

SYSTEMATIC COMPARISON OF THE STROMATEID FISHES OF THE
GENUS *PAMPUS* BONAPARTE (FAMILY STROMATEIDAE)

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ABSTRACT

Pampus chinensis (Euphrasen), *Pampus argenteus* (Euphrasen) and *Pampus echinogaster* (Basilewsky) are the three recognised species of the genus *Pampus*. The genus is described and a key is provided to the three species. The synonymies, details of range in variation in morphometric and meristic characters and distribution of each species is given. The three species can be completely distinguished on the basis of vertebral count. *P. argenteus* and *P. echinogaster* have falcate median fins preceded by peculiar trenchant spines which demarcates them from *P. chinensis*. *P. echinogaster* differs from *P. argenteus* in the higher number of gillrakers and vertebrae. The vertebral number is constant throughout the range of distribution in *P. chinensis* and *P. echinogaster*. Geographical variation in vertebral number is observed in *P. argenteus*, basing which four distinct allopatric races can be recognised in the Indo-West Pacific. In *P. argenteus*, speciation is in progress as evidenced by the similarity in form amongst the races coupled with divergence in the vertebral number.

INTRODUCTION

PAMPUS, one of the three genera of stromateid fishes, is widely distributed in the tropical and subtropical waters of the continental shelves from Japan to the Iranian Gulf. It is a coastal genus inhabiting upto a depth range of 100 metres. *Pampus* is considered to be the most advanced stromateid genus (Haedrich, 1967) and is popularly known as 'Pomfret' in the Eastern fisheries. The genus comprises three species; the Chinese pomfret *Pampus chinensis* (Euphrasen), silver pomfret *Pampus argenteus* (Euphrasen) and butterfly silver pomfret *Pampus echinogaster* (Basilewsky).

The systematics of the genus has been a perplexing matter as these fishes undergo spectacular changes during life (Pati, 1978) and have a wide range of distribution. As a result, numerous synonymies are in vogue and the same species had been described by different names causing confusion in scientific literature. Amongst populations, meristic characters often overlap making the delimitation of races a difficult problem. The short systematic accounts of Day (1878), De Beaufort and Chapman (1951), Abe and Kosakai (1964) and Haedrich

(1967) do not clarify the situation. The present paper deals with a detailed systematic investigation and morphological comparison of the fishes of the genus *Pampus* from their entire range of distribution confined to the Indo-West Pacific.

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MATERIALS AND METHODS

Specimens examined were either collected or obtained from different localities of the Indo-West Pacific Coast (Fig. 1). They have

been deposited in the Zoological Museum of Ravenshaw College, Cuttack, India. Methods of counting and measuring conform to those described by Haedrich (1967) and Horn (1970).

Material examined: The locality, the number of specimens, the range of standard length in cm are presented in order for each species. Two specimens from each locality were radiographed for examining vertebral counts.

P. argenteus

Pusan, S. Korea (35° 06' N 129° 03'E): 3, 22.2-29.0; Ushimado, Japan (34° 37' N 134° 10'E): 10, 19.9-27.0; Taipei, Taiwan (25° 04' N 121° 33'E): 3, 18.0-19.7; Singapore (1° 17' N 103° 51'E): 2, 14.2, 15.0; Chandipur (21° 27' N 87° 02'E), 34: 2.5-22.0; Paradip (20° 15' N 80° 40'E): 20, 11.0-22.1; Madras (13° 05' N 80° 17'E): 18, 16.0-21.0; Cochin (9° 58' N 76° 14'E): 8, 11.2-20.0; Bombay (18° 57' N 72° 50' E): 15.6-20.5; Kuwait (29° 30' N 48° 00'E): 4, 10.4-13.2.

P. chinensis

Taipei, Taiwan: 3, 12.5-12.7; Singapore: 2, 16.1, 16.5; Chandipur: 24, 3.1-30.0; Paradip: 3, 13.3-20.4; Madras: 10, 15.6-20.4; Cochin: 4, 12.8-23.1; Bombay: 4: 16.9-29.5.

P. echinogaster

Pusan, S. Korea: 2, 21.2, 24.4; Ushimado, Japan: 4, 15.5, 21.0.

SYSTEMATICS

Genus *Pampus* Bonaparte, 1837

Pampus Bonaparte, 1837: 48. (Subgenus: Type species not named but plainly *Stromateus candidus* Cuvier and Valenciennes, 1833: 391, by subsequent designation of Jordan, 1923: 187, Malabar Coast. A synonym of *Stromateus argenteus* Euphrasen, 1788: 49).

Stromateoides Bleeker, 1851: 368 (Type species: *Stromateus cinereus* Bloch, 1793: 90, by subsequent designation of Gill, 1862: 126. A synonym of *Stromateus argenteus* Euphrasen, 1788: 49).

Chondroplites Gill, 1862: 126 (Type species: *Stromateus atous* Cuvier and Valenciennes, 1833: 389, by original designation. A synonym of *Stromateus chinensis* Euphrasen, 1788: 53).

Leptolepis (Van Hasselt) Guichenot, 1867: 68 (Type species: *Leptolepis argenteus* Van Hasselt. Possibly intended for *Stromateus argenteus* Euphrasen, 1788: 49. Name preoccupied in fossils).

Diagnosis: The genus *Pampus* is distinguished from other stromateid genera by the combination of a very deep body without pelvic fin, fixed maxillary and gill membranes broadly united to the isthmus.

