

Studies on the variability among macrofouling test coupons exposed in Bombay harbour

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Estimations of within panel series variability with respect to number of species present, per cent coverage and species composition are done with the aid of statistical method. The quantification of macrofouling settled on test coupons (15 replicates) immersed for 30, 60 and 90 days during non-monsoon months was made. The paper discusses three biological parameters that are considered in evolving field method for assessing the sedentary life obtained from two different environments. The results suggest that at any specific time, variability between panels with respect to species composition is minimal at both the sites. For achieving 10% of confidence intervals (acceptable limit), 4-8 test coupons are adequate to give a dependable data. The study also revealed that variability exist within a series of panels at study sites, particularly variability in species count and per cent cover is high at nearshore waters than that at tidal basin.

Monitoring of the environment to assess the recruitment, growth, mortality and distribution of endemic fauna is necessitated because of several anthropogenic activities. Lately the problem of pollution has also added one more dimension to this. The method of exposing the test coupons for monitoring the biofouling growth as well as for testing the antifouling compositions has now been widely accepted¹⁻⁸. In an effort to generate data on fouling community by exposing panels, extensive work has been carried out at maritime institutions in temperate and semi-tropical regions⁹⁻¹⁶. Despite the extensive data generated on macrofouling, investigations of the variability between panels has been neglected area of research to date. Unless there is uniformly accepted method which stipulates number, size and substrates, it is not possible to compare fouling results obtained from different laboratories. Shoener & Green¹⁵ have commented that "it is none the less necessary one for establishing statistically valid results".

The Bombay harbour environment is being presently monitored for its chemical and biological characteristics with regard to pollution status of waters. The biological data obtained are also used in assessing the A/F and A/C paints. The work was carried out with the aim of deciding the minimum number of panels and appropriate parameter required for examining the biota based on

quantitative assessment. The parameters considered for estimating variability among test coupons were total number of sessile organisms attached, per cent cover and species composition. The statistical method applied for analysis of the data was as described by Sokal & Rohlf¹⁷.

Materials and Methods

In order to assess the variability among series of test coupons (panels), experiments were carried out at two sites in Bombay harbour (lat. 18° 55'N; long. 72° 50'E). These sites are—(i) near shore waters—relatively open clean waters located 0.5 km off the coast; wave action was relatively high and depth of water was 15 m; (ii) tidal basin—was semi enclosed water mass, close to shore, receiving untreated organic sewage through storm water culvert. The depth of water mass was 7.5 m. These sites differ from each other in respect of water quality and the pollution status¹⁸.

The test coupons of perspex (15×16×0.4 cm) were bolted on mild steel experimental frames and immersed at 1 m below the low tide level over a period of 30, 60 and 90 days. Replicate coupons (15) were withdrawn at 30 days interval over a period of 90 days.

The census of sedentary organisms and area covered by major taxa was made by using grid quadrat method^{4,19}. Census included all sessile species attached to the panels. At each withdrawal

12-15 test panels were examined and data obtained were computed for statistical analysis.

To estimate variability among series of test panels, parameters such as number of sessile species attached to panels, per cent covered by major groups and species composition were considered. The analysed data are interpreted in the form of "trumpet" diagram^{17,20}, which indicates the width of confidence intervals around the mean expressed as percentage of the mean. The change in the width of 95% confidence limit was recorded in relation to exposure period and habitats.

At study sites physico-chemical parameters such as temperature, salinity, DO, TSS, nitrate and phosphate were monitored following standard methods^{21,22}.

