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***Ligula intestinalis* in aquatic systems: taxonomy, epidemiology, pathology, and control — a concise narrative review**

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Article Info	Abstract
<p>Article history:</p> <p>Submit Date: 2 August 2025</p> <p>Accept Date: 18 August 2025</p> <p>Online Date: 4 December 2025</p>	<p><i>Ligula intestinalis</i> (Cestoda: Diphylobothriidae) is a cosmopolitan tapeworm with a three-host life cycle involving copepods, cyprinid fishes, and piscivorous birds. Its plerocercoid stage grows extensively within the fish's body cavity, compressing the viscera and causing profound reproductive impairment. Here we synthesize taxonomy and morphology, life cycle, epidemiology (with emphasis on Iran), pathology, zoonotic considerations, and control options. Molecular data increasingly support the synonymy of <i>Digramma</i> with <i>Ligula</i> and indicate low interspecific divergence within the complex. Regionally, prevalence varies widely (≈ 3–60% in Iran, depending on host, season, and locality) and can reach double-digit levels in African lakes. Gross lesions include abdominal distension and gonadal atrophy; histopathology commonly reveals ovarian/testicular degeneration and hepatic vacuolation. Despite sporadic claims, confirmed human infection by <i>L. intestinalis</i> has not been documented; risk is minimized by proper cooking and avoidance of raw freshwater fish. Effective control requires interrupting the life cycle (reducing copepods, excluding piscivorous birds from aquaculture), routine monitoring, biosecurity in semi-closed systems, and public education.</p>
<p>Keywords:</p> <p>Control strategies</p> <p>Epidemiology</p> <p>Freshwater fish</p> <p><i>Ligula intestinalis</i></p> <p>Pathology</p>	
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Introduction

Ligula intestinalis, a pseudophyllidean cestode of the family Diphyllbothriidae, is known to be a globally distributed parasite that primarily affects freshwater fish and piscivorous birds. The parasite is best known for its plerocercoid stage, which grows extensively within the body cavity of cyprinid fish and causes significant physiological and reproductive disruptions, including castration and growth retardation (Arme and Owen, 1968; Bouzid et al., 2008). In Iran, prevalence rates as high as 63% have been recorded in *Alburnoides bipunctatus* (Jalali and Barzegar, 2006; Ahmadiara et al., 2013). These high infection rates are associated with environmental factors, such as water temperature, host density, and the presence of migratory birds (Liao and Liang, 2003). Despite its significance, ambiguities remain concerning the taxonomic status of related species, particularly *Digramma interrupta*, and its differentiation from *L. intestinalis*. This review aims to provide a comprehensive synthesis of current knowledge on the taxonomy, life cycle, pathology, and epidemiology of *L. intestinalis*, with particular emphasis on data from Iran in comparison with global literature. Additionally, the article highlights research gaps and proposes strategies for control and future investigation. The life cycle begins when eggs released from adult tapeworms in bird intestines are passed into freshwater bodies via feces. Fish mainly cyprinids, such as *A. bipunctatus*, *Abramis brama*, *Rutilus rutilus*, and *Chalcalburnus* spp., become infected by consuming infected copepods. Studies in Iran have documented infection rates ranging from 3.4% in southeastern regions (Rahnama et al., 2024) to over 60% in northwestern provinces (Jalali and Barzegar, 2006; Ahmadiara et al., 2018). Birds serve as both definitive hosts and long-distance vectors, dispersing the parasite across freshwater ecosystems during seasonal migration (Liao and Liang, 2003). Several factors shape the prevalence and spread of *L. intestinalis*. Temperature: higher temperatures accelerate larval development. Host density: crowded fish populations facilitate the transmission of parasites. Bird migration: introduces the parasite to new watersheds. Water source connections: cross-border spread has been noted in Iran's northwest due to proximity to Turkish water systems (Ahmadiara et al., 2018).

