

STUDIES ON DEMERSAL FISHES OF THE DEEP NERITIC WATERS AND THE CONTINENTAL SLOPE

I. On the Stromateoid Fish *Psenes indicus* (Day) from the Indian Seas, with Comments on the Genus and Related Species and Notes on Its Biology

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INTRODUCTION

IN the course of the last seven years the senior author has been able to make collections of pelagic and bathypelagic fishes as well as neritic deep-water fishes found more abundantly towards the edge of the continental shelf, from off the south-west coast of India during cruises of the Research Vessel VARUNA and other vessels operating in association with it. These investigations, which are in progress, were taken up primarily for getting a more complete picture of the ichthyofauna of the area to enable proper identifications and studies of the fish eggs and larvae of the plankton collected during these cruises. Diverse gear, namely, otter trawls, Isaacs-Kidd mid-water trawls, longlines, driftnets, handlines and plankton ringnets of different sizes have been used for making the collections.

In this series it is proposed to deal with the bathypelagic fishes, and those borderline forms, namely, the neritic deepwater fishes found more abundantly towards the edge and the upper slope of the continental shelf. We have descriptive accounts of a few of the bathypelagic, and some of the deepwater fishes of the continental shelf in the excellent monographs by Alcock, Lloyd, and others based on collections made from R.I.M.S. "INVESTIGATOR" from parts of the Indian seas. However, many descriptions of species in these accounts are based on inadequate material, and little effort was made to study the material in relation to related species

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reported earlier from the Indo-Pacific and the Atlantic. Thus there is an urgent need for a reappraisal of the taxonomy and nomenclature of many of our deepwater fishes, as a prelude to work on the life-history, biology, etc., of the species. Efforts were made to collect samples as often as possible, and this has enabled the inclusion in this series of information relating to aspects of the biology of the species, such as its food, sex ratio in the catch, maturity, fecundity, spawning and spawning seasons. As such data on our neritic deepwater fishes and bathypelagic fishes are badly needed, it is felt that the information given here would be of added interest.

In Part I of this series, it is proposed to deal with *Psenes indicus* (Day) (Fig. 1), a neritic deepwater stromateoid fish closely allied to the pomfrets.

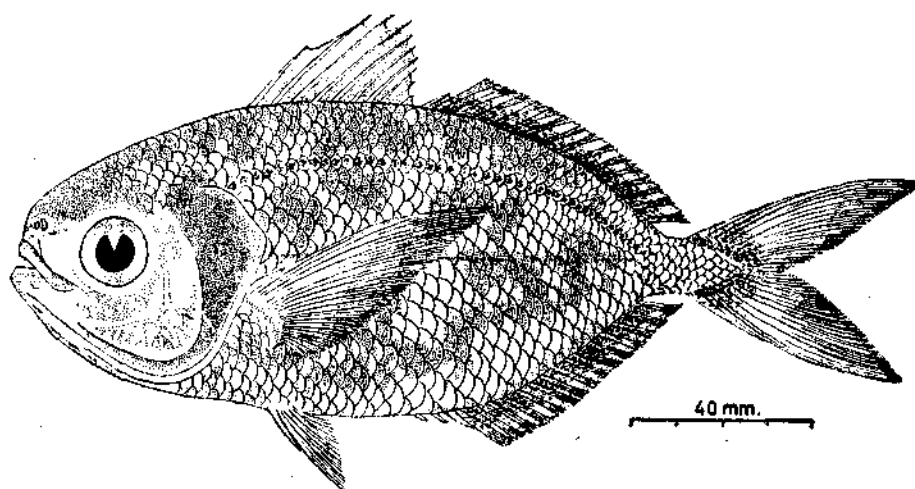


FIG. 1. *Psenes indicus* (Day). Lateral view.

ON THE GENUS *Psenes* VALENCIENNES, 1833

Day (1870) described *Cubiceps indicus* from the Madras coast, India, and later (1878) reassigned the species to the genus *Psenes* Valenciennes (1833). A study of the ichthyological works dealing with the species of the genus *Psenes* has drawn attention to the need for a re-study of *Psenes indicus* (Day) and related species. It may be mentioned here that the genus *Psenes* Valenciennes itself has been placed under the family Carangidae (Günther, 1860; Day, 1878), Stromateidae (Regan, 1902; Roule, 1919; Gilchrist and von Bonde, 1923; de Beaufort, 1951; Smith, J. L. B., 1949, 1956; Fourmanoir, 1961; Marshall, 1964; and others), and Nomeidae (Fowler, 1925; Berg, 1940; Herre, 1941, 1953; Munro, 1958; and others). Berg

(1940) distinguished the family Stromateidae ["*Stromateidae* + *Pampidae* Jordan" excluding genus *Apolectus* Cuvier and Valenciennes (= *Formio* Whitley) of family Formionidae] and family Nomeidae ("*Psenidae*; *Centrolophidae* + *Nomeidae* Jordan; *Lirinae* Buhler") of the suborder Stromateoidei on the structure of the pharynx as "posterior part of the pharynx with lateral sacs which are internally provided with papillae (*Stromateidae*) or longitudinal plications (*Nomeidae*). Both papillae and plications are supported by bone and bear teeth". On the disposition of the papillae (toothed) in the posterior part of the pharynx (Fig. 3 c, d), we consider *Psenes indicus* a representative of the family Stromateidae.

The several species at present known under the genus *Psenes* have at one time or another been treated under the genera *Seriola* (*Cubiceps*) Lowe (1843), *Navarchus* Filippi and Vernay (1859), *Cubiceps* Günther (1860), *Trachelocirrus* Doumet-Adanson (1863), etc. Miller (1946) indicated that most of the species of *Psenes* fall under three groups, namely, a *pellucidus*-group, a *cyanophrys*-group, and a *maculatus*-group. His remark that *Psenes regulus* Poey (1868) did not belong to any one of the above-mentioned groups on account of the low fin-ray counts and its colouration has been confirmed by more detailed work on the larval and adult stages of this species by McKenney (1961). The character of the fin-ray counts which separates *P. regulus* from the three groups of *Psenes* mentioned above is also said to be shared to some extent by species of *Cubiceps* described by Ginsburg (1954) (*C. nigriargentius* and *C. melanus*), a species of *Cubiceps* described by Chabanaud (1930) (*C. dollfusi*), and a new genus and species described by Belloc (1937) (*Paracubiceps ledanoisi*). They have also in common a pair of low keels on the caudal peduncle, and widely forked caudal fin. On the combination of these characters, McKenney (1961) suggested the placement of the five species *P. regulus*, *C. dollfusi*, *C. melanus*, *C. nigriargentius*, and *Paracubiceps ledanoisi* in the genus *Ariomma* Jordan and Snyder (1904), the genotype of which is *Ariomma lurida* Jordan and Snyder (1904). At the same time he remarks that a revision of the stromateoid fishes involving genera such as *Psenes*, *Cubiceps*, *Ariomma*, *Paracubiceps*, *Nomeus* and *Icticus* and their synonyms as currently understood may not show that *Ariomma* has a valid basis, but as a matter of convenience it may be tentatively used to bring together species having more characters in common with one another than with species of the genera in which they are currently placed, or on the same characters have a new genus such as *Paracubiceps* erected. However, in the present work we have not placed *Psenes indicus* under the genus *Ariomma* as we feel that any such nomenclatorial change should await a review of the group on a global basis.

McKenney (1961) has also drawn attention to the close similarity of *P. indicus*, *P. extraneus*, *P. regulus*, and *Cubiceps dollfusi*. Earlier, Jordan and Evermann (1896) considered *P. indicus* a synonym of *P. regulus*, but Regan (1902) treated them as distinct species differing markedly, *P. regulus* in having "..... adherent scales and in the colouration, and probably in other characters not supplied by Poey's incomplete description....." According to McKenney (1961) *P. indicus* and *P. regulus* differ apparently in the colour pattern, while they show comparable scale counts, fin-ray counts and body depths; and *P. extraneus* is also similar to *P. regulus* in scale counts, fin-ray counts and body proportions, differing in the colour of the pelvic fins which in comparable size of *P. regulus* are black and not yellow. Chabanaud's *Cubiceps dollfusi* is also said to be comparable to *P. regulus* in scale and fin-ray counts and depth of body, but differs in having no caudal keels and in apparently having an obscure barred colour pattern.

These references to the possible conspecificity of *P. indicus* to *P. regulus* have necessitated the presentation of a fuller discussion on the basis of the material of *P. indicus* available to us and the earlier work on related species mentioned above.

An up-to-date list of the species of the genus *Psenes* (*sensu lato*) will also be useful in a study of this nature. Legaspi's (1956) reference to some of the species of *Psenes* and the brief nomenclatorial discussions she has given are pertinent in this connection. Her list of sixteen species of *Psenes* given below has some notable omissions: *Psenes guamensis* Valenciennes (1833), *P. javanicus* Valenciennes (1833), *P. auritus* Valenciennes (1833), *P. leucurus* Valenciennes (1833), *P. cyanophrys* Valenciennes (1833), *P. maculatus* Lutken (1880), *P. indicus* (Day) (1870), *P. arafurensis* Günther (1888), *P. regulus* Poey (1868), *P. chapmani* Fowler (1906), *P. guttatus* Fowler (1934), *P. edwardsii* Eigenmann (1902), *P. pacificus* Meek and Hildebrand (1925), *P. pellucidus* Lutken (1880), *P. whiteleggi* Waite (1894), and *P. extraneus* Herre (1950). We would like to add to this list, *Psenes fuscus* Guichenot (1866) (= *P. cyanophrys*), *Cubiceps multiradiatus* Günther (1871) (= *P. cyanophrys*), *Psenes nigrescens* Lloyd (1909), *Psenes hilli* Ogilby (1915), *Psenes africanus* Gilchrist and von Bonde (1923), *Psenes stigmatpleuron* Fowler (1934), *Psenes rotundus* Smith (1949), and *Psenes benardi* Rossignol and Blache (1962). Smith (1961) created the genus *Papyrichthys* to accommodate *Psenes pellucidus* Lutken distinguishing this genus from *Psenes* mainly on the more numerous lateral line scales (lateral longitudinal scales) of the former, which exceeds

100. We may also add that the high anal fin-ray count of 33-34 seen in *P. pellucidus* is not met with in other species of *Psenes*.†

SPECIES OF THE GENUS *Psenes* VALENCIENNES FROM THE
INDIAN OCEAN

Of the 24 recent species of *Psenes* listed above, ten were described from various parts of the Indian Ocean as follows:

1. *Psenes africanus* Gilchrist and von Bonde from South African Coast, from several localities northwards from Mossal Bay.
2. *Psenes auratus* Valenciennes, from the Bay of Bengal.
3. *Cubiceps dollfusi* Chabanaud, from the Red Sea.
4. *Psenes fuscus* Guichenot, from Madagascar.
5. *Psenes guttatus* Fowler, from Natal Coast, South Africa.
6. *Cubiceps indicus* Day, from Madras Coast, India.
7. *Psenes javanicus* Valenciennes, from Batavia, Java (Indonesia).
8. *Psenes leucurus* Valenciennes, from "..... mers de l'Inde, sous l'equateur...."
9. *Psenes nigrescens* Lloyd, from the Andaman Sea.
10. *Psenes stigmaleuron* Fowler, from Natal Coast, South Africa.