Results

Two sites differ in macrofaunal composition. The attached sessile organisms mainly consist of bryozoan, polychaete, hydroid, barnacle and tunicate species. The species encountered at two sites are encrusting bryozoans—*Electra bengalensis**, *Membranipora annae*, *M. tenuis*, *Hippoporina americana**, *Acanthodesia* spp*; erect bryozoans—*Bugula bengalensis**, *B. neritina*, *B. stolonifera**, *Victorella pavidia**, *Nolella papuensis**; polychaetes—*Hydroides elegans**, *Hydroides operculatus*, *Apomatus* spp, *Chaetopterus variopedatus**, *Dasycone cingulata*; ascidians—*Styela bicolor**, *Symplegma reptans**, *S. brakenbielmi*, *Botrylloides magnicaecum*, *Diplosoma macdonaldi*, *Ascidia* spp; Cirripedes—*Balanus reticulatus*, *B. variegatus*, *Chirona amaryllis euamaryllis*; Molluscs—*Saccostrea cucullata*, *Crassostrea* spp (*indicates common at tidal basin). A total of 62 species were found settled on these panels. Of these, 78% of the organisms (48 species) were recorded from nearshore waters while 52% of the organisms (32 species) were observed at tidal basin.

Variability in number of sessile species in nearshore waters—Figure 1 indicates the width of confidence intervals (CI) changed during various periods. On the test coupon obtained from 30 days period, bryozoans followed by barnacles were the most predominant organisms settled on the test panels. The confidence intervals (CI) spanned around 20% on either side of the mean for a sample

size of 5 coupons (Fig. 1), and did not change much when 14 panels were used for analysis of the species variability. There after the CI decreased for the samples collected after 60 (13-15%) and 90 (10%) days period of exposure in nearshore waters. If CI at 10% is accepted as reasonable then sample size of the 13 coupons is adequate for monitoring the sedentary organisms at this site.

Variability in per cent cover in nearshore waters—Polychaetes : After 30 days exposure, the colonisation pattern varied at nearshore waters resulting in wide span of 37% on either side of mean with largest sample size (N=14). After 60 days, the confidence interval reduced to 20% at sample size of 5 coupons. After 90 days exposure, the outcome was similar to that of 60 days exposure. Subsequently width of CI reduced to 13% at sample size of 7 (Fig. 2). The results suggest that exposure of coupons beyond 60 days is not necessary.

Bryozoa: For bryozoans after 30 days exposure, the width of CI spanned 30% on either side of mean at sample size of 12. This was reduced considerably after 60 and 90 days exposure. To achieve 18-20 % span on either side 6 panels are required. The width of CI did not reduce below 15% on either side of mean even after 90 days exposure. It indicates though the per cent coverage was high, it varied from panel to panel (60.71 ± 4.20). Karande & Swami²³ have observed that the coverage of test panel by bryozoans at nearshore waters was 50-70%.

Variability among species composition in nearshore waters—Figure 1 shows the width of confidence intervals according to sample size, when species composition is used as assessing parameter. This parameter seems to be ideal. The result indicates irrespective of the exposure period, width of CI spanned always below 10% on either side of mean to the sample size of 5 to 7. It indicates that uniformity in species occurrence at this site is very high.

Variability in number of sessile species in tidal basin—The site is relatively polluted than nearshore waters. The range of dissolved oxygen varied between 0.81 to 4.47 mg.l⁻¹ (Table 1). It has been reported that the site is polluted and supports the good growth of sulfate reducing bacteria²⁴. The dominant species recorded at the site were *Chaetopterus variopedatus*, *Dasycone cingulata*,

Hydroides elegans and *Apomatus* spp. (Polychaetes), *Electra bengalensis*, *Hippoporina indica* and *Acanthodesia* spp. (Bryozoans) and *Styela bicolor*, *Ascidia* spp. and *Symplegma reptans* (Tunicates).

The panels have shown less variability in respect of species count. Figure 3 indicates width of CI for 30, 60 and 90 days, which spanned 10% on either side at sample size of 8-14. Variations in width of confidence at this site could be attributed to uneven settlement of *Styela bicolor* and *Ascidialla* spp.

Variability in per cent cover in tidal basin—Polychaetes : The per cent cover by

polychaetes in all periods was quite variable (Fig. 4). After 30 and 60 days, the width of CI did not reduce below 13% (15 and 13% respectively) but after 90 days exposure, 11% CI estimated at sample size of 10.

