The Occurrence of Forest Plants in the Desert Mountains of Mongolia and Their Bearing on the History of the Climate

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In: Proceedings of the symposium "Ecosystem Research in the Arid Environments of Central Asia: Results, Challenges, and Perspectives," Ulaanbaatar, Mongolia, June 23-24, 2004.
Erforschung biologischer Ressourcen der Mongolei (2005) 5.

Erforsch. biol. Ress. Mongolei (Halle/Saale) 2005 (9): 237–245

The occurrence of forest plants in the desert mountains of Mongolia and their bearing on the history of the climate[1]

E.J. Jäger

Abstract

The isolated occurrences of forest plants in the desert mountains of southern Mongolia raise questions as to the mode of their dispersal and the age and direction of former range connections. For species without a possibility of long distance dispersal, a once continuous distribution over the southern Mongolian mountain chains must be assumed. To the Gurvan Saykhan mountains, the forest plants immigrated from the west. Nevertheless their distribution types are eastern Asiatic, or else Eurasiatic with an eastern center of gravity. This shows that the seasonal type of the recent climate with summer rains in eastern Asia influences vegetation composition.

The climatic conditions at the time of continuous distribution should include a precipitation sum about 200–300 mm higher than today, as can be judged from the climatic envelope of the recent distribution of these forest plants. This deviates very much from the 'Atlas of paleoclimates', but it is corroborated by radiocarbon-dated macrofossils of *Picea, Pinus sibirica* and *Abies* found by Russian authors in middle holocene deposits in the Gobi Altay. Between 4000 and 3500 yr BP, when the dark taiga forests disappeared due to the aridization in southern Mongolia, also the forest plants in the Gurvan Saykhan became isolated.

Keywords forest plants, relics, southern Mongolia, paleoclimate, disjunction, dispersal

Introduction

The isolated occurrences of forest plants in the high mountains of the Gurvan Saykhan raise several questions:

1. How could the plants reach these isolated mountains? Are they characterized by a special type of dispersal, perhaps of long distance dispersal?
2. Which direction did they come from and along which route did they migrate?
3. During which geological time was the migration respectively the continuous distribution possible?
4. What climatic conditions enabled the plants to reach the Gurvan Saykhan?

Material & Methods

In order to discuss these questions, a list was compiled including all species of higher plants that are given by Grubov (1982, 1963 ff.) and Gubanov (1996) for the Gobi Altay, especially the Gurvan Saykhan, but not for the adjoining steppe regions like the Valley of Lakes or the Great Khalkha.

As many of these plants as possible were mapped using the literature, especially the Russian and Chinese floras, and some own observations. The range limits were interpreted climatically, in order to deduce information on the former climatic conditions that would have enabled the plants to cross the lowland around the Gurvan Saykhan.

The possibility of long distance dispersal was judged on the basis of the literature and the type of diaspores. A map (figure 1) showing the distance to the nearest high mountains was

[1] Results of the Mongolian-German Biological Expedition since 1962, No. 251.

taken from the National Atlas of Mongolia (Anonymous, 1990). Two profiles constructed on this basis show the desert valleys and lowland that had to be crossed (figure 2).

Results & Discussion

The number of plants restricted to the small forest relics and mountain tops in the Gobi Altay is rather high at approximately 70 for the forest plants and 90 for alpine plants. At least half of them were found on the Gurvan Saykhan.

The distance to the next high mountains is about 60 km to the west (the Altay mountain chain being quite continuous farther west), about 270 km to the summits of the Khangay (with Baga Bogd as a stepping stone between) and even more (over 550 km) to the nearest Chinese mountains that reach alpine heights (Yin Shan, Helan Shan, Nan Shan, see figures 1 & 2).

There is a great variety of dispersal types in these species. The ferns, *Pyrola rotundifolia* and *P. incarnata* (figure 3), species of *Gentiana, Gentianella, Valeriana, Erigeron, Salix* and others have light diaspores which are easily dispersed by wind over dozens of kilometers. Some species have fleshy seed coats or fruits and may be transported by birds, e.g. *Paeonia anomala* (figure 4), *Ribes nigrum, Ribes rubrum* and *Lonicera altaica*. The latter ones are also anthropochorous. These types of dispersal are very effective; we know that diaspores were brought to the Hawaiian islands by birds over a distance of 3600 km. The fruit calyces of *Myosotis* and the fruits of sedges or grasses like *Festuca sibirica* and *Festuca ovina* may be dispersed in the fleece of cattle. But there are also some species without any possibility of long distance dispersal, e.g. *Viola dissecta* (figure 5), *Moehringia lateriflora* or *Adoxa moschatellina* (figure 6). A migration other than step by step is very unlikely in these cases.

