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A Review on Gyrodactylidae and Dactylogyridae (Monogeneans) and Their Importance in Aquaculture

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Abstract: Monogeneans are parasitic worms, primarily on fishes, including, the Agnatha, the Chondrichthyes, and Osteichthyes. The monogenea includes at least two super-genera (*Dactylogyrus* and *Gyrodactylus*) each of which has hundreds of species, possible reason for this include their high host specificity and short generation time. They are widespread throughout freshwater and marine habitats and about 4000 species have been described so far. Usually little or no harm is done to the host, but on occasion these flukes contribute to disease of the host in artificial system where fish are subject to number of stress factors. Besides being long recognized parasites, potentially severe pathogens have appeared, quite recently such as *Gyrodactylus salaris* which has destroyed salmon population in Norway. As more species of fishes became cultivable with the development of aquaculture, the chances of fish losses caused by monogeneans will increase.

Key words: Monogeneans, Gyrodactylidae, Dactylogyridae, *Gyrodactylus salaris*, Aquaculture

Gyrodactylidae ve Dacylogyridae (Monogeneanlar) ve Bunların Akuakültürdeki Önemi

Özet: Monogenea`lar parazitik olarak genelde balıklarda; Agnatha, Chondrichthyes, and Osteichthyes`lerde görülürler. Monogenea`larin konakçı balığa karşı olan yüksek derecedeki seçiciliği ve yasam ömrünün kısa olmasına bağlı olarak, her biri yüzlerce türe sahip olan önemli en az iki üst cins (*Dactylogyrus* ve *Gyrodacylus)* içerir. Bunlar tatlı ve deniz sularında cok yaygın olarak bulunur ve bugüne kadar 4000`i aşkın türü tanımlanmıştır. Genelde konakçı balığa cok az yada hiç zarar vermezler, ama balıkların stres faktörleri ile yüz yüze geldikleri yapay kültür ortamlarında hastalıklara ve ölümlere yol açarlar. Örneğin, uzun zamandan beri bilinmeleriyle birlikte, son yıllarda *Gyrodacylus salaries*` in Norveç`teki salmon populasyonunu yok edecek bir patonsiyele sahip olduğu görülmüştür. Akuakültürün hızla gelişmesi ile birlikte yeni balık türlerinin kültür edilmesi sonucu, monogeneanlardan kaynaklanacak balık ölümlerininde artması beklenmektedir.

Anahtar kelimeler: Monogeneanlar, Gyrodactylidae, Dactylogyridae, *Gyrodactylus salaris*, Su ürünleri yetiştiriciliği

Introduction

The continued increase in the world's population has resulted in a demand for new food products and research into utilization of new resources. Thus, development of aquaculture during the last decades has resulted in much greater attention being paid to problems posed by parasites and their importance for fisheries leading to constrains in the productivity of aquaculture (Kennedy, 1993).

Most parasite species rarely cause problems in the natural environment but under culture conditions can become pathogenic, sometimes causing serious epizootic outbreaks, especially in intensive fish culture. This is particularly true for certain Protozoa, Monogenea and Copepoda which lack intermediate hosts and have direct lifecycle which can be completed easily in a closed system (Schaperclaus, 1991).

Environmental stress may reduce host resistance to pathogens, including helminthes. Besides direct losses caused by mortality, parasites may have considerable impact on growth and behaviour of fish, their resistance to other stressing factors, susceptibility to predation and their presence may also reduce marketability of fish (Schaperclaus, 1991).

Monogeneans are often present on marine and freshwater fish, but usually achieve status as significant pathogens only when present in overwhelming numbers in individual hosts. They may cause disease in fish by mechanical injuries, withdrawal of substances needed in host metabolism, and facilitating entrance of pathogenic microorganisms, thus causing

secondary infection by bacteria and fungi (Scholz, 1999).

