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THE CHEMOTHERAPY OF MONOGENEANS WHICH PARASITIZE FISH: A REVIEW

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Abstract. Monogeneans which parasitize fish are still treated by bathing the fish in solutions of simple chemicals or staining dyes. In the early 1960s an insecticide, trichlorphon, replaced to a large extent the formerly used simple chemicals. Its success was greater specificity against monogeneans and other ectoparasites, and to its great tolerance by the fish. The fact that the number of important monogenean species (i.e. *Pseudodactylogyrus anguillae, P. bini, Gyrodactylus salaris*) which cannot be treated sufficiently with simple chemicals or even trichlorphon is increasing, led to the need for systemically acting, novel chemotherapeutics. In laboratory and small scale trials praziquantel, levamisole, mebendazole and toltrazuril have been tested for efficacy against a broad spectrum of monogenean species.

In general, the application of a parasiticidal substance by bathing can be divided into three categories: (1) Dips, which are short immersions for less than 5 minutes, (2) short baths, for up to some hours, and (3) long baths, which may be extended for many days.

Despite attempts to control the spread of parasitic infections in intensive fish production by skillful diagnostic methods, import controls, and general advances in fish breeding, it seems likely that dangerous monogenean species will extend their ranges of distribution; this is the result of the common practice of international transfers and new imports of fish. In light of the above, and the ineffectiveness of formerly proven measures, there is a need for further investigation into novel chemotherapeutics against monogeneans and other fish parasites.

Due to their ubiquitous distribution, the monogeneans have played an important role since the beginning of aquaculture. For example, monogeneans were a serious problem in Israel's brackish water culture of mullets (Mugilidae) and gilthead seabreams (*Sparus auratus*), and in cultured Japanese yellowtails (*Seriola quinqueradiata*). Consequently, effective control measures have been developed; these were described by Sarig (1968, 1971) and Egusa (1983). Since such control measures often are associated with a particular type of fish breeding, parasitoses caused by monogeneans as well as by other parasites remain a general problem. For example, two newly introduced gill parasitic monogenean species (*Pseudodactylogyrus anguillae, P. bini*) are causing severe losses in commercial eel farming, as reported by Golovin (1977), Golovin and Shukhgalter (1979), Molnár (1983) and Buchmann et al. (1987). Formerly used therapeutic measures failed against these newly occurring species, as shown by Buchmann et al. (1987). However, recent tests using solutions either of mebendazole or of praziquantel led to good results in control of pseudodactylogyrosis, according to Székely and Molnár (1987), and Buchmann (1987). In Norwegian rivers, *Gyrodactylus salaris* affected fry and parr of the Atlantic salmon (*Salmo salar*). The estimated loss in Norwegian salmon fisheries was about 300 tons in 1985 and the spread of this parasite is continuing, according to Mo (1987).

These reports clearly demonstrate that monogeneans can still cause a dangerous plague in commercial fish production, especially when introduction of fish species from other countries occurs. Although there exist skillful diagnostic methods, import controls, and general advances in fish farming, new chemotherapeutics are needed, especially when new parasite species do not react to conventional treatment, or when long-known species become resistant to widely-used drugs (i.e., *G. elegans* against trichlorphon), as stated by Goven et al. (1980). A mass development of monogeneans can hinder fish breeding, when some or even one of the causations mentioned below are not considered:

— poor control of fish imports from allochthonous sources,
— poor growth conditions in fish farms,
— no correct stress management,
— polyculture rearing,
— overcrowding in fish ponds,
— development of resistance of parasites to drugs.

The present article reviews substances which are still in common use as agents against monogeneans in fish, and focuses also on new compounds. Their mode of action is discussed, as well as special risks in application and disadvantages. Also discussed are the means by which various bath treatments are employed to control monogeneans of fish. Finally, this review deals in general with the prevention of fish parasites.

Chemicals and drugs

Simple chemicals. Ammonia compounds. Four ammonium-containing compounds are commonly used in aqueous solution for treatment by bathing against dactylogyrids and gyrodactylids: ammonium hydroxide, ammonium chloride, tetramincopper sulphate, and ammonium trypaflavine.

