



**E Ö T V Ö S L O R Á N D U N I V E R S I T Y
F A C U L T Y O F N A T U R A L S C I E N C E S**

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D E P A R T M E N T O F P A L E O N T O L O G Y

**Taxonomic, palaeoenvironmental and evolutionary
investigations of the Late Miocene fish fauna of Lake**

Pannon

Doctoral theses

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Introduction

After the isolation of the Sarmatian Sea from the Paratethys a large lake system developed in the Carpathian Basin during the Late Miocene. It was the long-lived Lake Pannon, existing from the beginning of the Late Miocene (11.6 Ma) to the earliest Pliocene (4.5 Ma). The isolation, the climate, the subsidence of the lacustrine basin and the uplift and erosion of the adjacent areas comprise the abiotic parameters the interplay of which ensured the long-term existence of the lacustrine environment and its biota.

Endemic evolution has played a major role in the evolutionary history of the fauna of Lake Pannon. The rich and diverse endemic mollusc fauna has become known since the middle 1800s. Many of the calcareous nannoplankton, organic-walled microplankton, diatom, and ostracod species are also recognized as endemic (Magyar 2010). Three monographs have been published about the flora and fauna of the lake (Papp et al. 1985; Jámboř 1987; Stevanović et al. 1990), but, apart from a short summary about the Pannonian fish faunas of the Vienna and Beius Basins (Brzobohatý et Paná 1985), none of them included a detailed documentation of the fish fauna. Although, there are many sporadic references to fish remains from Lake Pannon deposits, the taxonomic composition and spatial and temporal changes of fish fauna are hardly known.

In my thesis I focused on the detailed investigation of the fish fauna. I specifically addressed the following questions: What was the composition of the fish fauna in Lake Pannon? What is the ratio of the marine survivors and freshwater invaders? How high is the level of endemism? Is it possible to recognise any kind of spatial and/or temporal patterns in the fish fauna? What ways did the Pannonian fish fauna influence the evolution of other fossil and recent ecosystem?

Methods

This study is based on literature data complemented with the investigation of new collections and materials deposited in various museums. Samples were processed with warm water by washing and sieving. The otoliths were picked under binocular microscope, the photos were taken by a Canon EOS 400D camera. Three samples were embedded in epoxy resin and transverse sections were prepared for geochemical and incremental structure studies. Data were analyzed by PAST paleontological statistics software.

New scientific results

1. I collected literature data about fish remains from different Pannonian localities and revised the otolith data.
2. Based on literature data and my new investigations, I presented the list of the fish taxa that lived in Lake Pannon and its adjacent areas during the Pannonian. Among the 54 fish species belonging to 22 families, presumably *Gadiculus* cf. *argenteus* is the only extant.
3. I refined the chronostratigraphic position and age of the fish remains collected from 41 Pannonian surface outcrops and 24 boreholes (Fig. 1). I assigned a Sarmatian age to the fish remains of Hernals, which were previously considered Pannonian by Koch (1904).
4. I excluded the possibility that fossilization was influenced by water chemistry. The environment of fossilization was not anoxic, because only a low number of complete fish skeletons were recovered from Lake Pannon deposits.
5. I presented the first detailed systematic descriptions of fish otoliths from eighteen Pannonian localities and revised otoliths from strata around Lake Balaton and Budapest-Kőbánya. Seven species („genus Gadidarum” *ponticum*, *Gadiculus* cf. *argenteus*, *Morone kuehni*, *Umbrina* aff. *cirrhosoides*, *Umbrina subcirrhosa*, *Gobius* cf. *dorsorostralis*, *Gobius praetiosus*) have been identified for the first time from Pannonian deposits of Hungary.
6. I discovered two new endemic forms: *Umbrina* aff. *cirrosa* and *Umbrina* aff. *cirrhosoides*, both derived from the Badenian ancestor *Umbrina cirrhosoides*.
7. I estimate the ratio of endemism as 44% in the fish fauna of Lake Pannon.
8. On the basis of the newest chronostratigraphic results, I proposed a stratigraphic distribution of the studied taxa (Fig. 2). The beginning of the Pannonian is characterised by a rich marine, semimarine fauna. The highest diversity can be observed in the *Lymnocardium conjugens* Zone. Apparently, marine forms are absent from the younger littoral mollusc zones.
9. I recognized a climate-induced faunal change at the boundary between *Lymnocarium ponticum* and *Lymnocarium decorum* Zones which can be explained by the influence of the Vallesian crisis.
10. Sciaenid forms are dominant in the fauna. The most frequent genera of the otolith associations are *Umbrina* and *Gobius*.

