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Biodiversity and paleobiogeography of the European freshwater Neogene: trends, hotspots and faunal turnovers

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We present an outline of a paleobiogeographic framework for the European fresh- and brackish-water systems during the Neogene. Data basis is a presence-absence matrix of lacustrine gastropods from over 2,700 localities. Cluster analyses were separately carried out on the datasets of the four time slices Early Miocene, Middle Miocene, Late Miocene, and Pliocene. Based on the results of the cluster analyses, the degree of endemicity, and geographical coherence, we classified the lake systems of the four time intervals into biogeographic units. The increasing degree of provincialism throughout the Neogene supported more detailed breakdowns in younger intervals. This pattern reflects the ongoing continentalization of Europe linked to the Alpidic Orogenesis. Additionally, the retreat of the Paratethys Sea and its isolation from the Mediterranean promoted the evolution of endemic faunas in surrounding lacustrine systems. Direct descendants such as long-lived Lake Pannon, Lake Dacia or Lake Slavonia persisted over several millions of years and promoted the evolution of highly diverse and endemic faunas. Because of their extensive duration they crucially influenced family-level composition, differences of the relative species richnesses per biogeographic unit, and rising rate of endemicity.
We show that the biogeographic classification as well as the existence of biodiversity hotspots are tightly linked to the formation and evolution of long-lived lacustrine environments and thus to Europe's geodynamic history. Heat maps are provided to visualize the shifting distributions of hotspots through time. The only physiographic factor that can be shown to be correlated with species richness is the size of a lake. Other factors such as latitude, longitude or temporal duration show weak relationships. Correlation of biodiversity trends to climatic parameters such as temperature and precipitation are feasible only for selected periods. Climate is considered to have only minor influence on the existence of hotspots but certainly affects their evolution and specific composition.