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Status and Distribution of Four Endemic Vascular Plants in the Gobi Altai

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Abstract

The paper presents distributional data on the four vascular plants *Papaver saichanense*, *Saussurea saichanensis*, *Potentilla ikonnikovii* and *Galitzkya macrocarpa*, all of which are restricted to Mongolian mountains. Updated biogeographical data demonstrate that all four are Mongolian endemics. In terms of their taxonomic relationships, *S. saichanensis* and *P. saichanense* belong to a group of species occurring mainly on continental Asian mountains. *Potentilla ikonnikovii* has relatives with a mainly East-Asian distribution, and the genus *Galitzkya* is a predominantly Mid-Asian element.

New maps of the local distribution in the Gobi Altai and adjacent mountains indicate that all species are highly fragmented and are so far only known to occur in less than a dozen localities. We have since discovered new sites and subsequently have little reason to regard the species as threatened, although the overall rarity suggests that some form of rough monitoring is advisable.

Key words: biogeography, distribution, endemism, flora, Gobi-Altai, Mongolia

Introduction

Endemism is a central issue in nature conservation and governments are often held responsible for the protection of those species that have the entire or at least major parts of their geographical range on the country's territory (Bonn *et al.*, 2002). Knowledge on the overall distribution of any given species is of straightforward importance in this respect (Jäger & Hoffmann, 1997). Responsibility measures have been implemented in schemes for setting priorities in species' conservation; prominent examples are the designation of so-called biodiversity hotspots (Myers *et al.*, 2000), or the Flora and Fauna Habitat Directive of the European Union, which assigns high priority to the conservation of European endemics and subendemics. However, numbers of restricted-range species are relatively low for most European countries (e.g. Germany; Welk, 2002) apart from the Mediterranean region.

The situation in Mongolia is comparable in this respect. Although the country covers a vast territory, the majority of the occurring species have even larger distributional ranges and are shared with neighbouring countries. The flora of Mongolia is divided along two principal gradients. The most obvious differences are between the northern parts - which belong to the central Siberian-Daurian floristic region, and the dry Gobi - which is part of the Central Asian floristic region (Meusel & Jäger, 1992). A somewhat less obvious, but equally important, distinction occurs between the western and eastern parts of Mongolia. The latter are characterized by predominant summer rains, lack of snow cover in winter, and relatively fast temperature changes in spring and autumn. The division line runs along a longitudinal line of 100°E (Hilbig *et al.*, 2004); east of this limit species mainly have eastern and Central Asian distributions, whereas west of this line many species comprise Mid-Asian or even Mediterranean elements.

Most of Mongolia's endemic and subendemic species are Central Asian elements (Grubov, 1989). Numbers of endemics listed differ between sources: a conservative estimate indicates 4% truly endemic, i.e. exclusively Mongolian vascular plants; if subendemics are included the number increases to some 10% of the flora (Grubov, 1989). Here, "subendemic" refers to Mongolian species with restricted ranges but which are also found in the neighbouring countries. A survey by Ulziikhutag

(1989) lists 5.9 % of the overall flora of Mongolia as endemic, and a further 8.1% as subendemic. Here, several species known to occur in the neighbouring parts of China are also listed as endemic, explaining at least part of the difference. Examples of subendemic species with a Central Asian distribution and with occurrences in the Gobi parts of Mongolia and China include *Psammochloa villosa* and *Hedysarum fruticosum* (Hilbig *et al.*, 1999). Central Asian species with their entire distribution range in Mongolia, i.e. country endemics in a strict sense, include *Galitzkya macrocarpa* and *Potentilla ikonnikovii* (Grubov, 1989). Mongolia clearly has a high level of responsibility for conservation of these species, as well as for those subendemics that have major parts of their distribution range on Mongolian territory.

Local abundance is a second important aspect of a given species' distributional status. There is a general tendency for restricted-range species to show low levels of abundances even in their distributional centre (e.g. Bonn *et al.*, 2002). Thus, rarity is a second important factor in conservation assessments (cf. IUCN, 2001), as small populations are widely held to face increasing risks of extinction ("small populations paradigm", see e.g. Channell & Lomolino, 2000).

The mountain ranges of the south-eastern Gobi Altai form archipelago-like islands of relatively moist conditions in an otherwise dry matrix of steppe and semi-desert environments (Gunin & Vostokova, 1995). Plant species of the upper mountain ranges have highly isolated populations and, not surprisingly, several endemic species have evolved in the dry mountains of Mongolia. The following is an assessment of the distribution status of the four vascular plant species that have their centre of distribution in southern Mongolian high mountains and are considered endemic by Ulziikhutag (1989): *Papaver saichanense* Grub.; *Saussurea saichanensis* Kom. ex Lipsch.; *Potentilla ikonnikovii* Juz.; *Galitzkya macrocarpa* (Ik.-Gal.) V. Bocz.

