Bull. Inst. Zool., Academia Sinica **18**(2): 79-87 (1979)

REDESCRIPTION OF A PROTANDROUS HERMAPHRODITIC MORAY EEL (*RHINOMUAENA QUAESITA* GARMAN)

SHIH-CHIEH SHEN, RUEY-PING LIN and FRANK CHENG-CHIH LIU

Department of Zoology National Taiwan University
Taipei, Taiwan, 107, Republic of China

(Received August 30, 1979)

Shih-Chieh Shen, Ruey-Ping Lin and Frank Cheng-Chih Liu (1979) Redescription of a protandrous hermaphroditic moray eel (*Rhinomuaena quaesita* Garman). *Bull. Inst. Zool., Academia Sinica* **18**(2): 79-87. *Rhinomuraena quaesita* Garman 1888, has been proved experimentally to be a hermaphroditic protandrous fish and *R. quaesita* is now considered as the senior synonym of *R. ambonensis*. The female phase is produced by sex reversal from the male phase and the sexes can be identified by its body color.

Rhinomuraena is an extremely slender coral reef moray-eel, easily distinguished from members of allied genera by the presence of expanded flaps on top of the tube-like anterior nostrils in adult stages and a barbel-like appendage at the apex of the pointed snout and three similar appendages on the symphysis of the lower jaw. *Rhinomuraena* and *R. quaesita* were nominated and described by Garman in 1888, based on one specimen (838 mm in TL.) collected from Ebon, Marshall Islands. Barbour (1908) described *R. ambonensis* based on one specimen (1,030 mm in TL.) collected from Ambon, Moluccas. Since then, several additional specimens have been reported by Weber and de Beaufort (1916), Kobayashi (1962) and Shen (1974) collected from Banda, Amami Oshima and Taiwan, respectively.

Barbour (1908) distinguished *R. ambonensis* from *R. quaesita* by three morphological characters: (1) three rows of teeth on both jaw, larger number of teeth; (2) 28 on lower jaw in *R. ambonensis* and 15 in *R. quaesita*, and (3) blue color in *R. ambonesis* but black in *R. quaesita.*

In the laboratory aquarium, we found that this fish can change its body color, such as black, blackish-blue, blue, bluish-yellow and yellow etc. In order to obtain further evidence to elucidate this phenomenon, we reared living specimens in aquarium to observe the succession of body color changes. In the meantime, we dissected the fishes to study the gross anatomy and histology of their gonads from individuals with different body color. Finally, we can prove *R. quaesita* is the senior synonym of *R. ambonensis.*

MATERIALS AND METHODS

Six living specimens and seven preserved specimens were used for the present study. The living specimens were purchased from different aquaria in Keelung and Taipei, Taiwan, and they were caught at the depth of 10 to 30 meters from the coral reef along the south eastern coast of Taiwan. The preserved specimens were obtained from Dr. John E. Rondall, Bernice P. Bishop Museum, Honolulu, Hawaii. The living specimens were kept in the laboratory aquarium to observe the variation of the body color. Living fishes from different color phase were dissected and their gonads were fixed in Bouin's solution, embedded in paraffin, sectioned in 7 microns in thickness and stained with Mayer's hematoxylin and eosin (Sheehan and Hrapchak, 1973; Culling 1966). The preserved specimens were studied afterward in the

TABLE 1
The meristic and morphometric characters of *Rhinomuraena quaesita* Garman.

Sex	Subadult	Male	Intersex	Female
Body color	Black	Blackish-blue; Blue.	Bluish-yellow	Yellow
Total length (mm)	630-635	650-1,030	995-1,220	1,175-?
Body length* (mm)	214-221	228-350	337-392	353-?
SEL in BL	42.3-44.2	42.8-43.9	43.0-47.0	41.5-
HL in BL	5.41-7.28	5.05-5.84	5.21-6.17	5.09-
ST-DO in BL	9.73-10.50	9.92-11.20	10.11-12.32	11.42-
Teeth on upper jaw	20-32	20-27	20-28	28-
Teeth on lower jaw	20-30	21-27	20-26	32-
Teeth on vomerine	9-10	13-17	10-15	17-

Note: * Body length is the length from the tip of snout to the anterior rim of anus.
BL is the abbreviation of body length.
SEL is the abbreviation of the length from the tip of snout to eye.
HL is the abbreviation of head length from the tip of snout to gill-opening.
ST-DO is the abbreviation of the length from the tip of snout to dorsal origin.

same way to compare with living specimens.