There are a variety of monogenean parasites recognized as pathogens of cultured and feral fish. The pathogenicity of monogeneans on fish has been recorded by many researchers (Paperna, 1963; Molnar, 1971), including *Dactylogyrus extensus*, *Dactylogyrus vastator*, *Dactylogyrus lamellatus*, *Gyrodactylus cyprini* in cultures of cyprinids fish, *Gyrodactylus luciopercae* pathogenic to pikeperch, *Gyrodactylus colemanensis* and *Gyrodactylus derjavini* to rainbow trout, *Gyrodactylus ictaluri* to *Ictalurus punctatus*, species of *Pseudodactylogyrus* appearing pathogenic parasites in farmed eels, or *Diplectanum aequans*, one of the most important pathogens in farmed sea bass (Molnar, 1971; Paperna, 1963; Scholz, 1999)

The most famous monogenean parasite in the last years is *Gyrodactylus salaris*, which caused significant losses in farms and several salmon populations in Norwegian rivers and. The spreading of *G. salaris* and its detrimental effect on native fish has shown how a presumed harmless organism may become a pathogen if it is introduced to new areas where the host lacks effective responses against it (Mo, 1994)

Morphology and Evolution

Monogeneans are ecto or endo-parasites commonly parasitising the gill, the gill chamber, skin and buccal cavity, and sometimes the uterus and body cavity of fish, amphibia, reptiles, mollusks and even mammals. Monogeneans are small worms, rarely exceeding 3cm in length. They bear a posterior attachment organ in the form of a haptor armed with hooks, clamps or suckers, and sometimes an anterior adhesive organ (Whittington, 1998).

The Class Monogenea belongs to the Phylum Platyhelmintes and they are monoecious, both male and female reproductive systems occurring in the same individual. The majority of monogeneans are oviparous producing quinolone tanned eggs, yellow-brown in color. *Gyrodactylus* however, reproduces by viviparity and thus the vitellaria are lacking (Yamaguti, 1963).

The Monogenea is divided into two subclasses; the Monopisthocotylea and the Polyopisthocotylea. The Subclass Monopisthocotylea possesses a single unit haptor with one or two pairs of hamuli and twelve to sixteen marginal hooks. Eye spots are present or absent, eg. *Gyrodactylus* lacks eyespots. A genito-intestinal canal is absent. There is oviparous or viviparous reproduction, e.g. *Gyrodactylus*. Major Monopisthocotylea families are the Gyrodactylidae, Dactylogyridae, Capsalidae, Tetraoncide and Acanthocotylidae (Gussev, 1985).

Polyopisthocotyleans possess a haptor, which is well developed and bears clamps and suckers. Hamuli may be present and an oral sucker is occasionally present anteriorly. A genito-intestinal canal is present (Llewellyn, 1963). Polyopisthocotylean families include the Megaloncidae, Polystomatidae, Diplozoidae and Diclidophoridae (Gussev, 1985).

Monogenea are believed to have originally been endoparasitic and subsequently adapted to an ectoparasitic way of life (Malmberg, 1990).

There is also a correlation between the evolutionary development of the Monogena and their host. Primitive monogeneans parasites primitive fish (Bychowsky, 1957; Malmberg, 1990), for example, the primitive genus *Dactylogyrus* mainly parasites cyprinids mostly in freshwater, while the more advanced genus *Gyrodactylus* parasites a wide range of host families in both fresh and sea water.

The global distribution of Monogenea

Monogeneas have a wide geographic distribution throughout freshwater and marine habitats. This can result from a cosmopolitan distribution of their hosts. The most important genus from pathological point of view are *Dactylogyrus* and *Gyrodactylus*. *Dactylogyrus* is the largest helminthes genus with more than 900 species described, all from freshwater. The majority of species have been described from the former USSR and China followed by North America Europe, India, South East Asia and Australia. The majority of the described species parasites cyprinids which were widespread in Laurasia (North America and Eurasia) before the continents parted, which reflects the current distribution of *Dactylogyrus* (Gibson *et al.*, 1996; Whittington, 1998). However, the apparent distribution of *Dactylogyrus* is also probably due to the fact that most research has been done in the former Soviet Union (Gussev 1962, 1985), China (Zhang *et al.*, 1990) and

North America (Mizelle and McDougal, 1970; Kritsky *et al.*, 1977).

