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SHELLFISH DESEASES AND THEIR CONTROL

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The problems confronting the fish farmers are experienced by shellfish farmers also in the matter of diseases amongst the tended stock although the nature of diseases vary. Shellfish culture in India is in the nascent stage and disease problems have not so far posed problems. But in order to put the farming system of oysters, mussels and clams on sound footing it is necessary to understand the common diseases and causes of the diseases amongst shelled forms facing the shellfish farmers in other countries.

Sinderman (1970) gives an exhaustive review of the 'diseases of shellfish' although in recent years Leibovitz (1978), Farley (1978), Sprague (1978), Cheng (1978), and Sinderman (1978) have added considerably to further the knowledge on the subject. Much of our knowledge concerns species of economic importance. Microbial pathogens that have been implicated in mass mortalities include bacteria, fungi and protozoans. Several parasites have been found to be pathogenic under specific environmental conditions. Most of the commercial bivalve molluscs occur often intertidally in shallow inshore waters. Unusual mortalities due to diseases appear to be more in these habitats than in offshore populations. Information on oyster diseases is more abundant than that on mussel, clam pearl oysters, scallop and abalone. This is partly due to the worldwide economic importance of oysters.

In culture system and natural beds direct threats to productivity is posed by the biological environment. The detrimental effects of cohabiting organisms fall into three basic categories (1) predation, (2) competition and (3) disease and parasitism.

PREDATION AND COMPETITION

Predation is less of cultured organism to other creatures preying upon them for food. Limited predation can weed out diseased members of a crop thus controlling infections. The predators of of sessile organisms are various species like sea-stars, octopi, fishes and rays, gastropods, crabs and some birds. Asterias rubens and A. forbesi kill young oysters in European countries. The shore crab Carcinides maenas, red crab Cancer productus, Murex erinaceous, Thais lamellosa, Polynices lewesii, Tritonalia japonica, Octopus vulgaris, Pagrus pagrus, Myliobatis aquila and the flat worm Stilochus pilidium are known predators in many oyster farming areas. Particular damage is done in the spat stage when spat are transplanted. In India, the gastropod Cymatium pileare is known for its predatory feeding of oyster spat. Hand removal is the best method to eliminate them. Similarly the green crab Scylla serrata feeds on young oysters.

Hand picking of predators, transfer of oysters to low saline waters or saturated saline media for a limited duration, trapping etc. are some of the methods adopted to eliminate predators. In Europe and U.S.A. dredges, mops and quicklime spreading over the beds are being used to control them. Removal of culture stock from natural predator range seems likely to be an effective measure for protection against demersal fishes, octopi and crabs as well. Birds do not pose much problem. Free swimming predators like marine mammals, rays, carnivorous fishes, octopi and squids have a wide diet range. Control through aggression suppressing pheromones (chemical signals) is now advocated in large-scale culture. Intra culture predation may be controlled by adequate feeding and provision of defensible niches. Mesh barriers, air barriers, electrical barriers for repulsion, accoustical barriers, chemical controls (pheromones to affect social, feeding behaviour) in fishes and animate barriers are some of the ways being devised at present.

Competition is defined as rivalry between cultured organisms and uncultured organisms for any environmental resources that may be limiting, thus tending to reduce cultured organisms' productivity. If little is known in mariculture about predation nothing is known about competition problems. When competitor forms are similar to cultured forms they can be allowed to coexist if cultured productivity degeneration is not serious. In the case of phytogenetically dissimilar forms to cultured forms, biological controls such as diseases and parasites might prove effective in controlling their numbers. Chemical control is also suggestible. All these show the obvious need for comprehensive empirical investigations of the whole spectrum of questions implied by predation and competition.

