Taxonomy and Biology of Cultivable High Valued Marine Demersal Finfishes

Rekha J. Nair
Central Marine Fisheries Research Institute, Kochi

In a world where the global population is expected to grow by another 2 billion to reach 9.6 billion people by 2050 and where more than 800 million continue to suffer from chronic hunger we must meet the huge challenge of feeding our planet while safeguarding its natural resources for future generations. (SOFIA, 2014). Global fish production has grown steadily in the last five decades, with food fish supply increasing at an average annual rate of 3.2 percent, outpacing world population growth at 1.6 percent.

Cage culture systems employed by farmers are currently as diverse as the number of species currently being raised, varying from traditional family-owned and operated cage farming operations (typical of most Asian countries) to modern commercial large-scale salmon and trout cage farming operations in northern Europe and the America. Commercial cage culture has beenmainly restricted to the culture of higher-value (in marketing terms) compound-feed-fed finfish species, including salmon (Atlantic salmon, cohosalmon and Chinook salmon), most major marineand freshwater carnivorous fish species (including Japanese amberjack, red seabream, yellow croaker, European seabass, gilthead seabream, cobia, Rainbow trout, Mandarin fish, snakehead)and an ever increasing proportion of omnivorous freshwater fish species (including Chinese carps, tilapia, *Colossoma*, and catfish). However in southeast Asian countries, marine species being cultured are groupers and snappers.

Groupers

a. Species cultured

A diversity of grouper species are cultured, but only a few are produced in hatcheries to any significant extent. *Cromileptes altivelis*, *Epinephelus fuscoguttatus*, *E. coioides*, *E. malabaricus*, *E. akaara*, *E. lanceolatus*, *E. tukula*, *E. areolatus*, *E. tauvina*and *E. polyphekadion* are reported (Rimmer, Williams and Phillips, 2000; Rimmer, Mc Bride and Williams, 2004) from hatcheries around the region and are expected to form the mainstay of grouper production in the future. Orangespotted grouper (*E. coioides*), greasy grouper (*E. tauvina*), Malabar grouper (*E. malabaricus*) and duskytail grouper (*E. bleekeri*) are cultured in cages in Myannmar using using fry and juveniles caught from the wild. Most grouper grow out is conducted in cages located in marine estuaries or sheltered coastal areas. Groupers are generally sold alive at a size range of 0.5–1.2 kg per fish, with the average weight for table-size fish being 850 g, requiring ready access to markets. In Thailand, six species of groupers (*Epinephelus coioides*, *E. malabaricus*, *E. areolatus*, *E. lanceolatus*, *E. fuscoguttatus* and *Plectropomus maculatus* are cultured. In Malaysia, interest in grouper culture has led to atleast six species being introduced. Commonly

cultured species include brown-marbled grouper (*Epinephelus fuscoguttatus*), orange-spotted grouper (*E. coioides*)and Malabar grouper (*E. malabaricus*). Other minorspecies include fourfinger threadfin (*Eleutheronema tetradactylum*).

Taxonomy: Groupers, rockcods, hinds, and seabasses belong to serranid Subfamily Epinephelinae which comprises of about 159 species in 15 genera. Grouper species are identified by their colour pattern, morphological characters including configuration and size of the fins, the shape and relative size of the head and various parts of the head and body; and the number of fin rays, scales and gill rakers body shape.

Species in Indian waters:

***Epinephelus merra* Bloch, 1793 - Honeycomb grouper**

D XI, 17; A III, 8; P 17; V I, 5.

Body robust, slightly compressed, elongated; mouth superior, large, maxilla exposed, slightly protractile; small, slender teeth on jaws, vomer and palatine; some small canines on front; eyes prominent; dorsal profile of the head sloped; pre-operculum serrated; one flat spine on operculum; small ctenoid scales; pectoral fin like an hand fan; caudal fin rounded.

