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Gill Structures of the Deep-sea Stomiatoid Fish, *Cyclothone microdon* (GÜNTHER)

Tamotsu IWAI*

(With 3 Text-figures)

During an exploratory cruise of the Kobe Marine Observatory Research Vessel Sympu-Maru on the western Pacific, a single adult and seven young of *Cyclothone microdon* (GÜNTHER) (Fig. 1), which appears to be a world-wide bathypelagic species, were captured in the plankton hauls. Of these, the taxonomic features of the adult specimen were comprehensibly reported by MATSUBARA (1955). The present species is peculiar in having unusually reduced gill; the gill-filaments are attached only to the lower limb of the branchial arch. Although this fact was briefly described by NYBELIN (1948) and ABE (1957), it seemed worthwhile to study such a remarkable structure in some detail, especially in relation to the behavior pattern of the fish. Thus, the results of observations are presented in the following communication.

It is a pleasure to express my hearty thanks to Prof. K. MATSUBARA for his cordial supervision and criticism. Thanks are also extended to Mr. K. FURUHASHI of the Kobe Marine Observatory for the privilege of examining these interesting materials.

Locality and date of materials: Station U 10, 33°17′N, 138°28′E; about 70 miles south off Omaezaki, Shizuoka Prefecture. Depth of net; 2000-1300m. September 2, 1954.

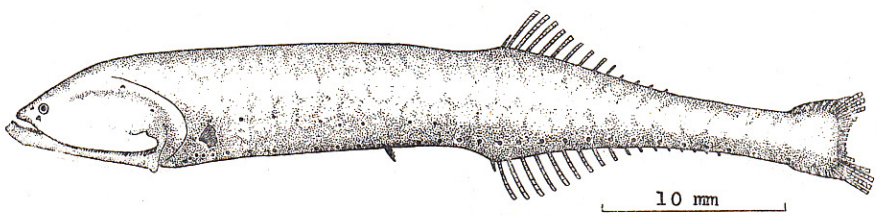

Fig. 1. *Cyclothone microdon* (GÜNTHER). (after MATSUBARA, 1955).

Descriptions: There are five branchial arches diminishing in size posteriorly, though the fifth one is modified into the pharyngeal bone bearing minute pharyngeal teeth. The gill-rakers are arranged in two rows along the anterior border of first four arches. The outer gill-rakers are slender, tapering gradually to a distal point. Each raker is sparsely armed with two rows of minute prickles. Counts of the outer gill-rakers on the first arch are 7 (on the epibranchial)+9 (on the ceratobranchial)+4 (on the hypobranchial) = 20 in 43.8 mm. (in standard length) specimen, and 6 + 7 + 3 = 16 in 19.5 mm. specimen. The inner gill-rakers are much shorter than the outer ones and their basal parts are armed with the band of minute prickles. Counts of the inner gill rakers on the first arch are 6 + 8 + 4 = 18 in 43.8 mm. specimen, and 4 + 6 +3 = 13 in 19.5 mm. specimen.

*Department of Fisheries, Kyoto University, Maizuru

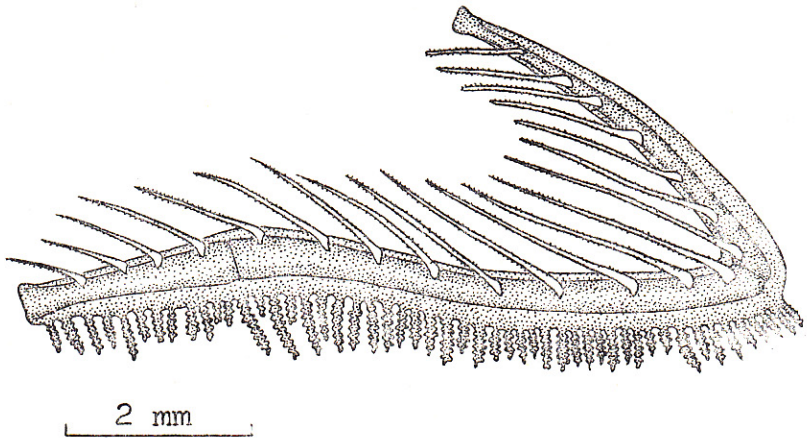

Fig. 2. Lateral aspect of first, left branchial arch of *Cyclothone microdon*.

