Common Antiparasitic Drugs Used in Aquaculture

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Abstract

Aquaculture plays a crucial role in meeting the increasing demand for animal protein and is the fastest-growing food production sector globally. The sustainability of aquaculture is mainly threatened by parasites, causing significant economic losses, reduced fish growth, increased mortality, and environmental concerns. A wide range of antiparasitic drugs and chemical therapeutics are currently used in aquaculture, including Praziquantel, Ivermectin, Doramectin, Emamectin benzoate, Deltamethrin, Azamethiphos, Hydrogen peroxide, Formaldehyde, Potassium permanganate, Methylene blue, Copper sulphate, Sodium chloride, Cypermethrin, and Peracetic acid. These agents differ in their target parasites, modes of action, route of administration, and regulatory requirements. While some compounds have established Maximum Residue Limits (MRLs) to ensure consumer safety, others require careful application because of environmental concerns and the potential development of drug resistance. The sustainability of parasite management in aquaculture relies on combining responsible use of antiparasitic treatments with improved husbandry practices, effective biosecurity measures, and strict regulatory oversight to safeguard environmental health and ensure long- term production efficiency.

Keywords: Aquaculture, Maximum Residue Limits (MRLs), Antiparasitic drugs, Parasite management

Introduction

Aquaculture is the fastest- growing food industry in the world, having the potential to address the declining wild fishery stocks and fulfil the protein demand of the human population, which is growing rapidly (Bostock *et al.*,2010). Parasitic diseases have a considerable impact on finfish and shellfish aquaculture worldwide, affecting farm productivity, economic viability, and sustainability. The global economic burden of parasites on finfish production is estimated at USD 9.6 billion annually (Shinn *et al.*, 2015). Certain fish parasites have the potential to infect humans, posing a public health concern. Furthermore, the spread of parasites to new ecosystems and wild fish populations creates environmental challenges that can limit the expansion of aquaculture operations (Shinn *et al.*, 2015). The biological characteristics of parasites limit the effectiveness of relying solely on chemical treatments in aquaculture. Variations in parasite diversity, life cycles, transmission routes, and environmental persistence require control measures that are tailored to specific groups and vulnerable stages of their life cycles. Integration of parasite ecology with effective farm management practices for reducing chemical use, minimizing environmental impacts, and ensuring sustainable aquaculture production (Chupani et al., 2026).

Depending on the location of the aquaculture farms, parasite infestations can be decreased by biomass growth by 3.6% to 16.5% during a production cycle (Abolofia *et al.*, 2017). Control and management of parasite infestation on farms are essential for fish health and welfare to maintain sustainable aquaculture production. Treatment strategies are very limited due to the wide diversity of parasite species, limited environmental regulations, and the increasing development of resistance to antiparasitic drugs (Burridge *et al.*, 2010). To ensure the safety of the fish products for consumers, the use of veterinary medicines in aquaculture is carefully regulated. The highest permissible levels of drug residues that may remain in fish tissue after treatment are the Maximum Residue Limits (MRLs). The establishment of these limits is done through detailed toxicological evaluations to protect human health (Hyder et al., 2013). To comply with these regulations, farmers must observe a withdrawal period, which is the time required between the final administration of the drug and the harvesting of fish. This allows residue concentrations to decline to acceptable levels before the fish enter the food chain (Chupani *et al.*, 2026).

Common Antiparasitic Drugs Used in Aquaculture, including target parasites, MRLs, Administration routes, and mechanisms of action

Antiparasitic Agent	Target Parasites	MRLs	Administration Route	Mode of Action	References
Praziquantel	Monogeneans, digeneans, cestodes (Tapeworms)	-	Oral feed, Bath and Dip treatment	Alters calcium ion permeability, causing paralysis	(Norbury *et al.*, 2022)

