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Spat Settlement and Growth of Mediterranean Mussel (*Mytilus galloprovincialis*) in Fish Cage Farms in Southeastern Black Sea Coast

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Abstract: Timing and density of spat settlement on artificial collectors Polypropylene (PP) and hemp with growth and culture potential of Mediterranean mussel, *Mytilus galloprovincialis* were studied at two sites (Trabzon-Sana and Rize) in the Southeastern Black sea coast. The growth of the mussels and environmental parameters were measured monthly from May 2003 to April 2004. Two different spat collectors (PP and hemp) hung on long-line mussel systems in April 2003. First observation of spat settlement at each sites was started in May. Mean value of spat settlement was determined as 7659±1495 mussels/m in Sana and 5774±1438 mussels/m in Rize. There was no significant difference found between spat collector ropes. Mean value of spat length was determined as 0.07±0.003 mm in Sana, 0.09±0.004 mm in Rize. At the end of the study, shell length of mussels reached 40.39±1.184 mm in Sana and 46.20±0.547 mm in Rize. In conclusion for mussel culture enough seed can be collected but spats must be stripped in 1 or 2 months after settlement and that mussels would be market size in 1^+ years.

Key words: Mussel, spat, settlement, artificial collector, shell length, repes

INTRODUCTION

Marine mussel from Mytilidae family is a sessile bivalve and has both ecological and economic importance. Mussels have a wide distribution in the Arctic, North Pacific and North Atlantic. They are commonly found in the littoral and sublittoral zones and in polyhaline portions of the coastal waters.

Marine mussels play an important role as ecological engineers and have a profound influence on the biodiversity of coastal waters. They have ability to filter selectively and to process large quantities of suspended material that can markedly influence the dynamics of coastal and estuarine systems with consequent implications for local patterns of biodiversity (Seed, 1976). Therefore, considering the incidence and severity of eutrophication worldwide during the recent years both natural beds and farms have important role to play.

Mussels are filter feeders and do not require additional feeding. Growth rate of mussels depends on various factors such as shore level (controls feeding time), degree of exposure to waves, population density, salinity, temperature and amount of food (both as live and dead particulate organic matter) in the water (Dare, 1980). These sessile species are particularly important for Black sea under increasing eutrophication threat, limited benthic biodiversity and sublittoral zone. However, recent surveys conducted in the Southeastern coast of Black sea showed that mussel beds were destroyed by exotic carnivorous species Rapa whelk (*Rapana thomasiana*). The marine mussels are also very important seafood source around the world including Western Europe and North America. In 2008, annual world mussel production was aproximately 1.7 mt and about 95% of them came from aquaculture.

The share of Turkey in this production was around 1.7 tthat of 5% of them came from aquaculture. The major part of Turkey's production exported to European countries comes from Aegean sea, sea of Marmara and Western Black sea.

A survey was conducted between Fatsa (Ordu) to Hopa, Artvin in 1999 to study the status of commercially exploitable beds. The beds known by local people and fisherman were also checked.

It was observed that the beds were either completely wiped out leaving empty shells or newly recovering with small individuals to check availability of spat for natural settlement and artificial collection to utilize in mussel farms.

Limited number of studies were performed on growth, spat settlement *M. galloprovincialis* along coast of Turkish seas including Aral (1999), Karayucel *et al.*

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(2002, 2003, 2010) and Yildiz *et al*. (2005, 2010). Most of these studies were performed on the coast of Sinop. Therefore, there is a need for extensive studies, particularly Southeastern part of the Black sea. The aim of this study was to investigate the timing and density of spat settlement on artificial collectors and growth performance of Mediterranean mussel (*M. galloprovincialis*) in the Southeastern Black sea.

MATERIALS AND METHODS

The study was performed from April 2003 to April 2004 on the coast of Trabzon-Sana and Rize in rainbow trout cages in the Southeastern Black sea coast (Fig. 1). Mussel spat collectors were connected to mooring ropes of cages. Study sites were 0.5-1 km far from the shore and the depths were 30-40 m. Spat collectors consist of three hemp and three polypropylene ropes with a diameter of 16 mm and length of 6 m at each sites. They were suspended from two commercial rainbow trout cages on mid-April.

