Fish Diseases and Parasites in Relation to the Environment

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Abstract: Although some diseases are not affected by subtle environmental changes, others are. Factors which may influence infection or the course of disease are: temperature, gaseous supersaturation, oxygen deficiency, mechanical and physiological trauma of the fish, malappropriate water chemistry, pollution, eutrophication, media for spore retention, and presence of intermediate hosts. Avitaminoses and neoplasias are often related to environmental changes.

Introduction

It has often been assumed that well-nourished fish living under optimum environmental conditions are more resistant to diseases than fish weakened by malnutrition or adverse environmental conditions. Although many adverse circumstances probably do weaken fish and make them more susceptible to certain diseases, the literature on this subject is meager, except for that concerning certain bacterial diseases. Further assumptions and conjectures should await the results of specific experiments and observations.

Effects of environmental factors on the etiology and course of the following diseases are discussed: viruses and bacteria, fungi, protozoa, helminths, neoplasia, and malnutrition.

Viruses and Bacteria

There is no indication that viruses are more infective for weakened than for healthy fish; in fact, the largest, healthiest-looking fish are often affected first in an epizootic. At least two virus diseases are greatly influenced by temperature: infectious hematopoietic necrosis of salmonids has never caused an acute epizootic at temperatures above 15°C (Amend, 1974), and the mortality rate of channel catfish (Ictalurus punctatus) infected with channel catfish virus was greatly reduced when the temperature was lowered from 28°C to 19°C (Plumb, 1973).

The effect of environmental stress on outbreaks of bacterial diseases was reviewed by Wedemeyer (1974) and Snieszko (1974). Warmwater fish that have overwintered at low temperatures are often susceptible to certain bacterial diseases including bacteremia caused by Aeromonas hydrophila (A. liquefaciens). Cytophaga psychrophilia causes coldwater disease of salmonids at 5–10°C. Apparently low temperatures reduce the effectiveness of the fish's cellular and humoral defenses. Coldwater disease can be controlled by increasing the temperature to 10–15°C. In Dee, a corynebacterial disease of plaice (Pleuronectes platessa), the disease is more severe at temperatures below 10°C than at higher temperatures (Roberts, 1975).

The gas blisters of gas bubble disease caused by supersaturation of the water with oxygen or nitrogen can cause skin lesions that invite bacterial invasion (Snieszko, 1974); he noted that oxygen deficiency of the water due to organic overload can apparently also pave the way for bacterial infection. J. Plumb (pers. comm.) demonstrated this relation for catfish infected with Aeromonas hydrophila,
after the dieoff of an algal bloom.

Organic overloading of water (eutrophication or pollution) also increases the numbers of certain potential bacterial fish pathogens (*Pseudomonas, Aeromonas, Vibrio, Pasteurella* and myxobacteria) and can initiate bacterial epizootics (Snieszko, 1974).

Corynebacterial kidney disease of trout in North America may occur in hard water but is more prevalent in soft water (less than 100 ppm as CaCO₃), and sublethal concentrations of heavy metals and pesticides can prepare the way for hemorrhagic bacteremias (Wedemeyer, 1974).

Documentation is lacking, but it is apparent that grave invasions of fish by ectoparasites such as *Ichthyophthirius multifiliis* (Ich) and monogenea provide an entry for bacterial pathogens. R. L. Taylor, Univ. Nevada (pers. comm.) reported that trout treated with anitbiotics for another purpose survived “Ich” infection, but that untreated trout died, indicating protozoacidal activity or control of secondary bacterial infection.

**Fungi**

Although some ectoparasitic fungi (*Saprolegnia* and relatives) are occasionally primary invaders, such infections usually follow stresses caused by temperature shock, mechanical and chemical injuries, and other infections and diseases (Hoffman, 1969). Epizootics occurring in nature are believed to be caused by spawning trauma, and by other diseases such as ulcerative dermal necrosis of salmonids.

**Protozoa**

Other than empirical observations that crowding of fish is conducive to the development and spread of ectoparasitic diseases, there have been few reports concerning the effect of environment on these diseases. Barrow (1954) observed that trypanosomal antibodies were absent in fish that were starved or held at 5°C; these fish would be prone to trypanosomiasis. Vladimirov and Flera (1974) found that fish that survived acute poisoning, and their unexposed progeny, as well as fish subjected to long-term subacute poisoning, exhibited increased susceptibility to invasion by “Ich”. The development of protozoa is influenced by temperature; Sinderman, (1965) found fewer herring infected in the colder regions off the Maine coast than in the warmer regions, and Halliday (1973) reported that it took 52 days for spores of *Myxosoma cerebralis* to form at 17°C but 120 days at 7°C. It is well known that *Chilodonella cyprini* causes epizootics at low temperatures (5–10°C) and Ich at higher temperatures (21–27°C). Sporozoa of fish are seldom a problem in fast flowing water in concrete raceways or ponds; however, they can be a great problem in earthen ponds where the accumulation of the spores in the mud, sand, or gravel creates an unfavorable environment for the fish.

