1978

MYCOBACTERIOSIS (TUBERCULOSIS) OF FISHES

S. F. Snieszko
U.S. Fish and Wildlife Service

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S. F. Snieszko

U.S. Fish and Wildlife Service
National Fisheries Center--Leetown
National Fish Health Research Laboratory
Kearneysville, West Virginia 25430

FISH DISEASE LEAFLET 55

UNITED STATES DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Division of Fishery Research
Washington, D. C. 20240

1978

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[1]Revision of *Fish Disease Leaflet* 7, Fish mycobacteriosis (tuberculosis), by Thomas J. Parisot and James W. Wood (1970).

INTRODUCTION

Mycobacteria are widely distributed in nature. They are abundant in the soil, on the surface of plants, on the skin of vertebrates, in human food (e.g., milk and butter), and in animal feeds. Most mycobacteria are saprophytic, but some species are highly pathogenic and cause diseases such as tuberculosis and leprosy in humans, and similar diseases in mammals, birds, reptiles, amphibians, and fishes.

Mycobacteria that cause diseases of fishes differ considerably from those that cause diseases in humans and other mammals. Therefore, to avoid association between tuberculosis in mammals and mycobacterial infections in fishes, it is better to call the disease "mycobacteriosis of fishes."

Mycobacteriosis is rare in wild freshwater food and game fishes. It is more frequent in wild marine fishes, and most frequent in cultured freshwater and marine captive or ornamental fishes. Mycobacteriosis is a fairly common and feared disease in large public aquariums.

In the 1950's, Pacific salmon returning to fresh water to spawn showed an increased incidence of the disease. The incidence was highest in salmon that had been maintained and fed in hatcheries for a year or more before release. While in the hatcheries, the young salmon were fed food containing raw viscera removed from adult salmon in fish canneries. Since some of the viscera contained mycobacterial lesions, the fish hatcheries were unknowingly contributing to the increase of mycobacteriosis for several years. When the addition of raw, unsterilized viscera to fish food was discontinued, mycobacteriosis was almost completely eradicated in Pacific salmonids.

ETIOLOGY

Fish pathogenic mycobacteria belong to the order Actinomycetales, family Mycobacteriaceae, and genus *Mycobacterium*. Fish mycobacteriosis should not be confused with nocardiosis, which is caused by *Nocardia asteroides*, a bacterium that also belongs to the order Actinomycetales.

Two species of mycobacteria that are considered as widely distributed and important pathogens of fishes are: (1) *Mycobacterium fortuitum* which is capable of causing disease in humans, cattle, and all cold-blooded vertebrates; and (2) *M. marinum*, which was originally isolated from diseased marine fishes and occasionally is also pathogenic to humans (Runyon et al. 1974). The differences between them are relatively small (Otte 1969). *Mycobacterium marinum* grows more slowly and produces orange pigment if exposed to light; *M. fortuitum* grows faster, and produces creamy-colored growth. Both are capable of causing disease in all vertebrates, including humans. *Mycobacterium marinum* is usually found in tropical saltwater fishes and *M. fortuitum* in freshwater fishes.

Ross (1960) isolated, from an epizootic of mycobacteriosis in chinook salmon (*Oncorhynchus tshawytscha*), a mycobacterium that produced water-soluble purple pigment, which he named *M. salmoniphilum*. It seems likely, however, that this

form was a variant of *M. fortuitum* (Ross 1970). Whereas fish pathogenic mycobacteria usually are easily isolated and grow well in culture media, the isolation of *M. salmoniphilum* was very difficult. Once it was isolated and cultured, however, further transfers grew well. Salmon inoculated with pure cultures developed gross lesions within several weeks. Re-isolations were made easily from these lesions. Even though the liver and other tissues of naturally infected chinook salmon contained large masses of mycobacteria, these fish were in relatively good condition and survived for several years in the ocean. Difficulties in obtaining successful primary isolation could perhaps be explained by the death of most of the mycobacteria by the time the infected fish returned to fresh water to spawn. Another possible explanation is that the mycobacterium isolated was different from the one which was present in large numbers, but would not grow on the culture media used.

