



THE GOATFISHES (FAMILY MULLIDAE) OF ANDAMAN AND NICOBAR ISLANDS

P.T. RAJAN, C.R. SREERAJ AND TITUS IMMANUEL

Zoological Survey of India, Andaman Nicobar Regional Centre

Haddo, Port Blair-744102

rajaptandaman@rediffmail.com

INTRODUCTION

Goatfishes are tropical marine perciform fish of the family Mullidae. Goatfishes are most associated with the reefs. Within the family there are approximately 6 genera and 70 species (Randall 2004, Uiblein and Heemstra 2009). Many species of goatfish are conspicuously coloured; however, they are not popular in aquarium. Rather, goatfish are valued food fish in many countries. The largest species, the dash-and dot goatfish (*Parupeneus barberinus*) grows to 55 centimeters in length; most species are less than half this size. Their bodies are deep and elongate with forked tail fins and widely separated dorsal fins. Goatfish are tireless benthic feeders, using a pair of long chemosensory barbels (“whiskers”) protruding from their chins to rifle through the sediments in search of a meal. Like goats, they seek anything edible; worms, crustaceans, molluscs and other small invertebrates are staple food. By day, many goatfish form large schools: these aggregates may contain both conspecifics and heterospecifics. For example, the yellowfin goatfish (*Mulloidichthys vanicolensis*) on the reef of the Andaman and Nicobar Islands is often seen congregating with blue-striped snappers (*Lutjanus kasmira*) (Family : Mullidae) (Fig. 1) and association of goatfish *Parupeneus cyclostomus* with bigeye trevally *Caranx sexfasciatus* (Fig. 5). With such mixed company, the yellowfin goatfishes are shallow water species, going no deeper than about 110 metres.

With common bluestripe snapper, *Lutjanus kasmira* (Forsskal, 1775), in Andaman Islands has resulted in vertical habitat shift in yellowfin goatfish, *Mulloidichthys vanicolensis*, towards staying more in

open water with increased height above the bottom reflecting asymmetrical competition. There is not a single species of goatfish known to enter rivers of these islands. All goatfish have the ability to change their colouration depending on their current activity. One notable example, the diurnal goldsaddle goatfish (*Parupeneus cyclostomus*) changes colour from a lemon-yellow to a pale cream while feeding and to dark phase with the terminal male of *Gomphosus caeruleus* (Family : Labridae) (Fig. 2). Diurnal species also tend to be solitary, but will school as juveniles. Goatfish are pelagic spawners; that is, they release many buoyant eggs into the water which become part of the plankton. The eggs float freely with the currents until hatching. The postlarva floats in surface waters until it reaches around 5 or 6 centimeters in length, when it takes on the adult, bottom-feeding, lifestyle.

METHODOLOGY

Samples of goatfish (Family Mullidae) were collected from the trawl fishery landings in the Andaman Islands in the fishing season during 1990-2010. Samples were separated into the different species (14 species). A total of 65 goatfish specimens were obtained. Specimens were preserved in 10% buffered formaldehyde. SCUBA gears are used for surveying, underwater observation and photography of goatfishes. Morphometric characters were measured with a caliper. Meristic characters that vary among species are referred to in the diagnoses and compared: the number of dorsal fin spines, pectoral fin rays, rudimentary and developed gill rakers on lower and upper limb and lateral line scales are recorded. In order to see the first minute dorsal fin spine in eight spine species a stereomicroscope was

used. Colour photographs for each species were taken with Nikon D 300 camera. Caudal fin photographs were taken for counts of caudal fin bars, include all bars from the base of each lobe to the lobe tip.

RESULTS

Studies of goatfish occurrence and abundance in natural habitats in Andaman and Nicobar Islands have been documented. Generally they prefer sand-associated bottoms, some species are more restricted to hard bottoms, and others occur in different depths. Fourteen species are recognized under three genera: *Mulloidichthys flavolineatus*, *Mulloidichthys vanicolensis*, *Parupeneus barberinus*, *Parupeneus cyclostomus*, *Parupeneus heptacanthus*, *Parupeneus indicus*, *Parupeneus macronema*, *Parupeneus pleurostigma*, *Parupeneus bifasciatus*, *Upeneus guttatus*, *Upeneus moluccensis*, *Upeneus sulphureus*, *Upeneus tragula* and *Upeneus vittatus*.

Mulloidichthys flavolineatus (Lacepede, 1801)

Yellowstripe goatfish

1801. *Mullus flavolineatus* Lacepede, *Hist. nat. Poiss.*, 3 : 384, 406 (Type locality : Hawaiian Islands).

Material examined : Junglighat fish market (South Andaman), 2 exs., 260 mm, 170 mm, ZSI ANRC 3941; Bidnabad (South Andaman), 1 ex., 205 mm, ZSI ANRC 3822.

Diagnosis : D. VII + I,8; A. I,6; P. 13-14; Gr. 7-8 + 22-25 = 29-33; Ll. 33-35; body depth 4.0-4.5, head depth 3.1-3.4 in SL, snout 2.0-2.5; interorbital 3.5-4.0, barbels 1.5-1.8, caudal peduncle depth 3.3-3.5, caudal peduncle length 1.1-1.3 in head. Body grey to olive on back, whitish on sides and belly; 1 or 2 longitudinal yellow bands; small dark blotch often present below first dorsal fin. Attains 40 cm Standard Length.

Distribution : Indo-Pacific from east coast of Africa to the Hawaiian Islands; French Polynesia and the Pitcairn group of Islands.

