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TECHNICAL SESSION V. SHELLFISH DISEASES AND CONTROL	CMFRI-CAS/MF/80/BP-18

PREDATION AND FOULING PROBLEMS IN MUSSEL CULTURE

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INTRODUCTION

Predation and competition for food and space, attack on shell valves by boring organisms, parasitic infestation and disease out-breaks are all some of the important factors causing economic loss to the mussel farmer because of the large scale destruction and mass mortality of the cultivated stock. Therefore in developing culture technology and in the actual farm management considerable research effort has gone in to study the various facets of the problem in order to evolve suitable strategies to tackle them by adequate preventive and curative measures. The scope of this paper is limited to considering the problems of predation and fouling in respect of mussels.

Predation is one of the potential factors for the disappearance or destruction of the natural as well as the tended stock. In natural system, depradation may start with

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the larval population and continue to affect upto the fishable stock. But in the culture system the seeded stock on ropes/stakes/racks or the full grown individuals in the farm may suffer most. Many species of marine invertebrates and vertebrates feed on mussels. Similarly fouling organisms including many marine forms pose problems in natural beds as well as in the farm. These foulers attach to the fully or partially submerged surfaces of structures and grow in profusion thus creating competition for either space or food or both.

PREDATION

Natural beds:

The larval stages of mussels undergo the usual vicissitude of falling prey to plankton feeding animals and the surviving stock metamorphose and settle down as spat. Polyclad worms, littoral gastropods, star fish, crabs, lobsters and fishes take a heavy toll of the juveniles as well as adult individuals. The dog whelk, Thais, a littoral gastropod predator in Europe feed heavily on mussels of rocky shores. Urosalpinx, Acanthina, Ceratosama, ocenebra and Jaton species are also known mussel predators. Asteroid star fishes are among major predators throughout the world. Asterias rubens and A. forbesi play havoc destroying 0-year class as happened in U.K. in 1975. In Denmark, sea-star is considered less of a serious predator. In Ireland Marthasterias glacialis is known to feed on transplanted stock of Mytilus edulis. Stichaster feeds heavily on Mytilus canaliculus in New Zealand and Pisaster ochraeus on M. californianus on the Pacific coast of U.S.A.

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The crabs Cancer and Carcinus take mussels in their diet. Edwards (1968) and Davies (1969) showed heavy mortality of plantigrades due to crab predation. Of the fishes that prey on mussels the golden mackerel Sparus aunata (Andreau, 1969) is known well. The flat fish (Pleuronectes spp.) also feed on young mussels. On off-shore beds, diving ducks and oyster catchers (Haematopus sp.) and other birds prey on intertidal mussels.

Mussel farm:

Predation of the farmed mussels is considerably less, especially in the hanging culture system. In France the sting ray 'Tere' (Trygon pastinaca) invades the mussels grown on stakes. The damage done to the mussel stock on ropes hung from rafts in Spain by the sparid fish Diplodus sargus has been reported (Korringa, 1976). It is also believed that Aurata aurata can destroy mussels grown in Parks in Italy. In Philippines, Australia, New Zeland, Yugoslavia and other countries fish predation does not seem to pose any problem. Very recently Appukuttan (1980) has reported mass destruction of Perna indica grown on ropes in the west coast of India by shoals of Rhabdosargus sarba which fed voraciously on the adult mussels. During the experimental transplantation of Perna viridis and P. indica attempted along the Tuticorin coast in India the seed mussels were devoured by Siganus sp. and Gaterin sp. Predation by lobsters has also been observed in the west coast of India.

Among gastropod predators Nucella lapillus (Spain coast) and Rapana thomasiana (Black-sea) have been reported. The seaurchin, Paracentrotus lividus (Spain) and Salmacis sp. (India) pose minor problems.

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FOULING

Natural beds:

In Spanish rias the ascidian Ciona (Andreau, 1968) are stated to be a serious competitor for space. The synascidian, Diplostoma sp., Ascidiella, Botryllus, and Herdmania species are the other tunicates which are common foulers. It may not be out of place to mention that a list of 100 ascidians figuring in fouling and its prevention has been given by Woods Hole Oceanographic Institute in 1952 indicating their potential importance, although not sufficiently abundant to be harmful. In India Diandrocarpa brackenheilmi and Polycarpa sp. seem to be common, apart from Herdmania spp.