Bryozoans: If bryozoans are considered for per cent cover, the outcome was different than polychaetes. After 30 and 60 days, the 95% confidence limit spanned to 8 and 11% on either side of mean to the sample number of 5 and 10 respectively. However, the per cent cover was highly variable within panels exposed for 90 days. Variations observed could be attributed to the

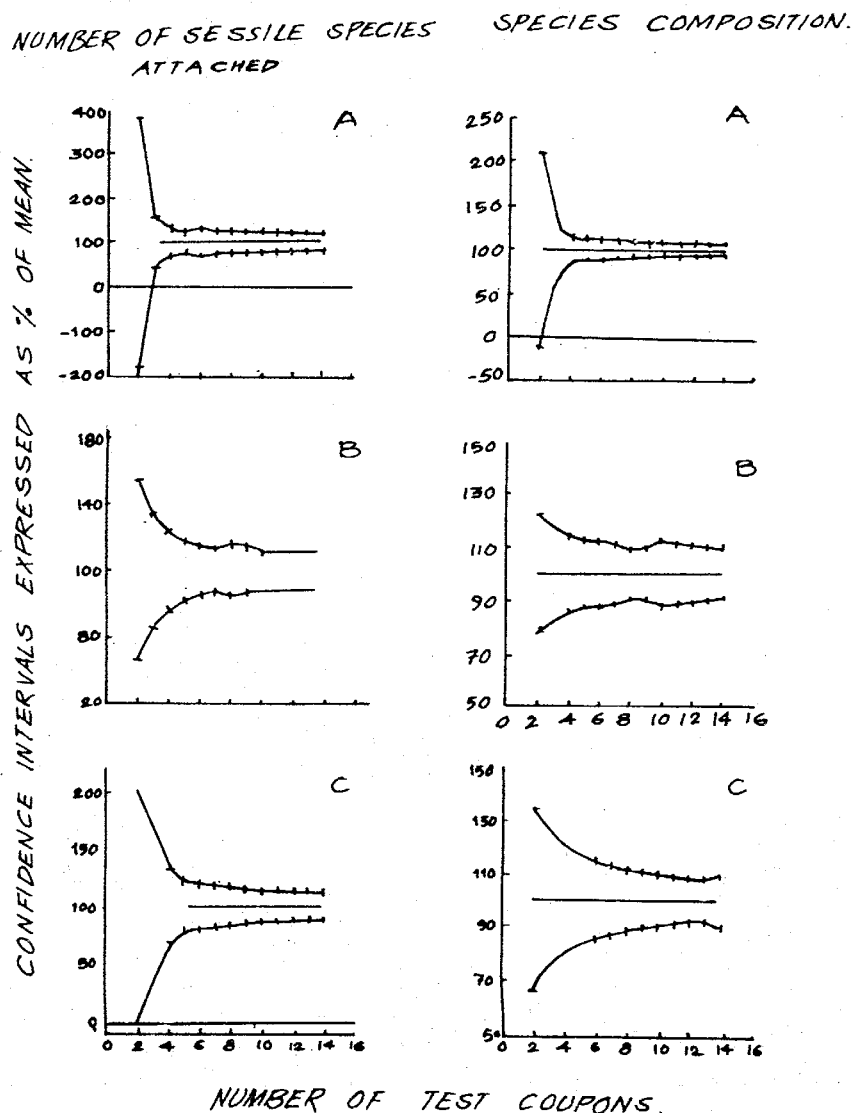


Fig. 1—The upper and lower 95% confidence limits plotted versus number of test coupons. (The data represent mean number of sessile species and species composition from 14 panels immersed at nearshore waters, A—30, B—60 and C—90 days).

occurrence of ascidians namely *S. reptans* and *S. bicolor* resulting in wide variations of CI (22-31%). Heavy occurrence of ascidians thus appears to have affected the colonisation of bryozoans on the panels exposed for 90 days.