Mulloidichthys vanicolensis (Valenciennes, 1831)

Flame goatfish

1831. *Upeneus vanicolensis* Valenciennes, *Hist. nat. Poiss.*, 7 : 521 (type locality : Vanicolo).

Material examined : Nancowry Island (Nicobar Group), 1 ex. 256 mm, ZSI ANRC 2503.

Diagnosis : D. VII + I,8; A. I,6; P. 13-14; Gr. 7-8 + 22-24 = 29-32; Ll. 32-35; body depth 3.8-4.0, head depth 3.2-3.4 SL, snout 2.5-2.8, interorbital 3.3-3.6, barbels 1.3-1.4, caudal peduncle depth 3.0-3.4, caudal peduncle length 1.2-1.4 in head. Body red orange to olive on back and whitish on sides and belly; yellow longitudinal band

often present; no dark blotch on sides under middle of first dorsal fin. Attains 38 cm Standard Length.

Distribution : Indo-Pacific from the east coast of Africa, Red Sea to the Hawaiian, Tuamotu Islands, north to southern Japan, south to Lord Howe Island and Micronesia.

Parupeneus barberinus (Lacepede, 1801)

1801. *Mullus barberinus* Lacepede, *Hist. nat. Poiss.*, 3 : 383, 406. (type locality : Indo-Pacific.)

Parupeneus barberinus : Randall, *Indo-Pacific Fishes*, (36) : 12.

Material examined : Mayabunder (North Andaman), 15.08.1991, 1 ex., 285 mm, ZSI ANRC 1678; Tarmugli Island (South Andaman, 1 ex., 243 mm, ZSI ANRC 2586; North bay (South Andaman), 1 ex., 156 mm, ZSI ANRC 3375.

Diagnosis : D. VIII + I,8; P. 16-18; Gr. 6-7 + 19-23 = 25-30; Ll. 27-29; body depth 3.1-3.5, head depth 2.9-3.2 SL, snout 1.8-2.1, interorbital 3.4-4.4, barbels 1.2-1.5, not reaching to pelvic fin base, caudal peduncle depth 2.8-3.0, caudal peduncle length 1.2-1.4 in head. Body brown to reddish brown, shading to whitish on sides and belly; a dark reddish brown stripe extending from tip of snout through eye across upper end of gill openings, and along upper side extending beneath rear base of second dorsal fin; caudal peduncle with a round dark reddish spot larger than eye diameter; fins without marks. Attains 55 cm Standard Length.

Distribution : Indo-West Pacific, from east coast of Africa, Red Sea to southern Australia and eastward to the line, Marquesan and tuamotu Islands.

Parupeneus cyclostomus (Lacepede, 1801)

Gold-saddle goatfish

1801. *Mullus cyclostomus* Lacepede, *Hist. nat. Poiss.*, 4 : 383, 404 (type locality : Indo-Pacific).

Parupeneus cyclostomus : Randall, *Indo-Pacific Fishes*, (36) : 22.

Material examined : Wandoor (South Andaman), 1 ex., 380 mm, ZSI ANRC 1958; Mayabunder (North Andaman), 1 ex., 250 mm, ZSI ANRC 3379; Bidnabad (South Andaman), 1 ex., 260 mm, ZSI ANRC 3825.

Diagnosis : D. VIII + I,8; P. 16-17; Gr. 6-7 + 21-24 = 27-31; Ll. 27-28; body depth 3.3-3.5, head depth 2.9-3.1 in SL, snout 1.8-2.0, interorbital 3.9-4.1, barbels 1.1-1.2, caudal peduncle depth 2.6-2.9, caudal peduncle length 1.4-1.5 in head. Body red, red-bluish or blue with a yellow saddle behind second dorsal and often with blue streaks on head; occasionally uniform yellow; two colour phases, one yellowish grey with blue markings on scales and a yellow saddle like spot on caudal

peduncle, the other entirely yellow, the yellow peduncular spot brighter yellow. Attains 50 cm Standard Length.

Distribution : Indo-Pacific. Red Sea to the Hawaiian, Marquesan, Tuamotu Islands, North to Ryukyu Island to New Caledonia and Rapa, throughout Micronesia.

***Parupeneus heptacanthus* (Lacepede, 1802)**

Cinnabar goatfish

Sciaena heptacantha Lacepede, *Hist. nat. Poiss.*, 4 : 308, 311 (type locality : not given).

Parupeneus heptacanthus : Randall, *Indo-Pacific Fishes*, (36) : 30.

Material examined : Bambooflat, 1 ex., 187 mm, ZSI ANRC 2194; Tarmugli Island, 2 exs., 210, 267 mm, ZSI ANRC 2749; Mayabunder (North Andaman), 1 ex., 160 mm, ZSI ANRC 3380; Bidnabad (South Andaman), 1 ex., 145 mm, ZSI ANRC 3824.

Diagnosis : D. VIII + 1,8; P. 16; Gr. 6-7 + 19-21 = 27-28; Ll. 27-28; body depth 2.9-3.1, head depth 3.3-3.4 in SL, snout 1.8-2.0, interorbital 3.8-4.2, barbels 1.1-1.4, caudal peduncle depth 3.1-3.5, caudal peduncle length 1.2-1.5 in head. Body brownish yellow to red shading to silvery white ventrally; scale margins darker with a blue to pearly spot centrally on the back. A small reddish spot on the 7th and 8th lateral line in adults; attains 30 cm standard length.

