

1-1-1999

## Growth and Mortality of Mussels ( *Mytilus edulis*L.) Reared inLantern Nets in Loch Kishorn, Scotland

SEDAT KARAYÜCEL

ISMİHAN KARAYÜCEL

Follow this and additional works at: <https://journals.tubitak.gov.tr/veterinary>



Part of the [Animal Sciences Commons](#), and the [Veterinary Medicine Commons](#)

---

### Recommended Citation

KARAYÜCEL, SEDAT and KARAYÜCEL, ISMİHAN (1999) "Growth and Mortality of Mussels ( *Mytilus edulis*L.) Reared inLantern Nets in Loch Kishorn, Scotland," *Turkish Journal of Veterinary & Animal Sciences*: Vol. 23: No. 5, Article 1. Available at: <https://journals.tubitak.gov.tr/veterinary/vol23/iss5/1>

This Article is brought to you for free and open access by TÜBİTAK Academic Journals. It has been accepted for inclusion in Turkish Journal of Veterinary & Animal Sciences by an authorized editor of TÜBİTAK Academic Journals. For more information, please contact [academic.publications@tubitak.gov.tr](mailto:academic.publications@tubitak.gov.tr).

## Growth and Mortality of Mussels (*Mytilus edulis* L.) Reared in Lantern Nets in Loch Kishorn, Scotland

Sedat KARAYÜCEL

Ondokuz Mayıs Üniversitesi, Sinop Su Ürünleri Fakültesi, 57000 Sinop-TURKEY

Ismihan KARAYÜCEL

Institute of Aquaculture, University of Stirling, FK9 4LA Scotland-UK.

Received: 26.06.1997

**Abstract:** One-year old rope grown mussels (*Mytilus edulis* L.) were held in experimental lantern nets at 2 m and 6 m depths in Loch Kishorn on the west coast of Scotland. Growth, mortality and shell morphology were monitored from May 1993 to August 1994. Water temperature, salinity, transparency and food availability were also determined. These showed a clear seasonal cycle, in consequence, growth of mussels was relatively rapid from May to November and very slow during the rest of the year. Depth had a insignificant effect on shell length and tissue growth ( $P>0.05$ ) due to similar environmental factors. Shell length growth and tissue growth exhibited different seasonal patterns and mussels reached marketable size of 50 mm over 2 years old. Shell morphology was similar at both depths ( $P>0.05$ ) while shell weight was significantly higher at 2 m than 6 m ( $P<0.05$ ). The natural cumulative mortality rate was found to be 13.6 % at 2 m and 16.7 % at 6 over the 15 months experimental period ( $P>0.05$ ). Most of the mortalities were occurred just after stocking and attributed to stress due to handling of mussels.

**Key Words:** Growth, mortality, mussel and *Mytilus*

### İskoçya'nın Kishorn Koy'unda Pinter Ağalarda Yetiştirilen Midyelerin (*Mytilus edulis* L.)

#### Ölüm ve Büyümelerinin Araştırılması

**Özet:** Halatlarda bir yaşına kadar büyüyen midyeler (*Mytilus edulis* L.) Batı İskoçya sahilinde Kishorn koyunda 2 ve 6 m derinliklerde pinter kafeslerde denemeye alınmıştır. Büyüme, ölüm ve kabuk morfolojisi Mayıs 1993'den Ağustos 1995'e kadar araştırılmıştır. Su sıcaklığı, tuzluluk, ışık geçirgenliği ve yem durumu da tespit edilmiştir. Bunlar açık bir şekilde mevsimsel döngü göstermişler, netice olarak, midyeler Mayıs ayından Kasım'a kadar hızlı ve yılın geri kalan kısmında ise çok yavaş bir büyüme göstermişlerdir. Kabuk boyu ve et büyümesi üzerinde benzer çevresel faktörlerden dolayı derinliğin etkisi önemli bulunmamıştır ( $P>0.05$ ). Kabuk ve etteki artış mevsimsel olarak farklı bir görünüm arzemiş ve midyeler iki yaşından sonra pazarlanabilir boy olan 50 mm'ye ulaşmıştır. İki mekteyedeki midyelerin kabuk ağırlıkları altı metredekilere göre daha fazla iken ( $P<0.05$ ), kabuk morfolojisi her iki derinlikte de benzer bulunmuştur ( $P>0.05$ ). Onbeş ayı aşkın bir deneme periyodunda doğal toplam ölüm oranı iki metrede %13.6 ve altı metrede %16.7 olarak bulunmuştur ( $P>0.05$ ). Ölüm oranlarının çoğu stoklamadan hemen sonra gerçekleşmiş ve bu durum midyelerin ellenmesinden dolayı strese bağlanmıştır.

