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# Carabid communities in forests of North Korea: their general characteristics, horizontal and vertical zonation

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## Introduction

In spite of a great distance from Central Europe, North Korea (DPRK) shows some similar features to Central Europe. Although position of the Korean Peninsula between 34° and 43° N creates conditions for a warmer climate than in Central Europe, absence of a massive warm stream like Gulf stream in Europe, influence of cold northern streams from the Ochotic Sea, as well as cold winter winds from East Siberia make the climate in winter much colder on major part of the peninsula. As result of this, the average temperatures in January sink from 2° in South East to -21° in North East. On the contrary, the warm summer monsoons allow the average temperature in July to reach 21°-27°C, similarly as in the northern Mediterranean or Balcanic Peninsula. Geomorphologically, the north-eastern part of the country is relatively flattened and, in some places, has a similar character as the Central European Hercynicum, whereas the central and southern parts are more similar to Carpathians. Beside this, similarly as South Slovakia and Moravia are influenced by the Balcanian and Mediterranean flora and fauna, a remarkable influence of oriental faunistic elements is observed in the southern of DPRK, where they immigrate from the subtropical southernmost part of the Peninsula or from southern Japan. In contrast, the northern parts are under a strong influence of East Siberian fauna and flora and have predominantly character of dark taiga. Because of certain isolation of the Korean peninsula, there also exist some endemics. The enormous geographic and ecological diversity of the Korean peninsula make from it an extraordinarily interesting object of biological investigations.

As to the Carabid fauna of North Korea, very little has been published so far. The first notices comes from 1860-1870-ies, from the travels of Motschulsky and Bates. Small pieces of information are scattered in numerous taxonomic works (among the synthetic works e. g. BREUNING 1934-1937, HABU 1967, 1973, 1978, 1982A, 1982B, 1983, 1984, 1987, HAUSER 1921, JEDLIČKA 1962, 1963, 1965, KRYZHANOVSKIY 1983, KÜHNELT 1941, LAFER 1989, LINDROTH 1956, NETOLITZKY 1942-1943, UENO et al. 1999) which, however, are not dedicated specially to the (North) Korean fauna. The first works dealing specially with the (North) Korean Carabids appeared as early in late 20. century (IMURA & LEZUKA, 1992, KWON & LEE 1984, 1986, PAWLOWSKI, 1974).

The aim of this contribution is to present preliminary result of investigations of Carabid communities of North Korean forests carried out during two expeditions of Slovak Academy of Sciences to DPRK, to compare them with Central European conditions and qualitatively characterize their vertical zonation.

## Material and methods

Material was collected during two trips to North Korea (DPRK) from early September to early November 1986 and from early June to early July 1990. The beetles were collected mostly individually, under stones, laying pieces of wood, bark, in litter, on river banks or on light. In a limited scale, due to one-days excursions in majority of localities visited, pitfall trapping also could be used.

During that time, almost all areas open to foreigners (Myonhangsan, Kumgansan, Rjongseon, Chonmasan and Suyansan mountains, close surroundings of cities of Heaju, Nampo, Wonsan, Kaesong, Pjongjang and larger surroundings of Paektusan mountain and Samjion lake, Fig. 1) were visited, some of them repeatedly. Most localities visited laid at low or middle altitudes up to 500 m, only in Myonhangsan mountains and in Paektusan mountain and in its surrounding localities laying at higher altitudes or even above timber line could be studied.

Because of character of sampling, the species assemblages and coenotic position of individual species are tentatively reconstructed from material taken in several similar localities.

As phytocoenological basis for this study, the papers of KOLBEK et al. (2001, in press) were used. The plant communities are distinguished at the level of alliances or, if possible, associations. The zoological nomenclature is conformous with Kryzanovskij et al. (1995).

### Forest communities specifications

According to KOLBEK et al. (in press), majority of the localities visited belonged to the alliance *Rhododendron mucronulati-Pinaeon densiflorae*. These stands were distributed up to the altitude of 500-600 m and were mostly more or less anthropogenously influenced. Particularly the broad-leaved trees (oaks) were suppressed in these stands. These stands formed forest vegetation in surroundings of Pyongyang (Ryongson mountains), in lower parts of Myohyangsan mountains, in Suyansan (surroundings of Haeju) and Chonmasan mountains (surroundings of Kaesong), where transition to the more thermophilous forests of *Lindero Quercion mongolicae* occurred at lower altitudes.

