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Field notes on a fouling serpulid *Hydroides elegans* Haswell (Polychaeta: Serpulidae) present in confined waters of Bombay

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Tubeworm *Hydroides elegans* Haswell is one of the major sedentary organisms that fouls the ships berthed in confined, polluted waters of wet basin in Bombay harbour. The species breeds and settles throughout the year and generates wet debris weighing around 8 kg.m^{-2} on immersed surface within a short span of 3 months. Tolerant to adverse seawater conditions as well as to potent toxins, the species is well established possibly because of the availability of rich and varied diatom flora as food.

Serpulid and sabellariid species are known to grow abundantly in polluted waters[1,2]. Their presence on ship hulls painted with antifouling coating containing alkyltin tributyl tin oxide (TBTO) indicates that the serpulids are tolerant to toxic chemicals. Calcareous tubes measuring almost 1 to 1.5 mm were noted on a shiphull implying that at least their larvae were resistant to this very potent toxin. The adults of *Hydroides elegans* in the laboratory assays[3] were found to have good tolerance to TBTO as compared to edible mussel *Perna viridis*[4] and *Uca pugilator*[5]. The laboratory studies also established that these tubeworms were very resistant to high concentrations of chlorine[6]. Tubeworm fouling has therefore been considered a major maintenance problem in shipping industry.

In wet basin in Bombay harbour, which is a stagnant, polluted water mass, *H. elegans* colonises in abundance in preference to relatively clean and turbulent coastal waters. The present work was carried out to investigate the factors that contribute to the growth and sustenance of *H. elegans* in this part of the harbour where ships are berthed for routine maintenance.

Materials and Methods

Two locations were used as study sites (lat. 18° 55′ E; 72°50′E). Wet basin is totally enclosed water mass which is periodically enreplenished with new seawater as and when its dock-gates are opened as an operational requirement. Water-depth here is around 6 m. The second site, the jetty, is exposed to open tidal waters where wave action, particularly during the monsoon, is severe. Depth at this site is 14 m.

The seawater parameters like temperature, salinity, dissolved oxygen (DO), *p*H, biochemical oxygen demand (BOD) were recorded at weekly intervals during the period January to December 1988, using standard methods[7]. For estimating hydrogen sulphide (H_2S) concentrations ASTM method was adopted[8]. Seawater turbulence was recorded by using 'Plaster of Paris' weight-loss method[9]. For monitoring the recruitment and growth of *H. elegans*, sets of 15 coupons (15 × 16 cm) were immersed at both sites at the beginning of every month and withdrawn at the end of 30 d for a period of one year. The census of the settled worms on the test coupons was made with the help of a grid of transparent acrylic sheet engraved accurately with 1 cm quadrates[10]. For monitoring the breeding in the species, 50 individuals were randomly removed from the coupons every fortnight. Animals were carefully extracted from their calcareous tubes and each one was separately held in 5 ml cavity dishes. Under this condition gravid individuals, as a result of 'shock' released eggs. A record of such individuals and the numbers and sizes of the eggs released was maintained. A bulk food of *H. elegans* comprises diatoms. Record of diatom species prevailing in the water column (planktonic), on the test coupons (periphytic) and in the guts of the worms (residual frustules) was maintained by adopting the standard methods[11].

Results and Discussion

It is observed from Table 1 that salinity in confined wet basin was low (minimum 9.43 × 10^{-3}) and the fluctuations recorded were very frequent and wide. In wet basin, dissolved oxygen (DO) was relatively low and fluctuated from time to time. It is also observed that here both biochemical oxygen demand (BOD) and concentration of H_2S were very high as compared to open jetty waters. Table 2 gives weight loss of dental blocks immersed at the two sites. It was presumed that the extent of the erosion of the blocks was related to the degree of water turbulence. Erosion was negligible in the wet basin implying thereby the absence of turbulence at this site. Absence of turbulence in the wet basin was also reflected in the lower values of total suspended solids (72 mg.l^{-1}) as compared to the open jetty waters (210 mg.l^{-1}). The wet basin, as was evident from the hydrographical data was a polluted stagnant water mass. In a recently conducted study (unpublished), the amounts of proteins, carbohydrates and lipids introduced as effluents in the confined waters have been found to be far higher than the normally prevailing values.

Whether or not *H. elegans* opted for the stagnant, high BOD and high H_2S water mass by choice was ascertained by recording its recruitment, density, seasonal abundance, biomass, breeding potential and growth in terms of length of calcareous tube. Table 3 shows, the numbers of individuals settling on the exposure coupons immersed in the wet basin and the near shore jetty during various months of the year. It was evident that at the jetty, this number, barring the warmer months of May and October did not exceed 1000 worms.m^{-2} area. On the other hand, in the wet basin, several thousand individuals gathered on the exposed coupons during most part of the year. During the monsoon months of July, August and September, the settlement was very heavy, probably because of lack of competition from the other sedentary organisms. That the settlement was very heavy in the

Table 1—Hydrographic conditions at wet basin and near shore water in Bombay harbour

