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Newly Observed Luminescence in Apogonid Fishes from the Philippines*

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(With 2 Text-Figures and 2 Plates)

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フィリッピンの発光性イシモチ類の新しい発見と観察

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Among marine fishes, the family Apogonidae contains a large number of small, shallow-water species (numbering approximately sixty) that are widely distributed in the Pacific and Indian Oceans. In particular, great numbers and variety are found in the Philippines-Caroline Islands-Samoa region, but they are also indigenous to the coastal waters of Japan, Hawaii, Northern Australia, and the Comoro Islands. Although the occurrence of luminosity in the family has not been extensively studied, six species are known to be luminous. In five of these, all belonging to the genus *Siphamia*[1,2] (*S. versicolor, S. majimai, S. elongata, S. cuneiceps*, and *S. roseigaster*), luminescence appears to be due to symbiotic luminous bacteria infecting the photogenic organs. The sixth species represents another genus and the blue luminescence of this form (*Apogon ellioti*) has been shown to be due not to bacteria, but to a separate enzymatic reaction. The luminescent organ system of *A. ellioti* was first described by Kato.[3] It consists of an oval-shaped lemon-yellow organ (1–2 mm diameter) which is connected by a duct to the second loop of the intestine. This organ lies in the translucent thoracic keel muscle through which the light passes to the exterior. Posteriorly, two small paired organs are found adjacent to and connected by a pair of ducts to the rectum. The former organ is called the thoracic or anterior luminous duct and the latter the anal or posterior luminous ducts. Each organ contains its own supply of luciferin (substrate) and luciferase (enzyme), and light is emitted continuously. A dark cold-water extract and a hot-water extract of the organ, when mixed, results in the emission of blue light (the "luciferin-luciferase reaction").[4]

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Previous biochemical and morphological studies have revealed the following facts concerning the luminescent system of *Apogon ellioti*. Both luciferin and luciferase give a light-emitting cross-reaction with the luciferin and luciferase of a small luminous fish, *Parapriacanthus ransonneti* (family Pempheridae), and with the luciferin and luciferase of *Cypridina hilgendorfii*, a small marine ostracod crustacean.[4,5] The luciferin and luciferase of *P. ransonneti* also give a light-emitting cross-reaction with the luciferin and luciferase of *C. hilgendorfii*. Thus there are cross-reactions among all three systems.[6] The luminescent organ system of *Apogon* possesses anatomical features that are similar to those of *Parapriacanthus*.[7,8] The chemical properties of *Cypridina* luciferin are closely related to or identical with those of *Apogon* luciferin[9] and *Parapriacanthus* luciferin.[6] All three species live in the same waters off the southern coast of Japan. *Cypridina* apparently constitutes a part of the diet of *Parapriacanthus ransonneti*, as shown by the finding of dead, but still luminescing organisms in the stomachs of about a dozen out of 2,300 *Parapriacanthus* specimens examined.[8] *Cypridina* thus far has not been found in the stomachs of *Apogon ellioti*, although more than 1,000 specimens have been examined. Because there exists a direct connection between the light organs and the digestive tract in both *Apogon* and *Parapriacanthus* (except for the posterior organ in the latter), there has been speculation that luciferin may actually arise through the ingestion of *Cypridina*.[8]

With respect to *Apogon ellioti* luciferase, however, it has been shown that the enzyme is not likely to be ingested (unless one assumes that it is modified after ingestion) since the chromatographic, immunologic, and kinetic properties of *Apogon* and *Cypridina hilgendorfii* luciferases are significantly different.[11] The fact that the luciferin of the shallow-water fish, *Porichthys porosissimus* (family Batrachoididae), of the Gulf of Mexico gives a light-emitting cross-reaction with *Cypridina* luciferase also suggests that the luciferins are produced independently in each organism,[12] since *Cypridina* is presumably absent or scarce in the Gulf of Mexico and is, therefore, not ingested by *Porichthys*. This conclusion can, however, not be considered unequivocable since the presence of luminous species of *Cypridina* has been previously reported in Jamaica.[13,14]