**Anahtar Sözcükler:** Büyüme, ölüm, midye ve *Mytilus*.

### Introduction

Mussel production has almost tripled to approximately 1000 tonnes over the last decade in Scotland (1). Loch Kishorn is one of the smallest and simplest sea lochs in Scotland, and affected by freshwater run-off from the surrounding mountains and River Kishorn from the north. It has biggest mussel farm in Scotland with a capacity of 300 tonnes ranged first place in terms of production capacity.

Mussels are filter feeders and mainly herbivorous, eating phytoplankton, but they also eat some zooplankton and much organic detritus (2). Most investigations have been based on environmental factors, because local factors determining nutritional conditions

can influence greatly the growth rate and mortality of marine bivalves. The effect of these main environmental variables on growth, physiology and survival of bivalves have been examined, using both alongside in-situ and in-vitro experiments around the world (3, 4, 5). The most important factors are particulate organic matter concentration and quality (6,7), duration of air exposure (8), population density (9), genotypic characteristics (10) and water current velocity (11). In addition, size, age, depth, salinity and temperature effect the growth of *Mytilus edulis* (12).

*Mytilus* is highly adaptable and especially tolerant of a wide range of environmental conditions. However, extremes in physical factors such as storms, temperature

Table 1. Mean ( $\pm$ SE), minimum and maximum values of environmental parameters measured at 2 m and 6 m depths. POM: particulate organic matter.

Depth		Temperature (°C)	Salinity (‰)	Seston (mg.l <sup>-1</sup> )	POM (mg.l <sup>-1</sup> )	Chlorophyll-a (mg.l <sup>-1</sup> )
2 m	Min.	5.5	30.0	1.5	0.80	0.04
	Max.	16.3	35.9	14.3	4.1	6.32
	Mean	11.07 $\pm$ 0.90	33.27 $\pm$ 0.36	4.76 $\pm$ 0.88	1.86 $\pm$ 0.24	1.76 $\pm$ 0.44
6 m	Min.	6.6	32.90	1.2	0.60	0.06
	Max.	15.7	36.10	15.2	3.20	8.03
	Mean	11.06 $\pm$ 0.81	33.79 $\pm$ 0.25	4.91 $\pm$ 0.90	1.80 $\pm$ 0.21	1.68 $\pm$ 0.50

and desiccation, and excessive deposition of silt are all known cause to mortality in mussels (13). Predation is undoubtedly the single most important source of natural mortality in *Mytilus*. Unfortunately there is not any available experiment on growth and mortality in Loch Kishorn. Therefore this study is the first experiment to find out the degree of natural mortality and to check differences either in growth parameters or environmental parameters depending on depths.

### Materials and Methods

Field studies were carried out on *Mytilus edulis* L. in Kishorn Shellfish Farm in Loch Kishorn on the west coast of Scotland from May 1993 to August 1994. As a result of variable salinity and terrestrial origin of suspended matter (=seston) on water surface, lantern nets were hung 2 m and 6 m below the surface from mussel raft culture system.