Month	Temp. (°C)	Sal. ($\times 10^{-3}$)	DO (mg.l^{-1})	*p*H	BOD (mg.l^{-1})	H_2S (mg.l^{-1})
January						
WB	25.00	36.48	2.96	7.85	50.54	31.77
NS	24.95	36.48	2.96	7.97	14.85	9.46
February						
WB	25.05	35.69	2.52	7.84	33.06	30.4
NS	24.85	36.23	2.01	7.99	12.23	13.51
March						
WB	28.50	38.61	1.78	7.68	30.58	41.90
NS	27.25	37.06	4.26	8.13	10.05	3.64
April						
WB	30.10	36.28	4.05	7.80	32.59	53.35
NS	28.75	36.89	3.77	7.86	12.23	13.51
May						
WB	30.75	37.41	3.74	7.28	33.90	64.76
NS	30.30	36.28	4.04	7.27	8.30	14.86
June						
WB	29.00	28.57	3.92	7.72	32.33	57.20
NS	29.00	29.01	5.15	8.01	9.61	35.13
July						
WB	29.75	26.89	3.94	7.78	42.81	42.57
NS	29.00	28.81	4.35	8.22	20.53	18.24
August						
WB	29.60	26.92	2.99	7.75	53.3	62.72
NS	27.60	28.98	3.06	7.86	20.53	16.89
September						
WB	27.80	33.96	2.50	7.65	52.86	55.18
NS	27.60	36.04	3.21	7.89	8.78	25.67
October						
WB	29.60	35.69	3.30	7.81	41.94	72.18
NS	28.25	37.11	2.10	7.68	12.23	25.27
November						
WB	28.70	37.27	1.71	7.53	30.40	58.29
NS	27.78	37.17	2.36	7.80	17.48	28.38
December						
WB	25.20	36.33	1.55	7.70	29.27	45.94
NS	25.27	37.09	3.49	8.20	12.23	27.30

WB—wet basin, NS—near shore

Table 2—Water turbulence as depicted by loss of weight of Plaster of Paris' dental blocks at the two study sites in Bombay harbour

Period	Percent average weight loss of dental blocks			
	Near shore		Wet basin	
Premonsoon (Feb.-May)	29.0±0.7	(48.5)	2.4±0.3	(23.7)
Monsoon (June-Sept.)	65.7±1.74	(76.1)	6.1±0.2	(16.1)
Postmonsoon (Oct.-Jan.)	35.5±0.9	(53.3)	4.5±0.25	(17.2)

Figures in parentheses denote maximum values

Table 3—Seasonal recruitment of *Hydroides elegans* at the two study sites in Bombay harbour

Month	Worms (no. $\times 10^3$.m^{-2})		Percent area covered		Wet wt.* (kg.m^{-2})
	Near shore	Wet basin	Near shore	Wet basin	Wet basin
Jan.'88	0.5±0.07	30±2.5	4.1	100	2.05
Feb.	0.3±0.04	86±4.7	2.7	100	1.25
March	0.4±0.05	762±4.2	4.4	100	6.35
April	0.4±0.04	0.5±0.17	16.1	8	1.06
May	1.3±0.05	0.8±0.3	17.0	25	2.94
June	0.03±008	124±5.2	0.1	100	1.6
July	0.1±0.04	123±20.7	0.9	100	0.29
Aug.	0.8±0.14	750±15.5	0.6	100	1.09
Sept.	0.9±0.22	180±14.2	10.8	100	0.68
Oct.	1.2±0.22	140±3.5	13.0	100	2.08
Nov.	0.8±0.14	1.5±0.31	11.0	15	1.0
Dec.	0.1±0.01	173±9.0	1.2	100	4.15

*Immersion period 120 d

wet basin was also evident from the data on the surface coverage by the tubeworms at the two sites. In the wet basin, barring warmer months of April and May and again the month of November, every unit cm^2 area (100 pc) of the immersed surfaces were fully covered. The coupons immersed at the jetty, on the other hand, remained relatively uncovered (Table 3).

Every month, 5 coupons exposed for a period of 120 d in the wet basin and at the jetty were withdrawn and the wet weights of the debris generated as a result of tubeworm growth were recorded (Table 3). The biomass generated on the exposure coupons in the wet basin during the monsoon months of June to September was around 0.29 to 1.6 $kg.m^{-2}$. During rest of the year, values recorded varied from 1.0 to 6.35 $kg.m^{-2}$. At the turbulent jetty site, on the other hand, the maximum weight generated was only around 0.05 $kg.m^{-2}$ at any given point of time.

It was observed (Table 4) that generally about 30 to 50% of *H. elegans* population residing in the wet basin was gravid at any given point of time. Majority of the individuals had eggs with diameters around 100 μm. Assuming that matured egg dimension of 100 μm is specific to this species, it is inferred that the eggs ready for the fertilization are continuously produced and released almost throughout the year. The higher incidence of matured eggs, however, were noted during the postmonsoon (October to January).