**Helminths**

Attempts to study the environment of Monogenea were made by Malmberg (1956), who found more *Gyrodactylus* in eutrophic than in oligotrophic waters. Apparently many Monogenea reproduce more rapidly at low than at high temperatures (Hoffman, 1964; Malmberg, 1956; Meyer, 1970; Rawson and Rogers, 1972); probably others have higher temperature optima. Eutrophication and pollution probably affect the parasites as well as the host, but no precise studies have been made; probably the Monogenea are as sensitive as their fish hosts to sub-optimal environments.

Infection of fish with digenetic trematodes is dependent on the presence of the appropriate snail host. It is likely that the snail, parasite and fish are all greatly influenced by the environment. In addition to other factors, snails must have a source of calcium for shell building; consequently digenetic trematode diseases cannot be transmitted is soft water where snails do not exist. All three animals (hosts and parasite) are also affected
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by temperature; because most trematodes
develop more rapidly in warm than in cold
water (Hoffman, 1958), one expects trematode
infections to be heaviest in hard, warm water
where snails are present. Most cestodes
also develop more rapidly at elevated tem-
peratures (Becker and Brunson, 1967; Kuper-
man and Shul’man, 1974), and all require
invertebrate hosts such as oligochaetes or
copepods whose presence or absence depends
on the availability of a suitable environment.

**Neoplasia**

Tumorigenic agents occur naturally and as
the result of man’s activities (Wellings, 1969).
The natural agents include various heavy
metals, inorganic compounds, hydrocarbons,
radioactivity, ultraviolet light, and viruses.
At least eight neoplasias are thought to be
induced by such agents:

1. Epidermal papillomas
   These vary from small plaque-like whitish
   epitheliomas to thick branching folds of
   epidermal cells supported on a connective
tissue stroma. They have been reported from
   barbels, *Barbus fluviatilis*; smelt, *Osmerus
eperlanus* and *O. mordax*; bullheads, *Ictalurus
   nebulosus*; eels, *Anguilla anguilla*; white croa-
ters, *Genyonemus lineatus*; dwarf gouramis,
   *Colisa lalia*; Japanese gobies, *Acanthogobius
   floridus*; flathead soles, *Hippoglossoides
   elassodon*; and starry flounders, *Platichthys
   stellatus* (Wellings, 1969). Probably most of
   these papillomas are virus induced. More
   experimental work is needed on the etiology.
The possible role of ectoparasites in the
transmission of virus-induced neoplasias has
not been proven.

2. Mesenchymal tumors
   Fibromas, fibrosarcomas, leiomyomas, and
   neurilemmomas have been reported several
times in isolated populations of goldfish, *Caras-
sius auratus*. I saw a typical case involving
several fish in a long greenhouse pond in
about 1968. Cursory observation suggested
that the tumors were caused by heredity
factors or environmental agents, or both.

3. Spindel cell sarcomas of walleyes
   Multiple skin sarcomas were observed on
   walleyes, *Stizostedion vitreum*, by R. Walker
   in New York. Electron microscopy showed
cytoplasmic virus-like particles.

4. Lymphosarcoma
   Lymphosarcomas have been seen in the
   kidney, but more often in the jaws, tongue,
   pharynx, and gills of northern pike, *Esox
   lucius*, in North America and Ireland. The
tumors are composed of sheets and cords of
round cells with basophilic ovoid or round
nuclei and little cytoplasm. The relatively
high incidence suggests a viral etiology.

5. Osteoma
   Vertebral osteomas of the sixth to eighth
caudal vertebrae of red tail, *Pagrosomas
   major*, are thought to be genetic or environ-
mentally induced.

6. Nerve sheath tumors
   Tumors resembling human neurilemmomas
   were observed in snappers, *Lutianus* spp.,
   from Tortuga. Genetic factors or environ-
mental agents are thought to be responsible.