First of all, we present an analysis of the overall geographical distribution range based on an updated compilation of available literature, thereby assessing Mongolia's level of responsibility. Secondly, we present new data on the species' local distribution in southern Mongolia. In combination, these data allow us to give some recommendations on their conservation statuses.

Materials and Methods

The number of flora references in the neighbouring territories has increased considerably in the last few years, so we had to consult 32 different sources to assemble the biogeographical data. A full reference list thereof has not been included here, but the information is available from us on request. Floristic data were used to compile the maps in Figs. 1-3. The maps also give the ranges of the most closely related species in order to demonstrate biogeographical affinities. The distribution of species in Mongolia can be inferred from the recent account given by Gubanov (1996), and detailed information provided by e.g. Grubov (2001). The authors have divided the country into 16 sub-regions, which are used to give a general impression of the local distribution in Mongolia (see inserts in Fig. 4).

Based on the available information on species distribution, fieldwork was restricted to southern Mongolia, and covered parts of the Mongolian Altai, the Gobi Altai and most mountain ranges south of the Altai system. The focus lay on the four major protected areas in the region. We visited all mountains >2000 m asl. in the Gobi Gurvan Saikhan National Park, but also sampled adjacent parts of the Gobi Altai (Arts Bogd, Ikh Bogd, Noyon Uul). Additionally, we checked several mountains in the Great Gobi A (Atas Bogd, Tsagaan Bogd, Endrengiin Nuruu) and Great Gobi B Special Protected Areas (Khavtagiin Nuruu and adjacent hills). The Little Gobi Special Protected Areas A & B were also surveyed but they lack high mountains, and thus suitable habitats. All species are restricted to the upper parts of mountain ranges (Table 1) with their relatively high rainfall. Species occur in shallow soil on steep slopes and on rock outcrops where they face limited competition from other plants and are often protected from intensive livestock grazing. Access to sites is difficult and sometimes dangerous with respect to the often highly weathered rock. Thus, we were unable to provide census data on population sizes.

Detailed maps were compiled based on SRTM topographical data ("shuttle radar topographical mission", downloaded from the Global Landcover Facility at http://glcf.umiacs.umd.edu/index.shtml) in a WGS 84 projection. Two sets of maps were compiled; for each species we provide a large-scale map of the overall geographic distribution and a small-scale map giving the local distribution within

our sampling area. Maps were compiled using ArcGIS 8.2.

Results and Discussion

Overall distribution

All four species belong, at least with respect to the distribution of their taxonomical relatives, to completely different biogeographical elements (Figs. 1-3). The flora of the study region is characterised by species with typically central to eastern Asian, continental distribution ranges. A similar general pattern is also found in *Papaver saichanense*. Unfortunately, its taxonomical status is not yet understood. *Papaver* species in the Mongolian mountains belong to a group of taxa around *Papaver nudicaule* (sect. *Meconella* Spach., syn. *Scapiflorae* Rchb. ex Elkan), but the exact relationships within that group remain unknown. Morphological differences among taxa are not conclusive (cf. Grubov, 1982), and chromosome numbers in this polyploidic complex have not yet been extensively studied. The specialist P. Hanelt (Gatersleben, Germany) tentatively named most of our specimens from the Gobi Gurvan Saikhan as *P. saichanense* Grub., which is an endemic taxon of the south-eastern Gobi Altai. However, *P. pseudocanescens* M. Pop., *P. nudicaule* L. and *P. pseudotenellum* Grub. also occur in the area (P. Hanelt, pers. comm.), as does *Papaver rubro-aurantiacum* (DC) Fisch. ex Steud. (Grubov, 1982). All these taxa are closely related and species' limits are unclear. Thus, we refrained from drawing a distribution map. The *Papaver nudicaule* group has a Turkestanian – Himalayan – western Chinese – Siberian distribution. The westernmost outposts are found in the eastern Caucasus and in western Afghanistan. There are also remote outposts in continental south-eastern Alaska, which must have migrated there when land bridges were formed during the Quaternary.

