Fish Diseases (Rem)

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COMMON FISH DISEASES IN MICHIGAN AND THEIR TREATMENT

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This outline was prepared to assist the Fisheries Supervisor in answering questions asked by sportsmen about fish disease, and as an aid in diagnosis and control of common hatchery diseases. No attempt was made to include all parasites, diseases and abnormalities of fish because it is recognized that the time and equipment necessary to identify more than the common diseases are not available to the Fisheries Supervisor. The occurrence of fish diseases in Michigan is given more completely in a recent report by **Allison** (Fish Diseases of Common Occurrence in Michigan). A discussion of diseases of hatchery fish may be found in greater detail in a publication of the U. S. Fish and Wildlife Service (Care and Diseases of Trout by Dr. H. S. Davis).

A. Types of parasites found in fish in Michigan waters.

Only the types of common parasites of fish, and a few examples are mentioned here.

I. Protozoa

a. Ichthyopthirius. Appears as white spots on the skin of warm water fish. Occasionally on trout.

II. Copepoda.

a. Salmincola edwardsii. Gill lice on brook trout.

III. Flat worms

a. Tapeworms. Bass tapeworm, etc.

b. Trematodes. Yellow grub, black spot, etc.

IV. Round- or threadworms

a. Ancyranthus cystidicola in swim-bladder of cisco.

V. Thorny-headed worms.

a. Echinorhynchus coregoni, found by anglers in intestine, body cavity and flesh of smelt.

VI. Leeches

a. Piscicola sp. on perch.

VII. Lampreys

a. Ichthyomyzon castaneus, on fresh-water fish.

B. Life cycles of common parasites.

I. Parasites needing snails for one host.

a. Yellow grub. Clinostomum marginatum.

Adult in mouth and throat of great blue heron .... eggs hatch in water .... snail (here one parasite may develop into 1000, or more parasites) .... fish .... bird (great blue heron).

Will live for short time in man if the yellow grub from fish is eaten alive. Common cooking practices kill all grubs.

b. Black spot. Neascus sp.

Adult in intestine of kingfisher .... eggs hatch in water .... snail (multiplication) .... fish (encyst in skin or flesh as black spot) .... kingfisher.

May infest man if eaten alive. Common cooking practices kill all grubs.

c. Liver and heart cysts. Neascus sp.

Cysts here described are about 0.5 mm long, oval in shape, appear whitish in the liver. Tapeworm cysts may also be present, but they are larger and longer. Neascus sp. cysts often cover the heart so that it appears white instead of red. The life cycle is essentially the same as in black spot. Since the parasites are discarded with the entrails, there is no question of infestation of man.

II. Life cycle of fish tapeworms.

In general, the life cycle of fish tapeworms is as follows: Adult in intestine of fish, ... egg passes into water and is eaten by small water "bug" (Hyallella, Daphnia, etc.) where it develops in the body cavity into the "first" larva (procercoid) .... "bug" eaten by fish, procercoid burrows through intestinal wall to body cavity or flesh and becomes the "second" larva (plerocercoid) .... small fish eaten by large fish, plerocercoid develops into adult tapeworm in intestine of fish.

The pleroceroid of bass tape, Proteocephalus ambloplitis, is found in the liver and gonads of fish, where it does not form a cyst but continues to move around through the tissue. The plerocercoids of some fish tapeworms settle in the flesh and get to be as much as half an inch long (Triaenophorus crassus in flesh of cisco, whitefish). The grubs are destroyed by common cooking practices.

III. Life cycle of parasitic copepods (gill lice).

The gill louse of brook trout, Salmincola edwardsii, may be used as an example and is as follows:

Eggs hatch .... attach to fish (or die in 2 days if unsuccessful) .... remain on fish for 2 to 3 weeks, when they become sexually mature .... mate .... males drop off fish and die, females remain on fish .... eggs produced twice in 2½ months .... female dies.

C. Fish Disease in the Hatchery

The purpose of this section is to provide information that will aid the Fisheries Supervisor, with his limited equipment and time, to identify and control some of the fish diseases commonly appearing in Michigan fish hatcheries. Further information concerning technical descriptions of the diseases, and a more complete list of fish diseases, may be found in the references listed.

The causative organism of some of these diseases can be identified by the aid of a dissecting binocular microscope. Identification of Octomitis and the various bacteria require the higher magnification of a compound microscope. However, many of the ailments of fish can be diagnosed by gross examination of the fish, by their behavior, and by a review of their recent history as to diet, handling, water conditions, etc. Not infrequently, losses are caused by a complication of several unfavorable conditions and one or more disease organisms acting simultaneously.

