

Growth and breeding in cheilostome biofouler, *Electra bengalensis* Stoliczka in Bombay waters, west coast of India

M Udhayakumar & A A Karande

Naval Chemical and Metallurgical Laboratory, Tiger Gate, Ballard Estate, Bombay 400 023, India

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Almost 70% of bryozoan settlement and consequent space occupied are due to *E. bengalensis* in Bombay coastal waters. This species breeds almost continuously and its recruitment is not affected by seasonal changes in water quality. The species grows very fast and achieves first maturity at a very early age. The number of sexually produced eggs in the species is the highest amongst 8 bryozoan species endemic to Bombay waters. All these features make this bryozoan a successful competitor despite the fact that the zooids produced per unit area of colony are fewer, the elimination of zooids by death is faster and the ability to grow over the other species is poorer.

Electra bengalensis is reported from open sea, estuaries, enclosed and polluted waters as well as from various depths¹. In coastal waters of Bombay, this species constitutes 60 to 75% of the total bryozoan growth on immersed test coupons. Swami and Karande² have noted that *E. bengalensis* is not seriously affected by extreme variations in salinity though its growth, not recruitment, is slower during the monsoon. Karande and Swami³ have reported that *E. bengalensis* is a poor competitor so far as its ability to interact and grow over other bryozoan colonies is concerned and yet it occupies maximum space on immersed surface as compared to other endemic species. This they have attributed to its ability to breed and settle throughout the year.

In this study some aspects of life history of *E. bengalensis* are examined. These include observations on its prevalence, breeding, growth and mortality in harbour waters of Bombay. Some observations are also made on few other encrusting species which share the same habitat with *E. bengalensis*. The aim of this work is to ascertain the factors that contribute towards the dominant presence of the species in Bombay waters.

Materials and Methods

The study was carried out at a near-shore station in Bombay harbour (lat. 18° 55' N; long. 72° 50' E), 500 m off the coast.

Perspex coupons (25 × 15, 12 × 10 and 15 × 4 cm) were exposed 1 m below the low tide level. Two sets, each containing 5 coupons of each size, were immersed at the beginning of every calendar month

and withdrawn for examination at the end of 30 and 60 d. The coupons of various sizes were immersed to obtain both isolated and interacting colonies. The present observations, however, were based on the study of the largest coupons. An area of 330 cm² of each panel was considered for the examination.

For the examination of coupons, a method earlier adopted by Winston and Jackson⁴ was adopted. In this method a transparent perspex grid was superimposed on each coupon to record growth of the colonies. The number of zooids was counted along a single row in a vector of a colony from the point of larval attachment to the periphery.

Results

Prevalence of *E. bengalensis*—The recruitment of *E. bengalensis* at the station is continuous and heavy (Table 1). The recruitment of the next most prevalent bryozoan is *Acanthodesia* sp. but as compared to *E. bengalensis* it is scarce.

Growth of colonies—The growth achieved by *E. bengalensis* is generally more than that of the other species. Six species examined for their growth and the consequent areas they occupy can roughly be divided into two groups. *E. bengalensis*, *Membranipora annae* and *M. tenuis* are fast growing species whereas *M. savartii*, *Acanthodesia* sp. and *Hippoporina indica* are relatively slow growing species. *E. bengalensis* grows to maximum size of 71.80 cm² in 80 d. *M. annae* occupies 42.21 cm² in the same period. Fig. 1 illustrates the maximum areas occupied by each of these species during 60 d growth. The fast growing ability of *E. bengalensis* is evident.

