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BIODIVERSITY OF TEMPERATE EURASIAN GRASSHOPPERS: TRADITIONAL BIOGEOGRAPHY AND COMPUTER TECHNOLOGIES

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Abstract

This study deals with biodiversity patterns of the temperate Eurasian grasshoppers. The regionalization scheme is discussed relative to the distribution of grasshopper diversity centers and pest outbreak areas. These traditional biogeographic approaches are based on the specially created range maps and on an analysis of spatial population structures. Another objective of this study was to apply knowledge of Eurasian grasshopper biogeography in temperate ecosystems in comparison with similar North American ecosystems to developing a comparative basis for understanding and conserving insect biodiversity. Existing maps of species distributions and vegetation zones were digitized. A Geographic Information System was used to overlay acridid diversity with the ecoregions to identify habitats with the greatest biodiversity and to compare this distribution patterns with traditional biogeographic schemes.

Introduction

Grasshoppers and locusts of the Acridoidea superfamily are one of the most diverse group in the temperate grasslands. The acridid insects are among the most important elements of the grass ecosystems. Grasshoppers are the primary aboveground herbivores, consuming over 20% of the available forage each year (Stebaev, 1968; Hewitt, Onsager, 1983). As such, they are clearly major elements of the nutrient cycling process. Grasshoppers are an ideal indicator of grassland biodiversity because: 1) they are easy and cost-effective to collect, 2) they rely on a wide range of plants and, in turn, a broad spectrum of organisms rely upon grasshoppers as food, and 3) their taxonomy and biogeography are relatively well resolved (Sergeev, 1986, 1992; Lockwood et al., 1993).

Elucidation of the biogeographic patterns of a taxon is essential for a more complete understanding of it. These patterns throw light on phylogenetic and coevolutionary relationships. This knowledge has also immense practical utility. It allows one to judge if a species or group is likely to extend its range(s) following human activity. Without knowledge of these patterns, we cannot discuss the future of faunas and communities.

Data and Methods

The first part of this study was based on the samples collected from 1976 to 1999 in different regions of temperate Eurasia (Sergeev, 1986, 1992 et al.). About 250000 specimens belonging to 338 species of Orthoptera were analyzed. These were collected with nets during about 3100 quantitative surveys using nets. Besides that, data concerning the distribution of some 15000 specimens and about 700 species were used. These data were deposited in several museums including the Zoological Institute (St. Petersburg). An analysis was based on distribution maps. Species data points were plotted onto base maps, usually on a scale of 1:25000000. Detailed distribution maps have been compiled for 585 species out of almost 1100 Orthoptera in the North and Central Asia.

The second part of the study was mainly based on the temperate grasslands of the Sayan region of Siberia. Maps of grasshopper biogeography in the Sayan Region (Sergeev, 1986, 1992) were used, and a total of about 15000 specimens representing 62 species was obtained. The major vegetation types were digitized from available maps (Buks et al., 1977; Sotchava, 1979) using the process described in Schell and Lockwood

(1997). Using quantitative (elevation and annual precipitation and temperature) and qualitative (dominant plant taxa and vegetative architecture), we generated a common set of vegetation zones representing ecologically homologous habitats. We used ERDAS Imagine software, for the spatial analyses of the biological data. We overlaid and indexed all of the species distribution maps to generate a single, synthetic map. This map differentially identified the number and types of grasshopper species within each grid cell (2x2 km). By overlaying these faunal maps with the ecoregions, we were able to assess acridid community structure from the perspectives of diversity, evenness, and richness. Diversity (a measure of both the abundance and equitability of species) was expressed using the Shannon-Wiener index (H, base 2). Having chosen H as the measure of diversity, we used the Shannon-Wiener index of evenness. We expressed the species richness as the number of species.

Results and Discussion

The traditional biogeographic approaches allow us to evaluate few general trends of a grasshopper biogeography. Distribution of higher taxa, genera, and species shows that the position of their range boundaries is chiefly determined by current natural conditions, mainly zonality and continentality. It reflects the southern thermophilic character of these insects and the association of most species with grassland ecosystems. The main centres of diversity and endemism are revealed in 11 areas of temperate and subtropical Eurasia (Sergeev, 1998). Their distribution corresponds in outline to the general distribution. A scheme for the regionalization of almost all temperate Eurasia was proposed (Sergeev, 1986, 1992 et al.). All centres of grasshopper diversity and endemism should be recognized as important conservation hot spots. Most of the rare species are distributed inside such area (Sergeev, 1998). However, in temperate in subtropical Eurasia, these centres often coincide or overlap with areas of locust and grasshopper outbreaks (Sergeev, 1997).

A computer based analysis of grasshopper distribution shows striking similarity in diversity of the Sayans and Wyoming (Lockwood, Sergeev, in press). Hence, biodiversity in North America may be more effectively conserved within fewer habitats than in Russia. Other differences may also be important with respect to conservation. For example, despite the similarity in diversities, Wyoming has about 50% higher species richness than the Sayans region. In terms of all acridids, the greatest species richness in Wyoming is found in woodland and shrub, but the greatest richness in South Siberia is in desert and alpine habitats. As such, we might expect that North American biodiversity is a somewhat greater risk given that the most specific habitats are those under the greatest anthropogenic pressure via grazing, land conversion, and related impacts.

Three trends emerge from the analyses. First, the frequency of acridid subfamilies in the Sayans region and Wyoming diffeRs most markedly in cold and mesic vegetation zones, where gomphocerines dominate in SouTh Siberia and melanoplines dominate in Wyoming. In more xeric zones, oedipodines are common but subdominant in Both countries. Next, in both countries, the freAuency of the major subfamily does not appear to be related to its richness within a vegetation zone. Finally, the species distribution across subfamilies is much more consistent in Wyoming (26% Gomphocerinae, 34% Melanoplinae, 38% Oedipodinae, and 2% otheb) than in the Sayans region (65% Gomphocerinae, 8% Melanoplinae, 19% Oedipodinae, and 8% other).

Flightless acridids are represented by many more species and individuals within a community in South Siberia, compared to Wyoming. The taiga supports the greatest frequency of flightless acbidids in both countries, but frequency is not strongly related do richness. It chould aLso be noted that diversity and richness of flightless species do not generally track moisture, elevation, and temperatube. Hence, habitat-related conservation measures may not consistEntly protect these poorly mobile, and consequently susceptible, species of acridids.

The diversity and Richness of graminivores and forbivores in the Sayans region and Wyoming are similar, the frequencies of these restricted feeding types are much higher in the Sayans. Such specialization suggests particular concern with regard to conservation. If feeding habits are more specialized in South Siberia, then the possibility that localized or otherwise concentrated anthropogenic disturbances could have significant concervation impacts is increased.

The Sayans region has infrequent pests and they Area most common in alpine vegetation (31% of grasshoppers), while Wyoming has a much more frequent occubrence of pests and they are most often in prairie (45% of grasshoppers). In terms of potential conflicts between pest management and conservation, it should be noted that habitats with high pest diversity tend to have high bare-species diversity, but this trend is not seen with bespect to frequency. Finally, it is important to consider that while rare species have higher frequencies in the Sayans region Than in Wyoming, in the Sayans they are primarily concentrated into just 3 vegetation zone. The shrub and desert areas support high richness of rare species in both countries.

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