Wooden pegs of 20 cm were placed to collectors at 100 cm intervals to increase the settlement surface and to prevent dropping of mussel clutches. Additional collectors were suspended to check the autumn settlement. The fish cages were chosen because of ready structure for suspending collectors, protection of the ropes, easy access and possibility of additional food from fish cages.

Water temperature was measured on each sampling site from surface and 3 m depth. Two liters water samples were collected from each site by a Nansen type sampler from 3.5 m depth to determine seston (total suspended matter) and chlorophyll-a concentration on each sampling date. Seston and chlorophyll-a were measured according to Stirling (1985) and Parson *et al*. (1984), respectively.

Monthly samplings were started in the middle of May and continued regularly. Spat samples from two type collectors at each site were collected from 10 cm sections of upper (0-3 m) and lower (3-6) parts of the ropes. The spats were transferred to laboratory in a cooling box and fixed with 5% formalin for later measurements. Total of 100 spats (50 from each collector and 25 from each depth) from each site were measured from umbo to valve edge under a microscope with an ocular micrometer. Size of spats were measured under microscope in May and June after that they were measured (accuracy of 0.01 mm) and weighed (accuracy of 0.001-0.01 g).

In order to determine spat density on ropes and in depths (1, 3 and 5 m), the spats were removed from 15 cm sections of two ropes at each site. The results were converted into the number of spats per meter of ropes. Growth as shell Length (L) and Live Weight (LW) was determined between July 2003 and April 2004. The length-weight relationship was determined by $W = a*L^b$ equation together with the equations of linear regression and Pearson's (Okumus, 1993). Minitab 13 software (USA, 2000) was used for statistical analyses, namely descriptive (mean, standard deviation, one-way Analysis of Variance (ANOVA). Where significant differences ($p<0.05$) were found, a multiple comparison test (Tukey's) was used for comparisons.

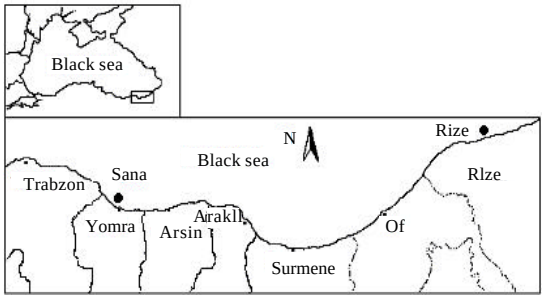

Fig. 1: The study area

RESULTS AND DISCUSSION

The annual cycle of temperature was similar at two sites ranging from 7.4°C in March to 26.5°C in July. Sechi disk depths showed marked seasonal fluctuations and varied from 4.0-13.5 m. Chlorophyll-a concentrations were lowest (<0.01 μg L^{-1}) in June to July and highest (1.08±0.105 μg L^{-1}) in March 2004 at Sana while in Rize values ranged between 0.10 μg L^{-1} in May and 2.12 μg L^{-1} in October. Maximum values of seston was measured as 11.07±1.40 mg L^{-1} in October in Rize and 12.87±4.21 mg L^{-1} in April in Sana whereas minimum values were 4.93 mg L^{-1} in Sana in July and 4.27±0.20 mg L^{-1} in Rize in March. Percentage of organic matter in the seston were 38.70±0.69% in Rize and 22.70±0.77% in Sana.

Main settlement took place in April and May at both sites. There was no settlement on autumn collectors. Overall settlement densities were 5673±1800 spat/m in Sana and 5218±2954 spat/m in Rize on PP ropes and 9646±4294 spat/m in Sana and 6270±4635 spat/m in Rize on Hemp ropes. Settlement densities were similar at both sites but the densities were increased with depths at both sites (Fig. 2). There was no significant difference between the depths and materials in sampling sites of Rize and Sana. Mean size at settlement was 0.07±0.003 mm in Sana and 0.09±0.004 mm in Rize. After 12 months mean shell

length measured 40.39±1.184 mm in Sana and 46.20±0.547 mm in Rize. Small portion (11% in Sana and 23% in Rize) of these mussels reached to marketable size (≥50 mm) after 1 year. Mean live weight of mussels reached from 0.20±0.021-8.92±0.282 g in Rize and from 0.07±0.010-6.02±0.466 g in Sana on PP ropes.

The length and weight values measured did not show any significant differences between the sites (Table 1). Initial length of suspended mussels were <1 mm at both sites in May and the main changes in size took place between May and August (Fig. 3). The length-weight relationship of suspended mussels was allometrical in April and July while it was isometric in December (Fig. 4).