Body grey above and lighter below; brown to black spots all over the body, hexagonal anteriorly, rounded posterior; fins rays of dorsal and caudal fin yellowish; pectoral and pelvic fins dark brown to black Brown body.

***Epinephelus polyphekadion* (Bleeker 1849)**

Camouflage grouper

D XI, 15; A III, 8; P 16; V I, 5; LL 47 to 52; Gr (8-10) + (15-17).

Dorsal profile of head evenly convex; maxilla reaches rear edge of eye; pre operculum rounded, the serrae at corner slightly enlarged; two undeveloped spines in operculum; inter spinous membranes moderately incised; caudal fin rounded; body scales ctenoid.

Body pale brownish covered with numerous small dark brown spots; some irregular dark blotches superimposed with the spots scattered in head and body; a prominent black blotch on caudal peduncle; dark spots extend all over head, including lower jaw, lips and inside of mouth; numerous small white spots on fins and a few on head and body.

***Epinephelus malabaricus* (Schneider, 1801)**

Malabar grouper

D XI, 14-16; A III, 8; P 18-20; V I, 5; Ll 98-114.

Body depth contained 3.0 to 3.6 times in standard length. Preopercle finely serrate, with a shallow notch, the serrae enlarged at the angle; rear nostrils not more than twice the size of anterior nostrils; lower gillrakers 13 to 16; midlateral part of lower jaw with 2 rows of teeth. midlateral body scales distinctly ctenoid with minute auxiliary scales.

Head and body generally pale greyish brown covered with small orange, golden brown, or dark brown spots. Five more or less distinct, slightly oblique, irregular, broad, dark bars on body; these bars are darker dorsally and the last 3 are usually bifurcate ventrally; the first 4 bars usually continued onto the dorsal fin, the last bar covers most of the caudal peduncle; usually 3 dark blotches on interopercle, the first 2 sometimes merging to one blotch; small, irregularly shaped and spaced, white spots visible on head and body of some fish; soft dorsal, caudal, anal and pectoral fins brownish-black with small dark spots on basal half of fins

***Epinephelusl anceolatus* (Bloch 1790) - Giant grouper**

D XI, 14; A III, 8; P 16; V I, 5; LL 46-51; Gr (9-11)+(17-19).

Body robust in adult and slightly deep in juveniles; dorsal profile of the head slightly convex; eyes small; mouth moderately big, terminal to superior; maxilla reaching rear edge of eye; pre-operculum finely serrated in edges; inter fin membrane of spines notched; soft rays of dorsal and anal fin, pectoral and caudal fins rounded.

Body greyish yellow above, grayish white below and sides with numerous uneven black blotches all over the body; head darker; fins yellowish with black blotches; juveniles with 3 irregular black bars in body, large adults dark brown to grey.

This species is protected under Indian Wild Life Protection Act (1971)

***Cephalophalis miniata* (Forsskål, 1775)**

Coral hind

D XI, 14; AIII, 8; P 17; V I, 5; LL 47-56; Gr 7-9+14-16.

Body moderately deep; dorsal profile of the head straight, with convex above eye; maxilla big, crossing the rear edge of eye; eyes small; pre-operculum rounded; soft rays of dorsal and anal fin, pectoral and caudal fins rounded.

Body orange to reddish brown, with small blue spots all over the body including fins; Margin of soft rays of dorsal and anal and caudal fins bluish.