I. Furunculosis

Causative Organism: Bacterium salmonicida, a bacterium which is a short rod 2 to 3 microns long with rounded ends.

Appearance of fish: Furunculosis means boil or furuncle disease and fish affected with this disease often have open ulcers and blisters containing blood and pus, which originate deep in the muscle. Another disease, called ulcer disease, also makes ulcers on the skin of fish, but they do not extend into the muscle tissue as does furunculosis.

Boils and ulcers do not always accompany attacks of furunculosis and some other symptom must be sought. The bacteria are carried in the blood vessels of the fish and frequently cause tiny haemorrhages which may be found in the lining of the body cavity, the fat around the stomach, and the swim or air bladder. The large intestine commonly appears highly inflamed and blood and pus may be pressed out through the vent of dead fish.

Fish may be infected with furunculosis but show a loss only slightly above normal. However, a sudden, severe loss may result by normal handling or transfer operations. For this reason small but chronic losses should be thoroughly investigated for this disease so that treatment can be initiated as early as possible.

Transmission: Bacteria are spread through the water by infected fish, from open ulcers or with the feces. Brook, and brown trout, most commonly affected by the disease, may not exhibit any of the symptoms but still harbor the bacteria and actually be carriers. Rainbow trout, which seldom show active symptoms of furunculosis, may also carry the bacteria in their intestines and thus aid in spreading the disease. The bacteria may infect fish either through the intestine when taken in with food, or through small breaks in the skin. Some workers now believe that the tiny wounds made by Gyrodactylus are used by the bacteria to gain entrance to the blood of fish, and that by treating frequently to keep Gyrodactylus infestations to a minimum, attacks of furunculosis can be reduced.

The bacteria will remain alive for some time in muck and debris of high organic content and will infect fish if contact is made.

Control measures: Furunculosis occurs occasionally in our streams, usually during hot weather. No means of control is known for epidemics in nature. However, where fish are confined under supervision in hatcheries, control measures can be applied.

Although furunculosis has been known and studied for more than 100 years, no means of control was known until Drs. Gutsell and Snieszko discovered in 1946 that sulfamerazine would destroy the bacterium. At first it appeared that the drug would completely cure furunculosis but recent studies indicate that all the bacteria are not killed. However, losses from this disease can be kept at a minimum by use of sulfamerazine.

In Michigan the dose recommended for treatment of furunculosis when it has developed to the point of causing loss of fish, is 16 grams (8 level teaspoonfuls or 2.7 tablespoonfuls) of sulfamerazine per each 100 pounds of food. This mixture is fed for 4 consecutive days and the dose reduced to 8 grams of the drug per 100 pounds of food, fed for the following 10 days. For full benefit of the drug and for prompt control of the disease, it is important that the first four feedings be given on consecutive days.

During periods when past experience has shown that furunculosis may appear, a prophylactic dose of 16 grams of sulfamerazine per 100 pounds should be fed once every 7 days without fail.

Sulfamerazine is insoluable in water and therefore allowing the mixture of food and drug to stand overnight will not aid in the mixing. The drug is most easily distributed in the food when it can be first mixed with dry feed. With present food conditions little dry food is used so it must be added directly to meat. This has been successfully done by suspending the drug in water in a glass fruit jar, having a lid perforated with a few holes. The contents of the jar are sprinkled into the food as it is being mixed in a mixer. Shaking the jar to eject the contents causes the drug to be well distributed in the water in the jar. If all fish are to receive adequate amounts of sulfamerazine, it is important that it be well mixed throughout the food.

II. Fungus:

Causative Organism: *Saprolegnia parasitica*, a water mold.

Appearance of fish: The fungus appears as tufts of white or gray threads and may be found on any part of the fish's body, extending outward for one-quarter of an inch or farther. It is attached to the fish by small root-like filaments which may extend through the skin into the tissue below. As the filaments grow through the skin, the surrounding tissues die, forming areas of dead skin sometimes causing the fish to die.

Transmission: Saprolegnia reproduces by forming great numbers of very tiny spores which are liberated into the water. The protective covering of mucus and skin effectively prevent a healthy fish from these spores, but if they contact the skin of a fish where it has been broked and the mucus removed, they adhere and begin growth. For this reason, fungus is usually considered a secondary infection because some agent, disease, predator or rough handling, caused the break in the skin.

Control Measures: Treatment by dipping in a 1/15,000 solution of oxalate crystals of malachite green (zinc free) for 30 seconds, or a pond treatment (described in section D) with the same chemical is effective. If the growth is heavy, two or three dips at intervals of 2 days may be necessary.

