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The conservation value of West Khentii, North Mongolia: evaluation of plant and butterfly communities

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ABSTRACT: We established a research station in the western buffer zone of the Strictly Protected Area of Khan Khentii, North Mongolia. The study site is situated in the forest steppe, the southern strip of the Siberian taiga forest. The southern slopes with high insolation are covered with steppe vegetation. It is the first time the flora and fauna of that region have been investigated systematically. So far, 538 of the 2823 plant species known from Mongolia have been identified at our study sites (an area of ca 100 km^2 is investigated), and 132 of Mongolia's 207 known butterfly species. The high species richness in our region may be attributed to the spatial heterogeneity of habitats, the overlapping of habitats along gradients, and the naturalness of the region. We classified 8 types of vegetation surrounding our research station. Sixteen species of plants at our study sites are listed in the *Mongolian Red Book* as threatened, out of 37 endangered species in the Khentii mountains (nearly 48000 km^2). Approximately half of the species of plants and butterflies are palaearctic species; of these, 30% of the plant species and 47% of the butterfly species are listed in Germany as threatened species. We assume that West Khentii harbors high biodiversity, which in Central Europe is at risk. We highlight the naturalness of the landscape in the buffer zone as an important reference area where palaearctic species under natural ecological conditions can be compared with Central European studies in human-dominated landscapes.

KEY WORDS: forest steppe, butterfly and plant communities, species richness, protection, Mongolia

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* We met Kazik Zarzycki at a congress in Germany in 1989, presenting a paper about the plant communities and butterflies of "his" Pieniny National Park. We were impressed with his data from a period of at least a decade, documenting good ecological thinking. After that we were invited to Kraków and the Pieniny National Park. On a joint excursion we has many discussions about plant ecology, learning from him about the botanical view of population biology and the interrelationships between flowering plants and insects, mainly butterflies. He documented the decline of Zygaenidae species in Pieniny. The discussions stimulated us to compare some of the Polish landscape with some of the German landscape, to determine the reasons for their different conservation values. Now we have begun long-term research cooperation in North Mongolia with the National University in Ulaanbaatar. Again we are focused on butterflies and plants in one part of our research, returning to the topics that brought us together. In presenting our first results we are highly appreciative of the involvement and friendship of Prof. Dr. Kazimierz Zarzycki.

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Introduction

In 1998 we began long-term cooperation between the Center for Nature Conservation, Goettingen (CNC) and the National University of Mongolia (NUM). The main emphasis of that cooperation is the establishment of new curricula in conservation and ecology, and research on natural dynamics in the forest steppe. The current medium-term objectives are these:

(1) to assess the conservation value of the West Khentii region in terms of national and international importance;

(2) to analyze the vegetation of the habitat mosaic in the forest steppe in relation to natural factors like topography, fire, and soil conditions;

(3) to study the butterfly fauna in regard to biogeography and genetics in comparison to European populations (palaearctic species);

(4) to compare the variability of bird and small mammal communities in the different habitats. Birds are used as indicators of habitat quality in quantitative terms of bird assemblages, guild structures and target species;

(5) to analyze the composition of the fish fauna and the age structure of the salmonid populations, and to compare natural rivers and rivers affected by gold mining and overfishing.

This paper focuses on objectives 1–3 and presents the first results on the ecological classification of the different vegetation types and the assessment of the conservation value of the plant and butterfly communities in comparison with their status in Central Europe.

Study site

Boreal coniferous forest and its transition to steppe in the Khentii region, Mongolia, was chosen as the project region. It is part of the proterozoic and paleozoic rock stratum of the Transbaikal mountains (Gravis 1974). Selection of this research area is justified by its global importance for biodiversity conservation due to its large and nearly vacant natural landscapes (Mühlenberg & Samiya 2000). In the Strictly Protected Area (SPA) at Khan Khentii (12000 km^2 of SPA and another 3000 km^2 of National Park; see map in Fig. 1), boreal coniferous forest (80% coverage) with large primeval forest areas predominates. In Mongolia the taiga runs into open steppe. This transition area is called forest steppe. In that region, boreal elements of the conifer forests meet floristic elements of the Central Asiatic steppe. The Khentii mountains are divided into two subprovinces (Savin *et al*. 1988): West and East Khentii. The lower forest border is about 700 m a.s.l. in West Khentii but about 1500 m a.s.l. in East Khentii. The climate has a humid Siberian character. The permafrost layer is higher in West Khentii than in East Khentii (Gravis 1974). Mesophytic elements are more frequent in West Khentii than in East Khentii; for example, *Abies sibirica* occurs only in West Khentii and *Picea obovata* forms forest stands only there. In West Khentii the mountain forest steppe is particularly diverse and its biodiversity is unique in Mongolia. East Khentii has lower annual rainfall and therefore reduced biodiversity. Due to high precipitation in Khentii compared to the rest of Mongolia (300–450 mm per year; wet season in July and August), all tree species characteristic of communities of the southern Siberian taiga are present in West Khentii. Boreal coniferous forests show high structural diversity and spatial heterogeneity. Forest stands spatially adjoining and closely associated, of different densities, heights, stratification,

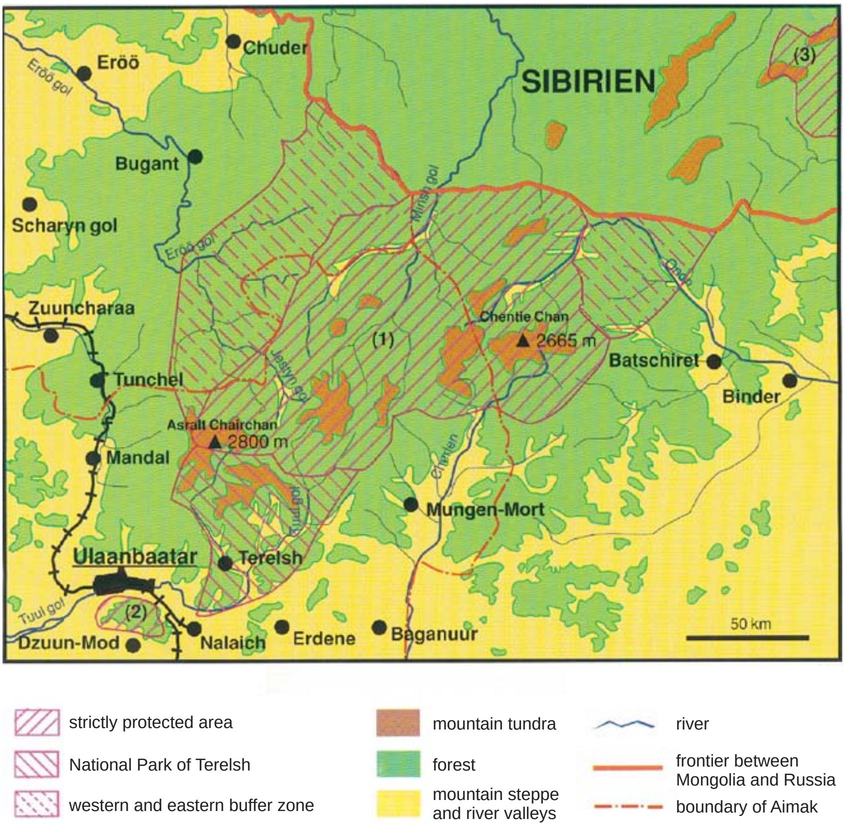

Fig. 1. Map of the protected areas of Khan Khentii, northern Mongolia (Ministry for Environment of Mongolia & WWF-Mongolia, 1994).

and age classes, represent many different stages and phases of succession due to natural disturbances (Treter 1993; Goldammer & Furyaer 1996). With the low annual rainfall, the relief determines the vegetation type above all (Tsedendash 1995).

This natural landscape is now threatened by uncontrolled forest exploitation due to the impoverishment of the rural population, causing, among other things, a significant increase in fire pressure (generally uncontrolled campfires) on the forest and steppe ecosystem (Ing 1999; Velsen-Zerweck 1998). As a consequence, the natural fire regime is now changing dramatically. In 1996 and 1997 only, 10 or 12 million hectares of forest and steppe landscape were overburned (Chuluunbaator & Erdenesaihan 2000).

A university partnership has been established between the University of Goettingen and the National University of Ulaanbaatar, funded by the DAAD[2]. A research station in Khonin Nuga (“Choninug”) was established at the western border of the Khan Khentii Protection Area with support from the VW foundation[3] in cooperation with the National Park authorities. The geographic location (GPS) is lat. 49°05′30″N and long. 107°17′55″E at about 1000 m a.s.l.

