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Development of Mussel (*M. galloprovincialis* L., 1819) Seed on Different Combined Collectors Used on Raft System, in Sinop, Black Sea

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Abstract: Raft system was practiced for mediterranean mussel (*Mytilus galloprovincialis*) culture in Sinop Region, Black sea. Four different types of collectors (A type collector was in 14 mm diameter nylon rope which is suspended from the the raft in known mussel settlement time. B type collector was in 14 mm diameter nylon rope which is suspended one month early from the known mussel settlement time. C type collector was in 22 mm diameter and made from old ship rope. D type colllector was in 19 mm diameter and made from old anchovy net) was conducted to investigate, effect of collector type on settlement. The results showed that collector types had a significant effect spat settlement. Both shape and surface structure of the collector was found significant ($p<0.05$). The filementous and thready surfaces of C and D type collectors were prefered by spats for initial settlement. D type collector had a highest density with 6.37±0.60 ind cm^{-2}. At the end of 8 months experimental period, the number of spats on A, B, C and D type collectors were found as 1218±7.90, 1344±6.80, 3480±5.10 and 3800±5.40 ind m^{-1}, respectively.

Key words: Raft culture, spat, collector types, settlements, Sinop, Black Sea

INTRODUCTION

Turkish aquaculture sector can be characterized by a low number of species and production diversity, mainly based on small family-owned farms in inland and big farms in the sea. Total fisheries production is 772.323 ton. Aquaculture production has grown steadily over the years. Aquaculture production was reached 139.873 ton while mussel production was 1.100 ton (0.79%) in 2007 (TUIK, 2008).

Mussel seed is critical for the development of industrial mussel cultivation (Fuentes and Molares, 1994). Many factors, both physical and biological, can influence mussel settlement in marine systems (Pineda, 2000). Once larvae are competent to settle, the presence of suitable substrata can be indicated by either biotic or abiotic cues, for example surface chemical characteristics, biofilm presence, orientation of the substratum, sunlight, texture and the presence of conspecifics, especially if the species shows gregariousness (Stamps and Krishnan, 1990; Harder *et al*., 2002). These cues and the biological and physical factors that influence settlement operate at different spatial and temporal scales (Bertness *et al*., 1996) and the high variability frequently observed in settlement rates can be explained by variation in this wide range of factors (Balch and Scheibling, 2000; Jeffery and Underwood, 2000).

The important factors affecting the spat settlement are composition and textural of materials. Settlement is defined as the point when an individual first takes up permanent residence on the substratum (Connell, 1985), although the mussel settlement process is dynamic and may involve various settlement substrates and transitions to new substrates (Alfaro, 2006). It was emphasized that in point of composition, the following characteristics are surface free energy (Nishida *et al*., 2003), wettability (Alfred *et al*., 2005) and associated fouling (Alfaro *et al*., 2006) and in point of textural properties, the available surface area (Walter and Liebezeit, 2003) and the thickness of filaments (King *et al*., 1990; Pulfrich, 1996; Lekang *et al*., 2003; Walter and Liebezeit, 2003) are important factors in larval settlement. The physicochemical characteristics of collector ropes can impact on the strength of seed attachment, thereby modifying the probability of detachment by physical disturbance (Lekang *et al*., 2003). Collection of natural spat is very important for the production of blue mussels, regardless of the type of production technology used (Lekang *et al*., 2003).

Longline system was experienced for both spat collection and production in the Black Sea. The results showed that spat could be collected efficiently on 16 mm diameter polypropylene ropes and the collectors should

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preferably be installed in January and February and the region was favourable for mussel culture (Karayücel *et al*., 2002, 2003).

MATERIALS AND METHODS

Mussel culture in raft system was carried out at depth of 13 m in Sinop (Fig. 1), in the Black Sea, Turkey from June 2005 to May 2006.

System design: Raft system was mainly constructed from steel pine wood beams and iron sac. For building raft system, 2 sac float with 3.5 mm thickness, 50×75×300 cm dimentions were used. Three steel bar (0.8×12×400 cm) were attached to the float diagonally while 6 pine wood beams (10×10×400 cm) were attached to steel bars by steel screws.

The raft system was moored from 4 side of the raft by using concreted block and 32 mm polypropylene riser (4:1 scope). Each concreted blocks with 10 m of 22 mm open link ground chain were connected to riser rope. Two rectangle sacs with 3.5 thickness was used as floats and 4 mm of angle iron welded all over corners of sacs to make the float system strong. Then 2 rectangle float were combined by 2 m galvanised pipe from the bottom of floats.