Variability in species composition in tidal basin—It is observed that variation among test coupons in respect to species composition was minimal. After 30 days, 10% confidence interval was estimated at sample size of 8. After 60 days, CI reduced to 7% on either side of mean at panel number 4, indicating consistent pattern in species composition (Fig. 3).

Results suggest that, if species composition is considered as parameter, irrespective of exposure time, 4-8 panels are adequate to get 95% CI spanned 10% on either side of mean (10% is acceptable limit for marine environment). It is important to note that

the organic pollution existing at the site did not influence the variability in species encountered on the panels. Hence, species composition emerged as an ideal parameter for assessing the biota obtained from polluted and unpolluted sites.

Table 1—Environmental parameters monitored during non-monsoon months at Bombay harbour

Parameters	Nearshore waters	Tidal basin
Temp. (°C)	24.2-31.8	25.1-32.0
pH	7.63-7.86	7.51-7.88
Salinity ($\times 10^{-3}$)	35.81-37.82	34.2-35.81
D.O. ($\mu\text{g.l}^{-1}$)	3.09-6.45	0.81-4.47
TSS (mg.l^{-1})	31.2-202.1	6.8-37.2
NO_3^- ($\mu\text{g-at.l}^{-1}$)	6.09-26.31	2.53-28.33
PO_4^{3-} ($\mu\text{g-at.l}^{-1}$)	0.83-6.03	2.64-9.14

Temp=Temperature, DO=dissolved oxygen
TSS=total suspended solid

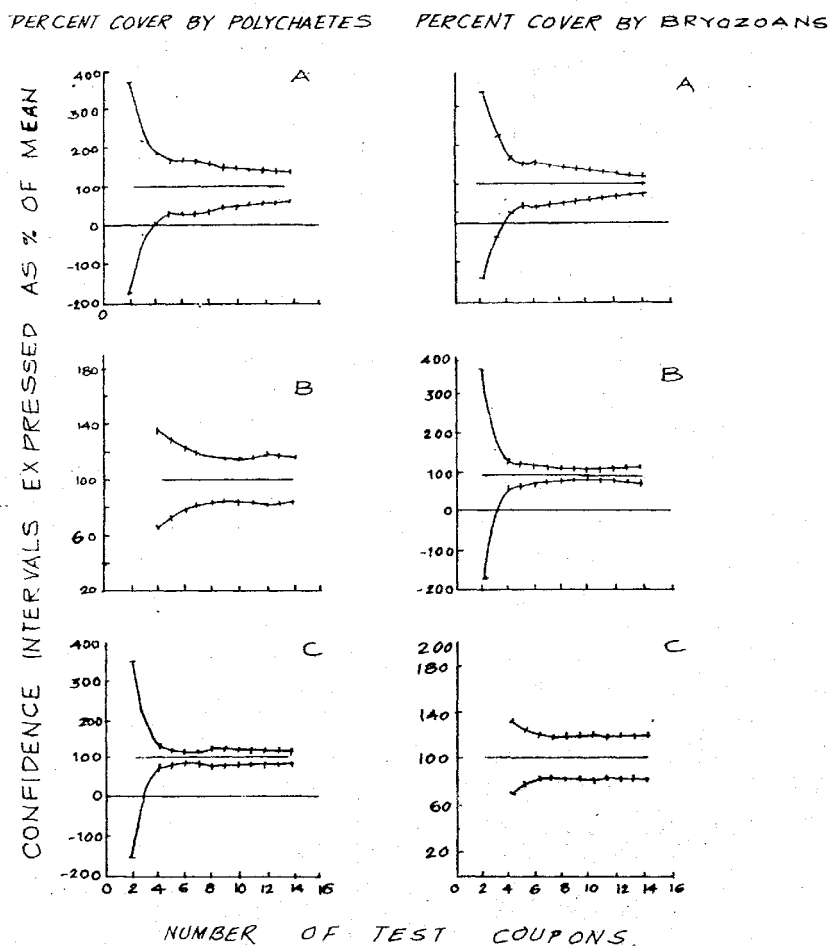


Fig. 2—Confidence limits for per cent covered by polychaetes and bryozoans on panels at nearshore waters.