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[2] Deutscher Akademischer Austauschdienst (DAAD), Bonn-Bad Godesberg

[3] Volkswagen-Stiftung, Hannover

Vegetation

The Khentii presents a separate floristic bioregion (Fig. 2). In the transition forest steppe zone, forest grows only on the northern slopes. The availability of water depends on the exposure and slope of the ground, due to the variation of insolation (Treter 1997). The shortage of water supply because of the low rainfall is compensated by the availability of water in the soil after thawing of the permafrost in the topsoil. On the southern slopes, however, high insolation dries out the soil, facilitating the dominance of steppe vegetation. Intense solar radiation removes thaw water from the topsoil by evaporation, and other water flows downhill from elevated sites and accumulates in depressions because it cannot penetrate deeply into frozen soils. Spring fires are common in stands on these elevated dry landscape elements (Valendik *et al.* 1998).

The forest is composed of a habitat mosaic due to natural disturbances and factors like topography and soil conditions. The natural dynamic is driven by fire, windfall and the ensuing succession. There are forest stands dominated by *Pinus sibirica* and *Pinus sylvestris*; other stands are dominated by *Picea obovata* and *Abies sibirica*. *Larix sibirica* stands exist in drier conditions, *Betula platyphylla*-*Larix sibirica* stands present mainly secondary forest after human impacts or frequent fires. Although saplings and young trees of most of the species are found everywhere, the old trees live at preferred species-specific sites.

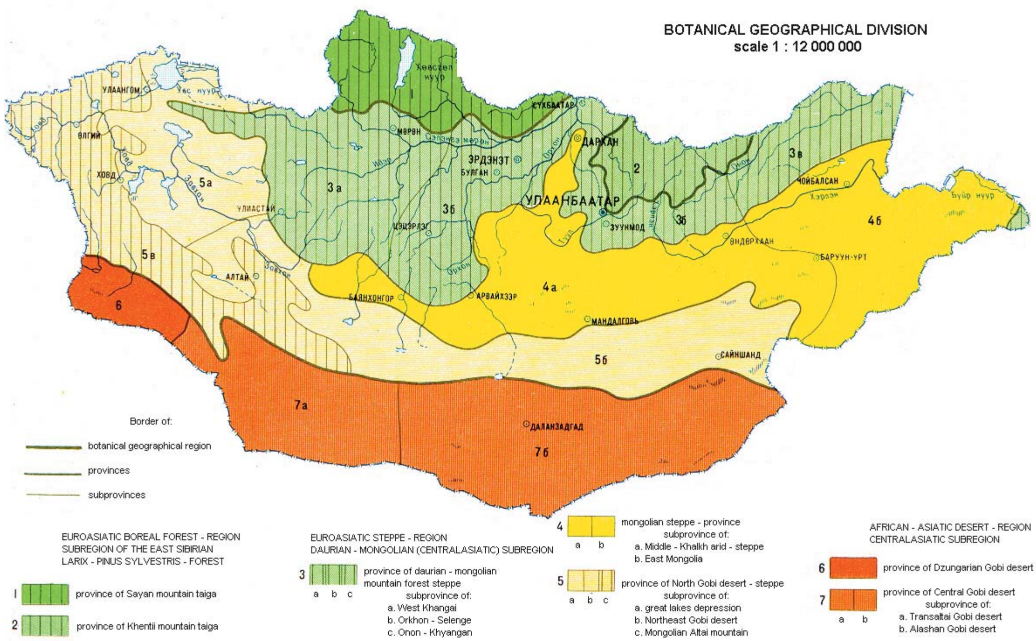

Fig. 2. Phytogeographical division of Mongolia (after E. M. Lavrenko in: *National Atlas of Mongolia* 1990).

The herbaceous vegetation was studied on 10 m × 10 m plots in different strata according to a matrix of these variables: slope exposure (N–S), canopy closure (open 10–30% to > 30%), soil structure (A+B horizon: < 10cm, < 40 cm, > 40 cm). The degree of coverage was estimated according to the Braun-Blanquet method (Dierschke 1994). This paper presents the first classification of the different vegetation types of West Khentii combined with zoological differentiation of habitats. A more detailed division of phytocoenoses will be discussed elsewhere (Dulamsuren, in prep.).

Classification of vegetation types

In the Khentii mountains, Hilbig and Knapp (1983) classified the alpine stratum (*Hochgebirgsstufe*, high mountains), the mountain stratum (*obere Bergstufe*) and the lower mountain stratum (*untere Bergstufe*). The high mountains are situated higher than 1600 m a.s.l. That stratum does not occur in our study sites in the surroundings of Khonin Nuga.

Altogether we may distinguish 8 types of vegetation in our region, shown in the profile diagram of Fig. 3.

1. The **mountain taiga** (mountain stratum with thick coniferous forest; Fig. 4) ranges in Khentii from about 1200 to 1600 m a.s.l., and extensive *Pinus sibirica* forest covers the northern, northwestern and western slopes. The herbaceous layer is relatively poor in

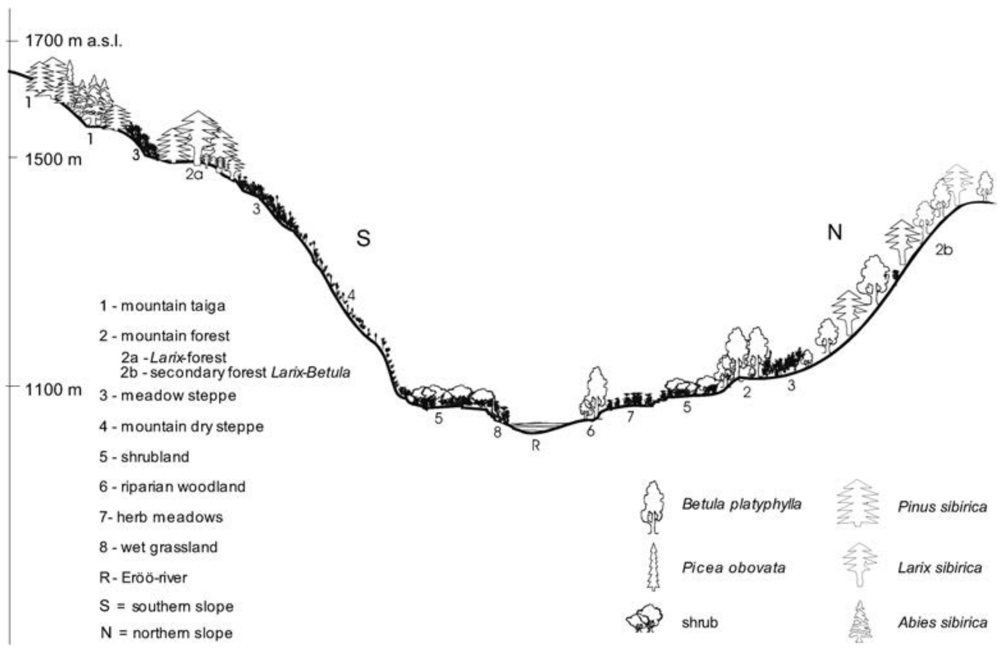

Fig. 3. Scheme of a profile diagram of vegetation cover in Khonin Nuga.

species numbers. Typical mosses are *Ptilium crista-castrensis, Pleurozium schreberi* and *Hylocomium splendens*. Dominant herb species are *Linnaea borealis, Vaccinium vitis-idaea, Lycopodium annotinum* (Fig. 5), *L. clavatum, Diphasiastrum complanatum (=Lycopodium complanatum), Ledum palustre, Bergenia crassifolia* and *Pyrola incarnata*. Associated with *Pinus sibirica* are *Picea obovata* and *Abies sibirica*; *Larix sibirica* occurs as well. The shrub stratum is characterised by *Lonicera altaica* and *Juniperus sibirica*. The soil belongs to the *Gebirgs-Dauerfrost-Taigaboeden* type (mountain podsole and young acidic podsole), (*Fiziko-geograficheskiy Atlas Mira* 1964).

