A Short Review on Ectoparasite Removal from Fish - Current Methods, Emerging Technologies and Control Strategies

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1. Introduction

The global aquaculture industry has expanded rapidly over the past few decades, contributing significantly to food security and livelihoods. However, with intensification and high stocking densities, disease outbreaks have become more frequent and severe. Fish infected with ectoparasites may exhibit visible lesions on their body surface and abnormal behaviours. Among these, ectoparasites are of particular concern as they cause direct damage to fish skin, fins, and gills, resulting in secondary infections, stress, reduced growth rates, and high mortality (Roberts, 2012). Examination of mucilage samples from the gills, skin, fins, and tails under a microscope can confirm the presence of ectoparasites. Common ectoparasites include *Ichthyophthirius multifiliis, Trichodina spp., Dactylogyrus, Gyrodactylus, Lernaea, Argulus, and Caligus*. Figure 1 shows the ectoparasites of fish. Ectoparasite control is vital not only for fish welfare but also for environmental sustainability and economic viability. Thus, this review explores a broad range of existing and emerging strategies to combat ectoparasitic infections in aquaculture.

2. Common Ectoparasites and Their Impacts

Ectoparasites vary in their morphology, host specificity, and pathogenic potential. Protozoans such as Ichthyophthirius multifiliis are common in freshwater fish, attaching to the skin and gills and causing respiratory distress (Matthews, 2005). Trichodina spp. are ciliated protozoans that can damage fish epithelium and facilitate bacterial co-infections. Monogeneans such as Dactylogyrus and Gyrodactylus affect gill and body surfaces, leading to hyperplasia and impaired oxygen uptake. Crustacean ectoparasites like Argulus (fish lice), Lernaea (anchor worm), and Caligus (sea lice) are particularly problematic in large-scale aquaculture operations. Figure 2 shows mechanism of ectoparasite affect fishes to cause infections. The ectoparasites feed on host tissue and blood, causing inflammation and secondary bacterial and fungal infections (Noga, 2010).

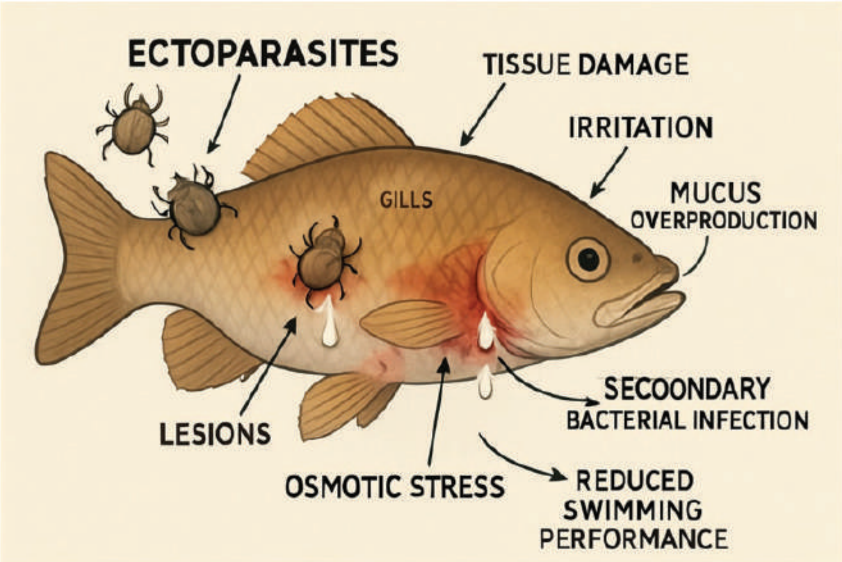

Figure 2: The mechanism of ectoparasite affect fishes to cause infections

3. Chemotherapeutic Treatments

Chemotherapy remains the primary line of defense against ectoparasites due to its immediate and observable effectiveness. Formalin, copper sulfate, potassium permanganate, and hydrogen peroxide are among the most commonly used chemicals. These agents function by disrupting parasite membranes or interfering with respiration and reproduction. For instance, formalin is effective against protozoans and monogeneans, but its carcinogenic nature and environmental persistence have raised concerns (Noga, 2010). Similarly, copper sulfate is widely used but can accumulate in sediments and become toxic to non-target organisms. Potassium permanganate (KMnO4), a strong oxidizing compound, is effective against a broad range of external parasites including Gyrodactylus, Dactylogyrus, Trichodina, and Ichthyobodo species. It acts by oxidizing the cellular structures of parasites and organic debris on fish surfaces and gills, improving respiration and reducing microbial load. Prolonged and frequent use of these chemicals has led to reduced efficacy and the emergence of resistant parasite strains. (Sommerville, 2012).

