MONOGENEAN (PLATYHELMINTHES) PARASITES OF FISH (A REVIEW)

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Vingnanam Journal of Science 30: 30- 45 (1994)

ABSTRACT Most monogeneans ectoparastitic on fish inhabit the skins, fins, gills, pseudobranchs and buccal cavities of fish and have a direct life cycle, and the parasites are well adapted to cause serious damage to the host. When stressors frequently associated with confinement in hatcheries, ponds and display aquaria are added, infestation levels may increase. In such cases, signs of distress and disease from epizootics will appear. Monogeneans can be significant pathogens of teleosts and elasmobranchs under confinement. Their presence can produce poor growth and mortality of infested hosts. The host response to monogeneans is usually nonspecific, involving infiltration of inflammatory cells, destruction of localized tissue and varying degree of hyperplasia. Host death often results from loss of respiratory surface for gaseous exchange, osmotic stress, anaemia and secondary infection by bacteria, virus and fungii. Suitable water quality standards must be established and maintained. Filtering systems cannot be left without proper supervision. Poorly nourished fish are easy prey to primary and secondary parasitic invasion. In line with the requirements for careful sanitation, earthen ponds with known mongenean infestations should be dried as completely as possible and treated with lime or some other product to kill eggs lying dormant in the sediment. Cement ponds, ponds with liners and aquaria should be rinsed and dried to prevent infections. Commercially available products such as Fan can be used to disinfect the facilities and equipment in use.

Introduction

Fish culture has increased significantly worldwide during the past 25 years. Approximately five million tons of edible fish were produced in 1985, compared to two million tons in 1970 (Nash 1988). Additionally the number of culture facilities producing fish to enhance wild stocks have also risen.

This aspect is now a growing trend in developed and developing countries world-wide. In the food and recreational aquaculture industries, fish are kept in a restricted space within an artificial system. However, they differ in that usually several species are kept in a single tank and they are less crowded. A number of stressors act in artificial systems, including oxygen deficiency, nutritional deficiencies, overcrowding, aggression from other fishes, handling, waste products, use of chemotherapeutic agents, unfavourable lighting, temperature and salinity levels that may result in immunocompromised fish that may increase their susceptibility to desease organisms. The relatively small volume of water fish inhabit in artificial systems compared to the natural environment concentrates hosts as well as disease agents, thereby increasing the chances of infection. It is estimated that at least 10 - 20 % of the fish loss in aquaculture is due to disease (Bauer *et al.* 1981).

Many problems which occur in aquaculture and the aquarium industry are caused by viral, bacterial and fungal diseases, in addition to protozoan and metazoan ectoparasites and endoparasites. Ectoparasites, mainly monogeneans, often cause greater losses. Unlike most other parasitic platyhelminths, e.g. digeneans and cestodes, monogeneans have a direct life cycle that can be completed easily in a closed system.

With the tremendous growth of the aquaculture industry, there has been an increased awareness of the Monogenea as pathogenic organisms (Thoney and Hargis, 1991). The purpose of this review is to give some guidance in translocation or transfaunation and pathology of monongeneans.

Translocation of hosts and transfaunation of parasites

Several monogeneans have been transferred with the introduction of cultured food and ornamental fishes from one country to another. *Dactylogyrus lamellatus* and several other species of *Dactylogyrus* were translocated to Europe along with cultured cyprinids from China, including grass carp, *Ctenophryngodon idella;* silver carp. *Hypophthalichthys molitrix;* and big head carp. *Aristichys nobilis* (Bauer *et al.* 1981). Bauer and Hoffman (1976) reported that several monogenans have been transfaunated along with movements of fish stocks. *Gyrodactylus cyprini* and two species of *Dactylogyrus* were introduced into the U.S.A. with common carp *Cyprinus carpio* from Europe. Three species of *Dactylogyrus* have entered USA along with gold fish *Carassius auratus* from Japan and three species

of *Cleidodiscus pricei* and three species of *Urocleidus* were carried to Europe from USA along with the introduction of brownbull head *Ictalurus nebulosus*.