2. The **mountain forest** (about 800–1200 m a.s.l. in Khentii) consists of *(a) Larix-Betula* forests on the northern and western slopes. *(b) Betula platyphylla-Larix sibirica* secondary forests (Fig. 6) are rich in undergrowth vegetation: *Calamagrostis obtusata, Vaccinium vitis-idaea, Maianthemum bifolium, Fragaria orientalis, Viola uniflora, Artemisia sericea, Atragene sibirica, Bromus pumpellianus, Geranium pseudosibiricum, Aconitum septentrionale, Equisetum sylvaticum, Iris ruthenica, Cacalia hastata, Lathyrus humilis* and *Vicia unijuga*. Typical in the shrub stratum are *Rosa acicularis, Spiraea flexuosa* and *Rhododendron dahuricum*. *Chamaeneron angustifolium* is frequent, occurring in particular in secondary forests after fire or clearcutting. The soil is *Gebirgs-Derno-Tiefdauerfrost-Taigaboden* (Kryotaigaboden; *Fiziko-geograficheskiy Atlas Mira* 1964). Dry eastern slopes with relatively shallow soil (< 30 cm) are covered with *Pinus sylvestris* mixed with *Larix* and *Betula*. In addition to the common plants of the conifer forest, heliophilous species of shrubland and steppe occur, such as *Chrysanthemum zawadskii, Silene repens, Melica turczaninoviana, Astragalus frigidus, Carex pediformis, Erigeron acer, Dracocephalum nutans, Polygonatum officinalis* and *Galium boreale*.

3. The **meadow steppe** (mesophilous grassland) has medium to deep soils (> 30 cm). It is not covered by trees, but trees are able to grow or were present in former times on these locations. The species composition includes the above mentioned heliophilous species of the eastern slopes, completed by *Aster alpinus, Campanula glomerata, Schizonepeta multifida, Koeleria macrantha, Poa attenuata, Stipa sibirica, Trisetum sibiricum, Antennaria dioica, Senecio campester, Scorzonera radiata* and *Lilium pumilum*. The soil belongs to the *Loeß-Wiesen-Kastannosem, Loeß-Tschernosem, Kastanno-Tschernosem, Paratschernosem* type (Succow & Kloss 1978).

4. The **mountain dry steppe** (dry grassland) occurs on southern slopes (Fig. 7). The soil is shallow (the A and B horizon together are less than 20 cm) and trees do not exist. In these patches, Daurican, Central Asiatic and Manchurian elements have immigrated: *Spiraea aquilegifolia, Cotoneaster melanocarpa, Woodsia ilvensis, Thymus dahurica, Veronica incana, Agropyron cristatum, Allium anisopodium, Artemisia commutata, Leontopodium leontopodioides* and *Festuca ovina*. In addition, *Orostachys spinosa, O. malacophylla, Aquilegia viridiflora, Patrinia sibirica, P. rupestris, Amblynotus rupestris, Eritrichium pauciflorum* and *Potentilla acaulis* are found on rocky soils.

5. **Shrubland** borders on the lower mountain stratum in the valley. Only a few species form the dense shrubs: *Betula fructicosa, B. fusca, Crataegus sanguinea* and *Salix* sp.

6. The **riparian woodland** is dominated by the trees *Populus laurifolia, Betula plathyphylla* or *Picea obovata*. The soil belongs to the *Kryoaueboeden* type (*Fiziko-geogra-*

Fig. 4. The mountain taiga is dominated by *Pinus sibirica* (Loud.) Mayr. Regrowth *Abies sibirica* Ledeb. is frequent. This forest presents pristine forest stands where only natural disturbances occur.

Fig. 5. The circumpolar species *Lycopodium annotinum* L. occurs only in Khentii in mountain taiga, indicating *Gebirgs-Dauerfrost-Taiga* soils (mountain podsole and young acidic podsole) (Savin & Dugarjav 1988).

Fig. 6. Secondary forest of *Betula platyphylla-Larix sibirica*, one series of the mountain forest. The habitat is rich in regrowth.

Fig. 7. Typical of the mountain dry steppe on rocky and flat soils of the southern slopes are plant species such as *Eritrichium pauciflorum* DC., *Pulsatilla turczaninovii* Krylov & Segevsk, *Orostachys malacophyllus* (Pall.) Fisch., *Patrinia rupestris* Bunge, *Potentilla tanacetifolia* Willd. *ex* Schlecht. and *Artemisia commutata* Bess., all seen on the picture.

ficheskiy Atlas Mira 1964). In the Khonin Nuga valley only *Betula plathyphylla* forms the riparian woodland. The understorey in the flood plains contains *Padus asiatica*, *Betula fusca, B. fructicosa, Crataegus sanguinea, Rosa acicularis, Dasiphora fructicosa, Ribes rubrum*, *Spiraea salicifolia* and *Salix* sp.

7. **Herb meadows** are found in the river valley next to mesophilous grassland. These meadows are rich in different herbs: *Filipendula palmata, F. ulmaria*, *Heracleum dissectum, Achillea alpina, Geum alleppicum, Sanguisorba officinalis, Lilium dahuricum* (Fig. 8) and *Elymus dahuricus* are frequent. Meadow steppe species such as *Hemerocalis*

Fig. 8. *Lilium dahuricum* Hort. *ex* Reuthe is a species from East Asia, listed in the *Mongolian Red Book* (Shiirevdamba *et al.* 1997) as very rare. It is frequent in the herb meadows surrounding our research station in Khonin Nuga. The flowers last from May to July.

minor are also found. The soil belongs to the *Loeß-Braunerde-Kryotaigaboden* type (Succow & Kloss 1978).

8. **Wet grassland** is characterised by *Carex meyeriana, C. dichroa, C. enervis, C. caespitosa, C. schmidtii, Ligularia sibirica, Caltha palustris, Halenia corniculata* and *Comarum palustre*. The soil belongs to the *Ton-Kryo-Vollgley* type (Succow & Kloss 1978).

Table 1 gives an overview of the diversity of the herbaceous plant species in our area. 17.5% of the plant species of Mongolia we found on 0.006% of the area of Mongolian territory, documenting the high biodiversity of West Khentii. One feature of the naturalness in that region is shown by the overlapping and meshed habitats along gradients (see Fig. 9).

The West-Khentii belongs to the Euroasiatic-Boreal-Forest-Region, Subregion of the East Siberian *Larix-Pinus sylvestris*-Forest, Province of Khentii mountain-taiga (Fig. 2; *Mongol Ulsyn undesnii Atlas* 1990). The biogeographical division of the flora of Khonin Nuga is shown in Table 2 and Fig. 10.

Table 1. Overview of the diversity of the flora in Khonin Nuga, compared with the Khentii-region and the Mongolian territory (Dulamsuren, unpubl.). Data for Mongolia and Khentii are taken from Gubanov (1996).

Flora	Mongolia			Khentíi			Khonin Nuga		
	Family	Genus	Species	Family	Genus	Species	Family	Genus	Species
Number of Lycopodiophyta	3	4	7	3	4	5	1	2	3
Number of Equisetophyta	1	1	9	1	1	6	1	1	5
Number of Polypodiophyta	10	15	30	9	12	14	5	8	10
Number of Pinophyta	3	6	21	3	6	16	3	6	7
Number of Magnoliophyta: Liliopsida	24	118	574	17	69	254	11	48	133
Number of Magnoliophyta: Magnoliopsida	87	518	2182	69	313	774	56	205	383
Altogether	128	662	2823	102	405	1069	77	270	541

Table 2. Explanations of the classification of biogeographical regions.

Floristic region	Known geographic distribution
Holarctic	entire Europe, North Africa, Asia without the tropics, almost total North America
Eurasia[a]	Europe and Asia, tropics excluded
Central Asia	Large parts of Kazakhstan, Kirgizistan, Northwest Uzbekistan, South- and Southwest Mongolia, Tibet, Quinghai, North- and Northwest China
East-palearctic	from Central to East Siberia, Far East, North- and Central Mongolia, Korea, Japan, partly China

[a] equal to zoogeographic division “palearctic”

Fig. 9. View of the valley of Khonin Nuga with the river Eroeoe. In front you see meadow steppe on a southwest slope. In the valley you meet herb meadows and riparian woodland behind the river; the mountains are covered with mountain forests.

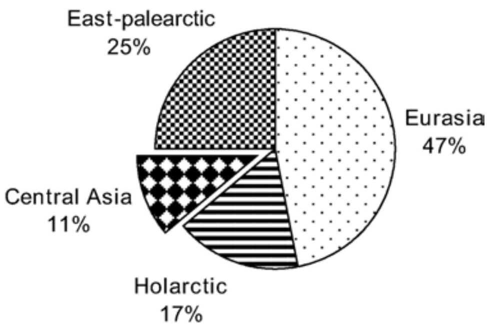

Fig. 10. Biogeography of the plant species of Khonin Nuga, northern Mongolia (n = 323).

