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# ON THE KIDNEY OF THE SAFFRON COD, *ELEGINUS GRACILIS*, AND ITS COLD ADAPTATION

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***Abstract:*** The structure and seasonal variations of the kidney of the saffron cod, *Eleginus gracilis*, were investigated by light microscopy.

The kidney is glomerular with nephron that consists only of proximal and collecting tubules. The glomeruli of fish collected in February showed atrophy and did not contain blood cells. By contrast, the glomeruli of fish collected in July were well vascularized and contained some blood cells.

These results may suggest seasonal changes in glomerular function with a reduced or non-functional condition of the glomeruli during winter when kidneys are physiologically similar to those of aglomerular fishes. These morphological differences in the glomeruli of *E. gracilis* may be related to the conservation of antifreeze glycoproteins in their sera and to the adaptation for cold water during the winter.

## 1. Introduction

Most of the many aglomerular fishes observed are sea-water teleosts (MARSHALL and GRAFFLIN, 1928; EDWARDS, 1928, 1929). Research so far has been focused on the nephron in relation to the renal function, especially the water and salts adjustments for their environments (SMITH, 1932; GRAFFLIN, 1937).

Many species of Antarctic teleosts have recently been reported to have aglomerular kidneys (DOBBS *et al.*, 1974; DOBBS and DEVRIES, 1975a). It has also been reported that most Antarctic fishes have freezing-point-depressing glycoproteins (antifreeze glycoproteins) in their blood sera. These have been studied in detail chemically (DEVRIES *et al.*, 1970). Aglomerularism in the Antarctic fishes may be related to the conservation of serum glycoproteins which have "antifreeze" properties (DOBBS *et al.*, 1974; DOBBS and DEVRIES, 1975b).

Antifreeze serum glycoproteins have been reported not only in Antarctic fishes but also in high-latitude cold-water fishes; further it has been noted that blood levels of these substances in the cold-water fishes show seasonal changes (DUMAN and DEVRIES, 1974a, b; FLETCHER, 1977; HEW *et al.*, 1981). Seasonal variations in antifreeze glycoproteins have recently been reported in the saffron cod, *Eleginus gracilis*, with a fivefold higher concentration of antifreeze glycoprotein in the serum of fish collected in March

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compared to fish collected in November (BURCHMAN *et al.*, 1984).

In the present study, an attempt has been made to observe the kidney morphology in the saffron cod, *Eleginus gracilis*, and compare the structure in winter and summer.

## 2. Materials and Methods

Saffron cod, *Eleginus gracilis*, were collected in February and July 1988 from lagoon Saroma Ko located on the Okhotsk Sea side of Hokkaido, Japan. Kidney tissues were fixed in 10% formalin and Bouin's fixative, embedded in paraffin, and sectioned at 6 $\mu$m using routine procedures. Sections were stained with hematoxylin and eosin.

The measurements of the Bowman's capsule and glomerular tuft were made on 20 sections from each of 3 fish. The statistical analyses between two groups, winter (February) and summer (July) fish, were performed by Student $T$ test.

## 3. Results and Discussion

In the complete serial sections, glomeruli were found in the kidney of the saffron cod (Figs. 1 and 3). The nephron of this fish consists only of the proximal tubule and collecting tubule which is typical of marine teleosts. In fish collected during winter (winter fish), the glomeruli showed atrophy and no blood cells were observed in the glomerulus (Figs. 1 and 2). By contrast, the glomeruli of fish collected during summer (summer fish) were well expanded and vascularized in the Bowman's capsule (Figs. 3 and 4). Some blood cells were also observed in the glomeruli of these fish. Sizes of both Bowman's capsule and glomerular tuft of the winter fish were smaller than those of the summer fish (Table 1). The differences between the winter and summer fish were statistically significant. Therefore, during the winter, there appears to be no blood flow to the glomerulus of the kidney: the glomerulus seems to be non-functional like that of aglomerular kidney physiologically. No morphological difference of the nephrons between the winter and summer fish was observed.

