

## Reproductive biology of some common coral reef fishes of the Indian EEZ

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### Abstract

The reproductive biology of some common coral reef fishes from the Lakshadweep (8° to 12°N and 71°45' to 73°45'E) and the Gulf of Mannar (8°48' to 9°14'N and 79°9' to 79°14'E) in the Indian EEZ during January 1991 to June 1992 is reported. Protogyny was prominent in labrids, while other species either matured synchronously or differentially, with males maturing earlier or later than females. Sex-ratio indicated that females were dominant in most species. Fecundity estimates varied greatly, from 700 to 2,25,850 ova per female. Whenever the environment is favourable the coral reef fish spawn on a daily, weekly, fortnightly and monthly basis. Total fecundity per year, therefore, is presumably very high. Most species appeared to be perennial spawners, some showed small breaks, while very few indicated biannual spawning. Continuous occurrence of juveniles in different size ranges confirmed the continuous spawning habits. Spawning activity was minimum during monsoon seasons, evidently an adaptation to tide over adverse environmental conditions prevailing at that time lest the eggs and larvae are transported far and wide. This was corroborated by peak settlement during pre-monsoon and post-monsoon seasons.

### Introduction

Reproductive strategies of coral reef fishes are diverse and not well known in India. They tend to be highly fecund species which produce eggs that vary greatly in number from tens to hundreds to thousands at a time, on a daily, fortnightly, monthly or less frequent schedules (Sale, 1991). He further recognized that reef fish are also flexible in how they determine sex. In addition to the conventional gonochoristic species in which the sex of individuals is fixed, there are numerous hermaphroditic species. Some of these are simultaneous hermaphrodites,

most of them sequential hermaphrodites, and in being so, a majority of the species are protogynous (female first, then male) while few are protandrous. Most reef fishes lay pelagic eggs although some lay demersal eggs with parental care, some are oral or mouth brooders and some are viviparous.

Once they hatch, most of them undergo two distinct phases in their life cycle, a pelagic larval phase followed by a reef resident phase in the parental habitat (Johannes, 1978; Sale, 1980) where they grow and change habitats within reef system to suit their adult life. Enormous

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information on the reproduction and recruitment of coral reef fishes exists world-over. Though extensive reef systems exist in the Indian EEZ, the life cycles and other aspects of biology of reef fishes and ecology have received the least attention. The present study therefore attempts to make a beginning in the documentation of certain aspects of the reproductive biology of 25 commonly occurring coral reef fishes from Lakshadweep and Gulf of Mannar region.

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### **Material and methods**

Twenty five commonly occurring species were selected mainly from Lakshadweep and a few from Gulf of Mannar region to study aspects of maturity and spawning during the period January 1991 to June 1992.

Five maturity stages, namely, immature, maturing, mature, ripe and spent were recognized based on macroscopic and microscopic examination of gonads for use in determining the size at first maturity. Sex, gonad weight, stage of

maturity and the standard length (SL) of individual fishes were recorded. To determine the size at first maturity, two broad categories were formed to designate immature (immature + maturing) and mature specimens (mature + ripe). Percentages tabulated against size groups indicated the minimum size at which mature fish occurred for the first time. Sex-ratio was computed based on total number of females and males recorded and ratio expressed as female : male. Fecundity was estimated by counting mature ova from preserved ripe ovaries.

To determine the spawning frequencies, diameters of intra-ovarian eggs from preserved ovaries were measured by means of an ocular micrometer with a magnification of 0.032 mm to each division. Ova were measured at random and frequency polygons drawn. Percentage occurrence of ripe and spent specimens on a monthly time scale were used to determine the spawning seasons.

### **Results**

The data collected on the maturity, spawning season, sex ratio and fecundity are summarized in Table 1. The percentage occurrence of ripe fish and the ova diameter frequency polygons are shown in figures 1 to 3 and figures 4 to 6 respectively.

### **Discussion**

Reproduction in reef fishes is known to be complex. Warner (1991) stated that life histories and sexual patterns are diverse with mature individuals occurring over a great ranges of sizes, and that average