The therapeutic effect of ammonium hydroxide and ammonium chloride depends upon their physical, osmotic and, in part, toxic activities on the fish and their ectoparasites. These substances provoke a strong secretion of slime in the skin, as a result of which the parasites lose their place of attachment. The NH_3 acts as a toxin only on the parasites, because it penetrates the cellular membranes more easily than NH_4^+ ions, as stated by Schäperclaus (1979). Tetramincopper sulphate has the same mode of action as the ammonium compounds mentioned above, but the specific toxicity of NH_3 is enhanced by the copper ion. In ammonium trypaflavine the toxic effect of NH_3 on the fish is lowered, whereas the parasiticidal effect is enhanced.

Despite the special effectiveness of ammonia against *Dactylogyrus*, *Gyrodactylus* and *Diplozoon* spp., which is considerably higher than that of formaline, its application is limited; this is because the dips or short time incubations are inconvenient in large farms. In addition, a NH_3—N—autointoxication of the infected fish may occur, and thus a NH_3—producing compound may give rise to sublethal or even lethal effects on the fish.

Sodium chloride. Bathing in sodium chloride solution is one of the oldest measures against ectoparasites of fish. The treatment should not be done in metal vessels containing zinc. The therapeutic effects are based mainly upon:
— an increased slime production during which the hosts get rid of their parasites, and
— toxic effects of free Na^+-ions (in fresh water only, where antagonistic K^+ or Ca^{++}-ions are absent).

However, the effectiveness of sodium chloride baths against dactylogyrids and gyrodactylids is not convincing, according to Ergens (1962).

Sodium chlorate is used in baths with prolonged exposure for freshwater fish.

In mariculture, sodium perborate and sodium peroxide pyrophosphate are effective in treating yellowtails (*Seriola* spp.), as described by Kabata (1985).

Potassium permanganate has some effect on dactylogyrids and gyrodactylids, but never brings about total eradication of the parasites. Its effect is probably based on the production of monatomic oxygen and manganese-protein complexes in the parasite's tegument. According to Sarig (1971), the use of potassium permanganate is strictly limited, because:

— its effective concentrations are close to the lethal doses for fish,
— only fish weighing more than 25 g can tolerate the compound,
— its effectiveness is drastically reduced by organic pollution, and
— the substance has only minor effects against subadult stages of monogeneans.

Staining dyes. Although the compounds described below are mainly used against protozoan parasites, they are mentioned in some articles as also being effective against monogeneans; therefore, they are listed here for completeness (see also Table 2).

Malachite green free of zinc oxalate, the most common dye used, has received much bad press because of suspected carcinogenic properties. This dye is applied as a pond treatment, or as a short time bath in separate containers. In Protozoa it destroys the cytochrome c, and also affects the fine structure of the chromosomes.

Methylene blue is most frequently used for treatment in aquaria, either for permanent exposure or as intermittent treatment for several days. Its parasiticidal effect is constituted mainly of an enhancement of the amount of intracellular O_2.

Acriflavine (neutral), a bacteriostatic dye, is also used against monogenoses as a long term treatment. When combined with ammonium hydroxide, it can be used as a dip. Acriflavin hydrochloride (Trypaflavin) can be applied as a long term treatment. Its parasiticidal effect is due to cytostatic action by blocking the DNA—RNA exchange. In the Soviet Union, Violet K is used as a continuous flush. This substance damages the cell nuclei of susceptible parasites.

Antimalarials. Two antimalarial medications, quinine hydrochloride and atebrine hydrochloride, are efficacious when used in long term baths. In general, these substances act as protoplasmic poisons, and furthermore, in Protozoa they intercalate with DNA. It may be that their mode of action in monogeneans closely resembles to that in Protozoa.

Formaldehyde. Formaldehyde has a markedly deleterious effect, especially against dactylogyrids and gyrodactylids. Its parasiticidal action depends upon its acting as a fixative. The main disadvantage is its relatively high toxicity for fish, but when used properly, even small fish, slightly affected by the treatment, recover in a short time. Details for applying formaldehyde as well as the other simple chemicals discussed above are indicated in Table 1. Table 2 summarizes the methods used in applying staining dyes and antimalarial compounds in the treatment of monogenean parasites of fish.

