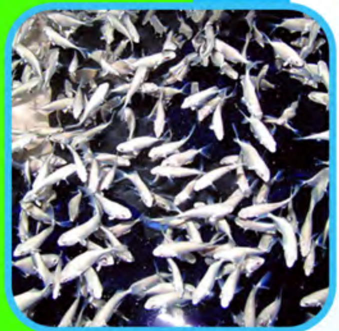

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CMFRI

Prioritized Species for Mariculture in India

भाकृअनुप
ICAR

ICAR - Central Marine Fisheries Research Institute

Prioritized Species for Mariculture in India

Compiled & Edited by

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CONTENTS

डॉ. जे. के. जेना
उप महानिदेशक (मत्स्य विज्ञान)

Dr. J. K. Jena
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FOREWORD

Mariculture has been recognized as an important avenue for ensuring nutritional security of growing fish-eating population in the country, especially in the backdrop of limitation in the availability of land resources and plateauing fish catch from the wild. ICAR-Central Marine Fisheries Research Institute, Kochi has been at the forefront of transforming the mariculture sector of the country through its pioneering research programmes on mariculture of finfishes and shellfishes. Success achieved in seed production and farming of cobia, pompano, grouper and pearlspot in recent years has provided the much needed impetus to this transformation.

Although India has been a home of vast array of marine finfishes and shellfishes, the mere existence of these large number of species does not ensure large-scale expansion of mariculture, since each species possesses unique set of challenges for seed production and farming. A fish farmer needs reliable information on a species and its culture aspects before he/she embarks on its culture. Hence, it is important to have a comprehensive database for potential cultivable finfish and shellfish species available in the country, covering the aspects of biology, their culture potential, status in the wild, economic viability in the culture systems, etc.

I am happy to learn that, in order to prioritize the potential finfish and shellfish species suitable for mariculture in India, an Expert Consultation was organised at Mandapam Regional Centre of ICAR-CMFRI during November 4-6, 2013. Further, it is gratifying to note that, as the outcome of the Consultation, an exhaustive book has also been prepared which includes factsheets for each of the prioritized species. I am sure the book will serve as an important guide for the researchers, farmers and other stakeholders having interest on mariculture in the country.

I deeply commend the effort taken by each and every members associated in the Consultation and further the scientists of ICAR-CMFRI for their invaluable contribution to the preparation of these factsheets and the book.

19/12/2016

(J. K. Jena)

PREFACE

Mariculture holds tremendous potential for fulfilling the demand of fish, as a source of dietary protein in the country. Keeping this in hindsight, ICAR-Central Marine Fisheries Research Institute, for the past several years has been trying to transform the mariculture sector of the country. In India, the potential coastal water area available for mariculture includes about 8.9 million ha of inshore waters for open-sea farming and 1.7 million ha of estuaries, backwaters, brackishwater lakes and swamps. High valued finfishes, crustaceans, molluscs, seaweeds and other marine organisms, possessing high reproductive capacity, short larval development, fast rate of growth, and physiological features to adjust to wide changes in the environment are available in our coastal waters. A large number of unemployed and under-employed fishermen exists who could advantageously take up coastal aquaculture.

Mariculture, in the past, concentrated wholly on culture of shrimps and it is only in the last few years that finfish mariculture has assumed importance. However, information on mariculture for finfish and other shellfishes are scanty with no organised database encompassing all aspects. Seed production technology has been developed by ICAR – CMFRI recently for a few species namely *Rachycentron canadum, Trachinotus blochii, Epinephelus coioides* and *Trachinotus mookalee.* Additionally, a large number of marine species are available in India which are amenable to mariculture but for which there are several challenges which have not been properly documented. With no concerted efforts in the past, it was decided to have a list of prioritized species of finfishes and shellfishes on which focused research can be undertaken in the near future.

In view of the above, in the workshop/consultation held at Mandapam Regional Centre, a list of prioritized finfishes and shellfishes was prepared for foodfish, conservation, ornamental and region-specific mariculture for the country. A total of 76 species was selected and it was envisaged to have a book with factsheets of individual species containing the challenges and the research gaps. This book is aimed at providing an insight into the morphological description; geographical distribution; habitat and biology; breeding in captive conditions; larval and nursery rearing; growout systems including food and feeding, growth rate, diseases and production, market and trade of each prioritized species. Sincere efforts have been put in place for providing reliable data and latest information on the above aspects in this publication. This book would be the first of its kind in India and would serve as a ready reckoner for breeders, farmers, traders, exporters, students and researchers.

We look forward to suggestions and constructive criticism from our readers for further improvement of this publication. We sincerely hope that this book will serve as a guide for selecting species for mariculture in India as well as for focusing mariculture research in India.

We gratefully acknowledge the invaluable contribution made by several scientists of ICAR – CMFRI to make this compilation possible. The authors are also grateful to Sri. P R Abhilash and Sri. David K M (CMFRI, Kochi) and Sri. V Uma Mahesh (RC of CMFRI, Visakhapatnam) for the figures and line drawings in the book. Thanks are also due to Dr. Boby Ignatius (CMFRI, Kochi), Dr. Vinod K (RC of CMFRI, Calicut), Dr. M. K. Anil (RC of CMFRI, Vizhinjam) Dr. Venkatesan V and Dr. Vidya R (Molluscan Fisheries Division, CMFRI, Kochi), Dr. I Jagadis, Dr. Asha P S and Smt. M Kavita (RC of CMFRI, Tuticorin), Sri. K. Mohammed Koya and Sri. Vinaya Kumar Vase (RC of CMFRI, Veraval), Dr. Anulekshmi C (Mumbai RC of CMFRI) and Dr. R Saravanan (RC of CMFRI, Mandapam) for their help during the preparation of this book. We gratefully acknowledge the efforts of Dr. Akhilesh K V (Mumbai RC of CMFRI) in this work. We also thank Sri. P. Pranav, Sri. Chinnibabu B, Sri. Jishnudev M A, Sri. P Bhaskar Rao, Sri. V Venkateswarlu and Sri. P Venkatesh for help with fish work.

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Overview of
"Species Prioritization for Mariculture/Conservation in India"

India is set to become the most populous nation by 2050 with the demand for fish estimated to be as high as 20.23 mt in the country by then. The marine fishing sector is thus faced with the daunting task of providing at least 10 mt in the coming years to sustain our growing population. With catches from the wild plateauing around 4.5 mt, it is not easy for the marine fisheries sector to rise to the challenge of feeding hungry mouths. It is in this context that mariculture gains importance and is poised as the most important option to ensure food security in the country.

CMFRI has thus embarked on an ambitious journey to revolutionize the mariculture sector of India. So far the potential for mariculture has not been realized fully in the country. Other than culture of shrimps in coastal brackishwater areas, emphasis on other species has been relatively poor. It is in this background that CMFRI is currently engaged in developing standard package of practices for a number of marine finfish species to be transferred to fish farmers in future. Seed production technology has been developed for a few species namely *Rachycentron canadum, Trachinotus blochii, Epinephelus coioides* and *Trachinotus mookalee.* However India is a hot-spot of marine finfish and shellfish biodiversity with an estimated 2,546 species of marine finfish and over 55 species of macruran decapods (Venkataraman and Mohideen, 2005). Thus in addition to the species already being studied, there may be a large number of marine species in India amenable to mariculture. However all species are not easy to culture with some providing challenges in broodstock development whereas others provide challenges during larval rearing, feeding, health management and so on. Hence even before the journey is fully undertaken, it was felt that a list of prioritized species of finfish and shellfish is needed on which focused research can be undertaken. With this objective in mind a workshop on "Species Prioritization for Mariculture/Conservation in India" was conducted at Mandapam Regional Centre of ICAR-CMFRI during 4^{th}-6^{th} November 2013. The specific objectives of the workshop were:

1) To prioritize finfish and shellfish species for food fish mariculture in India
2) To prioritize finfish and shellfish species for conservation mariculture in India
3) To prioritize finfish species for region-specific mariculture in India
4) To prioritize finfish and shellfish species for ornamental mariculture in India
5) To identify challenges in mariculture of prioritized species
6) To identify research gaps in species with already standardized culture protocols

The workshop was convened and chaired by Dr. A. Gopalakrishnan, Director, CMFRI. The other key participants of the workshop were Dr. G. Gopakumar, HoD, Mariculture, CMFRI along with 15 scientists of the Mariculture Division of CMFRI and one scientist from the Marine Biodiversity Division of CMFRI. The workshop proceeded to prioritize finfish and shellfish species based on a number of criteria (presented in the next section) following active discussions among the participants. By the end of the workshop, 76 species were listed as priority species for mariculture/biodiversity conservation in India. The output of the workshop was envisaged as a book with factsheets of individual prioritized species. This publication would then serve as a guide for selecting species for mariculture in India as well as for focusing mariculture research in India.

Methodology of prioritization

A set of key factors were used for prioritizing a species for mariculture. For each factor scores from 1 to 5 were given for a species with 1 being the lowest and 5 the highest. The key factors used were:

1) Economic value of species

Domestic market value

International market value

Regional market value and preference (for region-specific species)

2) Biology of species

Size at first maturity

Feeding habit (Omnivore-Carnivore-Herbivore and amenability to utilize pelleted feed)

Growth rate

Disease resistance/hardiness

Salinity and temperature tolerance

Colour and appearance (for ornamental fish)

3) Culture-ability of species

Suitability for farming

Ease of captive broodstock development and breeding

Ease of larval rearing

Ease of nursery and grow-out rearing

Ease of handling

Compatibility with other species

Compatibility with other species in aquarium (for ornamental fish)

4) Status in wild

Availability in commercial catches

Distribution and abundance

Broodstock availability

5) Information

Data availability on biology/life-history traits/breeding/culture

6) Economics of culture

Cost-effectiveness of culture

Following the procedures mentioned, the final list of prioritized species was arrived at. Based on local availability and expertise, the species were assigned to various regional/research centres and headquarters of CMFRI for further work. Additionally some species were given higher priority for the first 5 years and other species for the following years so as to make research more efficient. Species for which seed production has already been standarised have been coloured lilac ( ), species prioritized for the first five years have been coloured green ( ) and species prioritized for the 6th year onwards have been coloured blue ( ) in the following chapters. Scientific names of the species and their classification are based on World Register of Marine Species (www.marinespecies.org) as on 18th October 2017.

Recommendations of the workshop

Prioritized species for mariculture (food fishes)

The main objective of the workshop was to prioritize marine finfish and shellfish species for mariculture in India and to identify constraints/challenges for each species. The workshop identified 23 finfish species, 7 molluscan species, 4 shellfish species and 2 species of sea urchins for mariculture in India. Among the prioritized species, for *Epinephelus coioides, Trachinotus blochii, Trachinotus mookalee* and *Rachycentron canadum* the seed production technology has already been standardized; however, year round natural spawning, development of artificial feed and grow-out are issues which needs to be addressed and refined in the first five years. The other prioritized finfishes were *Caranx ignobilis, Gnathanodon speciosus, Lutjanus argentimaculatus* and *Lutjanus johnii* for the first five years and *for later years Acanthopagrus berda, Caranx sexfasciatus, Coryphaena hippurus, Cromileptes altivelis, Eleutheronema tetradactylum, Epinephelus malabaricus, Katsuwonus pelamis, Lethrinus lentjan, Lethrinus nebulosus, Pampus argenteus, Pampus chinensis, Parastromateus niger, Psettodes erumei, Siganus canaliculatus* and *Thunnus albacares.* The prioritized molluscan species were *Crassostrea madrasensis* and *Perna viridis* for the first five years and *Marcia opima, Meretrix meretrix, Paphia malabarica, Perna indica* and *Tegillarca granosa* for later years. The prioritized shellfish species were *Portunus pelagicus* and *Thenus unimaculatus* for the first five years and *Panulirus* *homarus homarus* and *Panulirus ornatus* for later years. The prioritized sea urchins were *Stomopneustes variolaris* and *Echinometra mathaei.* The constraints identified in most species were lack of information on life history traits, captive breeding, larviculture, feed and farming systems. It was recommended that for most species, studies on biology and life history were to be initiated. For species where broodstock development had been initiated, it was to be continued and for species where breeding had occurred, larval rearing was to be standardized and for species where larval rearing had been perfected, nursery and grow out practices/protocol were to be standardized.

Prioritized species for region-specific mariculture

Four species were prioritized for region-specific mariculture namely *Mugil cephalus* for Kerala, *Sillago sihama* for the south Canara coast, *Protonibea diacanthus* and *Otolithoides biauritus* for the north-west coast of India. The constraints were lack of information and research on captive breeding, seed production, larval rearing, feed management and farming systems in addition to lack of information on biology for the latter two species. Hence it was recommended that relevant studies should be undertaken for each species at the identified regions.

Prioritized species for conservation mariculture

Five species were identified for conservation through mariculture and subsequent sea ranching. The species identified were *Hippocampus kuda* and *Holothuria spinifera,* for the first five years. Three additional species were identified for work during 6th to 10th year namely *Epinephelus lanceolatus, Hippocampus trimaculatus* and *Holothuria scabra*. The constraints identified were lack of information on life history traits including reproductive biology, seed production and genetic stock structure. It was recommended that for the identified finfish species biological studies would be conducted with emphasis on genetic stock structure studies. For the identified shellfish and invertebrates, large scale sea ranching would be conducted pending clearance from Ministry of Environment & Forests, Govt. of India.

Prioritized species for ornamental mariculture

Thirty one species of finfish, shellfish and other invertebrates were identified for ornamental mariculture in India namely *Centropyge flavipectoralis, Chromis viridis, Chrysiptera cyanea, Dascyllus aruanus, Dascyllus trimaculatus, Labroides dimidiatus, Nemateleotris decora, Neoglyphidodon oxyodon, Platax teira, Pomacanthus semicirculatus, Pomacentrus pavo, Pseudanthias squamipinnis, Pseudochromis dilectus, Lysmata amboinensis, Ancylocaris brevicarpalis, Petrarctus rugosus, Entacmaea quadricolor, Heteractis magnifica, Stichodactyla gigantea, Cladiella australis, Xenia elongata, Cypraea tigris, Lambis lambis, Pinctada imbricata fucata, Pinctada margaritifera, Placuna placenta, Spondylus layardi, Tectus niloticus, Tridacna maxima, Turbo marmoratus* and *Volachlamys tranquebaria.* The constraints identified were larval survival, scaling up of seed production, breeding and seed production, lack of information on life history traits and artificial propagation.

Summary of factsheets

Following the workshop and its recommendations, base papers of the prioritized species were prepared. Several authors compiled information on biology, culture practices, diseases and trade for the prioritized species.

Food fishes

All the authors in addition to compiling the available information on each species have highlighted the need for more information on biology of the prioritized species from Indian waters. Groupers hold sway in the live reef fish trade and have been intensely cultured in south-east Asian countries. Being a hardy species and good domestic as well as international market, these species are having good prospect as an alternate species for Indian fish farmer. However, the availability of seeds is the major concern for its culture, because of difficulty in larval rearing due to small mouth gape as most of them are altricial type of larvae. Cobia and pompano (Indian and snubnose) being euryhaline are amenable for culture in coastal ponds and cages. They possess fast growth rate and excellent meat quality and hence are excellent species for mariculture.

Two species of perches of the genus *Lutjanus* are highly prized in the Indian market, but for which hatchery technology needs to be developed. The larvae of *Lutjanus* spp. are also of the altricial type, which need to be reared on smaller size copepod nauplii. *Acanthopagrus berda* is highly prized in the domestic market; however, no information is available on its biology and culture.

Indian salmon, *Eleutheronema tetradactylum* is a popular fish nationally but very limited information is available on its biology and culture. Three species of pomfrets of the genus *Pampus* and *Parastromateus* have been selected based on their popularity among Indians and great demand from Gulf countries. Though their larvae have survived in captivity, much more work has to be carried out on development of their broodstock and hatchery technology with grow-out practices.

Two carangids, *Caranx ignobilis* and *C. sexfasciatus*, present in Indian waters, are fast growing species. *C. ignobilis* has already been bred in captivity however its larval rearing, grow-out and farming systems need to be developed. Golden trevally, *Gnathanodon speciosus* is a popular food and ornamental fish, for which broodstock development, breeding and larval rearing protocol need to be developed in India. Rabbit fish, *Siganus canaliculatus* is one of the most economically important herbivorous fish having good potential for cage culture in India. However, their seed production technology needs to be worked out. *Psettodes erumei* is a highly valued table-fish whose broodstock development has been achieved in India; however, breeding and larval rearing of this species needs to be worked out.

Thunnus albacares, *Katsuwonus pelamis* and *Coryphaena hippurus* are known for their premium flesh quality in international market and can be good mariculture species for off shore cage culture. Steady progress has been reported about their breeding, hatchery and grow-out technologies from other countries; however in India, research attempt has to be initiated. Emphasis has to given for studying the biology of *Lethrinus nebulosus* and *Lethrinus lentjan,* as a prerequisite for developing broodstock, hatchery technology and grow-out system. *Crassostrea madrasensis, Perna viridis, Perna indica* and *Tegillarca granosa* have high local demand in domestic markets in selected pockets of the country and their broodstock development and seed production has been achieved on an experimental basis. However, cost-effective mass scale seed production needs to be worked out for scaling up the culture of these molluscan species. *Marcia opima, Meretrix meretrix* and *Paphia malabarica* enjoy a good demand for direct human consumption as well as in the shrimp feed industry. These species are also important inputs in the carbide industry. To meet these multifarious needs, mass scale seed production technology of these species needs to be developed.

Other than shrimps, lobsters *(Thenus unimaculatus, Panulirus homarus homarus* and *P. ornatus)* and marine crabs *(Portunus pelagicus)* are the other shellfish with high potential for culture with very high demand in domestic as well as international markets. However these species are mainly cultured with wild collected seed or adults for fattening due to lack of hatchery produced seeds. Thus the currently available nascent seed production technology must be standardized to meet the demand. Sea urchins like *Stomopneustes variolaris* and *Echinometra mathaei* have considerable demand for local fisherman communities. The life history, breeding and seed production need to be studied for these species.

Region - specific species

Some species like *Sillago sihama, Mugil cephalus, Protonibea diacanthus* and *Otolithoides biauritus* have localized market demand in some parts of the country. Although it is in a small scale, the demand is rising due to depleting wild catch. To supplement their capture fishery, it is very essential to develop their breeding and seed production technology to support their culture practices. Although *Mugil cephalus* has a patchy demand within and outside the country, it is a well-established farmed fish consumed in fresh and preserved condition. As its farming mainly relies on wild collected seeds, it is essential to develop its breeding and larval rearing technology to further develop its farming as well as to conserve the resource in the wild. The fishery of *Sillago sihama* is drastically decreasing but it has a high demand along the west coast of India. The air bladders of *Protonibea diacanthus* and *Otolithoides biauritus* make it a very lucrative candidate for mariculture. Thus research needs to be initiated in the direction of broodstock development and hatchery technology for *Sillago sihama, Protonibea diacanthus* and *Otolithoides biauritus.*

Conservation

Among the species identified for conservation, the most important are *Hippocampus kuda, Hippocampus trimaculatus* and *Holothuria scabra* for which seed production technologies are very well developed. These technologies must be used to produce quality seed on a large scale for ranching to increase their wild populations. Other species recommended for conservation, like

Holothuria spinifera and *Epinephelus* lanceolatus need to be studied for their biology to develop their breeding and seed production for ranching purposes.

Ornamental species (Teleosts/Invertebrates)

Many marine ornamental species of commercial importance have not been produced successfully under controlled conditions due to their delicate life cycle and environmental requirements. Although breeding and seed production of many ornamental fish species has been achieved, seed production is limited to small scale hatcheries due to many constraints such as difficulty in broodstock development and poor larval survival. These issues need to be addressed urgently to boost up their culture industry as well as for promotion of their export. *Pinctada fucata* and *Pinctada margaritifera* are valuable species for the pearl industry. A cost-effective hatchery technology needs to be developed for these two species. The other molluscan species included in this book enjoy a good demand in the ornamental shell craft industry for making ornaments like pearl buttons, pendants, ear rings, necklaces, bangles and decorative items. However, information is lacking on their life history and breeding which in turn is an obstacle for their culture.

Reference

Venkataraman, K. and Mohideen, W. 2005. Coastal and marine biodiversity of India. Indian J. Mar. Sci., 34(1): 57-75.

SPECIES ALREADY STANDARDISED

Food Fishes

Finfishes

1. *Epinephelus coioides*
2. *Trachinotus blochii*
3. *Trachinotus mookalee*
4. *Rachycentron canadum*

SPECIES PRIORITIZED FOR FIRST FIVE YEARS

Food Fishes

Finfishes

1. *Caranx ignobilis*
2. *Gnathanodon speciosus*
3. *Lutjanus argentimaculatus*
4. *Lutjanus johnii*
5. *Trachinotus mookalee*

Mollusca

1. *Crassostrea madrasensis*
2. *Perna viridis*

Crustaceans/Other Invertebrates

1. *Portunus pelagicus*
2. *Thenus unimaculatus*

Region specific species for mariculture

1. *Mugil cephalus*

Conservation/Sea-ranching

1. *Hippocampus kuda*
2. *Holothuria (Theelothuria) spinifera*

Ornamental species (Teleosts/Invertebrates)

1. *Centropyge flavipectoralis*
2. *Chromis viridis*
3. *Chrysiptera cyanea*
4. *Dascyllus aruanus*
5. *Dascyllus trimaculatus*
6. *Nemateleotris decora*
7. *Neoglyphidodon oxyodon*
8. *Pomacentrus pavo*
9. *Pseudochromis dilectus*
10. *Entacmaea quadricolor*
11. *Pinctada fucata*
12. *Pinctada margaritifera*

SPECIES PRIORITIZED FOR SIXTH YEAR ONWARDS

Food Fishes

Finfishes

1. *Acanthopagrus berda*
2. *Caranx sexfasciatus*
3. *Coryphaena hippurus*
4. *Cromileptes altivelis*
5. *Eleutheronema tetradactylum*
6. *Epinephelus malabaricus*
7. *Katsuwonus pelamis*
8. *Lethrinus lentjan*
9. *Lethrinus nebulosus*
10. *Pampus argenteus*
11. *Pampus chinensis*
12. *Parastromateus niger*
13. *Psettodes erumei*
14. *Siganus canaliculatus*
15. *Thunnus albacares*

Mollusca

1. *Marcia opima*
2. *Meretrix meretrix*
3. *Paphia malabarica*
4. *Perna indica*
5. *Tegillarca granosa*

Crustaceans/Other Invertebrates

1. *Panulirus homarus homarus*
2. *Panulirus ornatus*
3. *Echinometra mathaei*
4. *Stomopneustes variolaris*

Region specific species for mariculture

1. *Sillago sihama*
2. *Otolithoides biauritus*
3. *Protonibea diacanthus*

Conservation/Sea-ranching

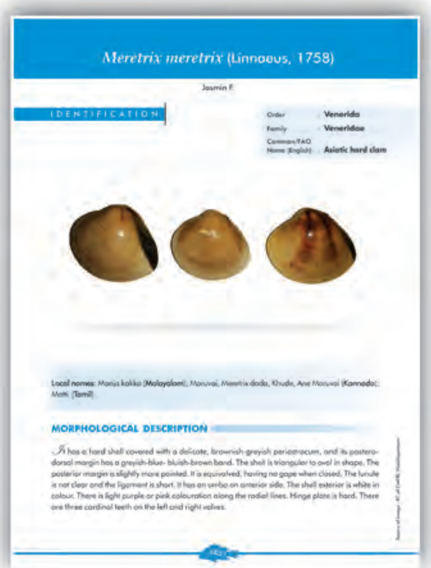
1. *Epinephelus lanceolatus*
2. *Hippocampus trimaculatus*
3. *Holothuria (Metriatyla) scabra*

Ornamental species (Teleosts/Invertebrates)

1. *Labroides dimidiatus*
2. *Platax teira*
3. *Pomacanthus semicirculatus*
4. *Pseudanthias squamipinnis*
5. *Lysmata amboinensis*
6. *Periclimenes brevicarpalis*
7. *Petrarctus rugosus*
8. *Heteractis magnifica*
9. *Stichodactyla gigantea*
10. *Cladiella australis*
11. *Xenia elongata*
12. *Cypraea tigiris*
13. *Lambis lambis*
14. *Placuna placenta*
15. *Spondylus layardi*
16. *Tectus niloticus*
17. *Tridacna maxima*
18. *Turbo marmoratus*
19. *Volachlamys tranquebaria*

Lilac colour depicts species already standardised

Green colour depicts species prioritized for the first five years



Blue colour depicts species prioritized from 6^{th} year onwards

FOOD FISHES
FINFISHES

Epinephelus coioides (Hamilton, 1822)

Ritesh Ranjan

IDENTIFICATION

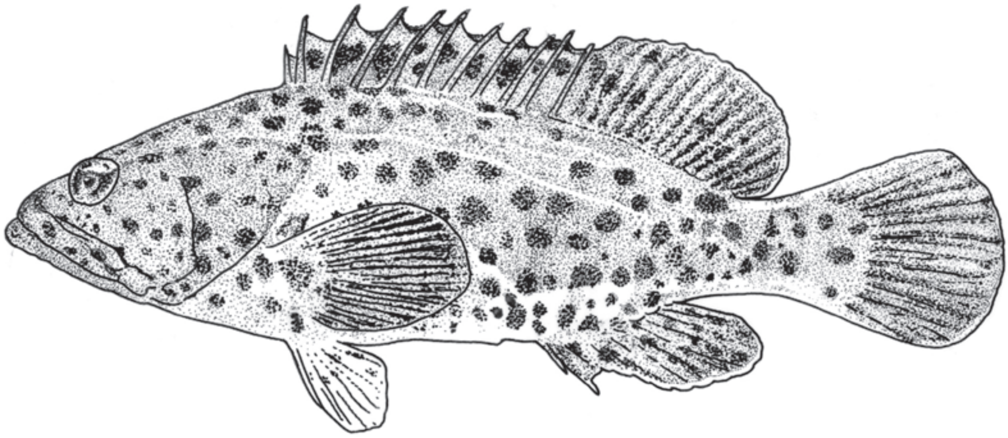
Order	:	**Perciformes**
Family	:	**Serranidae**
Common/FAO Name (English)	:	**Orange-spotted grouper**

Local Names: Hekaru, Gobra **(Marathi)**; Gobri, Wekhanu **(Konkani)**; Gopra, Muni meenu **(Kannada)**; Kalawa **(Malayalam)**; Kalava **(Tamil)**; Ratibonta, Bontha, Kodi punju **(Telugu)**; Bhala (Oriya)

MORPHOLOGICAL DESCRIPTION

Light greyish-brown dorsally, shading to whitish on sides and ventrally, with numerous small brownish orange or reddish brown spots on head and body and median fins; 5 slightly diagonal greyish brown bars on head and body which bifurcate ventrally, the first 4 extending basally into dorsal fin; brownish orange spots on body tend to be arranged in rows parallel to dark bars, this more evident on smaller than larger fish; large dark greyish brown blotches usually present on head, the most prominent behind the eyes and on opercle; fins whitish to light dusky with brownish orange to brown spots except distally on spinous portion of dorsal, caudal and pectoral fins. Small individuals of this species closely resemble *E. tauvina* and *E. malabaricus,* but have orange spots and lack hexagonal spots on the fins; body scales ctenoid except for nape, back, thorax, abdomen and above anal fin base with

Source of image : CMFRI, Kochi



cycloid scales, teeth on midside of lower jaw in 2 rows; nostrils subequal; serrae at corner of preopercle moderately enlarged; maximum depth of body 2.9-3.7 in SL; rounded caudal fin; short pelvic fins, 1.9-2.7 in head length; fourth dorsal spine usually longest; membranes of spinous portion of dorsal fin incised; pelvic fins not reaching anus. Dorsal spines (total): 11; Dorsal soft rays (total): 13-16; Anal spines: 3; Anal soft rays: 8; lateral-line scales 58-65; anterior lateral-line scales of adults branched; longitudinal scale series 100-118; gill rakers 8-10 + 14-17; pyloric caeca about 50 in total.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Orange- spotted grouper occurs in the western Indian Ocean from the southern Red Sea to Durban (South Africa) and east to the western Pacific where it is distributed from Ryukyu Islands (Japan) to New South Wales. It ranges east into Oceania only to Palau in the Northern Hemisphere and Fiji in the Southern. It has also migrated through the Suez Canal to the eastern Mediterranean. In India, this species is distributed all along the Indian coast from Gujarat to West Bengal including Andaman and Nicobar Island.

HABITAT AND BIOLOGY

Epinephelus coioides inhabit wide range of habitats including shallow reefs, lagoons, brackish water, over mud and rubble in depth to at least 30 m. Juveniles are commonly reported in the shallow waters of estuaries over sand, mud and gravel and among mangroves. *E. coioides* are eurythermal and euryhaline. It feeds mainly on fish followed by crabs, shrimps, squids, gastropods and bivalves.

Epinephelus coioides is a diandric protogynous species, where males are either derived from a juvenile phase or the transition of post spawning females. Females mature at 320 mm total length(TL) at an age of 2 years, whereas primary males mature at 242 mm TL at an age of 1 year. The sexual transition occurs at a TL of 550-750 mm at the age of 5-6 years. The major spawning period is March to June. In the southern Persian Gulf, spawning has been documented from March to May. In New Caledonia, spawning aggregations form in late October to early December. They probably spawn during restricted periods and form aggregations for spawning after the full and new moon. Fecundity estimates varied from 8,50,186 ova in a 350 mm TL fish to 29,04,912 ova for 620 mm TL. Eggs and early larvae are pelagic.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

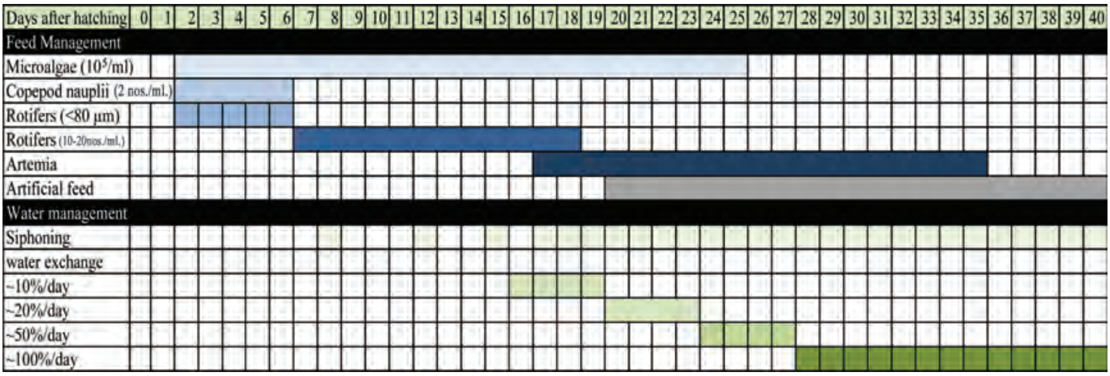
Usually brooders of *Epinephelus coioides* are collected from wild and reared in cages or tanks @ 1 kg/m^3 using sea water at a constant temperature of 27-29 °C and salinity 30-32 g/l. The fishes were either reared for a longer time (1-7 years) or were treated with hormonal manipulation for obtaining the male brooders. The fishes were fed with squid, sardine and clam @ 3-5 % body weight.

Fishes either spawned naturally or were induced to spawn with the help of human chorionic gonadotropin (hCG). At Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute, India, broodstock development was carried out in re-circulatory aquaculture system(RAS). The brooders spawned naturally in tank.

LARVAL REARING

Eggs were collected from spawning tank and were stocked in aquarium tank for segregating the floating eggs from the dead eggs. The floating eggs were collected and stocked at 200 nos/l in hatching tank and were incubated for 18- 20 h at 29-30 °C with moderate aeration until they hatched. The newly hatched larvae were collected from the water surface by glass beakers and transferred to larval rearing tanks. Alternatively, the floating eggs were also directly stocked in larval rearing tanks @ 10 nos/l for hatching as well as for larval rearing.

Larval rearing was conducted using 2, 5 and 10 m^3 concrete or FRP tanks with a minimum of 1 m water depth. Different authors have reported various methods for larval rearing. The most appropriate feeding and water management protocol established at Visakhapatnam for semi-intensive rearing of *E. coioides* larvae is given below:



NURSERY REARING

Two production systems are used for the nursery stage - indoor and outdoor. The indoor system uses tanks of different sizes while the outdoor system uses hapa in ponds as well as in cage or directly pond itself.

INDOOR SYSTEM

Tanks of different sizes (30 to 50 m^3) were used in either semi-intensive or intensive nursery rearing. Tanks were stocked with 2.5 cm fry at 50-200/m^3. Higher densities (> 1000/m^3) were stocked in flow-through or re-circulatory aquaculture systems. Sorting and grading are essential during the nursery phase. Fishes were fed to satiation either with high protein formulated feeds of various sizes or with finely chopped frozen or fresh fish mixed with a vitamin-mineral premix 4-6 times/day. Once the fish reached 6-8 cm, they were transferred to grow-out ponds or floating cages.

OUTDOOR SYSTEM

Hatchery reared or wild-caught fry were stocked in ponds or hapa nets until they reached 6-8 cm. Hapa nets (1 x 2 x 1.5 m; of 2 mm mesh size) were set in ponds or inside floating net cages and were stocked with fry of 2.5 cm @ 1000-2000 nos./net. The fishes were graded once in every 5-7 days until they reached 6-8 cm after 45-60 days. Fishes were fed to satiation (4-6 times/day) either with high protein formulated feeds of various sizes or with finely chopped frozen or fresh fish mixed with a vitamin-mineral premix.

GROW-OUT

Orange spotted grouper are cultured both in ponds and cages. However, they are preferably cultured in cages.

EARTHEN POND SYSTEMS

Ponds were prepared and fertilized for production of natural phytoplankton and zooplankton. Once natural food is abundant, adult tilapia were stocked at density of 5000-10000 nos./ha to produce fingerlings to serve as live food for the groupers. After one month of stocking tilapia, grouper fingerlings (6-8 cm TL) were stocked at the rate of 5000-10000 nos./ha. If tilapia fingerlings are not abundant, supplementary feeding can be carried out using chopped fish at 5 % of grouper fingerlings body weight (BW) per day, divided into two rations, in morning and late afternoon. When the fish reached an average size of 200 g, feeding was reduced to once daily with fresh or frozen chopped fish at 5 % BW or with pellets at 2 % BW. Around 20-50 % water was exchanged at least twice in a week. Paddle wheel aerators were used when DO fell below 4 mg/l. Water quality was maintained at pH 7.5-8.3, temperature 25-32 °C, salinity 20-35 g/l, DO 4-6 mg/l; NO_2-N <0.05 ppm and NH_3-N <0.02 mg/l.

FLOATING NET CAGE SYSTEMS

Floating net cages are used for culturing grouper. Eight mm mesh size is used for stocking 8-10 cm fingerlings whereas, 25 mm mesh are used for larger fishes. Grouper fingerlings were stocked at 15-20 nos./m^3. Fishes were fed with fresh or frozen chopped fish daily at 10 % BW or with pelleted feeds at 3 % BW, divided into two rations in the morning and late in the afternoon. Around 0.5 % vitamin and mineral premix is added to the properly thawed trash fish before feeding. The duration of culture in the grow-out phase was 6-12 months and depended on the preferred size at harvest.

FOOD AND FEEDING

Orange spotted groupers are carnivorous in nature. They require feed containing 45 % protein for optimal growth. They are fed on fresh/frozen trash fish or artificial pellet.

GROWTH RATE

The rearing system was found to influence the growth rate, where highest average daily weight gain of 0.59 g/day observed in RAS, followed by 0.4 g/day in pond and 0.26 g/day in cement tanks after one month when stocking fingerlings of 2-3 g and feeding with 45 % pellet feed @ 10 % body weight daily. Advanced orange spotted grouper fingerlings (15-20 g) had grown to 770.67±32.51 g and 35.28±0.87 cm after 9 months and 1014±82.44 g and 41.53±0.91 cm after 12 months of grow-out in cages.

DISEASES AND CONTROL MEASURES

The rapid development of *Epinephelus coioides* culture has led to the incidences of infectious diseases caused by bacteria, viruses and parasites that have become more and more severe which have resulted in serious economic losses in farms and hatcheries. The list of disease causing organisms reported in *E. coioides* and their control measures are listed below.

Disease & Causative agent	Control measures
Bacterial diseases	
Vibriosis (*Vibrio* sp.) *V. carchariae*	OmpK vaccination; freshwater bath for 10-15 minutes; oxalinic acid mixed with feed at 20 mg/kg of fish; terramycin added to feed at 7.5 g/kg for 5 days, reduced to 3.75 g/kg for the succeeding 5 days and prefuran bath treatment for 1 h at 2 mg/l
Pseudomonas spp.	-
Acinetobacter sp.	-
Viral infections	
Nervous necrosis virus (*Betanoda virus* sp.)	Screening of broodstock both pre- and post-spawning; disinfection of fertilized eggs using ozone or iodine; proper hatchery management; vaccination of fish
Singapore grouper irido virus	Follow best management practice
Grouper irido virus	Follow best management practice
Noda virus	Follow best management practice
Megalocyti virus	Follow best management practice
Parasitic disease	
Cryptocaryon irritans	Immobilized vaccination; freshwater bath for 1 h over 2-3 days; 0.5 mg/l copper sulfate ($CuSO_4$) treatment 2-3 times at 3-days interval for 5-7 days with strong aeration and the infected stocks should be transferred to parasite-free tanks.
Trichodina sp.	Bath with freshwater for 1 h for 3 days; 200 mg/l formalin bath for 30-60 minutes with strong aeration and 25-30 mg/l formalin treatment for 1-2 days
Neobenedenia girellae	Freshwater bath for 5-10 minutes and 150 mg/l hydrogen peroxide (H_2O_2) bath for 10-30 minutes
Lepeophtheirus sp.	Freshwater bath for 10-15 minutes; 150 mg/l hydrogen peroxide (H_2O_2) bath for 30 minutes and 200-250 mg/l formalin bath for 1 h
Gonapodasmius epinepheli	The intermediate hosts (gastropod molluscs) should be eliminated from the culture facility
Pseudohabdosynchus lantauensis	250 mg/l formalin bath for 2 h and 200 mg/l hydrogen peroxide (H_2O_2) bath for 1 h

Philometra sp., *Anisakis* sp. and *Raphidascaris* sp	Avoid feeding with infected trash fish; eliminate intermediate hosts (copepods); dry the pond bottom and disinfect the culture facilities with quicklime to destroy the eggs of the nematode
Rhexanella sp.	Manual removal; 200 mg/l formalin bath for 30-60 minutes and disinfect infected facility by drying the pond bottom for several weeks followed by liming
Zeylanicobdella arugamensis	Manual removal using wet cloth; 200-250 mg/l formalin bath for 1 h and culture facilities must be cleaned with detergent, disinfected with chlorine and exposed to intense sunlight for several weeks prior to use to eliminate cocoons of the parasite
Riboscyphidia sp., *Vorticella* sp., *Dactylogyrus* sp.	Follow best management practice

PRODUCTION, MARKET AND TRADE

PRODUCTION

The global production of groupers has increased tremendously because of its escalated demand with 60,774 t, 99,378 t, 1,63,093 t, and 1,98,690 t being produced in 1990, 2000, 2005, and 2007 respectively. The orange spotted grouper production from aquaculture was 596 t in 2015.

MARKET AND TRADE

Groupers form the basis of the multimillion-dollar live reef food fish (LRFF) trade based in Hong Kong. Live Reef Food Fish (LRFF) are supplied by around 20 countries in the Asia-Pacific region and at least 60 % of the international trade is through export to Hong Kong where, as much as 50 % is re-exported to mainland China. The majority of the live marine fish consumed in Hong Kong is imported by sea or air.

The major grouper supplier countries are Indonesia, People's Republic of China, Pakistan, Philippines and Malaysia. Hong Kong is the largest consumer of LRFF worldwide with around 60% of the trade arriving by air. In 2008, the import by air of live grouper alone into Hong Kong totalled 6,766 t worth US$ 101 million. Austrade reported that in 2009 Hong Kong imported more than 38,000 t of live fish. Singapore is the second largest market in the region for live grouper, importing 1,228 t worth US$ 10 million in 2008. China imported 6,111 t and 7,711 t live food fish (mainly reef fish) in 2008 and 2009 respectively. Live groupers fetched higher prices than any other group of top-graded fish, and a price of 3-5 times or more is paid for live specimens of the right size (600-1000 g). A premium is also paid on products with "clean", "green" and "organic" credentials (10 % - 50 % premium for foods carrying China's Green Food certification). The wholesale price of live market-size orange spotted grouper was about US$ 21.45/kg (11.70 to 40.30/kg) in December 2016 in Hong Kong and other South East Asian countries. The price of orange spotted grouper is around ₹400/kg in India.

CHALLENGES TO MARICULTURE

Visakhapatnam Regional Centre of ICAR-CMFRI, Visakhapatnam, Andhra Pradesh, India has developed the technology for broodstock development, larval rearing, nursery rearing and grow-out culture of the species. However, the following researchable issues need to be sorted out for this species in India.

High density larviculture with high survival rate

Standardization of culture protocol in different culture systems

Standardization of feed for culture

Disease management

FUTURE PROSPECTS

Groupers are ideal candidate species for intensive aquaculture particularly in the Asia-Pacific region because of high consumer demand, desirable taste, hardiness in a crowded environment, fast growth and efficient feed conversion. Groupers are popular carnivorous fish with a high market demand in many parts of the world, such as in Kuwait, Indonesia, Singapore, Malaysia, Thailand, Philippines, Hong Kong, Taiwan, China, Mexico, Japan, and the USA. Orange spotted grouper fetches very high price of US$ 21.45/kg (varying from 11.70 to 40.30 $/ kg) in international market (Hong Kong and other South East Asian countries). It also fetches a fairly good price (₹ 400/ kg) in Indian domestic market. Orange-spotted grouper are cultured either in ponds or cages and being euryhaline, it thrives well in even brackishwater environment. Thus, it possesses a good prospect for the Indian farmer as an alternate species to compensate the decrease in shrimp production caused by environmental and pond deterioration.

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Trachinotus blochii (Lacepède, 1801)

A. K. Abdul Nazar, R. Jayakumar and Ritesh Ranjan

IDENTIFICATION

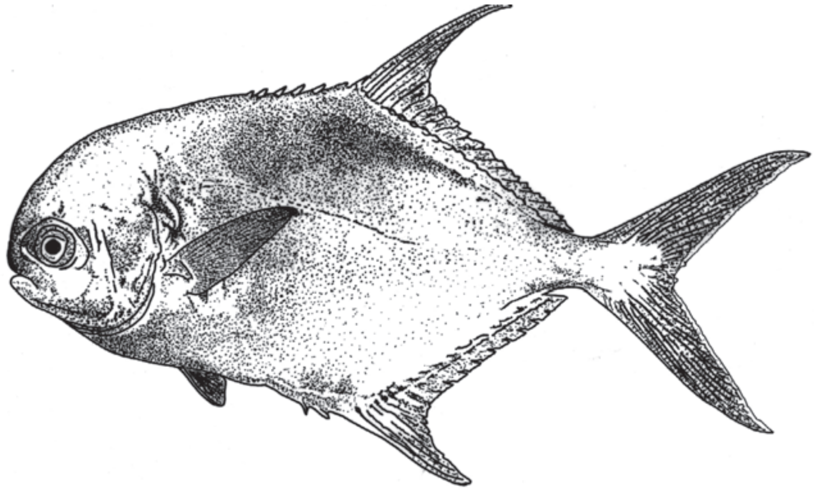
Order	:	**Perciformes**
Family	:	**Carangidae**
Common/FAO Name (English)	:	**Snubnose pompano**

Local Names: Katattitaka, Ladagoo **(Marathi)**; Manjavela, Peeyada, Valodivatta **(Malayalam)**; Sevani parai **(Tamil)**; Sanduva paara, Kootili **(Telugu)**

MORPHOLOGICAL DESCRIPTION

The snubnose pompano has a fusiform body shape, exhibiting a general oval shape, elongated towards the posterior end. Gill rakers are 9-12. Body ovate in young to subovate in large adults and compressed with depth of 5 cm; profile of snout broadly rounded, in adults becoming nearly straight to interorbital region; both jaws with bands of small villiform teeth; tongue toothless (except 2 or 3 slender teeth rarely on small specimens). Two separate dorsal fins, with first six short spines (the anterior spines often becoming completely embedded in large adults) followed by one spine and 18 to 20 soft rays; two anal fins, with first two detached spines (becoming embedded in large adults) followed by one spine and 16 to 18 soft rays; height of second dorsal fin lobe 35 to 60 percent of fork length in specimens of 10-40 cm fork length; pelvic fins shorter than pectoral fins, lateral line

Source of image : CMFRI, Kochi



only slightly irregular, weakly convex above pectoral fin, becoming straight posteriorly. No scutes or caudal peduncle grooves. First pre-dorsal lobe shaped like an inverted tear-drop or oval shaped, this character is easily observed by a simple dissection along mid line of nap, supra occipital bone of skull thin and blade like in adults. Vertebrae 10+14.

Colour: Head and body generally silvery, blue grey above, paler below; large adults occasionally golden yellow especially snout and lower half of body. Second dorsal fin dark, lobe of fin dusky orange; anal fin dusky dirty orange, lobe with a brownish anterior margin; caudal fin dark to dirty orange with leading edges of fin darkest. Pelvic fins white to dirty orange, pectoral fins dark. Juveniles silvery with pale fins except lobes of median fins and anterior half of pelvic fins which are brownish to dirty orange.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Snubnose pompano are distributed throughout the Indian Ocean. It is also found in the Indo-West Pacific, from southern Japan to northern Australia and Lord Howe island, and eastward to Samoa, Tonga, Marina and Marshall islands. In addition, this species has been reported from Atlantic Ocean. In India, this species is distributed all along the Indian coast from Gujarat to West Bengal including Andaman and Nicobar Island.

HABITAT AND BIOLOGY

Trachinotus blochii inhabits shallow, coastal waters over coral and rocky reefs. Juvenile snubnose pompano are commonly found in sandy areas or near sandy-clay estuaries. It is occasionally observed in small schools. Snubnose pompano is reported in depths from 0.4 to 55 m, however invariably they are found in areas of less than 7 m depth. Their maximum recorded total length is 65 cm (5 kg).

Trachinotus blochii diet consists of crabs, mussels and worms. It feeds mainly on fish followed by crab, shrimp, squid, gastropod and bivalve. At the juvenile stage they tend to group together, becoming solitary as adults and they feed on sand molluscs and other invertebrates. Juvenile pompano is apparently an opportunistic feeder. It is observed to be a planktivore, primarily consuming copepods and some benthic organisms including polychaetes.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Breeding and seed production of *Trachinotus blochii* was successfully standardised at Mandapam Regional Centre of ICAR-Central Marine Fisheries Research Institute. Adults or sub-adults of *Trachinotus blochii* were collected from wild and reared in cages or tank for broodstock development. Fishes were fed on low value fish and squid supplemented with vitamins and mineral premix @1 % of the food ad libitum daily. The fishes were cannulated on reaching 1.0 kg size to assess the gonadal maturity as well as sex. Fishes were conditioned through photo-thermal regulation to accelerate the gonadal maturity. The matured brooders spawned naturally or by hormonal induction. However, induced breeding was most commonly practiced. Once the intra-ovarian eggs attained 450-500 μm sizes, fishes were induced to spawn by using human chorionic gonadotropin (hCG) at the rate of 350 IU/kg body weight for male and female as a single dose. Alternatively, gonadotropin-releasing hormone (GnRH) was used at a dosage of 150 μg/kg body weight in both sexes. Snubnose pompano generally spawned after 36-48 h and 18-36 h of hCG and GnRH injection respectively. The buoyant fertilized eggs were scooped gently using 500 μm net. The collected eggs were incubated @ 200-500 eggs/l in glass jar aquarium or in tank. The hatching of eggs occurred 18 to 24 h after fertilization. Subsequent spawnings of snubnose pompano were achieved at an interval of 30-35 days, when maintained in the RAS with photo-thermal regime.

LARVAL REARING

Green water technique was employed for larval rearing. The newly hatched larvae were stocked at a density of 5 larvae per litre of water. The tanks were provided with mild aeration and green water i.e., *Nannochloropsis occulata* at a cell density of 10^5/ml. The mouth of the larvae opened on 3rd day of post-hatch (dph) with a mouth size of around 230 μm. The larvae were fed from 3 dph to 10 dph with enriched rotifers at a density of 5-6 rotifers/ml, wherever possible wild collected copepods were added as supplements. Enriched *Artemia* nauplii were provided at a density of 1-2/ml during 8-19 dph. Weaning to larval inert feeds began on 15 dph. From 25 dph onwards, feeding was entirely on larval inert feeds. The metamorphosis of the larvae started from 18 dph and all the larvae metamorphosed into juveniles by 25 dph. Critical stages of larval rearing where maximum mortality occurred, was during 3-5 dph and subsequent mortalities were negligible. The water exchange was practically zero until 7 dph and from 8-14 dph, it was gradually increased from 10-100 % daily.

NURSERY REARING

Nursery rearing of fingerlings was carried out for a period of 2 to 3 weeks for growing them to stockable sizes of 2 g and for grow out culture in cages, it was reared for 4-5 weeks till the juveniles reached a size of about 15 g. Two production systems were used for the nursery stage - indoor and outdoor. The indoor system used tanks of different sizes, while the outdoor system used hapa in ponds as well as in cage or directly the pond itself.

INDOOR SYSTEM

Fry of 25-30 days old were reared in indoor tank system till it reached a size of 2.5-3.8 cm. After 25-30 dph, the fry were fed with artificial feed of 800 μm size. Thereafter, fingerlings were fed with progressively larger size ranges of floating extruded pellet feeds. Daily water exchange of 100 percent was recommended. After 55 dph, the fingerlings with size ranging from 2.5-3.8 cm were supplied to farmers for stocking in hapas or ponds or cages for further nursery rearing and grow-out thereafter.

OUTDOOR SYSTEM

The nursery rearing of juveniles was carried out in tanks or hapas / pens fixed inside ponds or sea cages fitted with smaller mesh nets. When the nursery rearing was carried out in cages or in hapas/ pens inside ponds, the nets were cleaned or brushed daily to maintain the free flow of seawater. When indoor nursery was practiced, proper water quality and optimum aeration was maintained in the tanks. Suitable sized formulated floating pellet feeds (1000-1800 μm diameter) were provided during nursery rearing. Floating pellet feed containing 40-50 % crude protein and 10 % crude fat were more suitable for successful nursery rearing. For reducing the grow out period of pompano from 8 months to 4 months, nursery rearing was continued until the fish reached 100 g size in dedicated nursery pond/cage.

GROW-OUT

Snubnose pompano are cultured in ponds, pens and cages. In Vietnam, cage farming of snubnose pompano is well developed by feeding with trash fish and extruded pellet feeds. In India, ICAR-CMFRI has undertaken farming trials in freshwater ponds, brackishwater ponds and cages installed in the sea. Among all methods, farming of snubnose pompano in low saline brackish water ponds yielded good harvest.

The fishes grew from 2.5-3.0 cm size of weight 1.5-2.0 g to 250-300 g after 240 days with a survival of 45 % in freshwater culture (zero salinity) in earthen pond. In brackish water, it grew to 450-500 g after 240 days culture with a survival of 94 %. The fishes were fed with floating pellet feed containing 32 % crude protein and 6 % crude fat. In pond farming, it is advisable to stock 1-1.5

nos./m^3. Water quality parameters like optimal algal bloom, pH and dissolved oxygen were maintained by exchanging 10 % of the water once a week for the initial period of three months; 20 % per week after 3 months and 30 % per week after 6 months. If water colour was too dark due to algal bloom, the quantum of water exchange was proportionately increased. Use of paddle wheel aerators was necessary whenever the dissolved oxygen level was lower than 4 mg/l.

Open sea cage farming was attempted in the Gulf of Mannar side of Vedalai Village, Ramanathapuram District, Tamil Nadu, India. About 4,000 fingerlings of 2.5 to 3.0 cm size weighing 1.5 to 2.0 g were stocked initially in hapas (10 m × 10 m) erected in the sea. Fishes were fed with chopped low value marine fishes. Once the pompano fingerlings attained 25 g they were shifted to galvanized iron cages of dimensions 4 m × 4 m × 3 m. Fishes reared in the cage were fed with chopped, low value fishes. After 240 days of culture, the fishes attained only 250-275 g with a survival rate of 72 %. A stocking density of upto 20 nos./m^3 is possible in sea cages.

FOOD AND FEEDING

Snubnose pompano are carnivorous in nature. They require feed containg 45 % protein for optimal growth. They are fed on fresh/frozen trash fish or artificial pellet.

GROWTH RATE

The fish grew from 2.00±0.04 g to 464.65±10.25 g in brackish water ponds whereas it grew to 250-275 g in sea cages during a culture period of 240 days.

DISEASES AND CONTROL MEASURES

Several types of diseases associated with poor water quality management are noticed in the adults, juveniles and fingerlings. Among the microbial diseases, vibriosis, a bacterial disease causing significant losses of fish in farms is frequently encountered. Vibriosis resulted in severe skin, muscle, fin, eye and internal organ damage of the fish. Diseases caused by protozoans and metazoan ectoparasites resulted in severe health issues in juveniles and adult pompano. Proper treatment of hatchery and farm water and biosecurity measures addressed most diseases. Mass mortalities in the farm occurred mainly due to the outbreak of vibriosis and protozoan parasites.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Commercial production of snubnose pompano appeared to have begun in Asia in the early 1990s in Singapore, with much of the production destined for markets in Hong Kong by 1995. By the later part of the 2000s, production had expanded in China, and today it is reported to be over 1,10,000 t annually. Outside China, significant production has been recorded in Vietnam and Indonesia. In Vietnam, approximately 700 t a year of snubnose pompano have been produced by marine farms. In recent years, limited amounts of snubnose pompano production has commenced in other Asian countries, including Malaysia, India and Philippines.

MARKET AND TRADE

The availability of snubnose pompano from the wild is scarce and irregular, and hence the growing demand can be met only through aquaculture. In the international market, the dockside price of snubnose pompano averaged to US$ 8 /kg, though there is significant country variation. Indeed, in India, the current price of snubnose pompano is about US$ 2.78 /kg at the fish landing centres and around US$ 5.30 /kg in the retail markets.

CHALLENGES TO MARICULTURE

The Mandapam Regional Centre of ICAR-CMFRI has developed the technology for broodstock development, larval rearing, nursery rearing and grow-out culture of this species. However, there are several researchable issues which need to be sorted out for this species in India.

Year round spawning and seed production
High density larval rearing
Enhancement of larval survival
Cage culture of the species under different environmental parameters
Mixed culture prospects of the species with shrimp
Standardization of feed for grow out culture (artificial feed vs low value fish)
Disease management

FUTURE PROSPECTS

Snubnose pompano is one of the topmost candidate species for mariculture, owing to its fast growth, good meat quality and high market demand. This species is cultured in varying salinity, which is suitable for coastal mariculture in India. Additionally, the seed production technology is available in India. Thus, this species is a good candidate species for mariculture if the seed production and farming technology percolates to the aquaculture industry.

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Trachinotus mookalee Cuvier, 1832

Ritesh Ranjan, A.K. Abdul Nazar and Rengarajan Jayakumar

IDENTIFICATION

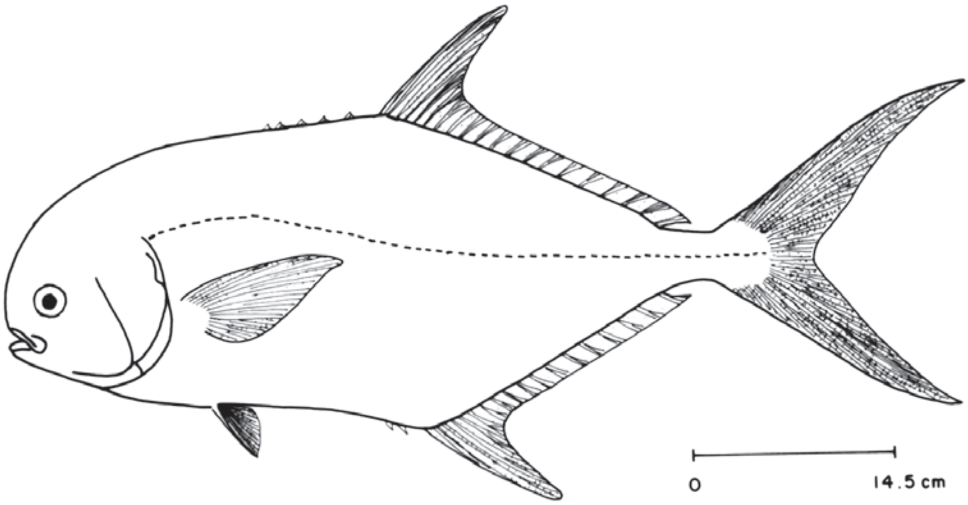
Order	:	**Perciformes**
Family	:	**Carangidae**
Common/FAO Name (English)	:	**Indian pompano**

Common names : Mooku para (**Telugu**); Aavoli para, Valavodu, Vella-odu (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

Body ovate in young to sub-ovate in large adults and compressed; profile of snout broadly rounded, in adults becoming nearly straight in the inter-orbital region. Both jaws with bands of small villiform teeth; tongue with a narrow band of teeth, persisting to about 50 cm fork lengths; gillrakers (including rudiments) 5-8 upper and 8-10 lower on first gill arch; 2 separate dorsal fins, the first with 6 short spines (the anterior spines often becoming completely embedded in large adults), followed by 1 spine and 18-20 soft rays; anal fin with 2 detached spines (becoming embedded in large adults), followed by 1 spine and 16-18 soft rays; height of second dorsal fin lobe 24 to 34 % of fork length in specimens 10 to 40 cm fork length; pelvic fins shorter than pectoral fins. Lateral line only slightly irregular, weakly convex above pectoral fin, becoming straight posteriorly. No scutes or caudal peduncle grooves. First pre-dorsal bone shaped like an inverted "L" with the arm projecting anteriorly, this character is easily observed by a simple dissection along midline of nape; supra-occipital bone becoming broad and sausage-shaped in specimens larger than about 30 cm fork length. Vertebrae 10+14. In live specimen, head and body generally silvery, greenish to bluish-grey dorsally, paler below; large adults sometimes with body mostly bronze or greenish-golden. Second dorsal and caudal fins dusky yellow, leading edges and fin tips darkest; anal fin bright to dirty yellow, lobe without a brownish anterior margin. Pelvic fins pale yellow to white; pectoral fins dark. Juveniles are silvery with pale yellow fins, except distal half of dorsal fin lobe which is black.

Source of image : RC of CMFRI, Visakhapatnam



PROFILE

GEOGRAPHICAL DISTRIBUTION

Indian pompano is distributed in western Indian Ocean from the Gulf of Oman eastward to Sri Lanka. Its range also extends to Singapore, Gulf of Thailand and Hong Kong. In India it has been reported both from the east and west coasts.

HABITAT AND BIOLOGY

Indian pompano is most common in shallow coastal waters in a number of environments, including coral and rocky reefs and shore faces and tidal flats. The species has a wide salinity tolerance, as evident from the ranges from which juvenile and sub-adult fish are caught in Indian waters. The young fish eventually move to inshore reefs as they mature, before again moving to deeper outer reefs.

The species predominantly takes molluscans (gastropods and bivalves) as prey; however, it supplements its diet with a varied array of other invertebrates and fish. The former includes crustaceans such as shrimps, decapods and copepods. The larger fish on reefs tend to move between reefs regularly, which is thought to be due to prey availability. Studies of different size classes of fish have found their diets change with age in some locations, with the changes relating to an increased volume of fish taken. Diet studies at Visakhapatnam, India have shown that the diet of Indian pompano is dominated by gastropods, bivalves and crabs.

Spawning is known to occur throughout the year depending upon the temperature. Off north Andhra Pradesh, spawning season is thought to be during Feb-April. Fish aggregate in large schools prior to spawning, with pairs breaking off the main aggregation to commence spawning. Size at first maturity estimated at Visakhapatnam was 690 mm TL (approximately 3.9 kg body weight). The smallest mature female fish observed at Visakhapatnam measured 600 mm fork length (FL). The largest specimen recorded was 77 cm FL; 90 cm total length and weighed 8.1 kg. A specimen weighing 9.45 kg has been obtained at Visakhapatnam, India.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Broodstock development, breeding and larval rearing of Indian pompano were carried out at Visakhapatnam R. C. of ICAR-CMFRI, India. The broodstock were developed in 6 m dia cage installed in sea. The cage was stocked with adult and sub adult of Indian pompano (2-4 kg) collected from wild @ 2 kg/m^3 for broodstock development. The fishes were fed twice a day with squids and sardines @ 5 % of body weight supplemented with vitamin and mineral mixture. After one year of rearing in sea cages, the brooders attained a size range of 4 to 5.5 kg. The females weighing 4.0-4.5 kg and males weighing 4.5-5.0 kg were selected and injected with single dose of hCG @ 350 IU/kg and yielded fertilized eggs. Spawning was recorded after 36 h of injection. The size of the fertilized eggs was 950-1000 µm. The eggs hatched out after 22-24 h of incubation at a temperature range of 28-30 °C. The hatching rate was estimated to be 80 %. The broodstock development was also carried out in re-circulatory system at VRC of ICAR-CMFRI, Visakhapatnam. The sub-adults of 650 g were reared in re-circulatory system for developing broodstock. The fishes were fed on squids and clam meat for gonadal development. The female with > 450 μm ova size and oozing male were injected with single dose of hCG @ 350 IU/kg body weight for yielding fertilized eggs. Subsequent spawnings of Indian pompano were achieved at an interval of 35-40 days in re-circulatory aquaculture system.

LARVAL REARING

The newly hatched larvae measured 2.1-2.2 mm in total length. The mouth opening was formed after 42-46 h post hatch. Green water was used for larval rearing. Rotifers were added from 2nd dph onwards @ 10-20 nos./ml. *Artemia* nauplii were used in larval rearing tank from 9th dph. Weaning of larvae with inert diet was started from 15th day. Metamorphosis of the larvae started from 17th day and was completed by 22nd day. The size of the metamorphosed fry ranged from 16 to 17 mm.

NURSERY REARING

The fingerlings were stocked in 2 t capacity FRP tank and were fed with artificial pellet containing 45 % protein and low value fish @ 10 % body weight twice daily. They attained 36 g weight after 2 months of rearing.

GROW-OUT

Information not available

FOOD AND FEEDING

Indian pompano is carnivorous in nature. It feeds upon clam, mussel, fish, shrimp. In culture, it was fed with artificial pellets and low value fish.

GROWTH RATE

Indian pompano grew from 42.80±2.32 g to 126±3.17 g after two months of culture in FRP tank and after 9 months of rearing, fish attained an average size of 969.9±67.5 g.

DISEASES AND CONTROL MEASURES

Parasitic copepod *Caligus* spp. infestation has been observed in broodstock stocked in tanks as well as cages. It can be controlled by giving formalin treatment in freshwater for 15 min regularly for 4 weeks.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Only a small quantity is caught in capture fisheries along the east coast of India, especially along Andhra Pradesh and Tamil Nadu region. The domestic price in India at harbor is around ₹ 200-250/ kg.

CHALLENGES TO MARICULTURE

Visakhapatnam Regional Centre of ICAR-CMFRI, Visakhapatnam, Andhra Pradesh, India has developed the technology for broodstock development, larval rearing, nursery rearing of the species. However, the following researchable issues need to be sorted out for this species in India.

Year round spawning and seed production

High density larviculture with high survival rate

Mixed culture prospects of the species with shrimp

Standardization of culture protocol in different culture systems

Standardization of feed for culture

Disease management

FUTURE PROSPECTS

Preliminary culture has shown good growth with fish attaining 1 kg within 10 months of culture. The domestic demand as well as price is high. Hence if seed production of the species is standardised and transferred to the field it will prove to be a good candidate for fish famers to culture in coastal pond and cages. Thus the species has a good prospect for mariculture in India.

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Rachycentron canadum (Linnaeus, 1766)

A. K. Abdul Nazar and R. Jayakumar

IDENTIFICATION

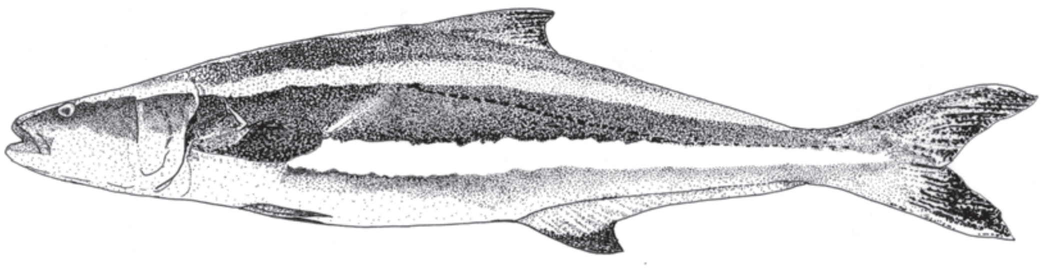
Order	:	**Perciformes**
Family	:	**Rachycentridae**
Common/FAO Name (English)	:	**Cobia**

Source of image : CMFRI, Kochi

Local names: Modasa **(Gujarati)**; Madusa, Maddus, Sakala, Sakla **(Marathi)**; Robal **(Kannada)**; Modha **(Malayalam)**; Kadal viral **(Tamil)**; Nalla matta **(Telugu)**

MORPHOLOGICAL DESCRIPTION

Cobia has an elongated fusiform (spindle-shaped) body and a broad, flattened head. Eyes are small and the lower jaw projects slightly past the upper. Fibrous villiform teeth line the jaws, the tongue, and the roof of mouth. Body of the fish is smooth with small scales. It is dark brown in colour, grading to white on the belly with two darker brown horizontal bands on the flanks. The stripes are more prominent during spawning, when they darken and the background colour lightens. The large pectoral fins are normally carried horizontally. First dorsal fin with 7-9 (usually 8) short but strong isolated spines each depressed into a groove, not connected by a membrane, 28-33 rays. Second dorsal fin long, anterior rays somewhat elevated in adults. Pectoral fins pointed, becoming more falcate with age. Anal fin similar to dorsal, but shorter; 1-3 spines, 23-27 rays. Caudal fin lunate in



adults, upper lobe longer than lower (caudal fin rounded in young, the central rays much prolonged). Scales small, embedded in thick skin; lateral line slightly wavy anteriorly.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Cobia is distributed worldwide in tropical, subtropical and warm-temperate waters of the west and east Atlantic Ocean throughout the Caribbean and in the Indo-Pacific off India, Australia and Japan. In the western Atlantic Ocean, this pelagic fish occurs from Nova Scotia (Canada), south to Argentina, including the Caribbean Sea. It is abundant in warm waters off the coast of United States from the Chesapeake Bay south and throughout the Gulf of Mexico. In the eastern Atlantic Ocean, it ranges from Morocco to South Africa and in the Indo-West Pacific from East Africa and Japan to Australia. Cobia does not occur in the eastern Pacific Ocean.

During autumn and winter months, the fish migrates south and offshore to warmer waters. Cobia prefers water temperatures between 20-30 °C. Seeking shelter in harbors and around wrecks and reefs, the fish is often found off south Florida and the Florida Keys. In early spring, migration occurs northward along the Atlantic coast.

HABITAT AND BIOLOGY

Cobia is found in both coastal and continental shelf waters, although it is typically considered to be an offshore species. They are often found associated with structures in the sea, such as oil and gas platforms, weedlines, buoys, etc. Juvenile fish are found often among Sargassum patches or weedlines where they seek shelter from predators and can feed. It is also found inshore inhabiting bays, inlets and mangroves. It is eurythermal tolerating a wide range of temperatures, from 1.6 to 32.2 °C though it prefers warm water (>20 °C). It is also euryhaline living at salinities of 5 to 44.5 g/l. Cobia are opportunistic feeders and examination of stomach contents have revealed various fish, shrimp, squid, and in particular, crabs. In the northwestern Gulf of Mexico, it spawned multiple times from April to September, with a peak in July. Sexual maturity is reported in males at 1-2 years and in females at 2-3 years, with females growing both larger and faster with maximum sizes up to 60 kg. Spawning occurs in both nearshore and offshore waters where females release several hundred thousand to several million eggs (1.4 mm diameter). A recent study conducted from Indian waters estimated a mean fecundity of 1.24 million eggs. The viable eggs begin development, are heavily pigmented, buoyant, and hatch in approximately 24 h. Cobia larvae grow rapidly and are large in comparison to most marine species.

Maximum ages observed for cobia in the Gulf of Mexico were 9 and 11 years for males and females respectively, while off the North Carolina coast maximum ages were 14 and 13 years. Females reach sexual maturity at 3 years of age and males at 2 years in the Chesapeake Bay region.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

In Taiwan broodstock fishes for spawning were initially caught from the wild; however, after the species became subsequently farmed, 1.5-2 year old cobia (approximately 10 kg) were selected from the grow-out cages and transported to onshore ponds. These spawning ponds (400-600 m^2 and 1.5 m deep) were stocked with 100 adult cobia at a sex ratio of 1:1. They spawn naturally year round, with peaks in the spring and fall when water temperatures were 23-27 °C.

Spawning efforts in the USA have also been successful, utilizing round fiberglass tanks 5.5-6.0 m in diameter and 1.5-1.8 m deep to hold adult cobia. The tanks have an egg collector and are either operated as recirculating systems, flow-through, or a combination of both, depending on the biological filtration capacity of the system. Broodstock collection generally involved capturing and transporting juvenile or adult wild-caught cobia (often during their natural spawning season) into the tank systems, where 2-3 year old fish would spawn either naturally or after being induced with photoperiod and temperature manipulations. Research on maintaining and extending the cobia spawning season in the USA has resulted in the production of fertilized eggs during 10 months of the year thus far, with the goal of realizing year-round egg production in the future.

Being a large fish, broodstock development in FRP/RCC tanks is possible only with recirculating aquaculture system because of its high metabolic rate. Alternatively, broodstock development is more effective in circular (6 meter diameter and 4.5 meter net cage length) or square (5 m × 5m) sea cages. In India, cobia broodstock was developed and induced breeding was achieved for the first time at Mandapam Regional Centre of the ICAR- Central Marine Fisheries Research Institute (CMFRI). The broodstock was developed in sea cages of 6 m diameter and 3.5 m depth. Sexes were separated about two months prior to the onset of breeding season and stocked in separate cages. Female with intra-ovarian egg diameter of 700 μm along with two males were selected for induced spawning.

The brooders were induced with human chorionic gonadotropin (hCG) at doses of 500 IU per kg body weight for females and 250 IU per kg body weight for males. Spawning was noted after 39 h of intra-muscular injection. The total eggs spawned were estimated as 2.1 million. About 90 % fertilization was recorded (fertilized eggs amounted to 1.9 million). The eggs were collected using a 500 μm mesh net and stocked in incubation tanks. The eggs hatched after 22 h of incubation at a temperature range of 28-30 °C.

LARVAL REARING

The fertilized eggs were collected, either from tanks or spawning ponds. After hatching and absorption of the yolk sac (usually by day 3), the larvae were provided with adequate amounts of proper sized feed, such as enriched rotifers (*Brachionus plicatilis*) at the rate of 10-12 nos./ml or copepod nauplii, four times a day till 10 dph. Newly hatched larvae normally measured 3.4 mm size. Larval mouth opens at 3 days post hatch (dph). From 8 dph, the larvae were fed with enriched *Artemia* nauplii at the rate of 1-3 nos./ml, 2-3 times per day. During the rotifer and *Artemia* feeding stage, green water technique was used in the larviculture system with the microalgae *Nannocloropsis occulata* at the cell density of $1x10^5$ cells/ml. Metamorphosis started from 18-21 dph. While weaning the fish larvae from rotifers to *Artemia* nauplii, co-feeding with rotifers was continued due to the presence of different size groups of larvae. The weaning to artificial larval diets was started from 15-18 dph. While weaning, formulated feed was given 30 minutes prior to feeding with live feed. Size of the artificial feed should be smaller than the mouth size of the fish. Continuous water exchange is required during weaning stage. Between 25-40 dph, the larvae are highly cannibalistic and hence size-grading should be undertaken at every four days interval. During this stage, the fry was weaned totally to artificial diets. Larval rearing was practiced both intensively in tanks and extensively in ponds.

The major factors affecting the growth and survival of larvae are nutrition, environmental conditions and handling stress. As there is a high demand for essential fatty acids (EFAs), enrichment are needed for live-feeds. The water exchange was practically nil till 7 dph and it was gradually increased from 10-100 % during 8-12 dph. The environmental conditions required during the larviculture period are DO: > 5 mg/l, NH_3: < 0.1mg/l, pH: 7.8-8.4, salinity: 25-35 g/l, water temperature: 27-33 °C. The rearing density of cobia in tank systems during the early stages remains a challenging aspect of culture that needs to be improved upon for scaling to commercial viability. So far, a modest harvest of 1 fish/l after weaning, regardless of the initial stocking rate is normal, although some promising research in the USA during 2005-2006 has resulted in the production of over 2 fish/l and researchers are hoping to double that number in future trials.

NURSERY REARING

Nursery is carried out in hapas or sea cages or indoor FRP/cement tanks. During nursery rearing, it is advisable to feed the juveniles with formulated feed of 1200 μm size, which can be increased to 1800 μm size from 55 dph onwards. Once the juveniles reach a size of 15 g, they are stocked in sea cages or land based ponds for grow-out farming.

In Taiwan Province of China, the fishes were raised in a series of outdoor ponds until they reached a large enough size to be stocked into a near shore or offshore grow-out cage system. During the larval rearing stage, 'greenwater' nursery ponds <5000 m^2 in area and 1-1.2 m depth with an adequate bloom of *Chlorella*, copepods, and rotifers were utilized. This method typically resulted in larval survival of 5-10 % from hatch to day 20, after which the fishes were moved to two or three pond systems during the next 2 months, depending on the characteristics of the operation. To reduce cannibalism and size variability, cobia were graded weekly after day 45 dph until they reached approximately 30 g (around day 75 dph), which was considered the minimum size for stocking in cages. Cobia were fed 5-6 times a day to satiation at a rate of 5 % body weight up to 30 g; after this the feeding rate was reduced to 2-3 % body weight as the fish approached 200 g. Some producers continue raising the juvenile fish from 30 g up to 600-1000 g in outdoor ponds, while others use smaller (20-200 m^3) near shore cages. From this point onwards the overall goal, whether in ponds or cages, is to raise the young cobia large enough to be stocked into a grow-out cage system, yet small enough to be transported in large numbers with minimal mortality.

GROW-OUT

Trials on sea cage farming carried out at Mandapam, India showed that the fishes attained an average weight of 2.5 kg in six months and 7.3 kg in twelve months. The species was grown in salinity as low as 15 g/l and experiments revealed that the growth and survival at 15 g/l is comparable to that in seawater.

The Taiwanese method, which utilizes outdoor ponds for broodstock and nursery phases, tends to be more extensive when compared to current efforts in the USA, which typically involve tank culture of broodstock and early juveniles. From that point on, however, grow-out methods are similar in both locations, as they utilize net pens or cages of various sizes and types to rear the cobia to harvestable size. Successful grow-out of cobia has been reported in near shore and offshore cages, utilizing both surface and submerged systems during the longest and final stage of production. Taiwanese producers' use 1,000-2,000 m^3 cages, while some operations in the Caribbean have used 3,000 m^3 submersible systems successfully. In order to minimize grow-out time as well as disease issues, cobia produced in cages are located in sites that provide warm (26 ^{0}C and above) clean water and adequate flow rates through the cage system to provide high dissolved oxygen levels continuously. Harvest numbers vary depending on the stocking rates and water temperature, but the grow-out period for pellet fed cobia is generally about 1-1.5 years, with fish reaching a final weight of 6-10 kg at harvest densities of 10-15 kg/m^3.

FOOD AND FEEDING

Cobia being voracious feeders, often engulf their prey whole. They are carnivores, feeding on crustaceans, cephalopods, and small fishes such as mullets, eels, jacks, snappers, pinfishes, croakers, grunts, and herring. A favorite food is crab, hence the common name of "crabeater". Cobia often cruises in shoals of 3-100 fish, hunting for food during migrations in shallow water along the shoreline.

They are also known to feed in a manner similar to remoras. Cobia follows rays, turtles, and sharks, sneaking into scavenge whatever is left behind.

GROWTH RATE

Growth rates of hatchery-reared cobia cultured in submersible cages off Puerto Rico and Bahamas was 6.035 kg (specific growth rate (SGR) = 2.10%/day) in 363 days and 3.545 kg (SGR = 2.04%/day) in 346 days.

Under hypersaline conditions in the Emirates of Abu Dhabi, within a growth period of 12 months, the average body weight attained was 2.87 kg, ranging in size from 1.78 to 3.86 kg. The feed conversion ratio attained was about 2.0.

In India, 37 g fish stocked in cages attained a size of 400 g after 85 days of farming. Similarly, fish of average length 26 cm and weight 118 g attained a size of 47 to 64 cm (average of 57.2 cm) and weight from 0.845 to 1.968 kg (average of 1.4 kg) after 4.5 months of culture in cages.