**Table 1.** Details of maturity size, spawning season, sex ratio and fecundity of coral reef fishes in the Indian EEZ

Species	Maturity (mm)	Spawning season	Sex ratio (F:M)	Fecundity
<i>Acanthurus leucosternon</i>	101-110 (F) 111-120 (M)	September-April	1:1	19004-25603
<i>A. triostegus</i>	100 (F) 71-80 (M)	November-May	1:0.82	10963-20400
<i>Chaetodon collare</i>	101-110 (F) 91-100 (M)	February-April	1:0.49	2763-31065
<i>C. melannotus</i>	71-80	August-May	1:0.96	1492-24532
<i>C. octofasciatus</i>	71-80	February-July September-October	1:1.64	1060-2879
<i>C. trifasciatus</i>	81-90	August-January March-May	1:0.67	1984-21975
<i>Cheilio inermis</i>	121-150 (F)	November-April	1:0.8	2982-6834
<i>Chrysiptera unimaculata</i>	31-40	March - May, October	1:0.55	1265-4592
<i>Dascyllus trimaculatus</i>	31-40 (F) 51-60 (M)	April - May August-December	1:0.49	809-9634
<i>Gnathodentex aureolineatus</i>	111-120 (F) 121-130 (M)	August-November January-April	1:0.59	19800-45632
<i>Halichoeres scapularis</i>	51-60 (F) 61-70 (M)	April-May November-December	1:0.15	9992-15633
<i>Lutjanus gibbus</i>	151-170 (F) 111-130 (M)	January-April August-October	1:0.67	46774-130698
<i>L. kasmira</i>	91-110 (F) 111-130 (M)	October-March	1:0.75	33752-225850
<i>Melichthys indicus</i>	111-120	September-December April-May	1:0.8	2056-9329
<i>Mulloides flavolineatus</i>	91-110	January-May October-November	1:0.78	4638-12946
<i>Myripristis murdjan</i>	111-120 (F) 71-80 (M)	September	1:0.48	11163-22689
<i>Neoniphon sammara</i>	71-80	November-May	1:0.39	7973-15323
<i>Paracirrhites forsteri</i>	71-80 (F) 51-60 (M)	January-May October-November	1:0.45	734-1894
<i>Parupeneus barberinus</i>	111-130 (F) 151-170 (M)	October-May (except December & February)	1:0.61	9234-10988
<i>P. bifasciatus</i>	91-110 (F) 131-150 (M)	September-April (except December)	1:0.60	2968-146373
<i>Plectorhinchus orientalis</i>	181-230 (F) 231-280 (M)	December-May (except February)	1:0.57	8927-16342
<i>Pomacentrus pavo</i>	41-50	March-May (higher %)	1:0.58	700-2396
<i>Rhinecanthus aculeatus</i>	91-100 (F) 81-90 (M)	April (higher %)	1:0.73	936-7262
<i>Thalassoma hardwicki</i>	81-90 (F) 101 (M)	February-May September-December	1:0.23	4600-8743
<i>T. lunare</i>	91-100 (F) 131 (M)	January-May October-December	1:0.28	3342-10360

longevities range from a few months to many years. Some species are heterosexual, others show change in sex while some others are hermaphrodites.

*Size at first maturity and sex ratio* : Both females and males of *Acanthurus leucosternon* were found to attain maturity in the size range of 101 to 110 mm SL. Maturation process in females seemed to prolong up to a SL of 120 mm. In general, this species appeared to mature at relatively smaller sizes as compared to the maximum size obtained in this study (151 to 160 mm). Resson (1983) found *A. coeruleus* to mature at about 13 cm FL (fork length) and *A. bahianus* at about 11 cm FL. Though length measures, species and the geographic area (Caribbean region) vary from the present study, their size at first maturity appears to be similar to that of *A. leucosternon*. Further, Resson (1983) reported that sexes are separate amongst the acanthurids and found no evidence of sexual dimorphism. The sex ratio of 1:1 in the present study possibly supports the fact. In contrast to *A. leucosternon*, *A. triostegus* matured at an even smaller size range (81 to 90 mm), perhaps due to a relatively smaller size attained by this species.

The four chaetodontid species recorded were found to mature between 61 to 100 mm SL. Burgess (1978) observed that according to maximum standard length of the various species, specimens in the size range below 40 to 60 mm SL were considered juveniles. In the present study, size ranges of *Chaetodon melannotus* and

*C. octofasciatus* are in accordance with the observation of Burgess (1978) and could be termed juveniles as sex was indeterminate below 60 mm, while in *C. collare* and *C. trifasciatus* it was below 80 and 70 mm SL respectively. Sizes at first maturity in all the 4 species appeared to be closer to maximum sizes collected in the present study. Ralston (1976) stated that by the time of sexual maturity at approximately one year of age, butterflyfishes reached 70 to 75% of their maximum size; similar observations were made in the present study. Size at first maturity for *C. collare* and *C. trifasciatus* occurred at relatively larger lengths (91 to 110 mm and 81 to 90 mm size groups respectively) compared to *C. melannotus* and *C. octofasciatus* (71 to 80 mm size group). Males and females matured synchronously except in *C. collare* where males matured later (101 to 110 mm). As pair formation in butterflyfishes is a well known fact (Fricke, 1986), synchronous maturity of males and females is perhaps in groups of 5 to 10 individuals and pair bonding did not appear to be strong. This could probably explain the differential maturity of males and females. All chaetodontids studied were dominated by the number of females except in the case of *C. octofasciatus* where males dominated. Lobel (1989) found that the sex ratio of mature *C. multinctus* collected in pairs was 1 : 1, while Vijay Anand (1990) recorded a ratio of 1 : 1.70 (male : female). Collection of mature pairs would have yielded a sex ratio of 1:1 but in the present study pairs were not always efficiently captured, and further the collection of