A number of monogeneans have also been recorded from Turkey (Akmirza, 1998; Sonmez and Koksal, 1997; Ögut *et al.*, 2003; Soylu, 2003). Akmirza (1998) listed *Pseudaxine trachuri* from Horse Mackerel, coughed in Aegean Sea and Sönmez ve Köksal (1997) listed *Dactylogyrus* spp and *Tetraonchus* sp from Mogan lack in Turkey. Ögut *et al.*, (2003) recorded *Gyrodactylus* spp from rainbow trout farms and Soylu (2003) has recorded *Dactylogyrus* spp from tench. Despite these studies, Turkish monogenean fauna is still poorly documented and many species labeled only species level still remain to be properly identified because of taxonomic difficulties and misidentification. This suggests that there are many monogenean species remaining to be described from Turkish freshwater fish.

The increasing extent of anthropochore fish movements has considerable potential for the dissemination of parasites (Kennedy, 1993; Kennedy and Bush, 1994). A number of monogeneans have been transferred to North America, including *D. anchoratus*, *D. vastator*, *D. wageneri*, *D. amphibothrium* and *G. cyprini* with common carp, goldfish and ruffe. On the other hand, *Cleidodiscus pricei* and *Urocleidus reticulates* were carried to Europe with the brown bullhead from the United States (Bauer and Hoffman, 1976).

In some cases the transfer of monogenean species has resulted in severe consequences on native fish. It has been suggested that Atlantic smolts introduced into Norway from the Baltic region, brought *G. salaris* into Norway (Malmberg, 1989). The native salmon population of Norway were much more susceptible to this pathogen than Baltic fish population and mass mortalities of salmon occurred in some Norwegian rivers (Bakke *et al.*, 1990).

Similarly, *Pseudodactylogyrus* spp. have spread from the Far East to Russia and most of Europe (Skorikova *et al.*, 1996). Consequently, they have caused massive damage in eel farms in Europe (Buchman *et al.*, 1987). The introduction of sturgeon, *Acipencer stellatus*, into the Aral Sea from the Caspian Sea brought with the monogenean, *Nitzschia sturionis*, which was highly pathogenic to the local sturgeon species, *Acipenser nudiventris* (Lutta, 1941). This variation in disease resistance occurs among geographic strains of host species.

The introduced parasite has a set of requirements both biotic and abiotic to ensure its survival and colonization. Fortunately, these requirements are rarely met and newly transferred parasites often fail to establish. Monogenea, however, through their direct life cycle, have a higher chance of survival and so establishment (Kennedy and Pojmanska, 1996).

The geographical range of many monogenean species is unknown. The distribution of many is local and this is further compounded by taxonomic problems, which inhibits the identification of the species. This is certainly true for *Dactylogyrus* and *Gyrodactylus* species, which have frequently been misidentified or recorded merely as *Dactylogyrus* sp or *Gyrodactylus* sp.

There is range of variation in parasite community richness between different species of fish and different localities. Price and Clancy (1983) found a significant relationship between the number of helminthes species per host and the geographical range of the host fish species. Guegan and Kennedy (1993) have suggested that helminth community richness reflects the period of time spend by the host species since its establishment in the region. Generally, native species harbor richer helminth community than introduced species. In addition to the time hypothesis, ecological and phylogenetic factors also contribute to helminthes community richness (Kennedy and Pojmanska, 1996). Successful colonization requires a suitable climate, water quality and the presence of suitable hosts at a sufficiently high density. Consequently, where the extent and frequency of anthropochore transfers of fish increases, an awareness of the possibilities of introduction and establishment of a parasite species in a new environments is very important (Kennedy and Pojmanska, 1996).

