World Journal of Zoology 6 (2): 173-178, 2011
ISSN 1817-3098


# Role of Epibiotic Algae on the Recruitment and Biomass of Horse Mussels, *Modiolus* spp in Pudhumadam Coast, Gulf of Mannar

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**Abstract:** Mussels form an important functional group in intertidal system and they are widespread and abundant in rocky shores. Habitats composed of living ecosystem engineers, such as mussels, are subject to direct and indirect interactions with organisms which live among them. These interactions may affect the presence and structure of habitat and hence, the associated taxa. The present study examined the direct effects of ephemeral epibiotic algal mats on the biomass and recruitment of mussels (*Modiolus* spp; < 5mm Length) in the intertidal rocky coastline of Pudhumadam, Gulf of Mannar. The field experiment showed the presence of mussel *Modiolus* spp. Recruitment and biomass in mussel patches were examined at intertidal rocky coastline of Pudhumadam (Lat 09°16.26' N and Lon 79°00.11' E) between the period July 2009 and November 2010. Sampling plots were laid in 10 sites at intervals of 100 meters in 1 kilometer stretch of the coast. Three experimental treatments were made to study the recruitment of < 5mm length *Modiolus* spp, such as (1) mussels covered with epibiotic algae (2) mussels that had epibiotic algae removed (shaved) and (3) mussels without epibiotic algae naturally. At each site, eight plots (25cm x 25cm) were used. The epibiotic algal mass comprised approximately 95% of *Acanthopora spicifera* and *Chaetomorpha antennia*. The results showed that the presence of epibionts approximately doubled the chance of mussel recruitment.

**Key words:** *Modiolus* spp · *Acanthopora spicifera* · *Chaetomorpha antennia* · Mussel patch and recruitment

## INTRODUCTION

Mussels are an important functional group of the intertidal systems and they are widespread and abundant on rocky shores [1-3]. Mussels can be thought of as both “allogenic” and “autogenic” bioengineers [4], forming structurally complex entities that provide habitat and refuge for a wide variety of associated organisms. Hard substrates exposed to intertidal and shallow - subtidal waters provide varied habitats for colonization by marine algae and invertebrates. Many studies have shown that one of the most important characteristics of rocky shore communities is their great spatial and temporal variability which arises from a combination of biotic and physical factors [5]. On rocky shores, mussel beds allow colonization by infaunal organisms which cannot otherwise live there [6]. Mussel beds, therefore, provide habitats for many organisms [7] and any factors which affect the habitat may influence the diversity of associated assemblages and the functioning of the system. Mussels often live in mechanically stressful environments and their survival is dependent on their ability to form a strong attachment to the shore [8]. Mussels adopt two main strategies to reduce the risk of dislodgement by wave action on exposed shores i.e., by reduced shell size and increased byssal thread production [9-11]. Factors which increase the hydrodynamic forces exerted on mussels ares important determinants of mussel survival as they increase the risk of dislodgement and probable death [8].

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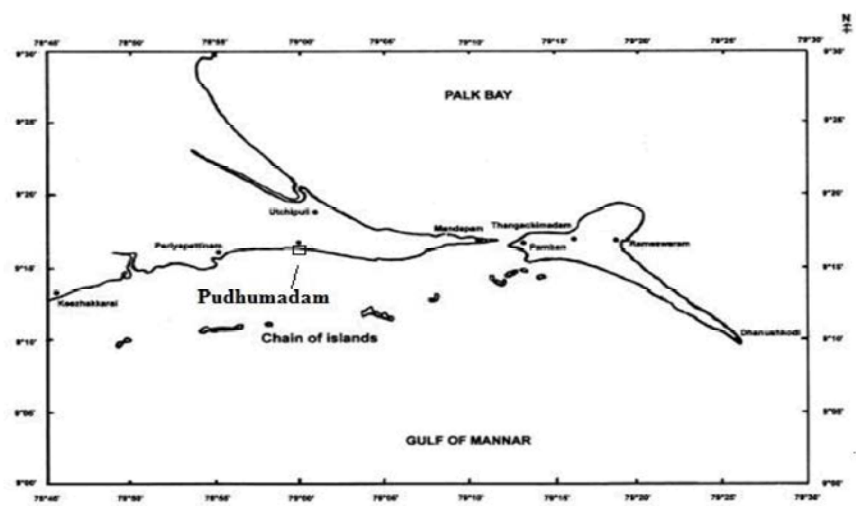
Epibionts can increase drag-induced loading, increasing the risk of dislodgement [12]. Epibionts that form thin encrusting layers generally have no effect, but larger epibionts such as macroalgae may increase the effect of drag and lift and hence, the probability of mussel dislodgement and mortality [8, 13, 14]. In sub-tidal mussel beds, dislodgement induced by algae is a more important cause of mussel mortality than predation [15]. If such effects are related to increased wave action, the importance of epibiotic algae in structuring intertidal communities is likely to increase because the frequency and intensity of storms is predicted to increase due to global warming [16, 17].

