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Gill tissue recovery after copper exposure in *Carassius gibelio* (Pisces: Cyprinidae)

Research Article

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Abstract: We investigated the influence of copper in a long-time treatment with concentrations of 0.05 mg L^{-1} and 0.1 mg L^{-1} to track the histopathological changes in gills of *Carassius gibelio*, and to find at what extent they will recover after the effect of the copper concentrations stops. Treatment with copper lasted 21 days and the recovery time was of the same duration. The results of histological examination showed degenerative changes (resulting in thinner secondary lamellae and filamentary epithelium), and hyperplastic and hypertrophic changes (proliferation, vasodilatation, aneurysms, epithelial interstitial edema, and fusion) in gills under the influence of two concentrations. The degenerative changes have higher prevalence at low concentrations, while hyperplastic and hypertrophic ones – at high concentrations. After the period of recovery they remained the same, but the extent of expression on the surface of gill filaments changed. The long-time copper intoxication in low concentrations of copper affects gill structure, causing severe changes whose recovery is a slow process that requires a longer period of time.

Keywords: *Histopathology • Gill epitelium • Heavy metal • Fish • Long-time exposure*

1. Introduction

Copper, in certain concentrations, is highly toxic metal for freshwater fish, causing pathological changes in their body [1,2]. Only mercury is more toxic to fish than copper is. The values of LC_{50} for 96 hours depend on medium conditions (pH, temperature, hardness) and fluctuate within 0.017–1.0 mg L^{-1}. The chronic effect of sublethal copper concentrations decreases the survival, growth and reproduction rate of the fish. Copper ions induce secretion of gill epithelium, resulting in death for the fish of asphyxiation [3]. In fish farms, copper sulphate is used to control pathogenic organisms and algae, and thus it can cause harm to fish themselves [4]. Copper accumulation in fish tissues and organs increases with higher metal concentrations and longer periods of exposure [5,6].

Crucian carp is a widespread species in the Bulgarian and European waters. It is also resistant to changes in environment factors, as well as to different types of pollution [7]. According to De Boeck *et al*. [8] and Schjolden *et al*. [9], the crucian carp is resistant to copper. This species is less sensitive in environmental conditions than the trout and common carp [10].

Gills of freshwater fish are the main receptor for toxic metals, through which the substances incoming with water are transported to the bloodstream [11]. Playle *et al*. [12,13], Mac Rae *et al*. [14], and Santore *et al*. [15] present the gills as competitive ligands for binding copper and other metals, and their study

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