Distribution : Indo-West Pacific, Red Sea and east Africa to southern Japan and Lord Howe Island and throughout Micronesia.

***Parupeneus indicus* (Shaw, 1803)**

Indian goatfish

1803. *Mullus indicus* Shaw, *Gen. Zoology*, 4 : 611 (type locality : Vizagapatnam, Andhra Pradesh, India).

Parupeneus indicus : Randall, *Indo-Pacific Fishes*, (36) : 32.

Material examined : Little Andaman, 2 exs., 53, 102 mm, ZSI ANRC 2996; Port Blair (South Andaman), 1 ex., 116 mm, ZSI ANRC 2746; Tarmugli Island (South Andaman), 1 ex., 223 mm, ZSI ANRC 2747; North bay (South Andaman), 1 ex., 255 mm, ZSI ANRC 3376; Bidnabad (South Andaman), 1 ex., 280 mm, ZSI ANRC 3826; Junglighat fish market, 1 ex., 150 mm, ZSI ANRC 4732.

Diagnosis : D. VIII + 1,8; P. 16-17; Gr. 6 + 19-21 = 25-27; Ll. 26-29; body depth 3.3-3.5, head depth 3.1-3.3 in SL, snout 1.9-2.2, interorbital 3.7-4.0, barbels 1.3-1.5, caudal peduncle depth 2.6-2.8, caudal peduncle length 1.2-1.4 in head. Body greenish brown to reddish brown shading to whitish or pale pink ventrally; a large elongate yellow spot centered on lateral line below

posterior part of first dorsal fin to anterior part of second dorsal fin; caudal peduncle with a round black spot larger than eye diameter; few blue lines radiating from eye; narrow pale blue bands on second dorsal, anal and caudal fin. Attains 40 cm Standard Length.

Distribution : Indo-Pacific. East coast of Africa to Samoa and Tonga, north to the Philippines, the Ogasawara Island, south to New Caledonia; Palau to Kosrae, Caroline Islands in Micronesia.

***Parupeneus macronemus* (Lacepede, 1801)**

Long-barbel goatfish

1801. *Mullus macronemus* Lacepede, *Hist. nat. Poiss.*, 3 : 383, 404 (type locality : Indo-Pacific).

Parupeneus indicus : Randall, *Indo-Pacific Fishes*, (36) : 38.

Material examined : Mayabunder (North Andaman), 2 exs., 277 mm, ZSI ANRC 1921; Bambooflat (South Andaman), 1 ex., 215 mm, ZSI ANRC 2009; North bay (South Andaman), 1 ex., 205 mm, ZSI ANRC 3377; Bidnabad (South Andaman), 1 ex., 155 mm, ZSI ANRC 3827; Inglis Island (South Andaman), 2 exs., ZSI ANRC 4027.

Diagnosis : D. VIII + 1,8; P. 15-16; Gr. 8-9 + 26-29 = 34-38; Ll. 27-28; body depth 2.9-3.2, head depth 2.9-3.2 in SL, snout 1.7-2.0, interorbital 3.6-4.1, barbels 1.1-1.4, caudal peduncle depth 2.5-3.0, caudal peduncle length 1.3-1.5 in head. Last ray of second dorsal fin extending beyond caudal peduncle blotch in adults. Body reddish brown shading to paler ventrally and posteriorly with a dark brown stripe passing from tip of snout, through eye to rear end of second dorsal fin base; a round black spot larger than eye diameter on the caudal peduncle; basal third of second dorsal fin black, with a narrow extension to posterior tip of fin. Attains 35 cm Standard Length.

Distribution : Indo-Pacific : Red sea to Sodwana bay, South Africa extends to east to Indonesia and the Philippines.

***Parupeneus pleurostigma* (Bennett, 1831)**

Blackspot goatfish

1831. *Upeneus pleurostigma* Bennett, *Proc. Zool. Soc., London* : 59 (type locality : Mauritius).

Parupeneus indicus : Randall, *Indo-Pacific Fishes*, (36) : 47.

Material examined : Port Blair (South Andaman), 2 exs., 188, 191 mm, ZSI ANRC 1681; Bambooflat (South Andaman), 1 ex., 187 mm, ZSI ANRC 2194.

Diagnosis : D. VIII + 1, 8; P. 15-17; Gr. 6-7 + 22-23 = 28-30; Ll. 27-29; body depth 3.5-3.7, head depth 2.9-3.2 SL, snout 1.9-2.1, interorbital 3.3-3.6, barbels 1.5-1.7,

caudal peduncle depth 3.0-3.3, caudal peduncle length 1.2-1.4 in head. Third and last anal rays longest. Body pinkish dorsally, lighter pink to whitish ventrally; a large round dark spot on the lateral line below the posterior end of spinous dorsal fin; a broad dusky to reddish patch usually present on the dorsal side under rear part of second dorsal fin base; a row of pale blue spots on each scale above lateral line on caudal peduncle; blue spots and lines around eye and on upper part of opercle; base of second dorsal fin dark. Attains 30 cm Standard Length.

Distribution : Indo-Pacific, from east coast of Africa to the Hawaiian Islands and French Polynesia.

Parupeneus trifasciatus (Lacepede, 1801)

Doublebar goatfish

1801. *Mullus trifasciatus* Lacepede, *Hist. nat. Poiss.*, 383, 404 (type locality : Indo-Pacific).

Parupeneus trifasciatus : Randall and Myers, *Zool. Stud.*, 41(4) : 432.