The Gulf of Mannar falls in the Indo-Pacific region, considered to be one of world's richest marine biological resource regions. This is considered a hyper fragile environment, inhabiting all types of flora and fauna. Horse mussels (*Modiolus* spp) (family: *Mytilidae*) are one of the most popular benthic species in the Southeast coast of India. The present study investigated the effects of epibiotic algae on the recruitment of horse mussel *Modiolus* spp in the rocky shoreline of Pudhumadam, Gulf of Mannar.

## MATERIAL AND METHODS

The effects of ephemeral epibiotic algal mats on mussel *Modiolus* spp recruitment in mussel patches were examined in the intertidal rocky coastline of Pudhumadam (Lat 09°16.26' N and Lon 94°12.88' E) (Fig. 1) during the period between July 2009 and October 2010. Ten sampling sites were laid at intervals of 100 meters in a 1 kilometer stretch of the coast. This area was all exposed rocky shore characterized by mosaics of patchy distribution of species typical of the region, such as mussels and oysters with ephemeral macroalgae which grow both on rock and attached to mussels. The mussel patches comprises of mixed populations of *M. phillipinarum* and *M. metacalfi* [18] distributed throughout the year.

To examine the effect of epibiotic fucoids on the survival of mussels, three treatments were designed. Three experimental treatments were made to study the recruitment of < 5mm length *Modiolus* spp, such as (1) mussels covered with epibiotic algae (algae) (2) mussels that had epibiotic algae removed (shaved) and (3) mussels without epibiotic algae naturally (no algae). The algae treatment was considered as mussels which were covered 100% in dense epibiotic algal mats. The algal mats comprised approximately 95% of *A.spicifera* and *C.antennia*. The shaved treatment was essential as a control, so that the potentially confounding influence of factors which covary with the occurrence of epibionts on mussels would be assessed. At each site, eight plots (25 x 25cm) containing mussels with epibiotic algae were selected along the shore and marked with stainless steel washers. In four of these plots chosen randomly, all the algae were removed from the mussels with a scalpel. At each location, four additional patches of mussels without epibiotic algae naturally, were also selected and marked. The mussel patches assigned to the shaved treatment were maintained like that by removing all epibiotic algae




Source: Kumaraguru *et al*. 2003

Fig. 1: Study site – Pudhumadam coast, Gulf of Mannar

every 2 weeks. The mussels in the algae and no algae treatments were also manipulated to simulate the effect of the interference involved in removing the algae for the shaved treatment. Destructive samples (10 x 10 cm) were taken from all patches. Upon returning to the laboratory, all interstitial and epibiotic material were removed. All small mussels were removed from the samples and counted to estimate the number of recruits in each patch, under each treatment. For the purpose of this study, all mussels < 5 mm in length were considered as recruits. It is possible that these small mussels are not recent recruits, because small mussels are known to persist [19]. To estimate the overall biomass of mussels in each patch, all other mussels were oven dried at 75°C until constant weight was reached and their dry weight was measured. Measurements of individual mussels prior to commencement of the experiment showed that each patch contained similar numbers of mussels. One way ANOVA was used to test the significance between different treatments for biomass and recruitments. Student–Newman–Keuls procedure was used to compare among levels of significant terms [3, 20].

## RESULTS

Results from the mussels recruitment clearly show that recruitment was not affected significantly by the presence of epibiotic algal mass (Table. 1 and Fig. 2). Significant differences between treatments were observed. Similar number of mussels was observed than those had epibiont and those have been shaved (Table. 2 and Fig. 3). The presence of epibiotic mats had no effect on the number of mussels in paches.

