

Sphincter-like Musculature Surrounding the Urino-genital Duct of Some Teleosts

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Abstract We examined histologically the reproductive ducts of thirteen species of teleosts and found distinct striated muscle fasciculi surrounding the reproductive duct and the ureter only in both sexes of chum salmon, Ayu, carp and goldfish. Although the musculature, unlike the sphincter of mammals, are not tubi-form, their ventral (in salmon) or ventral and dorsal (in Ayu) gaps are filled with dense connective tissue, or the two ducts are enclosed with the fasciculi and the intestinal wall, which are connected with each other with loose connective tissue (in carp and goldfish). Furthermore, muscle fibers run circularly around the two ducts. These arrangements imply a possibility that it acts as a sphincter of the ureter usually and as that of the reproductive duct during the spawning season. In other fishes, most of which are more advanced teleosts than the above four species of fishes, the sphincter-like musculature was not found, but other presumptive sphinctering structures exist. Considering our results, sphinctering mechanisms for the two ducts are assumed to have changed several times with the evolution of the teleosts and the musculature found in the present four species of fishes is probably one of the most primitive systems.

In fishes, which have either naked ovaries lacking the ovarian membrane, e.g., the salmonids (Kendall, 1921; Nomura, 1962), the osmerids (Kendall, 1921) and the anguillids (Tesch, 1977), or hollow ovaries covered with a thin elastic ovarian membrane, e.g., the cyprinids (Yamamoto and Yamazaki, 1961), the lateral trunk musculature is conceivably the only organ that can produce ovipositing force (Aronson, 1957; Hoar, 1957), though this was demonstrated only in chum salmon (Uematsu et al., 1980; Uematsu and Yamamori, 1982). The female salmon digs a spawning bed with a vigorous vertical flapping of her tail (Jones and Ball, 1954; Sano and Nagasawa, 1958; Tautz and Groot, 1975) and the two cyprinids, carp and goldfish, spawn among spawning substrates while making several strong tail beats (Breder and Rosen, 1966). During their spawning behavior, the elevated abdominal pressure resulting from abrupt body bends will make ovulated egg leak futilely through the genital opening unless there are some structures always closing the opening except at a moment of oviposition.

The reproductive system of teleosts has been investigated anatomically and histologically by many scientists from different points of views.

However, only a little information exists on the structure of the reproductive duct. Moreover, most of it is concerned with fishes which have both muscular ovarian membranes and muscular oviducts (Essenberg, 1923; Robinson and Rugh, 1943; Yamamoto, 1963; Hosokawa and Nambu, 1971). Young (1931) found a sphincter at the end of the urino-genital duct of *Uranoscopus*. Aronson (1957) conceived the existence of the oviduct sphincter in teleosts and its sudden relaxation at oviposition. However, the structure and the functions of the sphincter are obscure, because their descriptions were neither detailed nor definite.

In the present study, we examined histologically the structure around the urino-genital ducts of thirteen species of teleosts including chum salmon, Ayu, carp and goldfish in order to find the structure for sphinctering the ducts.

Materials and methods

We used mainly both sexes of mature chum salmon *Oncorhynchus keta* caught at the Urahama River, Iwate Prefecture, mature and immature Ayu *Plecoglossus altivelis* obtained from Hiroshima Prefectural Freshwater Fisheries Experimental Station and Shiga Prefectural Fisheries Experimental Station, and mature and