DISEASES AND CONTROL MEASURES

Parasites of cobia include a variety of trematodes, cestodes, nematodes, acanthocephalans, and copepods as well as barnacles. Thirty individuals of a single trematode species, *Stephanostomum pseudoditrematis*, were found in the intestine of a single cobia taken from the Indian Ocean. Infestations of the nematode, *Iheringascaris inquies* are quite common in the stomachs of cobia. Nephrocalcinosis (kidney stones) cause significant mortality during both the hatchery and grow-out stages. A Sphaerospora-like myxosporean infection caused 90 % mortality in Taiwan.

Disease & Causative agent	Control measures
Bacterial diseases	
Pasteurellosis/*Photobacterium damsela* sub sp. *Piscicida*	No known treatment but vaccine is being developed
Vibriosis/*Vibrio alginolyticus*; *V. vulnificus* and *V. parahaemolyticus*	Administer antibiotics; remove diseased fish; disinfect system; reduce stress
Secondary bacterial infection (after *Neobenedenia* infestation)/ *Streptococcus* sp	Administer antibiotics; remove diseased fish; disinfect system; reduce stress
Viral infections	
Lymphocystis/Iridovirus	No known treatment; disinfect system; quarantine fish
Parasitic disease	
Marine velvet disease; Amyloodiniosis/*Amyloodinium ocellatum*	Copper sulphate pentahydrate; decreasing salinity (freshwater dip); flushing; formalin bath/treatment; mechanical filtration at a minimum of 40 μm

Cryptocaryonosis; marine whitespot/ *Cryptocaryon irritans*	Prolonged copper immersion; freshwater dips; formalin treatment; decreasing salinity to 15 g/l or less for 2 weeks; decreasing system temperature to <19 °C
Sessile, colonial, ciliate infestation/*Epistylis* spp	Formalin treatment; freshwater bath/dip; antibiotics for severe bacterial infection
Trichodinosis/*Trichodina* sp.	Formalin treatment; freshwater bath; copper treatment; praziquantel bath or prolonged immersion
Monogenean infestation/*Neobenedenia* sp.	Formalin treatment; freshwater bath; copper treatment; praziquantel bath or prolonged immersion
Myxidiosis/ Sphaerospora-like myxosporidean	No known treatment; disinfect system; quarantine fish
Coccidiosis/*Coccidia* spp.	Treat fish with oral monensin; reduce stress

PRODUCTION, MARKET AND TRADE

PRODUCTION

According to FAO, the aquaculture production of cobia was 961 t in 1998, which increased to 40,329 t in 2014. Of the production reported to FAO in 2004, 80.6 % was produced in China and the remaining rest in Taiwan Province of China. The total value of the global production of this species in 2004 was US$ 3,62,06,000.

MARKET AND TRADE

In China and Taiwan Province of China, both the rapid growth rate and good flesh quality makes cobia potentially one of the most important marine finfish for future production. In these two countries, the fish has a relatively high market value when compared to other finfishes. Larger fishes (8-10 kg) are sold whole domestically, while Japan is the primary destination for smaller (6-8 kg) fish sold, both whole and headless (some for sashimi), with fillet product typically exported to other markets. The prices vary according to size; the market value in Taiwan Province of China for whole fish weighing 17 lb (7.7 kg) and larger was US$ 5.50/kg in 2004. Cobia in Taiwan Province of China are typically starved the day before harvest and 6 kg fish or larger are selected, killed, bled and chilled before whole fish or fillets are packed in ice. Cobia enters the market whole/gutted, headless, or filleted, depending on the final market destination. As the wild caught fish does not represent a major fishery and the farming of cobia is in its infancy, details on market and trade are lacking elsewhere.

In India, it is sold as whole or steaks in domestic market. It has a very good demand in states like Kerala, Tamil Nadu, Maharashtra, West Bengal, Karnataka and Goa. Cobia also commands a good price in the export market. During 2011 nearly 2,377 t of cobia was exported from India. Cobia is mainly exported as frozen whole fish, IQF, head on gutted fish and steaks. The present production is not enough to meet the increasing demand both in domestic and export market. The preferred export size of cobia is above 3 kg. Though, China is a major producer, it also imports cobia from other countries for domestic consumption.

CHALLENGES TO MARICULTURE

The Mandapam Regional Centre of ICAR-CMFRI has developed the technology for broodstock development, larval rearing, nursery rearing and grow-out culture of this species. However, there are several researchable issues which need to be sorted out for this species in India.

Year round spawning and seed production

High density larval rearing techniques

Enhancement of larval survival

Pond culture of the species under different environmental parameters

Standardization of feed for grow out culture (artificial feed vs low value fish)

Disease management

FUTURE PROSPECTS

Cobia has all the qualities needed for a successful species in aquaculture. The fast growth rate, adaptability for captive breeding, low cost of production, good meat quality and high market demand especially for sashimi industry are some of the attributes that make cobia an excellent species for aquaculture. This species are cultured in varying salinity, which suits perfectly the coastal mariculture in India. Additionally, the seed production technology is available in India. Thus this species is a good candidate species for mariculture if the seed production technology percolates to the aquaculture industry.

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Caranx ignobilis (Forsskål, 1775)

M. Sakthivel, Rengarajan Jayakumar and Biji Xavier

IDENTIFICATION

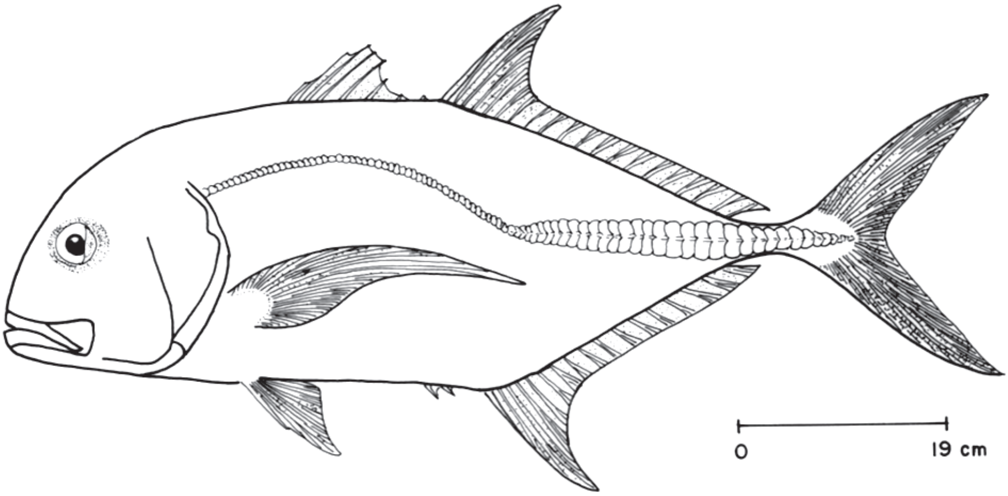
Order	:	**Perciformes**
Family	:	**Carangidae**
Common/FAO Name (English)	:	**Giant trevally**

Local names: Kuluvel, Manjavalan para, Manja para (**Malayalam**); Pulee paarai, Komaaraa paarai, Vennai paarai, Thaengaa paarai, Sem paarai, Keeleesai paarai (**Tamil**); Munjal paarah, Pulli paarah, Jarradendree paarah (**Telugu**)

MORPHOLOGICAL DESCRIPTION

It has an oval-shaped, compressed body with the dorsal body being more convex than the ventral part. The dorsal fin is split into two with a fully spinous part anteriorly with 8 spines and a soft part posteriorly with one spine followed by 17-22 rays. The anal fin has two free spines anteriorly, followed by one spine and 15-17 soft rays. The pelvic fins have a spine followed by 19-21 soft rays. The caudal fin is forked and pectoral fins are falcate. The lateral line is arched anteriorly, straightening into a line below the second dorsal fin lobe. The chest is scale-less with the exception of a small patch of scales in front of the pelvic fins. The upper jaw has an outer row of canine teeth with an inner band of smaller teeth, while the lower jaw has a single row of conical teeth. The species has 20-24 gill rakers in total and 24 vertebrae are present. It has an adipose eyelid.

Source of image : RC of CMFRI, Visakhapatnam



The giant trevally changes colour as it grows. At sizes less than 50 cm, males and females both are silvery-grey with dorsal part (including head) being darker. As the fish grows beyond 50 cm sexual dimorphism in colouration appears, with males becoming dusky to jet-black and females remaining silvery-grey. Silvery striations and markings on dorsal part of the body and sometimes black dots are also seen on larger fish. Fins are generally light grey to black, sometimes yellow coloured also.

PROFILE

GEOGRAPHICAL DISTRIBUTION

The giant trevally is widely distributed throughout the tropical and subtropical waters of the Indian and Pacific Oceans, ranging from Africa, Red Sea and Persian Gulf to Asia, including Pakistan, India and onto south-east Asia, the Indonesian Archipelago and northern Australia. In the Indian Ocean it has also been reported from Maldives, Seychelles, Madagascar and the Cocos Islands. In the Pacific region it is found up to the norther tip of New Zealand and onwards into the western Pacific regions of Tonga, Western Samoa and Polynesia with the western limit of its distribution being the Hawaiian Islands.

HABITAT AND BIOLOGY

The giant trevally inhabits a very wide range of habitats from offshore and inshore marine environments to low saline waters of estuaries and rivers. It is also easily attracted to artificial reefs, where studies have found it to be one of the predominant species around these structures in Taiwan. It is a solitary fish on attaining sexual maturity, only schooling for the purposes of reproduction and more rarely for feeding. Juveniles and sub-adults commonly school, both in marine and estuarine environments. At smaller sizes, the species is prey to sharks, and large individuals have been recorded as a host of the shark sucker, *Echeneis naucrates*, a fish which is normally seen attached to the undersides of sharks.

Caranx ignobilis reaches sexual maturity at 54 to 61 cm in length and three to four years of age. Spawning occurs during the warmer months. In southern Africa, this occurs between July and March, with a peak between November and March; in the Philippines between December and January; and in Hawaii between April and November. It is the largest member of the genus *Caranx*, with a recorded maximum length of 170 cm and a weight of 80 kg. The average length reported is 100 cm.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

The captive breeding and seed production of the species has been reported from the Philippines in 2006. The successful induced breeding was carried out at National Fisheries Research and Development Institute, National Fisheries Biological Centre, Butang, Phillipines. The sexually matured brooders of age 5-7 years with 500 µm ova diameter were selected and were injected intramuscularly, with two doses of human chorionic gonadatropin (hCG; 1000 IU/kg) and two doses of Luteinizing hormone-releasing hormone analog (LHRHa) separately for two groups of fish. After injection, fish were stocked in 40 t (5 m diameter) circular tank. Spawning occurred 24-36.5 h after second dose of hCG and 25-52 h after LHRHa injection. The eggs were pelagic, clear and spherical with a single oil globule and mean diameter 800 µm. The mean number of eggs spawned was 3,500-4,000 eggs/g of fish weight. The eggs hatched out in 11-17 h. The fertilization and hatching rate was 60.88 % and 71.07 % respectively.

LARVAL REARING

Newly hatched larvae measured 1.6 mm mean length. Larval rearing was carried out in concrete tanks (3 x 3 m) with green water system using *Nannochloropsis* sp. Larvae were fed initially with rotifer (*Brachionus* spp.) and followed by brine shrimp (*Artemia salina*). Heavy mortalities were observed during 1-7 and 19-22 days of larval rearing. The metamorphosis was completed within 26-28 days and at that time, larvae measured a mean length of 8.1 mm.

The giant trevally's early larval stages and their behaviour have been extensively described, with all fins formed in 8 mm size of fish; with larvae and sub-juveniles being silver in colour with six dark vertical bars. Growth rates in larvae between 8.0 and 16.5 mm were on average 0.36 mm/day. The speed at which larvae swam increased with age from 12 cm/s at 8 mm in length to 40 cm/s at 16.5 mm. The species became an effective swimmer (is able to swim against a current) around 7-14 mm.

NURSERY REARING

Information not available

GROW-OUT

Grow out culture was carried out in cage in Philippines. A 10 x 10 m cages were stocked with 900 juveniles (50-100 g) and cultured for a period of 8-12 months. During this period the fish grew to an average of 23-27 cm with weights of approximately 600 g. This species has been cultured in floating cages in lagoons in Tahiti on an experimental basis. In Tahiti it was seen that for this species to grow well, either trash fish or pelletized feed with 40 % protein is good. The pellet feed should be moistened and contain 15 % fresh fish which is an appetizer (bonito fish in Tahiti) for the fish to feed well. With this feed the fish attained an average 420 g in 180 days.

FOOD AND FEEDING

The fish is carnivorous in nature. Young ones feed on juveniles of sardines, anchovies, other finfishes, prawns, crab instars and amphipods. Major food components of large fishes include *Decapterus* sp., other carangids, silver bellies, threadfin breams, goatfishes, lizardfishes, crabs and prawns. In cage culture, fish were fed with low value fish such as *Oreochromis niloticus, Carassius auratus, Parachromis manaaguenis,* silverfish, cardinal fish and archer fish.

GROWTH RATE

Daily growth was estimated to be between 3.82 and 20.87 g/day, with larger fish growing at a more rapid rate. Length of one year old was 18 cm, two years was 35 cm and by three years, the fish was around 50 to 60 cm. Giant trevally were grown to a size of 750 g in 12 months from 5 g in cages in Philippines. In Tahiti the fish attained an average of 420 g in 180 days.

DISEASES AND CONTROL MEASURES

Acanthocephalus dirus infection in internal organs was reported in *C. ignobilis*. These parasites destroy the internal tissues of the fish.

PRODUCTION, MARKET AND TRADE

PRODUCTION

The species is cultured in cages in the Philippines and farmed on a small scale in Malaysia. It is also a very popular sport fish in the Indo-Pacific area. In India too its demand as a sport fish is on the rise.

MARKET AND TRADE

The fishes of genus *Caranx* have good consumer acceptability due to their flesh quality without inter muscular bones. It is marketed as fresh, frozen, salted and smoked. Even fish meal and fish oil were prepared from this fish. Approximate price for the fish in domestic market in India is ₹ 180/kg. The average weekly price in international market is US $ 3-4/kg.

CHALLENGES TO MARICULTURE

The breeding and seed production of *Caranx ignobilis* has been reported from different countries; however it has not been reported from India. The main researchable issues, which have to be sorted out for this species in India, are (i) Healthy broodstock development protocol (ii) Larval rearing protocol: standardization of larval rearing by environmental and nutritional manipulation (iii) Disease and feed management and (iv) culture practices.

FUTURE PROSPECTS

Caranx ignobilis is a good candidate species for mariculture due to its fast growth, good meat quality and high market value. With the development of successful captive breeding and hatchery seed production practices, the culture of *C. ignobilis* will be established in future.

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Gnathanodon speciosus (Forsskål, 1775)

Ritesh Ranjan

IDENTIFICATION

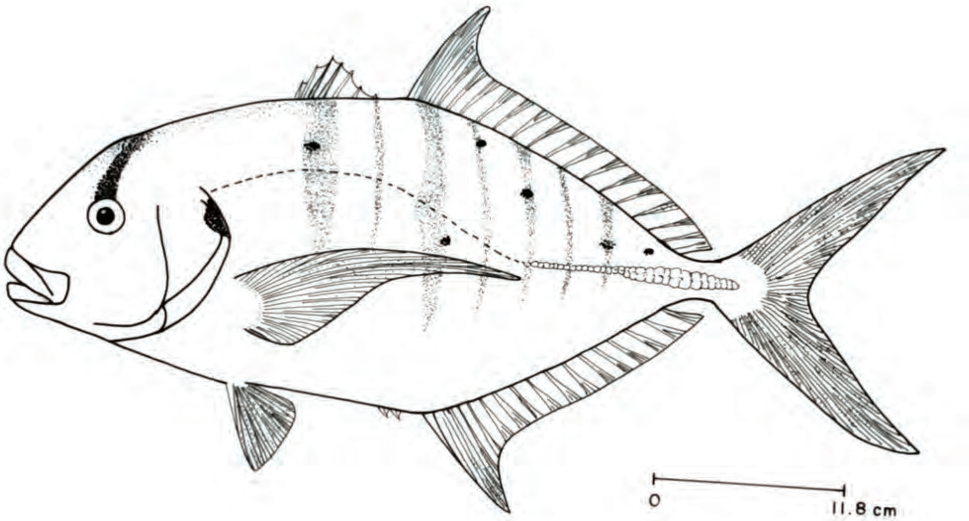
Order	:	**Perciformes**
Family	:	**Carangidae**
Common/FAO Name (English)	:	**Golden trevally**

Source of image : CMFRI, Kochi

Local names: Gondlu (**Kannada**); Para (**Malayalam**); Komara parai, Parai, Pulli parai, Sema parai, Thenga parai, Vennai parai (**Tamil**); Manjal parai, Pulli parai (**Telugu**)

MORPHOLOGICAL DESCRIPTION

Body is compressed and oblong; lips noticeably papillose and upper jaw strongly protractile. Eye diameter smaller than snout length; upper jaw without teeth; lower jaw with a few feeble teeth in young (smaller than 10 cm fork length) and absent in adults. Gill rakers (including rudiments) present are 7 to 9 upper, 19 to 22 lower and 27 to 30 on first gill arch. Two separate dorsal fins, the first with 7 spines, the second with 1 spine and 18-20 soft rays; anal fin with 2 detached spines followed by 1 spine and 15-17 soft rays; lobe of second dorsal fin shorter than head length. Lateral line anteriorly with a moderate regular arch, with junction of curved and straight parts below second dorsal fin between 9th to 14th soft rays; straight part of lateral line with 17-24 scales followed by 17-26 scutes. Breast completely scaled. There are 10 + 14 vertebrae. The species is characterized by the presence of black vertical bands on the body, which fade as the fish grows, to become black patches or spots. The fish is yellowish green dorsally and pale yellow ventrally. Juveniles are silvery to yellow in colour with 7-11 black vertical bands.



PROFILE

GEOGRAPHICAL DISTRIBUTION

Golden trevally is widely distributed throughout the tropical and sub-tropical waters of the Indian and Pacific Oceans. In the Indian Ocean, the species is distributed from South Africa along the east African coastline, including the Red Sea and the Persian Gulf, extending east towards along the Indian and south-east Asian countries, and south up to Indonesia and northern Australia. In the Pacific Ocean, the species is spread throughout the south east Asian region and Indonesian archipelago, north to mainland China and Japan and south to eastern Australia and New Zealand. Golden trevally has been recorded from many central Pacific Islands, including Hawaii, with their distribution extending to Central America. In America, its range extends from the Gulf of California in the north to Columbia in the south. In India, this species is distributed all along the Indian coast from Gujarat to West Bengal including Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

The golden trevally predominantly occupies the inshore waters of varying substrates and deeper continental shelf reefs. In coastal areas, the species inhabits rocky and coral reefs as well as open sand flats where it forages for food. Golden trevally feeds mainly on crustaceans such as shrimps, crabs, amphipods and other fossorial invertebrates. They also feed on small fishes. It has a highly protractile mouth which is used to form a tube to suck prey out of both reef and algae-dominated habitats as well as for filtering organisms out of sandy substrate.

The sexes of golden trevally are separate. The fishes mature at a length of 32.5 cm. Spawning period in the Pacific Ocean is late February to early October with a peak from late April to early

September. Distinct spawning peaks are correlated to the first and third quarters of the moon. In the Indian Ocean, spawning occurred in April and May. Generally, spawning occurs from early evening upto night. Males and females are almost equally distributed in natural wild populations. Eggs and early larvae are pelagic. The fish has a maximum reported age of 15 years and maximum size of 15 kg.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

At Research Institute for Mariculture, Gondal, Bali, Indonesia, spawners (0.5-2.5 kg) were reared and acclimatized in 30-50 m^3 round-concrete tanks with water exchange of 200-300 % per day. The fishes were fed twice a day at 3-5 % of body weight. Air stones (4-6 nos.) were provided in the tanks for maintaining dissolved oxygen levels. Twenty brooders (in ratio of 1 male: 3-4 females) had spawned 68 times in tanks producing 68,80,000 fertilized eggs. Generally, the fishes spawned between 17:00 to 19:00 hrs. The fertilized eggs were buoyant and semi-transparent. The eggs had an average diameter of 910±60 µm. The fertilized eggs contained a single oil globule measuring 260±10 µm in diameter. Hatching time varied from 18-22 h, depending upon water temperature. The salinity requirement during the hatching period was 32-33 g/l.

In another study in Florida, USA, golden trevally brooders of average size 2.4 kg were stocked in 4.5 t Recirculatory Aquaculture Systems (RAS) at 26 °C at 33.92 g/l salinity. The fish were fed with frozen capelin, squid and krill to satiation levels twice daily. The fish were anesthetized and depending on maturity levels, were administered with 75 µg of Ovaplant (Western Chemical) pellet. Three spawning events were reported, each at 48 h, 72 h and 96 h after administration of Ovaplant at an average production of 15,900 eggs/kg of female body weight. Hatching occurred within 6 h of collection of eggs.

LARVAL REARING

In Indonesia, larval rearing was conducted using 1-10 m^3 concrete FRP tanks. Tanks were cleaned and dried before use and were filled up to 75 cm depth with filtered sea water. The newly hatched larvae (2.73±0.10 mm total length) were stocked in tanks at 10-30 nos./l, within 3-4 h after hatching. Water exchange in larval tanks commenced from day 10 with 10-20 % of the total volume and was increased up to 50-80 %. The 30 days post-hatch (dph) fry were maintained in a flow-through system. Bottom siphoning was started from day 12 and was thereafter done on every alternate day. Larval rearing was completed within 35 days, by which time the larvae attained a size of 3-4 cm. Survival rate was 10-20 % during larval rearing.

In the Florida study, the larvae were stocked in 104 l cylindrical tanks with black walls and white bottom. Two stocking densities were used @ 136 and 173 larvae/l. Water exchange was to the tune of 200 % upto 2nd dph and photoperiod was maintained at 12 h (08:00-20:00 hrs). Larvae were fed a mixture of copepod nauplii *Parvocalanus* sp., rotifer *Brachionus plicatilis*, Instar I *Artemia* nauplii (INVE Aquaculture, Thailand), dry diet (Otohime B1, Japan) or a combination of these components from 2nd dph onwards. Once feeding commenced, water was exchanged during 20:00 hrs at the rate of 200-400 % to remove unwanted feed and other wastes. Larvae grew up to 46 mm in 45 days of larval rearing. Metamorphosis was completed by 30 dph and the survival during 45 days of larval rearing was 4.27 %.

NURSERY REARING

Golden trevally fingerlings of 3-4 cm size were used for nursery rearing in Indonesia. Juveniles (110.70±25.02 mm) attained the banded pattern and colour similar to that of adult fish after 100 days of culture. Feeding trials of golden trevally have been conducted in Indonesia in floating net cages. Juveniles of 40 g each were stocked at 40 nos. per 1m x 1m x 1.5 m cages with artificial feeding. The fish grew to 100 g in two months with survival of 87 %. Juveniles of more than 10 cm size are used for cage culture in south-east Asian countries mainly in Singapore, Taiwan, Malaysia and Indonesia.

FOOD AND FEEDING

Golden trevally is carnivorous, feeding mainly on fishes, crustaceans, bivalves, etc. In culture systems, they are grown on fish, krill, squid and artificial pellets.

GROWTH RATE

Though information on growth rate is limited, studies in UAE have shown that the species shows seasonal differences in growth. It was found to grow fastest during summer months of April to August and slowest in the winter months of September to March.

DISEASES AND CONTROL MEASURES

The parasitic nematode *Metobronema magnum* has been reported from the species. Another Digenean parasite *Stephanostomum talakitok* has been reported in the species from Australia.

PRODUCTION, MARKET AND TRADE

PRODUCTION

The species is often caught using hooks and lines, gill nets and other artisanal fish trapping methods. It forms a regular part of the fisheries for UAE, Qatar and Bahrain and to a much lesser extent for Australia and Singapore. The global golden trevally catch has increased from 1,187 t in 2000 to 3,475 t in 2010. It is farmed in cages in Singapore, Taiwan, Malaysia and Indonesia.

MARKET AND TRADE

The major suppliers of golden trevally are Indonesia, Singapore, Taiwan and Malaysia. The wholesale price of market-sized golden trevally was about US $ 6-8/kg in 2008 in Hong Kong and other south-east Asian countries. In addition, it has also been marketed as ornamental fish in international markets because of its golden-yellowish color and vertical black stripes on its body. Golden trevally is often marketed as pilot fish in the aquarium trade and juveniles may retail over US $ 50. The price of golden trevally in the Indian market is around ₹ 200/kg.

CHALLENGES TO MARICULTURE

The main researchable issues, which have to be addressed for this species in India are (i) Broodstock development protocol (ii) Breeding and larval rearing protocol with environmental and nutritional interference (iii) Standardization of techniques for nursery rearing and grow out and (iv) Feed and disease management.

FUTURE PROSPECTS

Golden trevally is an ideal candidate species for aquaculture diversification, particularly in the Asia-Pacific region, because of consumer demand, desirable taste, hardiness in a crowded environment, fast growth and efficient feed conversion. It fetches a good price in international markets (Hong Kong and other south-east Asian countries) as well as in domestic markets of India also. Additionally, it has also been marketed as ornamental fish in international markets. Thus this species can be a good candidate for culture in abandoned shrimp ponds and floating cages.

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Lutjanus argentimaculatus (Forsskål, 1775)

K. K. Philipose, Jayasree Loka, T. Senthil Murugan and Ritesh Ranjan

IDENTIFICATION

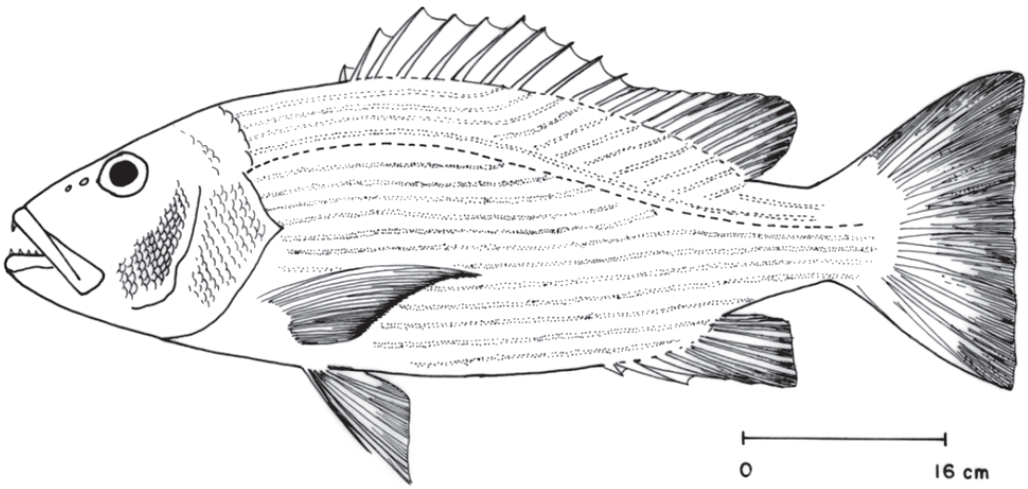
Order	:	**Perciformes**
Family	:	**Lutjanidae**
Common/FAO Name (English)	:	**Mangrove red snapper**

Local names: Ratado (**Gujarati**); Chawari tamb, Tambusa (**Marathi**); Tambus (**Konkani**); Tamboos, Chembali (**Kannada**); Murumeen, Pahari, Chempalli, Chemkalava (**Malayalam**); Chenganni, Cheppili, Karuvalai, Karva, Nethiprion, Paruthivala meen, Paruthikanni, Patani-keeli, Tokkal, Vekkattai (**Tamil**); Kaliviyya, Rangu, Rangoo, Thundava (**Telugu**); Dhala-chandi (**Oriya**)

MORPHOLOGICAL DESCRIPTION

The body of *Lutjanus argentimaculatus* is moderately deep (maximum depth 2.5 to 3.1 times in standard length), snout is slightly pointed, pre-orbital bone is relatively broad and is wider than eye diameter. The pre-opercular notch and knob are poorly developed, vomerine tooth patch is crescent-shaped without a medial posterior extension and the tongue has a patch of granular teeth. The first gill arch has 16-20 gill rakers with the lower limb having 9-12 (including rudiments). The dorsal fin has 10 spines and 13-14 soft rays, the anal fin has 3 spines and 8 soft rays and the posterior profile of dorsal and anal fins is rounded. The pectoral fins have 16-17 rays and the caudal fin shape ranges from emarginate to nearly truncate. The scale rows on the back are roughly parallel to the lateral line, or parallel below the spinous part of dorsal fin and sometimes rise obliquely posteriorly, or rarely with entirely oblique rows.

Source of image : RC of CMFRI, Visakhapatnam



The back and sides of the fish range from greenish-brown to reddish colour; belly silvery or whitish with specimens from deep water frequently being fully reddish. Juvenile fish have series of about eight whitish bars crossing the sides, and 1 or 2 blue lines across their cheek.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Lutjanus argentimaculatus is distributed in the Indian Ocean and Pacific Ocean, from Africa eastwards to Samoa and from the Ryukyus in the north to Australia in the south. It has also been recorded from the coast of Lebanon in the Mediterranean Sea though it is not established in the Mediterranean Sea. In India, it has been reported from both the east and west coasts with more landings from the southern states.

HABITAT AND BIOLOGY

Lutjanus argentimaculatus is a euryhaline species. It has a complex life history with distinct inshore and offshore phases. Juveniles are primarily found in estuaries, rivers, coastal wetlands and tidal creeks. Adults are often found in groups around coral reefs and sometimes they migrate to offshore, deeper reef areas, even penetrating to depths beyond 100 m. This species is a nocturnal feeder and feeds mostly on fishes and crustaceans. Maximum recorded size is 104 cm length and 14.50 kg weight. Maximum reported age is 37 year.

It is a gonochoristic fish i.e. male and female gonads are present in separate individuals. In Australia, the length at 50 % maturity was found to be 512 mm for females and 449 mm for males. During spawning, distinct courtship behaviour is noticed. They are highly fecund and batch spawners with an average fecundity of 5,26,000 eggs/kg body weight of female fish. The species is also known to aggregate for spawning purposes in Palau. Larvae are planktonic.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

The broodstock development of mangrove snapper was carried out in cages at Southeast Asian Fisheries Development Center, Tigbauan, Iloila, Philippines. The adult or sub-adult fish were either collected from wild or reared from hatchery produced fry and stocked in floating net cage of 6 m diameter and 3 m depth with mesh size 12-22 mm for broodstock development. The cage was stocked with 12 to 14 females and 14 to 15 males. Fish were fed low value fish at the rate of 5 % of their total body weight every other day. The annual salinity and temperature ranged from 25 to 36 g/l and from 25 to 32 °C respectively. The cage reared mangrove red snapper spawned between midnight and early morning hours from March to November.

In China, broodstock were raised from wild collected juveniles reared for 7 years in captivity. Thirty mature fish (14 females and 16 males) were selected from them and stocked in a concrete pond of 3,000 t capacity having 3 m water depth with a salinity of 30-33 g/l and temperature of 22.8-25.5 °C to acclimatized them prior to spawning. The female and male weights were 6.92-8.36 and 6.48-7.42 kg respectively. Water was continuously changed at the rate of 40 % per day. The fishes were fed with low value fish such as carangid, *Scombrid* spp. and squid at the rate of 3 % body weight per day. The broodstock spawned naturally five months after stocking. Spawning usually occurred between 23:00 hrs and midnight. The hatching rate varied from 34.8 to 99.5 %. Fertilized eggs were transparent, spherical and pelagic in nature, measuring 0.74-0.81 mm in diameter with a single oil globule (0.14-0.16 mm diameter) at the vegetal pole. The eggs hatched out after 16-22 h at 25.8-28.7 °C.

LARVAL REARING

Newly hatched out larvae measured 1.62-1.94 mm in total length. The larvae had yolk sacs, which got fully reabsorbed after 66-90 h after hatching. The mouth opened after 2 days of hatching. The larvae were reared in 4 t circular FRP tank. The larvae were stocked at a density of 5-16.4 nos./l. Rotifers were fed to larvae at the rate 10-20 nos./ml from starting till 40 days of rearing. *Nannochloropsis* sp. was added in tank at the rate of 3-5 x 10^6 cells/ml from 0 day to 40 days. *Artemia* nauplii were fed at the rate of 1-2 nos./ml from 20^{th} days onwards. In addition copepod was added from 25^{th} day at the rate of 5 nos./ml. Artificial feed was given from 30 dph onwards. The salinity during larval rearing was 30±2 g/l and water temperature ranged from 24-30 °C. Water was maintained static till 10 dph with mild aeration. Water was exchanged at 10 % daily from 10 dph and 33 % daily from 20 dph. Flow through at the rate of 15-20 l/min. was maintained from 30 dph onwards. Metamorphosis occurred at 10.5-17.2 mm size. The juveniles reached a mean total length of 49.4±4.3 mm after 50 days of rearing with average survival of 21.1 %.

NURSERY REARING

Fry from wild or hatchery was reared for 3 month for nursery rearing. Nursery rearing was carried out either in pond or cages inside the pond.

GROW-OUT

The mangrove red snapper is mainly cultured in south-east Asian countries such as Malaysia, Hong Kong, Singapore, Thailand, Philippines and Taiwan. This species in primarily raised in cage culture system. In Thailand, juveniles were cultured in relatively small cages (3 x 2 m) and fed with trash fish. Good growth and survival has been reported when juveniles were stocked at 60-90 fish/ m^3. Juveniles of mangrove red snapper (20 g) were stocked at the rate of 90 nos./m^3 in 3 m diameter floating cages in Thailand. They were fed with chopped carangids, *Selaroides* spp. till satiation twice daily. The environmental parameters such as water temperature, salinity and dissolved oxygen during the culture was 28.9 °C, 31 g/l and 7.8 mg/l respectively. The fish attained a size of 806 g with feed efficiency 15.6 % and survival 83 % after 10 months of culture. The recommended juvenile size for grow out is about 20-100 g average weight in Indonesia. The stocking density followed in pond is 5000 nos./ ha or 5 nos./m^3 when stocked in cages inside the pond.

FOOD AND FEEDING

Lutjanus argentimaculatus is carnivorous in nature. In culture systems, it feeds well on low value fish such as *Selaroides* spp., sardine, *Decapterus* sp. and artificial diets. The optimal requirement of protein in fingerlings diet is 42.8 %. In Indonesia, reported dietary protein requirement is about 48-50 %.

GROWTH RATE

Juveniles cultured in tank grew from 8.0 g to 110 g in 90 days in Pakistan. In another experiment, they attained a size of 806 g from 20 g and 963 g from 34 g after 10 months and 2.3 kg after 22 months of culture in cage. The growth was better at a stocking density of 50 nos./m^2 than with 110 or 152 nos./m^2. Fish stocked at 100 nos./m^2 fed once per day grew from 20 to 500 g in 9-10 months. In India, the fish attained a size of 750-900 g from 15-20 g after 8 months and 1.1 to 1.3 kg after 13 months of culture period.

DISEASES AND CONTROL MEASURES

The bacterial infection *Vibrio harveyi* has been reported from cage culture of mangrove red snapper from Karwar, Karnataka, India. In addition, around 21 species of endoparasite; six trematode, eight nematode, three acanthocephalan, one cestode and three trypanorhyncha species has been reported from wild along Karachi coast, Pakistan.

PRODUCTION, MARKET AND TRADE

PRODUCTION

The fish is cultured in pond as well as cages. The global production of mangrove red snapper was 4,683 t and 4,620 t reported in 2006 and 2007 respectively.

MARKET AND TRADE

This is an excellent food fish because it does not get rancid easily when frozen. It commands a good export market price with no limit on body size. The fish is marketed fresh, frozen, dried or salted. Approximate price for the fish in local market in India is ₹ 280/kg. The average weekly price in live market of Hong Kong is US $ 5-6/kg.

CHALLENGES TO MARICULTURE

Though the broodstock development, breeding and seed production is standardized by many countries, India is yet to standardize these technologies. Thus in India the main researchable issues, which have to be sorted out for this species are (i) Healthy broodstock development protocol (ii) Larval rearing protocol: standardization of larval rearing by environmental and nutritional manipulation (iii) Disease and feed management and (iv) Culture practices.

FUTURE PROSPECTS

Mangrove red snapper is a fast growing, high-value fish which has good domestic demand and commands good price. Development of seed production and hatchery technology will lead to its widespread farming in cages and coastal ponds enhancing the supply without affecting the natural population.

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Lutjanus johnii (Bloch, 1792)

K. K. Philipose, Jayasree Loka, T. Senthil Murugan and Ritesh Ranjan

IDENTIFICATION

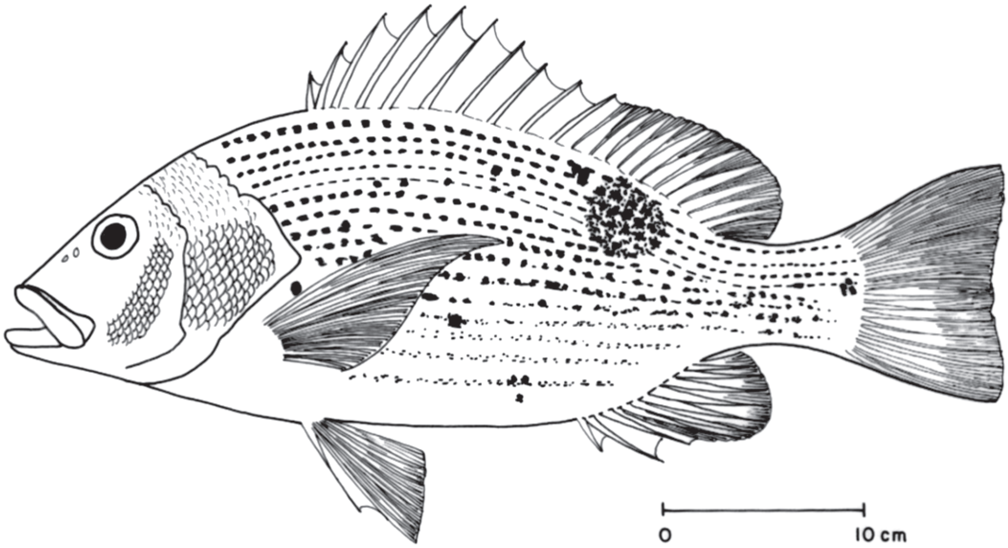
Order	:	**Perciformes**
Family	:	**Lutjanidae**
Common/FAO Name (English)	:	**John's Snapper**

Source of image : RC of CMFRI, Visakhapatnam

Local names: Tamb, Gurka tamb (**Gujarati**); Chawari tamb, Tambusa (**Marathi**); Tambus (**Konkani**); Tamboos, Chembali (**Kannada**); Murumeen, Pahari, Chempalli, Chembolay (**Malayalam**); Cheppili, Karuvalai, Karva, Nethiprion, Paruthivala meen, Paruthikanni, Patani-keeli, Tokkal, Vekkattai (**Tamil**); Kaliviyya, Rangu, Rangoo, Thundava (**Telugu**); Dhala-chandi Chenganni (**Oriya**)

MORPHOLOGICAL DESCRIPTION

This fish is characterized by a large black blotch situated below the anterior dorsal-fin rays, on the upper part of the body. The head is steeply sloped and the pre-orbital width is equal to or larger than the eye diameter. Pre-opercular notch and knob are poorly developed. Scale rows on back parallel to the lateral line. The scales have a dark sport in the centre which gives the overall appearance of horizontal lines on the fish. The dorsal fin has 10 spines and 13-14 rays, anal fin has 3 spines and 8 rays. The species is yellow-orangish dorsally with a bronze to silvery colour ventrally.



PROFILE

GEOGRAPHICAL DISTRIBUTION

Lutjanus johnii is widely distributed in the Indo-west Pacific, extending from east Africa to Fiji, north to the Ryukyu Islands and south to Australia. This species, a large Lutjanid, dominates the near-shore community of reef fishes from the Kimberley region (~124° E) in north-western Australia, across northern Australia, and down the Queensland coast to at least 23° S. In India, this species is reported from both east and west coasts.

HABITAT AND BIOLOGY

John's snappers are normal inhabitants of coral reefs, rocks, deep sea, estuarine and sometimes in lower reaches of freshwater streams. Adults are found in coral reef areas and juveniles in mangrove estuaries. Off South Africa, it displays a preference for slightly silty and turbid regions in the vicinity of shallow offshore banks. It is caught mainly at night on coral banks off Mafia Island (Tanzania) in 9 to 12 m depths and off Zanzibar in about 75 m. Off east Africa, spawning occurs during spring and summer with a peak activity in October. Estimated maximum age is 50 to 60 years. The tendency of John's snapper to congregate in large schools in relatively shallow water around snags and pinnacles, coupled with advances in sounder and GPS technologies, have raised concerns for the potential for overfishing of this species.

BREEDING IN CAPTIVE CONDITIONS

Research on breeding and seed production of John's snappers started in Singapore during 1970s. Adults or sub-adults were collected from wild and reared in cages (6-7 kg/m^3) and in tanks (1 kg/m^3) for broodstock development. Fishes spawned naturally and if not, were induced to spawn with the help of hCG. The fecundity on an average was 0.92 million eggs per female. The fertilization rate was high in spontaneous spawning (67 %) than that of artificial spawning (44-48 %). Fertilized egg was transparent, spherical and non-adhesive. Fertilized egg was usually buoyant with a single oil globule. The egg diameter ranged from 770 to 850 µm with a mean of 800 µm. The diameter of oil globule was about 20 % of the egg diameter, with a range of 150 to 170 µm and a mean of 160 µm. The incubation time was highly temperature dependent, being 14.5-15.0 h at 29.0-29.5 °C and 17.0-17.5 h at 27.5-28.0 °C.

LARVAL REARING

Studies on the larval rearing of John's snapper have been carried out at various places with different protocols. Generally, larval rearing of John's snapper was carried out in green water system, where larvae were fed with different live feeds such as rotifers, copepod nauplii, copepod adult, *Artemia* nauplii and microencapsulated diet in various stages of its development. On day 0 (the day when larvae hatched out), tanks were filled with sea water and inoculated with *Isochrysis* sp. and *Rhodomonas* sp. at density of 5-10 x 10^5 cells/ml. Adult *Acartia* sp. were stocked on the same day in the same tank at density of 30 to 60 nos./l. Larvae were stocked into the tank at density of 1-2 nos./l on day 2. Copepods are essential first feed for *L. johnii* larvae, which can feed on rotifers only after 3 to 4 days of eating copepods. Plankton bloom was monitored daily and extra microalgae or zooplankton was added, whenever necessary. The rotifers were added on day 3 to the larval rearing tank. Water exchange was started from day 10, with 10 % daily exchange, increasing to 100 % by day 30. *Artemia* nauplii were added in tank at 0.5 nos./l from day 12 to day 30. Weaning of larvae on artificial feed started from 25th day and lasted for 3 to 7 days. Fishes were transferred to nursery tanks after metamorphosis, which was completed in 35-40 days.

NURSERY REARING

Two production systems were used for nursery rearing of hatchery produced fry in Singapore; indoor and outdoor. The indoor system used tanks of different sizes while the outdoor system used hapas in ponds as well as in cages or directly in the pond itself.

GROW-OUT

Cage aquaculture of John’s snapper is reported from many Asian countries like China, Pakistan, Malaysia, Hong Kong, Indonesia, Philippines and India. John's snapper is mostly cultured in Singapore.

They grew from 90 g to 600-800 g in 6-8 months when fed with trash fish. The species has also been grown in cages in Pakistan both as monoculture and along with *Pomadasys kakaan* where it has been found suitable for cage culture.

FOOD AND FEEDING

John's snapper is carnivorous, feeding mainly on fishes and crustaceans. In culture systems, it can be grown on trash fish and artificial pellets.

GROWTH RATE

The fish attains a size of 600-800 g from 90 g in 6-8 months culture duration, when fed with trash fish.

DISEASES AND CONTROL MEASURES

A nematode species, *Cucullanus vishakhapatnamensis* has been reported from the intestine of *L. johnii* caught at Vishakhapatnam, east coast of India. The metazoan fish parasite *Anisakis* sp. was reported from the stomach wall of *L. johnii* from Indonesia. A nematode, *Procamallanus* sp. and an annelid species *Zeylanicobdella arugamensis* was also reported from *L. johnii*. Hemorrhagic septicemia caused by *Pseudomonas alcaligenes* has been reported from India.

PRODUCTION, MARKET AND TRADE

PRODUCTION

In south-east Asia, *L. johnii* is important in both capture fisheries and sea cage mariculture. John's snapper forms a minor fishery in India. It is occasionally caught in trawls, with hand lines, bottom long lines, traps or bottom set gill nets. Their size in wild catches ranges from 30 to 50 cm, with maximum published weight of 10.5 kg. These fishes have wide market acceptance for their excellent eating characteristics and generally command high market prices. Global production of this species was 20 and 26 t in 2006 and 2007 respectively.

MARKET AND TRADE

Lutjanus johnii commands premium price when sold live in seafood restaurants in the Asia-Pacific region. Most fish are sold fresh on ice, usually gilled and gutted, filleted. The retail price of John's snapper is ₹ 250/kg in domestic Indian market.

CHALLENGES TO MARICULTURE

Hatchery technology for seed production is yet to be achieved in India. Once this is achieved, the technology has to be standardised and scaled up for adoption.

FUTURE PROSPECTS

The species has a very good domestic demand and, in future, with availability of adequate number of hatchery produced seeds, it has the potential to be a top candidate species for cage farming and coastal mariculture in India.

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Acanthopagrus berda (Forsskål, 1775)

P. P. Suresh Babu, M. T. Shilta, P. K. Asokan and K. Vinod

IDENTIFICATION

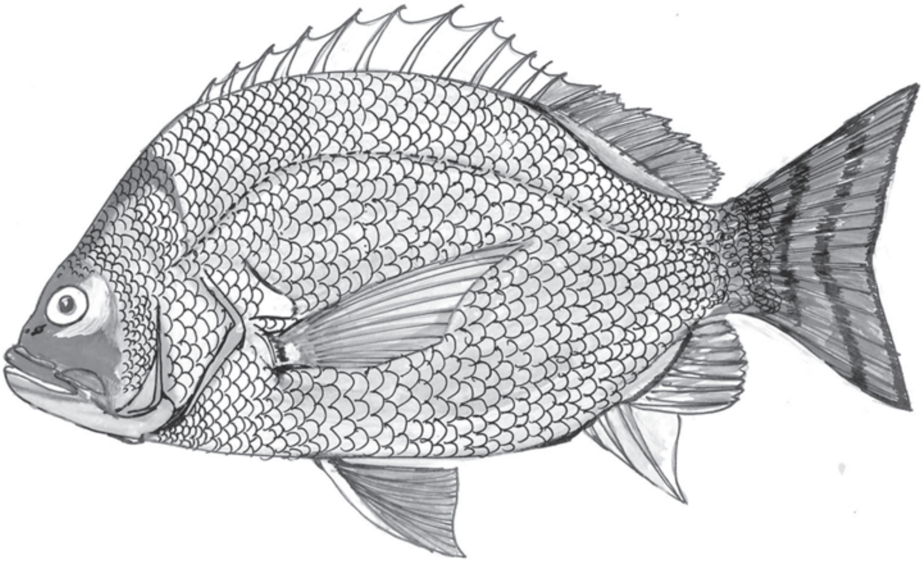
Order	:	**Perciformes**
Family	:	**Sparidae**
Common/FAO Name (English)	:	**Goldsilk seabream**

Local names: Kali kishi, Kharapla, (**Gujarati**); Kali kishi, Khadakpalu, Khadak-paalu (**Marathi**); Aree, Aaree, Karuthaaree (**Malayalam**); Aree, Cooree, Karuppu mattawa (**Tamil**); Calamara, Barrbal (**Telugu**)

MORPHOLOGICAL DESCRIPTION

Acanthopagrus berda has a fairly deep, compressed body with depth about twice in standard length. Head is about 3 or 4 times in standard length with straight upper profile (sometimes with a bulge above eye) and pointed snout. Both jaws contain 4-6 large, compressed teeth in front, followed by 3-5 rows of molar-like teeth; upper lateral teeth of outer row conical and blunt. There are about 9-11 gill rakers on the lower limb of first arch. The species has a single dorsal fin with 11 (rarely 12) spines and 10-13 soft rays. The spines of dorsal fin appear alternately broad and narrow on either side with 4^{th} to 6^{th} spines longest. Anal fin contain 3 spines and 8 or 9 soft rays. Caudal fin is slightly forked, with rounded lobes. Scales are large, 43-45 in lateral line; 4-4.5 scale rows between lateral line and 4^{th} dorsal spine and presence of a scaly sheath at base of dorsal and anal fins. Pelvic fin contains a long axillary process. Colour is usually dark silver or dull brown with silvery reflections; upper part of body and base of scales darkest and a dark edge along opercle. Spinous part of dorsal fin with a dark edge; pectoral fins dusky with a yellow tinge and caudal fin grey with darker shading.

Source of image : RC of CMFRI, Kozhikode



PROFILE

GEOGRAPHICAL DISTRIBUTION

Acanthopagrus berda is widely distributed throughout the tropical Indo-West Pacific region, occurring from South Africa to India and extending to Japan, East Indies and Northern Australia. In South Africa it is found along the east coast, where its range extends southwards to Port Elizabeth. This species commonly occurs in the Indian Ocean, along South Africa, Mozambique, the Red Sea, Phuket and Malaysia (Penang Island and Langkawi Island, near Singapore). In India, it is available in south-west coast as well as Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

Acanthopagrus berda inhabits a very wide range of environments namely marine, freshwater and brackishwater and the species is known to tolerate low saline waters of estuaries and rivers. This species enters freshwaters of Zimbabwe and South Africa (Lower Zambezi, Lucuara River). They inhabit coastal shallow waters, with common occurrence in brackishwater swamps or estuaries at a depth range of about 50 m. Larger adults tend to be solitary and occur in deeper waters, while the smaller species and young ones form aggregations and are often found in estuaries. They are found abundant in tropical mangrove estuaries. In South Africa presence of this species from various estuarine systems has been reported.

It is a protandric hermaphrodite, changing sex from male to female. Males and juveniles dominate the smaller size classes and females dominate the larger size classes. It attains a maximum of 900 mm total length (TL) and 3.2 kg total weight. In Japan, Kuwait and South Africa lengths of 450-750 mm have been recorded; but the majority caught in South African waters are < 400 mm TL. Length at 50 % maturity of this species has been established at 220 mm TL. The maximum reported age is about 14 years. A popular angling species often caught with hook and line and locally exploited by artisanal fishers along the Indian coast. Spawning is known to occur between May-August, with peak spawning in May and June. An increase in abundance of this species is noted near the mouth of the St. Lucia Estuary, Republic of South Africa between April and July suggested that spawning occurs close to inshore in the vicinity of the bar mouth.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

The adult fishes feeds mainly on echinoderms, worms, crustaceans, molluscs and small fishes. A study conducted in Pakistan suggests that juveniles weighing from 10.2 g and 56.3 g can perform well on 42 % protein diet with 20 % lipid level under available laboratory conditions.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Caligus epidemicus infection was reported from Australian waters.

PRODUCTION, MARKET AND TRADE

PRODUCTION

FAO Regional Commission for Fisheries (RECOFI) reported that the landings of *A. berda* showed an overall increasing trend from 20 t in 2000 to 63 t in 2011.

MARKET AND TRADE

The fishes of genus *Acanthopagrus* have good consumer acceptability due to their excellent meat quality. Approximate price for the fish in local market in India is ₹ 470/ kg.

CHALLENGES TO MARICULTURE

Breeding and seed production of various *Acanthopagrus* spp. has been reported from different parts of the world. However reports on breeding and seed production of *A. berda* are scanty. The main researchable issues, which have to be sorted out for this species in India, are (i) Protocol for domestication and development of broodstock (ii) Larval rearing protocol (iii) Disease and feed management (iv) Aquaculture practices.

FUTURE PROSPECTS

Acanthopagrus berda is an important fish in fisheries and aquaculture because of its high recreational value, excellent meat quality, high economic value, ability to tolerate wide variations in environmental parameters such as salinity and temperature and fast growth. Therefore, this speices in tropical Indian waters has the potential to attract commercial interests in the near future.

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Caranx sexfasciatus Quoy & Gaimard, 1825

Rengarajan Jayakumar, A. K. Abdul Nazar, and Ritesh Ranjan

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Carangidae**
Common/FAO Name (English)	:	**Bigeye trevally**

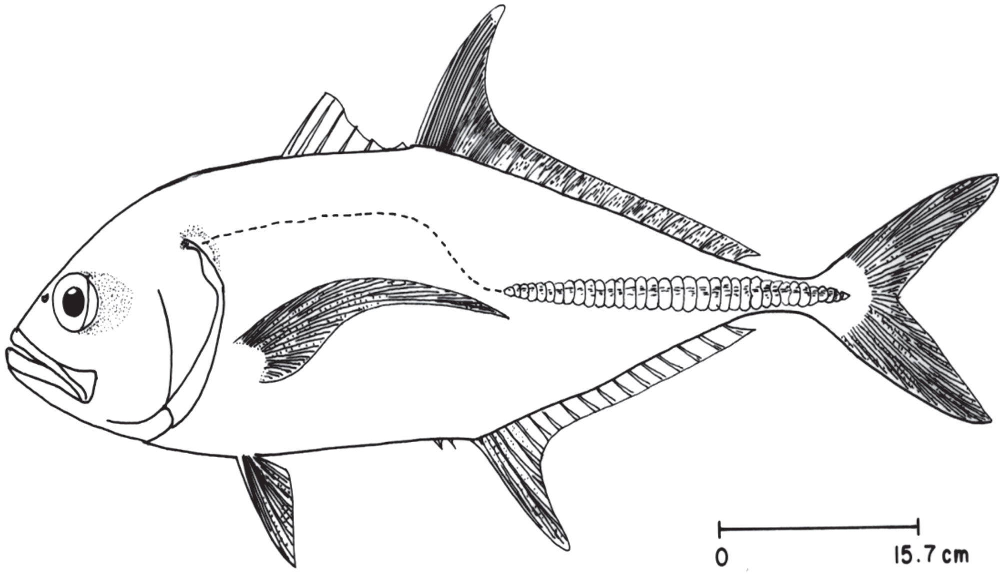
Local names: Bangada, Kala bangada (**Gujarati**); Kala bangada (**Marathi**); Gondlu (**Kannada**); Kuluvel, Maduthala, Varayan para, Vatta (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

The bigeye trevally has a body shape similar to the giant trevally. However it has a slightly more pointed snout which is greater in length than eye diameter. All fins are similar to giant trevally fins with slight differences only in the soft ray numbers. Dorsal fin rays are 19-22; anal fin rays are 14-17; pelvic fin rays are 17-18. Caudal fin is strongly forked while the pectoral fin is falcate as in giant trevally. However, unlike the giant trevally, in this species the breast is completely covered with scales. The species has well-developed adipose eyelids; mouth with an outer row of canine teeth and an inner row of villiform teeth in the upper jaw, and conical teeth on the lower jaw. The bigeye trevally has 21-25 gill rakers and 25 vertebrae.

Similar to the giant trevally, the bigeye trevally shows colour changes as the fish grows. Juveniles are silvery-yellow in colour, with 5 to 6 dark vertical bands. The bands lighten as the fish grows and disappear completely in adult fish. Adult fish are silvery-olive to blue green colour dorsally and silvery-white ventrally. Fins also darken in colour as the fish grows. The tip of the second dorsal fin has a distinctive white tip in adults.

Source of image : RC of CMFRI, Mandapam Camp



PROFILE

GEOGRAPHICAL DISTRIBUTION

The bigeye trevally is widely distributed in the Indian and Pacific Oceans. In the Indian Ocean, it extends from South Africa, the Red Sea and Persian Gulf, further eastwards to India, south-east Asia, Indonesia and Indian Ocean islands. It extends north to Japan and south to Australia in the Indo-Pacific region. In the Pacific Ocean, the bigeye trevally is distributed in most islands including Hawaii, and extends further east to west coast of North America where it ranges from California in the north to Ecuador and the Galapagos Islands in the south.

HABITAT AND BIOLOGY

The bigeye trevally is an inshore species with some occurrence in offshore waters. It is mostly found near corals or rocky areas with juveniles being further inshore than the adults. Some tide-associated movement has also been reported for this species. The juveniles of this species have been reported from estuaries as well as from open waters, indicating their large salinity tolerance. The species has been reported to congregate around stationary buoys in open ocean waters, indicating that it may follow floating debris far out to sea. Studies in South Africa have shown a positive correlation between the abundance of this species and water temperature. The bigeye trevally mainly feeds on small fish; with some inclusion of a varied array of invertebrates also. These include crustaceans such as shrimps, copepods, decapods and stomatopods and other invertebrates like cephalopods, gastropods, jelly fish, sponges and even species of open ocean sea-skater insects, of which it is the primary predator. Evidence from South African estuaries indicates a shift in diet as the fish grows. Young fish below 20 cm in length feed on other juvenile fish and penaied shrimps, while fish larger than 20 cm feed almost exclusively on small fish. The adult of this species are thought to move between coral reefs based on food availability. Bigeye trevally is a prey for other larger animals like sharks, other larger carangid fish, sea lions and various birds.

This species matures around 42 cm, with both males and females reaching maturity at a similar length and age. Spawning season varies with area, occurring between July and September in the east Pacific and during November to March in South Africa. Reports indicate that spawning may occur during new moon periods. The species is considered nocturnal and it is known to form semi-stationary to stationary aggregations of nearly thousands of individuals during the day. These large schools of the fish move from reef to reef and reach specific destinations for the purpose of spawning. Prior to spawning, pairs break off from the main aggregation to commence spawning. Courtship and spawning has been observed at dusk. The spawning pair increases their swimming speed to leave the school, with the male fish underneath, instantly changing colour to black. The colour-changed male fish chases off any other individual that approaches the pair. The fish then press their ventral surfaces together to spawn, often swimming almost horizontally. Once spawning is over they revert back to their silvery colour and return to the school. Even though the fish forms large spawning aggregations, mass spawning is not a common occurrence. The larvae of bigeye trevally have been described extensively, with defining features being a conspicuously pigmented supra-occipital crest, relatively deep body and an anal fin ray count of 15-17, the lowest of any east Pacific carangid. There has been little research into the later stages of growth and their growth rates. The bigeye trevally has recorded a maximum size of 120 cm in length and 18.0 kg in weight.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

The species was one of the three species of non-reef fish (other two being, *Caranx malabaricus* and *Lates calcarifer*) that was cultured in cages in Sabah, Malaysia during the mid-1990s. Seed was collected from the wild. Box-shaped cages attached to frames were used for culture of reef fishes including *C. sexfasciatus*. Mesh size of the cage nets ranged from 0.5 to 3-4 inches. Depending on size of fish, either small or large cages were used for culture. Stocking density ranged from 0.6-23 kg/m^3 depending on the species and availability of wild seed. Trash fish was the major feed, fed at 10 % of body weight per day. Period of culture ranged from 8-12 months. Survival of the species ranged from 60-80 % and varied from region to region.

FOOD AND FEEDING

Information not available

GROWTH RATE

Juveniles (50 to 85 g) have been reported to attain 300-450 g in 150-180 days with 80-90 % survival in cages along west coast of India.

DISEASES AND CONTROL MEASURES

Caligus spp. infestation in bigeye trevally has been reported in Phillipines and Taiwan.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

The species attracts good demand in India with domestic market price of ₹ 350-400/kg.

CHALLENGES TO MARICULTURE

The main researchable issues, which have to be sorted out for this species in India, are (i) Domestication and broodstock development protocol (ii) Natural as well as induced breeding (iii) Larval rearing protocol: standardization of larval rearing by environmental and nutritional manipulations (iv) Standardization of techniques for nursery rearing and grow-out culture (v) Disease and feed management.

FUTURE PROSPECTS

Caranx sexfasciatus is an ideal candidate species for mariculture since it has shown good growth in preliminary cage culture carried out using wild seed in west coast of India. It is a high value fish (fairly good domestic demand as well as price) with good meat quality. Research can be focused on the captive broodstock development, breeding and larviculture of the species so that full fledge farming trials can be undertaken. In addition, this fish is known to form spawning aggregations, thus it is highly vulnerable to being over-fished. Hence exploring and popularizing mariculture of this species will go a long way in conserving the populations in the wild.

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Coryphaena hippurus Linnaeus, 1758

B. Santhosh, Prathibha Rohit, E. M. Abdussamad and Sekar Megarajan

IDENTIFICATION

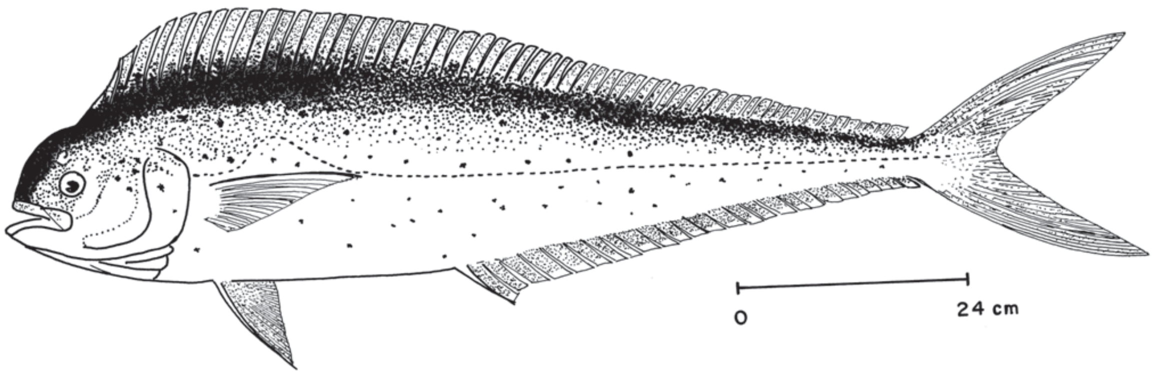
Order	:	**Perciformes**
Family	:	**Coryphaenidae**
Common/FAO Name (English)	:	**Mahi-mahi**

Local names: Himra machhi (**Gujarati**); Popat masa, Abanoos, Himra masa (**Marathi**); Thondrotte (**Kannada**); Avoli, Karuvoli, Vellavoli, Rocket fish, Affunosi, Pullimodha, Padalan, Chain cover (**Malayalam**); Badahlan, Koppurai-kulavanna, (**Tamil**); Hylesu, Babbaasipara (**Telugu**); Baal (**Oriya**)

MORPHOLOGICAL DESCRIPTION

The common dolphinfish is an elongate and compressed fish with small cycloid scales. The mouth is large with fine teeth arranged in bands. There is a small oval tooth patch on the tongue. The lateral line is straight with an upward curve over the pectoral fin. The dorsal fin is very long, extending from the nape to the tail and has 58-66 soft rays. The anal fin is also very long, extending from behind the anus to the tail and has 25-31 soft rays. Neither of the two fins has any spine. The pelvic fins fit into a groove on the ventral part of the body. The pectoral fin has 19-21 rays. The caudal fin has 17 principal rays with 10-14 upper and lower secondary rays. The species is brilliantly coloured with golden colour laterally, metallic blues and greens dorsally and white and yellow ventrally. Smaller fishes have conspicuous vertical bars on the sides of the body. In juveniles, tips of the caudal fin are white and the pelvic fins are black.

Source of image : RC of CMFRI, Visakhapatnam



PROFILE

GEOGRAPHICAL DISTRIBUTION

The common dolphinfish is widely distributed in tropical and subtropical waters and is commonly found in the Atlantic, Indian and Pacific oceans. It is available all along the Indian coast with large abundance in the southern region. Its distribution ranges from 47° N - 38° S and 180° W - 180° E and between temperatures of 21-30 °C.

HABITAT AND BIOLOGY

Juveniles often form schools and adults are distributed in open oceanic waters. In early life stages it feeds on zooplankton and later, on all forms of fishes, crustaceans and squids. Mature fishes exhibit sexual dimorphism with males possessing a prominent bony crest in front of the head. It attains sexual maturity at around 40 cm size and produces 1,50,000-2,00,000 eggs/kg body weight of female per spawning. It spawns almost round the year. Eggs and larvae are pelagic.

BREEDING IN CAPTIVE CONDITIONS

The research on artificial breeding and culture of common dolphin fish started in 1975. Breeding of the fish in captivity has been achieved successfully in Waikiki Aquarium and Oceanic Institute, Hawaii, USA. Broodstock was raised in confined environment using large live healthy fishes caught by barbless hooks. Best survival was achieved for fishes stocked at less than 45 cm fork length. However, the most dependable way to get broodstock was to raise them from eggs as it ensured no parasites, and was adapted to water quality in the tank, food quality and tank design. Broodstock raised in circular tanks gave good survival than the ones maintained in rectangular tanks. Females spawned on every other day throughout the year. By the time males were 15 kg (15 months or less), captive females were 4.5 kg, and produced at least 2,00,000 eggs on every second day. It spawned in captive tanks without hormone induction, but in some cases hormone was used. The spawning activity was recorded during night at Hawaii, where as in other places, spawning of the fish was reported during dusk time i.e. 15:35 to 17:45 hrs.

LARVAL REARING

The fertilized eggs were 1.3-1.6 mm in diameter and they were incubated for two days in a submerged, heavily aerated, screened vessel, with 10 % seawater exchange per minute at Oceanic Institute, Hawaii, USA. The eggs hatched out in about 60 h and after hatching, the larvae was ready for first feeding in two (26-27 °C) to three days (24-25 °C). During this period, the larvae developed pigmented eyes and functional mouth parts. The best rearing tanks were gel coated fibreglass with conical bottom and central aeration (no diffusers). In larval rearing, a concentration of 0.5 to 2 x 10^4 algal cells/ml was maintained till day 25. Rotifers were added in the larval rearing tank at 1-2 nos./ml and were maintained the same till 6th day. Copepods were given between days 6-22; in this phase, heavy mortality was observed if larvae were not well fed prior to metamorphosis. In around 12-14 days, pelvic fins emerged, and the straight gut became twisted and several organs were added. Postlarvae (PLs) spent more time near the tank bottom.

NURSERY REARING

At Oceanic Institute, Hawaii, USA, larvae grow rapidly and began to metamorphose at around 17 dph and after metamorphosis, it was considered as juvenile. The nursery phase was between day 20 and day 50 and high mortality rate was observed during this period. In nursery phase, larvae were acclimatized to artificial feeds. In Oceanic Institute, Hawaii, less than 15 % survival rate was observed, even at lower stocking density. Survival was exceptionally high (60 %) when continuous size grading was performed. Research from different parts of the world suggests that high density culture with low maintenance yields 30-40 % survival. In Hawaii, it was observed that during the 25 days of nursery rearing, the larvae grew 85 fold from an average of 0.05 g to 6 g wet weight. During this phase, larvae were initially fed with enriched *Artemia* nauplii and were then simultaneously weaned with artificial diet of 0.5-1 mm size. Larvae were highly aggressive and showed cannibalistic nature. Raceway culture in nursery phase was found to be successful.

GROW-OUT

Fish grew at an average rate of 4 % per day from 40 to 180 days of culture and reached an average harvestable weight of 1.7 kg after 180 days at Oceanic Institute, Hawaii, USA. In another trial conducted for 240 days, males reached up to 4.0 kg and females up to 2.0 kg with an average mixed population weight of 2.4 kg. Fish reared in captivity at Oceanic Institute, Hawaii grew to 4.93 kg and 75.8 cm in 9.5 months from hatching. Absolute growth rates (AGR's) in weight and length were 19.18 g/day and 0.227 cm/day. During grow-out, it was fed with artificial pelleted feed having 53.75 % of crude protein and the feed conversion ratio (FCR) was 1.6 (dry feed/live fish). In another experiment, a wild-caught juvenile kept in captivity grew from less than 1 kg to nearly 16 kg in one year, with growth rates of 4.3 kg (from 0.7 to about 5 kg) in 30 days.

FOOD AND FEEDING

In culture, larvae are fed with rotifers, *Artemia* and copepods. During grow-out, dry or semi-moist (10-30 % moisture) diets are fed containing over 50 % crude protein, 10 % crude fat (expressed on a moisture-free basis) and a high calorific content (5.0 cal/mg). In wild, it feeds on a wide variety of pelagic fishes, crustaceans and cephalopods.

GROWTH RATE

In Hawaii, it was observed that during the 25 days of nursery period, the larvae grow 85 fold from an average of 0.05 g to 6 g wet weight. In another experiment, 1.6 g fish fed with chopped herring and squid grew to 1.3 kg after 130 days culture in circular tank. It showed different growth rates in different grow-out systems. The reported ideal growth rates being 2 kg in 6 months and 9 kg in one year when fed with fish and squid and 5.4 kg in 8.7 months when fed with commercially available pellets.

DISEASES AND CONTROL MEASURES

Vibriosis, caused by *Vibrio alginolyticus*, occurs in cultured dolphinfish. Clinical signs include anorexia, caudal fin erosion and epidermal lesions. A 10 day treatment with 75 mg Terramycin (oxytetracycline hydrochloride)/kg body weight in the feed results in control of the disease. Red tail disease, caused by stress, is encountered in the grow-out system between 40-90 days of culture. In addition, in culture, there are reports of different parasitic infestations caused by protozoa, worms, etc.

PRODUCTION, MARKET AND TRADE

PRODUCTION

The total production from wild in 2014 was 1,15,658 t.

MARKET AND TRADE

It is an exceptionally versatile fish having firm white meat and a delicate flavour. Broiled, poached, baked, sautéed, grilled, or pan-fried mahi-mahi delivers a truly sensational taste. It is generally marketed fresh and frozen and has high demand in the export market, especially in Japan and Taiwan. It is popular as a food fish and also as a game fish in the Caribbean region, south-eastern United States, east Africa, Taiwan, Japan, China, and Hawaii. The wholesale price in Hawaii is around US $ 9/kg. In Florida, USA the price is US $ 2.24/kg.

CHALLENGES TO MARICULTURE

Culture of this species has not been initiated in India till date though India has good dolphinfish resources. Research needs to be focussed on broodstock development, breeding, larval survival, nutritional, environmental and other physiological requirements with respect to Indian condition. Basic reproductive biology and trophodynamics of the species needs to be studied from Indian waters.

FUTURE PROSPECTS

It has long been recognized as a high-value pelagic fish with excellent potential for aquaculture. Like other fast growing fishes, it has a very high growth rate and a high food conversion ratio (1:1-1:1.5). Captive spawning and egg production happens naturally throughout the year. Life cycle has been established in confined systems. Additionally, it has a good international market. Therefore, developing breeding, seed production and culture technology in confined environment tailor-made for Indian conditions will bring more income generating avenues to the Indian farmer.

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Cromileptes altivelis (Valenciennes, 1828)

Muktha M.

IDENTIFICATION

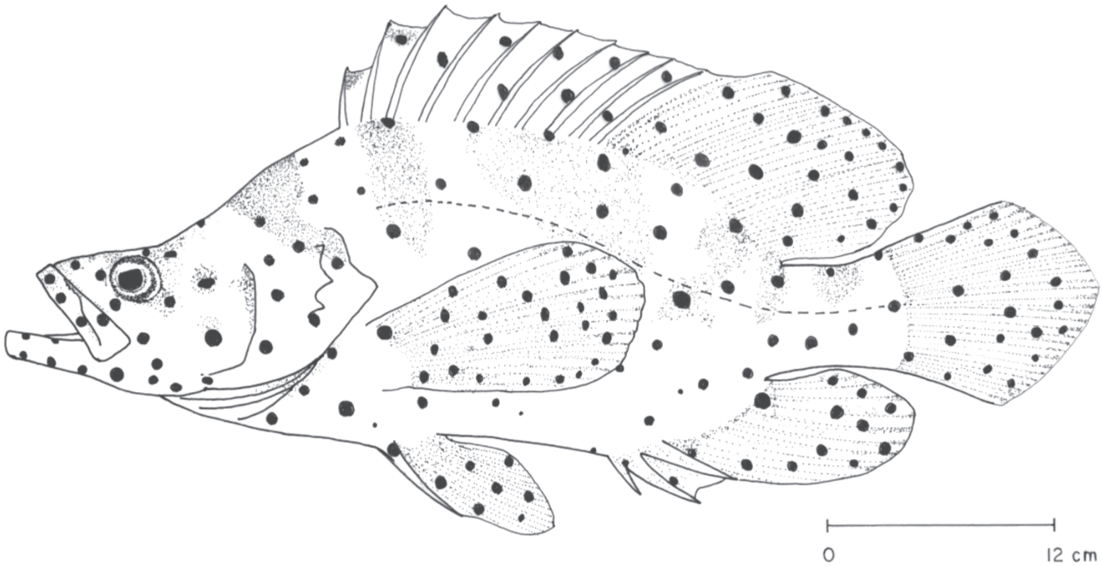
Order	:	**Perciformes**
Family	:	**Serranidae**
Common/FAO Name (English)	:	**Humpback grouper**

Local names: Kalava **(Malyalam)**

MORPHOLOGICAL DESCRIPTION

Compressed body with depth less than head length, head length 2.5-2.8 times in standard length, anterior part of head low and flattened, dorsal profile deeply concave behind eyes, pre-orbital is very narrow, canine teeth completely absent, jaws have villiform teeth, maxilla extending to rear half of eye, pre-operculum angle serrated but lacking any large spines, 2 flat spines on operculum, gill rakers are short numbering 8-11 on upper limb and 13-17 on lower limb, dorsal fin with 10 spines and17-19 soft rays, dorsal fin origin is over the opercle, anal fin with 3 spines and 9-11 soft rays, pectoral fin rounded with 17-18 rays, caudal fin rounded, scales are smooth, lateral line scales 54-62, pyloric caeca 13. Colour of the species is light with a number of dark spots on the body. Maximum size recorded is 71 cm total length (TL).

Source of image : www.fishbase.org



PROFILE

GEOGRAPHICAL DISTRIBUTION

Humpback grouper occurs in western Pacific from southern Japan (Ogasawara) to southern Queensland and northern western Australia and eastward to Fiji. In India, this species is rare, few specimens have been collected from Kanyakumari, Tamil Nadu and Vizhinjam, Kerala.

HABITAT AND BIOLOGY

Cromileptes altivelis inhabits shallow waters of coral and rocky reefs and is also found in tidal pools. Juveniles are found in inshore areas, lagoons, fringing reefs and sea grass beds. It feeds on bottom-living invertebrates and fish. It is a monandric protogynous hermaphrodite and moves in pairs or as individuals and does not form large spawning aggregations. The maturity of females is between 30 and 40 cm TL. The first age of sexual maturation in females has been reported at 155 mm standard length (SL) at 1.5 years age. First maturation at 2 years has been reported from Australia. Length at which 50 % of the population is male was estimated to be 547 mm fork length

(FL) in Australia. It has been reported that females are more numerous among smaller and younger fish and males in larger and older fish. Transitional individuals occur over a number of ages indicating a flexible sex-change process in this species. Spawning round the year has been reported from Indonesia and for restricted months (October-January) from Australia. Multiple spawning has been reported in a single season. The spawning pattern follows a lunar rhythm. Spawning occurs for 7-10 days around each new moon day in most cases. Maximum size recorded is 71 cm. Sizes of 350 to 710 mm FL have been determined to be between 1 and 19 years old.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Due to its high demand the first spawning trial was conducted as early as 1979 in Indonesia. However its first larval rearing cycle was successfully completed at Gondol, Indonesia in 1996. The first time mass seed production (> 1,00,000 seed) of humpback grouper was achieved at Gondol, Indonesia during 1999-2000.

In Indonesia wild collected mature male and female fish were kept in 100 t circular tanks for acclimatization. Water was maintained at a depth of 2 m with 200-300 % daily water exchange. Mature male fish were 2.9-3.4 kg and female fish were 1.48-2.3 kg size. The male female ratio was 1:5. The fish were fed sardines, squid and vitamin-mineral mixture. Natural spawning occurred generally during new moon phase. The number of eggs released ranged from 0.4-4.2 million per spawning event. The fertilization rate was 80-98 %. The fertilized eggs after spawning were transferred to 1-2 t capacity hatching tanks. The hatching rate was 10.3-88.8 %. Water salinity was 33-34 g/l and temperature was 28-30 °C. Incubation period was 18-20 h. In another study in Indonesia hatching time ranged from 18 h 41 min to 20 h 29 min. Hatching rate was higher for eggs at densities less than 1,500/l than those stocked at higher densities. Hatching rate was also higher for eggs which had 200 % or more daily water exchange as compared to lower water exchange rates. Aeration rate also affected hatching with increased aeration rates enabling higher hatching rates and larval survival. This study concluded that for good hatching rates for humpback grouper egg density of 500/l with water exchange of 200 % per day at aeration rates of 600 ml/min was optimal.