Description: Body very deep, laterally compressed, dorsal and ventral profiles equally convex. A continuous dorsal fin, both dorsal and anal fin preceded by none or 5-10 flat blade like trenchant spines protruding slightly from the surface. Dorsal fin originating above the pectoral insertion; and fin originating at or middle of the body and slightly behind the origin of the soft dorsal. Anterior most rays of the median fins produced, the rays of the posterior two third of the fin short and subequal. Pectoral fin long, fanlike, the base of the fin inclined at about 45°. No pelvic fin. Pelvic bones without a ventral spine, caudal fin robust, distinctly forked. Scales small, cycloid, wedge-shaped, deciduous and extending onto the bases of median fins. Lateral line not keeled. Head nearly 25 per cent of standard length, top of the head naked with numerous subdermal canals. Eyes with narrow adipose eyelids. Mouth subterminal, small, curved downwards. Premaxillary non-protractile; maxillary immobile, covered with skin and extends to beneath first third of eye. Lacrymals very much reduced, subocular shelf absent. Teeth minute, laterally compressed, close set; upper jaw teeth simple and lower jaw teeth with 3 to 5 cusps. Gill membranes broadly united to isthmus. Gill openings restricted to a vertical slit on each side. Gill rakers small, less than a quarter of the gill filaments; with or without teeth, widely spaced. Pseudo-

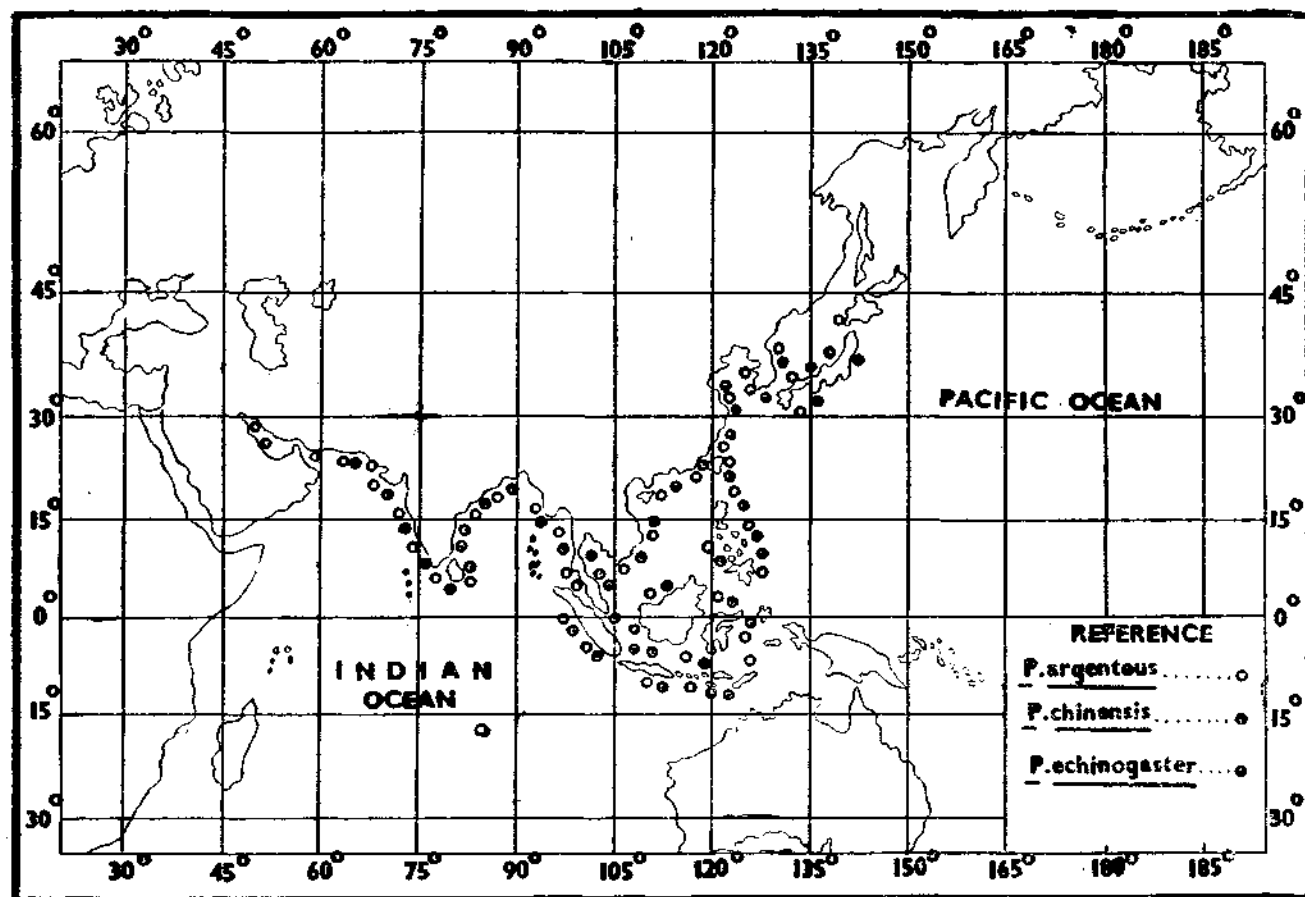


Fig. 1. Distribution of *Pampus* spp.

branch absent. Five branchiostegal rays, three on the ceratohyal and two on the epihyal. Skeleton light and spongy. Pelvic bones long, pointed at both ends. Vertebrae $14 + 19 = 33$ to $15 + 26 = 41$. First interhaemal stout, forms an abrupt angle with haemal spine. Two small inconspicuous patches of upper pharyngeal teeth. Gizzard or toothed pharyngeal sac or oesophageal sac present.