7. Undifferentiated sarcomas
   A viral etiology is thought to be responsible
   for these visceral tumors of the aquarium
   fish, *Poecilia reticulatus* and *Pristella ridlei*.

8. Experimentally induced chordomas
   Tumorous overgrowths of physalliferous
cells and fibroblasts were induced in teleost
embryos by beta-aminopropionitrile in water.

**Nutritional**

The absence of a natural essential food
ingredient in a pond can be an environmental
condition causing a nutritional disease. In
channel catfish farming it was long assumed
that if fish held in earthen ponds were sup-
plied incomplete commercial diets they would
find enough trace foods to supply all of their
requirements. This proved erroneous; many
nutritional deficiencies became apparent, par-
ticularly in cage culture. Nutritional deficien-
cies were recently reviewed by Lovell (1975),
Snieszko (1972), and Ashley (1972).

Of the nutritional diseases, vitamin deficiency
diseases are probably best known because some of the disease signs are spectacular. In fish, as in other animals, vitamin deficiencies often increase susceptibility to infectious diseases (notably *Aeromonas hydrophila*) and ectoparasitic infections. Anemic Atlantic salmon were more vulnerable to ichthyophthiriasis than were those whose anemia was cured with supplemental vitamins A and B (Malikova et al., 1961).

As an example, Table 1, modified from Lovell (1975), shows the responses of channel catfish fingerlings to vitamin deficiencies.

Carcinogens in the food can lead to neoplasias. The recent epizootics of hepatoma induced by aflatoxin, a mycotoxin from contaminating *Aspergillus flavus*, provided an excellent opportunity for study (Ashley, 1969).

**Conclusions**

Although much more experimental work is needed, the following somewhat tentative conclusions can be drawn from the above records: 1. Temperature is a very important factor in the environment—it may effect the disease agent, fish, or other host. 2. Viruses attack healthy non-stressed fish, but bacteria, fungi, and helminths often attack debilitated fish more readily than healthy fish. 3. Eutrophication, pollution, and malnutrition often are precursors to certain bacterial diseases, but helminth diseases are dependent on all the factors necessary to produce the various hosts in large numbers. 4. Some diseases are dependent only on bringing the disease agent and fish together, and are not influenced by the environmental factors mentioned. 5. Malnutrition, such as avitaminosis, due to insufficient natural food, is often related to the environment. 6. Neoplasias may be induced by certain chemicals and viruses in the environment.

**References**


Becker, C. D., and W. D. Brunson. 1967. *Diphyll-


Discussion

J. E. Halver: We have found onset of bacterial diseases first in nutrient deficient groups of fish—doesn't nutritional status determine degree of resistance to many bacterial rickettsial, and parasitic diseases?

H. K. Dupree: This is not well documented, but the observations of many indicate that malnourished fish are more susceptible than well nourished fish to bacterial and certain parasitic diseases. This was clearly shown by Malikova et al. (1961) in their work with vitamins A and B and Icthyophthirius multifiliis infections. A series of experiments in which vitamin deficient fish and well nourished fish are challenged with various pathogens would be very rewarding.

K. Wolf: Ichthyophthirius is a ubiquitous parasite which causes severe loss of fishes in most parts of the world. Would you please comment on the current work at Stuttgart, Arkansas, which has to do with control of Ichthyophthirius multifiliis infections. A series of experiments in which vitamin deficient fish and well nourished fish are challenged with various pathogens would be very rewarding.

H. K. Dupree: Due to reconstruction of the parasitology laboratory, work on Ich is still in the planning stage. However, in preliminary work, G. L. Hoffman and R. E. Putz...
have shown that drug screening can be done in vitro, using tomites. R. Heckman at the parasitology laboratory at Brigham Young University, Provo, Utah, has devised similar tests independently. Dr Hoffman will try to find the best available control in three-categories: (1) chemical additive to the water, (2) systemic protozoacide, and (3) drug control of secondary bacterial infections.

T. Kimura: According to your paper and some other reports, the corynebacterial kidney disease of trout is believed to occur only in soft water. However, recently I found an outbreak in salmon reared in sea water. The initial infection may have occurred in fresh water, but serious damage was observed several months after transplantation from fresh water to sea water. This disease is considered to be one of the problems in sea water cultivation of salmon. Have you any information on this problem?

H. K. Dupree: I can only conjecture because I know of no reports of sea-borne kidney disease. Because kidney disease is often latent, the smolts probably were infected before reaching salt water. Kidney disease has been a problem in our Pacific salmon but, insofar as I know, has been a problem only in the freshwater phase of the young fish.