Insecticidal substances. Due to severe residual problems in most insecticides, only one substance, trichlorphon, is in use as a treatment against monogeneans; it is used especially against *Dactylogyrus* and *Gyrodactylus* spp. (see Table 3). Its high effectiveness in large-scale trials has been reported by Prost and Studnicka (1966), and, in fact, treatment with high dilutions in ponds is common worldwide. Treatment with trichlorphon containing baths is economical; when used in containers, it can be re-used up to five times. Trichlorphon in containers can be neutralized by the addition of an equal volume of equimolar NaOH. According to Schäperclaus (1979), trichlorphon and closely related compounds are well tolerated by fish; depending upon the species, age and water temperature, they can tolerate doses far higher

Table 1. Simple chemicals commonly used against monogeneans: methods of application

Compound	Effective concentration	Preferable mode of incubation (time interval)
Ammonium hydroxide, Ammonium chloride	0.5–0.7 g/l	Dipping (5–7 mins), time depends upon temperature
Tetramincopper sulphate	0.1–0.2 g/l	Short bath (for some hours, at 2 day intervals; 3–4 times)
Ammoniumtrypaflavine	1 g/l	Dipping (for 0.5–3 mins), time depends upon temperature
Sodium chloride (should never be used in galvanized vessels, because very toxic zinc chloride may be generated)	60 g/l; especially against *Dactylogyrus* spp.; young fish in weaker solutions with 10–15 g/l	Dipping (~20 sec); young fish in short bath (~0.3 h)
Sodium chlorate	3 g/l	Long bath (of indeterminate length)
Sodium perborate	0.5 g/l or 1 g/l, or 10 g/l	Dipping (in 0.5 g/l: 10 mins) Dipping (in 1 g/l: 2–3 mins) Dipping (in 10 g/l: 1 min)
Sodium peroxide pyrophosphate	10 g/l 1 g/l	Dipping (in 10 g/l: 15–30 sec) Long bath (1 g/l: indeterminate duration)
Potassium permanganate	1–2 g/l	Dipping (30–40 sec)
Formaldehyde	0.25–0.3 g/l 0.5 –1 g/l	Short bath (lower concentration: 30 mins; higher concentration: 15 mins)

than the curative doses (30 times higher in common carp, 200 times higher in minnow). Within the fish trichlorphon is rapidly metabolized to dichlorvos, and, excreted into the water, where it is rapidly broken down, as stated by Ghittino and Maletto (1971). Trichlorphon exerts negative effects neither on the oxygen content of the water nor on the pH value.

However, several disadvantages limit the use of trichlorphon: (1) its effectiveness against monogeneans is drastically reduced in seawater; (2) it is not very effective against the subadult stages and eggs of monogeneans; (3) resistance occurs in some gyrodactylid species, as reported by Goven et al. (1980), and (4) the important monogenean species *Pseudodactylogyrus anguillae* and *P. bini* are not seriously affected by trichlorphon, as stated by Buchmann et al. (1987).

In recent years, some authors have had some reservations concerning the use of trichlorphon for large scale administration because of public health and environmental hazards, due to pollution with phosphorous compounds. These points require clarification. However — according to Obermeier (1974) — many studies confirm

Table 2. Staining dyes¹) and antimalarial compounds effective against monogeneans: methods of application

Coumpound	Effective concentration	Preferable mode of incubation (time interval)
Malachite green	2 mg/l	Dipping (2 mg/l, 1 min)
(zinc oxalate free form)	1 mg/l	Dipping (1 mg/l, 5 mins), 2 times on 2 successive days
	0.16 mg/l	Long bath (0.16 mg/l, 25 h)
	0.15 mg/l	Long bath (0.15 mg/l, 3 days)
Methylene blue	1 mg/l	Long bath (7 days)
Acriflavine (neutral)	10 mg/l	Long bath of indeterminate duration
Mixture with ammonium hydrochloride	100 mg/l	Dipping (60—90 sec)
Violet K	0.2 mg/1000 l	Continuous flush
Quinine hydrochloride	15 mg/l	Long baths (many days duration)
Atebrine hydrochloride	10 mg/l	Long baths (many days duration)

¹) The staining dyes listed in this table are mainly used against protozoan parasites, but are mentioned by some authors as being effective against monogeneans. Despite their nonspecific activity against monogeneans, they are listed here for completeness.