The body length (preanal length) was measured from the tip of snout to the anterior rim of anus. The length of snout was measured from the tip of snout to the anterior margin of eye. The length of head was measured from the tip of snout to the posterior edge of gill opening. The distance between snout tip and dorsal origin was measured from the tip of snout to the anterior base of the dorsal fin. The data of meristic and morphometric measurements are listed in Table 1.

RESULTS

I. Relationship between total length and sex:

The relation of sex to total length was investigated by observing the sequential changes of body color of living specimens in aquarium and compared with the result of histological study (Table 2). We found that the total length of juvenile or subadult stage is mostly ranged from 630 mm to 635 mm. The total length of male stage is terminated around the range from 650 mm to 1,030 mm, while the female stage started around 1,175 mm so far. But the intersex obviously ranged from 995 mm to 1,220 mm (Table 2).

II. Histological studies of gonads relative to variations of body color:

From rearing living specimens in the aquarium, we found that the body color changed from black to blue and from blue to yellow anteroposteriorly. Change from blue to yellow was not reversible, but change from blue to black was possible for a very short time and then continued to change from black to blue. From histological study, we found that the black color is the juvenile or subadult stage (Fig. 1) of *R. quaesita*, the blue color is the male terminal stage (Fig. 2), and the yellow color is the female terminal stage (Fig. 4). The bluish yellow color is the intersex (Fig. 3).

The serial sections of whole gonad from thirteen specimens were made. The gonads of black and blue fish contained testicular tissue only (Table 2; Fig. 5). On the contrary, no testicular tissue could be found in yellow fish (Table 2; Fig. 6). The ovarian tissue appeared in the gonad of the fish with yellow body color (Table 2; Fig. 6). But, in some specimens with blue posteriorly and yellow anteriorly, we found that the gonads contain both ovarian and testicular tissue (Fig. 7, 8). The relative proportion between ovarian and testicular tissue was related to the change of body color. When the blue color fish was

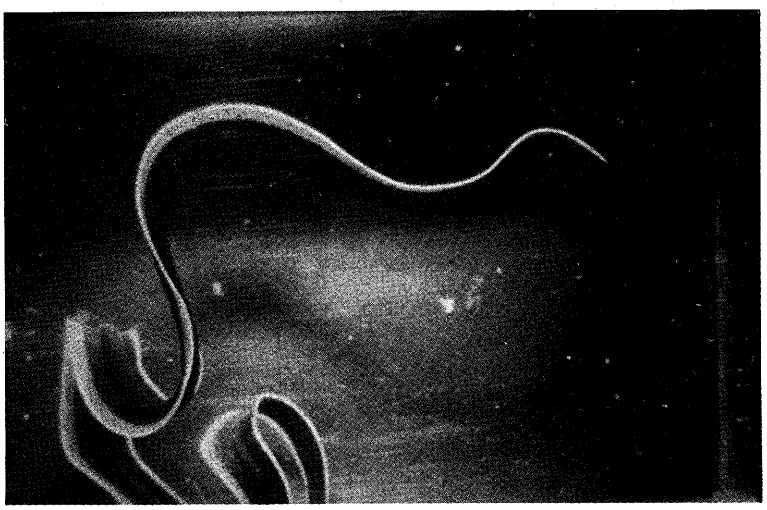

Fig. 1. The juvenile or subadult stage of *Rhinomuraena quaesita* Garman.