The distributional centre of the genus *Saussurea* (>20 species) shows a rather similar spatial extent, including the presence of outposts in SE-Alaska (four species). *Saussurea glanduligera* is the species most closely related to *S. saichanensis* (Lipshits, 1979); both form the series *Glanduligera* (Fig. 1). *Saussurea glanduligera* is widespread in Central Asian highlands. In contrast, *S. saichanensis* is endemic to Mongolia with

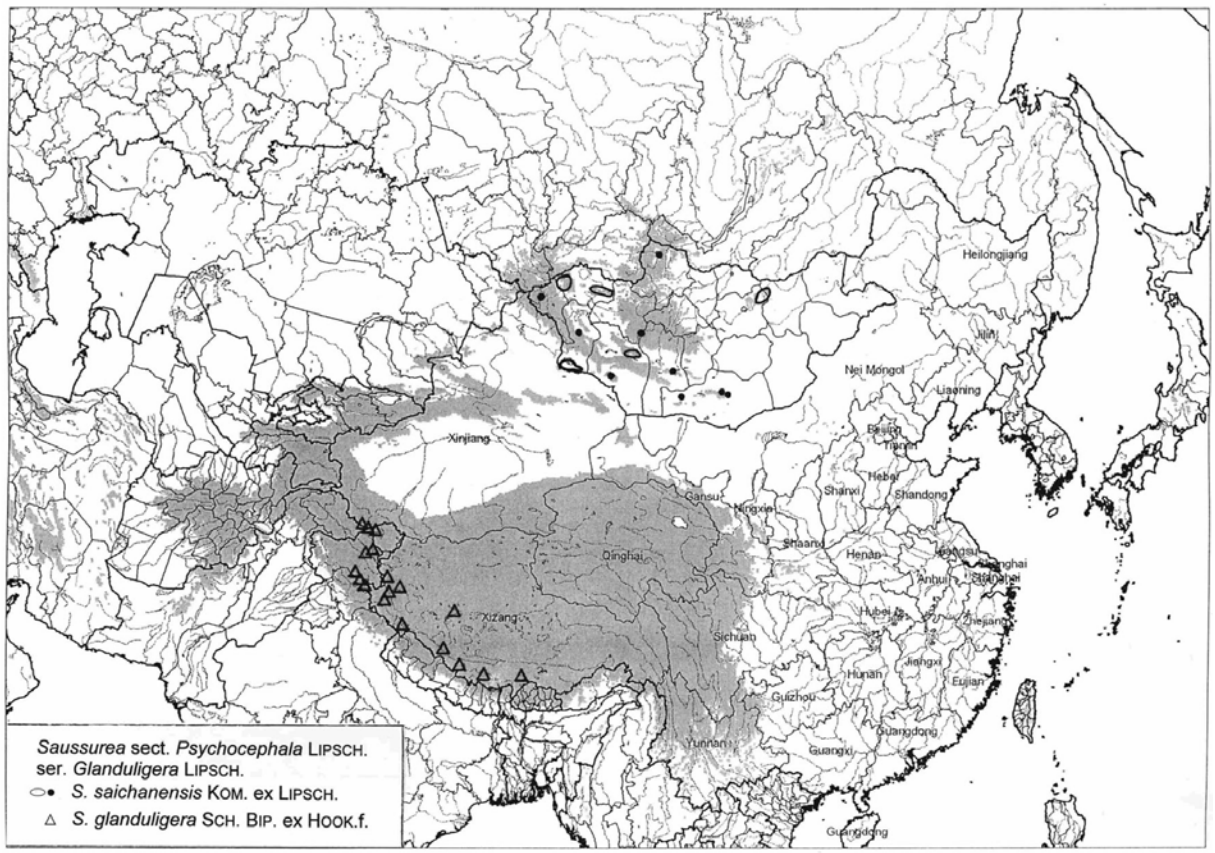

Figure 1. Distribution range of *Saussurea saichanensis* Kom. ex. Lipsch. and *Saussurea glanduligera* Sch. Bip ex Hook f., the only other species of the series *Glanduligera* Lipsch.