In oysters and mussels the foulers and epibionts pose problems. Ascidiella, Botryllus, Ciona settlement oust the spat settlement and cause poor growth and mortality. D.D.T. dissolved in oil is sprayed on tiles or spat collectors to ward off these. 300 ml of fluid containg 2% JEZO which consists of 20% D.D.T. in oil with a detergent is used effectively. The slipper limpet, Crepidula fornicata (cup) competes for space with oysters in Holland. Hand removal of this is resorted to during nights. In Colpomenia sinuosa called "oyster thief" which smother the oyster spat by profuse overgrowth Perwinkle control by Littorina littorea helps Sea lettuce, Ulva lactuca also growing on oyster cages or beds creates anaerobic conditions. Schizoporella (Bryozoan) an epibiont creats problems in French coast. These are periodically scraped. Diplostoma listerianum a synascidian is weeded out by prolonged immersion of oysters in a solution of brine or in freshwater. Modiolus phaseolinus, the horse mussel, competes for space in Norway. These are difficult to control but due to manual operations these are removed. Similar problems in Indian coastal waters can be solved by developing local measures.

DISEASES

The diseases may be classified broadly into (a) infectious, (b) parasitic, (c) non-communicable and unknown etiology. Parasitic infestation may be endoparasitic or ectoparasitic. Infectious diseases are caused by viruses, bacteria, fungi, protozoans and less commonly by algae. Other causes of debilitation and mortality include deficiencies, wounds, poisons, environmental factors etc.

Microbial diseases of viral, bacterial, fungal and protozoal etiology tend to destroy the tissues of the host and multiply within the host. The pathology depends on intensity of dose, resistance of individuals, infective dose, environmental variables and host nutrition. The effect may be from chronic to acute afflictions leading to mortality. Viruses are known etiological agents for fibro epithelial tumour. Baculovirus, reolike virus (RLV) causing neurological damage, herpes like virus (HLC) damaging hemocytes and picarnolike virus (CBV) afflicting epidermal tissues, cause serious damage to the stock. Bacterial disease caused by Vibrio (Vibriosis) also leads to mortality. Pseudomonas, Mycobacterium, Myxobacterium, Chondrococcus and Aeromonas are also known to affect the farmed stock seriously. Most of these bacteria present in sea water or on the surface of fishes invade and cause pathological effects if hosts are injured or subjected to severe environmental stress. Protozoa and cnidospora are among the best known serious pathogens of marine fishes and shellfishes. Haemoflagellates, ciliates, myxosporidia, microsporidia and coccidia bring out severe effects on hosts causing nerve and gonad degeneration and castration. Parasitic diseases are caused by Helminths (Trematodes, cestodes, nematodes and acanthocephalans) and parasitic copepods. Helminths as larval infection are of great significance. Growth retardation, tissue disruption, metabolic disturbances and mortality of hosts in serious infections are characteristic of helminth invasion of the host. These invariably weaken the host and help the entry of secondary invaders leading to mortality. Table 1 gives a compilation of various diseases among shellfishes reported from all over the world and the organisms causing the diseases.

Disease agent	Host	Effect	Area from where reported
1.	2.	3.	4.
I. Oysters:			
(a) Bacterial:			
1. gram negative motile bacillus Achromobacter	C. gigas	Large-scale mortality (focal necrosis)	Japan
2. gram positive bacillus	"	Multiple abscesses (focal necrosis)	Japan, Maryland & Willafa Bay USA
3. Aeromonas sp.	Larval & juveniles of C. virginica O. edulis	Mortality	-
(b) Fungal:			
1. Dermocystidium marinum	C. virginica	Mortality	Atlantic coast, Gulf coast of USA.
	O. frons	"	Florida
	O. equestris	"	Texas
	C. rhichophorae	"	Peurto-Rico
	O. edulis	"	Holland
2. Monilia sp.	O. edulis	Mortality by 'shell disease'	Holland France
	C. angulata	"	U.K.
3. Ostracobiabe implexa	C. virginica	Mortality	USA
4. Myotomus ostrearum	O. edulis	Mortality 'foot disease" (Maladie du pied) (Muscle atropy)	France, Europe
	C. virginica	"	USA
	C. gryphoides	"	India