Prophylactic measures would necessarily be directed towards preventing injury to the fish. The worm, Gyrodactylus, will injure the skin of fish so that the fungus spores can gain foothold. Regular pond treatments with formalin would eliminate this parasite.

III. Gyro:

Causative Organism: Gyrodactylus elegans, a parasitic flatworm (trematode) about 0.4 mm long, armed at its posterior end with an attachment organ consisting of a pair of large hooks, or anchors, which are surrounded by a disk-like organ bearing numerous small hooks along its outer border. Can be seen by the aid of a binocular dissecting microscope.

Appearance of fish: Fish with heavy infections appear distinctly irritated, frequently rubbing their sides on the bottom of the pond. Frequently the fins will be frayed, particularly the dorsal fin, and growths of fungus may be present. Microscopical examination of small scrapings from a frayed fin or fungused area placed in a drop of water should be sufficient to demonstrate the presence of this parasite.

The importance of this parasite is not its direct affect on fish, unless the fish is infested with an exceptionally large number of worms, but in the possible secondary infections that may arise (furunculosis; fungus).

Transmission: Gyrodactylus normally stays on one fish, unless dislodged accidentally, when it is carried along by water currents and dies unless it comes into contact with another fish. In hatchery ponds crowded conditions enhance its chance of attaching to another fish. Each worm has both male and female reproductive organs, hence every worm is a potential mother. The life history is very simple since Gyrodactylus does not lay eggs but bears live young that are fully armed with organs of attachment and are able to forage for themselves immediately after birth. Thus it is easy to understand how a heavy infestation can quickly be established.

Control measures: Gyrodactylus can easily be killed by dipping for 1 minute in a 1 to 500 solution of acetic acid or by a pond treatment for 1 hour with a 1 to 4000 concentration of formalin. The latter method is used in Michigan and is described in detail in section D.

Weekly treatment with formalin is prophylaxis that should be practiced where ever possible.

IV. Gill Disease

Causative Organism: Bacterial gill disease is caused by bacteria that are rod shaped and form long (0.1 mm.) filaments which usually lie side by side on the surface of the gills. Due to the difficulty of producing this bacteria on culture media, it has been but incompletely studied and has not been given a specific name.

Injury to gill filaments of very young fish by sharp suspended particles may also cause a condition known as "gill disease".

Diet also has been accused of causing a "gill disease" having the same symptoms as bacterial gill disease.

Appearance of fish: In Michigan, most losses from gill disease are sustained by trout fry from ½ to 1 inch in length and rainbow trout appear to be most frequently attacked. The fish affected are sluggish and have no appetite. At first, the gills are deeply red, swollen and congested. Later, the filaments become fused together, appearing as solid plates instead of separate filaments. Increased secretion of mucus by the gills is noticeable and this further complicates the condition because particles of dirt and other debris in the water adheres to the mucus and causes additional congestion, making it more difficult for the fish to breathe.

Transmission: Certain fish, especially older fish that appear to be in perfect health, may carry small numbers of bacteria on their gills and be a source of infection to the smaller individuals when they are carried to the fish by the water. It is thought that the disease is carried over from one year to the next by these older fish.

Control Measures: A recently developed chemical, pyridylmercuric acetate, has proven to be very effective for the control of bacterial gill disease and is less toxic to fish than some chemicals previously used. It is used at a dilution of 1 to 500,000 for a period of one hour. In treating fish in troughs, the weight of the water in the trough, when lowered about two inches below normal depth, is computed in grams, and the amount of PMA (pyridylmercuric acetate) equal to 1/500,000 of that weight is determined. For instance, if the water weighs 225,000 grams, it will require 0.5 grams to give a dilution of 1 to 500,000. To apply the treatment, inlet water is shut off, the water level lowered two inches and held at that level during treatment. The PMA is dissolved in one gallon of water, sprinkled uniformly over the entire length of the trough and allowed to stand for one hour. While the PMA is being added to the trough, the water in the trough should be stirred with a small paddle or stick to insure thorough mixing.

Treatment of bacterial gill disease with copper sulphate and with potassium permanganate has also been recommended. Details may be found in "Care and Diseases of Trout" by Dr. H. S. Davis.

Stations that have yearly recurrences of gill disease with concurrent heavy losses should anticipate such attacks and begin weekly prophylactic treatments before the disease has become established.

V. Octomitus salmonis.

Causative Organism: Octomitus salmonis is a protozoan (one-cell) parasite belonging to a group called Flagellata because they possess several long hairs (flagella) which they lash back and forth to produce locomotion. Octomitus is pear-shaped and must be viewed through a compound microscope to be identified.