Material examined : Outram Island (Ritchie's Archipelago), 1 ex., 185 mm, ZSI ANRC 2531; Narcondam Island, 1 ex., 185 mm, ZSI ANRC 2523; Mayabunder (North Andaman), 1 ex., 260 mm, ZSI ANRC 3378; Bidnabad (South Andaman), 1 ex., 135 mm, ZSI ANRC 3823.

Diagnosis : D. VIII + I,8; P. 15-17; Gr. 7-8 + 27-30 = 34-38; Ll. 27-28; body depth 2.9-3.1, head depth 3.3-3.4 SL, snout 1.8-1.9, interorbital 3.1-3.3, barbels 1.7-1.8, caudal peduncle depth 2.2-2.4, caudal peduncle length 1.1-1.2 in head. Body yellowish grey to brownish red shading to whitish ventrally; three broad saddle-like bars, 1st below first dorsal fin, 2nd below second dorsal fin and 3rd one on middle of caudal peduncle; some fish may have only two well defined bars; a dark area generally present surrounding the eye and extending through interorbital space; scales pale at center on dorsal side. Attains 35 cm Standard Length.

Distribution : Indo-West Pacific south to Sodwana Bay.

SPECIES ACCOUNTS

Based on combination of the number of dorsal fin spines, gill rakers, number of pectoral fin rays and bars on caudal fin (Lachner 1954, Thomas 1969, Sainsbury *et al.* 1985, Golani 2001, Randall 2001, Kim and Nakaya 2002), four major species complex can be distinguished.

Species complex 1 : The "*Japonicus* group" : 7 dorsal fin spines distinguish this group clearly from all others; in addition, these species have 21-32 total gill rakers and 13-15 pectoral fin rays; fresh fish of this

group have bar on caudal lobe. This complex includes *Upeneus guttatus* from Andaman and Nicobar Islands.

Species complex 2 : The "*tragula* group" : 8 dorsal fin spines 18-25 total gill rakers and 13-14 pectoral fin rays; species have bar on caudal fin lobe. This complex includes *Upeneus tragula* from Andaman and Nicobar Islands.

Species complex 3 : The "*moluccensis* group" : 8 dorsal fin spines, 26-33 total gill rakers, 15-17 pectoral fin rays, bars on upper caudal fin lobe. This complex includes *Upeneus moluccensis*, *Upeneus sulphureus* from Andaman and Nicobar Islands.

Species complex 4 : The "*vittatus* group" : 8 dorsal fin spines, 26-32 total gill rakers, 15-17 pectoral fin rays and bars on caudal fin lobes in fresh and preserved fish. This complex includes *Upeneus vittatus* from Andaman and Nicobar Islands.

Upeneus guttatus (Day, 1868)

Day's goatfish

1868. *Upeneoides guttatus* Day, *Proc. Zool. Soc., London* : 938 (Type locality : Madras).

Upeneus guttatus : Randall and Kulbicki 2006. *Zoological Studies*, 45 : 301.

Material examined : Junglighat fish market (South Andaman), 1 ex., 180 mm, ZSI ANRC 6762.

Diagnosis : Dorsal fins VII + 9; pectoral fins 13-14; gill rakers 6-8 + 16-18 = 23-25; lateral line scales 28-31; body depth at first dorsal fin origin 22-25% SL; body depth at anus 19-23; caudal peduncle depth 9.3-11; maximum head depth 18-22; head depth through eye 15-19; head length 26-30; orbit length 6.3-8.8; upper jaw length 9.6-12; barbel length 16-19; caudal fin length 25-30; anal fin height 15-19; pelvic fin length 19-23; pectoral fin length 20-22; first dorsal fin height 20-24; second dorsal fin height 14-18% SL; total bars on caudal fin 10-13, upper caudal fin lobe with 5 reddish bars, of similar width or narrower than the pale interspaces between the bars, not retained on preserved fish; no lateral body stripes; first dorsal fin tip pale; barbels yellow or white in fresh fish; body white below lateral line, covered by red pigmentation above lateral line which may also reach down ventrally, forming red patches or blotches; belly white. Attains 20 cm Standard Length.

Distribution : Red Sea to Somalia, Kenya, Mozambique, South Africa, Madagascar, Reunion, Seychelles, India, Sri Lanka, Bay of Bengal, Andaman Sea, Malaysia, Singapore, Northern Australia and Philippines.

Remarks : New record for the Andaman and Nicobar Islands.

***Upeneus moluccensis* (Bleeker 1855)**
Goldband goatfish

1855. *Upeneoides moluccensis* Bleeker, Nat. Tijdschr. Ned-Indie : 409 (type locality : Ambon, Moluccan Islands).
Upeneus moluccensis Randall and Kulbicki 2006. *Zoological Studies*, **45** : 301-302.

Material examined : Port Blair (South Andaman), 1 ex., 185 mm, ZSI ANRC 1888; Chouldari (South Andaman), 2 exs., 154, 178 mm, ZSI ANRC 2998; Mayabunder (North Andaman), 1 ex., 160 mm, ZSI ANRC 3381; Bidnabad (South Andaman), 1 ex., 160 mm, ZSI ANRC 3828; Inglis Island (South Andaman), 1 ex., mm, ZSI ANRC 4053.