Table 1: ANOVA of the effect of algal epibionts on biomass

| Source of variation | *df* | MS | F | P |
|---|---|---|---|---|
| Epibiont | 15 | 0.001278 | 0.0817 | 1.000 |
| Shaved | 15 | 0.001653 | 0.2020 | 0.990 |
| No Epibiont | 15 | 0.005556 | 0.6504 | 0.8107 |
| Epibiont x shaved x | 2 | 36.52 | 76230 | < 0.0001 |
| no epibiont Residual | 6 | 0.0004798 | | |
| Student-Newman-Kuels test | | | | |
| Shaved x no epibiont | | | | 0.01 (s) |
| Shaved x epibiont | | | | 0.01 (s) |
| Epibiont x no epibiont | | | | 0.01 (s) |

Abbreviation: s – significant; ns - not significant.

Table 2: ANOVA of the effect of algal epibionts on recruitment

| Source of variation | *df* | MS | F | P |
|---|---|---|---|---|
| Epibiont | 15 | 7847 | 1899 | < 0.0001 |
| Shaved | 15 | 8923 | 1300 | < 0.0001 |
| No Epibiont | 15 | 8596 | 5962 | < 0.0001 |
| Epibiont x shaved x no | 2 | 424.4 | 857.2 | < 0.0001 |
| epibiont Residual | 27 | 0.4952 | | |
| Student-Newman-Kuels test | | | | |
| Shaved x no epibiont | | | | 0.01 (ns) |
| Shaved x epibiont | | | | 0.01 (ns) |
| Epibiont x no epibiont | | | | 0.01 (ns) |

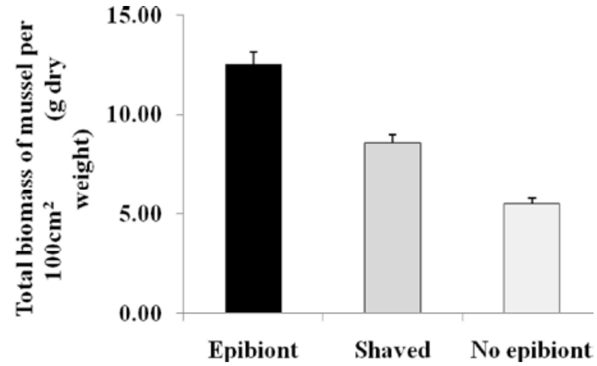



Fig. 2: Dry weight of mussels per plot (100 cm$^2$) after 15 months with algal epibionts (grey bars),algal epibionts shaved off (hatched bars) and without algal epibionts (white bars). Shown are mean (+ S.E), n = 3.

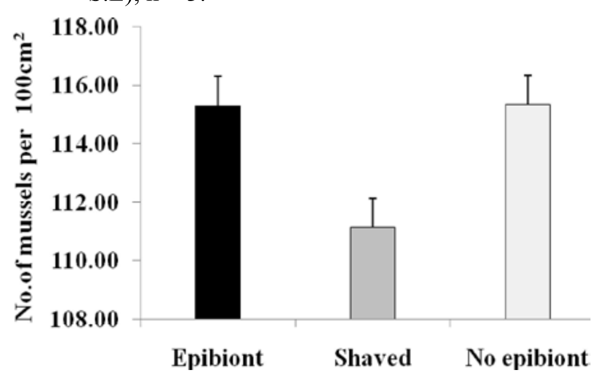



Fig 3: Number of small mussels in mussel beds per plot (100 cm$^2$) with algal epibionts (grey bars), algal epibionts shaved off (hatched bars) and without algal epibionts (white bars). Shown are mean (+ S.E), n = 3.