Transport of Atlantic salmon smolts from the Baltic into Norway introduced *Gyrodactylus salaris*, a parasite harmful to Norwegian fish but not to some other stocks (Malmberg 1989). This monogenan was first observed in hatchery populations and subsequently transferred to local river with stocking. This resulted in devastating effects on the natural Atlantic salmon population in Norwegian rivers (Johnson and Jensen 1986).

Pseudodactylogyrus anguillae and *Pseudodactylogyrus bini* are important pathogens of European eel *Anguilla anguilla*. These parasites are believed to have translocated to Europe along with cultured eels from Asia (Buchmann *et al.* 1987).

Most monogeneans are quite host specific in nature, but in crowded, stressed conditions this may breakdown. *Gyrodactylus salaris*, normally parasitic on *Salmo salar*, can infest several other salmonid fishes in culture systems. In contrast, *Demophthiroides* and *Dermophthirius* show a high degree of host specificity to the elasmobranch hosts even in a confined space in an aquarium (Nigrelli and Breader, 1934). The degree of host specificity may vary according to physiological, morphological or ecological reasons.

Transfer of parasities could be reduced or might be eliminated by examining fish stocks prior to shipment, or by strict quarantine procedures at the arrival destination. Heavily infected stocks could be avoided, with lightly infected ones treated before shipment. Careful preshipment inspection or screening for fish disease is recommended to reduce the transfer of pathogenic organisms into a new site. Quarantine, in addition to treatment, is highly recommended for any incoming stocks to a recipient country. A procedure for the International Transocation of Biological stocks has been developed by International Council for the Exploration of the Seas (ICES).

In each programme requiring holding the animals in close confinement, rigid procedures for maintaining cleanliness are critical. Application of good sanitation procedures are vital.

Pathology

Gyrodactyloidea

Kabata (1985) reviewed several patholgical conditions caused by *Gyrodactylus* in tropical fishes. Epidermal hyperplasia and copius mucus production often occur, which obscure chromatophores, making the skin paler than normal. Individual worms may cause localized petechial lesions. Heavy infestation frequently results in skin and scale sloughing. The parasites are shed along with these tissues. Lester (1972) reported that heavy infestations of *Gyrodactylus alexanderi* resulted in a mucoid layer of 0.5-1 µm thick being shed every couple of days from the skin of three-spined stickleback, *Gasterosteus aculeatus*.

Lester (1972) also mentioned that the 16 marginal hooklets on the opisthaptor of *G. alexanderi* distorted those epidermal cells of the host with which they were in contact. The hamuli were not embedded in the host tissue and left no marks under normal circumstances but did depress host epidermal cells. When an individual worm pulled out from its host, the hamuli would have contained host epidermal layer apparently. Although the individual hyperplasia occurred in some host individuals, typically there were no gross pathological signs.

Cone and Odense (1984) reported that heavy infestations of *Gyrodactylus salmonis* on rainbow trout cause fin erosion, pale body colour, epidermal hyperplasia with zones of degeneration and necrosis with an increased number of goblet cells. Marginal hooks of *G salmonis* penetrate deeper into the epithelial cells than other monogenean species whose attachment mechanisms have been reported. This monogenean species can kill young fry of *Salvelinus fontinalis*, mostly through disruption of the normal osmotic properties of the skin surface (Cusack and Cone 1986).

Some species of *Gyrodactylus* inhabit the gills and cause hyperplasia. This hyperplasia is most evident at the base between adjacent lamellae along with most of the length of the gill fillament. Lamellae can be completely destroyed and replaced by epithelial hyperplastic cells in areas where the density of worms is high.

Dactylogyroidea

Most of the species reported as pathogenic belong to the families Dactylogyridae, which occur mostly in fresh water, Tetraoncidae, which occur on salmonid fishes in fresh water, Ancyrocephalidae, which occur on fishes in both marine and fresh waters and Diplectanidae, which are mostly marine. Dactylogyroids have been reported to be pathogenic to a wide phylogenetic range of hosts, including eels, salmonids, poeciliids, charcids, cyprinids, clarids, gadids, gastrerosteids, cichlids, percichthyids, sciaenids, sparids and serranids.