Some of these are synonyms of earlier-described species from the Atlantic and the Pacific Oceans. In addition to these, at least two species described from other oceans have been reported from the Indian Ocean and at present we are able to recognise as valid only four species from this ocean as follows:

1. *Psenes arafurensis* Günther, 1888

Synonyms: Nil.

2. *Psenes cyanophrys* Valenciennes, 1833

Synonyms: *Psenes auratus* Valenciennes; *P. fuscus* Guichenot;
P. guamensis Valenciennes; *P. javanicus* Valenciennes;

† Since this paper was completed, we find that Arambourg [1967: Resultats scientifiques de la Mission C. Arambourg en Syrie et en Iran (1938-39). II. Les Poissons Oligocenes de L'Iran. *Notes et Mem. Sur. Moyen-Orient*, 8: 1-210] has described a fossil fish from the Oligocene deposits of Iran as *Psenes* (?) *macrolepis*, with the meristic characters: Vertebrae 13 (+ ?) + 19; D. X-I-20; A. III-19; P. 12?; V. I-5.

P. leucurus Valenciennes; *P. chapmani* Fowler; and *Cubiceps multiradiatus* Günther. Doubtful synonym: *Psenes nigrescens* Lloyd.

3. *Psenes indicus* (Day), 1870

Synonyms: *Psenes africanus* Gilchrist and von Bonde; *P. extraneus* Herre. Doubtful synonym: *Cubiceps dollfusi* Chabanaud.

4. *Psenes whiteleggii* Waite, 1894

Doubtful synonyms: *Psenes guttatus* Fowler; and *P. stigmatopleuron* Fowler.

These four species may be distinguished as follows:

1. Soft dorsal and anal fins each with not more than 20 branched rays 2
Soft dorsal and anal fins each with 21 or more branched rays 3
2. D. X-XI, I, 12-16; A. III, 13-16; P₁ 23-25; lateral line perforated scales 39-49 (gill rakers on lower limb of outer arch 13-16) .. *P. indicus* (Day)
D. X-XI, I, 18-20; A. III, 17-19; P₁ 18; lateral line perforated scales 55-60 (gill rakers on lower limb of outer arch 16-19) *P. whiteleggii* Waite
3. Head length 2.5 in standard length; lateral line scales 47; L. tr. 3/20; D. XI, I, 22; A. III, 22 .. *P. arafurensis* Günther
Head length 3.0 or more in standard length; lateral line scales 52-62; L. tr. 4-6/22-27; D. X, I, 21-27, generally 23-25; A. III, 23-28 .. *P. cyanophrys* Valenciennes

The least known of these four species is *P. arafurensis* for which no redescription exists beyond the description of the holotype given by Günther (1888) and emended by Regan (1902). Norman (1939) while extending the distribution of this species to the Arabian Sea based on 9 specimens obtained during the *John Murray Expedition*, 1933-34, unfortunately has not given a description. Regan (1902) drew attention to the increased dorsal spin. count of XI in the holotype as against VII given by Günther. The L. tr

count of 9/1/20 given by de Beaufort (1951) for *P. arafurensis* is not in agreement with the count of 3/20 given by Regan (1902). The "Height 1.1" given for this species by de Beaufort (1951, p. 88, in 'key') should be 1.7 as mentioned by him in the description on p. 90, which incidentally is also drawn up after Günther, and Regan.

We are inclined to treat *P. guttatus* and *P. stigmatopleuron* as doubtful synonyms of *P. whiteleggi*, although Smith (1936, 1961) considers them conspecific, and as such junior synonyms. Norman (1939) recorded *P. guttatus* originally described from Natal Coast, from two stations of the *John Murray Expedition* 1933-34 from off the coast of Arabia and from the Gulf of Oman.

Regan (1902), and de Beaufort (1951) have treated four of the species of *Psenes* described by Valenciennes (1833), namely *P. auratus*, *P. guamensis*, *P. javanicus*, and *P. leucurus* along with *Cubiceps multiradiatus* Günther as synonyms of *P. cyanophrys*. One of the two species of *Psenes* described by Day (1878) from Madras is *P. javanicus* Val., which he characterised as having D. IX-X, I, 24-25; A. III, 24-25; P₁19; L. 1.55, with the remark that "*Psenes auratus* Cuv. & Val. ix, p. 264, has the same number of spines and rays, but the eye is said to be a little larger". As Day had given the lateral line as "nearly straight" and indicated it as such in Fig. 1, Plate 51 C. Weber (1913) was doubtful of the conspecificity of this species with *P. cyanophrys*, although Jordan and Evermann (1896) had earlier considered *P. javanicus* of Day synonymous with *P. cyanophrys*. Barnard (1927) was of the opinion that Day had possibly mistaken the horizontal septum between the myotomes for the lateral line and as such, he and later de Beaufort (1951) have also considered it a synonym of *P. cyanophrys*. Fowler (1906) described *Psenes chapmani* from N.W. of Cape Verde Islands, N.W. of Lesser Antilles, and the Sargasso Sea, but later (Fowler, 1936) considered it synonymous with *P. cyanophrys*.

The description of *P. nigrescens* given by Lloyd (1909) is deficient in several respects and as such it is possible to consider this only as a doubtful synonym of *P. cyanophrys*. The two points of difference we note are the slightly lower anal fin-ray count of III, 21-23, and the higher pectoral fin-ray count of 21 in *P. nigrescens* (versus A. III, 23-28, and P₁ 18 in *P. cyanophrys*). In the generic diagnosis of *Psenes* given by Regan (1902) and by de Beaufort (1951), the number of spines in the dorsal fin (excluding the single spine preceding the soft dorsal) is given as X-XI. However, we find that in the genotype *P. cyanophrys*, Valenciennes (1833) gives the dorsal count

as "D. 9-1/25". Legaspi (1956) has found 10 out of 26 post-larval and juvenile specimens of *P. cyanophrys* (9.4 to 66.0 mm. in standard length) with IX spines, the rest having X spines. In this region itself we find that Day (1878) has given IX-X spines for *P. javanicus* (= *P. cyanophrys*); and Lloyd (1909) has given IX dorsal spines for *P. nigrescens* (= ? *P. cyanophrys*). It is highly unlikely that error in counting could account for this lower dorsal spine count in all these cases. A re-examination of the types is, however, called for and if the count of IX spines is found to be correct, the generic diagnosis will also have to be emended. This brings us to another point, namely, the position of the origin of the pelvic fin in relation to that of the pectoral fin. Both Regan (1902) and de Beaufort (1951) mention that in *Psenes* the pelvics are inserted below the pectorals. In the case of *P. indicus* we find that with age (in the larger examples) the origin of the pelvic fin comes to lie distinctly posterior to the base of the pectoral, a condition which seems to also hold good for *P. regulus* from the Atlantic as could be seen from the figure of a 183.2 mm. specimen (S.L.) given by McKenney (1961, fig. 5, p. 224). This will have to be verified for other species of *Psenes* as well.

Elsewhere in this account we have given reasons for considering both *P. africanus* and *P. extraneus* as definite junior synonyms and *C. dollfusi* as a doubtful synonym of *P. indicus*.

It need be hardly emphasized that the genus *Psenes* is badly in need of a taxonomic revision to determine the validity and status of many of the nominal species discussed here.

Psenes indicus (Day), 1870

Material

All specimens were collected using otter trawls from R.V. VARUNA (V), R.V. KALAVA (K), and fishing vessel M3 (M3) of the Indo-Norwegian Project. The number of specimens in the samples saved, date of collection, depth and haul and positions are given below:

32: 15-10-1963, depth 45 m., 32 km. S.W. of Cochin (M3); 1: 17-10-1963, depth 45 m., 30 km. S.W. of Cochin (K); 9: 23-9-1964, depth 45 m., 30 km. S.W. of Cochin (K); 1: 10-10-1964, depth 30 m., off Quilon (V); 12: 8-2-1965, 45 m., S.W. of Cochin (V); 3: 14-5-1965, depth 130 m., 11° 30' N, 74° 50' E (V); 39: 14-5-1965, depth 68 m., 10° 26' N, 75° 41' E (V); 7: 14-5-1965, depth 65-68 m., 10° 21' N, 75° 39' E (V); 1: 25-9-1965,

depth 140 m., 12° 47' N, 74° 09' E (V); 18: 15-10-1965, depth 67-70 m., S.W. of Alleppey (K); 14: 4-11-1965, depth 56 m.; 11° 38' N, 75° 08' E (K); 11: 13-11-1965, depth 130 m., 9° 30' N, 75° 50' E (V); 18: 26-11-1965, depth 120 m., 13° 30' N, 73° 32' E (V); 2: 29-11-1965, depth 180 m., 11° 15' N, 74° 55' E (V).‡

Material of *Psenes regulus* Poey that we have examined for this study is also given below. The 14 specimens received on loan from the Tropical Atlantic Biological Laboratory, U.S. Bureau of Commercial Fisheries, Florida, U.S.A., were collected along the Florida Coast during trawlings from R.V. SILVER BAY as follows:

1: 26-10-1960, depth 30 fms., SB Stn. 2379 at 24° 45' N, 80° 40' W;
1: 28-10-1960, depth 30-32 fms, SB Stn. 2409 at 24° 35' N, 81° 07' W;
1: 28-10-1960, depth 30-35 fms, SB Stn. 2411 at 24° 32' N, 81° 21' W;
7: 30-10-1960, depth 18 fms, SB Stn. 2438 at 24° 51' N, 82° 39' W; 1:
30-10-1960, depth 15-18 fms, SB Stn. 2439 at 24° 51' N, 82° 37' W; 2:
14-12-1961, depth 35 fms, SB Stn. 3657 at 32° 02' N, 79° 23' W; and 1:
12-12-1963, depth 26-32 fms, SB Stn. 5408 at 31° 46·5' N, 79° 38·5' W.