The gonadal conditions of the tubeworms from an established population in the wet basin were also monitored (Table 5). For this study, the specimens from the coupons, exposed continuously for an extended period of 470 d, were removed at an interval of 30 d. The examination of individuals, comprising both old and freshly recruited tubeworms, revealed that between 25 to 60% of the population carried eggs at any given point of time.

The growth of *H. elegans*, measured in terms of tube-length, was very rapid (Table 6). This species achieved a maximum length of 18 mm in 15 d and 80 mm in 120 d. Most of the growth was achieved between 15 and 30 d after initial settlement on immersed surfaces.

Wet basin, because of its high organic content as a consequence of sewage pollution, supported rich and varied diatom flora (Table 7). The presence of the diatoms in the water column was not detected as often as on the exposure coupons or in the gut contents of the organisms. This can be attributed to the planktonic nature of the species as well as possibly to the

Table 4—Breeding potential of *Hydroides elegans* in the wet basin in terms of egg-bearing individuals

Period	Fortnight	Egg-bearing (%)	Eggs per individual (no. × 10^3)	Egg dia (μm)
Jan. 1988	I	34	3-10	100
	II	32	2-18	70
Feb.	I	28	6-23	80
	II	52	7-13	60
March	I	44	10-32	60
	II	61	3-11	60
April	I	56	5-17	65
	II	53	4-11	60
May	I	50	3-9	60
	II	46	1-11	70
June	I	62	15-21	75
	II	76	10-32	70
July	I	33	<1-16	65
	II	44	7-30	60
Aug.	I	34	3-30	70
	II	21	1-11	70
Sept.	I	47	<1-14	75
	II	46	1-20	70
Oct.	I	50	13-32	100
	II	46	1-20	70
Nov.	I	57	13-21	80
	II	40	3-8	80
Dec.	I	44	5-11	80
	II	34	2-9	100

Table 5—Per cent gravid individuals of *Hydroides elegans* population during 30 d to 470 d in wet basin in Bombay harbour

	Days of immersion							
	30	90	150	210	270	310	410	470
Egg-bearing individuals (%)	25	28	36	38	20	66	52	20

Table 6—Growth of *Hydroides elegans* during 120 days in wet-basin waters in Bombay harbour

	Days of immersion				
	15	30	60	90	120
Average length of calcareous tube (mm)	6.34±1.1 (18)*	31.04±2.6 (60)	37.10±2.8 (70)	44.40±2.8 (80)	45.37±2.7 (80)

*Figures in parentheses indicate maximum length attained

Table 7—Density of diatoms recorded as planktonic, periphytic and from the gut contents of *Hydroides elegans*

Species	Water column (no.l^{-1})	Coupon surface (no. cm^{-2})	Gut content (no. of frustules)
Amphora coffoeformis	205	38193	121
Nitzschia panduriformis	—	23706	72
Nitzschia palea	—	3951	6
Skeletonema costatum	—	—	39
Diploneis sp.	23	31608	121
Amphiprora paludosa	—	26340	53
Amphiprora gigantica	—	—	2
Lycmophora sp.	—	—	4
Pinnularia viridis	—	3951	—
Cymbella turgida	—	2634	8
Fragilaria oceanica	—	1317	2
Cyclotella sp.	457	—	35
Nitzschia closterium	—	—	2
Synedra ulna	—	1300	4
Coscinodiscus sp.	—	—	2
Navicula forcipata	—	14487	—
Navicula pygmea	—	35559	8
Navicula sp.	—	—	5
Navicula hennedeyii	—	1317	—
Achnanthes brevipes	—	—	1
Actynocyclus ehrenbergii	—	—	1
Achnanthes longipes	—	5268	—
Navicula peregrina	—	2634	—

inadequacy of the water sampling procedure. In the case of coupons, the periphytic diatoms remained adhered to the surface and in the case of gut contents, their frustules remained trapped until they were ejected out at periodical intervals. In both the cases therefore, higher numbers of the diatoms as compared to the water column were recorded. Amongst 23 species of diatoms, *Amphora coffoeformis* and *Diploneis* sp. (as revealed by their presence in the water column, in biological films and the gut contents) were notably dominant forms. Of these 23 species, almost 18 species were recorded in the guts of the adult worms. This suggested that the species ingested diatoms without any discrimination. Frustules of *A. coffoeformis*, *Diploneis* sp. *Nitzschia panduriformis*, *Skeletonema costatum* and *Cyclotella* sp. in that order, were the major residuals in the gut contents. The diatoms were thus found to be a major component of food of this species.

Many of the shell-dwelling sedentary organisms overcome the hazards of indifferent seawater conditions in a variety of ways. These organisms are able to circulate a large amount of seawater within the shell valves. When necessary they can exclude their soft body parts from the surrounding environment by closing their shells and by respiring anaerobically. They have ability to undergo ecdysis and can withstand long desiccation. Some of them can detoxify toxic elements entering the system by encapsulating them within an organic coating and discarding them periodically. *H. elegans* possesses some of these attributes but their successful presence in fouled basin waters in Bombay is possibly associated with the prevalence of a rich diatom flora on which they feed and also with the relatively low water turbulence prevailing at this site.

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