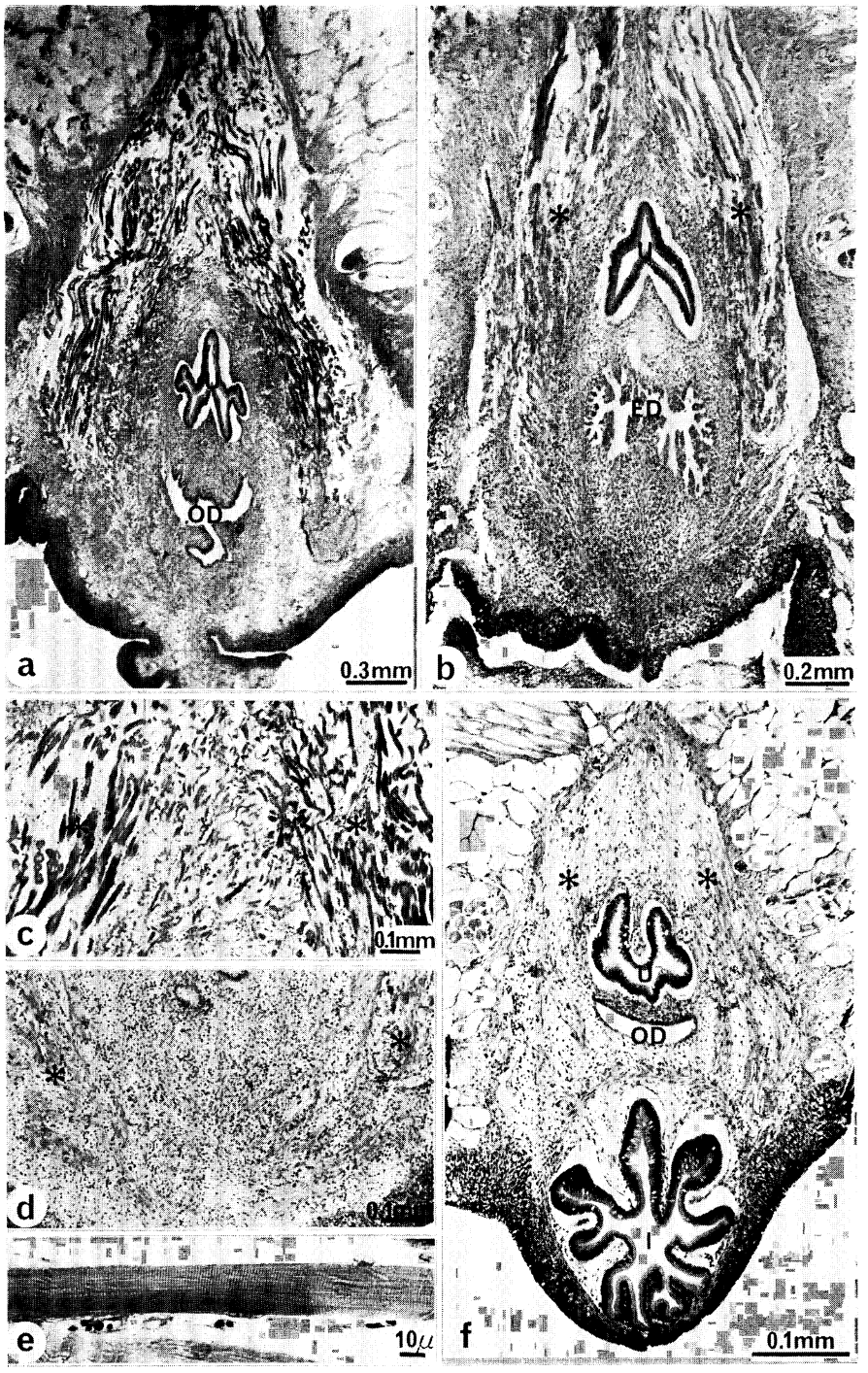

Fig. 5. The sphincter-like musculature in goldfish. (a) and (b): Transverse sections of the musculature (*) of the female and the male mature goldfish, respectively (female: 121 mm SL, male: 115 mm SL). (c) and (d): Dorsal and ventral connections of the muscle fasciculi of both sides in the musculature shown in (a). (e): Cross striations of a muscle fiber. (f): Transverse sections of the musculature (*) of a juvenile female goldfish (37 mm SL). (Abbreviations are as in Figs. 1–4).

