



3rd World Conference on Sustainability, Energy and Environment

Berlin, Germany

08 Dec - 09 Dec 2023

Biological and Ecological assessment of Freshwater Fish within the Zat Watershed (Morocco) across an altitudinal gradient

Ahnic Abdelilah, Naimi Mohamed, Aitboumalassa Fayçal, Khalki Hanane, Hanfour Souhaib

Sultan Moulay Slimane University, Beni-mellal Polydisciplinary Faculty Morocco

Abstract

The phenotypic flexibility and adaptability of freshwater fish can lead to morphological and structural changes in response to variations in their environment. The study of these responses is of paramount importance in understanding the vulnerability of these species to environmental perturbations, whether of natural or anthropogenic origin. In this research, we used an altitudinal gradient as an indicator of upstream and downstream environmental variations, and examined its impact on fish morphology and population structure. We chose the barbel, which occupies four different geographical stations, as a suitable biogeographical sample. We explored correlations between several variables using biological, ecological, morphological and environmental analyses. Analyses of water quality revealed a clear improvement upstream, favoring the isolation of *Luciobarbus ksibi* in terms of its adaptation to high altitudes, while downstream, the disappearance of *Luciobarbus magniatlantici* highlighted the sensitivity of these populations to variations in environmental quality. Along the altitudinal gradient, Ait Ourir barbels showed a reduction in the distance between their dorsal and pectoral fins as they moved upstream, while Tamgounssi barbels showed an increased eye diameter and maximum body depth. In contrast, upstream barbel from Mriouate and Zerouane showed higher values for eye diameter, with Mriouate showing a longer pre-orbital distance and Zerouane a shorter pre-orbital distance. These observations suggest potential adaptations of fish to different environmental conditions along the altitudinal gradient, in response to thermal and hydrological variations. Other morphometric and functional characteristics were also influenced by selective environmental factors. These



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results highlight the sensitivity of barbel to climate change, paving the way for future studies in the field of ecological conservation.

Keywords: Zat basin, Barbel fish, geometric morphometry, population structure, Vescero-Somatic Index, Gonado-Somatic Index, Scaled mass index.