1.	2.	3.	4.
5. Cladothrix dichotoma	O. edulis	Mass mortality	West Europe
6. Nocardia sp.	"	"	
7. Actinomycete (sp-?)	C. virginica C. angulata	? ?	USA France
8. Sirolpodium zoopthorum	Juvenile oysters	Mortality	USA
(c) Protozoa:			
1. Minchinia costalis	C. virginica(?)	Mortality (sea-side organism disease)	N. America east coast, Maryland, Virginia, Delaware Bay
2. M. nelsoni (MSX) (haplosporidian)	C. virginica	Mortality (Delaware Bay disease)	North Carolina, Delaware Bay, Chesopeake Bay
3. Chytridispsis ovicola (haplosporidian)	eggs of O. edulis	?	France
4. Nosema dollfusi (microsporidian) hyper parasite)	C. virginica	Mortality believed to cause extensive maortality but later found to be only affecting the quality of meat	USA
5. Nematopsis ostrearum (gregarine).	C. virginica		Virginia
6. N. prytherchi	"		Sonisiana
7. Hexamita nelsoni (flagellate)	O. edulis	Mortality 'Pit disease'	Holland
	O. lurida	Only diseased condition	Washington
8. Sphenophyra sp. (ciliate)	C. virginica	disease	Maryland
9. Orchitophyra stellarum	C. virginica	Gonad atrophy	Canada
10. Ancistrocoma pelseneeri	C. virginica	Disease of dig-tract	Atlantic coast & Gulf coast of USA

1.	2.	3.	4.
11. Vahlkampfia calkensi (=Flabellula calkensi)	C. virginica	Disease of dig-tract	Atlantic coast of USA
12. V. patuxent (amoebas) (=F. patuxent)			
(d) Helminths:			
(i) Trematoda			
1. Bucephalus haimeanus	O. edulis		Mediterranean sea
2. B. cuculus	C. virginica		
3. B. longicornutus	C. virginica	Retards growth	USA (S.Carolina)
	O. lutaria	Mortality	Newzealand
	O. gigas	?	Pacific coastal areas
4. Bucephalopsis haimeanus	C. madrasensis	Gonadal atrophy	India
5. Gymnophalloides tokiensis	C. gigas	Reproduction retarded	Japan
6. Proctoeces ostreae	C. gigas	"	Japan
7. Acanthoparyphium spinulosum	C. virginica	?	Texas
(ii) Cestoda:			
1.Tylocephalum sp.	C. virginica	?	Hawai, Florida, North Carolina
	C. gigas	?	Japan, Taiwan
	P. fucata	-	India, Ceylon
(e) Gastropod parasites:			
1. Odostomia bisuturalis	C. virginica	Deformity;damage and rarely death	USA
2. O. eulimoides	O. edulis		UK
3. O. impressa	C. virginica		USA

1.	2.	3.	4.
(f) Crustacean parasites:			
1. Mytilicola intestinalis	C. gigas	Poor condition index	Japan
2. M. orientalis	O. lurida	-	
II. Mussels:			
(a) Microbial deseases:			
1. Chytridiopsis mytilovum haplosporidian	Mytilus edulis	Eggs affected	West North Atlantic
	M. galloprovincialis	"	Mediterranean (Gulf of Naples)
2. Haplosporidium tumefacientis	M. californianus	Digestive gland enlargement	California
3. Nematopsis schneideri	M. edulis	Gill disease	France
4. N. legri (gregarine)	M. galloprovincialis	"	Italy
5. Ancistrocoma pelseneeri	Mytilus edulis	?	Baltic sea area
6. Kidderia mytili	Mytilus edulis		
7. Ancistruma mytili			
8. Hypocomides mytili (ciliates)			
(b) Helminths:			
1. Diastomum somateriae	M. edulis	Pearl formation	U.K.
2. D. margaritarum	"	"	French coast.
3. Cercaria tenuans	"	Orange sickness of mantle	U.K.
4. Cercaria milfordensis	"	" (at times lethal)	U.S.A.

1.	2.	3.	4.
C. Crustacean parasites	M. galloprovincialis	Intestine disease & mortality	Mediterranean
1. Mytilicola intestinalis	M. edulis	"	Germany, Holloand, Spain
2. M. perrecta	Modiolus sp.	-	U.K. Mexico
III. Clams:			
(a) Microbial disease:			
1. Dermocystidium	Donax sp.	Mass mortality	California
2. Hyaloklossia pelseneeri (Coccidian)	Tellina sp.	Kidney infection	Europe
3. Pseudoklossia glomerba	Tapės floridus T. virgeneus	Mild infection	Mediterranean
4. Nematopsis sp.	Solen vagina	Mantle disease	France
5. N. schneideri	Cardium Mactra Donax vittatus	Gill desease	France
6. Trichodina myicola	Mya arenaria	Palp affliction	California
7. Ancistrocoma myae	"		California, Massachuchetts
(b) Helminths:			
1. Himasthla larvae	Mya arenaria	Gill disease	California
2. Gymnophallus larvae	Mya arenaria		"
3. Postmonorchis donacis	Donax sp.		"
4. Anabothrium sp.	Gaper clam	Foot disease	Pacific coast of USA
5. Echeneibothrium sp.	Venerupis staminea	Tissue infection	California