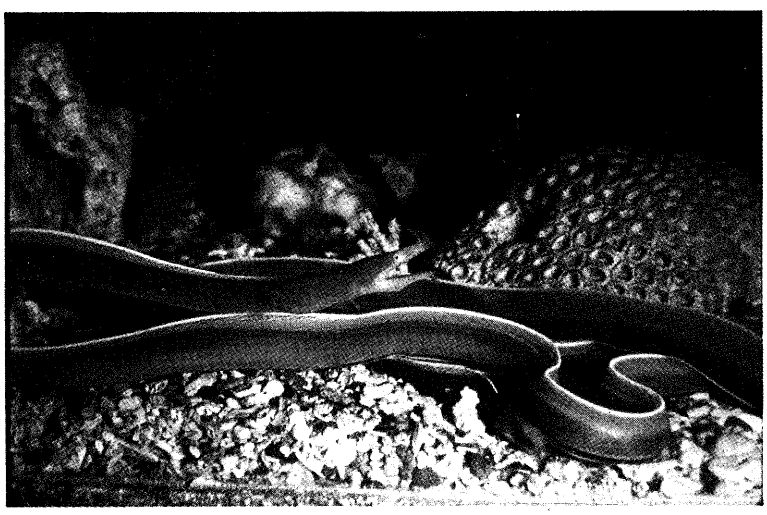

Fig. 2. The male stage of *Rhinomuraena quaesita* Garman.

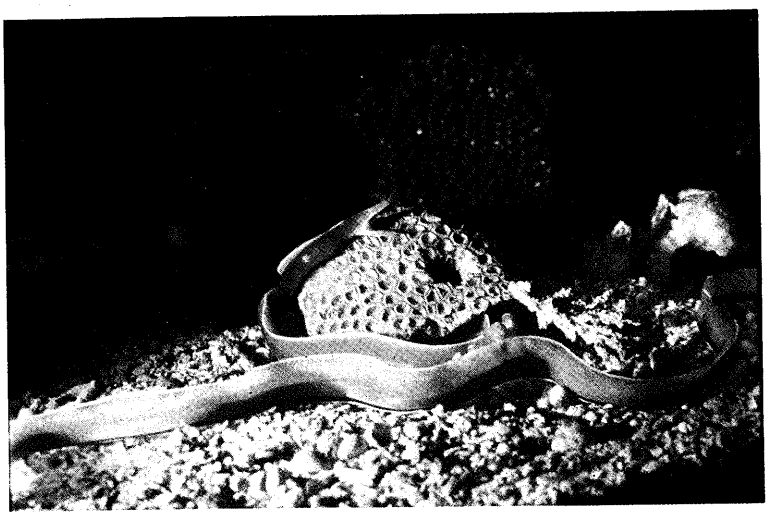

Fig. 3. The intersex stage of *Rhinomuraena quaesita* Garman.

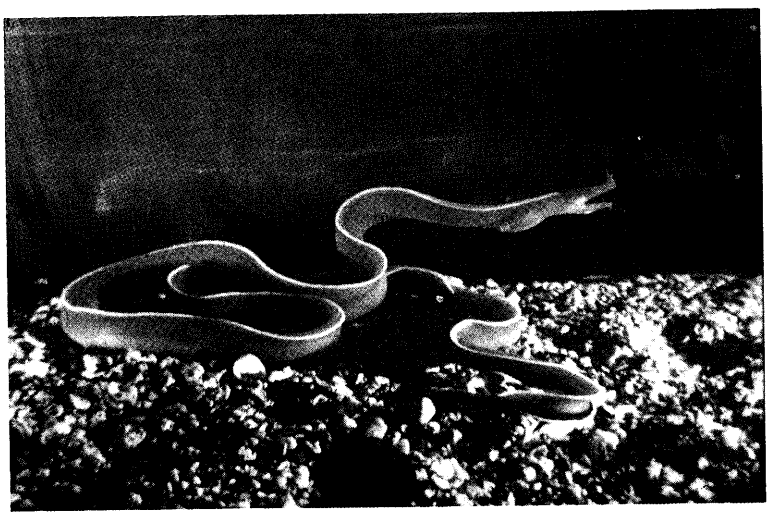

Fig. 4. The female stage of *Rhinomuraena quaesita* Garman.