Description

Meristic counts.— D_1 . X-XI; D_2 . I, 13-16; P_1 . ii, 21-23; A. III, 14-16. lateral line 39-49 perforated scales plus 5 to 10 scales in same row towards base of caudal; scales between insertion of first dorsal and lateral line 4-6; scales between anal origin and lateral line in oblique series 12-16; gill rakers 6-9 + 13-16. The frequencies of occurrence of meristic characters such as gill rakers, scales and fin-rays are given in the accompanying tables (Tables I-VI). As comparisons between *P. indicus* and *P. regulus* are made in this paper, in addition to the 14 specimens of the latter species examined by us, data for 9 specimens in the size range 14·1 to 183·2 mm. taken from literature (McKenney, 1961) are also included in Tables I-VI.

Body proportions.—Head 31·8 to 38·7; snout 7·4 to 11·5; eye 8·3 to 11·5; inter-orbital distance 10·5 to 13·0; length of maxilla 6·9 to 10·5; distance from tip of snout to first dorsal 34·8 to 42·9; distance from tip of snout to second dorsal (to origin of spine preceding soft dorsal) 55·4 to

‡ Since this paper was completed, we have been able to examine a few more collections of *P. indicus* as follows: 1: 5-2-1966, depth 105 m., 8° 29' N, 76° 30' E (V); 1: 25-8-1966; depth 90 m., 12° 00' N, 74° 42' E (V); and 1: 6-9-1966 depth 25-30 m., off Quilon (V). These data are also incorporated in the distribution map (Fig. 8).

61.5; pre-pelvic distance 39.0 to 44.0; preanal distance 56.6 to 64.9; length of caudal peduncle 10.0 to 12.9; least depth of caudal peduncle 6.3 to 9.2; length of pectoral fin 30.2 to 38.1; length of pelvic fin 13.6 to 17.8; and greatest depth of body 37.3 to 48.2 per cent in standard length. Snout 22.2 to 32.0; inter-orbital distance 30.8 to 37.9; diameter of eye 25.0 to 33.8; and least depth of caudal peduncle 18.8 to 25.0 per cent of head length.

In addition, the base of the anal fin is 31.3 to 38.7; the height of the longest dorsal spine 11.9 to 17.1; greatest height of the soft dorsal 8.3 to 12.5; greatest depth of anal 8.6 to 12.1; distance from origin of pelvic fin to origin of anal fin 18.8 to 24.5; length of the longest gill raker 2.3 to 3.6; and length of the longest gill filament 6.1 to 8.4 per cent of standard length.

The snout in *P. indicus* is bluntly rounded and the nostrils are situated much closer to the tip of the snout than to the anterior margin of the orbit. The posterior end of the maxilla extends to the line below the anterior margin of the orbit. The anterior part of the inter-orbital space and the snout are devoid of scales but numerous mucous pores are present. Above the orbit short mucous canals are present (Fig. 2, C). The teeth (Fig. 2, D) are minute, villiform, of uniform size and uniserially arranged in the jaws. The nature and disposition of the pharyngeal teeth and the pyloric caeca are shown in Fig. 3 b & e.

Colour.—Postmortem: Purplish-grey along the dorsal side of the body becoming silvery to whitish along the side of the abdomen. The sides of the body do not show any distinct barred colour pattern but irregular greyish patches are present and along the midlateral part of the body a narrow linear dark streak to base of caudal can be made out in some specimens. In specimens preserved in formalin the head and the upper half of the body are dusky and the ventral part of the body whitish. Irregular dusky patches are present along the side of the body as shown in Fig. 2 a & b. The interspinous membrane of the first dorsal, the second dorsal, anal (especially the margin) and the caudal fins (especially the margin) are dusky, while the pectorals and pelvic fins are hyaline. The dark pigmentation along with inner lining of the operculum shows through the opercular bones giving the portion of the head a dusky appearance. A golden hue is present on part of the opercle covering the dusky area in freshly preserved specimens. This

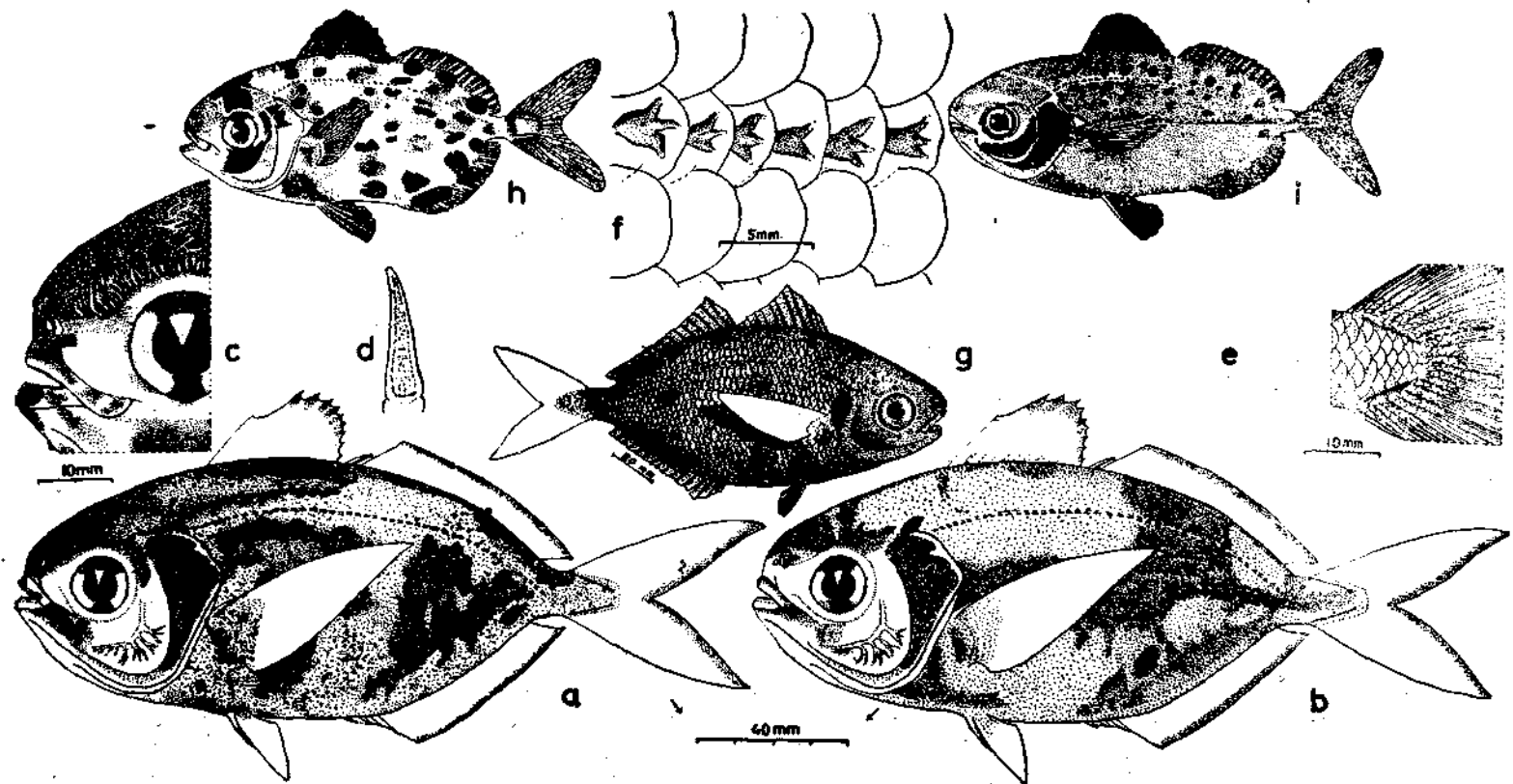


FIG. 2. *Psenes indicus* (Day) a-b. Lateral view showing variations in body colour; c. Anterior part of head showing mucous canals and pores; d. jaw tooth enlarged; e. Posterior end of caudal peduncle showing keels; f. Lateral line scales showing branched tubules; g. *Psenes africanus* (Gilchrist and von Bonde); h-i. *Psenes regulus* 91.2 and 183.2 mm respectively (Fig. g is after Gilchrist and von Bonde—fin rays omitted, and Figs. h and i after Mc Kenney (1961)).

eye is characterised by two semilunar silvery to whitish bands anterior and posterior to the pupils.

Scales.—The scales on the sides of the body, except the lateral line series are mostly deciduous. The scales along the lateral line are distinctly broader than long. The tubule on the lateral line scale is broad and runs from the base of the scale to almost the apex where it may be either bifidly or trifidly branched (Fig. 2 *f*). Scales are present at the bases of the second dorsal, anal, and the basal part of the caudal fin-rays. Two low caudal keels are present at the base of the caudal fin posterior to the caudal peduncle proper, and they are not very conspicuous (Fig. 2 *e*).

Since the shape and the structure of the scales may be of some value in species discrimination, details of scales taken from different parts of the body of a specimen measuring 152 mm in standard length are given in Table V. Complete basal and apical circuli are few and in the counts shown in Table V, the counts of incomplete circuli abutting on the sensory tubule have also been included. The nucleus is ill-defined, but situated more in the anterior half of the scale. The lateral circuli are well defined and laterally curved and are not drawn into V-shape as for the scales on the body below the lateral line and behind the pectorals. In the latter area the scales are more or less hexagonal, being broader than long. The nucleus is minute and centrally situated and in the typical scales it is slightly broader than long. However, a few scales from this region show broad diffuse nuclei situated more in the basal half of the scale. These have not been measured. Scales of the caudal peduncle are more or less oblong, being distinctly longer than broad, with the nucleus situated almost centrally (slightly nearer basal margin than to apical margin). Few complete and incomplete basal radii are present. In view of the narrowing of the scales anteriorly, most of the apical circuli do not extend laterally. Deviations from this general pattern of scale structure were not seen in scales from similar places examined in a few specimens.

Some authors have given the counts of the lateral longitudinal scales along the middle of the body to the base of the caudal fin. This count will be much lower than the counts made along the lateral line *plus* the few un-perforated scales in the same row on the caudal peduncle to the base of the caudal fin as shown below;

Standard length	No. of lateral longitudinal scales	No. of lateral line scales plus unperforated scales on caudal peduncle
165 mm.	36	48+5 (53)
138 „	39	44+4 (48)
128 „	40	45+5 (50)
148 „	39	46+5 (51)
124 „	42	44+4 (48)
155 „	39	45+5 (50)

The frequency of occurrence of these scale counts in *P. indicus* is given in Tables VI-A and VI-B.

Fin-ray Counts.—As will be seen from Tables I and III there is considerable overlap in the counts of the spinous dorsal, soft dorsal, and anal fin-rays in *P. indicus* and *P. regulus*. However, some difference is noticeable in the pectoral fin-ray counts in the two species (Table II). The most frequent count of 22 rays is seen even in early juvenile specimens of 15 mm. in *P. regulus* (McKenney, 1961, Table I, p. 213) and as such the size of the specimen does not appear to be the primary reason for this difference. Examination of more material of *P. regulus* would no doubt clarify this.