Colour grey with metallic reflections merging to silvery white on belly; young with spots. The term 'pampus' or 'pampano' is derived from a vernacular name used by the nineteenth century East Indian Spanish and Portuguese colonials signifying a silvery compressed fish. In Orissa-West Bengal coast of India, the vernacular name is 'Chandi' meaning silvery fish.

Distribution: Indo-West Pacific (Fig. 1).

KEY TO THE SPECIES OF THE GENUS *PAMPUS*

Dorsal and anal fins not falcate; no blade-like spines before median fins; caudal moderately forked, lobes equal.
 *Pampus chinensis* (Euphrasen, 1788)

Dorsal and anal fins falcate; flat blade like spines before median fins; caudal widely forked, lobes unequal

- a. Vertebrae 34 to 37, dorsal fin rays 37 to 43, gill rakers 10-13.
 . . . *Pampus argenteus* (Euphrasen, 1788)
- b. Vertebrae 41, dorsal fin rays 42 to 49
 . . . *Pampus echinogaster* (Basilewsky, 1855)

Pampus chinensis Euphrasen, 1788 (Fig. 2 a)

- Stromateus chinensis* Euphrasen, 1788 : 53 (Type locality 'Castellum Chinese Brocca Tigris').
- Stromateus atoo kotoa* Russel, 1803 : 33 (brief descr. Vizagapatam).
- Stromateus albus* Cuvier and Valenciennes, 1833 : 388 (brief descr., Pondicherry).
- Stromateus atous* Cuvier and Valenciennes, 1833 : 389 (brief descr., Vizagapatam) Richardson, 1845 :

273 (brief descr., China and Japan); Jerdon, 1851 : 137 (brief descr., Madras); Gunther, 1860 : 399 (brief descr.); Kner, 1865 : 148 (brief descr.).

Stromateus candidus Bleeker, 1849 : 9 (list, Madura).
Stromateus sinensis Cantor, 1849 : 1122 (synon, descr., Malaya); Day, 1865 : 76 (descr., Malabar); Day, 1878 : 246, pl. 57 (descr., India); Vinciguerra, 1890 : 171 (brief descr., Burma); Hora, 1919 : 484 (brief descr., Siam); Wu, 1929 : 28 (brief descr., Amoy); Pillay, 1929 : 363 (list, Travancore); Spence and Prater, 1931 : 977 (fish supply, west coast of India); Moses, 1947 : 4 (fishery, Baroda); Pillay, 1948 : 54 (fishery Kathiawar); Pillay and Shaw, 1949 : 780 (fishery and fry, Kathiawar); Apsangikar, 1953 : 41 (brief anatomy); Basheeruddin and Nayar, 1962 : 173 (juveniles, Madras); Khalid, Mirza and Khan, 1968 (fatty acids); Chandy, 1970 : 99 (brief descr.).

Stromateoides atokota Bleeker, 1851 : 369 (brief descr., Malaysia); Bleeker, 1852 b : 76 (brief descr., Singapore).

Stromateoides atous Bleeker, 1860 : 27 (list Sumatra).

Stromateoides sinensis Regan, 1902 : 205 (rev. family); Bühler, 1930 : 61 (digestive system); Giltay, 1933 : 104 (brief descr., Indonesia).

Pampus sinensis Fowler, 1936 : 193 (list, China).

Pampus chinensis De Beaufort and Chapman, 1951 : 94 (descr., Indo-Pacific); Kulkarni, 1953 : 921 (local names, Bombay); Munro, 1955 : 224 (descr., Ceylon); Misra, 1962 : 299 (key ident., India); Mohapatra, 1966 : 10 (local name, Orissa; Hooli and Nadkarni, 1966 : 194 (descr., urinogen. syst.); Kuthalingam, 1967 : 63 (brief account, Bay of Bengal); Rao, 1967 : 277 (food and feeding habits); Haedrich, 1967 : 111 (brief systematics); Murty, 1969 : 29 (catalog, India); Biswas and Mohanty, 1971 : 42 (fishery); Bilguese and Khanum 1971 : 67 (parasite); Haedrich and Horn, 1972 : 30 (key ident.); Rao, 1972 : 208 (pop. dynamics); Fischer and Whitehead, 1974 : 4 (species ident. sheet), Sen, 1975 (list, Sunderbans); Jhingran, 1975 : 59 (list, India); Pati, 1978 (fishery and biology).

Diagnosis : *Pampus chinensis* is distinguished from the other species in the absence of peculiar blade-like spines before the median fins. The dorsal and anal fins are not falcate; caudal fin has almost equal lobes.

Description : Proportional measurements are given in Table 1 and the meristic values in

TABLE 1. Proportional measurements (as percentage of SL) of *Pampus chinensis* (size-range 100—300 mm SL.)