The gill-filaments are arranged on the posterior border of the lower limb of first, second and fourth branchial arches. It is of interest that on the third arch the gill-filaments are restricted to the anterior half of the lower limb, so that three-fourths of whole length of this arch lack the gill-filament. Each gill-filament is obsolescent and is cluster-like in general appearance. About 51 filaments are set in a zigzag lengthwise series on the lower limb of the first branchial arch in 43.8 mm. specimen (Fig. 2). In 19.5 mm. specimen, the filaments are scarcely developed and papilla-like in shape. The gill-lamellae bearing a plexus of capillaries that facilitate the gas exchange are so few in number, 12-25 per filament, as compared with other teleostean fishes (Fig. 3 A). This may imply that the surface area of gill-filamens which make possible the respiratory function is considerably limited, though in compensation for it the cutaneous respiratory function might be developed in this species.

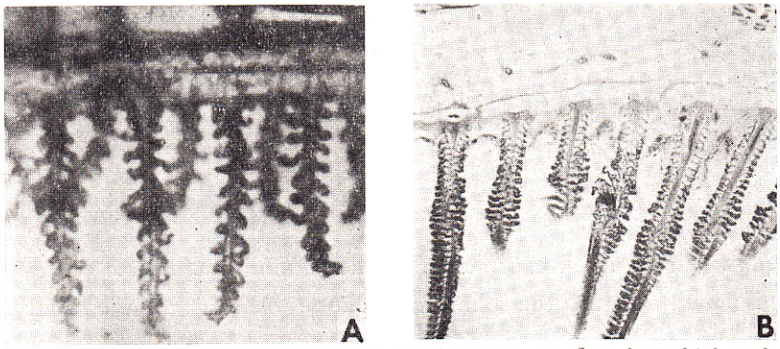

Fig. 3 Photomicrographs comparing gill-filaments on first branchial arch between two closely related deep-sea fishes of the same family, Gonostomatidae, (A) *Cyclothone microdon*. x 60. (B) *Yarrella elongata*. x 33

Unusual reduction of the branchial elements in *C. microdon* may be shown by comparison with *Yarrella elongata* MATSUBARA which is one of closely related species to the former one. The structure of gill-rakers is fundamentally the same in *Cyclothone* and *Yarrella*, though the minute prickles attached to them are somewhat different. In *Yarrella* the number of the gill-rakers on the first branchial arch is 6+7+4=17 on the outer side and is 5+7+4=16 on the inner side. Each outer gill-raker is armed with 2-3 rows of minute prickles. The basal portion of inner gill-raker is provided with the band of about 10 minute prickles, and in addition, 2-4 prickles are arranged in a len-

gthwise series along the midline of the raker.

The great difference in the appearance of gill-filament between these two species is exemplified. In *Yarrella*, the gill-filaments are well developed, and are closely set in two series on the posterior border of both upper and lower limbs of all branchial branchial arches except for the fifth one which is modified into the pharyngeal bone. And each of these primary filaments is furnished with numerous fine gill-lamellae as is the case with many other teleostean fishes (Fig. 3 B.)

Distribution: In her extensive review on the distribution of deep-sea fishes, GREY (1956) stated that *C. microdon* is a world-wide species, including high latitudes in north Atlantic and Antarctic seas. The majority of specimens have to date been caught from depths between 1000 and 1600 m. It is quite evident that the species inhabits bathypelagic waters.

Consideration and conclusion: The fact that the respiratory apparatus of *C. microdon* is distinctly reduced is suggesting that the respiratory capacity of this species is strictly limited. On the basis of this evidence, two inferences concerned with its behavior would be offered. On the one hand the fish may inhabit somewhat cold environment and on the other hand this species does not look like any of the powerful swimmer.

