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The floristic and faunistic Korean refugium during the last glacial period and its significance in postglacial biota formation.

Abstract. The hypothesis that the Manchurian-Korean refugium of forest flora and fauna played a role in the formation of the European biota in the postglacial period is confirmed by: geographical vicariance in the Palaearctic region, the distribution of fossil species, the similarity of the present-day climate to that in the Tertiary, the disappearance of the sea barrier between Europe and Asia in the Quaternary, ecological corridors serving as migration pathways between Europe and the Far East. The data point to the importance of studies of the biota of Poland and Korea for the explanation of the genesis and evolution of the living world.

Key words: biota migration, Korea, Europe, postglacial period.

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INTRODUCTION

In order to clarify the genesis of the biota of a given area, it is necessary to know the present-day flora and fauna there, the geographical ranges of the species, habitat conditions and alterations in the climatic conditions in the past. Also important is the knowledge of contemporary and past geographical barriers and species dispersal centres that have supplied local floras and faunas. A calendar of events must also be constructed in order to situate the biota-formation processes on the geological time scale.

The current flora and fauna formation processes in the Northern Hemisphere, taking place within the last 14 000 years, rank among the newest events in the history of evolution. Species diversity varies substantially in different parts of the Holarctic. Sites rich in flora and fauna are found

alongside poorer areas. The identification of the causes and extent of such phenomena is an important objective of the biological sciences.

THE SIGNIFICANCE OF KOREAN BIOTA FOR EUROPE

Faunal and floral studies in the Korean Peninsula are very important for explaining the origin of the biota of the Palaearctic, and particularly Europe. This belief is warranted by the results of studies so far carried out. The following has been revealed:

1. Numerous cases of geographical vicariance (Fig. 1), i.e. separation of geographical ranges in Eurasia resulting in the existence of two populations, sometimes two subspecies or sister species, where one form occurs in Europe and the other in the Far East, usually also in Korea. Many examples of such distribution pattern compiled BERG (1933) for fishes. Similiar disjunctive ranges are frequent among plants (SZAFER 1952) e.g. in common European linden tree.

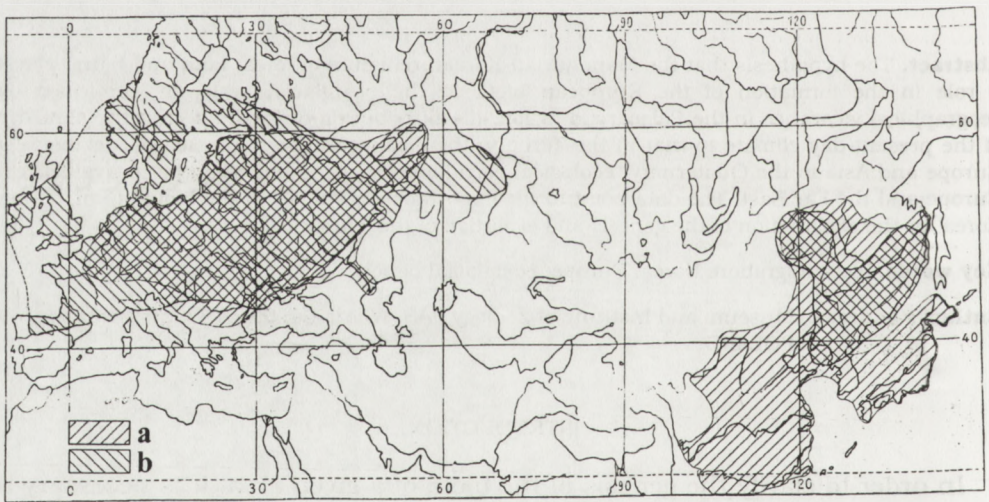


Fig. 1. Distribution of thunder-fish *Misgurnus fossilis* (L.) (a) and of the linden *Tilia cordata* L. (b) (after BERG 1933 and SZAFER 1952).

