BIOLOGY OF THE BLUEPULLER, *CHROMIS CAERULEUS* (CUVIER), FROM MINICOY ATOLL

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ABSTRACT

Chromis caeruleus, a resident reef fish on live ramose corals forming a dominant component in lagoons through-out Laskhadweep, is an important live-bait for tuna. The species is diurnal in habit and is an active zooplankton feeder. Analysis of the gut contents reveals little selectivity in feeding.

The separate formulae to express the length weight relationship of the mature adults and juveniles are:

Mature adults: Log W = —4.2234 + 2.6777 log. L

$$W = 0.0000\ L^{2.6777.}$$

Juvenils: Log W = —5.1718 + 3.3169 log L.

$$W = 0.00000\ L^{3.3169.}$$

The species attain a T.L. of 64 mm by the end of first year of life and a T.L. of 95 mm by the end of second year. The empirical values for monthly average growth rate for the first year is 5.3 mm and for the second year is 2.6 mm. Fitting of von Bertalanffy's equation to the growth rate data did not show much variation from the above values. The ratio of males to females during the period of observation showed a higher rate for the females. During 1981-82, Male : Female was 1 : 1.44 and during 82 to 83, M : F is 1 : 1.09.

Fecundity varied from 4000 to 8000 eggs. The individual fish may spawn more than once in a year. The size at first maturity is 38 mm T.L. The minimum T.L. noticed at spawning was 40 mm. The species spawns as Minicoy throughout the year. The active breeding season is about 9 months, from August to April, with a lull period from May to July. The planktonic phase of the larvae lasts about 2 to 3 weeks. Settlement of postlarvae on corals takes place in all the months and, at first settlement, the postlarvae are about 8 mm in T.L.

INTRODUCTION

Despite the importance of many reef fishes as food, aquarium fishes and live-baits in tuna fishery, detailed studies on their biology and ecology are very few. The major reason for the paucity of extended studies on reef-fishes is the remote locations of reefs from centres of research, coupled with practical difficulties in obtaining samples throughout the year. However, recent studies from several localities in the Indo-Pacific and Caribbean, (Randall 1961, Smith 1961, Aiken 1983, Reeson 1983, 1983a, Thomson and Munro 1983, Wyatt 1983) have elucidated many aspects of the biology and ecology of reef fishes.

Chromis caeruleus (Cuvier) forms an important component of the resident reef fishes throughout Lakshadweep, expecially in lagoon shoals and ramos live coral isolates (Pillai et al MS). The species is an important live-bait for tuna in the traditional pole-and-line fishery. In view of its importance, it was felt necessary to gather information on the ecology and biology of this species, since practically nothing had been known on these aspects from our waters. The work was carried out during July 1981 to June 1983.

Earlier studies on *C. caeruleus* are only that of Hiatt and Strasburg (1969), who described its food and of Swerdloff (1970) and Sale 1971), who briefly described its spawning behaviour. Since detailed studies on the biology of the species from elsewhere are not available, effective comparison of the present results is not possible.

Material and Methods

The material for the present study was collected mostly from the lagoon of Minicoy during July 1981 to June 1983. Samples were obtained at low tides either by breaking out a coral with resident fishes and then emptying the contents into a scoopnent or by luring the fishes out of the coral thickets by sprinkling mashed meet of crabs and catching them with a small net. The first method yielded all the modal sizes in a coral colony, whereas the second method (method used by local fishermen) yielded mostly subadults and adult fishes. The data on 1173 specimens were used in the interpretations. Total length was recorded in mm and weight in mg, for length-weight relationship studies. In determining the fecundity, one entire lobe of the ovary was teased out and the total number of ova counted with the help of a plankton counting chamber, and the fecundity was calculated from the relative weight of lobe of ovary. Samples were collected on weekly or biweekly basis, depending on the weather and tide. All data were taken from fresh samples, mostly within three hours of collection from the field.

Food and Feeding

Condition of feed: Altogether 955 guts were examined between July 1981 and June 1983 to determine the feeding condition and nature of food. The samples were collected during forenoon or afternoon, depending on the nature of the tide. The ½ full, ¾ full and gorged stomachs were all taken together as fully fed. The condition of the stomachs in percentage for the various months are presented in Table 1. In general, the fish were fully fed during day throughout the

TABLE 1. *Condition of feed of* C. caeruleus, *in percentages of empty and fully-fed individuals, based on pooled data for July* 1981 *to June* 1983.