Appearance of fish: Octomitus ordinarily affects fish less than 3 or 4 inches in length, larger fish showing no ill effects from an infestation. The parasite lives in the intestine of the fish, sometime entering the epithelial cells of the intestine and pyloric caeca. It appears in two forms, an acute, high-loss form, and a chronic form in which the fish gradually weaken and become very inactive, finally dying. Typically, the disease in the acute form appears shortly after the young fish begin to feed. The fish demonstrate their distress by rapid whirling or corkscrew movements, sometimes resting on the bottom of the trough and bend their bodies spasmodically from side to side. Although other intestinal upsets may cause the fish to perform similar antics, these should always be regarded with suspicion.

The more common, chronic form is characterized by loss of appetite and vitality. "Pin-heads", fish with small, thin bodies and a large head, are common and regarded as a fairly reliable symptom of the disease. Another indication of Octomitus is the spotty nature of its outbreaks in hatchery troughs. It will appear simultaneously, scattered through the hatchery in troughs that are not connected in any way.

Transmission: Octomitus forms cysts that can live in the water for days or weeks. Fish become infested when the cysts are swallowed. Only one cyst is necessary to cause a heavy infestation in fish because the protozoan multiplies by dividing in half, and each half also dividing when it becomes mature, etc.

Control Measures: Since the protozoan lives in the intestine, the fish must be treated internally. There are several drugs that have been added to the diet to control Octomitus (calomel, carbon tetrachloride) but the most successful one is carbarsone. In Michigan we use 1 gram of carbarsone per 1 pound of food (1 level teaspoonful of carbarsone weighs 4 grams). The drug should be well mixed in the food and fed immediately after mixing. The fish should receive this drug for 4 consecutive days. In case the parasites have become established within the cells, they cannot be reached by the treatment.

An unfortunate circumstance in the treatment of this disease is that the sick fish lose their appetite and no one has ever explained how to get the drug into fish that won't eat, except by individual force-feeding which is impossible with great numbers of fish ½-inch long. Thus it is important to recognize the disease in its early stages before it has spread to the entire stock so that treatment can be instituted before the fish lose their appetite.

At stations where this disease appears at approximately the same time every year, prophylactic measures are important. Since carbarsone is not toxic to the fish, they can be treated every week during the danger period.

VI. Fin Rot:

Causative Organism: Believed to be a rod-shaped bacterium. Compound microscope necessary for identification.

Appearance of fish: The fins of a fish gradually rot away. The dorsal fin is usually attacked first, and other fins may become involved later. Infection may begin in the caudal fin and it may be completely rotted away. Davis reports, "Ordinarily the first noticeable indication of the disease is a more or less distinct white line along the outer margin of the fin. This white streak gradually moves toward the base of the fin, while at the same time the outer margin becomes badly frayed, owing to the disintegration of the tissue between the frayed fins. This process continues until eventually the entire fin may be destroyed."

In rainbow trout, the dorsal fin may develop a similar white, thickened area along the margin, but this is due to scar tissue from irritation by the tendency of the species to nip each other when overcrowded conditions prevail. By looking at the fin with a hand lens, the margin will appear smooth instead of ragged as in fin rot.

Transmission: Bacteria are transmitted from one fish to another through the water. Crowded conditions make the transfer relatively sure. Since the bacteria invades the tissue, badly infected fish cannot be cured because chemicals applied externally do not reach the bacteria. Such fish should be destroyed because if not, they will reinfect clean fish after a treatment has been given.

Control Measures: In the case of fin rot, the best method of control is to dip the fish in a 1 to 2000 solution of copper sulphate for 1 or 2 minutes. If the infection is severe, it may be necessary to repeat the treatment several times at intervals of 24 hours to completely check the disease.

Pond treatments have been used with varied success, but where there is danger of the bacteria invading tissue, and thus out of reach of the chemical, it is best to be sure that each fish has received the recommended dosage of chemical.

VII. Diet:

This section will not include specific diets to be followed or detailed analyses of diets. Information of that nature can be found elsewhere in detail far beyond application in Michigan hatcheries because of present limited availability of trout food at feasible cost. It must be remembered that although certain diets may be successful elsewhere, the great volume of food needed in our state and the great variety of conditions from one station to another gives rise to problems not encountered elsewhere. Consequently, only general suggestions for maintaining a fundamental diet will be given here. A healthy, well fed fish is more resistant to disease than a poorly fed, weak fish. The diet must be varied to some extent to include necessary vitamins, because, for example, fish may be well fed on a diet high in pork content and still be weak because of dropsy and fatty degeneration of the liver that was caused by too much pork. Diets containing high percentages of other foods also lead to conditions that weaken the fish. In other words, quality of the food is as important as quantity in the production of healthy fish.