Diagnosis : Dorsal fins VIII + 9; pectoral fins 14-16; gill rakers 7-8 + 18-20 = 26-27; lateral line scales 33-35; body depth at first dorsal fin origin 24-26% SL; body depth at anus 21-23; caudal peduncle depth 9.0-10; maximum head depth 20-22; head depth through eye 16-17; head length 27-29; orbit length 7.3-8.9; upper jaw length 11-12; barbel length 15-17; caudal fin length 27-30; anal fin height 13-15; pelvic fin length 17-22; pectoral fin length 25-27; first dorsal fin height 20-23; second dorsal fin height 14-16% SL; 6-8 thin red bars on upper caudal fin lobe, faintly retained on preserved fish; no bars on lower caudal fin lobe, but a broad band covering the entire lower lobe apart from distal, inner margin; most of lower caudal fin lobe pigmentation lost in preserved fish; one conspicuous yellow or gold mid-lateral body stripe from eye to upper caudal fin base, not retained on preserved fish; first dorsal fin tip dark, also in preserved fish; barbells white; body silvery-rose, darkened above lateral stripe. Attains 20 cm Standard Length.

Distribution : Eastern Mediterranean, Red Sea to Mozambique, Arabian Sea, Madagascar, India, Andaman Sea, Indonesia, New Caledonia, Philippines, Taiwan and southern Japan.

***Upeneus sulphureus* Cuvier 1829**
Sulphur goatfish

1829. *Upeneus sulphureus* Cuvier, *Hist. nat. Poiss.* : 450 (type locality : Antjer, western Java).
Upeneus sulphureus Randall and Kulbicki 2006. *Zoological Studies*, **45** : 304.

Material examined : Port Blair (South Andaman), 1 ex., 185 mm, ZSI ANRC 2744; Mayabunder (North Andaman), 1 ex., 180 mm, ZSI ANRC 3382; Bidnabad (South Andaman), 1 ex., 185 mm, ZSI ANRC 3829; Wandoor (South Andaman), 1 ex., 240 mm, ZSI ANRC

3942; Junglighat fish market, 1 ex., 130 mm, ZSI ANRC 4731.

Diagnosis : Dorsal fins VIII + 9; pectoral fins 15-16; gill rakers 7-8 + 19-21 = 27-28; lateral line scales 31-34; body depth at first dorsal fin origin 25-28% SL; body depth at anus 25-27; caudal peduncle depth 11-12; maximum head depth 23-25; head depth through eye 18-20; head length 29-30; orbit length 7.4-8.7; upper jaw length 11-13; barbel length 17-21; caudal fin length 27-30; anal fin height 16-18; pelvic fin length 20-22; pectoral fin length 24-26; first dorsal fin height 23-26; second dorsal fin height 17-18% SL; no bars on caudal fin lobes; lower lobe base yellowish, upper lobe base grey, some of the caudal fin lobe pigmentation retained on preserved fish; two conspicuous yellow body stripes, one mid lateral from operculum to caudal fin base, the other starting behind pectoral fin base and reaching back to caudal fin base; first dorsal fin tip black; barbels white; body ventrally white and dorsally pale brown. Attains 23 cm Standard Length.

Distribution : Red Sea, Persian Gulf, Madagascar, Seychelles, Reunion, Pakistan, India, Sri Lanka, Andaman Sea, Indonesia, New Guinea, Fiji, New Caledonia, Philippines, and southern Japan.

***Upeneus tragula* Richardson, 1846**
Freckled goatfish

1846. *Upeneus tragula* Richardson, *Rep. Br. Ass. Advmt. Sci.*, : 220 (type locality : Gaungzhou, China).
Upeneus tragula Randall and Kulbicki 2006. *Zoological Studies*, **45** : 305-306.

Material examined : Chidiyatapu (South Andaman), 2 exs., 145 mm, ZSI ANRC 2010; Mayabunder (North Andaman), 2 exs., 85, 125 mm, ZSI ANRC 1918; Bambooflat (South Andaman, 2 exs., 220 mm, ZSI ANRC 2140; Tarmugli Island (South Andaman), 1 ex., 226 mm, ZSI ANRC 2750; North bay (South Andaman), 1 ex., 155 mm, ZSI ANRC 3384; Bidnabad (South Andaman), 1 ex., 145 mm, ZSI ANRC 3830; Junglighat fish market, 1 ex., 155 mm, ZSI ANRC 4734.

Diagnosis : Dorsal fins VIII + 9; pectoral fin rays 13-14; gill rakers 5-6 + 14-17 = 19-23; lateral line scales 28-30; body depth at first dorsal fin origin 22-26% SL; body depth at anus 20-22; caudal peduncle depth 9.9-11; maximum head depth 19-23; head depth through eye 15-17; head length 27-31; orbit length 6.1-8.3; upper jaw length 11-14; barbel length 15-18; caudal fin length 28-32; anal fin height 16-19; pelvic fin length 20-24; pectoral fin length 19-21; first dorsal fin height 21-24; second dorsal fin height 18-22% SL; total bars on caudal fin 10-12 or more, upper caudal fin lobe with 4-6 brown,

dark brown or black bars; 4-7 brown, dark brown or black bars on lower lobe; one brown to black mid-lateral body stripe from tip of snout to caudal fin base; body above stripe greenish grey, body below stripe white or beige, also on paired fins; dark mark very close to first and second dorsal fin tips; barbels yellow in fresh fish; most of body and fin pigmentation retained on preserved fish. Attains 30 cm Standard Length.

Distribution : Red Sea to Mozambique, Oman, Persian Gulf, India, Sri Lanka, Myanmar, Indonesia, Cambodia, Thailand, Singapore, Sabah, Vietnam, Philippines, Papua New Guinea, Palau and Southern Japan.

