation (Kochmer and Handel, 1986; Mazer 1989; Feinsinger 1987; Grime et al. 1981; Herrera, 1992; Jordano 1995; Lord et al. 1995; Smith-Ramírez et al. 1998; Zhang et al. 2004).

In addition to these basic constrains, life historical traits, like seed mass, would impose further restrictions on germination behavior (Smith-Ramírez et al. 1998; Jurado and Flores 2005). Seed mass may affect germination and seedling characteristics and, then, population recruitment. Hence, large numbers of research focus on the relationship of seed mass and seed germinability. Seed mass has been found to affect germination rate and percent germination, but a consistent picture is not apparent. Most of these studies observed an increase (Weis 1982; Wulff 1986; Winn 1988; Vera 1997), some others a decrease (Counts and Lee 1991) or no alteration (Mckersie et al. 1981; Piper 1986; Eriksson 1999) in seed germination with increasing seed mass.

Despite a recent growing interest in seed mass variation and quite large number of empirical studies on seed germination, very few studies have been addressed to test seed mass and germination in a whole plant community (Garwood 1983; Westoby et al. 1992; Leishman et al. 1995; Lord et al. 1995, Jurado and Flores 2005). However, the study of germination of seeds collected from one community at the same time may provide important information to understand the dynamics of a community. In this study, we build up a database of 570 species (involving 10 classes, 22 orders, 37 families, 169 genera) collected from the alpine meadow on the eastern Tsinghai–Tibet plateau. We tested whether seed mass and germination were associated with phylogeny constraint and environmental variables such as habitat and altitude, and also quantified the relationship between seed mass and germinability. Specifically, we tested (1) if seeds mass of plant species at high altitude or in south slope and bottomland were smaller than that at low altitude or in north slope, boscage and forest edge; (2) if seeds germinability of plant species at high altitude or in south slope and bottomland were stronger than that at low altitude or in north slope, boscage and forest edge; (3) if smaller seeds had a weak germinability; and (4) if seed mass and germination variation were strongly constrained by phylogeny.

Material and methods

Study site

The region of this study is located on the eastern Tsinghai–Tibet plateau (101°–103° E, 34°–35°70′ N). The altitude ranges from 2,800 to 4,200 m, and the climate is cold Humid-Alpine with mean annual rainfall of 450–780 mm. Mean annual temperature is 1.2°C with –10.7°C in January and 11.7°C in July, and there are on average 270 frost days a year. The grassland type mainly belongs to alpine meadow (59.32%), which is dominated by many monocotyledons, for example, Gramineae, Cyperaceae, and various dicotyledons, such as Ranunculaceae, Polygonaceae, Saxifragaceae, Compositae, Scrophulariaceae, Gentianaceae, Leguminnosae.

The database

In this study, we build up a database of 570 species (involving 10 classes, 22 orders, 37 families, 169 genera) collected from the alpine meadow on the eastern Tsinghai–Tibet plateau. The sample represented 60% of the species, 40% of the genera, and 40% of the families reported from the area. Seeds were gathered from July to October in 2004, and species included not only native but also introduced ones. Seeds were collected at the start of natural dispersal. Enveloped seeds were spread on tables and allowed to air-dry to a constant mass at room temperature (approximately 15°C) before being weighed. Seed mass was defined as the weight of the embryo and endosperm, plus the seed coat. Structures having the function of contributing to dispersal were not included as part of the seed mass. Seeds were pooled per species and we selected stochasticly three subsamples of 100 seeds from the pooled samples. The average weight of the three subsamples was used as seed mass variable. The germination experiment was started on the middle ten days of March (starting season of germination), in 2005. Seeds were placed in covered Petri dishes (9 cm diameter) on a double layers of moistened filter paper, then placed in temperature chambers at a diurnal fluctuation of 20°C (25°C day,12 h; 5°C night,12 h) with 24-h darkness (not considering the effect of light) and a relative humidity of about 70%. The temperature of the germination trial resembled natural conditions for April and May: it approximated to the daily maximum and minimum temperature in 5 cm-deep soil. All of the species had three replicates of 50 seeds. Every day, the percentage of seeds germinated was recorded, newly emerged seedlings were removed from the Petri dishes, and seeds were regularly watered with distilled water. A seed was considered as germination when the radicle was visible. The experiment of seed germination lasted 60 days.

A weighted germination index (WGI) described by Reddy et al.(1985) was calculated with maximum weight given to the seeds germinating early and less to those germinating late. And larger WGI values mean higher percentage.

$$\mathrm{WGI} = [60 \times n_1 + 59 \times n_2 + \cdots + 1 \times n_{60}]/60 \times N$$

where $n_1, n_2, \ldots, n_{60}$ are the number of seeds that germinated on 1st, 2nd, and subsequent days until the 60th day, respectively; $60, 59, \ldots, 1$ are the weights given to the seeds germinated on 1st, 2nd, and subsequent days until the 60th day. N is the total number of seeds placed for germination.

Statistical analysis

Both phylogenetic and ecological correlates of seed mass and germination were taken into account in the present study. Results of germination characteristic were presented as mean ± SE, which was analyzed using analysis of variance (ANOVA). Data on the WGI were arcsine square root transformed before statistical analysis to ensure homogeneity of variance (Gulzar and Khan 2001), and data on the seed mass were log-transformed (Leishman et al. 1995). To assess the variation in seed mass and germination among 570 species with increasing altitude in the flora, we analyzed the relationship between mean seed mass (or mean WGI) and altitudinal gradients. The data of altitude gradients were determined by the height above sea level species collected and not normalized, therefore, Spearman's correlation coefficient was used to explain their correlations. In the same way, we tested the relationship between seed mass classes and WGI. The GLM procedure was used to examine the explanatory power of habitat, altitude, and taxonomic membership on seed mass and WGI, as well as the effect of seed mass on WGI. In GLMs, the altitudes as the categorical variable were divided into three classes: <3,300, 3,300–3,600 m, and >3,600 m; the habitats were classified into five categories: bottomland, boscage, north slope, south slope, and forest edge; and seeds were sorted by weight into 104 size classes, on the basis of 5-mg intervals (Note: because some mass classes were missing or had only one or fewer species when seed mass > 2.3 mg, not all mass classes were sorted by 5-mg interval). A GLM on a categorical variable is equivalent to a one-way ANOVA. When a dataset is unbalanced, GLM, instead of ANOVA, should be used for variance analysis. Variables can be fitted sequentially, where r^2 measures the proportion of variation, and F-value tests the significance of the variation accounted for. Moreover, the family, order, and class affiliation of each species were added for the data set, using the Angiosperm Phylogeny Group II (2003). All analyses were performed with the SPSS 12.0 procedure.

Results

The effects of habitat and altitude on seed mass and WGI

The frequency of seed mass classes on a log scale produced a partial normal distribution (Fig. 1). Within the alpine meadow on the eastern Tsinghai–Tibet plateau, the seed mass of 570 plant species spanned four magnitudes from 10^{-2} to 10^{2} mg.

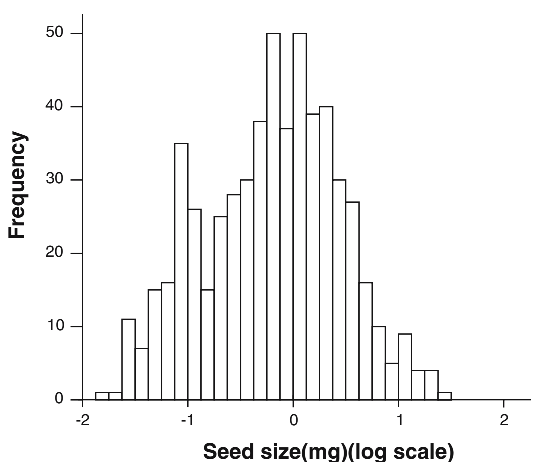


Fig. 1 Seed mass distribution

Table 1 Powers of habitat, altitude, class, order, family and genus to explain log seed mass variation in GLM containing a categorical variable

Source	df	F	P	R^2
Habitat	4	2.12	0.077	1.5
Altitude	2	5.18	0.006	1.8
class	9	8.94	0	12.6
Order	21	12.13	0	31.7
family	35	11.95	0	43.9
genus	167	12.54	0	83.9

The R^2 values were calculated by dividing Type I sums of squares (SS) for each categorical variable by total SS

In our general linear models (GLMs), habitats and altitudes could account for 1.5% and 1.8% variation in log seed mass, respectively. Seed mass had significant difference among altitudes but no among habitats (Table 1). There was a significant negative correlation between seed mass and altitude (R = 0.664, P = 0.004, Fig. 2), which was in accord with the former studies (Baker 1972).