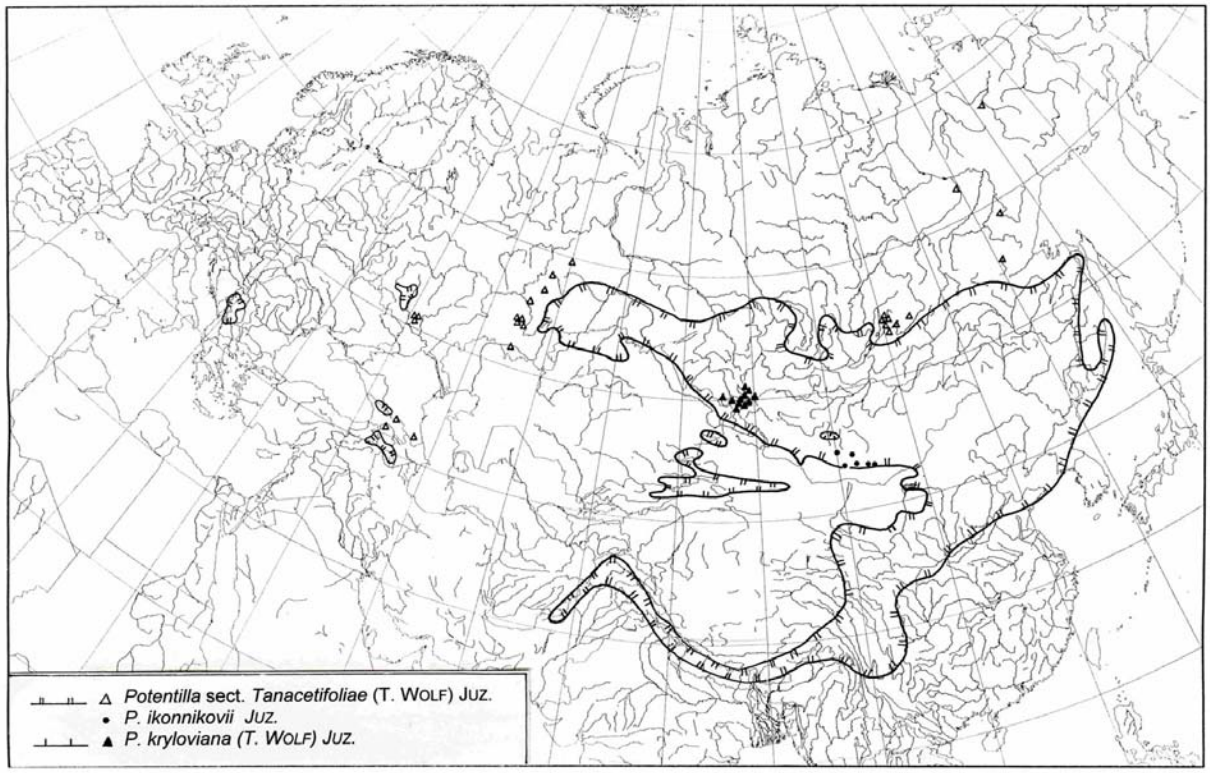

Figure 2. Range of *Potentilla ikonnikovii* Juz., *Potentilla kryloviana* Th. Wolf, and the overall distribution of the sect. *Tanacetifoliae* Th. Wolf (= ser. *Tanacetifoliae* (Th. Wolf) Yü et Li). *Potentilla* sect. *Tanacetifoliae* (Th. Wolf) Juz. comprises the following 18 species: *P. acervata* Soják, *P. astragalifolia* Bge., *P. bannehalensis* Camb., *P. bryoides* Soják, *P. clarkei* Hook., *P. coriandrifolia* D. Don, *P. crenulata* Yü et Li, *P. gerardiana* Lindl. ex Lehm., *P. granulosa* Yü et Li, *P. griffithii* Hook. f., *P. hypargyrea* Hand.-Mazz., *P. ikonnikovii* Juz., *P. kryloviana* Th.Wolf (the closest relative of *P. ikonnikovii*), *P. lancinata* Card., *P. longifolia* Willd. ex Schlecht., *P. pimpinelloides* L., *P. visianii* Panè., *P. tanacetifolia* Willd. ex Schlecht.

somewhat scattered occurrences from the far western to northern parts of the country; in the south, the species occurs from the western Mongolian Altai to the Gobi Gurvan Saikhan. So far, it has not been found in any neighbouring country.

The distributional range of *Potentilla ikonnikovii* and related species is much more extensive compared to the previously described (east-) central Asian mountain distributions. The section *Tanacetifoliae* covers some 18, mainly typical eastern Asian, species (Fig. 2). The group of species is widely distributed in continental central and eastern Asia; outposts in regions with summer precipitation occur in eastern Afghanistan, Armenia, westwards to the Caucasus, with some glacial relics surviving in the calcareous outcrops around Voronesh and Kursk, in the western part of the Balkan Peninsula and northwards to Jakutsk and the Kolyma region. The closest relative to *P. ikonnikovii* is *P. kryloviana* (Juzepchuk, 1955). The latter occurs in the south-eastern Altai with an outpost in the southern Khangai. *Potentilla ikonnikovii* is an endemic of the Gobi Altai, but the distribution of its relatives implies that it has reached the Gobi Gurvan Saikhan from the north-west rather than from the south-west (Tien Shan) or the east. Thus, in this respect biogeographical affinities are similar to those described for *P. saichanense* and *S. saichanensis*.