LARVAL REARING

Larval rearing is difficult since the humpback grouper larvae are very sensitive to the environment during the metamorphosis stage and hence show high mortalities. Newly hatched larvae were stocked in 10 t tanks at stocking rates of 10-15 larvae/l. Salinity of seawater was 33-34 g/l with temperatures of 28-30 °C. *Nannochloropsis* sp. was added into the tanks within 24 hours of larval stocking at densities of 2-3 x 10^5 cells/ml and the same was maintained till the 20^{th} day. SS-type rotifers were introduced from the 2^{nd} day and maintained till the 5^{th} day at densities of 7-10 nos./ml. S-type rotifers were introduced on the 5^{th} day and maintained till the 15^{th} day at densities of 10-15 nos./ml. This was discontinued after the 20^{th} day. Newly hatched *Artemia* nauplii were supplied from 15^{th} day onwards at densities of 0.1 nos./ml which was increased to 0.2 nos./ml by the 18th day. From the 18th to 45th day density of *Artemia* was increased to 0.5 nos./ml. Commercial feed was also started from the 20th day onwards. Feed size was increased from 230 µm to 820 µm from day 20 to 50. The average size at the end of larval rearing of 50 days was 2.44 cm. The survival rate of larvae was 2.63-5.13 %. A study in Indonesia has reported that water temperature influenced the growth, spine development, feeding and survival of humpback larvae significantly. The study found that larval growth was best in water temperature of 31 °C. The study found that spine development occurred faster at higher water temperatures. Feeding rates were highest at 28 °C and 31 °C. Survival was highest at 28 °C. Artificial lighting (1000 to 1500 lux) was provided during the larval rearing period.

PERIOD OF CULTURE	DURATION OF LIGHT (hrs)
Day 2	08:00 to 20:00
Day 3 to Day 5	05:45 (Just before sunrise) to 22:00
Day 6	05:45 to 21:00
Day 7 to 10	05:45 to 20:00
Day 11 onwards	05:45 to 19:00 (30 min after sunset)

NURSERY REARING

Nursery rearing of humpback grouper involves rearing the 2-3 cm sized larvae to fingerling sizes of 5-10 cm which can then be stocked in cages for grow-out. Tank rearing has been found to suit humpback grouper the best during nursery rearing. Tanks can be of any shape with illumination of 600 lux is suitable. Good quality seawater which is exchanged daily at the rate of 300 % is required. The optimum water quality parameters for nursery rearing of humpback grouper are temperature 27-32 °C, salinity 25-35 g/l, DO 6-8 mg/l, pH 7.8-8.3 and unionized ammonia < 0.02 mg/l. Nursery rearing of humpback grouper was also carried out in cages in Indonesia. Net cages of size 1m x 1m x 1.5 m are used for rearing the groupers to 9-12 cm sizes. The nursery rearing of humpback grouper in net cages lasted for 3-4 months at stocking densities of 150-200/cage. Fish were fed 3-4 times daily with a mix of trash fish and commercial diets *ad libitum*. Net was changed every 7-10 days to maintain water quality and prevent disease attacks. Once fish reached 15-17 cm, stocking density was reduced to 75-100 nos./cage.

GROW-OUT

Grow out of humpback grouper was carried out in floating net cages in Indonesia of sizes 3m x 3m x 3m. The fish of size 15-17 cm were stocked in cages at densities of 50-75 fish/cage. They were fed trash fish and pellet feed incorporated with Vit. C and minerals 1-2 times daily *ad libitum*. The market size of 500 g was reached after culture of 16-19 months. The survival of humpback grouper was 50-90 %. The FCR varied from 5.44-13.52.

FOOD AND FEEDING

Fingerlings of humpback grouper of less than 50 g have been shown to require feeds of 50-56 % crude protein and 9-15 % fat. In grow-out system, fish were fed with trash fish and pellet feed. The pellet feed should not have less than 53 % crude protein and 10-12% lipid.

GROWTH RATE

Humpback grouper grew to a size of 20-29.5 g after 14 weeks of culture from 4.1 g. They attained a size of 400-600 g after 18-20 months of culture.

DISEASES AND CONTROL MEASURES

The rapid development of humpback grouper culture led to the incidence of infectious diseases caused by bacteria, parasites and viruses that have become more and more severe which has resulted in serious economic losses in farms and hatcheries. The list of disease causing organisms reported in *C. altivelis* and their control measures are listed below.

Disease & Causative agent	Control measures
Bacterial diseases	
Fin rot (*Flexibacter maritimus*)	Freshwater bath for 10-15 min
Viral infections	
Nervous necrosis virus (*Betanodavirus* sp.)	Screening of Broodstock both pre- and post-spawning, disinfection of fertilized eggs using ozone or iodine, proper hatchery management, vaccination of fish
Fungal disease	
Ichthyophoniosis (*Ichthyophonus* sp.)	Caution when using trash fish as feed
Parasitic disease	
Amyloodioniosis (*Amyloodinium ocellatum*)	Use of filtered and disinfected water, freshwater bath, bath in 0.5 mg/l copper sulphate for 3-5 days or 200 mg/l formalin for 30-60 min
Cryptocaryonosis (*Cryptocaryon irritans*)	Maintain 1 h in freshwater over 2-3 days, treatment with 0.5 mg/l copper sulphate for 5-7 days with strong aeration
Trichodiniosis (*Trichodina* sp., *Trichodinella* sp. and *Tripartiella* sp.)	Freshwater bath for 1 h for 3 days, chemical treatment using 200 mg/l formalin for 30-60 min with strong aeration or 25-30 mg/l formalin for 1-2 days

Skin monogeneans (*Benedenia epinepheli*, *Benedenia* spp., *Neobenedenia girellae* and *Neobenedenia* spp.)	Freshwater bath for 5-30 minutes, treatment with 150 mg/l hydrogen peroxide for 10-30 min with strong aeration
Gill monogeneans (*Pseudorhabdosynochus* spp., *Megalocotyloides* spp. and *Diplectanum Epinepheli*)	Bath with 200 mg/l hydrogen peroxide for 1 h, 100-200 mg/l formalin treatment for 30-60 min with strong aeration
Nematode induced infections (*Philometra* sp., *Anisakis* sp. and *Raphidascaris* sp.)	Avoid feeding with infected trash fish, eliminate intermediate hosts (*copepods*), dry the pond bottom, disinfect the culture facilities with quicklime to destroy the eggs of the nematode
Sea lice Infection (*Caligus epidemicus*, *Caligus* sp. and *Lepeophtheirus* sp.)	Sufficient water exchange, Freshwater bath for 10-15 min, chemical treatment using 150 mg/l hydrogen peroxide for 30 min or 200-250 mg/l formalin for 1 h with strong aeration
Leech induced infections	Use of filtered water, manual removal using wet cloth, bath with 200-250 mg/l formalin for 1 h with strong aeration, culture facilities must be cleaned, disinfected with chlorine and exposed to intense sunlight for several weeks prior to use to eliminate cocoons of the parasite.
Nutritional disease	
Lipodosis Fish scurvy	Proper handling and storage of feed use of stable form of ascorbic acid in diet in required quantities
Nutritional myopathy accompanying ceroidosis	Proper food management, rancidity to be prevented by frozen storage of food, use of anti-oxidants, enrichment of food with vitamin complex
Thiamin deficiency	Long-term feeding with only sardine or anchovy should be avoided, enrichment of food with vitamin complex

Environmental disease	
Swim bladder stress syndrome	Harvest, if market size fish is affected, remove small affected fish to prevent infections, remove gas by piercing the abdomen of brooders followed by treating the site with 0.1 % acriflavine

PRODUCTION, MARKET AND TRADE

PRODUCTION

Global production was 3 t and 1 t in 2006 and 2007 respectively.

MARKET AND TRADE

It is the most priced fish in the live reef food fish trade in Hong Kong. The volume of humpback grouper imported into China during 1997-2005 ranged from 133 kg to 8,700 kg with an estimated peak value of US $ 1,276,000. During 1999-2002 its retail price ranged from US $ 82-118/kg in Hong Kong. In addition, juveniles of humpback grouper have high demand in the aquarium trade as ornamental fish. Juveniles of 5-10 cm size fetched US $1 in Indonesia and US $ 8-10 in Singapore and Australia. As part of the aquarium trade this species is exported from Indonesia to USA, Singapore and Hong Kong. Larger humpback groupers occupy the prominent spot in the live reef food fish industry. The major exporting countries are Indonesia, Vietnam, Taiwan, Philippines, Thailand and Australia.

CHALLENGES TO MARICULTURE

The main researchable issues, which have to be sorted out for this species in India are (i) Broodstock development protocol: mature broodstock of both sexes is required simultaneously for reliable seed production of grouper. However obtaining males from the wild for spawning is difficult because groupers are protogynous hermaphrodites (ii) Larval rearing protocol: standardization of larval rearing by environmental and nutritional interference (iii) Disease and feed management (iv) Selective breeding for enhancement of growth rate since this species is naturally slow growing.

FUTURE PROSPECTS

Humpback grouper is a popular fish with a high market demand in many parts of the world, such as Indonesia, Singapore, Malaysia, Thailand, Philippines, Hong Kong, Taiwan and China. It fetches a very high price (US $ 82-118/kg) in the international market (Hong Kong and other south-east Asian countries). In addition, it has a very good market demand as ornamental fish. It thrives well in ponds as well as cages. So it can be an ideal species for Indian mariculture, though the growth rate is slow, which can be compensated by the higher price.

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Eleutheronema tetradactylum (Shaw, 1804)

Boby Ignatius, Imelda Joseph and Sekar Megarajan

IDENTIFICATION

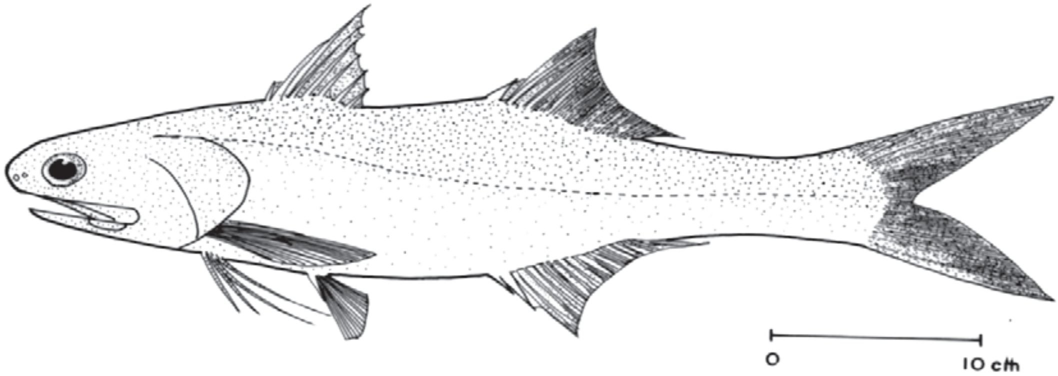
Order	:	**Perciformes**
Family	:	**Polynemidae**
Common/FAO Name (English)	:	**Fourfinger threadfin**

Source of image : CMFRI, Kochi

Local names: Rawas (**Marathi**); Vameenu (**Kannada**); Bameen, Thamuthi, Vazhmeen, Norakudiyan, Wahmeen (**Malayalam**); Pozhakkala, Yevakal (**Tamil**); Maga (**Telugu**); Guchhia, Sahal (**Bengali**)

MORPHOLOGICAL DESCRIPTION

There are 9 dorsal spines and 13-15 dorsal soft rays. There are 3 anal spines and 14-16 anal soft rays. The species has 4 unbranced pectoral filaments. Vomer has deciduous tooth plates on both sides, except in juveniles. Villiform teeth present. Posterior part of maxilla is deep, 3-4 % of standard length. There is a short tooth plate extension onto lateral surface of lower jaw. Air bladder is absent. Colour silvery-green with yellowish-white on the sides and abdomen.



PROFILE

GEOGRAPHICAL DISTRIBUTION

Eleutheronema *tetradactylum* is distributed in Indo-West Pacific from Persian Gulf to Papua New Guinea and northern Australia. In India, it occurs all along east and west coasts and forms a major fishery in Sunderbans on the east coast and Mumbai and Saurashtra on the west coast.

HABITAT AND BIOLOGY

Adults occur in shallow coastal waters and also ascend rivers, mainly in the winter. Juveniles are found in estuaries. Smaller fish form loose schools, however, larger fish are either solitary or move in pairs. It is carnivorous and the choice of feed varies according to size. Larvae (7-30 mm total length) feed mainly on copepods and mysids and occasionally also consume shrimp larvae. Juveniles (31-60 TL) feed on shrimps and mysids. It has been observed that the fish is a protandrous hermaphrodite and it becomes female after 2 years. Recent study from India indicates that mean length of male fish is 240 mm TL, with transition to female starting from 288 mm TL. Mature females were > 380 mm TL. However, gonochoristic individuals have also been reported for this species from Australia and India. Two spawning seasons, i.e. January-April and July-September, have been reported from the west coast of India with a single spawning event for a fish in a season. The species matures at a size between 36 and 39 cm. Gonadosomatic Index (GSI) ranged between 1.04 to 18.33 and ova diameter of fully matured egg varied between 400 µm to 790 µm with fecundity 1.0-2.09 million. The species can grow to more than 1 m in length with a maximum life span of 7 years.

BREEDING IN CAPTIVE CONDITIONS

Detailed information on commercial scale breeding and seed production of the species in captivity is scarce. However, reports mention that a private hatchery in Malaysia has achieved breeding in captivity, but seed production could not be achieved. Limited information is available from India, but there are reports on collection of eggs from naturally matured fish in the Tua Nali area in the Chilka Lake during January-June. Matured oozing eggs of 625-860 µm were collected from fish measuring 575-715 mm in length. The collected eggs were characterized by a single oil globule measuring 274-366 µm in size. In an another experiment, fertilized eggs were collected from same area using tow net, the collected developing eggs measuring 720 to 990 µm and showing blastoderm disc with a single oil globule ranging from 270 to 370 µm.

LARVAL REARING

Larval rearing of the fish in confined environment is not known. However, an attempt was made to hatch and rear the larvae in confined environment using wild collected eggs in West Bengal, India. The fertilized eggs collected from wild hatched after 12-14 h. The hatchlings measured 1.45 to 1.55 mm, characterized with 27 myotomes including an un-segmented mesoderm. Immediately hatched out larvae exhibited a tendency to float with their belly up. One day old larvae attained a length of 1.80 mm with considerably reduced size of yolk and oil globule. However, all hatched out larvae died after 32 hours post hatching, by which time they reached a size of 1.95 to 2.1 mm.

NURSERY REARING

Information not available

GROW-OUT

This species has been identified as one of the potential candidate species for culture in most of the Asian countries like Malaysia, Singapore, Thailand and China. It has been cultured in earthen ponds and cages using wild seed. There is limited information on the details of grow-out culture. A study was conducted to estimate their growth performance in Bangladesh using wild collected seeds of 36.14 g in brackish water ponds. Fish grew to 80 g in 45 days with a stocking density of 0.5 individuals/m^3 in earthen ponds. Average growth rate ranged from 0.56 to 2.8 g/day with 70-80 % survival rate. During grow out, the fishes were fed with chopped low value fish and the observed FCR was 2.3.

FOOD AND FEEDING

This species is carnivorous with characteristics exhibiting its predatory, voracious and cannibalistic nature. The young fish feed on zooplankton like copepod nauplii and amphipods with their filter feeding mechanism. As they grow in size, they feed on larger plankton like mysids, megalopa larvae, shrimp and fish larvae. Adult fish feed on polychaetes, decapods, stomatopods, shrimps and fish. In grow out, this species feeds on chopped low value fish.

GROWTH RATE

The observed growth rate in earthen pond culture varied from 0.56 to 2.80 g/day during 45 days culture of wild seed (36.14 g). It has been observed in different studies that stocking density, water quality parameters and feeding affects their growth rate. In Chilka Lake, India, the early broodstock of this species is reported to grow very fast in the first year up to 30 cm, then growth slows down and it reaches 47.5 cm in second year and 60 cm in the third year.

DISEASES AND CONTROL MEASURES

Two protozoan diseases have been reported from this species:

1. Neoechinorhynchus Disease - This is a parasitic infestation caused by *Neoechinorhynchus* sp. Infestation is common in the intestine and viscera.

2. Procerovum Disease - This is a parasitic infestation caused by *Procerovum calderoni*. Infestation occurs in the musculature and base of fins.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Aquaculture production of the fish has been reported from three countries viz., Singapore, Taiwan province of China and Thailand. The estimated production in 2007 from this region was 914 t. Of the three countries, production was mainly from Taiwan province of China. Total capture fisheries production for the year 2011 was 11,149 t, with major catch coming from Indonesia.

MARKET AND TRADE

This is an excellent food fish, forming a good fishery in the Hooghly estuary of India. The average estimated price of the fish was ₹ 270-290/kg. The fish is sold as live in south-east Asian markets. A survey conducted in Malaysian fish markets indicates that the fish is sold for ₹ 340/kg in live and ₹ 250/kg in dead condition.

CHALLENGES TO MARICULTURE

Presently, there is very little scientific information available on biology, ecology and culture of *E. tetradactylum* from India which is hindering its mariculture. Though the fish is a high value finfish, many of the culture aspects have not yet studied. Breeding of the fish in confined environment has been initiated, but needs to be standardised further. Similarly, larval rearing, nursery rearing and disease management also needs to be studied and standardised.

FUTURE PROSPECTS

The demand for *Eleutheronema tetradactylum* is high in the domestic market and is growing at a rapid pace. The fish is one of the highly esteemed table fish both at home and abroad. If a higher yielding culture technology (mono or poly) for *E. tetradactylum* becomes established, utilizing the abandoned coastal shrimp ponds of sub-tropical and tropical countries, with encouraging economic profits for farmers, a noteworthy and huge fish industry could come forward.

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Epinephelus malabaricus (Bloch & Schneider, 1801)

Pralaya Ranjan Behera

IDENTIFICATION

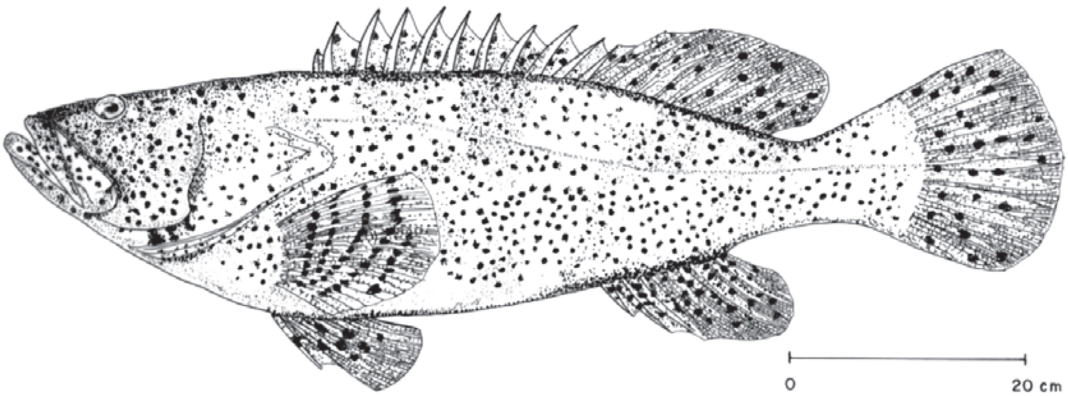
Order	:	**Perciformes**
Family	:	**Serranidae**
Common/FAO Name (English)	:	**Malabar grouper**

Local names: Wekhanu (**Gujarati**); Hekaru, Gobra (**Marathi**); Gobri (**Konkani**); Gopra, Muni meen (**Kannada**); Pulli kalawa, Kalawa (**Malayalam**); Kalava, Punni-kalava, Azhuka (**Tamil**); Kodi punju, Bontha (**Telugu**); Bhala (**Oriya**)

MORPHOLOGICAL DESCRIPTION

Body is elongate with body depth 3.0 to 3.7 in standard length (for fish of 15 to 69 cm standard length). The interorbital area is flat or slightly convex and the preopercle is sub-angular, with enlarged serrae at the angle. The maxilla extends past the rear edge of the orbit. There are 8-11 gill rakers on the upper limb and 14-18 on the lower limb. Dorsal fin has 11 spines and 14-16 rays, the third to fifth spines are slightly longer than posterior spines. The anal fin has 3 spines and 8 rays, the third spine is usually the longest. The pectoral fin has 18-20 rays. The caudal fin is rounded. The lateral-line has 54-64 scales. Pyloric caecae are numerous with more than 80 branches. Head and body brownish, covered with small, well-separated, blackish brown spots which extend onto chest, lower jaw and gular area and roof of mouth; head and body also with scattered white spots and blotches; 5 irregular, oblique, dark brown bars (more or less interrupted by pale spots) often visible on body; fins with scattered small black spots.

Source of image : CMFRI, Kochi



PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is distributed in the Indo-Pacific area. It occurs in continental and insular localities: off Gulf of Aqaba, Sudan, Saudi Arabia, Djibouti, Ethiopia, Kenya, Zanzibar, Tanzania, Mozambique, Oman, Madagascar, Comoros, Seychelles, India, Sri Lanka, Indonesia, Singapore, Philippines, Taiwan, China, Papua New Guinea, New Ireland, Caroline Islands, New Caledonia, and Tonga. In Australia, it occurs from the Northern Territory to New South Wales. This species is common along the west coast of India and in the Gulf of Mannar. It has been reported all along the Indian coast except from Odisha and West Bengal.

HABITAT AND BIOLOGY

A common species found in a variety of habitats such as coral and rocky reefs, tide pools, estuaries, mangrove swamps and sandy or mud bottom from shore to depths of 150 m. Juveniles of the species are found near shore and in estuaries. The fish feeds primarily on fishes and crustaceans and occasionally on cephalopods.

Epinephelus malabaricus is a monandric protogynous hermaphrodite species. The size at first maturity in females is 78.6 cm in coastal waters of Tanzania and 76.2 cm to 83.9 cm from north-western Australia. Sex change from female to male has been reported at size ranges of 105.5 cm to 114.7 cm at corresponding age of more than 10 years. Spawning aggregations have been reported from Andaman Islands. The spawning season is from September to February. Eggs are spherical, smooth and floating in nature.

The species has a very low resilience to fishing, with a minimum population doubling time more than 14 years. This species is solitary in nature. The maximum recorded total length is 150 cm which corresponds to a weight of 53 kg.

BREEDING IN CAPTIVE CONDITIONS

Seed production technology of grouper is being developed at National Institute of Coastal Aquaculture (NICA) since 1984 using techniques similar for seabass, *Lates calcarifer*. Mass propagation was reported at NICA since 1990-1996, with inconsistent production. In India, experimental culture of groupers was initiated two decades back by CMFRI, Kochi. Success was achieved in broodstock development, sex inversion and captive spawning of *E. malabaricus*. Broodstock development and sex inversion of the species was carried out at the mariculture laboratory at Vizhinjam Research Centre of CMFRI, India.

Broodstock development and seed production of *E. malabaricus* was carried out at NICA hatchery, Thailand. Broodfishes were transported from net cages to a 150 t outdoor tank at the hatchery. The broodfish were fed fresh sardines at the rate of 1-2 % of body weight each day. Vitamin E at the rate of 400 mg was added to 1 kg of feed once a week. The broodstock feed was supplemented with vitamin C, premix and fish oil at the rate of 0.3, 0.3 and 0.35 g/week. The salinity and temperature of water was 30-31 g/l and 28-30 °C respectively. Aeration was supplied to the water at the rate of 4-5 l/m^3/sec continuously. Water exchange (50-80 %) was carried out every day. The broodfishes were induced to spawn by two methods viz., by water manipulation and by hormone induction. Water manipulation involved changing 80 % of the water over a period of 5 days before new moon or full moon. Subsequently, new water was added to the tank with continuous flow through until dusk each day. Fish spawned during the beginning of new moon or full moon and once spawning started, it continued for 7-10 days. In the second method, spawning was induced by hormone injection. Puberogen hormone was used at the rate of 100 IU/kg and 50 IU/kg for female and male brooders, respectively. In Taiwan, the males and females of *E. malabaricus* were injected with gonadotropin hormone to induce maturation and ovulation. Both male and female were stripped for milt and ova and artificial fertilization was followed. The egg production and spawning frequency of broodfishes injected with hormone were higher than those treated by water manipulation.The grouper lay eggs at night from 21:00-24:00 hrs. The following morning, fertilized eggs were collected and transferred to a funnel fibreglass tank (500 l) at a stocking density of 1,000-2,000 eggs/l. The fertilized eggs hatched within 17-19 h at a water temperature of 26-29 °C and salinity of 30-31 g/l.

LARVAL REARING

A cement tank measuring 4m x 6m x 1.5 m containing 25 t of water was used as larval rearing tank. The hatched out larvae were stocked in larval rearing tank at 10-15 nos./l. Screened rotifers of less than 125 µm were added to the larval rearing tank after 48 h of hatching. In Taiwan, 96 h old larvae were fed with oyster trochophore followed with rotifers, copepods, *Artemia* nauplii, eel meat and frozen mysids. From day 5 onwards, unscreened rotifers were used for larval rearing. *Artemia* nauplii were added in the larval rearing tank from day 15 onwards. In about a month's time, postlarvae reached a length of 1.5 cm and after 3 months they reached 8 cm with an average survival of 14 %.

NURSERY REARING

Epinephelus malabaricus fry (1.0-2.5 cm) either from the wild or from fish hatchery needs nursing before stocking to pond or cage. Concrete tanks, nylon net cages and earthen ponds can be used for nursing facilities. Round or rectangular-shaped concrete ponds or tanks with a water capacity of 1-30 t were stocked at densities of 15-50 nos./m^3 and earthen ponds with areas ranging from 800 m^2 up to 3200 m^2 were stocked at 25-100 nos./m^2 and were fed with trash fish. Grading based on size was needed for homogenous growth and minimizes losses due to cannibalism. The fishes can be partially or fully harvested by seine and sold or transferred to culture. The survival rates of harvested fingerling were low in earthen pond when compared to concrete tanks.

Net cage (1m x 1m x 1.5 m) nursing exhibited better results than concrete ponds. Stocking of fingerlings of size 5.7 cm (3.1 gm) at 300-500 nos./m^3 and feeding with trash fish for 75 days produced 14.1 cm (49.9 gm) with survival rate of 91.1 %.

GROW-OUT

The Malabar grouper is cultured in ponds and cages, however generally, cage culture is preferred for grow out. A good fish pond for grow-out should have an area of about 800-1600 m^2 with 1.5-2.0 m water depth. Ponds were prepared and fertilized. Once the natural feed (plankton) was abundant, juveniles were stocked in to the pond. During culture, 40-70 % of water exchange was performed daily. FCR for pond culture of Malabar grouper was high (3.2-3.6:1).

Different shapes and sizes of cages are used for culture. The net mesh size depends on size of fish to be cultured, ranging from 1-2.5 cm for nursery and 5-7 cm for grow out. The stocking density recommended is 15 fish/m^2 but can be stocked at higher densities ranging from 30-200 fish/m^2. Cage culture was performed for six months in Gulf of Mannar along south-east coast of India. A study on the grow-out production of the Malabar grouper was carried out by CMFRI in indoor FRP tanks of 5 t capacity, with re-circulating sea water systems, using indigenously made *in situ* biofilters in the field mariculture laboratory at Kochi Fisheries Harbour in 1999.

FOOD AND FEEDING

Majority of fish farmers use low value fish for feeding groupers. These fishes prefer the yellowstripe trevally (*Selaroides leptolepis*), threadfin bream (*Nemipterus hexodon*), fringescale sardine (*Sardinella fimbriata*) and round scad (*Decapterus russelli*) which can be minced, chopped, cut or whole fed depending on size of fish to be fed.

GROWTH RATE

They can grow from egg to 600 g in about 1 year with cage grow out system. Fingerlings of size 3.1 g fed with low value fish grew to 49.9 g in 75 days.

DISEASES AND CONTROL MEASURES

Disease/Causative agent	Measures
Viral Diseases	
Piscine nodavirus of the genus *Betanodavirus*	Strict husbandry management in the hatchery phase
Fish Lymphocystis Disease virus (FLDV)	Avoid skin damage and quarantine of new fish Early detection of viral pathogens in the hatchery
Bacterial Diseases	
Vibrio parahaemolyticus, V. alginolyticus, V. vulnificus, and *V. carchariae*	Oxalinic acid mixed with feed (20 mg/kg of feed); Terramycin to feed (7.5 g/kg for first 5 days followed by 3.75 g/kg for the next 5 days)
Streptococcus sp.	Oxalinic acid mixed with feed (20 mg/kg of feed)
Cytophaga sp., *Flexibacter* sp. or *Flavobacterium* sp.	Oxalinic acid mixed with feed at 20 mg/kg of feed and oxytetracycline at 75 mg/kg of feed/ day for 10 days; Acriflavin dip at 100 mg/l for 1 min and potassium permanganate bath at 2-4 mg/l
Parasitic Diseases	
Cryptocaryon irritans	Vaccination; Freshwater bath for 1 h for 2-3 days; 0.5 mg/l copper sulphate ($CuSO_4$) treatment for 5-7 days with strong aeration
Trichodina, Trichodinella and *Tripartiella*	Freshwater bath for 1 h for 3 days; 200 mg/l formalin treatment for 30-60 min with strong aeration; 25-30 mg/l formalin treatment for 1 - 2 days
Benedenia epinepheli, Benedenia spp., *Neobenedenia girellae* and *Neobenedenia* spp.	Freshwater bath for 5-30 min; 150 mg/l hydrogen peroxide (H_2O_2) treatment for 10-30 min
Pseudorhabdosynochus spp., *Megalocotyloides* spp. and *Diplectanum epinepheli*	200 mg/l hydrogen peroxide treatment for 1 h; 100-200 mg/l formalin treatment for 30-60 min

Gonapodasmius epinepheli	Elimination of intermediate hosts (gastropod molluscs)
Philometra sp., *Anisakis* sp. and *Raphidascaris* sp.	Elimination of intermediate hosts (copepods), Drying the pond bottom; Disinfecting the culture
Caligus epidemicus, Caligus sp. and *Lepeophtheirus* sp.	Sufficient water exchange
Isopod	Manual removal of parasite
Leeches	200-250 mg/l formalin treatment for 1h

PRODUCTION, MARKET AND TRADE

PRODUCTION

Malabar groupers have been cultured mainly in Taiwan, Thailand, Philippines and Singapore. The reported global production was 84 t and 57 t in 2006 and 2007 respectively.

MARKET AND TRADE

Groupers, in recent years, have assumed commercial importance in view of their good quality meat and high consumer demand, in local and export markets. The largest market for live grouper is in Asia, traditionally Hong Kong but now China and Singapore are the major markets. *Epinephelus malabaricus* is one of the 13 principal species in the live-fish export trade from the Indo-Pacific region. The price of the item in domestic market is around ₹ 450/ kg in India.

CHALLENGES TO MARICULTURE

The main researchable issues, which have to be sorted out for this species in India, are (i) Broodstock development protocol: mature broodstock of both sexes is required simultaneously for reliable seed production. However, for obtaining males from the wild for spawning is cumbersome because groupers are protogynous hermaphrodites (ii) Larval rearing protocol: standardization of larval rearing by environmental and nutritional manipulations (iii) Standardization of techniques for nursery rearing and grow-out culture (iv) Disease and feed management.

FUTURE PROSPECTS

Groupers are ideal candidate species for intensive aquaculture particularly in the Asia-Pacific region because of high consumer demand, desirable taste and hardiness in a crowded environment, fast growth and efficient feed conversion. Groupers are popular fish with a high market demand in many parts of the world, such as in Kuwait, Indonesia, Singapore, Malaysia, Thailand, Philippines, Hong Kong, Taiwan, China, Mexico, Japan, and USA. Malabar grouper being a popular food fish, domestically and internationally, offer a good source of income for farmers culturing it.

SUGGESTED READING

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Katsuwonus pelamis (Linnaeus, 1758)

B. Santhosh, Prathibha Rohit and E. M. Abdussamad

IDENTIFICATION

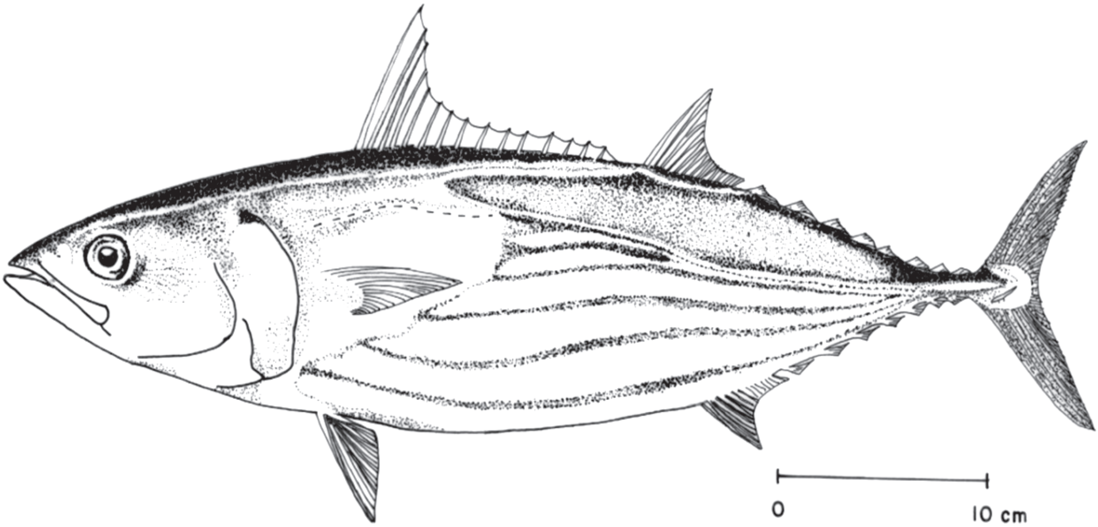
Order	:	**Perciformes**
Family	:	**Scombridae**
Common/FAO Name (English)	:	**Skipjack tuna**

Local names: Gedara (**Gujarati**); Bugudi, Gedar, Kuppa (**Marathi**); Bugudi, Kuppa, Gedar (**Kannada**); Varayan choora (**Malayalam**); Kalililamas (**Lakshadweep**); Varisoorai (**Tamil**); Mas choora, Namalasoora (**Telugu**); Baal, Disco tumbala (**Oriya**)

MORPHOLOGICAL DESCRIPTION

Skipjack tuna has a robust, rounded and elongated body. It has two dorsal fins, separated by a small inter space. A strong keel is present on each side at the base of the caudal fin in between two smaller keels. Second dorsal fin is followed by 7-9 finlets and anal fin is followed by 7-8 finlets. Interpelvic process is paired. Scales are present only in corselet region and on the lateral line. Dorsal colour is dark purplish-blue and ventral colour is silvery white with 4 to 6 striking horizontal dark bands.

Source of image : RC of CMFRI, Visakhapatnam



GEOGRAPHICAL DISTRIBUTION

Skipjack tuna has a cosmopolitan distribution and is reported from most of the tropical and temperate waters except the eastern Mediterranean Sea and the Black Sea. It is seen within the geographical limits of 55° - 60° N and 45° - 50° S.

HABITAT AND BIOLOGY

Skipjack tuna is an epipelagic species, strictly oceanic in distribution. It is highly migratory and is associated with regions of upwelling and is rarely found below 250 m. It is more abundant in the equatorial region round-the-year. Large shoals are generally observed around oceanic Islands, over seamounts and along the shelf beak areas of east and west coast of the mainland. The main factor limiting its distribution is temperature. The preferred surface water temperature is between 17 to 30 °C. It forms large schools in association with other tunas in the mixed layer. Distributed along the coast of mainland and island territories, it aggregates in areas of convergence, boundaries between cold and warm water masses, upwelling regions and regions with hydrographic discontinuities. It exhibits a strong tendency to school in surface waters with birds, drifting objects, sharks and whales and shows a characteristic jumping behaviour. It remains in surface waters during the night and moves to deeper waters during the day.

Food items consist of a wide range of fishes, crustaceans and molluscs especially cephalopods. No marked cannibalistic tendency is reported in this species. Feeding activity is at its peak during early morning and late afternoon hours. The maximum age is not known but is estimated to be around 8-12 years. Both male and female matures at an age of about 1.5 years. It spawns throughout the year with a peak during monsoon. In India, major spawning peak is from December-March, with a minor peak from June-August. In the waters of Minicoy, spawning is for an extended period from January to April and from June to September with peaks in January and June. Maturity is observed from 38 cm fork length and the size at first maturity is 41 cm. Relative fecundity ranges from 80,000 to 3,00,000 eggs/kg body weight. Relative fecundity increases with size of the fish. The exploited size in Indian waters range from 12 to 82 cm fork length. Length distribution from different regions shows marked differences. It grows relatively faster in Indian waters.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Research on seed production and culture of different tuna species in captivity started in 1969 in Japan. Initially the research focused on artificial fertilisation using wild collected brooders and culture in confined environment using wild collected seeds. However, success was not achieved for skipjack tuna.

LARVAL REARING

For eggs obtained from ripe wild females, larval survival was less than 4.5 days in Japan. The newly hatched out larvae measure 2.5 mm in length.

NURSERY REARING

Information not available

GROW-OUT

Grow-out culture in cages was tried using wild caught fishes in the early 1970s in Japan, but detailed information on the type of cage used, fish growth rate, feeding and survival is not available.

FOOD AND FEEDING

Skipjack tuna hatchlings feed on plankton. Early juvenile feeds on copepods and *Diaphanosoma* sp. and late juvenile is piscivorous, feeding on small fish, crustaceans and molluscs. In wild, adults predominantly feed on fishes, crustaceans and molluscs. Wide array of food items consumed suggests that it is a highly opportunistic feeder. Feeding activity is at its peak during early morning and late afternoon hours.

GROWTH RATE

Growth rate under confinement has not been reported. Maximum daily growth rate of wild collected juveniles based on otolith (sagitta) measurements is approximately 3 mm. In wild, it attains a length of 406 mm, 493 mm, 569 mm, 638 mm and 680 mm at the end of 1 to 5 years.

DISEASES AND CONTROL MEASURES

There is no information available on the diseases, except a few reports of parasites affecting it in the wild.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Global catch in 2014 was 30,58,608 t, with maximum catches recorded from Maldives, France, Spain, Malaysia, Sri Lanka and Indonesia. It is the second most dominant oceanic tuna species landed in India. Landings over the years exhibited an increasing trend till 2007, and thereafter, it registered a downtrend to 14,761 t in 2010. Average annual landing during 2008-2011 was 20,924 t, which is 24.6 % of the estimated potential (85,200 t) from EEZ.

MARKET AND TRADE

It is an ideal species for the preparation of high quality sashimi and is reported to have stronger taste than other tunas and shorter shelf life. It is marketed fresh, frozen, dried, canned and also smoke dried. Retail value in India market ranges from ₹ 100-150/kg.

CHALLENGES TO MARICULTURE

No information is available on the captive breeding and larval rearing of this species. It is therefore, essential to have basic information on fish and larval behaviour and on its rearing in confined environment, with the help of information available from the wild. Being a fast moving and pelagic fish, appropriate water quality requirements can be a barrier for its near shore culture.

FUTURE PROSPECTS

High quality sashimi grade is in high demand and fetches higher prices in the international market. Developing breeding and culture technology to meet this demand is of paramount importance in near future.

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Lethrinus lentjan (Lacepéde, 1802)

Muktha M.

IDENTIFICATION

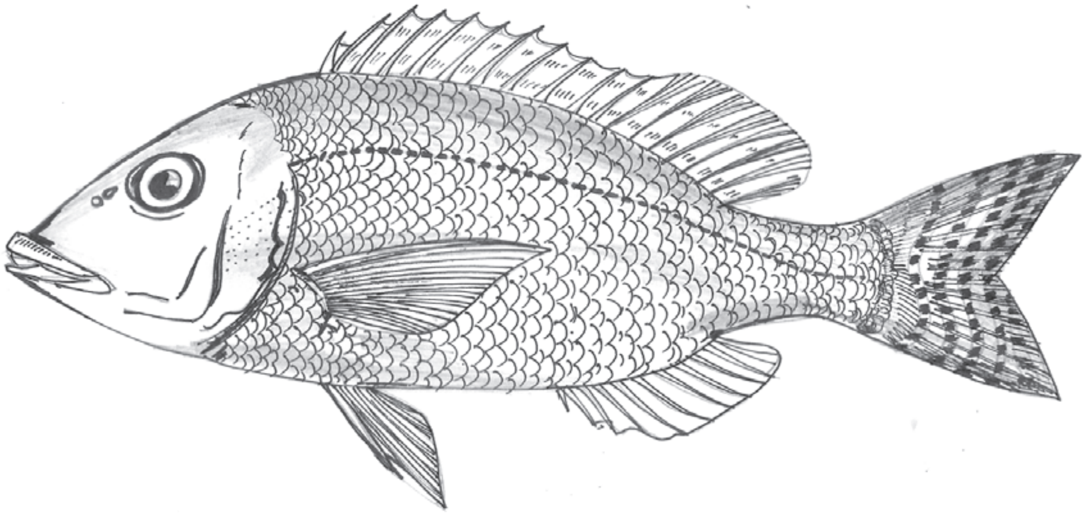
Order	:	**Perciformes**
Family	:	**Lethrinidae**
Common/FAO Name (English)	:	**Pink ear emperor fish**

Source of image : CMFRI, Kochi

Local names: Dhamil (**Marathi**); Kadu, Pulli velameen, Velameen (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

Lethrinus lentjan has 10 spines and 9 soft rays in the dorsal fin, 3 spines and 8 soft rays in the anal fin. The base of pectoral fin has very few scales and sometimes may even be naked. This fish is distinguished by the reddish colour on posterior margin of the operculum, hence the name pink ear emperor fish. The base of the pectoral fin can also be red sometimes. Body is olive-greenish in colour, becoming lighter colour ventrally. The dorsal scales may have a white centre occasionally. The dorsal fin is white with a reddish margin and orange colouration, pelvic fins and anal fin can be whitish to orange, pectoral fin shows large variation in colour from white to yellow to pink. Caudal fin has orange-reddish patterns.



PROFILE

GEOGRAPHICAL DISTRIBUTION

The pink ear emperor fish is distributed widely in the Indo-West Pacific area, extending from the Red Sea and Persian Gulf to Australia and New Caledonia and Tonga. In India, it has been reported from Kerala and south-east coast.

HABITAT AND BIOLOGY

The species is coastal in distribution, mainly found in sandy areas, seagrass areas, mangroves, lagoons and coral reefs. Juveniles are found closer to the shore whereas adults are solitary and are found in deeper waters. In a study from northern Mozambique, only juveniles of this species were found over seagrass beds. The species has been described as a member of the "mesocarnivore specialist" fish which typically feed on slow moving invertebrates. This species has a high body form and molariform teeth, which helps it to feed on hard and soft shelled benthic invertebrates primarily crustaceans, molluscs, echinoderms, polychaete worms and certain fishes. Studies from the south-east coast of India also indicated the dominance of crustaceans, particularly brachyurans (mainly Charybdis, Thalamita and other crabs) in its diet. Molluscs (bivalves and gastropods) were the second most dominant food item. Juveniles feed more on amphipods and crustacean larvae while the adult fed more on crustaceans, molluscs and echinoderms.

It is a protogynous hermaphrodite with juveniles first maturing into female fish and then the female converts to male fish. In the Red Sea, females are reported to convert to males during the fifth year when it is approximately 30 cm. Along the south-east Indian coast the species is reported to spawn twice a year, during December to February and then from June to August. Size at first maturity for female fish is reported to be at 300 mm along the south-east coast of India. The growth is reported to be fast in the first year and then slow after that. The species is estimated to reach approximately 15, 27, 36, 42 and 47 cm at the end of the first, second, third, fourth and fifth year respectively in the wild. *Lethrinus lentjan* is a marine, reef-associated fish with a maximum reported size of 52 cm and maximum age of 19 years.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Rearing of broodstock of *Lethrinus lentjan* was carried out at Vizhinjam RC of ICAR-CMFRI in an RAS. Successful spawning was observed with 95 % fertilization rate.

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

No information is available on feeding in culture systems. However in the wild the species feeds on crustaceans and molluscs primarily.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Larvae of the cestode *Nybelinia bisulcata* and *Pseudogrillotia* sp. have been reported from *L. lentjan* from Yemen. Polymicrobial skin lesions causing mass mortality of this species was reported from Kanyakumari. The digenean parasite *Orthodena tropica* has been reported from this species from New Caledonia waters. Monogenean parasites of this fish include *Calydiscoides duplicostatus* and *C. difficilis*.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Information not available

CHALLENGES TO MARICULTURE

Mariculture of the pink ear emperor has yet to take off in India. Research on broodstock maintenance, their domestication, larval rearing, nursery rearing and grow out needs to be initiated. So far no reports are available on culture of this species anywhere in the world.

FUTURE PROSPECTS

Lethrinus lentjan is a highly valuable fish in many parts of the world particularly in the Persian Gulf countries. In India it forms a minor fishery and commands a good demand in the domestic market. This is a good candidate for mariculture provided culture techniques can be developed and standardized for this species in India.

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Lethrinus nebulosus (Forsskål, 1775)

B. Santhosh and M. K. Anil

IDENTIFICATION

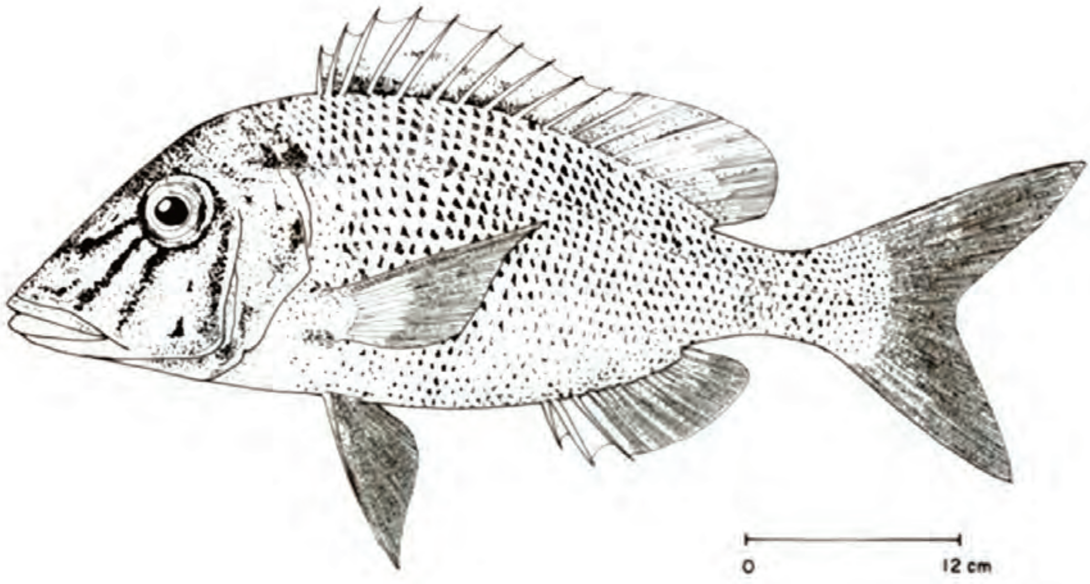
Order	:	**Perciformes**
Family	:	**Lethrinidae**
Common/FAO Name (English)	:	**Spangled emperor**

Local names: Dhamil (**Marathi**); Kokkaru (**Kannada**); Chemballi, Kadu, Velameen (**Malayalam**); Koranguvela, Koranguvelu, Pulli vela meen, Valameen, Velameen, Vela meen (**Tamil**); Karwa (**Telugu**)

MORPHOLOGICAL DESCRIPTION

Body is moderately deep, yellowish brown colour with bluish spots and streaks dorsally and pale white with faint yellow lines ventrally. The scales on the dorsal sides are with a blue central mark surrounded with yellow-olive colour which gives a spangled appearance. The head has several characteristic silvery blue streaks radiating forward and ventrally from eye. Upper parts of the pectoral fins are also with faint blue colour. Dorsal fin is with 10 spines and 9 soft rays and anal fin is with 3 spines and 8 soft rays. Cheek is scale-less and inner surface of pectoral fin is densely covered with scales. The fins are dusky white with yellowish tinge and reddish colour is present on the edge of the dorsal fin. Juveniles are with blotches or stripes especially in the chin region.

Source of image : RC of CMFRI, Vizhinjam



PROFILE

GEOGRAPHICAL DISTRIBUTION

This fish is widely distributed in the equatorial areas of Pacific and Indian Oceans especially Red Sea, Persian Gulf, southern India, east Africa to southern Japan and Samoa and between Queensland and northern New South Wales in Australia.

HABITAT AND BIOLOGY

Lethrinus nebulosus inhabits near shore areas with rocky or sandy bottom, seagrass areas, mangrove areas and coral reef areas (36° N-32° S) within a depth rage of 0-75 m. They appear to be more common in outer coastal waters to the west and east of Australia than they are in the north. Juveniles and sub adults are often seen in large schools but adults are more solitary or form small groups. The species is carnivorous and prefers bivalves and gastropods. Food items include smaller fishes, crustaceans, annelids and echinoderms. This fish is a protogynus hermaphrodite which attains sexual maturity within 3-5 years. Small young fishes (2-3 years) will be females and change to males around the age of 4-5 years with mean length of 40 cm. The fish can live upto 30-40 years.

Reports say that the fecundity of this species ranges from 4-7 million. The spawning season is well defined, occurring once a year during March, April and early May off southern Arabia. The spawning peak was found to be after full moon. Almost all spawning activity occurs within three lunar cycles and stops after new moon. This is the largest emperor fish which grows up to 90 cm size and more than 10 kg.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Artificial breeding and seed production technologies were developed in Japan, Taiwan and China. This species has already been farmed in China and Taiwan in sea cages. The larvae of this species have been used as feed for culture of Pacific blue fin tuna in Japan. This has good potential to tolerate wider salinity ranges and can be farmed in euryhaline conditions also. However, the detailed report is not available.

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

Information not available

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Several fragmented reports are available especially on the taxonomic descriptions of monogenean, digenean and crustacean parasites infecting *Lethrinus nebulosus*. Reports of diseases and control measures are rare. Red sea bream iridoviral disease was reported from Australia. Monogenean *Calydiscoides* spp. has been reported from New Caledonia. *Encotyllabe* infestation was also reported from Philippines.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Commercial level culture operations of this species were reported from China and Taiwan but there is no report available on the production of this species. Market and trade is still dependent on natural production. This fish is mostly marketed in fresh and frozen condition. The price of spangled emperor is around ₹ 250/ kg in India.

CHALLENGES TO MARICULTURE

Standardisation of breeding protocol is essential for this species. More basic research is required for studying the breeding biology, brood-stock development and breeding operations for this species. Cost effective culture technologies should also be evaluated before large scale seed production.

FUTURE PROSPECTS

This species is comparatively hardy and can tolerate a wide range of salinity. It is also not a very sensitive fish to environmental changes. Commercial farming is in progress in Taiwan and China. The species has very good market in India also.

SUGGESTED READING

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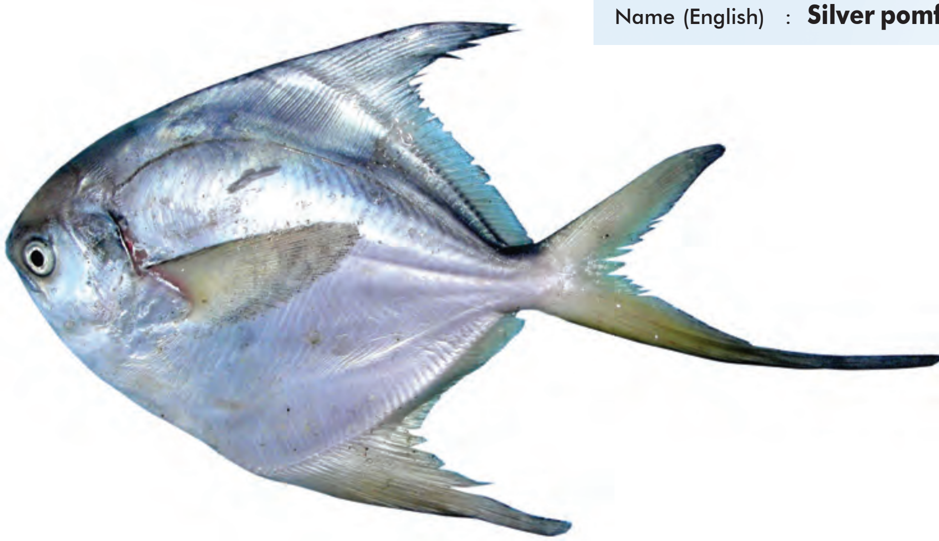
Pampus argenteus (Euphrasen, 1788)

Joe K. Kizhakudan, Shoba Joe Kizhakudan and Ritesh Ranjan

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Stromateidae**
Common/FAO Name (English)	:	**Silver pomfret**

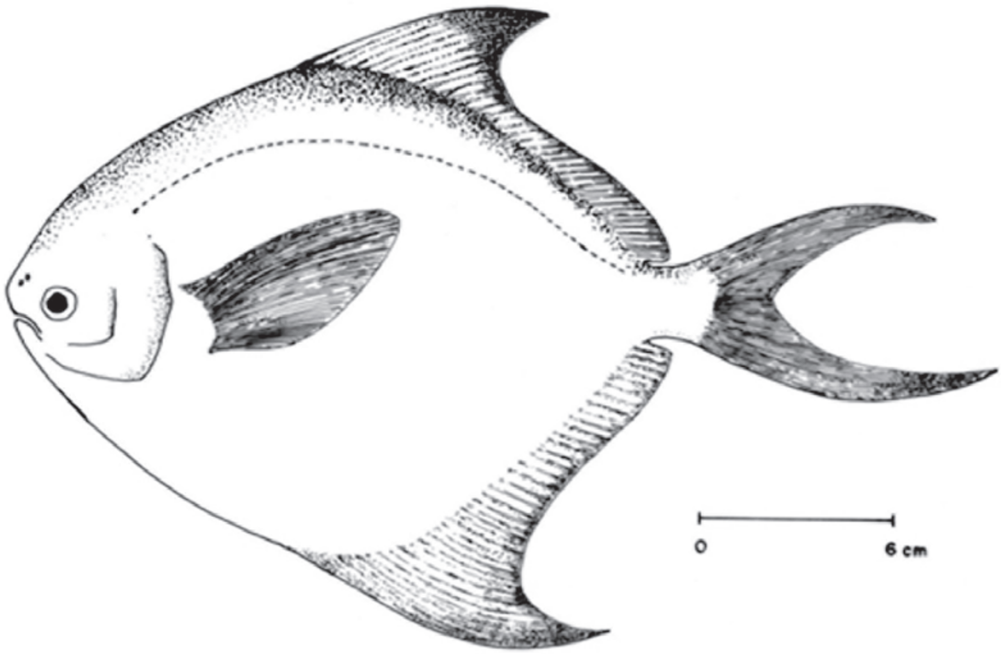


Local names: Paplet, Vichuda (**Gujarati**); Paplet, Chandava, Saraga (**Marathi**); Surangat (**Konkani**); Manji, Thondrette/Thondrotte (**Kannada**); Vella-avoli, Karuvolli, Veluthaavoli (**Malayalam**); Karuvaval, Vavval, Vellavavvel, Vellaivaval (**Tamil**); Chanduva, Nallachanduva, Thellachanduva (**Telugu**); Chandee, Ghia (**Oriya**); Chandi, Pomfret (**Bengali**)

MORPHOLOGICAL DESCRIPTION

Oval shaped compressed body, grey above grading to silvery white towards the belly, with small black dots all over the body. No dorsal spines; dorsal soft rays 37-43. There are 5-10 blade-like spines before the dorsal and anal fins. No operculum; gill opening reduced to a vertical slit on the side of the body; gill membrane broadly united to isthmus. Pelvic fins absent. Deeply forked caudal fin with longer lower lobe. Dorsal, anal and caudal fins falcate.

Source of image : CMFRI, Kochi



PROFILE

GEOGRAPHICAL DISTRIBUTION

Silver pomfret occurs in Indo-West Pacific waters, from Persian Gulf to Japan (north to Hokkaido), excluding Australia. They are also reported from the Adriatic, Hawaii and north-eastern Atlantic.

HABITAT AND BIOLOGY

They are schooling meso-pelagic fishes inhabiting shallow to deep waters and muddy bottoms, up to 100 m depth. Young are commonly reported from estuaries. Diet studies have indicated that the diet of silver pomfret consists of a broad spectrum of food types, but was dominated by crustaceans, with copepods and their eggs constituting 39 % and other non-copepod crustaceans constituting 16 %. Other major diet components were Bacillariophyta (21 %), Mollusca (11 %), fish scales (10 %), fish eggs and larvae (3 %). Copepods, other non-copepod crustaceans, and molluscs occured in higher frequencies with an increase in size of fish (up to 18.5-20.4 cm), while Bacillariophytes tended to increase in stomachs at fish sizes between 22.5-24.5 cm.

The females were usually bigger in size than the males in Kuwait waters. The male matures after reaching a size of 13.0 cm and females mature at a size of 16.0 cm standard length. Generally spawning period varies from mid-May to early October in Kuwait waters. The spawning occurred in water depth between 5 and 12 m at temperature range of 26 to 32.8 °C and salinity of 39 g/l. Silver pomfret is a multiple batch spawner. Large females spawned earlier than smaller females and at the spawning site males dominated females by 3:1. Peak spawning occurred in evening hours during outgoing tide. Spawning events were concentrated during the first and third quarters of the moon period, indicating a semi-lunar reproduction cycle. One female would spawn at least six times during the season. The average relative batch fecundity was 176.3 eggs/g somatic weight (SW), corresponding to a relative total fecundity of 1058 eggs/g SW. Bigger fish produced heavier eggs and the egg weight decreased as the spawning season progressed. Maximum reported length: 60 cm; common 30 cm.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Studies on silver pomfret culture have been carried out at Kuwait and China. The larval rearing of silver pomfret was successfully carried out at Mariculture and Fisheries Department, Kuwait Institute of Scientific Research, Kuwait in 2005. The following sections deal with the work carried out at MFD/KISR, Kuwait.

The broodstock was raised from the eggs obtained from the wild at MFD/KISR, Kuwait. The brooders were reared in 125 m^3 tank. The fertilized eggs were obtained through natural spawning as well as induced spawning. The fertilized eggs were spherical, transparent and pelagic in nature. The mean diameter of silver pomfret eggs ranged from 1,050 to 1,120 µm.

LARVAL REARING

Larvae were reared in concrete tanks containing saline water (25.0 to 28.0 g/l) at water temperature of 19-24 °C. The size of newly hatched larvae averaged 2.4±0.1 mm. The larvae were fed with rotifers (*Brachionus plicatilis*), *Artemia* nauplii and formulated feed. The initial feeding started on the third day after hatching. The length of silver pomfret reached 2.0-2.7 cm after 50 days of culture period from hatching. The survival rate of larvae was 5-14 %. The juveniles attained a size of 3.5 g within 50 days post hatching.

NURSERY REARING

The silver pomfret fingerlings of size 9-11 g were stocked in FRP tank and were fed with dry feed pellet as well as minced meat for 154 days. The fish attained a size of 19-26 g after 154 days of culture. The fish were fed at satiation rate five times a day at two hours interval starting at 08:00 hrs six days a week. A flow through system was maintained @ 2 l/min for 1 t round FRP tank with a water volume of 500 l.

GROW-OUT

The culture of silver pomfret has been carried out in tidal fed farm in Balasore, Orissa. Silver pomfret attained a marketable size at the end of second year. Therefore, stocking of alternate series of ponds during successive years would be necessary to ensure harvest from at least 50 % of the pond each year. One hectare of aquaculture pond can be stocked with 12,500 early juveniles and with 80 % survival, the harvest at the end of second year would yield 2 t of silver pomfret.

FOOD AND FEEDING

The major food item of silver pomfret was zooplankton mainly copepod. In addition to this, fish were fed on artificially prepared pellet and minced meat during culture.

GROWTH RATE

Under ambient culture conditions the average body weight increased from 3.7 g to 81.9 g within 3 months of culture period. Silver pomfret grows to a size of about 12.5 cm standard length after first year and weighs around 100 g. At the end of the second year, the fish attained a size of 18.0 cm and weighed around 200 g.

DISEASES AND CONTROL MEASURES

The parasite *Uronema* sp. has been reported to infect sub adult silver pomfret reared in captive condition in Kuwait. The bacterial disease Streptococcosis caused by *Streptococcus agalactie* has been reported in larval stage of silver pomfret from Kuwait.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Pampus argenteus is a highly valued food fish with great demand in international and domestic markets. The fishery is an economically significant one, particularly in countries like China, India, Kuwait and Iran.

MARKET AND TRADE

The species is marketed fresh and frozen. In addition to being a popular foodfish, silver pomfret is also used in Chinese medicine. The price of silver pomfret is around ₹ 400/ kg (US $ 6-7/kg) in India.

CHALLENGES TO MARICULTURE

The main researchable issues, which have to be sorted out for this species in India are (i) Domestication of the fish for developing healthy broodstock (ii) Development of broodstock management protocol (iii) Larval rearing protocol: standardization of larval rearing by environmental and nutritional manipulation (iv) Disease and feed management (v) Development of different grow-out systems.

FUTURE PROSPECTS

Estimates by CMFRI indicate that over the last fifteen years, although the landings of this resource in India has not shown much change, the contribution of this species to the total landing of all pomfrets has reduced from 68.8 % in 1997 to 56.8 % in 2011, which could be cause for concern. With the possible threat of decline in wild catches, it would be apt to develop a suitable aquaculture system for pomfrets in India. This is a promising species for aquaculture production because there is adequate existing knowledge about its biological and technological requirements.

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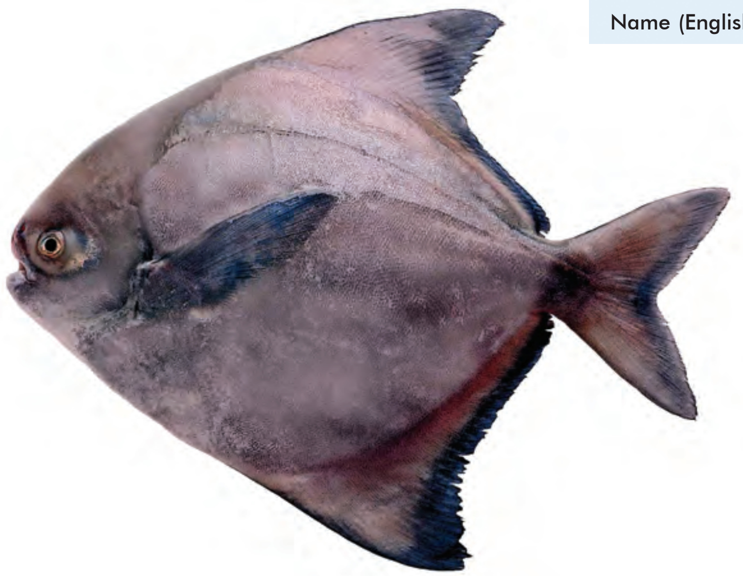
Pampus chinensis (Euphrasen, 1788)

Joe K. Kizhakudan, Shoba Joe Kizhakudan and Muktha M.

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Stromateidae**
Common/FAO Name (English)	:	**Chinese silver pomfret**

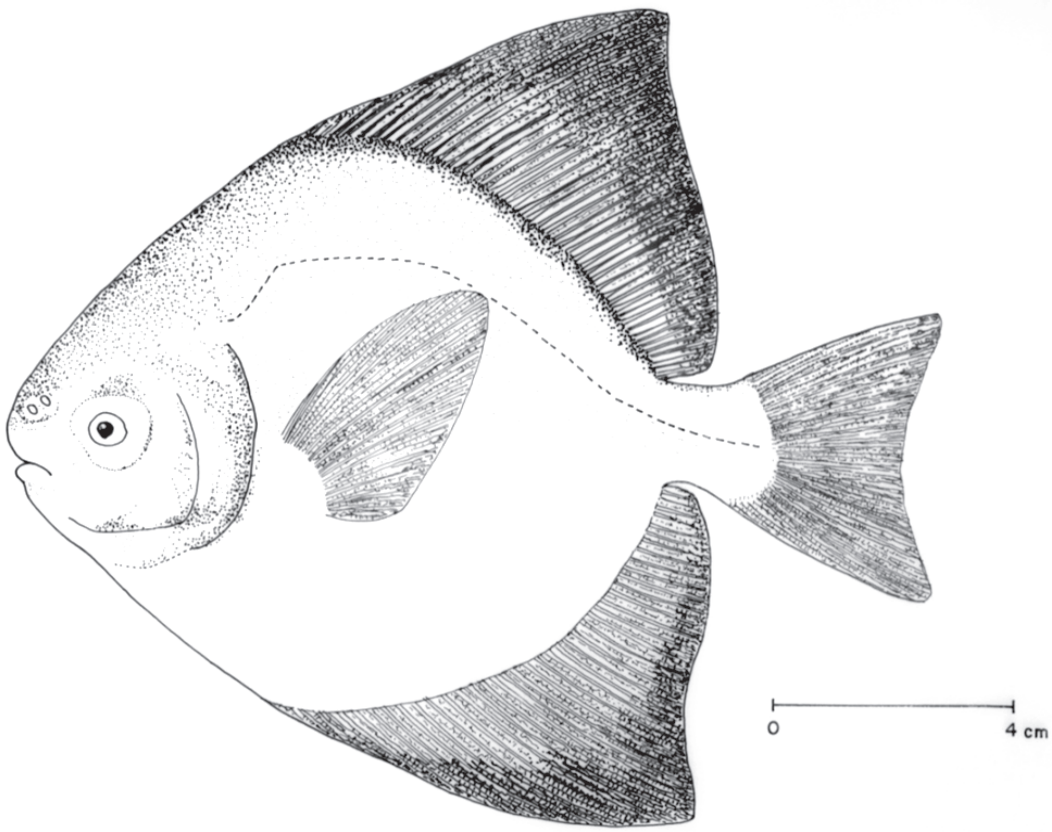


Source of image : CMFRI, Kochi

Local names: Kafri, Pathu, Vichuda (**Gujarati**); Chandava, Kapri, Kalwad, Khalwad (**Marathi**); Paplet (**Konkani**); Balimanji, Manji (**Kannada**); Avoli, Vella-avoli, Velutha-avoli (**Malayalam**); Karappuvavel, Karu-vaval, Mongang-vaval (**Tamil**); Chanduva (**Telugu**); Dhala-chandi (**Oriya**); Chandi, Pomfret (**Bengali**)

MORPHOLOGICAL DESCRIPTION

Laterally compressed oval shape body, grey or brown coloured dorsally and silvery white on lateral sides and fins. Blunt snout with small mouth and eye shorter than snout; straight forehead. Dorsal and anal spines absent; dorsal soft rays 43-50; anal rays 39-42. Caudal peduncle short and deeply compressed with no scutes. Small, cycloid scales, barely extending onto fin bases. Naked patch on head and nape with longitudinal sensory canals, patch not extending above pectoral-fin base.



PROFILE

GEOGRAPHICAL DISTRIBUTION

Pampus chinensis is distributed in Indo-West Pacific regions from Persian Gulf to eastern Indonesia and north upto Japan. In India, it is found along both the east and west coasts.

HABITAT AND BIOLOGY

These are benthopelagic marine or brackishwater amphidromous fish, which enter estuaries. It occurs seasonally, either single or in small schools over muddy bottoms. It feeds on ctenophores, salps, medusae, and other zooplankton groups but also preys on small benthic animals. Mouth is terminal in juveniles which becomes slightly superior in adults indicating possible diet changes with size.

The females attain maturity at 29 cm size whereas males mature at 26 cm size. The spawning season is restricted to the three months of September to November along the north-east coast of India. The initial gonadal development occurs with maximum photoperiod in June to culminate in spawning in September, October and November at low point of their photoperiodic curve. Post larvae and juveniles occur along the north-east coast of India during November to January. Juveniles range from 2.5-5.0 cm in size with emarginated caudal fins, which later turn forked in juveniles of size 6.0-7.0 cm standard length. Maximum recorded length is 40 cm; common length is 20 cm.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Twelve trials were attempted to breed *Pampus chinensis* by collecting ripe males and gravid female caught in drift gill net from Phang-nga Bay, Thailand. The eggs were fertilized and 3,24,000 newly hatched larvae were obtained. The eggs of silver pomfret were pelagic with diameter of 1120±20 µm. The eggs hatched out within 16-18 h at salinity of 30 g/l and temperature 26-30 °C.

LARVAL REARING

Silver pomfret larvae were ready for external feeds, *i.e.* they developed open mouths, 40 h post-hatching. At this time, *i.e.* from 2nd dph the larvae were fed with rotifers. The larvae survived till 25 dph. The length of the larvae at 0, 1, 10, 20 and 23 dph was 2.40, 3.29, 3.60, 5.40 and 6.00 mm respectively.

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

Information not available

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

The monogenea parasite, *Bicotyle vellavoli* has been reported to infect gill of the Chinese silver pomfret.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Supports minor fishery of commercial importance in regions of occurrence, including India. Of late there has been a spurt in the landings in India, increasing from 515 t in 1996 to 5,420 t in

2011. The contribution of this species to the total pomfret landings in the country increased from 1.5 % in 1996 to 9 % in 2011.

MARKET AND TRADE

This is a popular food fish in India. The fish is marketed as fresh as well as iced. The price of Chinese silver pomfret is approximately ₹ 350/ kg in India.

CHALLENGES TO MARICULTURE

The fish is very delicate to handle. Domestication programs have not been attempted or documented. Live larvae collected from coastal waters off Kovalam in Tamil Nadu have survived in captivity; however feeding has been a problem. The main researchable issues, which have to be sorted out for the species are (i) Domestication for development of broodstock and its breeding (ii) Larval rearing protocol: standardization of larval rearing by environmental and nutritional manipulation is an absolute essentiality (iii) Disease and feed management in the hatchery system and (iv) Grow out culture technique.

FUTURE PROSPECTS

Chinese silver pomfret being euryhaline in nature can thrive well in even brackishwater environment. Thus, it has good prospects for the Indian farmer as an alternate species to compensate the decrease in shrimp production caused by environmental and pond deterioration. Domestication of *Pampus argenteus* could be the model for establishing a culture system for this species also. Captive breeding and hatchery rearing hold the key to augmenting the production of the species.

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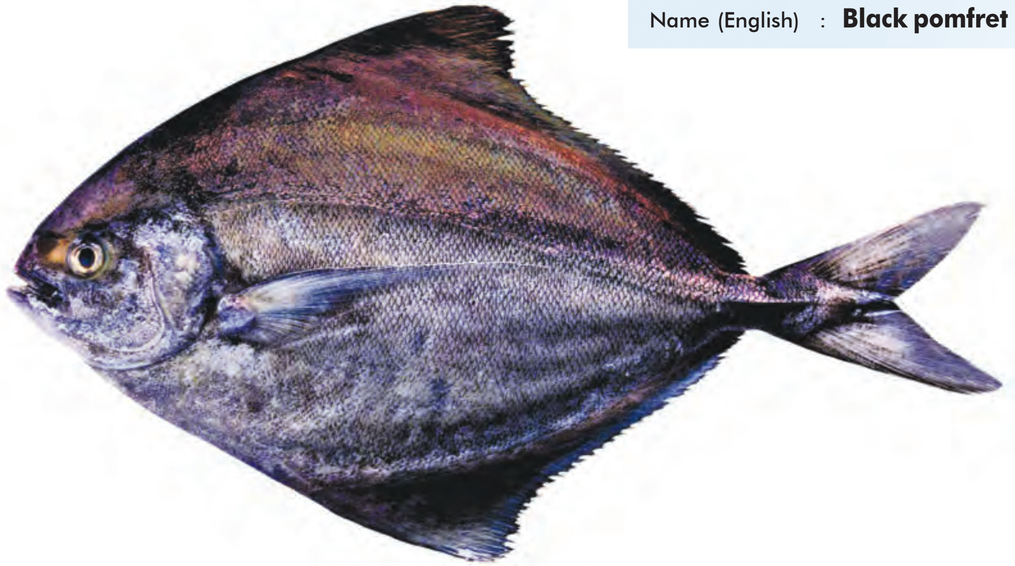
Parastromateus niger (Bloch, 1795)

Joe K. Kizhakudan and Shoba Joe Kizhakudan

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Carangidae**
Common/FAO Name (English)	:	**Black pomfret**

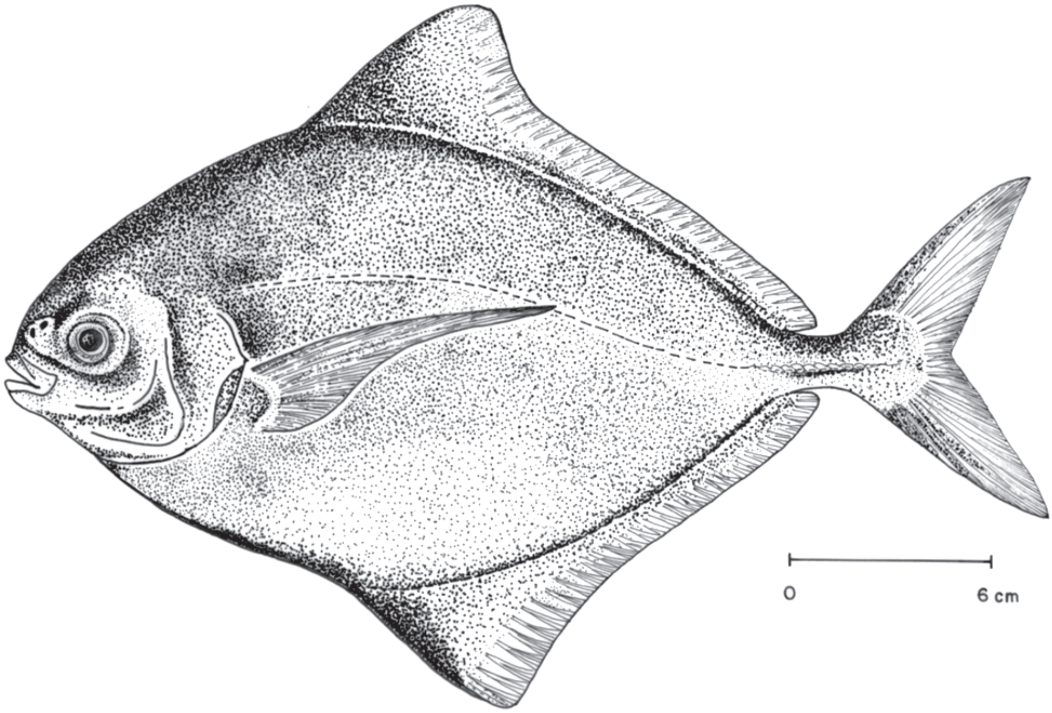


Local names: Adadio, Halwa (**Gujarati**); Halwa (**Marathi**); Halwa (**Konkani**); Kari manji (**Kannada**); Avoli, Karutha, Maachan, Karuvoli, Vellavoli, Karauthakoli (**Malayalam**); Vaval, Karuvaval (**Tamil**); Nalla Chanduva (**Telugu**)

MORPHOLOGICAL DESCRIPTION

Body is rhomboid, scaly, strongly compressed and deep grey-brown to dark grey in colour. The head is blunt with a terminal mouth. Both dorsal and anal fins are triangular. The sickle-shaped slender pectoral fin extends beyond mid-body. A number of small scutes are present on the slender caudal peduncle. Dorsal fin is with 2-6 spines and 41-46 soft rays; anal fin is with 2 spines and 35-40 soft rays. Pelvic fins are absent in fish over 9 cm size. Body is silvery-grey coloured with four narrow white bars along the flanks; the first bar starting from just behind the opercle. Belly is white. The anterior parts of dorsal and anal fins are bluish-grey.

Source of image : CMFRI, Kochi



PROFILE

GEOGRAPHICAL DISTRIBUTION

The black pomfrets is distributed in the tropical, subtropical and temperate seas of the world; in Indian and Pacific oceans, across the Persian Gulf and Oman Sea, China and the Malay Archipelago. In India, it is widely distributed along both the east and west coasts.

HABITAT AND BIOLOGY

Parastromateus niger is the only known member of its genus. It is a mid-water pelagic species living in marine and brackishwater environments and inhabits depth ranges from 15-105 m. Mostly, the adults inhabit coastal areas with muddy substrate. It is found near the bottom during daytime and near the surface at night. It enters estuaries and normally forms large schools. It is carnivorous, feeding mainly on zooplankton, and small fishes, crustaceans and molluscans.

Size at first maturity for female is 32 cm and for male is 30 cm. Breeding periods varies with the location. In Maharashtra, spawning is from October to December while in Gujarat, it is from February to August. Along east coast, spawning is observed from January to February. It is capable of multiple spawning throughout the reproductive season. Relative batch fecundity is 336 eggs/g ovary-free body weight and total average relative fecundity is 948 eggs/g ovary-free body weight. The observed swimming behaviour in the confined environment (cage) is different when compared to other carangids. It swims on its side with its dorsally oriented pectoral fin erected like a sail. The swimming behaviour helps it to feed on plankton and small pelagic invertebrates which migrate to shallow waters at night.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Scientific study on grow-out culture in confined environment is not available. Reports are available on cage farming in 2004 in Johore Strait, along the north coast of Singapore near Pulau Ubin, wherein a small school of 10-15 fishes caught near the cage site were transported to adjacent floating cages and reared to marketable sizes.

