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The Fat-containing Swim-bladder of the Stomiatoid Fish,

Yarrella elongata MATSUBARA

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(With 3 Text-figures)

With the interest in problems of the structure and function, the teleostean swim-bladders have been adequately studied and reviewed from the viewpoints of anatomy and physiology. Although the swim-bladders exhibit great varieties in structure, those of adult teleosts can be divided into two major types by the presence or absence of the pneumatic duct. The first type of the swim-bladder has a pneumatic duct which opens into the oesophagus or stomach. The term "Physostomous" has been employed in description of this type. The other one so called "Physoclistous" lacks the pneumatic duct, though the duct is usually present in the early embryonic stage. It has been convincingly demonstrated that the physoclistous fishes regulate the volume of gases in the swim-bladder by the gas gland lying in the epithelium of the inner wall of the bladder.

Recently, JONES and MARSHALL (1953) and MARSHALL (1954) found a remarkable evidence that certain stomiatoid fishes, e. g., *Cyclothone microdon* and *Gonostoma elongatum.* possess a distinct swim-bladder which modified into a fat-storing organ.

Yarrella elongata MATSUBARA, belonging to the family Gonostomatidae together with *Cyclothone* and *Gonostoma,* appears to inhabit the deep waters along the Pacific coast of Japan, and is occasionally taken by motor trawlers. This deep-sea fish is slender and laterally compressed (Fig. 1). Ground coloration of the body preserved in formalin is silvery gray with a longitudinal dark brown band extending along the dorsal border of the body. There is a well developed series of the luminous organs along the ventral contour of the body and on the head.

During the course of the anatomical survey of the stomiatoid fishes, the author's attention was directed to the fact that the swim-bladder of *Yarrella elongata* is filled with fatty substance. The following report presents data on the gross anatomy of this unusual swim-bladder.

The author wishes to express his gratitude to Prof. K. MATSUBARA, under whose direction this study was carried out. Thanks are also due to Dr. Y. HANEDA of the Yokosuka City Museum for his valuable suggestions concerning the behavior pattern of *Yarrella.*

Materials examined: The material thus far examined consisted of 10 specimens taken from Kumano-Nada at a depth of about 200m. in November, 1954. Measurements of these specimens ranged from 147.0mm. to 184.5mm. in standard length.

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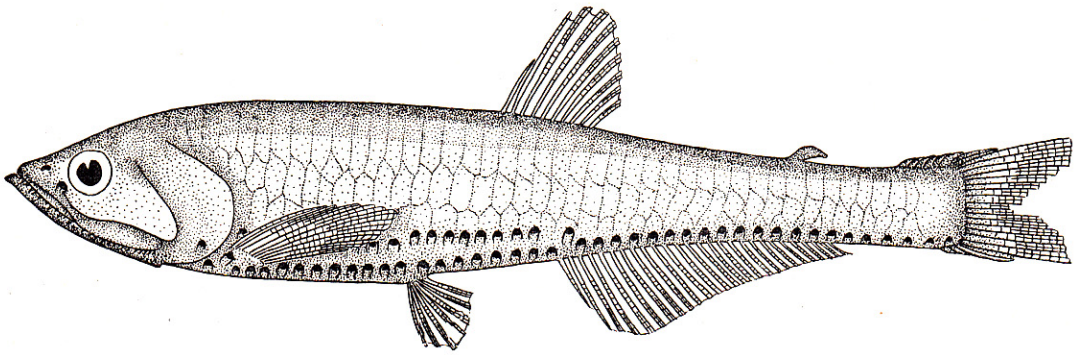

Fig. 1. Lateral aspect of *Yarrella elongata* MATSUBARA.

Anatomy of the swim-bladder: The swim-bladder of *Yarrella elongata* is a closed type in structure and lies between the alimentary canal and the kidney (Fig. 2). It originates below the 7-9th vertebra and the posterior end reaches below the 19-20th vertebra. The bladder is a slender tube in general appearance. Taking as an example 149.0mm. specimen, the bladder is approximately 31.5mm. in length and 2.5mm. in diameter. The bladder wall is formed of a thin membrane of connective tissue and is translucent.

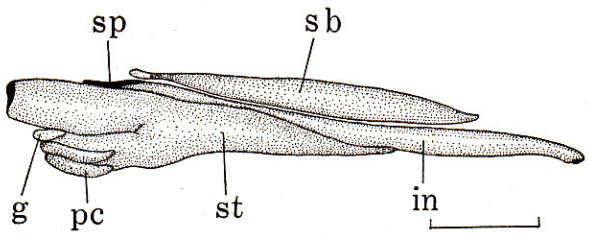

Fig. 2. Lateral aspect of viscera especially showing the position of the swim-bladder. g. gall-bladder; in. intestine; pc. pyloric caecum; sb. swim-bladder; sp. spleen; st. stomach. Scale bar indicates 10mm.

It is a remarkable fact that a large proportion of the bladder cavity is filled with viscous fatty substance without gas. In the specimen preserved in formalin, the fatty substance is brownish yellow in color and is readily recognized through the bladder wall. It is common knowledge that the teleostean swim-bladder is usually filled with gases which are composed of a mixture of oxygen, carbon dioxide and nitrogen. Accordingly, the peculiar swim-bladder of *Yarrella* may serve to somewhat different way as compared with that of the other fishes.