Experimental conditions: Four types of spat collector ropes (A type collector was in 14 mm diameter nylon rope which is suspended from the the raft in known mussel settlement time. B type collector was in 14 mm diameter nylon rope which is suspended one month early form the known mussel settlement time. C type collector was in 22 mm diameter and made from old ship rope. D type colllector was in 19 mm diameter and made from old anchovy net) were used for spat settlement experiment (Fig. 2). Each collector types were represented by 5 collector ropes.

Length of 6 m ropes used as spat collectors and 25 cm of wooden pegs (2 cm Ø pipe) inserted crosswise to collector ropes with 30-50 cm intervals and 3 kg concreted weight tied to end of ropes against wave action and tangle of culture rope.

A, C, D types of collectors were hunged on May 2005 while B type of collectors was hunged on April 2005 from raft system with a distance of 0.5 m (Fig. 3).

Sampling procedure: During the sampling period mussel weight and length were measured from each type of collectors from June 2005 to May 2006. To determine spat density, triplicate spat samples (selected one each of 4 type collectors) were taken at monthly intervals from A, B, C and D type collectors. In each sampling date, three from each types collectors were selected and a 30 cm section of the collector were grazed.

The collector ropes were lifted gently to prevent loss of spat and the spat were removed from 30 cm of each rope into 20 L tank filled with sea water. The spat were transfered to the laboratory in a box. All spats were scrubbed for encrusting organism (e.g., barnacles, epifauna and seaweeds). They counted acording to owing each type collectors. Then mussel samples were taken by a sub-sampling method for biometric measurements. (Quayle and Newkirk, 1989).

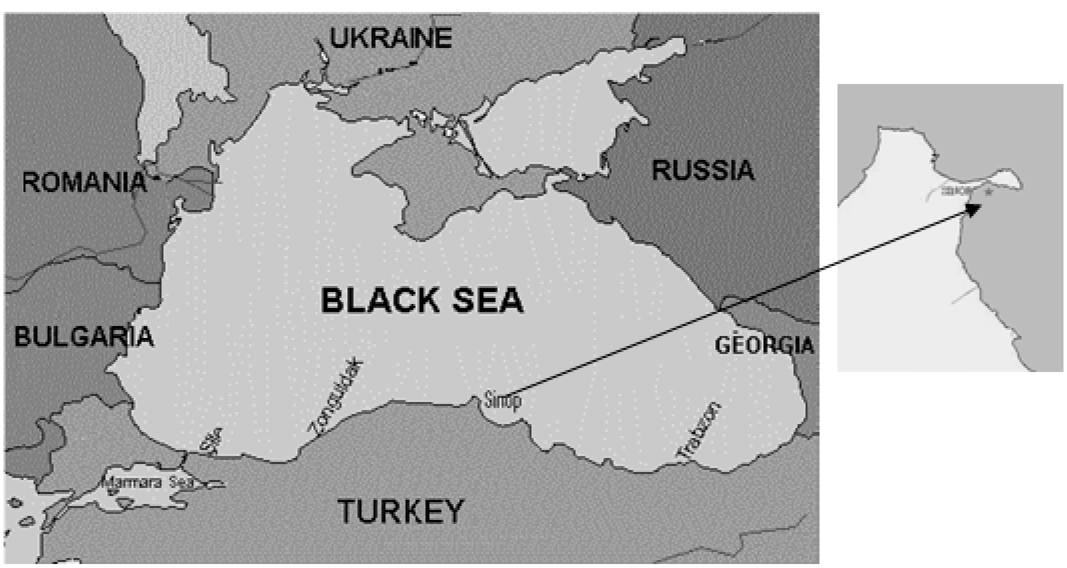

Fig. 1: The map of experiment site in Turkey

Fig. 2: Four types of collector ropes (A type collector was in 14 mm diameter nylon rope which is suspended from the the raft in known mussel settlement time. B type collector was in 14 mm diameter nylon rope which is suspended one month early form the known mussel settlement time. C type collector was in 22 mm diameter and made from old ship rope. D type colllector was in 19 mm diameter and made from old anchovy net)