The following suggestions are only a few of the many that could be made.

a. Fresh meat should be fed at least once every week. Lack of fresh meat causes anemia in trout. Rainbow trout are more sensitive to this lack than are brook or brown trout.

b. In the absence of ocean products or iodized salt in the diet, 1 tablespoonful of a mixture of 1 percent iodine dissolved in a 1 percent solution of potassium iodide should be thoroughly mixed with every 50 pounds of food to prevent thyroid deficiency and goiter. This condition has been common in our hatchery fish during the past few years.

c. A steady diet of any one product should be avoided, unless the food contains a good variety of essentials, as does the Cortland formula. The results and weakening effects of a deficient diet may require a long period before any effect on the fish is noted, and may never be recognized by the fish culturist but show up only as increased losses from diseases that are usually considered of little importance.

d. Brook, brown and rainbow trout are different species of trout and their nutritional needs are slightly different. Although a good balanced diet is usually sufficient for all species, steady diets of one product may satisfy one species but not the others. In the present predicament, where good trout foods are hard to obtain, variation of the diet is especially important. One example of the difference in nutritional requirements has been demonstrated in Michigan hatcheries, and in some of the Federal hatcheries, during the past several years (1946-47-48). It was found that yearling brook trout fed on a diet containing more than 25 percent horse products (liver, hearts or meat) developed blindness from which they do not recover, accompanied by light body color, but the brown and rainbow trout were not affected.

e. The addition of one tablespoonful of mineral oil per 15 quart pail of feed every two weeks will help to avoid intestinal disturbances due to faulty elimination.

f. Under no conditions should spoiled meat be fed to fish.

VIII. General observations on prevention of fish disease:

Cleanliness around the hatchery is the first step in reducing fish disease. The meat room should be kept clean for obvious reasons. Soaps, brushes, and other tools used in the troughs and ponds should be regularly disinfected, and a complete set assigned to groups of troughs or ponds to prevent transfer of disease from one trough or pond to the entire hatchery. Tools used in a pond or trough containing sick fish should be used only in that enclosure and thoroughly disinfected after each usage. In-service-training of men responsible for cleaning the screens and feeding the fish will teach them to recognize conditions that warrant the isolation of certain troughs or ponds to prevent the spread of disease.

Some ponds accumulate silt and muck, mixed with uneaten food more rapidly than do others. Accumulations of this kind harbor bacteria that cause fish disease and trouble is sure to follow if these conditions are permitted to persist.

The transfer of fish and eggs from one hatchery to another may be responsible also for transfer of disease. Diseased fish should not be transferred to another hatchery under any circumstances. Eggs shipped in should be treated with a 1 to 2000 solution of neutral acriflavine to kill bacteria on their external surface. The treatment should be made in a special treating box made so that a stack of egg trays can be immersed in the solution. To a treating box holding 55-56 quarts, add 745 cc. of a 3.5 percent solution of neutral acriflavine. (1634 cc of 3.5 percent solution, sufficient for treating 400,000 trout eggs in this box, is made by dissolving with slight heat, 58 grams of neutral acriflavine in 1634 cc of water). After treatment of each 100,000 eggs, reinforce with 300 cc. of 3.5 percent neutral acriflavine. Eggs should remain in the treating box for 30 minutes, during which time they should be rolled 3 or 4 times to insure treatment of all surfaces. Eggs should be carefully picked before treatment.

Finally, good common "horse sense", and a realization that diseases, whether in man or fish, may be caused by definite organisms and that diseases are spread by contaminated water, tools, clothing, and hands will go far in control and prevention of fish disease in hatcheries.

D. Mechanics of treatment of fish disease.

I. Introduction.

The use of chemicals and drugs in treatment of fish disease always involves computations of quantities of materials. Since the quantities to be used are often in different measuring systems, conversion tables most frequently used in this work are included in the text.