The family Apogonidae is represented in the Philippine Islands by about 40 species.[15] Thousands of specimens belonging to 25 species were collected at Cebu during May and October of 1968 for the purposes of this investigation. All of these were examined for luminosity, but only six species gave positive results. The luminosity of one of these, *Apogon ellioti*, had, as noted above, been previously investigated and the specimens of this species were not used except for limited cross-reaction studies. The other luminous species that were used are: *Archamia fucata* (Cantor), 58 specimesn; *Archamia zosterophora* (Bleeker), 18 specimens; *Archamia lineolata* Cuvier and Valenciennes, 62 specimesn; *Apogon striata* (Smith and Radcliffe), 23 specimens; *Rhabdamia cypselura* Weber, 624 specimens. The specimens ranged in size from approximately 40 to 70 mm in standard length. These five species proved to be highly interesting because they all possessed the luciferin-luciferase type of reaction system and

the ability to cross-react with extracts from *Cypridina hilgendorfii*, a combination of two characteristics hitherto demonstrated in only three species of luminous fishes. It may be noted here that one additional species of luminous fish, the pempherid *Parapriacanthus ransonneti*, was also found at Cebu, but this was not subjected to further examination except in some cross-reaction tests.

Schematic drawings of the luminescent organ systems of *Archamia lineolata* and *Rhabdamia cypselura* are presented in Figures 1 and 2. The diagrams illustrate the positions of the luminous body or duct, the translucent muscle that acts like a lens to diffuse the light, and the related anatomical structures. In *Archamia lineolata* the luminous body, containing the luciferin and luciferase, is formed by the second loop of the intestine and the pyloric caeca (Fig. 1, PHOT, IN and PC). The light emitted by the second loop of the intestine, (PHOT) however, is brighter than that of the pyloric caeca. No luminous organ is present at the anus. The translucent keel muscle, acting like a lens, serves to transmit the light ventrally (TM). The luminous organs are similarly constructed and arranged in *Archamia fucata* and *A. zosterophora*. The luminous organ of *Rhabdamia cypselura* possesses substantially different features: the distal ends of a pair of pyloric caeca are transformed into luminous bodies or ducts (Fig. 2c, PHOT). A pair of transparent lens-like organs, encircled with black pigments, are situated in the ventral-lateral wall of the body cavity (Figs. 2b and 3d, L). The luminous ducts are attached to the lens-like organs and light is transmitted to the outside through them. These

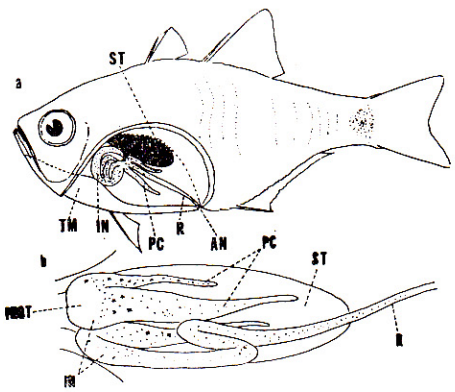

Fig. 1. Diagram of *Archamia lineolata* from the left lateral (a) and ventral (b) aspect showing the luminescent organ system. PHOT, strog luminous area of intestine IN, intestine; PC, pyloric caeca; TM, translucent muscle; R, rectum; AN, anus; ST, stomach. Liver, reproductive organ, and swim bladder, not shown. The luminous material is contained in the intestine and pyloric caeca, and light is transmitted through the translucent muscle (TM).

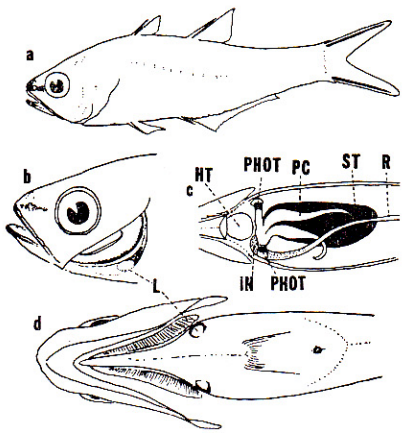

Fig. 2. Diagram of *Rhabdamia cypselura* from the left lateral and ventral abdominal aspects, showing the luminescent organ system. PHOT, luminous duct; PC, pyloric caeca; L, lens-like organ; IN, intestine; R, rectum; ST, stomach; HT, heart. Liver, reproductive organ, and swim bladder, not shown. Only the ends of the pyloric caeca are luminous and the intestine and rest of the pyloric caeca are non-luminous.

two distinct types of luminous organs each differ markedly from that found in *Apogon ellioti*, and to an even greater degree from the system of *Siphamia* which involves symbiotic luminous bacteria. The luminous organ of *Apogon striata* is similar to that of *Apogo ellioti*, but lack of anal luminous ducts. It thus appears that the luminescent organ systems of apogonids may be roughly divided into four types: (1) *Siphamia* type, (2) *Apogon ellioti* type, (3) *Archamia lineolata* type (including *A. fucata,* and *A. zosterophora*), and (4) *Rhabdamia cypselura* type.