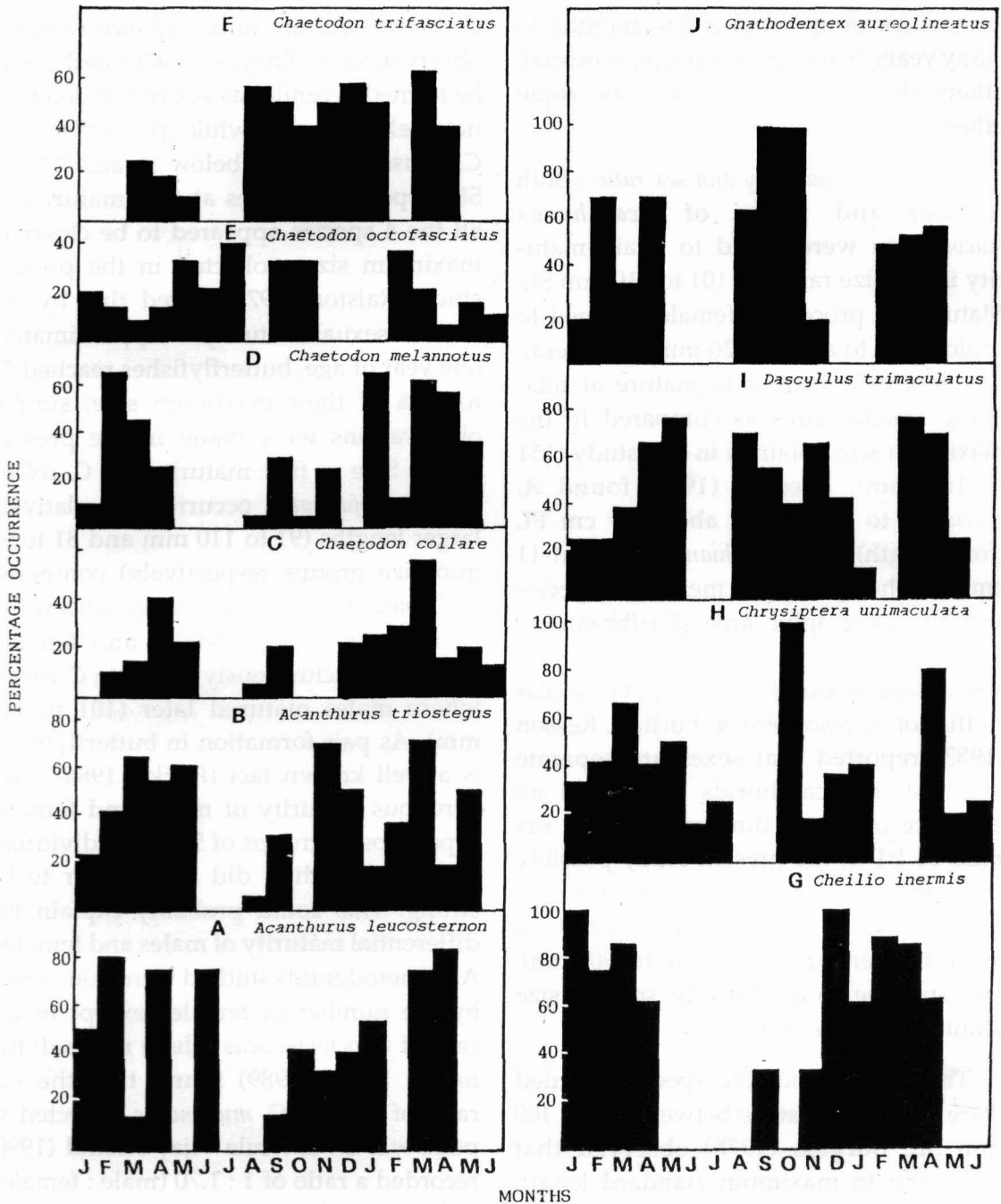


Fig. 1. Percentage occurrence of ripe fish in ten species of coral reef fishes

small groups of sub-adults could have varied ratios.

Larger maturity sizes (121 to 150 mm) in *Cheilio inermis* perhaps dependent on

its long body feature. Protogyny is strongly developed in Labridae with the occurrence of two types of males namely, the primary and secondary males (Robertson and Choat, 1974; Warner and Robertson, 1978). The males recorded in *C. inermis* in the present study were perhaps large secondary males (271 to 300 mm) and this cannot be considered as size at first maturity. Inclusion of a few primary males could have helped in determining the maturity sizes in males. The high difference in the sex ratio is possibly due to the protogyny that is predominant in labrids. A similar picture was evident in *Halichoeres scapularis* but sizes at which fish matured were smaller (61 to 70 mm). Data indicated the presence of primary and secondary males. However, the sex ratio pattern reflected on protogyny.