FOOD AND FEEDING

Food and feeding habit in confined environment has not been studied. In the wild, it is carnivorous, feeding on zooplankton with special preference for crustacean larvae.

GROWTH RATE

Growth rate in confined environment is not available. In wild, along the Iranian Coast of Oman Sea, it attains 21 cm and 190 g in 1 year and 56 cm and 2.16 kg in 6 years.

DISEASES AND CONTROL MEASURES

No report on diseases in culture is available, since culture in confined environment is not practiced. Reports of isopod parasitic infestation caused by *Cymothoa eremite* and parasitic copepod infestation are available. Digenetic parasite, *Lecithocladium bulbolabrum* is observed in the small intestine.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Indonesia is the top producer in the world, followed by Thailand and Malaysia. Total catch globally in 2011 was 63,691 t. Landing in India has increased from about 13,315 t in 1997 to 20,493 t in 2011.

MARKET AND TRADE

It is a highly relished food fish, marketed fresh, dried or salted. It is an economically important fish in Singapore commanding a price range of around US $ 8-20/kg. In India, the price of fresh fish ranges from ₹ 250-300/kg.

CHALLENGES TO MARICULTURE

Broodstock development, breeding, larval rearing and culture in confined environment have not been initiated in India. Also information on behaviour and survival of adults and juveniles in captivity is not available. Therefore, basic studies on breeding and culture need to be initiated and technology needs to be developed in India.

FUTURE PROSPECTS

The fish has important traits like moderate growth, good taste, high price and good consumer acceptance which make it a suitable candidate for mariculture.

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Psettodes erumei (Bloch & Schneider, 1801)

Joe K. Kizhakudan

IDENTIFICATION

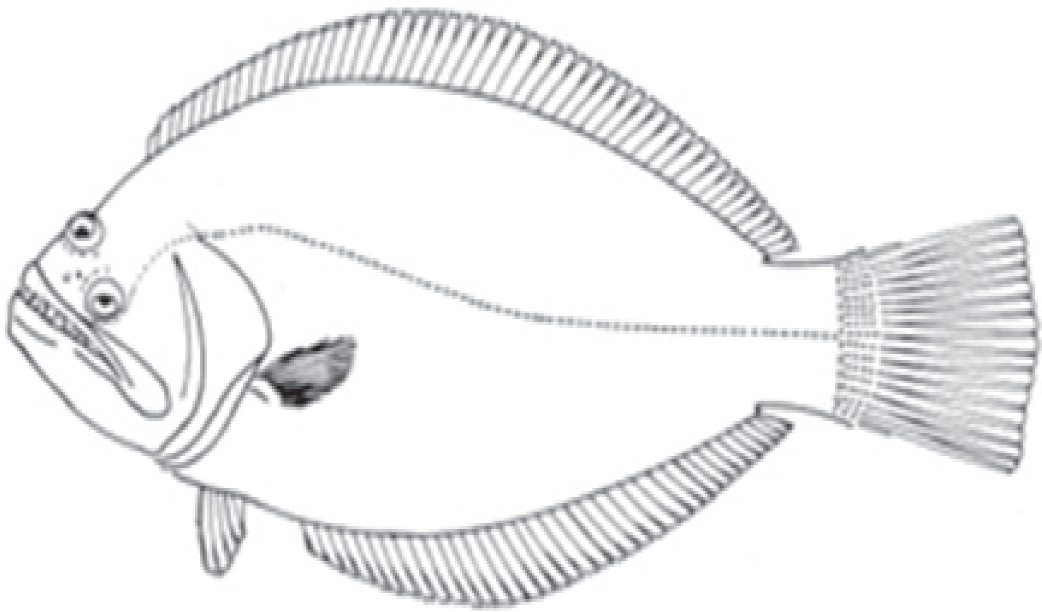
Order	:	**Pleuronectiformes**
Family	:	**Psettodidae**
Common/FAO Name (English)	:	**Indian halibut**

Local names: Haria (**Gujarati**); Bakas, Zhipali (**Marathi**); Boxlep (**Konkani**); Aayirampalli, Panjukadiyan (**Malayalam**); Erumeinakku (**Tamil**); Norunalaka, Adalam (**Telugu**)

MORPHOLOGICAL DESCRIPTION

Oval, flat body, usually brown or grey in colour, often with dark bands. Blind side occasionally partially coloured. Large mouth with several strong pointed teeth. Both eyes either on left or right side. Maxilla reaches beyond the posterior edge of lower eye. Gill rakers are not developed. There are 9-11 dorsal spines, 38-45 dorsal soft rays, 1 anal spine and 33-43 anal soft rays in this species. Dorsal fin origin well posterior to eyes; anterior fin rays spinous; lateral line almost straight. Tips of dorsal, anal and caudal fins black.

Source of image : RC of CMFRI, Chennai



PROFILE

GEOGRAPHICAL DISTRIBUTION

The Indian halibut occurs in the Indo-West Pacific region from east Africa and Red Sea to Japan and Australia and all along the Indian coast.

HABITAT AND BIOLOGY

Psettodes erumei is a bottom dwelling, piscivorous marine flatfish found in depth range 1-100 m, usually 20-50 m. They are mainly recorded on sandy and muddy bottoms. They are nocturnal, usually deeply buried in the substrate during the day, and moving out for hunting at night. In captivity these fishes are mostly sedentary, swim vertically up occasionally and rest of the time move horizontally with the flat white ventral surface beneath. They exhibit high levels of camouflage when live and normally their colour and pattern resembles that of the sandy substrate. If probed and handled the band pattern turns deeper and brownish and when taken out the dorsal skin colour turns dark brown. They are hardy to handle, scales are firm and can remain outside water for several minutes. It feeds on benthic fish like cardinal fishes, eels, silver bellies, threadfin breams, lizardfish, anchovies and milkfish. Younger fish feeds mainly on invertebrates like *Sepia* sp. and crabs, which are gradually replaced by small fish mostly *Engraulis* sp. and *Clupea* sp. as the halibut grows. The fish is highly predacious and predominantly piscivorous.

The size range of the fish landed at Kovalam, Chennai ranged from 255-545 mm with fecundity ranging from 19,740 to 3,00,699. Depending on the ovarian maturation stage, the number of eggs/ g ranged from 1,420 to 3,850 in the wild sample. The size at maturity of the species ranges between 371-390 mm total length and ripe gonads are often seen during March-May. The spawning period is restricted during March to May along the Pakistan coast. In India spawning season differs on each coast. Along the west coast off Bombay, the species spawns during September and October. However, the spawning season is from May to September with peak in May to August in Porto Novo waters in south India. It breeds only once in a year for 3 to 4 months in Porto Novo waters. They spawn in two batches. Females outnumber males in nature. Maximum length in fishery is 64 cm with common size being 50 cm.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Domestication and spawning of *Psettodes erumei* was achieved at Kovalam Field Lab of CMFRI in 2013. Wild caught fish of size range 130-555 mm total length (TL) were domesticated in captivity. A single female fish of weight 1.87 kg spawned in a 2 t black FRP tank. Spawning occurred in early morning and the fish released approximately 60,000 eggs. However none of the eggs survived beyond 16 h.

LARVAL REARING

Though information on larval rearing is not available, reports on larval description of *Psettodes erumei* are available. The larvae of this species can be easily identified by 9-10 long anterior dorsal rays which are not present in the larvae of other flatfish. Also the larvae have large head, strong canine teeth and pre-operculum with spines.

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

Information not available

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

The skin and respiratory surfaces of this species are quite vulnerable to external parasites and trematodes as they remain in the substrate for long. Periodic treatments with formaldehyde and deworming agents can help in long survival of these fish. Several digenetic trematodes have been reported from this species from Indian waters. *Dasyrhynchus thomasi*, a cestode has been reported from this species from Indian waters.

PRODUCTION, MARKET AND TRADE

PRODUCTION

In 2014 approximately 1,784 t of *P. erumei* were landed in India. No information is available on quantities of cultured Indian halibut.

MARKET AND TRADE

It is a highly valued table-fish with white meat yield between 42-49 %, making it an attractive fish for culture. The price of Indian halibut is around ₹ 300/ kg in India.

CHALLENGES TO MARICULTURE

The main researchable issues, which have to be sorted out for this species in India are (i) Broodstock management protocol (ii) Larval rearing protocol: standardization of larval rearing by environmental and nutritional manipulation (iii) Disease and feed management and (iv) Grow out techniques.

FUTURE PROSPECTS

The fish is highly suitable for fillet preparation with meat yield of around 42-49 %. With its high demand in the domestic market, amenability to processing and high value, it is a good candidate for mariculture in India.

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Siganus canaliculatus (Park, 1797)

Boby Ignatius, Imelda Joseph and Sekar Megarajan

IDENTIFICATION

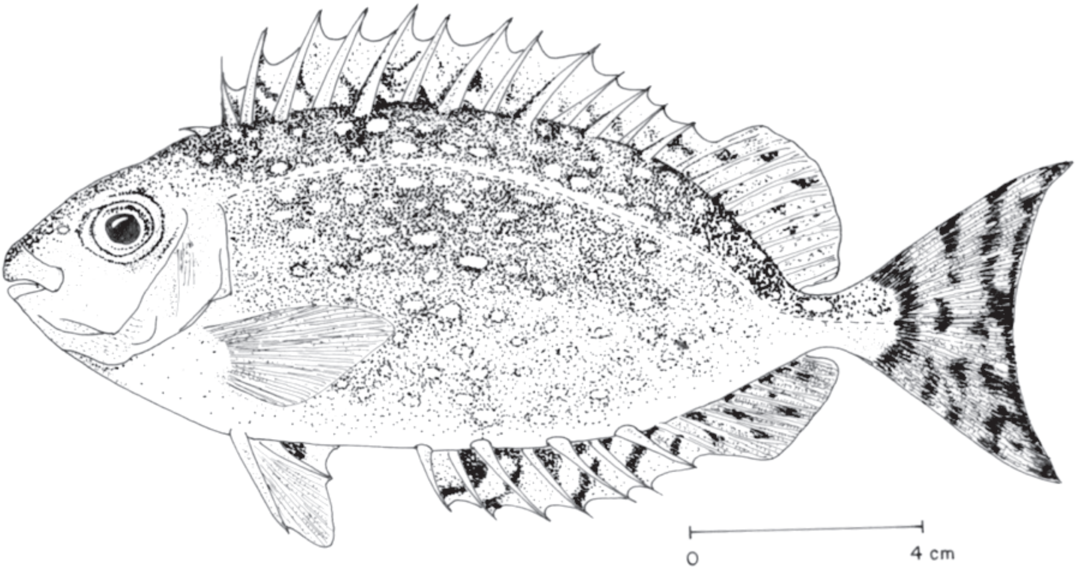
Order	:	**Perciformes**
Family	:	**Siganidae**
Common/FAO Name (English)	:	**Rabbitfish**

Local names: Kutri, Dhagavir (**Marathi**); Marapaiya (**Kannada**); Karadu meen, Kattara, Poola (**Malayalam**); Oora, Orameen (**Tamil**); Warawah (**Telugu**)

MORPHOLOGICAL DESCRIPTION

The body is compressed and slender. Snout is blunt and anterior nostril has a long flap in juveniles which disappears in adult fish. A forward-directed spine is present in front of dorsal fin. Dorsal fin rays are banded. The caudal fin is almost emarginated in specimens under 10 cm standard length and forked in larger fish. Scales are minute with 21-27 scale rows between lateral line and base of anterior dorsal spines. Cheeks are scaleless. The fish is greenish-grey dorsally and silver ventrally and nape and sides are covered with whitish-blue spots in horizontal rows. Caudal fin is either plain grey or irregularly barred with pale and dark grey.

Source of image : fishbase.org



PROFILE

GEOGRAPHICAL DISTRIBUTION

The rabbitfish is distributed widely in the Indo-West Pacific region extending from the Persian Gulf to Western Australia. It has been reported form east and west coast of India.

HABITAT AND BIOLOGY

The species inhabits inshore areas, algae reefs, estuaries, river mouths with sea grass beds and lagoons with algae-rubble habitats. Juveniles form very large schools in shallow bays and coral reef flats. Adults form smaller schools of 20 fish. Adult fishes occur in offshore, deep, clear waters. This species is mostly herbivorous in nature, feeding on benthic algae and to some extent on sea grass. However, it has also been reported to feed on amphipods, copepods, sponges, foraminifera, crustaceans and brittle stars suggesting that it may be opportunistic omnivores. It is active during the day. In India, the occurrence of this species is high and its sizes vary from 20-25 cm, with a maximum of 45 cm in length. They are able to tolerate a wide range of water quality parameters; salinity (17-37 g/l), temperatures (23-30 °C), dissolved oxygen at least 2 mg/l and pH up to 9.

The fish is a multiple spawner, larger fish spawn more than once in a spawning season. Peak spawning season is April and May. Spawning is correlated to lunar cycle in nature. Absolute fecundity ranges from 42,253 to 10,00,000. Tidal level is the most important factor impacting the natural spawning in fish. Lunar cycle influences the natural spawning in the fish with spawning observed mostly in the lunar phase, 2-4 days after new moon during midnight or early morning. Natural spawning of the fish as observed in different months from different countries are January-April with a peak in February-March in Singapore, January-April in Philippines, March-June in Hong Kong and March-May in southern Arabian Gulf. Juveniles arrive from the fringing reefs, to the patch reefs and associated seaweed beds and finally onto the seagrass.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Different species of *Siganus* including *Siganus canaliculatus* were tried for breeding in captivity in late 1970's in different countries. The fishes brought from the wild were conditioned in confined environment and injected with different hormones like hCG, LHRH, etc for spawning. The fish spawned with single or multiple injections of hCG. The doses of hormone used ranged from 250 to 300 IU/kg body weight. Multiple injections were given at 24 h interval. Stripping, 5-10 h after the final injection has also been reported for females of this species. Fish implanted with LHRHa silastic pellets spawned ten days in advance. The response of the fish to hormonal injection depended on the stage of oocytes development. Stress and excitement due to handling also triggered spawning in hormone treated fish. Fish was also found to spawn naturally in confined environment without hormonal inducement.

The fertilized eggs were demersal, adhesive, small and spherical with many oil globules. The reticulation on the egg membrane was responsible for the adhesiveness of the eggs. Fertilised eggs measured 420-700 µm in diameter and took 18-35 h to hatch at 22-30 °C. Hatching time was also dependent on egg size and incubation salinity.

LARVAL REARING

The newly hatched out larvae aggregated near the surface and stayed in water column with its head down. They started feeding from second day onwards. While feeding, larvae fed at the sides and bottom of the rearing container. It was observed that the larvae on day 12 nibbled on algae growing on walls of the tank and on day 15 showed aggressive feeding behaviour. Larvae on day 18, began to stay deeper in the water column and on day 23 onwards started metamorphosis. Cannibalism, in some cases, has been reported before metamorphosis. Metamorphosis was accompanied with rapid and obvious changes in external appearance. The larval stage, when the body was highly transparent and the abdomen was silvery gave way to the juvenile stage, when the entire body turned light brown as that in the adult. This transformation starts on day 23 to 25 for this species. The eggs and larvae of the fish were able to tolerate salinity ranging from 15.8 to 32.2 g/l. Temperature and salinity of 30 °C and 32 g/l were found optimum for larval rearing.

NURSERY REARING

Larvae attained the juvenile stage once they acquired the complete spines and fin rays characteristics of the adult. Juveniles also closely resembled the adults in body shape and colour, but may or may not live in the same habitat as the adults. The initial size of the juvenile was around 20-24 mm, after a 2-3 months period. The rate of transformation was affected by temperature, type of food given, etc. The juvenile stage lasted for 6 to 9 months, until they attained first sexual maturity. The juveniles could tolerate high variation in the water quality parameters. They could survive at least 5 g/l salinity, 2 mg/l dissolved oxygen and 23 °C temperature. Their optimum growth was recorded at 10-15 g/l salinity and 26-30 °C temperature. In general, the growth varied in the nursery and it depended on culture system and diet.

In floating cages, juveniles weighing 10 g attained 114 g within 5 months with weight gain of 6.5 g/week. In concrete tank, the fish attained 7.85 g from 0.34 g in 3 months with weight gain of 0.63 g/week. In another floating cage, juvenile reached 60.97 g from 29.8 g in a month with weight gain of 7.79 g/week. The stocking density varied from 30 to 60 nos./m^3 at 15-20 g weight. Fish stocked at 30 nos./m^3 (13 g) showed maximum growth with pelleted feed at 2.3 % body weight. Contrarily, fish stocked at 50 nos./m^3 showed maximum growth with rice bran and lab-lab (a complex of blue-green algae, diatoms, bacteria others) as feed.

GROW-OUT

The fish has been cultured in brackish water ponds in Philippines and in embanked lagoons in Mauritius. In Malaysia, Singapore, Guam and Hong Kong, experimental culture in floating net cages, pens, ponds and raceway systems has been tried. In coastal ponds of Philippines, the fish has been reported to attain a marketable size of 150 g within 5-7 months. This species is preferred for culture because of its herbivorous feeding habits, fairly good growth and economic value. In grow-out ponds, the fish is reared for 4-6 months at a stocking rate of 1500-2000 fingerlings/ha depending on the volume of food in the pond and the size of fish at stocking. Fish reared in cages in Mandapam, east coast of India, reached marketable size of 20 cm within six months using pelleted feed. In cages, fish can be stocked at densities of up to 150 fish/m^3 with no risk of cannibalism, where the fish attained a market size of 100 g in 4-5 months.

FOOD AND FEEDING

Food and feeding habits varies according to the life stage of the fish. The larvae are zooplankton feeders, the juveniles and adults are primarily herbivorous. During larval rearing, they fed on rotifers (*Brachionus* sp.) of less than 90 micron in size at density of 10-20 individuals/ml, copepod nauplius and mixed planktons like *Isochrysis, Chlorella*, etc. Additionally, in the hatchery, rabbitfish larvae were also fed with *Artemia* nauplii and artificial diet. They feed by nibbling on the marine vegetation, often browsing in schools with heads directed downwards during the day and in the evening. The recommended food in the rearing pond includes filamentous algae like *Cladophora linum*, *Chaetomorpha* sp., and *Enteromorpha tubulasa*. In grow out system, they are fed with rice bran, algal mat and pelleted feed.

Under captivity, the fish consumes both vegetable and animal origin feeds, including pellets. Feeding trials have suggested that the dietary protein requirement for this species is above 30 %. Fish fed with high dietary protein grew faster than fish fed with less proteins or live seaweed.

GROWTH RATE

Many studies on the growth of rabbitfish have conflicting results perhaps due to variations in culture system and diet. Growth of fry and fingerlings is generally slow and the average growth rate of the same species varies with the holding system. In floating cages, juveniles weighing 10 g attained 114 g within 5 months with weight gain of 6.5 g/week. In concrete tank, the fish attained 7.85 g from 0.34 g in 3 months with weight gain of 0.63 g/week. In another floating cage in Indonesia, juvenile reached 60.97 g from 29.8 g in a month with weight gain of 7.79 g/week. It grows to a mean length of 8 cm in about 3 months, 10 cm in about 4-5 months and 14 cm in 7-8 months.

DISEASES AND CONTROL MEASURES

A monogenetic trematode causing tissue ischemia, a respiratory disease, was reported in *S. canaliculatus*. Microsporidian infestation of the gills leads to death in the species. Exophthalmia, bloated stomach, body lesions and fin rot are also encountered in captive reared fishes. Mass mortality of cultured fish in cages was reported from the north-east coast of Singapore. Some fishes changed body coloration, moved sluggishly and later became blind. Prior to death, the fish exhibited violent movement, convulsion, and seizure. Mortality was due to a Gram-positive bacterium with characteristics similar to those of *Streptococcus faecium*.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Siganus canaliculatus is one of the most economically important herbivorous fishes captured in the Palk Bay and Gulf of Mannar in Tamil Nadu coast, India. Farming of this species in Saudi Arabia and United Arab Emirates yielded 9 t in 1986. The world aquaculture production of the fish in 2006 was around 1 t. However, the production data after 2006 is not available.

MARKET AND TRADE

Traditional rabbitfish fishery existed in countries such as Guam and the Philippines, where the market value of the fish was high. In general, during the Chinese new year, their market price in Singapore market increases by at least twenty-thirty fold. This is because of Chinese superstitious belief that rabbitfish is a symbol of good fortune. During this period, most of the rabbitfishes caught contain running roe, the fish tastes sweeter and their meat is more tender.

CHALLENGES TO MARICULTURE

The available information on the economics and socio cultural aspects of rabbitfish farming is scanty. Mass production of seed is yet to be achieved. Wild seeds are available in great quantities in different periods. However, methods for their capture, handling, and transport need to be standarised. Fry collecting grounds should be identified and described. In addition, protocol for broodstock development; breeding and larval rearing has to be developed for mass scale culture of the species.

FUTURE PROSPECTS

Results obtained worldwide have shown that cage culture of rabbitfish can yield high returns. So it has to be attempted and standardized in India. Based on the report available, the fish has got wide distribution in the areas where seaweeds are abundant. Therefore, seed collection needs more concentration in these areas for supply to other parts for culture. Since the fish is omnivorous in nature, it could be cultured in cages or ponds without much investment for feed. Their habit of feeding on algae coupled with good demand makes it a suitable fish for culture in the region where larger quantities of seaweeds are available.

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Thunnus albacares (Bonnaterre, 1788)

B. Santhosh, Prathibha Rohit, E. M. Abdussamad and Sekar Megarajan

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Scombridae**
Common/FAO Name (English)	:	**Yellowfin tuna**

Local names: Gedar, Gedara (**Gujarati**); Bugudi, Kuppa (**Marathi**); Gedar, Kuppa (**Kannada**); Kerachoora, Manjachoora, Poovanchoora (**Malayalam**); Quintal choora, Poovanchoora, Kannchmas (**Lakshadweep**); Choora, Kelavalai, Soccer (**Tamil**); Reecasoora (**Telugu**); Baal (**Oriya**)

MORPHOLOGICAL DESCRIPTION

The yellowfin tuna is a large sized tuna with deep yellow fins and finlets. It is characterized by its fusiform shape with metallic dark blue colouration. Body is elongate, fusiform and slightly compressed, with depth less than 25 % of fork length. Caudal peduncle is very slender. First gill arch has 26-34 gill rakers. Two dorsal fins are separated by a narrow interspace. Dorsal fin is followed by 9 free finlets and anal fin is followed by 7-10 finlets. Dorsal and anal fins are very long in large specimens. Pectoral fin is moderately long, reaching beyond second dorsal fin. Body is with small scales; belly with about 20 broken, nearly vertical pale lines. Dorsal and anal fins and finlets are bright yellow.

Source of image : CMFRI, Kochi

PROFILE

GEOGRAPHICAL DISTRIBUTION

It is typically a pelagic species distributed in all warmer (tropical and subtropical) areas, except the Mediterranean Sea.

HABITAT AND BIOLOGY

It is typically an epipelagic, oceanic fish which prefers to live around the thermocline ranging between 18 to 31 °C and do not generally occur below 100 m in depth. The species aggregates around island territories, seamounts and shelf break areas of mainland coasts. Juvenile fish form large aggregations along shelf-break areas and over seamounts. It forms strong schools with the same species and also with other species of tuna. It schools primarily by size, either in mono-species or multi-species groups. It is often reported to school in association with dolphins and other large mammals, drifting objects and boats. The maximum reported length is 280 cm, with a maximum weight of 400 kg. It is one of the most popular game fishes in many countries.

Mean size in the catch along the Indian waters is 66.3 cm. The length range in the fishery varied from 22 cm to 201 cm, with majority in 44-82 cm size groups representing 80.9 % of the catch in numbers. It is a nonselective and an opportunistic feeder, feeding on available prey. It is a sight oriented predator. Studies from India indicated that its diet consists mainly of teleost fishes (69.9 %), crustaceans (17.4 %) and cephalopods (12.7 %). Carangids are dominant in the gut and are represented by *Decapterus* spp. and *Selar* spp. Coastal tunas (*E. affinis*, *A. thazard* and *A. rochei*), flyingfishes, hemiramphids, belonids, *Priacanthus*, lizardfishes, ribbonfishes, clupeids and myctophids are also preyed upon and are found frequently in the stomach contents. Crustaceans in diet are represented by pelagic (*Portunus* spp.) and demersal (*Charybdis* spp.) crabs and occasionally by deep sea prawns and *Acetes*. Oceanic squids and octopus represent the cephalopods which are consumed. All stages of gonadal development are observed throughout the year in India. It is a year round spawner with peak spawning during August to January. Size at first maturity is 57.6 cm, at an age of 13.5 months. Relative fecundity varied between 1,97,263 and 8,14,557 with a mean of 4,36,330.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Attempts to breed yellowfin tuna in captivity started in 1969 in Japan. Initial trials were made by stripping the mature fishes from the wild. Since 1970s several attempts for breeding, seed production and culture in captivity has been carried out by different organisations in different countries. At present, technology has been standardised for broodstock development, breeding and seed production.

Rearing of yellowfin tuna larvae was first conducted at the Shirahama Fisheries Laboratory of Kinki University, Japan in 1970. In Japan Sea-Farming Association (JASFA), spontaneous spawning of yellowfin tuna was observed in floating net pens in 1992, and subsequently rearing trials for larvae and juveniles was conducted. However, the survival rate of the larvae was very low because of heavy mortalities during developmental stages.

The Inter-American Tropical Tuna Commission (IATTC) has been spawning yellowfin tuna successfully in captive condition, since 1996. For broodstock development, pre-adults from local stocks ranging in size from 2-8 kg caught by trolling line are transported to the broodstock rearing unit in small fibreglass boats, equipped with a 400 l fibreglass 'live-well'. After transportation, the fishes are administered with an injection of the antibiotic, Oxytetracline at 50 mg/kg weight. The antibiotic is primarily used to stain the fish's otolith (ear bone), which helps to accurately estimate the age when the fish dies and also provides an added benefit of reducing bacterial infections. After transferring to broodstock tank, the average survival time in captivity is two years and most deaths are the result of wall strikes. Injuries due to wall strikes are common problems associated with broodstock maintenance, especially when the stocking density is greater than 0.75 kg/m^3. To avoid the problem, the wall of brood-stock tanks is painted with black stripes to improve the contrast and help the tuna see the wall. An approximate loss of 30 % of the broodstock is due to wall strikes.

Yellowfin tuna mature at two years of age and at a size of approximately 15 kg. Sub-adults of 2 to 6 kg took 6 to 8 months in captivity for reaching maturity. Once fish matured, depending on water temperature, spawning occurred naturally (without hormone induction) on an almost daily basis. Water temperature was the main external factor controlling the occurrence and timing of spawning in yellowfin, with regular spawning recorded at water temperatures above 23.3 °C. Broodstock were very sensitive to rapid changes in temperature, even 0.5 °C temperature drop from the optimum range of 24 to 28 °C affected the spawning activity. When the temperature was greater than 25 °C, broodstock spawned in the evening (18:00-22:00 hrs) and spawning occurred in the afternoon or early evening (14:00-18:00 hrs), when the temperature was less than 25 °C. The buoyant fertilised eggs were collected from the tank, and the fertilised eggs measured 950-1,000 µm in diameter with a 220 µm oil globule. Eggs hatched out after 28 h at temperatures below 25 °C, whereas at 29 °C, incubation lasted only for 18 h.

LARVAL REARING

Hatching rate was usually above 90 %, but less than 50 % hatching was also observed. The newly hatched larvae measured 2.5 mm in length and 30 µg in weight. Larvae were stocked into the tank at a density of 15 larvae/l. Feeding commenced on 2nd dph. Larvae at first feeding averaged 3.3 mm in length and 22 µg in weight. The commonly used first feed was rotifer (enriched with commercially available enrichment medium) and preserved microalgae paste (*Nannochloropsis* sp.). Rotifers were maintained in the larval rearing tank at a fairly low density of 4-5 nos./ml. A mixture of micro algae (*Nannochloropsis* sp., *Thalassiosera* sp. etc) was used to maintain cell density at approximately 2 x 10^6 algal cells/ml in the rearing tank water. The density was high when compared to that used in the culture of other marine fish larvae. It was to improve the visual contrast of the prey, and also to minimise cannibalism among the larvae. When the larvae reached 4.5 mm in length (typically 9-11 dph), they were transitioned from rotifers to *Artemia* nauplii over a two-day period. When the larvae reach 6 mm in length (approximately 14 dph), newly hatched tuna larvae were also introduced as a food source for the more advanced larvae. It was believed that in this stage they became piscivorous in the wild and hence newly hatched larvae were introduced as feed. Feeding of enriched *Artemia* was continued till 24 dph. At approximately 60 days, newly hatched larvae as feed were slowly withdrawn and were replaced with finely chopped trash fish. Unlike other marine finfishes, weaning of larvae with artificial pellets was not successful. Tuna larvae sank at night causing mortality at the initial stages. Photoperiod regulation involving 12 h of light and 12 h of darkness was able to control the sinking mortality at night to an extent.

NURSERY REARING

Little information is available on nursery rearing, as it is not commonly practiced. Early-larval growth (the first 2 weeks) in length and weight is exponential (< 0.35 mm/day in length and 20 to 35 % body weight/day), increasing significantly during the late-larval and early-juvenile stages (> 0.6 mm/day and 30 to 50 % body weight/day). Yellowfin larvae become piscivorous at around 6.5

mm in length, with the piscivorous ones growing more rapidly than individuals that are zooplanktivorous.

GROW-OUT

Grow-out of yellowfin tuna has been carried out since 1970 at Kagoshima Prefectural-Fishery laboratory and Kinki University laboratory, Japan using wild caught juveniles in circular or octagonal floating cages of 8-30 m diameter. Anchovies, sand eel and jack mackerel are used for feeding the young tuna while raw or frozen sardine, saury and horse mackerel are mostly given as feed for the bigger fishes. After two years and four months of rearing, young fishes attain a length of 85 cm and a weight of 11 kg. In Oman, wild fishes collected from purse-seining are cultured in towing cages and fattening cages (48 m diameter and 30 m net depth). The wild fishes weighing 25-40 kg are shifted to fattening cage for culture. Fishes are fed with sardines for enhancing the fat content and are then harvested.

FOOD AND FEEDING

During early larval stages, in captivity, it is fed with rotifer, copepods and brine shrimp. As juvenile are piscivorous, it starts feeding on trash fishes. In grow-out, it is fed with sardines, anchovies and herrings. Broodstock are fed on equal ratios of squid and sardine. A vitamin and mineral premix is added at 0.5-1.5 % of feed weight. Feed is applied at several places around the tank to prevent collisions between the actively feeding fish. Broodstock fishes are fed daily on a fixed ration depending on their weight and water temperature. Daily ration ranges from approximately 5 % for smaller fishes in warm water to 1 % for larger fishes in cooler water. FCR ranges from 10.9 to 34.6.

GROWTH RATE

Yellowfin tuna grows very fast and attain 30 cm in 6 months. After two years and four months of rearing, young fishes attain a length of 85 cm and a weight of 11 kg.

DISEASES AND CONTROL MEASURES

Yellowfin tuna hosts more than 50 species of parasites in the wild. Endoparasite infection from broodstock tank water to the larvae through the eggs is reported. It is controlled by a formalin (25-100 mg/l) bath to the eggs, just after fertilization. Good water exchange and sanitation is essential to avoid the spread of parasites. A protozoan disease, Coccidiosis, caused by *Goussia auxidis* is reported. Blood fluke infection caused by *Cardicola ahi* is also reported.

PRODUCTION, MARKET AND TRADE

PRODUCTION

It is the most dominant oceanic tuna species landings by coastal and oceanic fishing fleets. The average annual landing in India in 2012 was 27,269 t. Global catch is more than 1 million metric t. Commercial culture operations of yellowfin tuna is still in infancy. In 2007, 1,210 t was produced through aquaculture from Mexico and Oman. No culture production data is available for the subsequent years.

MARKET AND TRADE

Market and trade is dependent on wild capture. It is ideal for the preparation of high quality sashimi. It is marketed fresh, frozen, dried, canned and also smoke dried. In Mexico and Oman, yellowfin tuna produced through aquaculture were sold at prices equivalent to ₹ 550/kg.

CHALLENGES TO MARICULTURE

Though breeding and seed production has been initiated and achieved to an extent in confined environment, large scale larval rearing is a major issue. Weaning the larvae to artificial feed is an area of concern in nursery rearing. More basic research is required before embarking on commercial seed production. Cost effective onshore and offshore cage culture technologies are required. The major researchable issue for India are development of protocol for domestication, broodstock maturation, breeding and larval rearing.

FUTURE PROSPECTS

Initial success of seed production and culture of yellowfin tuna shows the possibility of future expansion. Yellowfin tuna because of its smaller size, early maturing nature and availability of easy management options are easier to farm than bluefin tunas. High growth coupled with consumer preference has lead to their over exploitation. Tuna ranching can be used as a tool to enhance the population in the wild. In the above context, breeding and seed production in captivity and developing commercial-scale hatchery techniques is essential to satisfy the demand and to alleviate the subsequent fishing pressure on wild stocks.

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FOOD FISHES
MOLLUSCS

Crassostrea madrasensis (Preston, 1916)*

Biji Xavier

IDENTIFICATION

Order	:	**Ostreida**
Family	:	**Ostreidae**
Common/FAO Name (English)	:	**Indian backwater oyster**

Source of image : CMFRI, Kochi

Local names: Kadal muringa, Muringa, Muru (**Malayalam**); Ali, Kalungu, Patti (**Tamil**); Muri (**Kannada**)

MORPHOLOGICAL DESCRIPTION

The Indian backwater oyster is an irregularly shaped oyster with straight shells. The shell has a deep left valve and concave right valve. The hinge which joins the shells is narrow and long. The animal has a right and left mantle lobe which encloses the mantle cavity which in turn encloses the rest of the organs.

**Crassostrea bilineata* (Roding, 1798) as per Huber,M. (2010)

PROFILE

GEOGRAPHICAL DISTRIBUTION

Crassostrea madrasensis is widely distributed along both the east and west coasts of India. Along east coast, it is available in Bahuda estuary, Visakhapatnam; Sarada estuary, Kakinada; deltas of Godavari and Krishna rivers; Pulikat Lake; Ennore; Guggalore and Mandapam. Along west coast, it is distributed in Anchengo back water; Ashtamudi and Vembanad lakes; Kochin harbour and backwaters; Azhikode; Beypore; Thellicherry; Elathur; Chauyar estuary; Pavanji; Sambhavi; Sitanadhi; Coondapur; Venkatapur; Sharavathi and Kalinadhi estuaries and Pirotan Islands, Gujarat. It also occurs along Pakistan coast.

HABITAT AND BIOLOGY

It is a euryhaline brackish water oyster, inhabiting backwaters, estuaries, ports and harbours. It also occurs occasionally in open sea as thick bed. It is found in intertidal zones at depths of around 4 m. It grows to a maximum size of 212 mm and larger ones are available in estuaries.

Oysters have separate sexes generally but hermaphrodites are also present. In one spawning, a female of length 80-90 mm size releases 10-15 million eggs. The eggs and sperm are discharged directly into the water, where fertilization and development takes place. Larvae drift for few weeks and attach to substrate, when they are one-third millimeter long.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

The induced breeding, larval rearing and spat production of *C. madrasensis* has been successfully achieved at Tuticorin R. C. of CMFRI. Oysters (1 yr old) with uniform gonadal state were used for broodstock development. The stocking density used for broodstock development was 25 individuals/ 100 l of water. They were fed a mixture of *Chaetoceros affinis, Skeletonema costatum, Thalassiosira subtilis, Nitzschia closterium, Isochrysis galbana, Pavlova* sp. and *Chlorella salina.* Food was provided twice daily and a cell concentration of 0.8-1.0 x 10^6 cells/ml was maintained. Water was exchanged every day morning prior to feeding. The matured individual was induced to spawn with a temperature increase of 2-4 °C above the ambient. Males spawned first, which induced the females to spawn. The fertilized eggs settled at the bottom and reached morula stage within 4 h.

LARVAL REARING

The 'straight hinge' or 'D' shell larval stage was observed after 20 h of fertilization and the larvae measured 66 µm in length on first day. It was reared in rectangular FRP tank and fed with phytoflagellates. Early umbo stage (100 µm) was obtained on 3rd day and late umbo stage (260-270 µm) between 12-15 days. Eyed and pediveliger stages were observed on 13-17 and 14-18 days, respectively. At pediveliger stage, the larvae developed functional foot, sank to the bottom and started crawling (swimming creeping stage). The pediveliger larvae settled down, losing the velum totally. The shell edges grew hexagonally and the larvae developed the characteristic adult features and metamorphosed into spat of 450 µm in length. The mixture of *Isochrysis* spp. and *Pavlova* spp. were used as feed during different larval stages. However the concentration of algae was increased based on the larvae's nutritional requirements, viz., 'D' shape: 3,000-4,000 cells/ml/ larvae; early umbo: 4,000-5,000 cells/ml/larvae; umbo: 5,000-8,000 cells/ml/larvae; late umbo: 8,000-10,000 cells/ml/larvae and eyed, pediveliger and spat: 10,000-12,000 cells/ml/larvae.

NURSERY REARING

Nursery rearing of spat can be carried out either in tank or in wild in natural water. In tank, spat were fed with *Chaetoceros* spp., *Skeletonema costatum*, *Thalassiosira*, *Nitzschia* spp. and other phytoflagellates. In wild, the spat were stocked in netlon net cages in natural water, where no additional feed was supplemented. Spat cultured in natural waters exhibited rapid growth of 62.5 mm in 6 months with a growth rate of 10.2 mm/month.

GROW OUT

Bottom culture and off bottom culture are the two culture practices followed for the oyster culture. Off bottom culture methods include rack and string or ren culture, where oyster shell is used as ren for spat collection. This method is suitable for shallow estuaries, bays and back waters of 1-1.25 m depth. Rack is a fixed structure from which shell strings are suspended for the collection of spat. The estimated production is 80 t/ha/yr for a period of 7-10 months of culture. In rack and tray method, cultch free nursery reared spat of 25 mm size are transferred to trays (40 x 40 x 10 cm) @ 150 to 200 spat/tray. The tray is knitted with synthetic twine of suitable mesh size and suspended from rack. Once the shell grows to a size of 50 mm, it can be transferred to bigger rectangular trays and again suspended from racks. The estimated production is 120 t/ha/yr. In stake culture, stakes hold the shells with spat. In this system, nursery rearing is carried out for 2 months and grow out is continued for 10 months. The estimated production is 20 t/ha. Raft culture is an oyster farming method suitable for sheltered bays with depth more than 5 m. So far this method has not been tried in India. In long line culture, long ropes or cables are anchored at each end and are supported at intervals by floats. This farming method is practiced in deeper waters.

FOOD AND FEEDING

This oyster feeds on organic detritus and phytoplankton (mainly diatom and dinoflagellates) by filtering sea water with the ciliary action of its gills.

GROWTH RATE

Growth depends on food availability and environmental factors like temperature and salinity. Fast growth of spat occurs during the first three months. An average size of 87 mm is reached at the end of one year with a growth rate of 12.6 mm/month.

DISEASES AND CONTROL MEASURES

Multinucleated Sphere Unknown (MSX) disease caused by single-celled parasite, *Haplosporidium nelson*; Oyster trematode disease caused by *Gymnophallid metacercariae*; Metacercaria infection caused by sporocyst; Bucephalosis infection caused by cercariae of *Bucephalus* has been reported in *C. madrasensis*. In addition, *Vibrio alginolyticus*, *V. parahaemolyticus* and *V. harveyi* are the dominant bacterial flora infecting the backwater oyster. Reports are available on the presence of protozoan parasite *Perkinsus beihaiensis* in *Crassostrea madrasensis* from the Indian subcontinent, which caused mass mortalities in wild and farmed bivalve populations.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Estimated world production of oyster is one million tonnes per annum. USA, Japan and Korea are largest producers of oyster through culture.

MARKET AND TRADE

Major oyster market in the world is represented by four countries namely, South Korea, Japan, USA and France. Global trade in oyster products are in the form of fresh, chilled, frozen, canned in brine, smoked, salted and dried oysters to the tune of 3,00,000 mt. Small scale farming of edible oyster is practiced to meet the domestic demand in India. However oyster shell powder is exported to the Arab countries. Edible oysters are usually marketed as live oysters with shell, shucked oyster meat, frozen oyster meat and canned oyster meat. Value added products suitable for the Indian domestic market viz., oyster pickle, dried oyster, smoked oyster in oil, canned oyster in brine, minced meat products, battered and breaded IQF meat, soups, oyster chowder, and oyster extracts etc. have also been developed.

CHALLENGES TO MARICULTURE

Though mass scale production has been achieved successfully in the hatchery, heavy mortality due to bacterial, fungal or viral diseases are common. Hence studies on larval diseases and their control measures need to be undertaken to ensure higher survival in production systems. In addition, consumer preference, market structure and marketing channel needs to be studied. Oyster culture is labour intensive. In order to ameliorate the non availability of skilled labour and increasing labour cost there is an urgent need for mechanization of the post harvesting process. Environmental monitoring of shellfish culture areas need to be strictly followed since these areas are mostly exposed to bacterial, industrial and domestic sewage pollution.

FUTURE PROSPECTS

India is blessed with good oyster resources which have small pockets of good demand. However the future of edible oyster mariculture depends on the successful development of its market throughout the country as well as exploring its export potential.

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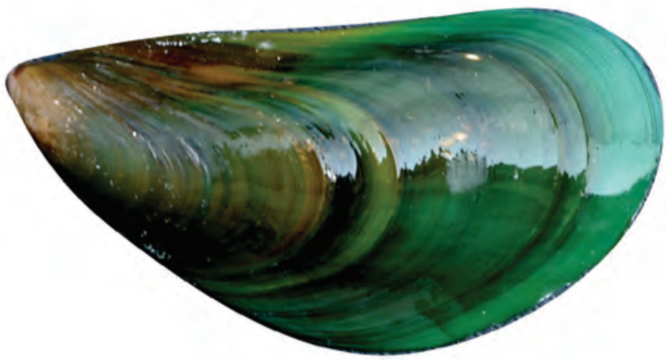
Perna viridis (Linnaeus, 1758)

Biji Xavier

IDENTIFICATION

Order	:	**Mytilida**
Family	:	**Mytilidae**
Common/FAO Name (English)	:	**Green mussel**

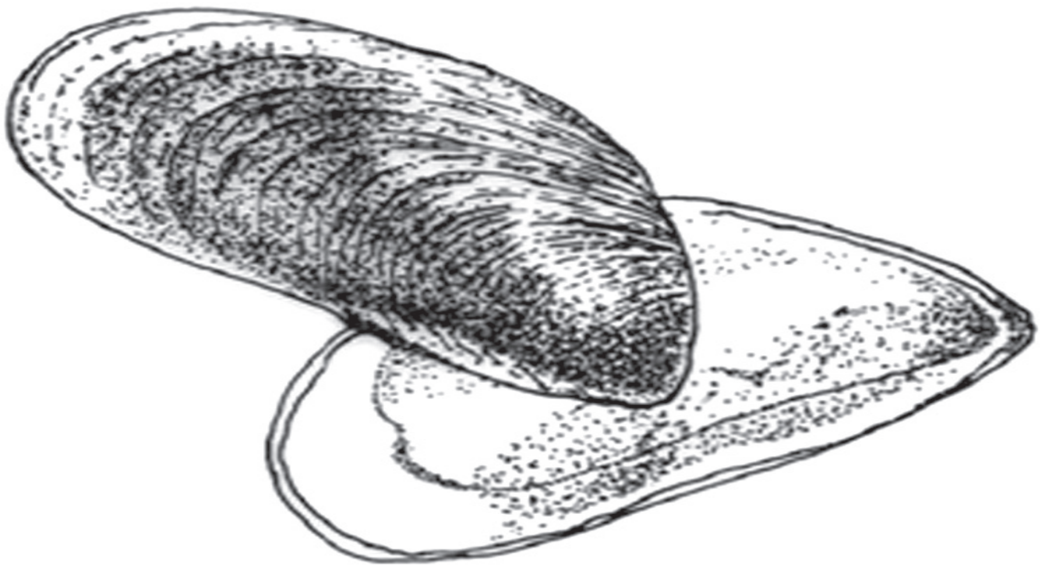


Source of image : Molluscan Fisheries Division, CMFRI, Kochi

Local names: Kakkai (**Marathi**); Pachali (**Kannada**); Kallumakkai, Kadukka, Chippi (**Malayalam**); Pachai alli (**Tamil**); Alichippalu (**Telugu**)

MORPHOLOGICAL DESCRIPTION

Perna viridis is characterised by an elongate shell with pointed and swollen anterior end and a compressed posterior end. Umbo is tapering sharply at the terminal. Ventral margin is concave and long, whereas anterior margin is reduced. Outer surface possesses concentric growth marks and faint radial lines. The smooth periostracum (outer shell) is thick and dark green, with finely pitted ligamental ridge. Shell hinge has two teeth in the left and one small tooth in the right valve. In adults, the anterior adductor scar is absent. Anterior retractor scar is separate, situated at posterior end of ligament and is elongate-ovate in shape. Younger mussels are bright green and as it ages, the colour becomes darker. It has a large mobile foot and produces byssus, which helps it to attach to its substrate.



PROFILE

GEOGRAPHICAL DISTRIBUTION

This species is widely distributed in the Indo-Pacific region. It is native to Malaysia and is reported from Persian Gulf, New Guinea and Japan. It is distributed naturally in the intertidal areas along the Indian coast. Along east coast, it is available in Chilika lake, Visakhapatnam, Kakinada, Chennai, Puducherry, Cuddalore, Porto Novo and Port Blair and along west coast, it is available in Kollam, Alapuzha, Kochi, Calicut, Kasargod, Mangalore, Karwar, Goa, Malvan, Ratnagiri and Gulf of Kutch.

HABITAT AND BIOLOGY

The green mussel typically occurs at shallow depths of 10 m and inhabits intertidal, sub tidal and estuarine environments. It remains mostly attached to submerged marine objects in high densities. It can tolerate a wide range of salinity (18-33 g/l) and temperature (10-35 °C). Sexes are separate and sexual maturity occurs at 15-30 mm shell length. Sexually mature male possesses creamy white gonadal tissue, whereas in female, it is reddish in colour. Fertilization is external. Spawning is closely related to monsoon rainfall. Life span is 2-4 years.

BREEDING IN CAPTIVE CONDITIONS

Water temperature plays a key role in the gonadal maturation and induced spawning. Complete spawning was achieved by the gradual increase of temperature from 20-35 °C @ 3 or 4 °C/5 days. Temperature stimulation resulted in gonadal growth, increase in gonadal index and change in cellular composition of testis and ovary. As the individual matured, gonadal tissue proliferated throughout the mantle region. In males, the mantle tissue turned creamy to milky white in colour whereas, in females it was orange to brick red colour. Chemicals like Tris and hydrogen peroxide were also used to induce spawning.

LARVAL REARING

In Tahiti, larval rearing was conducted in cylindro-conical tanks of 800 l capacity. Larvae are fed with *Monochrysis lutheri* and *Isochrysis* spp. at initial concentration of 25,000 cells/ml. Water exchange was done on every second day. During metamorphosis, *Isochrysis* spp. (12,500 cells/ml), *M. lutheri* (12,500 cells/ml) and *Skeletonema costatum* (50,000 cells/ml) were added daily. Metamorphosis and spat settlement was observed on 10th and 17th day, respectively. The survival from D stage to marketable spat size (7-8 mm and 40 mg) was 10 %.

In India, at Visakhapatnam R. C. of CMFRI, larvae were stocked initially @ 5-10 nos./ml, which was gradually reduced at settlement stage to 2-3 nos./ml. The larvae were fed from second day onwards with *Isochrysis galbana* @ 5,000 cells/larvae/day, with increase in cell density to 8,000 cells/larvae/day at umbo stage and 10,000 cells/larvae/day at pediveliger stage. After settlement, spats were fed with *I. galbana* and *Chaetoceros calcitrans*. The spat settlement rate achieved was 23.5 %.

NURSERY REARING

Information not available

GROW OUT

On-bottom culture and off-bottom culture are the two culture practises in vogue. Off bottom culture involves stake or pole, rack, raft (shallow and intertidal waters) and long line (deeper open waters). In France, intertidal pole culture, known as Bouchot culture, yields annually an average production of 25 kg mussel from each pole. Stake culture practiced in Thailand and Philippines produces 8-12 kg of mussel from each pole. On-bottom culture widely practiced in Netherlands, Denmark and Germany yields 80 t/ha. Rack culture is widely used for farming green mussel in India and Philippines.

FOOD AND FEEDING

Perna viridis is a filter feeder, feeding on zooplankton, phytoplankton and suspended fine organic material. It preferentially feeds on dinoflagellates and diatoms in times of bloom.

GROWTH RATE

Growth rate is influenced by temperature, food availability and water movements. Growth rates vary in the first year from 49.7 mm (Hong Kong) to 120 mm (India). Growth is maximum at 2 m below the surface, where environmental factors are conducive in the form of increased productivity and low fluctuations in temperature and salinity.

DISEASES AND CONTROL MEASURES

Nematopsis sp. infects *Perna viridis*. *Cryptosporidium* protozoan parasites are reported and it acts as a reservoir of *Cryptosporidium* food borne infections.

PRODUCTION, MARKET AND TRADE

PRODUCTION

According to FAO, world mussel production during 2006 was 1.89 million t, valued at 1.2 billion US $. Globally 2,82,000 t was produced through culture in 2005. The total culture production in India was about 17,000 t in 2008.

MARKET AND TRADE

Extracts of *Perna viridis* have medicinal importance as source of anti-HIV activity. Green mussel extract (GMe) (patented product of CMFRI), is an effective green alternative to synthetic non steroidal anti inflammatory drugs, containing 100 % natural marine bioactive anti inflammatory principles. Green mussel is also consumed fresh in India. In the domestic market, green mussel products are popularised and sold through the involvement of women self help groups.

CHALLENGES TO MARICULTURE

Presently culture is fully dependent on natural wild seed collection. However, culture of green mussel will be not sustainable with the seed collected from the wild. Thus there is urgent need to develop the technology for seed production. Though, the seed production technology for green mussel is available on experimental basis, the cost of seed produced by these technologies is very high. For sustaining the green mussel seed production technology, the cost involved in seed production should be brought down, where the farmer can afford to buy and use them for culture. Hence, there is an urgent need to initiate mass scale production of hatchery reared seeds through mariculture. The main researchable issues, which have to be sorted out for this species in India, are larval rearing protocols with emphasis on bringing down the cost of production.

FUTURE PROSPECTS

Presently mussel seed available from the wild is used for farming which is not sustainable and is not enough to meet the requirements of mussel farmers. So commercial seed production of green mussel is required urgently for assured seed supply for ensuring that green mussel culture is an economically viable venture for mussel farmers.

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Marcia opima (Gmelin, 1791)

Biji Xavier

IDENTIFICATION

Order	:	**Venerida**
Family	:	**Veneridae**
Common/FAO Name (English)	:	**Venus shell**

Source of image : RC of CMFRI, Tuticorin

Local names: Njavala kakka (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

Marcia opima has a small, glossy, puffed-up shell which ranges from a creamish-brown to grey colour. There are radial dark markings on the shell running from the umbo to the shell margin. Inner surface of the shell is white. Hinge has three teeth and a long ligament. Anterior lateral teeth is absent in left valve, but corresponding depression is present on the right valve.

PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is distributed in Indo-Pacific region from northwest Indian Ocean and the Aden Gulf to Indonesia. *Marcia opima* is abundantly present along the estuaries and backwaters of South India. It prefers river-mouths and is found burrowing in the mudflats of Gulf of Mannar, Ashtamudi and Kayamkulam Lakes, Ratnagiri, north Kanara, Bombay and Chennai coasts.

HABITAT AND BIOLOGY

It is found in muddy-sandy substratum at depths of 1 m. It prefers high salinity and is mostly seen near barmouths. Size at first maturity is 18-20 mm. Two spawning peaks are recorded, one in November-January and the other in May-June. Maximum shell length recorded is 58 mm. It grows to 26-33.8 mm in one year and life span is about 3 years. Sexual maturity is observed at size of 11-12 mm, when it is 3 months old.

BREEDING IN CAPTIVE CONDITIONS

The broodstock development, breeding and larval rearing of *Marcia opima* was carried out on an experimental basis at Tuticorin R. C. of CMFRI. Shells of 30-48 mm length collected from wild were used as brooders. They were fed with *Isochrysis galbana* and *Chaetoceros* sp. They were induced to spawn by raising the temperature to 32 °C for about half an hour. Diameter of the fertilized eggs ranged from 43 to 59 µm. The fertilized eggs and morula were collected in a 40 µm sieve and transferred to larval rearing tanks (1,000 l capacity), after passing through a 100 µm sieve for removing the debris.

LARVAL REARING

Larvae ('D' shape) were stocked at densities varying from 0.2-1.2 larvae/ml. Larvae were fed with *Isochrysis galbana* at concentration of 5,000 cells/larva/day. The early and late umbo stages were reached on 5th and 7th day, respectively. Subsequently, feeding was increased to 8,000 cells/larvae/day. Settlement started on day 9 and 10 post-fertilization. Settlement was completed by 11th day, when the larvae measured 273 x 260 µm. At settlement, feeding was increased to 10,000 cells/spat/day. On 18th and 20th day, feeding was gradually increased to 12,000 and 20,000 cells/spat/day, respectively. On day 45, the juvenile size varied from 1.7 mm to 3.4 mm.

NURSERY REARING

Information not available

GROW OUT

Information not available

FOOD AND FEEDING

It is a filter feeder, feeding mostly on marine phytoflagellates.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Good export market for frozen clam meat exists for *Marcia opima*. The shells are utilized for calcium carbide industry.

CHALLENGES TO MARICULTURE

Standardisation of seed production technology for mass scale propagation is a challenge. The main researchable issues, which have to be sorted out for this species in India, are (i) Larval rearing protocol: standardization of larval rearing by environmental and nutritional manipulation (ii) Nursery rearing protocols and (iii) Suitable farming methods.

FUTURE PROSPECTS

The species is having good local market demand as well as export value. However breeding and seed production as well as farming technology needs to be popularized further. Popularizing the technology already developed by CMFRI among fish farmers can go a long way in ensuring their livelihood security.

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Meretrix meretrix (Linnaeus, 1758)

Jasmin F.

IDENTIFICATION

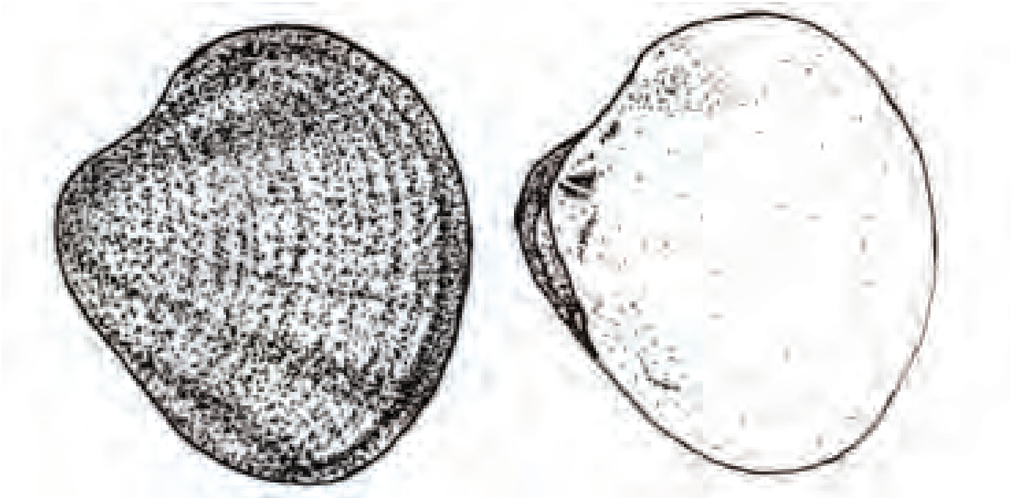
Order	:	**Venerida**
Family	:	**Veneridae**
Common/FAO Name (English)	:	**Asiatic hard clam**

Local names: Manja kakka (**Malayalam**); Maruvai, Meretrix dada, Khude, Ane maruvai (**Kannada**); Matti (**Tamil**)

MORPHOLOGICAL DESCRIPTION

It has a hard shell covered with a delicate, brownish-greyish periostracum, and its postero-dorsal margin has a greyish-blue- bluish-brown band. The shell is triangular to oval in shape. The posterior margin is slightly more pointed. It is equivalved, having no gape when closed. The lunule is not clear and the ligament is short. It has an umbo on anterior side. The shell exterior is white in colour. There is light purple or pink colouration along the radial lines. Hinge plate is hard. There are three cardinal teeth on the left and right valves.

Source of image : RC of CMFRI, Visakhapatnam



PROFILE

GEOGRAPHICAL DISTRIBUTION

Meretrix meretrix is a large bivalve which is distributed in Philippines, Australia, Singapore, Indonesia, Thailand, South Africa, Malaysia, Indonesia, Vietnam, China, Japan, Korea and Papua New Guinea. It is also widely spread along the west and east coasts of India. It occurs along the west coast in Kalbadevi and Bhatea creeks of Maharashtra; Chaporal, Sal, Mandovi and Zuari estuaries of Goa; Kalinadi, Tadri and Coondapur of Karnataka and Thellicherry and Ashtamudi lake of Kerala. Along the east coast, it occurs in major estuaries of Tamil Nadu, Andhra Pradesh and in the Chilika Lake.

HABITAT AND BIOLOGY

It inhabits marine and estuarine habitats. It is distributed in the sandy mud flats upto a depth of 4 m. Life span is 7-8 years with size ranging from 14.6-91 mm. They are dioecious. It followed a clear pattern of annual reproductive cycle with a long breeding period, extending from September to January in west coast and during September and May along the east coast of India . Gonads of female have light brown colour and male gonads have milky white colour when mature. In Vietnam a study found that the size at first maturity of the hard clam is 40 mm. Absolute fecundity ranged from 3,18,400 to 38,25,000 eggs/individual and the average was 11,81,151 eggs/individual. They are filter feeders which feed on microalgae.

BREEDING IN CAPTIVE CONDITIONS

Hatchery technology for seed production was developed by Tuticorin R. C. of CMFRI. The clams of length ranging 34.3-88 mm were collected from the Korampallam creek, Tuticorin and 20 of them were conditioned in 50 t FRP tanks containing sea water at temperature 24-26 °C. They were fed with *Isochrysis galbana* once a day. After 10-15 days a thermal shock (rise of 4-5 °C) was given to induce spawning. The males usually spawned first followed by females. After spawning the parents were removed from the tank. The fertilized eggs settled at the bottom and the supernatant was removed with fresh sea water. The morula larvae developed after 2-4 h.

In China, broodstock, collected from shallow water were conditioned in seawater from 18 to 24 °C for 10 days. They were fed an algal diet of *Phaeodactlyum tricormtum* and *Isochrysis galbana*. Mature clams were induced to spawn by air-drying without light for 4-6 h followed by thermal shock at 27-28 °C in filtered seawater. After 24 h the veliger larvae were collected and reared at different stocking densities.

LARVAL REARING

The larvae or spat were reared in hatchery for three months using algal diet at Tuticorin. Spat settlement at size of 184 µm occured between day 8^{th} to 12^{th} post fertilization. On day 75, average size of 2.9 mm was attained with survival ranging from 2.8 to 18.8 %. The trochophore larvae developed 9 h after fertilization, and then changed to D shaped larvae in 20 h. It was fed with *Isochrysis galbana* at 5,000 cells/larva/day. On the 4^{th} day, on reaching umbo stage, feeding was increased to 8,000 cells/larva/day. Metamorphosis to pediveliger larvae occurred on the 6^{th} day with subsequent foot development and was completed by the 10^{th} day. At this stage, feeding was increased to10,000 cells/larva/day. Settlement occurred between 6^{th} and 10^{th} day, depending on the habitat.

NURSERY REARING

Hatchery produced young clams of 7.8 mm grew to 14.5 mm in 5 months. Exposure of 2 mm seed to fluctuating salinities revealed high growth rate (189.65 %) at 20 g/l.

GROW-OUT

In the estuarine regions along Ratnagiri, the clams were traditionally kept in pits at stocking density of 1,000 to 1,500 nos./m^2 for a short period of 8 to 10 days. Clams were transplanted at 10 m and 30 m away from the shore, in the intertidal zones of the estuary, at stocking density of 100 individuals/m^2. Clams, after one year, attained average length of 39.91±3.79 mm, average weight of 19.2±4.06 g and average meat weight of 3.4±0.26 g when transplanted 10 m away, and when transplanted 30 m away attain average length of 37.76±3.75 mm, average weight of 18.45±3.06 g and average meat weight of 2.45±0.39 g.

FOOD AND FEEDING

It is a filter feeder, which feeds on phytoplankton and in captive conditions it prefers microalgae like *Isochrysis galbana*.

GROWTH RATE

Monthly growth rate for hatchery reared seeds varied from 0.15 mm to 2.20 mm.

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

During 1984, the production was about 17,115 t from Taiwan province of China. China is still a major producer with 30,711 t in 2002.

MARKET AND TRADE

It is commonly collected from shallow waters for human consumption. Tamil Nadu, Pondicherry and Andhra Pradesh possess rich clam resource which is used mostly as shrimp feed. Domestic consumption is negligible in these states. Clam shells are used in the manufacture of cement, calcium carbide, sand-lime bricks and lime.

CHALLENGES TO MARICULTURE

Culture in India is on an experimental scale, and hence mass scale development of production systems, including breeding and larval and nursery rearing in confined environment has to be developed.

FUTURE PROSPECTS

In order to protect the existing resources and to increase the possibilities of long-term exploitation, research should focus on large scale culture in captivity.

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Paphia malabarica (Dillwyn, 1817)*

Jasmin F.

IDENTIFICATION

Order	:	**Venerida**
Family	:	**Veneridae**
Common/FAO Name (English)	:	**Short neck clam**

* *Protapes gallus* (Gmelin, 1791) as per Huber,M. (2010)

Source of image : Molluscan Fisheries Division , CMFRI , Kochi

Local names: Tisre (**Konkani**); Chippi kallu, Kesha maruvai (**Kannada**); Poovan kakka (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

The short neck clam has a shell which is triangular to oval in shape with rounded anterior and posterior margins. Shell is more or less long and smooth but the outer surface of shell has concentric ridges. Hinge area is short and has narrow diverging teeth. The pallial sinus is not too deep and is 'U' shaped.

PROFILE

GEOGRAPHICAL DISTRIBUTION

It is distributed from the Gulf of Oman to Japan; covering India, China, Sumatra and the Philippines. It is distributed along both the east and west coast of India in many estuaries and coastal waters. Along the west coast, it forms a major fishery in Mulky, Gurupur, Udyavara and Coondapoor estuaries of Karnataka and Azhikkal, Chittari and Ashtamudi estuaries of Kerala.

HABITAT AND BIOLOGY

The short neck clam inhabits marine and estuarine habitats. It is distributed in the sandy mud flats upto a depth of 4 m. In Mulky estuary, sexes are almost equally distributed, except in August when males outnumber females. However, in estuaries in Kerala, females outnumber males in most of the months. Size at first maturity is 20 mm for females and 22 mm for males. It spawns once in a year. Spawning season is from September to February. Average lengths are 6 cm, with a maximum of 8.6 cm. They are filter feeders which feed on microalgae species like *Nannochloropsis salina*, *Isochrysis galbana*, *Dicrateria inornata*, *Chaetoceros calcitrans*, *Tetraselmis gracilis* and *Dunaliella salina*.

BREEDING IN CAPTIVE CONDITIONS

The breeding and larval rearing of *Paphia malabarica* was successfully carried out on an experimental basis at Tuticorin R. C. of CMFRI. Broodstock collected from the wild were transported and conditioned at 24-25 °C for about 20 days for gonadal development. It was fed a mixture of *Isochrysis galbana* and *Chaetoceros calcitrans* for one week prior to thermal stimulation. The clams were dried in the dark for 4-6 h and are then shifted to filtered seawater maintained at high temperature (0.45 µm, 28-30 °C) for induction of spawning. It spawned 4-6 h after induction. Both sperms and eggs were allowed to fertilize for few minutes. About 24 h after fertilization, eggs developed into D-shaped larvae.

LARVAL REARING

D-shaped larvae transferred to larval rearing tanks were fed with *Nannochloropsis salina* at density of 5 x 10^3 cells/ml. Water was completely exchanged daily and continuous aeration was provided. Spat settlement occurred on 9th day and was completed by 12th day. Size of spat was 286 µm. Maximum survival varied from 73.4 % to 84.5 % at pH between 8.0 and 8.1 during the umbo stage on day 6.

NURSERY REARING

Hatchery produced spat of size 2-3 mm in shell length were stocked at density of 1,000 nos./bag in nylon bags of 1-2 mm mesh. A nylon meshed fish net was stitched over it for additional protection against damage by crabs and fishes. Bags were suspended from racks in shallow calm waters. Bags were periodically cleaned to remove silt, predators and foulers. After 6 weeks of stocking, spats attained a shell length of 10-15 mm and were ready for grow-out.

GROW-OUT

Clam seed of 10.7-12.4 mm shell length grew to 30.4-34.6 mm (7.8-9.5 g) in 3.5 to 5.5 months. Production was 14.3 to 59.3 t/ha with a retrieval of 7 to 17.6 %.

FOOD AND FEEDING

It is a filter feeder, feeding on phytoplankton viz., *Nannochloropsis salina*, *Isochrysis galbana*, *Dicrateria inornata*, *Chaetoceros calcitrans*, *Tetraselmis gracilis* and *Dunaliella salina*.

GROWTH RATE

In 3 months, the hatchery produced seed grew to a mean length of 2.9 mm with a maximum of 4.2 mm. Higher growth rate (30.5 %) was observed at 28 g/l salinity. By ranching in natural beds the hatchery produced seeds of 12.4 mm grew up to 32.4 to 36.6 mm in 4-5 months.

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

The short neck clam fishery of the Ashtamudi Lake of Kerala was the first Marine Stewardship Council (MSC) certified fishery of India. The production (green weight catch) of this clam from Ashtamudi Estuary was 11,052 t in 2011 and 11,174 t in 2012.

MARKET AND TRADE

In India, this clam is used for human consumption especially in Kerala. In other states like Tamil Nadu, Pondicherry and Andhra Pradesh, this clam is used as part of shrimp feeds. The shells are used for manufacture of cement, calcium carbide, sand-lime and bricks. The short neck clam, together with *Meretrix meretrix*, contributes 80-90 % of the total clams exported from India. The meat of the short neck clam caught in the Ashtamudi Lake MSC certified fishery is exported to Vietnam, Thailand, Indonesia and Malaysia after processing and is valued to fetch nearly ₹ 10 crore/annum.

CHALLENGES TO MARICULTURE

Though technologies for broodstock development, larval rearing, nursery rearing and grow out have been standardized, these need to be scaled for higher adoption rates in the fish farming community.

FUTURE PROSPECTS

The short neck clam forms a major part of the clams exported from India. The meat is consumed domestically and the shell is used in a variety of industries. Hence mariculture of this species can lead to increased exports from India, thereby earning much needed foreign exchange, as well as contribute to industries which use clam shell resources.

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Perna indica (Kuriakose & Nair, 1976)*

Biji Xavier

IDENTIFICATION

Order	:	**Mytilida**
Family	:	**Mytilidae**
Common/FAO Name (English)	:	**Brown mussel**

Local names: Kallumakkai, Kadukka (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

Brown mussels as the name suggests have brown coloured shells. They have elongate, equivalved and equilateral shells with pointed and straight anterior end. Dorsal ligamental margin and ventral shell margin are straight. The two valves of the shell are hinged at the anterior end with terminal umbo. Interior of shell is lustrous with muscle scar deeply impressed. It has a finger shaped, thick and extensible foot. Byssus threads emanate from the byssus stem and the threads are long, thick and strong with a well developed attachment disc at their distal end. It can change its position by discarding old byssus threads and secreting new ones.

* *Perna perna* (Linnaeus, 1758) as per Wood et al., 2007.

Source of image : Molluscan Fisheries Division, CMFRI, Kochi

PROFILE

GEOGRAPHICAL DISTRIBUTION

The mussel beds are spread both in west coast (Quilon to Cape Comorin) and east coast (Cape Comorin to Thiruchendur). Important centres are Cape Comorin, Colachal, Muttom, Poovar, Vizhinjam, Kovalam, Varkalai and Quilon.

HABITAT AND BIOLOGY

The species forms dense populations along the rocky coasts from the intertidal region to depths of 10 m. Large sized individuals are found at 0.5 to 2 m depth. Maximum recorded length is 121 mm. Sexes are separate and fertilization is external. Natural spawning starts in May and lasts till September with peak during July to August.

BREEDING IN CAPTIVE CONDITIONS

The breeding and larval rearing of *Perna indica* was successfully carried out on an experimental basis at Vizhinjam R. C. of CMFRI. Brooders collected from wild were used for breeding purpose. Rise in temperature by 4 °C from normal led to successful spawning. The sperm released from the male induced the females to spawn. Fertilized eggs sank to the bottom and reached morula stage within four hours of spawning.

LARVAL REARING

Larval rearing was done in FRP tanks with filtered sea water. The larval density was maintained at 10,000-15,000 nos./l upto 5th day and subsequently reduced to 5,000-6000 nos./l. Trochophore larvae developed after 7 h of fertilization. The larvae reached early veliger and D shape at 20 h and 24 h post fertilization. Early umbo and late umbo stages were observed on 7th and 9th day, respectively. At this stage, larvae were characterised by the presence of thick greenish yellow digestive gland in the antero-dorsal region, which was visible through the transparent shell. On 13th day, larvae reached the eyed stage, characterized by dark pigmented eye spot ventral to the digestive gland. From 16th day onwards, pediveliger larvae observed were with slightly oblique valve, protruding foot and reduced velum. Shells became thick and appearance of brown colouration started. From 17th day onwards, the velum totally disappeared and pediveliger larvae started settling. It reached a length of 780 µm on 21st day and 2.7 mm on 32nd day. Larva were fed with microalgae *Isochrysis galbana* and *Pavlova* sp. from straight hinge veliger stage. The quantity of microalgae fed was increased gradually as the larvae grew to umbo (5,850 cells/larvae/day), eyed (11,700 cells/larvae/day) and pediveliger (17,550 cells/larvae/day) stages. Mixed phytoplankton comprised chiefly of *Isochrysis galbana* (30,000 cells/ml/day) were fed to the spat.

NURSERY REARING

Spat settled in hatchery tanks or wild collected were nursed, either in open sea or in enclosed bay system, for further growth.

GROW-OUT

Rope culture was initiated in 1971 at Vizhinjam, Kerala, India. Production from the bay area was around 150 t and from open sea was around 180-200 t. Ideal length of mussel for seeding was 20-35 mm. Roofing tiles, iron cages and split nylon ropes were used as spat collectors. Seeds were also collected manually from the rocks with the help of iron chisel. The collected seeds were cleaned and spread over a piece of old cotton net or mosquito net and the nylon rope was kept over the net. The net was wrapped over the rope keeping the seeds intact, and both the ends of the net were stitched with cotton twine. After seeding, the ropes were suspended from rafts.

One hundred seeded (25-40 mm size seed) ropes were suspended from long lines (20 m long), which were spaced 5 m apart and were provided with 100 l capacity barrels for floatation. Seeded mussels attached to the ropes within 3-4 days. During six months of culture, average monthly growth rate was 6.55 mm. The average production (shell on weight) was 52.6 kg/rope (11.76 kg/m of rope). Suspended mussel culture using floating rafts was also productive with an average production of 10 kg mussels/m length of rope.

FOOD AND FEEDING

It is a filter feeder, feeding on phytoplankton.

GROWTH RATE

Average growth rate in rope culture in bays was 35 mm/year, whereas in open sea, it was 25 mm in 5 months. Mussels grew faster in open sea conditions.

DISEASES AND CONTROL MEASURES

Boring sponge infestation was most commonly observed in raft and rope cultured mussels. Major species includes *Cliona lobata*, *Cliona vastifica*, *Cliona margaritifera* and *Cliona celata*. Epizootic fungus, *Sirolpidium* sp. caused heavy mortality in larvae in culture systems. It was prevented by proper treatment of seawater. Raising water temperature to 32.5 °C for several hours also killed the fungus without affecting the larvae. Bacterial toxins from *Vibrio* and *Pseudomonas* impacted larvae. Epizootics such as bryozoans, ciliates and ascidians were controlled by the use of pentachlorophenyl (1 mg/l), formalin (40 mg/l) and dichlorophene.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Spain leads in mussel farming with a production of 7,70,000 t in 2005. Total mussel production in India was about 20,000 t in 2009-2010.

MARKET AND TRADE

Brown mussel has good demand in markets of Kerala. The products are prepared and marketed through the intervention of Self Help Groups (SHGs) in the state.

CHALLENGES TO MARICULTURE

Limited availability of natural mussel seed, seasonality of the natural mussel spat, lower growth rate in brackish water and the difficulties in maintaining the mussel rafts in open sea are the major constraints for large scale mussel farming. Hence, mass scale availability of hatchery produced seeds round the year is of paramount importance and needs to be prioritised for boosting mariculture.

FUTURE PROSPECTS

The local demand for mussel meat is high in south west coast of India. Currently culture systems in place use wild seed which is not sustainable. Hatchery production of brown mussel seed will be a solution to this challenge, ensuring conservation of wild stocks while earning livelihood to the mussel farmers.

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Tegillarca granosa (Linnaeus, 1758)

Jasmin F.

IDENTIFICATION

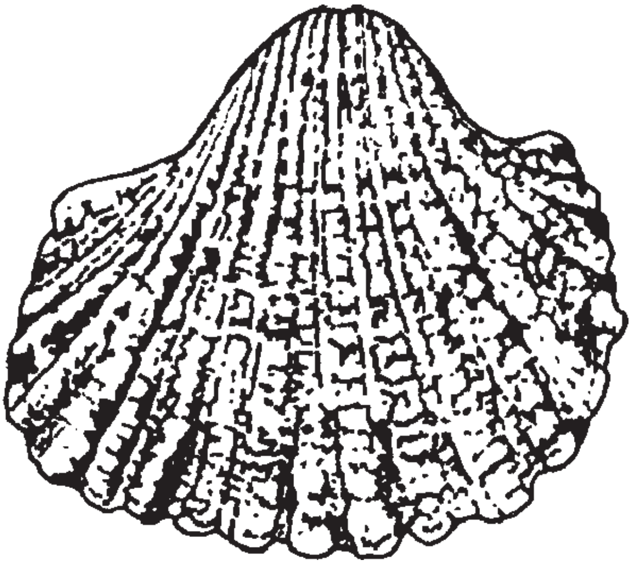
Order	:	**Arcida**
Family	:	**Arcidae**
Common/FAO Name (English)	:	**Blood clam**

Source of image : RC of CMFRI, Visakhapatnam

Local names: Arippan kakka, Kallan kakka (**Malayalam**); Buditha gulla (**Telugu**)

MORPHOLOGICAL DESCRIPTION

Shells are equivalved, thick and solid, ovate in shape and strongly inflated. It is feebly equilateral in shape. The umbones are of strongly protruding type and the cardinal area is large. There are about 18 radial ribs (15 to 20) on each valve. The radial ribs are broad and have clear knobs. Periostracum is thin and smooth. The margins have distinct crenulations corresponding with the outer radial ribs. The byssal gape is not present. Outer surface is white in colour with a yellowish brown periostracum covering. Inner surface is white with light yellow tinge towards the umbonal cavity.



PROFILE

GEOGRAPHICAL DISTRIBUTION

It is distributed in the Indo-west Pacific region, from east Africa to Polynesia, north to Japan, China, Malaysia, Taiwan, Thailand and south to northern and eastern Australia. In India, it forms a fishery of good quantity at Kakinada Bay and a small fishery in Tuticorin and Chennai.

HABITAT AND BIOLOGY

It is a benthic brackish water species which can live up to 20 m water depths but is mostly found in the littoral zone. It inhabits muddy bottoms, mainly in protected bays and estuaries, or in mangroves. It is sessile or burrower, and is a filter feeder, feeding low in the food chain. Feeding habit is related to the bottom feed where it lives. Important diet components are organic detritus (98%), phytoplankton and unicellular algae.

It begins to mature at an age of 1+ to 2+ years and reproduces throughout the year. It can have 2-4 reproductive cycles in a year and their duration can vary considerably between years according to a study at Kakinada Bay, India. Males attain maturity at 20 mm and females at 24 mm length. One female can produce 5,18,400-23,13,200 eggs. Embryos develop into free-swimming trochophore larvae, succeeded by the bivalve veliger, resembling a miniature clam.