Habitats and altitudes could account for 0.5% and 0.7% variation in arcsine square root WGI, respectively. WGI had no significant difference among altitudes or habitats (Table 2). But there was significant negative correlation between WGI and altitude (R = 0.549, P = 0.035, Fig. 2), which was opposite to the former studies that have found a positive relationship. This result suggests that decreased germination percentage and later onset to germination go with increasing altitudes.

The effect of seed mass on WGI

Seed mass could account for 24.1% variation in arcsine square root WGI (Table 2). And there was a significant negatively correlation between WGI and seed mass (R = 0.534, P < 0.001, Fig. 4), which was in contrast to other studies that have found a positive relationship. That is, decreased germination percentage and later onset to germination go with increasing seed mass.

The effect of phylogeny on seed mass and WGI

In GLMs, taxonomic membership had statistical significant effects on log seed mass and arcsine

Fig. 2 Mean seed mass, mean arcsine square root WGI along altitudinal gradients. Species were sampled along altitudinal gradients of 2,800–4,100 m. The total number of species is 570

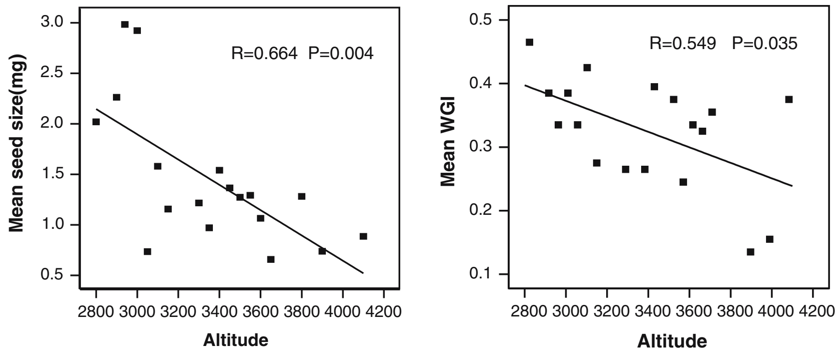


Table 2 Powers of habitat, altitude, seed mass, class, order, family and genus to explain arcsine square root WGI variation in GLM containing a categorical variable

Source	df	*F*	*P*	R^2
Habitat	4	0.70	0.59	0.5
Altitude	2	2.12	0.12	0.7
Class	9	8.63	0.000	12.2
Order	21	8.02	0.000	23.5
Family	35	7.89	0.000	34.1
Genus	167	4.54	0.000	65.4
Seed mass	103	1.43	0.007	24.1

The R^2 values were calculated by dividing Type I sums of squares (SS) for each categorical variable by total SS

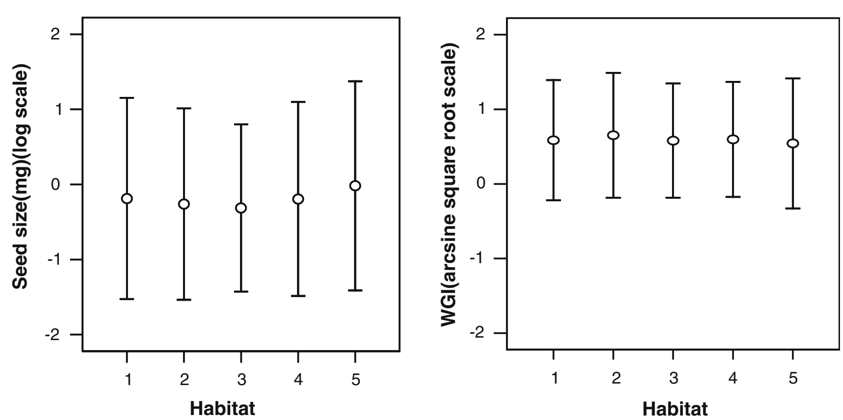
square root WGI (Table 1). Family and genus membership accounted for most of the variation in log seed mass (43.9% and 83.9%, respectively), and in arcsine square root WGI (34.1% and 65.4%, respectively) in GLM containing a categorical variable. The strong generic effects on seed mass and WGI suggest that such variation within genera is constrained, and may be a general pattern. Thus, it was evident that seed mass and germination was strongly related to phylogeny.

Discussion

The effects of habitat and altitude on seed mass and WGI

There was an approximate normal distribution of seed mass on a log scale, and the five habitats had no significant difference on seed mass (Table 1, Figs. 1 and 3). Our result is in accord with the former studies. There were some reports that, most variation in seed mass occurs between species within habitat, rather than between habitats within the same climate zone (see Zhang et al. 2004). In the most detailed across-species study of variation in seed mass with environmental conditions, seed mass of herbaceous species of the Californian flora decreased with increasing altitude as well as with decreasing soil moisture

Fig. 3 Mean log seed mass and arcsine square root WGI values of species in each of the habitats: (1) bottomland; (2) boscage; (3) north slope; (4) south slope; and (5) forest edge. Error bars show standard deviation. The total number of species is 570



(Baker 1972), but Pluess (2005) confirmed that seed mass tended to increase rather than decrease with higher altitude. There was significant negative correlation between seed mass and altitudes in this study (Fig. 2). We considered that it might be the result of selective pressures over long-term ecological time. It has been suggested that the length of the growth period in a habitat might constrain the upper limit of seed mass by constraining the amount of time available for seed provisioning (see Zhang et al. 2004). Selection for larger seeds may also be constraint because of a shortage of carbon due to the short duration of the growing season at high altitude. Net primary productivity (NPP) may offer an alternative explanation for smaller seeds in the alpine meadow. NPP is generally thought to be lower towards high altitude (Bondeau et al. 1999). It seemed reasonable to expect that lower NPP was translated into lower mass of seeds produced per unit area. In this way, selection would favor smaller seeds in lower productivity environments with increasing altitude.

The five habitats had no significant difference on seed germination (Table 2, Fig. 3). This result is in accord with the former studies. For example, Seven species of *Alstroemeria* that grow in different mountain and lowland habitats in South America exhibited similar germination strategies, regardless of their habitat of origin (see Figueroa and Armesto 2001); Baskin et al. (1993) reported analogous results when dormancy types were compared among species in the family Asteraceae; Species belonging to the Arcto-Tertiary flora presently inhabiting deciduous North American forest, had germination strategies that matched those of congeneric species presently occurring in East Asia (Baskin and Baskin 1998).

Germination percentage and rate could be influenced by altitude at which seeds were collected (Vera 1997). Holm (1994) found that seed germinability decreased or increased with altitude according to species and between years. In this study, there was no significant difference on WGI among the altitude classes (Table 2), but significant negative correlation between WGI and altitudes (Fig. 2). That is, decreasing percentage and later onset of germination go with altitude. We considered that it might be an adaptation to the diverse environment. Once there is a suitable environment, the rapid germinating of these species could take possession of blank place in a short time and have the advantage in time and space. But, it is a risk that seeds germinate rapidly in the inducement of single environmental factor (such as the increasing of soil temperature). It is likely to result in dying out of some species in an area (Harper 1977; Freas and Kemp 1983; Cummins and Miller 2001), especially in the unpredictable environment of the alpine meadow.