Most pomacentrids are smaller territorial fishes. Early onset of maturity in *Chrysiptera unimaculata* and *Dascyllus trimaculatus* (21 to 30 mm and 31 to 40 mm respectively) is possibly due to small body size and these may also be relatively short lived species. Males in the former species matured later than females; and females dominated in both species. Pillai and Madan Mohan (1990) reported the size at first maturity of *Abudefduf glaucus* to be 60 mm TL. It is perhaps advantageous for them to mature at smaller sizes and maximize egg production. Such observations were made on *Pomacentrus pavo* with females as the dominant sex.

Females of *Gnathodentex aureolineatus* were dominant and matured earlier than males. The maximum size recorded for *G.*

*aureolineatus* by Jones and Kumaran (1980) was 165 mm while in the present study, it was 150 mm. Despite small body size, this species appeared to mature at a relatively later age.

Males of *Lutjanus gibbus* matured earlier than females. Thompson and Munro (1983) suggested that an early maturity in males of some Caribbean lutjanids could be due to a faster growth rate in males. Apart from this reasoning, it may be possible that females of *L. gibbus* matured relatively later than males. Fully mature females were recorded above 191 mm while males occurred above 151 mm. Females of *L. kasmira* were dominant and matured earlier than males. The overall sizes at first maturity appeared to be lower for this species occurring in Lakshadweep as compared to those in Andaman Islands. Rangarajan (1971) found that in the case of *L. kasmira* from Andamans, maturity sets in at 170 mm and 50% of them were mature at 200 mm. The reasons for this difference remain unclear.

Hermaphroditism, heterosexuality or inter-sexuality have not been reported in Balistidae (Aikon, 1983). Synchronous maturation of females and males of *Melichthys indicus* could possibly be attributed to lack of complicated sexuality patterns. Maturity for both sexes was attained between 111 and 120 mm with females as the dominant sex.

Males and females of *Mulloides flavolineatus* matured at 91 to 110 mm SL and the process appeared to be prolonged upto 130 mm in females.