Molecular weights of antifreeze glycoproteins range from 2600 to 33700. Molecules of this size are readily filtered through glomerular membranes. Usually they are reabsorbed in the tubules after breaking into the smallest components which are resynthesized again into glycoproteins. However, the costs of reabsorption and resynthesization would be high. Therefore, most Antarctic fish, to combat freezing, are thought to have antifreeze glycoproteins with a wide size-range in their sera and have no glomerulus in the kidney. This enables them to conserve the antifreeze glycoprotein in their sera, without undergoing filtration through the glomerulus (DOBBS *et al.*, 1974).

The morphological differences in the glomeruli of *E. gracilis* during winter and summer may also be related to the conservation of antifreeze glycoproteins in their sera and to the adaptation for cold water during the winter. Among the Antarctic fishes, as an exception it was reported that some glomeruli were found in the kidney of *Austrolycichthys brachycephalus* (OGAWA and FUKUCHI, 1988). The glomeruli in this fish showed atrophy. This atrophic structure of the glomeruli appears to be comparable to that of the glomeruli of *E. gracilis* during the winter in the present investigation.

There may be seasonal changes in glomerular filtration and these changes are related to temperature as such or to seasonal variations in hormone production. In freshwater-adapted teleosts, the administration of prolactin increases both urine flow and glomer-

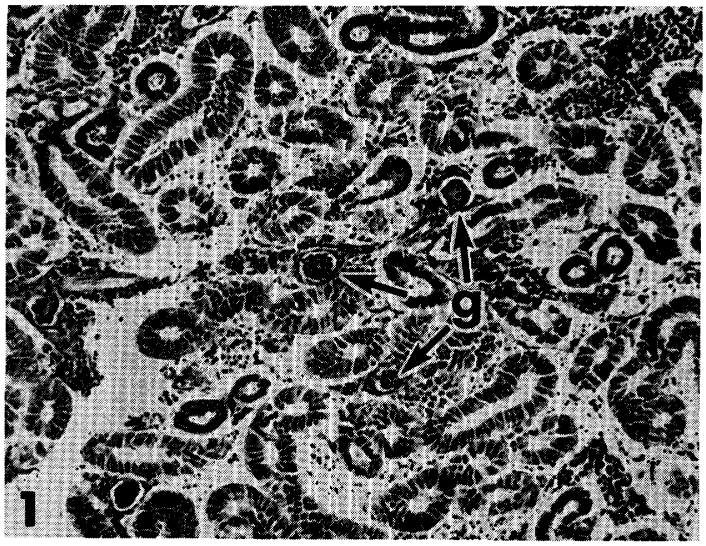


*Fig. 1. Kidney of the saffron cod,* Eleginus gracilis, *collected in February. g : glomerulus. ×130.*

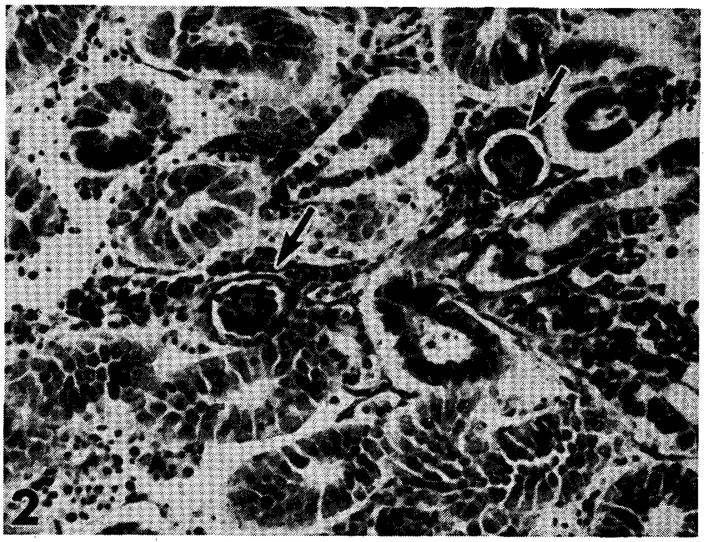


*Fig. 2. A higher magnification of the kidney of saffron cod collected in February. Note the atrophic structure of the glomerulus (arrows). ×270.*