Table 3. The insecticide trichlorphon and chemotherapeutics effective against monogeneans: methods of application

Compound	Effective concentration	Preferable mode of incubation (time interval)
Trichlorphon	5 mg/l	Short bath (5 mg/l, 30 min)
	0.4 mg/l	Long bath (0.4 mg/l, 6 h)
	0.2 mg/l	Long bath (0.2 mg/l, 24 h)
Levamisole	50 mg/l	Short bath (2 h)
Niclosamide	0.075—0.1 mg/l	Short bath (2 h)
Praziquantel	10 mg/l	Short bath (3 h)
		Long bath (up to 48 h)
Mebendazole	100 mg/l	Short bath (100 mg/l, 10 mins)
	1 mg/l	Long bath (1 mg/l, 24 h)
Toltrazuril	10—20 mg/l	Short bath (2—4 h)

the safety of trichlorphon when it is properly used. The photosynthetic activity of lower plants is not affected in concentrations up to 10 mg/l. Small zooplankton can be reduced when application at a dose of 0.25 mg/l is repeated for several weeks, but its population density is normalized two weeks later. In effective concentrations, trichlorphon is tolerated by small invertebrates (*Tubifex* spp., *Dreissena polymorpha*, *Cyclops* spp., *Cambarus affinis*). Among vertebrates, the tadpoles of the common toad (*Bufo bufo*) tolerate trichlorphon well. Under experimental conditions, water birds (ducklings and subadult sea gulls) do not tolerate trichlorphon when it is applied orally at 215 mg/kg body weight. These data clearly indicate that under proper application trichlorphon should not have negative effects on other animals.

When given in therapeutic concentrations for long term treatment (0.25—0.3 mg/l), the residuals of trichlorphon in fish range from 0.0083 µg/kg body weight (in eels 1 day after incubation in 0.25 ppm/1 day) to 0.0021 µg/kg body weight in trout (10 days after 0.25 ppm/1 day). These concentrations are below the critical levels stated in most veterinary and public health regulations.

In general trichlorphon works as an inhibitor of the enzyme acetylcholinesterase; a continuous flow of stimuli from the nerve cells is generated, which leads to a complete exhaustion of the terminal organs. This effect is dose dependent; in general, invertebrates react at lower concentrations than do vertebrates. Buchmann and Mellergaard (1988) have mapped the nervous system of *P. anguillae* by histochemical methods that demonstrate the presence of endogenous cholinesterases using substrates like indoxyl acetate, acetylthiocholine iodide or butyryl thiocholine iodide. Although *P. anguillae* — and *P. bini* — are not lethally damaged by treatment with trichlorphon, the authors showed that the cholinesterase activity in the nervous system of *P. anguillae* was inhibited by this drug. The reasons for its efficacy against other monogenean species remains unknown and *in vitro* experiments are needed to clarify whether the effects of this drug on monogeneans can be explained mainly by the cholinesterase inhibition, or whether additional effects may be involved.

Chemotherapeutics. Levamisole. This substance is in veterinary use as an anthelmintic compound against a wide spectrum of nematodes. To test for effectiveness against monogeneans, in our laboratory sticklebacks (*Gasterosteus aculeatus*) naturally infected with *Gyrodactylus arcuatus* were chosen. Schmahl and Taraschewski (1987) showed that severe damage to the parasites resulted when infected fish were incubated in solutions containing levamisole at an exposure of up to 2 h. After the treatment, the fish showed no signs of toxic or other negative effects on vital functions or behaviour.

As explained by Raether (1988), levamisole appears to be a cholinergic agonist/ /antagonist at the neuromuscular junction; first it may act as a ganglion—stimulating compound. It may also induce neuromuscular depolarization, causing spastic contraction of nematode muscle. This spastic paralysis of susceptible nematodes causes their expulsion from their site of attachment. The spastic effect of levamisole has been proposed to act via a ganglion on the augmentory component of the dual neural control mechanism of nematode muscle which is responsible for muscle tone. In addition there is some evidence that levamisole affects the conversion of glucose into glycogen and thus contributes to its anthelmintic activity. In a comparable manner the detachment of *G. arcuatus* from the hosts's skin during incubation with levamisole may occur.

Niclosamide. Preparations containing niclosamide are commonly used against parasitoses in fish caused by tapeworms. When given orally, the drug is well tolerated by fish, whereas when present in the water it is highly toxic to fish.

However, when applied by bathing in separate containers at very low concentrations and for short exposure times, niclosamide has a reasonable efficacy against *G. arcuatus* in sticklebacks, as shown by Schmahl and Taraschewski (1987).