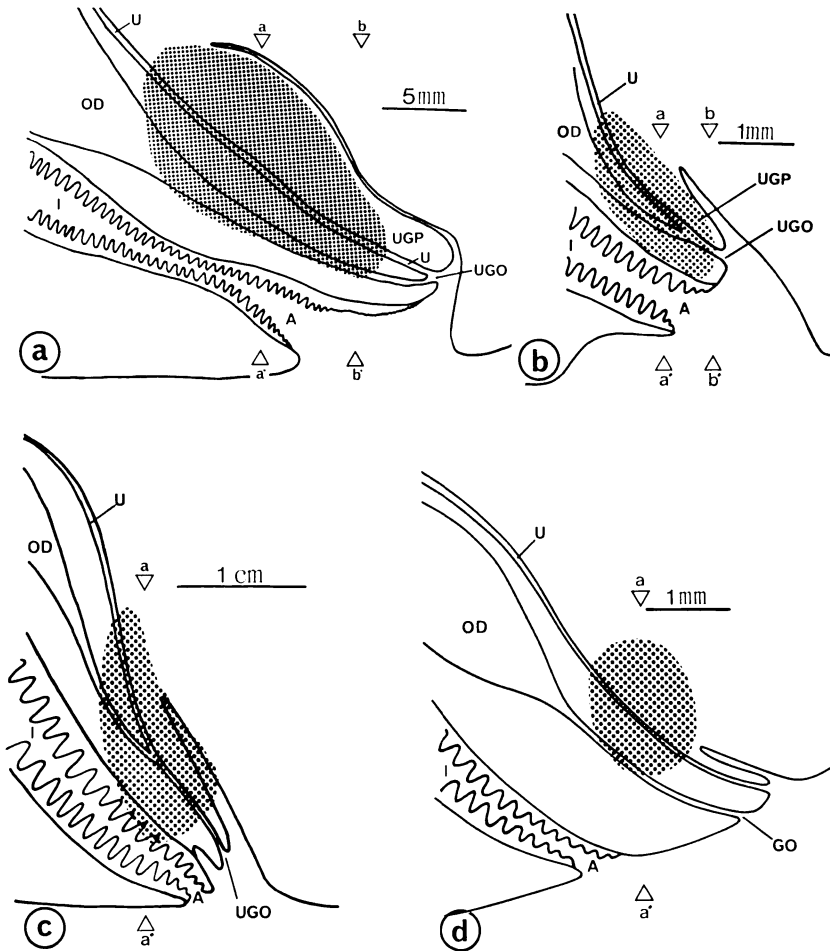


Fig. 1. Diagrams showing the lateral views of the sphincter-like musculatures (stippled areas) of mature females of chum salmon (a), Ayu (b), carp (c) and goldfish (d), all of which are reconstructed from the serial transverse sections. The transverse sections through a-a' and b-b' in (a) are corresponding to Fig. 2a and Fig. 2e, respectively, a-a' and b-b' in (b) are to Fig. 3a and Fig. 3e, respectively, a-a' in (c) is to Fig. 4a and a-a' in (d) is to Fig. 5a. (A: anus, GO: genital opening, I: intestine, OD: oviduct, U: ureter, UGO: urinogenital opening, UGP: urinogenital papilla).

juvenile carp *Cyprinus carpio* and goldfish *Carassius auratus* purchased from local fish farms in Shizuoka and Aichi Pref., respectively. In addition to the above four species of fishes, several other fishes reared at the Fisheries Laboratory of the University of Tokyo, Maisaka, Shizuoka Prefecture, were also inspected. They were *Anguilla japonica*, *Acanthogobius flavimanus*, *Glossogobius olivaceus*, *Limanda yokohamae*, *Misgrunus anguillicaudatus*, *Oryzias latipes*, *Sarotherodon niloticus*, *Sillago sihama*

and *Tilapia zilli*.

For histological investigation, the cloaca region, including the urino-genital opening, the anus and the reproductive duct, were dissected out and were fixed in Bouin's solution for several days. After dehydration and clearing, the materials were embedded in paraffin and serially sectioned at 5~10 μ m in the transverse plane. Sections were stained with Mayer's acid hemalum-eosin or Hansen's iron hemalum-picrofuchsin.