The effect of seed mass on WGI

To our surprising, seed mass was significantly negatively correlated with WGI values in this study (Fig. 4). That is lower germination percentage and later germinating go with increasing seed mass. This result was in contrast to many studies that have found a positive relationship between seed mass and germination percentage (or germinating rate) (Stanton 1984; Wulff 1986; Winn 1988; Vera 1997), while it accords with other studies (Grime 1979; Mckersie et al. 1981; Counts and Lee 1991).

Many hypotheses about the merits of larger versus smaller seed mass treat large seeds as adaptations for overcoming various kinds of hazard conditions during seedling establishment

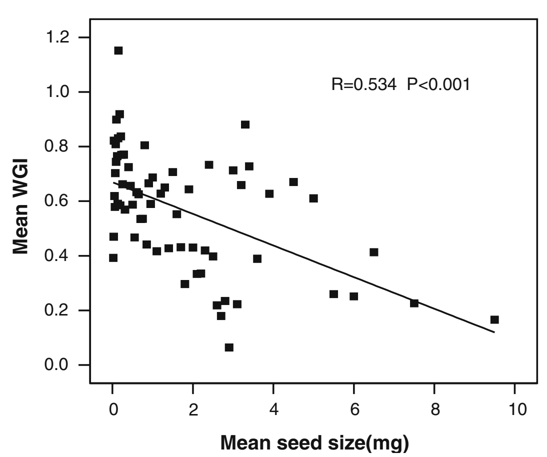


Fig. 4 The relationships between mean seed mass and mean arcsine square root WGI values. The total number of species is 558 (except 18 species with seed mass > 10 mg because of fewer species numbers in each seed mass classes)

(Wulff 1986; Westoby et al. 1992). But if smaller seeds germinate more rapidly than larger seeds, they could get a competitive advantage derived from earlier growth period (Hendrix 1984). Furthermore, germination rate of larger seeds would not be too fast because of their usual opacity of thick and hard seed coats (Pearson et al. 2002). Then, it is reasonable that larger seeds had lower percent germination than smaller seeds in a given time.

The effect of phylogeny on seed mass and WGI

A growing number of studies have documented that phylogenetic relatedness of plant species within a community could account for a significant proportion of interspecific variation in reproductive traits. For example, phylogenetic closeness explained much interspecific variation in breeding systems, seed mass, flowering phonologies, fleshy-fruit traits and reproductive syndromes in Mediterranean, tropical and temperate floras (see Figueroa and Armesto 2001). For example, seed germination rates of species belonging to the same plant families in Sheffield, England, were more similar than those of species in different families (Grime et al. 1981); Figueroa and Armesto confirmed that phylogenetic relationships significantly influenced GT (mean time of seed germination in days from sowing) for species in the forest flora of Chiloé; The phylogenetic pattern of seed mass was also previously shown in different floras (Mazer 1990; Lord et al. 1995). In this study, most of the variation of the total variance could be explained by taxonomic membership (Table 2). The strong familial or generic effects on seed mass and WGI suggest that such variation within families or genera is constrained, and may be a general pattern. The biological and evolutionary interpretation of the close association between seed mass (or germinability) and phylogenetic affinity in the alpine meadow is complex. One possible interpretation is that phylogeny imposes limits to variability in reproductive traits within a clade, because of similar developmental and design constrains in related species (Lanyon 1993; Mckitrick 1993; Miles and Dunham 1993; Yokoyama 1994; Ackerley and Donoghue 1995).

Conclusions

In summary, our results suggest that seed mass and germinability were strongly correlated with taxonomic membership in the alpine meadow on the eastern Tsinghai–Tibet plateau. Despite seed size and germinability had no significant difference among habitats, they were significantly correlated with altitudes. In addition, there was significant negative correlation between seed germinability and seed mass. Thus, the variation of seed size and germinability was constrained not only by phylogeny but also by ecological factors. Moreover, we suggest that other possible correlates may exist between seed mass (or germination) and additional ecological related factors (for example, life form, seed dispersal mode and post-dispersal predation) that were not evaluated in this study. Therefore, taking a comprehensive view, we considered that seed mass and germination might be the result of both selective pressures over long-term ecological time and constraints over long-standing evolutionary history of the taxonomic membership. We suggest that correlates of ecology and phylogeny should be taken into account in comparative studies on seed mass and seed germination among species.

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Appendix

The habitat, altitude and seed mass of species in an alpine meadow on the eastern Tibetan plateau. The Angiosperm Phylogeny Group II (2003) was used to assign the affiliation of each species to higher levels. Habitat—(1) bottomland; (2) boskage; (3) north slope; (4) south slope; and (5) forest edge. Altitude—the height at which seed were collected. Seed mass—mean value per 100 seeds.

Class / Order / Family / Genus / Species	habitat	altitude (m)	seed mass (g)(± SE)
Monocots			
Asparagales			
Iridaceae			
Iris Linn.			
Iris lactea var.chinensis	5	2900	1.7789±0.0118
Iris tenuifolia Pall	2	3470	1.3443±0.0000
Liliales			
Liliaceae			
Allium Linn.			
Allium beesianum	1	3500	0.0395±0.0007
Allium chrysanthum	1	3300	0.0551±0.0009
Allium cyaneum	4	3700	0.0484±0.0004
Allium ramosum	4	2940	0.1126±0.0015
Allium sikkimense	3	3050	0.0529±0.0004
Asparagus Linn.			
Asparagus filicinus	1	2940	2.5770±0.0388
Fritillaria Linn.			
Fritillaria przewalskii	2	3400	0.0838±0.0016
Lilium Linn.			
Lilium callosum	5	2900	0.2753±0.0025
Lilium pumilum	3	2800	0.2115±0.0011
Polygonatum Mill			
Polygonatum cirrhifolium	2	2800	0.5956±0.0471
Polygonatum sibiricum	4	2940	0.9324±0.0063
Polygonatum verticillatum	4	2800	1.2126±0.0183
Commelinids			
Poales			
Cyperaceae			
Blysmus Panz.			
Blysmus sinocompressus	1	3500	0.0678±0.0010
Carex Linn.			
Carex scabrirostris Kükenth.	1	3400	0.0297±0.0005
Carex sp1	3	3600	0.1309±0.0018
Carex sp2	1	2900	0.0465±0.0007
Carex sp3	5	2900	0.1342±0.0007
Carex sp4	2	3470	0.0711±0.0015
Carex sp5	3	3550	0.0454±0.0042
Carex sp6	1	3300	0.0485±0.0007
Carex sp7	1	3300	0.0735±0.0005
Carex stipitinux Clarke	2	3470	0.0601±0.0004
Kobresia Willd.			
Kobresia bellardii	1	3500	0.0713±0.0014
Kobresia capillifo	4	3500	0.1503±0.0030
Kobresia humilis	1	3550	0.0633±0.0006
Kobresia kansuensis Kükenth	3	3600	0.0941±0.0012
Kobresia tibetica Maxim.	4	3900	0.1517±0.0008
Kobresia macrantha Böcklr	2	3470	0.0496±0.0025
Kobresia setchwanensis	4	3500	0.1260±0.0087
Kobresia kansuensis Kükenth	3	3650	0.0672±0.0013
Kobresia sp	1	3300	0.0499±0.0016
Scirpus Linn.			
Scirpus pumilus Vahl	3	3400	0.0524±0.0003