Duplicate one litre water samples were collected by a Nansen type sampling bottle from 2 m and 6 m depth to determine seston (total suspended matter), particulate organic matter (POM) and chlorophyll-a and on each sampling date, salinity and temperature were measured with a Salinity Temperature Bridge at the both depths to represent rope length in the raft system at the experimental site. Determination of seston, particulate organic matter and chlorophyll-a were measured according to Stirling (14) methods.

Experimental mussels were one year old rope grown mussels used from spat collectors from raft system and mussels were reared experimentally in lantern nets in

Loch Kishorn. Extra large and small mussels were removed to leave a uniform size with a mean of 24.04 $\pm$ 0.47 mm ( $\pm$ SE). Mussels were held in four lantern nets hung from raft at 2 different points below 2 m and 6 m. Each lantern net contained three experimental trays (40 cm diameter plastic tray) at a density of 150 mussels per tray or 450 mussels per lantern net. Sampling was carried out monthly, 6-8 mussels from each experimental tray were randomly collected over the 15 months experimental period (samples from 2 lantern nets represented each depth). On each sampling date, empty shells were counted and removed to determine mortality and lantern nets were brushed and cleaned of fouling organisms. All samples were placed in a labelled mesh bag and transported to the Institute of Aquaculture (University of Stirling) in a cool box..

The growth parameters measured were change in length, tissue, live weight, dry meat weight and ash-free dry meat weight (AFDMW)(15). The percentage increase in each parameters was calculated as absolute growth estimate divided by its initial value. Monthly specific growth rate (SGR) were calculated from following equation:

$$\text{SGR (\%)} = [(\ln L_2 - \ln L_1) / (T_2 - T_1)] * 100$$

where,  $L_1$  and  $L_2$  are mean shell length at the time  $T_1$  and  $T_2$  in days ( $T_2 - T_1$  was an average 30 days) (15).

Mortality calculation of cumulative mortality was determined using the following equation: Cumulative mortality (%) =  $(N_t / N_0) * 100$

where,  $N_t$  is the number of empty shell mussels removed

Table 2. Mean initial ( $\pm$ SE), final growth parameters and increments at 2 m and 6 m in the lantern net experiment. LW: live weight, WMW: wet meat weight, DMW: dry meat weight and AFDMW: ash-free dry meat weight.

Parameters		2 m	6 m
Length (mm)	Initial	24.14 $\pm$ 0.40	24.14 $\pm$ 0.40
	Final	52.92 $\pm$ 0.72	51.03 $\pm$ 0.60
	Increment	28.78	26.89
LW (g)	Initial	1.40 $\pm$ 0.08	1.40 $\pm$ 0.08
	Final	13.89 $\pm$ 0.56	12.30 $\pm$ 0.39
	Increments	12.49	10.9
WMW (g)	Initial	0.62 $\pm$ 0.03	0.62 $\pm$ 0.03
	Final	4.91 $\pm$ 0.19	5.33 $\pm$ 0.19
	Increment	4.29	4.71
DMW (g)	Initial	0.158 $\pm$ 0.08	0.158 $\pm$ 0.08
	Final	0.974 $\pm$ 0.04	1.167 $\pm$ 0.41
	Increment	0.816	1.01
AFDMW (g)	Initial	0.0154 $\pm$ 0.001	0.0154 $\pm$ 0.001
	Final	0.0798 $\pm$ 0.003	0.0735 $\pm$ 0.003
	Increment	0.0644	0.0581

Table 3. Mean ( $\pm$ SE) shell characteristics of mussels from two different depths reared in lantern nets. Superscript letters indicate one-way ANOVA test comparison. Values in the same column with the same superscript are not significantly different ( $P>0.05$ ). W: shell width, H: shell height and L: shell length.