Biology: Groupers are protogynous hermaphrodites. The gonad lies ventral and slightly posterior to the swim bladder. The ovary is in the form of a bilobed sac that unites posteriorly to form a common oviduct In a mature female, numerous oocytes are arrayed in lamellae surrounding a central lumen,with spermatogenic tissue in small dormant cryptson the periphery of the lamellae. After spawning asa female for one or more years, the grouper changes sex and thereafter functions as a male. Atsexual transition, the oocytes degenerate, the spermatogonia proliferate, and the ovary is transformed into a functional testis. Evidence of the ovarian origin of the testes are the remnants of oocytes andthe ovarian lumen, which can be seen in cross-sections of the testes. This protogynous mode of reproduction is complicated in certain species bythe 'occurrence of some large females that do not change sex and some small males that are mature atthe same size as the smallest females. (Heemstra and Randall, 1993)

Most fishes are gonochorists (Wootton 1991; Helfman *et al.* 1997), which means they are either born as males or females and reproduce only as one sex throughout life. But many species, including many serranids, exhibit several sexual patterns such as hermaphroditism (Sadovy de Mitcheson and Liu 2008). Hermaphroditism includes simultaneous and sequential hermaphroditism and the latter is further divided into protogyny and protandry (Sadovy and Shapiro 1987). *Epinephelus malabaricus* change sex between 97 and 113 cm TL with

the length at 50% sexual maturity of female *Epinephelus malabaricus* reported to be 79 cm (7.5 kg) (Lydia and Ian 2013). *E. tauvina*, is a protogynous hermaphrodite and sexual transition is found to occur in individuals 55-75 cm in length, and is related to spawning activity. Fecundity estimates for *E. tauvina*, of length 35.142.3 cm ranged from 850 186 to 2 904 921.

In the case of *E. tauvina*, lunar cycle has been shown to affect the reproductive cycle. The fish matures at 52 cm total length ie 4- 5 years old whereas *E. chlorostigma* attains sexual maturity at 28 cm TL.

Giant grouper (*E. lanceolatus*) is popular with farmers for its hardiness and rapid growth and is reported to grow to around 3 kg in its first year.

The Serranidae exhibit both synchronous and protogynous hermaphroditism (Lavenda, 1949; Reinboth, 1962,1970; Smith, 1965; Yamamoto, 1969; Atz, 1964;Bortone, 1977; Bouain, 1981) as well as the gonochoristic pattern. Van Oordt(1933) made the first observations on hermaphroditism in *Epinephelus* from the Java Sea. and since that time there have been several reports on sex transformation in this genus (Smith, 1965; Reinboth, 1968; Moe, 1969; Tan & Tan, 1974; Brusle & Brusle, 1975a,b; Chen *et al.,* 1977, 1980)

Snappers

The snapper is a demersal fish occurring on the continental shelf down to a depth of about 200 m, but most abundant in depths of less than 70 m. It lives on all kinds of bottom-sand, mud, rocks-There are several species of seabream cultured in Asia, mainly in more temperate parts of the region.These include squirefish (*Chrysophrys auratus*), goldlined seabream *Rhabdosargussarba*), blackporgy (*Acanthopagrus schelgeliischlegelii*) and redseabream (*Pagrus major*). In Thailand, *Lutjanus argentimaculatus* is the major species cultured. In Malaysia, Snappers (Lutjanidae) are next in importance; these include the yellow streakedsnapper (*Lutjanus lemniscatus*), the mangrove red snapper (*L. argentimaculatus*), John's snapper (*L. johnii*) and the crimson snapper (*L. erythropterus*).

Adult red snappers were primarily piscivorous, although in certain seasons, they fed heavily on tunicates. Juvenile red snappers fed primarily on crustaceans, but periodically took fish

Biology: They are solitary and wary fish, rarely found in groups or schools except during spawning aggregations (Domeier et al., 1996). Snapper is a serial spawner and releases many batches of eggs over a period of several months Water temperature is the most important factor influencing the timing of the breeding period. Eggs are spherical, with a diameter of 0.85- 0.97 mm and a single oil droplet 0,1H,25 mm in diameter. The yolk is non-segmented, Snapper eggs are planktonic and after fertilisation float freely in the sea until hatching, which takes from 36 to 54 hours, depending on temperature.The snapper's capacity to spawn many times during a season enables it to produce a very large number of eggs and is one of the reasons for its great success as a culture species.