Month	No. of Specimens examined	Empty	Fully fed
Jul	71	40.85	59.15
Aug	63	55.55	44.45
Sept	89	7.87	92.13
Oct	45	60.00	40.00
Nov	119	26.05	73.95
Dec	74	1.35	98.65
Jan	18	5.56	94.44
Feb	143	0.70	99.3
Mar	86	3.49	96.51
Apr	102	5.88	94.12
May	69	69.57	30.43
June	76	32.89	67.11

year. However, there was relative increase of percentages in fully fed conditions from November to April. The water of the lagoon and open ocean generally remain calm during this period with relatively low suspended sediments. It is likely that the calm condition of the waters is more suitable for the species to feed on plankton than the turbid condition. Studies on the seasonal fluctuation and production of zooplankton in Minicoy are still in a preliminary stage and hence it is premature to attempt to correlate plankton biomass, environmental condition and feeding activity of planktonphagous fishes of the lagoon in Minicoy.

Food: Chromis caeruleus is a typical zooplankton feeder and is a diurnal reef-fish. Larger specimens maintain a greater feeding territory than the smaller specimens do (Pillai et al, MS). There seems to be little selectivity in feeding. Anaylsis of the gut showed lucifers, copepods, mysids foraminifera, and, sometimes, filamentous algae and calcareous sand. Copepods formed the bulk of the food and included *Paracalanus* sp, *Labidocera* sp. *Corycaeus, Sapphirina* and

Euterpina spp. Amphipods were represented by *Hyperia* sp. Hiatt and Strasburg (1960) have stated that the species often devour the freshly layed eggs of their own. According to Swerdloff (1970), the eggs are attached by means of an adhesive stalk and are not planktonic. If eggs are present in the gut as stated by Hiatt and Strasburg (loc, cit), there is a possibility that the fish may feed from bottom also. However, in spite of our examining hundreds of guts, we have not found fish eggs in the contents. The presence of filamentous algae and sand particles along with food could be due to chance entry while feeding plankton. Though the species is chiefly a plankton feeder, it was found to accept readily all kinds of minced flesh in the aquarium soon after they were brought from the fields. In fact, it is this feeding behaviour of the species which is being exploited by fishermen while catching them, luring them out from their habitat with mashed crab meat.

LENGTH-WEIGHT RELATIONSHIP

A total of 348 specimens were used to study the length-weight relationship of the species. These include 150 matured males, equal number of matured females and 48 juveniles. The corrected sums of squares and products as well as the estimates for regression coefficient (b) for different categories are as follows:

	DF	Sx^2	Sy^2	Sxy	b
Males	149	1.5595	13.4257	4.3698	2.7320
Females	149	1.4719	11.2140	3.8610	2.6232
Juveniles	47	0.6125	—3.7960	2.0316	3.3169

DF: Degree of freedom. b: regression coefficient.

The length-weight relationship for males and females separately are as follows:

Males $\log W = -4.3190 + 2.7320 \log L$

$W = 0.000048\ L^{2.7320}$

Females $\log W = -4.1281 + 2.6232 \log L.$

$W = 0.000074 L^{2.6232}$

Co-variance test between males and females indicates no significant variation. Hence a common formula for both mature males and mature females is derived, as:

$\text{Log } W = -4.2234 + 2.6777 \log L$

$W = 0.0000\ L^{2.6777.}$

Value for coefficient of determination is 89.78%.

However, for the juveniles a separate formula to express the length-weight relationship had to be given as follows:

Log W -5.1718 + 3.3169 log L

$W = 0.00000\ L^{3.3169}$

AGE AND GROWTH

Length-frequency distribution: A total of 1173 specimens were utilized in the length-frequency analysis. The total length ranged from 8 mm to 88 mm (88 mm, a male specimen). All samples throughout the year displayed multimodal size range (Figs. 1 and 2). This multimodal size range is due to the repeated settlement (recruitment) of pestlarvae of *C. caerulous* on coral colonies in various months (Pillai, et al, MS). Field observations have shown that the postlarvae on first settlement is on the average 8 mm T.L. and is more or less two weeks old after hatching (*vide infra*).