TABLE I
Frequency of dorsal spines and rays in *P. indicus* and *P. regulus*

Species	Spinous dorsal (D ₁)			Soft dorsal (D ₂)				No. of Specimens
	X	XI	XII	I, 13	I, 14	I, 15	I, 16	
<i>P. indicus</i>	.. 4	100	—	1	1	101	1	104
<i>P. regulus</i>	.. —	29	2*	—	—	31*	—	31

* The count of XII dorsal spines is for two specimens 14.1 and 14.8 mm in standard length in which the single spine preceding the soft dorsal has not yet differentiated from the spinous dorsal. For convenience, these specimens in which the dorsal fin count is given by McKenny (1961) as "XII, 15" are given here under the soft dorsal count of I, 15.

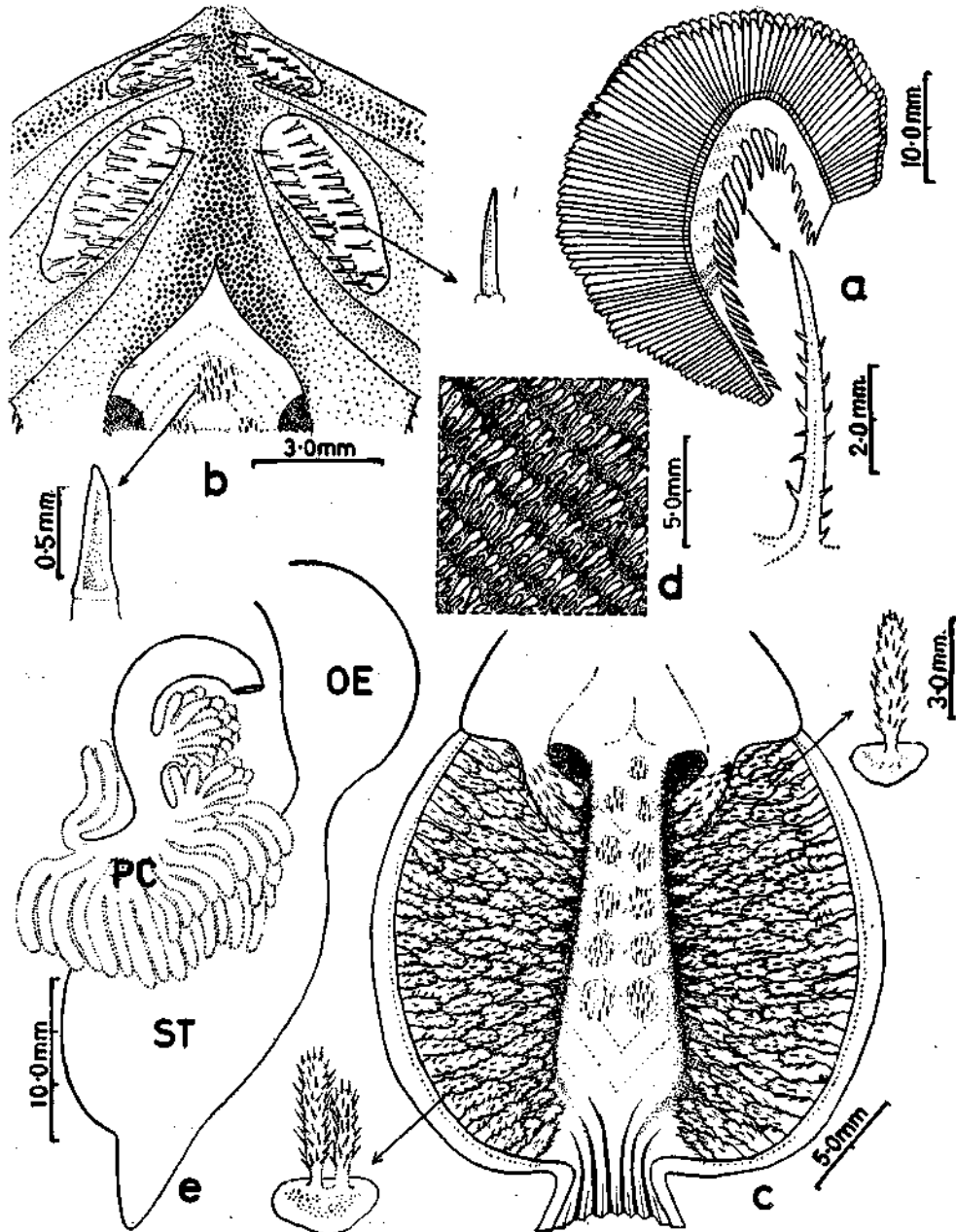


FIG. 3. *Psenes indicus* (Day) a. Outer gill arch with raker enlarged; b. Pharyngeal region showing nature and disposition of teeth; c. Pharyngeal sac showing nature and disposition of toothed papillae; d. Arrangement of papillae of the pharyngeal sac in oblique rows when viewed ventrally; e. Disposition of pyloric caeca (PC) in relation to oesophagus (OE) and Stomach (ST).

TABLE II

Frequency of pectoral fin-rays in *P. indicus* and *P. regulus* (counts taken on the left side and total number of rays — branched + unbranched — indicated)

Species	20	21	22	23* (II, 21)	24* (II, 22)	25* (II, 23)	No. of specimens
<i>P. indicus</i> .. ..	..	..	..	51	42	11	104
<i>P. regulus</i> ..	1†	3 + 1†	14	10	3	..	32

* Both branched and unbranched rays of the pectoral fin have been counted by us for *P. indicus*. However, total counts are given (e.g., II, 21 = 23) to be consistent with the data given for *P. regulus* by McKenny (1961).

† Counts indicated as doubtful (?) by McKenny (1961).

TABLE III

Frequency of anal fin-ray counts in *P. indicus* and *P. regulus*

Species	III, 14	III, 15	III, 16	No. of specimens
<i>P. indicus</i> ..	1	101	1	103
<i>P. regulus</i> ..	..	31	..	31

Gill rakers.—The gill rakers are short and pointed and each raker bears minute teeth as shown in Fig. 3 a. The frequencies of gill raker counts are given in Tables IV A–B. Gill raker counts of *P. regulus* ranging from 5.3 mm to 183 mm in S.L. given by McKenny (1961) indicate that normal counts of adults are present at a very early stage by the time the fish attains about 14 mm (S.L.). Early juveniles of *P. indicus* are not available in our collection, but the frequency of gill raker counts in the two species shows considerable overlap, the most frequent counts being 8 + 1 + 14–15 in *P. indicus*, and 8 + 1 + 15 in *P. regulus*. The combined counts for the upper and lower limbs of the outer arch show 23 to be the most frequent count in *P. indicus*, while it is 24 in *P. regulus*.

TABLE IV (A)

Comparison of gill raker counts of the outer arch in *P. indicus* and *P. regulus**

No. of gill rakers excluding one at angle	Upper limb				Lower limb				Total No. of specimens
	6	7	8	9	13	14	15	16	
<i>P. indicus</i> †									
Number	2	33	63	6	6	48	46	4	104
(%)	1.92	31.73	60.58	5.77	5.77	46.15	44.23	3.85	..
<i>P. regulus</i> †									
Number	—	11	16	—	—	5	15	7	27
(%)	—	40.74	59.26	—	—	18.5	55.6	25.9	..

* 104 specimens of *P. indicus* 107 to 165 mm in S.L. 13 specimens of *P. regulus* 14.1 to 183.2 mm in S.L. (after McKenny, 1961) and 14 specimens examined by us.

† Mean counts for *P. indicus* and *P. regulus* are: upper limb 7.71 and 7.59 and lower limb 14.46 and 15.07 respectively.

TABLE IV (B)

Combined (upper + angle + lower limb) frequency of gill raker counts in *P. indicus* and *P. regulus*

Species	No. of specimens	Total number of gill rakers							Mean
		20	21	22	23	24	25	26	
<i>P. indicus</i> ...	104	2	2	19	42	33	5	1	23.17
<i>P. regulus</i> ..	27	—	—	4	5	14	4	—	23.66

TABLE V

Scale characteristics in a 152 mm (S.L.) *P. indicus* (Day) [Range of measurements (average measurements) and counts are indicated]

(All measurements are in mm)

Location	L. 1. scales from below anterior part of D ₁ (A)	Scales from side of body below middle of pectoral (B)	Scales from lateral side of caudal peduncle (C)
No. of scales	6	5	6
Length	3.9-4.5 (4.06)	6.1-6.4 (6.22)	4.2-5.0 (4.40)
Width	4.7-5.2 (4.93)	8.1-8.8 (8.54)	2.7-3.7 (3.28)
Posterior edge of nucleus to posterior margin of scale ..	0.6-1.0 (0.73)	3.3-3.7 (3.58)	1.8-2.5 (2.07)
Length of nucleus	0.9-1.3 (1.13)	0.10 (0.10)	0.6-1.05 (0.83)
Width of nucleus	1.0-1.3 (1.18)	0.35-0.4 (0.39)	0.8-1.1 (0.98)
No. of complete basal radii (Range)*	0-1	1-3	2-5
No. of incomplete basal radii (Range)	0	0-2	0-3
No. of basal circuli	20-25	38-44	24-31
No. of apical circuli	6-7	76-94	55-69
No. of lateral circuli	16-25	25-29	14-19

* Apical and lateral radii are wanting.

TABLE VI (A)

Frequency of occurrence of perforated scales in the lateral line in *P. indicus*

No. of scales	39	40	41	42	43	44	45	46	47	48	49	Total No. of specimens
No. of specimens	2	8	6	9	17	29	17	9	3	3	1	104

(Mean = 43.67)

TABLE VI (B)
*Frequency of occurrence of lateral line perforated plus unperforated scales to base of caudal fin in P. indicus**

No. of scales	45	46	47	48	49	50	51	52	53	54	55	Total No. of specimens
No. of specimens	1	—	8	19	23	24	19	4	4	1	1	104

* *P. regulus* is said to have 50 to 60 scales in the lateral line to the base of the caudal fin. The mean count for *P. indicus* is 50.07.