The narrow valleys along the rivers and brooks flowing through the forests stand belonged to the association *Parthenicisso tricuspidati-Fraxinetum rhynchophyllae*. Stands of this association, however, formed only very narrow strips in the forests of *Rhododendron mucronulati-Pinaeon densiflorae* and never formed an analogy of extensive Central European floodplain forests. Association *Parthenicisso tricuspidati-Fraxinetum rhynchophyllae* probably represents the potential vegetation in the forest-like Potogang park at the margin of Pyongyang centre.

The forests in lower altitudes in the Kumgansan mountains belonged to the union *Lindero Quercion mongolicae*. These forest were also anthropogenically influenced in surroundings of human settlements. This type of forest includes the most xerophilous forests in southern parts of DPRK close to 38<sup>th</sup> parallel. At middle altitudes of Kumgansan mountains, this union was represented by the association *Saso Quercetum mongolicae* reaching up to altitudes of 600 m.

The stands at middle altitudes (around 1100-1200 m.) in the Suyansan and Myohyangsan mountains (39°-40° N) belonged the alliance *Pino koraiensis-Quercion mongolicae*. In localities visited in the Suyansan mountains, this union was represented by the association *Vaccinio Quercetum mongolicae*.

The highest altitudes (up 1900 m) of Myohyangsan mountains were covered by stands of the alliance *Abieti neprolepis - Piceion jezoensis*.

The stands at the lower altitudes in wider surroundings of Paektusan mountain (around 42° N) at altitudes of 1200-1400 m belonged to the union *Ledo decumbentis - Lariceto olgensis* or (at altitudes of 1360-1450 m) *Goodyero repentis- Piceetum jezoensis*. The park-like forest at altitudes of 1700-1800 m in Paektusan mountain, under the timber line, belonged to the association *Rhododendro aurei - Laricetum olgensis*. Above 1800 m, tundra-like vegetation covered slopes of this volcano. The vertical and horizontal zonation of the vegetation in the localities visited is schematised in fig. 2.

### Zoogeographical characteristic of Korean carabid fauna

Up to present 346 species (54,8 % of species found or probable in Czechoslovakia) of Carabids were recorded from whole Korean peninsula according different literary sources (KWON 1984). Obviously, the full species richness has not been discovered. A much larger number of species is known to occur in the adjacent area of Russian Cisamuria and Maritime region or in the Russian far East (Table 1, Fig. 3). Many of them will be found also in north eastern parts of Korean peninsula. A much larger number of species also occurs in Japan. Even if excluding about 200 strictly endemic species of the Trechitae supertribus, *Carabus* and *Colpodes* genera, there is more than 600 of species which could be also found particularly in the southern part of Korean peninsula. Even in course of this investigation, 22 species new for Korea, but occurring in adjacent countries were discovered.

The real number of Carabid species occurring in Korea may range, due to a great geographic diversity and total area of the country (almost 220 000 km<sup>2</sup>), between 600-700. Doubtless some endemic species will be also found there, as illustrated by a considerable number of species of the Tachyini tribus described recently (PAWLOWSKI 1974).

Table 1. Number of Carabid species recorded in Korea adjacent countries and in the former Czechoslovakia according to different authors.

Author	Region	Area in mil. km <sup>2</sup>	Species	Genera
Lafer 1989	Russian Far East	7.29	593	84
Kryzhanovskij et al. 1995	Cisamuria & Maritime Region	2.43	485	92
Lafer 1989	Korea	0.22	171	55
Kwon & Lee 1986	Korea	0.22	346	82
Uéno et al. 1999	Japan	0.38	818	176
Hürka 1996	Czechoslovakia	0.13	631	92

According to present knowledge, expansion of species from Northeast China and Russian Far East plays the deciding role in forming of Carabid fauna. of Korea. It is shown by number of all known species which decreases from the North to South and by an inverse trend in number of species of the s.c. truncatipenes group (a artificial collective name for supertribes Labiitae, Pentagonitae, Odacanthitae and subfamily Brachininae), whose representatives are mostly thermophilous and, in Korea, are of the oriental origin (Table 2).