Age and growth: The age and growth of the species was determined by Peterson's method of length-frequency progression. As is indicated in figure 3, four modes, viz. A, B, C and D, could be followed for a reasonably long period to determine the progression of size. The mode A with a T.L. of 12 mm reached a size of 68 mm in twelve months while mode C with the same initial 12 mm T.L. progressed to 64 mm in eleven months. Mode B, with an initial T.L. of 28 mm, progressed to 84 mm in fourteen months. Finally, mode D progressed to 56 mm T.L. from 20 mm in eight months. By tracing the progression of individual modes through successive months and by fixing the age of 12 mm fish as more or less one month since hatching, it is estimated that the species attains an average monthly growth of 5.3 mm and would reach a total length of 64 mm by the end of the first year. By fixing 64 mm as the T.L. of the fish at the end of the first year, an average increase of 2.6 mm per month is taken for the second year (Fig. 5). This means that, by the end of the second year, a T.L. of about 95 mm would be attained by the species. The rate of growth is high during the first 6 months of the fish, and it is more or less 6 to 7 mm by the time the species attain first sexual maturity. After this there is a relative slowing down of growth rate to 4 mm per month. During the second year the rate of growth still slows down to an average 2.6 mm per month.

Using a length range of 8 to 88 mm (T.L.) the values of growth parameters for this species of von Bertalanffy-s equation was determined as follows.

$L = 113.7$ mm; $k = 0.8229$ (annual basis) and $t_o = 0.036$ (year).

From the above the theoretical value of T.L. at the end of the first year will be 65.23 mm and at the end of the second year will be 92.42 mm. The monthly growth rate is 5.43 mm for the first year and 2.26 mm for the second year.

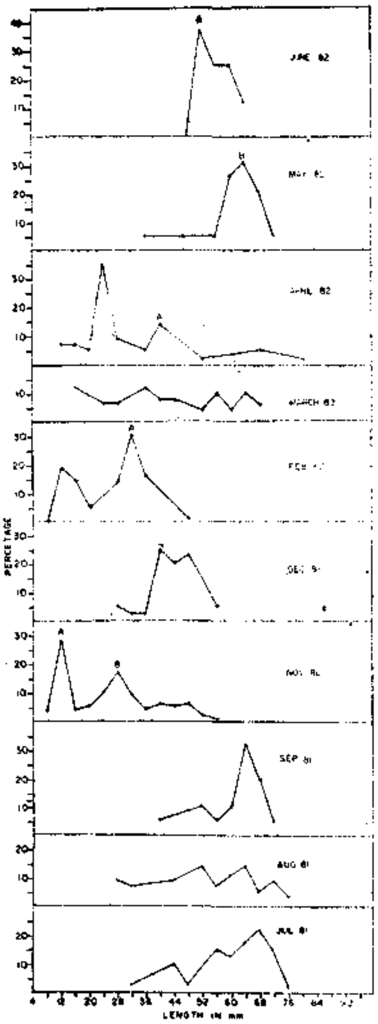

FIG. 1. Length-frequency of *C. caeruleus* during July 1981 to June 1982 from Minicoy Atoll.

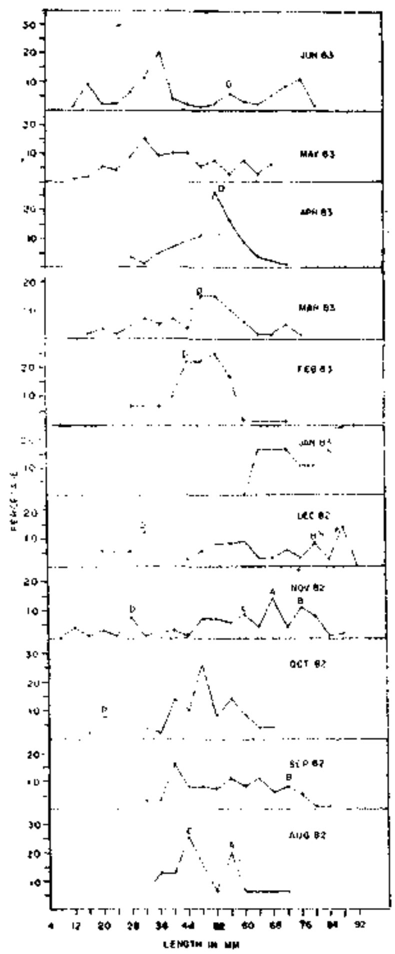

FIG. 2. Length-frequency of *C. caeruleus* during August, 1982 to June 1983 from Minicoy Atoll.