There are many encrusting, creeping, soft-tube building and hard-tube building forms, plants, animals and plant-like animal growths which settle down increasing the complexity of the fouling community. The problem of fouling appears to be serious in tropical and warm temperate waters, where the growth is rapid. Many of these forms have nuisance value and a few like Molialus spp, and Crepidula fornicata are serious competitors for space. Plants like Colpomenia sinuosa, Ulva lactuca and Codium sp. are also reported to create problems by profuse over-growth. The enormity of the fouling problem is such that, as Weiss (1948) stated, that a bucket of foulers when allowed to grow to maturity would weigh as high as 301.0 t.

So far as India is concerned the most common forms (Purushotham and Rao, 1971) in the mussel bed areas are as follows:

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(i) Coelenterates:- Laomedia bistriata, L. spinulosa, Bimeria franciscana and Pennaria sp; Sea anemones.

(ii) Annelida:- Calcareous tubes of serpulids Mercierella sp. Serpula vermicularis, Hydroides norvegica, Parchment tubes of sabellids and free living species like Perinereis cavifrons.

(iii) Arthropods:- Balanus amphitrite, B. tintinnabulum tintinnabulum, Cthamalus stellatus, Amphipods and Isopods like Corophium triaenonyx, Melita zeylanica, Cirolana, Sphaeroma, Metaponorthus and crabs.

(iv) Ectoprocta:- Bugula, Electra, Schizoporella and Zoobotryon species, Amathia distans, Crisia, Membranipora and Bowerbankia species. These are next in abundance to barnacles.

(v) Molluscs:- Anomia sp, Crassostrea cucullata, Modiolus striatubus, M. barbatus.

(vi) Tunicates:- Herdmania spp., Botrylloides sp., Botryllus sp., Polycarpa sp. Diandrocarpa sp.

(vii) Filamentous Algae, Padina, Codium, Valoniopsis sp. Hypnea sp. and Halimeda sp.

Mussel farm:

The pattern of settlement of foulers resembles the fouling in natural beds excepting that the complexity is increased because of the change to the three-dimensional environment. The succession of animal communities and intensity of fouling varies from season to season and from

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one geographical area to another. Therefore the problems faced by the culturist can be solved by studying the local conditions and devising proper methods to minimise the ill-effects of fouling community.

REMARKS

The question of mussel predation by fishes and crabs has not so far assumed serious dimensions in many countries practising culture. But this should not give room to complacency since the depredation, even though sporadic, might wipe out harvestable stock thus affecting production. Hanson (1974) suggests several methods, like air barriers, electrical barriers, acoustical barriers, animate barriers and chemical control to contain the menace. But in a country like India introduction of barriers technique is not possible in the present stage of development and economy of the industry. Sea-star menace is comparatively absent even in the natural beds and in raft culture the bottom living animals do not hold out much threat. However there is one source of predation to be guarded against namely the polyclad worms which are commonly noticed on the culture ropes. On many occasions planarians had been found wriggling inside the empty shell valves of mussel seed and adults. Whether the mussel flesh had been eaten away by them or it is a case of the worms occupying dead shell valves is not clear. However polyclads are known oyster enemies according to Bromhall (quoted by Davies, 1968) and mussel meat may also quite possibly fall within their diet range.

The restrictions imposed by fouling organisms can be tackled by inexpensive methods. Some of the methods followed in containing these are 1. Exposure of the culture ropes to

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atmosphere. In the fixed cultivation in the Gulf of Trieste, Favnetto (1968) states that all foulers except barnacles are killed by leaving the ropes out of water in the shade for a day. The ropes are then replaced in water. Lambert (1939) describes similar method for French Mediterranean coast also. Hs.Brenko and Igic (1968) recommend immersion in fresh water for not longer than a day. Desirable biological and chemical controls have been suggested and followed in many areas of the world. Treatment of rope with D.D.T. spray before seeding also may be useful to keep down fouling intensity. Periodical cleaning of the stock and removal of undesirable growths is also recommended, especially during seasons of peak fouling.

Where the question of fouling is not on the mussel stock but on the wooden raft structures or on the oil barrel floats caution needs to be exercised in proper maintenance like painting or by coating them with anti-corrosive and anti-fouling paints. Thus heavy boring by Teredo can be kept down as otherwise the raft might not be strong enough to withstand wave-beating and might in due course disintegrate. From the foregoing account it is clear that predation control and antifouling measures are important aspects needing careful action.