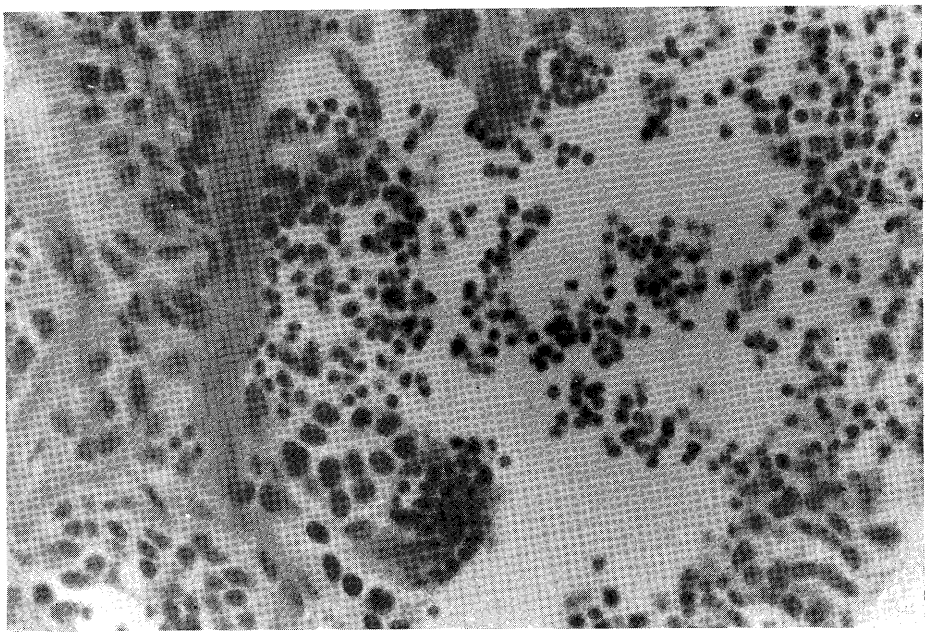

Fig. 5. A section of gonads of male phase with black or blue body color. (200×)

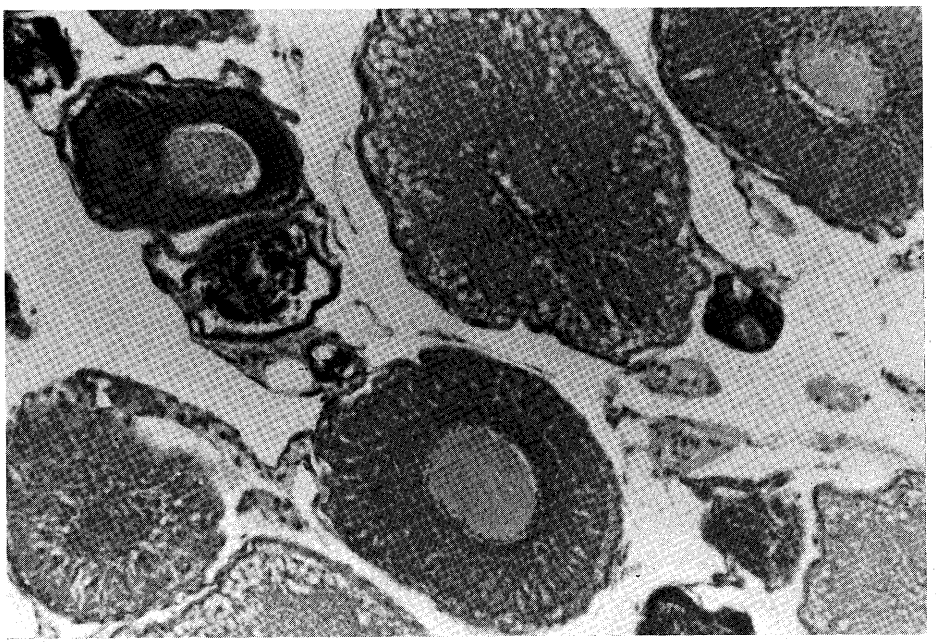

Fig. 6. A section of gonads of female phase with yellow body color. (50×)