SIGNS OF THE DISEASE

The external gross signs of mycobacteriosis may vary, depending on the species of fish affected and the water temperature. Usually in dense fish populations held at relatively high temperatures the progress of the disease and frequency of signs increase. Among these signs are emaciation, loss of appetite, sunken abdomens, shallow grayish irregular ulcerations, fin rot, deformities of the vertebral column and mandible, exophthalmos, and loss of one or both eyes. Fish become listless and show difficulties in maintaining balance.

Some of the diseased adult Pacific salmon were smaller and more vividly colored than the others that returned to fresh water to spawn. Such salmon usually had undeveloped gonads. In contrast, diseased ornamental fishes usually lose their vivid coloration.

The internal signs are more characteristic. They consist of the presence of small grayish tubercles or nodules in the liver, spleen, and kidney. These nodules are typical granulomas, filled with large masses of mycobacteria.

Pathogenesis of mycobacteriosis in fishes is not known. It seems likely that considerable destruction of internal organs results in emaciation and death. When there are extensive open dermal lesions it seems likely that, as in corynebacterial kidney disease (Hunn 1964), plasma proteins are lost. It is not known whether the mycobacteria in fish lesions produce toxins.

DIAGNOSIS

Diagnosis of mycobacteriosis is relatively easy. Lesions caused by these bacteria contain rod-shaped, gram-positive bacilli. Differentiation from other gram-positive rods is made by the acid-fast (Ziehl-Neelsen) staining method. Establishing the presence of acid-fast bacteria in a lesion is sufficient for routine diagnosis.

Mycobacteria may be isolated on special media that are commercially available. Separation of *Mycobacterium fortuitum* from *M. marinum* requires culturing on differential media and performance of numerous tests.

Nocardia asteroides, which also causes infections in fishes, is also gram-positive and partly acid-fast, and is easily grown on culture media. It may occasionally be mistaken for a mycobacterium because of these similarities.

SOURCES AND RESERVOIR OF INFECTION

Mycobacteria are common in nature. The obligate pathogens, such as the human tubercle bacillus, probably survive in infected humans and perhaps in other mammals. The fish pathogenic bacteria are probably opportunistic pathogens that may survive outside infected hosts. This viewpoint is supported by the observation that humans can become infected from contact with diseased fishes, or at swimming pools, or even at sea beaches.

Massive outbreaks of mycobacteriosis in salmonids raised in hatcheries and fed raw salmon viscera indicated that some wild salmon must have been infected and that mycobacteria present in these fish were the source of massive infections in hatchery fish fed contaminated food. Therefore it is assumed that infected fishes are the main sources and reservoirs of mycobacteria.

MODE OF TRANSMISSION

It is well established that infection is transmitted by the oral route. It has also been found that fish and humans can be infected through skin abrasions.

INCUBATION PERIOD

The incubation period varies greatly and depends on susceptibility, temperature, and the severity of exposure. It is difficult to specify the length of incubation (the time from infection to the appearance of the first signs of the disease). In salmon infected by the oral route, the incubation period may last for several years. In ornamental fishes kept in somewhat crowded aquariums and at higher temperatures, it may last only a few weeks or months.

PERIOD OF COMMUNICABILITY

Once a fish becomes infected, some of the mycobacteria in the lesion survive until the fish dies, and probably for some time after the carcass decomposes. It is safe to assume that any infected fish is a likely source of infection.

GEOGRAPHIC AND HOST RANGE, AND ECONOMIC IMPORTANCE OF MYCOBACTERIOSIS

Fishes with mycobacteriosis are found worldwide, in all seas and occasionally in fresh water. All teleost fishes should be considered as susceptible to infection. The economic importance of the disease is another matter. I am not aware of significant outbreaks of mycobacteriosis in any wild or cultured freshwater salmonids. In pond food fishes mycobacteriosis is relatively rare. Tubercular lesions have occasionally been found in marine coldwater fishes and specimens with mycobacteriosis are common among ornamental tropical marine fishes. Outbreaks of mycobacteriosis occur occasionally in cultured freshwater cyprinids. The first case of mycobacteriosis was seen in carp (*Cyprinus*

carpio) in a pond in France. Outbreaks in goldfish *(Carassius auratus)* have also been reported--including a recent one in Georgia.