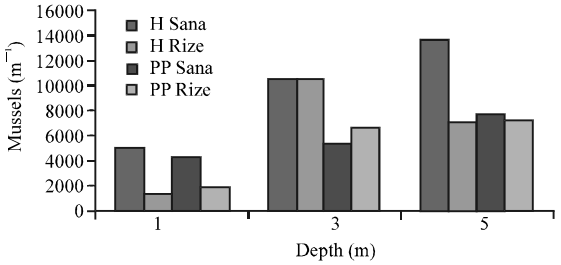

Fig. 2: Spat settlements according to sites, collectors and depths

Mussel aquaculture still depends on natural settlement of spats on collectors. In current study, the timing of settlement takes place during May and June and no autumn settlements were observed. In contrast, the previous studies of Ivanov (1971) in Kerch, Aral (1999) and Karayucel *et al.* (2002) in Sinop reported two spat settlements, major one in April-May and 2nd one in late autumn. Karayucel *et al.* (2002) reported that spat collectors were most efficient in February and March when heavy spat settlement occurred and predation and fouling were minimal.

Table 1: Monthly growth (as shell length and live weight) of mussels on PP ropes at sites (mean±standard error)

	Length (mm)		Live weight (g)	
Month-years	Sana	Rize	Sana	Rize
May-03	0.07±0.003	0.09±0.004	-	-
June	1.85±0.228	4.03±0.179	-	-
July	7.20±0.337	10.73±0.453	0.07±0.010	0.20±0.021
August	12.58±0.455	21.79±0.427	0.23±0.020	1.00±0.055
September	14.80±0.310	22.63±0.428	0.40±0.016	1.14±0.056
October	21.32±0.406	22.97±0.581	1.10±0.059	1.44±0.103
November	28.54±0.329	23.13±0.501	2.41±0.086	1.44±0.087
December	32.29±0.478	34.29±0.459	3.68±0.156	3.70±0.166
January-04	37.68±0.486	35.33±0.497	4.48±0.164	4.20±0.179
February	37.67±0.580	39.45±0.451	5.33±0.234	5.35±0.137
March	40.68±0.972	43.53±0.510	6.11±0.405	7.25±0.249
April	40.39±1.184	46.20±0.547	6.02±0.466	8.92±0.282

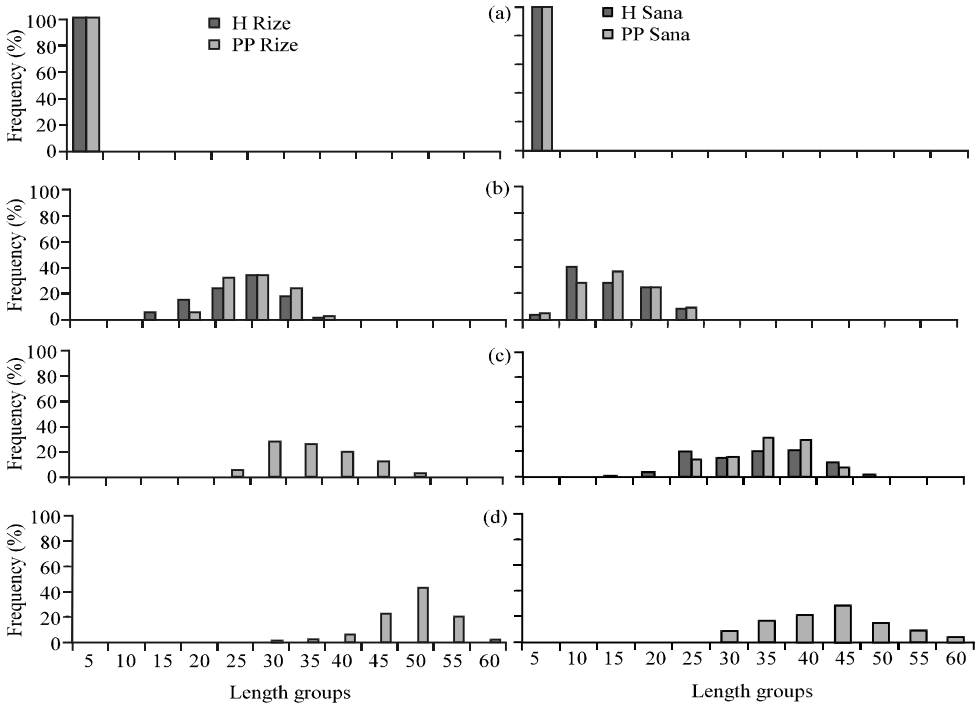

Fig. 3: Length frequency distribution (%) of Hemp and PP ropes at sites according to; a) May, 2003; b) Agust, 2003; c) December, 2003 and d) April, 2004