All Dactylogyrids are oviparous. Depending on the temperature a large number of eggs may be produced. Most eggs are swept out of the branchial chamber in the excurrent flow. They may hatch in five days and can mature within a week. Because larvae must actively seek a suitable host, individual hosts do not necessarily acquire large numbers of parasites as rapidly as happens with oviparous Gyrodactylids, that are born directly onto an already infested host. However in crowded situations worm prevalences and intensities can build up rapidly. Buchmann *et al.* (1987) and Chan and Wuu (1984) reported *Pseudodactylogyrus* infections in European eels and the Iapanese eel, *Anguilla japonica*, respectivley. Parasites were generally introduced along with elvers into farms. Eels in European farms are highly susceptible to both *Psuedodactylogyrus anguillae* and *Psuedodactylogyrus bini* (Egusa 1979), which cause pathogenic problems, including hyperaemia of the mandibular skin and the gills. Infestations in Japanese eels resulted in increased mucus secretion, epithelial hyperplasia and destruction of the gill filaments. The hamuli of the opisthaptor of these species penetrate deeply into the gill primary cartilage and in some occasions the entire opisthaptor seems to be embedded into the gill tissue. Several species of *Dactylogyrus* have been reported as pathogenic to carp, *Cyprinus carpio*, in aquaculture facilities in the U.S.S.R. (Bauer 1951). *Dactylogyrus vastator* has a considerable reputation for causing mass mortalities in fingerling stages. Colder temperature tends to prevent development and growth in this species. *Dactylogyrus solidus* differs from *D. vastator* in being much larger and more cold tolerant. Infestations are retained through winter so that older fish are infected. In Northern areas where summers are cool, infestation may be retained throughout the year. Infestation causes thickening of the epithelium, which interferes with normal respiratory function. Thirty to forty parasities can kill fingerlings of 3-4 cm standard length.

Paperna (1963) described aspect of *D. vastator* infection in carp from the Mediterenean, where young fish of just four days and only 8 mm standard length become infected. Gill hyperplasia and reduction in general growth were observed. Larger individual host fish usually had greater intensities but less gill damage. However, when host populations reached a certain level larger fish also showed patholgical changes. He concluded that as long as fish were not overcrowded and growth remained optimal, regeneration of gill tissue was sufficiently rapid to counteract the damage caused even by large numbers of parasites. Fast regeneration of host epithelium has been reported by Kearn (1963, 1976) and Smyth and Halton (1983). After the host reached 30-40 mm, intensities on carp declined. Evidently the hyperplasia that had developed on the gills was unsuitable for the parasites (Paperna 1963). Sloughing of hyperplastic tissue along with attached *D. vastator* result in the recovery of fish (Paperna 1964).

Roubal (1986) examined several monogeneans infesting the yellow bream *Acanthopagrus australis* in Australia. Out of the three species of *Lamellodiscus* that were studied, two smaller species caused little pathology. The third species, *Lamellodiscus major*, was larger and caused a severe tissue response with proliferating epithelium filling the interlamellar spaces on adjacent filaments. The ancryocephalid *Haliotrema spariensis* also caused a severe gill tissue response in *A. australis* (Roubal 1987; 1989). Hyperplastic tissue occurred at the attachment site and in adjacent areas indicating that worms feed on various sites on the gills (Roubal 1989). Ultramicroscopy (TEM) revealed degenerated chloride cells in both the edematous and hyperplastic epithelia. There were dilated tubular reticulum and mitochondria with various degrees of swelling and membranous destruction. Extensive infiltration of lymphocytes, eosinophils, macrophages and neutrophils occurred in the epithelial and sub epithelial regions of gill filaments. Ultrastructural observations of gill filaments showed no major cytopathological features that were parasite species-specific (Roubal 1989). Wobser *et al.* (1976) noticed a diffused epithelial hyperplasia on the gills of Arctic grayling *Thyallus arcticus*, associated with the movement and feeding of large numbers of *Tetraonchus rauschi*. Infiltration of lymphocytes were associated with the presence of worms and their location.