Deltamethrin	*Lepeoptheirus salmonis*	10 µg/kg	Bath treatment	Sodium channel blocker	(Helgesen et al., 2014)
Ivermectin	Sea lice (Copepods)	-	Oral administration	Causes paralysis by enhancing chloride ion influx	(Horsberg, 2012)
Doramectin	Lernaea cyprinacea	-	Oral administration Intramuscular injection	Causing paralysis and brain damage	(Horsberg, 2012)
Emamectin Benzoate	Sea lice (*Lepeophtheirus salmonis, Caliguss pp.*)	100 µg/kg Slice 2mg/g	Medicated feed (SLICE™)	It activates glutamate-gated chloride channels, causing paralysis	(Horsberg, 2012)
Diflubenzuron and Teflubenzuron	*Lepeophtheirus salmonis*	500 µg/kg	Medicated feed	Inhibits chitin synthesis	(Parsons *et al.*, 2021)
Azamethiphos	*Lepeophtheirus salmonis* *Caligus spp.*	No MRL required	Bath	Inhibits Acetylcholinesterase	(Jansen *et al.*, 2016)
Imidacloprid	*Lepeophtheirus salmonis*	600 µg/kg	Bath	Nicotinic acetylcholine receptor agonist	(Aldrin *et al.*, 2023)
Hydrogen peroxide (FDA Approved)	Protozoans and gill parasites	No MRL required	Bath	Cell damage and Oxidative stress	(Mitchell and Collins, 1997)
Formaldehyde (FDA Approved)	Controls protozoans (*Ichthyophthirius, Chilodonella, Costia, Scyphidia, Epistylis, Trichodina*) and monogeneans (*Cleididiscus, Gyrodactylus, Dactylogyrus*)	No MRL required	Bath	DNA damage and protein cross-linking	(Treves-Brown, 2000)
Potassium Permanganate (KMnO4)	Ectoparasite	No MRL required	Immersion	Strong oxidizing agent, disrupting cellular functions	(Floyd, 1993)
Methylene blue	Ectoparasite (Ich and Costia)	10 µg/kg	Bath	Disrupting parasite cellular respiration	(Umeda *et al.*, 2006)
Copper sulphate ($CuSO_4$)	*Ichthyopthirius* *Amyloodinium* *Argulus* *Saprolegnia parasitica*	No MRL required	Bath	Toxic disruption of parasite metabolism	(Sun *et al.*, 2014)
Sodium chloride (NaCl)	Ectoparasite and monogeneans	No MRL required	Bath	Osmotic shock	(Phillips, 2000)
Cypermethrin	Ectoparasite	50 µg/kg	Bath	Neurotoxic pyrethroid action	(Jesna *et al.*, 2024)
Peracetic Acid	Ectoparasite (*Ichthyophthirius multifilis)*	No MRL required	Bath	Oxidative damage	(Abu-Elala et al., 2021)

Commonly used Antiparasitic for Protozoans

Antiparasitic Agents	Target Parasite Fish	Dosage	Administration Route	References
Formalin	*Ichthyophthirius multifiliis, Trichodina, Chilodonella, Ichthyoboda*	15-25 mg/L prolonged bath	Bath treatment	(Noga,2010)
Hydrogen peroxide	*Ichthyophthirius, Ichthyoboda*, marine protozoans	50-150mg/L for 30-60 min	Bath treatment	(Noga,2010)
Potassium permanganate	*Trichodina, Costia*,	2-5 mg/L for 1-4 h	Bath treatment	(Noga,2010)
Copper sulphate	Ciliates, Dinoflagellates	0.15-0.25mg/L	Bath treatment	(Robert, 2012)
Acriflavine	Ectoparasite	5-10 mg/L	Bath treatment	(Woo and Buchmann, 2012)
Methylene blue	Ectoparasite	2-5mg/L	Bath treatment	(Robert, 2012)
Chloroquine phosphate	Cryptocaryon irritans, Amyloodinium ocellatum	10mg/L	Immersion/Oral	(Noga,2010)
Metronidazole	Hexamita, Spironucleus	25-50 mg/kg body weight/day for 5-10 days	Oral feed	(Woo and Buchmann, 2012)
Ronidazole	Flagellates	10-20 mg/kg/day	Oral feed	(Woo and Buchmann, 2012)
Dimetridazole	Flagellates	25-50 mg/kg/day	Oral feed	(Robert, 2012)
Malachite green* (Banned)	*Ichthyophthirius*, ectoparasite	0.05-0.15mg/L	Bath treatment	(Alderman, 1985)

Commonly Used Antiparasitic for Metazoans

Antiparasitic Agents	Target Parasite Fish	Dosage	Administration Route	References
Praziquantel	Monogeneans, digeneans, cestodes	2-10mg/L bath: 35-75 mg/kg oral	Oral, bath	(Noga,2010)
Albendazole	Nematodes, cestodes	10-20 mg/kg/day	Oral	(Woo and Buchmann, 2012)
Mebendazole	Nematodes	25-50 mg/kg/day	Oral	(Woo and Buchmann, 2012)
Levamisole	Nematodes	5-10mg/kg oral; 2-10mg/L bath	Oral, bath	(Robert, 2012)
Ivermectin	Nematodes, ectoparasite	0.05mg/kg feed	Oral	(Shoop *et al.*, 1995)
Emamectin benzoate	Nematodes	0.05-0.35 mg/kg/day feed for 7-14 days	Oral	(Stone *et al.*, 2000)
Niclosamide	Cestodes	50-100 mg/kg	Oral	(Woo and Buchmann, 2012)
Triclabendazole	Digenean trematodes	10-20 mg/kg	oral	(Robert, 2012)
Trichlorfon	Monogeneans and helminths	0.25-1.0mg/L	Bath treatment	(Noga,2010)
Dichlorvos	Helminth	0.25- 0.5mg/L	Bath treatment	(Robert, 2012)