REEPRODUCTION

Morphology of Gonads

The ovaries are bilobed, symmetrical, club-shaped and with a small vas deferens. Each lobe, when fully matured, range from 10 to 15 mm in length, depending on the size of the fish, and the thickness at mid-length is almost half of the length. Fully matured ones yellow to dark-yellow in colour.

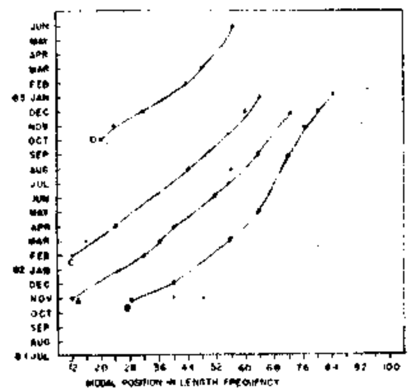

FIG. 3. Modal position in length-frequency distribution in *C. caeruleus* to show growth rate.

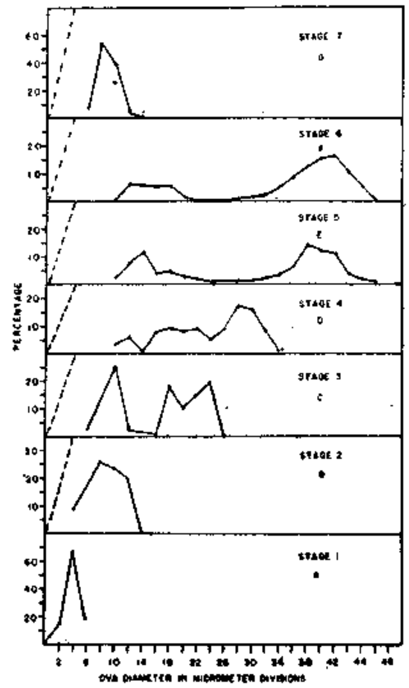

FIG. 4. Ova-diameter-frequency polygon of *C. caeruleus* of different maturity stages.

Testis bilobed, thick, flat and creamy white in colour. In early stages they are narrow, thread-like. In adults the testes almost extend to two-thirds of the body cavity.

Classification of Maturity Stages

Based on the external morphology and the size of the ova, the ovaries are classified into seven stages as follows (after Laevastu 1965). (In ova measurements, 85 microdivision: of the oculometer are equal to 1 mm.)

Stage I (*Virgin or Immature*): The ovary can be detected with the help of a handlens. They look transparent and occupy only one-fourth of the body cavity. Ova transparent, with a large nucleus at the centre. They range from 1 to 6 md. in diameter, with a mode at 4 md. Ova of the same size and nature are seen in all other stages of ovary, also indicating continuous proliferation.

Testis at this stage is very small, narrow and thread-like, occupying one-fourth of the body cavity.

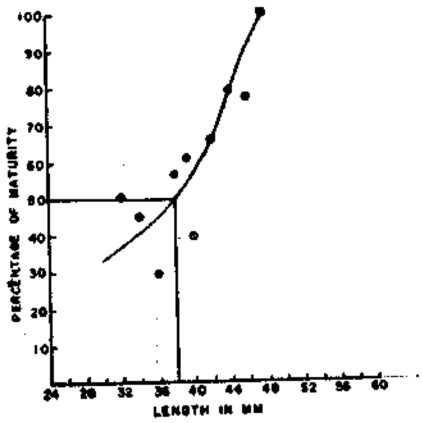

FIG. 5. Size at first maturity of *C. caeruleus* based on samples collected from July 1981 June 1983 from Minicoy.

Stage II (Immature Virgin and Spent Recovering): Ovary more enlarged and conspicuous than in Stage I. Ova measure 1 to 14 md with mode at 8 md. Ovary occupy about one-third of the body cavity.

Testis slightly more enlarged than in stage I but essentially thread-like and transparent.

Stage III (Maturing or Developming): Ovary conspicuously visible to the naked eye and extends to half length of the body cavity. Three distinct groups of ova are present. The larger ones are 16 to 26 md. and are clearly separated from the smaller ones. Ova show signs of yolk deposition and assumes yellow colour. Ovarian walls with dialated blood vessels.