## DISCUSSION

The results clearly showed that the presence of fucoid epibionts increased the chance of mussels being lost from plots and is thus of considerable importance influencing the structure of mussel populations. This effect appears to be transient, because when the epibionts were removed, the likelihood of mussel recruiment was increased to a similar rate as mussels that naturally had no algae. These results are similar to previous findings based on populations of *M. californianus* and *M. edulis* [8, 12]. Laboratory studies have shown that there was no relationship between surface area of an algal epibiont and mussel dislodgement [8]. Results of the present study suggest that in a natural situation similar effects influenced mussel recruitment. Connor *et al*. [3] reported that the presence of epibiotic fucoids had no effect on the strength of mussel attachment to the shore and mussel survival increased to a similar rate as mussels that naturally had no algae. The dense algal mats that cover patches of mussels, for half of the year, do not appear to have any effect on the growth or productivity of host mussels. These results suggest that the reproductive output of mussels was not affected by the presence of epibionts [3]. The presence of epibionts, therefore, does not appear to affect the ability of mussels to feed, as suggested by Paine and Suchanek [7].

These results are contrary to the findings of another study that examined the effect of epibiotic algae on mussel growth and biomass [12]. Dittman and Robles [12] tested the effect of algal epibionts on mussel growth directly and found that the growth rate of *M. californianus* was affected negatively by the presence of red algal turf epibionts. The present results are different because the algal species in this study were ephemeral and differ morphologically from red algal turf species. Further, this study found similar number of individuals in mussel beds with algal epibionts as with no epibionts as reported by Connor *et al*. [3]. There are two possible explanations for this outcome. First, there may be other factors that affect the recruitment of both mussels and algae, such that algae covary with mussel recruits but do not affect them. Another possibility is that although the algal epibionts do not form a physical barrier to the movement of mussel recruits another mechanism may be responsible [3].

Laboratory studies have suggested that chemical cues exuded from macroalgae influence mussel recruitment [21]. Algal epibionts may leave chemical cues amongst the mussel patches after they have been removed. A series of carefully planned experiments are required to deduce whether this is the case. Regardless, the present as they stand do not support the model that algal epibionts affect mussel recruitment. These findings are consistent with those found for *M. californianus* [22]. Petersen [22] found that filamentous algae growing on *M. californianus* had no effect on the density of settlers or plantigrades into patches of adult mussels. It must also be considered that young mussels can persist in populations throughout the year and their abundance may reflect cumulative long-term recruitment patterns [9, 20].

In this study only negative effects between algal epibionts and mussels have been identified. Based on a study of sheltered rocky shores, Bertness *et al*. [23] concluded that the interaction between epibiont and host varies. They found initially that algal canopies affected mussel recruitment, growth and survival positively. The nature of this relationship changed, however, with varying tidal height, highlighting the fact that the nature and strength of interspecific interactions are highly context dependent Bertness *et al*. [23]. Other studies have identified both negative and positive interactions between epibionts and mussel survival [3, 24]. The present experiments were carried out on exposed rocky shores, where bottom-up processes may often be more important than top-down processes. Menge [25] and McQuaid and Lindsay [26] have described the dominance of bottom-up regulation on exposed rocky shores. The latter also found that the growth rate of mussels is affected by wave action and it was shown previously that filter-feeder biomass is higher on more exposed shores [27]. Wave exposure affects mussel biomass and this affects indirectly higher trophic levels, thus, regulating communities from the bottom-up [28-31]. It is not surprising that the present results differ from studies carried out in systems dominated by top-down processes and it is probably not useful to attempt to draw general conclusions from such different systems [32]. A positive effect of epibionts on mussels appears most likely in systems where top-down processes dominate. Vance [33] found that epibionts on clams (*Chama pellucida* (Broderip) decreased the probability that the host would be detected by predatory sea stars (*Pisaster giganteus* (Stimpson). These clams are usually covered in epibionts and they commonly occur only in areas characterised by low mortality rates of sessile organisms [33]. Similarly, epibiotic sponges increased the survival of scallops (*Chlamys asperrima* (Lamarck) by masking them from predatory sea stars (*Coscinasterias calamaria* (Gray) and by reducing the adhesion of the sea stars feet [35, 36]. Predation pressure on the sponges and the scallops was the major force leading to this mutually positive interaction [34].

This study has revealed a strong negative interaction between mussels and their fucoid epibionts on exposed shores. The importance of such indirect effects had been emphasised by Wootton [36], Menge [37] and Underwood [38]. These direct and potential indirect interactions are likely to be key processes affecting community structure and diversity on mussel-dominated shores.

## ACKNOWLEDGEMENT

One of the authors L.Palanikumar (JRF) kindly acknowledges the fellowship grant from Ministry of Earth Science - ICMAM, Chennai, India.

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