In the use of chemicals to treat fish disease, several fundamentals must be constantly borne in mind. First, fish are entirely dependent upon water for their very existence and any changes in its physical properties affect them. Temperature, oxygen content, chemicals, etc., are important variable constituents to which fish have very definite tolerances. Higher water temperatures increase the metabolism of fish and when the temperatures near the upper limit of tolerance, weaken the fish. Consequently when fish are being treated with chemicals for disease, water temperature must always be considered. If the instructions are for a dip of from one to three minutes in a certain solution, the shorter time should be used with high temperatures. If there is any question in regard to the length of time fish should remain in a treating solution, always try a few fish first at different lengths of time before subjecting a great number of fish to the treatment so that if conditions will not permit a longer treatment the loss will be held to a minimum. The same caution should be used when you are using a treatment to which you are unaccustomed. Some treatments recommended have been developed to cure certain diseases without killing the fish and frequently the margin of safety is relatively small, that is, the concentration of the chemical necessary to kill the causative organism is very near a concentration that will also kill the fish.

That is why directions should be closely followed and proper concentrations used. The wrong way to test new treatments, as has been practiced, is to treat all the fish at once, but with a greatly reduced amount of the chemical. This method results only in a waste of the chemical and, since it does not affect the disease, the operator has no further confidence in the chemical and the whole treatment is a failure.

Some chemicals react slightly differently in various waters. Since the water supply for our various hatcheries comes from different sources and watersheds we can expect slight modifications in treatment of fish disease to be necessary. Copper sulphate is one of the most variable chemicals that we use. Added to some waters, it quickly turns to a cloudy, powder blue color. The light blue color is due to copper carbonate formed from the copper sulphate by the water. Copper carbonate is tolerated in high concentrations by fish, ... and also fish disease organisms! Therefore, a larger amount of copper sulfate can be used in waters of this type than in waters where the added copper sulphate remains clear blue, and thus remains as sulfate and with high toxicity to both fish and disease. In using the dipping method of treatment, this variability can be overcome by the addition of enough acetic acid to the solution in the dipping box to prevent formation of the light blue carbonate. Then definite treating times can be worked out, with only temperature as a variable factor.

Prophylaxis is an important part of fish culture that is not practiced as generally in Michigan as it should be. The results are not immediately evident and so it is not spectacular, and it is quite impossible to prove that if the fish do not contract any disease, it was because of prophylaxis. Also, just as in human medicine, disease occasionally breaks out in spite of any preventative that is used. However, prophylaxis does keep the fish in a more healthy condition at all times so they can withstand better any disease that might break out. As has already been done successfully at some stations, a study of the times of the year that certain diseases regularly occur can be made and prophylactic treatment for that specific disease begun before the disease is scheduled to appear.

II. Dipping Method:

The dipping method is used only for treatment of external diseases and consists simply of immersing the fish in a chemical bath for short periods of time. A dipping box and basket is used by some hatcheries for treatment of fish by this method. The basket should be made with wooden slides and a screen bottom, and of a size that it will fit into the dipping box with only a small amount of surrounding room. After the dipping box has been charged with the correct mixture, fish are placed in the dipping basket and transferred into the mixture. When the correct time for treatment has elapsed, the dipping basket with the fish is lifted out, placed in fresh water and the fish transferred to the trough or raceway. The advantage of the dipping box over the practice of holding fish in a net while being treated is that the fish have more freedom of movement, allowing better contact with the chemical, and they are less liable to be hurt by crowding. If a dipping box is used, a definite quantity of water and chemicals can be used each time rather than computing amounts each time as when a different sized container is used each time. Another advantage of the dipping method is that exact proportions of chemicals and water can be used for definite periods of time, as opposed to close approximations of proportions necessarily used in the pond treatment. The principal disadvantage to dipping is that the fish must be handled. In cases where small fish are held in a large pond, it is impracticable to try to collect all of them for dipping. In cases of extreme hot or cold weather, picking up the fish may do as much or more damage than the disease. Because the fish do not have to be handled, the pond treatment method should be used whenever possible.

Dip treatment is used for external diseases only. The following table includes the chemicals commonly used:

Disease	Chemical	Concentration	Time
Gyrodactylus	*Acetic Acid	1/500	1 minute
Fin Rot	Copper Sulfate	1/2000	1-3 minutes
	Malachite Green	1/15,000	1 minute
Gill Disease	Copper Sulfate	1/2000	2 minutes
Fungus	Malachite Green	1/10,000	2 minutes

*Method now obsolete. Replaced by prolonged treatment, as noted later.