Scirpus setaceus Linn.	4	3500	0.0462±0.0010
Scirpus triqueter Linn.	4	3900	0.0413±0.0017
Juncaceae			
Juncus Linn.			
Juncus effusus Linn.	1	3500	0.0028±0.0001
Juncus sphacelatus Decne	4	3600	0.0036±0.0001
Juncus spp.	1	3300	0.0031±0.0002
Juncus thomsonii Buchen.	4	3650	0.0026±0.0000
Poaceae(Gramineae)			
Achnatherum Beauv.			
Achnatherum inebrians	1	2800	0.1143±0.0004
Achnatherum sibiricum	4	2800	0.3041±0.0035
Achnatherum splendens	1	2800	0.0878±0.0012
Agrostis Linn.			
Agrostis alba Linn	5	2900	0.0106±0.0000
Agrostis matsumurae	1	3300	0.0069±0.0003
Agrostis sp1	4	3000	0.0077±0.0002
Agrostis sp2	1	3300	0.0085±0.0001
Agrostis sp3	3	3150	0.0117±0.0006
Agrostis sp4	4	3100	0.0603±0.0012
Agrostis stolonifera Linn	2	3470	0.0128±0.0001
Agrostis trinii Turcz.	4	3500	0.0365±0.0006
Aneurolepidium Nevski			
Aneurolepidium dasystachys	1	2900	0.4342±0.0056
Aristida Linn.			
Aristida triseta Keng	3	3500	1.4363±0.0192
Arundinella Raddi			
Arundinella anomala Steud.	1	3400	0.0146±0.0003
Brachypodium Beauv.			
Brachypodium sp.	1	3500	0.3037±0.0060
Brachypodium sylvaticum	1	2800	0.3891±0.2327
Bromus Linn.			
Bromus magnus Keng	5	2900	0.2481±0.0042
Bromus sinensis Keng+H146	3	3400	0.3911±0.0039
Bromus sp.	1	2900	0.3434±0.0015
Bromus tectorum Linn.	1	3500	0.4286±0.0089
Deschampsia Beauv.			
Deschampsia caespitosa	1	3300	0.0290±0.0008
Deyeuxia Clarion			
Deyeuxia arundinacea	4	3470	0.0259±0.0004
Deyeuxia scabrescens	3	3350	0.0491±0.0010
Deyeuxia sp1	4	3000	0.1084±0.0111
Deyeuxia sp2	2	3470	0.0182±0.0005
Elymus Linn.			
Elymus dahuricus	4	3600	0.3069±0.0081
Elymus tangutorum	1	2900	0.4550±0.0065
Festuca Linn.			
Festuca ovina Linn.	4	3650	0.0432±0.0025
Festuca rubra Linn.	3	3150	0.0620±0.0032
Festuca sinensis Keng	1	3500	0.0829±0.0014
Helictotrichon Bess.			
Helictotrichon leianthum	2	3470	0.0396±0.0006
Helictotrichon schellianum	4	3400	0.0258±0.0005
Helictotrichon sp	2	3470	0.2474±0.0055
Helictotrichon tibeticum	4	4100	0.1112±0.0259
Koeleria Pers.			
Koeleria cristata	4	3000	0.0290±0.0002
Melica Linn.			

Mellica scabrosa	2	3470	0.0511±0.0172
Orinus Hitchc.			
Orinus kokonorica	4	2800	0.0473±0.0008
Oryzopsis Michx.			
Oryzopsis munroi	1	3800	0.2477±0.0009
Poa Linn.			
Poa botryoides Trin.	1	3500	0.0266±0.0004
Poa declinata Keng	1	3500	0.0333±0.0018
Poa poophagorum Bor	4	2900	0.0223±0.0002
Poa pratensis Linn.	4	4020	0.0209±0.0005
Poa schoenites Keng	3	3600	0.0245±0.0009
Poa sinattenuata Keng var. vivipara	3	3550	0.0761±0.0003
Ptilagrostis Griseb.			
Ptilagrostis concinna	4	3550	0.0793±0.0019
Ptilagrostis dichotoma	4	3700	0.0948±0.0014
Ptilagrostis junatovii	1	3500	0.0415±0.0011
Ptilagrostis monghol	4	2900	0.1489±0.0024
Ptilagrostis sp	2	3470	0.0288±0.0004
Roegneria C.Koch			
Roegneria kokonorica	1	3300	0.3483±0.0069
Roegneria nutans	2	3470	0.4065±0.0037
Roegneria stricta	4	3000	0.3299±0.0049
Stipa Linn.			
Stipa aliena Keng	4	3340	0.2334±0.0215
Stipa capillacea Keng	4	3000	0.4628±0.0037
Stipa przewalskyi	3	2800	0.3813±0.2913
Stipa purpurea	4	3100	0.2217±0.0035
Stipa sp1	4	3700	0.4042±0.0249
Stipa sp2	4	3000	0.4342±0.0025
Eudicots			
Ranunculales			
Papaveraceae			
Dicranostigma Kook			
Dicranostigma lactucoides	1	2940	0.0618±0.0006
Meconopsis Vig.			
Meconopsis horridula	4	4020	0.0177±0.0002
Meconopsis integrifolia	2	3470	0.0392±0.0006
Meconopsis punicea	4	3470	0.0500±0.0010
Meconopsis sp1	1	3550	0.0514±0.0013
Meconopsis sp2	3	3400	0.0539±0.0009
Ranunculaceae			
Aconitum Linn.			
Aconitum gymnandrum	1	2900	0.0645±0.0004
Aconitum sinomontanum	1	3300	0.1611±0.0060
Aconitum sp	4	3500	0.0901±0.0014
Anemone Linn.			
Anemone rivularis	1	2900	0.5470±0.0071
Aquilegia Linn.			
Aquilegia viridiflora	5	2900	0.1182±0.0000
Cimicifuga Linn.			
Cimicifuga foetida Linn.	2	2800	0.0358±0.0009
Clematis Linn.			
Clematis peterae	5	2900	0.4129±0.0120
Clematis tangutica	4	3000	0.1837±0.0021
Delphinium Linn.			
Delphinium albocoeruleum	2	2800	0.0690±0.0021
Delphinium caeruleum	1	2940	0.0585±0.0036
Delphinium kamaoense var	4	3100	0.0662±0.0028

Delphinium sp1	1	2800	0.0731±0.0019
Delphinium sp2	1	3500	0.0671±0.0006
Delphinium tatsienense Franch.	2	3470	0.0806±0.0007
Ranunculus Linn			
Ranunculus affinis	1	3300	0.0260±0.0007
Ranunculus nephelogenes	1	3470	0.0350±0.0007
Thalictrum Linn.			
Thalictrum delavayi	1	3300	0.1974±0.0011
Thalictrum sp1	4	3100	0.0670±0.0011
Thalictrum sp2	2	3150	0.1704±0.0032
Thalictrum sp3	1	2940	0.1107±0.0033
Thalictrum sp4	4	3000	0.0900±0.0005
Thalictrum sp5	2	3470	0.3009±0.0077
Thalictrum thunbergii	5	2900	0.0377±0.0094
Thalictrum uncatum Maxim.	5	2900	0.5007±0.0064
Trollius Linn.			
Trollius farreri Stapf.	3	3050	0.0483±0.0010
Core Eudicots			
Caryophyllales			
Amaranthaceae			
Chenopodium Linn			
Chenopodium aristatum	1	2800	0.0140±0.0020
Chenopodium botrys	1	2900	0.0144±0.0002
Chenopodium glaucum	4	2900	0.0911±0.0009
Chenopodium iljinii Golosk.	1	2900	0.0720±0.0005
Chenopodium sp1	5	2900	0.0930±0.0029
Chenopodium sp2	4	3500	0.0488±0.0008
Chenopodium sp3	1	3500	0.0819±0.0013
Chenopodium sp4	1	3400	0.0601±0.0007
Corispermum Linn.			
Corispermum declinatum	1	2800	0.1424±0.0020
Kochia Roth			
Kochia scoparia	3	3600	0.0363±0.0004
Caryophyllaceae			
Arenaria Linn.			
Arenaria giraldii	1	3500	0.0073±0.0001
Arenaria Serpyllifolia	1	3500	0.0017±0.0001
Arenaria sp	2	3470	0.0126±0.0003
Cerastium Linn.			
Cerastium arvense	1	3470	0.0655±0.0043
Cerastium sp1	1	3500	0.0162±0.0002
Cerastium sp2	1	3300	0.2157±0.2002
Dianthus Linn.			
Dianthus sp1	2	3470	0.0142±0.0003
Dianthus sp2	3	2940	0.0768±0.0012
Dianthus superbus	4	2900	0.0730±0.0022
Lepyrodiclis Fenzl			
Lepyrodiclis holosteoides	1	3500	0.1743±0.0020
Melandrium Roehl.			
Melandrium apricum	5	2900	0.0220±0.0005
Melandrium sp1	3	3600	0.0311±0.0004
Melandrium sp2	3	2940	0.0293±0.0002
Melandrium sp3	4	3800	0.0087±0.0000
Melandrium sp4	4	2800	0.0235±0.0004
Melandrium sp5	2	3470	0.0094±0.0001
Melandrium sp6	4	3470	0.0187±0.00001
Melandrium sp7	2	3470	0.0092±0.0003
Silene Linn.			