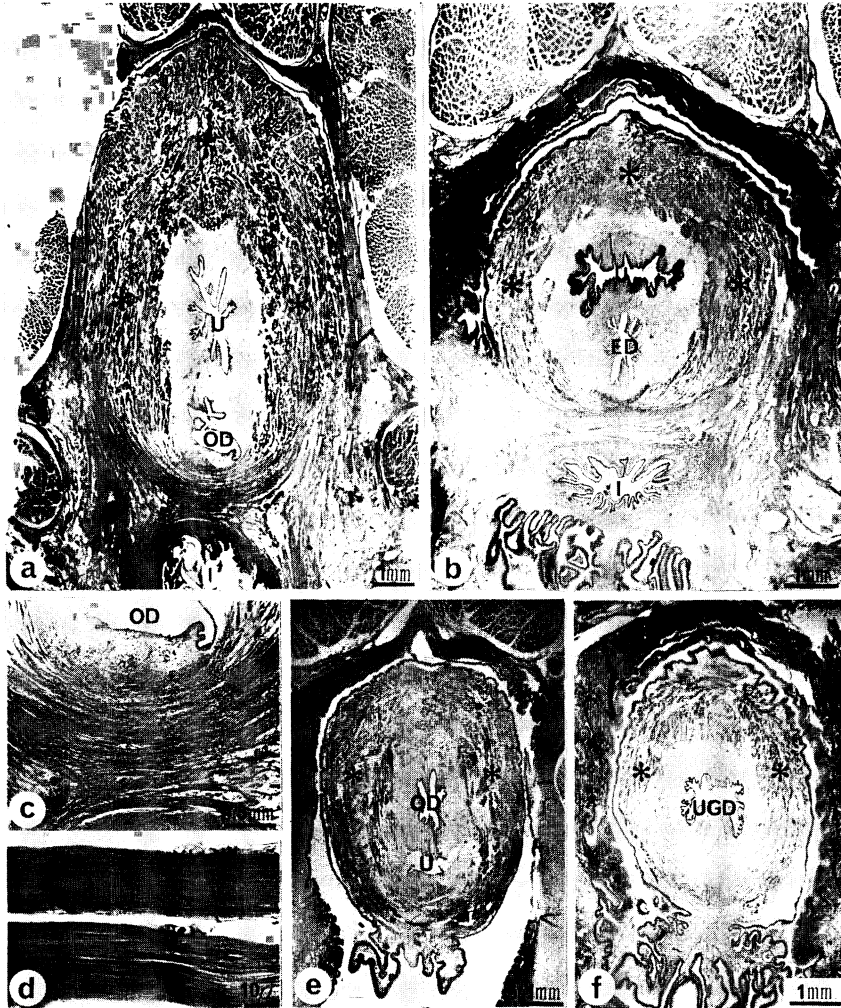


Fig. 2. The sphincter-like musculature in chum salmon. (a) and (b): Transverse sections of the sphincter-like musculatures (*) of the female and the male mature chum salmon, respectively (female: 585 mm SL, male: 553 mm SL). (c): A high power view of the ventral connection of left and right parts of the musculature shown in (a). (d): Cross striations of muscle fibers in the musculature. (e) and (f): Transverse sections of the urinogenital papilla of the female and the male, respectively. (ED: ejaculatory duct, other abbreviations are as in Fig. 1).

Results

We found distinct musculature surrounding both the reproductive duct and the ureter near their external openings in both sexes of chum salmon, Ayu, carp and goldfish. The musculature is composed of striated muscles (Figs. 2d, 3g, 4e, 5e) and is nearly symmetrical to each other with respect to the sagittal plane (Figs. 1, 2a, b, 3a, b, 4a, b, 5a, b). Muscle fibers are distributed in the musculature more or less

circularly around the two ducts. The size and the direction of muscle fibers are not so constant as those of the trunk musculature (Figs. 2a, b, 3a, b, 4a, b, 5a, b). Besides the common structures stated above, there are some structural differences in the musculature according to species, as below.

Chum salmon. The musculature is shaped three-dimensionally as a saddle and each ventral margin of the left and right parts of the musculature join together with dense connec-