Niclosamide inhibits oxidative phosphorylation in mitochondria, and in susceptible helminths the uptake of oxygen and glucose are blocked. It primarily affects the scolex and proximal segments of cestodes and *in vitro* causes spasms and/or paralysis in tissue preparations from various helminths, e.g., *Dipylidium caninum* and *Fasciola hepatica*. Niclosamide is, like other salicylanilides a hydrogen ionophore and translocates protons through the inner mitochondrial membrane. The rate of oxidation of NADH is then no longer limited by the supply of ATP for phosphorylation, causing uncontrolled oxidation and thus energy depletion, as stated by Raether (1988). However, its mode of action in *G. arcuatus* still remains to be defined.

Praziquantel. The anthelminthic praziquantel is the drug of choice against a wide spectrum of mammalian platyhelminths, and has also been reported to be very efficacious against fish parasitic cestodes and digeneans, as well as against monogeneans, including the important eel parasite *Pseudodactylogyrus bini*, as shown by Schmahl and Mehlhorn (1985), Schmahl and Taraschewski (1987), and Buchmann (1987). Since praziquantel affects a wide spectrum of fish parasitic platyhelminths, it is still profitable to use it, in spite of its high cost, in the treatment of valuable fish. The administration of praziquantel typically causes paralysis in susceptible worms (cestodes, digeneans as well as in monogeneans) or damages their tegument. Its mode of action at the molecular level which promotes these effects may arise from changes in the flux of divalent cations — particularly calcium — which is a consequence of an increased membrane permeability. As shown by Buchmann and Mellergaard (1988), in the monogenean *P. bini* neither NADH—diaphorase nor succinate—dehydrogenase were inactivated by praziquantel. Therefore it seems that a different and presently unknown mechanism must be involved in *P. bini*.

Mebendazole. This drug is commonly used against nematodes. Recently, it has been proven by Székely and Molnár (1987) to be effective against *Pseudodactylogyrus* infections in eels. Its mode of action in monogeneans still remains unclear. In general, mebendazole is a potent inhibitor of glucose uptake, and furthermore may exert its primary effects on the cytoplasmic microtubules of intestinal cells of susceptible nematodes and cestodes. Subsequently, cellular activities such as secretion, absorption, digestion, or formation of mitochondrial membranes are disturbed. It is interesting that all benzimidazoles exert ovicidal activities, and thus probably affect monogenean eggs still adhering at the gills during the incubation. Therefore, one source of a new infection is reduced by the treatment.

Toltrazuril. In recent investigations done by Schmahl and Mehlhorn (1988), the efficacy of toltrazuril on the gill-parasitizing monogenean species *D. vastator*, *D. extensus*, *D. cornu*, and *P. bini* and the skin parasitizing species *G. arcuatus* has been demonstrated. Its broad spectrum of effects against fish parasites is promising. Depending on the age of fish, the therapeutic index* of toltrazuril when applied by bathing with 10 mg/l ranged from 3—10 for different food fish species, as stated by Schmahl et al. (1988). Higher drug concentrations ($\geq$ 20 mg/l) in some cases disturbed the swimming behaviour of the fish under treatment. However, these effects disappeared completely when the fish were placed in fresh water.

To date, there is no information on the biochemical mode of action of toltrazuril in monogeneans. Investigations of monogenean species by scanning and transmission

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* Therapeutic index: Concerning investigations in toltrazuril, it was calculated as the difference between lethal concentration for 98 % of the parasites and lethal concentration for 10 % of the fish tested.

electron microscopy showed that exposure to toltrazuril led to a marked vacuolization and disruption of the tegument. In ultrathin sections, the vacuoles seemed to originate immediately from derivatives of the surface membrane and resemble the effects of praziquantel as shown by Schmahl and Mehlhorn (1985). Table 3 summarizes the methods of application to fish of trichlorphon and the chemotherapeutics discussed above.

Methods of applying chemicals to monogenean infected fish

In general, the treatment against monogeneans as well as other ectoparastites is achieve by bathing the infected fish in water containing dissolved chemicals or drugs. Actually, there is no report describing whether therapy against monogeneans has been tried via the oral route. Therefore, bathing the fish infected by monogeneans is still the mode of choice for treatment, because the parasite will react to "topical" application of drugs. It is an easy way of treating large populations and equally suitable for single fish, and, from the pharmacological perspective, treatment by bathing is a combination of percutaneous and perbranchious application. The drug may enter the fish via the gills, the whole epithelium of the body, and — in part — via the oral route. Thus, a certain titre of the substance will be established in the fish's organism.