The following table may be useful in making up the solutions needed:

The following table gives the weight in <u>grams</u> of the chemical and the volume of water to which it must be added to give the desired dilution:

Dilution	1 gal	2	3	4	5	6	7	8	9	10	15	20	25
1:1000	3.78	7.57	11.36	15.14	18.93	22.71	26.50	30.28	34.07	37.85	56.78	75.70	94.6
1:2000	1.89	3.79	5.68	7.57	9.46	11.36	13.25	15.14	17.03	18.93	28.39	37.85	47.3
1:3000	1.26	2.52	3.78	5.05	6.31	7.57	8.83	10.09	11.35	12.62	18.92	25.23	31.5
1:4000	.95	1.89	2.84	3.78	4.73	5.68	6.62	7.57	8.52	9.46	14.19	18.92	23.6
1:5000	.76	1.51	2.27	3.03	3.79	4.54	5.30	6.06	6.81	7.57	11.36	15.14	18.9
1:10,000	.38	.76	1.14	1.51	1.89	2.27	2.65	3.03	3.41	3.79	5.68	7.57	9.4
1:15,000	.25	.50	.76	1.01	1.26	1.51	1.77	2.02	2.27	2.52	3.78	5.05	6.3
1:20,000	.19	.38	.57	.76	.95	1.14	1.32	1.51	1.70	1.89	2.84	3.78	4.7
1:100,000	.038	.08	.11	.15	.19	.23	.26	.30	.34	.38	.57	.76	.9

Consult the following table if a one percent solution of the chemical is available:

Dilution Desired	Units of a 1-100 Solution	Units of Water
1-1,000	10.0	90.0
1-2,000	5.00	95.0
1-3,000	3.30	96.7
1-4,000	2.50	97.5
1-5,000	2.00	98.0
1-6,000	1.67	98.33
1-7,000	1.43	98.57
1-8,000	1.25	98.75
1-9,000	1.11	98.89
1-10,000	1.00	99.00
1-11,000	0.909	99.091
1-12,000	0.833	99.167
1-13,000	0.769	99.231
1-14,000	0.714	99.286
1-15,000	0.667	99.333
1-16,000	0.625	99.375
1-17,000	0.588	99.412
1-18,000	0.555	99.445
1-19,000	0.526	99.474
1-20,000	0.500	99.500
1-25,000	0.400	99.600
1-30,000	0.333	99.667
1-35,000	0.286	99.714
1-40,000	0.250	99.750
1-45,000	0.22	99.778

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(Continued)

Dilution Desired	Units of a 1-100 Solution	Units of Water
1-50,000	0.200	99.800
1-55,000	0.182	99.818
1-60,000	0.167	99.833
1-65,000	0.154	99.846
1-70,000	0.143	99.857
1-75,000	0.133	99.867
1-80,000	0.125	99.875
1-85,000	0.118	99.882
1-90,000	0.111	99.889
1-95,000	0.105	99.895
1-100,000	0.100	99.900

To obtain a desired dilution of copper sulfate, another method may be used. In a large jar dissolve by heating as much of the chemical as will go into the solution, set aside in a quiet place and allow to cool. To use this saturated solution of the chemical, determine the dilution that is needed: take the temperature of the saturated solution and refer to the following table for the number of ounces of the saturated solution to be added to one gallon of water to make a solution of the strength needed. Multiply this figure by the number of gallons of solution required and measure out the resulting product and add to the water.

AMOUNT OF FLUID OUNCES OF A SATURATED SOLUTION OF COPPER SULPHATE NEEDED TO ADD TO ONE GALLON OF WATER TO GIVE THE DESIRED DILUTION

	Temperature of Saturated Solution			
Dilution	35°-45°	45°-55°	55°-65°	65°-75°
1/1000:	.92	.85	.78	.73
1/2000:	.46 (13.6 cc)	.42 (12.4 cc)	.39 (11.5 cc)	.37
1/10,000:	.09	.08	.08	.07

In working around a hatchery it is frequently desirable to know the equivalent value of various units of measure. For this reason the following table of conversion factors is appended.

To Convert From	To	Multiply By
Acres	Square feet	43,560.
Centimeters	Inches	0.3937
Cubic cms.	Drams	0.27053
Cubic cms.	Ounces (fluid)	0.033814
Cubic feet per sec.	Gallons per minute	448.831
Cubic feet	Gallons	7.481
Cubic inches	Cubic cms.	16.3872
Cubic meters	Gallons	264.173
Gallons	Cubic cms.	3785.4
Gallons	Ounces	128.
Gallons	Cubic inches	231.
Gallons of water	Pounds	8.34
Grams	Ounces	0.03527
Inches	Centimeters	2.54
Inches	Millimeters	25.4
Liters	Gallons	0.26418
Liters	Ounces	33.8143
Ounces	Grams	28.35
Ounces (fluid)	Cubic cms.	29.57
Pounds	Grains	7000.
Pounds	Grams	453.59