	N	R	X	SE	V
Head length ..	40	21-28	24.0	0.46	1.91
Snout length ..	40	4-7	6.1	0.05	0.81
Eye diameter ..	40	4-6	5.6	0.06	1.76
Length of upper jaw ..	40	5-9	7.6	0.08	1.05
Interorbital width ..	40	12-15	13.2	0.12	0.90
Length of pectoral fin ..	40	29-39	33.4	0.75	2.24
Predorsal distance ..	40	29-45	37.9	1.18	3.11
Preanal distance ..	40	33-45	40.6	1.15	2.83
Maximum depth of body ..	40	63-80	71.3	1.20	1.68
Least depth of caudal peduncle ..	40	10-13	11.9	0.05	0.42
Mean value ..					1.67

N — number of specimens ; X — mean ; SE — standard error of mean ;
R — range of values ; V — coefficient of variation.

TABLE 2. Meristic values of *Pampus chinensis*

	N	R	X	SE	V
Dorsal fin rays ..	40	40-49	43.6	1.08	2.47
Predorsal spines ..	40	—	—	—	—
Anal fin rays ..	40	39-43	40.5	0.80	1.97
Preanal spines ..	40	—	—	—	—
Pectoral fin-rays ..	40	24-27	24.5	0.06	0.24
Total gill rakers ..	40	11-14	12.5	0.05	0.04
Total vertebral ..	40	33	—	—	—
Mean value ..					1.18

Table 2. Body very deep and compressed. Dorsal and anal fins gradually diminishing in height posteriorly. No blade-like spines before dorsal and anal fins; rudimentary spines not appearing above the skin. Dorsal with 40-49 rays and anal with 39-43 rays. Pelvic absent; pectoral somewhat fanlike with 24-27 rays. Caudal fin slightly forked.

Colour: Colour brownish grey above with metallic reflection becoming lighter and silvery below, body dotted all over with brown pigments, fin silvery grey.

Distribution: Coasts of Pakistan, India, Bangladesh, Burma, Sri Lanka, Malaysia, Singapore, Indonesia, Thailand, Vietnam, China, Korea, Taiwan and Philippines (Fig. 1).

Pampus argenteus Euphrasen, 1788 (Fig. 2 b)

Stromateus argenteus Euphrasen, 1788 : 49 (Type locality 'Castellum Chinese Bocca Tigris'); Bloch, 1793 : 92 (brief descr.); Russel 1803 : 35 (brief descr., Vizagapatam); Cuvier and Valenciennes, 1833 : 393 (brief descr.); Cantor, 1849 : 1124 (synon. descr., Malaya); Gunther, 1860 : 400 (brief descr.); Day, 1865 : 77 (descr. adult, Malabar); Volz, 1903 : (brief descr., Sumatra); Chandy, 1970 : 99 (brief descr.); Gupta and Sehgal, 1970 : 230 (parasites).

Stromateus cinereus Bloch, 1793 : 90 (brief descr. semi adult); Cantor, 1849 : 1125 (synon. descr. Malaysia); Gunther, 1860 : 400 (brief descr.); Day, 1865 : 70 (descr. immature, Malabar); Kner, 1865 : 148 (brief descr.); Heller, 1868 : 175 (brief descr.); Day, 1878 : 247, pl. 53 (descr., India); Hora, 1919 : 484 (brief descr., Siam); Vinciguerra, 1926 : 93 (list, Borneo); Wu, 1929 : 87 (brief descr. Amoy); Pillay, 1929 : 363 (list,

Travancore); Spence and Prater, 1931 : 977 (fish supply, west coast of India); Chauhan, 1945 : 160 (parasite); Moses, 1947 : 4 (fishery, Baroda); Pillay, 1948 : 54 (fishery, Kathiawar); Pillay and Shaw, 1949 : 780 (fishery and fry, Kathiawar); Apsangikar, 1953 : 41 (brief anatomy); Tripathi, 1954 : 231 (parasite); Singh, 1969 : 175 (deformity); Gupta and Sehgal, 1970 b : 270 (parasite); Dutta, Laha, Chaudhury, De *et al.* 1973 (fishery, Hoogly Matlah Estuary); Gupta and Ahmed, 1976 : 142 (parasite).

Stromateus tella sandawah Russel, 1803 : 31 (brief descr., Vizagapatam).

138 (brief descr., Madras); Soljan, 1948 : 118 & 383 (record, Adriatic); Le Danois, 1962 : 233 (list, fam. stromateidae).

Stromateus punctatissimus Temminck and Schlegel, 1850 : 121 (brief descr., Japan).

Stromateoides cinereus Bleeker, 1851 : 368 (brief descr. Malaysia); Bleeker, 1852 a : 19 (brief descr., Batavia); Regan, 1902 : 205 (rev. family); Jordan and Starks, 1906 : 516 (brief descr., Manchuria); Machan, 1930 : 438 (brief descr., Padang); Bühler, 1930 : 61 (digestive system).

Stromateoides aculeatus Bleeker, 1853 : 37 (brief descr., Japan).