Snapper is a predatory fish and its food is extremely varied. Its ability to feed on almost any animal food available enables it to penetrate different habitats and is another reason for its great success as a species.

Snappers in Indian waters

Mangrove snapper - Lutjanus argentimaculatus

Halibut

The name flounder is used for several only distantly related species, though all are in the suborder Pleuronectoidei (families Achiropsettidae, Bothidae, Pleuronectidae, Paralichthyidae and Samaridae). Some of the better known species that are important in fisheries are:

- Western Atlantic
- Gulf flounder - *Paralichthys albigutta*
- Southern flounder - *Paralichthys lethostigma*
- Summer flounder (also known as *fluke*) - *Paralichthys dentatus*
- Winter flounder - *Pseudopleuronectes americanus*
- European waters
- European flounder - *Platichthys flesus*
- Northwestern Pacific
- Olive flounder - *Paralichthys olivaceus*

Species in Indian waters:

***Psettodes erumei* or the Indian halibut**: *P. erumei* is highly predacious benthic fish which lives on muddy and sandy bottomsof the continental shelf down to about 100 meters depthand is predominantly piscivorous in habit. Body is oval and flat, but thicker than in most other flatfishes. Mouth large with strong teeth; maxillary extends well beyond hind edge of lower eye; both eyes are on left or right side; upper eye lying immediately below dorsal edge. Gillrakers are not developed. Dorsal fin origin is well posterior to eyes; anterior fin rays isspinous. Lateral line is almost straight. Body colour is usually brownish grey, sometimes with 4 broad, dark crossbars. Dorsal, analand caudal fin tips black. Blind side is white to partially coloured. Diet is mainly fish with Molluscs and arthropods supplemented to some extent. *Paralichthys olivaceus* the Bastardhalibut is cultured in onshore tank farms.

Temperate species

Psetta maxima is a benthic marine species, living on sandy and muddy bottoms, from shallow waters to 100 m. *Psetta maxima* is a gonochoric species with separate sexes. Younger individuals tend to live in shallower areas cryptic, imitating the colour of the substrate. Juveniles are carnivorous feeding on molluscs and crustaceans, and adults feed mainly on fish and cephalopods. Spawning (sequenced, every 2-4 days) usually takes place between February and April inclusive in the Mediterranean, and between May and July inclusive in the Atlantic. Eggs have a single fat drop. Larvae are initially symmetric, but by the end of metamorphosis (day 40-50, 25 mm) the right eye has moved to the left, giving rise to asymmetry.

***Solea* spp**.

Body oval in shape. Blind side of head covered with numerous small hair-like fringes; upper eye is separated from dorsal profile of head by a distance distinctly greater than its diameter; anterior nostril of blind side surrounded by a small ridge but not enlarged, distance from this nostril to head profile contained 1.5 to 1.8 times in distance from nostril to mouth cleft; anterior nostril on eyed side with tube directed backwards, not reaching anterior margin of eye. Dorsal fin has 72 to 95 rays, with origin on dorsal profile of head before the eyes. Anal fin with 53 to 80 rays. Pectoral fins equally well developed on both sides, with 7 to 10 rays, the fin on eyed side asymmetrical in shape. Base of caudal fin united by a membrane to last ray of dorsal and anal fins, but caudal peduncle still distinct. Lateral line with 116 to 163 tubed scales, its supratemporal prolongation with a smooth curve on head. Eyed side greyish brown to reddish brown in colour; blind side white. Pectoral fin of eyed side with a black blotch restricted to distal end of fin; hind part of caudal darker than rest of fin.