***Upeneus vittatus* (Forsskal 1775)**

Striped goatfish

1775. *Mullus vittatus* Forsskal *Descript. Anim.* : 31 (type locality : Jeddah, Red Sea). 1846. *Rep. Br. Ass. Advmt. Sci.* : 220 (type locality : Gaungzhou, China).

Upeneus tragula Randall and Kulbicki 2006. *Zoological Studies*, **45** : 306.

Material examined : Hut Bay (Little Andaman), 1 ex., 140 mm, ZSI ANRC 1919; Port Blair (South Andaman) 1 ex., 160 mm, ZSI ANRC 1622; Chouldari (South Andaman), 1 ex., 226 mm, ZSI ANRC 2997; Nancowry Island (Nicobar Group), Mayabunder (North Andaman), 1 ex., 280 mm, ZSI ANRC 3383; Bidnabad (South Andaman), 1 ex., 355 mm, ZSI ANRC 3831; Inglis Island (South Andaman), 1 ex., mm, ZSI ANRC 4054; Junglighat fish market, 2 exs., 132 mm, 160 mm, ZSI ANRC 4730 & 4733.

Diagnosis : Dorsal fins VIII + 9; pectoral fin rays 15-16; gill rakers 7-8 + 19-21 = 27-29; lateral line scales 36-38; body depth at first dorsal fin origin 25-29% SL; body depth at anal fin origin 21-24; caudal peduncle depth 9.9-12; maximum head depth 21-26; head depth through eye 18-20; head length 30-31; orbit length 7.0-8.7; upper jaw length 11-13; barbel length 17-21; caudal fin length 26-30; anal fin height 15-16; pelvic fin length 18-21; pectoral fin length 22-24; first dorsal fin height 22-25; second dorsal fin height 14-16% SL; total bars on caudal fin 7-9, upper caudal fin lobe with 4-5 brown or dark brown bars; 3-4 brown or dark brown on lower caudal fin lobe; bars on both caudal fin lobe retained on preserved fish; first dorsal fin tip dark; two yellow or pale brown mid-lateral body stripes, one from eye to caudal fin base, where it joins the proximal upper caudal fin lobe bar, and other stripe below, from pectoral fin base to caudal peduncle, continued by proximal most lower caudal fin lobe bar; two dorsolateral brown or pale brown stripes, the lower one extending from

operculum to behind second dorsal fin, the upper one much shorter, beginning below first dorsal fin origin to second dorsal fin origin; lateral body stripes not retained on preserved fish; barbels white; body white to silvery, dorsally dark reddish-brown, belly white, faint yellowish patches along pelvic and anal fin bases. Attains 28 cm Standard Length.

Distribution : Red Sea to South Africa, Madagascar, Reunion, Mauritius, Indonesia, Thailand, New Guinea, New Caledonia, Palau, southern Japan, Palau, Mariana Islands, Fiji, Samoa Islands, Society Islands, Marquesas Islands and Hawaii.

DISCUSSION

Coastal waters are highly structured, covering a large variety of different bottom types that are inhabited by a diverse assemblage of organisms. Many of these habitats are still insufficiently known and require continued effort to sample, describe and register all species. However, due to increasing signs of human induced local and global impacts there is also a pressing need to study further coastal organisms to understand their ecological role and function and to evaluate their potential use as indicators and/or key species for coastal ecosystem monitoring and management. Some key species act as 'ecosystem engineers' as they physically change the environment, either by themselves or by manipulating distinct habitat features. This study highlights the goatfishes, family Mullidae, as a group of mainly coastal organisms that have a high value for ecosystem monitoring and management, but also require intensified systematic and ecological research. In the last few years, considerable research on coastal fishes has been carried out to examine the effects of both naturally varying factors and human induced modifications on habitat utilization at different scales (Rajan, 2010). Goatfishes occur in a broad range of habitats, mostly close to or near the bottom of the littoral zone. However, some species may be found down to depths of 500 m and surface-dwelling goatfish larvae have sometimes been found drifting in the outer shelf or in oceanic waters (Deudero 2002). Most goatfish species shift to bottom life soon after metamorphosis, coinciding with barbel development (McCormick 1993) and changes in eye structure (Shand 1997). However, some species may remain in the open water as juveniles (McCormick & Milicich 1993) or feed on plankton even during later ontogenetic stages (Krajewski & Bonaldo 2006). Studies on goatfish habitat use have considered depth as well as various bottom types, including hard and soft bottoms, open sandy

areas and those overgrown with vegetation. Clear preferences for distinct habitat types, but also differences among species and size/age classes, have been reported. Goatfishes are most frequently found on sandy bottoms adjacent to hard bottoms, including coral reefs. Apart from daily short-distance movements within and among foraging and resting sites (Holland *et al.* 1993; Meyer *et al.* 2000), they may also show seasonal migrations, in particular during the reproductive period, leading to the formation of spawning aggregations (Colin & Clavijo 1978; Lobel 1978; Thresher 1984; Colin 1996; Machias & Labropoulou 2002; Claydon 2004). Juvenile goatfishes are often encountered on soft bottoms, in seagrass beds or mangroves, and at different depths than adults, reflecting both horizontal and vertical ontogenetic habitat shifts. Serving as recruitment habitats, seagrass habitats may contribute positively to adult goatfish abundance in adjacent areas (Dorenbosch *et al.* 2005). Ontogenetic habitat shifts may also occur during later life history and coincide with changes in foraging mode, social behaviour and the formation of multi-species associations.