	Depth	Length (mm)	Weight (g)	Height (mm)	Width (mm)	W:L	W:H	H:L
Y <sub>initial</sub>		24.14 $\pm$ 0.40	0.39 $\pm$ 0.02	13.04 $\pm$ 0.19	8.16 $\pm$ 0.15	0.34 $\pm$ 0.004	0.63 $\pm$ 0.008	0.54 $\pm$ 0.005
Final	2 m	52.92 $\pm$ 0.72 <sup>a</sup>	4.56 $\pm$ 0.18 <sup>b</sup>	25.79 $\pm$ 0.32 <sup>a</sup>	19.88 $\pm$ 0.34 <sup>a</sup>	0.38 $\pm$ 0.004 <sup>a</sup>	0.77 $\pm$ 0.009 <sup>a</sup>	0.49 $\pm$ 0.004 <sup>a</sup>
	6 m	51.03 $\pm$ 0.60 <sup>a</sup>	3.96 $\pm$ 0.13 <sup>a</sup>	25.12 $\pm$ 0.30 <sup>a</sup>	18.77 $\pm$ 0.26 <sup>a</sup>	0.37 $\pm$ 0.004 <sup>a</sup>	0.75 $\pm$ 0.009 <sup>a</sup>	0.49 $\pm$ 0.003 <sup>a</sup>

from the lantern after t time and No is the number of mussels at the beginning.

Correlation matrix analysis was performed to evaluate the relationship between growth parameters and environmental factors. One-way ANOVA was applied to test for differences in shell characteristics and growth parameters between the depths and student t test was practiced to find out difference between the depths. Both contingency table (Chi-squared) and ANOVA were used to test significance of variance in mortality. All statistics were executed using a MINITAB software.

### Results

Mean ( $\pm$ SE), minimum and maximum values of environmental factors at 2 m and 6 m are given in Table 1. Transparency (Secchi disk depth) was obtained 7.31 $\pm$ 0.5 m with a minimum of 4.5 m and maximum 10.5 m in the loch. Temperature had a positive relationship with salinity ( $P<0.05$ ), while seston and particulate organic matter (POM) had a high positive relationship with chlorophyll-a ( $P<0.001$ ).

Monthly distribution of growth parameters (shell length, live weight, and dry meat are depicted in Figure 1 A,B and C and initial, final and increments values are given in Table 2. Shell growth was occurred higher in the small mussels compared with larger ones. The increments in shell length was higher at 2 m than 6 m but the difference was not significant ( $P>0.05$ ). At 2 m, 68 % of increase in length occurred from May to September, while at 6m, the length increase was 63 % over the same period. Shell growth was almost absent during the winter because of low available food and low temperature.

The monthly distribution of specific growth rate (SGR) ranged from 0.04 % to 26.8 % at a depth of 2 m,

