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A REVIEW OF METHODS TO CONTROL ICHTHYOPHTHIRIASIS

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ICHTHYOPHTHIRIASIS, OR WHITE-SPOT DISEASE, of freshwater fishes of temperate and tropical waters is caused by the ciliate protozoan *Ichthyophthirius multifiliis*. The life cycle of the parasite has been described by a number of authors including Van Duijn [*31*], Reichenbach-Klinke and Elkan [*25*], and Bauer [*7*]. The adult parasite lives between the epidermis and cutis of the host fish and feeds on damaged host tissue and body fluids. A proliferation of the epidermal cells in the region of the infestation gives rise to the "white-spot" by which the disease is recognized. The mature parasite leaves the host and sinks to the water bottom where it secretes a soft jellylike covering. The parasite then undergoes rapid division and can produce up to 2,000 young. When reproduction is completed, the young parasites are liberated from the cyst and swim in search of a new host. The timing of the different stages in the life cycle is dependent on water temperature; for example, at 18° to 20° C. the encysted stage lasts approximately 24 hours; the motile young parasite remains viable for 48 hours, and the stage within the host takes from 1 to 3 weeks to reach maturity.

The Salmon and Freshwater Fisheries Laboratory maintains small stocks of fish for experimental purposes. These fish have been periodically subjected to outbreaks of ichthyophthiriasis. The primary method of control has included the use of methylene blue for a 3-week period, but it must be started early. This treatment affects the feeding habits of the fish and results in poor quality fish. The search for an alternative method of treatment included an extensive review of the literature supplemented by personal experience.

FINDINGS

Rotted turves.—Many of the earlier treatment methods relate to uncontrolled conditions and must be considered as unreliable unless supported by tests conducted in controlled conditions. For example, Hervey and Hems [*15*] cite a reported case of eradication of *Ichthyophthirius* using a layer of sieved rotted sod on the bottom of the aquarium, but state that other workers had no success with this method.

Paraffin oil and sodium carbonate.—The literature stresses the fact that few, if any, of the eradication techniques have a direct effect on the parasite while embedded in the host. This stage of the parasite is unaffected by externally applied reagents, and thus it is difficult to see how such treatments as wiping the surface of the fish with paraffin oil [*15*] and dipping the infected fish in a saturated sodium carbonate solution [*10*] can be effective. All of the efficacious treatments appear to act on the free-living stages of the parasite and thus have to be applied for a sufficient time for all of the parasites on the host to have passed to the free-living stage.

Separating the motile stage from the host.—Various methods such as placing fish in cages in running water [*7, 12, 16*], moving fish to recently well-dried ponds at daily intervals [*7, 25*], and simply spreading the fish among a number of ponds [*16*] have been tried. Aquarium techniques using the same principle include the use of false mesh bottoms [*24, 28*]. These methods can only limit the incidence of reinfection. They also increase the chance of physical damage because of excessive handling and require extensive facilities to keep fish at low densities.

Temperature.—Increasing the temperature to 30° to 33° C. as a control technique [*31*] is unsuitable for most coldwater fish; however, the periodic raising and lowering of water temperature can be beneficial. Caution should be used with this method since rapid temperature changes can cause mortality. Increasing the temperature within the tolerance range of the fish reduces the time required for a complete life cycle. This in turn reduces the treatment time required to eliminate the parasite.

Salt.—The use of common salt is one of the recommended treatments. Butcher [*9*] and Hickling [*16*] recommended the gradual buildup to a concentration of 1.5 to 2 percent. Different Russian authors [*7*] recommend concentrations of 0.6 percent sea salt, 0.7 percent sodium chloride, or a mixture of sodium chloride and magnesium chloride in the proportion 7:3 to give a 0.6 percent solution. Allen and Avault [*2*] report that brackish water may be used to eradicate *Ichthyophthirius* from channel catfish. The use of salt in aquariums with mesh floors and no water flow [*23, 24, 28*] is a unique control technique. A high salt concentration can be maintained under the false floor while the fish remain in a lower concentration. Parasites emerging from the host drop to the tank floor where they are killed by the salt concentration. Personal experience with the use of salt has shown that it is not the panacea that it has been considered to be. The treatment did not eradicate the parasite; however, it may be beneficial in reducing the osmotic stress imposed by the presence of open wounds.

Methylene blue.—One of the most frequently recommended methods of treatment is the use of 5 milligrams per liter (5 ppm) of methylene blue [*8, 14, 15, 31*]. The main advantages of this treatment are the low toxicity and cost. The fact that it is inactivated by organic detritus can be overcome by increasing the dosage without harming the fish. The disadvantages of this treatment include poor quality of the fish after treatment, difficulty in assessing progress of the treatment, and some strains of *I. multifiliis* seem to be more resistant than others.

