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NOTE

# Xenobiotic excretion in fish with aglomerular kidneys

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ABSTRACT: Foreign chemicals in teleost fish are primarily excreted via urine and bile. Xenobiotics and their metabolites excreted via urine are filtered in the glomerulus and/or secreted by tubular transport within the kidney. Contrary to most fish species, such as the Atlantic cod *Gadus morhua*, the polar cod *Boreogadus saida* displays a complete absence of the glomerular apparatus. We examined the excretory routes in an aglomerular (*B. saida*) vs a glomerular (*G. morhua*) gadoid fish. Using an inert polysacharride as a model compound, it is demonstrated that this xenobiotic is excreted solely via the urine in *G. morhua* and via the bile in *B. saida*.

KEY WORDS: Polar fish · Aglomerular kidney · Xenobiotic excretion · Environmental pollutants

The nephron is the structural and functional unit of the vertebrate kidney. It is basically segmental, comprising the renal corpuscle (glomerulus) and the renal tubulus which is linked to the urinary bladder via the collecting system (Dantzler 1988). This basic pattern may be highly modified according to the habitat and mode of life displayed by teleost fish (Hentschel & Elger 1992). Histomorphological analysis of the kidney from *Gadus morhua* showed that glomeruli were numerous and appeared to be well developed. By contrast, our examination of the kidney from *Boreogadus saida* revealed a complete lack of glomeruli (J. S. Christiansen, A. B. Amin & K. Ingebrigtsen unpubl.). Although aglomerular nephrons have not previously been reported for a true Arctic fish species, the evolution of aglomerularism is a well-known phenomenon amongst the Antarctic notothenioids (Eastman 1993 and references therein). Aglomerular nephrons in Antarctic fish have been suggested to represent an adaptation to reduce water efflux and to prevent the loss of low molecular weight compounds such as the vital antifreezes (Dobbs et al. 1974). Likewise, the absence of glomeruli may be regarded as a protective mechanism in *B. saida*, which survival also depends on antifreezes in systemic circulation (Osuga & Feeney 1978).

Laminaran is a water-soluble polysaccharide (mol. wt. ~4.5 kDa) that is readily excreted into the urine in both mammals and fish. Tritiated laminaran was administered into the caudal vein of both *Gadus morhua* and *Boreogadus saida* (n = 4 for each species) in order to trace excretory routes for this particular xenobiotic using tape-section autoradiography and radiochromatographic analysis (Sephadex G-25 gel) (Dalmo et al. 1994). The results were unequivocal (Fig. 1). In *G. morhua*, laminaran was excreted exclusively in the urine. This was in sharp contrast to the aglomerular *B. saida* in which laminaran was concentrated in the bile but not in the urine.

The inability of aglomerular fish to perform ultrafiltration implies that urinary excretion of xenobiotics and their metabolites may be hampered (Pritchard & Bend 1984). This, in turn, may result in an increased hepato-biliar excretion of such compounds. The toxic properties and the retention time of xenobiotics excreted via bile may be significantly affected due to bioactivation mediated by the intestinal microflora and reabsorption (Bakke et al. 1982). Consequently, although highly advantageous for fish dependent on antifreezes, aglomerular nephrons may represent a disadvantage when xenobiotics are introduced into the environment.

There is reason to believe that the Arctic marine ecosystem is being increasingly loaded with various xenobiotics from industrial discharges transported into the Arctic, and due to human activities in the Arctic itself (Christiansen & George 1995, Stange & Klungsøyr 1995). Gadoid fish are a major component in Arctic marine food-webs and *Boreogadus saida* is

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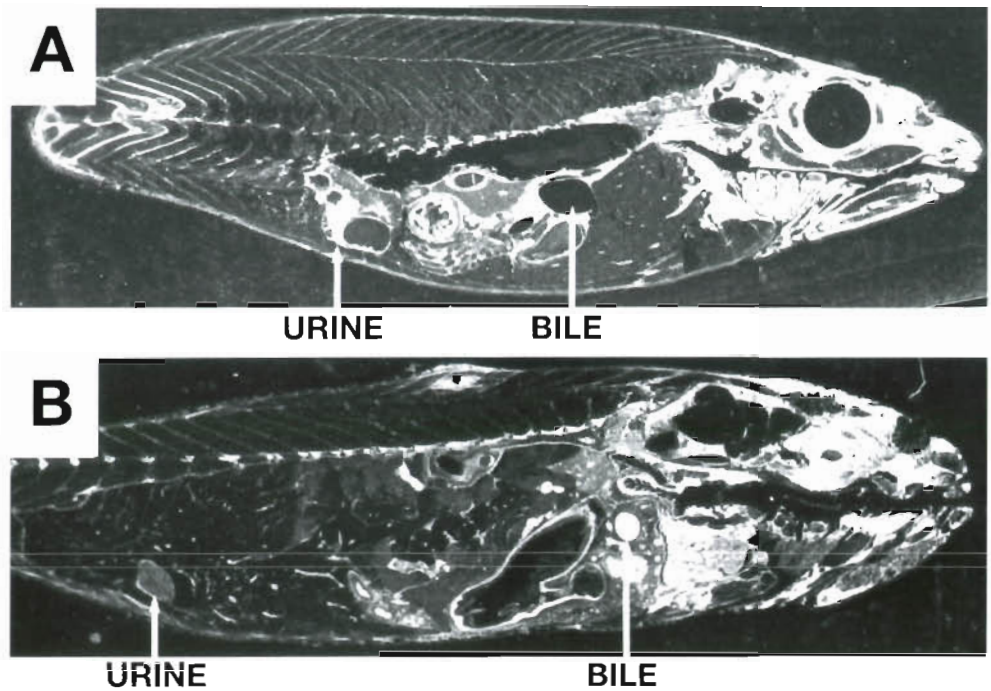


Fig. 1. Tape-section autoradiograms (section thickness: 30 µm; exposure time: 2 mo) of (A) Atlantic cod *Gadus morhua* and (B) polar cod *Boreogadus saida* 72 h after intravenous administration of $^{3}$H-laminaran (12 mg; 36 MBq kg$^{-1}$ body weight). White areas correspond to high concentrations of radiolabelled compound. Wild *B. saida* (body size ~50 g), collected in the Pechora Sea, Russia (70° N, 54° E), were acclimated to full strength sea water at a constant temperature of approximately 0°C (Christiansen 1995). Artificially raised *G. morhua* (body size ~50 g) originated from a local stock near Tromsø, Norway, and were held under similar conditions as *B. saida* at an ambient temperature of about 5°C

recognized as the piscine key species inhabiting the subzero waters of the Arctic Ocean (Hobson & Welch 1992). Therefore, we urge that the specialized renal anatomy and physiology displayed by *B. saida* (as well as other polar fish species) should be contemplated in future studies aimed at assessing the biological impact of environmental pollutants in the polar oceans.

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