Table 1—Seasonal composition (%) of bryozoan colony on 30 and 60 d-old coupons

Species	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
30 d coupons												
<i>Electra bengalensis</i>	95.60	0	32.00	76.4	74.93	78.48	77.72	80.67	86.07	92.0	92.92	76.90
<i>Acanthodesia</i> sp.	4.36	12.5	42.30	19.6	7.04	1.45	7.72	4.20	3.79	0	0	2.19
<i>Hippoporina indica</i>	0	0	1.28	1.2	10.96	18.89	11.81	14.28	0	8.0	2.02	1.09
<i>Membranipora annae</i>	0	37.5	11.53	0.4	2.40	0.58	0.45	0	2.53	0	3.03	17.58
<i>Membranipora tenuis</i>	0	0	2.56	0.4	4.17	0.58	2.27	0.84	0	0	1.01	0
<i>Membranipora savartii</i>	0	50.0	10.25	2.0	1.04	0	0	0	1.26	0	1.01	2.19
<i>Celleporaria pilaefera</i>	0	0	0	0	0.26	0	0	0	0	0	0	0
<i>Hippopodina feegeensis</i>	0	0	0	0	0	0	0	0	6.32	0	0	0
60 d coupons												
<i>Electra bengalensis</i>	72.38*	7.04	64.73	81.73	60.60	31.34	74.64	60.49	71.42	79.03	71.87	41.17
<i>Acanthodesia</i> sp.	6.69	21.12	18.75	7.82	2.02	0	7.04	4.93	0	0	6.25	23.56
<i>Hippoporina indica</i>	0	39.43	8.48	3.47	28.78	59.70	5.63	23.45	20.00	17.74	6.25	29.39
<i>Membranipora annae</i>	20.50	16.90	3.12	2.60	8.08	7.46	4.22	4.93	8.57	1.61	12.50	5.88
<i>Membranipora tenuis</i>	0	1.40	3.12	3.47	0	1.49	5.63	6.17	0	0	0	0
<i>Membranipora savartii</i>	0.41	14.08	1.78	0.86	0.50	0	2.81	0	0	1.61	3.12	0
<i>Celleporaria pilaefera</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hippopodina feegeensis</i>	0	0	0	0	0	0	0	0	0	0	0	0

*Coupons exposed in May and examined at June end

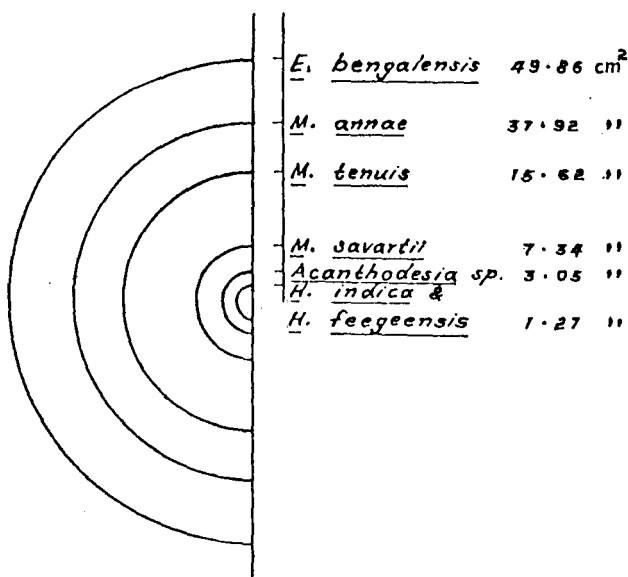


Fig. 1—Diagrammatic representation of areas covered by individual colonies of 7 encrusting bryozoan species during 60 d growth. (Maximum growth in 80 d: *E. bengalensis* = 71.80 cm²; *M. annae* = 42.21 cm²)

Breeding—The breeding of 4 common species, *E. bengalensis*, *Acanthodesia* sp., *H. indica* and *M. annae* is closely followed. Table 2 gives number of colonies in active stage of breeding. It is evident that *E. bengalensis* is more prolific breeder than the other cheilostomes. Generally over 30% of colonies show eggs in various stages of development. In warmer months of March, April and October, breeding ac-

Table 2—Per cent matured colonies of bryozoans during various times of the year

Month	Species			
	<i>E. bengalensis</i>	<i>Acanthodesia</i> sp.	<i>H. indica</i>	<i>M. annae</i>
June	31.7	0	NR	0
July	33.7	0	0	20.0
Aug.	26.2	19.0	5.3	0
Sept.	61.4	28.6	20.0	33.3
Oct.	0.8	0	0	14.3
Nov.	76.2	NR	25.0	60.0
Dec.	32.0	0	0	66.6
Jan.	36.0	25.0	13.3	25.0
Feb.	38.4	0	14.3	0
March	4.1	NR	0	0
April	13.1	0	0	0
May	10.0	0	0	0

NR = no recruitment, 0 = no breeding

tivity is suppressed. The three other species do not show sustained breeding.