Mycobacteriosis is an important disease in saltwater aquarium fishes and has been reported from large public aquariums. It is also present in ornamental freshwater fishes. Crowding contributes to the severity and frequency in outbreaks among fishes.

Occasionally people handling ornamental fishes become infected with bothersome skin lesions, which eventually heal spontaneously.

A recently reported human infection in Australia was treated effectively with sulphamethoxazole potentiated with trimethoprim (Kelly 1976).

METHODS OF CONTROL

Prevention

Prevention is thus far based solely on avoidance of infection. Therefore, suspected or infected fishes should never be introduced into a pond or aquarium. Quarantine is important in ornamental fishes.

Since infection by the oral route is well documented, food containing unsterilized fish flesh should not be used. If water is recirculated among a number of aquariums it should be continuously filtered and decontaminated by ultraviolet radiation. Mycobacteria are very resistant to the action of disinfectants--a characteristic that can be effectively used to isolate them from other microorganisms.

Treatment

Tests performed with pure cultures of mycobacteria isolated from diseased fishes show that their resistance to drugs is high. Conroy (1970) reported that the antibiotic Kanamycin mixed with food was effective in curing mycobacteriosis among ornamental fishes. The recommended dosage is 0.01% by weight, in food.

It has recently been reported that Kanamycin is absorbed from water by fishes; however, the significance of this absorption in the control of fish mycobacteriosis is as yet unknown.

ANNOTATED BIBLIOGRAPHY

Adams, R. M., J. S. Remington, J. Steinberg, and J. Seibert. 1970. Tropical fish aquariums. A source of *Mycobacterium marinum* infections resembling sporotrichosis. J. Am. Med. Assoc. 211(3):457-461.

Tropical fish aquariums are a possible, though uncommon, source for *Mycobacterium marinum* skin infections, which may assume the morphological pattern of sporotrichosis. Three patients with this condition were observed for 2 years. Shortly before onset, each patient experienced a minor abrasion on the hand before he cleaned an aquarium where many of the fish had recently died. Smear cultures of material obtained from the lesions revealed an atypical acid-fast organism, and in each case *M. marinum* was identified. A smear culture from the aquarium of one patient showed *M. marinum*, and acid-fast organisms were observed in the material obtained from the tubing of the aquarium of the other patient.

Amlacher, E. 1970. Textbook of fish diseases. T.F.H. Publications, Inc., Neptune City, N. J. 302 pp. (Transl. from German by D. A. Conroy and R. L. Herman).

Contains a well-illustrated section on piscine tuberculosis *(Tuberculosis piscium)* and a list of fish species in which this disease was reported.

Amlacher, E. 1976. Taschenbuch der Fischkrankheiten. 3rd edition. Gustav Fischer Verlag, Jena. Germany. 394 pp.

This book contains a section on *Tuberculosis piscium* that is profusely illustrated with black-and-white and color illustrations and contains detailed information on the disease.

Ashburner, L. D. 1977. Mycobacteriosis in hatchery-confined chinook salmon (*Oncorhynchus tshawytscha* Walbaum) in Australia. J. Fish Biol. 10(6): 523-528.

Incidence of mycobacteriosis in chinook salmon held in a freshwater fish hatchery at Snobs Creek in Australia was on the increase. Vertical transmission through ovarian pathway was suspected.

Barksdale, L., and H.-S. Kim. 1977. *Mycobacterium.* Bacteriol. Rev. 41(1): 217-372.

A detailed review of the genus *Mycobacterium*, including morphology, physiology, chemistry, and immunology. Taxonomy limited to the relationship between mycobacteria, *Nocardia*, and corynebacteria.

Bataillon, Dubard, and Terre. 1897. Un nouveau type de tuberculose. Comptes Rendus Hebdomadaires des Séances et Mémoires de la Société de Biologie. Tome Quatrième-Dixieme, Serie Quarante-Neuvième de la Collection. Pages 446-449.