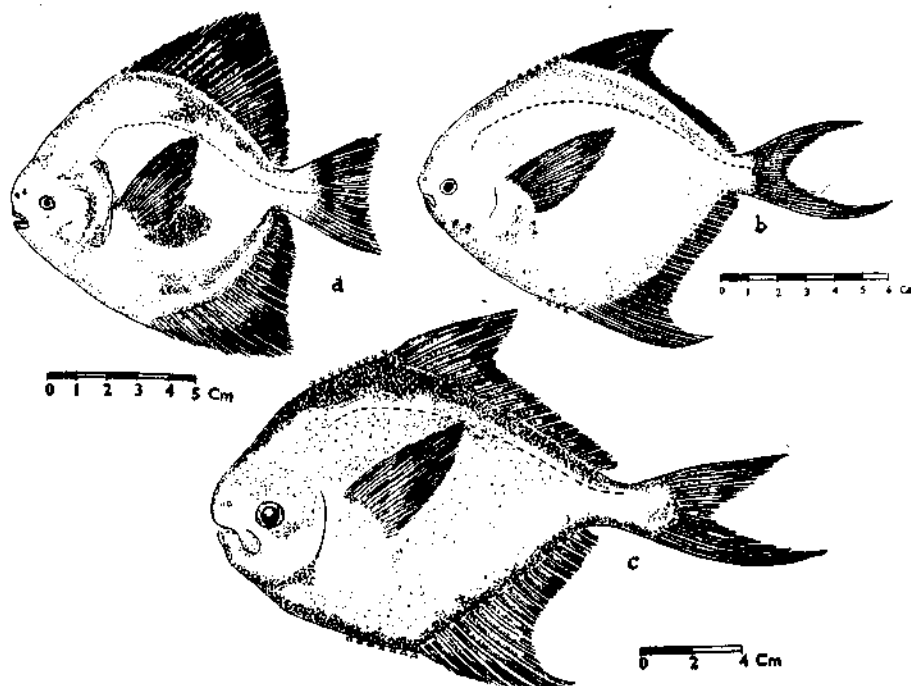


Fig. 2 a. *Pampus chinensis* (11.0 cm SL, 21° 27' N—87° 02' E), b. *P. argenteus* (11.5 cm SL, 21° 27' N—87° 02' E) and c. *P. echinogaster* (17.5 cm SL, 34° 37' N—134° 10' E).

Stromateus sudi sandawah Russel, 1803 : 34 (brief descr. immature, Vizagapatam).

Stromateus candidus Cuvier and Valenciennes, 1833 : 391 (brief descr., Pondichery); Jerdon, 1851 : 137 (brief descr., Madras); Le Danois, 1962 : 232 (list, fam. stromateidae).

Stromateus securifer Cuvier and Valenciennes, 1833 : 394 (brief descr., immature, Bombay); Le Danois, 1962 : 232 (list, fam. stromateidae).

Stromateus griseus Cuvier and Valenciennes, 1833 : 395 (brief descr., Pondichery); Jerdon, 1851 :

Pampus cinereus Fowler, 1905 : 499 (brief descr., Borneo); Fowler, 1928 : 109 (brief descr., Bombay); Fowler, 1934 : 150 (brief descr., Siam); Blegvad and Loppenthin, 1944 : 178 (brief descr., Iranian Gulf).

Stromateoides argenteus Jordan and Seale, 1907 : 8 (brief descr., Luzon and Panay); Jordan and Metz, 1913 : 2 (brief descr., Korea); Jordan, Tanaka and Snyder, 1913 : 135 (list, Japan); Fowler, 1931 : 293 (descr., Hongkong); Mori, 1952 : 139 (list, Korea).

Pampus lighti Evermann and Shaw, 1927 : 114 (brief descr., Nanking); Herre, 1935 : 291 (brief descr., Hongkong); Herre, 1953 : 19 (check list, Philippines).

Pampus simoprosopus Fowler, 1934 : 150 (brief descr., Siam).

Pampus argenteus Fowler, 1936 : 194 (list, China); Fowler, 1938 : 349 (record, Hawaii); Suyehiro, 1942 : 10 (feeding habits, Japan); De Beaufort and Chapman, 1951 : 92 (descr., Indo-Pacific); Kulkarni, 1953 : 921 (local names, Bombay); Munro, 1955 : 224 (descr., Ceylon); Rege, 1958 : 1 (biology, Bombay); Rege and Bal, 1959 : 403 (biology, Bombay); Chopra, 1960 : 392 (relation, ctenophores and medusae); Misra, 1962 : 298 (key ident., India); Rege and Bal, 1964 : 75 (feeding habits, Bombay); Kewalramani and Pathak, 1964 : 5 (note, fishery); Ueno, 1965 : 2 (short descr.); Isokawa, Kubota Kosakai, Satomura, Tsubouchi and Sera, 1965 : 103 (oesophageal sac.); Ueno and Abe, 1966 : 229 (distribution Hokkaido); Nath, 1966 : 140 (biology, seasonal distribution); Mohapatra, 1966 : 9 (local name, Orissa); Kuthalingam, 1967 : 59 (biology and fishery, Bay of Bengal); Rao, 1967 : 277 (food and feeding habits); Solochanan and Rao, 1967 : 9 (vertical distribution); Mito and Senta, 1967 : 948 (develop and prelarva); Haedrich, 1967 (brief systematics); Gopkumar and Nair, 1967 : 229 (lipids); Gopalan, 1969 : 785 (maturity and spawning, Arabian Sea); Murty, 1969 : 29 (catal., India); Hafeezullah, 1970 : 53 (parasite); Perumal and Alagarwami, 1970 : 186 (record landing, India); Nagbhusanam, 1971 : 359 (distribution with depth); Gupta and Meherotra, 1971 : 461 (parasite); Desai and Akhunj, 1971 : 161 (hypothalamo-neurohypophysial complex); Khann and Meherotra, 1971 : (histomorph, buccopharynx); Banerjee and Chakrabarty, 1972 : 75 (fishery, lower Sunderbans); Kuronuma and Abe, 1972 : 105 (brief descr., Kuwait); Fischer and Whitehead, 1974 : 4 (species ident. sheet); Haedrich and Horn, 1972 : 30 (key ident.); Kuthalingam, Majumdar and Chatterjee, 1973 : 338 (resources, W. Bengal and Orissa Coast); Roy and Roy, 1974 : 40 (fishery, Balasore); Sen, 1975 : 501 (list Sunderbans); Jhingran, 1975 : 59 (list, India); Kotthaus, 1977 : 34 (short descr. Arabian Sea); Pati, 1978 (fishery and biology).