For the *in vitro* studies, dried light organs were used. Soon after collecting the specimens, the organs were removed by dissection, air-dried, and stored over $CaCl_2$. After returning from the Philippines, the organs were thoroughly dried under vacuum. Because in the case of some species a limited number of organs was obtained, those of *Archamia fucata, A. lineolata,* and *Rhabdamia cypselura* were studied primarily. Luciferase was prepared by grinding 1 to 3 organs in 3.5 ml of 0.1 M sodium phosphate buffer, pH 6.8, in an all-glass homogenizer chilled in an ice-bath. The homogenate was dialyzed overnight against 0.1 M sodium phosphate buffer, pH 6.8, at 4°C. After centrifuging at 15,000×g for 1 hour at 5°C, the supernatant was used directly. Luciferin was prepared by homogenizing three light organs in 3.5 ml of boiling distilled water for 1 minute, then rapidly cooling in an ice-bath, centrifuging at 15,000×g for 5 minutes, and using the supernatant immediately. When the organs were first ground in phosphate buffer, the extract exhibited a blue luminescence that was readily visible in the dark. The luminescence lasted from several minutes to 4 hours, with the extracts showing the longest luminescence presumably containing the greatest amount of luciferin. Dark extracts again became luminous when fresh luciferin (hot-water extract) was added. The luminescence of all three systems was found to be oxygen dependent. Bubbling 99.99% argon through the extract contained in a closed system extinguished the luminescence in about 10 minutes (as observed with the 30-minute dark-adapted eye). Blowing air into the extract immediately restored luminescence to approximately its original intensity. The procedure was repeated several times with the same result. The luciferin-luciferase test was carried out using the crude preparations of luciferin and luciferase. In the case of all three species, luminescence appeared immediately when the extracts were mixed. The three systems, therefore, resemble those of *Apogon, Parapriacanthus,* and *Cypridina* in giving a positive luciferin-luciferase reaction. The crude preparations of luciferin and luciferase were further used for cross-reaction studies, which also included luciferins and luciferases of *Apogon ellioti* (Kochi, Japan) and *Parapriacanthus ransonneti* (Izu, Japan), in both instances prepared from the dried thoracic light organs as described above, and of *Cypridina hilgendorfii* (Tateyama, Japan), prepared from dried organisms as previously described.[16,17] The luciferins and luciferases of *Archamia fucata, A. lineolata, Rhabdamia cypselura, Apogon ellioti, Parapriacanthus ransonneti,* and *Cypridina hilgendorfii* all cross-reacted with light-emission. In addition, hot and cold-water extracts were prepared from freshly dissected organs of *Archamia zosterophora, A. lineolata, Apogon striata, Rhabdamia cypselura, Apogon ellioti,* and *Parapriacanthus ransonneti*

Table I. Luminescence Cross-reaction of Hot- and Cold-water Extracts of Luminous Organs of Philippine Apogonids

Hot-water extract	Cold-water extract	Luciferin-luciferase reaction
Archamia zosterophora	*Cypridina hilgendorfii*	+
C. hilgendorfii	*A. zosterophora*	+
Apogon striata	*C. hilgendorfii*	+
C. hilgendorfii	*Apogon striata*	+
A. zosterophora	*Rhabdamia cypselura*	+
Rhabdamia cypselura	*A. zosterophora*	+
Apogon striata	*Rhabdamia cypselura*	+
R. cypselura	*A. striata*	+
Apogon ellioti (Cebu)	*Apogon ellioti* (Cebu)	+
" " "	" " (Japan)	+
" " (Japan)	" " (Cebu)	+
" " (Cebu)	*Archamia lineolata*	+
Archamia lineolata	*Apogon ellioti* (Cebu)	+
A. ellioti (Cebu)	*Rhabdamia cypselura*	+
Rhabdamia cypselura	*Apogon ellioti* (Cebu)	+
Parapriacanthus ransonneti (Cebu)	*Archamia lineolata*	+
A. lineolata	*P. ransonneti* (Cebu)	+
R. cypselura	*P. ransonneti* (Cebu)	+

Fresh organs were used, except for *Cypridina hilgendorfii* and *Apogon ellioti* (Japan).

and tested at Cebu. The results are shown in Table I and indicate a reciprocal cross-reaction between the luciferins and luciferases of these organisms.

