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Bacterial Diseases of Fishes and Their Control

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In the contemporary approach toward understanding communicable diseases, epidemiology or epizootiology plays an important role in attempts to explain relationships between the hosts, pathogens, environments, and outbreaks of diseases (Wedemeyer et al., 1976). Discussing this relationship seems to be my favorite hobby. It can be represented in the form of an equation: $H + P + S^2 = D$.

In this equation, H represents the species and strain of the host, its age, and inherited susceptibility to any particular disease; P represents the pathogen causing the disease with all its variability; and S represents stress of the environment. The square of S is used because the stress caused by environment increases in geometrical progression when the conditions are approaching the limits of tolerance by the host. The D represents the disease which results if the three components listed on the left side of the equation are in proper qualitative and quantitative proportions. In discussing bacterial diseases of aquatic animals, one must always consider the role of all three factors.

Numerous species of bacteria are capable of causing diseases in fish and shellfish. Many are well known (Bullock et al., 1971). Unfortunately, when one tries to identify and name them, one is confronted with problems. "Bergey's Manual" (Buchanan and Gibbons, 1974) is recognized as the most authoritative text on bacterial taxonomy; however, taxonomy is becoming a separate branch of bacteriology that almost exists for its own sake.

In each new edition of "Bergey's Manual," a considerable number of changes are made, as would be expected. The new eighth edition lists many changes of names of bacteria that cause diseases in fish and shellfish. Although such changes are unavoidable, they have resulted in a number of name changes for several species of fish pathogens during recent years. Consequently, it is sometimes difficult to establish the identity of a fish pathogenic bacterium described on numerous occasions during the span of only a few decades.

The Fish Health Section of the American Fisheries Society has charged an ad hoc committee with the task of attempting to clarify the taxonomic problems. Fish pathologists have found that the current edition of "Bergey's Manual" does not recognize such well-known names as *Aeromonas liquefaciens*, or the fish pathogenic myxobacteria (except *Chondrococcus columnaris*, whose generic name has been changed to *Flexibacter*). *Gaffkya homari* has been changed several times and is now *Aerococcus viridans*, supposedly identical with the human pathogen causing subacute endocarditis (*Endocarditis lenta*) (Stewart, 1978). This synonymy is difficult to accept for anyone with experience with these pathogens when isolated from lobsters or humans. Also missing from the Manual are *Hemophilus piscium* and *Pasteurella piscicida*.

So much for the bacteria; now about the hosts. If one takes into consideration the number of species of pathogenic bacteria and the number of species of fish and shellfish that may become infected with these bacteria, the number of bacterial species known to date is relatively small.

The specific susceptibility of aquatic animals to various bacteria can be observed only in the species that are cultured, or at least kept in captivity for awhile. In general, marine fishes are susceptible to diseases caused by *Vibrio anguillarum*, and freshwater species to those caused by *Aeromonas hydrophila* and *A. salmonicida*. *Gaffkya homari (Aerococcus viridans)* seems to be an exclusive pathogen of lobsters, unless one accepts the possibility that this organism is identical with the one causing subacute endocarditis in humans.

It seems that the species of the host is not the only significant factor in determining the species of bacterial pathogen involved; environment seems to be important also. For example, outbreaks of diseases caused by *A. salmonicida* have often been reported in nonsalmonids that were exposed to infection at a proper range of temperature. Vibriosis in marine and estuarine fishes is usually associated with crowding and increased temperatures. Spring viremia of carp and bacterial hemorrhagic septicemia (Fijan, 1972), caused by *A. hydrophila*, are associated with the spring season, temperature, management practices, and water pollution. Kidney disease of freshwater salmonids is associated with the nature of the water supply, and possibly the presence of external parasites (Warren, 1963). Mycobacteriosis of several species of Pacific salmon was caused by feeding infected viscera of raw salmon, some of which contained mycobacteria (Wood and Ordal, 1958). A catastrophic outbreak of pasteurellosis of white perch, *Morone americana,* and striped bass, *M. saxatilis,* in the Chesapeake Bay in 1963 was probably initiated by environmental stress of a hot, dry summer (Snieszko et al., 1964). The same pathogen causes diseases in fish cultured in cages in Japan and is also known in the Gulf Coast area.

One could give more examples on the role of environment in the health and disease of fish and shellfish. This is not necessary, however, because the subject was recently treated in detail by Wedemeyer et al. (1976).

Knowledge of bacterial diseases would have little practical value if it did not result in improved control of these diseases. In control of fish diseases, one should avoid ideas based too much on analogies with diseases of humans and domestic animals. Fish and shellfish are aquatic and poikilothermic, and these are important differences.

What means do we have for control of bacterial diseases of aquatic animals? The first one is avoidance of exposure to pathogens. This is possible in relatively few fish cultural facilities—only those having clean water. One of these fortunate areas is in the Snake River Canyon in Idaho, where an almost limitless supply of fresh water from artesian wells is an effective shield for protection from infectious diseases. But, even in that area, conditions are changing for the worse due to increasing reuse of water and transfer of infected fish.

Much pondfish culture and marine culture of fish and shellfish takes place in open waters where fish pathogens are present. Under such conditions, avoidance is not possible, and use of chemotherapeutic drugs is expensive and transitory. Immunization is a recent and growing control measure that is proving highly promising (Anderson, 1974; Fryer et al., 1976). Although immunization of humans is the most effective means of disease control, the immune response in fishes is dependent on temperature and that in shellfish is still a mystery that somehow works very well in nature.

Immunization of cold-blooded vertebrates was started many years ago, but little progress was made because the response was negligible at low temperatures and the necessity of handling each animal made it impractical on a large scale. Oral immunization of salmonids was introduced by D. C. Duff of Canada about 40 years ago, but with only limited success. Only during the last 10 years has sufficient progress been made by G. W. Klontz, J. L. Fryer, D. F. Amend, D. P. Anderson, and others to make it effective, but mainly under laboratory conditions (Fryer et al., 1976). However, during the last 5 years, immunization of fish by oral administration of antigen and by immersion of fish, with or without preconditioning, is becoming so promising that two commercial laboratories in the United States are now manufacturing fish vaccines.

A commercial vaccine for immunization against enteric redmouth disease (ERM) is also available, and a vaccine against *Vibrio anguillarum* has been licensed. Other bacterial vaccines are under development and antiviral vaccines will most likely be available also.

Outbreaks of bacterial diseases are influenced by the susceptibility of the host, virulence of the pathogens, and quality of the environment (Wedemeyer et al., 1976). Therefore, control of diseases of fish and shellfish is primarily a managerial problem. It is very important for aquacultural managers to have a thorough understanding of biology, physiology, microbiology, immunology, ecology, and therapy. It is necessary for managers to be properly trained and capable of making proper evaluations of the disease problem. Reduction of losses caused by bacterial and other diseases of fishes will require integration and evaluation of all that is known about the nature of the disease, and proper and timely application of control measures.

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