Conservation status of the plant species in West Khentii

In the *Mongolian Red Book* (Shiirevdamba *et al.* 1997) plants are categorized as very rare and rare. Table 3 shows the species known from Khentii (Gubanov 1996) and from Khonin Nuga listed in the Red Book. About 4% of the plant species of Mongolia are listed as threatened[4] and the same relation holds for the flora of Khentii and Khonin Nuga as well (see Table 4). Of the very rare species of Khentii, 59% are forest species and 41%

Table 3. List of the threatened plant species of Khentii and of the study site, Khonin Nuga. Classification according to the *Mongolian Red Book* (Shiirevdamba *et al.* 1997): 1 – very rare; 2 – rare.

Species	Khentii	Khonin Nuga	Species	Khentii	Khonin Nuga
Abies sibirica	1	1	*Lycopodium complanatum*	2	2
Acorus calamus	1		*Mitella nuda*	1	1
Adonis mongolica	1		*Neottia camtschatea*	1	
Adonis sibirica	2	2	*Neottianthe cucullata*	1	1
Allium altaicum	2	2	*Orchis fuchsii*	1	
Caryopteris mongolica	2		*Paeonia anomala*	2	2
Convallaria keiskei	1		*Platanthera bifolia*	1	
Corrallorhiza trifida	1		*Rhodiola rosea*	1	1
Cypripedium calceolus	1	1	*Rhododendron aureum*	1	
Cypripedium macranthon	1	1	*Rhododendron dauricum*	1	1
Drosera anglica	1		*Rhododendron parvifolium*	1	
Drosera rotundifolia	1		*Sambucus manshurica*	1	1
Festuca komorovii	2		*Saussurea dorogostaiskii*	2	
Gentiana algida	1		*Saussurea involucrata*	1	
Juniperus pseudosabina	2		*Saxifraga hirculus*	1	
Juniperus sabina	1		*Stellaria dichotoma*	2	2
Lilium dauricum	1	1	*Vaccinium myrtillus*	1	
Lycopodium alpinum	1		*Valeriana officinalis*	2	2
Lycopodium clavatum	1	1			

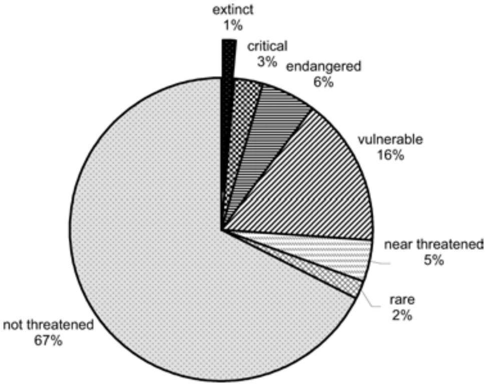

Fig. 11. Percentages of the different categories of threat to the palearctic plant species living in Germany (n = 156). Data from Bundesamt fuer Naturschutz (1996).

[4] Rare and very rare species are considered threatened, but further studies on risk assessment are necessary.

Table 4. Plant species of the surroundings of Khonin Nuga which occur also in Germany (G) and Poland (PL), and their respective threat status according to the "Red List of Germany" (Bundesamt für Naturschutz 1996) and the the *List of threatened plants in Poland* (Zarzycki *et al*. 1992).

		IUCN Categories[a]					IUCN Categories[a]		
No	Species	PL	G	MN[b]	No	Species	PL	G	MN[b]
1	*Achillea millefolium*	–	–	–	44	*Ceratodon purpureus*	–	–	–
2	*Adoxa moschatellina*	–	–	–	45	*Chamaeneron angustifolium*	–	–	–
3	*Agropyron repens*	–	–	–	46	*Chenopodium alba*	–	–	–
4	*Agrostis gigantea*	–	–	–	47	*Chrysosplenium alternifolium*	–	–	–
5	*Allium lineare*	–	EN	–	48	*Descurainia sophia*	–	–	–
6	*A. schoenoprasum*	–	–	–	49	*Dianthus superbus*	VU	VU	–
7	*A. senescens*	–	–	–	50	*Dicranum bonjeanii*	–	VU	–
8	*A. strictum*	–	EN	–	51	*D. polysetum*	–	–	–
9	*A. victoralis*	–	–	–	52	*Draba nemorosa*	–	–	–
10	*Alopecurus arundinaceus*	–	CR	–	53	*Dracocephalum ruyschiana*	VU	EW	–
11	*A. aequalis*	–	–	–	54	*Entodon concinnus*	–	nt	–
12	*Androsacea septentrionalis*	–	CR	–	55	*Equisetum fluviatile*	–	–	–
13	*Anemone sylvestris*	–	VU	–	56	*E. pratensis*	–	–	–
14	*Antennaria dioica*	–	VU	–	57	*E. pratense*	–	–	–
15	*Anthoxanthum odoratum*	–	–	–	58	*E. sylvaticum*	–	–	–
16	*Anthriscus sylvestris*	–	–	–	59	*Euphrasia hirtella*	–	Rare[c]	–
17	*Arabis hirsuta*	–	–	–	60	*Eurhynchium pulchellum*	–	–	–
18	*Artemisia dracunculus*	–	–	–	61	*Empetrum sibiricum*	–	VU	–
19	*A. laciniata*	–	EN	–	62	*Festuca ovina*	–	–	–
20	*A. scoparia*	–	–	–	63	*F. rubra*	–	–	–
21	*A. vulgaris*	–	–	–	64	*Filipendula ulmaria*	–	–	–
22	*Aster alpinus*	–	–	–	65	*Galeopsis bifida*	–	–	–
23	*Astragalus frigidus*	–	–	–	66	*Galium boreale*	–	–	–
24	*Athyrium filix-femina*	–	–	–	67	*G. uliginosum*	–	–	–
25	*Aulacomnium palustre*	–	nt	–	68	*G. verum*	–	–	–
26	*Bromus inermis*	–	–	–	69	*Geranium pratense*	–	–	–
27	*Bryoerythrophyllum recurv.*	–	–	–	70	*G. sibiricum*	–	–	–
28	*Butomus umbellatus*	–	–	–	71	*Goodyera repens*	–	EN	–
29	*Calamagrostis epigejos*	–	–	–	72	*Gymnadenia conopsea*	–	EN	–
30	*Callittriche palustris*	–	–	–	73	*Hieracium echioides*	–	VU	–
31	*Caltha palustris*	–	–	–	74	*H. umbellatum*	–	–	–
32	*Campanula glomerata*	–	–	–	75	*Hippuris vulgaris*	–	VU	–
33	*Cardamine parviflora*	Rare[c]	VU	–	76	*Impatiens noli-tangere*	–	–	–
34	*Carduus crispus*	–	–	–	77	*Iris sibirica*	VU	VU	–
35	*Carex caespitosa*	–	VU	–	78	*Juncus alpinus*	–	VU	–
36	*C. globularis*	Rare[c]	nr	–	79	*Koeleria macrantha*	–	–	–
37	*C. obtusata*	–	CR	–	80	*Lamium album*	–	–	–
38	*C. rostrata*	–	–	–	81	*Lathyrus palustris*	VU	VU	–
39	*C. vaginata*	VU	Rare[c]	–	82	*L. pratensis*	–	–	–
40	*C. vesicaria*	–	–	–	83	*Ledum palustre*	–	VU	–
41	*Carum carvi*	–	–	–	84	*Ligularia sibirica*	Rare[c]	nr	–
42	*Cerastium arvense*	–	–	–	85	*Linnaea borealis*	–	VU	–
43	*C. cerastoides*	–	–	–	86	*Lycopodium annotinum*	–	–	–

(cont.)

Table 4. Continued.