Goatfish is a commercially important demersal fish group throughout their distribution around the world and are considered to be one of the most important fishery resources in the Andaman Islands due to their delicacy, the price recently reached about 60 rupees/kg. Goatfish species are relevant to fisheries in Andaman Islands and several species have high economic importance. For instance, in Andaman Islands at least five goatfish species are the target of fisheries, the gold-band mullet and the striped mullet have been favourite food fishes. The term key species has been used in ecology to rule out those taxa that significantly contribute to the formation and sustaining of community structure and interaction among co-occurring species. The absence of key species would lead to a considerable decline in ecosystem coherence and integrity. Due to their very active foraging behaviour with vigorous stirring up of sediments by their barbels and mouths, goatfishes may provide important ecosystem services, including resuspension and the formation of mixed species foraging associations (Fig.3). These and additional characteristics of their resource use may render goatfishes essential components of food webs in sand-associated coastal ecosystems. Many littoral hard bottoms undergo a continuous erosion process due to wave action and diverse mining or scraping organisms that contribute to sedimentation and the formation of sandy areas in the immediate

surroundings. This is particularly evident on coral reefs, which are usually surrounded by sand habitats in the back- and fore-reef areas, as well as in reef canals, crevices and between reef patches. Corals feed themselves on microscopic food organisms that may, to a large extent, derive from currents transporting them towards the reefs, but there may also be a trophic link between sand bottoms and reef-forming corals, one possible mechanism being the looping back of nutrients from bottom sediments into the open water and surrounding areas by resuspension. The resuspension of bottom sediments can be enhanced by currents or wave action, but also by distinct organisms. There may also be important indirect effects on the sediment-dwelling fauna itself (Choat & Kingett 1982) and on other fish species that often follow goatfishes, thus forming mixed-species foraging associations. The formation of multi-species foraging associations (also called mixed-species, heterospecific or interspecific associations or shoals) may arise if food sources occur that can be shared with advantage. The stirring-up of sediments by goatfishes leads to the uplifting of formerly hidden detritus and other organic material into the water column. This activity attracts other species that follow goatfishes and feed on the newly available particles. Goatfishes themselves may profit, because foraging in larger groups reduces the predation risk. Detailed morphological studies of an organism group are the prerequisite for understanding systematics, ecology and diversity. Till today, most species are described based on morphological characters, although genetics is becoming increasingly important. Knowledge of the shape, structure, and relative size of external and internal body characters facilitates the interpretation of a species' capability to adapt to distinct environmental conditions. However, many other morphological traits of goatfishes, such as body size, coloration, head form, otolith form, or the number of countable characters, such as gillrakers, fin rays, or vertebrae, may vary interspecifically (Thomas 1969; Randall 2004) or intraspecifically (Uiblein *et al.* 1998). Currently, 70 species of goatfishes are known and in the last 13 years, eleven new goatfish species have been described. Some genera have been proven to be particularly specious, the most diverse being *Parupeneus*, which consists of 27 species (Uiblein and Heemstra 2010), followed by *Upeneus* with 26 species. From future revisions, more detailed systematic information can be obtained and from further exploration of remote areas, like isolated islands, new discoveries of goatfish species can be expected. All descriptions of goatfish species so far

have been based exclusively on morphological data. In some cases, morphological variation may be higher than differentiation found at the genetic level (Stepien *et al.* 1994).

CONCLUSIONS

Many knowledge gaps still exist in goatfish ecology and systematics. However, the currently available data suggest that goatfishes may indeed be suitable habitat indicators and may also qualify as key species in coastal sand-associated ecosystems. Because of considerable inter- and intraspecific variations in habitat preferences, food selection, behaviour, and body structure, special attention should be paid to treat species, populations, and size classes separately from each other. Because not all goatfish species are equally well known and even some new ones may be encountered, exploration, monitoring, and management focusing on this group should be co-ordinated worldwide, thus enhancing information exchange and initiating joint research efforts in goatfish ecology and systematics. At the same time, this study may also serve as a model for screening other organisms for their potential as ecosystem indicators. Fresh colouration of head, body and fins is important for species diagnosis. The number and configuration of bars on the caudal fin are also useful to distinguish several species. The fish fauna of Andaman and Nicobar Islands that comprises more than 572 islands, islets and deep water habitats is not well known. The genus *Upeneus* Cuvier 1829 was reviewed from India by Kumaran and Randall 1984 and for the Western Indian Ocean (Uiblein and Heemstra 2010). A particular problem in the taxonomy of Mullidae is the dearth of diagnostic characters. One of the few useful meristic characters is the number of dorsal fin spines, which requires careful examination in order to detect the minute recumbent first spine. Another important character is the number of pectoral fin rays. A third useful character is the number of gill rakers. In this account 65 specimens comprising 14 species were examined from the Andaman and Nicobar Islands from the field collections. One of the goals was to the use of relatively quickly identifiable meristic, morphometric and colour characters. Goat fishes are considered to be one of the most important fishery resources in the Andaman and Nicobar Islands, due to their high prices and marketable power that recently reached about 60 Rs./kg in the local market. In conclusion, the available results suggested that, goatfishes in the Andaman and Nicobar Islands are not overexploited and it is due to effective management regulations such marine reserves

which act as the nursery and spawning grounds and shallow waters which protect the fish during spawning and also protect juveniles and recruits. Detailed studies involving the gear selectivity for the trawl to find the suitable mesh size should be undertaken.