Compounds known to stimulate light emission from tissue extracts of other luminescent systems were also examined. These tests were carried out using organ extracts of *Rhabdamia cypselura*, ground as before and centrifuged at 15,000 × g for 5 minutes. The most striking effect was obtained with extracts undergoing a slow decay in light intensity. The addition of either reduced nicotinamide-adenine dinucleotide (NAD) or reduced nicotinamide-adenine dinucleotide phosphate (NADP) caused an immediate and prolonged stimulation of light emission. The stimulation in the case of some extracts was very marked and lasted for many minutes, after which the luminescence decayed very slowly. The stimulating effect of reduced NADP appeared to be slightly greater than that of reduced NAD of equal concentration but the difference was not marked. The addition of NAD and NADP alone had no effect on light intensity. Extracts of the thoracic light organ (either dried or fresh) of *Apogon ellioti* (Kochi, Japan), prepared by the same procedure, were either only slightly stimulated or not stimulated at all by reduced NAD and reduced NADP. A slight stimulation of *Parapriacanthus* extract by reduced NAD has been previously reported[7]. The stimulating effect of reduced NAD and reduced NADP on light emission appears to be a new and characteristic property of the *Rhabdamia cypselura* luminescent system. Slowly decaying luminescnet extracts of *Cypridina hilgendorfii* were not affected by these compounds. Adenosine triphosphate and reduced flavin mononucleotide also had no effect on any of the above extracts. No conclusions could be drawn on the effect of these cofactors on the luminescent systems of *Archamia fucata* and

A. lineolata due to the low level of light-intensity of the extracts. Studies of the *Archamia fucata, A. lineolata* and *Rhabdamia cypselura* luminescent systems are presently in progress.

The luminescent cross-reactions observed among the Philippine apogonids, *Apogon ellioti, Parapriacanthus ransonneti,* and the ostracod *Cypridina hilgendorfii* appear to offer further support for the theory that luciferin and luciferase have an independent origin in each of these organisms. *Apogon ellioti* is distributed from Japan through Southeast Asia and Australia, whereas *Parapriacanthus ransonneti* is known from Japan to the Ryūkyū and Marshall Islands. While *C. hilgendorfii* is found in the coastal waters of Japan, extending from Chiba to Kyūshū, the organism is absent from the Philippine Archipelago. No report appears to exist in the literature conconcerning the presence of *C. hilgendorfii* in the Philippine Islands and attempts to collect it there have been unsuccessful. A luminous ostracod crustacean that is indigenous to the Philippines, however, is *Cypridina noctiluca,* which has wide distribution in the coastal waters of Southeast Asia, the Indian Ocean, and northern regions of Australia. *Cypridina noctiluca* is a small (2.0 mm long) free-swimming, pelagic organism, whereas *C. hilgendorfii* (3.0 mm long) is a bottom-dweller that lives in the sand. The Japanese *A. ellioti* lives at a depth of about 55–75 meters, but the normal depth ranges of the Philippine apogonids have not been determined, nor is it known whether or not they feed on pelagic organisms such as *C. noctiluca* to obtain their light-emitting components. Such a mechanism, however, would explain the cross-reactions between the Philippine apogonids and *C. hilgendorfii* since the luciferins and luciferases of *C. noctiluca* and *C. hilgendorfii* have been previously shown to cross-react.[18] The present observations suggest that luciferin may be more widely distributed as a common substrate than heretofore believed and point to the need for carrying out a more thorough investigation of these systems.

イシモチ科 Apogonidae 魚類は世界に 60 種類ほど知られているが発光するのは例外的で，最初に加藤 (1947) によってツマグロイシモチ *Apogon marginatus* の発光が報告せられ，岩井，浅野(1958) は *Apogon ellioti* の発光器について報告した。*Apogon marginatus* は *A. ellioti* の synonym であったが，本魚の発光器は胸部筋肉内に埋没し，消化管と連絡のある胸部発光腺と，直腸と連絡のある一対の肛門発光腺が腹部筋肉内にある。発光腺内容物は Luciferin Luciferase Reaction があり，発光魚キンメモドキ *Parapriacanthus ransonneti*, ウミボタル *Cypridina hilgendorfii* の発光物質との間にも Luciferin Luciferase Crose Reaction のある化学物質である (羽根田，JONSON, SIE 1959)。