Several types of baths may be used depending upon fish species, choice of chemical or drug, and the number of fish which may be treated, as outlined by Herman (1972).

Dipping: This involves incubation in a concentrated solution of the effective agent for up to 5 mins, and therefore, a large number of fish can be treated in a short period. The main disadvantage is additional stress or even handling injuries to the fish.

Therefore dipping may be employed only in the case of an acute infection. In any case, one has to weigh the necessity of a high initial dose against the stress factors.

Short baths: These are often achieved in separate containers or during transportation. Exposure takes normally one to a few hours, and the containers must be well aerated to avoid an oxygen depletion during the treatment.

Long baths: This method is mainly achieved in large-scale farming where fish cannot be easily caught. The exposure time is from a few hours to some days, and only chemicals or drugs with a high therapeutic index are suitable for this type of treatment. The substances used must be degradable by natural processes. An acute monogenosis cannot be treated by this method, because the concentrations of the chemicals or drugs are normally too low to act rapidly.

Constant flow: This is mainly employed in open cultures, for example in rivers, where the water supply is constant and there is an uncontrolled source of infection. The drugs or chemicals are metered by special pump systems, flow siphons or filters with a special filter inlet. The constant presence of chemicals is necessary to prevent outbreaks of infections when fish are constantly exposed to infective stages of the parasites. In recirculating systems, chemicals must be used with great caution, when filtration is achieved by biological filters, because the microorganisms in the filters can be destroyed by the therapeutic agents.

Covering and marking of cage frames: A modified application is the incorporation of parasiticidal compounds into the paints of cage frames in open cage cultures; this is actually done with tri-butyl-tinoxide against *Benedenia seriolae* parasitizing yellowtails, as reported by Egusa (1983). This method may be developed further in the future, by incorporation of chemotherapeutics into the paints of the frames, or even application with a bolus, which disperses a constant amount of the therapeutic agent under defined conditions.

Application and toxicity

Treatment of fish parsites by the addition of chemicals to water inflicts some difficulties. It is not easy to calculate the exact concentration of a therapeutic additive in an open pond system. An undesirable degree of dilution may happen, which may lead to ineffectiveness of the measure, and, probably, resistance in the target parasites against the compond may be favoured. The structure of the substance may be altered by ingredients of the water. In every case, a substance will act not only on the fish and their parasites, but also on other organisms sharing their habitat. These problems can be avoided by transferring the infected fish to small containers for bath treatment.

Concluding remarks

The development of aquaculture has been accompanied by an increasing number of transfers and introduction of species into allochthonous localities. Thus, the risk of imported parasitoses is always present. As stated by Molnár (1984), in most cases the infections caused by monogeneans — as well as by other pathogenic agents — are a consequence of ill-considered fish introduction. To minimize the risks of adverse effects arising from the introduction of non-indigenous species, especially marine fish, but also freshwater fish, the International Council for the Exploration of the Sea adopted a revised code, whose topics have been summarized by Sindermann (1984), as follows:

- conduct comprehensive disease study in natural habitat,
- transfer to closed systems in recipient area,
- maintain and study closed system population,
- develop brood stock in closed systems,
- grow isolated F_1 individuals and destroy the original introductions, and
- introduce small lots to natural waters, and continue the disease study.

Most important points in prevention from monogenoses as well as other parasitoses will be the improvement of the hygienic standard, adequate water quality, proper nutrition, and reduction of stress factors. A must for a sufficient hygienic status in recirculation cultures (i.e. eel farming) are filter systems and sedimentors included in the technology. To avoid stress the following factors should be taken into consideration: (1) correct nutrition, (2) intensive system engineering, (3) optimum density determination, and (4) water quality standards. Regardless of the culture system employed an important point in avoiding disease is the availability of adequate diagnostic services. However, a parasite-free (or parasite-deficient) status can be achieved only through regular control by highly effective chemotherapeutics. Major problems to the use of chemicals may arise from restrictions due to the public health implications of residues, when fish are raised for human consumption. The application of chemicals should be strictly in accordance with veterinary and public health regulations.

Nevertheless, considering the increasing number of reports dealing with severe problems caused by hitherto unknown parasitoses in large scale fish farming, there exists an urgent need for novel chemotherapeutics. These must be highly efficacious against hazardous parasites — and also safely applicable.

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