Psenes africanus GILCHRIST AND VON BONDE (1923), AND
Psenes extraneus HERRE (1950) CONSIDERED SYNONYMS
 OF *Psenes indicus* (DAY)

The description of *P. africanus* is based on a single specimen (180 mm) out of 14 specimens obtained from moderately deep waters of the continental shelf off South Africa. There are some discrepancies between the description and figure of this species given by Gilchrist and von Bonde. The anal fin-ray count is given as III, 13, but III, 14 rays are clearly shown in the figure (pl. 18, fig. 1 reproduced here in Text-Fig. 2 g). Similarly, the pelvic fin-ray count is given as I, 6 while the figure shows I, 5 rays which is characteristic for the genus. The anterior ray of the soft dorsal is said to be equal in length to the longest spine, but in pl. 18, fig. 1, the longest ray of the soft dorsal is shown to be much shorter than the longest spine. The latter is probably correct as in the typical *P. indicus* (adult) we find that the length of the longest soft dorsal ray is less than $\frac{2}{3}$ the length of the longest dorsal spine.

The fourth spine of the first dorsal is said to be the longest in *P. africanus* and in pl. 18, fig. 1 this is shown as such with a markedly progressive reduction in the 3rd, 2nd and 1st spines. In our material of *P. indicus* the 1st dorsal spine is about 0.5 to 0.6 the length of the longest spine, the 2nd, 3rd, and 4th spines being of almost equal length. The latter condition also obtains for Day's types from Madras as could be seen from his illustration of the species (pl. 34, fig. 2). The pectoral fin-ray count of 18 rays given for *P. africanus* is much lower than the count of ii, 21-23 (total 23-25) we find for *P. indicus* and would need re-examining for the South African specimens, especially the types. But for this, there is hardly any difference

between *P. indicus* and *P. africanus* to consider them as distinct species as could be seen from the details given in Table VII.

TABLE VII

Characters	<i>P. africanus</i> Gilchrist and von Bonde (1923)	<i>P. extraneus</i> Herre (1950)	<i>P. indicus</i> (Day) (based on present re- description)
D ₁	.. X	XI	X-XI
D ₂	.. I, 16	II, 14	I, 13-16 (exceptionally I, 13; I, 14 or I, 16)
A	.. III, 13 (in fig. 1, pl. 18 shown as III, 14).	III, 15	III, 14-16, mainly III, 15
P ₁	.. 18	..	ii, 21-23 (total 23-25)
P ₂	.. I, 6 (in fig. 1, pl. 18 shown as I, 5)	..	I, 5
Lateral line scales	50 (44 perforated scales shown in fig. 1, pl. 18)	About 55 "but owing to their deciduous character their number is uncer- tain"	39-49 perforated scales + 5-10 unperforated scales in same series to base of caudal
L. tr.	.. 4/14	—	4-6/12-16
Gill rakers	.. Not given	6 + 14	6-8 + 13-16 (gene- rally 8 + 14-15)
Maxillary	.. Not surpassing line through anterior margin of eye	Same	Same
Greatest depth of body in S.L.	2.2	2.4	2.1 -2.6
Head length in in S.L.	3.3	3.1	2.59-3.14
Eye diameter in head length	3.0	..	2.96-4.0
Length of pectoral fin in S.L.	"Equal to head" (3.3)	3.4	2.6-3.3
Snout length in eye diameter	0.8	—	0.77-1.2 (in 35 out of 88 specimens the snout length is equal or slightly greater than eye diameter)

Herre (1950) described *Psenes extraneus* from a single partly damaged specimen 97 mm long, purchased in the Batangas Market, and caught in the Batangas Bay, Batangas Province, Luzon, Philippines. He was aware of the close similarity of his new species to *P. indicus* as he remarks that "... it is evidently closely related to *Psenes indicus* (Day). A large series might show it to be only a variation of *P. indicus*..." As we have examined a good series of specimens of *P. indicus* we find that there is hardly a single character on which these two species can be separated (see Table VII). The only difference we note is Herre's mention of two dorsal spines in *P. extraneus*, which is apparently an error in counting as the genus is characterised by only a single spine in the second dorsal.

Chabanaud (1930) described *Cubiceps dollfusi* from the Gulf of Suez based on seven specimens. McKenny (1961) commented on the close similarity of this species to *P. indicus* (Day), *P. extraneus* Herre, and *P. regulus* Poey. The similarities especially between *C. dollfusi* and *P. regulus* and incidentally *P. indicus* are in the presence of the low caudal keels, the scale counts, fin-ray counts and body depth. However, we have not come across a spinous dorsal count of XII spines in *P. indicus*, the range in *C. dollfusi* being X–XII. The gill raker counts in *C. dollfusi* is not known, nor is a drawing of this species available. The Director, Museum d'Histoire Naturelle de Paris, writes that the types of *C. dollfusi* are not in the Museum collections. Until such time that the types are re-examined, we are inclined to consider *Cubiceps dollfusi* as only a doubtful synonym of *P. indicus*.

Fowler (1925) while describing a 65 mm specimen of *P. indicus* from Richard's Bay, Natal, gives the dorsal fin and gill raker counts as: D. X, I, 18; rakers 10 + 15. The second dorsal fin-ray count as well as the raker count for the upper limb are slightly more than what is seen for *P. indicus*. However, his description covering other characters shows close agreement with that of the typical *P. indicus*. A re-examination of Fowler's specimen for re-checking the above counts may be necessary, especially as two other workers from that area, namely, Smith (1949, 1961), and Fourmanoir (1957) give the dorsal fin-ray counts for South African and Madagascar specimens of *P. indicus* as D. X, I, 14–16. These authors have not given details of gill raker counts for this species. We would like to point to the omission of *Psenes africanus* Gilchrist and von Bonde, either as a valid species or as a synonym in Smith's (1949) exhaustive treatise on the *Sea Fishes of Southern Africa*.

The fin-ray, scale counts, and body proportions for *P. indicus* given by Regan (1902: coast of Madras); Blegvad (1944: Persian Gulf and Gulf of

Oman); Smith (1961: South Africa), and Fourmanoir (1961): Madagascar fall within the range of variations we have given here for specimens from the south-west coast of India.

The synonyms and more important references relating to *Psenes indicus* (Day) are given below:

Psenes indicus (Day), 1870

Cubiceps indicus Day, 1870. *Proc. zool. Soc. London*, p. 690 (Type locality: Madras where several specimens were captured at sea..).

Psenes indicus Day, 1878, *Fish. India*, p. 237, pl. 34, fig. 2 (Madras Coast); *id.*, 1889, *Fauna Brit. India*, *Fish.* 2: 185 (Madras Coast); Regan, 1902. *Ann. Mag. Nat. Hist. Ser. 7*, 10: 126-27 (Coast of Madras; Fowler, 1925. *Proc. Acad. Nat. Sci. Philad.*, 77: 212 (Richard's Bay, Natal); Barnard, 1927. *Ann. S. African Mus.* 21 (2); Fowler, 1929. *Proc. Acad. Nat. Sci. Philad.*, 81: 604 (Hong Kong); *id.*, 1934, *Ibid.*, 86: 405; Blegvad, 1944. *Danish Sci. Invest. Iranian Gulf*, Pt. 3: 180-81, fig. 107 (Persian Gulf and Gulf of Oman); Smith, 1949. *Sea Fish. Southern Africa*, p. 306, also 1961 Ed., p. 306, fig. 852 (Knysna to Beira, South Africa); *id.*, 1956, *Ann. Mag. Nat. Hist.*, Ser. 12, 9: 722 (Aldabra Id.); Fourmanoir, 1961. *Mem. l'Inst. Sci. Madagascar Ser. F*, 4: 95, fig. 8 (Nosy-Be, Madagascar); *id.*, 1965. *Cahiers O.R.S.T.O.M. Oceanographie, Spec. No. July*, 1965, p. 83.

Psenes africanus Gilchrist and von Bonde., 1923. *Union S. Africa Fisher. Mar. biol. Surv. Rept.*, 3 for 1922, No. 4: 8-9, pl. 18, fig. 1 (Type locality: S.S. "Pickle", Stn. nos. 192 and 280; S.S. "Pieter Faure" collection from Natal and Cape Coasts).

Psenes extraneus Herre, 1951. *Philippine J. Sci.*, 79 (3): 341-42 (Type locality: Batangas Bay, Batangas Province, Luzon, Philippines); 1953, *U.S. Fish. & Wildl. Serv., Res. Rept.*, No. 20: 260.

Cubiceps dollfusi Chabanaud, 1930. *Bull. du. Mus. d'Inst. Nat. Paris*, Ser. 2, 2 (5): 519-23 (Type locality: Gulf of Suez).

COMPARISONS OF BODY PROPORTIONS DURING GROWTH IN
P. indicus AND *P. regulus*

Some idea of changes in body proportions during growth can be seen from the data presented in Fig. 4. Detailed comparisons for all sizes are not