This paper has historical value because it is the first report of tuberculosis in fishes. It reports an outbreak of mycobacteriosis in pond carp in the garden of a sanitarium for tubercular patients. Isolated cultures were not pathogenic to warm-blooded laboratory animals. They grew best at 23 to 25 C, but could be adapted to grow at 36 C.

Bernstad, S. 1974. *Mycobacterium borstelense* isolated from aquarium fishes with tuberculosis lesions. Scand. J. Infect. Dis. 6:241-246.

Four cultures of mycobacteria were isolated from three species of diseased ornamental fishes: neon tetras *(Hyphessobrycon innesi)*, dwarf guarami *(Colisa lalia)*, and veiltail goldfish *(Carassius auratus)*. All cultures were fast growing and therefore belonged to group IV of the Runyon classification. They were identified tentatively as *Mycobacterium borstelense*. Not pathogenic to white mice but pathogenic to fishes.

Clark, F. H., and C. Shepard. 1963. Effect of environmental temperatures on infection with *Mycobacterium marinum (Balnei)* of mice and a number of poikilothermic species. J. Bacteriol. 86(5):1057-1069.

Temperature greatly affected growth of this bacterium in media and had a decisive effect on production of infection in animals. In warm-blooded animals, infections developed in extremities that have a lower temperature than the main body. In cold-blooded animals the greatest pathogenicity was correlated with optimum temperature for the pathogen.

Collins, F. M., V. Montalbine, and N. E. Morrison. 1975. Growth of *Mycobacterium marinum* in the footpads of T-cell-depleted mice. Infect. Immun. 11(5):1088-1093.

Cultures of *Mycobacterium marinum* were injected into footpads of specific pathogen-free C57B1/6 mice. Some mice were depleted of T-cells (T-cells are in the thymus). Infection took place with typical immune reaction in mice with T-cells. Local immune reaction was absent but infection occurred in mice with depleted T-cells.

Conroy, D. A. 1970. Piscine tuberculosis in the sea water environment. Pages 273-278 in S. F. Snieszko, ed. Symposium on diseases of fishes and shellfishes. Am. Fish. Soc., Spec. Publ. 5.

A review describing the characteristics of piscine tuberculosis, histopathology, frequency, etiology, incidence, and control. Kanamycin mixed with fish food at a rate of 0.01% by weight was apparently effective in treatment of diseased freshwater fishes.

Conroy, D. A., and E. B. Solarolo. 1965. Sensitivity of some acid-fast bacteria of piscine origin to certain chemotherapeutic substances. J. Fish. Res. Board Can. 22(1):243-245.

Kanamycin was found to be the most effective drug both in vitro and in vivo. Detailed results of in vivo tests were not given.

Hunn, J. B. 1964. Some patho-physiologic effects of bacterial kidney disease in brook trout. Proc. Soc. Exp. Biol. Med. 117(2):383-385.

In diseased trouts, hematocrits averaged 44% below normal and plasma proteins 52% below normal. Electrophoresis indicated that the faster migrating protein fractions were most drastically reduced.

Jenkins, D. E. 1965. Current status of atypical mycobacteria. Clin. Notes Respir. Dis. 4:3-11.

This review discusses human infection with seven types of mycobacteria. *Mycobacterium balnei* and *M. fortuitum* from water or fish are the least pathogenic and diseases caused by them are most easily cured. On the other hand, *M. kansasii* causes a severe disease that is less responsive to treatment.

Kelly, R. 1976. *Mycobacterium marinum* infection from a tropical fish tank treatment with trimethoprim and sulphamethoxazole. Med. J. Aust. 2:681-682.

Mycobacterium marinum was isolated from a lesion on a human thumb and from the water of a tank of tropical fish.

Lund, J. E., and S. Abernethy. 1978. Lesions of tuberculosis in mountain whitefish. J. Wildl. Dis. 14(2):222-228.