Discussion

Study revealed that at nearshore waters initially (30, 60 days), the variability of the total attached organisms was high. Thereafter, a uniform colonisation was observed. To estimate 10% span on either side of the mean, 13 panels are required for assessment of fouling. Our data corroborated with that of Karande *et al.*¹ who observed 10% CI at sample size of 12 at nearshore waters.

The variability among the panels was found to be high when percentage cover was used for analysis. The width of CI did not reduce below 15%. Mook¹¹ estimated the variability in total per cent cover for

subtropical estuarine fouling panels, and reported that 72% of potential cover was obtained in five replicates. In the present study, wide intervals of 20-30% were observed at sample size of 4 to 10 at both the sites when per cent cover by polychaete was considered. If bryozoan is considered as a covering group, the outcome was better, 10% confidence limit around the mean was estimated at sample size of 5 to 10. Shoener & Green¹⁵ have made similar observations at a temperate estuarine site. They have reported that 10 replicates generally give 95% CI span 10% on either side of mean during first year of colonisation.

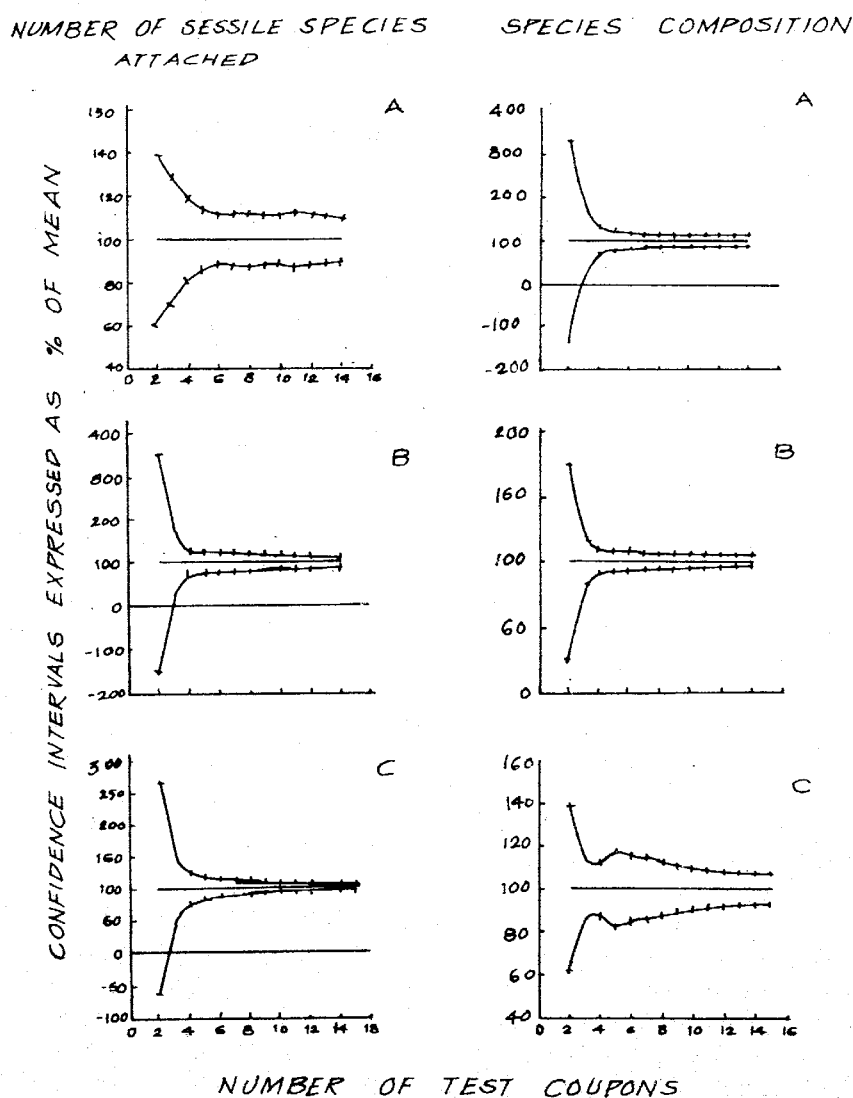


Fig. 3—The confidence limits expressed as per cent of mean plotted versus number of test coupons. (The data represent mean number of sessile species and species composition from 14 panels immersed at tidal basin. A—30, B—60 and C—90 days).