No	Species	IUCN Categories[a] PL	G	MN[b]	No	Species	IUCN Categories[a] PL	G	MN[b]
87	*L. clavatum*	–	VU	R[b]	125	*Pyrola rotundifolia*	–	VU	–
88	*L. complanatum*	–	–	VR[b]	126	*Ranunculus repens*	–	–	–
89	*Maianthemum bifolium*	–	–	–	127	*R. reptans*	VU	CR	–
90	*Medicago falcata*	–	–	–	128	*Rhodiola rosea*	–	Rare[c]	–
91	*Milium effusum*	–	–	–	129	*Rhodobryum roseum*	–	nt	–
92	*Moneses uniflora*	–	–	–	130	*Rhytidium rugosum*	–	VU	–
93	*Medicago falcata*	–	–	–	131	*Ribes nigrum*	–	–	–
94	*Myriophyllum spicatum*	–	–	–	132	*R. rubrum*	–	–	–
95	*Neottianthe cuculata*	Rare[c]	nr	VR[b]	133	*Rubus saxatilis*	–	–	–
96	*Odontides rubra*	–	–	–	134	*Rumex acetosa*	–	–	–
97	*Oncophorus wahlenbergii*	–	EW	–	135	*R. acetosella*	–	–	–
98	*Oxalis acetosella*	–	–	–	136	*Salix caprea*	–	–	–
99	*Paris quadrifolia*	–	–	–	137	*Sanguisorba officinalis*	–	–	–
100	*Parnassia palustris*	–	VU	–	138	*Saussurea alpina*	Rare[c]	Rare[c]	–
101	*Pedicularis verticillata*	–	–	–	139	*Scirpus radicans*	–	VU	–
102	*P. sceptrum-carolinum*	EN	EN	–	140	*Scutellaria galericulata*	–	–	–
103	*Pinus sylvestris*	–	–	–	141	*Senecio vulgaris*	–	–	–
104	*Plantago major* subsp. *major*	–	–	–	142	*Sphagnum squarrosum*	–	nt	–
105	*Pleurozium schreberi*	–	–	–	143	*Stellaria crassifolia*	–	CR	–
106	*Poa nemoralis*	–	–	–	144	*S. graminea*	–	–	–
107	*P. palustris*	–	–	–	145	*S. palustris*	–	VU	–
108	*P. pratensis*	–	–	–	146	*Tanacetum vulgare*	–	–	–
109	*Polygonatum odoratum*	–	–	–	147	*Taraxacum officinale*	–	–	–
110	*Polygonum aviculare*	–	–	–	148	*Thalictrum minus*	–	–	–
111	*P. hydropiper*	–	–	–	149	*Th. simplex*	–	EN	–
112	*P. lapathifolim*	–	–	–	150	*Thlaspi arvense*	–	–	–
113	*P. viviparum*	–	–	–	151	*Trientalis europaea*	–	–	–
114	*Polygala hybrida*	DD	nr	–	152	*Trisetum sibiricum*	Rare[c]	nr	–
115	*Polytrichium commune*	–	nt	–	153	*Utricularia vulgaris*	–	VU	–
116	*P. juniperinum*	–	–	–	154	*Vaccinium uliginosum*	–	–	–
117	*Populus tremula*	–	–	–	155	*V. vitis-idaea*	–	–	–
118	*Potamogeton gramineus*	–	EN	–	156	*Valeriana officinalis*	–	–	R[b]
119	*Potentilla anserina*	–	–	–	157	*Veronica anagallis-aquatica*	–	–	–
120	*Primula farinosa*	CR	VU	–	158	*V. longifolia*	–	VU	–
121	*Pteridium aquilinum*	–	–	–	159	*Vicia cracca*	–	–	–
122	*Ptilidium ciliare*	–	nt	–	160	*Viola biflora*	–	–	–
123	*Ptilium crista-castrensis*	–	nt	–	161	*Woodsia ilvensis*	CR	EN	–
124	*Pylaisia polyantha*	–	VU	–					

[a] IUCN Red List Categories (1994): EW – extinct in the Wild; CR – critical; EN – endagered; VU – vulnerable; DD – data deficient; nt – near threatened. nr = now record.

[b] Mongolian Red Data List: R – rare; VR – very rare.

[c] Rare – IUCN red List (1994). Taxa with small world populations that are not at present Endagered, Vulnerable or Very rare, but are at risk. These taxa are usually localised within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

live in open grasslands (n = 27). Four species of the *Mongolian Red Book* occur also in Germany, listed in Germany as endangered (*Lycopodium complanatum*), vulnerable (*Lycopodium clavatum*), and not threatened (*Valeriana officinalis*).

The conservation status of the Eurasian plant species at Khonin Nuga are listed in Table 4 for Poland and Germany.

About one third of the palaearctic species from our study area in Khonin Nuga are classified in Germany as threatened (see Fig. 11).

Butterfly community

Species richness and biogeography

In the 1999 and 2000 season we captured 132 species from 6 families (Table 5); 5 species have not been identified yet. Our survey presents the first systematic captures of the butterflies of West Khentii (cf. Forster 1968). The study site covers an area of about 100 km^2. Assuming approximately 207 butterfly species altogether in Mongolia (Moenchbayar 1999), nearly half of the whole butterfly fauna of Mongolia are found around our research station. The high species richness in our region may be attributed to the following:

(1) relatively high rainfall;
(2) spatial heterogeneity of habitats;
(3) overlapping of habitats along gradients;
(4) the naturalness of the region;
(5) great extension of habitats.

Table 5. Species richness of butterfly families in Khonin Nuga.

Family	Species number
Hesperiidae	5
Papiolionidae	4
Pieridae	17
Satyridae	26
Nymphalidae	38
Lycaenidae	42
Sum	132

A list of the species identified so far is given in Appendix. D'Abrera (1990, 1992, 1993) and Tuzov (1997) were used for determination; uncertain species were confirmed by Mey and Kuenner[5].

[5] Museum of Natural Science, Humboldt University of Berlin, 10115 Berlin, Germany.

Table 6. Classification of butterfly distribution into four zoogeographic regions.

Zoogeographic region	Known geographic distribution
Palaearctic	Europe and Asia, tropics excluded. Often known only from certain countries.
Holarctic	Europe, Asia, and North America, circumpolar. Some species only known from Siberia and Canada.
Central Asia	Known from countries in Central Asia.
East Asia	East Siberia, Korea, Japan, partly China.

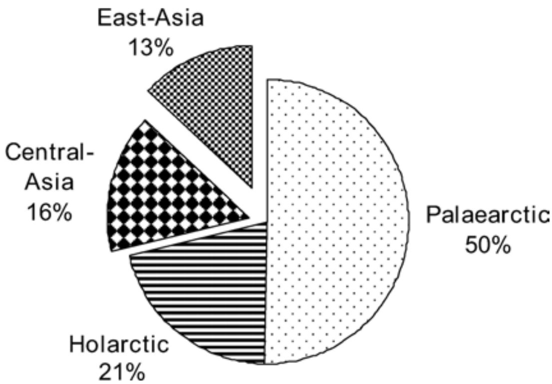

Fig. 12. Biogeography of butterflies of West Khentii, Mongolia (n = 85).

A rough classification of the geographic range of the species was given, based on D'Abrera (1990, 1992, 1993). We formed four groups (Table 6). Even though the classification is not unequivocal for all species, the zoogeographic description of the fauna of West Khentii will not change markedly (Fig. 12). It belongs to the Transbaikal bioregion (Sokolov & Semenova 1986).

Phenology and habitats

Each capture was assigned to a habitat described above in Fig. 3. Locations on the border of two habitat types or with dry and wet patches on a micro-scale (< 0.1 ha) have been classified as grassland mosaic (GM). Table 7 lists Fisher's alpha diversity indices (Williams 1964). The relation of captured specimens to species is shown in Fig. 13.

Table 7. Diversity of the butterfly community in different habitats. The index shows the alpha-diversity from the log series (Williams 1964). Explanation of habitats is given in legend of Fig. 13.

	GM	HM	MDS	MF	MS	RW	WG	Total
alpha-diversity	30.18	21.61	32.0	15.54	29.0	11.0	31.0	35.34

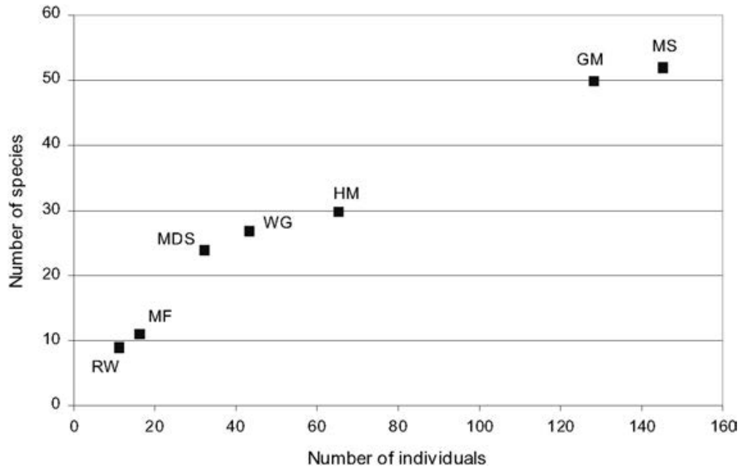

Fig. 13. Butterfly species accumulation for individuals captured in the different habitats. GM – grassland mosaic of mesophilous and dry grassland, HM – herb meadows, MDS – mountain dry steppe, MF – mountain forest, MS – meadow steppe, RW – riparian woodland, WG – wet grassland.