Tropical species

Soleasenegalensis has numerous small hair-like fringes; upper eye is separated from the dorsal profile of the head by a distance distinctly greater than the diameter of the eye; anterior nostril of blind-side is surrounded by a small ridge but not enlarged, distance from anterior nostril to head profile is 1.5–1.9 times the distance from nostril to mouth cleft; anterior nostril on eyed-side with tube directed backwards, not reaching anterior margin of eye. Dorsal fin, with 73–86 rays, originates on dorsal profile of head anterior to the eyes. Anal fin has 61–74 rays. Pectoral fins are equally well developed on both sides, with 7–10 rays, the fin on eyed-side is asymmetrical in shape. The base of the caudal fin is united by a membrane to the last rays of dorsal and anal fins, but caudal peduncle is still distinct. Lateral line with 116–165 pored scales, with its supra-temporal prolongation describing a smooth curve on head. Colouration of eyed-side varies from greyish-brown to reddish-brown, with large and diffuse dark spots; blind-side is white. Pectoral fin of eyed-side has a black blotch on the distal end; hind part of tail darker than rest of fin. Average adult size is 30–40 cm, but can reach up to 70 cm size (standard length).

S. senegalensis is better adapted than *S. solea* to the warmer waters of temperate climates, and therefore is more suitable for production along the southern coast of Spain and Portugal. During the 1980s, it was cultured extensively in earthen ponds, which often were former salt production ponds. Since then, numerous research projects in Portugal and Spain have studied methods to improve production.

Soleasolea

A demersal marine species living on sandy or muddy bottoms, ranging from near shore to 200 m of depth. Adults feed mainly on polychaete worms, molluscs and small crustaceans. Females reportedly reach sexual maturity around four years old and total length of 27–30 cm. Spawning periods differ depending on geographical location: in the Mediterranean spawning takes place between January and April, with two peaks in February; in the Bay of Biscay spawning occurs between December and May; and in the North Sea spawning happens between April and June. The optimal temperature for spawning ranges from 8 to 12 °C.

Rabbitfish

Rabbit fishes belong to the genus *Siganus* of the family Siganidae. *Siganus* species are all remarkably similar to each other in most of the features. All species possess thirteen dorsal fin spines, and seven anal fin spines. The genus *Siganus* is also unique among marine fish having two pectoral spines on each side which are separated by three soft rays. Along with these twenty-four spines, one procumbent spine is found in front of the first dorsal spine which is part of the proximal pterygiophore. It is completely embedded or sometime protrudes from a small groove and collectively makes up the main defense of fish. The spines are poisonous. The teeth are also remarkably similar to each other. The number of teeth and the overall shape are "identical." with a single row on top and the bottom jaw. They are very compressed and incisiform in shape. The teeth also overlap and are individually spadelike and pointed.

Species in Indian waters:

***Siganus canaliculatus* (Park, 1797)**

Distinctive Characters: Body compressed, fairly slender, with a headwith a concave slope above eye. Snout is blunt, anterior nostril is with a long flap in juveniles (shortening with age, absent in old fish);tip of flap reaching

less than halfway to posterior nostril in specimens larger than 12 cm standard length. A forward-directed spine is present in front of dorsal fin; last dorsal spine the shortest, contained 0.5 to 0.6 times of the longest dorsal spine; last anal spine contained 1.2 to 1.5 times of the longest anal spine (usually the third). Caudal fin is almost emarginate in specimens under 10 cm SL, forked in larger fish. Scales minute with naked cheeks or with few to many very fine scales; 21 to 27 scale rows between lateral line and bases of leading dorsal spines. Colour in live fish is highly variable from greenish grey on dorsal side to silver on ventral side; numerous pearly blue match-head size spots covering nape and sides, arranged more or less in horizontal rows. Caudal fin grey or with pale and dark grey bars; pectoral fins hyaline; dorsal, anal and pelvic spines and rays have same colour as adjacent areas of sides; fin membranes greyish in colour; after death fins usually with pale and dark grey, dorsal fin rays banded.

Biology: Common rabbit fish reported from India are *Siganus javus, S. canaliculatus, S.lineatus , S.stellatus, S. vermiculatus*.

