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Economic impacts of aquatic parasites on global finfish production

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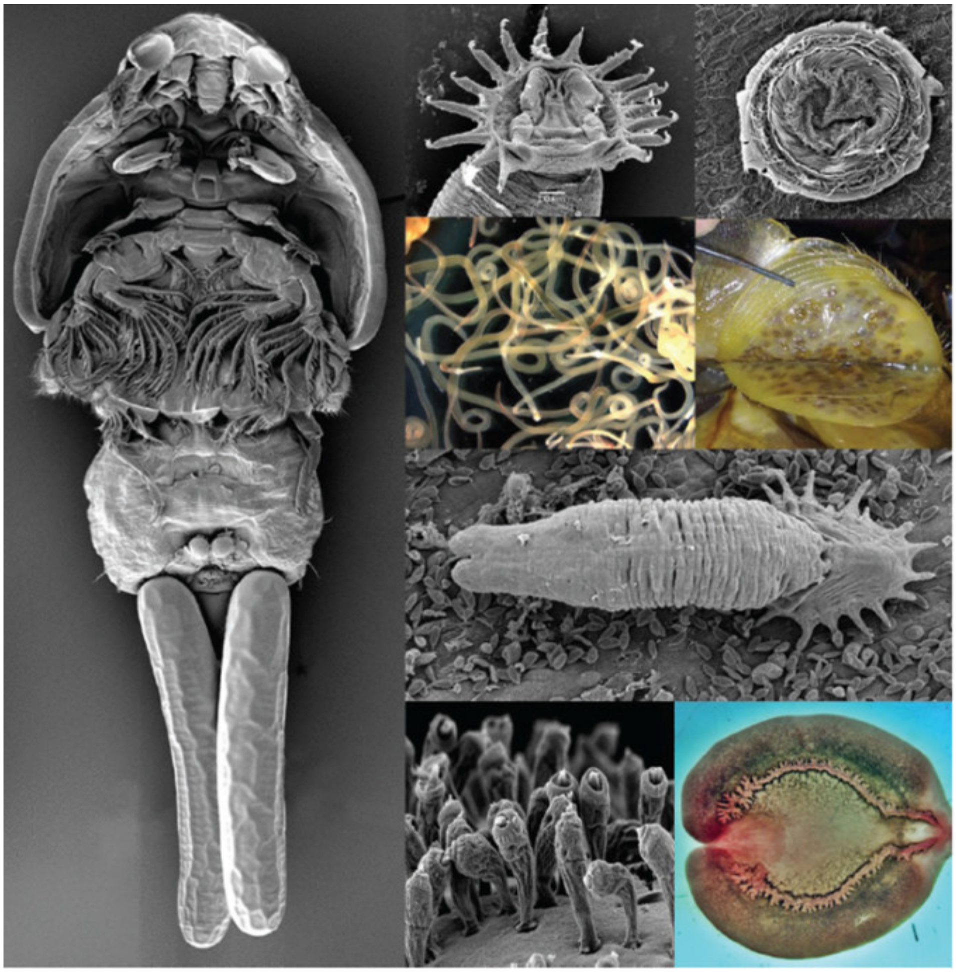
As aquaculture intensifies, so will the prevalence and severity of parasite infections



Commonly encountered parasites of aquatic animals include (from left) *Caligus elongatus*, the monogenean *Gyrodactylus salaris*, the ciliate protozoan *Trichodina* and *Anisakis* nematodes. On the second row, right, the eggs of the turbellarian *Bdelloura candida* are shown on the gills of a horseshoe crab. The image on the third row shows *Gyrodactylus salaris* on the fin of an Atlantic salmon, followed by the sessile *peritrich Apiosoma* on the skin of a freshwater fish and the monogenean *Dictyocotyle coeliaca* from the body cavity of a ray.

Obligate and opportunistic parasites play a critical role in determining the productivity, sustainability and economic viability of global finfish aquaculture enterprises. Without stringent and appropriate control measures, the impacts of these pathogens can often be significant.

Estimating the true impacts of each parasite event, however, is complicated, as costs can be affected by a diverse assortment of environmental and management factors. The factors can range from direct losses in production to the more indirect costs of longer-term control and management of infections and the wider, downstream socioeconomic impacts on livelihoods and satellite industries associated with the primary producer.

Certain parasite infections may be predictable, as they occur regularly, while others are unpredictable because they arise sporadically. In each case, there can be costs for treating and managing infections once they are established, but for predictable infections, there also are costs associated with prophylactic treatment and management.

Table 1 provides some estimates of economic loss associated with notable protistan and metazoan parasite events in some of the world's leading finfish production industries. The figures provided in Table 1 were extracted from a larger study by the authors in which the potential economic costs related to 498 specific events attributable to a range of key parasite pathogens were detailed.

Acceptance of losses

A significant proportion of stock losses occur within the hatchery/nursery phases of production. In many industries, these are factored into and accepted as part of normal operational practices.