The colony sizes (diameters) at first maturity of 5 species namely *Acanthodesia* sp., *E. bengalensis*, *M. annae*, *M. tenuis* and *H. indica* are 3, 6, 18, 20 and 15 mm respectively. *Acanthodesia* sp. and *E. bengalensis* become mature at very early stages of their growth as compared to the others which start breeding only when they achieve minimum diameter of 18 to 20 mm.

Breeding potential—Monitoring of egg production in *E. bengalensis* was carried out during various times of the year. The year was divided into 4 parts. At each sampling, 25 colonies from 5 coupons immersed at the station for 60 d were randomly examined. From each colony 5 zooids were screened for the egg counting. In *H. indica* it was not possible to count the eggs since these were held in ovicells. Also no egg counting was possible in *Hippopodina feegeensis* and *Celleporaria pilaefera* because of their morphological features.

It is seen from Tables 3 and 4 that the average numbers of eggs per zooid of *E. bengalensis* vary with the samplings. Generally each zooid in this species shows 20 eggs, the maximum number of eggs counted being 40.

Table 4 gives numbers of zooids per unit area of the colony and numbers of eggs per zooid in 8 bryozoan species. In all these species, average numbers of eggs per zooid vary with the time of sampling, however, two nodal average numbers are discernible. In *E. bengalensis* more eggs are produced as compared to the other species.

It is further observed from Table 4 that the 2 competing species *E. bengalensis* and *Acanthodesia* sp. have 6 and 13 zooids per mm² of colony respectively. Zooids of *Acanthodesia* sp. are smaller than those of *E. bengalensis* and therefore the former's potential as a colony to produce more eggs is evident. *E. bengalensis*, however, compensates this by producing a larger number of eggs than those produced by *Acanthodesia* sp.

Growth and mortality—Jackson⁵ has described a typical pattern of growth and death of zooids in a

bryozoan colony. New zooids appearing almost simultaneously along the periphery develop zooid organs, frontal wall, avicularia and ovicells. There is a zonation of zooid function along the proximal-distal axis. Four such zones are discernible in a colony at a given time. These are (i) proximal zone of dead zooids, (ii) defunct zooids with no eggs, (iii) active zooids with eggs and (iv) potential zooids with no ovicells (presently).

Zooids in zones (i) and (ii) are sexually non-productive whereas those in zones (iii) and (iv) are sexually potential zooids. New zooids are continuously formed at the distal periphery and older zooids perish proximally. The zooids in the zone (ii) i.e. distal to zone (i) discontinue to produce ovicells and die in a course of time.

Table 5 shows ratios between live area (ii to iv) and dead area (i) in 6 bryozoan species studied. In *E. bengalensis* this ratio is very small as compared to most of the other species. It thus suggests that in *E. bengalensis*, the rate of elimination of zooids by death proceeds at a faster pace than that in other species. The rate of death of zooids in 5 species *M. annae*, *Acanthodesia* sp., *M. tenuis*, *M. savartii* and *H. indica* decreases in that order. It is not possible to estimate the rate of zooid elimination in *H. feegeensis* and *C. pilaefera* because of their patchy settlement.

Zooid reproductive functions—The rate of death of zooids proximally and the emergence of young zooids distally in a colony decide the breeding potential of species. A comparative study of this process was made in two species, *E. bengalensis* and *H. indica*. The latter species was considered because it was the only species which did not show dead zooids at least until the end of 55-60 d of growth.