tive tissue just above the intestine (Fig. 2c). The gross transverse sections of them form a circle in males (Fig. 2b) and dorso-ventrally extended oval in females (Fig. 2a). The musculature is sheathed with thick connective tissue and covered further, externally, with the lateral trunk muscles (Fig. 2a, b). The musculature extends into the urino-genital papilla retaining its general arrangement (Fig. 2e, f). There are moderate loose connective tissues between the two ducts and the musculature (Fig. 2a, b, e, f).

Ayu. There are no structural differences in the musculature between both sexes of adults (Fig. 3a, b, e, f). It is composed of two muscle fasciculi, which are symmetrical and connected to each other in their dorsal and ventral margins on the sagittal plane with connective tissue (Fig. 3c, d). The reproductive duct and the ureter are completely contained within a space enclosed with fat tissue, not directly with the trunk muscles as in chum salmon (Fig. 3a, b). In immature fish, the musculature is relatively small and undeveloped, whereas it shows the general arrangement found in the adult (Fig. 3h).

Carp and goldfish. The structure of the musculature is basically the same in both sexes, but it is much more developed in the female (Figs. 4a, b, 5a, b). The musculature is composed of two muscle fasciculi which are situated on either side of the ureter and the reproductive duct (Figs. 4a, b, 5a, b). Unlike in salmon and Ayu, the musculature is simply embedded in relatively loose connective tissue, which is further surrounded with fat tissue. Accordingly, the connection of the two fasciculi looks less rigid than those of the previous two species (Figs. 4c, d, 5c, e). The dorsal margins of the two fasciculi are located close to each other just above the ureter (Figs. 4c, 5c), and their broad bases cover in the intestine (Figs. 4d, 5d). In other words, the two ducts are enclosed within the intestine and the two muscle fasciculi. The size and the direction of muscle fibers running in the fasciculi are less constant than those in the trunk muscles. In juveniles, 4 month old carp (Fig. 4f) and 5 month old goldfish (Fig. 5f), general arrangements of the musculature are almost the same as those in adults, but the reproductive duct is undeveloped or absent and the musculature itself is also less developed; that is, muscle fibers in them are very scarce.

Discussion

Salmon discharge gametes by long-lasting, convulsive contractions of almost all the lateral trunk musculature while hovering over in a spawning bed dug by the female (Uematsu et al., 1980; Uematsu and Yamamori, 1982). It may be much the same case in Ayu, because the ovary also lacks the closed ovarian membrane and spawning fish open their mouth and erect every fin like salmon (Nishida, 1978; Honda, 1979). As for carp and goldfish, both spawn among spawning substrates while making strong tail beats (Breder and Rosen, 1966). On the basis of an observation that the ovaries of the two fishes are covered with a thin elastic ovarian membrane, they are assumed to oviposit eggs also by the trunk musculature. Since the musculature is primarily used for swimming, it seems probable that for a moment the intraperitoneal pressure is elevated to a high enough level to induce leaks of eggs or sperm when the fish makes abrupt turns or dashes, unless there are some structures sphincteringthe reproductive duct. However, we have never observed such useless gamete leakage even in the four species of fishes exhibiting forceful spawning behavior.