2. Species with currently limited realms often show broad geographical ranges in fossil material (SZAFER 1952). This pertains especially to evolutionally older species found as early as the Tertiary, as shown by sweet chestnut *Castanea* MILL., a species distributed in Tertiary in Central and Western Europe and in north-west areas of U.S.A., now limited to the southern parts of the Holarctis.

3. The Korean Peninsula was part of the greatest forest fauna refugium in the east part of Palaearctic during the Pleistocene. In the postglacial period it became the dispersal centre for that fauna (REINIG 1937).

4. Habitat conditions in Central Europe and Korea are similar nowadays and there are considerable similarities in the histories of habitat changes in these two areas in the Tertiary and Holocene (TERMIER & TERMIER 1952).

5. The emergence and disappearance of geographical barriers in Eurasia is relatively well documented, making it possible to pinpoint the periods of isolation between the faunas of the Far East and Europe as well as the periods when expansion and migration of species was possible even between such distant areas as Korea and Europe (SCHWARZBACH 1961).

6. Studies of the ranges of certain species have helped to identify possible migration pathways of plants and animals between Korea and Europe (de LATTIN 1967). Among numerous examples the existence of corridors joining European and Korean fauna, the distribution of some butterflies. (Fig. 2) corresponds to the belt of favourable environmental conditions forming a migration route for many other species.

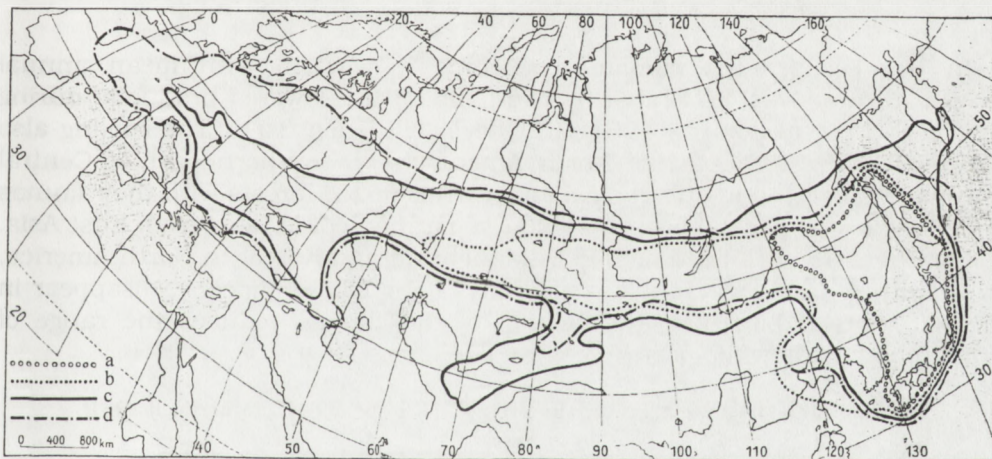


Fig. 2. Distribution of four butterfly species showing an ecological corridor between Middle Europe and Korea; a - *Neozephyrus taxila* BREM., b - *Lasiommata deidamia* EV., c - *Neptis caenobita* STOLL., d - *Minois dryas* Sc.

7. Studies of faunal and floral dynamics reveal numerous species to be expanding or reducing their geographical ranges at present. These processes are confirmed by historical data, especially from Europe (de LATTIN 1967).

The study and documentation of the above processes on more extensive material is crucial to elucidating the origin of contemporary flora and fauna, both in Central Europe and the Korean Peninsula.

The origin of present-day Central European biotas, including those in the territory of Poland, is particularly difficult to investigate. The difficulty stems mainly from past geological processes occurring in this area throughout the Tertiary. Most of the time (for about 60 million years) Europe was affected by transgression of the Arctic Ocean, which separated the continent from Asia.

The vast water expanse of the Northern Sea kept Europe fragmented into isolated islands (TERMIER & TERMIER 1952).

