

Further Report on the Luminous Fish of the Family Paralepididae

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(with 1 text-figure and 1 plate)

ハダカエソ科 Paralepididae 魚類の発光

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1. Introduction

The fish of the family Paralepididae or "Barracudina" belong to the order Myctophida. They are common the deeper open waters of the Pacific and are an important food for other large oceanic fish. In the order Myctophida the family Paralepididae is second in number to the family Myctophidae. According to HARRY (ROFEN) the family Paralepididae comprises seven genera and 48 species in Pacific waters and also in Bermuda. Recently he published one new genus 5 new species and 2 new subspecies of the family. No luminous fish had hitherto been observed in this family, but I observed and reported, in 1958, on the luminosity of two species, *Lestidium prolixum* and *L. japonicum*. This was a preliminary report. Almost all the fish of the Paralepididae have a slender, translucent body. The intestine is covered with a black membrane. In *Lestidium prolixum*, the luminous organ was a long thin, yellowish structure extending on a median line from a point near the anus to the forepart of the fish. In *Lestidium japonicum* it was two long yellowish structure joined at either end to form one organe.

These luminous organ are most remarkable, for although in the order Myctophida almost all the species of the family Myctophidae have luminous organs, it had been

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supposed that no luminous organs existed in the family Paralepididae. I desired to find out whether luminosity in this family was confined to the two above-mentioned species, or whether it was just being overlooked in the other species.

The relation of the evolution of a luminous organ to the taxonomy of animals possess an interesting problem.

Among closely related animals there are often many which possess a luminous organ while the others do not. Thus, there are many species of shrimp with luminous organs, but no luminous crab has ever been found. There are many luminous squid, but no luminous octopos. Among fishes that emit light by bacterial symbiosis, almost all the species of the families Leiognathidae and Coryphaenoididae have a luminous organ, while in the family Monocentridae and *Paratrachichthys prosthemi* of the family Trachichthyidae the phenomenon is seen in some special species. Again the family Pempheridae the species *Parapriacanthus*, in the family Apogonidae the species *Apogon ellioti*, and all the species of the genus *Siphamia* have a luminous organ.

Thus there appears to be no direct relation between the taxonomy of the fish and the possession of a luminous organ. Therefore, it would be interesting to determine whether all or only special species of the family Paralepididae are luminous.

For 1958 years I have examined fresh specimens of *L. japonicum* and *L. proluxum* obtained at the fish markets of Manazuru, Kanagawa-prefecture, and Owase, Mie Prefecture. In addition, during my collecting expedition around the world from 1959 to 1960, I was able to examine preserved specimens of other species as shown in Table 1 in the following collections: Dr. R. R. ROSEN's collection at the Laboratory of the George Vanderbilt Foundation; Stanford University Natural Museum; U. S. National Museum, Wash., D. C.; Funchal Municipal Museum, Madeira, Portugal. In addition to the two Japanese species and *Notolepis coasti* found in the stomach of a whale caught in the Arctic region, 31 specimens of 9 genera, 27 species were examined.

Of these, only the genus *Lestidium* possessed a luminous organ.

In *L. proluxum*, *L. elegans*, and *L. atlanticum*, a long yellowish organ runs along the median line from in front of the anus to the end of the keel muscle. This organ is made up of a long, yellowish luminous substance covered by a long, transparent muscle. If a transverse section is examined, the black intestinal membrane can be seen to be parted where it joins the luminous organ.

The luminous substance consists of an inner and an outer tissue. The back of the outer tissue is whitish, not transparent, and functions as a reflector. It borders on the intestinal cavity. The outer tissue, in contact with this reflector, is fibrous in character, merging into luminous cells and connecting to the inner tissue. The light of these luminous tissues passes through translucent fat and muscle tissue which lies on top of them. Thus the organ appears as a luminous line above the median line. The luminous organ of *L. elegans* has nearly the same structure, but the reflector and the luminous tissue are more clearly distinguished. *Lestidium japonicum*, *L. pofi*, and *L. intermedius* have a double luminous organ which joins in front of the anus and at the end of the keel muscle. The structure is the same as that of *L. proluxum*, but