III. Pond treatment

The pond treatment is a method of treating fish disease in the trough or pond, eliminating the necessity of handling the fish. The present trend in treating fish for disease is in favor of the pond method, recognizing that excessive handling of fish may aggravate disease and increase losses. Whenever possible, the pond treatment should be used rather than the dipping method. It must be remembered, however, that it is important that the concentration of the chemical used be kept at the required strength. The doses recommended are based on the concentration necessary to destroy the disease organism and still leave a margin of safety for the fish. If the concentration falls below that recommended, the disease will not be arrested, the fish will be further weakened by conditions imposed by the treatment and the chemical will be wasted. Under certain conditions where there is a considerable question as to whether the necessary concentration can be maintained it is best to employ the dipping method and only through experience can these instances be recognized.

In using formalin as a pond treatment, first determine the volume of water in the pond to be treated when it is drawn down to an average depth of about one foot. Then compute the amount of formalin necessary to make a 1/4000 dilution. Distribute the amount of formalin in several spraying devices, as backsprayers used in forest fire fighting, and dilute about 10 times with water. Next, draw down the pond to the predetermined level, shut off both inlet and outlet, and spray the diluted formalin into the pond as rapidly as possible, making sure that it is well distributed over the surface to avoid local areas of high concentrations. After one hour has elapsed, flush out the pond for several minutes and refill with water.

A word of caution should be noted here. The operator of the sprayer should be aware of the wind direction so that the formalin will not be blown into his eyes. No permanent injury will result but introduction of formalin into the eyes is a very painful experience.

The pond treatment with malachite green differs from the formalin treatment in that the chemical is allowed to drift through the pond or trough with normal water current rather than being held for a specified length of time.

To pond treat with malachite green, compute the number of gallons of water in the pond when it is drawn down to an average depth of one foot. Weigh the amount of malachite green needed (one pound per 11,000 gallons of water) and dissolve in about four gallons of water. The chemical will not completely dissolve in this amount of water but additional water can be added as the fluid is used. Lower the pond to an average depth of one foot and open the inlet to allow a normal flow of water (the flow normally used when the pond is full). With a hand dipper, or some other convenient device, rapidly add the solution of malachite green to the pond, starting at the head end and working towards the foot of the pond. After the water has again become clear, (it usually takes from 20 to 25 minutes) return the water to its normal level. If the treatment has been effective, fungus on the fish will be dyed a green color. If the fungus is not dyed, either the chemical passed through the pond too rapidly, or the amount used was not sufficient, and another treatment will be necessary. When fungus growth is unusually heavy, several treatments at intervals of 2 days may be required to effect control. To avoid staining the clothes and skin, malachite green crystals should be handled with care.

Pond treatment with copper sulphate involves the same principle as with malachite, that of creating a "cloud" of the chemical in the water and causing the fish to swim through it. In the treatment of bacterial diseases (fin rot), however, there is no way to determine immediately whether the treatment has been effective (as in malachite green for fungus), and because temperature and composition of the water are variable, causing a difference in the potency of copper sulphate, it is very difficult to use exact figures in recommending its use in the pond. In general, larger fish can withstand higher concentrations than smaller fish can. At Grayling, in ponds 200 feet long, 15 feet wide by 20 inches deep, the fish are held by a seine to the lower one-fourth of the pond and 5 gallons of a concentrated solution of copper sulphate is mixed with the water just above the seine. The resulting "cloud" passes over the fish with the normal flow of water through the pond. The amount of chemical, however, is varied with the size of fish to be treated and with water conditions. Pond treatment with copper sulphate can be successful, but each hatchery must work out the proper dose for its water conditions. To be successful, the concentration must be strong enough to kill bacteria, yet not kill the fish. Since copper sulphate is toxic to fish, the tendency has been to give treatments that are too weak rather than too strong.

Copper sulphate is also useful in preventing the excess growth of weeds in rearing ponds. Ten gallons of a 5 percent solution added to the water three times a week is effective. The solution should be added at the inlet, drop by drop so that a concentration of approximately 1/100,000 is maintained. This concentration will not affect fish in the ponds. The treatment should be started before the weeds have attained a heavy growth.

REFERENCES

There are very few references concerning diseases of fish that attempt to present all the parasites, bacteria, tumors, malformations, predator marks, physiology, and other factors that influence the health of fish. The great number of studies that have been made concerning fish disease have been published singly in a wide variety of scientific journals. Consequently, in a report of this nature only a few of the most pertinent references can be given. The Transactions of the American Fisheries Society, the Progressive Fish Culturist, and The Canadian Fish Culturist are publications that regularly report studies of fish disease.

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