Epidemiology (global and regional patterns)

Global prevalence and distribution

L. intestinalis is widely distributed in freshwater ecosystems throughout Europe, Asia, Africa, and parts of the Americas. Infection rates vary significantly based on geography, host species, and environmental conditions. In Europe, high prevalence has been reported in cyprinid fish from lakes and rivers in the Czech republic, Poland, Romania, and the United Kingdom, often exceeding 20% in some water bodies (Arme and Owen, 1968; Bouzid et al., 2008). *L. intestinalis* co-infections have been found in *Hemiculter lucidus* and *A. brama*, raising questions about species boundaries (Dubinina, 1980; Ahmadiara et al., 2018). In Africa, a recent study from Ethiopia (Geta et al., 2024) identified a 16.2% infection rate in fish from Lake Tana, with significant histopathological impacts. In South America, *Ligula* infections have been recorded in fish from reservoirs in Brazil, though prevalence remains comparatively low (Silva et al., 2022). In East and Southeast Asia, moderate to high infection rates have been documented, especially in China, where strain variability has also been noted (Li et al., 2003). Migratory birds are thought to contribute significantly to the parasite's spread across regions.

Epidemiology in Iran

Iran has been a source for *L. intestinalis* research in recent decades. Studies from various regions have shown a wide range of infection rates across freshwater systems and fish hosts: Northwest Iran. Ahmadiara et al. (2013) reported infection rates of 63.2% in *A. bipunctatus* and 16% in *A. brama* from Maragheh Dam and Anzali Lagoon. In North and Northeast, Jalali and Barzegar (2006) detected high rates in Zarivar Lake, while recent studies from Gilan province (2024) showed persistent circulation of *Ligula* in the Siah Darvishan River with molecular confirmation (Ahmadiara and Nikpay, 2024). In Central Iran and Southeastern Iran, Rahnama et al. (2024) found a relatively lower prevalence (3.4%) across seven fish species in the Sistan, possibly due to higher water temperatures and ecological differences. In all regions, infection is more common in older or larger fish, and prevalence is often seasonal, higher in late spring and summer

when water temperatures rise, and copepod activity peaks.

Host-specificity and risk factors

While *L. intestinalis* can infect multiple cyprinid species, studies suggest certain preferences, likely influenced by feeding behavior, size, and environmental overlap with copepod populations (Olson *et al.*, 2002; Bouzid *et al.*, 2008). Risk factors associated with higher prevalence include:

Water temperature >15°C

Presence of migratory piscivorous birds

Abundant copepod populations

Shallow water bodies with organic enrichment

Implications for aquaculture and biodiversity

The presence of *L. intestinalis* in semi-closed systems (e.g., reservoirs, fish farms, and artificial lakes) poses a significant threat to aquaculture, especially in regions like Gilan, Mazandaran, and Azerbaijan. The parasite not only reduces fish productivity but can also alter host population dynamics, affecting biodiversity (Britton *et al.*, 2009). Despite this, *L. intestinalis* still under-recognized in national fish health surveillance programs, and few integrated monitoring efforts exist.

Pathological findings

Infection by *L. intestinalis* plerocercoids can lead to significant pathological changes in freshwater fish, both grossly and microscopically.

Gross pathological findings

Infected fish often exhibit visibly distended abdomens due to the large size of the plerocercoid (sometimes >30 cm), which occupies much of the peritoneal cavity: abdominal swelling and emaciation, compression and displacement of visceral organs, including the liver, gonads, and intestines, marked atrophy or total degeneration of the gonads, especially in females, and enlarged and pale liver, often with signs of pressure necrosis.

Histopathological alterations

Multiple histopathological studies, including those conducted in Iran (Rahmati-Holasoo *et al.*, 2011; Ahmadiara *et al.*, 2013), have documented the following key microscopic changes:

Severe ovarian atrophy and loss of follicular structures, degeneration of testicular seminiferous tubules, focal hepatic necrosis and vacuolation, chronic inflammation in the serosal linings of internal organs, compression of swim bladder and kidney tissues, peritonitis, and mild fibrosis of the coelomic cavity. These changes can lead to functional castration of the host, rendering it unable to reproduce and thus influencing population dynamics.

Physiological and behavioral impacts

Infected fish frequently show:

Retarded growth and low condition factors

Loss of appetite and abnormal swimming behavior

Reduced escape response to predators

Suppression of sexual maturation

In field studies, the absence of mature gonads in heavily infected fish populations has been associated with long-term declines in reproductive output and recruitment, particularly in minor lakes or closed reservoirs (Jalali and Barzegar, 2006; Britton *et al.*, 2009).