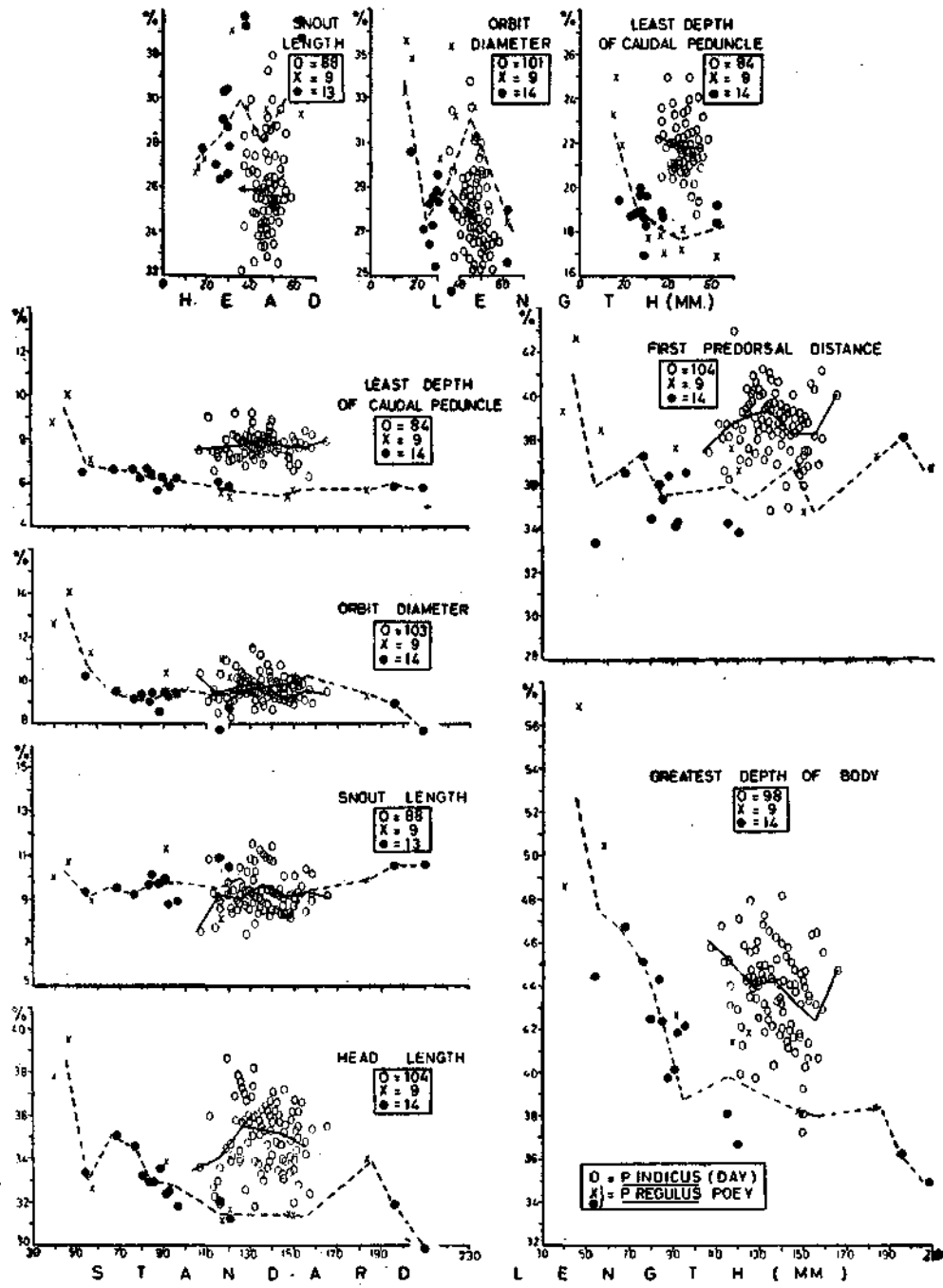


FIG. 4. Changes in body proportions in juveniles and adults of *P. indicus* and *P. regulus*. (O) = *P. indicus* (X) = *P. regulus* — data from McKenney (1961). 14 specimens of *P. regulus* examined by us.

possible as specimens of *P. indicus* less than 103 mm and greater than 165 mm in standard length are not available, though we have examined specimens of *P. regulus* from 54 mm to 209 mm. The length measurements of 9 specimens of *P. regulus* given by McKenney (1961) are also included for these comparisons. The dashed line (for *P. regulus*) and the continuous line (for *P. indicus*) connecting the mean percentage in 10 mm size groups are given in Fig. 4 to facilitate visual comparison. It may be noted that in similar-sized specimens the percentage of orbit diameter and snout length in relation to standard length shows considerable overlap. The percentage of head length, least depth of caudal peduncle, greatest depth of body, and first predorsal distance are relatively greater in similar-sized specimens in *P. indicus*. Similarly, the percentage of the least depth of caudal peduncle in relation to head length is greater in *P. indicus*. However, the percentage of snout length and orbit diameter in relation to head length are greater in similar-sized specimens of *P. regulus*. The general changes in body proportions in different size groups are better seen in *P. regulus* where there are data for specimens over a larger size range as shown in Fig. 4, which is self-explanatory.

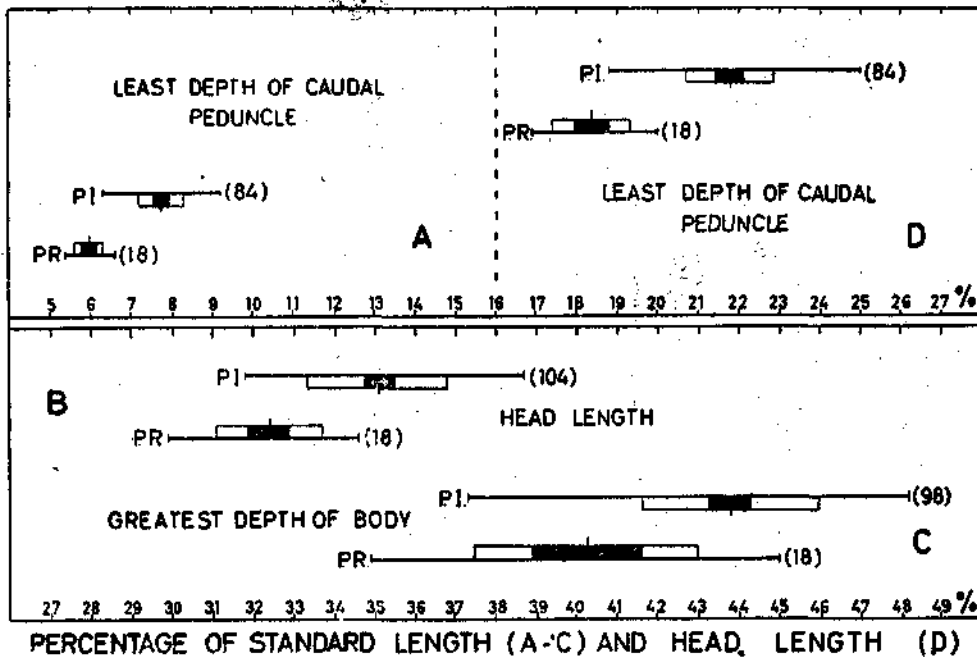


FIG. 5. Graph showing variations in four characters between *P. indicus* (PI) and *P. regulus* (PR). (The horizontal line represents the total range; the short vertical line the mean; the solid rectangle two standard errors on each side of the mean; the hollow rectangle one standard deviation on each side of the mean). The number of specimens is given in parenthesis.

TABLE VIII
Biometric data of selected morphological characters of P. indicus and P. regulus

Characters (Proportions expressed as percentages of standard length or head length)	<i>P. indicus</i> (Range 107 to 165 mm S.L.)					<i>P. regulus</i> † (Range 91.2 to 183.2 mm S.L.)					Differences between Means	t	P
	No.	Range	Mean	σ	σ_{M1}	No.	Range	Mean	σ	σ_{M1}			
1. Least depth of caudal peduncle/head length	84	18.8- 25.0	21.83	1.1045	0.1205	18	16.9- 20.0	18.38	0.9360	0.2206	3.45	13.72	
2. Head length/standard length	104	31.8- 38.7	35.10	1.6882	0.1655	18	29.9- 34.6	32.37	1.1508	0.2712	2.73	8.59	1.96 at 5% level
3. Least depth of caudal peduncle/standard length	84	6.3 9.2	7.74	0.5020	0.0548	18	5.4- 6.6	5.96	0.3575	0.0843	1.78	17.71	
4. Greatest depth of body/ standard length	98	37.3- 48.2	43.79	2.2342	0.2257	18	36.2- 45.1	40.24	2.7669	0.6522	3.55	5.14	

† 12 out of the 18 specimens were examined by us. For 6 the data were taken from McKerny (1961).

Four characters selected, namely, the percentage of the least depth of caudal peduncle, the greatest depth of body and the length of head in relation to the standard length, and the percentage of the least depth of caudal peduncle in relation to head length in specimens of *P. indicus* in the size range 103 to 165 mm in standard length, and *P. regulus* from 76.5 to 209 mm in standard length show differences that are statistically significant (Table VIII). These data are also graphically shown in Fig. 5. The *t* values were calculated using the formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

where \bar{x}_1 and \bar{x}_2 are the means and S_1^2 and S_2^2 are the standard deviations and n_1 and n_2 the number of specimens.

These differences, combined with the differences in the colouration of the two species, especially the black pelvic fins of *P. regulus* (versus hyaline in *P. indicus*), and the distinct black blotches on the sides of the body in the former, should help to separate the two species, though considerable overlap is seen in meristic characters.

OBSERVATIONS ON THE BIOLOGY OF *Psenes indicus* (Day)

(i) *Food*.—Limitations of material do not permit a detailed study. The examination of the stomachs of 101 specimens collected at different times showed that most of the stomachs had digested or partly digested food as a bolus. A few, especially those taken on 8-2-1965 from 45 m. S-W of Cochin had several undigested ostracods in the pharynx and the stomach. The identifiable items of food in the stomachs were as follows:

- (1) Along with the digested pulpy matter, the following were also noticed as rare inclusions: *Thalassiosira* sp., *Gymnodinium* sp., and *Pyrocystis* sp.
- (2) Ostracods: large numbers were present in the stomachs of six specimens caught on 8-2-1965, all fresh.
- (3) Partly digested alima larvae were present in the stomachs of 5 specimens.
- (4) Hyperid Amphipoda: present as rare inclusions.
- (5) Calanoid copepods: *Temora turbinata*, *T. stylifera*, *Candacia bradyi*, and *Acrocalanus* sp. present as rare inclusions.

(6) Partly digested remains of a juvenile fish (clupeoid) measuring 1.5 cm in length were seen in the stomach of one specimen.

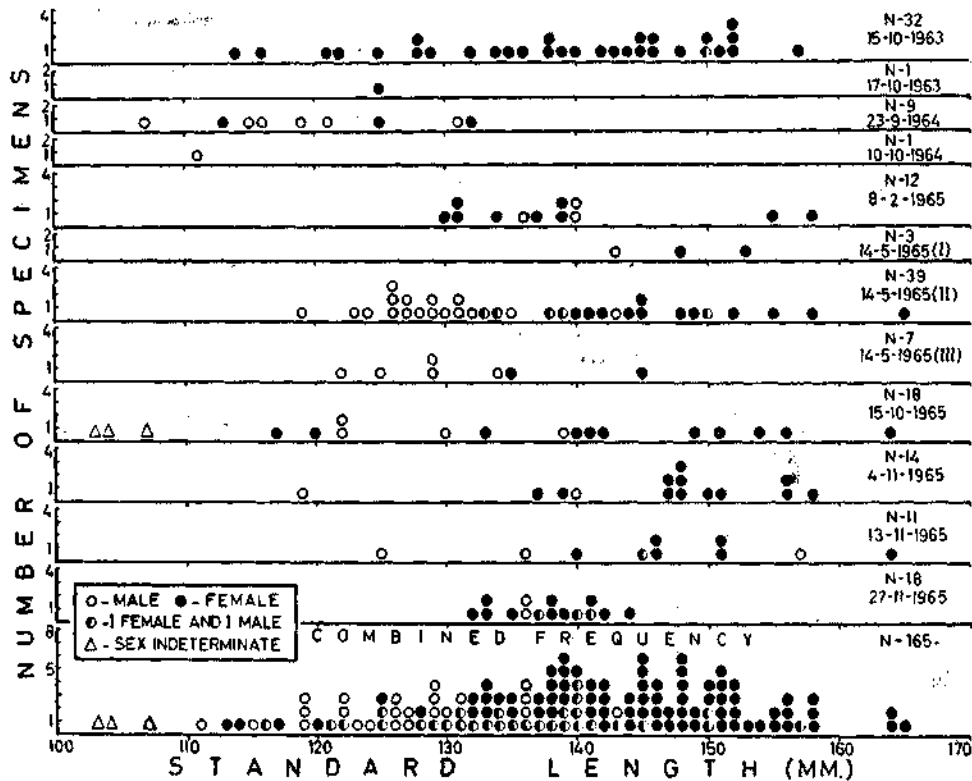


FIG. 6. *Psenes indicus* (Day). Frequency of occurrence of sexes in relation to size in the catch.