SUMMARY

Currently, 70 species of goatfishes are known, the family occurring widely in tropical, subtropical and temperate habitats from the upper littoral down to the upper slope. Studies of goatfish occurrence and abundance in natural habitats in Andaman and Nicobar Islands have been documented. Generally they prefer sand-associated bottoms, some species are more restricted to hard bottoms, and others occupy various depths. Fourteen species are recognized under three genera: *Mulloidichthys flavolineatus*, *Mulloidichthys vanicolensis*, *Parupeneus barberinus*, *Parupeneus cyclostomus*, *Parupeneus heptacanthus*, *Parupeneus indicus*, *Parupeneus macronema*, *Parupeneus pleurostigma*, *Parupeneus bifasciatus*, *Upeneus guttatus*, *Upeneus moluccensis*, *Upeneus sulphureus*, *Upeneus tragula* and *Upeneus vittatus*. Goatfishes respond to human-induced factors such as fisheries and habitat modification, as reflected by abundance, size, or weight changes, or changes in their distributional range. Goatfishes may act as allochthonous ecosystem engineers through their vigorous foraging behaviour with barbells and mouth, which leads to the stirring-up of sediments and associated detritus particles high into the water column. Goatfishes play a key role in the formation of multi-species foraging associations as a nuclear species that are followed by many other species. There is a considerable lack of basic systematic and taxonomic knowledge, new species still being described and intraspecific morphological variation and genetic differentiation requiring more detailed studies. Goatfishes clearly deserve more attention in future coastal habitat exploration, monitoring and management efforts.

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Fig. 1. Yellowfin goatfish (*Mulloidichthys vanicolensis*) congregating with blue-striped snappers (*Lutjanus kasmira*).



Fig. 2. (*Parupeneus cyclostomus*) dark phase with the terminal male of *Gomphosus caeruleus* (Family : Labridae) (Photo : Sreeraj).

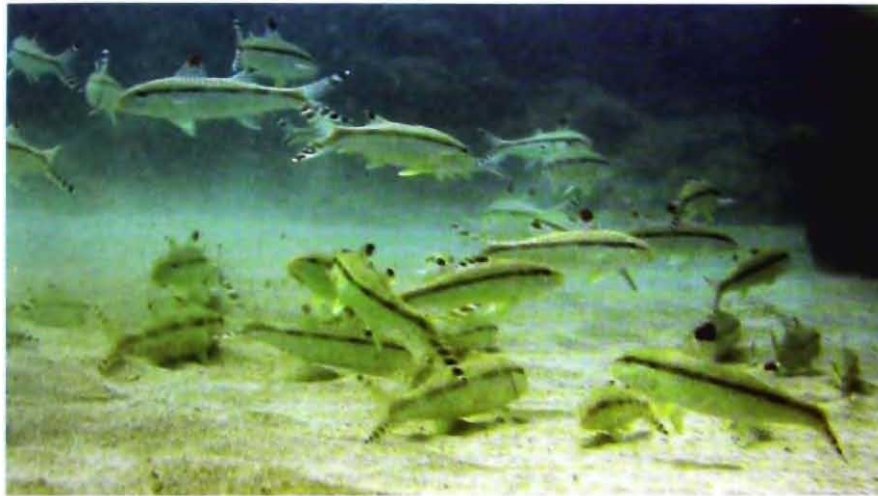


Fig. 3. Goatfish aggregates during feeding (*Upeneus tragula*).



Mulloidichthys flavolineatus (Lacepede) 28 cm SL.



Mulloidichthys vanicolensis (Valenciennes) 26 cm SL.



Parupeneus cyclostomus (Lacepede) 31cm SL.



Parupeneus barberinus (Lacepede) 36 cm SL.



Parupeneus cyclostomus Yellow phase (Photo : Sreeraj).



Parupeneus cyclostomus Dark phase (Photo : Sreeraj).



Parupeneus cyclostomus Blue colour (Photo : Sreeraj).



Parupeneus heptacanthus (Lacepede) 22 cm SL.



Parupeneus indicus (Shaw) 32 cm SL.



Parupeneus macronemus (Lacepede) 22 cm SL.



Parupeneus pleurostigma (Bennett, 1831) 24 cm (Photo : Titus).



Parupeneus trifasciatus (Lacepede) 28 cm SL.



Upeneus guttatus (Day) 18 cm SL.



Upeneus moluccensis (Bleeker) 15 cm SL.



Upeneus sulphureus Cuvier 13 cm SL.



Upeneus vittatus (Forsskal 1775) 21 cm SL.



Upeneus tragula Richardson 26 cm SL.

Caudal fin pattern in *Upeneus* sp.



Upeneus vittatus (7-9 bars).



Upeneus moluccensis (6-8 bars on upper lobe only).



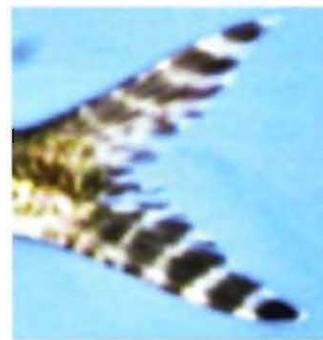
Upeneus guttatus (10-12 bars).



Upeneus sulphureus (no bar).



140 mm (9-10 bars).



160 mm (11-12).



260 mm (14-15 bars).

Upeneus tragula (in larger specimen the number of caudal bar is more).



Fig. 4. Association of goatfish *Parupeneus macronemus* with parrotfish *Scarus bleekeri* (Initial phase).