William's alpha index (Fisher *et al*. 1943) is sensitive to species richness but less so to sample size. The highest diversity was found on the mountain dry steppe, even though the sample was small there. The rather low differences in alpha-diversity between habitats can be explained by the small sample size. We do not expect many more species to be found in the region, however. Another reason for the low difference could be the natural proximity of the classified habitats. A transect of about 500 m can cross the different habitat types MDS, HM, WG, RW, and MS. A sharp delimitation of adult flight areas does not seem possible in this natural landscape.

In contrast to Western and Central Europe, the climate in Mongolia is strongly continental. Frost occurs in May and from September on. The vegetation period appears to be shorter than in Western and Central Europe, but high insolation enables some butterfly species to complete at least two generations per year. We met the adults of some species in May and again in July and August. Some species have their flight period in spring (May)[6] and autumn (September) as well (Table 8). Figure 14 shows the significant difference in body size between the two periods for the species *Cupido argiades*, indicating two different generations.

Our data about the phenology of the adult butterflies correspond to the references for most of the species. In Mongolia, as in Europe, the overwintering stage for some species is the adult. Many species seem to have only one generation in Khonin Nuga, whereas they are known in Western and Central Europe as bivoltine or multivoltine (*Aricia agestis*, *Boloria selenis*, *Lopinga deidamia*, *Plebejus argyrognomon*, *Polyommatus thersites*).

[6] D. Myagmarsuren, the ranger of Khonin Nuga, observed flying butterflies in March.

Table 8. Flight period of the butterfly species of Khonin Nuga which were caught at least in two months in 1999. The full species list with names of authors is shown in Appendix 1. w – overwintering as adults, uv – univoltin, bv – bivoltin, mv – multivoltin, more than two generations per year are possible, VI-VIII – flight period from June to August, 22d – average life span of adults in days, —— – no information available.

Species	May	June	July	August	Sept.	Life cycle in Western and Central Europe according to references
Aglais urticae		X	X	X	X	II–XI[a], w, bv[b], mv[a], uv in high altitudes[a], 320d[c]
Aphantopus hyperantus			X	X		VI–VIII[a,] , uv[c], 20d[c]
Aporia crataegi		X	X			VI–VII[a], V–X[d], uv[a, c], mv[d], 10d[c]
Aricia agestis			X	X		VI, VIII, IX–X[a], mv[a, c], 22d[c]
Boloria angarensis			X	X		——
Boloria selenis			X	X		IV–IX[d], bv[d]
Brenthis ino			X	X		VI–VIII[a], uv[c], 16d[c]
Coenonympha amaryllis			X	X		VI–VIII[d]
Coenonympha oedippus		X	X			VI–VIII[d], uv[c], 12d[c]
Colias aurora		X	X	X		——
Colias hyale		X		X	X	V–X[a], mv[a, c], 18d[c]
Colias tyche	X			X	X	VI–VII[d]
Cupido argiades	X	X	X	X		IV–IX[a], mv[a, c], 20d[c]
Erebia neriene			X	X		VII–VIII[d]
Fabriciana niobe			X	X		VI–IX[a], uv[a, c], 18d[c]
Glaucopsyche lycormas	X	X				——
Inachis io	X		X	X		I–V, VII–VIII, IX–XII[a], w, mv[a], bv[c], 320d[c]
Kretania eurypilus				X	X	——
Leptidea sinapis	X		X			IV–X[a, d], bv[a, c], 12d[c]
Lopinga achine		X	X			VI–VIII[a], uv[a, c], 12d[c]
Lopinga deidamia		X	X			VI–VIII[d], bv[d]
Lycaena vigaureae			X	X	X	VI–IX[a], uv[a, c], 32d[c]
Mellicta aurelia			X	X		VI–VII[a], uv[a, c], 18d[c]
Mesoacidalia aglaja			X	X		VI–VIII[a], uv[a, c], 20d[c]
Minois dryas			X	X	X	VII–VIII[a], VI–IX[d], uv[a, c], 25d[c]
Neptis rivularis		X	X			VI–VII[a], uv[a]
Nymphalis antiopa	X			X	X	IV–X[a], III–VI, VII–IX[c], w, uv[a, c], 300d[c]
Nymphalis polychloros	X		X		X	III–V, VII–X[a], w, uv[a, c], 300d[c]
Nymphalis vau-album	X		X	X		——
Oeneis fulla	X		X			V–VI[d]
Oeneis nanna	X	X				VI–VII[d]
Papilio machaon	X		X		X	IV–X[a], bv[a], uv in high altitudes[a], uv[8], uv-mv[c], 18d[c]
Parnassius nomion			X	X		VII–VIII[d]
Pieris tadjika				X	X	VI–VII[d]
Plebejus argyrognomon			X	X		V–VI, VII–VIII[a], bv[a], uv–mv[c], 16d[c]
Plebejus subsolanus	X		X	X	X	——
Polygonia c-album	X			X		III–X[a], w, bv[a], uv–bv[c], 320d[c]
Polyommatus eumedon			X	X		V–VIII[a], uv[a, c], 20d[c]

Table 8. Continued.

Species	May	June	July	August	Sept.	Life cycle in Western and Central Europe according to references
Polyommatus icadius	X			X		—
Polyommatus semiargus		X	X	X		V–X[a], mv[a], uv–mv[c], 16d[c]
Polyommatus thersites		X		X		IV–VI, VII–IX[a], bv–mv[a, c], 20d[c]
Polyommatus venus			X	X		—

[a] Schweizerischer Bund für Naturschutz (1987); [b] Dennis (1992); [c] Settele *et al.* (1999); [d] Tuzov *et al.* 1997.

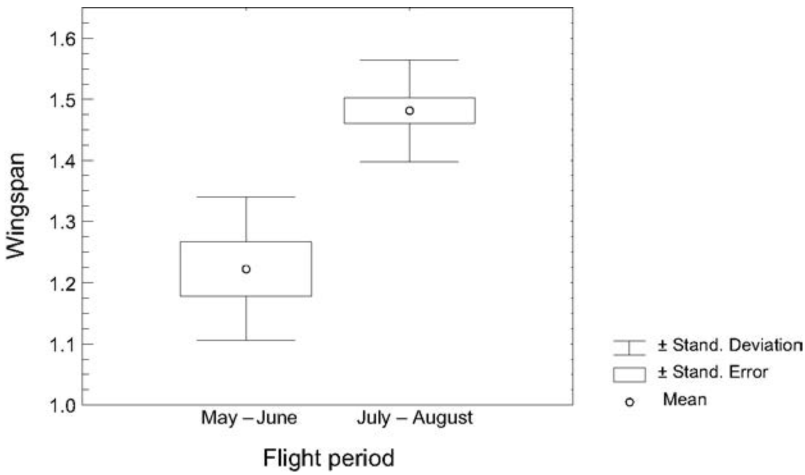

Fig. 14. Mean wingspan (mm) of *Everes argiades* Pallas captured around Khonin Nuga, during two flight periods. The difference was significant (Mann-Whitney *U*-test, $p = 0.000005$; Statsoft 1995).

Certain species appear late in the year in Khonin Nuga although they start their flight period early in Europe (*Pieris tadjika, Polyommatus eumedon*). A few species appear early in the year in Khonin Nuga; this differs from the data of references (*Colias tyche*, *Oeneis nanna*). *Minois dryas* perhaps can manage two generations in Khonin Nuga.

Population structure and population biology

Preliminary recapture experiments revealed high mobility for most butterflies. Of 277 specimens (presenting 10 species) released we recaptured 36 (13%) within 8 days. Recapture rates of less mobile individuals are known to reach 30% (Fischer *et al*. 1999), and recapture rates up to 63% (maximum) even for mobile species are attained (Vogel 1998). The overall low recapture rate in Khonin Nuga indicates the high mobility of most species[7], not limited by sharp habitat boundaries. We could observe many butterflies en-

[7] We do not infer a high mortality rate because we recaptured marked specimens after 8 days.

tering sparse secondary taiga forest straight ahead. Dry grasslands change to wet grasslands without distinct transitions. We suggest that most butterfly species live in large populations, at least in metapopulations ranging over hundreds of kilometers.

Maculinea teleius was investigated in more detail because the biology of *Maculinea* and its conservation have been intensively studied in Europe (Thomas 1984; Clarke *et al*. 1997; Figurny-Puchalska & Woyciechowski 1998) but not in Asia where open landscapes remained unchanged. Research in Asia may prove crucial to a better understanding of *Maculinea* conservation problems in Europe. Until now we found in addition to *M. teleius* only few specimens of *M. cyanecula* Eversmann, although known food plants of the genus *Thymus*, *Gentiana* and *Sanguisorba* all occur. Caterpillars of *M. teleius* were found only on flower heads of *Sanguisorba officinalis*, as in Europe. *Sanguisorba* occurs not only in wet grassland but also in mesophilous to dry grassland on slopes, and invades the scarce secondary *Larix-Betula* forest as well. The density of caterpillars increases significantly with the availability of flower heads. The highest population density of *Sanguisorba* is found in herb meadows and wet grasslands.