In contrast, *Galitzkya macrocarpa* is a western element and belongs to a biogeographical group of species that is very rare in the flora of Mongolia east of 100°E. The genus *Galitzkya* is concentrated in the continental regions of Mid-Asia (Fig. 3), which receive at least part of their precipitation in winter. This is also implied by the species' morphology, as *Galitzkya* spp. have a suffruticose growth form and are semi-evergreen, while the other three species are herbs that bear leaves only in summer and have tap roots or a rhizome (Table 1). *Galitzkya spathulata* is among the most widespread and common species in the petrophytic steppes of mountains and hills in central Kazakhstan. Eastwards, the species is replaced by *G. potaninii* with occurrences in eastern Xinjiang,

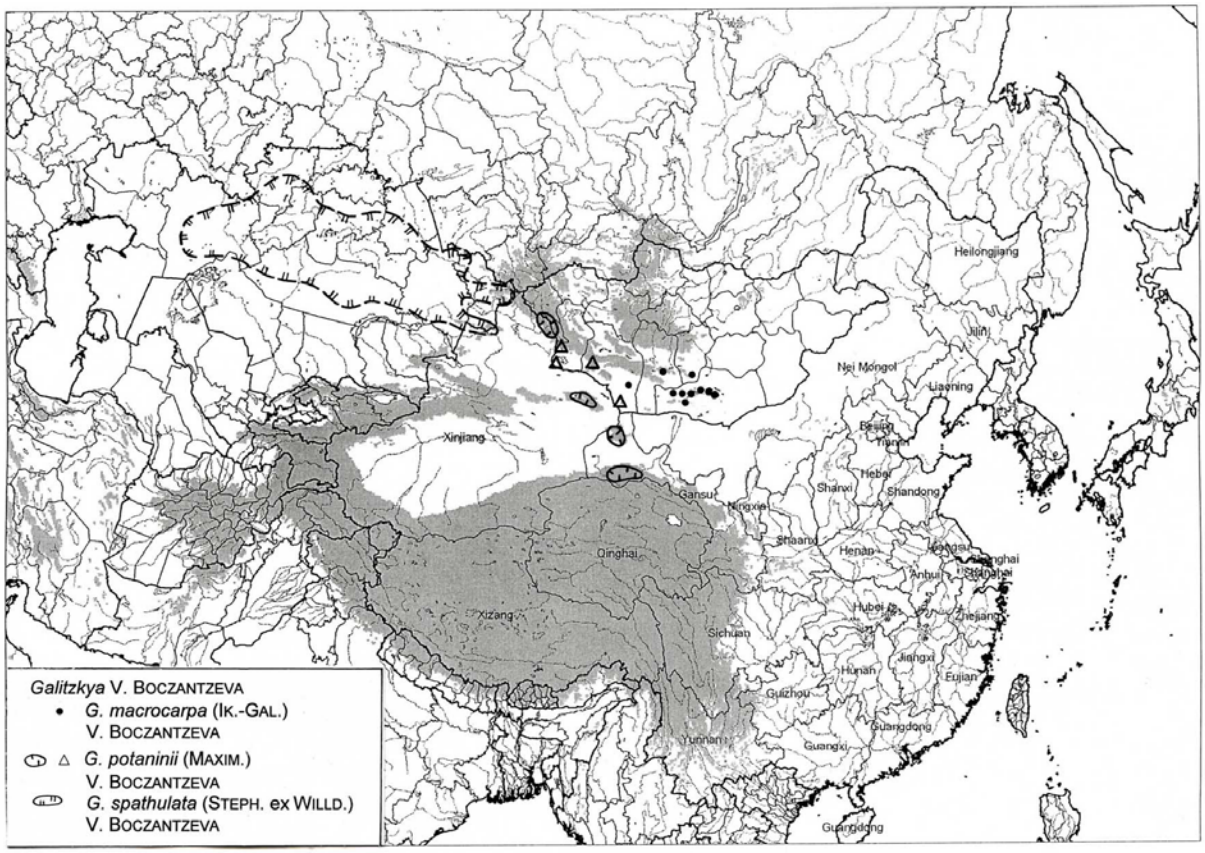

Figure 3. Range of *Galitzkya macrocarpa* (Ik.-Gal.) V. Boczantzeva, *Galitzkya potaninii* (Maxim.) V. Boczantzeva, and *Galitzkya spathulata* (Steph. ex Willd.) V. Boczantzeva.

western Gansu and south-western Mongolia. *Galitzkya macrocarpa* occupies the easternmost outposts in this continental western Asian genus and is an endemic of the Gobi Altai and adjacent mountain regions in Mongolia.

Local distribution

The taxonomic difficulties render an assessment of the distribution of *Papaver saichanense* almost impossible. We collected samples that were tentatively named *Papaver saichanense* (P. Hanelt, pers. comm.) from all three main ranges of the Gobi Gurvan Saikhan and from the Ikh Bogd (2200-2800 asl., Fig. 4). However, only samples from the Khalgan and from the Zuun Saikhan are clearly identified based on morphological characteristics given in Grubov (1982). In any case, populations of poppies are commonly found in moist mountain steppes of the upper slopes and are often quite large (numbering dozens, to hundreds of flowering individuals on any given slope). Thus, we might conclude that the south-eastern Gobi Altai hosts a distinct taxon within the *P. nudicaule* group, which occurs on the moister mountain ranges of the Gobi Altai and develops reasonably large populations

Table 1. Major life history traits for the four species assessed.