Silene conoidea Linn.	5	2900	0.1248±0.0009
Silene gallica Linn.	4	2800	0.0211±0.0002
Stellaria Linn.			
Stellaria media	1	2900	0.0580±0.0004
Stellaria umbellata	2	3470	0.0097±0.0001
Polygonaceae			
Polygonum Linn.			
Polygonum aviculare Linn.	1	2940	0.1945±0.0032
Polygonum hydropiper Linn.	3	3900	0.1036±0.0000
Polygonum lapathifolium Linn.	1	3300	0.0770±0.0024
Polygonum macrophyllum D.Don	4	3100	0.0652±0.0005
Polygonum sieboldii Meisn.	5	2900	1.1878±0.0553
Polygonum sp1	4	3600	0.0567±0.0021
Polygonum sp2	4	3000	0.1014±0.0048
Polygonum sp3	5	2900	0.1888±0.0155
Polygonum sp4	5	2900	0.6573±0.0000
Polygonum viviparum Linn.	4	3100	0.1568±0.0045
Polygonum wallichii Meisn.	4	4020	0.0503±0.0006
Rumex Linn.			
Rumex acetosa Linn.	1	3500	0.1894±0.0025
Rumex crispus Linn.	4	3600	0.1936±0.0051
Rumex dentatus Linn.	1	2900	0.3342±0.0031
Rumex patientia Linn.	1	3300	0.2583±0.0025
Saxifragales			
Crassulaceae			
Orostachys(DC.)Fisch			
Orostachys spinosus	4	2800	0.0048±0.0001
Rhodiola Linn.			
Rhodiola atuntsuensis	4	4100	0.0161±0.0017
Rhodiola quadrifida	4	4100	0.0240±0.0003
Sedum Linn.			
Sedum aizoon H217Linn.	5	2900	0.0100±0.0003
Sedum dugueyi Hamet	1	3500	0.0033±0.0001
Sedum erici-magnusii Fröd	2	3150	0.0127±0.0000
Sedum sp1	4	2800	0.0069±0.0000
Sedum sp2	2	3470	0.0048±0.0002
Sedum sp3	3	3550	0.0073±0.0000
Sedum sp4	3	3400	0.0070±0.0001
Saxifragaceae			
Parnassia Linn.			
Parnassia palustris Linn.	4	3400	0.0048±0.0002
Parnassia trinervis Drude	1	3500	0.0050±0.0001
Saxifrage Tourn.ex Linn.			
Saxifrage oresbia Anth.	1	3300	0.0034±0.0001
Saxifrage pseudohirculus Engl.	2	3470	0.0022±0.0001
Saxifrage stolonifera Cutt.	4	3400	0.0026±0.0000
Rosids			
Geraniales			
Geraniaceae			
Geranium			
Geranium pratense Linn.	1	3550	0.6467±0.0000
Geranium wilfordii Maxim.	1	2940	0.3233±0.0004
Erodium L'Hér.			
Erodium sp	4	2800	0.5751±0.0000
Biebersteinia Steph.ex Fisch.			
Biebersteinia heterostemon	4	2940	0.3180±0.0033
Myrtales			
Onagraceae			

Epilobium Linn.			
Epilobium angulatum Linn.	4	2900	0.0084±0.0001
Epilobium hirsutum Linn.	4	3500	0.0130±0.0003
Epilobium paluster Linn.	3	2940	0.0128±0.0000
Epilobium sp	3	3500	0.0067±0.0006
EurosidsⅠ			
Zygophyllaceae			
Nitraria Linn.			
Nitraria tangutorum Bobr.	1	2800	0.0706±0.0004
Tribulus Linn.			
Tribulus terrester Linn.	2	2800	0.1237±0.0016
Fabales			
Fabaceae(Leguminosae)			
Astragalus Linn.			
Astragalus capillipes Fisch	5	2900	0.2671±0.0000
Astragalus complanatus R.Br	5	2900	0.1191±0.0055
Astragalus macrotrichusPet.-Stib	1	3500	0.2216±0.0028
Astragalus polycladus Bur.et Franch.	3	3500	0.1139±0.0003
Astragalus przewalskii Bunge	3	3050	0.1770±0.0034
Astragalus pseudoscoparius Gontsch.	2	3470	0.3708±0.0097
Astragalus sp1	2	3470	0.2093±0.0048
Astragalus sp2	2	3150	0.3228±0.0036
Astragalus sp3	2	3500	0.2563±0.0012
Astragalus sp4	4	3500	0.1434±0.0022
Astragalus sp5	2	3470	0.2082±0.0025
Astragalus sp6	2	3400	0.3877±0.0070
Astragalus sp7	4	3000	0.1264±0.0004
Astragalus sp8	1	2900	0.1292±0.0025
Astragalus sp9	2	3500	0.2821±0.0050
Astragalus sp10	1	3300	0.3107±0.0042
Astragalus sp11	5	3400	0.2558±0.0026
Astragalus sp12	3	3600	0.3648±0.0019
Astragalus sp13	1	3500	0.1430±0.0031
Astragalus tongolensis Ulbr.	4	3400	0.4987±0.0007
Caragana Fabr.			
Caragana brevifolia	1	2940	0.9239±0.0000
Caragana jubata	2	3470	1.0133±0.0000
Caragana sinica	2	3470	0.6514±0.0416
Gueldenstaedtia Fisch.			
Gueldenstaedtia multiflora	1	3300	0.2086±0.0048
Hedysarum Linn.			
Hedysarum sp	4	3470	0.3521±0.0038
Hedysarum tanguticum	4	3500	0.3837±0.0048
Lathyrus Linn.			
Lathyrus odoratus Linn.	4	3100	1.1976±0.0000
Medicago Linn.			
Medicago falcata Linn.	5	2900	0.1750±0.0016
Medicago minima	4	3000	0.1952±0.0040
Medicago ruthenica	3	2800	0.2135±0.0023
Medicago sativa Linn.	1	2800	0.2100±0.0000
Melilotus Miller			
Melilotus officinalis	5	2900	0.2146±0.0007
Oxytropis DC.			
Oxytropis falcata Bunge	1	3300	0.3644±0.0061
Oxytropis glabra	4	4020	0.2561±0.0000
Oxytropis kansuensis	4	3500	0.1183±0.0011
Oxytropis ochrocephala	3	3400	0.1381±0.0012
Oxytropis sp1	4	2900	0.1656±0.0009