Myrmica scabrinodis, the obligatory host ant of *M. teleius*, does not occur at our study site. The *Myrmica* species we observed in the vicinity of *Sanguisorba* belong to *M. angulinodis*, *M. forcipata* and *M. arnoldi*. A fourth *Myrmica* species has not been identified yet. Experiments with adoption of *Maculinea teleius* caterpillars were conducted with two *M. angulinodis* nests. Two weeks after leaving the flowers, one caterpillar was found in the brood chambers of one of the colonies (Fig. 15). Our data suggest that the *M. an-*

Fig. 15. The larvae of *Maculinea teleius* Bergstr. feed first on *Sanguisorba officinalis* L. obligatory second host in Europe is the ant species *Myrmica scabrinodis* Nylander. We now have evidence of a new host ant: *Myrmica angulinodis* (see picture). The butterfly larva preys on the brood of the ants but is tolerated because of its attractive scent glands.

gulinodis ant is a host for *M. teleius*. Numerous nests and foragers of this species were found in habitats where the caterpillars were present in *S. officinalis* flower beds. *Myrmica angulinodis* is known only from Central and Western Asia (Radchenko 1994). In Europe, each *Maculinea* species usually depends on a specific host species of *Myrmica* (Thomas *et al*. 1989).

Conservation status of the palaearctic populations

About half of the species found in West Khentii occur also in Central Europe (see Fig. 14). On the species level, most of them are listed in Germany in the *Red Data Book* as threatened (see Fig. 16). Because the landscape is unchanged in northern Mongolia, we assume that these same species are not yet threatened there (see also the section above about population structure). Therefore Mongolia has a high potential for maintenance of biodiversity, which in Central Europe is at risk.

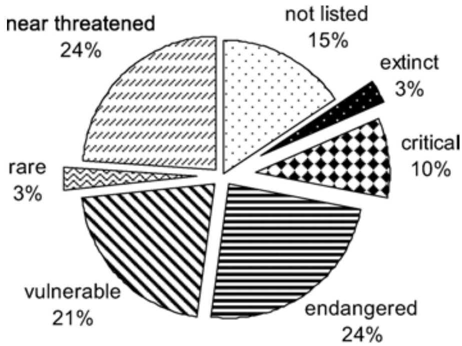

Fig. 16. Percentages of the different categories of threat to the palaearctic butterfly species living in Germany (n = 47). Data from Bundesamt für Naturschutz (1998). For the explanation of the categories see legend in Appendix.

The secure position of butterflies in northern Mongolia does not replace the need to preserve those species in Germany. They differ genetically (Figurny-Puchalska *et al*. 2000), and conservation should avert threats to species in their whole range. For some species we can derive valuable information for their conservation needs in Central Europe by comparing their population biology in natural conditions. Attention will be paid in particular to species with especially high threatened status (Munguira *et al*. 1993), such as *Maculinea teleius* (score of 14[8] and *Lycaena helle* (score of 6); both are typical wetland lycaenids. The key factor in determining the size, stability and persistence of *Maculinea* species in Europe is the state of the local community of *Myrmica* ants (Elmes *et al*. 1998). Due to differences in the host spectrum, we do not know the status of *Maculinea* species in Mongolia. The ecology of the potential host ant species is not yet

[8] The highest scores given to the species of conservation concern were 15, the lowest 1.

studied. In terms of the vulnerability of the species in Europe, Kudrna (1986) reports that *Coenonympha hero* and *C. oedippus* are even more threatened than *Maculinea teleius* and *Lycaena helle* (see Appendix). The species with the highest chorological index (Kudrna 1986), indicating low resistance due to their occurrence in isolated populations or very restricted ranges in Europe, are *L. helle*, *Polyommatus eros*, *Pieris chlorodice*, *Boloria freija*, *B. selenis*, *Coenonympha amaryllis*, *C. hero* and *C. oedippus*.

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Appendix

List of the butterfly species captured in 1999 and 2000 in the surroundings of Khonin Nuga, West Khentii, North Mongolia. The habitats in which the species were found are indicated as follows: MF – mountain forest, MS – meadow steppe, MDS – mountain dry steppe, RW – riparian woodland, HM – herb meadows, HM^m – herb meadows near Minji, WG – wet grassland, GM – grassland mosaic of mesophilous and dry grassland. CI – Chorological index (Kudrna 1986), describing the biogeographic disposition of European species. It is composed of the range size, range composition and range affinity. The CI value increases with the reduction of the biogeographic disposition (i.e., the natural resistance potential) of the species. The highest possible value is 14 (Kudrna 1986). VI – Vulnerability index (Kudrna 1986), composed of the decline recorded, habitat vulnerability and species vulnerability. The VI value increases with the increase of the anthropogenic threat, and the maximum value is 6 points (Kudrna 1986).

Species name	Geographic range	Habitat	Threat status[a]	CI	VI
HESPERIIDAE					
Carterocephalus palaemon Pallas	Holarctic	GM; MS; WG	Nt		
Erynnis tages Linnaeus	Palaearctic	MDS; MS	Nt		
Ochlades venatus Bremer & Grey	East-Asia	RW			
Pyrgus maculatus maculatus Bremer & Grey	Central-Asia	MDS; MS; HM			
Pyrgus malvae Linnaeus	Palaearctic	MS; HM	Nt		
PAPILIONIDAE					
Papilio machaon Linnaeus	Holarctic	GM; MDS; MS	Nt	5	–
Papilio xuthus Linnaeus	East-Asia	HM			
Parnassius apollo Linnaeus	Palaearctic	MDS; MF	CR	8	3
Parnassius nomion nomion Fischer de Waldheim	Central-Asia	MS; GM; MDS			
PIERIDAE					
Anthocharis cardamines Linnaeus	Palaearctic	MS	0	5	–
Aporia crataegi Linnaeus	Palaearctic	MS, WG	Nt	5	–
Aporia hippa hippa Bremer	East-Asia	RW			
Colias alpherakii Staudinger	Central-Asia	HM, MS			
Colias aurora Esper	East-Asia	MS, WG, MF			
Colias hayle Linnaeus	Palaearctic	GM, MS, WG	0	6	–
Colias palaeno Linnaeus	Holarctic	HM^m	EN	8	4
Colias poliographus Motschulsky	Holarctic	HM^m			
Colias staudingeri Alpheraky	Holarctic	RW			
Colias heos Herbst	Holarctic	HM, MS			
Colias tyche Boeber	East-Asia	GM			
Leptidae morsei Fenton	Palaearctic	GM, HM		8	–
Leptidae sinapis Linnaeus	Palaearctic	MS, RW, WG	Nt	5	–
Pieris chlorodice Huebner	Holarctic	HM		10	–
Pieris daplidice Linnaeus	Palaearctic	GM	0	5	–
Pieris napi Linnaeus	Holarctic	MS	0	4	–
Pieris tadjika Grum-Grschimailo	Central-Asia	GM,MDS, MS			
SATYRIDAE					
Aphantopus hyperantus Linnaeus	Palaearctic	MS, HM, MDS, MF, WG	0	6	–
Boeberia parmenio Boeber	Central-Asia	MS, WG			

(cont.)

APPENDIX. Continued.