The results of survey of the water temperature on Sympu-Maru Station U 10 show 2.77°C at 1300 m. layer and 2.15°C at 2000 m. layer respectively. It is very probable that in such deep layers, no remarkable seasonal variation occur in water temperature. It is a common knowledge that there is a positive correlation between the standard metabolism of fish and the water temperature surrounding them. The fish inhabiting the cold environment would not stand in need of so high level of the oxygen uptake. Therefore, it is not unlikely to assume that the respiratory organ of this species has secondary reduced due chiefly to the influence of such environmental fact as low water temperature.

GRAY (1954), studying on the gill structure of 31 marine fishes, concluded that swift swimming fishes are provided with relatively greatergill area than sluggish, benthic fishes, and benthic fishes have fewer gill-lamellae than do fast swimmers. That the gill area of *C. microdon* is extremely small would suggest that this fish does not belong to the group of swift swimmer.

According to JONES and MARSHALL (1953), the swimbladder of the adult *C. microdon* inhabiting below 500 m. is much reduced to the fat-storing organ, while the post larvae which inhabit shallower water have normal swimbladder. This would lead one to suppose that the adults do not undertake an excessive vertical migration as some of the plankton feeding deep-sea fishes do.

In addition to these facts, the placement and structure of the fins of this species are not established as the propulsive organ. The ossification of each fin ray is not well progressed. The musculature supporting the fins is also too reduced to take charge of the vigorous swimming. The dorsal fin is inserted slightly behind middle of the body excluding the caudal fin. The anal fin is opposed to the dorsal fin. BERTELSEN and MARSHALL (1956) commented that the opposed, backwardly-set dorsal and anal fins in Stomiatidae, Miripinnati, and certain other groups presumably give stability of the body in the yawing plane.

Judging from the foregoing discussions it may be possible to make the conclusion that the locomotor pattern of *C. microdon* is not propulsive, but perhaps is bathypelagic gliding nature.

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抄　　録

深海魚オニハダカの鰓の構造について

岩　井　　保

オニハダカ *Cyclothone microdon* (GUNTHER) は、全身黒褐色で、体表に小さい発光器をそなえた、体長5～6cmの小型の深海魚である（第1図）。各鰓の発達は悪く、採集されたとき、大部分の鰓は破損している場合が多い。この魚は、太平洋、印度洋、大西洋、南氷洋に広く分布するが、水深1000～1600mのいわゆる深海の中層に棲息しているようで、そのために、我国での採集記録は比較的少い。筆者は神戸海洋気象台古橋賢造氏の御好意で、1954年9月、御前崎南方70哩の観測点において、海洋観測船春風丸のプランクトンネットによって採集された成魚1、稚魚7、計8尾の標本を調査する機会を得た。

これらの標本の分類形質は、今までに報告された *C. microdon* の記載とほぼ一致するが、特に興味深いのは、鰓の構造が著しく退化していることである。第1鰓弓の鰓耙数は、体長43.8mmの成魚で20本で、細長く、外側に2列の微小棘をそなえ、特に退化現象は認められない。しかし、鰓弁は退化の傾向著しく、第1,2,4鰓弓では下半部、つまり角鰓骨、下鰓骨の部分にのみ、第3鰓弓では、下鰓骨の部分にのみそれぞれ存在する。すなわち、全ての鰓弓の上半（上鰓骨の部分）は全く鰓弁を欠く。個々の鰓弁についてみても、みな萎縮して短く、また数も少い。さらに、鰓弁の両側にならぶ毛細血管網を有する薄板の数も、他の硬骨魚類の鰓弁と比較してはるかに少い（第3図）。したがって、オニハダカの鰓の呼吸表面積は著しく制約されているものと思われる。このように、呼吸器官に顕著な退化的現象がみられるのは、魚の生活状態と何等かの関係があるように思われる。まず考えられるのは、この魚はほとんど運動しないのではないかということで、これは、1)鰓の発達が悪いこと、2)鰾が退縮していることなどの事実からも想像できる。つぎに、棲息深度が深く、環境の水温が低いこと（春風丸の採集観測点の水深1300m.および2000m.の水温はそれぞれ2.77°C、2.15°Cであった）から、魚の基礎代謝量も低く、呼吸量も多くを必要としないものと推察できる。これらの事実を綜合して考えると、オニハダカは深海の中層で浮游生活をしていて、その生活に適応して鰓が二次的に退縮したものと解釈できよう。