Skinner (1982) conducted a study comparing gill patholgy and infestations of the monogeneans *Ancyrocephalus parvus* on timucu, *Strongylura timucu*, *Ancyrocephalus* sp. on gray snapper, *Lutjanus griseus* and *Gerres cinereus* in relation to water quality in two areas within South Biscayne Bay of Florida. Fish from a polluted area had gills with increased mucus production, epithelial and mucus

cell hyperplasia, fused lamellae and clubbing of filaments. Intensities of monogeneans were significantly greater in the polluted area. However, the intensities were not always assoicated with the observed pathological conditions. Pollutants were an irritant to the fishes that produced changed physical and physiological conditions of the host fish, which of course reduces resistance to possible infestation by monogenean parasites. Khan and Kicenuik (1988) found that cod, *Gadus morhua*, chronically exposed to hydrocarbons had greater abundances of *Gyrodactylus* sp. than controls 16 weeks following their last exposure.

Linguadactyloides brinkmanni attaches itself deep in the gill tissue of the host, the black finned pacu, *Colossoma macropomum*. This worm actively penetrates the host tissue with its opisthaptor deep into the tissues until it reaches the cartilaginous tissue of the primary gill cartilage. Overgrowth of cartilage permanently fixes the worm in position. A basic inflammatory response, with infiltration of both erythrocytes and leucocytes occurs during penetration. Some haemorrhaging occurs initially. Movement of the worm maintains a funnel-like tube from the gill surface to the cartilage. Epithelial hyperplasia occurs along the filament. Hyperplasia of the epithelium overgrows the opisthaptor of *Dactylogyrus iwanowi* in the cyprinid *Leuciscus brandtii* and *Linguadactyla molvae* on the gadid, *Molva dipterygia elongata* (Bychowsky, 1957). Granulation tissue composed of fibroblasts and collagen surrounded the opisthaptor.

Capsaloidea

The capsaloidea occur primarily in marine waters. Few genera are pathogenic. However, a few species are reported as pathogenic to a wide range of hosts including elasmobranchs, such as squalids, myliobatids, pristids and carchahinids and teleosts including megalopids, carangids, scropaenids, ephippids, kuhliids, hexagrammids, mugilids, soleids and bothiids.

Although monogeneans are generally host specific in natural populations, specificity may break down in crowded community aquaria. *Neobenedenia melleni* was reported from three chaetodontids three pomacanthids, one lutjanid and one serranid in nature (Nigrelli 1947), suggesting that this species had a potential for infecting a wide range of hosts should other potential hosts species be confined with a "natural" host. A large number of families of fishes have been infested

by *N. melleni*, including Acanthuridae, Arridae, Balistidae, Diiodontidae, Carangidae, Chaetodontidae, Holocentridae, Labridae, Lobotidae, Serrinidae, Sparidae and Triglidae.

Capsalloids are oviparous and capable of producing larger quantities of eggs than Dactylogyridae. For example, *Benedeniella posterocolpa* may produce 87 eggs/ day (Thoney 1990) versus less than 10 eggs /day by *Pseudodactylogyrus bini* (Buchaman *et al.* 1987) by 9.3 eggs/ day by *D.vastator at 18°C (Paperna* 1963) and 29 eggs / day by *D. vastator* at 29°C (Prost 1963 and Molnar 1971).

Lemon shark, *Negaprion brevirostris* is commonly infested with *Dermophthirius nigrelli*. During pathogenic levels of infection greyish patches and open wounds develop on the skin and become infected with bacteria of the *Vibrio* species-complex (Cheung *et al* 1982). Similar lesions occur when the small toothed saw fish *Pristis pectinata* is infected with *Dermophthirioides pristis* and Galapagos shark *Carahinus galapagensis* infected with *Dermophthirius carcharhini*. Histological sections show that the opisthaptor depresses and erodes the epidermis and ruptures goblet cells at the base of the sales (Rand *et al.* 1986). It was suggested that the impaired physiological activities of the tissues made the scales more susceptible to dislodgement and that the parasite could act as a lever, helping to lift, loosen, and dislodge scales as the worm extended and moved during feeding on the host surface. Open wounds would then be susceptible to further infection by secondary pathogens such as bacteria and fungi.