Oxytropis sp2	3	3600	0.1744±0.0010
Oxytropis sp3	4	3500	0.1213±0.0015
Oxytropis yunnanensis	2	3470	0.1074±0.0016
Trigonella Linn.			
Trigonella sp	1	2900	0.1732±0.0012
Thermopsis R.Br.			
Thermopsis lanceolata	4	3000	1.8922±0.0615
Vicia Linn.			
Vicia angustifolia Linn	1	2900	1.2526±0.0299
Vicia cracca Linn.	4	2800	1.5062±0.0186
Vicia multicaulis Ledeb.	1	2900	0.8612±0.0296
Vicia sepium Linn.	4	3000	1.8861±0.0634
Vicia sp	5	2900	0.9833±0.0152
Vicia unijuga A.Br.	3	3150	1.0193±0.0096
Malpighiales			
Clusiaceae			
Hypericum Linn.			
Hypericum ascyron Linn.	2	3150	0.0192±0.0001
Hypericum przewalskii Maxim.	1	2940	0.0209±0.0002
Picrodendraceae			
Euphorbia Linn.			
Euphorbia esula Linn.	4	3500	0.1380±0.0029
Euphorbia helioscopia Linn.	1	2900	0.1016±0.0049
Rosales			
Rosaceae			
Agrimonia Linn.			
Agrimonia pilosa Ledeb.	5	2900	1.0550±0.0207
Geum Linn.			
Geum aleppicum Jacq.	1	2940	0.1120±0.0035
Potentilla Linn.			
Potentilla bifurca Linn.	4	3500	0.0568±0.0000
Potentilla fragarioides Linn.	1	2940	0.0268±0.0016
Potentilla fruticosa Linn.	1	3400	0.3469±0.3334
Potentilla potaninii Wolf	3	3050	0.0296±0.0004
Potentilla viscosa Donn	4	2920	0.0558±0.0003
Sibbaldia Linn.			
Sibbaldia sp	3	3650	0.0739±0.0011
Sibiraea Maxim.			
Sibiraea angustata(Rehd.)Hand.-Mazz.	3	3500	0.0098±0.0000
Spiraea Linn.			
Spiraea alpina Pall.	4	3470	0.0040±0.0001
Spiraea mongolica Maxim.	4	3340	0.0089±0.0001
Spiraea rosthornii Pritz.	5	2900	0.0031±0.0000
Sorbaria(Ser.)A.Br.ex Aschers.			
Sorbaria arborea Schneid.	5	2900	0.0085±0.0002
Sorbaria sorbifolia(Linn.)A.Br.	3	2800	0.0084±0.0007
EurosidsⅡ			
Brassicales			
Brassicaceae(Cruciferae)			
Arabis Linn.			
Arabis pendula Linn.	5	2900	0.0273±0.0001
Capsella Medic.			
Capsella bursa-pastoris(Linn.)Medic.	2	3470	0.0141±0.0004
Descurainia Webb et Berth.			
Descurainia sophia(Linn.)Schur.	1	3500	0.0190±0.0005
Draba Linn.			
Draba eriopoda Turcz.	4	3500	0.0109±0.0002
Draba nemorosa Linn.	1	3500	0.0192±0.0000

Draba oreades Schrenk	2	3470	0.0082±0.0001
Draba sp1	4	4020	0.0039±0.0000
Draba sp2	4	4020	0.0049±0.0002
Draba torticarpa L.L.Lou et T.Y.Cheo	4	2800	0.0122±0.0002
Lepidium Linn.			
Lepidium apetalum Willd.	1	3500	0.0216±0.0002
Rorippa Scop.			
Rorippa globosa(Turcz.)Hayek	2	3470	0.0054±0.0002
Thlaspi Linn.			
Thlaspi arvense Linn.	1	3300	0.1190±0.0029
Thlaspi sp1	2	3470	0.1004±0.0013
Thlaspi sp2	3	3050	0.1524±0.0006
Thlaspi sp3	5	2900	0.1307±0.0023
Malvales			
Malvaceae			
Malva Linn.			
Malva verticillata Linn.	5	2900	0.2666±0.0088
Malva verticillata var.chinensis	1	2900	0.3332±0.0088
Asterids			
Ericales			
Primulaceae			
Androsace Linn.			
Androsace erecta Maxim.	4	3100	0.0044±0.0000
Androsace incana Lam.	4	4100	0.1357±0.0009
Androsace sp1	4	3470	0.0363±0.0006
Androsace sp2	4	2800	0.0792±0.0005
Androsace sp3	2	3470	0.1064±0.0038
Primula Linn.			
Primula sp1	1	3470	0.0090±0.0001
Primula sp2	1	3300	0.0268±0.0006
Primula sp3	1	3400	0.0313±0.0002
Primula sp4	4	2800	0.0092±0.0001
Euasteridsl			
Boraginaceae			
Asperugo Linn.			
Asperugo procumbens Linn.	1	2800	0.2155±0.0011
Lappula V.Wolf.			
Lappula myosotis	4	2800	0.1291±0.0029
Lappula patula	1	3470	0.1014±0.0014
Lithospermum Linn.			
Lithospermum sp1	1	3470	0.2920±0.0170
Lithospermum sp2	4	2800	2.0034±0.0165
Microula Benth.			
Microula sikkimensis	1	3500	0.2112±0.0082
Gentianales			
Gentianaceae			
Comastoma(Wettst.)Toyokuni			
Comastoma pulmonarium	4	3500	0.0251±0.0008
Comastoma tenellum	4	3000	0.0172±0.0005
Gentiana Linn.			
Gentiana cephalantha	4	3000	0.0234±0.0010
Gentiana dahuricaca Fisch.	1	3300	0.0210±0.0002
Gentiana decumbens L.F.	4	3000	0.0219±0.0006
Gentiana flavomaculata Hayata	4	3000	0.0234±0.0003
Gentiana leucomelaena Maxim.	1	2900	0.0075±0.0000
Gentiana sp1	1	3000	0.0299±0.0006
Gentiana sp2	2	3470	0.0510±0.0015
Gentiana sp3	3	3600	0.0264±0.0006

Gentiana sp4	3	3600	0.0092±0.0003
Gentiana sp5	4	2800	0.1293±0.0018
Gentiana sp6	3	3550	0.0074±0.0003
Gentiana spathulifolia Maxim.ex Kusnez.	1	2900	0.0026±0.0000
Gentiana stipitata Edgew.	4	3600	0.0077±0.0001
Gentiana straminea Marxim.	4	3500	0.0188±0.0005
Gentiana striata Maxim	4	3600	0.0598±0.0007
Gentiana szechenyii Kanitz	4	3000	0.0085±0.0006
Gentianopsis Ma			
Gentianopsis sp1	4	3000	0.0065±0.0001
Gentianopsis sp2	4	3500	0.0106±0.0003
Gentianopsis sp3	3	3650	0.0084±0.0002
Gentianopsis sp4	5	2900	0.0066±0.0002
Gentianopsis sp5	4	4100	0.0113±0.0004
Gentianopsis sp6	1	2800	0.0224±0.0034
Halenia Borkh.			
Halenia corniculata	4	3700	0.1235±0.0040
Halenia sp1	4	3470	0.1437±0.0026
Halenia sp2	3	3050	0.1515±0.0019
Halenia sp3	3	2900	0.0536±0.0026
Halenia sp4	2	3470	0.1321±0.0036
Swertia Linn.			
Swertia bimaculata	3	3050	0.0324±0.0004
Swertia manchurica	4	3900	0.0269±0.0006
Swertia wolfangiana	3	3600	0.0056±0.0003
Swertia yunnanensis	1	2800	0.0104±0.0004
Rubiaceae			
Galium Linn.			
Galium boreale Linn.	4	3500	0.0838±0.0010
Galium sp1	1	3000	0.0689±0.0011
Galium sp2	3	2800	0.0962±0.0021
Galium sp3	4	3100	0.0622±0.0022
Galium sp4	4	3600	0.0576±0.0035
Galium trifidum Linn.	1	2800	0.6236±0.0227
Galium verum Linn.	1	2940	0.4925±0.0267
Rubia Linn.			
Rubia cordifolia Linn.	5	2900	1.1228±0.0000
Theligonum Linn.			
Theligonum macranthum	2	3150	0.0099±0.0005
Lamiales			
Labiatae			
Dracocephalum Linn.			
Dracocephalum rupestre	4	3600	0.1575±0.0031
Dracocephalum ruyschiana	1	2900	0.1382±0.0261
Dracocephalum sp	4	3100	0.2479±0.0088
Dracocephalum tanguticum	5	2900	0.1880±0.0029
Elsholtzia Willd.			
Elsholtzia calycocar	5	2900	0.0284±0.0007
Elsholtzia ciliata	1	3300	0.1445±0.0014
Elsholtzia densa Benth.	4	3500	0.1125±0.0019
Galeopsis Linn.			
Galeopsis bifida Boenn.	1	2900	0.3702±0.0058
Lamiophlomis Kudo			
Lamiophlomis rotata	4	3700	0.4013±0.0000
Lamiophlomis sp	4	3600	0.2084±0.0031
Lamium Linn.			
Lamium amplexicaule	1	2900	0.0678±0.0002
Nepeta Linn.			