PERCENT COVER BY POLYCHAETES PERCENT COVER BY BRYOZOANS.

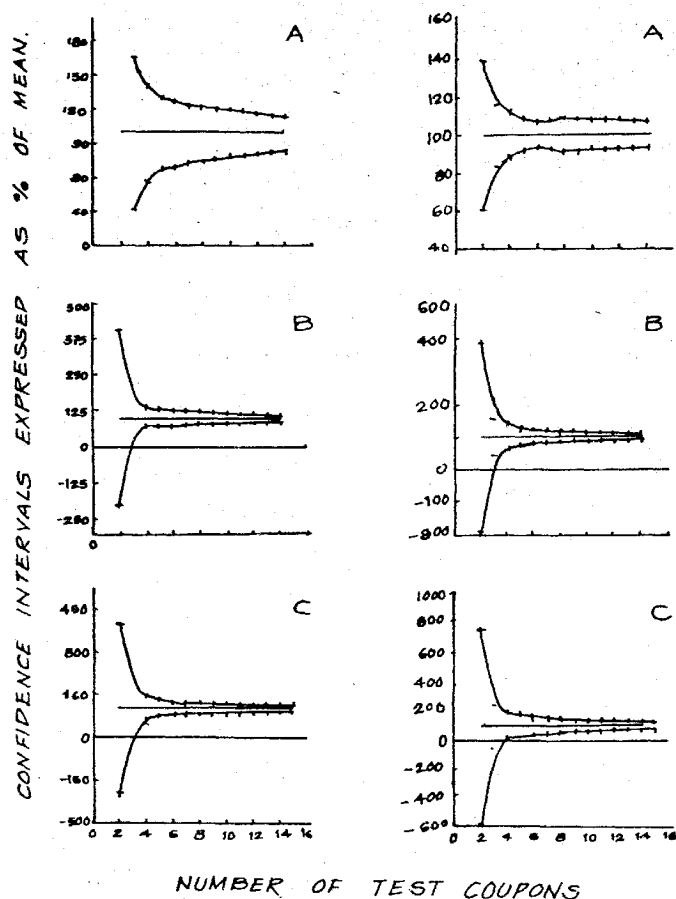


Fig. 4—Confidence limits for per cent covered by polychaetes and bryozoans on panels at tidal basin.

At tidal basin, when variability with respect to species count and species composition was estimated, the CI spanned 10% on either side of mean at sample size of 8-10. If 10% is acceptable limit for tropical condition then 8 panels will give dependable results at tidal basin. Chiappa¹⁴ investigated the variability in temperate waters and concluded that if community composition is prime aim then only 3 to 9 replicates are required to achieve a confidence value close to 100%.

Present study revealed that variability exist within a series of panels exposed at two sites in waters of Bombay harbour. Particularly, variability in species count and per cent cover was high at nearshore waters. Osman¹² had also reported variations within series of panels exposed in temperate waters. If species composition is

considered as assessing parameter, 4-8 panels would give a 95% confidence intervals span 10% on either side of mean at both the sites. It has been reported that 10% of confidence interval is acceptable limit for temperate waters. Hence it may also be applied to tropical waters of Bombay harbour.

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