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# The impact of suspended culture of the edible oyster *Crassostrea madrasensis* (Preston) on benthic faunal assemblages

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## Abstract

The impact of suspended farming of the edible oyster, *Crassostrea madrasensis* (Preston) on the benthic faunal community structure was studied. The species composition of the faunal samples collected during January to September 2002 from an experimental farm which supported an oyster biomass of 27 to 288 kg in 25 $m^2$ area in Ashtamudi Lake, Kerala, were compared with that of a reference (non-farming) site. The faunal density was almost similar at the farm site, 1278 no. $m^{-2}$ and at the reference site 1470 no. $m^{-2}$. At the farm site, 22 species of annelids belonging to 16 genera and at the reference site 23 species under 19 genera were recorded. The Shannon Weiner function (H') was only slightly higher (2.64) at the reference site, than at the farm site (2.53). Almost similar Simpson ($1-\lambda$) dominance indices were also obtained. The Pielou's (J') evenness index was 0.79 at the reference site while at the farm site it was marginally lower (0.75). The Margalef (d) species richness index was higher (4.05) at the farm site than at the reference site (3.70). These differences in univariate diversity indices were not significant ($P>0.05$). The benthic faunal community structure at both sites were similar and there was no negative impact due to short-term farming of oysters.

**Keywords**: Oyster culture, oyster biomass, benthic fauna, diversity indices

## Introduction

Considerable changes are reported to occur in bivalve farm sites. Biodeposition by farmed oysters and mussels generally provides a strong input of organic matter of high quality to benthic assemblages. Organic loading in the marine environment usually involves an increase in sediment oxygen demand by benthic micro-organisms and fauna, and subsequent depletion of oxygen in pore water and near bottom water (Pearson and Rosenberg, 1978). Castel *et al*. (1989) investigated the influence of oyster (*Crassostrea gigas*) parks on the abundance and biomass patterns of meio and macrobenthos in tidal flats. Decreases in macrofaunal abundance have been detected in areas of extensive intertidal oyster cultivation (Heral *et al*., 1986; Castel *et al*., 1989). Dinet *et al*. (1990) studied bivalve aquaculture sites and observed that as biodeposition by *Crassostrea gigas* and *Mytilus edulis* increased, there was a commensurate decline in meiofaunal populations associated with sediment anoxia and elevated $NH_4^+$ in sediment pore water. Nugues *et al*. (1996) noted small, but significant changes in the macrofauna community sampled beneath oyster trestles, compared with that found in adjacent uncultivated areas. Moore (1996) who studied the impact of an inter- tidal oyster farm on the benthos in Dungarvan Harbour compared the benthos at the control site to that at the site with oyster trestles. An increase of sediment mud content associated with oyster farming zone was noticed. In India, edible oyster farming has become a seasonal avocation for many villagers since 1996. Farming is done by the rack and ren method in which the rens are suspended from the wooden platforms. The farm units are usually small (5m x 5 m) and the crop period is six to eight months during the post and pre-monsoon season when the salinity is above 22 ppt. This study was done to assess the impact of oyster farming on the benthic faunal community.

## Materials and methods

For assessing the impact of oyster culture on benthic macrofauna, replicate sediment samples were taken from an experimental rack farm of 5m x 5 m stocked with approximately 30,000 oysters on 500 rens of 1.5m length in Ashtamudi Lake, Kerala. The reference site (non-farm) was selected 100m away from the farm site. The sediment samples were taken using a PVC cylinder (150mm height x 150mm diameter) as suggested by Nugues *et al*. (1996) during every second week of the month starting from January to September 2002. Samples were sieved *in situ* in a 0.5 mm mesh sieve, fixed in 4% buffered formalin and stained with Rose Bengal vital stain. In the laboratory, the fauna were sorted to phylum level and preserved in 4% buffered formalin for further identification. The fauna were identified to the lowest possible taxonomic level and classified following standard nomenclature of Fauvel (1953) and Day (1967). The number of each individual species that occurred in a sample and the number of individuals of particular species present in the sample were noted and the data of replicates were averaged for further statistical analysis.

Univariate community measures (number of species, number of individuals) were calculated using the PRIMER statistical software package developed by the Plymouth Marine Laboratory (Clarke and Warwick, 1994). Two measures of species diversity were calculated: Simpson's reciprocal, D, was chosen as a Type II index which is more sensitive to changes in more abundant species and the exponential of the Shannon – Weiner function (exp H') was used as Type I index, most sensitive to changes in rare species (Peet, 1974). Differences between the values of these statistics were also tested using nested ANOVA of SAS statistical package, Version 9.2.

Comparisons of individuals or gross community parameters such as species richness or diversity may fail to appreciate directional changes in relative species abundance. However, these changes may be detectable using multivariate discrimination techniques such as those described in Clarke and Warwick (1994). The similarity matrix was constructed using the Bray – Curtis similarity index after 4th root transformation of data. The macrobenthic community structure among the sampling was tested using analysis of similarity (ANOSIM). The interpretation of ANOSIM result is based upon the calculation of global R statistic value. The relative contributions of each species to the average similarities of these groupings were calculated using SIMPER analyses.