Admittedly, we know of rare events of untypical dispersal. Ridley (1930) described a frog rain far from the nearest pond or a worm rain far from the forest where a cyclone lifted these animals together with the water or the litter in the forest, or even the case of a horse heaved up by such a wind in America and put down some kilometers away.

But if we exclude such singularities and assume a step by step migration, then the climate must have been suitable for the growth of forests also in the valleys and basins west of the Gurvan Saykhan. The lower forest boundary should have been about 1000 meters lower than today. This would mean that the mean annual precipitation was at least 200 mm higher in summer than today, provided the temperature of July was only at about 15–17 °C, not 20–22 °C as today, otherwise the summer precipitation would have had to reach 400 mm. This is evident from the climatic conditions at the southern distribution limit of the Gurvan Saykhan forest plants.

The continuous distribution was presumably disrupted in the middle holocene. One could ask if these connections are not older and date perhaps back to the interglacial times of the quaternary. This is theoretically possible, but the isolation cannot be very old. Otherwise, such polymorphic species as *Adoxa moschatellina* and *Viola dissecta* would have differentiated due to an independent evolution.

The reconstruction of climate during that time according to the 'Atlas of paleoclimates' (Frenzel, 1992) deviates greatly from the values deduced above. But even the two reconstructions within this atlas by the Russian and German authors are quite different. According to Klimanov the mean annual precipitation in southern Mongolia in the period 6000–5500 yr BP was at least 100 mm higher than at present, but according to Frenzel's map for the period 7000–6500 yr BP it was more than 30 mm lower than today in Eastern Mongolia and even more than 60 mm lower in the western part! (That would mean less than no rain in the Dzungarian Gobi!) The temperatures reconstructed by these authors for the same period do not differ considerably: In southern Mongolia, January was 2–3 °C warmer than today according to Klimanov, February was 1–2 °C warmer according to Frenzel. July had a mean temperature 0–1 °C warmer than

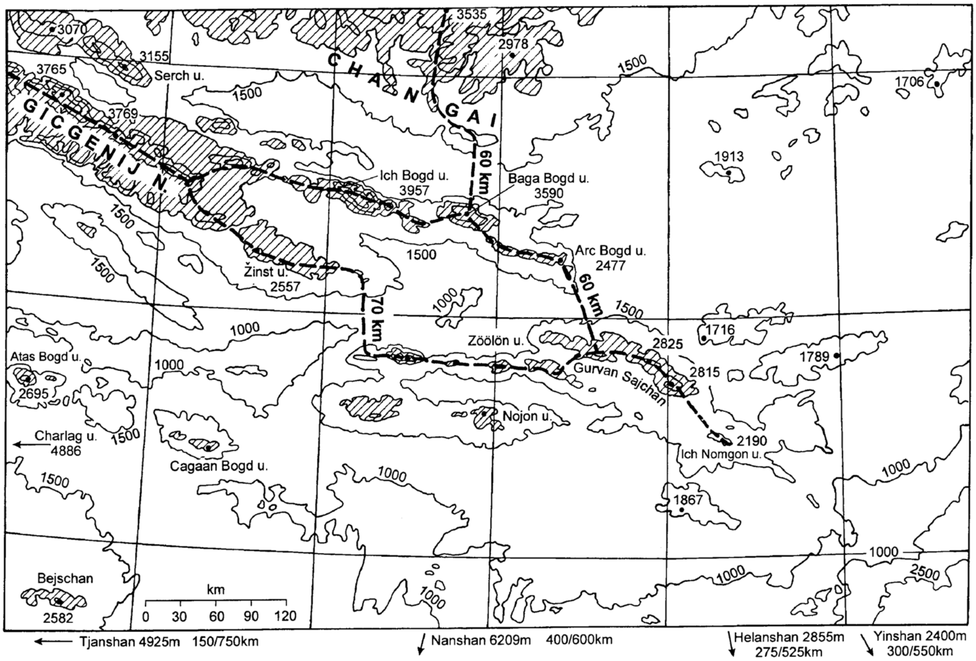

Figure 1: Map of the location of the Gobi Gurvan Saykhan and the distances and possible migration paths of forest plants from the Altay and Khangay mountains (Source: Mongolian National Atlas, Anonymous, 1990).