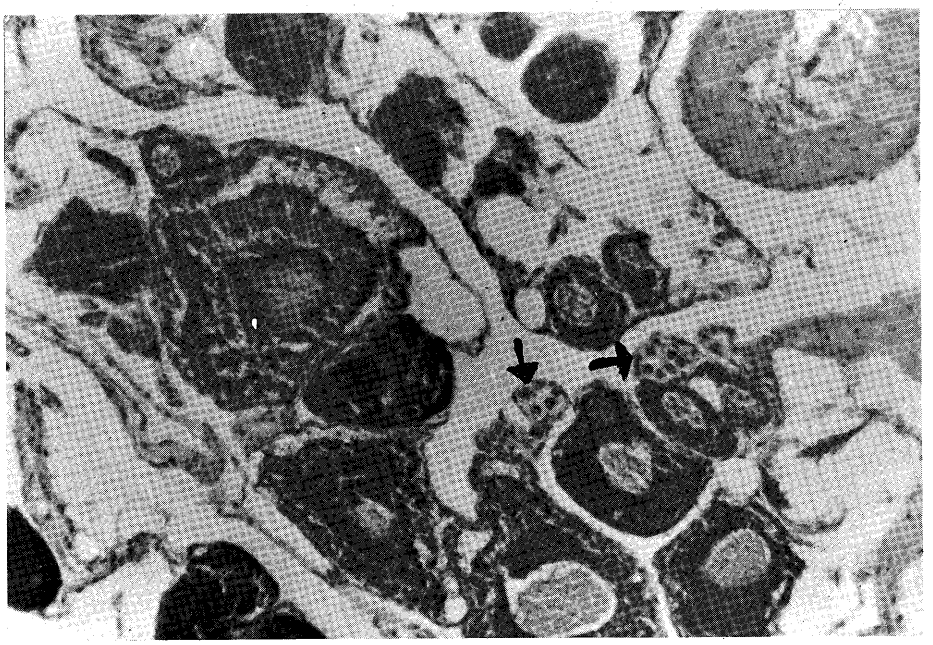

Fig. 7. A section of gonads of intersex phase with blueish-yellow body color. (50×) Testicular tissue scattered in the ovary tissue and shown by arrows.

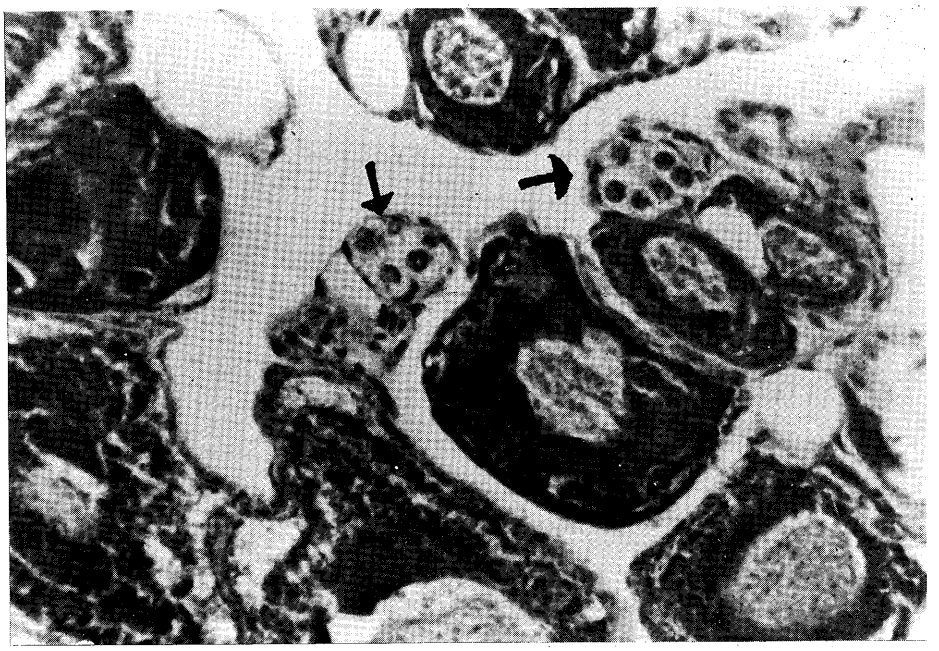

Fig. 8. A higher magnification of testicular tissue shown by arrows in Fig. 7. (100×)