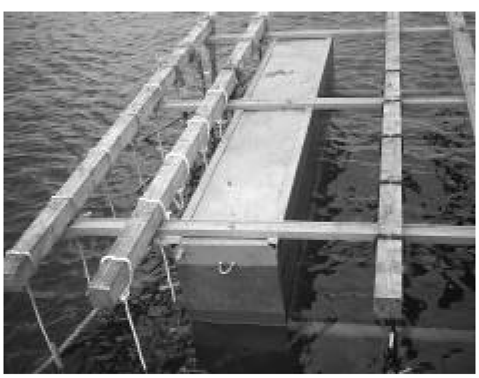

Fig. 3: Raft system and spat collectors

Environmental parameters: Temperature, salinity, chlorophyll a seston (Total Particulate Matter (TPM)), Particulate Inorganic Matter (PIM) and Particulate Organic Matter (POM), were measured monthly from May 2005-2006. Seawater samples were taken at 3 m depth using a nansen bottle at the experimental site. *In situ* water temperature and salinity was measured using a probe (YSI 6600). In the laboratory, triplicate water samples (3 L) were filtered onto Whatman GF/C fillters to determime chlorophyll a (μ gL^{-1}), seston (TPM) (mg L^{-1}) and POM (mg L^{-1}) concentration according to Stirling (1985).

Morphometric measurements and statistical analyses: Growth was estimated from changes in shell length and live weight. Live weight (total weight of mussel) was obtained by blotting animals with tissue paper and weighing to the nearest 0001 g. Shell length (maximum anterior-posterior axis) was measured to the nearest 0.1 mm with a caliper (Seed, 1969). Monthly Specific Growth Rate (SGR%) were found from following formulate:

$$SGR\% = \left[\frac{(\ln L_2 - L_1)}{(T_2 - T_1)}\right] \times 100$$

where, L_1 and L_2 are the mean shell lengths at times T_1 and T_2 (Chatterji *et al*., 1984).

A correlation matrix was used to determine the relationships between the enviromental factors and growth parameters. Statistical analyses were carried out by using MINITAB software 13.

RESULTS

Environmentalparameters: Environmental parameters are shown in Fig. 4 and 5. The temperature ranged from 7.5-25.05°C with a mean of 14.9±1.7°C. Salinity ranged from 16.8-17.97% with a mean of 17.59±0.10% and there

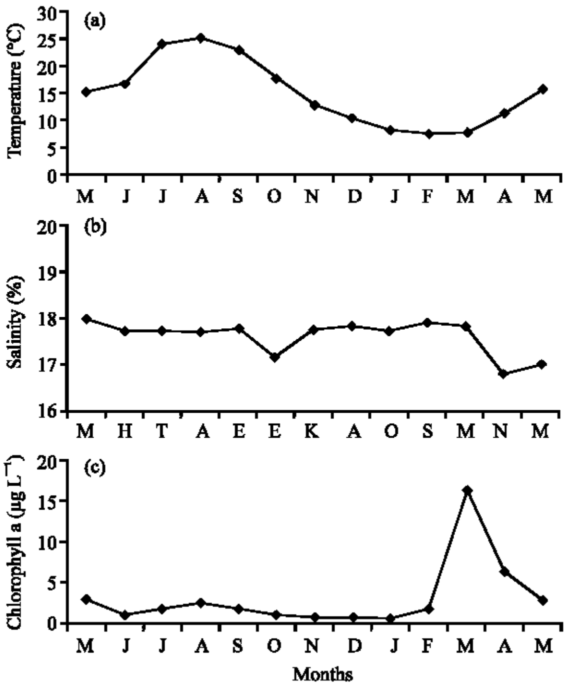

Fig. 4: Monthly distribution of mean temperature (a), salinity (b), chlorophyll a (c) from May 2005-2006

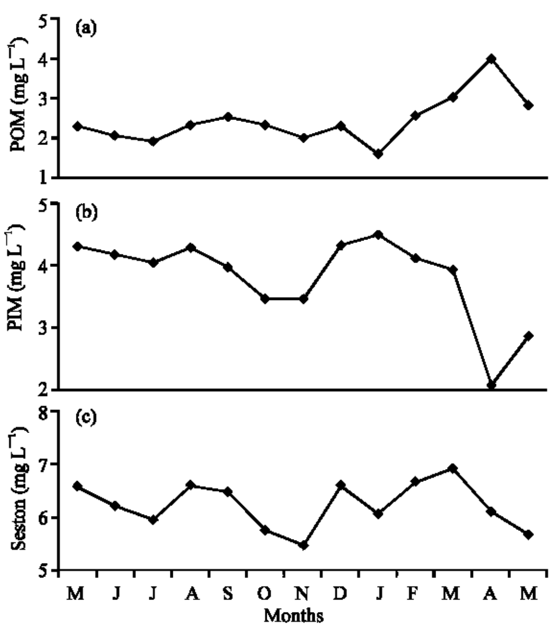

Fig. 5: Monthly distribution of mean particulate organic matter (a), particulate inorganic matter (b) and seston (c) from May 2005-2006

was not a clear seasonal pattern. Chlorophyll a peaked in March (16.3 µg L^{-1}) as a result of spring algal bloom and decreased reached its lowest value in January