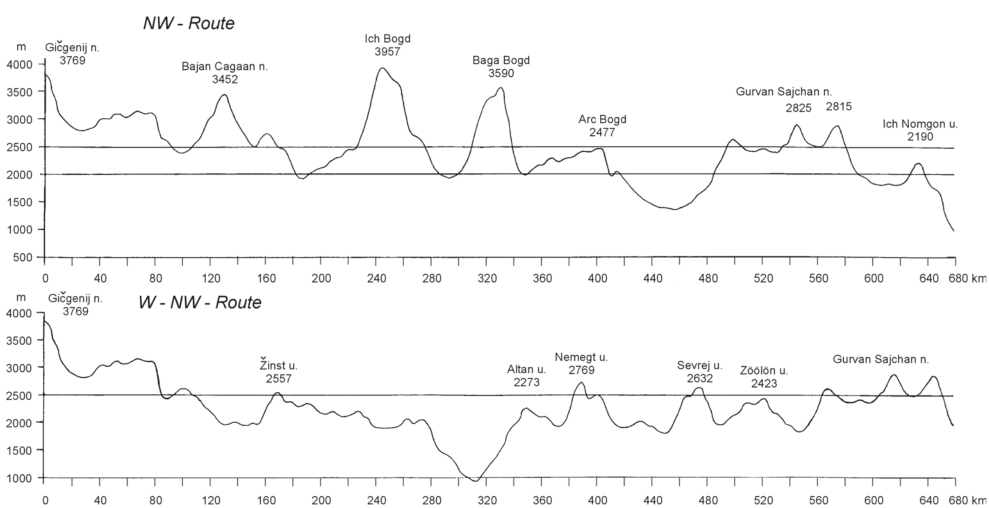

Figure 2: Profile from Gurvan Saykhan to the nearest high mountains of the Mongolian Altay.

today according to Klimanov and August was 1–2 °C warmer according to Frenzel (data for the same period and the same months are not given).