	Papaver saichanense	*Saussurea saichanensis*	*Galitzkya macrocarpa*	*Potentilla ikonnikovii*
Live form	rosette - hemicryptophyte	semi-rosette - hemicryptophyte	suffruticose - chamaephyte	rosette - hemicryptophyte
Leaf phenology	summer green	summer green	evergreen	summer green
Flowering time	Jun. / Jul.	Jul. / Aug.	Jun. / Jul.	Jun. – Aug.
Pollination	insects	insects	insects	insects
Seed shed	Aug.	Aug. / Sept.	Jul. / Aug.	Jul. – Sept
Seed dispersal	semachorous	anemochorous (zoochorous?)	anemochorous	endozoochorous?
Altitudinal range	alpine	alpine	montane - alpine	montane - alpine
Habitat	stony mountain meadows	mountain meadows, rock crevices	rock crevices	rock crevices

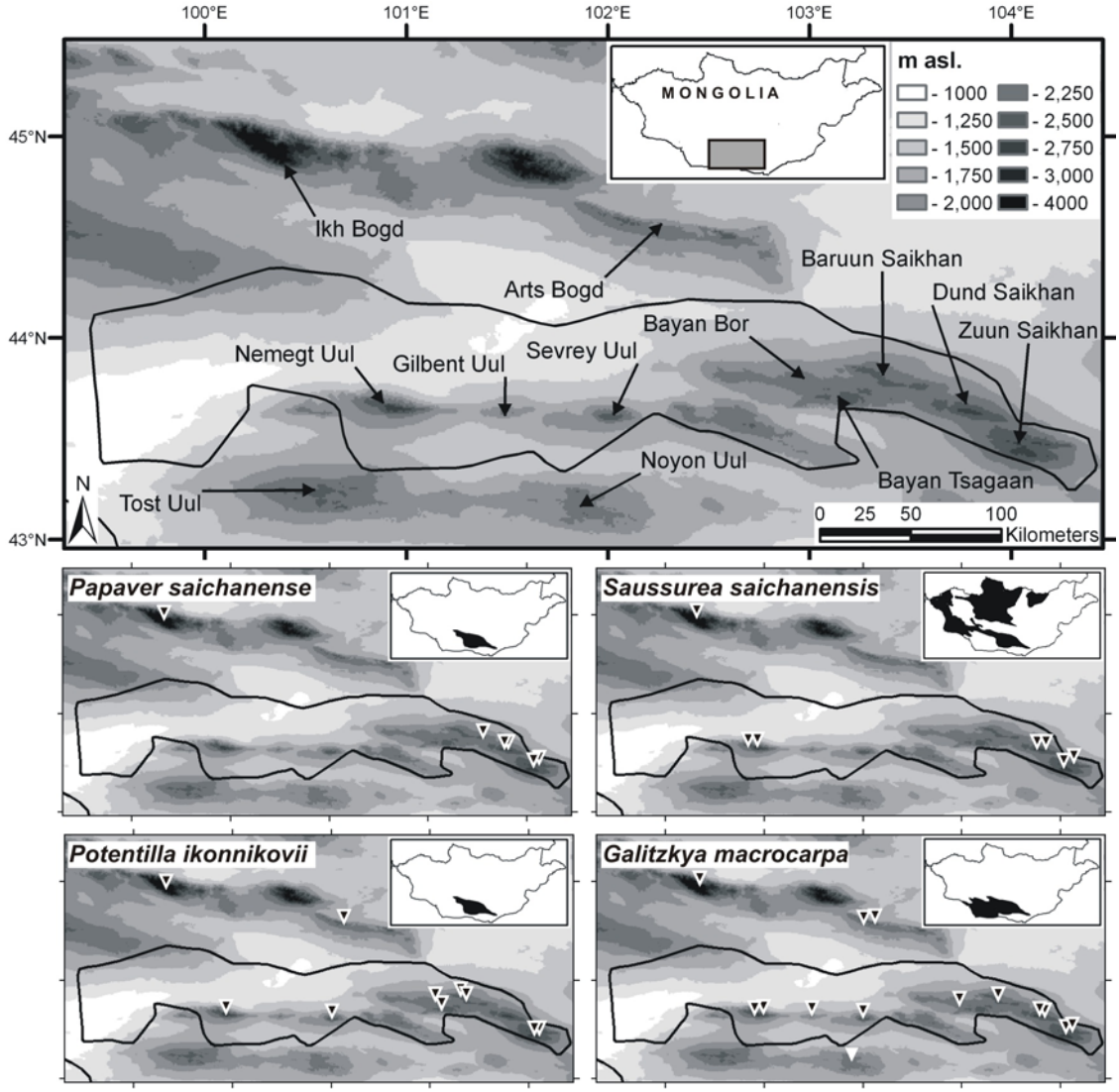

Figure 4. Local distribution of the four species in the Gobi Altai. The large map gives collecting localities and their names, the continuous line demarcates the boundaries of the Gobi Gurvan Saikhan National Park. Small maps describe the local distribution. ‘ ’ indicates our own records; ‘▽’ indicates records from the literature that were not checked during our survey. Small inserts in species’ maps give distribution in the main floristic regions of Mongolia according to Gubanov (1996).

there.

Saussurea saichanensis can also be found in mountain steppes (2200-2800 m asl.), where populations can amount to several dozen to hundreds of specimens. The largest sites were in the Zuun Saikhan and the Dund Saikhan, whereas populations in the dry Nemegt Uul were smaller and less dense. The species is the most widely distributed of the four discussed here, and it is also known to occur in Tolbo Kungay in the Khovd region, Tsengel, Khan Khokhii, Mankhan, Aj Bogd, Taishiryn Uul, Ikh Khavtag Uul in the Dsungarian Gobi, Khasagt Khairkhan (Dod Nur) in the Mongolian Altai and Otgontenger from Khangai. It has also been found near Khovsgol and in parts of Khentii (Grubov, 1982; Gubanov, 1996; Herbarium of the Botanical Institute of the Mongolian Academy of Science, Ulaanbaatar).

Potentilla ikonnikovii is easily identified in the field because of its pinnate leaves and its habitat requirements, as the species is restricted to rock fissures and small crevices between 2050 and 2500 m asl. Thus, it occupies similar sites as *G. macrocarpa*. *Potentilla* occurs on almost all ranges in the Gobi Gurvan Saikhan, except for the Dund Saikhan where it is apparently absent (Fig. 4). However, a transplantation experiment revealed that the species can grow in the upper Dund