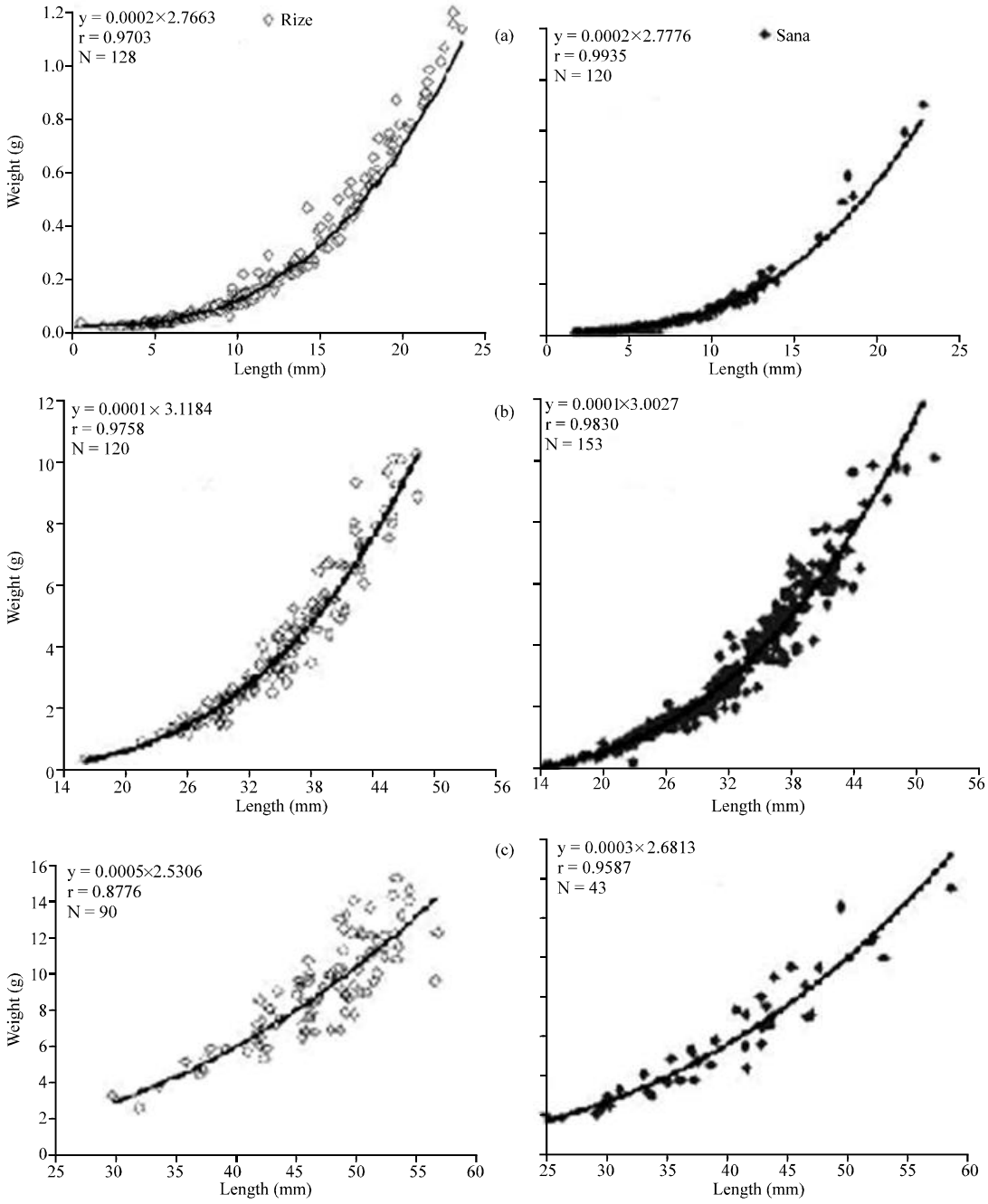

Fig. 4: Length-weight relationship of sites according to; a) July, 2003; b) December, 2003 and c) April, 2004