Acriflavine.—Hickling [*16*] and Schäperclaus [*28*] recommend the use of acriflavine (trypaflavine) at a concentration of 10 mg/l (10 ppm). Personal experience indicates that this method is satisfactory for treating most outbreaks of the disease though occasionally some fish respond very poorly to the treatment. Van Duijn [*31*] contends that acriflavine causes temporary sterility and possibly genetic aberrations in fish; therefore, it should be used with caution.

Penicillin.—This antibiotic has been reported to be effective against *I. multifiliis* [*20*]. However, it is known to act against gram-negative bacteria through their distinctive cell wall structure, and it is difficult to imagine how it could combat a protozoan infection. It may be that the beneficial effect noted is due to the effect penicillin has on secondary bacterial infections although most of the bacteria pathogenic to fish are gram-negative and resistant to penicillin.

Quinine.—At a concentration of 10 mg/l (10 ppm) quinine has been proposed as a treatment for ichthyophthiriasis [*18*]. The recommended treatment was raised to 30 mg/l [*31*]; however, this concentration is toxic to some fish [*28*]. Van Duijn [*31*] reports that the compound is more effective at pH 6.5 and recommends an adjustment of the pH to this value. Further, he advises that the concentration should be built up by the addition of three equal doses at 12-hour intervals. This reagent has one of the same defects as methylene blue in that it is inactivated by organic detritus, but unlike methylene blue, overdosing with quinine is dangerous because of the smaller differential between its toxicity to the parasite and fish. Experience has shown that the treatment must be extended for at least 24 days to ensure complete eradication of the parasite. At the end of this treatment the fish tend to be in poor condition.

Mepacrine.—Slater [*29*] used mepacrine hydrochloride (quinacrine hydrochloride) at a concentration of 3 mg/l (3 ppm) for the eradication of persistent cases of ichthyophthiriasis. This reagent is much more toxic than quinine; therefore, Van Duijn [*31*] recommends that it should be used only for cases which do not respond to other treatments.

Malachite green.—Avdos'ev [*6*] reports that a minimum concentration of 0.5 mg/l (0.5 ppm) of malachite green oxalate is effective against *Ichthyophthirius*. Allison [*4*] had success with concentrations of 0.05 to 0.10 mg/l and this treatment is used by many in the

United States. Alabaster [1] found that the toxicity threshold concentration to harlequins (*Rasbora heteromorpha*) is 0.11 mg/l. Although the harlequin is sensitive to toxicants it is apparent that great care must be exercised if the oxalate formulation is used as an extended treatment. Alabaster [1] also reported that the threshold concentration of the zinc chloride formulation of malachite green to harlequins is 0.06 mg/l. Therefore, if malachite green is used to control *Ichthyophthirius* it is essential to know the formulation. The difference in parasite and fish toxicity is much too small to recommend either formulation without qualification.

Mercury compounds.—Butcher [9] mentions the use of mercurochrome for controlling white-spot, but fails to state the concentration. Van Duijn [31] describes the use of mercurochrome at a concentration of 1 mg/l (1 ppm), but advises against it because of delayed mortalities resulting from its use. Our experience is that 1 mg/l is an effective concentration, but the fish require careful attention after the completion of the treatment to restore them to good condition. Two other mercury compounds have been used against *Ichthyophthirius:* pyridyl mercuric acetate by Clemens and Sneed [11] and mercurous chromate by Hervy and Hems [15]. Van Horn and Katz [32] showed that 0.14 mg/l (0.14 ppm) pyridyl mercuric acetate was beneficial to the health of fish but that a concentration of above 0.15 mg/l was toxic to fish. Rodgers et al. [26] showed that concentrations tolerated by fish varied with species and size. The toxicity of most chromates varies widely with the species, pH and hardness of the water [22], and thus the use of mercuric chromate is not advised for the control of white-spot disease.

Formalin.—Various authors [19, 13, 25, 23] refer to the use of formalin at concentrations between 100 and 250 milliliters per liter (100-250 ppm) as a short-term bath, but these methods are not completely effective, as the higher concentrations cause some risk to heavily parasitized fish and require the handling of fish with the subsequent risk of mechanical damage. Allison [3] reports that the application of 15 milliliters per liter of formalin every other day controls ichthyophthiriasis usually in 5 to 7 days. However Hoffman [17] warns that oxygen depletion may result during warm weather if the formalin kills algae, and Van Duijn [31] advises against the use of formalin solutions below 18° C. because of detrimental effects to the mucous coat.

Copper sulphate.—It has been used to control external parasites of fish. Amlacher [5] and Meyer [23] report that 1.5 and 0.5 mg/l respectively have been used successfully against ichthyophthiriasis but care has to be taken especially in soft water since these concentrations are close to the maximum tolerated by many fish species.