4. Biological Control Measures

The use of cleaner fish in marine aquaculture has garnered significant attention due to its potential to mitigate parasitic infestations, particularly sea lice, which pose substantial challenges to sustainable fish farming. Brooker et al., (2018) highlight that the domestication and application of cleaner fish species, such as wrasse, are progressing rapidly. The ecological and genetic considerations associated with cleaner fish translocation are critical, given that the reliance on wild-caught specimens may threaten local biodiversity and population stability. This concern is compounded by the fact that the high demand for cleaner fish in aquaculture has led to extensive wild harvesting, which may not be sustainable in the long term.

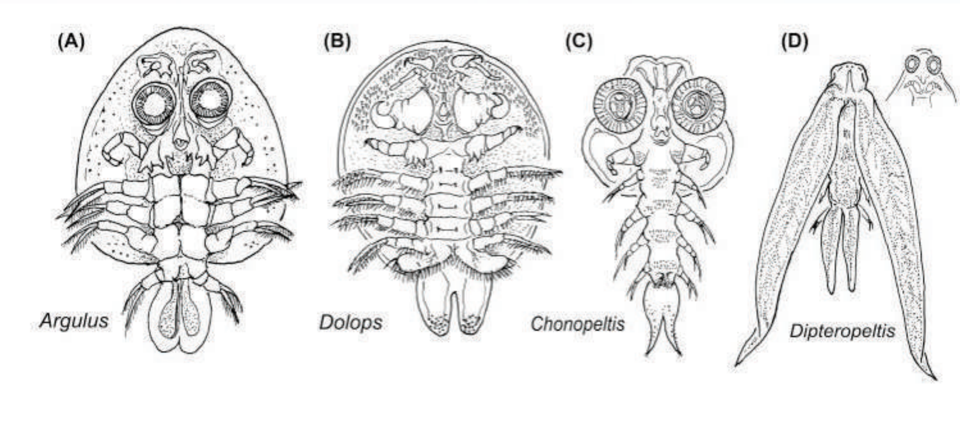

Figure 1: Ectoparasites of Fish (Courtesy: Eduardo Suárez-Morales - ScienceDirect)

5. Phytotherapy Remedies

Phytotherapy the use of plant-based compounds for disease prevention and treatment has gained significant traction in aquaculture as a safe and eco-friendly method for controlling ectoparasites. Various medicinal plants and herbal extracts exhibit antiparasitic, immunostimulant, and anti-inflammatory properties, making them valuable in integrated ectoparasite management strategies. For example, neem (Azadirachta indica) has shown efficacy against Argulus and Lernaea, while garlic (Allium sativum) acts against protozoan infections by altering osmoregulation in parasites (Sivaram et al., 2004). The safety profile of plant-based remedies, such as those derived from seeds of Cucurbita maxima and Carica papaya, has been demonstrated in controlling monogenean parasites, further supporting their application in aquaculture (Ankit sharma et al 2025).

6. Challenges in Vaccine Development

The development of vaccines targeting ectoparasite removal in fish faces numerous challenges. One significant obstacle is the complex immune response elicited by ectoparasites such as Argulus siamensis. Kar et al. 2015 demonstrated that infection with A. siamensis induces transcriptional changes in immunoglobulin isotypes in rohu, indicating an active but potentially insufficient immune response. Experimental vaccines for Ichthyophthirius multifiliis have employed immobilization antigens (i-antigens) to stimulate protective antibody responses (Clark & Dickerson, 1997). Despite initial success in lab trials, field-level efficacy has been inconsistent. The lack of commercial vaccines for ectoparasites indicates the need for further research in antigen selection, adjuvants, and delivery systems.

7. Emerging technologies

7.1 Neonicotinoids

A method for removing ectoparasites from a fish in water may comprise administering to the fish a neonicotinoid such as imidacloprid to remove the ectoparasites from the fish and exchanging the water comprising the neonicotinoid and the removed ectoparasites with replacement water, thereby separating the removed ectoparasites and the fish. The method may comprise the further step of preventing release of the removed ectoparasites into the environment, for example by passing sample of the water comprising the removed ectoparasite through a mesh filter (Marshall et al., 2017).