Species name	Geographic range	Habitat	Threat status[a]	CI	VI
Coenonympha amaryllis Stoll in Cramer	Central-Asia	GM, MS		11[e]	–
Coenonympha glycerion Borkhausen	Palaearctic	MS, GM, WG, MDS	VU	7	–
Coenonympha hero Linnaeus	Palaearctic	HM, MDS	CR	10	5
Coenonympha oedippus Fabricius	Palaearctic	MS, MF, WG	EW	12	5
Erebia aethiops Esper	Palaearctic	MS, HM	VU	7	–
Erebia jeniseiensis Trybom	East-Asia (Japan)	GM, MS		–	–
Erebia konzhantschikovi Sheljuzhko	Holarctic (Eastern Siberia)	HM[m]			
Erebia ligea Linnaeus	Palaearctic	MF	Nt	6	–
Erebia medusa Denis & Schiffermueller	Palaearctic	MS, GM, WG	Nt	6	–
Erebia neriene Boeber	East-Asia	GM, MS, MDS, HM, WG			
Erebia niphonica Janson	East-Asia (Japan)	MS			
Hyponephele lycaon Rottemburg	Palaearctic	RW, MS	EN	7	–
Hyponephele pasimelas Staudinger	East-Asia	GM			
Lasiommato maero Linnaeus	Palaearctic	MF	Nt	5	–
Lopinga achine Scopoli	Palaearctic	MS, HM	CR	8	–
Lopinga deidamia Eversmann	East-Asia (Japan)	MS, WG			
Minois dryas Scopoli	Palaearctic	MDS, MS, WG	EN	8	1
Oeneis mongolica Oberthuer	East-Asia (Mongolia)	MS			
Oeneis nanna Menetries	East-Asia	GM, MS			
Oeneis norna Thunberg	Holarctic	GM		11	–
Oeneis tarpeia Pallas	East-Asia (Mongolia)	HM			
Oeneis sculda Eversmann	Holarctic	MS, HM			
Oeneis urda Eversmann	East-Asia	GM			
Thriphysa phryne Pallas	Palaearctic (Central-Asia)	MS		9	–
NYMPHALIDAE					
Aglais urticae Linnaeus	Palaearctic	MDS, MS, WG, GM	0	4	–
Araschnia levana Linnaeus	Palaearctic	RW	0	7	–
Argynnis paphia Linnaeus	Palaearctic	MS, MF, MDS, GM	0	5	–
Boloria angarensis Erschoff	East-Asia (Siberia)	GM, MDS		8	–
Boloria eunomia Esper	Holarctic	HM, WG	EN	10	3
Boloria euphrosyne Linnaeus	Palaearctic	HM, RW	VU	5	–
Boloria freija Thunberg	Holarctic	MF		11	–
Boloria oscarus Eversmann	Holarctic	MS			1
Boloria selene Denis & Schiffermueller	Palaearctic	MS, HM, WG	Nt	5	–
Boloria selenis Eversmann	Palaearctic	MDS, RW, GM		11	–
Boloria titania Esper	Holarctic	HM, RW	VU	10	–
Brenthis daphne Denis & Schiffermueller	Palaearctic	HM, MDS, RW	CR	8	–
Brenthis ino Rottemburg	Palaearctic	MS, MDS, HM, GM, MF, WG	Nt	7	–
Euphydryas aurinia Rottemburg	Holarctic	RW	EN	8	2
Euphydryas intermedia Menetries	Holarctic	RW, GM			

Appendix. Continued.

Species name	Geographic range	Habitat	Threat status[a]	CI	VI
Euphydryas maturna Linnaeus	Holarctic	HM, WG, GM, RW	CR	9	2
Fabriciana adippe Denis & Schiffermueller	Palaearctic	MS	VU	5	–
Fabriciana niobe Linnaeus	Palaearctic	MS, GM, MDS, WG	EN	5	–
Inachis io Linnaeus	Palaearctic	MS, RW, MDS, GM	0	4	–
Limenitus populi Linnaeus	Palaearctic	MS	EN	7	2
Melitaea arcesia Bremer	Central-Asia	HM			
Melitaea cinxia Linnaeus	Palaearctic	MS, MF, RW	EN	5	–
Melitaea diamina Lang	Palaearctic	WG, MDS	VU	7	2
Melitaea didyma Esper	Palaearctic	GM, WG	EN	7	–
Melitaea phoebe Denis & Schiffermueller	Holarctic	GM	EN	7	–
Mellicta athalia Rottemburg	Holarctic	WG, HM, RW	VU	5	–
Mellicta aurelia Nickerl	Palaearctic	HM	VU	9	–
Mellicta britomartis Assmann	Holarctic	MS, RW, MDS, GM	VU	9	–
Mellicta centralasiae Wnukowsky	Central-Asia (Siberia)	RW			
Mellicta plotina Bremer	Central-Asia (Siberia)	RW, MS			
Mesoacidalia aglaja Linnaeus	Palaearctic	HM, MDS, MS, WG	Nt	5	–
Neptis rivularis Scopoli	Palaearctic	HM, MS, MDS		9	2
Neptis sappho Pallas	Palaearctic	MF, MS		10	–
Nymphalis antiopa Linnaeus	Palaearctic	GM, MS, WG	Nt	6	–
Nymphalis polychloros Linnaeus	Palaearctic	RW, GM, HM	VU	6	–
Nymphalis vau- album Denis & Schiffermueller	East-Asia	HM, GM, MS, MF,RW			
Polygonia c-album Linnaeus	Central-Asia	MS, RW		5	–
Vanessa cardui Linnaeus	Holarctic	MS	0	4	–
Lycaenidae					
Agrodiaetus amandus Schneider	Palaearctic	MDS, HM, GM	0	7	1
Albulina orbitulus de Prunner	Palaearctic	GM, HM	R	9	–
Agriades diodorus Bremer	East-Asia	MDS			
Aricia agestis Denis & Schiffermueller	Palaearctic	HM, GM	Nt	7	–
Aricia allous? Hübner	Holarctic	RW			
Aricia eumedon Esper	Palaearctic	HM, MDS, MS, WG	EN	7	–
Cupido minimus Fuessly	Palaearctic	GM	Nt	6	–
Cupido osiris Meigen	Palaearctic	MS	EW	9	–
Cupido prosecusa Erschoff	Central-Asia	GM; MS; MDS			
Cyaniris bellis Freyer	Palaearctic	HM			
Everes argiades Pallas	Palaearctic	GM, HM, MS, MDS, MF, WG	EN	6	–
Everes fischeri Eversmann	Holarctic	MDS			
Glaucopsyche lycormas Butler	Central-Asia	GM, WG			
Kretania eurypilus Freyer	Holarctic	HM, MS		11	–
Lycaena alciphron Rottemburg	Palaearctic	HM	EN	7	–
Lycaena dispar Haworth	Palaearctic	RW, GM	EN	10	6

(cont.)

Species name	Geographic range	Habitat	Threat status[a]	CI	VI
Lycaena helle Denis & Schiffermueller	Palaearctic	GM, WG, RW, MS, HM	CR	10	4
Lycaena virgaureae Linnaeus	Palaearctic	GM, MS, MDS, HM	VU	7	–
Lycandra bellargus Rottemburg	Palaearctic	GM	VU	6	–
Maculinea cyanecula Eversmann	Central-Asia (Mongolia)	GM, MS			
Maculinea teleius Bergstraesser	Palaearctic	GM, MS	EN	8	3
Nordmannia pruni Linnaeus	Palaearctic	RW, HM	Nt	6	–
Plebeius argus Linnaeus	Palaearctic	MDS	VU	5	–
Plebeius argyrognomon Bergstraesser	Palaearctic	HM, GM, MS, WG	VU	7	–
Plebeius eversmanni Staudinger	Central-Asia	HM			
Plebeius idas Linnaeus	Palaearctic	MS	EN		
Plebeius nushibi Zhdanko	Holarctic	MDS			
Plebeius subsolanus Eversmann	East-Asia	GM, MS, HM, MDS, WG			
Polymmatus semiargus Rottemburg	Palaearctic	MDS, WG, RW	Nt	5	–
Polyommatus eros Ochsenheimer	Palaearctic [c]	GM	R	10	–
Polyommatus icadius Grum-Grschimailo	Central-Asia	GM, MS			
Polyommatus icarus Rottemburg	Central-Asia	GM, HM		4	–
Polyommatus loewii Zeller	Central-Asia	GM, WG, MS			
Polyommatus nepalensis Forster	Central-Asia (Nepal)	GM			
Polyommatus pseuderos Moore	Central-Asia	MS, GM			
Polyommatus thersites? Cantener	Palaearctic	RW	VU	8	–
Polyommatus venus Staudinger	Central-Asia	WG			
Scolitantides orion Pallas	Palaearctic	GM, CR	8	–	
Thechla betulae Linnaeus	Palaearctic	MS, MF		6	–
Thersamonolycaena violacea Staudinger	Central-Asia (Mongolia)	MDS			
Vacciniina kwaja ? Evans	Holarctic	MDS			
Vacciniina optilete Knoch	Palaearctic	GM	EN	8	3

[a] Threat status in Germany, data from Bundesamt fuer Naturschutz (ed.) 1998. The categories are: EW – Extinct in the wild, CR – critical, EN – endangered, VU – vulnerable, Nt – near threatened, e.g. declining, R – rare and range restricted, 0 = apparently not threatened; [b] species with their "headquarters" in Europe (Kudrna 1986); [c] species with their "headquarters" in Europe (Kudrna 1986); [d] found in May 2000; [e] the western border of the geographic range is S Urals.