Several species of the family Capsalidae have been reported to be pathogenic to hosts under culture. *Entobdella soleae* causes problems in brood stock of Dover sole *Solea solea* (Anderson and Conroy 1968). *Benedenia monticelli* was observed to cause lesions in natural populations of grey mullet *Liza carinata*. Severe pathological conditions were reported including eroded snouts with exposed bone, eroded gular, and opercular membrances, hemorrhagic buccal ulcerations, hyperplastic and necrotic skin areas of heavy infestations, thickened cornea and adipose eyelid resulting in chalky white appearance and emaciation. The lesions were found to be assoicated with motile rod shaped bacteria. Congestion, edema and infiltration of eosinophils, macrophages and lymphocytes are assoicated with a severe inflammatory reaction in dermal and subdermal layers. Uninfested worms placed with infested hosts began dying in four to six weeks. However a few individuals eventually lost their worms. The overcrowding conditions causing this epizootic in this feral population duplicated

conditions common to those in culture situations. This situation would be similar to cage or sea pen culture, where hosts are confined in crowded circumstances in natural waters. Leong and Wong (1988) found that intensities of the diplectanid, *Pseudorhabdosynochus epinepheli* increased on cultured grouper, *Epinephelus malabaricus*, kept in cages. Eggs released by most monogenean species usually settle to the bottom and develop (Whittington 1990). However, *Dionchus*, which occur on cobia, *Rachycentron canadum*, and on remoras (Echendidae) attach bundles of eggs to gill filaments (Kearn 1986). The egg capsule filament of *Dionchus remorae* loops around the tip of a gill filament thus securing egg bundles (Kearn 1986). A hyperplastic host response overgrows the loop fixing it to the gill. Adjacent filaments may also have local foci of hyperplasia. Continuous infection of the host and survival of the endemic population of parasites is thus secured.

Oligonchoinea

The Oligonchoinea is composed of several superfamilies, including Discocotyloidea, Mazocraeioidea and Microcotyloidea. They occur mostly in marine waters. Several species are known from cultured fish. Only some have been implicated as causative agents of fish diseases. The species known to be pathogenic in a wide phylogenetic range including clupeids, engraulids, salmonids, carangids (Eto *et al.* 1976: Lawler 1977; Egusa 1983; Paperna *et al.* 1984) chaetodontids, pomacanthids and siganids (Roberts 1978; Paperna *et al.* 1984). Oligonchoineans are oviparous and usually produce fewer eggs than capsaloidea. Developmental times vary greatly, but are generally within the same range as those of Capsaloidea.

Most polyopisthocotyleans have not been reported to be overtly pathogenic. As polyopisthocotyleans are blood feeders the host does not show any pathological signs or host response compared to other parasites which browse widely on epithelium while feeding as do the mucus and epithelial feeders. These have attachment clamps which do not penetrate deeply into host tissues like the hamuli and marginal hooklets found in other monogeneans. Thoney (1986) reported that laboratory reared *Sebastes melanops* heavily infested with *Microcotyle sebastis*, did not show any signs of stress or pathology. Higher intensities of parasites may weaken the host, permitting capture by predatory fish or infection by other disease agents. When a certain number of polyopisthocotylean occur on an individual host, they can become pathogenic and cause mortalities at the final stage.

Discocotyle sagittata has caused serious gill damage to salmonids in Europe and *Axine heterocera* has killed sea cage cultures *Siganus* sp. in Japan (Roberts 1978; Egusa 1979). Heavy infestations of *Aspinatrium pogoniae* killed black drum, *Pogonias cromis*. The fish lost appetite before its death. *Allobivagina* sp. infests several species of *Siganus* in the Mediterranean sea (Paperna *et al.* 1984). Intensities rarely exceed 10 parasites per fish in wild populations. However, this species can cause mass mortalities in cultured fish measuring 60-80 mm total length. Moribund fish have an average of 150 worms per fish and are emaciated and anaemic, with less than 10% haematocrit value. Haematocrit value shows a direct correlation with the number of worms host harbours. Anaemi fish have predominantly immature erythrocytes, which indicates a high turnover of red blood cells. Uninfected fish placed with infested fish rapidly acquire worms and become moribund or die within a month. Eventually, in cases in which death does not intervene, parasites are lost and surviving hosts become resistant to infestation.

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Received for publication October 1993