On the basis of the quality of the food present in the stomach it would appear that the fish although caught from moderate depths of the continental shelf, feeds on mid-water planktonic organisms.

(ii) *Sex and size.*—From our collections as well as previous records it would appear that *P. indicus* does not grow to a large size as *Parastromateus niger* (Bloch) (about 70 cm) or even *Pampus argenteus* (Euphrasen) (about 30 cm). The largest specimen that we have examined is only 22.2 cm in total length (16.5 cm in standard length). Gilchrist and von Bonde (1923) record specimens upto 180 mm. in total length (as *P. africanus*); Blegvad (1944) from 98 to 170 mm in total length; while records of specimens by Regan (1902), Fowler (1925), Herre (1950) and others are of specimens about 100 mm or less in total length.

The average fresh weight of 14 specimens measuring 13.5 to 16.5 cm in standard length (all females) is 115 gm. The weight of the largest specimen (16.5 cm in S.L.) is 180 gm.

Differentiation of sex based on external characters is difficult as sexual dimorphism is not evident. There is a paucity of information on the size ranges of both sexes of adult stromateoid fishes. From the material at hand it would appear that the females of *P. indicus* may attain a larger size than males. In Fig. 6, we have shown the frequency of occurrence of males and females in this species from which it will be seen that 87.04% of males (47 out of 54) are 140 mm or less in standard length, while 54.63% of females (59 out of 108) are over 140 mm in standard length. Three specimens, 103, 104, and 107 mm are immature and the sex is indeterminable. The apparent size differences in the sexes may not be on account of specimens being taken from completely segregated shoals as generally mixed catches were present in the same haul.

(iii) *Maturity*.—Since the collections were made at irregular intervals depending on the operation of trawls at moderate depths of the continental shelf it has not been possible to obtain all stages of maturity. Hence, we are hesitant to define the stages of maturity, although in general these may be said to correspond with the conventional stages recognised for other fishes.

The males of *P. indicus* not only appear to be smaller in size, but evidently attain maturity at a comparatively smaller size than the females. An examination of the males collected during part of the spawning season in May and in October 1965 indicates that the males are fully mature and have well developed, enlarged, flattened, testes extending to over $\frac{2}{3}$ the length of the body cavity, with loose milt, even in specimens 119 mm in standard length. This was noted in specimens taken in three separate hauls on 14-5-1965 from R.V. VARUNA and also on 15-10-1965 from R.V. KALAVA. Ovaries of specimens upto 130 mm were found to be immature, cylindrical and both lobes of almost equal length, being about 2-5 mm at the widest and about 38 mm long. Females 140 mm and upwards in standard length were found to have 'ripe' ovaries or partly spent ovaries. (In mature 145 mm specimen ovaries extend the entire length of the body cavity, measuring 51 mm in length and 18 mm at the widest, and posteriorly projecting as a lobe into the post-anal region.) One specimen with apparently partially spent ovaries measured 135 mm (S.L.). The available data point to the first spawning in the females taking place when the fish attains about 135 mm in standard length,

(iv) *Fecundity*.—For estimating the fecundity, the ovaries of 17 mature specimens were examined. The total wet weights of the ovaries were taken after removing the excess moisture by gently pressing the ovaries between blotting-paper. Portions of the ovaries from three different parts (namely, the middle of the left ovary, and the apical and basal halves of the right ovary) made up to about 10% of the total weight of the ovaries were taken and weighed to the nearest 0.01 mg. The ova counts were carried out under a binocular microscope. In Table IX, Columns 6 and 7, the combined ova counts for the three portions are given from which total counts of the ova have been estimated. There was no difficulty in separating the ova of the most advanced mode.

From the details given in Table IX it will be seen that the estimated total number of ova in the ovaries varies from 38,800 to 1,17,800 (mean = 79,500). Five out of the seventeen specimens (Nos. 13 to 17 in Table IX) have ovaries in partly spent or spent recovering condition, and barring these, the estimated ova counts vary from 48,900 to 1,12,800 (mean = 81,700). Similarly, the estimated number of ova in the most advanced mode for the first 12 mature ripe ovaries (Table IX) varies from 12,201 to 40,533 (mean = 24,900).

The ova diameters have also been measured to find out the modal patterns and in Table IX the data are arranged in such a manner (see 'Remarks' column) as to correspond with the sequence of ova diameter frequency polygons shown in Fig. 7, B-F.

SPAWNING SEASON AND SPAWNING FREQUENCY

The available data are not sufficient to indicate a prolonged spawning season, but there are indications from the several (6 or 7) modes seen as well as from the estimated number of ova in the most advanced mode that the fish does not shed all the ripe ova at one time, but the ova mature in batches and are spawned at intervals. It is also difficult at this stage to say whether there is one or more peaks of spawning during the spawning season or seasons. We have obtained mature females 135 mm and upwards in standard length during the months of May and October showing maturity stages of gonads corresponding to Stage V (ripe); and Stage VI (ripe running or partially spent); the latter with a batch of ova (0.78 to 1.05 mm in diameter), well differentiated from the preceding modes (Fig. 7, E). One specimen 144 mm (S.L.) obtained in May 1965 (partially spent or spent recovering) has a few degenerate residual eggs falling within the above size range, and with the most advanced mode comprising ova from 0.42 to 0.68 mm,

TABLE IX
Details of ovum counts in mature specimens of P. indicus

Serial No.	Standard Length (mm)	Total weight* (gm)	Total weight of ovaries (gm)	Weight of part of ovary taken for ovum count†	Estimated total ova counts‡	Estimated total ova of most advanced mode	Remarks
1	152	110.8	2.86	0.17	62,500	21,681	Text-Fig. 6, B—Mature ripe
2	152	104.0	3.97	0.33	87,400	30,300	
3	145	98.2	3.15	0.58	74,600	26,422	
4	150	106.6	6.62	0.77	77,000	25,748	Text-Fig. 6, C—Mature ripe
5	153	144.0	3.88	0.397	48,900	13,565	Text-Fig. 6, D—Mature ripe.
6	148	121.2	3.16	0.339	77,700	20,135	
7	139	101.0	4.96	0.174	88,000	17,157	
8	155	123.0	2.69	0.133	61,500	12,201	
9	165	166.0	3.68	0.109	98,600	18,252	
10	164	180.0	8.02	1.092	1,12,800	40,533	Mature ripe (not figured)
11	156	155.0	7.81	1.480	86,000	34,317	
12	151	148.0	5.91	1.226	1,05,300	37,664	
13	148	113.0	1.06	0.127	38,800	3,909	Text-Fig. 6, E—Ripe running (?) or partially spent
14	135	92.0	3.93	0.233	57,700	3,634	
15	145	113.0	7.48	0.248	1,17,800	7,781	
16	150	115.0	3.19	0.136	55,300	7,121	
17	144	109.0	4.20	0.130	1,01,000	24,710	Text-Fig. 6, F—Partially spent or spent recovering (?)

* Specimens could not be weighed fresh. The data are for preserved material.

† 'Part ovary' would mean the combined weight of three parts each of the left and right ovaries.

‡ Corrected to nearest hundred.

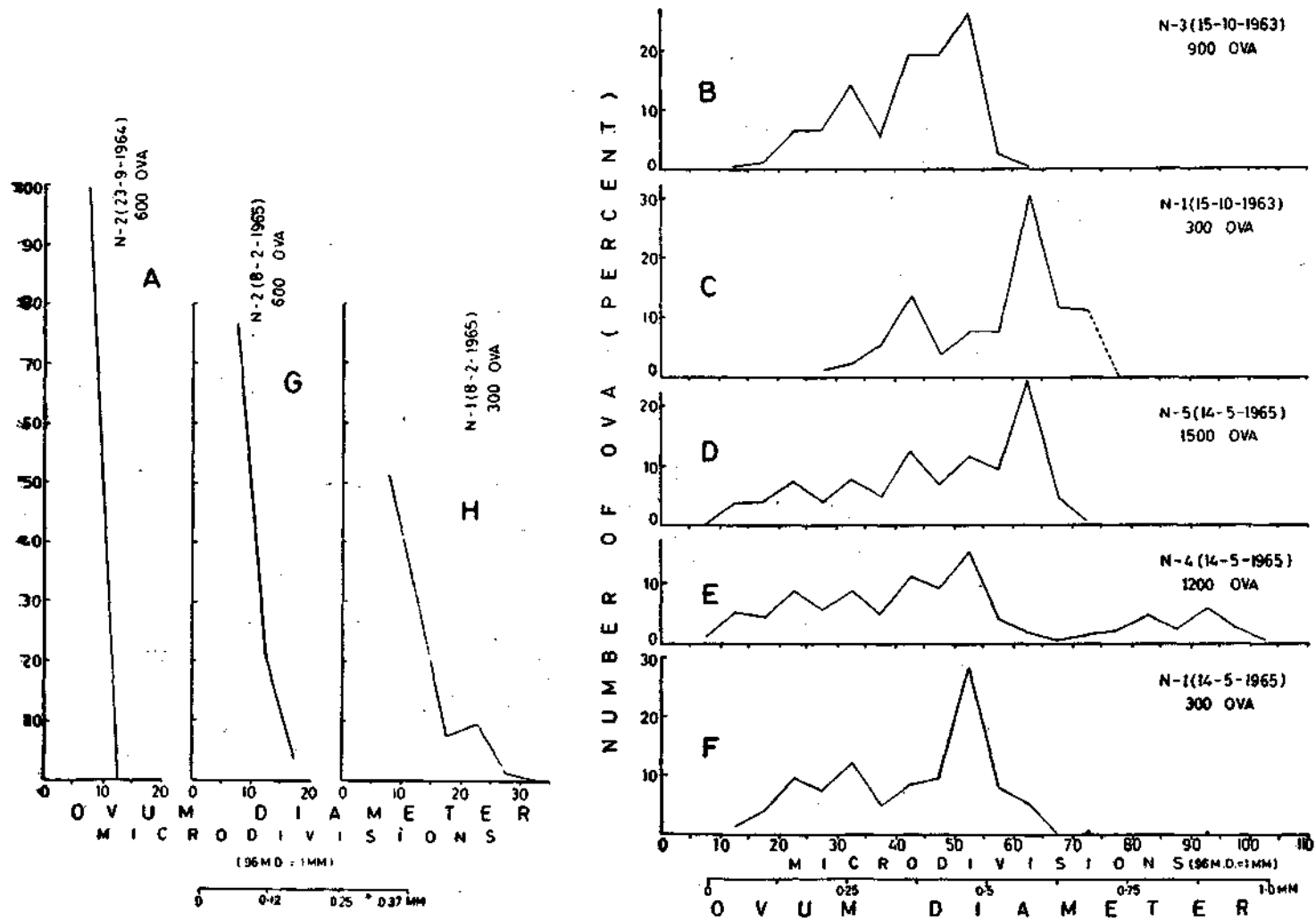


FIG. 7. *Psenes indicus* (Day). Ova diameter frequency polygons of (A) immature; (B, C, D), mature ripe; (E) ripe running; (F) partially spent; (G & H) spent recovering ovaries.