7.2 Electrolytic Ozone Water

The innovative method for removing ectoparasites from breeding fish using an electrolysis type ozone generating device. This device generates ozone water by electrolyzing raw material water, which is then stored in a tank. Breeding fish are placed in this electrolytic ozone water, effectively expelling the ectoparasites. This method offers a novel approach to managing ectoparasite infestations in aquaculture, enhancing fish health and potentially improving breeding outcomes (Osako et al., 2011).

7.3 Mechanical and Physical Removal

Mechanical and physical methods provide immediate and non-chemical means of ectoparasite removal, particularly useful during severe infestations. Techniques such as freshwater or saltwater baths are commonly employed to dislodge external parasites like Argulus, Lernaea, and Ichthyophthirius multifiliis. Freshwater bathing is especially effective in marine fish, as osmotic shock causes the detachment of ectoparasites from the skin and gills (Noga, 2010). Mechanical filtration systems in recirculating aquaculture setups also help by removing free-living larval stages before they can reinfect hosts.

8. Environmental Management

Environmental management is the first line of defense against ectoparasitic outbreaks in aquaculture. Optimal water quality specifically parameters like temperature, dissolved oxygen, pH, ammonia, and turbidity plays a crucial role in suppressing ectoparasite proliferation and enhancing fish immunity. Poor water conditions are known to stress fish, compromising their epithelial barriers and making them more susceptible to ectoparasitic attachment and invasion (Martins et al., 2011). Overstocking, another critical factor, increases host density, which can accelerate the spread and severity of parasite infestations, particularly for directly transmitting species like Gyrodactylus and Ichthyophthirius (Costello, 2006). Implementing proper stocking densities, regular water exchange disrupts the favourable for parasite reproduction.

9. Integrated Strategies in Ectoparasite Control in Aquaculture

9.1 Expanded on Host-Parasite Interaction Dynamics

Understanding the host-parasite relationship is critical for designing effective control strategies. Ectoparasites interact with fish through complex immunological, behavioural, and physiological pathways. These parasites exploit mucosal surfaces such as the skin and gills, often initiating localized immune suppression to evade host defenses. Environmental stress, nutritional deficiency, and compromised immunity often exacerbate parasitic outbreaks (Buchmann & Lindenstrom, 2002). Studying these dynamics allows the identification of immune markers and targets for vaccine or feed-based interventions.

9.2 Role of Functional Feeds

Functional feeds enriched with probiotics, prebiotics, and immunostimulants have shown promise in reducing ectoparasite infestations indirectly by boosting innate immune responses. These diets enhance mucosal and systemic immunity, reduce oxidative stress, and often possess direct antiparasitic properties. Additives like β-glucans, mannan oligosaccharides, nucleotides, and herbal extracts (e.g., neem, garlic, turmeric) stimulate innate defenses that reduce parasite establishment and burden (Dawood et al., 2020).

9.3 Life Cycle Disruption Strategies

Targeting specific stages of parasite life cycles offers a precise and environmentally sound approach to ectoparasite control. Many ectoparasites have free-living infective stages (e.g., theronts of Ichthyophthirius, oncomiracidia of monogeneans), which are vulnerable to physical, chemical, or biological disruption. Strategies such as UV sterilization in recirculating aquaculture systems (RAS), periodic drying of ponds, and stocking of biological control agents like copepod predators or prawns reduce infective-stage survival. Salt baths and temperature shocks are also used to break parasite transmission cycles.

9.4 Breeding for Genetic Resistance

Selective breeding for parasite-resistant fish strains is a long-term and cost-effective solution to ectoparasite control. Certain breeds or strains show enhanced resistance due to stronger mucosal immunity, epithelial resilience, or lower susceptibility to parasite attachment. For example, some strains of Atlantic salmon have demonstrated natural resistance to sea lice (Lepeophtheirus salmonis), while resistant Nile tilapia strains have shown reduced infestations by Gyrodactylus spp (Houston et al., 2008).

10. Conclusion

Ectoparasite infestations remain a persistent challenge in aquaculture, significantly impacting fish health, productivity, and farmer livelihoods. While conventional chemotherapeutic methods have provided short-term relief, they often come with environmental risks, residue concerns, and the threat of resistance development. In response, a range of sustainable, eco-friendly alternatives has emerged. Biological control methods including the use of cleaner organisms, probiotics and functional feeds offer promising non-chemical options. Phytotherapy remedies further enhance fish resilience with natural bioactive compounds. Novel approaches such as selective breeding for genetic resistance represent the future of integrated ectoparasite control. Moreover, understanding host–parasite dynamics, disrupting parasite life cycles are critical for effective long-term management.

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