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Dynamics of East European modern amphibians and reptiles species distribution areas and their potential use in Quaternary stratigraphy

Dynamiques des aires de distribution des espèces d'amphibiens et reptiles d'Europe orientale et potentiel pour leur utilisation en stratigraphie du Quaternaire

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ABSTRACT

The last appearance dates and especially occurrences of amphibian and reptile species have a rather limited stratigraphic potential in Quaternary deposits. However, changes in their areas of distribution against the background of climate variations open some possibilities for biostratigraphy. Based on fossil assemblages of amphibians and reptiles, interglacial or periglacial conditions can be distinguished. Substitution of forest associations by those typical for forest-steppes or steppes within the limits of the modern forest zone can be attributed to climate aridization at the onset of a glaciation. Therefore, during paleogeographic reconstructions, it is important to determine a natural zone, instead of an assortment of possible biotopes. Glacial intervals for modern steppe zones can theoretically be visualized by the emergence of desert taxa. Distribution areas of amphibians and reptiles during interglacial optima show different outlines. They usually varied slightly, but sometimes the range of some species expanded (*Bufotes viridis*) or species disappeared (*Strauchbufo raddei*) from a large part of their original distribution. Such changes can be used to define large age intervals within a regional biostratigraphy.

Mots clés :
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Possibilités
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RÉSUMÉ

Les dates de dernière apparition, et plus spécialement, de présence d'espèces d'amphibiens et de reptiles ont plutôt un potentiel stratigraphique limité pour les sédiments quaternaires. Néanmoins, les changements de leurs aires de distribution liées aux variations climatiques offrent quelques possibilités pour la biostratigraphie. Basées sur les assemblages fossiles d'amphibiens et de reptiles, les conditions interglaciaires ou périglaciaires peuvent être distinguées. Les remplacements d'associations forestières par des associations de steppe arborée, puis steppiques, à l'intérieur des limites actuelles des zones boisées peuvent être attribués à une aridification du climat liée au début d'une glaciation. Par conséquent, lors de reconstructions paléogéographiques, il est important de déterminer un seul environnement naturel au lieu d'un assortiment de possibles biotopes. Les intervalles glaciaires pour les zones steppiques actuelles peuvent théoriquement être visualisés par l'émergence

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de taxons désertiques. Les aires de distribution des amphibiens et reptiles durant les optimums interglaciaires montrent des schémas différents. Généralement, elles varient peu, mais parfois certaines espèces s'étendent (*Bufotes viridis*) ou disparaissent (*Strauchbufo raddei*) d'une grande part de leur distribution originelle. De tels changements peuvent être alors utilisés pour définir de larges périodes chronologiques dans le cadre d'une biostratigraphie régionale.

1. Introduction

In biostratigraphy, the relative age of sedimentary rocks is determined on the basis of changes in a species or a species complex over time (Kholmovoy et al., 2008; Stepanov and Mesezhnikov, 1979). Thus, the duration of stratigraphic divisions can, at least, not be shorter than the time of a species' existence, and the occurrence or extinction of species is assumed to be simultaneous throughout the entire distribution area. This method is widely used in the stratigraphy of Pre-Quaternary sediments.

But, this provides a problem for the biostratigraphic subdivision of Quaternary deposits. One of their specific features is the relatively short duration of assignable intervals, which is shorter than the duration of a species' existence. Modern morphological species of East European amphibians and reptiles already appeared in the fossil record prior to the Quaternary glaciations. Note that we are considering "morphological species". There is a recent tendency to increase the number of species in herpetology, as, in particular, subspecies are converted to species (compare Bannikov et al., 1977 with Ananjeva et al., 1998, then with Ananjeva et al., 2006 and Kuzmin, 2012). The species level is based on genomic features, karyotypes, and reproductive isolation, while the morphology, especially of the skeleton, can be close or even similar (Borkin et al., 2003; Pisanets, 2010; Stöck et al., 2008; Wielstra et al., 2013 and others). Such species probably have a shorter temporal duration, but because these differences cannot be seen in the fossil material, this classification is absolutely inapplicable in stratigraphy. Thus, it is impossible to determine the stratigraphic intervals within the limits of the last million years on the basis of modern amphibian and reptile species occurrences. However, some boundaries can be established on the basis of the disappearance of extinct forms. For example, representatives of Palaeobatrachidae lived in territory of the East Europe up to the Muchkapian (MIS 15, 621–568 kyr BP according to Iossifova et al., 2009) interglacial (Ratnikov, 1997; Wuttke et al., 2012).