Diagnosis : *Pampus argenteus* can be easily distinguished from *Pampus chinensis* by the presence of falcate median fins preceded by

blade-like spines and a deeply forked caudal fin with longer ventral lobe. The species differs from *Pampus echinogaster* by lesser vertebral count, lower number of gill rakers and more pyloric caeca.

Description : Proportional measurements are given in Table 3 and the meristic counts in Table 4. Body very deep and compressed. Dorsal fin elongated to form a falcate lobe, the rays of the posterior two third subequal. Anal similar to dorsal, anal fin lobe often extremely produced. Dorsal preceded by V—X spines and with 37-43 rays. Anal with V-VII spines and 34-43 rays. Predorsal and preanal spines sink beneath the flesh with age, not discernible in specimens of more than 230 mm SL. No pelvic fin. Pectoral fin somewhat fan-like with 24-47 rays. Caudal fin deeply forked, the lower lobe usually longer.

Colour : Greyish silvery above, becoming lighter below, minute black pigment spots all over the body, dorsal and anal fins grey with dark margin.

Distribution : Persian Gulf, coasts of Pakistan; India, Bangladesh, Burma, Sri Lanka, Malaysia, Singapore, Indonesia, Thailand, Vietnam, China, Korea, Japan, Riu Kiu Islands, Taiwan and Philippines (Fig. 1). The northward distribution of the species in western Pacific Ocean extends upto the waters of Hokkaido (Ueno and Abe, 1966). There are records of specimens from Hawaii (Fowler, 1938) and Rijeka along Adriatic (Soljan, 1948). But subsequent reports are not available from either place.

***Pampus echinogaster* (Basilewsky) 1855**
(Fig. 2 c)

Stromateus echinogaster Basilewsky, 1855 : 223 (Type locality 'Vocatur Chinice').

Stromatoides echinogaster Jordan and Metz, 1913 : 28 (descr., Chinnampo, Port Arthur); Mori, 1952 : 139 (list, Korea); Chyung, 1961 : 518 (Illustrated encyclopedia, Korea).

Pampus echinogaster Reeves, 1927 : 9 (catal, N. China); Mori, 1928 : 6 (catal. Chinnampo,

TABLE 3. *Proportional measurements (as percentage of SL) of Pampus argenteus (size-range 100—290 mm SL.)*

	N	R	X	SE	V
Head length ..	71	18-28	23.4	0.74	3.16
Snout length ...	71	3-6	4.8	0.10	2.08
Eye diameter ..	71	4-7	5.1	0.19	3.72
Length of upper jaw ..	71	5-8	6.6	0.12	1.81
Interorbital width ..	71	9-14	10.7	0.11	1.02
Length of pectoral fin ..	71	29-42	39.1	0.62	1.58
Predorsal distance ..	71	37-46	43.2	0.46	1.06
Preanal distance ..	71	38-55	46.6	1.20	2.57
Maximum depth of body ..	71	53-73	62.4	0.48	0.76
Least depth of caudal peduncle ..	71	8-12	10.7	0.08	0.74
Mean value ..					1.85

TABLE 4. *Meristic values of Pampus argenteus*

	N	R	X	SE	V
Dorsal fin-rays ..	71	37-43	40.2	0.65	1.61
Predorsal spines ..	71	5-10	7.6	0.20	2.63
Anal fin-rays ..	71	34-43	38.4	1.20	3.12
Preanal spines ..	71	5-7	5.8	0.09	1.55
Pectoral fin-rays ..	71	24-27	25.1	0.07	0.27
Total gill rakers ..	60	10-13	11.0	0.06	0.54
Total vertebrae ..	60	34-37	35.8	0.12	0.33
Mean value ..					1.43

TABLE 5. *Proportional measurements (as percentage of SL) of Pampus echinogaster (size-range 155—214 mm SL.)*

	N	R	X	SE	V
Head length ..	6	21-25	22.8	0.24	1.05
Snout length ..	6	5-6	5.3	0.04	0.75
Eye diameter ..	6	4-5	4.1	0.04	0.97
Length of upper jaw ..	6	6-7	6.5	0.05	0.89
Interorbital width ..	6	9-10	9.8	0.06	0.61
Length of pectoral fin ..	6	33-36	35.0	0.12	0.34
Predorsal distance ..	6	40-47	42.0	0.45	1.07
Preanal distance ..	6	43-51	44.3	0.42	0.94
Maximum depth of body ..	6	65-76	67.3	0.36	0.53
Least depth of caudal peduncle ..	6	8-10	8.3	0.05	0.60
Mean value ..					0.77

Korea); Mori and Uchida, 1934 : 12 (rev. catal. fish Korea); Abe and Kosakai, 1964 : 29 (systematics); Isokawa, Kubota, Kosakai, Satomura, Tsubouchi and Sera, 1965 : 103 (oesophageal sac).