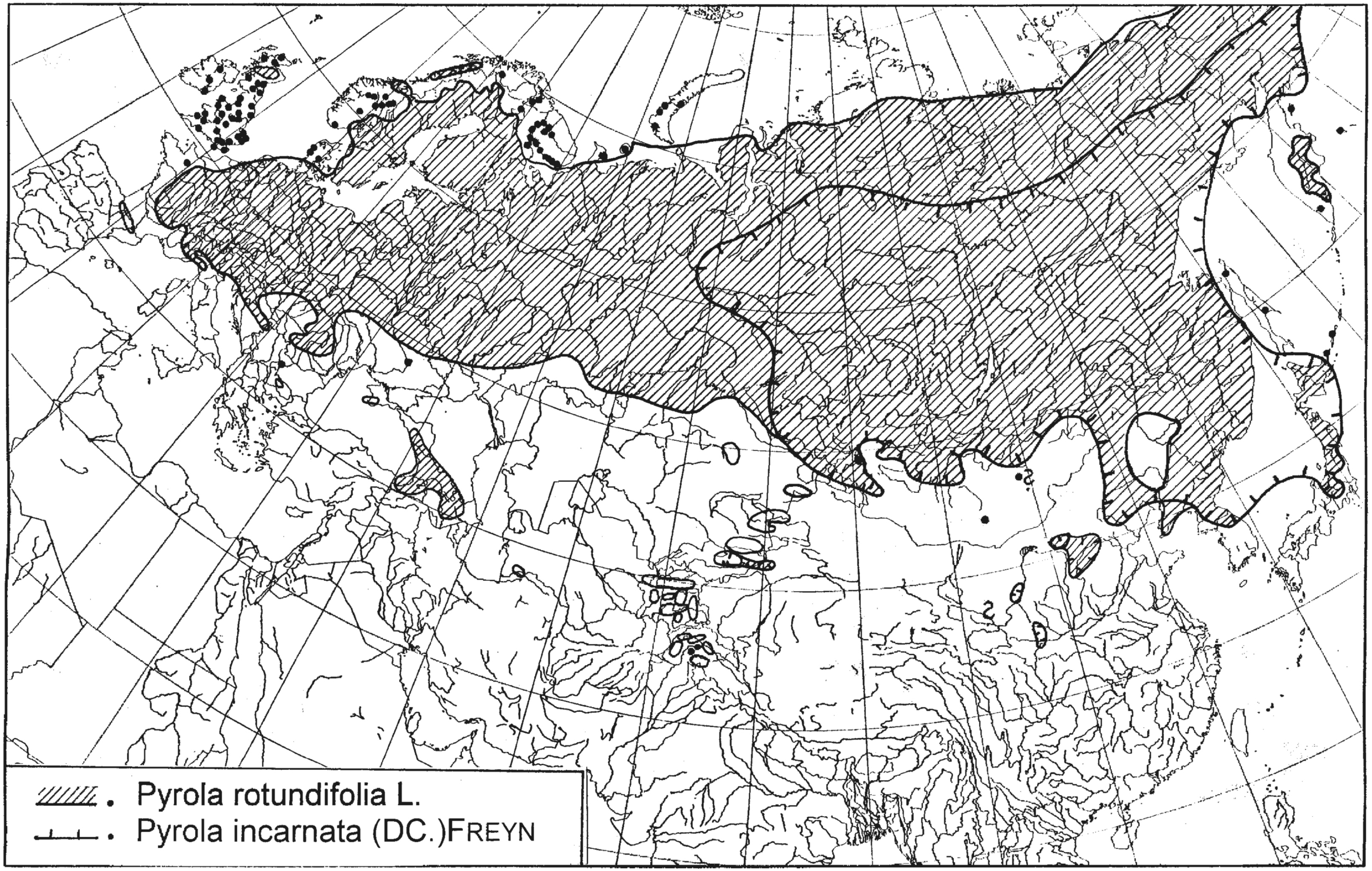

Figure 3: Distribution of *Pyrola rotundifolia* L. and *P. incarnata* (DC.) Freyn in Eurasia.