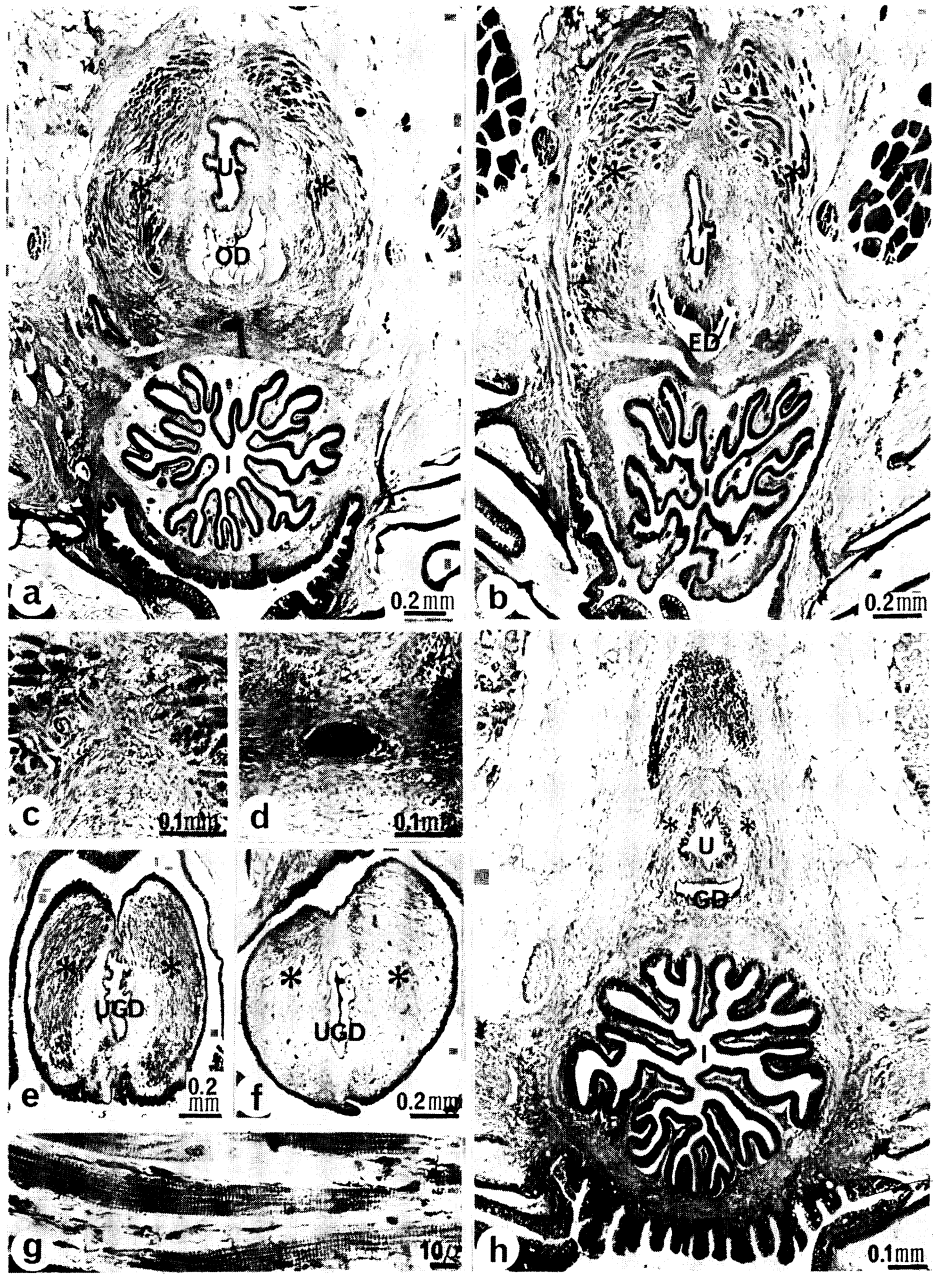


Fig. 3. The sphincter-like musculature in Ayu. (a) and (b): Transverse sections of the sphincter-like musculature (*) of the female and the male mature Ayu, respectively (female: 137 mm SL. male: 146 mm SL). (c) and (d): High power views of dorsal and ventral connections of left and right fasciculi of the musculature shown in (a), respectively. (e) and (f): Transverse sections of the urinogenital papilla of the female and the male, respectively. (g): Cross striations of muscle fibers in the musculature. (h): Transverse section of the musculature (*) of an immature fish (107 mm SL). (GD: genital duct, other abbreviations are as in Figs. 1 and 2).