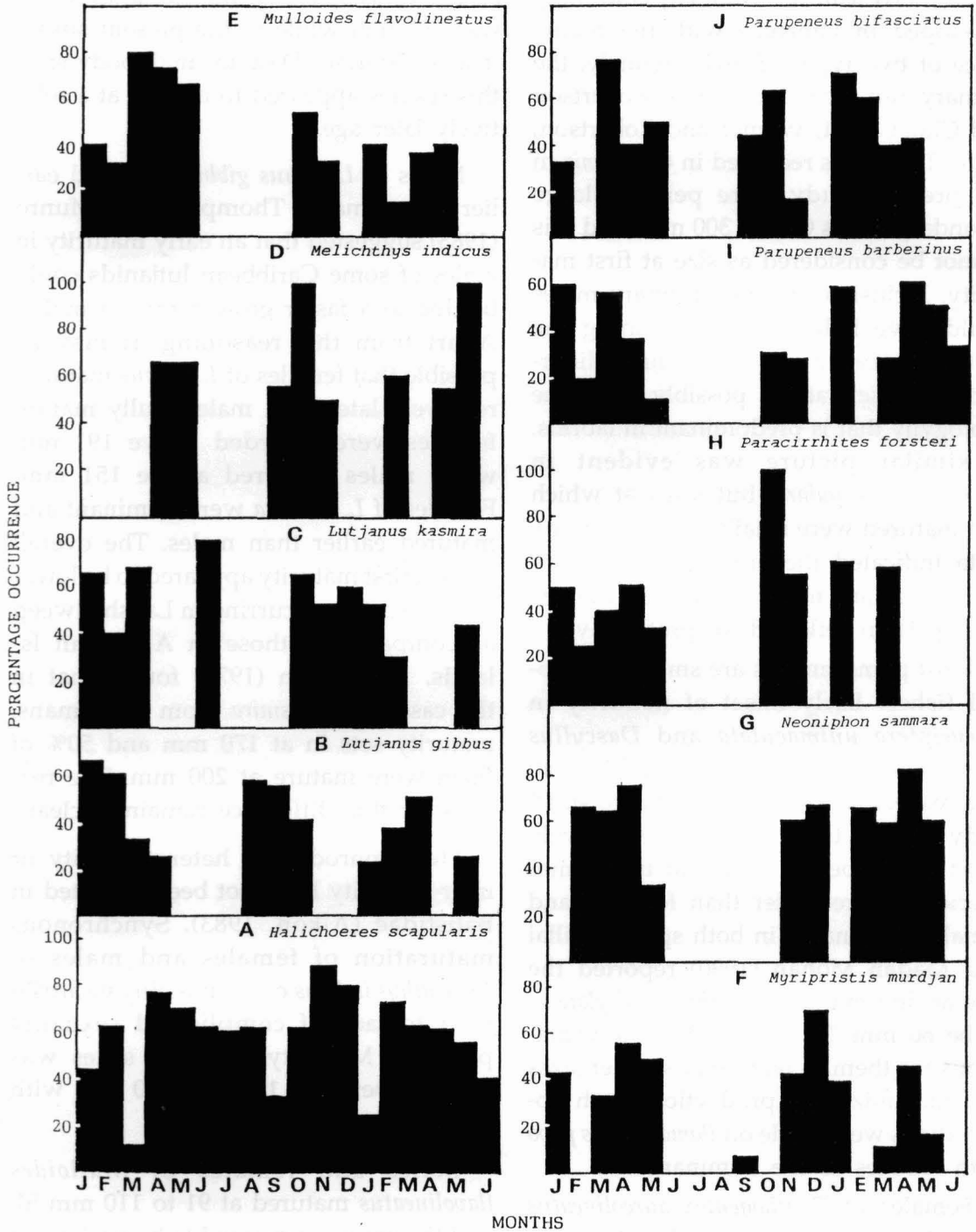


Fig. 2. Percentage occurrence of ripe fish in ten species of coral reef fishes

In comparison to *Mulloidichthys martinicus* which matured between 175 and 185 mm FL (Munro, 1976), the species in the present study matured at smaller body lengths. The predominance of females of *M. martinicus* (Munro, 1976) was similar to the sex ratio of 1 : 0.78 (female : male) in *M. flavolineatus*.

Males of *Myripristis murdjan* matured much earlier than females. Fully mature males measured above 81 mm while the same in females was above 131 mm. As these are schooling species and the number of males are relatively less (sex ratio = 1 : 0.48), it would possible be advantageous for males to mature earlier to ensure reproductive success. In contrast, though the number of males was less in *Neoniphon sammara*, differential maturity did not occur and females were dominant.

Females of *Parucirrhites forsteri* were dominant and attained maturity at larger sizes (71 to 80 mm) as compared to males (51 to 60 mm). As information on their social systems could not be obtained, no conclusions can be drawn about their sexuality.

Females of *Parapeneus barberinus* and *P. bifasciatus* dominated and matured at smaller sizes (111 to 130 mm and 91 to 110 mm respectively) compared to males (151 to 170 mm and 131 to 150 mm respectively). Munro (1983) reported that *Pseudupeneus maculatus* may probably mature at sizes less than 16 cm FL and *M. martinicus* between 17.50 to 18.50 cm FL. Though the species under consideration

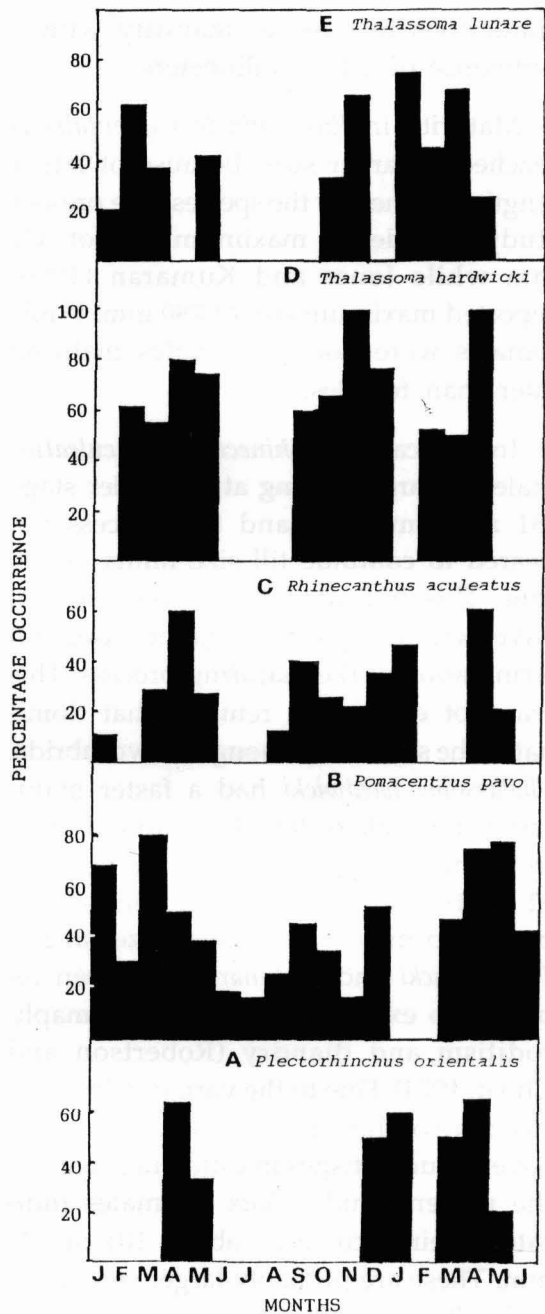


Fig. 3. Percentage occurrence of ripe fish in five species of coral reef fishes

are different, on the basis of the family, Mullidae, these species appear to show



similarities in sizes of maturity with a difference of a few millimeters.