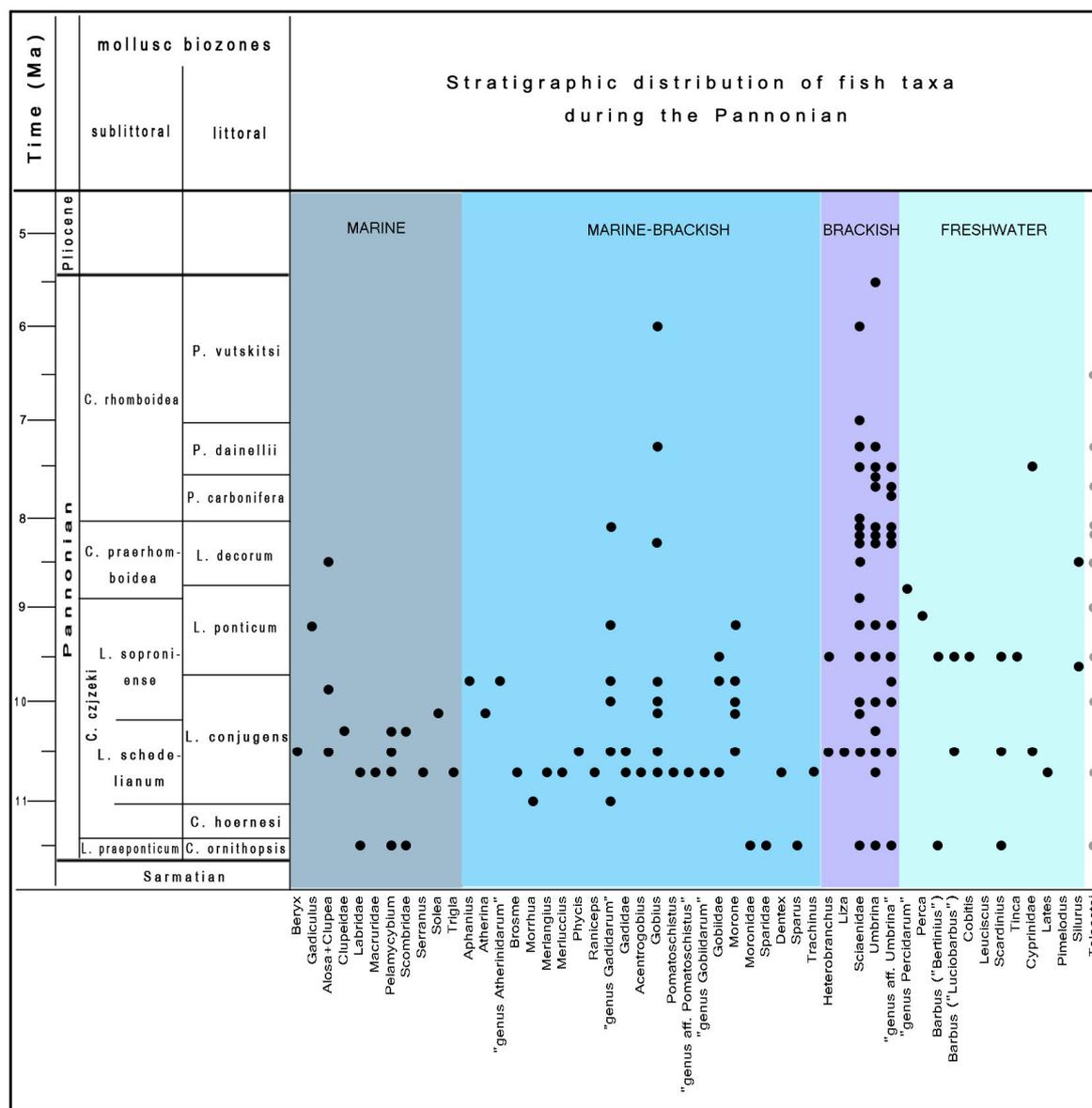


Fig. 2 – Stratigraphic distribution of fish taxa during the Pannonian.

12. I pointed out that benthopelagic species dominate the fish fauna (74%). Epipelagic, mesopelagic and benthic forms are subordinate.
13. On the basis of the comparison of the fish fauna of Lake Pannon with Eastern Paratethyan and modern Ponto-Caspian faunas at genus level I recognised that
 - there are common genera both with Eastern Paratethyan (*Clupea*, *Aphanius*, *Scardinius*, *Merluccius*, *Sparus*) and Ponto-Caspian (*Alosa*, *Liza*) regions,
 - there are common genera (*Atherina*, *Gobius* and *Silurus*), as well as the members of Cyprinidae present in all three regions,

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- the marine genera dwelling Lake Pannon (e.g. *Morone*, *Liza*, *Sparus*, *Solea*, Gadidae) are known mainly from Sarmatian strata of the Eastern Paratethys,
 - the closest relatives of marine-brackish taxa of Lake Pannon are among the marine atlanto-mediterranean genera of the Black Sea,
 - the relatives of the recent fishes of the Caspian Sea were discovered in the fluvial sediments overlying lacustrine beds of Lake Pannon.

Conclusions

Although the fossil material is scarce and sporadic, the 305 literature references and 320 otolith specimens coming from more than 50 localities allow us to draw some conclusions about the fish fauna of Lake Pannon. After the isolation of Lake Pannon, its originally marine fish fauna adapted to the fresher conditions, thus a semimarine-brackish fauna evolved, completed with freshwater invaders from the adjacent river systems. Sciaenid species are dominant in the fish assemblage. The known fishes of Lake Pannon lived in nearshore, shallow water environments, most of them are benthopelagic. They tolerated the mixed water of the estuaries; the fauna mainly consists of euryhaline forms, such as sciaenid, gadid, gobiid and moronid species. Its composition is related at the genus level to the euryhaline faunas of the Eastern Paratethys. The isolated lacustrine environment ensured the conditions to endemic evolution, the estimated proportion of endemic species is 44%.

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