Table 1. Examined Specimens of the Fishes Family Paralepididae

No.	Species	Examined Specimens	Luminous Organ
1	<i>Omosudis</i> sp.	Loc. USF & WL Service "Oregon" Sta. 1362. From the stomach of <i>Alepisaurus ferox</i> . Culf of Mexico. Group No. 16, Cat No. 49257	None
2	<i>O. lowei</i>	Combat Sta. 295. Traul. Stomach of <i>Alepisaurus</i> .	None
3	" "	Woods Hole Oceanographic Institution	None
4	<i>Stemonosudis intermedia</i>	Stanford University Natural History Museum Gr. No. 16, Cat. No. 15356. Loc. Bermuda Coll. Beebe Bermuda Coll.	None
5	<i>Sudis hyalima</i>		None
6	<i>Evermannella indica</i>	Chicago Natural History Museum 49863	None
7	<i>E. melanoderma</i>	CNHM 49863	None
8	<i>E. normalops</i>		None
9	<i>Anotopterus pharao</i>	Funchal Municipal Museum	None
10	<i>Notolepis coruscans</i>	SUNHM Gr. No. 16. Cat. No. 49270-49271	None
11	<i>N. coatsi</i> DOLLO	From the Stomach of Whale. From Dr. T. ABE	None
12	<i>Paralepis borealis</i>	U. S. National Museum Rec'd Nov. 5, 1958	None
13	<i>P. rissoi</i>	" " Rec'd "	None
14	<i>P. coregonoides</i>	Delaware July 17, 1958	None
15	<i>P. brevirostris</i>		None
16	<i>P. harrmi</i>	Funchal Municipal Museum 14702	None
17	<i>P. brevis</i>	U. S. National Museum 37860	None
18	<i>P. pseudosphyraenoides</i>	U. S. National Museum Gr. No. 16. Cat. No. 15084. Loc. Funchal, Madeira at night near surface, Coll. Maul.	Black line situated on the median line, but it is doubtful where this is a luminous organ
19	<i>Macroparalepis affinis</i>	Stanford Univ. Natural History Museum Gr. 16. Cat. No. 15080. Loc. Near Funchal Madeira. From the Stomach of <i>Alepisaurus ferox</i>	None
20	<i>M. intermedius</i>		None
21	<i>M. n. sp.</i>	Chicago Rec'd Nov. 5, 1958	None
22	<i>M. barysoma</i>	Rec'd Dec. 2, 1958	None
23	<i>Lestidium prolixum</i>	Yokosuka City Museum. Gr. No. 5. Loc. Owase Fish Market. Coll. IWAI	A long yellowish luminous organ which extend on a medium line
24	<i>L. elegans</i>	Yale University Bing. Ocean. Lab. Feb. 25, 1959. Total length 175 mm	Long luminous organ on a median line. 96 mm length
25	<i>L. atlanticum</i>	Nov. 10, 1950	A long luminous organ which extend on a median line from the forepart of the anal fin to the end of keel muscle
26	<i>L. japonicum</i>	Yokosuka City Museum. Gr. No. 5. Loc. Manazuru Fish Market. Coll. ABE	Long yellowish luminous organ separated in two line, which are joined together at each end, to form one organ

Table 1 (Continued)

No.	Species	Examined Specimens	Luminous Organ
27	<i>L.</i> "	U. S. National Museum. 102814	"
28	<i>L. intermedius</i> (Syn. <i>Sudis intermedius</i>)	Tulane Univ. Collections Gulf of Mexico Sept. 29, 1951. Coll. No. Oregon 489. Total length of fish 130 mm	Severely two luminous long line connected at each end. 66 mm length
29	<i>L. pofi</i> HARRY	Loc. Celebes. 175 mm. Total length	Two long luminous organ measured 58 mm in length connected at each end



Fig. 1. *Lestidium prolixum*, showing long transparent muscle, which extend on a median line from a point near the anus to the forepart of the fish. Long yellowish luminous structure runs beneath this muscle.

it is separated on either side of the median line. The black membrane covering the intestines parts at the luminous organ. In the family Paralepididae, *Paralepis pseudo-paralepis* has a line similar to the luminous organ above the median line, but it is doubtful where this a true luminous organ. *Macroparalepis affinis* has on the median line a substance similar to that of the luminous organ, but this clearly does not have a luminous function. The other genera *Omosudis*, *Stemonosudis*, *Anotopterus Evermannella*, *Paralepis*, *Sudis*, and *Notolepis* show not even a trace of a luminous organ.

Recently ROFEN (1963) reported in *Pontosudis*, new genus has no luminous organ. Consequently, in the family Paralepididae the possession of a luminous organ is a special occurrence confined to the genus *Lestidium*. Moreover, not all the species of this genus possess one: *Lestidium mirabile*, for instance, does not.