Table 6 gives the areas occupied by colonies as well as the number of zooids in each of the 4 zones (i to iv) of *E. bengalensis* and *H. indica*. It is observed that in *E. bengalensis*, generally one-half to one-fifth of the colony shows dead zooids. On the other

Table 3—Average number of eggs produced in *E. bengalensis* zooids

Sample	Aug. to Dec.	Dec. to Feb.	Feb. to April	April to June
I	21.66 ± 4.4	19.16 ± 2.1	23.33 ± 1.6	8.5 ± 1.5
II	20.00 ± 3.5	21.28 ± 1.0	10.50 ± 2.4	7.6 ± 1.4

Table 4—Number of zooids per unit area (mm²) of colony and number of eggs per zooid in some bryozoans

Species	Zooids (no. mm ⁻²)	Ranking of size of zooids	Av. range of egg no. zooid ⁻¹	Maximum no. of eggs
<i>Acanthodesia</i> sp.	13.37 ± 0.44	1*	8-12	30
<i>Celleporaria pilaefera</i>	12.51 ± 1.42	2	+	+
<i>Membranipora savartii</i>	11.13 ± 0.58	3	10-12	12
<i>Membranipora annae</i>	10.58 ± 0.91	4	6-7	40
<i>Hippoporina indica</i>	8.07 ± 0.22	5	Ovicells	Ovicells
<i>Membranipora tenuis</i>	7.64 ± 1.17	6	7-12	30
<i>Electra bengalensis</i>	6.35 ± 0.35	7	7-23	40
<i>Hippopodina feegeensis</i>	2.37	8	+	+

* *Acanthodesia* sp. zooids are smallest and *H. feegeensis* are the largest

+ = Difficult to assess because of morphology as well as rarity of specimens

Table 5—Ratio between live and dead portions of individual bryozoan colonies of various size classes

Species	Size class (mm)				
	55	20	35	50	65
<i>E. bengalensis</i>					
A	25.5	35.6	—	15.7	54.5
B	74.4	64.3	—	84.3	45.5
B/A	2.9	1.8	—	5.3	0.8
<i>Acanthodesia</i> sp.					
A	7.7	6.6	18.6	—	—
B	92.3	93.3	81.2	—	—
B/A	11.9	14.1	4.3	—	—
<i>H. indica</i>					
A	4.7	0.4	—	—	—
B	95.3	99.6	—	—	—
B/A	20.2	249.0	—	—	—
<i>M. annae</i>					
A	18.0	22.9	37.6	28.8	6.0
B	81.9	77.1	62.3	71.2	94.0
B/A	4.5	3.3	1.6	2.4	15.6
<i>M. tenuis</i>					
A	13.4	1.3	3.4	57.5	0.07
B	86.5	98.6	96.5	42.5	99.9
B/A	6.4	75.8	28.3	0.7	VH
<i>M. savartii</i>					
A	15.6	9.5	—	—	—
B	84.3	90.5	—	—	—
B/A	5.4	9.5	—	—	—

A = percent dead area; B = percent live area; VH = very high

hand, in *H. indica* not only the zooids in the proximal region are alive even in 60 d old colonies (63.65 to 380.18 mm² area) but also the number of active zooids and the potential young zooids is far higher than the spent zooids in the colony. It is evident therefore that *E. bengalensis* which displays a higher rate of mortality of zooids as well as high incidence of defunct zooids, is at a disadvantage *vis a vis* *H. indica* which shows no mortality and also a minimal number of inactive zooids in the proximal region. In *E. bengalensis*, however, the loss of zooids is compensated by faster growth. It is found that *H. indica* grows to a size of 380 mm² in 60 d, whereas *E. bengalensis* grows to a size of 2829 mm² during half that period.

Discussion

The community patterns developed on marine substrates depend on several factors like predation, availability and access to food, morphological fea-

Table 6—Number of zooids in four portions of individual colonies of various dimensions of *E. bengalensis* and *H. indica*

[Values in parentheses denote number of zooids]