However, there are other opportunities to use modern amphibian and reptilian species for stratigraphic purposes within the limits of the Quaternary period, connected with the dynamics of the distribution areas of modern herpetofauna species. Here, we shall focus on the Pleistocene herpetofaunal assemblages from the East European plain.

2. Modern natural zones and distribution areas of amphibians and reptiles from Eastern Europe

East Europe extends from north to south about 3000 km. We can observe consecutive meridional change of natural zones named on the basis of their vegetation type: tundra, forest-tundra, zone of coniferous forests (taiga), zone of mixed and deciduous forests, forest-steppe, steppe, desert and mountain zones (Fig. 1).

Distributions of modern amphibians and reptiles cover at present almost the whole of Eastern Europe, and their limits of distribution are determined by different factors: presence of sufficiently long seasons with positive temperatures, the degree of water warming during amphibian larval development, and so on (Bannikov and Denisova, 1956). Notably, the distribution boundaries closely coincide with natural zone transitions (Fig. 2).

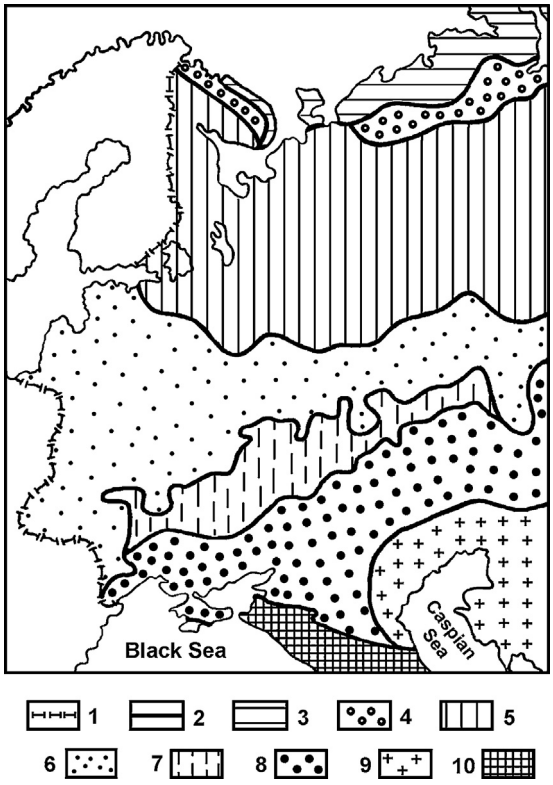

Fig. 1. Natural zones of Eastern Europe (according Nikolaeva, 1986, simplified). Symbols: 1 – western boundaries of Russia, Latvia, Belarus, Ukraine and Moldova; 2 – natural zone boundaries; 3 – tundra; 4 – forest-tundra; 5 – coniferous forests; 6 – mixed and deciduous forest; 7 – forest-steppe; 8 – steppe; 9 – desert; 10 – mountain zones.
Fig. 1. Zones naturelles d'Europe orientale (simplifié de Nikolaeva, 1986). Symboles : 1 – frontières occidentales de l'ex-Union soviétique ; 2 – limites des zones naturelles ; 3 – toundra ; 4 – toundra arborée ; 5 – forêts de conifères ; 6 – forêts mixte et à feuilles caduques ; 7 – steppe arborée ; 8 – steppe ; 9 – désert ; 10 – zones montagneuses.

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