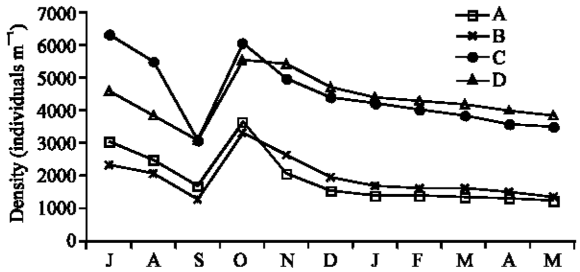

Fig. 6: Monthly mean changes in spat density on all type of the collectors from June 2005 May 2006 (A type collector: 14 mm diameter nylon rope which is suspended from the the raft in known mussel settlement time. B type collector: 14 mm diameter nylon rope which is suspended one month early form the known mussel settlement time. C type collector: 22 mm diameter and made from old ship rope. D type colllector: 19 mm diameter and made from old anchovy net)

(0.53 µg L^{-1}), with a mean of 3.07±1.18 µg L^{-1}. Monthly seasonal chlorophyll a concentration was significantly different ($p<0.05$) and in general higher in spring and lower in winter. POM ranged 1.58-4 mg L^{-1} with a mean of 2.42±0.17 mg L^{-1}, while seston ranged from 5.45-6.92 mg L^{-1}, with a mean of 6.21±0.12 mg L^{-1}. There was a positive relationship between chlorophyll a and POM ($p<0.05$). Salinity and temperature did not significantly correlate with chlorophyll a, POM and seston ($p>0.05$). When chlorophyll a, POM and seston peaked, the temperature was minimum. There was a clear seasonal pattern in the temperature but the other environmental factors did not show clear seasonal pattern.

Growth: There was higher setlement on the C type collector than others types in 1st and 2 months.

Young spat have a more rounded shape and brighter shell color than older spat. The monthly spat density on all type of the collectors are depicted in Fig. 6.

Mean monthly SGR% on the A, B, C, D type of the collectors was 20.02±4.59, 19.73±4.38, 19.61±4.16 and 19.10±3.41, respectively. At the end of 11 months, mean monthly shell length and live weight were 44.00±0.65 mm and 11.60±0.31 g on the A type; 45.00±0.68 mm and 11.0±0.26 g on B type; 44.40±0.78 mm and weigth 11.8±0.45 g on C type; 44.90±0.60 mm and weigth 11.43±0.35 g on D type, respectiely (Fig. 7). Length frequencies of spat on all types of collectors for October (A), January (B) and May 2006 (C) are shown in Fig. 8.

The observation showed that barnacles settled in July-August, continued to developed throughout the

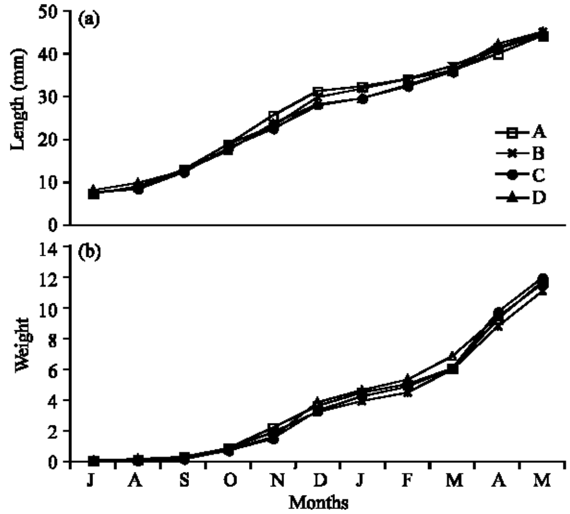

Fig. 7: Monthly mean shell length and live weight of spat from July 2005 to May 2006 for A, B, C, D type of collectors