Saikhan, so dispersal limitations may cause its limited distribution. Counting of specimens was not feasible due to the inaccessibility of the habitat, but where present several specimens were usually found in a radius of <10 m. Nonetheless, populations appear to be somewhat smaller and the species is, on the whole, less widely distributed than *G. macrocarpa*. We saw a single herbarium specimen that apparently originated from the Khadjin Uul in the Mongolian Altai.

Galitzkya macrocarpa was commonly found at mountain sites in the region at altitudes ranging between 1950 and 2570 m asl. It has colonised all ranges in the Gobi Gurvan Saikhan NP, and also occurs on several sites in the Arts Bogd. We visited parts of the neighbouring Noyon Uul without finding specimens of the species, but previous records from there seem reasonable, and the Tost Uul may also be colonised. We were unable to find *G. macrocarpa* in the Endrengiyn Nuruu, and found only *G. potaninii* in the Trans-Altai Gobi (Atas Bogd). Though we lack quantitative data, we had little difficulty in finding between 5 and 15 individuals of *G. macrocarpa* within a radius of 10 m at colonized sites, so populations are at least not extremely small.

All four species were found to be flowering. Flowers were even produced in the zud (drought) year of 2001 and in dry 2002, but numbers appeared higher in the moist years of 2003 and 2004. Flower production in 2005 was similar to 2002. Thus, seed production is presumably reduced in drought years but seeds were nonetheless produced during the whole observation period.

In summary, *P. ikonnikovii* is known from one district (Gobi-Altai, see inserts Fig. 4), but there may be an outpost in a second (Mongolian Altai). *G. macrocarpa* occurs in two districts (Gobi-Altai and Trans-Altai), while *P. saichanense* appears to be restricted to the Gobi-Altai district. *S. saichanensis* is the most widespread species, with occurrences in seven districts (Khovsgol, Khentii, Khangai, Khovd, Mongolian Altai, Gobi-Altai and Dzungarian Gobi).

Recommendations for species' conservation

The distributional data clearly show that all four species are true endemics of Mongolia. Moreover, *Galitzkya* is a small genus with only three species (Boczantzeva, 1979), and Mongolia takes part of the range of *G. potaninii*. The survival of this species may be also questionable if Mongolian populations became extinct. Thus, from a biogeographical point of view, Mongolia has full responsibility for their survival, and should be highly concerned about all four species.