The sphincter-like musculature found in the four species of fishes, i.e., chum salmon, Ayu, carp and goldfish, were not completely tubiform, but they possessed some structural features implying that they can act as the sphincters of the ureter and the reproductive duct. In salmon and Ayu, ventral (in salmon) or ventral and dorsal (in Ayu) margins of left and right parts of the musculature are connected with each other with dense connective tissue. Furthermore, muscle fibers run circularly within them around the two ducts. On the other hand, the musculatures found in carp and goldfish are shaped like inverted V or U in the transverse plane. Besides, the reproductive duct and the ureter enclosed with the musculature look very narrow. Therefore, contraction of the musculature could lift up the elastic tissue situated between the reproductive duct and the intestine, and consequently result in closure of the two ducts. Although it may be premature to conclude that this musculature acts as the sphincter for the two ducts, the observations stated above strongly suggest this possibility. Judging from the fact that at usual handling of the ovulated or sper-

miated fishes a moderate touch on the belly of the fishes brings about gamete leakage through the genital opening, the closure of the two ducts by the musculature is not as tight as the sphincter of mammals.

The result that fishes possess sphincter-like musculature throughout their lives may indicate its necessity to their usual life. Furthermore, considering the arrangement of the musculature, it encloses the ureter more profoundly than the reproductive duct. This musculature might usually act as the ureter sphincter. In the spawning season, the musculature might play a role in maintaining gametes inside the body by exerting a minimal force, not permitting leakages during swimming. At spawning it allows them to pass through the reproductive duct with a minimal friction. If the assumptions put forth in this paper are correct, the musculature has a dual function: it is used to sphinct both the ureter and the reproductive duct during spawning season.

The musculature is composed of striated muscles and is symmetrical with respect to the sagittal plane. There are some of characteristics found in the voluntary muscles, such as the trunk muscles and the fin muscles (Harder, 1979). Therefore, the sphincter-like musculature might be derived from these muscles and innervated by the voluntary nerves arising from the spinal cord, as has been pointed out by Young (1931) on *Uranoscopus*.

Salmonids and cyprinids, some of which possess sphincter-like musculature as already shown, belong to a relatively primitive teleost group (Greenwood et al., 1966). On the other hand, all other fishes examined in this paper lack such musculature, but they possess either an elastic wall surrounding the narrow outlet(s) of the two ducts or a circular muscle layer in the urino-genital papilla. Except for the eel, they are members of Acanthopterygii, which is thought to be the most diverse and specialized group among teleost (Greenwood et al., 1966). In addition to this, there are some morphological differences in the sphincter-like musculature even among chum salmon, Ayu, carp and goldfish. Though detailed descriptions and discussions about them will be made elsewhere, these facts may imply that the sphincter mechanisms for the two ducts have changed on the way of the teleost's evolutional trends. In other words, the sphincter-like musculature of these four species of fishes might be the most primitive system for sphincter the two ducts and be taken over by simpler structures found in other species examined in this study. To determine this, further careful study is needed of the urinogenital system of more species of teleosts from the view-points of systematic differences.

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(KU: Faculty of Applied Biologivcal Science, Hiroshima University, Midori-machi 2–17, Fukuyama, Hiroshima 720, Japan; TH: College of Agriculture and Veterinary Medicine, Nihon University, Simouma-cho 3–34–1, Setagaya-ku, Tokyo 154, Japan.)

数種の真骨魚に見られた生殖管と尿管を囲む括約筋様筋群の形態

植松一真・日比谷　京

真骨魚 13 種の生殖管ならびに尿管の末端周辺部位の構造を組織学的に検討した．このうち，シロサケ・アユ・コイ・キンギョにのみ両管を取り囲む特徴的な横紋筋群が見い出された．その形態には多少の種間差が見られたが，いずれの種においても同筋の収縮は両管を閉塞しうると判断された．また，成熟した雌雄ばかりでなく未熟な個体も同筋を有することから，同筋は通常，尿管を括約し，産卵期になると生殖管の括約筋として機能するものと思われる．残りの魚種には類似の構造が見い出されなかったことから，両管を括約する機構は魚類の進化とともに変化してきたものと考えられる．

(植松：720 福山市緑町 2–17　広島大学生物生産学部；日比谷：154 世田谷区下馬町 3–34–1　日本大学農獣医学部)