Maturity in *Plectorhinchus orientalis* is reached at larger sizes because of larger lengths attained by the species. The present study recorded a maximum size of 380 mm while Jones and Kumaran (1980) reported maximum size of 280 mm. While females were dominant males matured later than females.

In the case of *Rhinecanthus aculeatus*, males began maturing at an earlier stage (81 mm onwards) and the process appeared to continue till size limits of 130 mm. This indicated that males did not have definite cut-off points for onset and termination of the maturing process. This was not evident in females that dominated the sex ratio. Among the two labrids, *Thalassoma hardwicki* had a faster maturation rate where females matured at 81 to 90 mm while *T. lunare* it was between 91 to 100 mm. Wrasses in general appeared to mature at smaller size ranges. *T. hardwicki* and *T. lunare* have been reported to exhibit protogynous hermaphroditism and diandry (Robertson and Choat, 1974). Due to the variation in social structure of these fishes, collections might have included fishes in different stages. In the present study, data on males indicated their occurrence above 101 or 131 mm. These are probably larger secondary males. It is likely that primary males occur at smaller sizes and represent diandry (as seen in *H. scapularis*). Due to protogynous nature, the sex ratio tends to weigh more for females. However, only a complete

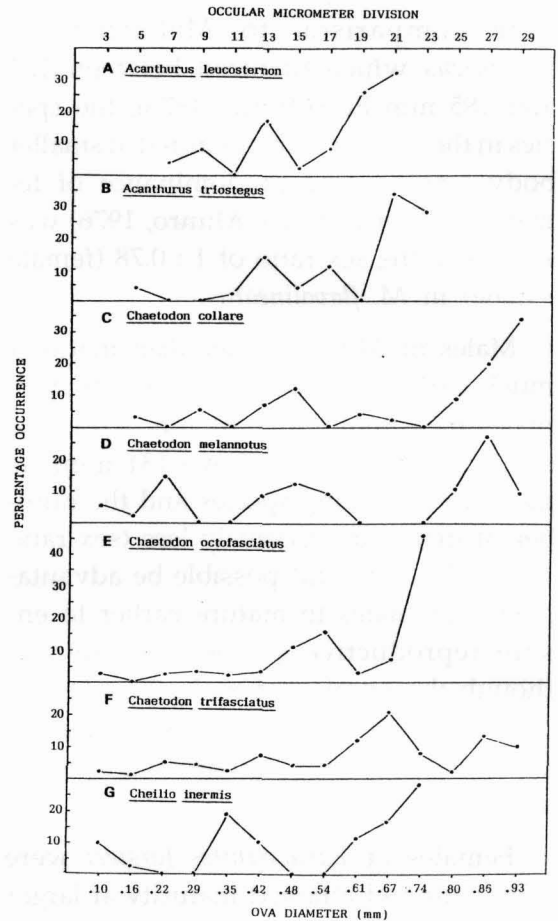


Fig. 4. Ova diameter frequency polygons of seven species of coral reef fishes

inclusion of individuals will give a realistic sex ratio in labrids.

**Fecundity:** Fecundity estimates exhibit a high variation perhaps due to diverse modes involved in spawning. Apart from pelagic eggs, fish lay demersal eggs with parental care, some are oral or body brooders and some are viviparous. Coral reef fishes are known to be highly fecund with annual egg production ranges from 10,000 to 1,00,000 per female (Sale, 1980). In the present study, the overall fecundity

range was 700 to 2,25,850 eggs per female. Estimates probably varied due to size differences in the gonads, mature fish selected and the species.

Randall (1961) observed 40,000 mature eggs in a single female of *A. triostegus*, while in the present study a range of 10,963 to 20,200 was recorded. *A. leucosternon* had a relatively higher fecundity. Balistids lay demersal eggs (Barlow, 1981; Thresher, 1991) with some parental care. The low fecundity range of 936 to 7262 in *R. aculeatus* is possibly due to parental care exhibited by this species. The nature of eggs in *M. indicus* is not certain as this species was frequently observed in the water column, and indicates a relatively higher fecundity range (2,056 to 9,329). Fecundity estimate in some chaetodontid species like *C. aculeatus* was 2090, collected after gamete release; 2,900 to 12,900 in *C. capistratus* (Colin, 1989) and 10,368 to 38,400 in *C. auriga* from Lakshadweep (Vijay Anand, 1990). Fecundities of 1,492 to 24,532 (*C. melanotus*), 1,060 to 2,879 (*C. octofasciatus*), 1984 to 21,975 (*C. trifasciatus*) and 2,763 to 31,065 (*C. collare*) were roughly comparable. Leis (1991) reported cirrhitids to have pelagic eggs but *P. forsteri* showed a low fecundity (734 to 1894) and this could possibly be due to small gonads examined. Relatively high fecundities in *P. orientalis*, *M. murdjan* and *N. sammara* possibly indicate pelagic spawning modes. Vijay Anand (1990) observed a fecundity of 4,704 to 8,743 in *H. centiquadrus* from Lakshadweep. *H. scapularis* had a relatively higher fecundity of 9,992 to 15,633.