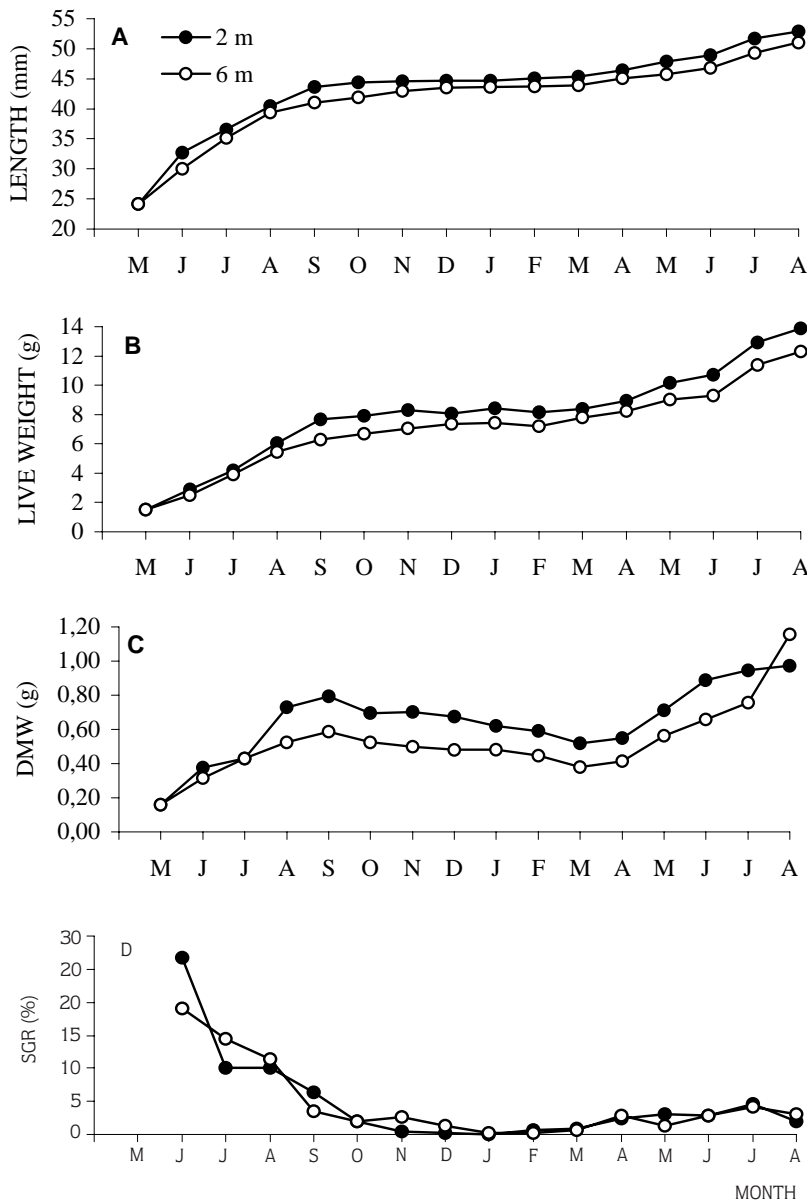


Figure 1. Monthly distribution of shell length (A), live weight (B), dry meat weight (DMW) (C) and specific growth rate (SGR) (D) at 2 m and 6 m depths from May 1993 to August 1994

while it ranged from 0.12 % to 19.2 % at 6 m depth (Figure 1 D). Average SGR values were 4.8 % and 4.7 % at 2 m and 6 m respectively over the 15 months experimental period and maximum values for SGR were obtained in June at both depths. High SGR values reflected available food and temperature conditions, with minimum values coinciding with low temperature and low food supply in winter.

Live weight was affected by gonadal development and gamete release, as well as by growth changes in tissue and shell weight. Some negative increments in wet meat

weight were recorded due to spawning or consumption of reserved energy source.

Mortality rate was higher in the younger mussels than the older ones. Cumulative mortality was found to be 16.7 % at 2 m, compared to 13.6 % at 6 m ( $P > 0.05$ ). Mean monthly mortality 1.1 % and 0.9 % at 2 m and 6 m depth, respectively. 37.4 % of the total mortality was recorded in May 1993 at 2 m, while 38.2 % of the total mortality at 6 m occurred in June 1993. The highest mortality rate was observed in the young mussels just after stocking them into the lantern nets which can be

attributed to the handling stress. The differences in the mortalities with depth were not significant over the 15 months experimental period ( $\chi^2=3.841$ ,  $P>0.05$ ).

The effect of depth on mean values and ratios of shell characteristics analysed by one way ANOVA and results are given in Table 3. Shell length differed insignificantly ( $P>0.05$ ), but shell weight showed significant difference between the two depths over the 15 months experimental period ( $P<0.05$ ). Shell height and shell width were noted to be slightly higher at 2 m than 6 m, but were not significantly higher ( $P>0.05$ ).

### Discussion

Seed and Suchanek (13) reported that several environmental factors can modulate growth in *Mytilus*. Growth parameters in mussels are mainly affected by interaction of several environmental parameters, particularly temperature and food availability (16).