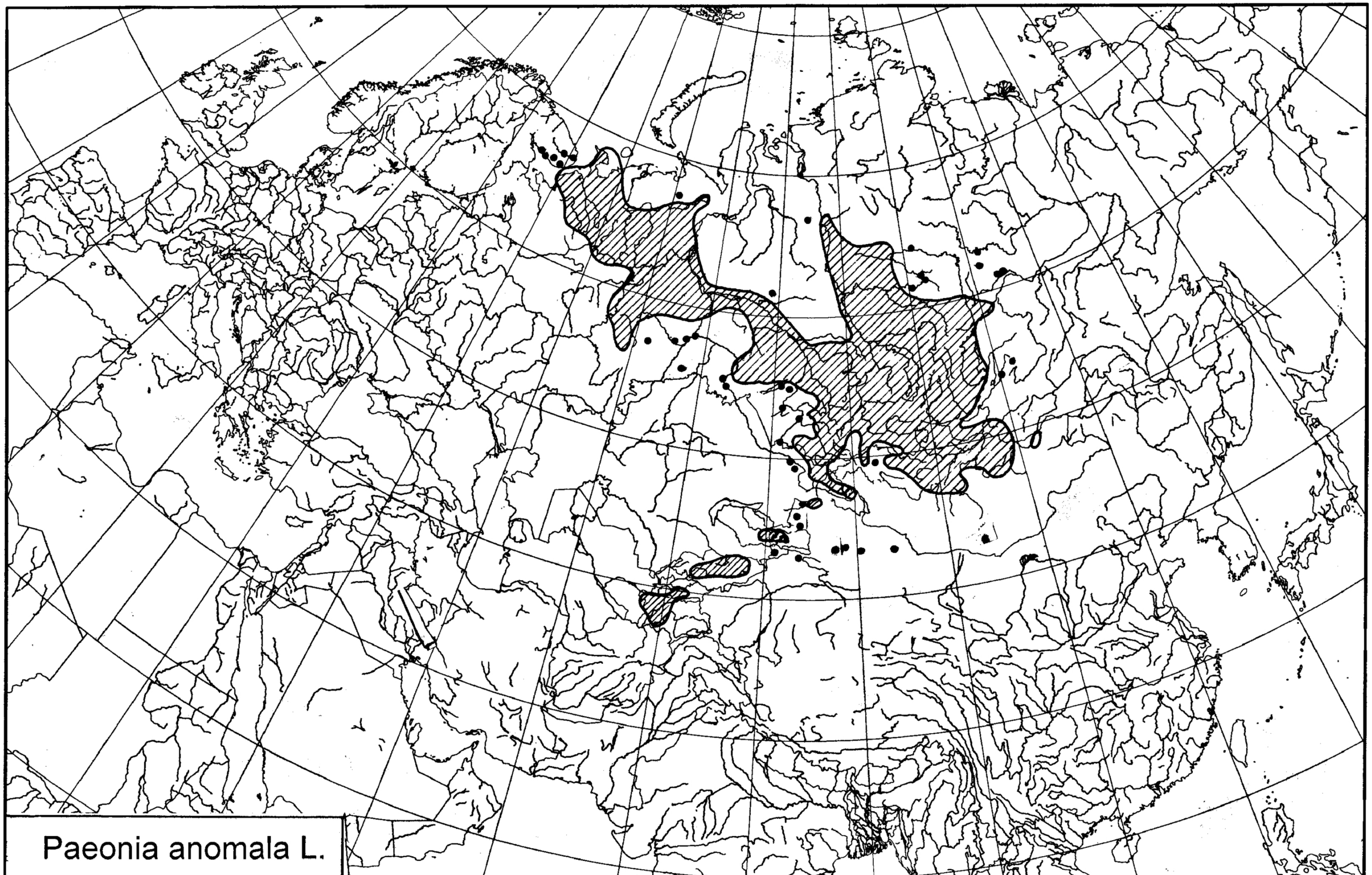

Figure 4: General distribution of *Paeonia anomala* L.