TABLE 2
The correlation of total length, body color and gonad condition

Catalog No.	Total length (mm)	Body color	Gonad condition
NTUM05106	630	Black	Inmature male, few spermatocytes, abundant non-differentiated germ cells.
BpBM 19287	635	Black	Ditto.
NTUM05103	650	Blackish-blue	Completely testicular tissue with various stages of spermatocytes, some sperm.
BpBM 19418	780	Blackish blue	Completely testicular tissue with various stages of spermatocytes, more sperm.
NTUM01719	858	Blackish blue	Testicular tissue with various stages of spermatocytes, few sperm.
NTUM05101	903	Blackish blue	Ditto.
BpBM 14187	920	Black	Active male, testicular tissue with various stages of spermatocytes, many sperms, no ovary tissue.
NTUM05105	995	Bluish yellow	Highly developed female, few spermatocytes, ovary tissue with various stages of oöcytes.
BpBM 12080	1,030	Blue	Active male, many sperms, no ovary tissue.
BpBM 08675	1,104	Bluish yellow	Active female, ovary tissue with more mature eggs, no obvious testicular tissue.
BpBM 13640	1,110	Bluish yellow	Ditto.
NTUM05104	1,175	Yellow	Active female, ovary tissue with many mature eggs, no testicular tissue.
BpBM 14191	1,220	Bluish yellow	Ditto.

Note: NTUM=National Taiwan University Museum.
BpBM=Bernice P. Bishop Museum.

changing into yellow color posteriorly, the ovarian tissue was more abundant and the testicular tissue disappearing gradually. As the blue fish became completely yellow, the testicular tissue in the gonad disappeared completely. Thus, we conclude: yellow is the color of the female phase.

REDESCRIPTION

Genus *Rhinomuraena* Garman, 1888

Rhinomuraena Garman, 1888:114 (Type-species: *Rhinomuraena quaesita* Garman, 1888, by monotypy and original designation; type-locality: Ebon, Marshall Islands).

Rhinomuraena quaesita Garman, 1888

Rhinomuraena quaesita Garman, 1888:114-116: Schultz, 1953:98; Burges & Axelrod, 1972:275, 1974:999; Shen, 1974:181-190.

Rhinomuraena ambonensis Barbour, 1908:40; Weber & de Beaufort, 1916:353; Kobayashi, 1962:36; Burgess & Axelrod, 1972:275; 1974:998; Shen, 1974:181-190.

Description: Dorsal rays 835-877; anal rays 543-555; vertebrae 89-93+177-197=270-286.

Body very slender and elongate, somewhat compressed. Head compressed; pointed snout at its apex with a barbel-like appendage and three similar ones on the symphysis of the lower jaw in juvenile stage (Fig. 9-A); but with two lateral forked barbels anteriorly in adult stage (Fig. 9-B, C). Eyes small, covered by skin. Anterior nostrils produced into tubes in juvenile (Fig. 9-A) and expanded distally with foliaceous appendages in adult (Fig. 9-B, C); posterior nostrils open ovally at the anterior upper border of eyes. Mouth cleft extending far behind eye, closing completely. Pectorals absent. Dorsal and anal well developed and confluent with caudal. Origin of dorsal around the middle of head and far before gill openings. Tail extremely elongate, more than twice the preanal length. All teeth pointed conical, uniserial. The series of maxillary teeth continues on the intermaxillary plate