None of the species are listed in the Mongolian Red Data book (Shiirevdamba *et al.*, 1997), and they are similarly absent from IUCN's International Red List. In fact, the latter does not include a single vascular plant from the Mongolian flora (http://www.redlist.org). In order to be listed as "endangered", restricted-range species must have an overall geographical range smaller than 5000 km², or a so-called "area of occupancy" (i.e. actual habitat) of <500 km² (IUCN, 2001). To be listed as "vulnerable", the species' geographical range must be <20,000 km², or the species must not occupy >2000 km². GIS-based analysis of potential habitats suggests that *P. saichanense*, *P. ikonnikovii* and *G. macrocarpa* definitely qualify as vulnerable by the latter criterion. In addition, *S. saichanensis*, whose overall range is much greater than that required for the "vulnerable" categorisation, has a scattered distribution which suggests that area of occupancy could be smaller than 2000 km². Further research would be required to confirm as such.

A second criterion is to be met for inclusion in the Red List. In context of our study, evidence of shrinking populations or loss of habitats would be the most obvious second problem, but our survey in the Gobi Altai region gives no evidence of either. We have newly confirmed most of the populations previously described in the literature and have also added new records. Most of the suitable sites identified are apparently colonised, and populations are at least not extremely small. Moreover, more populations may be found in future studies. The previously published floristic data cover the entire vast country and are comparatively detailed. However, our new records hint at some of the still existing gaps. Our survey covered most southern Mongolian mountains over the last 5 years, but we have still certainly not seen every spot of potential habitat. Because all our new records were within or close to the already known distribution ranges of the four endemics, we nonetheless doubt that the general pattern will change much with more data becoming available.

Another criterion for listing as vulnerable is described as a species being "severely fragmented or known to exist in no more then 10 locations" (IUCN, 2001). All species are severely fragmented and *P. ikonnikovii* and *P. saichanense* are known to occur in fewer than ten populations (Fig. 2, 4). The

number of occurrences of *S. saichanensis* and *G. macrocarpa* is around ten, so all four species can be considered rare. Knowledge on the local distribution is still insufficient, but all four species could easily become "vulnerable" if a few populations disappear, or if numbers of individuals start to decline.

G. macrocarpa and *P. ikonnikovii* grow in rock fissures and are unlikely to be affected by livestock grazing. *S. saichanensis* grows on rocks and also in heavily grazed mountain steppes, but as a rosette plant appears to be equally grazing-tolerant as the mountain steppe species *P. saichanense*. Thus, there is little reason to expect detrimental impact from human land use. Sites in the Gobi Altai are dry and sexual regeneration is apparently limited in some mountain steppe species (e.g. Wesche *et al.*, 2005). Climate change could pose a problem in this respect, although at present there is no evidence that southern Mongolia is getting drier (Jacoby *et al.*, 2000). Temperatures are currently rising, but all species colonise a wide altitudinal and therefore thermal range. Rising temperatures could lead to increased evapotranspiration, but coinciding rising levels of atmospheric CO_2 should increase water use efficiency (Christensen *et al.*, 2004), so overall effects of climate change on these species should be negligible.

In summary, our data indicated that all four species are Mongolian endemics and add to the biodiversity value of the country. None of them is significantly threatened at the moment, although some monitoring of their overall distribution is advisable with respect to the limited number of available records. However, no immediate dangers are discernible and we subsequently have enough reason to be confident that future generations will be able to take delight in these gemstones of the Mongolian flora.

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Хураангуй

Энэхүү өгүүлэлд Монгол орны уулархаг бүс нутгуудад тархсан *Papaver saichanense*, *Saussurea saichanensis*, *Potentilla ikonnikovii* and *Galitzkya macrocarpa* зэрэг 4 зүйлийн ургамлын тархалтыг авч үзсэн болно. Шинэчилсэн биогеографийн анализын дүнд эдгээр 4 зүйл бүгд Монголын эндемик болох нь тогтоогдов. Ангилал зүйн холбогдлын үүднээс авч үзвэл *S. saichanensis*, *P. saichanense* зүйлүүд Азийн уулархаг нутгуудад тархсан зүйлийн бүлэгт багтах бол *Potentilla ikonnikovii* зүйл Зүүн Азийн тархалттай зүйлүүдтэй холбоотой, *Galitzkya* төрөл нь дундад Азийн элемент болох нь тогтоогдов. Говь Алтайн нуруу болон түүнтэй зэргэлдээх уулсад эдгээр ургамлын тархсан байдлыг харуулсан шинэ зургаас авч үзвэл бүх зүйлүүд тасархайтсан тархалттай бөгөөд 12-оос бага цэгээс тэмдэглэгдсэн юм. Бид эдгээр ургамлын тархалтын шинэ цэгийг тогтоосон бөгөөд хэдийгээр мониторингийн судалгааг хийх шаардлагатай хэмээн үзэж байгаа боловч тэдгээрийг ховордож буй зүйлүүд хэмээн тооцох үндэслэлийг мөн тогтоосон юм.

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