The luminous organ of *Lestidium* is of the closed type and emits light as intracellular luminescence. Outwardly, the organ is similar to that of the *Acropoma* or the *Coryphaenoididae*, but it has no connection with the intestine. The light is self-luminous.

Attempts to cultivate luminous bacteria, by the usual methods, from the luminous organ gave negative results. After death the luminous substance emits a bluish light continuously. Luminescence is not recovered when water is poured over the dried luminous duct and it is viewed in the dark. A negative Luciferine Luciferase reaction is obtained by mixing hot and cold water extract of luminous tissue in the dark.

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抄 録

ハダカエソ科 Paralepididae の深海魚はハダカイワシ目 Myctophida に属し、この目の中ではハダカイワシ科 Myctophidae に次で大きい科で、ハダカイワシ科の魚がほとんどすべて発光器を持つているのに、ハダカエソ科の魚は発光器を持たないものと考えられていた、(HARRY 1953)、兎が著者は京大水産学教室の岩井保博士の示唆により同氏より送られたマツバラナメハダカ *Lestidium prolixum* の標本について、その発光性を検討し、また、東海区水産研究所の阿部宗明博士よりハダカエソ *Lestidium japonicum* の生の材料の寄贈を受けて、その発光を確認し、上記2種の魚は発光器を持つことを報告した (HANEDA, 1958)。

ROFEN (HARRY) (1951, 1953) によれば、太平洋およびバーミユダ等から本科の魚7属48種を報告しているが発光器の存在については記載されていない。著者は発光器の出現が、*Lestidium* 属のみに見られるものか、あるいは他の属でも見られるものかを知りたいと思っていたが、1959年より1960年にかけての採集旅行の折、たまたまスタンフォード大学に ROFEN 博士をたずね、ワシントンの国立博物館に SCHULTZ 博士、ポルトガルのマデイラ島フンチャロ博物館に MAUL 博士をたずねる機会を得、本科の魚の所蔵標本を見る機会を与えられた、観察した標本は第1表に示す9属27種であつた。この中、発光器を認めたのは *Lestidium* 属のみで他の属では全く発光器を認めることは出来なかつた。

Lestidium 属の中、*Lestidium prolixum*, *L. elegans*, *L. atlanticum* の3種は、腹部正中線上を、肛門の前方より胸部竜骨筋の先端まで長く延びた淡黄色の発光器で、その断面をみると、内外2層となり内部の層は腹腔に接し、腹腔に接する部がやや不透明白色で反射層となり外層は平行に走る透明なセンイ組織となり両端は内臓を包む黒色素層になっている。この外層は透明で、レンズの作用をなすものと考えられる。腹部正中線上を、凸形の透明な筋肉組織が丁度発光体の上を走っているのでこの組織はレンズの役割をしている。

Lestidium japonicum, *L. intermedius*, *L. pofi* の3種は、発光器の構造は基本的には前記3種と同様であるが、発光体は正中線を境として左右2本に分れ胸部竜骨筋の先端より肛門の前方に達し、両端で結合している。長い1本の発光線が中央より分れて2本となり両端が結合しているわけである。内臓を包む黒色素層は、発光体の外層と結合している。同様に正中線上を凸形の長い筋肉組織が走っているので左右の長い発光

器の光を強めるレンズの役割をはたしているようである。発光体の内層の反射層はあまりはっきりしない。

この属の魚の発光器は、外観、ホタルジャコや、ソコダラ科の魚の発光器に似ているが根本的に全く異ったもので、外部への開孔がない。ホタルジャコ、ソコダラ科の魚の発光器は開孔式で発光バクテリアを腺内に培養しているのに反し、本属の魚の発光器は閉鎖式で、発光は魚自体のもので、発光細胞によって光るものである。

発光は、魚の死後でも新鮮なものは連線的な光がみられる。ハダカイワシ類の発光器が死後、間もなく消光するのと大きな違いがあり、一見、発光体は発光バクテリアではないかとの疑問を起させるが、細菌培養試験の結果は全く陰性であった。また発光器を乾かして、水を後から加えても発光しない。ルチフェリン、ルチフェラーゼ反応も陰性であった。

前報告において、*Paralepididae* において、発光器は属、または種の分類上、重要な特徴となるかもしれぬと言ったが、*Paralepididae* においては発光器は、*Lestidium* 属にのみみられる特殊な場合であって、分類学上の特徴とはならないものである。