These differences may arise either from ecological differences between Western and Eastern Black sea coast or inter-annual fluctuations in environmental parameters, e.g., water temperature, light and timing of phytoplankton blooms and thus changes in reproductive cycle of mussels. The settlement densities of mussels mostly depend on collector type in same environmental conditions (Lekang *et al*., 2003). In the research made by Ariman and Duzgunes (2004) between March and June, 1996 in Trabzon Yomra Harbour, the highest spat density among the different types of collectors was determined as averagely most 317±67.65 mussels/10 cm in synthetic fiber ropes with a diameter of 1.5 cm. In a research conducted by Yildirim in Mersin bay (Urla-Izmir) on raft system in December, 1997 and January 1998, the best spat settlement was found as 463 mussels/m in a polyethylene

cage net. The least adherence was observed on a hemp net placed on the raft in October. In the research made by Yildiz *et al*. (2005) in Canakkale strait Kilya (Poyraz) inlet, he determined the settlement density of *M. galloprovincialis*' in on a collector made of net rope as 2045 mussels/100 cm^2 in June 2002 and 8813 mussels/100 cm^2 in July, 2002. Later in the same study, Yildiz *et al*. (2010) found the settlement amount on the ropes as 14184 mussels 0.25 m^{-1} in November 2002, 15485 mussels 0.25 m^{-1} in March, 2003 and the lowest density as 3713 mussels 0.25 m^{-1} in February, 2004. In this study, the settlement amount was relatively higher in Sana (mean 7659±1495 mussels/m Sana and 5774±1438 mussels/m Rize) but no statistically significant difference were found between the stations. It is understood that settlement amount is higher than the spat density mentioned by Okumus (1993) which is necessary for mussel breeding.

When evaluation is made according to collector types, it can be seen that settlement is relatively denser on hemp rope (mean 7958±1797 mussels/m hemp and 5446±899 mussels/m PP). However, the corrosive effect of sea on hemp rope resulted as spoiling, breaking off and mass spillage of mussels in a short time period. Therefore, researchers suggest that the hemp found in the market should only be used for spat collection and that it is not suitable for long time breeding. The attachment densities of spats on collectors vary according to depth. Ariman and Duzgunes states that spats settle denser in 2-3 m depth while Okumus (1993) states that the settlement of spats on the final meters of ropes is not important. In this study where similar results were obtained while the settlement is denser on the lower part of hemp ropes in Sana (<1 m) ($p<0.05$), no difference were observed in PP ropes. However in Rize, the density difference in two ropes related with depth was found statistically significant ($p<0.05$).

Among the reasons for this swashes and light intensity near the surface are worth to mention. There were not differences between the two sites for mussel settlement. This was an expected result considering distance between the sites (32 mile), hydrographic characteristics of the open bays and state of mussel beds. During the current study, average length and weight of mussels on ropes reached 40.39±1.184 and 46.2±0.547 mm in Sana and Rize in 12 months, respectively.

The results indicated that growth in Southeastern Black sea is comparable with Sinop region which seems to be more favorable for bivalves including mussels. One year old rope-grown mussels with a mean length of 37.6±0.52 mm and live weight of 5.02±0.28 g were collected from fish farm mooring ropes and cultured in nylon socks from July 1997 to June 1998 in Sinop, located on the West coast of Southern Black sea (Karayucel *et al*., 2003). At the end of 11 months shell growth in the nylon socks increased 20.21 mm, reaching 57.81±0.88 mm (range 47.3-68.8 mm) while the weight increased 11.87 g reaching 16.89±0.76 g (range 10.27-36.83 g). In another study in the same area, Aral (1999) reported that the mussels on suspended ropes reached 45.73±0.30 mm shell length in 13 months and 72.84±0.74 mm in 18 months. Okumus (1993), tried integrated mussel and salmon breeding in 2 separate stations in West coasts of Scotland and determined the annual length increases of mussels between 20.1 and 25.9 mm in both stations.

CONCLUSION

The present study has demonstrated that suspended artificial collectors placed in the water column in April to May can gather enough spats for commercial mussel culture. Hemp collectors are suitable only to collect spats but not for on growing. Mussels can reach market size between 12 and 16 months.

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