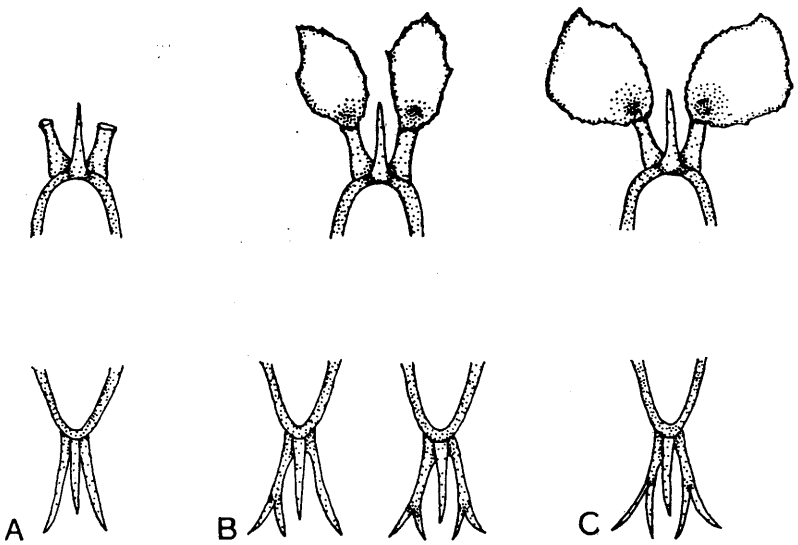

Fig. 9. Diagram of upper jaw with an appendage between two nasal tubes, lower jaw with three similar barbel-like appendages in juvenile stage (A); upper jaw with an appendage between two nasal tubes each ending with expanded foliaceous appendage, lower jaw with two lateral barbel-like appendages branched distally except the middle one in male stage (B) or female stage (C).

which also carries mesially three depressible and somewhat longer teeth. Gill-openings larger than eye, situated at lower half of body, forming a kind of tube.

The color in life black on head, trunk and tail in juvenile stage (Fig. 1); azure blue in male stage (Fig. 2); yellow in female stage (Fig. 4); upper half of dorsal all yellow with white margin (Fig. 1, Fig. 2, & Fig. 4); lower edge of anal white; lower lip white except at and near the symphysis; gill-opening with white edge; a yellowish stripe on mandible from rictus to the anterior lower margin of eye in juvenile stage; both jaws and gill-opening yellow in adult stage.

Color of preserved specimens dark brown or blackish on head, trunk and tail, all fins pale, anterior margin of gill-opening white, a white stripe on mandible from rictus to the level below anterior margin of eye in juvenile stage; but in male stage, blackish or dark blue on head, trunk and tail, dorsal brownish and whitish distally, anal black with white margin, snout, nasal tubes, filamentous appendages, lower jaw and gill-opening whitish, upper jaw blackish; while in female pale except the blackish base of anal fin.

DISCUSSION

The present study demonstrates that *R. quaesita* is a protandrous hermaphroditic fish. From a comparison between the present study and Barbour's report (1908), we can easily draw the conclusion that *R. ambonensis* is the junior synonym of *R. quaesita.*

However, it is necessary to do the additional research to find out how this fish changes its body color and to know how long each stage will be sustained from juvenile to terminal female fish. If these can be done, we believe the ratio of the sex of this fish can be controlled artificially. From the morphological characters, such as body extremely elongate, barbel-like appendages on both jaws, anterior nostrils with expanded foliaceous appendages, and so on. We as concerned fish toxonomists believe further evidence should be sought.

Then we can decide whether or not *Rhinomuraena* should be separated from Family Muraenidae to build up a new family by comparative osteological study of the bony structures among different species in Family Muraenidae.

Acknowledgement: Special thanks are due to Dr. John E. Randall for his kind support and for lending the preserved specimens from Bernice P. Bishop Museum, Honolulu, Hawaii, and Dr. Yao-Sung Lin for his critical reading of this manuscript. Grateful acknowledgements also extend to Miss S. C. Su for her assistance in microscopy and Mr. C. H. Lee for measuring and feeding the fish.

We also like to express our gratitude for the financial support, NSC-68-0201-02(23) from National Science Council.

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黑身管鼻鰟之重新描述及其性轉變(雄性變雌性)之研究

沈世傑　林瑞萍　劉正齊

黑身管鼻鰟 (*Rhinomuraena quaesita*) 已經由實驗證明具有幼魚相及由雄性轉變成雌性之兩性相，因此發現藍身管鼻鰟 (*R. ambonensis*) 爲黑身管鼻鰟之同種異名，該魚之性別可由體色之互異而判別之。