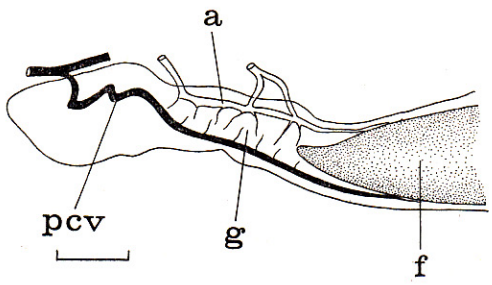

Fig. 3. Diagrammatic aspect of the anterior portion of swim-bladder showing the reduced gas gland. a. artery branched from the dorsal aorta; f. fatty substance; g. gas gland; pcv. branch of posterior cardinal vein. Scale bar indicates 1 mm.

The gas gland locating on the anterior end of the swim-bladder is much reduced and vestigial. The blood supply to the gland is not well developed. The arteries entering the gland arise from the branches of the dorsal aorta (Fig. 3). The venous vessels of the gas gland appears to join the posterior cardinal vein. Such a reduced vasculer system of the gas gland may suggest that the gland does not serve as a gas-secreting organ.

Considerations and conclusion: It is generally conceded that the teleostean swim-bladders variously act, at least by species, such as hydrostatic organ, respiratory organ and sound producing organ. Of these most common and important function seems to be a hydrostatic. JOHNSTON (1953), working with the embryo of largemouth black bass, confirmed the hydrostatic function of the swim-bladder from the evidence that the vertical ascent of the larvae coincides in time with the initial gas secretion of the swim-bladder.

According to JONES and MARSHALL (1953) the deep-sea fishes of the families Gonostomatidae, Sternoptychidae and Myctophidae, many of which are known to migrate vertically, are provided with a well developed swim-bladder. In these fishes, the bladder may probably serve as a hydrostatic organ. Conversely, the swim-bladder is entirely absent in some other deep-sea fishes of the families Alepocephalidae, Bathylagidae and Ceratiidae. MARSHALL (1954) presented an explanation to this inconsistency as follows: The deep-sea fishes, lacking the swim-bladder, contain buoyant fat into the body tissue and their ossification of the skeletal system is poorly developed. These evidences may compensate for loss of the swim-bladder.

According to MARSHALL (1954), *Gonostoma denudatum* inhabiting above 500 m. possesses a well developed swim-bladder and *G. elongatum* living in deeper layer bears a long fat-charged bladder, but *G. bathyphilum* inhabiting below a depth of 500 m. lacks the swim-bladder. Similar evidence has been mentioned by JONES and MARSHALL (1953) in the fishes of the genus *Cyclothone*. In these genera, there is a tendency toward the reduction of the swim-bladder with an increment of inhabiting depth.

The fundamental structure of the swim-bladder of *Yarrella elongata* is quite similar to that of *Cyclothone microdon* and *Gonostoma elongatum*, though the location of the reduced gas gland is not agreed to that of latter ones. JONES and MARSHALL (1953)

considered this modified bladder as a fat-storing organ. This is indeed a reasonable conjecture. In regard to this peculiar bladder, however, there extends some problems to be discussed in relation to the behavior of *Yarrella*.

Based upon the data concerning the observation of luminous fishes, HANEDA (1958) has suggested to the author that *Yarrella elongata* appears to inhabit the bathypelagic layer and does not undertake the vertical migration. This evidence would lead one to suppose that the bladder filled with buoyant fat serve to maintain the constant density of the body, which facilitate the gliding movement in the deep-sea bathypelagic layer. Therefore, it might be conceivable that the gases of the swim-bladder of *Yarrella elongata* were replaced by buoyant fatty substance as an adaptation to the behavior pattern.

References

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抄　　録

リュウグウハダの脂肪鰾について

岩　井　　保

硬骨魚類の鰾は、消化管の前部より分化したもので、発生の初期には、鰾は気道によって消化管と連絡している。しかし、成魚の鰾をよく観察すると、種類によって気道をそなえたものと、失っているものとがある。終生気道をそなえている鰾を有管鰾、成長とともに気道が消失する鰾を無管鰾という。

リュウグウハダカは本邦太平洋側の深海に分布する発光器をそなえた深海魚で、体色は腹部が銀白色、背側は褐色である。本種の鰾は気道のない無管鰾で、消化管の背側、腎臓との中間の第7～9—19～20番目の脊椎骨の下方にあり、形は管状である。鰾壁は薄く、半透明である。鰾の前部にはガス腺が認められるが、ガスの分泌機能をもっているかどうかは疑わしいほど退縮している。

この鰾で、とくに注目されるのは、鰾の内腔が油性物質によって満たされていることである。一般に、無管鰾魚類は鰾の表皮にあるガス腺によって鰾内ガスを調節するのが普通で、このように油性物質を含んだ鰾は、リュウグウハダカと共にヨコエソ科に属する *Cyclothone microdon* および *Gonostoma elongatum* に存在することが報告されてはいるが、極めて珍しい事実である。MARSHALL (1954) によると、同じ *Gonostoma* 属に属するものでも、500m. 以浅に棲息する *G. denudatum* はよく発達した鰾をもっているが、より深いところに分布する *G. elongatum* では鰾は退縮して脂肪で満たされている。さらに深海に住む *G. bathyphilum* では鰾は全く消失している。したがって後二種の鰾はその主な機能の一つである比重調節作用を司っていないようにも思える。しかし、鰾が油で満たされていれば、魚がつねに同じ比重を保って、深海の中層に浮游生活をするのには好都合なことかもしれない。リュウグウハダカも深海に常住し、極端な垂直洄游をしないようであるから、その脂肪鰾もこのような生態に適応して特化したものではなかろうか。