Chloramine-T.—It is reported to be effective against white-spot disease and is used by aquarists in a number of countries for this purpose [31]. However, Van Duijn [31] does not recommend its use because it is absorbed by organic detritus and forms toxic compounds with metals. Sterba [30] advises against its use because the toxicity varies with the hardness of the water. It has been shown by Cross and Hursey (in preparation) that contact with the metals commonly encountered in fisheries management does not adversely affect the toxicity to fish and that, provided the hardness and—more important—the pH of the water is known, it is possible to recommend a dosage efficacious in eradicating the parasite. Its general antiseptic properties make it efficient against many of the secondary infections encountered.

Trichlorinated phenols.—Boarder [8] states that a mixture of trichlorinated phenols, marketed in Britain under the trade name TCP, may be used against *I. multifiliis*. However, it seems that there are better remedies available from the consideration of both effectiveness and cost.

pH.—Rychlicki [27] has shown that a pH value of 8.5 is detrimental to the survival of the free-living stages of the parasite and has proposed the application of quick-lime to a pond to attain such a pH value. Work in this laboratory has shown that the parasite is killed at a pH of 8.0 in soft water, but our water supply has a hardness of approximately 270 mg/l (as calcium carbonate) and a pH of 7.9. The treatment is not successful under these conditions.

Mixtures of chemicals.—While this paper has dealt with a number of remedies involving the administering of one chemical alone, no attempt will be made to discuss methods involving mixtures of chemicals. However it should be noted that many mixtures have been proposed, but that with the possible exception of the mixture of formalin and malachite green proposed by Leteux and Meyer [*21*] generally these methods are too expensive for large-scale application and have met with failure due to the greatly increased toxicity of the resultant mixtures.

The table summarizes the advantages and disadvantages of the different remedies for ichthyophthiriasis. The merits of the methods have been assessed on the following criteria:

1. The efficiency of the method. The method should eradicate the parasite, and at the end of the treatment the fish should be in good condition.

2. The practicability of the method. In this category is included the cost of the reagents, labor and equipment, and the facilities required.

3. An assessment of the degree of latitude between a concentration controlling the disease and a concentration causing fish mortality—the therapeutic index.

The choice of a method to control ichthyophthiriasis seems to lie between methylene blue, formalin, and chloramine-T (see table). Considering all of the factors discussed, chloramine-T seems to be the best treatment available, providing the water hardness and pH value are known. A full account of the treatment is reported by Cross and Hursey (in preparation). Chloramine-T has been used by this laboratory for 3 years and has proved effective against all but very advanced cases of white-spot disease.

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Assessment of methods of eradicating Ichthyophthiriasis

[The criteria of assessment are discussed in the text]

Method	Reference	Efficiency	Practicability	Therapeutic index	Remarks
Chloramine-T (sodium paratoluene sulphochloramide).	Cross and Hursey (in prep)	good	good	moderate	A good method provided pH and water hardness are known.
Methylene blue	Van Duijn *31*	do.	moderate	good	A good method but fish condition may deteriorate; not effective against secondary infections.
Formalin	Allison *3*	do.	good	moderate	Effective only against early stages; should not be used at low temperatures.
Quinine	Van Duijn *31*	do.	moderate	do.	Fish in poor condition at end of treatment.
Fish cage	Hickling *16*	moderate	poor	—	Require good facilities for handling fish.
Change of pond	Bauer *7*	do.	do.	—	(Require good facilities for handling fish.)
TCP (trichlorinated phenols).	Boarder *8*	do.	good	moderate	Not totally effective; expensive.
Malachite green (oxalate formulation).	Avdos' ev *6*	do.	do.	poor	Affects feeding of fish; carcinogenic.
Mercurochrome	Van Duijn *31*	do.	moderate	do.	Long term mortality may result.
Acriflavine (trypaflavine)	Schaperclaus *28*	do.	good	moderate	May cause temporary sterility.
Mepacrine (quinacrine)	Slater *29*	do.	moderate	poor	To be used only in stubborn cases.
Copper sulphate	Meyer *23*	do.	good	do.	Requires knowledge of water quality.
Penicillin	Kristensen *20*	do.	poor	good	Doubt as to effectiveness.
Liquid paraffin	Hervey and Hems *15*	poor	do.	do.	Not an effective treatment.
Sodium carbonate	Canfield *10*	do.	do.	do.	Do.
Thinning out	Hickling *16*	do.	do.	—	Requires good facilities for handling fish.
Heat	Van Duijn *31*	do.	moderate	—	Not effective as sole agent but may be used in conjunction with other remedies.
pH	Rychlicki *27*	do.	do.	good	Doubt as to effectiveness.
Brackish water	Allen and Avault *2*	do.	good	moderate	Not an effective treatment.
Sea salt	Bauer *7*	do.	do.	do.	Do.
Sodium chloride	Butcher *9*	do.	do.	do.	Do.
Pyridyl mercuric acetate	Clements and Sneed *11*	do.	moderate	poor	Long term mortalities may result.
Mercuric chromate	Hervey and Hems *15*	do.	do.	do.	Do.
Rotted turves	do.	do.	do.	—	Not an effective method.

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