Nepeta cataria Linn.	5	2900	0.1220±0.0038
Nepeta densiflora	1	3300	0.1290±0.0004
Salvia Linn.			
Salvia roborowskii	1	3470	0.2005±0.0020
Salvia sp1	1	2900	0.2126±0.0071
Salvia sp2	5	2900	0.4559±0.0289
Scutellaria Linn.			
Scutellaria hypericifolia	4	3500	0.0968±0.0013
Scutellaria rehderiana	1	2800	0.0816±0.0030
Scutellaria scordifolia	4	2800	0.0723±0.0000
Thymus Linn.			
Thymus mongolicus	3	2900	0.0202±0.0002
Plantaginaceae			
Plantago Linn .			
Plantago asiatica	3	3150	0.0336±0.0005
Plantago spp1.	2	3470	0.0288±0.0016
Plantago spp2.	1	3500	0.0217±0.0006
Scrophulariaceae			
Euphrasia Linn.			
Euphrasia pectinata	1	3300	0.0098±0.0001
Euphrasia sp1	3	3630	0.0076±0.0000
Euphrasia sp2	3	3050	0.0100±0.0001
Euphrasia sp3	4	3000	0.0093±0.0001
Euphrasia sp4	4	3100	0.0136±0.0001
Euphrasia sp5	4	3500	0.0051±0.0013
Lancea Hook.f.et Thoms			
Lancea sp1	1	2900	0.0087±0.0002
Lancea sp2	2	3470	0.0060±0.0000
Lancea tibetica	1	3300	0.0073±0.0000
Pedicularis Linn.			
Pedicularis alaschanica	4	3100	0.1458±0.0010
Pedicularis cheilanthifolia	4	4100	0.0429±0.0007
Pedicularis chinensis	4	3470	0.1089±0.0018
Pedicularis decorissima	1	3400	0.2680±0.0000
Pedicularis ingens	4	3900	0.0332±0.0009
Pedicularis kansuensis	4	3500	0.0639±0.0022
Pedicularis longiflora var.tubiformis	4	3300	0.0747±0.0029
Pedicularis megalantha Don	3	3450	0.0596±0.0000
Pedicularis przewalskii	3	3050	0.0292±0.0009
Pedicularis rudis	5	2900	0.0650±0.0008
Pedicularis semitorta	2	3470	0.0727±0.0020
Pedicularis sp1	4	3500	0.1126±0.0010
Pedicularis sp2	3	3500	0.1728±0.0020
Pedicularis sp3	3	3600	0.0757±0.0013
Pedicularis sp4	3	2940	0.0496±0.0001
Pedicularis sp5	2	3470	0.0792±0.00028
Pedicularis sp6	5	2900	0.2733±0.0025
Pedicularis sp7	4	2800	0.1697±0.0009
Pedicularis sp8	3	3300	0.0931±0.0015
Pedicularis sp9	2	3470	0.0565±0.0013
Pedicularis sp10	3	3650	0.0465±0.0010
Pedicularis sp11	5	2900	0.0846±0.0031
Pedicularis sp12	3	2900	0.0294±0.0010
Pedicularis sp13	4	3600	0.0541±0.0001
Pedicularis trichoglossa	3	3400	0.0380±0.0005
Pedicularis verticillata	1	3470	0.0550±0.0015
Pedicularis wardii	3	3600	0.2790±0.0455
Veronica Linn.			

Veronica didyma	1	3300	0.0036±0.0000
Veronica eriogyne	4	3500	0.0059±0.0001
Veronica sp1	1	2800	0.0302±0.0006
Veronica sp2	1	2940	0.0040±0.0001
Veronica sp3	3	2940	0.0053±0.0001
Veronica sp4	4	3900	0.0059±0.0001
Veronica sp5	1	3300	0.0031±0.0001
Veronica Viloba L.	2	3470	0.0052±0.0001
Scrofella Maxim.			
Scrofella chinensis	1	3300	0.0066±0.0002
Scrophularia Linn.			
Scrophularia ningpoensis	3	2940	0.0125±0.0003
Solanales			
Convolvulaceae			
Cuscuta Linn.			
Cuscuta chinensis Lam.	5	2900	0.0379±0.0005
Solanaceae			
Hyoscyamus Linn.			
Hyoscyamus niger	4	2800	0.0511±0.0010
Przewalskia Maxim.			
Przewalskia tangutica	1	2940	0.6841±0.0088
EuasteridsⅡ			
Apiales			
Apiaceae			
Bupleurum Linn.			
Bupleurum smithii var.parvifolium	4	3100	0.0807±0.0032
Bupleurum smithii Wolff	5	2900	0.0995±0.0009
Bupleurum sp1	3	3600	0.0726±0.0011
Bupleurum sp2	4	3900	0.0599±0.0019
Bupleurum sp3	2	3470	0.0898±0.0023
Daucus Linn.			
Daucus carota Linn.	3	3600	0.0557±0.0009
Daucus spp1.	1	3300	0.1941±0.0011
Daucus spp2.	1	3500	0.5095±0.0028
Daucus spp3.	5	2900	0.1834±0.0027
Foeniculum Mill.			
Foeniculum spp1.	4	3100	0.1562±0.0030
Foeniculum spp2.	2	3470	0.1620±0.0013
Foeniculum spp3.	1	2940	0.1638v0.0050
Heracleum linn.			
Heracleum hemsleyanum	2	3470	0.1799±0.0024
Heracleum moellendorffii	2	3470	0.2538±0.0026
Ligusticum Linn.			
Ligusticum sinense	2	3150	0.2174±0.0051
Pleurospermum Hoffm.			
Pleurospermum camtschatium	3	3050	0.1809±0.0027
Pleurospermum sp	2	3470	0.1141±0.0002
Apium Linn.			
Apium sp1	1	2940	0.0350±0.0004
Apium sp2	5	2900	0.1209±0.0039
Saposhnikovia Schischk.			
Saposhnikovia divaricata	4	3100	0.2612±0.0038
Saposhnikovia sp1	3	3700	0.1585±0.0043
Saposhnikovia sp2	2	3470	0.0972±0.0025
Saposhnikovia sp3	4	3000	0.2097±0.0050
Saposhnikovia sp4	3	2800	0.0792±0.0006
Sinolimprichtia Wolff			
Sinolimprichtia alpina	4	3470	0.2930±0.0039