Testis start broadening and thickening. They become white in colour.

Stage IV (Mature): Ovary conspicuously yellow or yellowish-brown in colour, Almost club-shaped. The blood vessels are enlarged. Ova 10 to 34 md, the larger ones between 26 to 34 md. Ova with yolk granules.

Testis flat, thick and white in colour, extends to more than half of the body cavity.

Stage V (Gravid or Ripe): Ovary looks solid, dark-yellow, extends to two-thirds of the body cavity. Three stages of ova, namely, formative, maturing and fully matured are present. Fully matured ova 32-48 md. Eggs yellow in colour.

Testis very thick, flat, creamy-white and extends to two-thirds of the body cavity.

Stage VI (Spawning): Ova as in stage V. But mostly free from the ovarian wall; mode 42 md. The larger ova up to 48 md. Ova become further yellowish-dark.

Testis as in Stage V with no visible change.

Stage VII (Spent): Ovary shrunk. A few dark spots visible on the distal half. Ova look and measure similar to Virgin Stage II. The ovary looks flaccid. Testis also shrunk.

Progression of Ova to Maturity

For maturity studies, one of the lobes of the ovary was fully teased out, the eggs homogenized and a sample was used for taking measurements. The ova-diameter polygons, drawn at a class-interval of two micrometer divisions, are presented in Fig. 4A to 4G. In Stage I the ova measured from 0.01 mm to 0.97 mm, with a mode of 0.05 mm (4 md). In Stage II (Fig. 4, B) one batch of

TABLE 2. *Percentages of different stages of maturity of* C. caeruleus *during different months of the year. Data from July* 1981 *to June* 1983 *pooled. (Only females are considered).*

Month	No. examined	Percentage of Stages of maturity I	II	III	IV	V	VI	VII
Jul	40	2.5	5.0	45.0	2.5	—	12.5	32.5
Aug	30	10.0	27.0	20.0	3.0	10.0	23.0	7.0
Sept	52	—	15.0	19.0	6.0	39.0	19.0	2.0
Oct	23	4.0	39.0	35.0	4.0	—	—	18.0
Nov	52	2.0	10.0	42.0	15.0	10.0	6.0	15.0
Dec	32	—	—	3.0	16.0	66.0	12.0	3.0
Jan	8	—	—	—	—	37.5	62.5	—
Feb	60	—	3.3	—	—	18.3	78.3	—
Mar	49	4.0	31.0	16.0	10.0	27.0	12.0	—
Apr	48	—	16.0	15.0	15.0	39.0	15.0	—
May	36	—	11.0	64.0	14.0	5.5	—	5.5
June	32	—	12.5	43.8	31.3	9.4	3.0	—

ova got clearly separated from the proliferating early stage and was on way to further maturity. They had a mode of 0.09 mm (8 md). In stage III (Fig. 4,C) three categories of ova were seen. The maturing larger ones had a mode at 0.28 mm (24 md), with intermediate ones, with a mode at 0.1 mm, and the initial proliferating stages. In stage IV (Fig. 4, D), the progressing mode was at the diameter of 0.35 mm and had yolk deposition started. The ripening ova of stage V had a mode at 0.45 mm (28 md) and were clarly (Fig. 4E) separated from the progressing ova. In stage VI (Fig. 4, F) those ready for spawning had increased a little more in size from those in Stage V and had mode at 42 md (0.49 mm), and some were free. In stage VII (Fig. 4, G) the ova measurements were comparable to that of virgin II. Rarely, a few of the unspawned eggs were seen, which were very dark yellow in colour.

Sex Ratio

Monthwise percentage occurrence of males and females in the population from July 1981 to June 1983 is presented in Table 3. The ratio of males to females during July 81 to June 82 was estimated to be 1 : 1.44 and for July 82 to June 83 to be 1 : 1.09.

TABLE 3. *Percentage of males and females of* Chromis caeruelus *from July* 1981 *to June* 1983.