BREEDING IN CAPTIVE CONDITIONS

Breeding, larval rearing and nursery rearing of blood clam have been reported from Tuticorin R. C. of CMFRI. Twenty-five *T. granosa* specimens were collected from Tuticorin of length ranging from 39 to 74 mm and transferred to 100 l FRP tank containing seawater. They were kept in the conditioning room at 24-26 °C water temperature and fed intensively with *Isochrysis galbana*. They were induced to spawn with thermal shock of 4-7 °C. The fertilized eggs were cleaned using 40 µm and 100 µm sieves to remove excess sperm, debris, etc. and collected in 1 t FRP rearing tank. The water was changed completely on even days and half the volume of water replaced on the odd days. Gentle aeration was given in the rearing tank. *I. galbana* was given as food once a day. The eggs were spherical, light pink red in colour. Fertilization occured within minutes and soon after, the eggs became opaque. Cell division was observed within 10 min. After passing through the blastula and gastrula stages, the morula larvae developed in 3-4 h, trochophore larvae in 5 h and veliger larvae in 20-26 h after fertilization.

LARVAL REARING

On first day, *Isochrysis galbana* was fed at 5,000 cells/larva/day. Early umbo stage was observed on 7th day and the feed was increased to 7,000 cells/larva/day. Advanced umbo stage was reached on 12th day. On day 14, some of the larvae developed foot and on day 16, majority developed foot, marking the advent of pediveliger stage. Hinge of 12-16 days old larvae showed 14-16 teeth, arranged in a linear series, leaving a gap in the middle. Feeding rate was increased to 10,000 cells/larva/day from day 14 onwards. Settlement of the larvae was first observed on day 16 and the majority had settled by day 18.

NURSERY REARING

On day 20, for the post set clam, the algal cell ration was increased to 12,000 cells/larva/day. On day 22, the shell of the spat showed 18 ribs, a characteristic feature of the adult. On 31st day, the spiny periostracum was observed on spat shells. Feed was increased to 15,000 cells/spat/day on day 25 and further to 20,000 cells/spat/day on day 40. From day 48 to day 59, it was increased to 25,000 cells/spat/day. Hatchery produced seed had an average length of 2.42 µm.

GROW-OUT

It is cultured in China, Japan, Philippines, Thailand, Indonesia and Malaysia. In Thailand, cockles are usually cultivated on mud in the intertidal zone with a water salinity of around 10-32 g/l. Experimental pen, box and off-bottom culture in Kakinada Bay has been carried out by Kakinada R. C. of CMFRI. Clams were cultured in pens, boxes and off-bottom, in nylon mesh cages suspended from rafts at Kakinada Bay. It did not thrive when suspended in the water column in metal ring cages without muddy substratum. Growth rate in the pen was faster. Hatchery produced seeds were reared from day 60 onwards in 40 x 40 x 10 cm cages made of 6 mm iron rod and covered with an inner 0.6 mm and outer 20 mm mesh synthetic webbing. Cages were hung from racks at 1 m depth with each cage containing 100 clam seeds.

FOOD AND FEEDING

It feeds on plankton and detritus.

GROWTH RATE

Growth rate is 3.3 mm/month.

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Culture production has increased from 2,52,233 t in 1995 to 3,15,811 t in 1999. Capture production during the same period ranges from 1,415 t to 6,503 t. Thailand imports from Malaysia, every year, few thousand tonnes of seeds and adults. Production in Thailand was around 20,000 t to 21,000 t per year during 1996-1997.

MARKET AND TRADE

It is commonly collected from shallow waters for human consumption. Kerala, Tamil Nadu, Pondicherry and Andhra Pradesh possess rich clam resource which is used mostly as shrimp feed. Domestic consumption is negligible in these states, except Kerala. Clam shells are used in the manufacture of cement, calcium carbide, sand-lime bricks and lime.

CHALLENGES TO MARICULTURE

Seed availability from wild for culture is a major constraint. Culture in India has been on an experimental scale, and hence mass scale development of production systems, including breeding, larval and nursery rearing in confined environment has to be developed.

FUTURE PROSPECTS

The culture of this clam can be a good source of employment to women's self help groups and fisherwomen cooperatives. Since the species is edible and the shell has multiple uses its culture will be a good means of livelihood for the farmers.

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FOOD FISHES

CRUSTACEANS/ OTHER INVERTEBRATES

Portunus (Portunus) pelagicus (Linnaeus, 1758)

Joe K. Kizhakudan and Loveson L. Edward

IDENTIFICATION

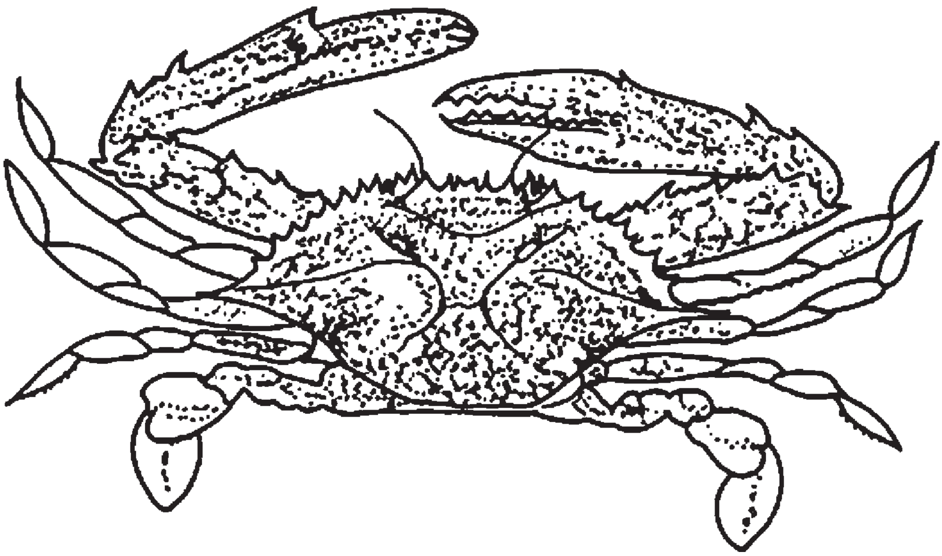
Order	:	**Decapoda**
Family	:	**Portunidae**
Common/FAO Name (English)	:	**Blue swimmer crab**

Local names: Karachla (**Gujarati**); Khekhara (**Marathi**); Denji (**Kannada**); Kora njandu, Kavalan njandu (**Malayalam**); Pulli nandu (**Tamil**); Gelai peeta (**Telugu**); Chitra kankda (**Oriya**); Naksakankda (**Bengali**)

MORPHOLOGICAL DESCRIPTION

Carapace rough to granulose, front with 4 acute triangular teeth; 9 teeth on each anterolateral margin, and the last tooth being larger than the preceding teeth. Chelae elongate in males; larger chelae with conical tooth at base of finger, typically males have bluish green colour markings and females are dull green or greenish brown.

Source of image : RC of CMFRI, Chennai



PROFILE

GEOGRAPHICAL DISTRIBUTION

The blue swimmer crab occurs throughout the Indian and the west Pacific Oceans: from Japan, and Philippines throughout south-east and east Asia, to Indonesia, the east of Australia, Fiji Islands and westward to the Red Sea and east Africa. It is present in the Mediterranean Sea as a lessepsian migrant, southern Pacific Ocean, along the coast of Egypt, Mozambique, Kenya, Israel, Lebanon, Turkey, the Syrian Arab Republic, Cyprus and the east southern coast of Sicily.

HABITAT AND BIOLOGY

It inhabits sandy and muddy bottoms in shallow waters at depths between 10 to 50 m, including areas near reefs, mangroves, seagrass and algal beds. Juveniles most commonly occur in intertidal shallower areas. Maximum carapace width is 20 cm for males with a common size of 14 cm.The recent revision in systematic places the dominant species in the eastern Indian Ocean as *Portunus reticulatus* and suspects the possibility of having a zone of hybridization in the Bay of Bengal for *P. pelagicus* and *P.*

reticulatus; studies are in progress to confirm this. The asymptotic length is estimated to range between 204.1 and 219.8 mm in males and 188.6 and 211.8 mm in females. Maximum size recorded in the fishery in India is 193 mm. The age at maturity is around 1 year. It is carnivorous feeding on a wide variety of sessile and slow moving benthic invertebrates (hermit crabs, gastropods, bivalves, ophiuroids and gammarid amphipods). It rarely consumes plant material.

As in other portunid crabs, copulation takes place only when the female is in the soft shelled condition, with a hard shelled male. Spawning occurs within 15-26 days after the copulatory moults, during the night hours. Fecundity ranges between 60,000 and 13,25,000 with an average of 5,44,782. The total days of incubation varies between 8-10. In most of the cases, nocturnal hatching of eggs is observed. When the larvae is about to hatch, the eggs are liberated from the pleopods by a conscious effort of the mother crab. The female raises its body with the help of its walking legs, its abdomen is fully stretched and its berry is vigorously jerked. Lifespan is around three years.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

The broodstock can be obtained from wild as well as culture. Berried females are caught from the wild. Berried females with yellow to grey eggs are selected and kept in holding tanks with a stocking density of 1 crab/t of water. Berried females are given a prophylactic treatment with potassium permanganate or formalin to prevent it from microbial and parasitic infections. The cultured crab of above 60 mm carapace width (CW) were selected and stocked in tank for captive maturation. The tank was of 2.5 m diameter with 8 t water capacity fitted with re-circulatory facility at bottom. An in situ sand bed filter of 5-10 cm height was set on a perforated, false bottom that was installed at about 15 cm height over the entire surface area of the maturation tank. An air-water lifting system was arranged in the tank through the air dispersing stones by fixing 4 PVC tubes in the peripheral region of the sand bed at equal distance so that water recirculation was maintained by lifting 300 % water/day. Daily, a 25-30 % water exchange was given and once in a week exchange was 100 %. The tank was covered to reduce light intensity. In captivity, the females are fed with prawn, mussel or squid and are provided with sand substrate and aeration.

Wild collected berried females yield good results when compared to laboratory reared females. The berried females with yellow eggs mature to black eggs in 5-7 days. Black egg berried females were transferred to hatching tanks. The fecundity of broodstock was usually between 0.4 to more than 1.5 million eggs depending on the feed and the crab size.

LARVAL REARING

The larval development includes four zoeal stages and a megalopa stage. The megalopa stage metamorphoses into the crab stage. Zoea is of typical brachygnath type. Zoea is with long rostral and dorsal spines and a short lateral spine on the carapace. The total duration of larval development varies between 14-17 days. The first and second zoeal stages span for 3-4 days each, third and fourth stages are 2-3 days each and megalopa is for 3-4 days. The commonly used feed for larval rearing is a mixture of *Nannochloropsis* sp. and rotifers during zoea 1 to zoea 4. During zoea 4 to megalopa, *Artemia* nauplii are used as live feed. Apart from this, microbound diets are also used.

NURSERY REARING

The baby crabs are stocked either in tank or earthen pond at the rate of 400-500 nos./m^2. The tank bed should be provided with additional substratum and sand. The depth of the water column should be maintained at least 80 cm. Generally prawn and egg custard is fed to the baby crab in the first week of stocking at the rate of 20 % of their biomass. From the second week onwards, the baby crab can be fed with cooked clam meat, small shrimp in addition to egg custard at the rate of 20 % of their body mass. Water exchange on alternate day at the rate of 20 % is to be carried out. Once the baby crab attains an average size of 10 mm carapace width (CW) it can be stocked in grow out pond. Nursery rearing with first crab instar shows a survival of 8.6±0.91% after 15 days of culture.

GROW-OUT

Earthen ponds are preferred for grow out culture of blue swimmer crab. At Mandapam, Tamilnadu, India, grow out culture of the species was performed by stocking first crab instar at the rate of 26 crab/ 10 m^2 in 0.06 ha pond. They were fed on commercial shrimp diet. It yielded 784 kg/ha after 135 days of culture with 32.0 % survival. Salinity of 20-25 g/l was found to be ideal for grow-out.

FOOD AND FEEDING

It is carnivorous and feeds on a wide variety of sessile and slow moving benthic invertebrates (hermit crabs, gastropods, bivalves, ophiuroids and gammarid amphipods). In culture systems, clam meat, shrimps and artificial pellet feed can be given as a feed.

GROWTH RATE

The first crab instars grew from 3 mm CW to 12.13±0.85 mm CW in 15 days culture in FRP tank. The first instar crab grew from 3 mm CW (0.007 g) to 116±8.4 mm CW (111.8±24.6 g) in 135 days culture in earthen pond.

DISEASES AND CONTROL MEASURES

Moult Death Syndrome (MDS) and stress related syndromes are reported. It is host to a number of parasites viz., *Diplothylacus sinensis*, *Heterosaccus indicus*, *Sacculina granifera*, *Thompsonia dofleini* and *Thompsonia sinensis*.

PRODUCTION, MARKET AND TRADE

PRODUCTION

The total catch reported by FAO for 2014 was 2,12,612 t. The countries with the largest catches are China (52,577 t) and Philippines (34,076 t).

MARKET AND TRADE

There is an increase in demand for frozen and tinned crab meat throughout the Indo-West Pacific. It is sold in local markets as fresh or frozen or is sent for the crab-flesh canning industry. The price for the crab in local market in India is ₹ 160-200/kg.

CHALLENGES TO MARICULTURE

Availability of berried broodstock and mass mortality in early and late larval stages are found as major hindrances in the progress of culture of this species. Issues related to nutritional deficiency during larval feeding, MDS, cannibalism and differential growth needs rectification by developing balanced diets and rearing designs with shelters.

FUTURE PROSPECTS

Crabs are in high demand both in their hard-shelled form as well as in their soft-shelled forms. Pasteurized crab meat for canning is also a popular product. Crabs also attract good demand in the domestic market. Thus with their international as well as domestic demand and price their culture is bound to provide good remuneration for the fish farmers.

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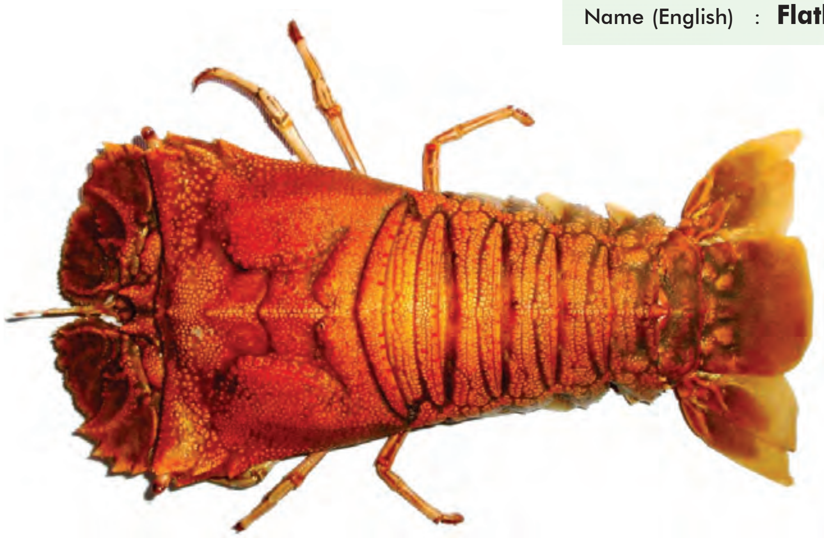
Thenus unimaculatus Burton & Davie, 2007

Joe K. Kizhakudan

IDENTIFICATION

Order	:	**Decapoda**
Family	:	**Scyllaridae**
Common/FAO Name (English)	:	**Flathead lobster**

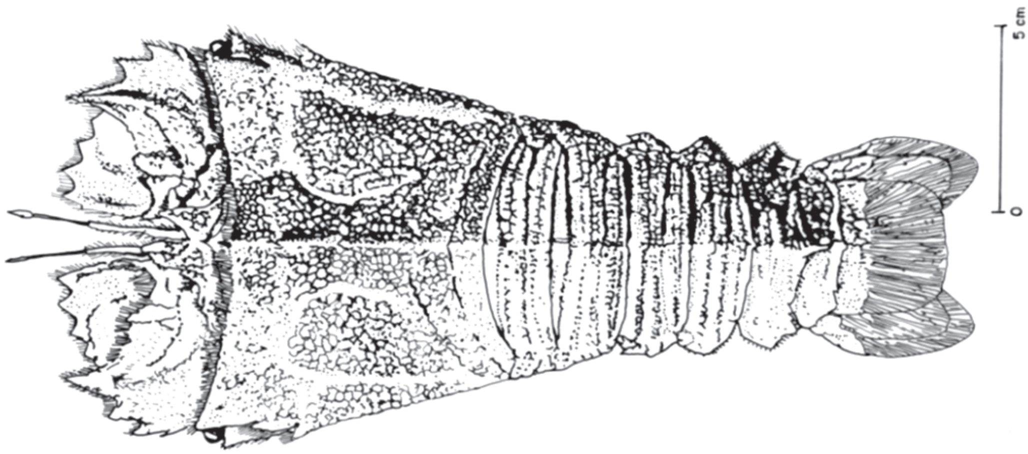


Source of image : RC of CMFRI, Chennai

Local names: Kaka (**Gujarati**); Phatphati (**Marathi**); Konju (**Kannada**); Poozhi konchu, Manal konchu, Adippan konchu (**Malayalam**); Madakku eral (**Tamil**); Tapatapalu (**Telugu**); Toptepa (**Oriya**); Patal chingri (**Bengali**)

MORPHOLOGICAL DESCRIPTION

The body of the flathead lobster is dorsoventrally flattened, brown dorsally with purplish brown granules; ventral surface yellowish white. It possesses typical purple spotting on the carapace and a purple blotch on the inner face of the merus of 1 or more pereopods. Carapace is trapezoid and depressed. The anterior part of lateral margin is with only two teeth. Rostrum is absent. Eyes are in distinct orbits. Frontal horns are absent. Antennae are plate-like. Antennules are yellowish white with red-brown bands. Fifth abdominal segment is armed with a strong postero-median spine. Pleura are directed downwards. Tail fan and pleopods are orange-red and internal sides of the pereopods are purplish.



PROFILE

GEOGRAPHICAL DISTRIBUTION

It is widely distributed in Asia and Australia. Its range extends in the Indo-West Pacific from the east coast of Africa (Southern Red Sea to Natal) to China, southern Japan, the Philippines and tropical Australia (western Australia to Queensland). In India, it is distributed along the coasts of Gujarat, Maharashtra, Kerala and Tamil Nadu.

HABITAT AND BIOLOGY

Flathead lobsters are bottom dwellers and prefer sand and mud habitats at depths ranging from10 to 50 m. It is found associated with soft substrate, sand or mud, or a mixture of the two, sometimes with shells or gravel. It buries into the substrate with only eyes and antennules visible during the daytime. It is a nocturnal feeder, feeding mainly on benthic bivalves and gastropods. Life span is 3-4 years. Spawning season is from November-April along the Indian coast. Fecundity ranges from 19,600 (60 mm carapace length female)- 59,500 (102 mm carapace length female). The maximum recorded size is 25 cm total length and 10 cm carapace length for females and 25 cm total length and 9 cm carapace length for males, with maximum weight varying from 450-500 g.

BREEDING IN CAPTIVE CONDITIONS

Captive breeding, larval rearing and indoor grow-out system has been developed by the CMFRI at its Kovalam Field Laboratory in Tamil Nadu, India. Technology for continuous mass scale seed production is presently being standardized. Captive maturation and breeding was successfully carried out in indoor FRP tanks using recirculatory system, with minimum light exposure and feeding. Ideal natural feeds are marine and coastal bivalves, specifically the marine wedge clam, *Donax* sp.

LARVAL REARING

Ideal larval rearing system uses high density with substrates or intensive raceways with false substrates and with higher rates of water exchange. It has four larval stages. At Kovalam Field Lab of CMFRI, larval rearing was completed in 26-30 days. The phyllosoma were stocked in larval rearing tanks at 10 nos./l. It was mostly phototactic and preferred specific zooplankters as live feed. It usually preferred ctenophores as live feed, but also accepted formulated diet. There was no dependency on mass phytoplankton culture or *Artemia*. The phyllosoma larvae underwent progressive moults and attained the post larval stage of puerulus and settled at the bottom. The duration of larval stages was shortened at higher temperature. Juveniles were sturdy and were easily maintained in captivity. The optimal pH for culture was 7.2-8.5 and optimal salinity was 30-39 g/l. When reared at higher salinity (36-37 g/l) and water pH (8-8.2) with minimum light exposure, the incubation period was found to decrease from 39-41 days at 25-27 °C to 32-35 days at 28-30 °C.

NURSERY REARING

The nursery phase lasted for 2-3 months, when the seed attained a size of 20-30 g.

GROW-OUT

Grow-out and fattening was successfully carried out in indoor and outdoor cement tanks at Kovalam. Natural diets (freshly chopped bivalve meat) were given along with artificial diets. Nursery and grow-out was for 9-12 months. Growth in laboratory-raised juveniles was on par with growth in wild-collected juveniles. Seed of 20 g attained 150 g in about 180 days. No cannibalism or growth retardation was recorded at higher densities. Transportation in moist packing is possible for 12 hours and in wet conditions for 20 hours for individuals weighing 50-150 g.

FOOD AND FEEDING

The preffered feed is fresh clam and mussel meat. Trash fish and commercial (shrimp) pellet feed has low acceptance. FCR is 1:4.

DISEASES AND CONTROL MEASURES

Moult Death Syndrome (MDS), tail rot and stress related milky muscle syndrome are problems in captive rearing. These can be controlled by following proper handling and domestication protocols. It is susceptible to fungal moulds when the organic loads in the substrate increases, which can be regulated by regular screening and management. Luminescent bacteria, fouling protozoa and filamental bacteria are some issues in larval rearing which needs to be addressed. To an extent, problems caused by filamentous and fouling forms are remedied through water quality screening and treatment but luminescent bacteria still remains a bottleneck.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Thenus unimaculatus contributes 5-24 % of the lobster landings along the Indian coast, with maximum landings from the north-west coast, followed by the south-east coast. Catch trends indicate decline in stock. The overall Indian marine lobster landing, from 2,400-2,500 t in the year 2000, declined by more than 75 % by 2006. There was some improvement in the years 2008 and 2009 averaging 1,800 t till 2010.

MARKET AND TRADE

It is marketed locally as live and fresh or frozen. The major markets are Japan, Australia, USA, Italy, Greece and France. In Taiwan, it is found in the markets year-around with maximum abundance during March to August. In the Philippines, it is priced lower than the spiny lobsters. The minimum legal export size in India is 150 g (65-66 mm CL; 160-164 mm TL). It is valued at US $13-20/kg. Meat yield ranges from 28-33 %. It is exported as frozen meat to European countries.

CHALLENGES TO MARICULTURE

Seed production, at present, is achieved only on a small scale, and cost-effectiveness has to be worked out. Technology on nursery rearing has to be standardized in outdoor cement tanks and ponds. Supplementary feeds for larval and grow-out phases needs to be developed. Health issues in the larval phase are being presently investigated by researchers of CMFRI.

FUTURE PROSPECTS

It is one of the most promising candidate species for lobster aquaculture in India. Broodstock can be raised and bred in captivity by environmental management. The relatively shorter duration of the larval phase is an advantage in captive rearing of the sand lobster. Its low consumption of feed makes it a more efficient converter and is comparatively cheaper to grow when compared to spiny lobsters. Increasing demand for live lobsters in the export market could be an impetus for farmers to take up lobster farming provided all the associated bottlenecks in culture are addressed.

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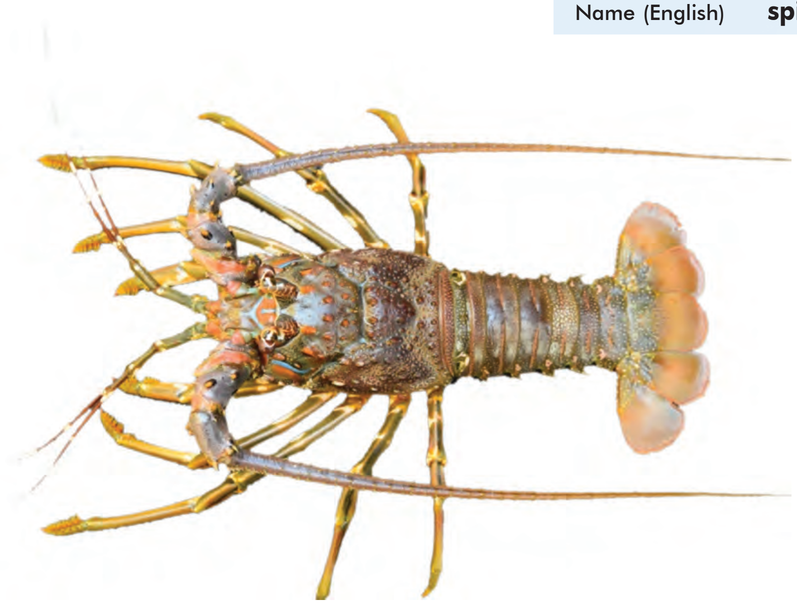
Panulirus homarus homarus (Linnaeus, 1758)

Joe K. Kizhakudan

IDENTIFICATION

Order	:	**Decapoda**
Family	:	**Palinuridae**
Common/FAO Name (English)	:	**Scalloped spiny lobster**

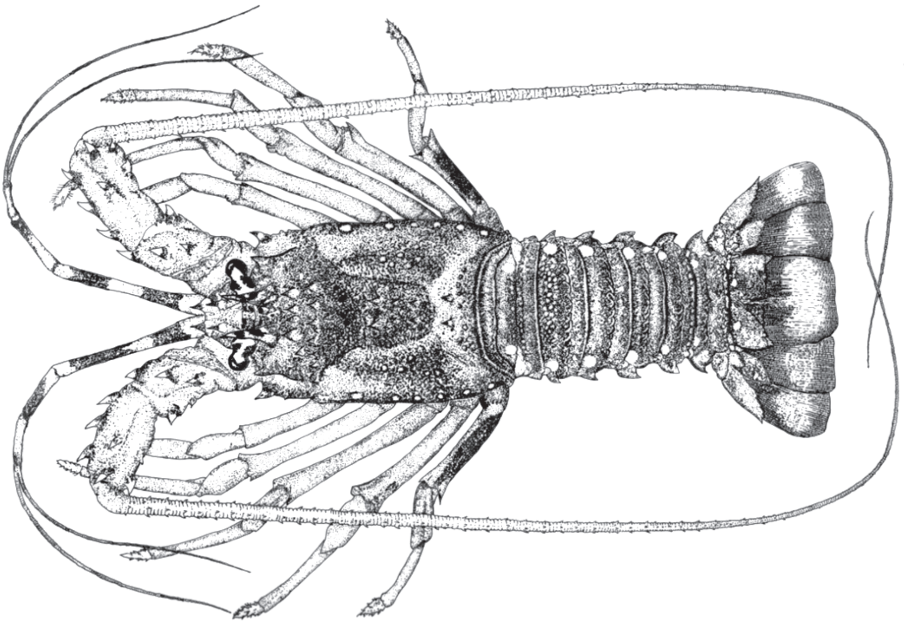


Local names: Titan (**Gujarati**); Shevand (**Marathi**); Konju (**Kannada**); Parra konchu, Kadal konchu, Raalu konchu (**Malayalam**); Singi eral (**Tamil**); Rati royya (**Telugu**); Bama royya (**Oriya**); Kanta chingri (**Bengali**)

MORPHOLOGICAL DESCRIPTION

The scalloped spiny lobster has a darkish green to reddish brown carapace, with fine white spots. No distinct abdominal bands are present; legs uniform darkish green like the carapace with indistinct spots and stripes of white. A light anterior spot is present at the base of the abdominal pleura. Antennules are banded and the antennular plate has 4 large spines arranged as a square with small spinules in between. Exopod of third maxilliped is absent. Anterior margin of transverse groove of abdominal somites is crenulated and interrupted in the middle.

Source of image : RC of CMFRI, Cheennai



PROFILE

GEOGRAPHICAL DISTRIBUTION

This species is found throughout the Indian coast and has a broad geographic range from Indo-West pacific region, east Africa to Japan, Indonesia, Australia, New Caledonia and probably the Marquesas Archipelago.

HABITAT AND BIOLOGY

It is a reef dwelling species, most commonly associated with coastal fringing rocky reefs and inshore areas of rocky reefs (1-15 m). It is found at depths of 1 to 90 m. Juveniles and adults are omnivorous, feeding on small crustaceans, molluscs, worms and algae. It is a nocturnal animal. It is also a social animal forming groups within and beneath reef structures. It matures at around 12 months post-puerulus, when the size of the animal is about 300 to 500 g. Each female produces 1,20,544-4,49,585 eggs per spawning, releasing nearly 85.7 % larvae, and can spawn 3-4 times in a year. Egg incubation takes 24-27 days, hatching occurs at night and the first stage phyllosoma larvae (< 2 mm carapace length) are released. The phyllosoma develop through 11 distinct stages involving up to 20 successive moults (instars) until the final stage, which has a carapace length of > 25 mm. The final stage phyllosoma metamorphoses into the puerulus, which is a free-swimming, non-feeding, transparent and lobster-like stage. This stage lasts for 2-3 weeks by which time the puerulus becomes pigmented and locates a suitable habitat. Following this, the larvae settle to the bottom, moult into the juvenile stage and become benthic. Maximum recorded total length is 31 cm with carapace length of 12 cm. Average length in Indian fisheries ranges from 20 to 25 cm.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Captive broodstock development and breeding were carried out at National Institute of Ocean Technology (NIOT), Chennai, India in 2003. Rectangular tank painted with black food-grade, nontoxic paint was used for broodstock development. Shelter was not provided in the tank. The broodstock were stocked at the rate of 4/m^2 with a sex ratio (male:female) of less than 1. However the sex ratio was changed to 1.4 males to 1 female resulting from mortality. The brooders were fed *ad libitum* with live green mussel, *Perna viridis* supplemented with live marine clam, *Donax cuneatus*. Water was exchanged in tune of 80 % per day. The number of spawning per year per female was observed to be 2 to 4. Generally, spawning occur during night or early morning.

LARVAL REARING

Hatchery production of lobster larvae (phyllosoma) is technically challenging because of the prolonged duration of larval development, the large number of moults involved and the delicate nature of the larvae. The larvae were reared several times up to phyllosoma stage by various researchers. Large numbers (5,000) of phyllosomal rearing conversions were achieved till fourth stage at Kovalam Field Laboratory of CMFRI.

NURSERY

The nursery rearing of pueruli was carried out by collecting them from wild. The captured pueruli are very delicate with high associated mortality (> 50 %). The lobsters grow to 10-30 g in 3-6 months during nursery phase. Then, it is harvested and stocked to grow-out cages. Mortality during the nursery phase is as high as 40 %, but under optimal conditions, it is less than 10 %. It is fed with chopped fish flesh.

GROW-OUT

Grow-out till date has been based only on naturally settled pueruli. In certain countries like Vietnam and Indonesia pueruli are particularly abundant and are easily caught. Grow-out of tropical spiny lobsters has been performed in sea cages in Vietnam and Indonesia. In Vietnam, these cages are simple frames of netting staked into the seafloor in shallow waters (< 3 m). In Lombok, Indonesia, grow-out is performed in floating sea cages that have been adapted from grouper culture. These cages are 2 to 3 m along each side and 2 m deep. A typical lobster farmer in Indonesia would have

5 to 10 cages for grow-out. Lobsters are stocked in cages at 10-50 g size each. The smaller lobsters were stocked into cages with smaller meshes to ensure that they do not escape. Stocking density is upto 30 nos./m^2. As lobsters grow, they are periodically harvested and manually graded to minimise the size variation within each cage. Larger lobsters are stocked at lower densities, around 5 nos./m^2 at 200 g and 2 nos./m^2 at 500 g. In Indonesia, where *P. homarus* is most commonly farmed, the desired market size is 100-300 g, which takes about 9 months to reach. Farmed lobsters are traditionally fed a mixture of fish, crustaceans and molluscs sourced from the nearby fish markets. In Vietnam, a broad variety of trash fish species are used based on the budget and preference of the farmer. It grows to 250 g in 12-15 months.

FOOD AND FEEDING

Generally they are omnivorous, grazing primarily on small crustaceans, molluscs, worms and algae. In culture system, they were fed with mixture of low value fish meat, clam and green mussel meat.

GROWTH RATE

The growth rate of spiny lobster is reported differently by different workers. Trials in India with mussels and clams as feed have yielded maximum growth rates of 0.75 g/day, whereas in sea cages off Vizhinjam with artificial diets, 0.5 % growth rates/day are observed and in sea cages off Chennai, when fed on Tilapia meat, growth rate of 0.5-0.7 g/day is recorded.

DISEASES AND CONTROL MEASURES

The common problem in cage farming at Vietnam is the Milky Disease/Milky Haemolymph Disease (Rickketsia) which is treated by oxytetracycline (OTC) incorporation in diets. Red body (Gaffkemia like symptoms), black gill and tail rot are possibly rectified by better management practices and formalin treatments. Loose shell and soft shell syndromes are addressed by nutritional supplements and upkeep of salinity requirements. Continual exposure to low temperature coupled with long transportation stress causes reddening with associated *Aerococcus viridans* infection and heavy mortality. *Vibrio vulnificus* is the causative pathogen resulting in tail necrosis and affecting lobster growth rates.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

In Indonesia, it is harvested at 100-300 g, fetching US $ 30-40/kg. It is preferred by the Chinese and the Taiwanese at a size of 100-300 g. It is served as sashimi (uncooked lobster) but is more commonly cooked.

CHALLENGES TO MARICULTURE

The major constraint to industry expansion is the non-availability of seed. The main challenge for seed production is the incomplete cycle of larval production. Disease is a major constraint and spiny lobster farming in Vietnam has already experienced the severity of disease outbreaks. Surveys of lobster farms have revealed access to credit as a principal bottleneck. In India, where the industry is nascent, credit is even more difficult to obtain and is mostly arranged with family or neighbours at exorbitant rates. Artificial feed and control of diseases are key areas which need to be addressed for promoting the farming.

FUTURE PROSPECTS

The domestic as well international price as well as demand is very high for lobsters. Thus, if technology for seed production and artificial diet are developed with better efficiency and economic edge, then aquaculture prospects are very promising.

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Panulirus ornatus (Fabricius, 1798)

Joe K. Kizhakudan

IDENTIFICATION

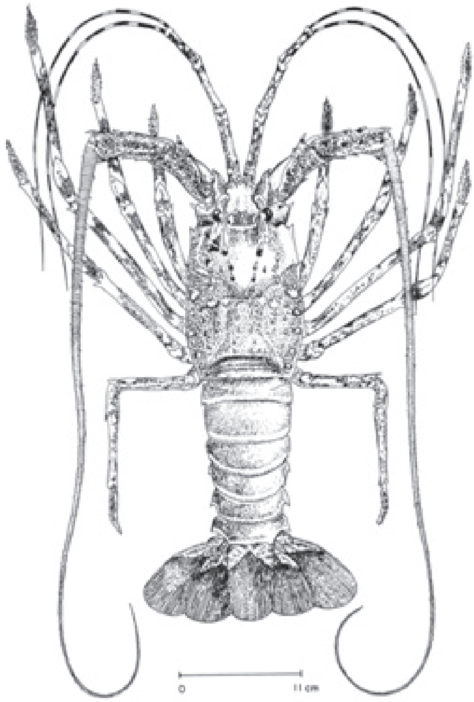
Order	:	**Decapoda**
Family	:	**Palinuridae**
Common/FAO Name (English)	:	**Ornate spiny lobster**

Source of image : RC of CMFRI, Chennai

Local names: Titan (**Gujarati**); Shevand (**Marathi**); Konju (**Kannada**); Parra konchu, Kadal konchu, Chitta konchu (**Malayalam**); Rani singi eral (**Tamil**); Rati royya (**Telugu**); Bama royya **(Oriya);** Jhata chingri (**Bengali**)

MORPHOLOGICAL DESCRIPTION

As the name suggests, the ornate spiny lobster is colourful with a bluish-green carapace and yellow-red spines. It is characterized with intricate streaks and spots of varying colours; frontal horns, walking legs and abdomen are brownish or greenish grey having contrasting dark and light colouration resulting in banded or marbled appearance, with minute indistinct speckles. The abdominal somites are smooth and naked, without transverse groove and whitish bands. Antennular plate has four spines with no small spines in between. Antennal flagella are distinctly banded and brightly coloured. Third maxilliped is without exopod. A large anterior eyespot is present near base of pleura accompanied by an oblique pale streak. Pleura are with white tips.



PROFILE

GEOGRAPHICAL DISTRIBUTION

Panulirus ornatus is distributed in the Indo-West pacific region, from the Red Sea and east Africa (South to Natal) to southern Japan, the Solomon Islands, Papua New Guinea, Australia, New Caledonia and Fiji. In India, it is mainly distributed along south-east coast.

HABITAT AND BIOLOGY

It is a reef dwelling species, found at depths of 1 to 50 m; most abundant on coral and coastal fringing rocky reefs and surroundings and shallow areas. It is found in sediment beds (50-60 m depth) during breeding migrations, indicating their broad environmental tolerances that make them suitable for aquaculture. It is solitary or lives in pairs; also found in larger concentrations during the juvenile phase. The juveniles and adults are omnivorous, grazing primarily on small crustaceans, molluscs, worms and algae. It matures in its second year post puerulus, when the size is > 90 mm carapace length (CL). Each female produces 5,18,181 to 19,79,522 eggs per spawning, and spawns 2-3 times in a year.

It undergoes spawning migrations to the edge of the continental shelf for releasing the larvae. Egg incubation takes 24-27 days. Hatching occurs at night, and the first stage phyllosoma larvae (< 2 mm carapace length) are released normally at 49.7 % efficiency from the total fecund eggs in a brood .The planktonic phyllosoma larvae develops through 11 distinct stages involving upto 20 successive moults (instars), until it reaches the final stage which has a carapace length of > 25 mm. The final stage phyllosoma metamorphoses into the puerulus, which is free-swimming and transparent (initially), looking like a lobster and lasts for 2-3 weeks, seeking a suitable habitat on or near coral reefs. The puerulus is a non-feeding stage living off accumulated energy reserves. Once suitable habitat is located, the puerulus, which is pigmented, settles to the bottom, moults to the first juvenile stage and takes on a benthic habit. It is one of the largest of the *Panulirus* species attaining a maximum body length (TL) of about 50 cm, but usual length ranges encountered in the fishery is much smaller (30-35 cm).

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Generally more than 1 kg size lobsters are used as broodstock. The ornate spiny lobster can be bred throughout the year through manipulation of captive environmental conditions. Brooders can produce 2,00,000-8,00,000 larvae with each female lobster capable of producing up to 4 broods per season. At the School of Tropical Biology, James Cook University, Australia, brooders were stocked in 2 t round polyethylene tanks supplied with semi-recirculated sea water, within an environmentally controlled room. The sex ratio used was 1:1.5 or greater (male:female). Exposure to photo-thermal regulation resulted in captive breeding. They were fed on mixed diet of live and frozen pipis *Plebidonax deltoids*, frozen green mussels *Perna canaliculus* and squid *Loligo opalescens* once per day after 15:00 hrs. Lobsters were fed at the rate of 3 % body weight per day.

LARVAL REARING

The larval rearing has been carried out on experimental basis in many places, however the complete larval cycle information is not available.

NURSERY REARING

The stocking density during the nursery phase is 50-100 pueruli/m^2 in submerged cages. This phase usually lasts for 3-6 months, during which the lobsters grow to 10-30 g.

GROW-OUT

Aquaculture practices till date are based on only naturally settled pueruli, which are very abundant in some areas of Vietnam. By the mid 1990s, Vietnamese fishers had developed techniques and identified locations to capture lobsters at the swimming (puerulus) stage; since 1996 the bulk of lobsters marketed from Vietnam have been farmed from an initial capture size of less than 5 g. More than 1,500 t of *P. ornatus* are farmed each year in sea cages in Vietnam. It grows well in sea cages. Grow-out cages are typically square in shape, 3 to 4 m along each side and 3 to 5 m deep.

FOOD AND FEEDING

It is cannibalistic in nature. It feeds well on mussel, clams, gastropods, fish meat and artificial diets.

GROWTH RATE

It grows well in aggregation during its juvenile phase, growing from puerulus to more than 1.0 kg in 18-20 months in Vietnam and from 100 g to 1.5 kg in 8 months in India.

DISEASES AND CONTROL MEASURES

The common problem in cage farming at Vietnam is the Milky Disease/Milky Haemolymph Disease (Rickketsia) which is treated by oxytetracyclin incorporation in diets. Red body (Gaffkemia like symptom), black gill and tail rot are possibly rectified by better management practices and formalin treatments. Loose shell and soft shell syndromes are addressed by nutritional supplements and upkeep of salinity requirements.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

The demand for *Panulirus ornatus* from the Chinese market is very high and the rates are very lucrative. Chinese consumers are specifically interested in *P. ornatus* as a sashimi product due to its flesh characteristics (pearly lustre, sweet taste and firm texture).

CHALLENGES TO MARICULTURE

The primary constraint to industry expansion is the non-availability of seed. Though certain countries like Vietnam have established the industry on wild caught seed this will not be sustainable. In the long term, the demand for future can only be secured with hatchery supplied seed. Another major constraint in spiny lobster farming is diseases. It is probably related to the feeding of trash fish, which brings in large volumes of organic materials and pollution. Substitution of trash fish with pelleted diet would control disease outbreak and increase profitability.

FUTURE PROSPECTS

Development of seed production technology will go a long way in improving farming activities. Research efforts from several countries in captive breeding and larval rearing are nearing commercialisation. With consistent seed supply, lobster farming will have an economic edge and the aquaculture will be very promising.

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Echinometra mathaei (Blainville, 1825)

R. Saravanan, B. Johnson and Loveson L. Edward

IDENTIFICATION

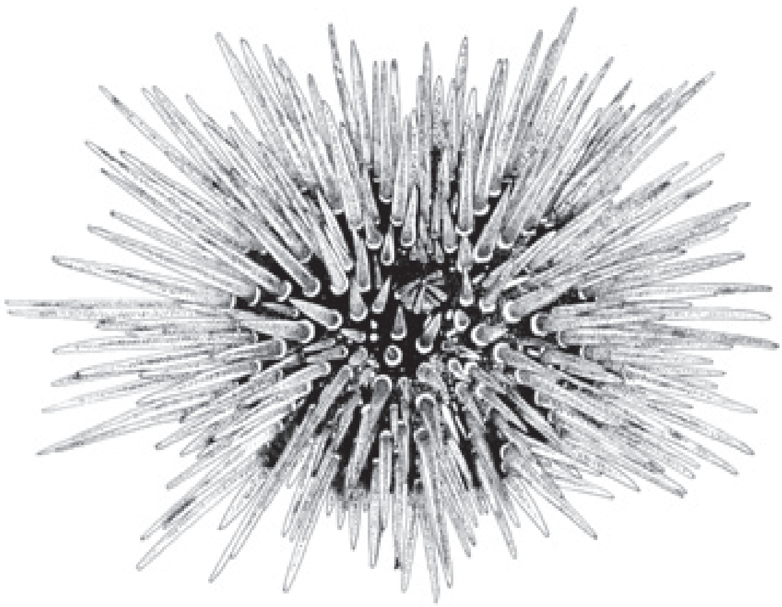
Order	:	**Camarodonta**
Family	:	**Echinometridae**
Common/FAO Name (English)	:	**Rock boring sea urchin**

Source of image : RC of CMFRI, Mandapam Camp

Local names: Samudra chokaro (**Gujarati**); Mahal (**Marathi**); Kadalacille (**Kannada**); Kadal chena (**Malayalam**); Kadalkutchi, Moorai, Muttankani, Kadal mulleli (**Tamil**); Samudra cinnavadu (**Telugu**)

MORPHOLOGICAL DESCRIPTION

The colour of the rock boring sea urchin is variable with the spines coloured purple or green with purple tips and the base coloured grey-green. It is characterized by a pale ring at the base of each spine. It shows commensalism with the shrimp *Athanas areteformi*.



PROFILE

GEOGRAPHICAL DISTRIBUTION

This sea urchin is distributed from Madagascar, the east Africa coast, Red Sea to Hawaii. It is tropical, found on reefs in the Indo-Pacific region. It occurs in Onotoa Atoll, Marshall Islands, Guam, Solomon Islands, Seleo Island, Netherlands, New Guinea, New Caledonia, south-east Arabia, Persian Gulf, India, Pakistan, Maldives, Ceylon, Australia, Philippine, China, south Japan, south Pacific and Hawaiian Islands. In India, it is found in Lakshadweep Islands, Tamil Nadu and Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

Echinometra mathaei occurs along inter-tidal rocks, boring it in shallow waters. It prefers benthic areas and inshore waters. It grows to a diameter of about 5 cm. It feeds on algae and small invertebrates. It is gonochoristic. Gametes are released into the water and fertilization is external. Brooding is common, eggs are held either on the peristome, around the periproct or deep into the concavities on the petaloids. Embryos develop into planktotrophic larvae (echinopluteus) and live for several months in this state, before sinking to the bottom and adhere on the ground using their tube feet, where they metamorphose into young urchins.

BREEDING IN CAPTIVE CONDITIONS

The captive breeding of this species was carried out at Vizhinjam R. C. of CMFRI. Wild collected sea urchins were maintained in FRP tanks and fed with green algae and seaweeds *Ulva* sp. Adult sea urchins weighing 40 to 85 g were selected for induced spawning. After washing in 0.5 % Ampicillin for 10 min, it was injected with 1.5 to 2 ml of 0.5 M Potassium Chloride (KCl, pH 6.1) on its oral (mouth) side. It sheds its gametes after 40 to 60 sec of injection. After shedding of gametes, it was removed from the beakers. The beakers were gently rotated in clockwise and anti-clockwise direction for uniform mixing. The beaker was provided with mild aeration and kept at room temperature (28 to 32 °C) for fertilization.

LARVAL REARING

Around 18 to 20 hours post-fertilization, free-swimming prism stage larvae hatched out. The larvae were stocked in a 50 l aquarium tank at the rate of 5 nos./ml. The larvae metamorphosed into a 2-arm echinopluteus stage on the second day. They were fed with micro-algal feeds such as *Isochrysis galbana*, *Chaetoceros calcitrans* and *Nannochloropsis* sp. Water was exchanged at the rate of 50 % in two days. Larvae metamorphosed to 4-arm, 6-arm and 8-arm stages on the 3rd, 15th and 20th day post-fertilization. The larvae reached competency in 20 to 22 days.

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

Information not available

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

It is host to a number of parasites viz., *Clavisodalis parvibullatus, Mecomerinx notabilis* and *Porcellidium echinophilum.*

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

The gonad of the sea urchin is a valuable sea food product in Asian and European markets. The gonads contain the carotenoid, echinenone, which is synthesised from ß-carotene. Gonad colour depends upon the level of echinenone, which in turn influences the market value. Roe is consumed by local fishermen population along the Indian coast.

CHALLENGES TO MARICULTURE

Researchable issues include food and feeding, breeding and seed production. Type of feed influences the morphology, growth and duration of larval development. Research needs to be focused on improving the desirable gonad colour (bright yellow orange) through a combination of algal feed and prepared (formulated) diets. The quality of gametes and feeding during larval rearing are important in determining survival rate and is critical for obtaining large numbers of larvae.

FUTURE PROSPECTS

Decrease in global catch due to an increase in fishing effort and the great demand has generated keen interest for culture. Market value of the rock boring sea urchin is mainly based on color, texture, size, taste and quality of gonads. Improving broodstock with quality feed, larval rearing with suitable algae and grow out to marketable sizes will influence the market value in Asian and European markets. Successful seed production on a commercial scale coupled with steady demand as seafood product offers scope for its culture in India.

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Stomopneustes variolaris (Lamarck, 1816)

R. Saravanan, B. Johnson and Loveson L. Edward

IDENTIFICATION

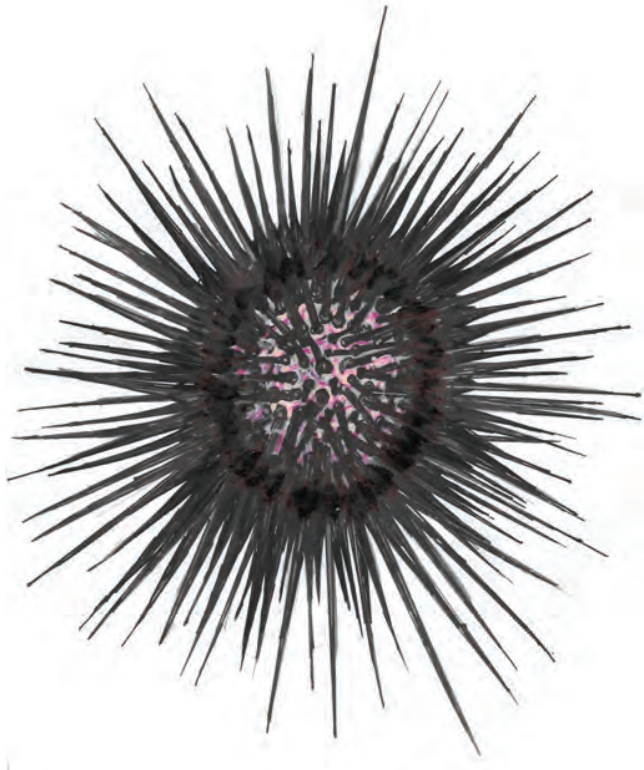
Order	:	**Stomopneustoida**
Family	:	**Stomopneustidae**
Common/FAO Name (English)	:	**Slate pencil sea urchin**

Local names: Samudra chokaro (**Gujarati**); Mahal (**Marathi**); Kadalacille (**Kannada**); Kadal chena (**Malayalam**); Kadalkutchi, Moorai, Muttankani, Kadal mulleli (**Tamil**); Samudra cinnavadu (**Telugu**)

MORPHOLOGICAL DESCRIPTION

This sea urchin is characterized by compound ambulacral plates of arbacioid type; primary spines long, stout, pointed; imperforate and non-crenulate primary tubercles; and a deep undulating groove between the inter-ambulacral series. The spines are sharp and generally black in colour, sometimes a blue-greenish tinge. They can be recognized by a zig-zag pattern on the upper face. The oral face is clear. The juveniles are clear and often with asymmetrical spines, caused by their habit of digging into soft rocks.

Source of image : RC of CMFRI, Mandapam Camp



PROFILE

GEOGRAPHICAL DISTRIBUTION

This sea urchin is distributed in the tropical Indo-Pacific region; from the Red Sea to Polynesia; tropical, Indo-West Pacific region; east coast of Africa to south Pacific Islands. It is also distributed in south-east Arabia, west India, Pakistan, Maldives, Ceylon, Bay of Bengal, East Indies, north Australia, China, south Japan and South Pacific Islands. In India, it has been recorded along Tamil Nadu (Gulf of Mannar, Mandapam, Chennai Coast and Kanyakumari), Andaman and Nicobar Islands (North Reef Island), Andhra Pradesh (Vishakhapatnam) and Lakshadweep (Minicoy, Chettalatt and Kilttan).

HABITAT AND BIOLOGY

It is found in rock pools, crevices, bores and overhangs. It is benthic, reef associated in coastal area. However, larvae are pelagic. It prefers shady areas with constant water circulation, however avoiding direct wave action. The shrimp *Athanas indicus* is a symbiont with this sea urchin. This sea urchin is an herbivore feeding on algae. Members of the class Echinoidea are gonochoric with external fertilization and egg brooding. Embryos develop into planktotrophic larvae (echinopluteus). This larval stage lasts for several months after which they sink to the bottom and adhere on the ground using their tube feet. They then metamorphose into young sea urchins. It is available in the depth range of littoral waters, near 18 m. It is found in benthic ecology and inshore waters.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

The induced spawning and larval rearing protocols for *S. variolaris* has been perfected for the purpose of studying the larval morphology and developmental biology by most workers, but commercial seed production and raising larvae for aquaculture purposes has not started globally.

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

Information not available

DISEASES AND CONTROL MEASURES

Parasitic infection by *Mecomerinx luculenta* and *Pseudanthessius luculentus* has been recorded in slate pencil sea urchin.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

The sea urchin gonad is a valuable product in international markets. The sea urchin gonads contain the carotenoid echinenone, which lends colour to the gonads. The colour levels of the sea urchin gonads influence their market value. The greater demand for sea urchin increased the fishing effort and leads to decrease in global catch of sea urchins. This has led to the practice of culturing sea urchins. The fishermen of the Kanyakumari districts and Karwar region are involved in wild harvest of sea urchins to cater to the needs of tourist industry and also for medicinal purposes.

CHALLENGES TO MARICULTURE

Research and development is needed in breeding and seed production, larval rearing protocols and diet studies of this species. Recent works are focused on combination of algal feed and prepared diets to improve the desirable gonad colour (bright yellow orange). Such studies are important since the types of feed available influence the morphology, growth and duration of the larval development.

FUTURE PROSPECTS

The demand for sea urchin and its aquaculture is mainly based on its edible part which is its gonads, and the price depends on the colour and quality of these gonads. Advancement of techniques for broodstock development, larval rearing and grow out will tremendously increase the availability of roe obtained from this species for supply to international markets. Hence sea urchin aquaculture in India has good scope if commercial scale seed production of this species is taken up.

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REGION SPECIFIC SPECIES FOR MARICULTURE

Mugil cephalus Linnaeus, 1758

Boby Ignatius, Imelda Joseph and Muktha M.

IDENTIFICATION

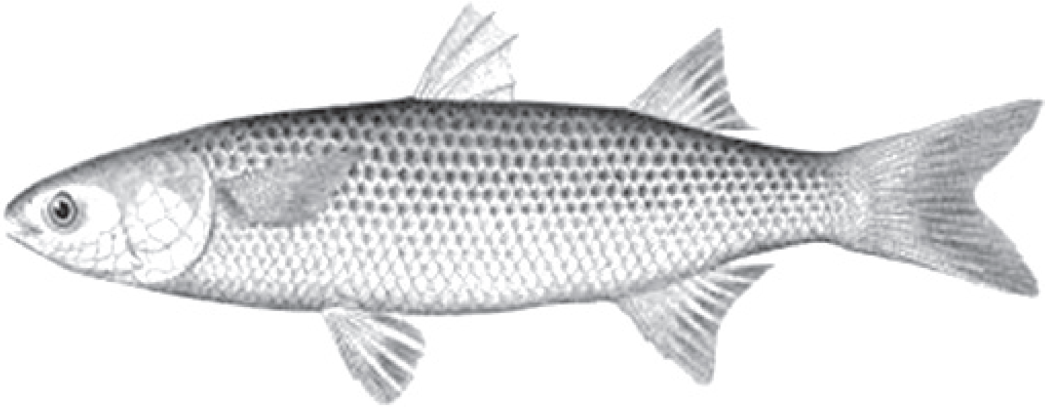
Order	:	**Perciformes**
Family	:	**Mugilidae**
Common/FAO Name (English)	:	**Flathead grey mullet**

Source of image : CMFRI, Kochi

Local names: Boi, Gandhiya, Bhomat (**Gujarati**); Boi, Boita, Bol, Mangan, Pilas, Pilsa, Sheroto (**Marathi**); Gobri, Wekhanu (**Konkani**); Mala (**Kannada**); Thirutha, Thirutha kanambu (**Malayalam**); Madavai, Kasmin, Manla (**Tamil**); Kathiparega, Meyman (**Telugu**)

MORPHOLOGICAL DESCRIPTION

Body is cylindrical, robust, with broad head. The width of head is more than width of the mouth cleft; adipose eyelid is highly developed, more than that of other mugilid species, covering most of the pupil; upper lip is thin, no papillae, labial teeth of upper jaw small, straight, and dense, in several rows; mouth cleft ends below posterior nostril. Two dorsal fins; the first one has 4 spines; the second has 8-9 soft rays. Anal fin has 8 soft fin rays. Pectoral fins short (when folded forward does not reach eye). It must be noted that dorsal and anal fin spine and ray count cannot be used as a distinguishing feature for *M. cephalus* since this overlaps with a number of other mugilids.



Pectoral fins are with 16-19 rays; pectoral axillary about one-third length of fin. Scales in lateral series is 36-45. Colour back blue/green, flanks and belly pale or silvery; scales on back and flanks usually streaked to form longitudinal stripes; dark pectoral axillary blotch. *Mugil cephalus* has been reported to be part of a species complex which involves 14 other mugilid species. Nearly 30 species of *Mugil* have been synonymised with *M. cephalus* indicating the level of taxonomic confusion that exists regarding this species.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Flathead grey mullets are distributed in Indian Ocean, Atlantic Ocean, Pacific Ocean and Mediterranean Sea. They are cosmopolitan in nature i.e. found in coastal waters of the tropical, subtropical and temperate zones of all seas. It is distributed from California, USA to Chile in Eastern Pacific; from Japan to Australia in Western Pacific; from India to South Africa in Western Indian Ocean; from Nova Scotia, Canada to Brazil in Western Atlantic; Cape Cod to southern Gulf of Mexico; Bay of Biscay to South Africa, including the Mediterranean Sea and Black Sea in Eastern Atlantic.

HABITAT AND BIOLOGY

Mugil cephalus is a coastal species that often enters estuaries and rivers. Usually it forms schools over sandy or muddy bottom, between 0 and 10 m, in highly salty to fresh waters that are warm or temperate from 8 to 24 °C. The grey mullet is catadromous and it can tolerate a wide range of water salinity. Adult mullet tolerate zero salinity to 75 g/l, while juveniles reach high salinity tolerance at lengths of 4-7 cm. Adults form spawning aggregations and migrate offshore to spawn. The larvae move inshore for cover from predators as well as for access to rich feeding grounds. After reaching 5 cm in length, juvenile mullets move into slightly deeper waters.

It is a diurnal feeder, feeding on zooplankton, dead plant matter and detritus. This species also grazes on epiphytes and epifauna from seagrasses and surface scum containing microalgae at the air-water interface. Larvae feed primarily on copepods, mosquito larvae, and plant debris when they are below 3.5 cm in length. The amount of sand and detritus in the stomach contents increases with length, indicating that more food is ingested from the bottom substrate as the fish grows. Reproduction takes place in the sea, at various times of the year depending on the location. They do not have an obligatory freshwater phase in its life cycle. The fish sexually matures at the age of 3-4 years. Females spawn 0.8 to 2.6 million eggs. The maximum length reported is 120 cm SL and maximum weight 12 kg.

PRODUCTION SYSTEMS

Mugil cephalus has been farmed intensively in different parts of the world since centuries. It has been farmed in Italy, Egypt, erstwhile Soviet Union, Israel, Taiwan, Hong Kong, Japan, Philippines, Indonesia, China and India. Intensive research efforts have gone into it's induced breeding and larval rearing. Several studies on induced breeding and larval rearing of this species has been published in the 1980s and 1990s from USA, Israel, Philippines, etc. Taiwan was the first country to complete the reproductive cycle of *M. cephalus* fully in captivity.

BREEDING IN CAPTIVE CONDITIONS

Mugil cephalus does not spawn naturally in captive conditions; it needs to be induced to spawn in captivity. However it does mature in captivity. Broodstock needs to be maintained at salinities of 32-35 g/l for good spawning. Successful broodstock maintenance has been reported from fish maintained in freshwater ponds, seawater ponds and rubber-lined dirt ponds filled with re-circulating seawater from countries other than India. In India, the Central Institute of Brackishwater Aquaculture (CIBA), Chennai successfully domesticated broodstock of *M. cephalus* in 100 t re-enforced concrete tank (RCC) with seawater circulation. Approximately 75-80 % of the water was exchanged daily. Tanks were cleaned on alternate days. Fish were fed pelleted maturation feed at 3 % of body weight daily. A high lipid feed was given during recouping period and low lipid during gonad maturation period. Period of maturation showed concurrence with exposure to shortened photoperiod and lower water temperatures. Spawning occurs only through stripping or hormonal induction (purified salmon gonadotropin, human chorionic gonadotropin, 17 α methyltestosterone, etc.) of the fish. At CIBA, female fish were injected with a priming dose of hCG @ 6000-10000 IU/kg body weight followed 24 h later by a resolving dose of Ovaprim @ 3-5 ml/kg body weight. Male fish were not given any hormones. At CIBA the fishes were stripped. However other workers have reported natural spawning behaviour following hormonal induction.During spawning, male fish starts getting active as the hydration of the female fish progresses. When the female releases the first set of eggs, the male is stimulated to release sperm. Once this happens, the female gives out eggs in large numbers continuously for some time.

Fertilized eggs remain floating in the water with hatching being influenced by water temperature. At CIBA hatching occurred in 30-32 h at a water temperature of 26-28 °C and salinity of 26 g/l. However the range of hatching reported globally ranges from 59-64 hours at temperatures of 20-24.5 °C and salinity of 24.39-35.29 g/l to 34-38 hours at temperatures of 23-24.5 °C and salinity of 30.1-33.8 g/l.

LARVAL REARING

Larvae start external feeding 3-5 dph and are liable to show adverse growth if not fed by 84 h post-hatch. The general larval rearing protocol is to rear the larvae along with rotifers as their exclusive feed, along with phytoplankton in the larval tank. Complete larval rearing is reported to take 42-55 days. Studies have shown that adding *Nannochloropsis oculata* along with rotifers in the larval tank ensures higher survival of larvae up to 15 dph. Feeding the larvae with enriched *Artemia nauplii* from 15-35 dph also ensures higher survival rates. The optimal stocking density suggested for successful larval rearing is 10-20 larvae/l of water along with 5-10 rotifers/ml and 5-7$\times$10^5 cells/ml of phytoplankton. It has also been reported that there are two critical periods during larval rearing when high mortality occurs 2nd-3rd day and 8th-11th days of rearing. These two periods are associated with an increase in specific gravity of larvae and consequent sinking of larvae to bottom of the tank. Larvae have been reported to grow from 2.63 mm to 17.69 mm by 42 days.

NURSERY REARING

The nursery rearing has been reported to be carried out in earthen ponds, where they depend mainly on natural food available in the pond. The pond was prepared by adding animal manure at the rate of 2.5 to 5.0 t/ha before filling the pond with water. Fry were stocked at the rate of 125 nos./m^2 fifteen days after filling the pond with water. Artificial pellets were given as supplemental feed. Even rice and wheat bran were used as an additional source of food. Chicken manure and chemical fertilizers (usually phosphate and nitrates) were added as and when required to maintain secchi disc readings of 20-30 cm. The fry were cultured in nursery ponds for 4-6 months, depending upon the size of fingerlings required for stocking in grow out system. Generally nursery rearing is carried out to produce 10 g mullet seeds. The optimum required protein level for mullet nursery rearing is 25 %.

The nursery rearing of mullet were also carried out in hapas fixed in pond. The fry of size 1.6 to 2.4 cm was stocked in hapas @ 400 nos./m^3 for initial 30 days then reduced to 200 nos./m^3 for next 60 days or until the fish attained a size of 10-15 cm. The fish were fed thrice a day with wet wheat flour and flattened rice.

GROW-OUT

It has been farmed in ponds and enclosures in many countries of the world. Culture of this species is prevalent in Italy, Egypt, Taiwan, Japan, Korea, Hawaii, Russia, Israel, Philippines, Hong Kong, etc. This species has been cultured along with carps in Israel and Hong Kong and with milkfish in Philippines. It can be cultured in freshwater, brackishwater and marine water. In India too this species has been farmed in Bengal, Madras and Kerala. Both pond culture as well as cage culture has been carried out successfully in India.

For pond culture, the ponds were prepared by drying, ploughing and manuring by adding animal manure at the rate of 2.5 to 5.0 t/ha before filling water in the pond. Water level was kept at a depth of 25-30 cm for 1-2 weeks for phytoplankton development. Then water level was increased to 1.5 to 1.75 m and fingerlings were stocked in the pond. Chicken manure and chemical fertilizers (usually phosphate and nitrates) were added as and when required to maintain secchi disc readings of 20-30 cm. Fish of 10-15 cm size were stocked @ 6175-7410 nos./ha in the pond. Rice and wheat bran were used as supplemental feeds. The culture period of mullet was 7-8 months. The production from such system was 4.3-5.6 t/ha/crop. In semi-intensive polyculture system, where mullet was stocked with carp and tilapia, @ 2,470-3,705 nos./ha together with 1,850-2,470 nos./ha of 100 g common carp juveniles and 61,750-74,100 nos./ha 10-15 g Nile tilapia fingerlings the yield was 20-30 t/ha/crop, of which 2-3 t were mullet.

Mullet can also be cultured in cages installed in backwater systems. The stocking density used for cage culture was 27 nos./m^3 of 10-15 g size. The fish grew to a size of 380-550 g after 195 days of culture. They were fed on artificial pellets.

FOOD AND FEEDING

Larvae are planktivorous, feeding particularly on calanoid and cyclopoid copepods. However when the larvae reach 10-20 mm SL size they start feeding on small invertebrates and benthos. Larger fish tend to feed on detritus and benthic microalgae particularly diatoms, along with other small invertebrates and meiofauna.

GROWTH RATE

The growth rate of the fish is highly influenced by temperature and salinity, hence there are varied reports of growth rates for this species. The growth rate in juveniles was reported as 17 mm per month during spring and summer which decreased to 5 mm per month during winter in a study along the Atlantic coast of USA. The fish is reported to grow faster in tropical waters reaching 14-18 cm SL in the first year, but attaining only 13-16 cm SL in temperate waters. Studies from Australia indicate that the species reaches 46 cm, 51 cm and 54 cm by the age of 5, 6 and 7 years. In culture systems, this species grows to a size of 0.75-1 kg after 7-8 months of culture period from 10-15 g size. They can grow to a size of 1.5-1.75 kg after two on growing seasons.

DISEASES AND CONTROL MEASURES

The disease reported in *Mugil cephalus* and their control measures are given below:

Disease	Agent	Syndrome	Measures
Viral Disease			
Iridoviral disease	*Iridovirus*	Systemic disease; congested fins; increased mucus production; highest mortality at lower temperatures (<24 °C)	Vaccination; environmental improvement
Bacterial Disease			
Red pest of eels, red sore, red boil, saltwater furunculosis	*Vibrio anguillarum*	Systemic infection; acute haemorrhagic and septicaemic disease with mass mortality; anorexia; darkening; abdominal distension, dermal haemorrhages; skin ulcers; occurrence of exophthalmos	Vaccination; environmental improvement
Streptococcosis	*Streptococcus faecalis*	Haemorrhagic areas on body surface	Antibacterial drugs in feed;environmen tal improvement
Bacterial fin rot	*Flexibactercolum naris*	Breakdown of tissues between fin rays (fin rot)	environmental improvement
Motile aeromonas septicaemia	*Aeromonas hydrophyla ; A. caviae* and *A. sobria*	Systemic infection;acute haemorrhagic and septicaemic disease; haemorrhagic spots on skin and base of fins; ulcers and skin necrosis; exophthalmia and dropsy	Environmental improvement; antibacterial drugs in feed
Parasitic Disease			
Gill myxobolosis	*Myxobolus goensis*	Gill infestation	Environmental improvement
Sea lice	*Caligus* spp.	Infestation occurs commonly in the skin	Medicated bath; environmental improvement
Epizootic ulcerative syndrome (EUS); Red spot disease	*Aphanomyces invadans*	Skin ulcers	Environmental improvement

PRODUCTION, MARKET AND TRADE

PRODUCTION

The global aquaculture production ranged from 1,040 t in 1950 to 12,360 t in 2014. The global capture production ranged from 18,100 t in 1950 to 1,30,139 t in 2012.

MARKET AND TRADE

Flathead grey mullet has a good market in many countries of the world namely Egypt, Taiwan, India, Israel, etc. It is marketed fresh, frozen, salted and dried and its eggs are considered a delicacy. In India the species has a good demand in the domestic market fetching up to ₹ 300/kg.

CHALLENGES TO MARICULTURE

Even though seed production in captivity has been achieved for *M. cephalus*, culture of the species in many parts of the world still depend on wild collected fry. This will eventually lead to pressure on wild populations. Hence to carry out sustainable aquaculture, scaling up of seed production is critical. In India, large scale hatchery production of seeds of *M. cephalus* is yet to become a reality. Studies indicate that *M. cephalus* consists of a cluster of ecologically specialized mugilids, perhaps even a species complex, which do not have uniform life-history traits. This can probably be a reason for the failure in large scale captive breeding of the species, especially when spawners are collected from different habitats.

FUTURE PROSPECTS

Since *Mugil cephalus* is a high valued fish in India, there is good scope for scaling up of seed production technology in the country. This also requires a thorough understanding of the species/ stock status of *M. cephalus* in Indian waters. Moreover there exists good potential for this species to be cultured in cages in estuarine and lagoon systems of the country.

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Sillago sihama (Forsskål, 1775)

K. K. Philipose, Jayasree Loka and T. Senthil Murugan

IDENTIFICATION

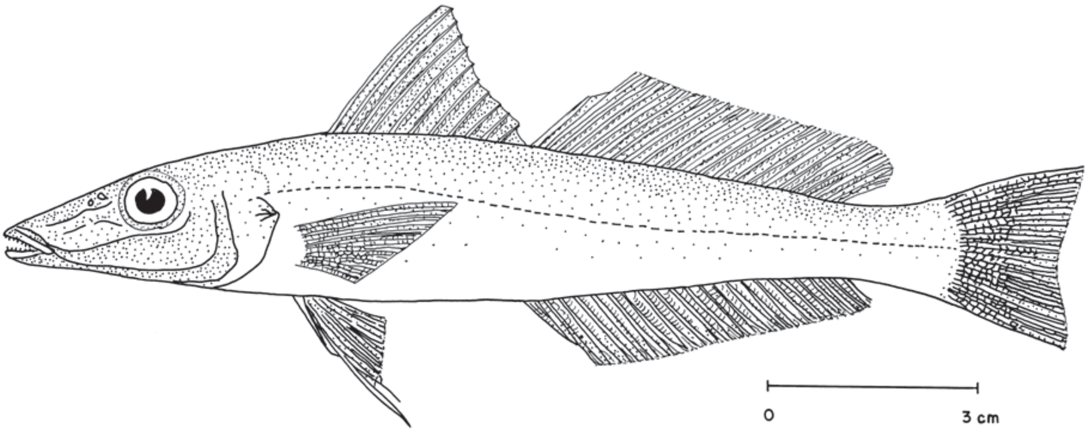
Order	:	**Perciformes**
Family	:	**Sillaginidae**
Common/FAO Name (English)	:	**Indian sand whiting**

Source of image : CMFRI, Kochi

Local names: Mudadi (**Marathi**); Mudoshi, Renavi (**Konkani**); Nogale, Kane (**Kannada**); Kalimeen, Kathiron, Poovan, Pooyam, Cudeerah, Noongal, Poozhan (**Malayalam**); Kelangan (**Tamil**); Soring (**Telugu**); Toul danti (**Oriya**)

MORPHOLOGICAL DESCRIPTION

Body elongated with a pointed snout, upper head profile slightly convex; mouth small and terminal, villiform teeth present in jaws and on vomer; 2 or 3 (usually 2) series of scales on cheeks; a small sharp spine on opercle; gill rakers on lower limb of first arch 7-9. Two dorsal fins; first dorsal fin higher than second and with 11 weak spines and second dorsal fin with 1 spine and 20-23 soft rays; anal fin with 2 spines and 21 or 23 soft rays. Lateral line scales from 66-72. Vertebrae are 34. The swim bladder has two anterior extensions extending forward, two lateral extensions and two posterior unequal tapering extensions. Body is silvery-brown to honey coloured



with ventral side lighter; a mid-lateral, silvery, longitudinal stripe normally present; dorsal fins dusky terminally with or without rows of dark brown spots on the second dorsal fin membrane; caudal fin dusky terminally; no dark blotch at the base of the pectoral fin; other fins hyaline; the anal fin frequently with a whitish margin.

PROFILE

GEOGRAPHICAL DISTRIBUTION

It is one of the most widely distributed fish in the family Sillaginidae, but mostly confined to Indian and western Pacific Oceans. It extends from north of South Africa along the west coast of Africa and into the Red Sea and Persian Gulf. It is common along the Indian and Asian coast, extending from Taiwan, Japan, Indonesian Archipelago, Philippines to as far south as northern Australia. In India, it occurs along both east and west coasts. It is reported from Kakinada, Chennai, Mandapam, Cochin, Karwar, Goa, Hooghly River, Chilika Lake, Pulicat Lake and Netravathy and Gangolli estuaries.

HABITAT AND BIOLOGY

This species inhabits shallow sandy bottoms of shores and bays, creeks, estuaries and coastal waters. It is commonly found in marine and estuarine environments and may even ascend rivers. It is very rarely captured by bottom trawling at depths of 0 to 20 m, as it buries itself in the sand when danger approaches. It is omnivorous, feeding on polychaete worms (*Marphysa* sp., *Perinereis* sp. and *Nereis* sp.), small prawns (*Penaeus* spp.) other crustaceans (*Ocypoda* sp., *Alpheus* sp. and *Gonodactylus* sp.) and amphipods. Smaller ones often feed on filamentous algae and copepods. The spawning season is from June to February with a peak during June-November in India. Length at first maturity of female and male are 179 and 159 mm. Fecundity varies from 6,956 to 48,373, showing positive correlation with length, body weight and ovary weight. Growth is rapid, attaining a length of 13 to 14 cm in about 1 year, 16 to 20 cm in 2 years, 20 to 24 cm in 3 years and 24 to 28 cm in 4 years.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Breeding, seed production and larval rearing has been attempted in different countries. In 2013, spawning and larval rearing was achieved in Aquaculture and Marine Studies Centre (AMSC), Abu Al Abyad Island, UAE. However detailed information about breeding and seed production is lacking.

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Culture tried in most Asian countries is still in its infancy. Culture in India was initiated 3-4 decades ago by CMFRI. Culture trials conducted in coastal ponds and pens indicate that it can be successfully cultured along with milk fish, grey mullets, pearl spot and prawns. Polyculture with shrimps and other brackish water species is a feasible option for enhancing the production in future.

FOOD AND FEEDING

The young one feed on filamentous algae and copepod. The adult feeds on polychaete worms *(Marphysa* sp., *Perinereis* sp. and *Nereis* sp.), small prawns (*Penaeus* sp.), other crustaceans (*Ocypoda* sp., *Alpheus* sp. and *Gonodactylus* sp.) and amphipods. In culture trials, fishes are fed with low value fish.

GROWTH RATE

Culture in different environments like salt water ponds, cages and net pens at Mandapam, India shows an average monthly growth of 11.4 mm (1.9 g), 10 mm (1.6 g) and 16.8 mm (8.1 g) respectively.

DISEASES AND CONTROL MEASURES

Observed disease and their controlling measures are given below.

Disease	Agent	Body parts infected	Measure
Torticaecum infestation	*Torticaecum nipponicum*	Musculature and intestine	Good prophylaxis and good husbandry measures
Rhipidocotyle infestation	*Rhipidocotyle eggletoni*	Musculature	Good prophylaxis and good husbandry measures
Procamallanus infestation	*Procamallanus philippinensis*	Stomach and intestine	Good prophylaxis and good husbandry measures
Parasitic infestation	*Parabrachiella jarai*	-	Good prophylaxis and good husbandry measures

PRODUCTION, MARKET AND TRADE

PRODUCTION

The total world production increased from 24 t in 2000 to 1,069 t in 2011. In India it constitutes a minor fishery with considerable economic importance.

MARKET AND TRADE

In China and Vietnam, it has a very good market. Dried fishes ranging in size from 5-11 cm are marketed from Vietnam, with a supply of 0.2 t/day. It commands a high price (₹ 300-400/kg) in different states of India, especially in coastal Karnataka. The demand is high throughout the year with a peak during the south-west monsoon, when fishing is suspended in the coastal waters because of turbulent weather.

CHALLENGES TO MARICULTURE

Fishery is on the decline due to improper fishing activities coupled with pollution and mangrove deforestation in coastal areas. A concentrated effort is required to conserve the species. Though captive seed production has been achieved elsewhere, it has not succeeded in India. Hence a concerted effort needs to be put forth for developing and standardizing protocols for broodstock development, breeding in captivity and larval rearing in India.

FUTURE PROSPECTS

It is an important brackishwater fish with potential for domestication and farming. In India, vast underutilized brackishwater areas are available, additionally protected bays, lagoons, estuaries could be effectively used for culture. Polyculture with shrimps and other brackish water species is a feasible option for enhancing the production and income in future. As market demand is high in Karnataka, hence fish cultured in other regions could be marketed there.