一方，Siphamia 属のヒカリイシモチ *Siphamia versicolor* (岩井 1958), *S. majinai* (岩井 1959) も胸部発光器があることが報告されたが，固定標本による研究であったため，発光を観察されていないし，発光腺内容についての観察はなされていなかった。1960年羽根田はフィリッピンのセブ魚市場で *Siphamia versicolor* を採集し，発光を観察したが，材料不足のため，発光内容の研究までに至らなかった。1964 年沖縄にて，ガンガセ *Diadema setosum* の長い棘の間に共生する *Siphamia versicolor* の生魚を得，発光内容は *Apogon ellioti* のような化学物質ではなく共生する発光細菌 (羽根田 1965) であることを報告した。その後オーストラリアのブリスベーン近くのモートン湾の *Siphamia cunicups, S. roseigaster* も同様の構造の発光魚であることを確認した (羽根田 1967)。

Siphamia 属の魚は全部発光するようであるが，現在，発光器が確認されている種類は，*Siphamia*

versicolor, *S. majimai*, *S. elongata*, *S. cuneicups* 及び *S. roseigaster* (*Adenapogon roseigaster*) の 5 種類である。

1968年 5 月，羽根田は再びフィリッピンのセブ市を訪れる機会を得，次の 5 種類のイシモチ科に属する魚の発光を確認し，発光器の構造を調べると共に，発光内容が発光細菌ではなく，*Apogon ellioti* のような化学物質であること，5 種の発光物質相互および，ツマグロイシモチ *Apogon ellioti*，キンメモドキ *Parapriacanthus ransonneti*，ウミボタル *Cypridina hilgendorfii* の間にも Luciferin Luciferase Crose Reaction のあることを確めた。

5 種の魚の発光腺を切りとり，乾燥材料として生化学の研究用として持ち帰った。この乾燥材料による生化学の研究は主として Tsuji，杉山が行なった。

今回新しく発光を確認した種類は次の 5 種である。すなわち

Archamia fucata (CANTOR)

A. zosterophora (BLEEKER)

A. lineolata CUVIER et VALENCIENNES

Apogon striata (SMITH et RADCLIFFE)

Rhabcamia cypselura WEBER

発光器の構造

発光器の構造は基本的にはツマグロイシモチ *Apogon ellioti* と同様で消化管と連絡する発光腺と，胸部骨筋，胸部，腹部の乳白色半透明の筋肉よりなっているが，*Archamia fucata*, *A. zosterophora*, *A. lineolata* は，同様の構造で腸管そのもの及び幽門垂に発光物質が含まれ発光する部位は黄色で，黒色色系斑が散在する。特に胸部筋肉に接する部位の腸管が強く光るが，胸部筋肉とは無関係である。*Apogon ellioti* のように，胸部筋肉内に発光腺が埋没することなく，腸管と幽門垂の光が胸部，腹部の筋肉を通してみられる。(Fig. 1. a. b.)

Apogon striata の発光器は *Apogon ellioti* とにているが，レモン色の胸部発光腺だけで肛門発光器を欠いている。

Rhobdamia cypselura は体長 40 mm. 幅 10 mm の小型のイシモチで，本種の発光器は非常に異なり，一対の幽門垂の先端部 0.6 mm 位の黄色の部のみが強い連続的の光を放ち，胸部に一対長楕円形の長径 1 mm の透明なレンズ様器官があり，幽門垂の先端の発光腺はこのレンズ様器官の内側にあるため，光はこの 2 つの器管を通してみられる。レンズ様器官の周辺には黒色色素がとりまき光が他にもれぬようになっている。

今イシモチ科魚類の発光器をその構造上より，また，発光内容より分類すると次の 4 つの型に分れる。

1. ヒカリイシモチ *Siphamia versicolor* 型

腸管と連結する発光腺が，胸部筋肉内に埋没し，光は乳白色半透明の胸部竜骨筋，腹部から尾部にかけての *Acropoma* や *Paratrachichthys* などにみられるような乳白色半透明の筋肉を通してみられる。発光腺内には発光化学物質はなく，共生する発光細菌ある。