Such fatalistic acceptance means losses are frequently underreported, hiding the severity and impacts of parasites such as omycete species belonging to the genera *Aphanomyces* and *Saprolegnia*; the dinoflagellates *Amyloodinium ocellatum* and *Piscinoodinium pillulare*; ciliate protozoans such as *Trichodina* species, *Ichthyophthirius multifiliis* and *Cryptocaryon irritans*; and species belonging to the monogenean genera *Gyrodactylus* and *Dactylogyrus*.

Estimating global costs

The authors recently began to estimate the global costs of parasitism by following production at four commercial Nile tilapia, *Oreochromis niloticus*, farms in Thailand over the course of 12 months to determine average mortality rates in the earlier stages of production. The data are presented in Figure 1. From these values, the following survival rates can be determined: egg production (77.5 percent hatch rate), swim-up fry (77.8 percent survival from hatched eggs, 60.8 percent survival of starting egg number), 21-day post-monosex fry (78.9 percent survival from swim-up fry, 48 percent survival of starting egg number) and in 2.5-cm nursery-size fish (83.3 percent survival from 21-day monosex stage, 40 percent survival of starting egg number).

Hatchery-based losses were then calculated using local production costs — 0.1 Thai baht (U.S. $0.0028) for each egg to swim-up stage, 0.2 baht ($0.0057) for each swim-up to monosex fry and 0.3 baht ($0.0085) for each monosex to nursery-size fish — and by assuming that 20 percent of the mortalities can be directly attributed to parasitic infection.

Given the broad diversity of aquaculture, the 267 food finfish species and categories listed by the Food and Agriculture Organization (FAO) of the United Nations and the vast spectrum of parasites that can impact their production, it is almost impossible to ascribe a single value that captures all the losses induced by parasite activity in each industry. Likewise, despite continuous health monitoring by on-site diagnosticians, it is technically impossible to determine the cause of mortality of every fish on site.

From the figures provided above and in Figure 1, for example, about 1.2 million 21-day post-monosex fry are lost each month (about 40,000/day). From a parallel study conducted by some of the current authors, it would appear that parasites account for an annual loss of $62 million to $175 million, representing 5.8 to 16.5 percent of the value of aquaculture production in the United Kingdom across all species reared in freshwater, brackish and marine systems.

To begin moving toward an estimate of loss attributable to parasitism, the figure of 20 percent is applied here to estimate stage-specific losses due to parasites within the hatchery phase of production. This is based on this latter study on aquaculture activities in the U.K. It is important to stress, however, that this is not 20 percent of global harvest production.

Global numbers

In 2013, the last year for which complete figures are available from FAO, the global production of finfish through aquaculture was 47.07 million metric tons (MT). If we assume an average sale weight of harvest-sized fish of 0.4 to 0.5 kg, the total number of harvest fish sold annually can be estimated at 94.14 billion to 117.68 billion.

If this figure is adjusted by assuming a 10 percent loss of fish between nursery and harvest, the annual number of post-nursery fish can be estimated as 103.55 billion to 129.44 billion. If the same percentages of parasite-induced loss are applied for each stage of finfish hatchery production, and assuming that $1.00 = 32.16 Thai baht, the annual global loss of juvenile fish can be estimated at between $107.31 million and $134.14 million.

Using the annual production of all farmed tilapia species for 2013, for example, which was 4.82 million MT, we can estimate there were 9.7 billion to 13.4 billion post-nursery fish produced and that the economic losses of juvenile tilapia to parasitic infection were $4.84 million to $6.66 million at the nursery stage, $5.84 million to $8.02 million at the monosex stage and $5.13 million to $7.05 million at the swim-up stage.

Secondary losses

However, these estimates are for the direct losses due to parasitic infections and do not account for the role that parasites can play in facilitating secondary infections and the resultant losses.

Considering post-nursery losses, the total production in 2013 was 40.50 million MT of freshwater fish valued at $1,641/MT, and 6.57 million MT of brackish and marine fish valued at $4,203/MT. If we assume parasites are responsible for the loss of 1 to 10 percent of harvest-size fish, then the value of these fish can be estimated at $945.00 million for 1.0 percent loss, $2.36 billion at 2.5 percent loss, $4.72 billion for 5 percent and $9.45 billion at 10 percent loss. If the hatchery and growout figures are combined, the annual global cost of parasites in finfish aquaculture can be very loosely and tentatively estimated at $1.05 billion to $9.58 billion.

Perspectives

Moving toward an accurate estimation of the global cost of parasite-associated impacts is dependent on detailed, high-quality data and the resources necessary to undertake such studies. However, as global aquaculture continues to grow and intensify, the prevalence and severity of parasite infections will similarly rise, as will the attendant economic costs of parasitism.

In addition, the increased trade in finfish and their products may facilitate the spread of parasites into new environments. Changing climatic conditions will also place increased pressure on aquaculture systems, current production practices and the interactions among wild and farmed aquatic stocks, parasite life cycles and transmission pathways.

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