Sphallerocarpus Bess.ex DC.			
Sphallerocarpus gracilis	1	3500	0.1600±0.0037
Asterales			
Asteraceae(Compositae)			
Ajania Poljark.			
Ajania fruticulosa	2	2800	0.0105±0.0001
Ajania tenuifolia	1	3500	0.0113±0.0004
Anaphalis DC.			
Anaphalis hancockii Maxim.	5	3300	0.0045±0.0001
Anaphalis lactea Maxim.	3	3050	0.0240±0.0003
Anaphalis latialata Ling	1	2940	0.0079±0.0002
Anaphalis margaritacea	5	2900	0.0055±0.0002
Anaphalis sp1	3	2800	0.0093±0.0001
Anaphalis sp2	2	3470	0.0092±0.0002
Arctium Linn.			
Arctium lappa	5	2900	1.6869±0.0439
Artemisia Linn.			
Artemisia annua Linn.	5	2900	0.0079±0.0002
Artemisia desetorum	4	3000	0.0189±0.0001
Artemisia dubia	5	2900	0.0085±0.0002
Artemisia hedinii	1	3600	0.0079±0.0002
Artemisia roxburghiana	2	3470	0.0122±0.0002
Artemisia sp1	1	2800	0.0027±0.0000
Artemisia sp2	4	2900	0.0136±0.0002
Artemisia sp3	4	2800	0.0153±0.0002
Artemisia sp4	5	2900	0.0390±0.0018
Artemisia sp5	3	2940	0.0024±0.0001
Artemisia sp6	4	4200	0.3052±0.0000
Artemisia vestita Wall.	4	2800	0.0137±0.0003
Aster Linn.			
Aster ageratoides	5	2900	0.0476±0.0001
Aster alpinus	2	3470	0.0745±0.0012
Aster asteroides	4	4100	0.0416±0.0003
Aster farreri	2	3470	0.0617±0.0016
Aster flaccidus	3	2900	0.0668±0.0023
Aster seneciodes	1	2900	0.0661±0.0009
Aster sp1	3	3600	0.0331±0.0003
Aster sp2	3	4100	0.0451±0.0014
Aster sp3	5	2900	0.1542±0.0006
Aster tataricus	3	3600	0.0328±0.0011
Aster tongolensis Franch.	4	3100	0.0636±0.0005
Asterothamnus Novopokr.			
Asterothamnus alyssoides	2	2800	0.0388±0.0006
Asterothamnus centraliasiaticus	5	3900	0.0387±0.0010
Cacalia Linn.			
Cacalia roborowskii	5	2900	0.0770±0.0018
Cacalia tangutica	5	2900	0.0405±0.0002
Carduus Linn.			
Carduus crispus	1	2940	0.4247±0.0029
Carpesium Linn.			
Carpesium cernuum	1	2900	0.0989±0.0043
Cirsium Mill.			
Cirsium esculentum	1	3300	0.2636±0.0000
Cirsium souliei	3	3500	0.3956±0.0138
Cirsium sp1	1	2940	0.2818±0.0138
Cirsium sp2	1	3300	0.4584±0.0039
Erigeron Linn.			
Erigeron acer	5	2900	0.0101±0.0000

Erigeron altaicus	4	3100	0.0293±0.0001
Erigeron elongatus	2	3470	0.0599±0.0042
Erigeron sp1	2	3470	0.0103±0.0001
Erigeron sp2	3	2800	0.2237±0.0038
Heteropappus Less.			
Heteropappus altaicus	1	2800	0.0473±0.0009
Heteropappus crenatifolius	4	3100	0.0360±0.0005
Heteropappus hispidus	3	2940	0.0319±0.0004
Heteropappus sp	4	2800	0.0557±0.0003
Lactuca Linn.			
Lactuca roborowskii	1	2800	0.0546±0.0000
Lactuca sativa Linn.	1	2900	0.0414±0.0001
Leibnitzia Cass.			
Leibnitzia anandria	4	3100	0.1324±0.0010
Leontopodium R.Br.			
Leontopodium calocephalum	2	3470	0.0105±0.0001
Leontopodium franchetii	2	3470	0.0111±0.0000
Leontopodium Haplophylloides	1	2940	0.0083±0.0002
Leontopodium japonicum	3	3600	0.0091±0.0001
Leontopodium leontopodioides	3	3650	0.0103±0.0001
Leontopodium longifolium	3	3500	0.0116±0.0008
Leontopodium souliei	3	3100	0.0077±0.0002
Leontopodium sp1	3	3050	0.0121±0.0001
Leontopodium sp2	4	3000	0.0044±0.0000
Leontopodium sp3	4	3470	0.0099±0.0007
Leontopodium sp4	1	3500	0.0072±0.0001
Leontopodium sp5	4	3000	0.0055±0.0002
Leontopodium sp6	2	3470	0.0109±0.0002
Leontopodium sp7	2	3470	0.0084±0.0001
Ligularia Cass.			
Ligularia odontomanes	2	3470	0.3838±0.0112
Ligularia przewalskii	2	3100	0.0980±0.0051
Ligularia sagitta	4	2800	0.0859±0.0015
Ligularia sp1	1	3500	0.0905±0.0030
Ligularia sp2	4	3600	0.1641±0.0045
Ligularia sp3	4	2900	0.0527±0.0016
Ligularia sp4	3	3150	0.0522±0.0023
Ligularia sp5	4	3400	0.2231±0.0003
Ligularia sp6	1	3300	0.1297±0.0014
Ligularia virgaurea	1	3300	0.0413±0.0011
Olgaea Iljin			
Olgaea tangutica			
Picris Linn.			
Picris hieracioides	1	2900	0.0093±0.0002
Picris hieracioides sp1	2	3470	0.0657±0.0007
Picris hieracioides sp2	3	3050	0.1192±0.0019
Picris hieracioides sp3	3	3650	0.1550±0.0031
Saussurea DC.			
Saussurea acroura	4	3000	0.1078±0.0026
Saussurea hieracioides	4	3700	0.2038±0.0002
Saussurea likiangensis	1	3500	0.1300±0.0043
Saussurea macrota	3	3500	0.1853±0.0019
Saussurea neofranchetii	4	4100	0.1068±0.0000
Saussurea nigrescens	3	3650	0.2030±0.0192
Saussurea oblongifolia	3	3050	0.1269±0.0070
Saussurea ochrochlaena	3	3600	0.2165±0.0090
Saussurea pulchra	3	3500	0.1874±0.0023
Saussurea purpurascens	2	3470	0.2037±0.0024

Saussurea salicifolia	3	3680	0.1170±0.0075
Saussurea sp1	4	2900	0.2602±0.0051
Saussurea sp2	4	3600	0.2403±0.0013
Saussurea sp3	5	2900	0.1233±0.0029
Saussurea sp4	4	3900	0.2040±0.0000
Saussurea sp5	3	3400	0.1305±0.0000
Saussurea sp6	4	3500	0.1888±0.0000
Saussurea sp7	4	4000	0.5648±0.0084
Saussurea sp8	4	4000	1.1234±0.0000
Saussurea sp9	4	3100	0.1756±0.0038
Saussurea sp10	4	3500	0.1300±0.0010
Saussurea stella	1	2900	0.1194±0.0019
Scorzonera Linn.			
Scorzonera albicaulis	1	3000	0.5426±0.0181
Scorzonera austiaca	1	3500	0.1260±0.0024
Senecio Linn.			
Senecio argunensis	1	2900	0.0577±0.0008
Senecio diversipinnus	5	2900	0.0897±0.0006
Serratula Linn.			
Serratula centauroides	1	2940	0.7116±0.0034
Sonchus Linn.			
Sonchus oleraceus	4	2940	0.0413±0.0005
Taraxacum sikkimense			
Taraxacum mongolicum	1	2900	0.0614±0.0006
Taraxacum sikkimense	4	4020	0.0838±0.0000
Taraxacum sp	4	3600	0.0807±0.0022
Xanthopappus C.Winkl.			
Xanthopappus subacaulis	4	2900	0.5652±0.0203
Compositae spp.			
Lobeliaceae			
Adenophora Fisch.			
Adenophora capillaris	3	2900	0.0165±0.0003
Adenophora potaninii	5	2900	0.1430±0.0000
Adenophora sp	5	2900	0.0163±0.0001
Adenophora stenanthina	1	3300	0.0196±0.0002
Campanula Linn.			
Campanula aristata Wall.	1	3500	0.0029±0.0001
Campanula medium Linn.	4	3600	0.0027±0.0001
Codonopsis Wall.			
Codonopsis pilosula	3	3600	0.0198±0.0003
Codonopsis sp1	3	3470	0.0191±0.0001
Codonopsis sp2	4	3600	0.0428±0.0001
Cyananathus Wall.ex Benth.			
Cyananathus inflatus	2	3470	0.0194±0.0001
Dipsacales			
Caprifoliaceae			
Sambucus Linn.			
Sambucus chinensis Lindl	5	2900	0.3439±0.0043
Dipsacaceae			
Morina Linn.			
Morina nepalensis var.alba	4	3400	0.4679±0.0016
Morina parviflora	4	3100	0.4404±0.0075
Dipsacus			
Dipsacus asperoides	5	2900	0.7602±0.0123
Valerianaceae			
Nardostachys DC.			
Nardostachys chinensis	2	3470	0.3632±0.0124
Nardostachys sp	4	3600	0.2888±0.0255
Patrinia Juss.			
Patrinia rupestris	1	2940	0.1569±0.0118

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