The dependence of growth and physiology on water temperature has been extensively investigated, and well documented for mussels (12, 17, 18). High positive correlation ( $P<0.01$ ) between water temperature and specific growth rate showed that water temperature had a strong effect on shell growth of mussels in Loch Kishorn. Similar results were obtained in White Sea (19) and in west coast of Scotland (20). Several authors have identified seasonal and regional variations in both the quantity and quality of utilizable food as important determinants of mussel growth (21,22). Heavy rainfall and run-off bring large quantities of particulate detritus and dissolved humic material into the Loch Kishorn. The positive relationship between chlorophyll-a and seston shows that the amount of seston was clearly affected by phytoplankton blooms over the experimental period. The

amount of particulate organic matter (POM) alone does not necessarily provide sufficient information on food availability and growth conditions due to the proportion of non-utilisable POM in seston (23). There was a high correlation between POM and chlorophyll-a in the present study and Riley (24) declared similar results that phytoplankton might be most important component of POM and the main food for mussels, particularly during spring and summer. Transparency was mainly affected by algal bloom and daily weather conditions.

Growth was very limited from December to March. In April, mussel shell growth faster when chlorophyll-a concentrations exceed  $1 \mu\text{g.l}^{-1}$ , but temperature is still around  $7-8^\circ\text{C}$  which shows that when food is available, growth is occurred without temperature limitation.

Over the experimental period, older mussels had a reduced growth rate that in agreement with Seed (8). The dry weight increased in summer and autumn when new gonad and nutrient reserves were built. These findings are identical to those of reports, both the United Kingdom and Holland (26, 27). During severe food storage, when energy demand from basal metabolism are not met by food uptake, the mussel will have a negative scope for growth and utilize its storage energy reserves, resulting in negative somatic growth (25) as observed.

The natural cumulative mortality was found to be 13.6 % at 2 m and 16.7 % at 6 m over a 15 months experimental period ( $P>0.05$ ). Most of the death in the mussels was occurred just after stocking and attributed to stress due to handling. Okumus (20) reported 4.7 % and 14.4 % in lantern nets over one year experimental period in Loch Etive and Loch Leven on the west coast of Scotland. In general, natural mortality in mussel populations results from an interaction of many biological and physical factors (27).

### References

1. Karayücel, S. Mussel Culture in Scotland. World Aquaculture.1997; 28 (1): 4-10.
2. Dare, P.J. Mussel Cultivation in England and Wales. Fish. Res. Tech. Rep. MAFF Direct. Fish.Res. Lowestoft. 1980; 56: 18 pp.
3. Incze, L.S., Lutz, R.A., Watling, L. Relationships Between Effects of Environmental Temperature and Seston on Growth and Mortality of *Mytilus edulis* L. in a Temperature Northern Estuary. Mar. Biol. 1980; 57: 147-156.
4. Loo, L.O., Rosenberg, R. *Mytilus edulis* Culture: Growth and Production in Western Sweeden. 1983; 35: 137-157.
5. Page, H.M., Richard, Y.O. Food Availability as a Limiting Factor to Mussel *Mytilus edulis* L. Growth in California Coastal Waters. Fish. Bull. 1990; 88 (4): 667-686.
6. Essink, K., Bos, A.H. Growth of Three Bivalve Molluscs Transplanted Along the Axis of the Ems Estuary. 1985. Neth. J. Sea Res. 1985; 19: 45-51.
7. Brown, J.R. Multivariate Analyses of the Role of Environmental Factors in Seasonal and Site Related Growth Variation in the Pacific Oyster *Crassostrea gigas*. Mar. Ecol. Prog. Ser. 1988; 9: 69-79.
8. Seed, R. The Ecology of *Mytilus edulis* L. (Lamellibranchiata) on Exposed Rocky Shores. 2. Growth and Mortality. Ecologia. 1969; 3: 317-350.