2. ツマグロイシモチ *Apogon ellioti* 型

腸管と連結する発光腺が胸部肛門に接した腹部筋肉内にあり，光は乳白色の胸部，腹部の筋肉を通してみられる，発光腺内は Luciferin Luciferase 反応のある発光化学物質である。*Apogon striata* はこの型である。

3. *Archamia fucata* 型

腸管，幽門垂そのものに発光物質が含まれ発光するが，胸部筋肉に接する部の腸管が膨大し特に強く光る。発光腺，腸管，幽門垂には発光物質を含み，発光細菌は共生していない。Luciferin Luciferase 反応のある発光化学物質によって光る。*A. zosterophora*, *A. lineolata* はこの型である。

4. *Rhabdamia cypselusa* 型

発光腺は一対の幽門垂の先端にあり，この部のみが光る。胸部に一対の 1 mm の長楕円形のレンズ様器官があり光はこの器官よりみられる。発光腺内容は Luciferin Luciferase 反応のある発光化学物質である。

発光物質の生化学

フィリッピンより持ち帰った乾燥発光腺は直ちに減圧乾燥した。採集材料の都合で実験に用いたのは *Acchamia fucata*, *A. lineolata* および *Rhabdamia cypselura* の 3 種類であった。3.5 m*l* の 0.1 M リン酸緩衝液（pH 6.8）を入れて，予め水浴で冷却しておいたガラス製ホモゲナイザーに，1 から 3 個の発光腺を入れ，磨潰した。この懸濁液は暗所で光が認められ発光は数分から，長いときは 4 時間も続いた。抽出液に 99.99% のアルゴンを通じて空気の接触を断つと，約 10 分以内に消光した。この消光した抽出液に酸素を送ると再び発光するのを認めた。一試料について，同様のことを数回繰返した。このことは発光に酸素を必要とする証明になった。Luciferin, Luciferase Reaction に使う溶液は次のようにして調製した。すなわち，上記の懸濁液を 4°C で 0.1 M リン酸緩衝液を用いて透析した後，5°C で 15,000 g の遠心分離し，上澄液を Luciferase 溶液とし，他方 Luciferin 溶液は 3 個の発光腺を 3.5 m*l* の 100°C の蒸溜水中で 1 分間磨潰し，ただちに水冷し，5°C で 15,000 g の遠心分離した上澄液である。

このように調製された上記 3 種の魚のそれぞれの Luciferin 溶液と Luciferase 溶液を混合すると発光した。これらの発光は *Apogon ellioti* 系 *Parapriacanthus ransonneti* 系 *Cypridina* 系の発光ににている。日本沿岸の *Apogon ellioti*, *Parapriacanthus ransonneti* の Luciferin 溶液，Luciferase 溶液も同様の方法で調製した。*Cypridina* は Tsuji (1955) Tsuji, SOWINSKI (1961) の方法で調製した。

今回，新しく発光の発見されたフィリッピンの 5 種のイシモチ類と，*Apogon ellioti*, *Parapriacanthus ransonneti*, *Cypridina hilgendorfii* との間の Luciferin, Luciferase Crose Reaction はプラスでありよく発光した。

生物発光系の抽出物の発光に影響をおよぼす物質の効果を上記 3 種の発光魚について調べた。試験直前に磨潰し，5 分間 15,000 g で遠心分離した *Rhabdamia cypselura* の上澄液の発光は持続時間が長い特長を持っている。この抽出液に還元ニコチン酸アミド-アデニン，ジヌクレオチド (NAD)，または還元ニコチンアミド-アデニン，ジヌクレオチド，リン酸 (NADP) を加えると，その発光は顕著なしかも持続的な刺激をうけ，両試薬の効力は，ほとんど同様であるが NADP の方がやや大きいようであった。*Apogon ellioti* の発光腺の抽出物に対しては，これらの試薬はほとんど，あるいは，全く効力を示さなかった。*Parapriacanthus ransonneti* の発光腺の抽出物に対する還元 NAD は微弱な効力しか示さないことはすでに報告した通りである。

Rhabdamia cypselura の発光腺抽出物の発光に対して還元 NAD および還元 NADP が，このように顕著な効力を示す事実は新しい興味ある知見である。ウミボタル *Cypridina* 抽出物の持続的な弱い発光には，これらの試薬は効力がなかった。また，以上の 3 種のフィリッピンのイシモチ類すなわち，*Archamia fucata*, *A. lineolata*, *Rhabdamia cypselura* および *Apogon ellioti*, *Parapriacanthus ransonneti* の発光腺抽出液の発光に対し，ATP や，フラビンモノヌクレオチドには効力がなかった。