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TECHNICAL SESSION VI	POST-HARVEST TECHNOLOGY AND MARKETING	CMFRI-CAS/MF/80/BP-19

PUBLIC HEALTH ASPECTS OF CULTURING AND PROCESSING OF MUSSELS AND OYSTERS

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INTRODUCTION

The culture of mussels, oysters and clams in shallow and intertidal areas in the inshore coastal and estuarine waters is being practised widely in developed countries to supplement the animal protein resources for human consumption. Spain, U.S.A., Japan, Canada and France have made notable progress among the nations who have taken to the bivalve culture. Of the average annual production of molluscs in the world of about 3.5 million tonnes, India's contribution is a meagre 2000 tonnes. There are extensive mussel beds along the rocky coasts of India and the clams and oysters in some of the estuaries and backwaters offer great scope for development.

FOOD VALUE

The value of the meat in the bivalves depends on its nutritive value. The chemical composition of the meat of oysters, mussels and clams is broadly as follows:

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	Moisture %	Protein %	Fat %	Ash %
Oysters (<u>Ostrea sp</u>.)	76.8	11.2	1.9	2.0
Mussels (<u>Mytilus sp</u>.)	83.3	10.2	1.6	1.9
Clams (<u>Meretrix sp</u>.)	75.2	10.3	2.1	2.1

The above molluscs are also very good sources of glycogen and minerals like calcium, phosphorus, iron and iodine, besides vitamins 'A' and 'B'. (Venkataraman and Chari, 1951).

CULTURE, ENVIRONS AND HEALTH HAZARDS

The culture production of the bivalves as well as production from natural beds pose some problems which have to be taken note of when these are harvested, processed and marketed. These molluscs are the most easily contaminated due to the nature of their habitats. Oyster and mussel beds are a potential hazard to public health on account of possible epidemic infections being carried by the shell fishes.

They are to be cultivated in areas which are away from possible sources of contamination like sewers, bathing places, drains, oil jetties, etc.

The oyster and mussel beds are invariably located along the coast and especially in river mouths with tidal and rain water movements. This provides the risk of dangerous contamination by pathogenic bacteria present in such environments. These bivalves filter the water of the

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environment but retain a substantial part of the bacteria present. They are sometimes eaten raw and if these bivalves are cultured in environments of insanitary conditions and if these are not properly treated or purified before being consumed raw, a serious health hazard due to bacterial food poisoning will result. The pathogenic organisms in contaminated sea water areas have been variously reported as Salmonella, Vibrio parahaemolyticus, Steptococci, E.Coli, Aerobacter aerogenes, Proteus, Para colon bacteria and Clostridium sp.

Another type of contamination or pollution of the oyster and mussels can be by heavy metals from industrial effluents. Arsenic, iron, cadmium, copper, zinc, lead, mercury are some of the metals reported to be absorbed by mussels. Radio active wastes let into the sea can also be a health hazard to the mussel as well as to the consuming public (Roberts, 1976).

There is an instance of bacterial mussel pollution reported by Venkataraman and Sreenivasan (1955) near Calicut. Faecal pollution (E.Coli type I, Paracolons and Proteus) has been observed in the mussel of the bivalve mainly during the South West monsoon (June-August) when the rain water carries the town refuse into the sea. Salmonella-shigella organisms were absent and so also vibrios.

Another health hazard can be from pesticides. Mussels are known to assimilate these organochlorines (D.D.T.), Endo sulfan, Toxaphene, Parathion etc.) washed

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into the beds from agricultural drainage by storms, which can be a risk to the consuming public if the meat of such bivalves are consumed raw or without any treatment before consumption, as such pesticides while not likely to be toxic to the bivalves can affect the consuming public.

Yet another type of health hazard reported elsewhere, though not in our country, is the paralytic shell fish poisoning due to consumption of the meat of mussels and oysters taken from beds during certain periods of the year when there was a bloom or heavy growth of planktonic organism. Dinoflagellates of the genus Gonyaulax are chiefly associated with the paralytic toxin formed in filter feeding molluscs. (Halsted, 1965; Robinson, 1968). Other organisms like Prorocentrum, Exuviaella and Gymnodinum sp. have also caused poisoning (Ingham et al, 1968). Normally these dinoflagellates are harmless, but when the blooms occur, (the so-called 'red tide'), vast number of the organisms are taken in by the filter feeders which accumulate the toxin in their flesh. If such affected shell fish are eaten by the public, the outcome can be serious, resulting in neurotoxic symptoms and occasionally death. (Halsted, 1965). The poison extracted from the mussel meat and the incriminating dinoflagellates seems to be a heat resistant alkaloid with muscarine-like action and a potent neurotoxin. It has also a depressant action (Pepler and Loubster, 1960). In our country, poisoning due to consumption of mussels or oysters of this nature has not been reported, though discoloration of patches of sea water due to blooms of Noctiluca, Trichodesmium, Hornellia

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marina and even *Gymnodinum* have been reported sporadically. (Subramanian, 1954; Prakash amd Sharma, 1964).