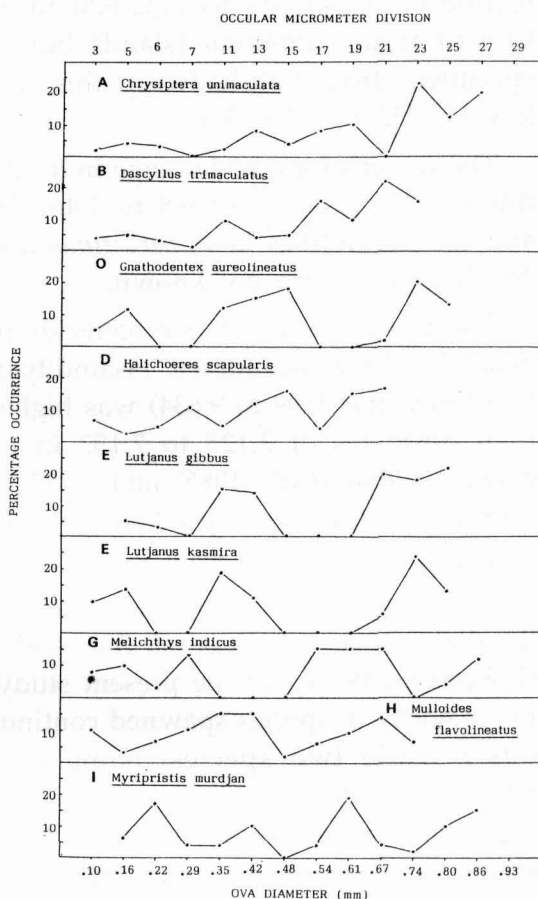


Fig. 5. Ova diameter frequency polygons of nine species of coral reef fishes

Low fecundity ranges in *T. hardwicki* and *T. lunare* may be due to high spawning frequency for which continuous output of mature egg is required. Spawning occurred in a daily basis in *C. dorsomaculata*, *T. duperrey*, and *T. lucasanum* (Tribble, 1982; Warner, 1982).

*G. aureolineatus* had a high fecundity probably because of its schooling and free swimming nature. A similar reasoning perhaps holds good for *L. gibbus* and *L. kasmira*. Rangarajan (1971) reported a

fecundity of 42,100 to 3,32,620 in *L. kasmira* from Andaman Islands but in specimens from Lakshadweep this was low (33,752 to 2,25,850).

The reasons for a wide range in fecundity in *P. bifasciatus* (2,968 to 1,46,373) and low fecundities in *P. barberinus* and *M. flavolineatus* are not known.

The three species of pomacentrids in general had low fecundities. Fecundity of *D. trimaculatus* (809 to 9,634) was higher than estimates of 2,125 to 7,157 in *D. aruanus* (Pillai *et al.*, 1985) and 1,032 to 1,993 in *D. reticulatus* (Vijay Anand, 1990).

**Spawning frequency:** There is a variety of pattern of spawning by reef fishes on the daily, lunar and seasonal time scales (Robertson, 1991). In the present study, the majority of species spawned continuously while two species, namely *A. triostegus* and *C. melannotus* spawned continuously but with short breaks. Nine species spawned intermittently and spawning was perhaps seasonal. Randall (1961) reported a lunar periodicity in the spawning of *A. triostegus* in Society Islands while Robertson (1983) observed in semi-lunar rhythm in eight acanthurid species from the Indo-Pacific. Observations on continuous spawning of *A. leucosternon* and *A. triostegus* (with breaks) perhaps support previous observations.

In the present study, chaetodontid eggs measured between 0.74 to 0.93 mm and most of the species were continuous spawners.