Description of mycobacteriosis in mountain whitefish *(Prosopium williamsoni)* from the Yakima River, Washington State. Pathology described in detail. Disease was caused by an as yet unidentified slow-growing *Mycobacterium*.

Nigrelli, R. F., and H. Vogel. 1963. Spontaneous tuberculosis in fishes and in other cold blooded vertebrates with special reference to *Mycobacterium fortuitum* Cruz from fish and human lesions. Zoologica 48(3):131-143.

Mycobacteriosis is a common disease of poikilothermic animals. It has been reported in 151 species of fishes, 11 species of amphibians, and 24 species of reptiles. At the New York Aquarium, mycobacteriosis was found in 40 species of fish and was especially prevalent in Characidae, Cyprinidae, and Poeciliidae. *Mycobacterium fortuitum* is pathogenic to humans.

Otte, E. 1969. Mykobakterielle Infektionen bei Fischen--Erreger und ihre Beurteilung [Mycobacterial infections in fishes--microorganisms and their review]. Z. Fischerei N.F. 17(5-7):515-546.

A review of mycobacterial diseases of fishes. Very informative, but not available in English, except as a summary in U.S. Fish and Wildlife Service *Sport Fishery Abstracts* 15(3):248.

Parisot, T. J. 1958. Tuberculosis of fish. I. A review of the literature with a description of the disease in salmonid fish. Bacteriol. Rev. 22:240-245.

Review of previous publications, with particular emphasis on identification of the organism and description of the disease in trout and salmon. Includes an extensive bibliography.

Ross, J. A. 1960. *Mycobacterium salmoniphilum* sp. nov. from salmonid fishes. Am. Rev. Respir. Dis. 81(2):241-250.

Cultures isolated from Pacific salmon were named *Mycobacterium salmoniphilum*. This species is very similar to *M. fortuitum* and seems to be a transition form between *Nocardia* and *Mycobacterium*.

Ross, A. J. 1970. Mycobacteriosis among Pacific salmonid fishes. Pages 279-283 in S. F. Snieszko, ed. A symposium on diseases of fishes and shellfishes. Am. Fish. Soc., Spec. Publ. 5.

Review of the disease in salmonids.

Ross, A. J., and H. E. Johnson. 1962. Studies of transmission of mycobacterial infections in chinook salmon. Prog. Fish-Cult. 24(4):147-149.

The inclusion of viscera and carcasses of infected adult salmon in the diet of juvenile salmonids is considered to be the major source of mycobacterial infections in hatchery-reared fish. Mycobacterial infection of the chinook salmon by transovarian passage or contact infection at the time of fertilization was not demonstrable under controlled conditions.

Runyon, E. H., L. G. Wayne, and G. P. Kubica. 1974. Mycobacteriaceae. Pages 681-701 in R. E. Buchanan and N. E. Gibbons, eds. Bergey's manual of determinative bacteriology, 8th edition. Williams and Wilkins Co., Baltimore, Maryland.

Swift, S., and H. Cohen. 1962. Granulomas of the skin due to *Mycobacterium balnei* after abrasions from a fish tank. N. Engl. J. Med. 267(24): 1244-1246.

Granulomatous skin lesions in humans that have followed abrasions acquired in swimming pools were reported. Some incidences reached epidemic proportions. The causative organism was described as *Mycobacterium balnei* and the disease was called "swimming-pool granuloma." The case reported deals with two human infections by *M. balnei* from a tropical-fish tank. Infection caused cutaneous granulomas on hands that did not respond to treatment, but slowly healed.

Vogel, H. 1958. Mycobacteria from cold-blooded animals. Am. Rev. Tuberc. Pulm. Dis. 77:823-838.

Review of the literature and a presentation of experimental data on serology and chemotherapy. Includes an extensive bibliography.

Wood, J. W., and E. J. Ordal. 1958. Tuberculosis in Pacific salmon and steelhead trout. Oreg. Fish Comm. Contrib. 25. 38 pp.

An important monograph that contains a description of the disease and color photographs of the microorganism.

☆U.S. Government Printing Office: 1978 — 779-188/37