Table 2. Different immigration tendency in all Carabids and in the mostly oriental representatives of the s.c. truncatipennes group (source data according Kwon 1986)

Region	Number of species	
	All Carabidae	"truncatipennes" only
North	227	6
Central	184	27
South & Chejudo Island	142	31

Most Carabid species known from in Korea are congeners of the species occurring in Central Europe. Few species are transpalearctic (e. g. *Carabus granulatus*, *Dolichus halensis*, *Pseudoophomus griseus*) or holarctic (*Loricera pilicornis*). However, there are large differences in species richness of some genera and in zoocenotic function of their species between Korea (East Asia) and Central Europe (Table 3).

Table 3. Comparison of species richness in some large Carabid genera in East Asia and Central Europe

	A	B	C	D
<b>Comparable</b>				
<i>Cicindela</i>	9	14	19	8
<i>Nebria</i>	13	11	15	8
<i>Carabus</i>	30	33	35	30
<i>Poecilus</i>	7	6	3	11
<i>Pterostichus</i>	63	31	72	44
<i>Bembidion</i>	49	25	52	77
<i>Amara</i>	43	13	14	54
<i>Harpalus</i> s. l.	48	28	27	47
<b>Richer in East Asia</b>				
<i>Synuchus</i>	10	10	15	1



<i>Curtonotus</i>	8	6	5	2
<i>Trichotichnus</i>	3	5	21	2
<i>Chlaenius</i>	13	18	27	9
<b>Richer in Europe</b>				
<i>Ophonus</i>	1			19
<i>Leistus</i>	1	1	5	10
<i>Dyschirius</i> s. l.	12	3	8	31
<i>Trechus</i>	4		6	20

Legend: A: Cisamuria and Maritime Region, Kryzhanovskij et al. 1995; B: Korea, Kwon & Lee 1986; C: Japan, Uéno et al. 1999; D: Czechoslovakia, Hůrka 1996

For example, *Dolichus halesis* occurring in Central Europe predominantly in arable land is a typical inhabitant of river shores in Korea. *Carabus granulatus*, which represents in Central European a typical component of floodplain forest fauna lowlands or penetrates there the field fauna of highlands, occurs in North Korea in highlands fields only.

Among the forest species, a large difference is in the *Synuchus* genus. In Central Europe it is represented only by *S. vivalis* which is, however, only recedent of subrecedent in all carabid communities at lower altitudes. In North Korea, 10-12 *Synuchus* species co-occur in carabid communities as dominant or subdominant species. A similar situation is in the genus *Trichotichnus*. The only abundant Central European species, *T. laevicollis*, is a subdominant - dominant species in forest communities from 3-6 vegetation tier. Five Korean *Trichotichnus* species often cohabit in one locality in forests at lower altitudes.

The role of typical European forest species of the genera *Abax* and *Molops* is overtaken by species of genera *Pterostichus*, *Trigonognatha*, *Pristosia* and *Synuchus* species.

The species of the genus *Trechus* which are particularly typical of European forests of 3-8 vegetation tiers species, have not in Korea any analogue abundant species.

## General patterns of community structure

### Body size structure

The Carabid communities in the North Korean forest consists mainly of the general *Carabus*, *Pterostichus*, *Synuchus*, *Pristosia* and *Trichotichnus*. The *Carabus* species play mainly the role of large (30-40 mm) predators. Only in the taiga-like forests they (*Carabus maclei*) also play role of middle sized predators (15-20 mm). The representatives of genera *Pterostichus*, *Trigonognatha*, *Synuchus* and *Pristosia* play role of middle sized (15-20 mm) or small (8-12 mm) predators. The *Trichotichnus* species play role of small (8-12 mm) predators. The niche of very small predators (2-5 mm) remains in most communities unoccupied. The only representative of this ecological group, *Epaphius ephippiatus*, occurred in the localities visited too rarely to may pay a similar role as the European *Trechus* species. In spite of this, the main common feature of the Central European and Korean Carabid communities - the body size structure - is very similar, particularly in forests at low altitudes.

