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Hierarchical Distribution Models of the Invasive Fish *Carassius gibelio* and *Pseudorasbora parva* and Prediction of Their Impact on Lake Sevan

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ABSTRACT

The hypothesis of climatic niche conservatism (CNC) of invasive fish species, Prussian carp *Carassius gibelio* (Bloch, 1782) and Stone moroko *Pseudorasbora parva* (Temminck & Schlegel, 1846), was tested, and their hierarchical spatial distribution models (hSDM) were constructed in Armenia and adjacent territories using a global set of species occurrence records (SORs) together with climatic, topographic, and dispersal-related variables. Results show that the CNC hypothesis is not rejected for either species. The climatic niches of *C. gibelio* and *P. parva* differ considerably (similarity index ~27%), with the niche breadth of *C. gibelio* significantly wider than that of *P. parva* ($P<0.05$). A novel hierarchical approach was applied to construct realistic models of potentially suitable habitats. At the first level, SDMs were developed using global SORs and climate variables and projected into the study area to create a climatic raster (SDMglobclim). At the second level, hSDMs were refined with local SORs, SDMglobclim, topographic, and dispersal-related variables. The resulting models confirmed that suitable habitats overlap with watercourses already colonized, while also identifying additional areas with high invasion risk. The hSDMs indicated that *C. gibelio* could potentially occupy the entire area of Lake Sevan, whereas *P. parva* would preferentially inhabit coastal zones. Analysis of biological traits and ecological impacts revealed their potential threats to Lake Sevan: intensification of algal blooms and turbidity, suppression of macrophytes, competition and sexual parasitism with native fishes, and transmission of viral, fungal, and parasitic diseases, some of which pose risks to human health.

Keywords: invasions, freshwater, Prussian carp, Stone moroko, niche conservatism, SDM

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