Leaving aside the immigration of equines and rhinoceroses from Asia in the Oligocene and Miocene, the formation of stable flora and fauna in Europe took place in the Pliocene, about 5 mln years ago. The main sources of the fauna were areas of eastern Siberia, Far East and China, the only areas in Eurasia which were never totally submerged but were always large continental mainlands ensuring continuous autochthonic evolution of land flora and fauna. The presence of a stable and broad passage to North America in most historical epochs has led to homogeneity of the faunas of Europe, Siberia, Far East and North America. This is reflected in the concept of the Holarctic region (REINIG 1937), relatively uniform in composition and origin of fauna, encompassing almost the whole of the Northern Hemisphere.

EUROPEAN ENVIRONMENTAL DISASTER IN THE PLEISTOCENE

In the Tertiary the climate of Europe was warm with mean annual temperature of 14–21°C (Table I). The temperature lowered gradually during that period (SCHWARZBACH 1961), but never fell below 10°C. The cooling also affected the western part of North America. The southern part of Central Europe was covered in subtropical forest while mixed forests with their faunas abounded in the central part. A similar separation could be seen in East Asia. It is particularly well documented in Manchuria and Korea. In North America, on the other hand, deciduous forests, prevailing in the Miocene, disappear in the Pliocene, and intense aridification of the climate reduces the range of coniferous forests while prairie ecosystems flourish.

Table I. Annual mean temperature in tertiary in Europe (after Schwarzbach 1961).

Period	Locality	Annual mean temperature	
		tertiary	current
Pliocene	Frankfurt a. M.	14	9
Miocene	Oeningen (Bodensee)	16	9
Oligocene	Rott near Köln	18	9
Eocene	London	21	10

The Pleistocene brings on a reduction in the mean annual temperature in the Northern Hemisphere – by 8–13°C in the temperate latitudes – leading to dramatic changes. Monthly temperatures only exceed 0° from May to September and frost prevails in the other months. Under such conditions three ice sheets (Scandinavian, British and Alpine) form and develop in Europe to cover a large part of the continent. The advancing glacier forces southward the flora and fauna of the warm and temperate zones (WOLDSTEDT 1954–1958). Refugia are formed in the Mediterranean region. Climate zonation can still be seen in a limited area at the outward edge of the glacier

and is accompanied by faunal and floral zones ranging from the Mediterranean biome to the tundra.

Glaciation in east Asia follows a different course. Huge masses of floating ice kill life in a large part of Siberia. However, its eastern parts, including the Ussuri Land, Korea, Manchuria and Japan, remain ice-free and fused by land bridges (Fig. 3). In North America the glacier covers only the northern half, leaving wide glacier-free areas where both fauna and flora can find a shelter.

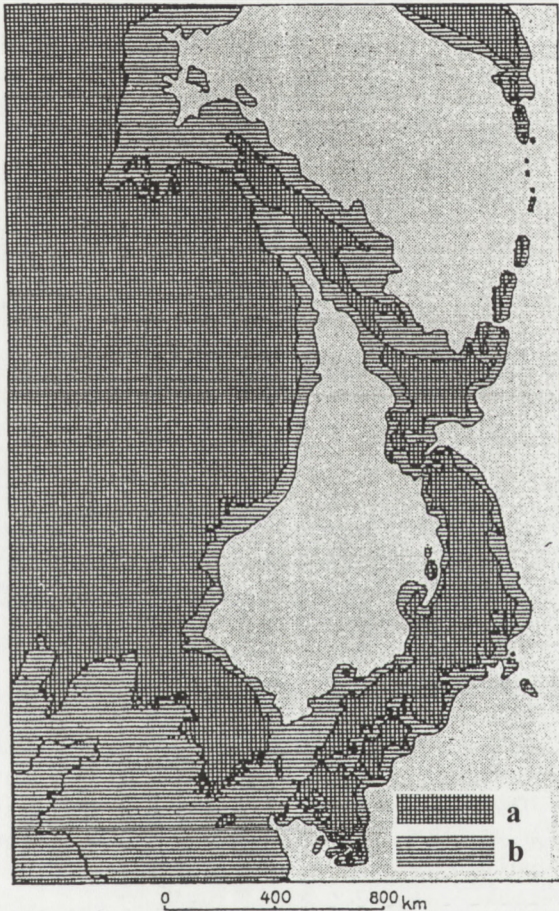


Fig. 3. Korean refugium as a part of the Manchurian centre (after REINIG 1937 and de LATTIN 1967); lands: a - actual, b - pleistocene.