Monogeneans are hermaphrodite worms, the majority of which produce eggs. All dactylogyrids are oviparous and the eggs are swept out of the host's branchial chamber with the water flow over the gills. In contrast, viviparous gyrodactylids give birth to individual worms and transmission to new hosts occurs easily in crowded environments such as in intensive fish farming. According to

Schaperclaus (1991) more than a million individuals can be produced from a single specimen of *Gyrodactylus* in one month. The life-cycle of *Gyrodactylus* is short, 1-3 days, and thus an epizootic can develop in a short period of time (Bychowsky, 1957; Thoney and Hargis, 1991)

The abundance of some species, including *D. vastator*, *D. solidus*, *D. minitus*, *D. auriculatus*, *G. kathariner*i and *Diclybothrium armatum* increases when the temperature drops (Paperna, 1963b; Reda, 1988; Schaperclaus, 1991) while others, including *D. extensus*, *D. wunderi*, *D. lamellatus*, *D. zandti*, *G. sprostonae*, *G. magnificus*, *Diclidophora sagittata*, *Tetraonchus borealis* and *Tetraonchus* monenteron are predominantly summer species and an increase in water temperatures causes a peak in their abundance (Reda, 1988; Wierzbicka, 1974; Dzika, 1987; Schaperclaus, 1991).

Other factors influencing egg production include salinity (Anderson, 1981), oxygen pressure (Houlihan and MacDonald, 1979) and photoperiod (Macdonald and Jones, 1978).

Monogeneans eggs have also been found to be resistant to a number of external factors, such as freezing, drying, boiling and the actions of enzymes. The eggs of *D. vastator* and *D. extensus* can over winter at the bottom of a pond until optimum conditions are obtained and they can commence their development Paperna, 1963). The treatment of eggs of *Polylabroides multispinosus*, a parasite of *Acanthogyrus australis*, with benzocaine had no effect on the viability of eggs (Diggles *et al.*, 1993).

Pathology induced by Monogenea

There are several types of pathology caused by monogeneans (Heggberget and Johnsen, 1982; Buchmann, 1988). *Gyrodactylus* infections often result in epidermal hyperplasia with zones of degeneration and excessive mucus production, resulting in pale skin. Infections frequently cause skin and scale sloughing and hyperaemia (Cone and Odense, 1988; Heggberget and Johnsen, 1982).

The typical response of gills to monogenean infection is marked by epithelial hyperplasis, thickening of the epithelium on the gill filament, mucus secretion and reduced growth. Heavy infection of *D. vastator* causes losses of up to 80-100% in carp populations (Golovina and Golovin, 1988). In addition, in many cases, secondary infections of bacteria and fungi are associated with monogenean infections (Cusack and Cone, 1985).

Conclusion

The commercial and economic importance of marine and freshwater monogeneans is well known (Scholz, 1999). Despite their direct life cycle and therefore, their potential to harm their hosts especially in aquaculture and public aquaria, there are few reports of monogeneans that have caused losses of fish stock in aquaculture and especially in Turkey. As more species of fishes become candidates as aquaculture develops, however, the chances of fish losses caused by monogeneans will increase. It is important, therefore, to know the range of parasites on fishes that are likely to be farmed. Not only identification of parasites is important but a basic understanding of the biology if the common parasitic species from potential candidates fishes for aquaculture can help to solve or prevent many of the problems they may cause. Monogeneans were among several groups of parasites predicted to cause mortalities among fishes in Turkey as aquaculture advances. Only few species of monogeneans are described so far from Turkey despite of wide diversity of fish life in Turkey. More knowledge in taxonomy, systematic and biology of the parasitic platyhelminths is required. Alternative methods of control of monogeneans should also be developed and more widely applied. All this will enable an increase in fish production without significantly increasing costs to control fish pathogens. Thereby contribute to further advancements of fisheries in the future.

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