1.	2.	3.	4.
(c) Crustacean			
1. Mytilicola mactrae	Mactra veneriformis	Tissue infection	Japan
2. M. perrecta	Mercenaria mercenaria	?	Mexico
IV. Scallops			
1. Pseudoklossia pectinis	Aequipecten maximus	Kidney infection	France
2. Nematopsis duorari	A. irradian	?	Florida
3. Paranisakis pectinis (now confirmed as Sulcascaris sulcata)	A. gibus A. irradians	Visceral mass disease	Florida
4. Odostomia seminuda	Calico scallops	Visceral mass damage	East coast USA
5. Boring sponge ?	Placopecten sp.	Shell damage poor yield of meat	Canada
V. Pearl oysters:			
1. Muttua margaritiferae	Margaritifera vulgaris (=Pinta fucata)	Gills	Ceylon
2. Musalia herdmani	"	"	"
3. Bucephalus margaritae	Pinctada martensi	Gonad	Japan
4. Echinocephalus uncinatus	P. vulgaris	Adductor muscles	Ceylon
		Gonadial affliction	Japan

Although remedial and curative measures have been taken to contain and eliminate the disease factors universally applicable methods are yet to be publicised. In the case of fishes, drugs used and their administration to treat certain diseases have been given by Amlacher (1970). It is of great importance to bestow attention to acquire specialised training in diagnosis and develop extension services for field application. A regional training programme is of high priority.

HARVESTING: TECHNIQUES OF HARVESTING
POST HARVEST TECHNOLOGY

S. MAHADEVAN

Fishing industry has been developing equipment and techniques for open sea harvesting for centuries. Harvesting in mariculture operations, coastal as well as open sea, should pose fewer problems than are found in naturally occurring stocks. Particularly so if the crop is sessile. The general principle underlying harvest is that the system should provide harvest of crops at the optimum point in the growth cycle, (i.e) the stage at which the ratio of rearing cost to marketing return is most favourable to culturist. The system should aim to transfer the harvested crop to the on site processing centre or marketing facility without significantly degrading the quality of the product. The effort in harvest should concentrate and harvest on a very high percentage of the crop intended for harvest. Unharvested material will be wasted and therefore affect the cost effectiveness of operations adversely. Harvesting system should be a non-labour-intensive work; bringing down capital and operational cost. It should also be so designed that it is done at rates that are compatible with on site transport to market disposal or harvest-processing rates so as to maximise capital equipment utilization and minimise temporary storage requirements. Cultured crops are mostly homogenous in species and size and therefore all the produce will be easily marketed without rejection for want of quality level.

Sessile organisms like molluscs attach themsleves or remain on some firm substrate. The harvesting system must remove them from the substrate without damage. The substrate thus becomes a part of the harvest strategy for easy removal and reutilization. At present oysters and mussels are the only molluscs cultured extensively. Mussels are grown in ropes and oysters are reared on cages, trays, racks, longlines, poles or sticks. At harvest the tended stock are removed individually and transferred to shore. Once open sea culture is successfully taken up and ropes of greater length are going to be employed for greater yield it is going to pose problems in lifting them manually and removing the mussels individually. Similar situation in line culture of oysters in deeper areas in Japan and Pacific region has been effectively carried out by Winches being employed to haul the ropes which are heavy due to oysters grown on them. In mussel culture also similar device is best employed to great advantage over the comparatively labour intensive practice in use. Removable growing racks are advocated in open sea culture in future for oyster growing. These can be used to grow oysters on both sides of rack and a mechanised removal by drawing the rack through closely spaced scraper blades will yield good results. Coating the surface with a material that could be peeled off at harvest taking the attached molluscs with it is also another alternative.