9. Broom, M.J. Analyses of Growth of *Anadora granosa* (Bivalve: Arcidae) in Natural, artificially Seeded and Experimental Populations. *Mar. Ecol. Prog. Ser.* 1982; 9: 69-79.
10. Dickie, L.M., Bordeu, P.R., Freeman, K.R. Influence of stock and Site on Growth and Mortality in Blue Mussels, *Mytilus edulis*. *Can. J. Fish. Aquat. Sci.* 1984; 41: 134-141.
11. Grizzle, R.E., Morin, P.J. Effect of Tidal Currents, Seston and Bottom Sediments on Growth of *Mercenaria merceneria* : Results of a field Experiment. *Mar. Biol.* 1989; 102: 85-93.
12. Jamieson, G.S., Nish, I.C., Clarke, C.S.L. Perspectives and Development Prospects of mussel Cultivation in Maritime Provinces of Canada. Preference AMRL 74-11. Halifax. Nova Socita. 1975; 75 pp.
13. Seed, R., Suchanek, T.H. Population and Community Ecology of *Mytilus*. In : E.M. Gosling (Ed). *The Mussel Mytilus : Ecology, Physiology, Genetic and Culture*. Elsevier Sci. Pub. Amsterdam. Nedherland. 1992; pp. 87-169.
14. Stirling, H.P. Chemical and Biological Methods of Water Analyses for Aquaculturist. Institute of Aquaculture. University of Stirling. 1985; 119 pp.
15. Chatterji, A., Ansari, J.A., Ingole, B.S., Parulekar, A.H. Growth of Green Mussels, *Perna viridis* L. in a Sea Water Circulation System. *Aquaculture*. 1984; 40: 47-55.
16. Karayücel, S. Influence of Environmental Factors on Spat Collection and Mussel (*Mytilus edulis* L.) Culture in Raft System in two Scottish Sea Lochs. University of Stirling. PhD. Thesis. 1996; 297 pp.
17. Page, H.M., Hubbard, D.M. Temporal Spatiat Patterns of Growth in Mussels *Mytilus edulis* on an Offshore Platform : Relationships to Water Temperature and Food Availability. *J. Exp. Mar. Biol. Ecol.* 1987; 111: 159-179.
18. Brown, J.R., Hartwick, E.B. Influence of Temperature, Salinity and Available Food Upon Suspended Culture of the Pacific Oyster, *Crassostrea gigas*. I. Absolute and Allometric Growth. *Aquaculture*. 1988; 70: 253-267.
19. Sukhotin, A.A., Kulakowski, E.E. Growth and Population Dynamics in Mussels (*Mytilus edulis* L.) Cultured in the White Sea. *Aquaculture*. 1992; 101: 59-73.
20. Okumus, I. Evaluation of Suspended Mussel (*Mytilus edulis* L.) Culture and Integrated Experimental Mariculture (Salmon-Mussel) Trials in Scottish Sea Lochs. University of Stirling. PhD. Thesis. 1993; 336 pp.
21. Ceccherelli, V.U., Rossi, R. Settlement, Growth and Production of Mussels, *Mytilus galloprovincialis*. *Mar. Ecol. Prog. Ser.* 1984; 16: 173-184.
22. Frechette, M., Bourget, E. Significance of Small -scale Spatio-temporal Heterogeneity in Plankton Abundance for Energy Flow in *Mytilus edulis*. *Mar. Biol.* 1987; 94: 231-240.
23. Riley, G.A. Particulate and Organic Matter in Sea Water. *Adv. Mar. Biol.* 1970; 8: 1-118.
24. Kautsky, N. Growth and Size Structure in Baltic *Mytilus edulis* Population. *Mar. Biol.* 1982; 68: 117-113.
25. Mason, J., Drinkwater, J. Experiment on Suspended Cultivation on Mussels in Scotland. *Scot. Fish. Inf., Pamphlet. 4.* DAFS. 1981; 15 pp.
26. Zandee, D.I., Kluytmans, J.H., Zunburg, W. Seasonal Variations in Biochemical Composition of *Mytilus edulis* with Reference to Energy Metabolism and Gametogenesis. *Nether. J. Sea. Res.* 1980; 14: 1-29.
27. Dare, P.J. Settlement, Growth and Production of the Mussels, *Mytilus edulis* (L.), in Morecambe Bay, England. *Fish. Invest., London Series II, 28* (1). Her Majesty's Stationery Office, London. 1976; 25pp.