### Spatial patterns of Carabid communities

The predominantly very steep slopes of north Korean mountains and impact of strong monsoon rains (they even arrange all the fallen pine needles laying on steep slopes into a vertical direction) lasting from late June to mid-August do not create so suitable conditions for Carabidae as in Central Europe. Similarly rich communities are developed in North Korean forest only locally in flat plateaus. Out of them Carabids can be observed only occasionally. On such places mostly only representatives of the genera *Synuchus* or *Trichotichnus* are occurring more regularly. The expressively patchy distribution of the North Korean Carabid communities is also supported by soil trophicity. The soils in North Korean forest developed almost exclusively on acid mother rocks. It is why the forest communities correspond mostly to the Zlatnikian tropical row A and B. As a result of this, the abundance of Carabids is everywhere relatively low. Such rich Carabid

communities, like in the Central lime stone areas (Slovenský kras cars, some parts of Malá Fatra mountains, Pavlovské kopce hills, Moravský kras carst) do not exist in North Korea.

#### *Ecological vicariance of some species*

The North Korean Carabid communities in forests consists exclusively from species whose geographic distribution is restricted to East Asia. There exist, however, pairs of some East Asian and (Central) Europeans species which take a very similar position in the communities. Some of them are even systematically related:

- an analogue of *Carabus coriaceus*, a large species preferring forest of low vegetation tiers, is *Carabus jankovskii* or *C. smaragdinus*,
- an analogue *Carabus nemoralis*, a middle sized, very tolerant forest species characteristic of low vegetation tiers, is *C. sternbergi*,
- an analogue of *Pterostichus oblongopunctatus*, an eurytopic forest species, is *Pterostichus transsibiricus*,
- an analogue of *Pterostichus melas* or *Pterostichus melanarius* in european (montane) forest is *Pterostichus eobius* in Korea,
- an analogue of *Poecilus cupreus* a species of open areas but occurring also in man-damaged floodplain forests, is *P. fortipes*, which however shows a stronger preference for forests, than both European species,
- an analogue of the European floodplain forest species *Platynus assimilis* and *Platynus krynickýi* is *Platynus magnus*, which shows even a similar antropotolerance as *P. assimilis* in urban parks.

#### **Horizontal and vertical zonation of Carabid communities**

- A) In the central and southern parts of DPRK, at the latitudes of about 39°-40° N, three groups of carabid communities can be distinguished along the altitudinal range of 0-1900 m (Fig. 2).
1. The forest of the alliances *Lindero Quercion mongolicae* and/or *Rhododendro mucronata* *Piceion densiflora* are characterised by the species *Carabus jankovskii*, *Carabus smaragdinus*, *Carabus sternbergi*, *Carabus seishinensis*, *Carabus canaliculatus*, *Carabus tuberculatus*, *Synuchus congruus*, *Synuchus agonus*, *Synuchus nitidus*, *Synuchus intermedius*, *Synuchus orbicollis*, *Synuchus rjabuchinu*, *Synuchus cycloderus*, *Synuchus chinensis*, *Synuchus evocatus*, *Trichotichnus corruscus*, *Leistus niger*, which play role of dominant or subdominant species. The recedent or subrecedent species are *Pristosia vigil*, *Diplous sibiricus*, *Pterostichus sulcitaris*, *Pterostichus klickai*, *Pterostichus microcephalus*, *Pterostichus interruptus*, *Triigonognatha levis*, *Cymindis daimio*. Among these species, *Carabus sternbergi*, *Synuchus congruus*, a *S. agonus* and *T. corruscus* are most frequent. In lighter, less dense stands *Poecilus fortipes* also occurs.
  2. The forests of *Pino koraensis Quercion mongolicae* in the altitudinal range of 600-1400 m are characterised by combination of the species *Carabus sternbergi*, *Carabus fraterculus*, *Pterostichus pertinax*, *Pterostichus dauricus*, *Pterostichus eobuius*, *Trichotichnus congruus* and absence of *Carabus jankovskii* and *Carabus smaragdinus*. *Pterostichus pertinax* plays role of a dominant to eudominant species.
  3. The forest of *Abieti nephrolepis Piceion jezoensis* in the altitudinal range of 1400-1900 m are characterised by predominance of *Acoptolabrus constricticollis* and presence of *Acoptolabrus starck* and *Pterostichus pertinax*. These species occur, however, only in close stand. In the summit zone, where the canopy is freer and where *Pinus pumila* occurs, abundance of Carabids is very low.
- B) In the northern part of DPRK, at the latitudes around 42° N, 1-2 groups of species can be distinguished:

1. The forests of *Ledo decumbentis Lariceto olgensis* at the altitudinal range of about 1000-1400 m are characterised by the species *Synuchus dulcigradus*, *Trichotichnus congruens*, *Pterostichus eobius* *Pterostichus transbaicalicus*, *Pterostichus tuberculiger*, *Pterostichus dauricus*

Presence of the same species is also characteristic for the communities in the stands of *Goodyero Lariceto olgensis* in the altitudinal range of 1500-1600 m and *Carici Abietetum* in the altitudinal range up to 1700 m. These forest communities could be distinguished from the precedent one only on base of quantitative characteristics, which however could not be obtained due to character of excursions.

2. The communities of *Rhododendro aurei Laricetum olgensis* in the altitudinal range of 1600-1800 m were characteristic by the presence of *Carabus maclei* and *Carabus aurocinctus*. These species are, however, to be expected also in lower altitudes in precedent three types of forest communities in lower quantities and in community with the species given above. The very small number recorded in this type of forest is due a very short excursion and collecting in mid-October.

- C. Carabids living in stands of *Parthenocisso tricuspidati - Fraxineto rhynchophylae* are limited only on narrow strips of this vegetation type along creek or in spring areas. Their composition in such habitats is strongly influenced by communities living in adjacent stands of alliance *Rhododendro mucronatae Pinion densiflorae*. Therefore they do not form there analogous communities to those of the Central European lowland forests. In spite of this, in lower altitude they may differ from the adjacent communities by presence or even high abundance of *Nebria coreica* and *Pterostichus sulcitaris*, where as in higher altitudes (Myohyangsan mountains) by *Nebria ochotica*, which is however a typical river bank species and did not belong to the proper forest fauna. Other species occurring in this type of stand are common with forest of *Rhododendro mucronulati Pinion densiflorae*.

Stands of *Parthenocisso tricuspidati - Fraxineto rhynchophylae* also may represent the potential vegetation on floodplains, where the forest vegetation does not exist in the present Korean landscape. It is however, to be expected, that in some places a spontaneous or artificially restoration of such communities can start. An example of this is the Potogang park at the margin of Pyongyang centre. This park shows many features similar to the parks Lužánky in Brno or Sad J. Kráľá in Bratislava. Due to it a species combination of *Platynus magnus*, *Chlaenius pallipes*, *Chlaenius virgulifer*, *Pseudoophonus capito*, *Perosophus jesoensis* occurring in this park may be hypothetically considered to represent the core of such natural communities. Particularly interesting in this case is predominance of *Platynus magnus* which resembles the high dominance of *Platynus assimilis* in Lužánky and Sad J. Kráľá., as well in some type of natural floodplain forests in Central Europe (c.f. ŠUSTEK 1994).

## Conclusions

Carabid communities in Korean peninsula show a very similar general features vertical zonation as in Central Europe. Similarly as in Central Europe (c. f. ŠUSTEK 2000), three groups species qualitatively distinguished along the altitudinal gradient of 0-1900 m in the southern and central part of the peninsula. In the northern part of the peninsula, which belongs to Siberian fauna and flora and is more similar to North-East European conditions, 1-2 groups of species can be qualitatively distinguished along the altitudinal gradient of ca. 1200-1800. They fit to a high degree the scheme of horizontal and vertical zonation of forest vegetation. In both cases the more detailed characteristic of their zonation could be characterised only quantitatively on the base of long-termed observations. There are however not strongly developed azonal communities of alluvia, which would be analogous to (Central) European conditions. The communities have a very similar pattern of body size structure as in (Central) Europe.

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Following figures are included in the CD-version of papers.

Fig. 1. Position of the mountain ranges in which the Carabids were collected.

Fig. 2. Scheme of vertical and horizontal zonation of forest vegetation in North Korea (abscissa latitude in ° N, ordinate altitude in m).

Fig. 3. Zoogeographical or political regions of East Asia covered by the taxonomic papers of Kryzhanovskij et al. (1995), Lafer (1989), Kwon & Lee (1986) and Ueno et al. (1999).

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