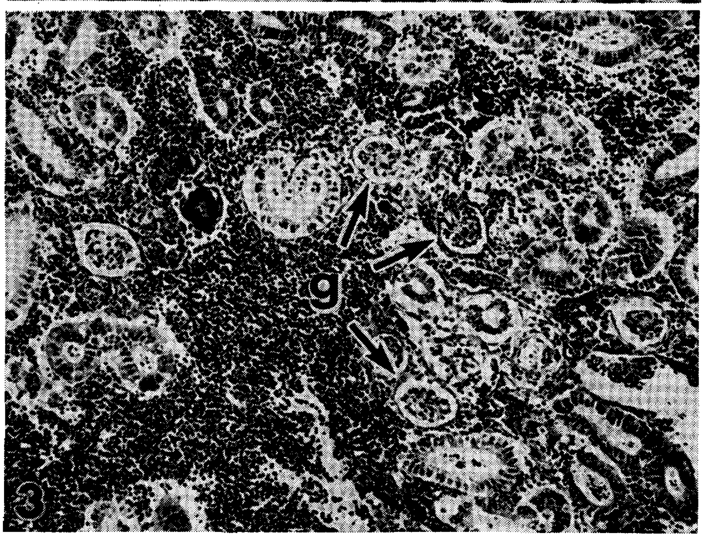


*Fig. 3. Kidney of the saffron cod collected in July. g: glomerulus. ×130.*

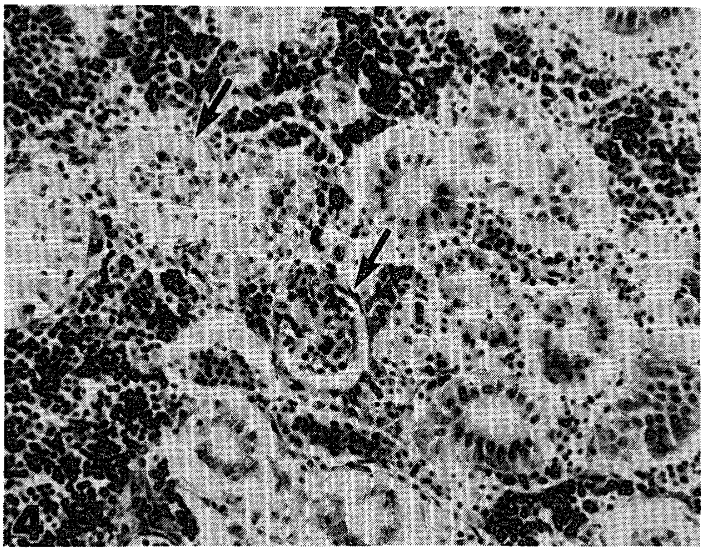

*Fig. 4. A higher magnification of the kidney of saffron cod collected in July. Note the well-vascularized glomerulus and some blood cells in the glomerulus (arrows). ×270.*

*Table 1. The seasonal differences of the sizes of Bowman's capsule and glomerular tuft in the kidney of saffron cod,* Eleginus gracilis.

| | Number of fish (SL, mm) | Number of renal corpuscles | Bowman's capsule (μm) | Glomerular tuft (μm) |
|---|---|---|---|---|
| Winter fish | 3 (185–310) | 60 | 33.3+6.6 | 23.3+5.6 |
| Summer fish | 3 (176–178) | 60 | 44.9+5.1* | 33.8+4.6* |

Note: All values are means and standard deviations.
SL: Standard length.
*: Significantly different from corresponding those of winter fish at $P<0.001$.

ular filtration rate. This appeared to be a specific glomerular effect, as the glomerular capillary tuft of this animal was enlarged after treatment with prolactin (LAM and LEATHERLAND, 1969). It is also known that the diuretic effect of neurohypophysial hormones in fishes reflects its action in increasing the glomerular filtration rate (SAWYER, 1972). In recent studies, winter flounder, *Pseudopleuronectes americanus*, were found to have an annual cycle of plasma antifreeze levels and the aspects of this annual cycle may be endogenous (FLETCEHR and SMITH, 1980; FLETCHER, 1981). It has been also shown that an intact pituitary is necessary for the disappearance of the antifreeze glycoprotein from the plasma of the winter flounder (FLETCHER *et al.*, 1978; HEW and FLETCHER, 1979).

Therefore, further investigation of the endocrine system, especially the pituitary, of fish at two different seasons is desirable.

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