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Otolithoides biauritus (Cantor, 1849)

Joe K. Kizhakudan, Shoba Joe Kizhakudan and Sekar Megarajan

IDENTIFICATION

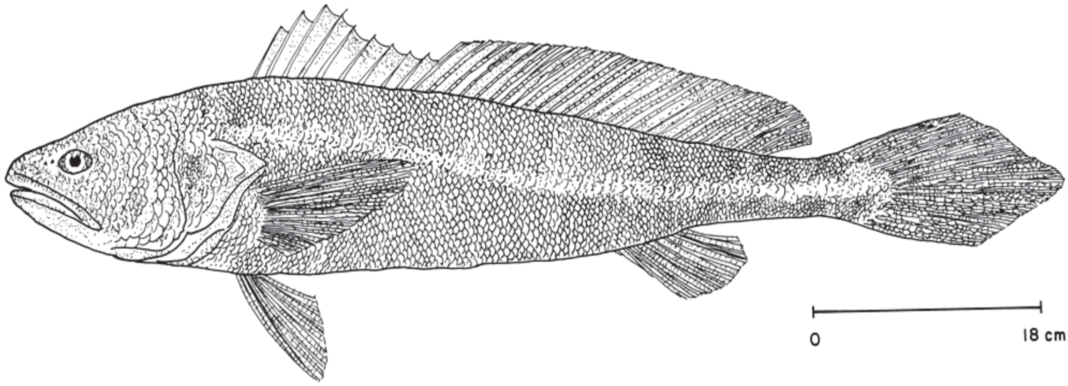
Order	:	**Perciformes**
Family	:	**Sciaenidae**
Common/FAO Name (English)	:	**Bronze croaker**

Source of image : RC of CMFRI, Veraval

Local names: Koth, Goyni (**Gujarati**); Koth (**Marathi**); Kora, Chemban kora (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

It has an acute snout with large terminal mouth, the upper jaw reaching back beyond the eye. No canine teeth are present, but a few small and strong teeth are present in both jaws. Lower gill rakers are 11. Swim bladder is carrot shaped with a single pair of appendages, arising from the posterior end of the bladder. Dorsal fin is with 8-9 spines followed by a low notch, second part of the fin is with one spine and 27-37 soft rays. Pectoral fin is moderate, about 75 % of head length. Anal fin is with two spines and 7-8 soft rays. The second anal spine is weak. Caudal fin is pointed. Cycloid scales on head and upper front of the body and ctenoid scales in other parts. Later line scales are reaching to tip of caudal fin. Head is green and grey in colour with a golden lateral line. Dorsal, anal and caudal fins are brown yellow to orange.



PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is distributed in the Indo-West Pacific region from Pakistan and Sri Lanka to the Malay Peninsula, Sumatra, Borneo and Vietnam. It is also reported from Antarctica, and United Kingdom. It is distributed in both the east and west coasts of India, with an abundance along the north-west coast.

HABITAT AND BIOLOGY

It is marine, demersal and amphidromous in nature. It is found in coastal and inshore waters. It is a carnivore and an active predator. The major food items are teleost fishes and crustaceans. Overall sex ratio is 1:1.09. Mature females occur throughout the year indicating a prolonged breeding season. However, the peak breeding season is from May to August in Gujarat and from August to January in Mumbai. The length at first maturity of females is 110.15 cm. Absolute fecundity ranges from 1,82,020 to 19,41,400. The reported maximum size is 152 cm at an age of 13 years.

PRODUCTION SYSTEMS

The fish is having demand for its meat and swim bladder in international market. However, research on breeding and culture in captivity has not been initiated.

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Literature on grow-out culture is not available. However, an attempt was made in Vietnam to culture the fish in cages using wild collected juveniles, but details are lacking.

FOOD AND FEEDING

Food and feeding habit in captivity has not been studied. In the wild, it is a carnivore and actively feeds on fishes and crustaceans.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Aquaculture production is not available. It forms a major catch along the north-west coast and more often, high unusual landings occur.

MARKET AND TRADE

The air bladder is in high demand in the international market, which is used for preparing isinglass in the beverage industry. Apart from airbladder, the skin is used as an alternate source of leather. It is also an important food fish. It is one of the most expensive fishes in Vietnam. Dried air bladder has very good export market in south-east Asian countries. From India, frozen fish is sold in the international market for about ₹ 250/kg. The dried air bladders are sold in local markets at ₹ 40,000-50,000/kg.

CHALLENGES TO MARICULTURE

The main researchable issues to be addressed for its culture in India are developing and standardizing protocols for domestication and brood stock development, larval rearing and culture in confined environment.

FUTURE PROSPECTS

Important characteristics like large size, high meat yield, good growth rate and high value for airbladders makes it a very lucrative candidate for mariculture. Culturing this species would provide a good source of income for farmers while protecting wild stocks.

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Protonibea diacanthus (Lacepède, 1802)

Joe K. Kizhakudan and Shoba Joe Kizhakudan

IDENTIFICATION

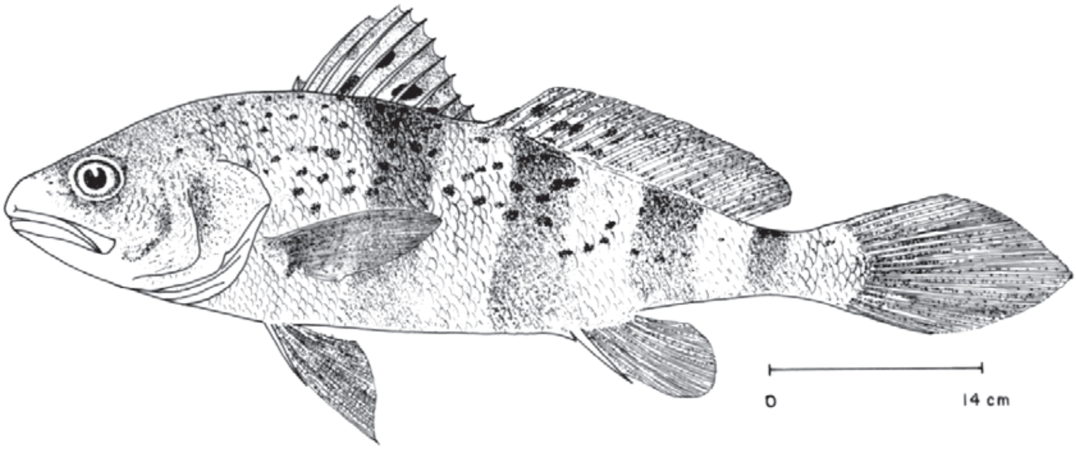
Order	:	**Perciformes**
Family	:	**Sciaenidae**
Common/FAO Name (English)	:	**Blackspotted croaker**

Source of image : RC of CMFRI, Chennai

Local names: Ghol (**Gujarati, Marathi**); Balde, Ghole, Goli (**Kanada**); Katla, Kora, Valiyakora, Varayan kora, Cherukora, Pallikora (**Malayalam**); Kathalai, Vellakathalai, Panna (**Tamil**); Gorasa, Nella-katchelee, Pullipanna (**Telugu**); Poma (**Bengali**)

MORPHOLOGICAL DESCRIPTION

Snout is pointed with large terminal mouth forming a low angle to the horizontal. Teeth are differentiated into large and small in both jaws. No canine teeth present. Lower gill rakers are 7 to 8. Dorsal fin spines are 9-10 followed by low notch and are with 22-24 soft rays. Pectoral fin is fairly small, a little more than half of the head. Anal fin is with 2 spines and seven soft rays. The second anal spine is strong. Rhomboid shaped caudal fin. Cycloid scales are present on snout and eyes and elsewhere, scales are ctenoid. Five dark blotches are present along back with many small black spots on top of head, upper half of body and dorsal and caudal fins. Pectoral, pelvic, anal and lower part of caudal fins is black.



PROFILE

GEOGRAPHICAL DISTRIBUTION

It is distributed in the Indo-West Pacific, from western Persian Gulf, along the coasts of India, Sri Lanka, Philippines, Borneo, New Guinea, northern Australia and Japan.

HABITAT AND BIOLOGY

It inhabits coastal muddy waters, off sea beds. It ascends tidal rivers and estuaries. It is a top predator (Trophic level > 3.5). The maximum reported length is 150 cm, with 100 cm size fishes common in the fishery. It feeds mainly on crustaceans and small fishes. It matures at an age of 3-4 years with peak breeding season from June-September. Fecundity ranges from few lakhs to few millions. The maximum recorded size and weight is around 1.5 m and 45 kg.

PRODUCTION SYSTEMS

There is no documented information on production or rearing systems for the species. Information obtained from private sources reveals successful breeding in floating cages at Singapore, albeit without any other information.

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

Food and feeding from confined environment has not been reported. In the wild, it is an opportunistic feeder, feeding mainly on fishes and prawns, but also on crabs, molluscs, and gastropods. The Malabar sole, *Cynoglossus macrostomus* and the penaeid prawns are its most preferred prey.

GROWTH RATE

Information on growth rate in captivity is not available. In wild, it grows rapidly and reaches 60 cm in around 2 years.

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

It forms a lucrative "ghol-koth" fishery along the north-west coast of India, off Maharashtra and Gujarat. It is caught with bottom trawls and bottom set gill nets. Bumper landings in individual hauls have been frequently documented. Aquaculture production has not been reported.

MARKET AND TRADE

It is consumed fresh, fried, dried or salted, and is targeted for its swim bladders (maws). Maws are highly priced because of their medicinal and commercial values. It is exported to countries of south-east Asia, such as Hong Kong, Singapore and Malaysia, where it is used to prepare isinglass, a form of collagen used mainly for the clarification of wine and beer in beverage industry and as traditional medicine (believed to prevent bleeding in patients with urinary problems) and cosmetics for women. Retail value of the fish in Indian market ranges from ₹ 450-600/kg and the dried air bladders fetches between ₹ 40,000-50,000/kg.

CHALLENGES TO MARICULTURE

No basic information is available on the eggs, larvae and juveniles. Collection of live fishes for broodstock development in confined environment is difficult when compared to other fishes because of its habitat and the gear (trawls and bottom set gill nets) in which it is captured. It lives in large groups and the fishery is highly specific to certain habitats. A system of trapping and transferring live fishes to sea cages has to be developed. Technology for captive rearing, maturation and spawning also needs to be evolved. This requires a better understanding of the breeding and the feeding behaviour and the location of the aggregation sites.

FUTURE PROSPECTS

Characters like large size, high meat yield, rapid growth rates and high value for air bladder makes it a very lucrative candidate for mariculture. As it is highly predatory, natural feeds would be more cost-effective than commercial feeds. Taking a cue from the techniques of captive breeding, seed production and culture developed successfully for other species of croakers, it is highly possible to achieve captive breeding, seed production and culture of ghol in near future.

SUGGESTED READING

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CONSERVATION/ SEA-RANCHING

Hippocampus kuda Bleeker, 1852

Boby Ignatius and Shoji Joseph

IDENTIFICATION

Order	:	**Syngnathiformes**
Family	:	**Syngnathidae**
Common/FAO Name (English)	:	**Spotted seahorse**

Source of image : RC of CMFRI, Kozhikode

Local names: Jalaghoda (**Gujarati**); Ghoda masa (**Marathi**); Kudure meenu (**Kannada**); Kadal kuthira (**Malayalam**); Kadal kuthirai (**Tamil**); Neeti gurram (**Telugu**); Samudra ghoda (**Oriya**); Samudrik asma (**Bengali**)

MORPHOLOGICAL DESCRIPTION

Dorsal soft rays are 17-18 and anal soft rays are 4. It is distinguished by low, rounded bumps along the body. It has a thick snout and a deep head. Eyes can move independently. Adult male has a brooding pouch.

PROFILE

GEOGRAPHICAL DISTRIBUTION

The spotted seahorse occurs in the Indo-Pacific; Pakistan and India to southern Japan, Hawaii and the Society Islands. It is found in Australia, Cambodia, China (Hong Kong SAR and Province of Taiwan), Fiji, France (New Caledonia and Tahiti), Indonesia, Malaysia, Papua New Guinea, Philippines, Federated States of Micronesia, Singapore, Solomon Islands, Thailand, Tonga, United States of America (Hawaii) and Vietnam.

HABITAT AND BIOLOGY

It is found in shallow inshore waters upto a depth of 40-50 m with more distribution up to 8 m; in mangroves, seagrass beds and estuaries; and on steep mud slopes. It has also been recorded from open waters attached to drifting Sargassum at 20 km away from land. Adult lengths, measured as distance from the tip of the tail to the top of the coronet (a cup-like depression found on top of the head), ranges between 7.0 and 17.0 cm. Adult weights vary with the reproductive stages of both males and females.

It exhibits parental care and shows high site fidelity. It has a relatively sparse distribution and a highly structured social behaviour.

It feeds on zooplankton and is ovoviviparous. As it is a poor swimmer, it utilizes its thick snout and specialized jaws to suck in its prey. The female gives eggs whereas the male broods the embryos for 20-28 days in its pouch. The male nourishes the embryos with a fluid that is secreted within its pouch. This fluid removes wastes and supplies the embryos with oxygen and nutrients. The juveniles on leaving the brooding pouch are fully independent. It is not monogamous. Breeding season is year round. Egg diameter averages 1.8 mm. Length at birth averages 7 mm. It generally remains anchored to substrates using its prehensile tail. It is generally solitary, except for its mates, and is active during the day. In general, pairs remain in close proximity to one another and avoid associations with non-pair individuals.

CONSERVATION

STATUS OF STOCK

Spotted *seahorses Hippocampus kuda* are listed as vulnerable (VU A4cd) under the World Conservation Union's IUCN Red List and are on the CITES Appendix II based on inferred declines of at least 30 % caused by targeted catch, incidental capture and habitat degradation. Though exact information is lacking there are indirect evidences of population declines. Since 2004, international trade is regulated through a licensing system (under CITES Appendix II) with a minimum size of capture fixed at 10 cm.

NEEDS

It is one of the most valuable species in the trade for traditional medicine, curios and aquaria. Its demand is high because of its large size, smooth texture and pale complexion when dried. It possesses all the desirable qualities for traditional medicinal purposes. It is incidentally caught in other fisheries and is affected by habitat degradation. Trade surveys conducted during 2000-2001 indicate an increase in the global trade of seahorses and other syngnathids. Though exact trade figures are not available, considerable population declines have been indicated, raising concerns about this species. The formulation of suitable conservation strategies of this overexploited stocks and the judicious management of resources with participatory approach, will be helpful in the improvement of India's foreign trade and to uplift the economic status of poor fishermen communities along Gulf of Mannar and Palk Bay.

STRATEGIES

Seahorse populations are thought to be endangered as a result of overfishing and habitat destruction. Culture and breeding under captive conditions in laboratories from different countries have been reported. Conservation and commercial mariculture, if permitted, will reduce the pressure on wild populations and its exploitation. To formulate a strategy for stock enhancement and also to curb the depletion of resources in future first of all an assessment of current status of the natural stock all along east coast of India is needed. Recent studies from different countries have shown that these species can be cultured and grown in captive conditions. So relaxation of rules for aquaculture and export of cultured seahorse may reduce the pressure on wild seahorses and its exploitation.

ISSUES

A further decline in its population is predicted if immediate intervention is lacking. One of the major issues affecting proper conservation is taxonomic confusion regarding this species. A detailed taxonomic description of the species is required before further studies on its biology, ecology and abundance can be studied.

FUTURE PROSPECTS

Mariculture of seahorse is currently seen as an alternate strategy to conserve wild seahorse populations, while ensuring livelihood for fishermen dependent on this resource. If the management measures include the restoration of overexploited seahorse stocks by conservation mariculture in the protected areas, it will help the future trade of sea horse from India. Initial research on its ability to grow and survive appears very promising, but further research is needed to determine whether aquaculture on a larger scale can effectively meet the high market demand, at the same time, preventing further depletion of native populations.

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Holothuria (Theelothuria) spinifera Théel, 1886

Joe K. Kizhakudan and P. S. Asha

IDENTIFICATION

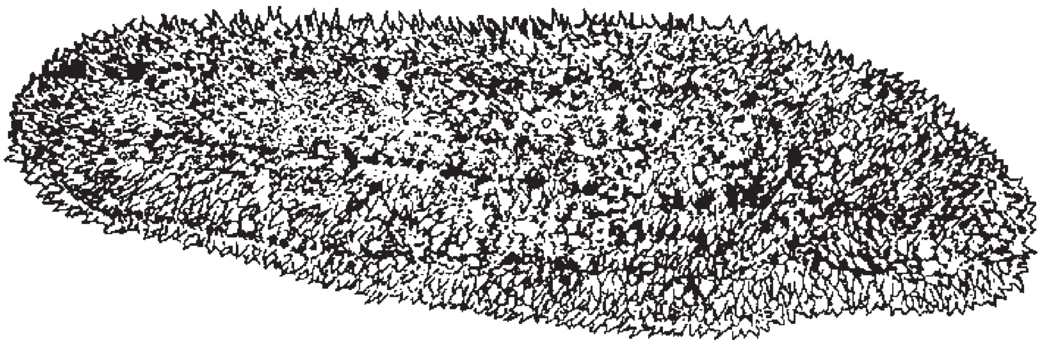
Order	:	**Holothuriida**
Family	:	**Holothuriidae**
Common/FAO Name (English)	:	**Brown sand fish**

Source of image : RC of CMFRI, Tuticorin

Local names: Samudra kakdi (**Marathi**); Kadal atta (**Malayalam**); Raja attai or Cheeni attai (**Tamil**); Samudra kakudi (**Oriya**); Samudrik sasha (**Bengali**)

MORPHOLOGICAL DESCRIPTION

The body is cylindrical with both ends rounded. Mouth is surrounded by a collar of papillae. It has 20 peltate tentacles. Anus is surrounded by five distinct cylindrical papillae. Colour is uniform brown with sharp projections all over the body. Lower side is lighter in colour.



PROFILE

GEOGRAPHICAL DISTRIBUTION

Sea cucumbers are distributed all over the world, particularly in tropical regions. It is reported to occur in China, north Australia, Persian Gulf, Philippines, Red Sea and Sri Lanka. Sea cucumbers are distributed in Lakshadweep, Andaman and Nicobar Island, Gulf of Kutch, Gulf of Mannar and Palk Bay in India.

HABITAT AND BIOLOGY

It is a highly burrowing species, found on clean sand and in slightly deeper waters. In India, it has a peak gametogenic activity during September and October, followed by a prolonged spawning period from November to March. It is gonochoristic and each individual has only one gonad. Spawning and fertilization are external and some exhibit brooding. During its life cycle, embryos develop into planktotrophic larvae (auricularia) and then into doliolaria (barrel-shaped stage), which later metamorphoses into juveniles. Most (78.1 %) of the sediment ingested is medium sand, followed by fine sand (18.9 %) and very less organic matter (1.5 %).

STATUS OF THE STOCK

Increase in demand and inadequate fishery management measures has led to the overexploitation of holothurian resources along Indian waters. Reduction in catch per unit effort and mean size over the years further supports its overexploitation status. Consequently in 2003, the Ministry of Environment and Forest, Government of India, imposed a total ban on both fishery and trade by listing this species under Schedule I of the Wild Life Protection Act of 1972. Moreover, declaring a part of Gulf of Mannar as a biosphere reserve has attributed to the protection of its stocks. A reliable long term estimate is not available on the exploited as well as on the potential stocks. As a result, IUCN listed this species as Data Deficient. It has already been declared as Endangered in China and included in the Chinese Red List.

NEED

Ban imposed on sea cucumber trade has caused a major impact on the economic status of poor fishermen along the south-east coast of India. Formulation of suitable conservation strategies for overexploited stocks and judicious management of resources will help to improve India's foreign trade and uplift the economic status of poor fishermen communities along Gulf of Mannar and Palk Bay.

STRATEGIES

Assessing the current status of the natural stocks along east coast will enable us to formulate strategies for curbing further depletion and enhancement of resources in the forthcoming years. Restoration by releasing hatchery produced juveniles to their natural habitat is an effective way to replenish the natural stocks. The technology for captive breeding, larval and juvenile rearing developed and standardized by CMFRI, Kochi will be of immense help in designing conservation measures through stock enhancement. By upgrading the existing larval and juvenile rearing techniques, cost effective mass production of juveniles can be carried out in an effective way. This will help in evolving strategies for conservation and sustainable fishery and export, ultimately improving the foreign exchange and the economic status of poor fishermen communities along Gulf of Mannar and Palk Bay.

ISSUES

In India, sea cucumber fishery is not organized; hence management measures cannot be effectively implemented. Poaching and illegal trade of both raw and dried sea cucumbers to neighbouring countries is an enforcement issue which needs to be addressed. Despite the awareness about ban and punishment, fishermen are illegally involving in these practices for their livelihood. With prohibition on fishery and trade in force, representations from fishermen welfare associations have been made to authorities, highlighting the negative impacts of ban on the livelihood of poor coastal fishing communities, urging the need for lifting the ban.

FUTURE PROSPECTS

As a preliminary effort to manage the fishery and trade, the Government in 2006 commissioned the Zoological Survey of India to undertake studies on population status. The surveys reported no recovery in the population size. The effectiveness of the current ban on the population is yet to be determined. However, it is understood that the ban would be lifted on a species-specific basis in a phased manner once the population attains the desired level. It will help in resolving the present social conflicts prevailing among the fishermen. Implementation of effective and sustainable management methods, involving various stakeholders from the fishermen to the exporters, will have to be made. The management measures are likely to include the restoration of overexploited holothurian stocks in the protected areas, thereby reducing the pressure on wild stocks. Training fishermen on sea cucumber aquaculture practices is required to meet the market demand and continuous stock assessment has to be performed.

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Epinephelus lanceolatus (Bloch, 1790)

Sekar Megarajan

IDENTIFICATION

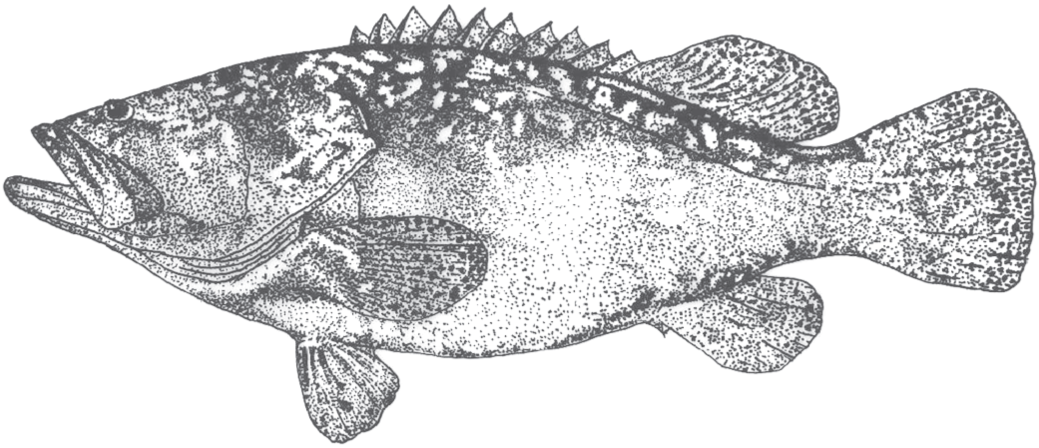
Order	:	**Perciformes**
Family	:	**Serranidae**
Common/FAO Name (English)	:	**Giant grouper**

Source of image : CMFRI, Kochi

Local names: Wekhali, Wekhru (**Gujarati**); Gobra, Hekru (**Marathi**); Kolaji (**Kannada**); Kolameen, Varayan kalawa, Pulli, Kadal karoopu (**Malayalam**); Ulta kalawa (**Tamil**); Bontoo (**Telugu**)

MORPHOLOGICAL DESCRIPTION

The giant grouper is characterized by its huge adult size, robust body, body depth of about 2.3-3.4 times of standard length (SL). Head length is 2.2-2.7 times in standard length, inter-orbital area is flat to slightly convex, preopercle is rounded. Eyes small; eye diameter 5.8-14 in head length; maxilla reaches past vertical at rear edge of eye; mid-lateral part of lower jaw is with 2 or 3 rows of teeth (for 20-25 cm SL fish) and increasing to 15-16 rows in a fish of 177 cm standard length. Gill rakers of juveniles are 8-10 on upper limb, 14-17 on lower limb; rudiments in adults are difficult to distinguish from the bony plates covering the gill arch. Dorsal fin with 11 spines and



14-16 rays, anal fin with 3 spines and 8 soft rays; pectoral-fin rays of 18-20; short pelvic fins and not reaching anus; caudal fin is rounded. Cycloid scales present on the body; body with auxiliary scales also; lateral body scales smooth with 54-62 lateral line scales. Colour of adults mottled green-grey to grey-brown colour, with small black dots on the fins, juveniles with variegated brown and yellow colour, and yellow fins with dark brown or black spots.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Epinephelus lanceolatus is the most widely distributed grouper but, rarely found at all locations; it is available throughout the Indo Pacific region including Red Sea. It occurs from Red Sea to Algoa Bay (South Africa) and eastward to Pitcairn Islands, including Hawaii (USA). In the western Pacific, it ranges northward to southern Japan and southward to Australia (from northern Western Australia to northern New South Wales). It is found in the entire Indian Ocean, but is rarely seen north of the Maldives. In south and south-east Asia, the fish is recorded from Japan, mainland China, Hainan Island, Philippines, Thailand, Malaysia and Indonesia. From Indian waters this species is reported from Andaman and Nicobar Islands and from the coasts of Andhra Pradesh and Odisha.

HABITAT AND BIOLOGY

Epinephelus lanceolatus is the largest of all coral reef dwelling bony fishes. It tends to be single and inhabits lagoon and seaward reefs at depth of a few to at least 50 m. Large individuals often have a home in a cave or wreck in which they frequently stay. The fish has been caught at depth of 100 m, but it is more often found in shallow waters. It even swims into brackish water areas. Individual fish of more than a meter long have been caught from close to shore and in harbours. Large adults are encountered offshore on wrecks and in areas of high relief; they appear to occupy limited home ranges with little inter-reef movement, and the same individuals were seen at specific reef sites for more than a year. Juveniles hide in reefs and are rarely seen; mostly bentho-pelagic and benthic in nature.

The fish mostly dwells in coral reefs and mainly feeds on spiny lobsters. It is also known to eat a variety of fishes including small fishes, sharks, and juvenile of sea turtles, octopuses and spiny lobsters. In South African estuaries, the main prey item is the mud crab. They are not fast swimmers over long distances and they often lie in wait for their prey or use their mouths and gills as powerful pumps to suck their prey from crevices. All food is swallowed as whole.

Like many other grouper species, it is a protogynous hermaphrodite. Spawning occurs during the summer months and is strongly influenced by the cycle of the moon. The females release eggs while the males release sperm into the open offshore waters. After fertilization, the eggs are dispersed by the water currents. The larvae transform into inch-long juveniles around 25 days after hatching. This animal is slow to reproduce. Life span of the species is observed to be 25-50 years.

This is the largest bony reef fish in the world and can grow up to 3 m long and 600 kg in weight, but more commonly they grow to 1.3 m in length and weigh 400 kg. The longest scientifically measured individual is 270 cm (8.86 feet) long and the maximum published weight for this species is 400 kg. This fish is believed to reach sexual maturity when it is around 105-130 cm long. Many species of grouper form spawning aggregation, but such behavior has not been commonly observed in this species.

CONSERVATION

STATUS OF STOCK

Presently, this species is listed as "Vulnerable" on the IUCN Red List of threatened species. In mid 1990s, IUCN recognized its vulnerability with respect to exploitation and categorized this under the vulnerable species. It means this species is likely to become endangered unless the circumstances threatening its survival and reproduction improve and it needs special concern because it is sensitive to pressure by human activities or natural events. Recent studies showed that the population trend of the species has been decreasing at 20 % every ten years, meaning its numbers are declining in the wild worldwide due to overfishing. Apart from overfishing, they require relatively large areas of reef to support their population.

NEED

Worldwide, the population of this species has declined drastically due to various commercial and recreational fishing activities, including the live reef food fish trade and the marine aquarium fish trade. These activities have adversely impacted the populations of this species. Being such a large predator, it is rare, even in areas unexploited by fishing practices and it has nearly been removed in areas where it has been heavily fished. In many places, it has all but disappeared primarily due to spear fishing. Since the species takes decades to grow, and juveniles are also relatively uncommon, there is little chance of giant individuals reappearing in unprotected areas.

Different sizes of this species have advantages in different aspects, like the gall bladder of the big giant grouper is an item of strong magical-medical significance to cure "soul loss and ease pain", and even today, the highly distinctive thick walled stomach of the species sells for a high price and the skin is appreciated. Compared to flesh of big grouper, the flesh of small fish is quite palatable and having good market demand around the world. The most preferred market size of this species is 45 to 90 cm in length mostly in south-east Asian markets, especially Hong Kong. Most fish that are sold by the live reef food fish trade are sub-adults that are sexually immature, hence limiting the numbers of fish that can survive to reproduce. Hong Kong is the major importer, and the source countries of the species includes Indonesia, Philippines, Australia, Malaysia, India (Andaman Islands) and Thailand. The retail price varies between US $ 100 to 169/kg depending on the size and small sized individuals fetch more prices, since it is mostly preferred. Apart from its trade as food fish, juvenile fishes are also found in the pet (aquarium) trade. When it is young, it sports beautiful colors and moves gracefully. This fish has been exploited heavily for the above mentioned reasons, and its population is getting reduced around the world. Due to the low level of abundance and its vulnerability to overfishing, this species should be totally protected by developing strategies like total ban on catch and existing stock should be replenished by declaring marine protected areas, installing Fish Aggregating Devices (FAD) and sea ranching.

STRATEGIES

This species is presently under vulnerable category and therefore, many countries are following different management strategies to protect this species. In Australia, the status of this species varies among the various territories. It is a protected species in New South Wales (NSW) waters under the Fisheries Management Act 1994 and in Queensland waters it is protected since 2003, where it is classified as "no take species" for recreational fishing and heavy penalties apply for taking or processing them. It is also protected in the waters of Western Australia. Under the Northern Territory Regulation Act, no species of the genus *Epinephelus* are taken if it exceeds 120 cm (almost 4 feet) in length. Similarly in New Zealand, this species is under the protected species list.

In India, it is a protected species and it is restricted to part II A of schedule I under the Indian Wildlife Protection Act 1972 (IWPA). Around the Indian coast, *E. lanceolatus* is distributed widely, but not very common with the exception of the waters of the Union Territory of Andaman Islands, the Laccadive Islands and in the Gulf of Mannar. To protect this species, India has imposed a total ban on capture and sale of the species. Shipment and marketing of the species is also prohibited. Accidental catches together with other groupers do occur, but these fishes cannot be openly marketed. In India, all the state governments have taken initiatives to protect this species by creating awareness through notices and appointing field staff for monitoring their capture and sale along with other protected species.

ISSUES

Presently, giant grouper stock is getting reduced worldwide, and there are several challenges existing in order to maintain and augment the decreasing stock. The major challenges are: late maturity, and extended time for population doubling, issues in hatchery technology, vast reef area requirement and management issues in implementing laws. The major issue is that of late sexual maturity of this species. The approximate size of sexual maturation for *E. lanceolatus* is 105-110 cm total length, which means that all smaller individuals and maybe some larger individuals are consumed before they reach sexual maturity. Fishing activity usually removes the largest size fish and therefore, old fishes are caught first, which leads to non-availability of species for reproduction to rejuvenate the stock. The minimum time required for population doubling is more than 14 years; therefore, doubling of the population takes time. Since this species dwells in reef areas, a large area of reef is required to maintain this large predator fish. Management issues include non-availability of biological information on migration, population structure and stock status for decision making on conservation plan.

FUTURE PROSPECTS

Epinephelus lanceolatus has high market demand in south-east Asian countries because of its meat quality and medicinal value. This species is protected and its fishing has been banned, but fishes from mariculture facilities using hatchery reared seeds are traded in south-east Asian markets. At present, seed production technology is restricted to Taiwan, Indonesia and Malaysia. If the seed production technology is developed and adopted in other countries as well, it might be helpful in replenishing the depleted stocks through sea ranching and also meet the market demand across the world. In India, availability of this species has been reported along the coast, so like other marine species such as cobia and pompano, the brood stock development and seed production technology can also be developed for this species. If the technology is developed, it can be utilized for sea ranching across the Indian coast, especially in marine protected areas for stock rejuvenation. In addition, with available seed resources, the mariculture activities of the species can be developed by farming them in cages, and this in turn will help in increasing the revenue though live fish trade, since it fetches high price in the live fish market

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Hippocampus trimaculatus Leach, 1814

Boby Ignatius and Shoji Joseph

IDENTIFICATION

Order	:	**Syngnathiformes**
Family	:	**Syngnathidae**
Common/FAO Name (English)	:	**Longnose seahorse**

Local names: Jalaghoda (**Gujarati**); Ghodamasa (**Marathi**); Kudure meenu (**Kannada**); Kadal kuthira (**Malayalam**); Kadal kuthirai (**Tamil**); Neeti gurram (**Telugu**); Samudra ghoda (**Oriya**); Samudrik asma (**Bengali**)

MORPHOLOGICAL DESCRIPTION

The longnose seahorse has a distinctive low coronet, in line with arch of neck, which is the bony projection or 'crown' on the top of its head and the coronet is visible as five small points. It has sharp hook-like cheek and eye spines (appear flat) and a narrow head. It has no nose spine. There are 18-22 dorsal soft rays, 16-19 pectoral soft rays and 4 anal soft rays. There are 11 trunk rings and 40-41 tail rings. Two trunk rings and one tail ring supports the dorsal fin. The animal can be golden-orange, brownish or black in colour with large dark spots on the back on the first, fourth and seventh trunk rings. Sometimes the animal is striped in brown and white.

Source of image : RC of CMFRI, Kozhikode

PROFILE

GEOGRAPHICAL DISTRIBUTION

It occurs in the Indo-Pacific region: from southern India to Japan, Australia and Tahiti.

HABITAT AND BIOLOGY

It inhabits gravel or sandy bottoms around shallow reefs; muddy estuaries and near mangroves, tolerating brackish waters. It is typically found at more than10 m depth, with a maximum reported depth of 100 m. It feeds on zooplankton. Since they are poor swimmers, they utilize their thick snouts and specialized jaws to suck in their prey. It is ovoviviparous in nature. The maximum recorded adult height is 17 cm. The male carries the eggs in a brood pouch which is found under the tail. In the wild, it is monogamous within a single breeding cycle, the male accepting eggs from only one female. Pair bond is reinforced by daily greetings that extend into courtships and the male giving birth. The female deposits eggs into the male's brood pouch, where he fertilises them, protects them, nourishes them, and regulates their environment. Gestation periods vary from 12 to 14 days at 30 °C under controlled conditions. Males go through more than one pregnancy in a breeding season. Breeding season is year round, with peak during March to May and in October. Maximum reported brood size is 1,783. The egg diameter averages 1 mm. Length at birth averages 6 mm.

STATUS OF STOCK

Longnose seahorse, *Hippocamus trimaculatus* is listed as vulnerable (VU A4cd) under the World Conservation Union's IUCN Red List and are on the CITES Appendix II. While detailed population numbers for *Hippocampus* trimaculatus remain unknown, analysis of international trade data shows that this is one of the species most often reported as being traded internationally, indicating heavy and widespread exploitation globally. The available evidence shows that in 1995, at least 32 countries traded syngnathids (seahorses and their immediate relatives), and trade in Asia alone exceeded 45 t of dried seahorses. By 2000, nearly 80 countries have traded syngnathids with many new sources in Africa and Latin America. New official data, trade surveys, and qualitative evidence all indicate that Asian trade in dried seahorses exceeded 50 t in 2000. Hundreds of thousands of live seahorses were traded internationally, with smaller ones also finding a ready market. Surveys from 2000 to 2001 suggest that the population is in decline. The main threat is trade in the Chinese medicine market. Since 2004, international trade is monitored through a licensing system (CITES II) with a minimum size of capture at 10 cm.

NEED

The entire genus *Hippocampus* is listed in Appendix II of CITES, effective from May 2004. The species is listed as Vulnerable by IUCN. Indian populations have been placed under Schedule-I of the Wildlife Protection Act (1972) in 2001 with ban on collection or trade. The impact of trade on population is considerable, especially when combined with the damage that is being inflicted on the vulnerable inshore marine habitats. It is at high risk from intense fishing because of its sparse distribution, low reproductive rates and reluctance to move from a site. The fishermen population and their economic status were severely affected by the ban imposed on fishing of sea horse and its trade. So there is an urgent need for formulation of suitable conservation strategies for judicious management of this resource from over exploitation with participatory approach.

STRATEGIES

Seahorse population is exploited and traded illegally for consumption as traditional Chinese medicine. Culture and breeding under captive conditions in laboratories from different countries have been reported. Conservation and commercial mariculture, if permitted, will reduce the pressure on wild populations and its exploitation. Assessing the current status of the natural stock of sea horses in India will enable us to formulate strategies to curb the further depletion and enhancement of resources in the future. Lab scale culture and breeding of this species from different countries have been reported under captive conditions. So conservation and commercial mariculture of this species of seahorse may reduce the pressure on wild seahorses and its exploitation provided rules permit for this type of activities.

ISSUES

Seahorses are threatened by targeted fishing, accidental capture in fishing gears (by catch), and degradation of their habitats. Curbing bycatch in trawls especially can be a daunting task. Similarly effective conservation can only occur if the species itself is clearly identified. To curb confusion in identifying from their relatives, taxonomic definitions must be established first before researchers can confidently understand the biology, ecology, and relative abundance of these seahorses.

FUTURE PROSPECTS

Conservation mariculture of the species is an alternative strategy to conserve native seahorse populations. This would help in stock enhancement as well as trade to a certain extent. Mass production of seed in hatchery and their grow-out culture in suitable systems have to be done for mariculture of the species in larger scale, effectively meeting the high market demand while preventing further depletion of native populations. Future trade of sea horse from India will enhance if the management measures includes the restoration of overexploited seahorse stocks by conservation mariculture in the protected areas.

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Holothuria (Metriatyla) scabra Jaeger, 1833

Joe K. Kizhakudan and P. S. Asha

IDENTIFICATION

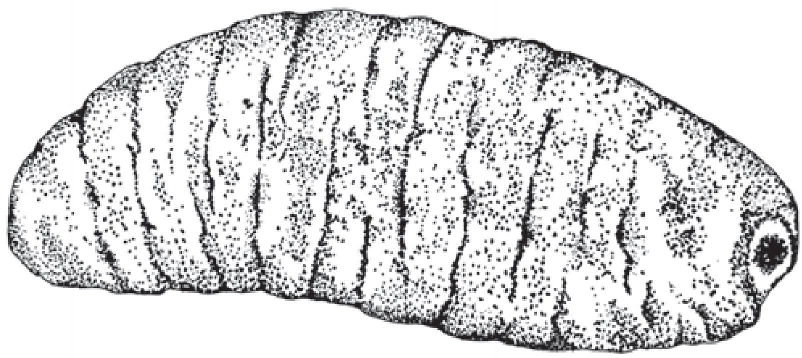
Order	:	**Holothuriida**
Family	:	**Holothuriidae**
Common/FAO Name (English)	:	**Sand fish**

Source of image : RC of CMFRI, Tuticorin

Local names: Samudra kakdi (**Marathi**); Vella kadal atta (**Malayalam**); Vella attai (**Tamil**); Samudra kakudi (**Oriya**); Samudrik sasha (**Bengali**)

MORPHOLOGICAL DESCRIPTION

Body is oval, arched dorsally and moderately flattened ventrally. Dorsal surface is with deep wrinkles and short papillae. Body is often covered by fine muddy-sand. Mouth is ventral with 20 small, greyish peltate tentacles. Anus is terminal. Colour is usually dark grey with white or yellow transverse strips. Ventral surface is white or light grey with fine dark spots.



PROFILE

GEOGRAPHICAL DISTRIBUTION

Sea cucumbers are distributed all over the world, particularly in tropical regions. It has a wide distribution in the tropical Indo-Pacific region excluding Hawaii, between latitudes 30° N and 30° S, from South Africa to the Red Sea, India, China and Japan to Australia, and to Micronesia in the north-east and Tonga in the south-east, not found further east than Fiji. Sea cucumbers are distributed in Andaman and Nicobar Islands, Lakshadweep, Gulf of Kutch, Gulf of Mannar and Palk Bay in India

HABITAT AND BIOLOGY

It is found in shallow waters up to a depth of 20 m. It is commonly found on inner flat fringing and lagoon reefs, coastal sand-flats and sea grass beds with muddy-sandy substrates. It attains maturity at 25 cm size. Spawning peak in India is during July to October. Near to equator, it spawns throughout the year. In Indonesia, it has two peak spawning periods, while in Philippines, the main spawning is from May to June and October to November. In Australia, it spawns in warmer months, but also undergoes a smaller secondary spawning peak later in the year.

STATUS OF THE STOCK

IUCN has listed it as Endangered, as 50 % decline in population was observed over the past 30-50 years. Increase in demand and inadequate fishery management measures have led to its over-exploitation. Consequently in 2003, the Ministry of Environment and Forest, Government of India, imposed a total ban on both fishery and trade by listing it under Schedule I of the Wild Life Protection Act of 1972. Moreover, declaring a part of Gulf of Mannar as a biosphere reserve has attributed to the protection of its stocks. A reliable long term estimate is not available on the exploited as well as on the potential stocks along Indian waters. Surveys conducted by Zoological Survey of India along Gulf of Mannar and Palk Bay reveal a numerical density of 19-25 individuals/10 m^2 and a biomass of 10.64-14.89 kg/10 m^2.

NEED

Ban imposed on sea cucumber trade has caused a major impact on the economic status of poor fishermen along the south-east coast of India. Formulation of suitable conservation strategies for overexploited stocks and judicious management of resources will help to improve India's foreign trade and uplift the economic status of poor fishermen communities along Gulf of Mannar and Palk Bay.

STRATEGIES

Assessing the current status of the natural stocks along east coast of india will enable us to formulate strategies for curbing further depletion and enhancement of resources in the forthcoming years. Restoration by releasing hatchery produced juveniles to their natural habitat is an effective way to replenish the natural stocks. The technology for captive breeding, larval and juvenile rearing developed and standardized by CMFRI will be of immense help in designing conservation measures through stock enhancement. By upgrading the existing larval and juvenile rearing techniques, cost effective mass production of juveniles can be carried out in an effective way. This will help in evolving strategies for conservation and sustainable fishery and export, ultimately improving the foreign exchange and the economic status of poor fishermen communities along Gulf of Mannar and Palk Bay.

ISSUES

In India, sea cucumber fishery is not organized; hence management measures cannot be effectively implemented. Poaching and illegal trade of both raw and dried sea cucumbers to neighbouring countries is an enforcement issue which needs to be addressed. Despite the awareness about ban and punishment, fishermen are illegally involving in fishing of this species for their livelihood. Representations from fishermen welfare associations have been made to authorities, highlighting the negative impacts of ban on the livelihood of poor coastal fishing communities, urging the need for lifting the ban.

FUTURE PROSPECTS

As a stepping stone to lift the ban on sea cucumber trade, the Government in 2006 commissioned the Zoological Survey of India to undertake studies on population status. The surveys reported no recovery in the population size. The effectiveness of the current ban on the population is yet to be determined. Implementation of effective and sustainable management methods, involving various stakeholders from the fishermen to the exporters, will have to be made. The management measures are likely to include the restoration of overexploited holothurian stocks in the protected areas, thereby reducing the pressure on wild stocks. Training fishermen on sea cucumber aquaculture practices is required to meet the market demand and continuous stock assessment has to be performed.

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ORNAMENTAL SPECIES (TELEOSTS/INVERTEBRATES)

Centropyge flavipectoralis Randall & Klausewitz, 1977

Rema Madhu, K. Madhu and Pralaya Ranjan Behera

IDENTIFICATION

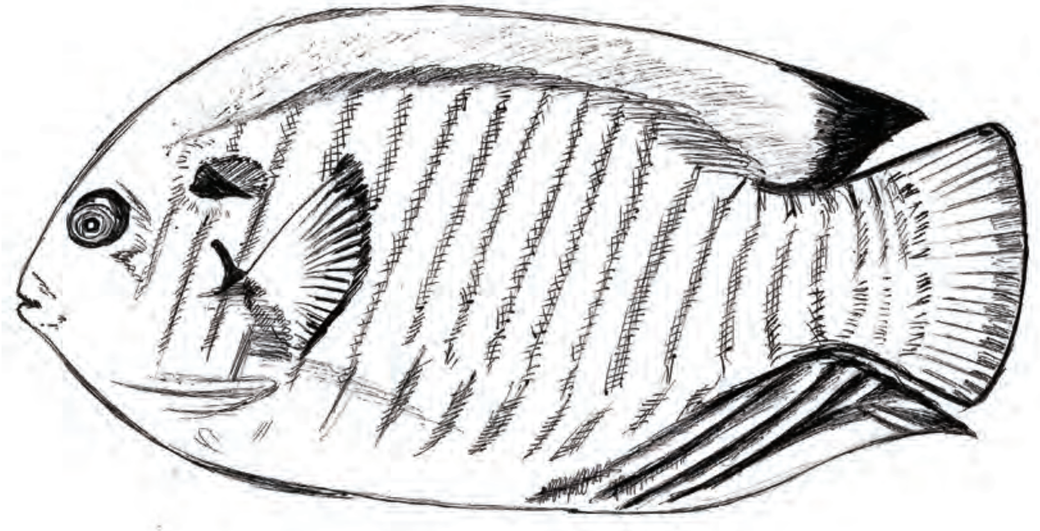
Order	:	**Perciformes**
Family	:	**Pomacanthidae**
Common/FAO Name (English)	:	**Yellowfin angelfish**

Local names: : Not available

MORPHOLOGICAL DESCRIPTION

This angelfish is dark brown to black in colour, with black/blue vertical stripes and bluish spots with a maximum reported size of 10 cm. Pectoral fins are golden brown; dorsal, caudal, and anal fins are dark brown with bluish hue and blue margins. It is recognized by the yellow pectoral fins. There are 14-15 dorsal spines and 14-15 dorsal soft rays; 3 anal fin spines and 16-18 anal soft rays. The posterior end of dorsal and anal fins are pointed and have filamentous extensions in large adults.

Source of image : www.reefbuilders.com



PROFILE

GEOGRAPHICAL DISTRIBUTION

This species is distributed in the western Indian Ocean, ranging from Sri Lanka and the Maldives in the west to the Andaman sea, coast of Thailand to Indonesia in the east. The species is reported to occur along the west coast of India and from the Gulf of Mannar along the east coast of India.

HABITAT AND BIOLOGY

The species is marine, reef-associated, non-migratory and inhabits depth ranges of 3-20 m. It is found in large aggregations above thickets of branching *Acropora* corals in sheltered areas of sub tidal reef flats and lagoons. The juveniles are closely tied to individual coral heads.

It is a protogynous hermaphrodite, however with no distinguishable differences in colour between males and females. Other species of this family are also protogynous hermaphrodites where the largest fish in the group changes to male. It is an aggressive and hardy fish. Spawning occurs in evening after an elaborate courtship. Courtship begins with the male fish swimming around the female fish. The male fish curves his body towards the female and his unpaired fins become erect. The female shows her readiness for spawning by ascending over her coral accompanied by fin flutter, erect unpaired fins, body quiver and blanching.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

FOOD AND FEEDING

This fish is omnivorous in nature. It feeds on algae, debris, sponges and small crustaceans. In captivity, the diet to be given includes *Spirulina*, marine algae, mysids or frozen shrimp and other meaty items.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Information not available

CHALLENGES TO MARICULTURE

The main researchable issues, which have to be addressed for this species in India, are (i) Domestication and broodstock development protocol (ii) Breeding and larval rearing protocol with environmental and nutritional interference (iii) Feed management.

FUTURE PROSPECTS

Captive production is a potential solution for reducing pressure on wild natural stocks. Successful captive breeding will relieve stress on wild populations and will reduce market prices making the species more affordable to hobbyists.

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Chromis viridis (Cuvier, 1830)

K. K. Anikuttan, A. K. Abdul Nazar, G. Gopakumar and Pralaya Ranjan Behera

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Pomacentridae**
Common/FAO Name (English)	:	**Blue green damselfish**

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Body is small, ovate and laterally compressed. Base of the body is greenish, with green to blue iridescence, fading to whitish or silvery below. Caudal fin deeply forked and tips may extend into short filaments. Dorsal and anal fins may also extend into short filaments. Scales are relatively large and easily dislodged. Dorsal fin with 12 spines and 9-10 rays. Anal fin with 2 spines and 10-11 rays. Pectoral rays 17-18. Body depth 2.0-2.1 in standard length. Suborbital bones scaled, with lower margins smooth. Preopercular margin smooth. A faint dusky spot at upper base of pectoral fin. A blue line from front of snout to eyes.

Source of image : RC of CMFRI, Mandapam Camp

PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is distributed in Indo-Pacific region from east coast of Africa to the Line Islands and Tuamotu Archipelago; north to Ryukyu Islands, south to the Great Barrier Reef and New Caledonia. It has also been reported from Indian waters.

HABITAT AND BIOLOGY

The species is marine, reef-associated and non-migratory and common in shallow lagoon reefs at depths of 1.5-12 m. Adults are found in large aggregations above thickets of branching *Acropora* corals in sheltered areas such as subtidal reef flats and lagoons, whereas juveniles are closely tied to individual coral heads. It exhibits dioecism. Males and females are of the same colour and size, yet differences are seen when the males change to a more yellow colour during spawning. Breeding happens on sand and rubble. The nests for laying eggs are prepared by males and each nest may be used by more than one female. Eggs are demersal and adhere to the substrate. It shows external fertilization. Males guard the nest and ventilate the fertilized eggs with their caudal fins. Eggs hatch out in 2 to 3 days. Males also feed on eggs which do not hatch.

BREEDING IN CAPTIVE CONDITIONS

Broodstock development, breeding and seed production was achieved by researchers of Mandapam R. C. of CMFRI. The broodstock development was carried out in 2 t FRP tanks fitted with biological filter. The fishes matured at 8-9 cm. During broodstock development the fish were fed boiled and finely chopped clam meat, squid meat, earth worm and adult *Artemia*. The excess feed and faecal matter was removed and about 25 % water was exchanged daily.

During experiments at CMFRI, Kochi the average frequency of spawning was 5 times per month. This species is a community egg layer where one male can mate with several females. The male drives each female to the suitable substrate to lay eggs and then the male fertilize it. This is done multiple times with each female till all eggs are spawned. The eggs were oval shaped and average length was 502 µm. Total number of eggs per spawning ranged from 1,300-1,500. The eggs are adhesive and in an aquarium, glass is generally the most suitable substrate. Once spawning is over the male guards the eggs against predators till the eggs hatch out in 3-4 days time.

LARVAL REARING

Larvae were altricial type with no mouth opening at the time of hatching. The average length of newly hatched larvae was 2.25 mm. The larvae were transferred to 5 t capacity round FRP tanks in which cultures of calanoid copepod, *Pseudodiaptomus serricaudatus* and the harpacticoid copepod, *Euterpina acutifrons* were maintained in green water produced by adding *Nannochloropsis* sp. culture. Mouth opening formed on the second day of hatching and the gape measured around 190 µm. Larvae started feeding on copepod nauplii from the third day of hatching. From the 32nd day of larval rearing, freshly hatched *Artemia* nauplii were supplemented. Metamorphosis started from 30th day and was completed by 49th day. The average survival rate was about 5 %.

FOOD AND FEEDING HABITS

It feeds on phytoplankton in the wild, but accepts all foods in captivity. It eats most meaty foods of suitable size as well as flakes or pelleted feeds. There are reports of it feeding on red algae. In captivity, broodstock were fed with boiled and finely chopped clam meat, squid meat, earth worm and adult *Artemia*.

GROWTH RATE

It is a relatively fast growing fish, attaining its maximum size of 10 cm within approximately 12-18 months.

DISEASES AND CONTROL MEASURES

The disease affecting *Chromis viridis* and their control measures are given below.

Disease/causative agent	Control measures
Bacterial diseases	
Fish tuberculosis	Kanamycin or Streptomycin (2 g/100 l for several days) followed by 25-40 % water change; Isoniazid or Rifampin (0.25-0.5 g/100 g food for 14 days)
Fin rot	Phenoxethol, Acriflavine, Tetracycline (3-4 g/100 l for 2-3 days) followed by water change
Pop-eye disease	Tetracycline

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Chromis viridis is an excellent marine aquarium fish and is in good demand in the international market. It is the highest imported fish in India from the Philippines, in terms of volume, with around 5,50,000 fish annually.

CHALLENGES TO MARICULTURE

Although spawning and hatching have been achieved in captivity, the major obstacle to successful mariculture of the species is poor survival of the larval stages. This is mainly due to small mouth gape of the first feeding larvae. Thus the effort has to be initiated to search a suitable feed and develop the technology for their production.

FUTURE PROSPECTS

The techniques for broodstock development, breeding and seed production is developed, which can be scaled up for commercial level production. Mass scale hatchery production can pave way for a sustainable marine ornamental fish trade in the near future, which will help in enhancing the economic status of the farmer as well as aquaculture production of the species.

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Chrysiptera cyanea (Quoy & Gaimard, 1825)

G. Tamilmani and G. Gopakumar

IDENTIFICATION

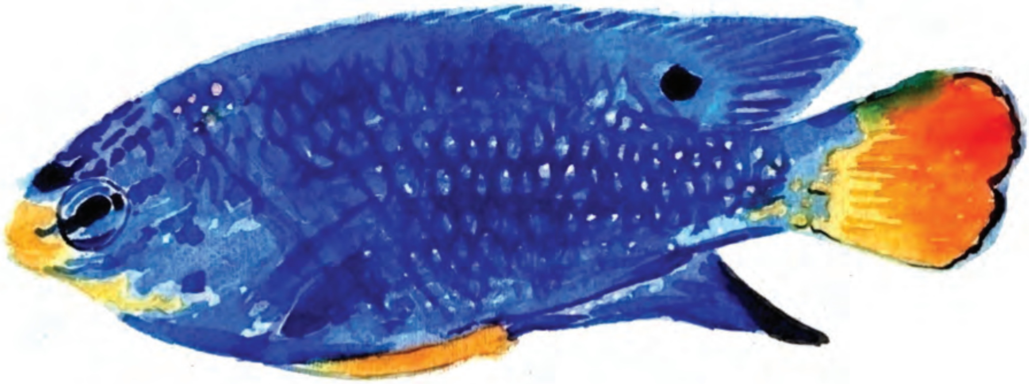
Order	:	**Perciformes**
Family	:	**Pomacentridae**
Common/FAO Name (English)	:	**Sapphire devil damsel**

Local names: Not available

MORPHOLOGICAL DESCRIPTION

The Sapphire devil damsel is characterized by its brilliant blue colour and a small black spot at the posterior base of the dorsal fin. Adult males sometimes develop an orange colour on caudal fin and ventral parts of the body. Females and juveniles usually lack the orange colour. There are 13 dorsal spines and 12-13 soft rays and 2 anal spine and 13-14 anal soft rays.

Source of image : RC of CMFRI, Mandapam Camp



PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is distributed in Indo-West Pacific region from eastern edge of the Indian Ocean and western Australia to New Guinea, New Britain, Solomon Islands, Marianas and Caroline Islands, Indonesia, Philippines, Taiwan and Ryukyu Islands. It is also known from Vanuatu and New Caledonia, Palau and Yap in Micronesia and Samoa. The species has been reported along both the coasts of India, from Lakshadweep and from Andaman Islands.

HABITAT AND BIOLOGY

The species is marine, reef-associated, non-migratory and inhibits at depths of 0-10 m. Adults are found amongst rubble and coral of clear sheltered lagoons and subtidal reef flats. Generally a single male groups with several females or juveniles. The maximum reported size for the species is 8.5 cm. It is oviparous with distinct pairing during breeding. Eggs are demersal and adhere to the substrate. Males guard and aerate the eggs. Larval duration ranges from 17-21 days.

BREEDING IN CAPTIVE CONDITIONS

Under captivity, broodstock development, breeding and larviculture techniques were developed and standardized by Mandapam R. C. of CMFRI, India. Broodstock development was done in rectangular 2 t capacity FRP tanks with biological filters. Six juvenile fishes of the sapphire devil damsel collected by liftnet were introduced into the tanks for broodstock development. First spawning was obtained in captivity after 8 months of maintenance in the broodstock tanks. The mature fish ranged in total length from 5-6.5 cm. The day before spawning, the parent fishes actively cleaned the site for attaching the eggs by rubbing it with their pelvic fins and picking off any loose particles or algae with their mouths. During spawning, females attached their eggs on the cleaned site, which were immediately fertilized by the males. Spawning occurred during morning hours. Approximately 2,000-2,500 eggs were present in a single spawn. The eggs were attached on the substrata provided inside the broodstock tanks. The eggs were oval shaped and measured around 1.3 mm in length and 0.6 mm in width. The periodicity of spawning ranged between 5 and 20 days. Hatching took place on the night of 3rd day at 28-30 °C. Hatching was delayed to 4th day or 5th day if the temperature was lower. During this period, the male parent took care of the eggs by protecting them and by fanning them with their pectoral fins and tail.

LARVAL REARING

The larvae were altricial type with no mouth opening at the time of hatching. The length of newly hatched larvae averaged 2.5 mm and the mouth gape was around 150 µm. Larviculture was done in 5 t capacity FRP tanks by employing green water produced by the microalgae *Nannochloropsis* sp. Different larviculture systems were experimented by varying the cell counts of green water and live feeds. The cell counts of green water were in three ranges - 19 x 10^4/ml,19 x 10^5/ml and 19 x 10^6/ml. Feeding was performed with different live feeds - enriched rotifer (*Brachionus rotundiformis*) alone, mixed culture of two copepods viz. *Euterpina acutifrons* and *Pseudodiaptomus serricaudatus*, copepods and rotifers together and copepods as starter feed for the first six days followed by enriched rotifers from 7 to 15 dph. Feeding with *B. rotundiformis* alone and with *B. rotundiformis* and copepods together was least successful. Co-culturing of the two selected species of copepods in optimum range of cell count of green water gave the best survival. Survival rate of larvae on 15 dph ranged from 5 to 8 %. A survival rate of 5-6 % was observed in larvae fed with copepods as starter feed up to 6 dph followed by enriched rotifers from 7 to 15 dph. A cell count of 1 x 10^5 cells/ml was found to be optimum, which yielded the maximum larval survival. After 15 dph, the larvae were fed with freshly hatched *Artemia* nauplii. No mortality was observed beyond this period. Metamorphosis of larvae started from 24th day and all the larvae metamorphosed by 30th day.

FOOD AND FEEDING

This species feeds on zooplankton, benthic invertebrates and filamentous algae. Its diet includes algae, tunicates and copepods.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Chrysiptera cyanea are prone to parasitic infestations, mainly isopod, *Livoneca* sp. It can be treated either with Trichlorfon (0.25-3.0 mg/l water for 3 days) or formalin (0.1 ml/l for 30-45 minutes or 1.0-1.5 ml/100 l for 2 days). The parasite can also be removed manually with the help of tweezers.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

The sapphire devil damselfish, *Chrysiptera cyanea* is one among the top ten species of marine ornamental fishes in the international trade. It is an excellent marine aquarium fish and is in good demand in the international market. For the years 1997-2002, *Chrysiptera* cyanea was one of the most commonly traded species in the EU and USA, with 11,776 and 73,536 numbers exported and 43,767 and 77,890 numbers imported.

CHALLENGES TO MARICULTURE

The critical phase of larviculture is initial feeding after mouth opening. After 15 dph, the mouth gape reaches around 450 µm, then it can be fed with freshly hatched *Artemia* nauplii. The absence of any mortality after 15 dph indicates that once the initial feeding problem is solved, larviculture is accomplished easily with conventional live feeds. Thus suitable feed has to be searched and developed for the initial feeding so that survival can be increased.

FUTURE PROSPECTS

Chrysiptera cyanea is one of the top most species in the international aquarium trade. Since breeding and larviculture techniques are already developed, production can be popularized. The breeding technique developed has the potential to be scaled up to commercial level for production of the species.

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Dascyllus aruanus (Linnaeus, 1758)

K. K. Anikuttan, A. K. Abdul Nazar and G. Gopakumar

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Pomacentridae**
Common/FAO Name (English)	:	**Whitetail dascyllus**

Source of image : RC of CMFRI, Mandapam Camp

Local names: Kallikkotti (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

There are 12 dorsal spines and 11-13 dorsal soft rays. There are 2 anal spines and 11-13 anal soft rays. The margins of preorbital, suborbital, and preoperculum are finely serrated. The depth of the body is 1.5-1.7 in standard length. Conical teeth on jaws. Pre-opercle is denticulated. This fish has a pale whitish-brownish colour and is easily identified by three broad dark bands across the body. The first band extends from the chin to the first two dorsal spines, the second from the base of pectoral fin to the 5th or 6th to 9th dorsal spines and the third from the anal fin to the soft dorsal fin. Dorsal and anal fins are brown. Caudal fin is greyish.

PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is distributed throughout most of the Indo-Pacific region from the Red Sea and east coast of Africa to French Polynesia and Ryuku Islands to New South Wales and Lord Howe Island. It is also reported along the coast of India, Lakshadweep and Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

The species is marine, reef-associated and non-migratory and inhabits a depth range of 0-20 m. *D. aruanus* lives among the branches of ramose corals throughout the Indo-Pacific region. Though, it prefers to be associated with live corals, it can easily adapt to dead coral colonies when live corals become scarce in nature due to their large scale death. The reported maximum length is 10 cm, the common length being 6 cm and the maximum age is 6 years.

The species is dioecious and exhibits external fertilization. Female is oviparous and exhibits distinct pairing during breeding. The individual fish spawns more than once in a year. The breeding season almost extends throughout the year, with an active period from April to January. The size at first maturity is 38 mm. Fecundity ranges from 2,125 to 7,157 eggs in an ovary at a time. Males are aggressive against other fishes while they tend eggs. Male selects and protects the nest and performs courtship dance 1 m above the nest and escorts the attracted females to the nest site where spawning happens. Eggs are demersal and adhere to the substrate. Harem-type social structure is observed with 1 male and several females following linear size dependent rank order; male spawns with the females in order of rank. Males invite females to spawn in their nests; protecting the eggs until they hatch. Male and the largest female protect the home territory. Eggs hatch out at 24-25 °C in 44-51 h, with hatched out larvae measuring approximately 2 mm and are pelagic; feeding on plankton. The pelagic phase of the larvae lasts about 2 weeks.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

The broodstock development, breeding and larviculture of *D. aruanus* was developed and standardized by CMFRI, Kochi, India in 2006. The technology of formulated feeds for their rearing and maintenance in hatchery was developed by researchers of CMFRI in 2008.The broodstock was developed in 1 t capacity tanks with biological filter. Feeding was done @ 5-10 % of body weight, once in a day with finely chopped fishes, shrimps and molluscan meat. The size range of brooder was 7 to 8 cm. It spawned in captivity after 4-8 months of maintenance in the broodstock tanks. Prior to spawning, the parent fishes actively cleaned the site for attaching the eggs by rubbing it with their pelvic fins and picking off any loose particles or algae with their mouths. During spawning, females attached their eggs on the cleaned site, which were immediately fertilized by the males. The number of eggs per spawning ranged from 12,000 to 15,000. The interval between two successive spawning ranged from 10 to 14 days. The eggs were attached either on the sides of the broodstock tank or on the substratum provided. Parental care by the male was noted. Spawning occurred during the morning hours. The eggs were oval in shape. The development of egg took place in 3 days at 28 °C.

LARVAL REARING

Larvae are altricial type with no mouth opening at the time of hatching. The average length of newly hatched larvae was 2.4 mm. The larvae were transferred to 5 t capacity round FRP tanks, in which mixed culture of two species of copepods viz., *Pseudodiaptomus serricaudatus* and *Euterpina acutifrons* were maintained in greenwater. Mouth opening formed on the second day, and the gape measured around 160 µm. The larvae started feeding from 3rd day of hatching. The highest number of egg bearing copepods and nauplii in the larviculture system and the maximum larval survival was noted when the cell count of the greenwater was maintained at a range of 1 x 10^5 cells to 6 x 10^5 cells/ml.

After 20 days, when the average size of the larvae was around 4 mm, with average mouth gape of around 450 µm, freshly hatched *Artemia* nauplii was fed *ad libitum*. No mortality was noted after 20 days. The larvae start metamorphosing from 25 dph and it was completed by 31 dph. Young ones measured 8.0-8.5 mm in length.

FOOD AND FEEDING

The species is diurnal, occurring in small groups, feeding on zooplankton, benthic invertebrates and filamentous algae. There is no selective feeding of plankton; however the dominant groups are copepods and amphipods. Filamentous algae and fragments of coralline material sometimes enter the stomach along with the plankton.

Formulated feeds containing protein levels ranging from 180 to 560 g/kg and an energy level of 19 MJ/kg are fed to individuals of < 200 mg and 200-300 mg sizes for periods of 35 and 63 days. Optimum protein range that elicited the best growth is between 360 and 470 g/kg. There are reports of growth rates in terms of SGR of 1.1 with formulated feed containing 520 g/kg protein and 150 g/kg lipid. Studies by CMFRI found higher growth, i.e., 1.93 with feed containing 360 g/kg protein and 55 g/kg lipid in fish weighing 200 mg for a period of 35 days.

GROWTH RATE

In wild, *Dascyllus aruanus* attains total length of 61 mm at the end of first year and 97 mm by the end of second year of its life.

DISEASES AND CONTROL MEASURES

Lymphocystis is an infectious viral disease reported for the first time from the white-tailed damselfish imported from the Philippines through California in 1976.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

It is a commercially important exotic aquarium fish from the Indo-Australian Pacific region. It is small, attractive and sells at US $ 1 to 5/fish in the international trade. During 1997-2002, worldwide 1,03,948 numbers were exported and 1,64,094 numbers were imported. In USA for the same period, 72,435 numbers were exported and 1,47,525 numbers were imported.

CHALLENGES TO MARICULTURE

Broodstock development, breeding and larval rearing in captivity have been achieved. There is a need to develop technique for nursery rearing and grow out culture of the species.

FUTURE PROSPECTS

Dascyllus aruanus is one of the topmost species in the marine ornamental fish trade. Techniques for captive breeding and larval rearing are available and hence a hatchery produced trade for the species can be developed.

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Dascyllus trimaculatus (Rüppell, 1829)

A. K. Abdul Nazar, G.Tamilmani and G. Gopakumar

IDENTIFICATION

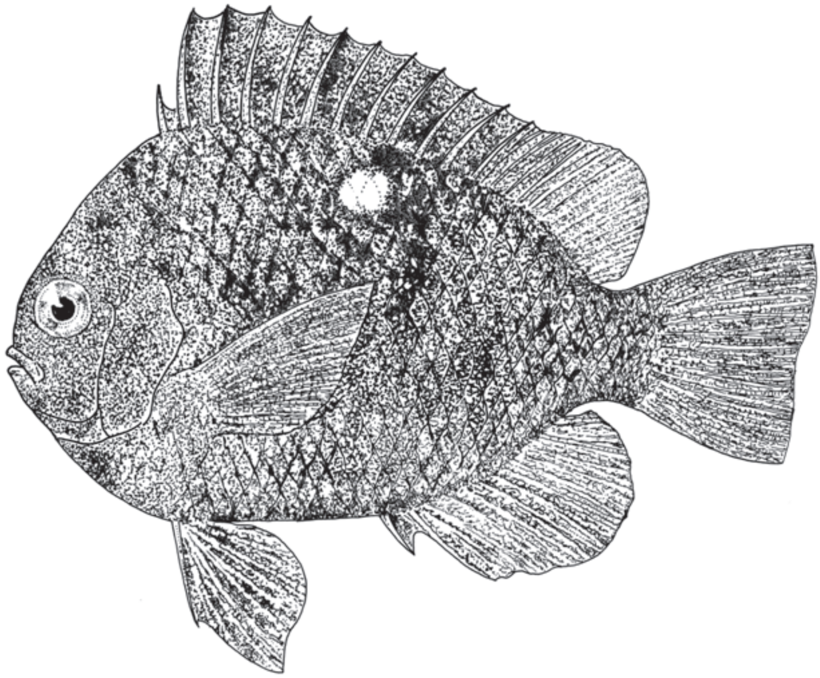
Order	:	**Perciformes**
Family	:	**Pomacentridae**
Common/FAO Name (English)	:	**Threespot dascyllus**

Source of image : RC of CMFRI, Mandapam Camp

Local names: Paarakkotti, Barakkoti, Karipadatham (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

Body is deep and mouth is oblique with maxillary almost reaching to below front border of the eye. Preorbital and suborbital with a row of elongate scales, the lower borders of which are finely denticulated. It has 4-5 irregular rows of scales on preopercle and one on inferior limb. A narrow posterior limb is naked. Hind border of preopercle is with minute denticulations. Scales on upper part of head reaching to end of snout, those before eyes are much smaller than the others. First



dorsal spine is short. Second or third and fourth dorsal spines are slightly longer than the others, almost as long as head without snout. Soft dorsal bluntly pointed, the first ray as long as the last spine, the middle rays as long as the longest dorsal spines. First anal spine is short, the second is as long as the longest dorsal spines. Teeth are in several rows in jaws, with outer row slightly enlarged. Caudal fin is slightly emarginate, with the upper lobe longer than the lower lobe. Dorsal fin has 12 spines and 14-15 rays, anal fin has 2 spines and 14 rays, pectoral fin has 2 spines and 17-18 rays and the pelvic fin has 1 spine and 5 rays. Colour is dark reddish brown to brownish black in larger specimens. The scales are with dark hind border. Young ones with white blotch on nape and another in lateral line below 7th to 9th or 10th dorsal fin spines. These two blotches gradually disappear with growth. Dorsal and anal fins are dark brown distally, light brown basally. Caudal and ventral fins are dark. Pectoral fins are pale to dusky with dusky brown blotch at the upper edge of base.

PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is distributed in the Indo-Pacific region from the Red Sea and east Africa to the Line and Pitcairn islands, north to southern Japan and south to Sydney in Australia. It has been reported from Indian waters also.

HABITAT AND BIOLOGY

Adults inhabit coral and rocky reefs whereas juveniles are often commensal with large sea anemones, sea urchins, or small coral heads. It is reef-associated and is moderately a common inhabitant of isolated coral heads and patches of rubble on sandy lagoons. It also inhabits passes and outer reef environments up to at least 55 m. It occurs in small to large aggregations.

The species is oviparous and exhibits distinct pairing during breeding. Eggs are demersal and adhere to the substrate. Males guard and aerate the eggs. While protogyny was originally proposed, recent studies confirm gonochorism in the form of non-functional hermaphroditism. In the wild its life span is 2 to 8 years, though it may live up to 20 years in captivity.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

The techniques for broodstock development, breeding and seed production of three spot damsel, *Dascyllus trimaculatus* have been developed and standardized by researchers of Mandapam Regional center of CMFRI. Broodstock development was done in 1 t FRP tanks with biological filter. Water in the broodstock tanks was exchanged @ 30 %, once in a week. Feeding of brooders was done once a day @ 5-10 % of its body weight with finely chopped fishes, shrimps and molluscan meat. The size range of brooders was 7-9 cm. The broodstock tanks were kept under translucent roofing to reduce the light intensity. Spawning in captivity was observed after 4-8 months of maintenance. Breeding was observed during early morning hours. Approximately 12,000 to 15,000 eggs were present in a single spawning. The eggs were attached either to the sides of the tanks or on the substrata provided inside the broodstock tanks. Average periodicity of spawning was 2 weeks. The development of egg took 3 days at 28 °C. Parental care by the male was noted. Hatching occurred on the evening of the fourth day of incubation. Studies on the effect of hormonal stimulation on the maturation and ovulation of oocytes were also conducted. Double injections of Surfagon (LHRHa) (5+15 µg/kg of fish body weight) with or without the addition of Eglonil (5+15 mg/kg) were used, and the interval between the injections ranged from 12 to 17 h. Ovulation was registered 33.5-42.0 h after the injection.

LARVAL REARING

Larvae were altricial type with no mouth opening at the time of hatching. The average length of newly hatched out larvae was 2.5 mm. The larvae were transferred to 5 t capacity circular FRP tanks in which harpacticoid copepod cultures were maintained in green water. Mouth opening appeared on the second day and the gape measured around 150 µm. The larvae started feeding on copepod nauplii from the third day of hatching. After two weeks, when the average size of the larvae reached 4 mm with an average mouth gape of 450 µm, freshly hatched *Artemia* nauplii were fed *ad libitum*. The larvae start metamorphosing from 35th day of hatching and all the larvae were metamorphosed by the 40th day. The just metamorphosed young ones measured 12-13 mm in length. The average survival rate ranged between 10-15 %.

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

Three spot dascyllus are omnivores. In the wild, it is a planktivore feeding on copepods and other planktonic crustaceans, but also consumes benthic algae and weeds in the process of ingesting smaller crustaceans inhabiting these algae covered surfaces. In captivity, it feeds on a variety of diet that includes meaty foods such as mysis shrimp, enriched brine shrimp, krill, finely chopped shrimp and other crustacean flesh. Studies on food and feeding in Red Sea, off the coast of Jordan, indicated that it fed on invertebrates such as amphipods, isopods and other crustaceans. Crustaceans, molluscs and polychaetes were present in its gut throughout the year, with crustaceans dominating.

GROWTH RATE

It can reach up to 14 cm but typically grows to about 12.5-13 cm in captivity.

DISEASES AND CONTROL MEASURES

Dascyllus trimaculatus is prone to parasitic infestations, mainly *Brooklynella hostilis*, which leads to skin turbidity. This parasite can be treated with the combination of formaldehyde (1 drop/4-5 l or 1 ml/100 l) and malachite green (1 ml or 20-25 drops/100 l). Quinacrine (100-250 mg/100 l for 10 days) is also effective, but can be toxic to weaker fish. The strongest fish is provided with freshwater baths to kill as many parasites as possible. Another disease reported in this species is bacterial infection either single or mixed strains. This can be treated with the help of any approved antibiotics, such as Penicillin (1.5-2 gm/100 l for 24 h); Tetracycline (3-4 gm/100 l for 2-3 days); short bath with Copper Sulphate or salt.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Damselfishes make up almost half of the global marine ornamental finfish trade. During 1997 to 2002, globally 78,536 numbers were exported and 1,02,650 numbers were imported. In EU and US for the same period, 33,078 and 69,572 numbers were imported and in US, 30,267 numbers were exported.

CHALLENGES TO MARICULTURE

Although spawning and hatching have been achieved in captivity, the major obstacle to successful mariculture of the species is poor survival of the larval stages. The poor larval survival is due to small mouth gape at initial feeding so research has to be carried out to find an appropriate feed for initial larval rearing.

FUTURE PROSPECTS

The techniques for broodstock development, breeding and seed production is developed and standardized, which can be scaled up for commercial level production. Mass scale hatchery production can pave way for a sustainable marine ornamental fish trade in the near future, which will help in enhancing the economic status of the farmer as well as aquaculture production of the species.

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Nemateleotris decora Randall & Allen, 1973

K. Madhu, Rema Madhu and Pralaya Ranjan Behera

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Microdesmidae**
Common/FAO Name (English)	:	**Elegant fire fish**

Local names: Not available

MORPHOLOGICAL DESCRIPTION

The elegant fire fish is a slender, colourful fish with a maximum reported size of 9 cm. There are 7 dorsal spines and 27-32 dorsal soft rays. There is a single anal spine and 28-31 anal soft rays. Longitudinal scale series is 135-160.The elevated first dorsal fin does not extend beyond anterior one-third of second dorsal fin. The posterior body scales are with ctenii, usually less than 10. The posterior-most rays of dorsal and anal fins are frequently branched in adults. The head is purple and the body is whitish or yellowish, gradually darkening to deep grey towards the tail, caudal fin is with broad red lobes and a central bluish area. The fins have longitudinal bands of purple, red, black and orange. It is characterized in having a violet snout and a mid-dorsal stripe on head. Fishes from Andaman Islands are with more vivid violet coloration and with duller red portions.

Source of image : www.fishwisepro.com

PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is native to tropical waters of the Indo-Pacific region; ranging from Philippines to Australia, Fiji to Ryuku islands, Mauritius to Samoa, New Caledonia, Maldives and Sri Lanka. In India, they are available from the Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

Nemateleotris decora is marine, reef-associated and found in depths ranging from 25-70 m. It is found over hard, open bottoms at the bases of reefs and over sand and rubble patches and also observed in deep coastal to outer reef drops-offs subjected to strong currents. It is often found in pairs and is monogamous. It is carnivorous in nature.

BREEDING IN CAPTIVE CONDITIONS

Courtship behaviour, captive breeding, embryonic and larval developments of *Nemateleotris decora* and its rearing has been developed by researchers of CMFRI, Kochi. The different age groups of 60 to 100 mm length and 1.3 to 2.8 g weight were stocked in 500 l glass aquaria for pair formation. The pairs are formed after 5-6 month of rearing and increased interaction was observed after pair formation. Consequently, formed pair was shifted to 250 l perspex broodstock tanks. The pairs were fed with cooked meat of squid, shrimp, green mussel, and raw fish egg mass at 10 % of their body weight in four split doses. The breeding behaviour consisted of cleaning, biting the egg, depositing substrate and rubbing the surface of the nest site with its anal and pectoral fins for making nest 5 days prior to spawning. Spawning was preceded by an obvious bulging and distension of female's abdomen. The courtship and spawning behaviour of female in the nest site was highly influenced by the male enticement. Each spawning consists of 400 to 500 eggs in white clutch, which was oval with length and width of 9 cm and 5 cm, respectively. In the parental care, the males showed more devotion to tend and guard the egg clutches than the females. The female was observed resting near to the nest with its pectoral fins spread. The incubation period lasts for 96 h at an average water temperature of 28±1 °C. The eggs were elongated, capsule-shaped with a length of 1.1±0.1 mm and a width of 0.37 to 0.4 mm.