Stromatoides sinensis Abe, 1963 : 105 (Key fish, Japan).

Diagnosis: *Pampus echinogaster* can be distinguished from *Pampus argenteus* by the greater vertebral count, higher number of gill rakers and lesser number of pyloric

Caudal fin deeply forked, the lower lobe usually longer.

Colour: Greyish silvery above, becoming lighter below, body and head irregularly speckled with fine black spots. Posterior part of the opercle and margins of vertical fins black; pectoral faint dusky.

Distribution: Coasts of China, Korea and Japan (Fig. 1).

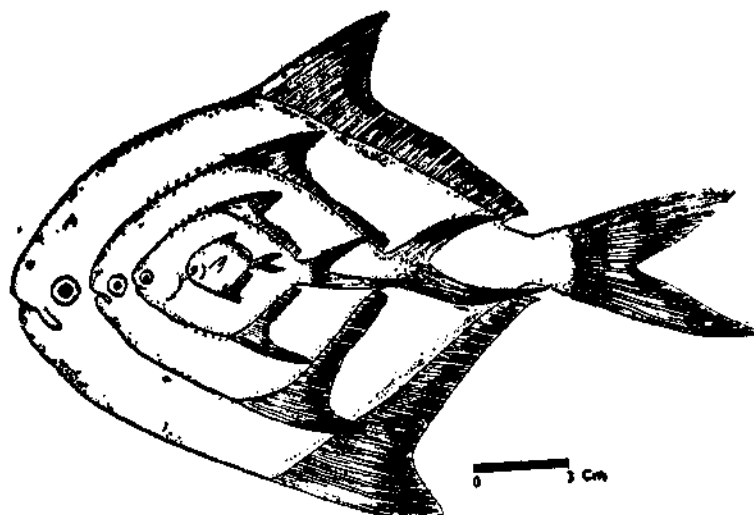


Fig. 3. Changes in body from accompanying growth in *P. argenteus*.

caeca. The species differs from *Pampus chinensis* by the presence of falcate median fins preceded by blade-like spines and a deeply forked caudal fin with longer ventral lobe.

Description: Proportional measurements are given in Table 5 and meristic counts in Table 6. Body very deep and compressed. Dorsal fin elongated to form a falcate lobe. Anal similar to dorsal, anal fin lobe often extremely produced. Dorsal preceded by VIII-X spines and with 42-49 rays. Anal with V-VII spines and 42-47 rays. Predorsal and preanal spines covered with flesh in adult samples. No pelvic fin. Pectoral elongate, slender with 24-25 rays.

COMPARISON

The three species of *Pampus* resemble one another in having deep and laterally compressed body, with single dorsal and anal fin, absence of pelvic fin, gill-membranes broadly united to the isthmus, gill openings not reaching the throat, the maxillary extending beneath the eye and five branchiostegal rays. They differ from each other in the shape of the median fins, mean number of the dorsal and anal fin rays, vertebral number and gill rakers.

Pampus chinensis can be easily distinguished from the other two species by the shape of its median fins, which are not falcate, but the fin rays gradually diminish in length posteriorly

TABLE 6. Meristic values of *Pampus echinogaster*

	N	R	X	SE	V
Dorsal fin-rays	.. 6	42-49	44.1	0.25	0.56
Predorsal spines	.. 6	8-10	8.4	0.07	0.83
Anal fin-rays	.. 6	42-47	41.6	0.10	0.24
Preanal spines	.. 6	5-7	5.6	0.06	1.07
Pectoral fin-rays	.. 6	24-27	25.3	0.07	0.27
Total gill rakers	.. 6	15-21	16.8	0.12	0.71
Total vertebrae	.. 6	41	—	—	—
Mean value	..				0.61

(Fig. 2 a). There are no spines preceding the median fins and the caudal fins are provided with equal lobes.

Pampus argenteus and *Pampus echinogaster* have falcate median fins. The dorsal fin is high in front forming a falcate lobe, sloping abruptly to the fourteenth or fifteenth ray. Anal is similar, with a falcate lobe. The peculiar blade-like dorsal and anal spines do not maintain constancy in number and sink totally beneath the flesh in adult specimen measuring 22-23 cm SL and above. The caudal lobes are equal in the young, the lower lobes becoming elongated in mature specimen and in old specimens the caudal lobes become subequal again (Fig. 3). Therefore the presence of spines before the median fins and the nature of caudal cannot be taken as reliable taxonomic characters for delimiting *P. argenteus* and *P. echinogaster* from *P. chinensis*. On the contrary the shape of the median fins readily distinguishes the two former species from the later.

The mouth is terminal in *P. chinensis* but slightly inferior in *P. argenteus* and *P. echinogaster*. Although the upper jaw teeth is simple in all the three species, the lower jaw teeth contain 3 cusps in *P. argenteus* and *P. echinogaster* and 5 cusps in *P. chinensis*. The gill rakers are comparatively longer and without teeth in *P. chinensis*, but are smaller with two terminal teeth in the other two species.

