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Latitudinal patterns in the diversity of two subgenera of the genus *Daphnia* O.F. Müller (Crustacea: Cladocera: Daphniidae)

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Abstract

Daphnia O.F. Müller (Crustacea: Cladocera: Daphniidae) is an important model in biology. It was concluded earlier that subgenus *Daphnia* s.str. occurs mainly in the northern hemisphere, subgenus *Daphnia* (*Ctenodaphnia*) in the southern hemisphere, which could suggest that: (1) the subgeneric differentiation is correlated with the Laurasia-Gondwanaland subdivision and (2) *D.* (*Ctenodaphnia*) is a taxon of Gondwanian origin. Some authors even discussed mechanisms of maintaince of the "ancient subgeneric north-south split", regarding such a pattern as paradoxical. But both molecular clock calculations and fossils of both subgenera from the Jurassic/Cretaceous boundary of Mongolia compromise such ideas and suggest an earlier, Pangaean, differentiation of the subgenera.

We discuss the distribution of *Daphnia* worldwide based on recent literature. Our analysis covers literature data on all described and on undescribed taxa revealed by genetical methods. Distributional data were associated with five main zones: southern cold (I), southern temperate (II), tropical (III), northern temperate (IV), and northern cold (V) zone. We found no "subgeneric north-south split": the distribution of *Daphnia* s.str. is dissymmetric between the hemispheres (antipolar), while that of *Ctenodaphnia* is sub-symmetric (bipolar). We suggest that both patterns are not of Mesozoic, but of Cenozoic origin. Mesozoic differentiation of the subgenera does not contradict a recent origin of the extant species, as found in e.g. Notostraca. A superficially attractive hypothesis about a Gondwanian origin of a taxon (*Daphnia* (*Ctenodaphnia*)) therefore did not pass the test of the fossil records. In addition, we agree with the opinion that an antipolar is only a variant of a bipolar pattern, as a result of an extinction in the southern hemisphere, and that these patterns are mid-late Cenozoic instead of Mesozoic.

Key words: Cladocera, Daphniidae, biogeography, distribution, continental endemism

Introduction

A search for gradients is among the primary tasks of biogeography. Many groups of organisms, including freshwater invertebrates, have a tropical diversity peak (Gaston 2000; Allen & Gillooly 2006; Hołyńska 2011). At the same time, preliminary data suggest that the Cladocera are an exception from this rule, their diversity maximum is outside the tropics (Korovchinsky 2006). Unfortunately, our knowledge of the cladocerans in different regions is outdated, while the dominance of ideas on the cosmopolitanism of freshwater animals during most of the 20th century and the identification of specimens using European and North American keys, falsely "revealed" Holarctic taxa everywhere (Frey 1982b, 1987).

The genus *Daphnia* O.F. Müller, 1776 (Crustacea: Cladocera: Daphniidae) is among best studied genera, because it is a model in biological studies, from toxicology to evolutionary biology (Peters & De Bernardi 1987; Stollewerk 2010; Harris et al. 2012). Many papers on *Daphnia* appear each year, but few deal with morphology, taxonomy, and biogeography. Interest in morphological taxonomy of *Daphnia* was lost in the 20th century, with few recent investigators studying them (Paggi 1996, 1999; Kotov et al. 2006, 2010; Juračka *et al*. 2010). Current progress in the taxonomy of *Daphnia* is, first of all, associated with molecular phylogenetic studies (Colbourne et al. 2006; Adamowicz et al. 2009; Juračka *et al*. 2010; Crease et al. 2012). Recent sequencing of genomes of two species (Ebert 2011) will apparently reinforce the potential of the molecular-phylogeneic analysis.

It is now obvious that the genus consists of three separate clades, with the rank of subgenera: *D.* (*Daphnia*), *D.* (*Ctenodaphnia*) Dybowski et Grochowski, 1895 and *D.* (*Australodaphnia*) Colbourne, Wilson et Hebert, 2006, as

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originates from a Pangaean global pattern. The pattern of the subgenus *Daphnia* (*Daphnia*) seem to be different from the latter. But we agree with Eskov (1984) that an antipolar pattern is the only a variant of a bipolar pattern, as a result of extinction in southern hemisphere.

Our data agree with an idea that for such antique organisms as the cladocera (Fryer 1987; Kotov & Taylor 2011) we have no chance to speak about centers of origin of macrotaxa using a biogeographic information. Too many geological and evolutionary events (in both taxa and communities) erase most part of information about earlier stages of a taxon differentiation. A search for traces of later Cenozoic events in the history of a taxon seems to be more attractive direction of biogeographic studies in the Cladocera.

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