The fauna- and flora-preserving areas of the glaciation period, the floristic and faunistic refugia, are distinguished on the basis of the fauna and flora involved. The majority are arboreal but there are also the eremial biotas of the steppe. For about 1 million years they kept their species isolated. The changes occurring in that period lead in numerous cases to the emergence of new subspecies or even species that are vicariants of forms preserved in the European refugia.

POSTGLACIAL RESTORING OF THE BIOTA

The postglacial period, also known as the fifth interglacial because of its short duration and non-specific climatic changes, started 14 000 years ago (BERGER et al 1985). In various parts of Europe and Asia, the ice sheet began to recede 12 000–10 000 years ago. According to Canadian data, the withdrawal of the glacier to the north could still be seen in historical times, when the areas had already been settled by Europeans.

In the Northern Hemisphere the climate of the Tertiary has not been restored after the glacier withdrew. Instead, a new pattern of climatic zones has developed with corresponding, almost latitudinal floral zones. The youngest zone, the tundra, forms the northernmost belt and is still developing in conditions hardly differing from those of the glacial period.

The taiga comprises vast expanses of coniferous forests, mostly in Siberia and Eastern Europe. The mixed and deciduous forest zone is seen in Europe north of the Alps and Carpathians. A similar flora, though much richer in species, is observed in the Korean Peninsula.

In the interglacial period the Eurasian and North American biota were restored under different conditions.

In North America the floristic and faunistic refugia clustered in the south were able to expand easily northwards so that fauna and flora was restored in areas formerly covered with ice. The absence of geographical barriers was the crucial factor.

In Eurasia, however, most refugial areas were still isolated by sea and mountain barriers and biota restoration has been following a more complex course. A number of refugia in the Mediterranean remain to this day so effectively isolated by the Pyrenees and Alps that their species have not been able to expand. The plants and animals found in many cases the 10 000-kilometre distance from Korea easier to negotiate than the several hundred kilometres separating them from the Mediterranean region with its abundant flora and fauna.

Data on links between the European biota and the Korean refugium are still fragmentary. Particularly little is known about the invertebrates of the Korean Peninsula. The development of a joint Polish-Korean study programme gives the opportunity to utilize the scientific resources of the two countries in order to describe biological diversity in our countries.

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STRESZCZENIE

[Tytuł: Koreańskie refugium florystyczne i faunistyczne i jego znaczenie dla formowania świata żywego Palearktyki w okresie polodowcowym]

Formowanie lądowej flory i fauny Holarktyki zamyka się w granicach ostatnich 14 000 lat. Centrum Koreańsko-Mandżurskie stanowi jeden z ważniejszych ośrodków rozprzestrzeniania się roślin i zwierząt w okresie polodowcowym. Hipotezę tę potwierdzają dane dotyczące rozmieszczenia refugium arborealnych w plejstocenie i dziś, liczne zjawiska wikariancji geograficznej w obrębie Palearktyki oraz rozmieszczenie gatunków kopalnych, obecnie reliktyw występujących na ograniczonych terytorialnie stanowiskach. Zgodne z tą koncepcją są również dane o trzeciorzędowym i obecnym klimacie Europy i Korei. Przez większą część trzeciorzędu morze izolowało rozczłonowaną wówczas Europę od kontynentu Azji. Bariera ta zaniknęła w czwartorzędzie. W holocenie powstały korytarze ekologiczne umożliwiające przemieszczanie się roślin i zwierząt między Europą a centrum Koreańsko-Mandżurskim. Swój fenomen jest to, że dzielący je dystans około 10 000 km okazał się łatwiejszy do przebycia dla licznych gatunków niż kilkusetkilometrowa odległość od refugium śródziemnomorskich.

Dane te wskazują na znaczenie badań flory i fauny Polski i Korei dla wyjaśnienia genezy i ewolucji świata żywego Palearktyki.