キンメモドキ *Parapriacanthus ransonneti* の Luciferin が，ウミボタル *Cypridina hilgendorfii* の Luciferin と性質が，ほとんど同一であること，ウミボタルがキンメモドキの胃内から発見されたこと，キンメモドキの発光器の解剖学上の根拠からキンメモドキは発光物質を食べたウミボタルから得ているのではないかとの考え（羽根田，ジョンソン，下村 1966）をいだいたが，キンメモドキの発光器，発光物質のよくにているツマグロイシモチ *Apogon ellioti* はウミボタルの棲息する深度より深い所におり，まだ胃内からウミボタルが発見されていないこと，ツマグロイシモチの Luciferase がウミボタルの Luciferase とは異なること，またウミボタルの棲息しないメキシコ湾の発光魚 *Porichthys porosissimus* とウミボタルとの間に Luciferin Luciferase Crose reaction (CORMIER, CRANE, and NAKANO 1967) のあることなどで，ウミボタルの Luciferin と同一性質の発光物質が海産の発光生物の中には異種の間にも共通にみられるのではないかと思われていたが，今回新しく発見されたフィリッピンの発光イシモチの一種 Rhabdamia cypselura の抽出物とウミボタルの抽出物に対する還元 AD や還元 NADP の効果の相異は，これらフィリッピンのイシモチ類の発光系が独立したもので，ウミボタルと関係のないものであることを示すものと考えられる。