(Fig. 7, F). Almost a similar condition, but with no indications of residual or degenerate ova, has been found in specimens during the months of October 1963 and May 1965 (Fig. 7, B, C & D). It is likely that at a time, part of the ova of the most advanced mode in the ripe ovaries may differentiate and may rapidly develop into the next mode measuring between 0.78 and 1.05 mm which may eventually be spawned. This presumption is mainly based on the fact that in a few specimens in the 'ripe running' (?) or partially spent condition the number of ova in the most advanced mode was relatively much less when compared to those in the 'ripe' ovaries. Apparently they are not degenerate residual ova as they are in good shape with a single well-developed oil globule which in two ova measuring 0.95 mm in diameter were 0.23 and 0.25 mm in diameter. Besides, when degenerate residual eggs have been found as in the 144 mm (S.L.) specimen mentioned above, their numbers are very few. Thus the available data indicate that *P. indicus* is a fractional spawner.

Females measuring 113 and 130 mm obtained during the month of September 1963, were found to be immature with ova less than 0.13 mm in diameter (Fig. 7, A). Specimens obtained during February 1965 (134, 139 and 150 mm in S.L.) (Fig. 7, G & H) were found to have maturing ovaries with ova up to 0.34 mm in diameter. From the size of the specimens as well as the degree of the development of the ova it is seen that specimens longer than 139 mm (S.L.) had already spawned and the ovaries were recovering.

HABITS AND ASSOCIATED FISHES

Our material as well as those reported on by Blegvad (1944) from the Iranian Gulf indicates that *P. indicus* occurs in small shoals in the mid-waters of the continental shelf and is not really demersal. The food of the species also suggests this.

It has not been possible to make a definite identification of the larvae of *P. indicus* from the plankton collections of R.V. VARUNA. However, it is presumed that as in the case of some of the other species of *Psenes*, namely, *P. regulus* and *P. cyanophrys* (Legaspi, 1956; McKenney, 1961), the larval and post-larval stages of *P. indicus* are also pelagic. There are no records of post-larvae or juveniles of *P. indicus* occurring in association with floating objects or jelly fishes as is the case of *P. cyanophrys*, *P. maculatus*, and other stromateoids.

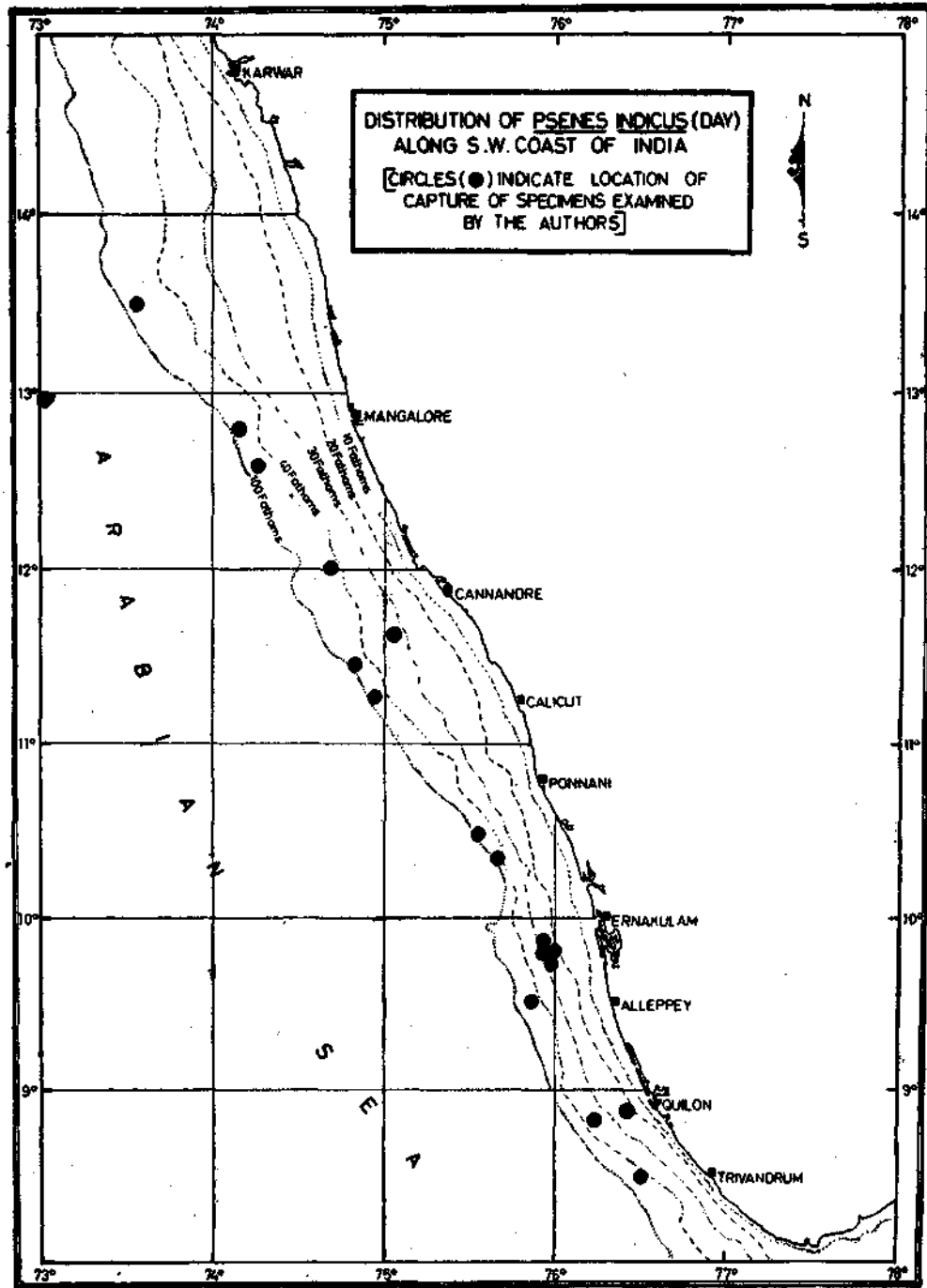


FIG. 8. Map showing the distribution of *Psenes indicus* (Day) off the south-west,

The following species were invariably present along with *P. indicus* in otter trawl collections: *Synodus indicus* (Day), *Saurida gracilis* (Quoy and Gaimard), *Saurida tumbil* (Bloch), *Decapterus ruseffi* (Rupell), *Nemipterus japonicus* (Bloch) and *Lutjanus* sp.

VERTICAL AND SPATIAL DISTRIBUTION

(1) *Vertical distribution.*—Some idea of the vertical distribution of *P. indicus* along the south-west coast of India may be obtained from Fig. 8, wherein locations of capture of this species in relation to depth contours are indicated. The largest number of specimens were obtained on 14-5-1965 when in a single haul about 900 specimens weighing approximately 95 kg were landed in a trawl haul made at 68 metre depth. Although our data for tabulating the vertical distributional pattern of adults of this species are insufficient, it more commonly occurs in waters 50 metres or more in depth. A similar trend is also evident from the data on depth of capture and number of specimens of *P. indicus* obtained in the course of 168 trawls at 136 stations in the Iranian Gulf and Gulf of Oman given by Belgvad (1944). The data summarised below show that more specimens were obtained in depths between 41 and 83 metres:

Depth (m)	No. of Stations	No. of hauls in which <i>P. indicus</i> occurred	Total No. of specimens of <i>P. indicus</i>	Average No. of specimens of <i>P. indicus</i> per haul
0-20	96	4	45	11.25
21-40	39	8	192	24
41-83	29	11	1057	96

Immature specimens of *P. indicus* generally occur in trawl catches within the 20-fathom line especially during the months October to January.

(2) *Spatial distribution.*—The spatial distribution of *P. indicus* and the related species *P. regulus* are shown in Fig. 9. Their distributions are exclusive and as could be seen from the map, there are several areas within the range of distribution of *P. indicus* in the Indo-Pacific where we do not have any definite records of this species. Further collections from

the moderately deep waters of the continental shelf of these waters will add to the existing knowledge of the geographical distribution of this species.

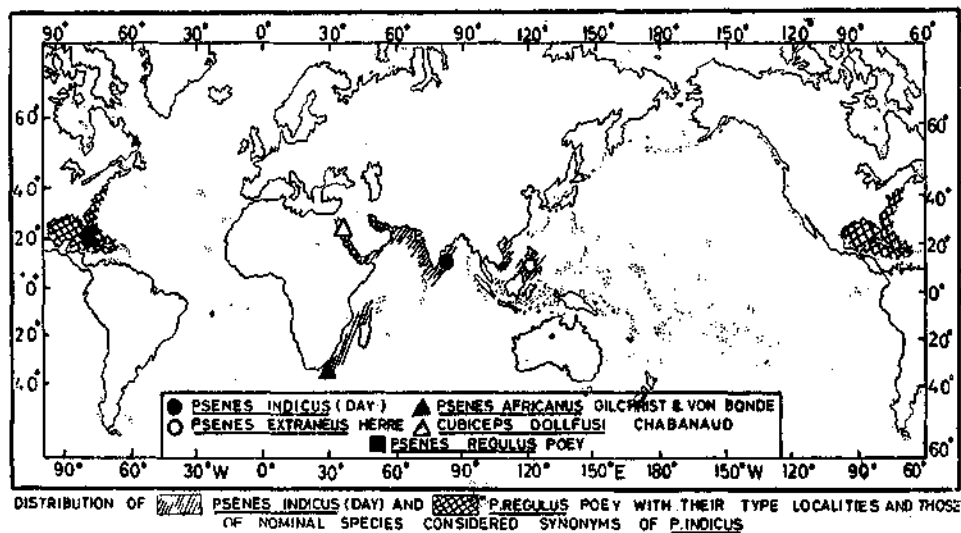


FIG. 9. Spatial distribution of *P. indicus* and *P. regulus*.

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