Zoonotic considerations

Overview

Unlike many other cestodes within the family Diphylobothriidae, such as *Diphylobothrium latum*, which is well-established as zoonotic, the gonads have not been definitively confirmed as a human pathogen. However, its widespread prevalence in freshwater fish and its phylogenetic proximity to zoonotic species have raised questions regarding its potential public health significance. *L. intestinalis* primarily considered a fish-bird parasite; occasional anecdotal reports and theoretical concerns have kept the debate about its zoonotic potential open (Eslami, 2006;

Ahmadiara, 2017).

Reports and evidence

To date, no confirmed human infections with *L. intestinalis*. Ahmadiara (2018) highlighted the possibility that ingestion of undercooked or raw fish harboring plerocercoids, especially in regions where traditional or local food practices involve such consumption, could theoretically lead to accidental human exposure, even if establishment and maturation in humans are unlikely.

Risk assessment

Plerocercoids are usually free in the body cavity, not within muscle tissue, the main edible portion of fish. Cooking and freezing effectively kill the larval stages (Ahmadiara, 2017). In addition, *L. intestinalis* may serve as a biomarker for environmental health, reflecting water quality, pollution levels, and biodiversity changes (Bouzid et al., 2008).

Recommendations

Although zoonotic transmission is currently unproven, the following precautionary measures are advisable:

Avoid consumption of raw or undercooked freshwater fish, Promote routine inspection of fish for plerocercoids in aquaculture and market settings, and Controlling *L. intestinalis* infections in aquatic systems poses significant challenges due to the complexity of its life cycle and the involvement of multiple trophic levels. However, understanding the transmission dynamics allows for the implementation of targeted interventions to minimize infection in fish populations and reduce ecological and economic damage.

Biological and ecological control measures

Interrupting life cycle

Since *L. intestinalis* reduces intermediate host density, especially copepods, via ecological manipulation (e.g., reducing organic enrichment in ponds and reservoirs). Controlling bird access to aquaculture systems, particularly piscivorous birds like herons and cormorants, which act as definitive hosts and disseminators (Yavuzcan et

al., 2003). Stocking of resistant fish species or using smaller/younger fish that are less likely to accumulate plerocercoids over time (Britton et al., 2009).

Public health and fish processing

Though the zoonotic risk remains uncertain, applying standard public health practices is advisable: ensure thorough cooking of freshwater fish to inactivate any larval stages, avoid consumption of raw fish, especially from lakes or rivers known to harbor the parasite, educate fish handlers and vendors on recognizing plerocercoid-infected fish, and removing visible parasites before sale (Bozorgnia et al., 2016).

Recommendations for aquaculture operations

Periodic monitoring of fish stocks for plerocercoid infection using abdominal palpation and necropsy. Quarantine and inspection protocols for newly introduced fish into semi-intensive systems. Bird-proof netting and scare devices to prevent access of migratory birds to fishponds. Rotational farming to break transmission cycles and reduce environmental egg load.

Research and policy needs

Despite its broad impact, Ligulosis screening into national fish health programs, particularly in endemic regions, such as Gilan, Mazandaran, and East Azerbaijan. Collaboration between veterinary parasitologists, ecologists, and fishery managers to implement integrated parasite management (IPM) systems.

In summary, *L. intestinalis* is a biologically and ecologically significant cestode parasite that continues to impact freshwater ecosystems worldwide, particularly through its impacts on fish health, reproduction, and aquaculture productivity. Its complex three-host life cycle, coupled with the ecological mobility of migratory birds, makes controlling its transmission a considerable challenge. In Iran, extensive research over the past two decades, particularly in northern and northwestern provinces, has documented alarmingly high prevalence rates in native cyprinid species. Although zoonotic transmission to humans has not been definitively proven, the parasite's proximity to other diphyllbothriids warrants continued public health vigilance, particularly in regions with cultural practices

involving the consumption of raw or undercooked fish. Efforts to control *L. intestinalis* must be multifaceted, combining environmental management, aquaculture biosecurity, fish population monitoring, and public education.

Conflict of Interest

No conflict of interest has been reported among the authors.

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