Harvest utilization

In coastal aquaculture shipboard installation for processing the raw material is dispensed with since the harvested product can be quickly transferred to shore without causing degradation of the flesh. The products harvested are transhipped to markets and disposed of fresh in the case of local markets. Where the markets are interior or in a far off place involving long duration journey by van or rail precautionary steps are to be taken to retain the wholesome nature of flesh.

Canning and freezing are two processes that are found useful in this. After shucking oysters or removal of mussel shell the flesh is suitably preserved.

Depuration

Marine bivalves such as oysters, mussels and clams are some of the shellfishes much relished. These being sedentary and growing so close to the shore are susceptible to sewage and other contamination. As they are filter feeders they may accumulate bacteria, virus or fungal pathogens in their body which may create nuisance to the persons eating the meat. Under certain conditions biotoxins, pesticides and heavy metals may also be absorbed by their tissues. Hence before consuming the flesh a high purity of these is essential before they are marketed. Commercial producers practise purification techniques but these differ from country to country. Simple washing in chlorinated water to exposure to ultra violet ray treatment and ozonisation method are adopted. Cleaning of bacteria contaminated oysters using their own physiological filtration was developed at U.K. Wells (1923) described a purification plan using chlorinated seawater. This method is still in vogue in many developed countries. Ultra violet sterilization has recently superceded this method. Coliform are eliminated to 99.9% by this method.

A simple purification system adopted and advocated is as follows:

Seawater is pumped into a sump and to a sedimentation tank of 4 chambers 1 m x 1.5 m x 1.2 m each. The water passes through these to filter bed thus reducing silt materials. All suspended particles and silt are effectively removed by sand filters in this tank (1.8 x 1.8 x 1.2 m). The water passes on to a ground level storage tank of 10,000 litre capacity.

Three tanks of 2.5 x 2.5 x 1.0 m get separate channels of supply from sump and separate drainage provided for each. The drainage valve is 50 cm high from bottom of tank so that 50 cm water column can be always maintained. The horizontal link is plugged while tank is used for cleaning and to drain water completely. Water jet is given to these tanks by pumps.

Oysters placed on wooden grids are lowered in one of these tanks in nylon knitted trays. Oysters are hosed throughly by strong seawater jet to remove external mud and dirt. Filtered seawater is filled in the next tank to 50 cm height to which the oysters from the first tank are then transferred and allowed to remain for 12 hrs. The bacteria are eliminated here by natural physiological process. The water is later drained and a strong jet of water is hosed on oysters to clear faeces and pseudo faeces on the oyster shells. The tank is refilled with water and the cleaned oysters are left there for another 12 hrs. At the end of this they are kept for one hour in freshly chlorinated water with 3 ppm chlorine. They are later dechlorinated by hosing filtered sea water and placed in a holding tank before disposal.

Though the need for depuration was felt even in very ancient times, even as recent as 1978, oysters were being exported without purification (Anon, 1978). Most of the countries wherein oyster is being cultivated at present in large quantities enjoy cold climate. In Europe and North America the temperature of seawater falls at times below 10°C and purification process in abnormally prolonged for 3 to 5 days irrespective of the method viz. chlorination, U.V. radiation and ozonisation, because of the slow filtering activity of the oysters at such low temperatures. This has been overcome by using heat exchangers to keep the water at elevated temperature, thereby making the process expensive. In Japan, possibly with a view to reduce the cost of production, the shucked oyster meat is chlorinated before being canned (Korringa, 1976). The Australian growers have found relaying the sewage contaminated oyster in clean marine area for a period of at least seven days, a more efficient method of depuration than cleaning them in tanks (Anon, 1977). Under certain circumstances even seven days may not be sufficient. Further studies conducted therein have shown that reduction in bacterial contamination in sewage effected oysters could be effectively done by freezing and keeping the oyster meat at -23°C for seven days (Anon, 1977, Quadri et al., 1976). In tropical countries our seawater is warmer and depuration takes only a few hours although the chlorination method of depuration of shellfishes is followed at present. It is intended to use a suitable ultraviolet steriliser to achieve maximum hygeneic standard of the products making it more safe for counsumption.

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