LARVAL REARING

Soon after hatching, the larvae were reared in green water of *Nannochloropsis oculata* and *Chlorella salina* (1:1 proportion at 1-5 × 10^6 cells/ml) till 40 days post hatch (dph) at an average water temperature of 29±1°C. The average size of the newly hatched out larva was 1.9±0.1 mm with a mouth gape of 90-110 µm. It had a transparent body and a small yolk sac. From 5^{th} day onwards, it showed active feeding. At 25 dph, it actively fed on the enriched *Artemia* nauplii. Larvae fed on *Euplotes* sp. and *Brachionus rotundiformis* showed a higher survival rate (66±0.23 %), whereas those fed on nauplii of copepod *Acartia danae* and *B. rotundiformis* showed less (40±0.40 %) survival rate. The larvae metamorphosed to juveniles between 35 and 40 dph and shifted from being partially pelagic to epibenthic. At this stage, all the juveniles exhibited light pink colouration on fins and yellow on the body.

FOOD AND FEEDING

It feeds on zooplankton, especially larvae of crustaceans and copepods in the wild. As mentioned above, in captivity, adult fish are amenable to feeding with cooked meat of squid, shrimp, green mussel and raw fish egg mass.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

It is of keen interest for the aquarium trade because of their amazing colours (light pink to white body, dark purple rear end and purple red fins), peaceful behaviour towards tank mates, hardiness, elongated shape and small size. It is the top ranked fish in the aquarium industry with an international market price of US $ 35-40/individual depending upon its size.

CHALLENGES TO MARICULTURE

A major impediment in the larval rearing is the first feeding, when the larvae shift from endogenous yolk reserves to exogenous feeding. To overcome this critical period, proper enrichment of live feeds with HUFA supplements is essential for its successful rearing. Prey capture success and prey selectivity during first feeding and subsequent larval development is a bottleneck, and due to it, the captive production of microdesmids is still in infancy when compared to clown fishes and other marine ornamental fishes. The major challenge is to increase the survival during the larval rearing through environmental and feed manipulation.

FUTURE PROSPECTS

It is considered a very good fish for reef tanks because of its hardiness, its ability to eat most fish foods offered and its capacity to remain disease free. Standardization of its larval rearing will help to reduce exploitation from the wild. The remuneration for the species is high. Thus the present species is having very good prospects for Indian farmer as good revenue earner.

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Neoglyphidodon oxyodon (Bleeker, 1858)

Rema Madhu and K. Madhu

IDENTIFICATION

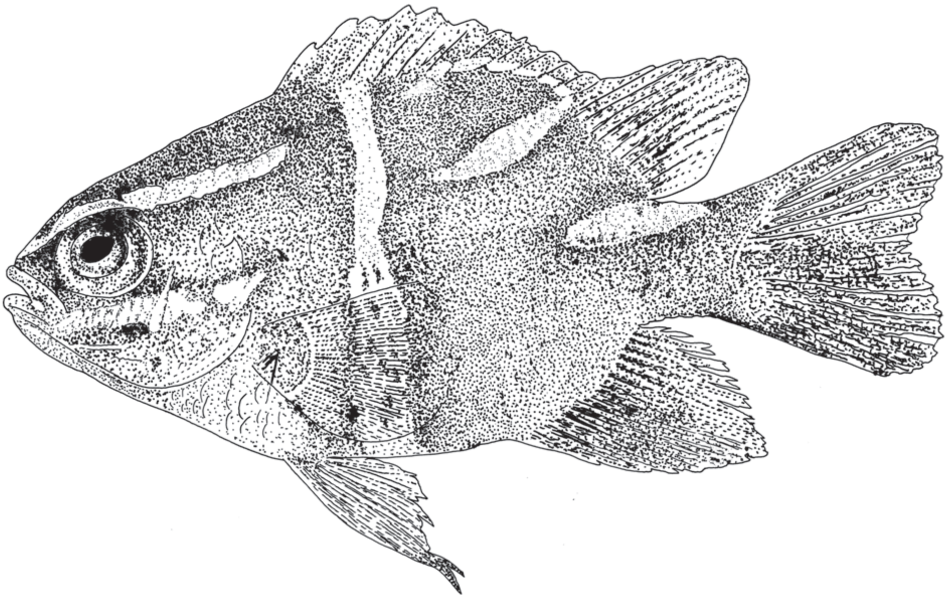
Order	:	**Perciformes**
Family	:	**Pomacentridae**
Common/FAO Name (English)	:	**Bluestreak damselfish**

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Bluestreak damselfish has an elongated oval shape and the body colour is black. There are two neon blue stripes starting from the snout, one strip below the eye and the other above it. Two more neon blue stripes are seen below the dorsal fin. There is also a large whitish vertical bar behind its head. Usually the tips of the fins have a neon blue tinge. It often loses its vibrant colouration as it matures, fading towards brown and black. There are 13 dorsal spines and 13-14 soft rays. There are 2 anal spines and 13-14 soft anal fin rays.

Source of image : www.biolib.cz



PROFILE

GEOGRAPHICAL DISTRIBUTION

It is found in the Indo-Australian Archipelago around the Philippines, Indonesia and Timor Sea. In India it is reported from the Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

The species is marine, reef-associated and non-migratory. It inhabits inshore reefs and lagoons in shallow depths ranging from 0 to 4 m. It is generally seen associated with *Acropora* coral heads used by the fish for shelter. Adults form pairs for spawning but otherwise form loose shoals of varying sizes. Juveniles are solitary in nature. Females are oviparous and exhibit distinct pairing during breeding. A female may lay as many as 20,000 eggs. Eggs are demersal and adhesive in nature. Males guard and aerate the eggs.

Males are territorial with active chasing of other males. The nest site is usually a coral surface or rocky ledge that is kept clean by the male fish. The male lures a female through a short courtship to the nest where she lays eggs. The male will fertilize these eggs immediately. Males can mate up to 5 females in a single spawning event and females use the same nest for egg laying. The eggs hatch out in 3 to 7 days, depending on water temperature, followed by about a 3 week larval period. The fry feed on plankton. It generally lives up to 6 years in the wild and up to 15 years in captivity with proper care.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Bluestreak damselfish has not yet been bred in captivity, probably because of the aggressiveness of the male fish. Successful breeding would require a large, non-predatory aquarium which would also increase the cost of the breeding system. It would optimally spawn between 26 °C to 28 °C. The eggs and larvae are much smaller than those of clownfish. There are reports that Annamalai University, India has developed the broodstock of this species. However, detailed information is lacking.

LARVAL REARING

Information not available

FOOD AND FEEDING

It is an omnivore feeding on algae, weeds, zooplankton and planktonic invertebrates in the wild. It can additionally feed on freeze dried, frozen, pellets, flakes or fresh meaty foods in aquariums. It needs to be fed occasionally and in small quantities throughout, to reduce its aggression.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

The species is very sturdy and strong, even as juveniles. However, it is victim to a "sudden death" phenomenon, wherein the fish suddenly dies without any signs. It is also susceptible to various other diseases, namely, Marine Itch caused by *Cryptocaryon irritans* (White Spot Disease or Crypt), Marine Velvet or Velvet Disease caused by *Oodinium ocellatum* (*Amyloodinium* ocellatum) and Uronema disease caused by *Uronema marinum*. All these are curable if noticed on time. Diseases are most often contracted when the salinity is lowered for long periods. Properly cleaned or quarantined live rocks and corals helps to prevent diseases

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Information not available

CHALLENGES TO MARICULTURE

This species is considered as the costliest of all damsel fish, although getting enough numbers from the wild is problematic. Hence getting enough numbers for captive breeding will be a challenge in itself. Domestication, broodstock development, breeding and larval rearing also needs to be carried out successfully.

FUTURE PROSPECTS

The young ones are with very beautiful coloration and gets along with large angelfish, butterflies, tangs and surgeonfish. It is one of the most hardiest and expensive fishes. Provided that there is regular supply from mariculture of this species, it has great scope for the domestic ornamental fish industry.

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Pomacentrus pavo (Bloch, 1787)

K. K. Anikuttan, G.Tamilmani, G. Gopakumar and Pralaya Ranjan Behera

IDENTIFICATION

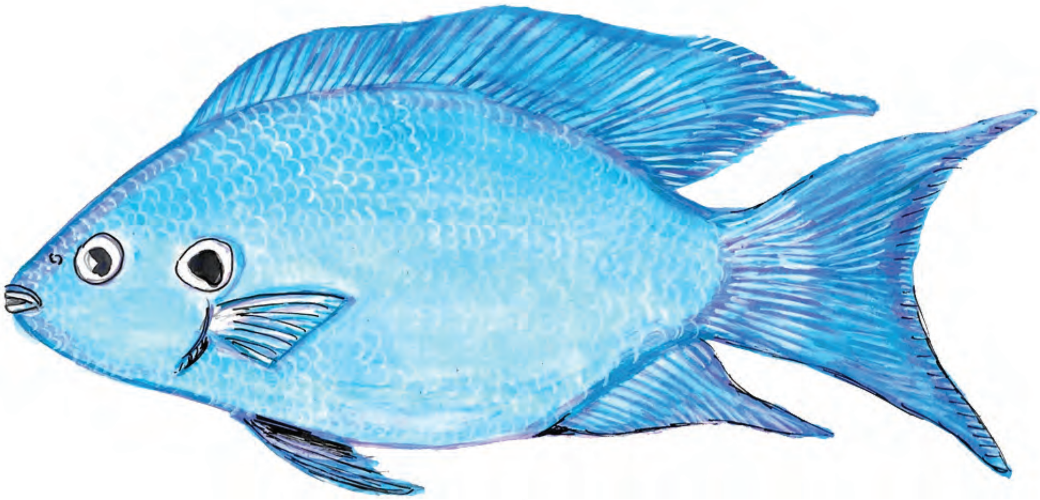
Order	:	**Perciformes**
Family	:	**Pomacentridae**
Common/FAO Name (English)	:	**Sapphire damsel**

Source of image : CMFRI, Kochi

Local names: Pachakkotti (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

The Sapphire damsel has 13 dorsal spines and 13-14 dorsal soft rays. There are 2 anal spines and 12-14 anal soft rays. Body colour is variable from metallic green to light blue. A small and usually distinct greenish ear spot is found. The tail is yellowish, especially when young. The head is with blue vermiculations and the body depth is 2.4-2.6 in standard length.



PROFILE

GEOGRAPHICAL DISTRIBUTION

The sapphire damsel is a small fish found in the tropical and temperate waters, throughout the world oceans. The species is distributed in the Indo-Pacific region ranging from east Africa to the Tuamoto Islands, north to Taiwan and south to Lord Howe Island. It is also reported from Maldives and along the coast of India from Lakshadweep Islands.

HABITAT AND BIOLOGY

It is a marine, reef-associated, non-migratory fish and a common inhabitant of isolated coral heads and patches of rubble on sandy lagoons and channel floors varying in depth from 1.5 to 12 m. It is usually seen in groups and commonly found around jetty structures. It is oviparous with distinct pairing observed during breeding. The eggs are demersal and adhere to the substrate. The males guard and aerate the eggs. Studies from India have reported that the size at first maturity ranges from 41 to 50 mm and females to be the dominant sex (sex ratio of 1:0.58). Spawning season is from March to May in India. Fecundity varies from 700 to 2,396 eggs.

BREEDING IN CAPTIVE CONDITIONS

Technology for breeding and seed production of sapphire damsel, *Pomacentrus pavo* has been developed by researchers of Mandapam R. C. of CMFRI. Wild collected fishes were stocked in broodstock tanks. The fishes were fed *ad libitum* with boiled mussel meat. Spawning started two months after introducing them to the breeding tank. Spawning was almost continuous throughout the period. The largest fish was the nest guarding male and the others were females. Multiple spawning was noticed. Spawning usually took place early in the morning. Occasionally spawning took place in late night hours. The spawning frequency and the number of eggs laid were very low initially but gradually increased. The number of spawning events ranged from 0 to 14 with an average of 7.4±1.24 spawning events per month. Usually spawning occurred in every 3-4 days during normal breeding periods. Initially, number of eggs laid was 400 per spawning. Afterwards it increased to a maximum of 3,788, with an average of 2656±78.74 eggs per spawning. Clutch size was fairly consistent after the initial spawning. During the 16 month period the total number of eggs laid was estimated to be 3,27,450. The incubation period was four days generally but occasionally extended to the fifth day. Hatching took place in the evening, 1 to 2 h after sunset.

LARVAL REARING

The newly hatched larvae were collected and stocked in larval rearing tanks. The hatchlings were pelagic with a single fin fold and movable jaws. Complete yolk exhaustion took place in 2-3 days after hatching. The total length and maximum mouth gape of the hatchlings of the species are 2.08 mm and 189 µm respectively. Green water system was adopted for larval rearing. The early larvae were found to feed on ciliates present in the microalgal debris for initial few days. Later they were fed with finely smashed ovaries and tissues of the mussel filtered through bolting silk of appropriate mesh size. As they grew they were fed with freshly hatched *Artemia nauplii* and *Moina micrura* till metamorphosis. Larval duration ranged from 37 to 41 days. Water exchange was done in the morning and evening @ 50 % initially and increasing to 100 % later.

FOOD AND FEEDING

It is omnivorous ; feeding on zooplankton and filamentous algae.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Lipoid liver disease and steatitis has been reported in captive sapphire damsels. The possible contributing factors are vitamin E deficiency/depletion, rancid feed and chronic stress.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

It is one of the most popular aquaria species in commercial and private operations and is one of the top ten most traded species globally.

CHALLENGES TO MARICULTURE

Although captive breeding and larviculture have been successfully carried out, mass scale hatchery production needs to be standardized.

FUTURE PROSPECTS

Pomacentrus pavo is one of the best species in the marine aquaria. Captive breeding and larviculture have been successfully carried out in India. Mass scale hatchery production can pave way for a sustainable marine ornamental fish trade in the near future.

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Pseudochromis dilectus Lubbock, 1976

K. Madhu, Rema Madhu and Pralaya Ranjan Behera

IDENTIFICATION

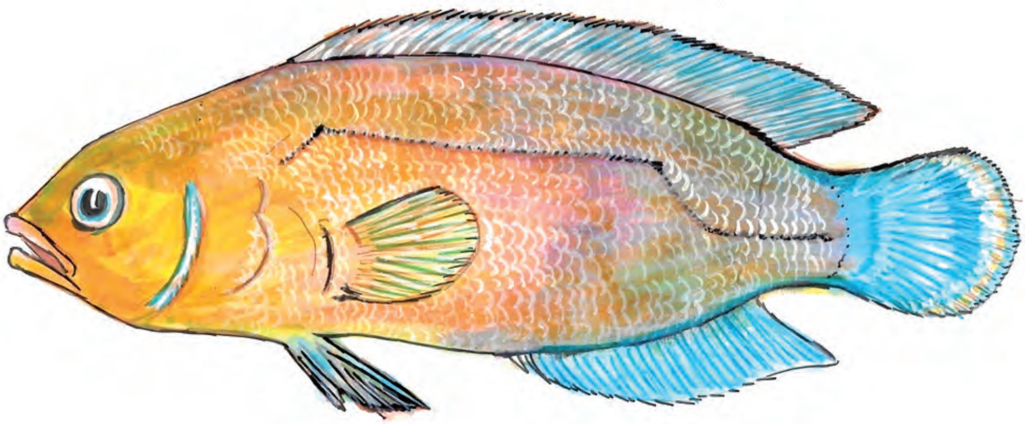
Order	:	**Perciformes**
Family	:	**Pseudochromidae**
Common/FAO Name (English)	:	**Redhead dottyback**

Source of image : www.biolib.cz

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Pseudochromis dilectus is black or gray in colour with bright orange-red head and shoulder area. It has an elongated body, with white accents. There is one spine on the pelvic fin. Pelvic fin insertion is underneath or before the pectoral fin base. Lateral line is variable (hindered or constant). The males are reddish, elongate and slender; while the females are dark green and smaller in appearance, with a plumpy abdomen.



PROFILE

GEOGRAPHICAL DISTRIBUTION

Pseudochromis dilectus is distributed in the western Indian Ocean and Sri Lanka. It is also known as the Sri Lanka Dottyback, as it is believed to have originated from the reefs of Sri Lanka. They are generally found in coral reefs and lagoons.

HABITAT AND BIOLOGY

The red head dottyback is a marine, demersal and tropical ornamental fish. It mostly inhabits rocky coastal areas containing soft corals. The common features in its environment are the presence of hiding spaces, mainly coral and rock crevices and caves that it can duck into quickly. It is territorial and semi-aggressive in nature. It can coexist along with all other types of fish as long as its home territory is not disturbed by others. All dottybacks are hermaphrodites. Since each fish can adopt either the male or female sexual organs, adding two like species into a tank together will result in a pair, provided they do not kill each other first. Parental care is exhibited by males.

BREEDING IN CAPTIVE CONDITIONS

The Redhead Dottyback has been successfully bred in captivity at CMFRI, Kochi. The fishes ranging in length from 70 to 120 mm were stocked in glass aquaria or 1 t FRP tank for pair formation. They were fed daily with prawn meat and adult *Artemia* along with pelleted feed (Trade name Varna, CMFRI, Kochi, India). The healthy pair formed was selected and stocked in 500 l perspex tanks (one pair/tank) for broodstock development. The pairs were fed with wet feeds such as meat of mussel, shrimp, squid and clam and were also provided with live feeds viz., adult *Daphnella celebensis* fed with mixed microalgae (*Tetraselmis chuii, Chaetoceros calcitrans, Nannochloropsis oculata, Chlorella salina and Isochrysis galbana*) and *Artemia* nauplii enriched with vitamins, minerals and fatty acids. The male made burrows a few days before spawning. At this time, the male chased the female and displayed "leading behavior," during which the male repeatedly approached the female, stopped and turned in front of her, then swam back to the chosen spawning site. This courtship behaviour lasted for an hour, after which the female followed the male into its burrow and spawning took place.

Spawning began 60 to 80 days after acquisition in to the broodstock tanks. Successive spawning was obtained at an interval of every 6 to 15 days in all the pairs. Spawning usually occurred during early morning and lasted for 1-2 h, during which the female gradually laid ball-shaped egg mass. During spawning the male remained inside the nest for most of the time but sometimes left the nest and the females for a short duration, until the female completed ova deposition. The deposited spherical egg ball with a diameter of 25 to 35 mm and consisting of 400-500 eggs, sank to the bottom of the nest. At this time, the male chased off the female and started taking care of the egg ball in the hiding place until hatching.

A single female released 400 to 500 eggs, which were inter-connected by fine threads. Size of the individual eggs varied between 1,743 and 1,919 µm. All the eggs were spherical in shape and transparent. The egg ball was, however, not attached to the substrata but remained free inside the burrow. During incubation, the egg ball was white/transparent on first and second day, subsequently turning dark with black spots on the 3rd day showing the eyes of the larvae and silvery on the 4th day due to the glittering eyes of the developing larvae inside the egg.

Hatching took place in the evening shortly after sunset on completion of 96 h of incubation at water temperatures of 26-28 °C, with darkness accelerating hatching. The larvae hatched almost synchronously within 1 h under darkness and the emerging larvae rotated in clockwise direction. The presence of male with the eggs ball presumably aided in accelerating the hatching process by agitating the eggs, and hatching percentage ranged from 91 to 95 %.

LARVAL REARING

The newly hatched out larvae ranged in length from 5.1 to 5.3 mm, having a very small yolk-sac and were positively phototactic. The body was transparent and the mouth gape measured 150 to 160 µm. First feeding started 10 to 12 h after hatching. Initially, the larvae were fed with enriched rotifer *Brachionus rotundiformis* and subsequently with *enriched B. plicatilis*, copepod nauplii and *Artemia* nauplii. By the 7th day, the larvae showed light red pigmentation and measured 8 to 9 mm. By the 14th day, the larvae reached a pre-settlement stage with a total length of 10 mm, and metamorphosed to juveniles in 35-40 days.

FOOD AND FEEDING

The species is carnivorous. In the wild, it feeds on small crustaceans, worms and zooplankton. In captivity, it is a ravenous feeder of all types of feeds, especially frozen (brine shrimp and krill) and fresh meaty foods. Larger species preferred large meaty items like pieces of scallop, shrimp and clams while smaller species preferred brine shrimp, mysis shrimp and other smaller foods. Flake food or pellet food was added to supplement its diet and to add more variety.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Hatchery produced and wild caught specimens are in high demand in export and import markets. The redhead dottyback is a species of keen interest in the marine aquarium trade. In India, the species is available in local markets at Rameswaram, Tamil Nadu and West Bengal.

CHALLENGES TO MARICULTURE

Redhead dottybacks are among the most popular cultured marine ornamental fishes, but issues related to pair formation and filial cannibalism has to be sorted out. The males are colourful and mainly used in trade thus the technique has to develop to produce more male population.

FUTURE PROSPECTS

It is ideal for reef aquariums. As its males are colourful than the females, males are selectively exploited from the nature for trade which is a threat to natural populations, thereby reducing its availability. Captive production is a potential solution for reducing pressure on the wild natural stocks. Successful captive breeding will relieve stress on wild populations and will reduce market prices making dottybacks more affordable to hobbyists.

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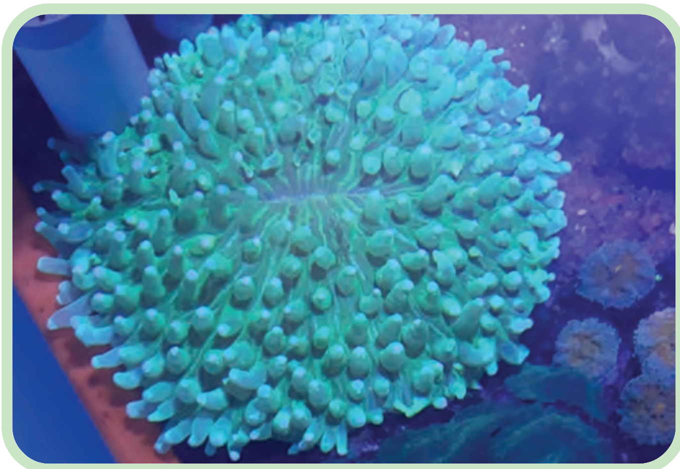
Entacmaea quadricolor (Leuckart in Rüppell & Leuckart, 1828)

Rema Madhu, K. Madhu and Pralaya Ranjan Behera

IDENTIFICATION

Order	:	**Actiniaria**
Family	:	**Actiniidae**
Common/FAO Name (English)	:	**Bubble tip anemone**

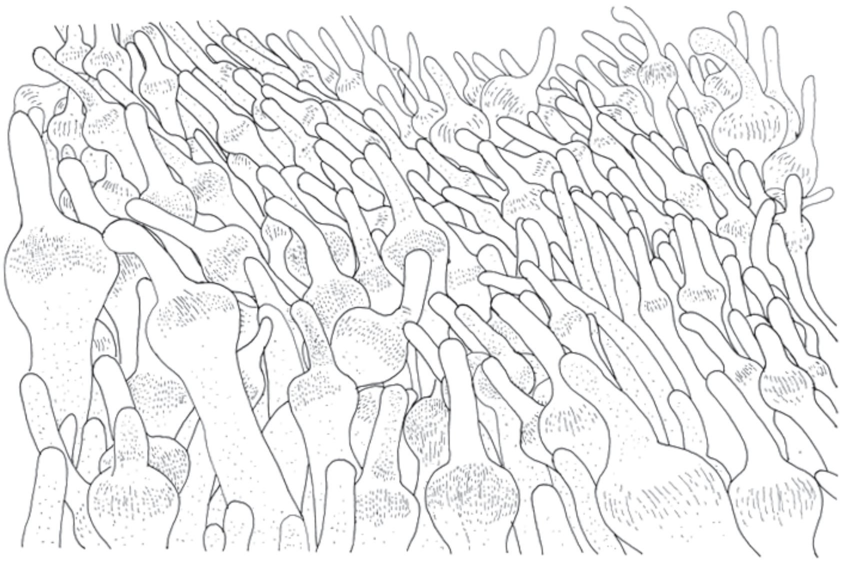


Local names: Not available

MORPHOLOGICAL DESCRIPTION

The bubble tip anemone is usually attached deeply in crevices or hidden in holes in reef, such that only the emergent tentacles are visible. Each tentacle is brown in colour and inflated near the end, with a white band near terminus, commonly with a red tip. Column is brownish to pinkish in colour and is smooth; oral disc broader than pedal disc. Column is without verrucae; gradually flared from the small pedal disc. Oral disc is brown in colour, same as tentacles. Tentacles collapse when disturbed.

Source of image : Mariculture Division , CMFRI , Kochi



PROFILE

GEOGRAPHICAL DISTRIBUTION

The bubble tip anemone is widespread throughout the tropical waters of the Indo-Pacific area, Micronesia and Melanesia to east Africa and the Red Sea and from Australia to Japan. In India, it has also been reported from Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

Large adults are found in dimly lit, deep waters where they are often solitary. Smaller young specimens are found in shallow, well-lit areas in groups. Bulbous tips on tentacles are seen in juveniles whereas adults have more stringy tips. The tips of the anemones are not bulbous, as long as it does not host the fish. It is semi-aggressive as it is mobile, although a contented bubble tip anemone will stay put once it has found a place to settle.

It reproduces asexually using longitudinal fission, when it splits in half from the foot or mouth to form a clone. Fission is brought about by stretching in opposite directions, thinning of tissue and final tearing perpendicular to the axis of stretching. It is also reported to mouth brood, wherein it broods the embryos for a few days in the oral cavity before releasing them back into the water. This activity supplies the embryos with their first zooxanthellae. When released, the embryos (planula) float and then connect and become a fully formed anemone.

The newly spawned eggs average 794 µm in diameter, and are covered by microvillus distributed over the egg surface, except for a single bare patch. Eggs contain abundant zooxanthellae. Fertilization is external and after cleavage and several steps forms the ciliated planula larva. Larval movement is first observed 36 h after spawning. Larval survival remains high during the first 4 days after spawning, and then decreases rapidly.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Entacmaea quadricolor has been bred in captivity. Anemones collected from subtropical reefs in the solitary Islands Marine Park, eastern Australia, were monitored in outdoor flow-through seawater tanks from 2003 to 2005. Sexually reproductive anemones were either male or female. The adults released their gametes synchronously into the water where the eggs were fertilized and further development occurred. Males generally began spawning prior to females. The synchronous nature of gamete release indicates similar responses in males and females to external factors like seawater temperature, photoperiod and lunar cycles.

Asexual propagation using fragmentation is widespread for its culture. It is propagated by cutting into halves or quarters. Anemones that are cut in half are larger in size, heal and grow quicker than those cut in quarters. Survival rate is higher (ranging from 89.3 % to 93.8 %) when the individuals are cut in halves. Even though, survival is lower (ranging from 62.5 % to 80.4 %) when the individuals are cut in quarters, it produces the greatest number of anemones. Feeding increased the oral disc growth and reduced wet weight loss, but did not significantly influence the growth of pedal disc.

LARVAL REARING

The embryos develop into early planulae about 14 h after spawning. Early larval stages are round to pear-shaped with a greenish-brown colour due to the presence of zooxanthellae. As the larvae develop, they elongate along the oral-aboral axis. Considerable variation in shape of larvae can be seen. Colour also changes to orange-brown. Larvae occasionally release mucus-like material from their oral pore. Survival of planulae is initially as high as 91.3 % at 4 days of age. However survival rate falls to as low as 21.9 % by the time of metamorphosis.

FOOD AND FEEDING

The bubble tip anemone is carnivorous in nature. In the wild, it derives its daily nutrition from its symbiotic algae, zooxanthellae, that dwells within its tissues. Nutrients are also obtained by filter feeding, using its sweeping tentacles to absorb nutrients from the water, or through wastes and debris cleaned from the surface of its resident partner clownfish. It also uses its venomous cells or nematocysts found in its tentacles to sting and capture prey. In captivity, it can be fed with chopped silversides, shrimp, krill, mussels and fresh fish as well as with frozen carnivore preparations, 2 to 4 times a week.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

It is difficult to diagnose symptoms and corresponding diseases in anemones. Insufficient light and insufficient feeding are detrimental for it.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Anemone fishes and their host, sea anemones, form the most recognized symbiotic association in reef environments, and hence are highly sought after in the marine aquarium trade. The beautiful sea anemone, costing about US $ 29 depending on size and colour, is collected for the live aquarium trade. These host anemones represent high-value species for collectors and are often preferentially harvested.

CHALLENGES TO MARICULTURE

Although spawning and hatching have been achieved in captivity, the major obstacle to successful mariculture of the species is rapid decrease in survival of planula larvae after 4 days of spawning.

FUTURE PROSPECTS

Sea anemones that host symbiotic anemone fishes are very much in demand in the aquarium trade. The development of reliable and cost-effective methods for culturing anemones would ensure a steady and sustainable supply to the industry without damaging natural coral ecosystems.

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Labroides dimidiatus (Valenciennes, 1839)

B. Santhosh and Biji Xavier

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Labridae**
Common/FAO Name (English)	:	**Blue streak cleaner wrasse**

Source of image : RC of CMFRI, Vizhinjam

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Blue streak cleaner wrasse is one of the most important and popular species of ornamental fish widely distributed in the natural waters of tropical countries. It is commercially valuable both as ornamental fish and for controlling ectoparasites. These are small fishes of about 9-14 cm size with blue to yellow colour dorsally, fading to white or yellow ventrally. There is a black stripe running from the eye to the caudal fin margin which widens posteriorly. Dorsal fin has 9 spines and 10-11 soft rays and anal fin has 3 spines and 10 soft rays. Maximum size reported is 17 cm.

PROFILE

GEOGRAPHICAL DISTRIBUTION

This is a widely distributed species commonly found in the rocky areas and coral reefs in tropical marine waters of the Indo-Pacific region from southern and eastern Africa and the Red Sea to the Tuamotus in the south Pacific and from southern Japan to the southern Great Barrier Reef and south-western Australia between 30° N - 30° S.

HABITAT AND BIOLOGY

Cleaner wrasse usually dwells in nearshore area within a depth range of 1-40 m and temperature range of 24-28 °C. It is reported to be a monandric hermaphrodite but later it was confirmed to have socially controlled sex reversal. The species lives in small groups with one male and few females. Males are larger and more dominant than all females. This small group forms a cleaning station where all other fishes visit for cleaning themselves. They are quick and agile swimmers which can leap through narrow crevices and also through the mouth and gill opening of larger fishes. These fishes show diurnal behaviour and in night they burrow themselves (for sleeping) till day light.

Cleaner wrasse is mainly carnivorous and feeds on external parasites. In tanks they can be fed with bivalve or crustacean meat. Spawning of this species is reported from Japan. Spawning season is from May to September. Eggs are spherical and will hatch within 30 h and larvae are 1.8 mm in size. They exhibit mating dance during courtship. Eggs and larvae are planktonic. Largest observed total length is nearly 11 cm. Individuals above 6 cm were observed to spawn. Sex change from female to male usually takes place before they are 3 years old.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

There are few reports stating incidental breeding of this species. Bi-directional sex change has been confirmed for this species. Distinct pairing during breeding has been observed. They are pelagic spawners. Sex reversal is completed in 14-18 days. It is a monandric species, with sex change at approximately 8.8 cm total length. Artificial breeding and commercial rearing of these are yet to be undertaken. There exists a huge demand for this species in the ornamental fish culture industry which is now met from wild collection which has reduced the population of this species in the wild. This species can be grown along with other cultured fishes in cages and pens to reduce the parasitic load.

Reports are available from Japan on spawning. Spawning in *L. dimidiatus* included a pair of male and female living within the male's territory. After the sequence of courtship displays, the pair rushed upward a few meters off the bottom, where eggs and sperm were released free into the water. Spawning occurred mostly at the offshore fringes of the reef in a male's territory. The eggs were buoyant, colourless and spherical measuring 660-690 µm in diameter, and contained numerous oil globules which joined together later. The egg membrane was smooth, without any conspicuous structure, the yellow not segmented and the perivitelline space narrow.

LARVAL REARING

Hatching took place 29-30 h after spawning. The newly hatched larvae measured 1.78-1.81 mm total length. The larvae were provided with *Brachionus plicatilis* as food.

FOOD AND FEEDING

Cleaner fish of all sizes mainly feed on gnathid isopod juveniles. Other items in their diet include scales, parasitic copepods and non-parasitic copepods. The number of gnathid isopods and scales in the diet increases with the size of the fish. Juveniles feed mostly on non parasitic copepods.

GROWTH RATE

During summer and autumn, juveniles grow very rapidly, whereas, in winter, growth is very less. Adults grow slower than juveniles.

DISEASES AND CONTROL MEASURES

The cleaner fishes control the parasites of other fishes. Practically, no information is available on the diseases affecting this species in the wild. In ornamental fish culture tanks, disease incidents are very less for this species. It is ideal for keeping in broodstock tanks for controlling external parasites of large brood fishes.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

There is good market demand for this species, which presently is being met from wild collections. The fishes are often caught by divers using small scoop nets and are transported in oxygen packed polythene bags. Nearly 87,000 numbers of *Labroides dimidiatus* has been imported worldwide from 1997-2002. Labridae contributes 6 % to the global trade and major countries which import are EU and United States.

CHALLENGES TO MARICULTURE

This species can be grown along with other cultured fishes in cages and pens to reduce the parasitic load, provided the habitat is supplemented with rocky areas or coral reefs. Basic research needs to be done in India. Attempts are being undertaken in many countries for standardising the technology of captive breeding and larval rearing.

FUTURE PROSPECTS

There is a very high demand for this species in the ornamental fish industry. If standardising the technology for captive breeding and larval rearing is successful, it will pave the way for India to contribute higher quantities of *Labroides dimidiatus* to the internatitional ornamental fish trade.

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Platax teira (Forsskål, 1775)

Rema Madhu and K. Madhu

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Ephippidae**
Common/FAO Name (English)	:	**Longfin batfish**

Source of image : CMFRI, Kochi

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Body is deep and compressed; body depth is 0.9-1.2 times standard length of fish. Juveniles are also deep bodied with very long pelvic fins and long anal and dorsal fins (which shorten on becoming adults). Fins are elevated in both adults and juveniles. The fish is covered with small, ctenoid scales. It has a terminal mouth with bands of tricuspid teeth. Adults are silver-grey in colour, with a dark band through the eye extending to origin of pelvic fin and from base of dorsal fin origin to belly. A black blotch may be present at the terminus of the second band. A small black vertical streak is often present at origin of anal fin. Median fins are with black margins posteriorly. Five pores are on each side of lower jaw. Preopercle is smooth and opercle is without spines. Dorsal spines (total): 5-6; dorsal soft rays (total): 28-37; anal spines: 3 and anal soft rays: 22-28.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Platax teira is distributed in tropical and subtropical waters of the Indo-West Pacific region from the Red Sea to South Africa, Japan (Hokkaido), Taiwan Province of China, Philippines, Indonesia, New Guinea, northern Australia and Melanesia. It is also reported from Bay of Islands, New Zealand and Persian Gulf.

HABITAT AND BIOLOGY

Adults are found in sheltered bays, offshore areas, lagoons and seaward reefs. Juveniles are found associated with floating debris and also in shallow reefs. These fish are found in small shoals around shipwrecks. Young fish are usually seen hovering under coral heads or in the shadows of boat moorings. *Platax teira* grows to more than 45 cm in length. It is an omnivore, feeding on plankton and marine algae, invertebrates (small, sessile and benthic) and finfishes and shellfishes (*Nemipterus* spp. and *Penaeus* spp.).

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Though they are known to be pelagic spawners, detailed information is lacking about the reproduction of this species and they have not been bred in aquariums, neither is there any information on sex differentiation.

LARVAL REARING

There have been attempts of larval rearing from Australia for studying the species specific behavioural ontogeny to gain an insight into the dispersal of the larvae. However, a detailed report on larval rearing is lacking.

FOOD AND FEEDING

This species readily accepts a meaty diet of crab meat, mussels, shrimp and scallops. Supplementing the meat diet with brine shrimp and vegetables is also recommended. It should be fed at least 3 times a day.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Monogenean parasite, *Sprostoniella teria* sp. nov. was reported from gill filaments of this fish in the Gulf of Arabia. Digenetic trematode *Multitestis bengalensis* has been reported from this species. Other digeneans reported are *Neomultitestis aspidogastriformis*, *M. magnacetabulum* and *Diploproctodaeum* rutellum. Parasitic copepods namely, *Caligus rotundigenitalis*, *Anuretes anomalus*, *A. branchialis* and *A. plataxi* have been reported from this species from Taiwan.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Kwun Tong in Hong Kong is the largest wholesale market for *Platax teira*.

CHALLENGES TO MARICULTURE

Basic research involving broodstock development and larval rearing needs to be initiated.

FUTURE PROSPECTS

Platax teira is a very peaceful and social fish and form schools with others of their species. Hatchery production for trade can be practiced once captive breeding and larviculture techniques are standardized. Since it is a popular fish in ornamental fish industry this would be a good income earner for farmers.

SUGGESTED READING

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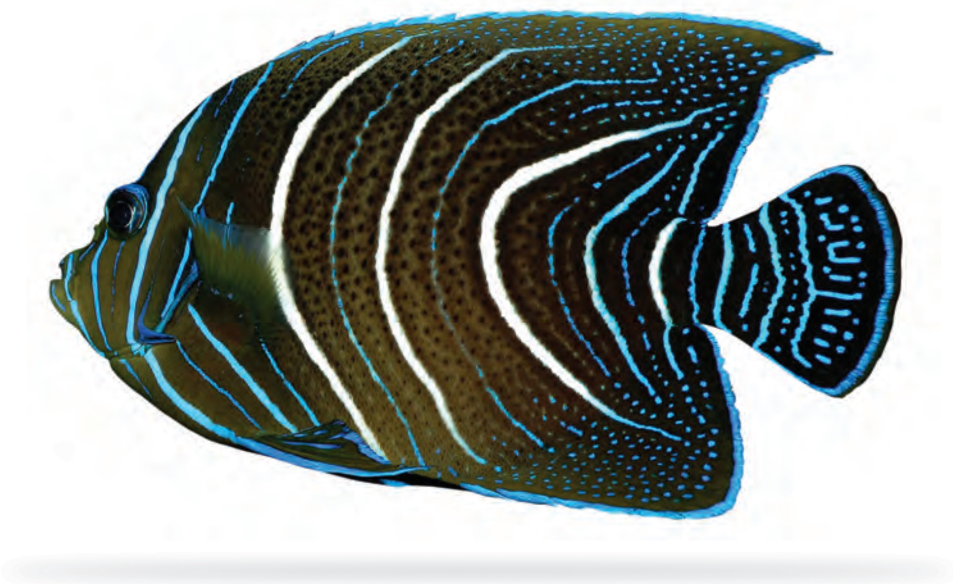
Pomacanthus semicirculatus (Cuvier, 1831)

K. Madhu, Rema Madhu and Biji Xavier

IDENTIFICATION

Order	:	**Perciformes**
Family	:	**Pomacanthidae**
Common/FAO Name (English)	:	**Semicircle angelfish**



Source of image : www.malawicichlidhomepage.com

Local names: Alla fish (**Tamil**); Lola thiratta (**Malayalam**)

MORPHOLOGICAL DESCRIPTION

The body of this fish is deep and compressed. This species has spectacular colouring both as juveniles and as adults. As juveniles of 3 inches or lesser sizes, the fish is dark coloured with brilliant white and blue stripes running vertically on the body. The stripes become semi-circular at the base of the body lending the epithet "Semicircle angel" to this fish. As the fish grows the bands fade out. During this period, dark blue banding near the tail turns to a pattern resembling the Arabic script, which gives rise to the name, Koran Angel. Adults become lighter in colour becoming golden-green in colour and develop blue and black speckles on the body. The fins, except for the pectorals, are rimmed in blue. The dorsal fin has 13 spines and 20-23 soft rays and the anal fin has 3 spines and 18-22 soft rays. Both these fins have filaments that trail behind as the fish swims. The pectoral fins are pale yellow and have 19-21 soft rays.

PROFILE

GEOGRAPHICAL DISTRIBUTION

It is widely distributed throughout the Indian Ocean and western Pacific Ocean from Red Sea to east coast of Africa to Japan, Fiji , the east coast of Australia and New Caledonia. In India it has been reported from Lakshadweep Islands, Tamil Nadu coast including Gulf of Mannar and the Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

The semicircle angelfish is found in protected coral reefs up to depths of 25 m. Juveniles prefer shallow reefs with some sandy substrate. Koran Angelfish is an omnivore. In the wild, it subsists on benthic algae/weeds, sponges, tunicates, ascidians, coral polyps, worms, crustaceans, molluscs, shrimps and other shellfishes. Adult angelfish develop a dependence on sponges. For juveniles, bulk of the diet is made up by algae and tiny animals that live among the algae.

In the wild, adults grow to 40 cm. The Koran Angelfish is an egg-scatterer, broadcasting both eggs and sperm simultaneously at dusk. Courtship includes coming together of the mating pair which then rises up in the water and broadcasting the eggs and sperm near the top surface of the water. Both males and females may mate with several others in the same evening. On spawning, the female releases 10,455 eggs which range from 570 to 640 µm diameter. Fertilized eggs are planktonic for first few weeks and later adopt a demersal habit on becoming fry.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Natural spawning in captivity was reported in 2006 in Taiwan. Brooders of size 35-40 cm total length (TL) were maintained in 30 t tanks with recirculation system. Salinity was maintained between 30-33 g/l and temperature between 21.8-31.7 °C. The fish were fed krill, squid, carangids, scombrids and marine algae (*Caulerpa racemosa*) at 3-5 % of body weight per day. Photoperiod was maintained at 12 light h and 12 dark h. During spawning, a male-female pair was observed; both sexes foraged solitarily, with minimal social interactions. Overt territoriality between the two individuals was noticed. Female fish released approximately 10,455 eggs per fish during the spawning event. Fertilized eggs of *P. semicirculatus* were transparent, spherical and pelagic, measuring 570-640 µm in diameter, and having a narrow perivitelline space, a clear and unsculptured chorion, a homogeneous and unsegmented yolk and a single oil globule measuring 160-180 µm in diameter at the vegetal pole. Most eggs hatched out within 18-21 h with incubation at 28.5 °C.

LARVAL REARING

Newly hatched larvae of the Koran angelfish measured 1.32-1.40 mm total length. Feeding the larvae with *Nannochloropsis* sp. along with *Gonyaulax* sp. and *Brachionus rotundiformis*, led to larval survival up to 17 days. Live feed was given twice a day. Water was kept almost static with very little aeration up to 10 dph. Water exchange at 10 % daily rate was started after 10 dph. During larval rearing temperature ranged from 26-28.2 °C, salinity 33.2-35 g/l, DO 5.62-8.09 mg/l and pH ranged from 7.85-8.25. In another study in Florida, USA it was found that *P. semicirculatus* reaches metamorphosis in 20-25 dph. In this particular study, it was observed that among a mix of live feeds, the most preyed upon one was the nauplii of the calanoid copepod *Parvocalanus crassirostris*, during first feeding. During first feeding larvae were of 3 mm size and grew to 4 mm by 7 dph. Thus the use of marine copepod nauplii or wild plankton containing an abundance of copepod is suggested for improving the initial feeding performance of this species.

FOOD AND FEEDING

In the wild, it feeds on algae, tunicates and sponges found on coral reefs. In captivity, a varied diet consisting of *Spirulina*, marine algae, and mysis or frozen shrimp is offered at least three times a day.

GROWTH RATE

Information not available

DISEASE AND CONTROL MEASURES

Koran Angelfish is not quite as sensitive as other *Pomacanthus*, but still needs a calm environment so as to not stress the fish, which could make them prone to disease.

Disease/causative agent	Control measures
White Spot Disease/*Cryptocaryon irritans*	Metronidazole (antibiotic) added to the water or mixed with the feed and fed to the fish 3 times a day for at least a week or until symptoms are gone Coppersafe, Quick-Cure
Velvet Disease/*Oodinium ocellatum*	Coppersafe, Quick-Cure

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Pomacanthus angel fishes are one among the most highly prized of the coral reef fishes containing 8 genera and 82 species worldwide. The Koran Angelfish *Pomacanthus semicirculatus* is a popular and very impressive species in marine aquariums world over. *Pomacanthidae* contributes 8 % to the global trade and the major importer is European Union.

CHALLENGES TO MARICULTURE

The major obstacle to successful mariculture of Koran angelfish is poor larval survival. Hence further research is warranted into larval rearing. Since copepod nauplii are a major requirement for initial feeding of this species, a protocol has to be developed for culture of suitable copepods.

FUTURE PROSPECTS

The Koran angelfish is a popular aquarium fish which can be handled easily by novices also, as compared to other species of angelfishes. Since the fish needs larger tanks for proper growth, it is a good candidate for corporate aquariums.

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Pseudanthias squamipinnis (Peters, 1855)

K. K. Anikuttan, A. K. Abdul Nazar, G. Gopakumar and Biji Xavier

IDENTIFICATION

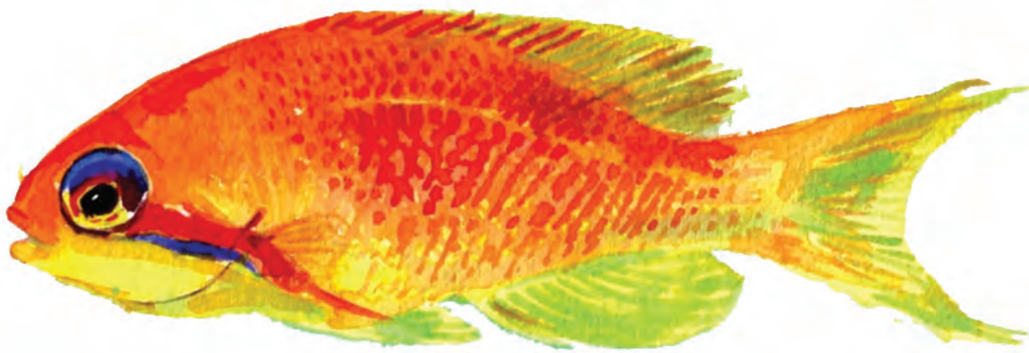
Order	:	**Perciformes**
Family	:	**Serranidae**
Common/FAO Name (English)	:	**Sea goldie**

Source of image : CMFRI, Kochi

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Dorsal spines (total): 10; dorsal soft rays (total): 15-17; anal spines: 3; anal soft rays: 6-7. Females characterized by violet-edged orange stripe behind eye and prolonged third dorsal spine. In males, the fleshy protuberance at front of upper lip is absent. Males are with elongated third dorsal spine and lunate caudal fin.



PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is distributed in the Indo-West Pacific region from Red Sea and Natal, South Africa to Niue, north to southern Japan and south to western Australia, New Caledonia, Lord Howe Island and Tonga.

HABITAT AND BIOLOGY

Adults form large aggregations and are found above coral outcrops or patch reefs of clear lagoons, channels, or outer reef slopes. The fish is known to be active in coral reefs during daytime and going into hiding in rocky crevices during night. The species is known to form stable social groups with a sex ratio of eight adult females to a single adult male. The sea goldie is a protogynous hermaphrodite and females can be made to convert to males by removal of male fish from the species aggregation. Removing a male from the social group induces the largest female fish to change into a male. Males are territorial and tend to stay within the same social group. Colour patterns of male and female fish are quite different. Female fish is orange-gold in colour with a violet strip running from eye to base of pectoral fins. Male fish on the other hand, are more reddish, with a dark reddish-brown strip running from eye to pectoral fin base. On sexual transformation from female to male, the fish also changes colour. It feeds on zooplankton. The fish is known to spawn daily during 9-10 months of the year. The eggs and larvae are planktonic which settle on to coral reefs on metamorphosis. This species is known to colonize artificial coral reef systems.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

FOOD AND FEEDING

Information not available

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Serranidae family contributes 2 % of the global marine ornamental fish trade. Maldives and Saudi Arabia are the major exporters of *Pseudanthias squamipinnis*. Globally 10,892 fishes were exported and 23,134 fishes were imported during 1997-2002. The European Union is the major importer of this species.

CHALLENGES TO MARICULTURE

Trade is mostly dependent on wild stocks. Breeding in captive conditions has not been reported so far. Hence, breeding, larval rearing and nursery rearing need to be standardized.

FUTURE PROSPECTS

This species is known to colonize artificial reefs. Hence such areas can become good grounds for broodstock retrieval till captive breeding is standardized. Being a high-frequency spawner, this species has good prospects of being cultured in captive conditions.

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Lysmata amboinensis (de Man, 1888)

B. Santhosh, M. K. Anil and Biji Xavier

IDENTIFICATION

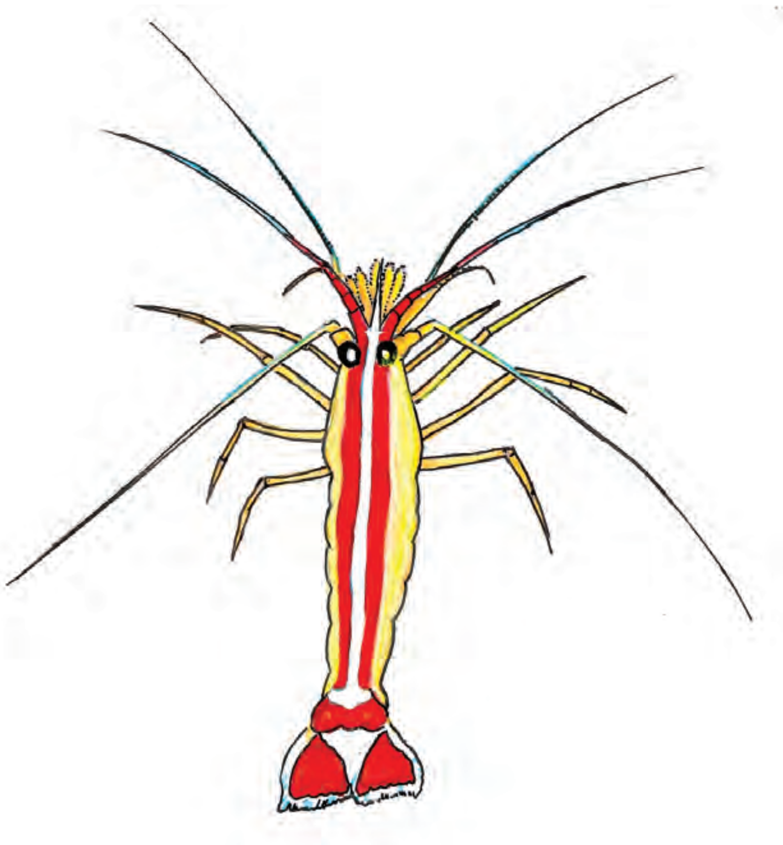
Order	:	**Decapoda**
Family	:	**Lysmatidae**
Common/FAO Name (English)	:	**Pacific cleaner shrimp**

Source of image : RC of CMFRI, Vizhinjam

Local names: Not available

MORPHOLOGICAL DESCRIPTION

The Pacific cleaner shrimp is easily identified by its colour patterns. The body is light brown with one white band dorsally and two red bands laterally running longitudinally. The tail has two white spots on either side. The antennae are white in colour and the first pair has red coloured base. It grows up to a maximum of 6 cm.



PROFILE

GEOGRAPHICAL DISTRIBUTION

Scarlet cleaner shrimp or Pacific cleaner shrimp is one of the most popular species of ornamental crustaceans distributed in the waters of the Indo-Pacific region in Indonesia and Sri Lanka.

HABITAT AND BIOLOGY

It is one of the popular marine shrimp, associated with coral reefs and compatible with smaller sized marine ornamental fishes. It hides in the near shore, shallow and protected areas within a temperature range of 25-30 °C. In the Indo-Pacific areas and the Red Sea, it is mostly found in caves and crevices of coral reefs. It especially needs shelter from predators when it is moulting. It is an omnivore and a scavenger and often feeds on the external parasites of fishes. As its name indicates, this species cleans fishes including moray eels and groupers feeding on their external parasites as well as on mucous and dead or injured tissue. The shrimp moults once every 3-8 weeks and spawns regularly every 2-3 weeks. *Lysmata amboinensis* is a protandrous simultaneous hermaphrodite, i.e. individuals start out as males (with ovo-testis, producing only sperm) but later convert to females with a functional ovo-testis, which can produce both eggs and sperm. However it is unable to self-fertilize or store sperms. Thus in the functional female phase, one individual of the mating pair acts as male (contributes sperm) and the other acts as female. The eggs (greenish in colour) are held in their brood pouch for 10-15 days and newly hatched larvae are released to the environment. The larvae are planktonic and metamorphose into juveniles within a period of 5-6 months.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

The Tropical Marine Centre (TMC) of the United Kingdom is actively engaged in breeding of *L. amboinensis* and *L. debelius*. Pair formation is easy because of their less aggressive behaviour and most adults are simultaneous hermaphrodites, therefore almost any two will do. There is no sperm storage in *Lysmata*, so cross fertilization is required. Each female produces several hundred to 2,000 eggs during each spawn and carries the embryo under abdomen until they hatch 10-15 days later. The colour of the egg mass gradually changes and eye spots appear 4-5 days before hatching. Within 12 h after hatching, the adult shrimp will moult, mate and spawn again. Male shrimp can mate anytime during the inter-moult, once within 24 h. In *L. amboinensis*, paired shrimp synchronize their moult cycles in staggered fashion, such that individuals alter sexual roles. The broodstock were fed with mussel, polychaetes and *Artemia* nauplii. In another study in Mexico, a continuous reproductive cycle was observed in captivity for the species, with an average of 575 larvae per spawn per animal being produced in the hatchery.

LARVAL REARING

In *Lysmata amboinensis* the larval duration is for 140 days. Nursery rearing has been tried with rotifer and *Artemia*. Reports state that supplementing a nutritionally superior commercial diet to *Artemia* nauplii significantly reduces the moulting time, hence shortening the larval duration and increasing the survival. *L. amboinensis* has complicated metamorphosis phases and requires appropriate settlement cues in captive rearing. The study from Mexico reported that *L. amboinensis* larvae were facultative primary lecithotrophes, i.e. instead of relying solely on yolk, they are able to ingest external food within 24 h of hatching. Feeding the larvae with microalgae such as *Tetraselmis chuii*, within few hours of hatching, stimulates enzyme production and digestion. Enriched rotifers during first 3 days results in better larval growth and thereafter feeding them with *Artemia* or nematodes promotes their further growth. Rotifers should be given at densities of 35-50 nos./ml for larvae stocked at 10 nos./l.

FOOD AND FEEDING

The Pacific cleaner shrimp is omnivorous and generally a scavenger, eating parasites and dead and injured tissues of fishes. It even cleans the inner surface of the mouth and gill cavity of fishes, without it being eaten.

GROWTH RATE

In a study conducted in Australia, the species was reported to increase in total length by 7-11 % over 4 months, while being fed at 3.5 % of body weight per day.

DISEASES AND CONTROL MEASURES

Cleaner shrimp controls the parasites of other fishes. Practically no information is available on the diseases affecting this species in the wild, except for one report of bopyrid parasite infecting this shrimp.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

This is one of the highly priced ornamental shrimp and there is good market demand at present, which is being met from wild collections. The species is caught by divers using small scoop nets and transported in oxygen packed polythene bags. Globally a total of 1,07,462 numbers were exported during 1998-2003 and 2,88,484 numbers were imported during 1988-2002. USA (35 %) and Taiwan (22 %) are the major exporters and USA (80 %) and UK (15 %) are the major importers of marine ornamental invertebrates.

CHALLENGES TO MARICULTURE

Broodstock development, domestication and larval rearing of *Lysmata amboinensis* needs to be initiated and standardised in India. The larval cycle has not been fully understood for this species which is a challenge to culturing this species in captivity. The long larval duration and low survival of larvae is also a challenge to be overcome.

FUTURE PROSPECTS

Being a valuable and in-demand marine ornamental decapod, culture of *L. amboinensis* should be promoted. Being a decapod, broodstock maintenance is easier than that of marine fishes and can be carried out on a large scale, utilizing the present network of shrimp hatcheries in the country.

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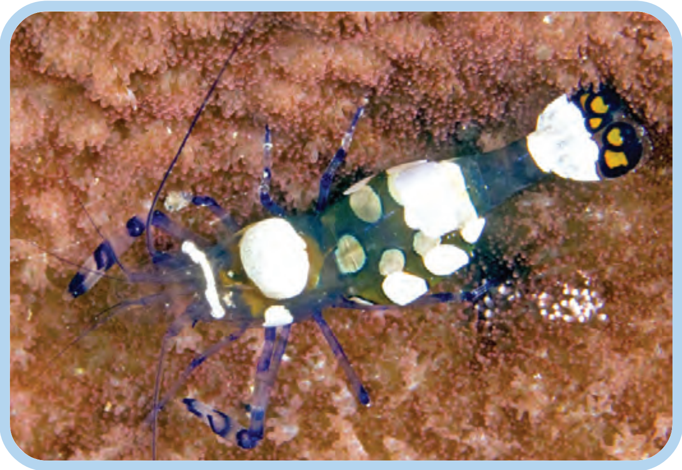
Ancylocaris brevicarpalis Schenkel, 1902

Joe K. Kizhakudan and Biji Xavier

IDENTIFICATION

Order	:	**Decapoda**
Family	:	**Palaemonidae**
Common/FAO Name (English)	:	**Glass anemone shrimp**

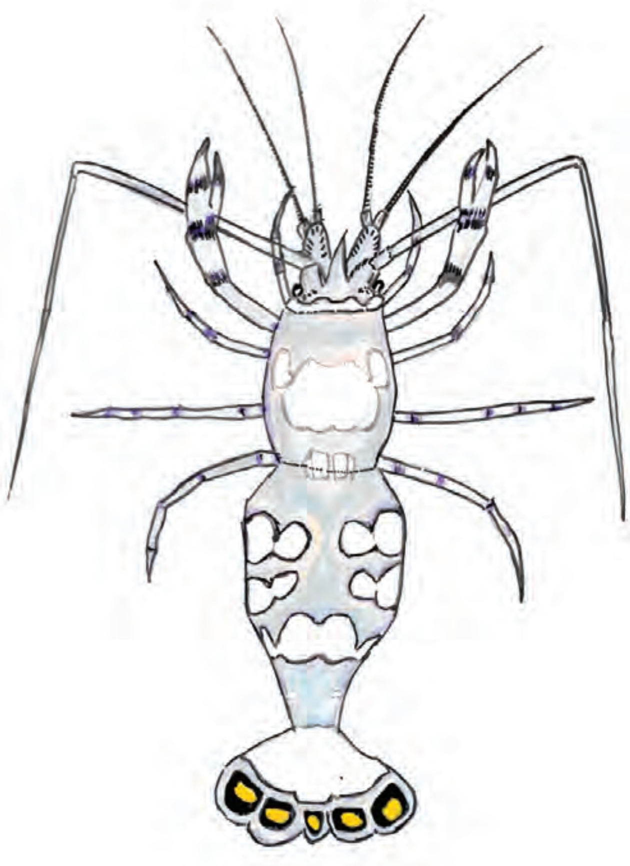


Source of image : www.casc.it

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Body is almost transparent, with some white spots over carapace and tail, and five orange spots outlined in black over the caudal fin. Since the entire body is transparent it provides a clear view of the internal organs like the hepatopancreas, central nervous system and alimentary system. The colour of hepatopancreas keeps changing with the status of nourishment and gonadal maturation. There is violet colouration at the joints on the legs and 5 spots on the uropod and telson, which are typical to this shrimp. Males are larger than females and have more white spots.



PROFILE

GEOGRAPHICAL DISTRIBUTION

This species is distributed in the tropical realms of the Indian and the Pacific oceans, from Mozambique to Japan, Australia and Papua New Guinea. In India, they have been reported from the south-east coast.

HABITAT AND BIOLOGY

Ancylocaris brevicarpalis lives in association with sea anemones and sea cucumbers, hence the name anemone shrimp. The anemone secretes a mucous which gets coated on the shrimp's body thereby preventing it from getting stung by the anemone. The shrimp also takes on the colouration of its host anemone or sea cucumber. During molting the shrimp hides from its host and once the exoskeleton forms it moves to the host to cover itself with the mucous again. In the absence of anemones and sea cucumbers as hosts, it lives symbiotically with mushroom corals, bubble corals and jelly fish. The anemone shrimp is found in coastal waters from 1 to 27 m in depth.

It is an omnivore, eating detritus and meaty bits of seafood. In the absence of food in its vicinity, the shrimps venture out in search of food or else, it eats the food of the host anemone. Members of the order Decapoda are mostly gonochorist. Their mating behaviour commonly reveals precopulatory courtship ritual (through olfactory and tactile cues), with usually indirect sperm transfer.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Larval development of *Ancylocaris brevicarpalis* with wild captured ovigerous females was studied in University of Ryukyus, Japan. A total of 300 larvae were observed to hatch from one female. Nine zoea stages and one decapodid stage was identified before they moulted to the first juvenile stage. The decapodid stage was reached in 18 days and first juvenile in 20 days at water temperatures of 27.4-28 °C. Newly hatched *Artemia* nauplii were fed to the larvae and the first juvenile stages.

FOOD AND FEEDING

Information not available

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

It is the most popular anemone shrimp species in the marine ornamental fish industry. Hence trade prospects are very high and they are valued at ₹ 1000-2000/individual.

CHALLENGES TO MARICULTURE

The major researchable issues related to *Ancylocaris brevicarpalis* are to develop protocols for domestication and development of broodstock and its captive breeding. Larval rearing protocols also need to be developed in India.

FUTURE PROSPECTS

Domestication, captive breeding and hatchery technology establishment for mass scale seed production of this species will augment the trade of this high-valued ornamental shrimp, thereby providing the Indian fish farmer with better economic prospects.

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Petrarctus rugosus (H. Milne Edwards, 1837)

Joe K. Kizhakudan and Biji Xavier

IDENTIFICATION

Order	:	**Decapoda**
Family	:	**Scyllaridae**
Common/FAO Name (English)	:	**Hunchback locust lobster**

Local names: Kal madakka erral (**Tamil**)

MORPHOLOGICAL DESCRIPTION

Carapace surface is very uneven with raised tubercles. There are few tubercles and many smooth areas between the post rostral and branchial carinae. The abdomen shows a distinct median longitudinal carina. Somite 1 is quite smooth, and has the transverse groove slightly noticeable in the extreme lateral parts. The exposed part of the following somites shows no arborescent pattern, but in each somite there is a wide transverse groove. The species is characterized by a smooth broad ridge before and after the transverse groove on somite 2. In the subsequent somites, these ridges are tuberculate. In somites 4 to 6, the posterior margin is tuberculate. The fourth antennal

Source of image : RC of CMFRI, Chennai

segment has a row of tubercles and a sharp and highly oblique median carina. The outer margin of the segment has 4-5 teeth and the inner margin has 5-7 teeth of different sizes. The anterior margin of the thoracic sternum is U-shaped. Thoracic sternites have a rounded median tubercle. Body is greyish or purplish brown in colour with dark spots. The distal segment of the antenna is often lighter. The first abdominal somite is dark blue colour dorsally.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Petrarctus rugosus has been reported from east Africa, specifically from the Red Sea to Mozambique, including northern Madagascar, Comoros and Socotra; the south China Sea, from Taiwan to the Philippines and Indonesia and also from Malaysia, Thailand, Cambodia, Vietnam and China; off northern Queensland, Australia; Pondicherry and Tamil Nadu, India.

HABITAT AND BIOLOGY

It is found to occur between 20 and 60 m, and also occasionally at 100 to 200 m depths. It prefers muddy or sandy substrates that can contain coral, shell grit or rubble. Their length ranges from 2.5 to 6 cm (males and females); with ovigerous females between 3-6 cm.

BREEDING IN CAPTIVE CONDITIONS

Captive breeding of *Petrarctus rugosus* was achieved at the National Institute of Oceanography, Chennai, India. Adult *P. rugosus* (9 females and 5 males) were stocked in 1 m^3 FRP tank with sand covering half the bottom. They were fed @ 5 % body weight with live marine clam meat (*Donax cuneatus*) and green mussel (*Perna viridis*). Mating usually occurred at night, followed by spawning. Newly spawned eggs were yellow-orange and changed to dark orange before hatching. Repetitive breeding was achieved. Number of eggs in a single brood varied from 2,747-22,619 and fecundity ranged from 4,117-39,518. The brooding period varied from 11-17 days with hatching rate ranging from 0-88 %.

LARVAL REARING

First three instars were fed with freshly hatched *Artemia* nauplii (6 nauplii/ml). A combination of feeds (*Artemia* nauplii with frozen Cyclop-eeze and shrimp post larval pellets) was added along with live clam meat (*Donax cuneatus*) and green mussel ovary (*Perna viridis*) one after the other, from fourth instar onwards. Survival was 100 % up to instar III, 50 % up to instar IV, 25 % up to instar VI and 17% up to instar VIII. Larval development of *P. rugosus* was completed within 51 days. Research at Madras R. C. of CMFRI on larval rearing revealed good success with *Artemia* nauplii bioenriched using cod liver oil and freshly extracted sardine oil. Shortening of inter-moult period between various larval stages was a significant feature of larval rearing at CMFRI.

FOOD AND FEEDING

Lobsters preferably accept shellfishes, mussels, soft clams and chopped trash fishes. Lobsters being nocturnal in feeding habit, food should be supplied at dusk.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Tail fan necrosis and shell disease reported from the species was due to unhygienic conditions of the tank bottom, poor water quality and improper sanitation in the culture facility. Gaffkemia reported during fattening in indoor systems was also due to poor water quality.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Information not available

CHALLENGES TO MARICULTURE

More research is required to standardize the broodstock development protocol and for larval and nursery rearing of *P. rugosus*.

FUTURE PROSPECTS

Standardization of technology for mass scale seed production of *P. rugosus* for marine ornamental culture will go a long way in enhancing the ornamental trade of this species.

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Heteractis magnifica (Quoy & Gaimard, 1833)

K. Madhu and Rema Madhu

IDENTIFICATION

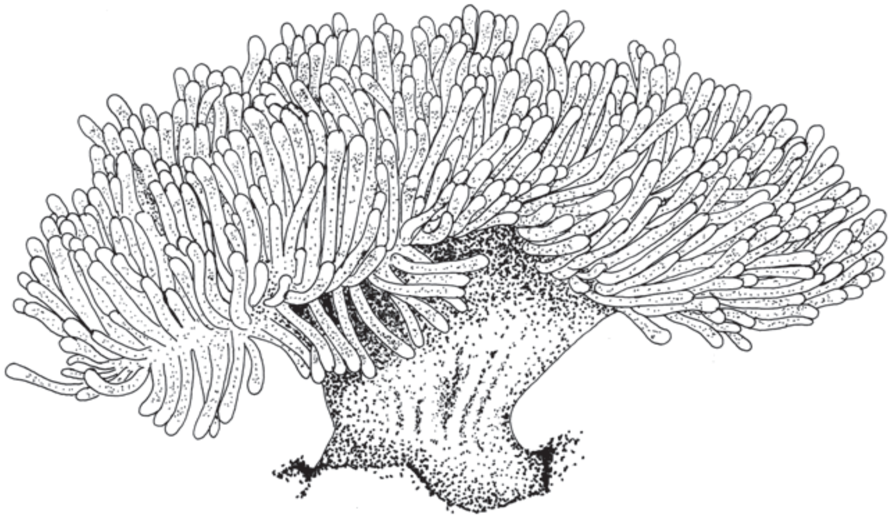
Order	:	**Actiniaria**
Family	:	**Stichodactylidae**
Common/FAO Name (English)	:	**Magnificent sea anemone**

Source of image : www.ratemyfishtank.com

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Heteractis magnifica lives its entire life in the polyp form (cylindrical column with tentacles). It has a sticky foot on a pedal disc, and an oral disc which contains the mouth and surrounding tentacles. The oral disc is as small as 1.25 cm and reaches 1 m in diameter. Its size ranges from 300 to 500 mm in diameter. The oral disc is yellow, brown, or green. Many tentacles (to 75 mm long) surround the oral disc, which are located within 20-30 mm of the mouth. Lower portion of tentacles is of same colour as the oral disc (usually shade of brown); the terminal portion yellow, green, or white; some tentacles bifurcate or are with side branches. It has a cylindrical column of



uniform bright colour (commonly blue, green, red, white or chestnut brown). The column is with longitudinal rows of translucent verrucae, with the same colour as column or slightly lighter or darker. The animal is capable of almost complete contraction so that only a tuft of tentacles is visible in the centre.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Heteractis magnifica is found in the Indo-Pacific region, extending from the Red Sea, south-east Asia, northern Australia to the western Pacific Regions including Ryukyu Islands and French Polynesia. In India it is seen in the Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

It is found in marine reefs in areas up to 50 m deep with a preferred temperature range of 24 to 32 °C. This species resides in clear waters with a strong current, typically occupying an exposed area and attached to a solid substrate. Smaller and solitary forms are found near the surface whereas colonies are formed in deeper areas. Identically coloured individuals form extensive beds in certain areas.

Anemones have stinging cells called nematocysts which release ichthyotoxins that keep away most predators. Magnificent sea anemones are hosts to many symbiotic clownfish, which protects the anemone from certain predators. The clownfish in turn are immune to the ichthyotoxins and gain protection within the anemone. *H. magnifica* is known to associate with 13 species of anemone fish.

Heteractis magnifica is carnivorous, feeding on small fishes, shrimps, isopods, amphipods, mussels, sea urchins, and plankton, which are caught using the stinging cells. The anemone also absorbs nutrients from the waste produced by the symbiotic clownfish associated with the anemone. Anemones also have symbiotic algae which provide the anemone with nutrients.

Heteractis magnifica reproduces sexually as well as asexually. In sexual reproduction, the male releases his sperm first which then stimulates the female to release her eggs. Fertilization is external and a ciliated planula larvae is formed eventually. Asexual reproduction can occur by budding, binary fission or pedal laceration. Asexual reproduction is more common during winter. The presence of the symbiotic clown fish, *Amphiprion* sp., increases the occurrence of asexual reproduction and growth.

The spawning of *Heteractis magnifica* has been reported form the Great Barrier Reef, Australia. Generally spawning occurs at night, during which, the oral disc becomes more conical in shape. Eggs range from 100 to 500 µm and are green in colour. They are given out either individually or attached as strings. Spawning continues for an hour and generally spawning was observed three days before and after the three-quarter moon.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

FOOD AND FEEDING

It needs regular feeding and seems to favour shrimps and other crustaceans over fish and molluscs. Depending on their size, anemones require feed at different frequencies. Large anemones need to be fed daily, medium sized individuals need to be fed 5 times a week and smaller sized individuals need to be fed upto 4 times a week.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Whenever light, water movement and water quality are low, anemone will detach from the substratum and look for other better conditions. Predators include other anemones, nudibranchs, sea stars, some angel fishes and bristle worms.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Heteractis spp. along with *Lysmata* spp. and *Stenopus* spp. contributes to 15 % of the world trade of marine invertebrates. During 1998-2002, *Heteractis* spp. traded globally ranged from 54,369-1,49,025 numbers. The major countries exporting the species were Mexico, Indonesia, Singapore, Fiji, Sri Lanka, Philippines, Solomon Islands, Palau and Vanuatu. Major destinations were USA, UK, Netherlands, France, Germany, Italy, Canada, Taiwan, Japan and Hong Kong.

CHALLENGES TO MARICULTURE

Captive breeding for the propagation of *Heteractis magnifica* is the major researchable issue.

FUTURE PROSPECTS

Extraction of specialized proteins from this species for use in biotechnological research is a promising area in addition to the aquarium trade. Hence coral aquaculture is a prioritized solution for reducing the harvesting pressure on natural coral reefs. The cultured corals may adapt better to aquarium conditions than wild caught corals.

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www.animal-world.com/index.html

Stichodactyla gigantea (Forsskål, 1775)

Rema Madhu and K. Madhu

IDENTIFICATION

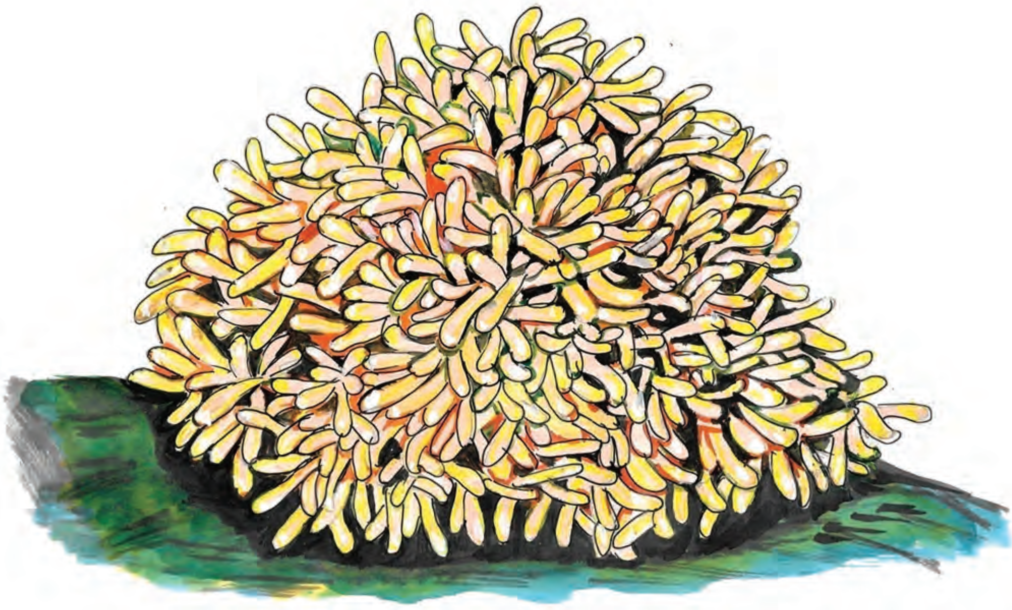
Order	:	**Actiniaria**
Family	:	**Stichodactylidae**
Common/FAO Name (English)	:	**Gigantic sea anemone**

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Deeply-folded oral disc (more pronounced with size), covered with short, stubby and slightly tapering tentacles (average 8-10 mm) that move constantly, making it look like its vibrating. The oral disc lies at the surface of sand and the presence of many tentacles gives it a carpet-like appearance, thus the name carpet anemone. Tentacles are extremely sticky but do not cause stinging sensation. The colour of the base of each tentacle is similar to the colour of the oral disc. The deeply folded disc differentiates it from other *Stichodactyla* species. The pedal column has a sticky foot to attach to a solid substrate. The individual changes location in case of unsuitable conditions by using the foot.

Source of image : Mariculture Division , CMFRI , Kochi



PROFILE

GEOGRAPHICAL DISTRIBUTION

Stichodactyla gigantea is found in the tropical regions of the Indo-Pacific region; Red Sea to Samoa, south-east Asia, northern Australia, western Pacific regions; from Australia to Ryukyu Islands. In India it is found in the Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

It is typical in shallow water areas exposed at low tides at depths of 2 to 20 m. They are solitary and are hosts to clownfish and several other marine animals. It has been known to associate with 8 species of clownfish. Protection from predators like other anemones, nudibranchs, sea stars, some angelfishes, triggers and large wrasses is enabled through nematocysts. It is a carnivore, which uses its nematocysts to capture prey like urchins, snails, crabs, shrimps, as well as small fishes. It also derives nutrition from zooxanthellae that dwells within their tissues. They also absorb nutrients from the wastes produced by the symbiotic clownfish.

Anemones multiply by sexual and asexual means. Asexually they reproduce by fission, which is when they split in half from the foot or mouth to form a clone. They will also reproduce using male and female sex glands or find another anemone of the opposite sex. During sexual reproduction, fertilization is internal and embryos are brooded internally. The juveniles or the planula larvae are given out into the water. The ciliated planula larvae then settle to the sea floor, develop a pedal disk and grow into a new anemone.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

FOOD AND FEEDING

When in the aquarium, supplemental feeding of raw table shrimps, clams, mussels, silversides, cods, squids and other marine based meats need to be done every few days. Pieces should be chopped or cut roughly to the size of the anemone's mouth.

GROWTH RATE

Juveniles of this species grew from 4 cm to 30 cm in three years in Palau when grown in floating baskets in outdoor tanks in direct sunlight without any direct feeding.

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Stichodactyla spp. is a popular marine ornamental invertebrate, falling in the top ten traded marine invertebrates in the world. As per estimates, during 1998-2002, nearly 27,341 numbers of this genus were traded in the world. Price of a brown carpet anemone is about ₹ 2,000 and that of a red carpet anemone can be as high as ₹ 25,000 per individual.

CHALLENGES TO MARICULTURE

Captive breeding for the propagation of *Stichodactyla gigantea* is the major challenge for mariculture.

FUTURE PROSPECTS

Stichodactyla gigantea have not been bred in captivity so far, and the development of captive breeding technology will help to reduce the dependency on wild. Sea anemone aquaculture is a prioritized solution for reducing the harvesting pressure on natural sources. Being a highly valuable ornamental species, it can form a good source of alternate income to fishermen and women.