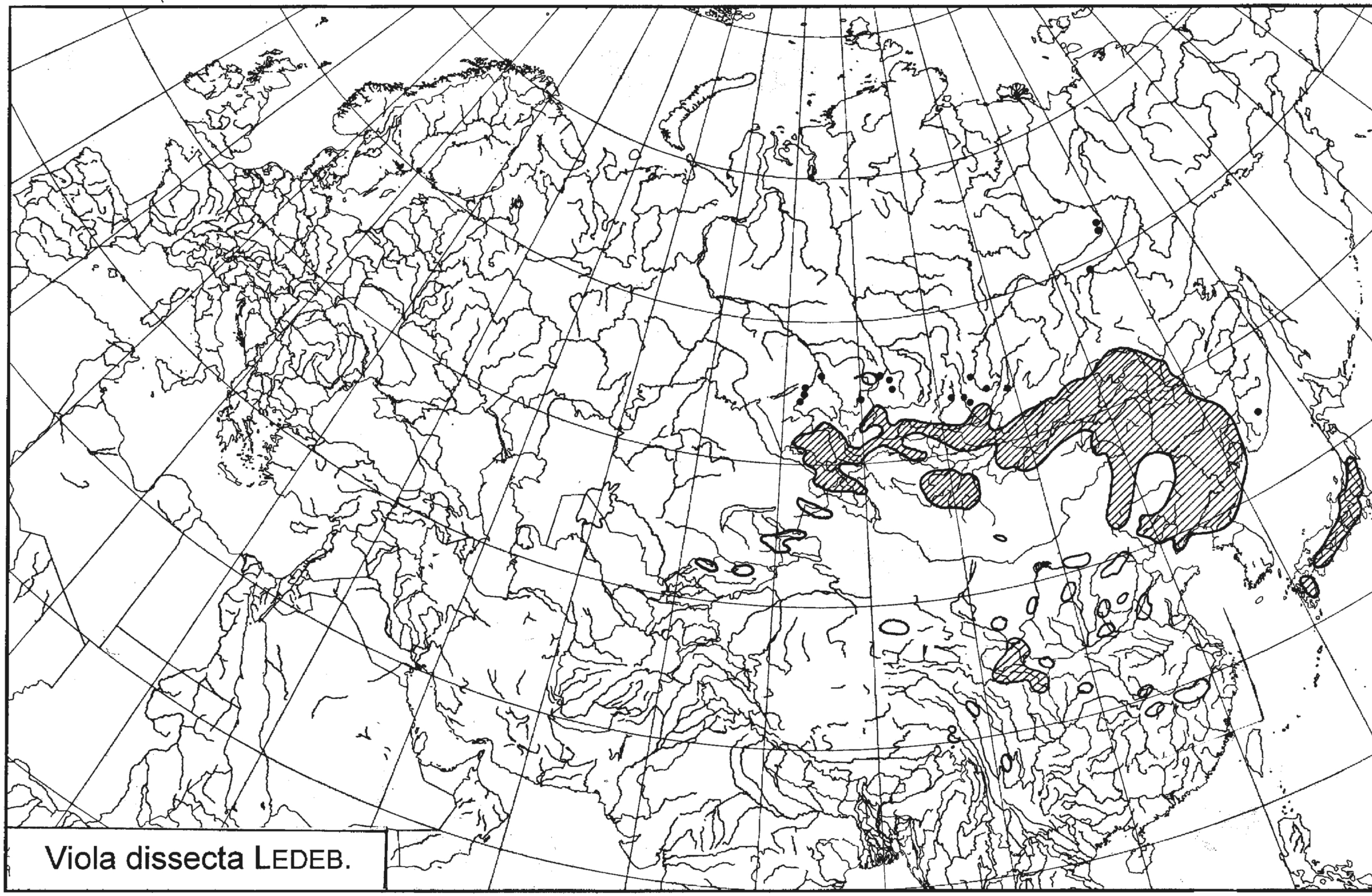

Figure 5: General distribution of *Viola dissecta* Ledeb.