Spawning in certain pomacentrids takes place on a daily basis during the

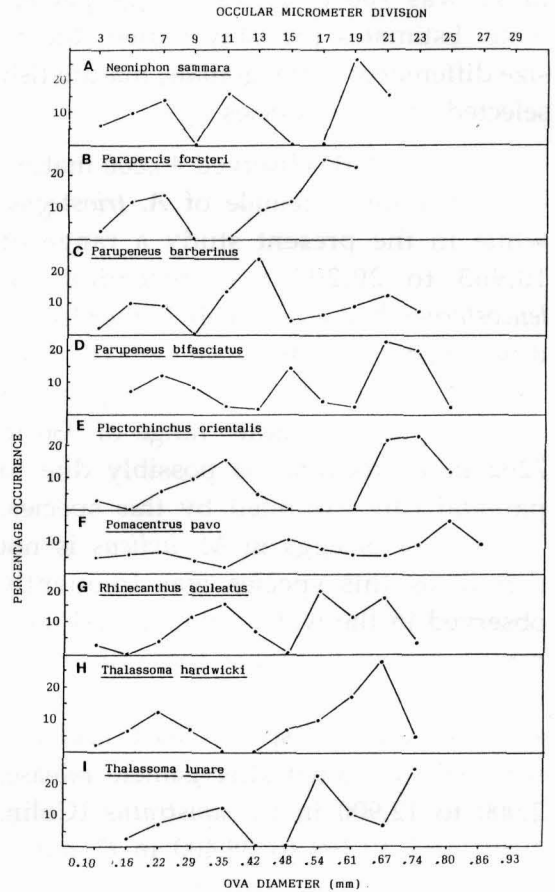


Fig. 6. Ova diameter frequency polygons of nine species of coral reef fishes

breeding season (Ochi, 1985) and continuous spawning in certain pomacentrid species from Lakshadweep was reported by Pillai *et al.* (1985). All reports indicated the egg shape to be elliptical. The three pomacentrid species in the present study had mature ova measuring between 0.74 and 0.86 mm along the longer axis and spawned continuously.

Mating in certain labrid species of the genus *Thalassoma* is a daily event during the reproductive season (Warner, 1982).

*T. hardwicki* and *T. lunare* in the present study spawned intermittently; these distinctions are possibly seasonal peaks. In contrast, *H. scapularis* spawned continuously, and a similar habit was observed by Vijay Anand (1990) for *H. centiquadrus* from Lakshadweep. Among the two balistids, *M. indicus* exhibited a discontinuous spawning, while *R. aculeatus* spawned continuously. The holocentrid and mullid species also indicated a continuous spawning habit.

*C. inermis*, *G. aureolineatus*, *L. gibbus*, *L. kasmira*, *P. forsteri* and *P. orientalis* indicated seasonality in spawning. The maximum size of mature ova of *L. kasmira* in Lakshadweep (0.80 mm) appeared to be larger than in specimens from Andamans (0.65 mm). The intervals between each spawning appeared to be short in all intermittently spawning individuals.

From the present observations, it is evident that a high fecundity and a continuous spawning frequency are perhaps helpful to overcome the uncertainties that larvae face before settling onto the reef.

*Spawning seasons:* Majority of the species spawned continuously throughout the year with peaks in pre-monsoon and post-monsoon season. Relatively few species preferred the monsoon season. These aspects, to an extent have already been substantiated while discussing the spawning frequency. However, the exact timing of spawning in reef fishes can only be obtained by tracking the occurrence of mature individuals.

Among the two acanthurids, *A.*

*leucosternon* had a protracted spawning period for about 8 months. Some ripe individuals seemed to occur in monsoon, but in general, monsoon months are perhaps avoided. The short breaks in spawning in *A. triostegus* were evident in the ova diameter polygons and the occurrence of spawning fish in three distinct time scales confirms the fact that it is a continuous spawner but with breaks.

The three species of chaetodontids from Gulf of Mannar namely, *C. collare*, *C. melannotus* and *C. octofasciatus* seem to be affected by the two monsoons and mature fish were either absent during the period. Therefore, variation in seasonal environmental conditions seem to locally alter spawning patterns. On an annual basis, *C. inermis* had two extended spawning peaks which coincided with pre-monsoon and post-monsoon seasons, which are supported by the ova diameter polygons indicating intermittent spawning. A similar reasoning holds good for other intermittent spawners like *L. gibbus*, *L. kasmira*, *P. forsteri* and *P. orientalis*.

Among the labrids, spawning in *H. scapularis* and *P. pavo* seemed to be uninterpreted by environmental conditions. While *T. hardwicki* and *T. lunare* characteristically avoided monsoon season, *M. indicus* spawned just before and after monsoon. *R. aculeatus* appeared to have an extended spawning season. The mullids, holocentrids and pomacentrids also spawned continuously but with breaks during monsoon.

The characteristic avoidance of mon-

soon seasons by spawning individuals in Lakshadweep is perhaps to tide over the unfavourable rough weather which would transport eggs and larvae to unfavourable destinations. Unusually bad weather may interfere with the seasonal timing of spawning of certain reef fish (Johannes, 1980). A dual monsoon effect observed in the Gulf of Mannar further supports the fact that environmental conditions can influence spawning season. Continuous spawning is perhaps a regular phenomena during the spawning seasons. This is also supported by the continuous occurrence of juveniles during the pre-monsoon and post-monsoon seasons.

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