Table 1. *Average abundance (no. m$^{-2}$) of benthic macrofauna at farm and reference sites*

| Species | Farm | Reference |
|---|---|---|
| *Ancistrosyllis parva* | 6 | 12 |
| *A. robusta* | 19 | 6 |
| *Capitella capitata* | 81 | 118 |
| *Ceratonereis keiskama* | 19 | 44 |
| *C. mirabilis* | 25 | 0 |
| *Cossura coasta* | 31 | 31 |
| *Diopatra monroi* | 0 | 62 |
| *D. neapolitana capensis* | 25 | 0 |
| *Drilonereis longa* | 19 | 37 |
| *Glycera unicornis* | 0 | 12 |
| *Glycinde kameruniana* | 0 | 44 |
| *Lumbrineris heteropoda* | 0 | 6 |
| *L. magalhaensis* | 12 | 0 |
| *Lysilla loveni* | 19 | 19 |
| *Maldanella harai* | 31 | 19 |
| *Mediomastus capensis* | 0 | 19 |
| *Megalomma quadrioculatum* | 0 | 6 |
| *Nephtys macroura* | 12 | 0 |
| *N. polybranchia* | 68 | 68 |
| *Nerindes gilchristi* | 6 | 19 |
| *Notomastus aberans* | 6 | 105 |
| *N. fauveli* | 6 | 37 |
| *N. latericeus* | 6 | 25 |
| *Petaloproctus terricola* | 12 | 31 |
| *Prinospio cirrifera* | 12 | 37 |
| *P. cirrobranchiata* | 25 | 0 |
| *P. pinnata* | 12 | 12 |
| *Spiophanes bombyx* | 19 | 12 |
| **Annelida Total** | **472** | **782** |
| *Alpheus* sp. | 6 | 0 |
| *Ampithoe* sp. | 31 | 0 |
| *Apseudus chilkensis* | 167 | 161 |
| *Penaeus* sp. | 19 | 6 |
| *Gammarus* sp. | 452 | 452 |
| *Tanaidacea* sp. | 86 | 0 |
| **Crustacea Total** | **762** | **619** |
| *Paphia malabarica* | 12 | 43 |
| **Mollusca Total** | **12** | **43** |
| Unidentified | 31 | 25 |
| **Grand Total** | **1278** | **1470** |

## Results

The benthic faunal community at the culture and reference sites consisted of different species of annelids, crustaceans and molluscs (Table 1). The number of individuals was more or less similar at both the farm site, 1278 no. m$^{-2}$ and at reference site (1470 no. m$^{-2}$). Crustaceans were the dominant group in the farm site, forming 60 % (762 no. m$^{-2}$) of the benthic community followed by annelids (37 %) and molluscs (1%). At the reference site, annelids contributed to 53% while crustaceans formed 42% and the molluscs 3% of total benthic community. Unidentified fauna formed 2% of the sample at the sites. At the farm site, 22 species of annelids belonging to 16 genera were recorded while at the other site there were 23 species of 19 genera. *Ceratonereis mirabilis, Diopatra neapolitana capensis, Lumbrineris magalhaensis, Nephtys macroura* and *Prinospio cirrobranchiata* occured only at the farm site while *Diopatra monroi, Glycera unicornis, Glycinde kameruniana, Lumbrineris heteropoda,* *Mediomastus capensis* and *Megalomma quadrioculatum* were recorded only from reference sites. Seventeen species were common to both areas

Crustaceans belonging to 6 genera *viz., Alpheus* sp., *Ampithoe* sp., *Tanaidacea* sp., *Apseudus chilkensis, Penaeus* sp. and *Gammarus* sp. were found at the farm site, but the former three genera were absent at the latter site. At both the areas *Gammarus* was numerically abundant. Molluscs were represented by the bivalve *Paphia malabarica*, but the density was high at the reference site.

Table 2. *Diversity measures of benthic faunal assemblages at the farm and reference sites*

| Diversity measure | Farm | Reference |
|---|---|---|
| Total species (S) | 30 | 28 |
| Total individuals (N) | 1278 | 1470 |
| Margalef (d) species richness index | 4.05 | 3.70 |
| Pielou's (J') evenness index | 0.75 | 0.79 |
| Shannon (H') diversity index | 2.53 | 2.64 |
| Simpson (1-λ) dominance index | 0.84 | 0.87 |
| Average Similarity percentage | 14.28 | 16.28 |
| Global R Statistic value | -0.07 | |