BACTERIAL POLLUTION IN OYSTERS AND MUSSELS AND PROCEDURE FOR RENDERING THEM SAFE

The fish feeding bivalves have a tendency to concentrate the coliform bacteria from the sea water and this fact underlines the public health significance of oysters as potential agents of enteric infection.

While it is advisable to culture oysters and mussels in unpolluted or 'safe' water spreads, it is difficult to avoid completely the pollution in such areas. So they must be marketed after a systematic cleaning since they are consumed raw. The cleaning or depuration methods are based on the principle that molluscs contaminated with Entero-bacteria free themselves from these bacteria within 24 to 48 hours when they are placed in water of sufficient salinity and devoid of bacteria. Chlorinated water subsequently dechlorinated is used. (Dodgson, 1928). This technique of chlorine treatment is now being replaced by ultra violet light or ozone treatment. Relaying of oysters before marketing in clean beds which are certified to be non-polluted has also helped the aqua-culturists to get a safer product. This technique can be adopted as a batch process ie. holding the bivalves in tanks where the seawater after chlorine and dechlorination treatments are filled in and kept for 12 hours whereafter the water is drained and refilled with a fresh batch of pure sea water. In the continuous process the pure sea water is allowed to flow through the holding tanks continuously where the

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bivalves are kept and the purification can be quickened by this procedure. In view of the similarity in the physiological functions among the bivalves, the methods applicable to cleanse oysters of harmful organisms can also be applied to others like mussels, clams, scallops, abalones etc.

MARKETING AND PROCESSING

Shellfishes are not only the most perishable of sea foods but also are the most easily contaminated due to the nature of their habitat.

A great many soil and water bacteria which apparently had no effect on oysters are found in the decomposing oyster meat.

Decomposition of the shucked meat from the shell fishes is due to the activities of spoilage bacteria as commonly found in fish like Pseudomonas, Achromobacter Escherichia, Micrococci etc. Methods of preservation must be directed towards this flora.

Pathogens when present in large numbers, survive freezing and cooking. Cooking should be vigorous if it is to kill E.coli and it may be impossible to remove the E.coli from the meats of the polluted shell fishes by washing alone. These bacteria are responsible for causing infections like diarrhoea, gastro-enteritis etc.

Bulk of the oysters and mussels are marketed in live conditions after the depuration process in most of the countries, since oysters are consumed raw while the mussels are cooked and utilised immediately.

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The meat from the mussels and oysters are shucked and washed well to remove sand, shell particles etc. and chilled in containers in ice boxes. The meat is marketed in this way for local consumption.

The shucked meat can also be cooked and frozen as for fish slices or prawns at -40°C and held in frozen storage at -23°C upto about 44 weeks for marketing as frozen molluscan meat.

George (1974) has shown that during freezing and storage of the frozen mussles, the total bacterial load comes down by 99% and the pathogenic germs like E. coli and faecal Streptococci are completely destroyed at the end of 44 weeks of storage at -23°C.

Canning of mussel meat in oil has been experimentally attempted at the Central Institute of Fisheries Technology (Balachandran and Nair, 1975) with promising results. Light smoke curing of mussels and drying to a moisture content of 10% after self purification of the live shell by giving a starvation treatment for one day to eject the sand in the meat followed by immersion in chlorinated water (5 ppm) for 2 hours has been reported by Muraleedharan et al (1979).

Mussel meat may be stewed, roasted, fried, creamed, pickled with vinegar or made into fritters and chowder.

Pickling is a common way of preservation of mussel meat. It is also used as a bait.

Mussels can be converted into protein concentrate (protein 70%) after isopropanol extraction.

Blue mussel meat is also used as a valuable feed for pigs in some areas of Russia. In Thailand, young mussels are harvested from the bamboo collectors and used as animal feed.

In the context of the development of brackish water spreads for molluscan aquaculture for supplementing the marine food resources, the following investigations are required to be carried out in our country as very little information is available at present.

(i) Survey of the grounds suitable for culture of the molluscs especially oysters and mussels with particular reference to the extent of pollution of these areas by industrial effluents, pesticides from irrigation drainage systems, and by pathogenic organisms and the identity of such organisms.

(ii) A depuration technique must be worked out and standardised to make the consumption of oysters and mussels safe for human consumption.

(iii) Research on such methods of preservation of the meats of these molluscs like drying, salting, pickling, freezing and canning and development of diversified products with these meats as the base may have to be intensified and the consumption of oysters and clams popularised among the masses.

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