Area of colony (mm ²)	Dead area	Defunct area	Active area	Growing area
<i>E. bengalensis</i>				
50.55	8.55 (55)	8.0 (52)	5.0 (32)	29.0 (184)
225.76	51.76 (330)	44.0 (282)	58.0 (369)	72.0 (460)
254.0	0 (0)	0 (0)	72.0 (460)	182.0 (1157)
602.0	72.0 (475)	118.0 (753)	288.0 (1829)	124.0 (789)
615.0	288.0 (1830)	0 (0)	95.0 (606)	232.0 (1473)
660.0	47.0 (298)	58.0 (372)	352.0 (2238)	203.0 (1289)
706.9	230.0 (1466)	0 (0)	48.0 (303)	429.0 (2724)
790.0	143.0 (910)	35.0 (224)	261.0 (1695)	351.0 (2000)
804.3	30.0 (193)	189.0 (1201)	102.0 (649)	483.0 (3067)
2829.0	597.0 (3783)	938.0 (5956)	841.0 (5344)	453.0 (2878)
<i>H. indica</i>				
63.65	—	2.54 (20)	12.65 (102)	48.46 (391)
78.05	—	2.01 (16)	7.22 (58)	68.82 (555)
113.11	—	8.36 (67)	10.46 (84)	94.29 (760)
132.73	—	5.34 (43)	22.32 (180)	105.07 (848)
153.95	—	18.09 (146)	26.09 (210)	109.77 (886)
176.73	—	6.51 (52)	38.87 (313)	131.35 (1060)
201.08	—	5.56 (45)	44.63 (360)	150.89 (1217)
227.0	—	6.15 (50)	52.35 (422)	168.5 (1581)
254.5	—	6.15 (50)	52.35 (422)	195.95 (1581)
314.2	—	8.06 (65)	84.37 (680)	221.76 (1789)
380.18	—	17.23 (139)	97.47 (786)	265.48 (2142)

tures, competition and co-operation interactions and physico-chemical characteristics of the environment^{6,7}. Availability of space for the settlement is one of the most important constraints so far as the success of the sessile organisms in terms of growth

and reproduction in a given environment is concerned^{4,5}. Among the sedentary metazoans, two distinct groups can be identified. The filamentous colonial organisms like hydroids and erect bryozoans, once having anchored to the substrate need no extra space for their further growth. On the other hand colonial ascidians, sponges and encrusting cheilostomes need added surface as they grow⁸.

In coastal waters of Bombay, the settlement of encrusting bryozoans has been very heavy². Among the 8 species prevalent here, the settlement and growth of *E. bengalensis* has been very heavy despite the fact that it has to compete not only with the other bryozoan species but also with sedentary forms like balanids, ascidians, polychaetes and other sessile species.

E. bengalensis at this study station occupies almost 30 to 40% of the total space occupied by the other encrusting species. In reality as earlier reported by Karande and Swami³, this species is a poor competitor so far as its ability to grow over the other bryozoan species is concerned. The species ability to cover the substratum is restricted by the other dominating species which display superior capacity to grow over *E. bengalensis*. The growth of individual colonies is also limited by intra-specific interactions.

Added to the above disadvantage, *E. bengalensis* is also handicapped by the larger size of its individual zooids. For instance, the number of zooids per unit area of the colony as compared to the other dominant *Acanthodesia* sp. is almost half thus reducing the number of ovicell producing units in the colony. Further, the longevity of individual zooids in colonies of *E. bengalensis* is very limited. The proximally spaced, older zooids perish very rapidly as compared to most of the other species incident at this study station.

It has been observed (unpublished data), that in the colonies of *E. bengalensis* interacting with the others, the death of zooids is significantly more than that in isolated colonies. This is not noted in two other species *M. savartii* and *H. indica*. It is also noted that interactions do not lead to early triggering of maturity in *E. bengalensis* as is observed in *M. annae* and *M. tenuis*.

A wide distribution of *E. bengalensis* reported earlier by several workers is owing to its ability to withstand salinity changes and chemical pollutants⁹⁻¹². Added to these, certain intrinsic features also contribute to the success of this bryozoan. *E. bengalensis* produces the largest number of eggs which it does almost throughout the year. More than 30% of the zooids in the colony bear eggs in various stages of development. The recruitment of *E. bengalensis* is therefore a continuous process in this coastal waters. It is also noted that though the longevity of individual zooids is shorter as compared to other species, the zooids achieve maturity at a very early age. For instance a colony achieving a diameter of only 6 mm, becomes sexually mature and produces eggs. The only other species which achieves early maturity amongst the 8 species studied is *Acanthodesia* sp. One more factor that contributes to the dominance of the species is its ability to grow at a very rapid rate. *E. bengalensis* occupies as much as 49.86 cm² in 60 d. All the other species except *M. annae* are very slow growing bryozoans. In *E. bengalensis* both rapid additions of new zooids and their early maturity enhance the breeding potential of a colony as a whole.

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