Table 3. *SIMPER analysis results showing the taxa that contributed with more than 90% of the dissimilarity between farm and reference sites of F1*

| Species | Average dissimilarity ± SD | Contribution % | Cumulative % |
|---|---|---|---|
| *Gammarus* sp. | 18.91 ± 0.99 | 22.84 | 22.84 |
| *Apseudus chilkensis* | 8.36 ± 1.04 | 10.10 | 32.95 |
| *Capitella capitata* | 5.71 ± 1.05 | 6.89 | 39.84 |
| *Nephtys polybranchia* | 5.34 ± 0.70 | 6.46 | 46.30 |
| *Notomastus aberans* | 4.28 ± 0.69 | 5.18 | 51.47 |
| *Diopatra monroi* | 3.48 ± 0.61 | 4.21 | 55.68 |
| *Cossura coasta* | 2.80 ± 0.67 | 3.38 | 59.07 |
| *Maldanella harai* | 2.53 ± 0.45 | 3.06 | 62.12 |
| *Petaloproctus terricola* | 2.08 ± 0.36 | 2.52 | 64.64 |
| *Glycinde kameruniana* | 2.02 ± 0.44 | 2.44 | 67.08 |
| *Prinospio cirrifera* | 1.98 ± 0.70 | 2.40 | 69.47 |
| *Ceratonereis keiskama* | 1.97 ± 0.73 | 2.38 | 71.85 |
| *Tanaidacea* sp. | 1.84 ± 0.46 | 2.22 | 74.07 |
| *Paphia malabarica* | 1.81 ± 0.44 | 2.19 | 76.26 |
| *Unidentified* | 1.76 ± 0.72 | 2.12 | 78.38 |
| *Drilonereis longa* | 1.63 ± 0.60 | 1.98 | 80.36 |
| *Notomastus fauveli* | 1.50 ± 0.56 | 1.81 | 82.17 |
| *Prinospio pinnata* | 1.39 ± 0.38 | 1.68 | 83.85 |
| *Prinospio cirrobranchiata* | 1.37 ± 0.45 | 1.66 | 85.51 |
| *Notomastus latericeus* | 1.31 ± 0.54 | 1.58 | 87.09 |
| *Ancistrosyllis robusta* | 1.25 ± 0.58 | 1.51 | 88.60 |
| *Penaeus* sp. | 1.22 ± 0.46 | 1.48 | 90.07 |

The benthic community structure analyses using PRIMER indicated high diversity and richness at both the sites (Table 2). The Shannon (H') was marginally higher (2.64) at the reference site than at the farm site (2.53). Simpson (1-λ) dominance indices were almost similar. The Pielou's (J') evenness index was 0.79 at the reference site while at the farm site it was marginally lower (0.75). The Margalef (d) species richness index was higher at the farm site, 4.05 while at the reference site it was 3.70. The differences in Univariate diversity indices were not significant (P>0.05).

Mutivariate analysis indicated the variation in the community structure. The low similarity percentage at both sites indicated the seasonal variations within the sites. The results of SIMPER analysis have indicated high similarity between the farm and the reference site. *Gammarus* sp, *Apseudus chilkensis, Capitella capitata, Nephtys polybranchia* and *Notomastus aberans* were the main taxa which contributed to the differences in the community structure (Table 3).

## Discussion

The benthic faunal community structure at the farm and reference sites were similar and there was no negative impact due to short-term farming of oysters when the biomass of the farm ranged between 27 to 288 kg (Ramalinga, 2006) over a period of eight months with an average density of 30,000 oysters per 25 m$^2$. The average number of oysters per shell (cultch) was 12. High seasonal variation in the community structure at both sites were noticed, but the overall faunal assemblage was similar without any marked change. Contrary to this, Kasper *et al.* (1985) found that the benthic community structure was strongly affected by the presence of mussel farms. They have attributed the reason to the build of reef –like aggregate including live mussel and shell materials which provide sites of attachment for large epibiota including tunicates and sponges. Decreased diversity of infaunal assemblages was also observed. In the oyster farms at Ashtamudi Lake such shell assemblages were not observed.

In the present study, average abundance of annelids and crustaceans was found to differ but the variations were not significant. However, in prolonged oyster farming, the average annelids abundance has been found to decrease with the period of farming. On the other hand the crustacean abundance decreased with advancing period of farming suggesting that these two groups were sensitive to organic enrichment and increased sedimentation rates. Such changes in benthic communities under shellfish farms have been documented in several studies ( Tenore *et al*., 1982; Cho *et al.* 1982; Findlay *et al*., 1995; Grant *et al.*, 1995; Stenton-Dozey *et al.*, 1999). Benthic community shifts associated with an increase in organic and silt composition beneath the oyster trestles have been reported by Simestad and Fresh (1995) and Nugues *et al.* (1996). In the present farm site also increased organic carbon content, silt and clay composition was observed but in short-term farming these changes were not significant (Ramalinga, 2006). Hence, it can be concluded that concurrent with the sediment texture and seasonal changes, variations occur in the benthic community structure at oyster farm sites but these changes are not significant in short term low-density operations.

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