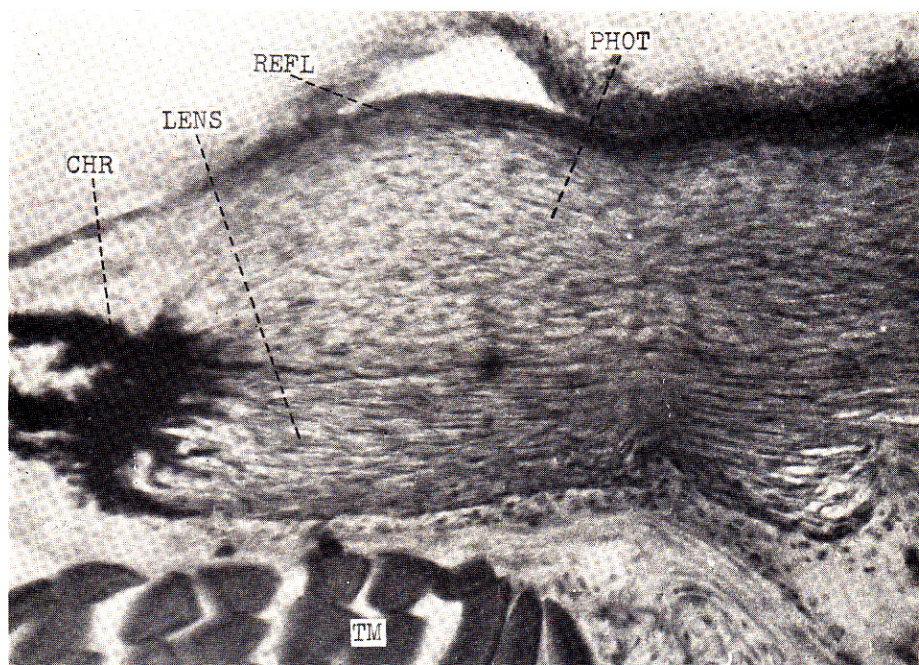


Fig. 2. Transverse section of the luminous structure of *Lestidium prolixum*, showing reflector (REFL), Luminous tissue (PHOT), Lens (LENS) and Pigment membran (CHR) and Translucent muscle (TM) serve as a lens.

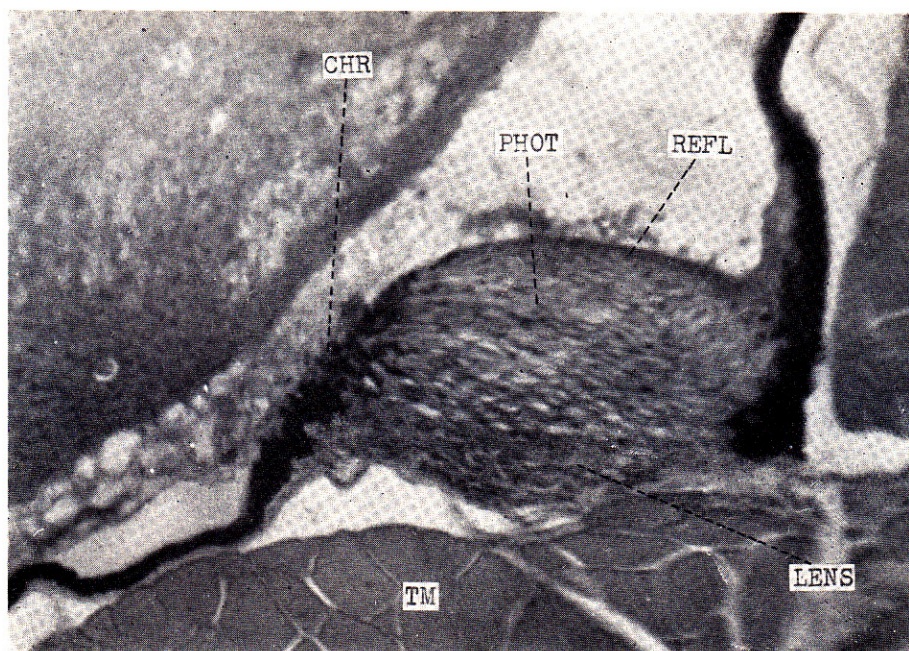


Fig. 3. Transverse section of the luminous structure of *Lestidium japonicum*, showing luminous tissue (PHOT), reflector (REFL), Pigment membrane (CHR) Lens (LENS) and transparent muscle (TM) which serve as a lense.