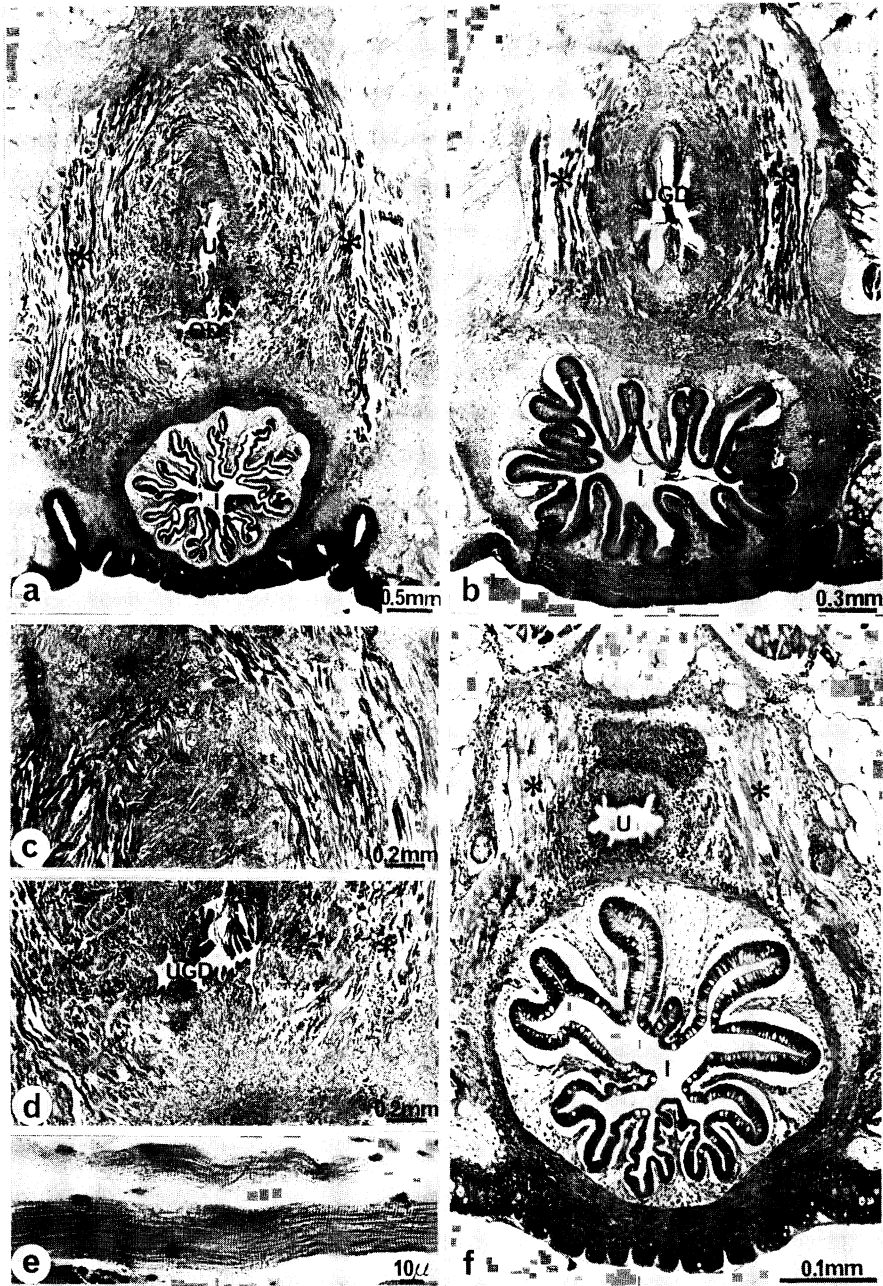


Fig. 4. The sphincter-like musculature in carp. (a) and (b): Transverse sections of the sphincter-like musculature (*) of the female and the male mature carp, respectively (female: 292 mm SL, male 172 mm SL). (c) and (d): High power views of dorsal and ventral connections of left and right muscle fasciculi of the musculature shown in (a), respectively. (e): Cross striations of muscle fibers of the musculature. (f): Transverse section of the musculature (*) of a juvenile carp (45 mm SL) whose sex could not be determined histologically. (UGD: urinogenital duct, other abbreviations are as in Figs. 1-3).