Month	1981-82			1982-83		
	Total Nos. of fish	% of Males	% of Females	Total Nos. of fish	% of Males	% of Females
July	63	36.51	63.49	—	—	—
Aug	47	51.06	48.94	15	53.33	46.67
Sept	19	36.84	63.16	70	42.86	57.14
Oct	—	—	—	45	48.89	51.11
Nov	26	46.15	53.85	74	48.65	51.35
Dec	38	39.47	60.53	25	64.00	36.00
Jan	—	—	—	18	55.56	44.44
Feb	8	75.00	25.00	85	31.76	68.24
Mar	29	27.59	72.41	56	50.00	50.00
Apr	24	29.17	70.83	79	51.90	48.10
May	32	40.63	59.37	50	50.00	50.00
June	17	52.94	47.06	52	53.85	46.15

Size at First Maturity

To determine the size at first maturity, the percentages of mature and immature females at various length frequencies of 2 mm interval (Table 4) were ascertained. Stages I and II ovaries were treated as immature and the rest mature. Stage III the ovary was observed at a minimum T.L. of 30 mm and Stage VII at a minimum length of 39 mm. The minimum size at first maturity at 50% level (Figure 5) was determined to be at 38 mm T.L.

TABLE 4. *Percentage of occurrence of immature and mature ovaries in* C. caeruleus, *at different size ranges from pooled data for July* 1981 *to June* 1983.

Size range in mm. T.L.	Immature	Mature
25-26	100	—
27-28	100	—
29-30	66.7	33.3
31-32	50	50
33-34	55.5	44.5
35-36	71.4	28.6
37-38	43.5	56.5
39-40	60.9	39.1
41-42	34.5	65.5
43-44	20.59	79.41
45-46	23.1	76.9
47-86	Nil	100.00

Fecundity: Ovaries of Stages V and VI were utilized for fecundity studies (Table 5). In addition to the total number of matured ova listed in the table, there were an additional 25% of maturing or immature ova (less than 10 md). The data presented showed vide variation in fecundity in relation to total length and body weight of fish. In Table 5, the 51 mm, 63 mm, 65 mm, 66 mm and 73 mm fish were not spawned whereas the rest were indicated to have partially

TABLE 5. *Fecundity of* Chromis caeruleus.

Length of fish mm	Wt. of fish g	Wt. of ovary mg	Total No. of matured ova	Ova per g body wt.	Stage
51	2.5	170	3862	1545	V
53	3.0	120	2588	863	V
62	4.5	145	3412	758	VI
62	4.0	90	1752	438	VI
63	4.5	250	6993	1554	VI
65	5.0	150	5156	1031	VI
66	4.5	250	5643	1254	VI
70	5.25	172	2511	478	VI
70	5.5	300	8070	1467	VI
71	5.5	170	2370	431	VI
73	6.0	380	7070	1178	V

shed the ova owing either to spawning or squeezing at the time of collection. In general, it may be stated that *C. caerulous* is capable of producing 4000 to 8000 eggs per spawning, depending on the age of the fish.

Reproductive Behaviour and Spawning

The details of the reproductive behaviour of the species given here is mostly based on the earlier studies of this species from the Pacific by Sweidloff (1970) and Sale (1971). The eggs are deposited in nets of algae or at the bottom of the coral and are attached by an adhesive thread (Swerdloff 1900). The species is a colonial breeder and a male may be spawning with 20 to 30 females at short interval of 2-3 days. The eggs are cared by the male and are hatched in two to three days. The larvae on hatching enter into a pelagic life which may last for two to three weeks (Sale, per comm.).

Breeding Season and Larval Recruitment

A total of 462 adult females were examined to determine the percentage of different stages of maturity in different month with a view to ascertaining the breeding season. The pooled data for July 1981 to June 1983 is presented in Table 2. Mature specimens along with juveniles were present in the samples almost throughout the year. Spent fishes (Stage VII) were not found in our samples during January to April. However, the high percentage of matured and ripe spawning fishes along with recovering stages indicates active spawning during this period also. The present study shows that *C. caeruleus* is almost a continuous breeder and the active period is for about 9 months from August to April.

The presence of maturing ova along with matured ova in all stages of ovary indicates that when a batch of ova are spawned out another batch would develop soon to spawning stage. Judging from the minimum size noticed at first maturity and the size at spawning and the rate of growth for the first year it seems that a fish may develop from Stage II to Stage VI in about 8 weeks. It is likely that the individual fish may spawn in batches, ie., single brood of ova is shed at intervals, as is in conformity with the habit of many reef fishes.

The post larvae settle on corals after the initial pelagic phase. Field observations indicate that there is a relative profusion in the settlement of larvae in Minicoy during December to April in the N.E. monsoon period.

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