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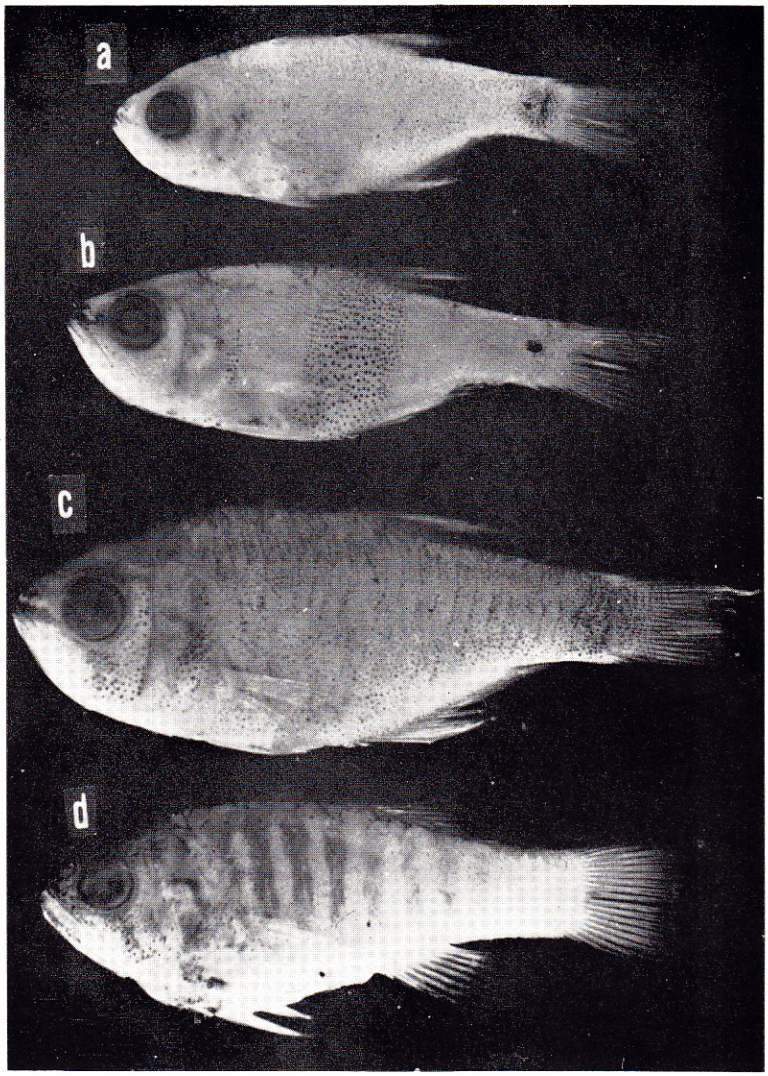
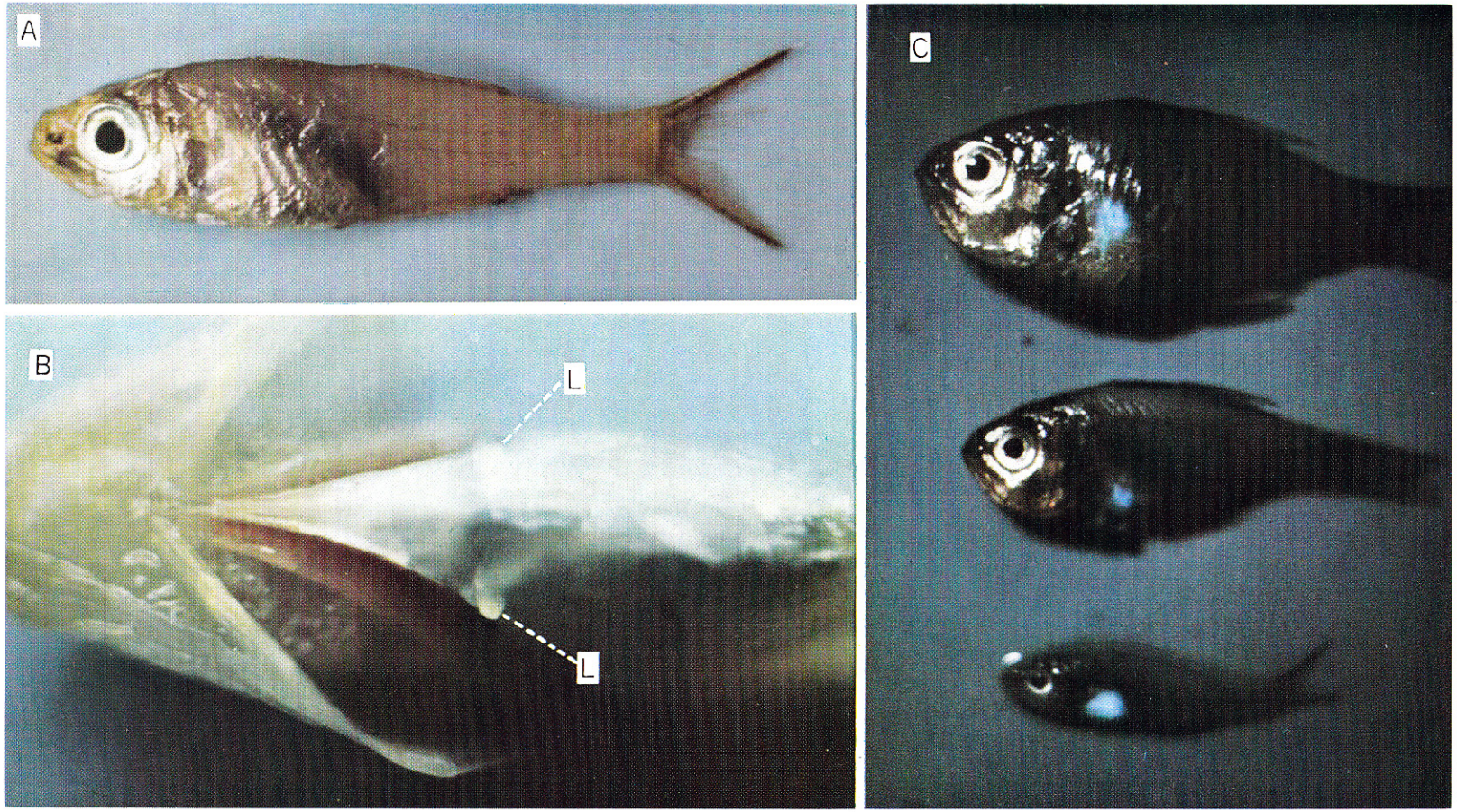


Plate I
a. *Archamia fucata* (CANTOR)
b. *A.zosterophora* (BLEEKER)
c. *A.lineolata* CUVIER et VALENCIENNES
d. *Apogon striata* (SMITH et RADCLIFFE)



A. *Rhabdamia cypselura*
B. Lens-like organs of *Rhabdamia cypselura*
C. *Archamia lineolata* (above), *A. fucata* (middle) and *Rhabdamia cypselura* (below). The fish picture, showing luminescence specimens was taken by a double exposure, involving 15 minutes exposures by the light of luminescence alone and a second exposure by a dim light. (Ekta chrom ASA 160 Film) L. Lens-like organ