SUGGESTED READING

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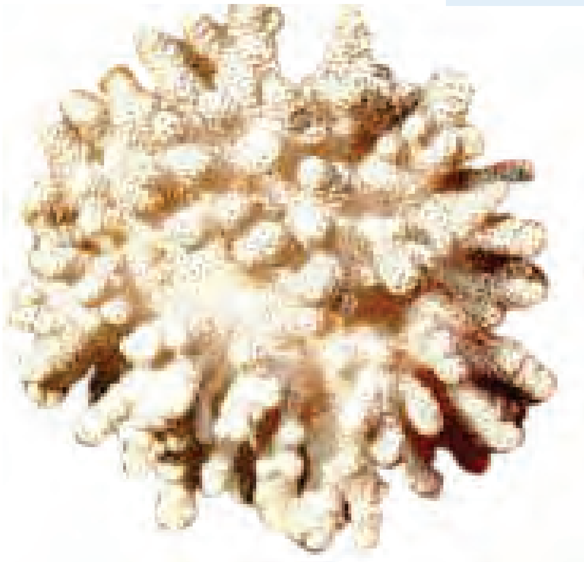
Wabnitz, C., Taylor, M., Green, E. and Razak, T. 2003. From Ocean to Aquarium. UNEP - WCMC, Cambridge, UK, 66 pp.

Cladiella australis (Macfadyen, 1936)

K. Madhu, Rema Madhu and Biji Xavier

IDENTIFICATION

Order	:	**Alcyonacea**
Family	:	**Alcyoniidae**
Common/FAO Name (English)	:	**Finger branching soft coral**



Local names: Not available

MORPHOLOGICAL DESCRIPTION

The species has stubby projections resembling fingers that are round to cone-shaped which project out from a short stalk. The projections branch-out in various directions and have polyps extending out from their tips. They are hardy and fast growing. Most specimens are pale in color, with contrasting greenish-brown to brown polyps. Corals of this genus are slimy to touch since they produce a lot of mucous. They can grow up to 41 cm in height.

Source of image : www.wetwebmedia.com

PROFILE

GEOGRAPHICAL DISTRIBUTION

It is distributed in the Indo-Pacific region; southern Taiwan, the Ryukyu Archipelago (Japan) and the Andaman Sea.

HABITAT AND BIOLOGY

It inhabits current swept reef areas; from back reefs to reef slopes, and reef flats and are found growing with other members of the Alcyoniidae family. It is often found in turbid waters. Similar to other soft coral species, it can reproduce asexually or sexually. During sexual reproduction gametes are released into the water. Reports also indicated internal fertilization and ejection of larvae from the adults. Like other soft corals, it may also use several different forms of reproduction, such as fission, fragmenting and/or branch dropping.

It captures microscopic food particles from the water column and can absorb dissolved organic matter. It is photosynthetic, having a symbiotic relationship with marine algae *zooxanthellae*, from where it also receives some of its nutrients. It also has many autozooid polyps (feeder polyps), which does not need phytoplankton (green water). In aquarium tanks, it feeds on small invertebrate larvae produced by the refugium or fully mature sand beds.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

In captivity, several methods of propagation, including constriction and cutting (fragging a small piece or large piece) are possible. *Cladiella* is suitable for propagation in aquarium, due to its ability to heal its wounds and regenerate its tissue rapidly. The most common practice for soft coral propagation is to remove tissue from the parent colony using sharp scissors or scalpel and leaving this tissue exposed to fresh seawater or dipping in sand for several days. These specimens can then be attached to a hard substrate within four to twelve months.

LARVAL REARING

Information not available

FOOD AND FEEDING

As *Cladiella* possesses *zooxanthella*, with which it shares a symbiotic relation, it does not require plankton or special feeds. However in cases where the coral is found to be shrinking in aquarium tanks, green water should be provided.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

This species is prone to diseases and when stressed, it releases a large amount of mucous. This mucous in turn attracts a large number of bacteria which can lead to diseases in the coral.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

This is one of the most commonly traded soft coral genus in the world. Indonesia is the largest exporter for soft corals and United States is the largest importer.

CHALLENGES TO MARICULTURE

Continuous propagation of *Cladiella australis* with suitable captive breeding technology is the major researchable issue.

FUTURE PROSPECTS

Cladiella is suitable in aquariums because of its tolerance to fluctuations in water quality and stress during collection and shipping and its regeneration of tissues. Once established, it tends to grow quickly and is regularly observed to propagate asexually. There are reports of women groups culturing soft corals as a source of income in other countries. Hence such examples can be emulated in India as well. Additionally *Cladiella* is a widely studied genus in terms of its bioactive molecules. Nearly 55 secondary metabolites have been isolated from various species of this genus. Hence propagation of *Cladiella australis* will provide a steady and sustainable source of this species for research.

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Xenia elongata Dana, 1846

K. Madhu and Rema Madhu

IDENTIFICATION

Order	:	**Alcyonacea**
Family	:	**Xeniidae**
Common/FAO Name (English)	:	**Pulse corals**

Source of image : Mariculture Division , CMFRI , Kochi

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Xenia elongata has unbranched stalks that are long, thick and smooth, from which the polyps arise. The stalks of this species can grow up to 3 inches in length. The stalk has a group of feathery polyps at the end, with each polyp situated on a 1 inch to 2 inch long stem. The polyps open and close in a pulsing motion, hence the common name of pulse corals. The corals growing in good lighted conditions are lighter coloured and stockier compared to ones growing in less lighted conditions.

PROFILE

GEOGRAPHICAL DISTRIBUTION

They are found in the Indo-Pacific region and the Red Sea.

HABITAT AND BIOLOGY

Xenia elongata are generally found growing in clear and bright, shallow areas of up to 10 m depths. They usually inhabit protected, fairly shallow nutrient rich back reef areas in the wild where gentle currents exist. The species does not possess any stinging ability and will not bother other corals. *Xenia* polyps pulse (opens and closes) every one to five seconds and this is thought to be a mechanism to increase photosynthesis by increasing exchange of oxygen with the water. The species is also considered to be a good bioindicator since it absorbs nutrients from the water directly. Hence any change in nutrient levels in the water is expected to be visible in this species. *Xenia* is photosynthetic and does not accept any known foods. It absorbs dissolved organic matter directly from the water as mentioned above. It also derives nutrition from the symbiotic association with marine algae zooxanthellae.

They reach sexual maturity within one year, and can reproduce by several methods. It can reproduce naturally by longitudinal fission, once the colony is mature. It also uses budding for reproduction, or pinnitomy, where the pinnules fall from the main coral onto various substrates and grow into new corals.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

It is easy to propagate *Xenia elongata* in captivity. An easy but slow way of propagating it is to place a rock next to the new growth shoot. Within a few days, the new growth will attach itself to the piece of rock and separate out. For getting larger quantities, an easy method is to submerge a bowl with coral chipping (5-10 mm pieces) in the aquarium tank and placing individual polyps in the bowl. Within a few days the polyps will be attached to the substrate and can be harvested in large quantities.

LARVAL REARING

Information not available

FOOD AND FEEDING

As *Xenia elongata* possesses zooxanthella, with which it shares a symbiotic relation, it does not require plankton or special feeds.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Pulse corals are one of the most popular marine invertebrates traded globally. Individual pieces of this species are priced around ₹ 2,000.

CHALLENGES TO MARICULTURE

Standardized propagation systems for *Xenia elongata* needs to be developed. Being a sensitive species, water conditions also needs to be standardized. Moreover an efficient system of transportation with minimal stress to the species should be explored.

FUTURE PROSPECTS

Xenia elongata being a very popular ornamental species can be a suitable candidate for culture by small-scale fish farmers and fisherwomen groups. Several diterpenes (potential anti-cancer agents) have been isolated from this species. Hence mariculture of this species will provide a good source of corals for research purposes without harming wild populations.

SUGGESTED READING

Arvedlund, M., Craggs, J. and Pecorelli, J. 2003. Coral culture - possible future trends and directions. In Cato, J. C. and Brown, C. L. (Eds.), Marine ornamental species: collection, culture, and conservation, p. 233- 248.

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Cypraea tigris Linnaeus, 1758

Jasmin F.

IDENTIFICATION

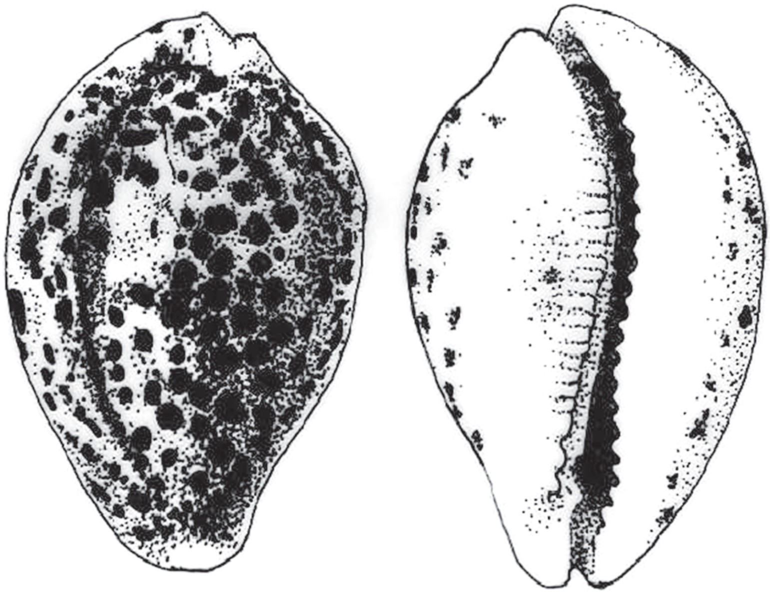
Order	:	**Littorinimorpha**
Family	:	**Cypraeidae**
Common/FAO Name (English)	:	**Tiger cowrie**

Local names: Not available

MORPHOLOGICAL DESCRIPTION

The tiger cowrie is a large, oval, dextral gastropod having a glossy and heavy shell. Dorsal side of the shell is pale in colour with dark circular spots. The ventral shell opening has a serrated margin. The mantle has two lateral extensions which can extend and cover the entire dorsal surface of the shell. The extensions meet at the midline of the dorsal surface of the shell. The mantle can be retracted into the shell through the ventral shell opening. The mantle has pin-like white-tipped projections on its surface.

Source of image : RC of CMFRI, Tuticorin



PROFILE

GEOGRAPHICAL DISTRIBUTION

The tiger cowrie is distributed along the Indo-Pacific region, from the eastern coast of Africa to Micronesia and Polynesia, the Coral Sea and around the Philippines. It is also found in Australia from northern New South Wales to northern Western Australia, Lord Howe Island. In India it is seen along the south-east coast and the Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

They are found at a depth range of 10 and 40 m, often associated with live branching coral colonies, such as *Acropora*. They spend most of their time either hiding under rocks or dead corals on the reef. At night, it comes out in search for food. Even though it looks harmless, it preys using its many rows of teeth to crunch and scrape up food. It is gonochoric and is a broadcast spawner. Embryos develop into planktonic trochophore larvae and later into juvenile veligers, before becoming fully grown adults. Adult measures up to 15 cm in length.

BREEDING IN CAPTIVE CONDITIONS

The broodstock development, breeding and larval rearing of *Cypraea tigris* was carried out on an experimental basis at Tuticorin R. C. of CMFRI. Brooders collected from wild were stocked in 1 t capacity tank with 750 l water. Sand was provided in bottom of the tank up to a height of 10 cm. The tank was provided with re-circulatory facility with 300 % water recirculation every day. The stocking density was 6 nos./750 l. They were fed on either with live macroalgae like *Ulva* spp. or with live clams.

Brooders with size and weight ranging from 83 to 96 mm (average size 89 mm) and 165 - 230 g (average weight 197 g) respectively spawned in captivity without any induction. The spawned egg case was pale grey in colour and each egg case was 2,550 µm in length and 1,440 µm in breadth. A single brooder laid approximately 560 cases. The egg cases turned dark grey after 4th day of egg laying and active veligers were seen within the egg cases. Incubation period of the captive laid egg cases was around 5 days. The veliger larvae emerged out after 5 days of egg laying.

LARVAL REARING

The size of the veliger was 550-590 µm. The veligers were reared in glass rearing containers at a stocking density of 100 nos./l. It was fed daily with *Isochrysis galbana* during morning hours. Larvae grew to 635-703 µm (668 µm) on 6 dph, 762-776 µm (769 µm) on 9 dph and an average of 912 µm on 14 dph. Till 14 dph most of the larvae retained their cilia but their activity was reduced. The foot became more prominent and frequently started protruding from the shell. The shell colour turned to brown. Survival of the larvae was observed for only 16 days post hatch.

FOOD AND FEEDING

It is an omnivore, feeding on both plants and animals. Juveniles eat turf algae and sponges, while adults eat fire coral and anemones.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Major problem in larval rearing is ciliate infection. Larvae shell severely infested with *Vorticella* sp. becomes inactive and rest on the tank bottom.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

The tiger cowrie forms food in many parts of its distribution range and its shell is used in the shell craft industry.

CHALLENGES TO MARICULTURE

Only experimental trials on culturing this species have been tried out in India which could not complete the larval cycle. Hence further research on ensuring larval survival needs to be carried out.

FUTURE PROSPECTS

The tiger cowrie is exploited in many countries because of its ornamental value. The species is also under threat due to destruction of coral reef habitats in its distribution range. Development of culture techniques is essential for meeting the demands of the ornamental shell industry as well as to conserve wild stocks of the species.

SUGGESTED READING

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Lambis lambis (Linnaeus, 1758)

Jasmin F.

IDENTIFICATION

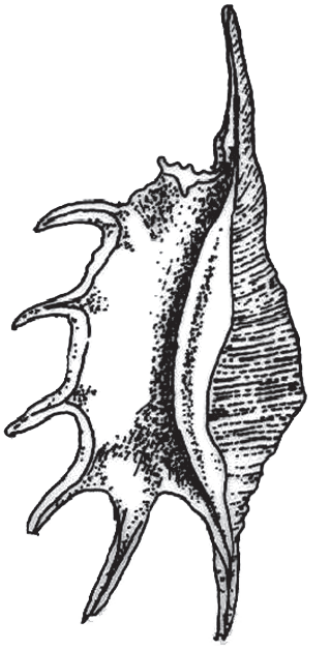
Order	:	**Littorinimorpha**
Family	:	**Strombidae**
Common/FAO Name (English)	:	**Common spider conch**

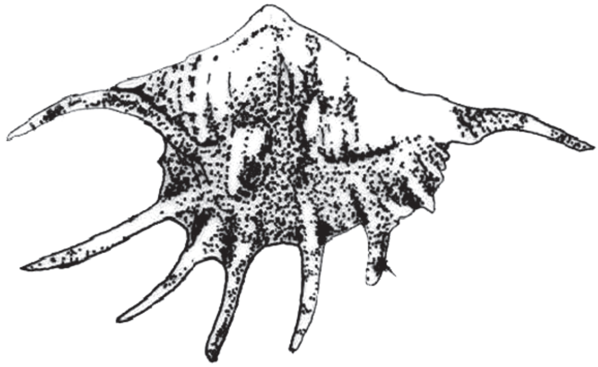
Source of image : RC of CMFRI, Tuticorin

Local names: Aiviral sangu (**Tamil**)

MORPHOLOGICAL DESCRIPTION

Lambis lambis or the common spider conch as the name typifies is easily identified by six extensions of the shell which resemble a spider's legs. The extensions of the shell are limited to flat lobes in juveniles and sub-adults. In males the anterior three extensions are short and bent backwards slightly. In females on the other hand, the anterior three extensions are long and dorsally recurved. The stromboid notch is present. The aperture of the shell is wide and often pink in colour. The anterior siphonal canal is long, through which water is drawn over the gills and into the mantle cavity. The colour of the shell is white or cream with brown, purplish or bluish black patches. The shell interior is glazed and either pink, orange or purple in colour.





PROFILE

GEOGRAPHICAL DISTRIBUTION

It is distributed in the Indo-West Pacific region along Aldabra, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Tanzania, Micronesia eastern Melanesia, Taiwan, southern Japan, northern Australia, the Persian Gulf and the Red Sea. It is reported along the south-east coast of India.

HABITAT AND BIOLOGY

It habitats mangrove areas, as well as reef flats and coral-rubble bottoms in shallow waters from low tide levels upto the depths of 5 m. It is usually found in association with red algae. There is a significant size difference between males and females. Usually males grow more than females in size. Average length of the shell is about 18 cm. The peak spawning activity of the species is during October-December.

BREEDING IN CAPTIVE CONDITIONS

The broodstock development, breeding and larval rearing of *Lambis lambis* was carried out on an experimental basis at Tuticorin R. C. of CMFRI. Brooders ranging from 152-184 mm and 80-400 g in size and weight were collected from wild and stocked in 1 t capacity tank with 750 l water. Sand was provided in bottom of the tank to a height of 10 cm. The tank was provided with re-circulatory facility with 300 % water re-circulation. The stocking density was 10 nos./750 l. Macroalgae collected from the sublittoral area (*Sargassum* spp., *Padina* spp. and *Ulva* spp.) were supplied as feed in the brooder tanks *ad libitum*. The male and female mating happened during late evening/ night. Several cylindrical white to pale brown coloured egg filaments were released during spawning. These egg filaments get attached to the seaweeds/boulders provided in the tanks. The diameter of the egg filament was 1,652-1,822 µm. There was about 22-25 eggs in one cm of egg filament strip. Spherical embryos measured 535-559 µm in diameter and were found enclosed within a transparent globular membrane. On 5th or 6th day, embryos developed as free veliger larvae.

LARVAL REARING

Larval rearing was carried out in 5 l glass beaker as well as 75 l FRP tank at density of 100 larvae/l. The size of the veliger larvae ranged from 617-637 µm. The larvae were fed once in the morning with pure culture of *Isochrysis galbana* at a concentration of 35,000 cells/ml for up to 5 days and then onwards at a concentration of 50,000 cells/ml for upto 21 days. Larvae took about 3 weeks to reach competency and metamorphose into post-larvae. 100 % post-larval mortality occurred during day 21 to 35 of larval rearing.

FOOD AND FEEDING

It is herbivorous, feeding on fine red algae. It exhibits a preference for *Ulva* spp. and grazes on it extensively without any mortality for more than a year. Brooders are fed on macroalgal diet including *Sargassum* spp., *Padina* spp. and *Ulva* spp.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Major problem in larval rearing is ciliate infection. Larvae shell severely infested with *Vorticella* sp. becomes inactive and rest on the tank bottom.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

The rate of the shell depends on the size and quality with processed shells fetching upwards of ₹ 50/shell.

CHALLENGES TO MARICULTURE

Currently culture of spider conch is on an experimental basis in the country. Though successful broodstock development, breeding and larval rearing has been achieved, nursery rearing has failed. Hence research on carrying out successful nursery rearing of spider conch needs to be carried out.

FUTURE PROSPECTS

Of the eleven known species of *Lambis* from Indian waters, six are listed under Schedule IV of the Indian Wildlife Protection Act, 1972, banning commercial exploitation. Mariculture practice of gastropods needs to be developed and should be used to conserve and replenish the depleted stocks.

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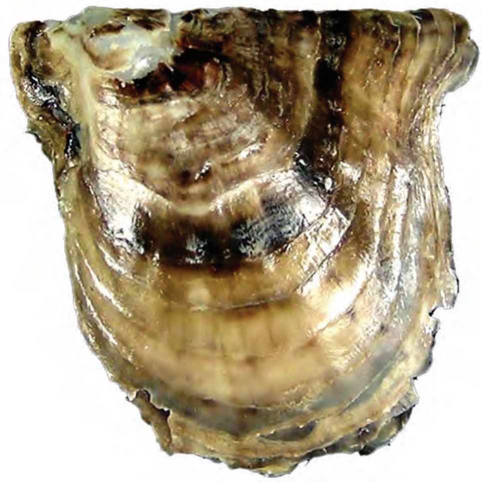
Pinctada imbricata fucata (Gould, 1850)*

Pralaya Ranjan Behera

IDENTIFICATION

Order	:	**Ostreida**
Family	:	**Pteriidae**
Common/FAO Name (English)	:	**Indian pearl oyster**



Local names: Muthu chippi (**Tamil and Malayalam**)

MORPHOLOGICAL DESCRIPTION

The Indian pearl oyster has a long hinge which is nearly 0.85 times the maximum width of the shell. The left valve is deeper than the right. Hinge teeth are present in both valves. Anterior ear is larger than the posterior ear and there is a slit-like abyssal notch. The outer shell is reddish or yellowish brown in colour with radial rays of lighter colour. The nacreous layer is thick and has a golden metallic luster.

Source of image : www.conchology.be.

* *Pinctada imbricata fucata* (Gould, 1850) as per Temkini, 2010.

PROFILE

GEOGRAPHICAL DISTRIBUTION

The species is distributed in the Indo-Pacific region from the Red Sea, Persian Gulf, India, China, Korea to Japan and further to the western Pacific Ocean. In India, it is available from both west (Gulf of Kutch, Karnataka and Kerala) and east coasts (Gulf of Mannar and Palk Bay, Tamil Nadu and Andhra Pradesh).

HABITAT AND BIOLOGY

It is a sedentary animal which is found attached to hard substratum including corals, sand grits, rocks and other submerged objects with the help of its byssus threads. In the Gulf of Mannar, it occurs in large numbers on the submerged rocky substrata known as paars. Paars lie at depths of 12 to 25 m off the coast along a stretch of 70 km. In the Palk Bay, it occurs sporadically on loose sandy substratum attached to submerged objects in littoral waters. In the Gulf of Kutch, it is found as stray individuals on the intertidal reefs known as Khaddas. Along the southwest coast of India, off Kerala, large numbers of spat are collected from mussel culture ropes.

It is dioecious. Occasionally, sexual changes are observed between different spawning seasons and protandry is observed. Age at first maturity is usually 2 years. Fast growing individuals mature in 1 year and slow growing individuals in 3 years. Spawning season is usually from June to July in Japan and from winter to spring in Red Sea. In India, maturity is reached within 7-8 months and multiple spawning is reported with dominance of females. Two peak spawning seasons (June-September and November-Decembers) are observed in a year. The mature oysters release their eggs and sperms in the water and eggs get fertilized as soon as they come in contact with the sperms. The fertilized eggs pass through different developmental and larval stages such as blastula, gastrula, trochopore, veliger, umbo, eye spot, pediveliger and plantigrade, before finally settling down as spat.

BREEDING IN CAPTIVE CONDITIONS

The broodstock development, breeding and larval rearing of *Pinctada fucata* was successfully carried out on an experimental basis at Tuticorin R. C. of CMFRI. Brooders were collected from wild and stocked in 1 t capacity tank with 750 l water. For round-the-year availability of spawners, it was kept at temperatures of less than 25 °C and was fed with mixed culture of algae, mostly *Chaetoceros* spp. Supplementing diet with raw corn flour at 30 mg/oyster/day was also effective for maturation. It spawned naturally and was also induced by chemical and thermal induction. Hydrogen peroxide (H_2O_2), tris buffer (hydroxymethyl amino methane), sodium hydroxide (NaOH) and ammonium hydroxide (NH_4OH) were used for spawning induction with varying degrees of success. However, the most preferred and suitable technique for inducing oysters to spawn was by thermal induction. The oysters kept at room temperatures of less than 25 °C in an air conditioning room were quickly changed to water having 5 to 6 °C higher temperature. This change stimulated the oysters to spawn. In all cases, the male oyster responded to the induction first and initiated spawning. The presence of sperms in the water column stimulated the females to respond within 30 min. After spawning was completed, oysters were removed and the water was left undisturbed for about 2 h to allow complete fertilization. The fertilized eggs settled down on the bottom. The water was filtered through a 20 µm nylon bolt sieve and the eggs collected were washed in filtered sea water. Early embryonic development started after 45 min of fertilization and the eggs metamorphosed into veliger larvae within 20 h of spawning. The veliger larvae measured on an average 62.5 µm.

LARVAL REARING

The larvae were transferred to larval rearing tanks. A stocking density of 1 million larvae/t of sea water was maintained. Water exchange was done on alternate days. Details of feeding protocol during larval rearing were as follows.

1. 1^{st} day, Veliger = 5,000 cells/larvae/day
2. $10\text{-}12^{th}$ day, Umbo = 10,000 cells/larvae/day
3. 15^{th} day, Eye spot = 15,000 cells/larvae/day
4. 18^{th} day, Pediveliger = 20,000 cells/larvae/day
5. 24^{th} day, Spat = 25,000 cells/larvae/day
6. Upto 60^{th} day, Spat = 50,000 cells/larvae/day
7. Upto 90^{th} day, 2-3 mm Spat = Mixed culture of Chaetoceros sp.
8. Farm

NURSERY REARING

Hatchery reared spats were stocked in outdoor nursery tanks. The spat density maintained was 5,000/m^2. Seawater was exchanged at a minimum rate of 10 % daily and the oysters were fed with a mixture of *Chaetoceros calcitrans*, *Isochrysis galbana* and *Nannochloropsis salina*. Concentration of algal cells fed was increased from 10,000 cells/ml to 75,000 cells/ml till the oysters reached adulthood (> 45 mm). On attaining adulthood, stocking rate was reduced to 50-60 oysters/m^2.

GROW-OUT

Farming is essentially for growing the wild collected/hatchery produced spats to implantable sized oysters and to grow the nucleated oysters for pearl production. Selection of farm site is of paramount importance. Congenial conditions such as protection, water current, clarity, optimum temperature and salinity regimens are considered while selecting the farm site, apart from the site being free from any kind of pollution. A deep sheltered bay/protected water bodies with sea conditions not too rough offers excellent sites for pearl oyster farming. In India, three different types of farming practices are adopted. Rack culture system is suitable for areas of shallow depths ranging from 2-5 m. A rack of 30 m^2 holds about 100 cages. Raft culture system is most suitable for farming in the sheltered bays with considerable depth. Rafts are generally almost square in shape. Long line culture system is practiced in the open sea where depth is more. This system is more suitable to withstand the high wind and wave action. In the onshore rearing technique developed at Visakhapatnam, seeds of 5.00 mm size were reared in cement tanks ranging in size from 250-500 m^2. A water level of 1 m was maintained. Oysters were held above the bottom; through a grid system constructed using PVC pipes. A stocking density of 125 nos./m^2 was maintained. Stocked oysters were fed with *Chaetoceros* spp. at a cell concentration of 75,000 cells/ml. Daily, 25 % of water was exchanged. Average growth of 50 mm in 6-7 months of stocking was achieved.

FOOD AND FEEDING

It is a filter feeder. Unicellular organisms including infusorians, foraminiferans and radiolarians form the major food of pearl oysters. However, minute embryos, larvae of various animals, algal filaments, spicules of alcyonarians and sponges are also seen in the stomach contents. Flagellates measuring less than 10 µm (*Isochrysis galbana*) are ideal food for pearl oyster larvae.

GROWTH RATE

Along south-east coast of India, mean dorso ventral mantle (DVM) length was 45 mm, 50 mm and 60 mm in the first, second and third year and 72 mm in 6 years. Higher growth rates to the tune of 56.17 mm in first year and 72.11 mm in second year from Visakhapatnam have also been reported. Largest individual recorded from natural beds of Gulf of Mannar was 75 mm (80 g) in about 72 months and from Gulf of Kutch was 86 mm in about 84 months. In native stocks from Arabian Sea, growth was faster and after one year it reached 62.5 mm. Record growths of about 105 mm and 110 g was achieved under onshore system in 3 years in Visakhapatnam. Oysters attained a length (DVM) of 29-48 mm and a weight of 8-10 g after six months. It reached a DVM length of 45-65 mm and a weight of 10-29 g after one year. At the end of second year, DVM length varied between 55-85 mm with a corresponding weight of 26-76 g. It reached a DVM length range of 65-105 mm and a corresponding weight range of 50-110 g after three years.

DISEASES AND CONTROL MEASURES

The occurrence of protozoan parasite, *Perkinsus olseni* in the wild and farmed pearl oyster is reported from the south-east coast of India. Copepod parasite, *Tylocephalum* sp. has also been reported. Mortality of farmed pearl oyster due to fouling organisms like barnacles, bryozoans, spats of molluscs, *Avicula* sp. and *Crassostrea* sp. and shell boring organisms like spionid polychaetes, Polydora ciliate and Clionid sponges, *Cliona celata* and *Cliona vastifica* has been reported from Gulf of Mannar and Tuticorin. Mass mortality of pearl oysters due to incidence of red tide caused by *Heterocapsa circularisquama* has been reported in Ago Bay of Japan in 1992.

The most effective method of controlling fouling growth is by cleaning the oysters, cages and farm materials regularly. In addition, periodical exposure of the oysters to sunlight for a few hours results in death of the larvae of most undesirable settlers. Fresh water, brine and chemical treatment are also found to be effective. The peak spawning and settlement season of major fouling organisms are avoided by properly timing the introduction of the new spat stocks in the farms. The boring polychaetes are easily killed by immersing the oysters in freshwater for about 6 h. The oyster shell valves infested with boring organisms can also be brushed with 1 % formalin, dipped in freshwater and returned to the sea. The above treatment is found to be effective against sponges and *Martesia* sp. and partly against *Polydora* sp. At a concentration of 78 g/l, brine kills all polychaete species within 8 h.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

Indian pearl oyster, *Pinctada fucata* is the major species for production of marine akoya pearl. Aquaculture of pearl oysters is an expanding multimillion dollar industry in the tropical marine environment of many countries, including Australia, French Polynesia, the Middle East, China, south-east Asia and Japan. Two major cultured akoya pearl producing countries are Japan and China. In 2004, they together constituted 22 % of the world supply, valued at 135 million US $. Marine akoya pearl produced has good demand in domestic markets also.

CHALLENGES TO MARICULTURE

Techniques for breeding and seed production, farming and mother oyster development, nucleation and pearl production have already been developed in India. To make this technique more viable and economically feasible, it is imperative to make critical analysis of the various technicalities involved in the culture strategy. Production of mother oysters for nucleation and pearl production on a continuous and commercial scale are big challenges for mariculture.

Pearl farming on commercial scale failed to catch the interest of entrepreneurs because the returns were very low. Reasons attributed were ecological condition of the seas around Indian coast, scarcity of protective bays, roughness and heavy wave actions in the open sea, heavy siltation and the absence of high primary production. The high rate of rejection of nucleus and low survival rate of implanted oysters make pearl farming less remunerative. Large pearls have superior value. The quality and size of pearls now produced in India do not fetch a very high price in the international market.

FUTURE PROSPECTS

Technology for culture of marine pearls and farming of pearl oyster in open sea and in shore-based systems has been developed. The demand for cultured pearls will not diminish in the near future and this provides a good opportunity for fish farmers to improve their livelihoods through pearl oyster culture. A tie-up of large corporate houses with small scale farmers can also go a long way in making the venture successful.

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Pinctada margaritifera (Linnaeus, 1758)

Pralaya Ranjan Behera

IDENTIFICATION

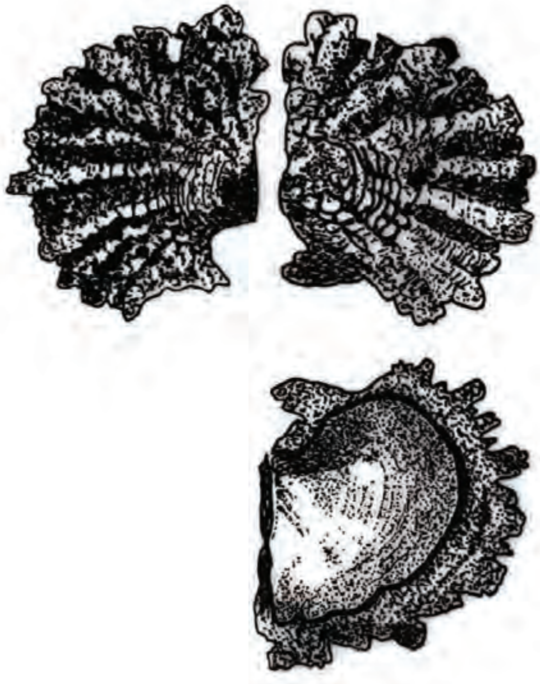
Order	:	**Ostreida**
Family	:	**Pteriidae**
Common/FAO Name (English)	:	**Black lip pearl oyster**

Local names: Muthu Chippi (**Tamil and Malayalam**)

MORPHOLOGICAL DESCRIPTION

The anterior margin of the shell extends in front of the anterior lobe. The anterior ear is well developed whereas the posterior ear and sinus are absent. The byssal notch is broad. The hinge is shorter than the width of the shell and is devoid of teeth. Left valves are moderately convex. The posterior end of the shell meets the hinge almost at a right angle. Outer shell is dark grayish-brown with greenish tinge and radially distributed white spots. The nacreous layer is iridescent with a silvery sheen and the non-nacreous margin is black. Due to the dark marginal colouration of the shell, it is also known as the 'Black-lip pearl oyster'.

Source of image : RC of CMFRI, Visakhapatnam



PROFILE

GEOGRAPHICAL DISTRIBUTION

Pinctada margaritifera is widely distributed in the Persian Gulf, Red Sea, Sudan, Papua New Guinea, Australia, French Polynesia, Indonesia, Andaman and Nicobar Islands, south-western part of Indian Ocean, Japan and Pacific Ocean. Along the Indian coast, the occurrence of black lip pearl oyster is sporadic. It is reported from Vizhinjam (Kerala), Lakshadweep Island, Gulf of Mannar (Tamil Nadu), and Visakhapatnam (Andhra Pradesh). It is endemic to the Andaman and Nicobar Islands.

HABITAT AND BIOLOGY

It is sedentary occupying the intertidal reef flats and is observed up to a depth of about 10 m. It is found attached with strong byssal threads to live or dead corals, block corals and large boulders. It is found attached to the coralline and sub-tidal regions in Andaman and Nicobar Islands.

Both protogyny and protandry have been reported for the species from different parts of the world. The spawning peak varies with locality. Major spawning in July and minor in November is observed in Taiwan and Japan, but it is different in Red Sea, where spawning occurs in June. Year round spawning is noted in French Polynesia. Onset of reproduction is regulated by sea surface temperature. Females outnumber males during the spawning season.

BREEDING IN CAPTIVE CONDITIONS

The broodstock development, breeding and larval rearing of *Pinctada margaritifera* was successfully carried out at Tuticorin R. C. of CMFRI. Black lip pearl oysters (shell height of 77-92 mm and weight of 70-97 g) collected from the pearl oyster beds of the Gulf of Mannar were placed in a meshwork basket and suspended at 5 m depth from rafts. After several months of maintenance, broodstock were brought to the hatchery, where it spawned spontaneously and profusely. Spawning was either natural and was also induced by thermal and chemical stimulation.

LARVAL REARING

The first polar body formed 24 min after fertilization and the fertilized eggs had a mean diameter of 59.9±1.4 µm. Fertilized eggs were stocked at a density of 30/ml in aerated fiberglass tanks (500 l) filled with filtered seawater at 28 °C. After 24 h, when the D-stage larvae (shell becomes D-shaped) had a mean shell length of 79.7±2.3 µm, they were collected with a 25 µm mesh sieve and stocked at a density of 2/ml in 500 l aerated fiberglass tanks. After 8 days of culture, early umbo stage (shell length of 110 µm) was reached and exhibited an average daily growth rate of 3.7 µm. Mean daily growth rate increased to 7.2 µm over the next 22 day period required for the larvae to reach the eye spot stage (shell length of 230 µm). Eye spots occurred in larvae that were 230 µm or greater in shell length and shortly after, it progressed to the pediveliger stage. Larvae were fed daily a mixed diet (1:1) of *Isochrysis galbana* and *Pavlova salina* at a concentration of 1-18 $\times$ 10^3 cells/ml.

NURSERY REARING

Nursery rearing can be carried out either in indoor system in hatchery or outdoor system in farm. In hatchery, it was fed a mixture of *Isochrysis galbana*, *Skeletonema* sp. and *Nitzschia* sp. at concentration of 2.5 x 10^3 cells/ml until a size of 1 mm, and was doubled thereafter. Feeding was given once a day. Water was exchanged daily. In the farm, spats were placed in pyramidal lantern nets covered with velon fabric of appropriate mesh and were suspended from rafts at depths of 5 m. Average density was 600 spat/net.

In the hatchery, growth of juveniles was very slow at 0.09 mm/day. On transplantation to the culture raft in the farm, growth rate increased to 0.4 mm/day. However, mortality of spat was more in the farm. Survival rate ranged from 15.16 % to 17.40 %.

GROW-OUT

Till the oysters reached 50-60 mm shell length, they were grown in intermediate grow-out systems with regular cleaning of shells. Once they reached 50-60 mm shell length, they were removed and transferred to the main grow-out system. When the oysters reach 90-120 mm, they were 'seeded' with the shell nucleus and a graft of mantle tissue for creating a cultured pearl. After the operation, the shells were kept ventral edge down and handled carefully with each oyster being placed in a catch bag. The oysters were then either ear-hung on ropes or placed in panel nets and carefully transferred to grow-out lines. After 4-6 weeks, the oysters were checked to see if it had rejected the nucleus. Any oysters that had rejected the nucleus, or were dead after the operation, were removed from the grow-out system. The 4-6 weekly cleaning cycles was resumed (if necessary) for the next 18-24 months, after which there was a second operation to remove the pearl. At this time, suitable oysters, i.e. those that have produced good pearls, were re-seeded with another nucleus to produce another pearl. For the second operation, there was no need for a graft of mantle tissue as the pearl sac has already formed and would continue to produce mother-of-pearl to coat the new nucleus.

FOOD AND FEEDING

The black lip pearl oyster is a filter feeder which feeds by filtering water across its gills to trap plankton and other digestible materials. Stomach contents of individuals collected from wild showed the presence of bivalve eggs (few), appendages of copepods and phytoplankters such as *Tetraselmis* sp. (abundant), *Navicula* sp., *Nitzschia* sp., *Oscillatoria* sp., *Fragilaria* sp., *Chaetoceros* sp., *Euglena* sp., *Amphora* sp. and *Diplonei* sp. Five microalgae species viz., *Pavlova salina*, *Isochrysis galbana*, *Chaetoceros calcitrans*, *Nannochloropsis oculata* and *Chlorella marina* are used as feed in hatchery and nursery rearing.

GROWTH RATE

Growth rate of 5 µm/day was reported during the first 7 days of larval rearing. Growth rate of spat was 0.09 mm/day in hatchery, whereas in farm, it was 0.4 mm/day during the 3 month rearing period. The 11 months old spat measured 38.8 mm in shell height, 33.2 mm in hinge length and 6 g in weight.

DISEASES AND CONTROL MEASURES

Mass mortality caused by necrosis of the adductor muscle by virus in pearl farms has been reported. *Perkinsus* sp. was isolated in Australia from the cultured oyster. In Europe, the parasitic copepod, *Anthessius pinctadae* was reported from pearl oyster. High mortality of oyster due to protistan parasites has been described from the Red Sea. Two polypous mesenchymal tumours in oysters were described from Australia. Occurrence of boring sponge (*Lithophaga* sp.) has been reported on the shell of the oyster. Shell boring polychaete (*Polydora* sp.) infestation is reported from Visakhapatnam, India.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

The black-lip pearl oyster is one of the valuable species for the pearl industry. It produces the black pearls and supports a multimillion dollar industry in the Pacific. It has traditionally been used as food, for ornaments, jewellery, tools and fish hooks in the Indo-Pacific region. French Polynesia and Cook Islands are the major producers of black south sea pearls. French Polynesia is also the major global supplier of Tahitian black pearl. Culture techniques for black pearls were first developed in French Polynesia and the industry grew quickly to create major export earnings estimated at US $ 200 million in 2000. The industry in French Polynesia alone is worth approximately US $ 140 million per year. Cook Islands later developed an industry that is now worth US $ 5 million. Black-lip pearl oyster in Andaman and Nicobar waters are presently utilized more for the shell craft industry than for the pearls.

CHALLENGES TO MARICULTURE

Nursery rearing of spat in sea and in closed conditions is plagued with the problems of fouling, environmental stress and predation by fish and invertebrates and this leads to high mortality. Production of mother oysters for nucleation and pearl production on a continuous and commercial scale are big challenges for Indian mariculture

FUTURE PROSPECTS

Black pearls are highly sought after in the international pearl industry. Large scale commercial production of blacklip pearl oyster will be a boon for oyster farmers for better economic returns while earning forex for the country.

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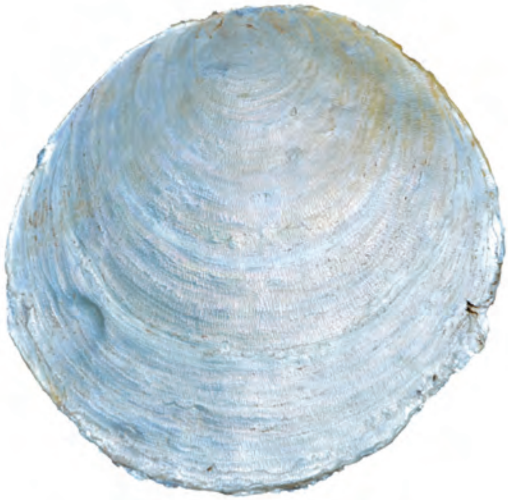
Placuna placenta (Linnaeus, 1758)

Pralaya Ranjan Behera

IDENTIFICATION

Order	:	**Pectinida**
Family	:	**Placunidae**
Common/FAO Name (English)	:	**Windowpane oyster**

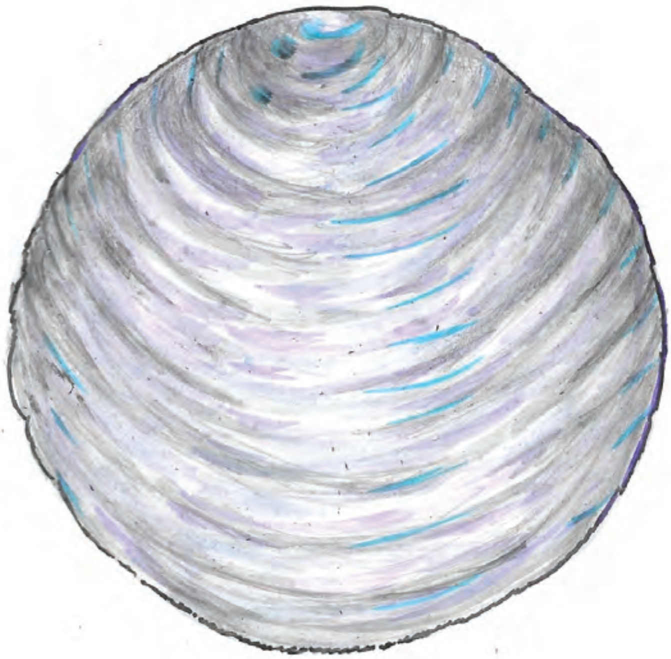


Local names: Kachga (**Marathi**); Talapugulla (**Telegu**)

MORPHOLOGICAL DESCRIPTION

The shell of the adult windowpane oyster is almost circular in shape with length approximately equal to height. The shell is very compressed and the shell valves are also very flat, rounded and translucent. Inner surface of the valve is pearly. The adductor impression is at about centre. The umbo is small. Two thin ridge-like teeth diverge from the umbo making a characteristic inverted V shape angle. The shell has a size of 14 cm or even more and has many concentric growth lines. The shell is white in color.

Source of image : Molluscon Fisheries Division , CMFRI , Kochi



PROFILE

GEOGRAPHICAL DISTRIBUTION

It is found in the Gulf of Aden, India, Malaya Peninsula, southern coasts of China and along the northern coasts of Borneo to the Philippines. In India, it is distributed in the Gulf of Kutch (Gujarat), Kakinada Bay (Andhra Pradesh), Nauxim bay (Zuari estuary in Goa) and Tuticorin bay (Tamil Nadu) and off Raigad district in Maharashtra.

HABITAT AND BIOLOGY

Placuna placenta is found on muddy or sandy substrata from shallow waters to depths of 100 m. It is euryhaline. The internal organs confine themselves to the superior shell i.e. towards the right valve. It lies with the convex surface down on the seabed. It is dioecious. Occurrences of hermaphroditism, though reported in lengths between 110 to 139 mm at Kakinada bay, are very rare. Size at first maturity is 68 mm in length for both sexes. It spawns at the onset of north-east monsoon in October along the Okha coast in India. In the Philippines, it matures at a size of about 70 mm and has an extended reproductive cycle for 8-12 months and spawning occurs usually from February to May. It releases 24 million eggs in a single spawning and 250 million eggs during the entire spawning season. Egg diameter is 70 µm.

BREEDING IN CAPTIVE CONDITIONS

Researchers from the Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC/AQD), Bangkok, Thailand have reported induced spawning of this species by water flow manipulation, UV irradiated seawater and photochemical methods. Sexually immature broodstocks collected from the wild were stocked and reared in tanks with mud substrate and were fed daily a mixture of *Isochrysis galbana* and *Tetraselmis tetrahele* at 2,00,000 cells/ml in 3:1 ratio for maturation. Sexually mature individuals spawned when exposed to UV light-irradiated seawater (925-1,395 mWh/l).

Broodstock development and induced spawning with thermal stimulation was carried out by researchers of Tuticorin R. C. of CMFRI, India in 2004. Broodstock collected from the wild were kept in aerated seawater tanks for 24 h. It was induced to spawn by thermal stimulation at 37 °C. Males started to spawn after 45 min, followed by females. Once spawning was over, the broodstock was removed and the eggs were allowed to fertilize. The eggs were yellow in color. The spawned eggs were spherical measuring 50 µm. Fertilization was immediate and the first polar body was released 15 min after fertilization.

LARVAL REARING

Embryos developed to D-shaped veliger larvae of shell length (SL) 80-86 µm after 19-20 h. Percentage production of straight-hinged larvae from fertilized eggs varied from 51 % to 63 %. D-shaped veliger larvae (one day old) were reared in UV light-irradiated seawater until metamorphosis to plantigrade. Larvae were fed daily with monoalgal diet of *I. galbana*, *T. tetrahele* or *Chaetoceros calcitrans* at densities of 10,000-30,000 cells/ml. The D-shaped veliger became globular resulting in the disappearance of straight hinge line on day 3, measuring 110 µm SL. On day 4, the typical umbo stage (140 µm in SL) constituted about 90 % of the population. Late umbo stage was reached at 210 µm SL on day 5, pediveliger at 215 µm SL on day 7 and plantigrade at 235 µm SL on day 8. The spat grew to 340 µm SL on day 10. The average shell height on day 1 was 65.2 µm; 81.6 µm on day 3; 121.6 µm on day 6; 205.8 µm on day 9 and 300 µm on day 13. Average daily growth rate was 23.0 µm from day 1 to day 13. Larval settlement to spat was observed between 8 to 14 days. Shell length increment varied from 9.92 to 11.38 µm/day. The spat had neither byssus nor cement gland for attachment and hence were allowed to settle on tank surface. The spat was transferred to farm on day 80. Survival rate at metamorphosis was highest (12.60 %) when fed with *I. galbana* and lowest when fed with *T. tetrahele* (5.1 %). The best salinity for embryonic development and larval survival at metamorphosis ranged from 22 to 34 g/l and for larval growth from 16 to 34 g/l. The tolerance to lower and higher salinities progressively increased as the larvae developed from embryo to the plantigrade stage.

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

It is a filter feeder; feeding on phytoplankton, zooplankton and organic detritus. In captivity, the microalgae, *Isochrysis galbana* and *Tetraselmis tetrahele* are ideal food for immature broodstock.

GROWTH RATE

In Philippines, growth of broodstock, in terms of increments in shell length and body weight was 15.0 mm and 12.6 g, respectively after 91 days of stocking. In India, the average growth in shell height of spat was 0.30 mm on day 13; 0.81 mm on day 22; 3.09 mm on day 36 and 12.44 mm on day 80 (average growth rate of 0.08 mm SL/day) during larval rearing. Growth rate of spat in farm was 0.59 mm/day.

DISEASES AND CONTROL MEASURES

Infestation of gonad and digestive diverticula by a bucephalid parasite was observed at Kakinada Bay. At Mandapam, it was heavily infested by the pea crab , *Pinnotheres placunae*. Larval cestodes and trematodes parasitize it and lay encrusted in the mantle edge. Polychaetes in mantle cavity are common at Okha, Gujarat. *Polychaetes Polydora* and *Eunice indica* have been recorded on its surface.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

In Philippines the translucent shell is used for the manufacture of lampshades and other shell craft items, which are exported to Europe, USA, Japan and West Germany. Philippine is the major producer of *P. placenta*, which ranks fifth in the fishery exports from the country. The export value from Philippines was US $ 36 million between 1986 and 1991. The meat is used in the preparation of bagoong, adobo, chowder and kapis omelet in the Philippines. In China, the shell is used in making medicinal preparations for diseases of eye and other ailments. In Ceylon, it is used in making a costly kind of slaked lime for applying on betel leaves used for chewing.

In India, initially the shells were used only in the lime industry at Kakinada, but later, there was good export of the flat right valve of the oyster. During 1968-1976; about 42 t of right valve alone were exported to Hong Kong and Japan by private traders from Kakinada. Subsequently it was also exported to Korea. From Tuticorin, the sundried shells are packed in polythene bas and transported to Bombay for sale. In Raigad district of Maharashtra, collection from the intertidal zone has started since 2013, in tune to the great demand that exists for shells from petroleum related industries, for capping and plugging the drilled holes after oil exploration surveys. Shells are also used in handicraft industry.

CHALLENGES TO MARICULTURE

The breeding, seed production and larval rearing of the species has already been established and standardised. The culture of windowpane oyster needs to be upscaled in India. However, further adoption of its culture depends on creating awareness among fish farmers about its export potential.

FUTURE PROSPECTS

Due to overexploitation for pearls and shells in considerable quantities every year, the resource is declining from wild at an alarming pace. Hence, it is protected under Schedule IV of the Indian Wildlife Protection Act, 1972. As captive seed production methods have been standardized, therefore, establishment of hatcheries for the replenishment of wild stock with hatchery produced spat will facilitate stock enhancement. Additionally it can be a foreign exchange earner if export channels are further developed to south-east Asian countries.

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Spondylus layardi Reeve, 1856

Pralaya Ranjan Behera

IDENTIFICATION

Order	:	**Pectinida**
Family	:	**Spondylidae**
Common/FAO Name (English)	:	**Spiny oyster**

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Shell is solid, pear shaped and moderately inflated with a height of 80 mm. Sculpture of obscure radial ribs ornamented with sparse spinose or narrowly spatulate spines in irregular rows, interstices with dense rows of small overlapping spines. Body color is dark purple or brown with some white or blood coloured spotting at the umbo; spines brown, rarely white; internally blue white with a dark brown, finely crenulated margin.

Source of image : www.bagniliggia.it

PROFILE

GEOGRAPHICAL DISTRIBUTION

It is distributed in Sri Lanka, Gulf of Aden, Red Sea, Saudi Arabia, Gulf of Aqaba and Philippines. It has been reported from east and west coasts of India and from Lakshadweep Islands.

HABITAT AND BIOLOGY

It is marine, inhabiting reefs. It is found mostly associated with dead corals.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

Information not available

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

It has great demand in international market for making ornaments.

CHALLENGES TO MARICULTURE

The main researchable issues, which have to be sorted out for this species, are (i) Life history study (ii) Healthy broodstock development protocol (iii) Larval rearing protocol and (iv) Culture practices.

FUTURE PROSPECTS

The thorny shell has ornamental value in the global market. Hence its culture would be a good source of income to people culturing them and those involved in its trade.

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Tectus niloticus (Linnaeus, 1767)

Jasmin F.

IDENTIFICATION

Order	:	-
Family	:	**Tegulidae**
Common/FAO Name (English)	:	**Commercial top shell**

Source of image : RC of CMFRI, Tuticorin

Local names: Not available

MORPHOLOGICAL DESCRIPTION

It is a marine gastropod having a conical shaped large shell. The base of the shell is spotted or radially streaked with crimson, violet or reddish brown colour. The spire is conical in shape and has an acute apex, usually eroded in most shells. The shells have 8-10 whorls. The outer shell is sub-perforate, have a thick layer of nacre; the first two are smooth; the last whorl is concave with bulging and projecting ends. The base of the shell is convex. The aperture is extended across and slanting. The columella is diagonal, terminating in a tooth below with a strong fold above, which is inserted into the axis. The operculum is thin, round, orange-brown in colour, and has about 10 whorls. Breadth of the shell is more than the height.

PROFILE

GEOGRAPHICAL DISTRIBUTION

It occurs in the Indo-Pacific region. In India it is distributed in the Andaman and Nicobar Islands and Gulf of Mannar. It has been successfully introduced in tropical oceanic islands, as far east as French Polynesia.

HABITAT AND BIOLOGY

Tectus niloticus inhabits shallow waters of coral and rocky reefs. It feeds on filamentous algae and generally avoids bottoms of sand and living corals. Population density decreases in deeper areas, while the mean sizes of individuals increase. It breeds during spring tides. Fertilization is external and shows nocturnal spawning. The presence of sperm induces females to spawn. Length of shell ranges from 50-165 mm and diameter from 100-120 mm.

BREEDING IN CAPTIVE CONDITIONS

Attempts on rearing *Tectus niloticus* in captivity has been undertaken at several locations viz., Palau, north Queensland in Australia, New Caledonia, India, Vanuatu and Okinawa in Japan with varying success.

Tectus niloticus spawning was often observed within a few days of new moon i.e. it spawned with lunar periodicity. Spawning was induced by thermal shock usually. Spawning generally happened in the early evening hours. Females spawned half a million to two million eggs in a 5-15 min spawning period; mostly about one million eggs per period. Spawning was always initiated by males, but females did not always spawn in response to the male spawning; females usually spawned about half as frequently as males. Some behavioural changes occurred shortly before spawning, like spending time at the waterline, cessation of feeding, and holding their heads partially inserted in shells. The right siphon, through which the eggs or sperm were released, was extended more than usual, and closed at the tip. Spawning lasted from about 5 to 15 min in females, and from about 10 min to an hour in males. The chances of spawning in well-fed specimens were more.

Breeding in captive conditions for stock enhancement was carried out in Australia, Indonesia and Vanuatu. More than 30 adults were collected for each spawning to ensure a good level of genetic variability. Spawning was induced by thermal shock in Australia and by strong aeration in Indonesia. The brooders were fed with brown and green algae growing on rocks and coral masses. About 100 specimens at a time were needed for the production of 5,00,000 seed shells of 3-4 mm in size.

Several artificial inductions are known to stimulate spawning such as drying, increase in temperature, hydrogen peroxide or a suspension of reproductive organs. *Tectus* spawned in activated sea water by ultra-violet (UV) rays, after they had been kept in static water for 24 h. When the UV activated sea water failed, the sea water temperature was increased by about 5 °C. Fully-matured *Tectus* also *spawned* naturally without any stimulation.

Parent shells were removed from the tank and held as males and females separately after spawning. The eggs of *T. niloticus* are covered with a thick layer of gelatinous material; which can be spoiled in warm water. The eggs should be kept at a low density or washed often by water exchange for the normal growth of eggs to veliger larvae. The 100 l polycarbonate hatching tank fitted with a plastic basket and covered with netting of 60-70 µm mesh were used to hatch the eggs. Egg density in larval rearing tank was 4-5/ml.

LARVAL REARING

Veliger larvae come up to the water surface after 20-24 h in hatching tank. They were collected and transferred to FRP tanks of 2.75 m^3 or 4 m^3 in volume where diatoms have been cultured in corrugated plates. The larvae fed on these cultured sessile diatoms. The sessile diatom medium was used in its culture, so seawater exchange was done only when the water quality was very poor, and only siphoning was done daily. The water in the tank used for algal culture was aerated finely to wash out the excess nutrients before larval culture. The duration of larval rearing was 2-3 months depending on the density. Seed was removed from the corrugated algal plates by hand or by immersing the plates in fresh water.

FOOD AND FEEDING

Larvae feed on benthic diatoms (*Nitzschia* sp. and *Navicula* sp.). Seaweeds and filamentous algae, other benthic algae and detritus are the main food of juveniles.

GROWTH RATE

Growth depends on the density of juveniles in the cages and the consequent competition for food and space. For density of 100/m^2, a basal diameter of 10-20 mm was achieved. On reduction of density to 50/m^2, yield increased to 25-40 mm basal diameter in 1.5 to 3 months. Reef-based cages yielded faster shell growth with an average of 2.6 mm/month in Vanuatu Island.

DISEASES AND CONTROL MEASURES

Boring sponges, bivalves (*Lithophaga* sp.) and gastropods (*Saptadanta nasika* and *Patella sp.*) bore into the periostracal and nacreous layers of the shell and damage it.

PRODUCTION, MARKET AND TRADE

PRODUCTION

It is one of the most economically important gastropod species especially in the Pacific Islands. Production of *Tectus* in the Thailand was 1,955 kg in 1994-1995; then decreased to 450 kg in 1995-1996 and increased again to 4,382 kg in 1996-1997.

MARKET AND TRADE

Shells are commercially exploited to make ornaments like pearl buttons, pendants, ear rings, necklaces, bangles etc. It is sold as decorative items, and is used in floor tiles, metallic paints and shampoo. Top shell is primarily targeted for its shell, which is processed into blank buttons and exported to China and Hong Kong for the fashion industry. The main top shell exporters are Indonesia, Philippines and Thailand and they export to Japan, Hong Kong, Europe, etc. In 2004, processed *T. niloticus* exported from Vanuatu Island was 35 t.

CHALLENGES TO MARICULTURE

Culture worldwide is on an experimental scale, and hence mass scale development of production systems, including breeding and larval and nursery rearing in confined environment has to be developed. Predation by fishes and ciliate infestation of larvae and boring by sponges, bivalves and gastropods are potential mariculture problems and need to be addressed urgently.

FUTURE PROSPECTS

It is a highly sought after resource both for food and other products from it, in the Pacific and Indo-Pacific regions. This has resulted in the species being over-harvested and the stocks becoming depleted. Currently, in India, the species is conserved under Schedule IV of Wild Life Protection Act, 1972. Releasing hatchery-reared juveniles is an option to replenish the reduced wild stocks. Similarly standardizing and popularizing the hatchery operations can lead to enhanced exports from India.

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Tridacna maxima (Röding, 1798)

Pralaya Ranjan Behera

IDENTIFICATION

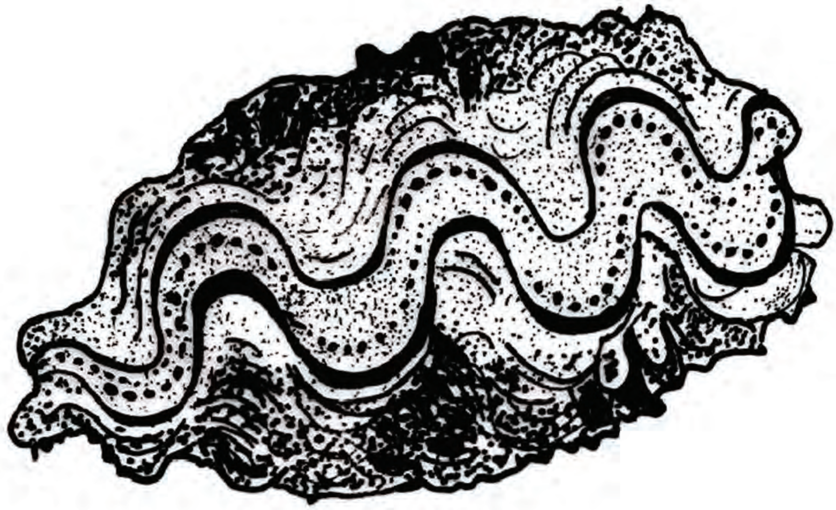
Order	:	**Cardiida**
Family	:	**Cardiidae**
Common/FAO Name (English)	:	**Small giant clam**

Source of image : RC of CMFRI, Tuticorin

Local names: Not known

MORPHOLOGICAL DESCRIPTION

The shell is strongly asymmetrical in form, typically being much longer than tall. Shell typically has 5 distinct ribs. The ribs have numerous very tightly spaced but light scutes. However, these are typically eroded away by the burrowing activities in their natural habitat. It has numerous scutes present only on the upper portion of the shell. Upper margin is strongly curved and each valve is symmetrical to the other. Byssal opening is variable in size, being moderate to relatively large. Mantle extension is well past the margin, completely hiding the shell and the scutes. In-current siphon is ringed with numerous small, simple tentacles.



It has a large shell that adheres to a rock by its byssus threads, which is a tuft of long and tough filaments protruding from a hole next to the hinge of the shell. The mantle side is bright blue, green or brown and is exposed and obscures the edges of the shell with its prominent and distinctively furrowed edges.

PROFILE

GEOGRAPHICAL DISTRIBUTION

It is widely distributed in the Indo-Pacific region from Egypt to Pitcairn Islands and Ogasawara, Japan to Lord Howe Island. In India, it is reported from west and east coasts, from Andaman and Nicobar Islands and Lakshadweep Islands.

HABITAT AND BIOLOGY

It is reef associated and inhabits depth ranges from 0-35 m. It is sessile attaching itself to rocks or dead corals. It does not need to filter-feed as much as other clams since it obtains most of the nutrients it requires from tiny photosynthetic algae known as zooxanthellae. At the juvenile stage it can acquire zooxanthellae and function symbiotically. It is a protandrous hermaphrodite. It reaches sexual maturity at a shell length of 4 cm at an age of two years. Reproduction is stimulated by the lunar cycle, the time of the day and the presence of other eggs and sperm in the water.

BREEDING IN CAPTIVE CONDITIONS

Induced spawning using macerated gonads was done at Anae Island, Guam. Adults were collected from the wild and kept in broodstock tanks. Ripe gonad was removed from sacrificed specimen and macerated in a blender using filtered sea water. On keeping the macerated gonads in sea water, clams starts releasing sperms within 2 to 3 minutes, which continued up to 6 hours, followed by release of eggs. Spawning was mostly observed from November to March. Approximate 2.08 - 2.9 millions eggs were released per spawning. Fertilized eggs measured 104.5 µm in diameter.

LARVAL REARING

After fertilization, typical bivalve spiral cleavage resulted in a spherical blastula. The rotating ciliated gastrulae were observed 7 hours after fertilization. Trochophore stage was reached 16 h post fertilization. Straight-hinge veliger stage was reached after 20 h of fertilization. Pediveligers developed by 9 days. Complete metamorphosis and final settlement was observed by day 12. The acquisition of zooxanthellae in the mantle of the juvenile occurred between 21-40 days. Smallest juvenile with zooxanthellae was 210 µm in shell length. In general, it acquired zooxanthellae immediately after metamorphosis. Juvenile shells with opaque patches were observed on day 47.

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

It is a myxotroph filter feeder and photosynthesizes via its *Zooxanthellae*. It derives its nutrition from uptake of dissolved matter through its epidermis and from its symbiotic relation with zooxanthellae, *Symbiodinium microadriaticum*.

GROWTH RATE

Growth rate of veliger shell was 2.7 µm/day. Shell growth rates after settlement and metamorphosis, until day 40 was 2.3 µm/day. After day 40, growth rate increased sharply (6.8 µm/day). This corresponded to a time when majority of juveniles acquired zooxanthellae. Juveniles attained a shell length of 400-835 µm after 91 days of fertilization. It grew to a mean size of 78.4 mm shell length in 19 months.

DISEASES AND CONTROL MEASURES

Ranellid snails (gastropods) of the genus *Cymatium* are the most destructive predator for cultured giant clams. Only method for controlling is regular inspection and removal of visible snails. With regular weekly inspection, mortalities are limited to a minimum. In land-based systems, infestation is prevented by screening water through 25 µm filter bags or other forms of filters. Pyramidellid snails belonging to the genera *Turbonilla, Pyrgiscus* and *Tathrella* also damage this species. Mantle bleaching due to rapid fluctuations in environmental conditions, especially temperature and light, is responsible for expelling of its zooxanthella from all parts of mantle, leaving it white and without pattern. Gas bubble disease is caused in culture by high levels of dissolved gases.

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

It is one of the main giant clam species traded globally. During 1994-2003, exports were recorded from 31 countries and territories (most notably from Australia, Fiji, the Federated States of Micronesia, French Polynesia, Kiribati, Madagascar, the Marshall Islands, Mozambique, New Caledonia, Papua New Guinea, Tonga, Vanuatu and Vietnam). It has good demand for the tourism based ornamental shell industry in Andaman and Nicobar Islands. The flesh is used as food in Andaman and Nicobar Islands. Valves are used as benitiers in churches.

CHALLENGES TO MARICULTURE

The breeding and seed production of the species has been reported from different countries; however it has not been reported from India. The main researchable issues, which have to be sorted out for this species in India, are (i) Life history study (ii) Healthy broodstock development protocol (iii) Larval rearing protocol: Standardization of larval rearing by environmental and nutritional manipulation.

FUTURE PROSPECTS

Due to overexploitation in considerable quantities every year for live ornamental trade, population is declining at a rapid pace. It is included in the Schedule I of Indian Wildlife (Protection) Act, 1972. It is protected under the IUCN red list, in which it is classified as Least Concern, Conservation Dependent. It is also protected under CITES Appendix II. The development of successful captive breeding and hatchery seed production practices will facilitate stock enhancement of the species. Hatchery reared seeds can be used to replenish wild stocks.

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Turbo marmoratus Linnaeus, 1758

Jasmin F.

IDENTIFICATION

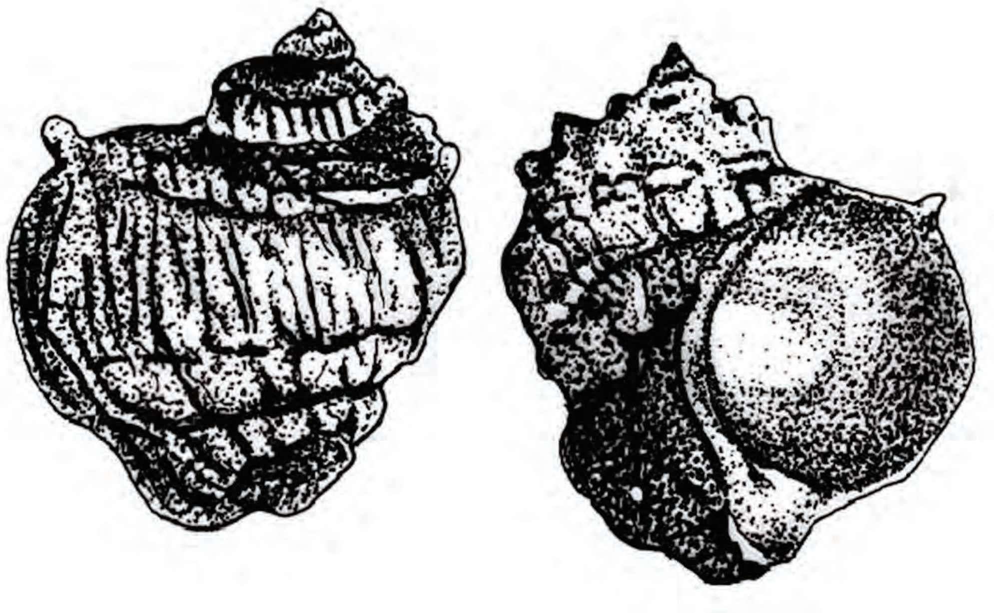
Order	:	-
Family	:	**Turbinidae**
Common/FAO Name (English)	:	**Great green turban shell**

Local names: Not available

MORPHOLOGICAL DESCRIPTION

Turbo marmoratus is a large marine snail. It has a thick, heavy shell, dextrally coiled and roughly turban-shaped. The body whorl is large, with a small, pointed spire. The length of the shell is roughly equal to the width. The spire whorls are rounded, but the body whorl has an angular shoulder. The shell is marked with fine axial growth lines and three large spiral ribs, bearing blunt tubercles. The aperture is very large, forming two-third of the length of the shell, and is nearly circular, surrounded by a thick pearly lip. The operculum is calcareous, with a granular surface. Adults have a smooth white operculum whereas opercula of juveniles have granules. The colour is dull uniform green (greyish-green) with spiral bands of chestnut. Aperture is golden and operculum is white in colour.

Source of image : www.commons.wikimedia.org



PROFILE

GEOGRAPHICAL DISTRIBUTION

Turbo marmoratus is distributed in the Indo-Pacific and West Pacific region from south and east Africa to Fiji, covering the Andaman and Nicobar Islands of India, Malaysia, Indonesia, Thailand, Philippines, east of Japan, Australia, French Polynesia, Vanuatu and Ryuku Island.

HABITAT AND BIOLOGY

It inhabits the flats and slopes of coral reefs, but is also found in subtropical warm temperate regions where coral reefs are absent. It is found at depths of 10 to 30 m. Juveniles live on reef crests, while adults occur deeper on slopes to about 20 m or more. It is mostly gonochoric and is a broadcast spawner with external fertilization. The eggs are laid in gelatinous masses which hatch into planktotrophic larvae and later into juvenile veligers, before developing into fully grown adults. It is an herbivorous marine gastropod. The shell reaches 18 to 22 cm in length. The size at first maturity reported is about 13 cm shell diameter. In tropical regions of their distribution, mature ones breed continuously throughout the year. A female green snail of wet weight 2.0 kg has up to 7 million eggs in a fully developed ovary.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Turbo marmoratus has been successfully bred at Okinawa Sea-Farming Centre, Japan. Broodstock animals ranging from12.6-20.8 cm shell diameter collected from the wild were kept in a 100 l polycarbonate tank at high density with good aeration for a day. The water which was fouled with the faecal matter and mucus from the animals was exchanged with fresh seawater the next day. This water exchange induced some snails to spawn. The males spawned first. The spawners were retained in a dark environment during induction of spawning. Spawning activity lasted up to half an hour. Since males were more responsive to induction, the sex ratio of snails was kept in favour of females. In another trial in Okinawa, the broodstock were collected and kept in outdoor concrete tanks without feeding for 1-7 days. These were then removed to smaller FRP tanks (1.6 x 1.0 x 0.65 m) for induction of spawning. In both the trials, seawater treated with UV-light was used for induction of spawning. Fertilized eggs hatched into trochophores in about 22 h at water temperatures between 21 °C and 23 °C and this can be reduced to 12 h at a temperature of 25 °C.

LARVAL REARING

On the first day after hatching, the trochophores and later, the veligers aggregated near the surface. The veligers were transferred to 4 t FRP tanks which had pre-culture of diatom. Culture seawater was not changed and only feeble aeration was given for the first 3-7 days. Pediveligers were formed on the third day and majority of the larvae settled during the fourth day. After this, settled juveniles were cultured in lentic seawater.

FOOD AND FEEDING

It feeds on attached algae and plant detritus. It feeds actively at night and forages among the rubbles for the algae. Adult green snail feed on epibenthic microalgae from limestone substrates. They also graze on macroalgae. In captive condition, green snail prefers green and red algae to brown algae even in dried conditions.

GROWTH RATE

In 3 months, the shell of early juveniles grew upto 3 mm diameter from less than 1 mm. The growth rate varied widely according to habitat and food availability; and shell width of 3 years old snails ranged from 1.5 to 6.5 cm.

DISEASES AND CONTROL MEASURES

Turbo marmoratus populations are susceptible to infestations of *Sabia* sp. causing juvenile mortality. Predation is a problem in outdoor culture systems where they are susceptible to predation by turbellarians.

PRODUCTION, MARKET AND TRADE

PRODUCTION

The Food and Agriculture Organisation of the United Nations (FAO) cites the total world production in 1985 at 500 t, based on the productions from only Australia and Malaysia. This had increased to 800 t in 1986 and to 1,000 t in 1987 and 1988.

MARKET AND TRADE

The flesh forms an important component of diet of fishermen and local communities throughout the Indo-West Pacific region. The nacreous shell is used in manufacture of buttons, and as inlay material for lacquerware, furniture and jewellery. It is also sold as decorative item, valued for its pearly shine. The large opercula are sold as paperweights or door stops. The green snail exports averaged 59.7 t/year in Papua New Guinea during 1950-1984. Annual exports from Solomon Islands averaged 7.1 t for the period 1981 to 1989. From Vanuatu Islands, exports averaged 21 t annually with a range of 7 to 65 t between 1966 and 1982. South Korea imported about 150 t of green snails in 1987. This species was used to be exported by Philippines, Malaysia, India and Indonesia to the USA, Japan and Korea in the 1970s. However, since then the quantities traded have decreased.

CHALLENGES TO MARICULTURE

The main challenges for green snail mariculture are the availability of broodstock and the high cost of hatchery practices and re-seeding failures due to high predation and survivability. Culture prospect of the species is yet to be explored in India.

FUTURE PROSPECTS

It is one of the most economically important gastropod species. It is used as an important traditional food item and a leading export item used as source for mother-of-pearl material for buttons and jewellery. In India the species is protected under Schedule IV of Wild Life Protection Act, 1972. However, with the development of successful captive breeding and hatchery seed production practices, the culture of *Turbo marmoratus* can be established in India, which will help in stock enhancement as well as provide resources for export.

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Volachlamys tranquebaria (Gmelin, 1791)

Pralaya Ranjan Behera

IDENTIFICATION

Order	:	**Pectinida**
Family	:	**Pectinidae**
Common/FAO Name (English)	:	**Tranquebar scallop**

Source of image : www.nmr- pics.nl

Local names: Not known

MORPHOLOGICAL DESCRIPTION

Shell has both external and internal distinct radial ribs. Both valves are convex and have ears of about the same size. Shell is sub-circular in outline and the ribs are without radial sculpture. The ribs are round and sharp with a small interspace. The shells are bigger in size and colorful. The shells range from 30 mm to 50 mm in height. Colour varies from brown with white flecks to orange and red.

PROFILE

GEOGRAPHICAL DISTRIBUTION

It is reported from the north-east side of the Indian Ocean. In India, it is reported from Vellar estuary and Gulf of Mannar, Tamil Nadu; from Pennera river estuary, Andhra Pradesh; from Odisha coast and from Digha coast, West-Bengal.

HABITAT AND BIOLOGY

It is mostly found in marine and estuarine environments. It lives on soft muddy bottoms and is adapted for dealing with turbid water conditions.

PRODUCTION SYSTEMS

BREEDING IN CAPTIVE CONDITIONS

Information not available

LARVAL REARING

Information not available

NURSERY REARING

Information not available

GROW-OUT

Information not available

FOOD AND FEEDING

It is an opportunistic filter feeder, feeding mainly on phytoplankton, micro zooplankton and foraminiferans.

GROWTH RATE

Information not available

DISEASES AND CONTROL MEASURES

Information not available

PRODUCTION, MARKET AND TRADE

PRODUCTION

Information not available

MARKET AND TRADE

It possesses ornamental value.

CHALLENGES TO MARICULTURE

The main researchable issues, which have to be sorted out for this species, are (i) Life history study (ii) Healthy broodstock development protocol (iii) Larval rearing protocol: Standardization of larval rearing by environmental and nutritional manipulation.

FUTURE PROSPECTS

This species has ornamental value. With the development of breeding and seed production technology, this can be used as a candidate species as a source of income for stakeholders involved in its culture and trade.

SUGGESTED READING

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RESEARCH GAPS IN ALREADY STANDARDIZED ORNAMENTAL SPECIES

Research gaps in already standardized ornamental species

Central Marine Fisheries Research Institute (CMFRI), Kochi has standardized the culture techniques for ten marine ornamental finfish species namely, *Amphiprion percula, A. ocellaris, A. clarkii, A. frenatus, A. nigripus, A.ephippium, A. sebae, A. sandaracinos, A. perideraion* and *Premnas biaculeatus*. Recently, the institute has successfully raised hybrid clown fishes and designer clowns (picasso, platinum, snowflakes, etc) and the protocols for larval rearing and fingerling production have been standardized. However gaps are still present with each standardized species, which needs to be addressed, before the technology can be transferred as an entire package.

Clown fishes

Source of image : CMFRI, Kochi

Species available in India for mariculture

Amphiprion percula, A. ocellaris, A. clarkii, A. frenatus, A.nigripus, A.ephippium, A.sebae, A. sandaracinos, A. perideraion, A. akallopisos, A. bicinctus, A. chrysogaster, A. melanopus, A. polymnus, Premnas biaculeatus.

Species for which breeding and seed production technology has been standardized

Amphiprion percula, A. ocellaris, A. clarkii, A. frenatus, A. nigripus, A.ephippium, A. sebae, A. sandaracinos, A. perideraion, Premnas biaculeatus

Species for which research needs to be carried out

Amphiprion akallopisos, A. bicinctus, A. chrysogaster, A. melanopus, A. polymnus

Research gaps to be filled in already bred species

- Year round spawning through manipulation of temperature and photoperiod (except for *Amphiprion percula*)
- Standardization of egg hatching techniques through manipulation of temperature and darkness.
- Use of enriched *Diaphanosoma celebensis* as an alternative live feed to replace *Artemia* nauplii in larval rearing of clown fishes.
- Selective breeding of misbar clownfishes
- Cross breeding of clownfishes
- Sex changing mechanism in clownfishes other than *A. percula* and *A. ocellaris*
- Breeding, larval rearing and development of hatchery technology for *A. akallopisos, A. bicinctus, A. chrysogaster, A. melanopus, A. polymnus*.
- Biochemical composition of eggs and larvae of clownfishes

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Prioritized Species for Mariculture in India

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