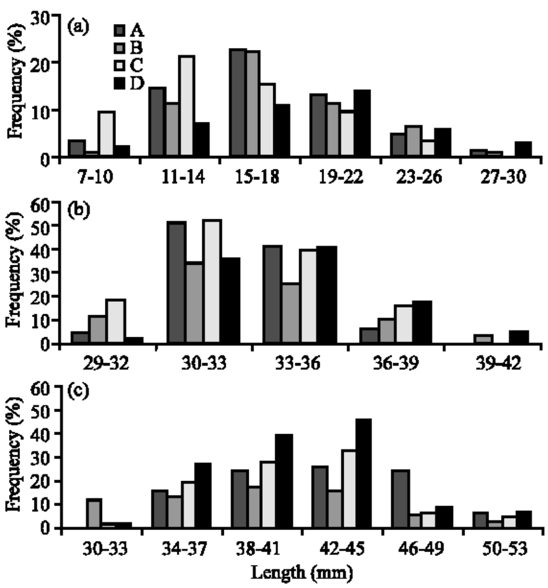

Fig. 8: Length frequencies of spat on all types of colector in October (a), January (b) and May 2006 (c)

summer and autumn and the few larvae of sea snail was observed in September and October on all type of the collectors (A, B, C, D type). The amont of barnacles decreased with depth.

There was a positive relationship betweeen shell length increament and temperature hovewer POM positively correlated with live weigth increament ($p<0.05$).

DISCUSSION

In marine systems, filamentous substrates such as hydroids and algae facilitate or enhance larval mussel settlement (Bayne, 1964; Standing, 1976; Dean and Hurd, 1980). Present study also showed that there was a significant effect of collector typeson spat settlement.

The most of spat settlement were occurred from July-October and new recruitment (seed) were observed rest of the year. But the number of larvae decreased during winter.

As the mussels had been grown under identical conditions, the characteristics of the materials in the collectors seem to be of importance for collection, growth and attachment of the mussels to the material (Lekang *et al*., 2003). Ropes with filamentous loops record the highest density values followed by ropes with non-filamentous loops (Filgueira *et al*., 2007). According to Mason and Drinkwater (1981), Pulfrich (1996), Folino-Rorem *et al*. (2006), blue mussel spats prefer thready and filamentous surfaces to settle. Examples of such surfaces are substrates covered with hydroids, filamentous algae or ropes with a thready surface (Alfaro *et al*., 2006; Filgueira *et al*., 2007; Peteiro *et al*., 2007) and could explain the greater settlement densities observed on filamentous structures in rope (Lekang *et al*., 2003). One of the main factors influencing settlement density on collector ropes is the available surface area (Walter and Liebezeit, 2003). In the present study, mussel attachment to the collectors varied according to collectors types. Greater settlement density was recorded on C (22 mm diameter) and D (19 mm diameter) types with filamentous ropes while in the early time the highest settlement density on C type collectors. Higher mussel settlement densities are obtained on C with greater available surface area, although a filamentous structure enhances the amount of settled individuals. Dense surface structure provides several attachment points for byssal threads. Hovewer C type collector had fringed filament, the reason of spat settlement on fringed filament, could be fallen in the long run. So the highest density on C type did not continue to the end of the study. As compared with SGR%, low density was resulted in better growth but not significant. The density of mussels on the collector gives an indication of the competition for area and nutrients. Lekang *et al*. (2003) were declared similar results.

The seasonal pattern of spat development is related to primary production. The large natural river supply of phosphorus and nitrogen, essential nutrients for marine plants and algae, has always made the Black Sea very fertile (Bakan and Büyükgüngör, 2000). So the relatively high nutrient levels and hence high phytoplankton content of coastal waters of the Black sea support great good growth and mussel farming. Growth rates were highest in autumn and spring and low in winter but resumed from April. Similar results were declared in many studies (Page and Hubbard, 1987; Mallet and Carver, 1989; Lauzon-Guay *et al*., 2005) and attributed to high water temperature and food availability in the spring and summer. Several studies showed that when chlorophyll a was high (between March and July), SGR% was found highest, too (Chatterji, 1984; Small and Van Stroken, 1990; Karayücel and Karayücel, 1999, 2000; Filgueira *et al*., 2007).

In the present study, mean shell length was better than those obtained in Scothland's west coast sea lochs because of high food rate and temperature (Karayücel and Karayücel, 2001). The difference on growth and survival rates is influenced to exposure air, environmental conditions, salinity and food availability (Dickie *et al*., 1984).

CONCLUSION

The experiment showed clearly that there was a significant effect of collector types on spat settlement due to it's material and structure. Growth was affected by environmental factors. There was not significant effect of collector types on growth.

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