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Systematics and biogeography of the genus *Besdolus* Ricker, 1952 (Plecoptera, Perlodidae): molecules do not match morphology

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Abstract

The Central-Southern European genus *Besdolus* was reinstated and revised by Zwick and Weinzierl (1995), and includes five species: *B. imhoffi* (Pictet), *B. ventralis* (Pictet), *B. bicolor* (Navás), *B. ravizzarum* Zwick & Weinzierl, and *B. illyricus* Kovács & Zwick. Overall, these species are rarely collected and have apparent relictual distributions. From the ecological point of view, *B. bicolor*, *B. ravizzarum* and *B. illyricus* seem to be more orophilic whereas *B. imhoffi* and *B. ventralis* are associated to lowland rivers. These species are sensitive to the environmental perturbations and are endangered taxa, threatened with extinction. Species identifications are difficult using available morphological characters. We sequenced a fragment of the mitochondrial gene COI to better understand the systematics and biogeography of this genus and to evaluate the molecular intra- and interspecific distances. Specific boundaries, species relationships, degree of isolation and molecular similarity are also presented. The molecular data do not fully support the validity of the five species. Molecular distances between *B. bicolor* and *B. ventralis* and between *B. imhoffi* and *B. illyricus* are similar to what has been previously reported for conspecific stonefly taxa. In this study, the results of the molecular approach are not congruent with the traditional morphological arrangement. Biogeographically, we hypothesize that a Central European stem species dispersing westward and southward diverged into two lineages, then differentiated on the three European main peninsulas.

Key words: Plecoptera, Perlodidae, *Besdolus*, cytochrome oxidase subunit-1, evolutionary rates, mtDNA, phylogeny, stoneflies

Introduction

The genus *Besdolus* has a Central-Southern European distribution, and was originally established as a new subgenus of *Isogenus* by Ricker (1952) and later included by Stark *et al*. (1986) in *Dictyogenus* Klapálek, 1904. The genus *Besdolus* was reinstated and revised by Zwick and Weinzierl (1995) and presently includes five species, *B. imhoffi* (Pictet, 1841), *B. ventralis* (Pictet, 1841), *B. bicolor* (Navás, 1909), *B. ravizzarum* Zwick & Weinzierl 1995, and *B. illyricus* Kovács & Zwick 2008. Overall, these species are considered rare and have apparent relictual distributions (Zwick & Weinzierl, 1995). *Besdolus bicolor* is known from historical records from Central Spain (a few sites in the Guadalajara, Albacete, Madrid and Teruel provinces) and from Andalusia (one site). Currently, this species occurs only in two mountain systems of Andalusia ("Sierra de Alhama, Tejera y Almijara"; "Sierra de Cazorla, Segura y Las Villas" (Tierno de Figueroa *et al*., 2003, updated). *Besdolus imhoffi* was once abundant in Central Europe (Switzerland, Germany, Austria, and Belgium) and in the former Yugoslavia (Zwick & Weinzierl, 1995). *Besdolus imhoffi* was not collected for decades but recently rediscovered at one site in Central Europe (Uffinger stream, Ammer Basin, Germany) and in several sites in Croatia (Popijac & Sivec, 2009; Kovács & Murányi, 2008). *Besdolus ravizzarum* occurs in a small portion of the Italian northern Apennines, where it has a scattered distribution in the same drainage basin and at three sites in France (Var, Haute Provence and Haute-Garonne provinces, from 2 males, 5 females and 4 larvae collected from 1942 to 1976). *Besdolus ventralis* was

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