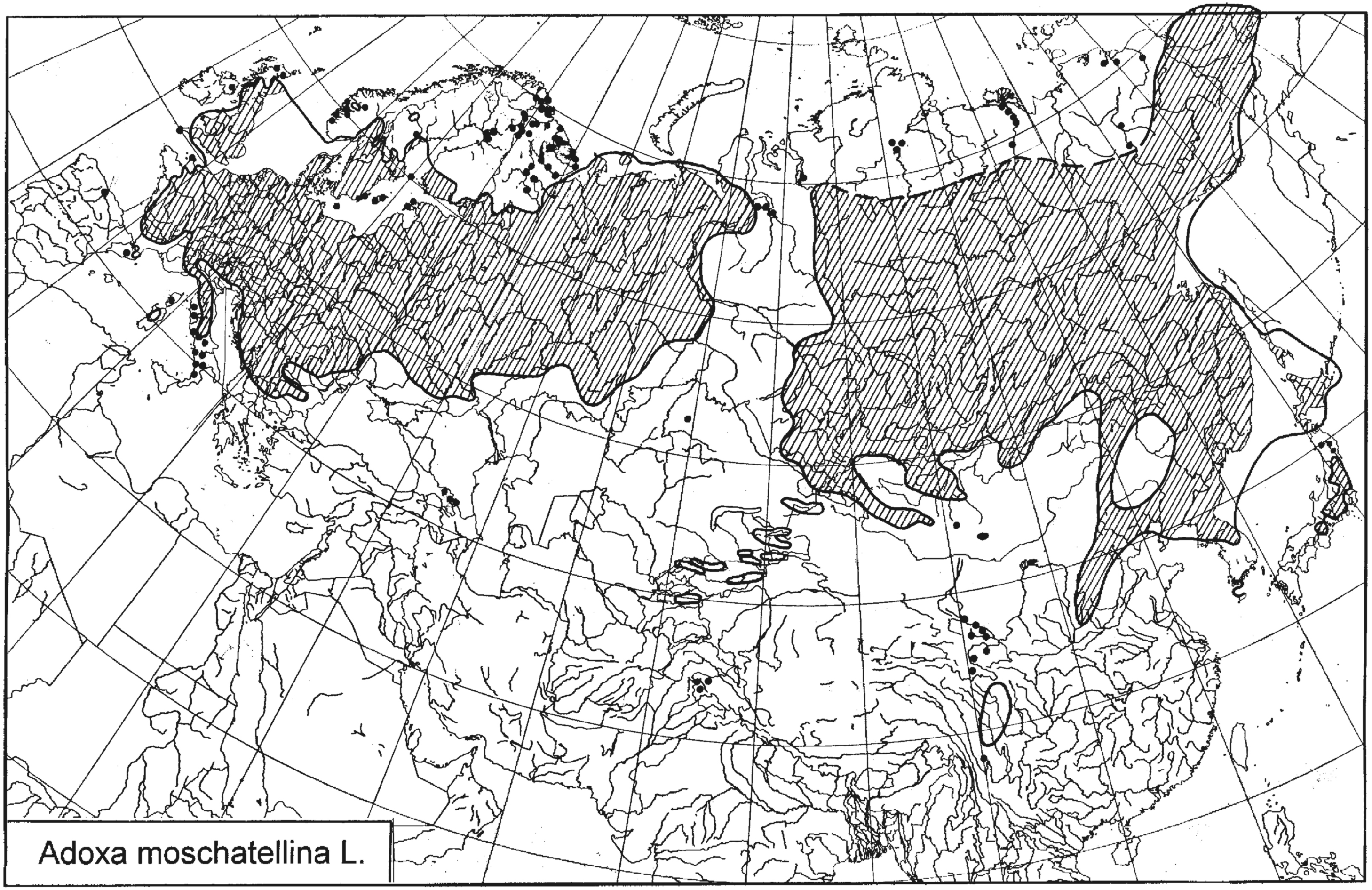

Figure 6: Distribution of *Adoxa moschatellina* L. in Eurasia.

Fortunately, there is evidence from dated woody macrofossils, that during the period of 4000 to 8000 yr BP forests of the dark taiga type with *Picea, Pinus sibirica* and even *Abies sibirica* were distributed also in the Gobi Altay (Dinesman et al., 1989). The climatic conditions of the dark taiga were analyzed by Tolmachev (1954). They include a short frost-free period of about 150 days, a cold winter with snow cover, a July mean of between 12 and 20 °C, and a continuously humid summer. The winter temperature could be as low as today in Mongolia.

All these data corroborate the reconstruction of a high humidity during the immigration of forest plants in the Gurvan Saykhan. Also the occurrence of *Camptosorus sibiricus*, a species of East Asiatic deciduous forests, in the Great Khalkha indicates a formerly humid climate (Knapp, 1989).

Concerning the direction of the immigration the distance to the nearest high mountains points to the Altay (figure 2) or else via the Gurvan Bogd to the Khangay. In fact, almost all of the Gurvan Saykhan forest and alpine plants have also been found in the Russian, Chinese or Mongolian Altay, whereas connections to Western China or to Tibet are rare.

Having answered the questions of how, in which time, under which conditions, and from where the plants came, there is one more interesting fact to be discussed relating to the biogeographical subdivision of Mongolia.

There is a very important phytogeographical boundary in Mongolia, which runs from North to South approximately along the 100th degree of longitude (Jäger et al., 1985; Kamelin & Gubanov, 1993). The Gurvan Saykhan lies clearly east of this line, but the plants of its high elevations came from the west! Nevertheless the patterns of their general distribution are clearly eastern Eurasiatic, most of them reach no farther west than to the Altay-Turkestan line that is the boundary of eastern and western Eurasia or they have a broad Eurasiatic distribution with evident concentration in the East. Distribution types with a western Eurasiatic center are totally absent.

In spite of the role of historical factors, the type of the recent seasonal climate selects also in this case. In the west-east-gradient of seasonal precipitation, eastern Mongolia lies in the summer rain climate with up to 90 % rain in summer, whereas western Mongolia takes an intermediate position with about 60 % summer rain. In southern and western Europe most of the precipitation falls during winter.

An expression of the west-east gradient (that is not to be confused with the gradient of continentality) is also known from distribution patterns of animals. Lopatin (1989) describes Transeurasiatic disjunctions with respect to the center of gravity as 'Eurodisjunct' and 'Asiadisjunct' respectively, but without ecological interpretation.

Conclusion

These examples demonstrate, how the general distribution patterns mirror the ecological valence of the plants. An investigation of the general distribution patterns of all Mongolian higher plants is under way in Halle together with Dr. Dulamsuren. It will help to understand the ecological constitution of the plants, their biological traits, the major phytogeographical subdivision of Central Asia, and also help to evaluate the responsibility of the country for the conservation of its rare plant species.

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