Commonly Used Antiparasitic for Crustaceans

Antiparasitic Agents	Target Parasite Fish	Dosage	Administration Route	References
Emamectin benzoate	*Lepeophtheirus salmonis, Caligus spp.*	0.05-0.35 mg/kg/day feed for 7-14 days	Oral feed	(Stone *et al.*, 2000)
Diflubenzuron	Sea lice	1-3 mg/L feed	Oral feed	(Treasurer and Grant, 1997)
Teflubenzuron	Sea lice	5-10 mg/kg feed	Oral feed	(Treasurer and Grant, 1997
Azamethiphos	Sea lice	0.1 – 0.2mg/L for 30-60 min	Bath treatment	(Roth *et al.*,1993)
Cypermethrin	Sea lice	5-10 µg/L	Bath treatment	(Treasurer and Grant, 1997
Deltamethrin	Sea lice	1-3 µg/L	Bath treatment	(Treasurer and Grant, 1997
Hydrogen peroxide	Sea lice	50-150mg/L for 30-60 min	Bath treatment	(Treasurer and Grant, 1997
Ivermectin	Sea lice	0.05mg/kg feed	Oral feed	(Shoop *et al.*, 1995)
Trichlorfon	*Argulus spp. Lernaea spp*	0.25-1.0mg/L	Bath treatment	(Noga,2010)
Potassium permanganate	*Argulus spp.*	2-5 mg/L for 1-4 h	Bath treatment	(Robert, 2012)
Salt treatment	*Argulus spp.* Ectoparasite	10-30 g/L dip or 2-5 g/L prolonged bath	Bath treatment	(Noga,2010)

The major antiparasitic drugs and chemicals are used in aquaculture for controlling a wide range of parasite infections in fish. Anthelminthic agents such as praziquantel are effective against monogeneans, digeneans, and cestodes by disrupting calcium-ion permeability and inducing paralysis in parasites. Macrocyclic lactones, including ivermectin and doramectin, are used against sea lice and anchor worm, causing paralysis through enhanced chloride ion influx. Emamectin benzoate is widely administered through medicated feed for sea lice and acts by activating glutamate- gated chloride channels. Chitin synthesis inhibitors such as diflubenzuron and teflubenzuron are effective against *Lepeophtheirus salmonis.* At the same time, azamethiphos and deltamethrin are commonly applied as bath treatments, targeting the nervous system through acetylcholinesterase inhibition and sodium channel disruption, respectively.

Several chemical therapeutants are used for ectoparasite management. Formaldehyde and Hydrogen peroxide are FDA-approved drugs used as antiparasitic agents in aquaculture. Hydrogen peroxide, Formaldehyde, potassium permanganate, Methylene blue, Copper sulphate, Cypermethrin, and Peracetic acid are primarily administered as bath or immersion treatments. Their mechanism includes oxidative damage, protein cross-linking, disruption of cellular respiration, osmotic shock, and neurotoxic effects. Maximum residue limits (MRLs) have been established for some compounds, including deltamethrin (10µg/kg), methylene blue (10µg/kg), Emamectin benzoate (100µg/kg), diflubenzuron and teflubenzuron (500µg/kg), imidacloprid (600µg/kg), and cypermethrin (50µg/kg). Several externally applied treatments do not require specific MRLs because of their rapid degradation or negligible tissue residues. For effective parasite management and sustainable aquaculture production, these therapeutants play a critical role in aquaculture.

The therapeutic doses of antiparasitic agents used in aquaculture are generally influenced by many factors like fish species, developmental stage, water temperature, salinity, treatment duration, parasite susceptibility. A single universal dose cannot be recommended for all the situations. Standard references such as (Noga, 2010) and (Roberts,2012) generally reported dosage ranges rather than fixed treatment concentrations. Therefore, the doses presented in this article should be considered as commonly reported therapeutic ranges. These dosages may require adjustment according to specific culture conditions and targeted species.

Conclusion

Modern aquaculture is facing one of the most significant challenges, which is parasitic diseases, affecting fish health, productivity, economic sustainability, and environmental integrity. Effective aquaculture management is essential to overcome infestation, which reduces growth performance, increases mortality, reduces feeding, and limits the expansion of aquaculture operations. The parasites have complex life cycles, diversity in parasite species, and resistance to commonly used treatments, which necessitate the adoption of targeted and integrated control strategies. Such an integrated approach will support long- term aquaculture productivity while minimizing environmental impacts and safeguarding public health.

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