The body proportions of the three species show considerable overlap in the morpho-

metric characters discussed (Table 1, 3 and 5). Amongst the meristic characters there is no overlap in the vertebral number. The total vertebral count is $14 + 19 = 33$ in *P. chinensis*; $14-16 + 20-21 = 34-37$ in *P. argenteus* and $15 + 26 = 41$ in *P. echinogaster*.

It is difficult to readily distinguish *P. echinogaster* from *P. argenteus* as no clearcut difference in the external features is apparent. *P. echinogaster* has significantly higher mean number of dorsal and anal fin rays. However, higher number of gillrakers and vertebral in *P. echinogaster* distinguishes it from *P. argenteus*. *P. argenteus* has nearly 600 slender pyloric caecae, which are relatively thicker and much less in number in *P. echinogaster*. The former species attains much smaller size than the later (Abe and Kasakai, 1964).

DISCUSSION

Gill (1884) divided the genus *Stromateoides* Bleeker (= *Pampus* Bonaparte) into two subgenera. The subgenus *Stromateoides* had prominent predorsal and preanal spines as well as falcate fins, the other subgenus *Chondroplites* had none. The former subgenera is evidently represented by *Pampus argenteus* and *Pampus echinogaster* and the latter by *Pampus chinensis*. Haedrich (1967) emphasized the need for a detailed investigation to decide if the distinctions really merit subgeneric recognition for these species.

The present investigation reveals that the characteristic blade-like spines of *P. argenteus* are absent in the larval stages and appear in early juveniles measuring 3.5-4.0 cm SL and start sinking into the flesh in immatures measuring 9-10 cm SL, disappearing in the adults of the size range 23-27 cm and above. Hence they are regressive characters, disappearing with age. At the same time the falcate nature of the median fins is not pronounced in early juveniles. Moreover young *P. argenteus* measuring upto 7.0-8.0 cm SL have equal lobes in the caudal fin. With further growth the lower lobe becomes elongated. In older specimens the tapering lower lobe becomes worn out, making the caudal lobes almost equal (Fig. 5). A similar situation is met with in the median spines and caudal lobes in *P. echinogaster* (Jordan and Metz, 1913). As pointed out by Mayr (1969), regressive characters and narrow specialisations are of low taxonomic weight for delimiting higher taxa. It is evident, therefore, that the distinction centred around median fins and spines does not deserve sub-generic recognition amongst the species of the genus.

On the basis of the vertebral number, four distinct populations of silver pomfret *Pampus argenteus* can be recognised. The population from the coasts of Western Pacific have 34 vertebrae and those from the Strait of Malacca possess 35 vertebrae. The vertebral number was observed to be 36 in the samples collected from Bay of Bengal and 37 in the population inhabiting in the Arabian Sea and the Persian Gulf. It is of interest to note that an increasingly higher number of vertebrae are encountered while passing from the east towards the western longitude. Haedrich (1967) recorded 34-41 vertebrae in *P. argenteus* and 38-41 vertebrae in *P. echinogaster*. But only 34-37 vertebrae were encountered in the present investigation from far off localities of Indo-Pacific. The vertebral number in *P. echinogaster* was observed to be only 41, which also agrees with the record of Abe and Kosakai (1964).

It is a question as to whether these allopatric populations inhabiting different geographical limits are to be regarded as full species or subspecies. These populations are quite similar and do not differ either in the body form, or colouration and markings. They exhibit overlap in the morphometric and meristic characters except the vertebral count. Although vertebral number as a systematic character should be used with caution, it has been used with confidence in other stromateid fishes. In the closely allied genus *Peprilus*, vertebral number has been used to distinguish closely related species (Horn, 1970). It is difficult to compare the ecology of the different populations since very little is known from many localities. The fish is a carnivore feeding mainly on zooplankton (Suyehiro, 1942; Rege, 1958; Kulkarni, 1958; Chopra, 1960; Nath, 1966; Kuthalingam, 1967; Rao, 1967; Pati, 1978). It spawns from early July to late August in the Seto Inland Sea of Japan (Mito and Senta, 1967). The spawning season extends from February to August in the Bay of Bengal and the Arabian Sea during which the fish spawns twice (Gopalan, 1964; Pati, 1978). More variational studies and knowledge of natural history are needed to resolve the question of assignment of rank to the different populations. The marked similarity in form, coupled with variation in vertebral number and spawning habit is probably due to the fact that active speciation is in progress in the genus.

An increase in the number of vertebrae, degeneration of tissues in general and the elements in the skull are the principal trends in the evolution of stromateid fishes (Haedrich, 1967). Judging from that angle, *P. chinensis* can be considered to be the most primitive and *P. echinogaster* the most highly derived form in the genus *Pampus*.

The distribution of *P. chinensis* and *P. argenteus* is mostly sympatric, with a wide range extending from the coasts of Japan around Southeast Asia upto the Gulf of Iran.

P. echinogaster has a narrow range confined to the seas of Japan, Korea and North China. The exclusive Indo-West Pacific distribution points to the fact that the genus must have evolved from some element in the Tethyan fauna. The disruption of Tethys Sea in Miocene diastrophic changes in Pliocene, the emergence and submergence of landmass associated with the Pleistocene glacial periods and the prevailing current systems appear to have been important in the dispersal, differentiation and speciation of the genus.

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