S. canliculatus is generally found and its sizes vary from 20-25 cm, with a maximum of 45 cm TL. They are found in coral reef areas, mangrove swamps and shallow lagoons (Saoud *et al.*, 2008) and are able to tolerate a wide range of salinity (17-37 ppt), low dissolved oxygen upto 2 ppm and pH upto 9 and high stocking densities andgrow well in temperatures between 23 and 30°C. All these characters make this species suitable for culture.

Siganus canaliculatus are reported to grow to a length of 8 cm in about 3 months, 10 cm in about 4½ months and 14 cm in 7–8 months. The juveniles and adults are primarily herbivorous, feeding on different Kinds of benthic algae. Under captivity, they become omnivorous, feeding on a variety of food of both vegetable and animal origin, including feed pellets in the culture system. Juveniles form schools in algal and seagrass beds, feeding mainly on filamentous algae. Rabbitfish have also been reported to eat amphipods, copepods, sponges, foraminifera, crustaceans and brittle stars which suggest that these species may in fact be opportunistic omnivores. Adults are also schooling and move into shallow water with the rising tide to feed on benthic plants. The seeds are usually collected from the wild by scoop nets, dip nets, seine nets, etc. during season. The larvae can be fed with a mixture of phytoplankton, rotifers, copepods and the larvae of Artemia in culture (Bensam. 1993). Two-fold increase in the length and ten fold increase in weight over 5 weeks have been reported in the fry fed with algae and fish feed pellets.

Siganids are lunar-spawners. April and May are the peak months of spawning in tropical waters. The arrival of juveniles starts from the fringing reefs, to the patch reefs and associated seaweed beds and finally onto the seagrass (mostly Enhalusacoroides) beds. The main spawning season of *Siganus canaliculatus* in Singapore and Philippine waters has been reported to be from January to April (Lam, 1974; Manacop, 1937). In Palau, *S. canaliculatus* spawns during March to May [31] (Hasse et al. 1977). Occurrence of juveniles of *S. canaliculatus* was reported during February through May in the Gulf of Mannar (Mohan, 1985). The spawning season of the species also extends from November to February. In HongKong, *S. canaliculatus* has a definite spawning period from March to June (Tseng and Chan 1982). Mating occurs in synchronization with the lunar cycle for some of the rabbitfish. *Siganus canaliculatus* spawns four to seven days after the new moon in both Guam. Study on reproductive biology of *S .canaliculatus* in the Southern Arabian Gulf (Grandcourt *et al* 2007) and research on schooling of rabbitfish within mariculture facilities indicates that the eggs are adhesive, though not demersal, hatching within three days. After four weeks of a pelagic life, the larvae settle and begin feeding on filamentous algae.

The defined spawning period of *S. canaliculatus* supports the contention that seasonal reproductive cycles are common among tropical fishes (Robertson, 1990). Spawning of this species has been reported to occur between January and April in Philippines. In Singapore Sadovy (1998) has reported similar spawning. Furthermore, there was a small peak in the gonadosomatic index in November, suggesting that a second but less well-defined spawning season exists. A second, although less pronounced, spawning period has also been reported for this species in Singapore, Philippines and Palau. Studies on Induced spawning of *S. canaliculatus* has been carried out by Patrick G. Bryan 1974. The reproductive cycle of *S. canaliculatus* in the southern India, therefore appears to be the same as it is observed in other locations of the Indo-Pacific. Female influenced sex ratios are a characteristic (though not diagnostic) feature of protogynous species Sadovy, 1996).

Asia-Pacific region is characterised by a high species diversity that reflects the biodiversity of the region. But development of breeding technology for these species is highly demanding both on a monetary basis as well as on the research front. Cage culture has great development potential. Hence, research has to look into more and more species for which information on biology is available, more and more species which has faster growth rate and better feed conversion ratios. This will certainly go a long way in improving the food security planning in the country.