Parasite Assemblages in Fish Hosts

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Abstract

A review of various factors affecting parasite assemblages in fish hosts is presented. These factors are broadly divided into two: Biotic and abiotic factors. Biotic factors such as host age and size, host size and parasites size, host specificity, host diet and host sex and their influence on the abundance and distribution of parasites are considered and highlighted. Equally, seasonality and other environmental factors that may facilitate the establishment and proliferations of parasites in host populations are also highlighted.

Keywords: Parasite, Factors, Assemblages, Fish hosts

Introduction

There are numerous biotic and abiotic factors that affect parasite assemblages (Bauer, 1959; Esch, 1982; Kennedy, 1995). The term assemblages is used here to refer to all microhabitat, in (gastrointestinal) or on (external surfaces) the fish hosts (Poulin, 2004). These factors include the following: physiological condition of the fish host, host diet, host size, evolutionary history and environmental factors, such as season of the year, size and type of water body, altitude, temperature, salinity, oxygen content and pH (Bauer, 1959; Chubb, 1970; Kennedy, 1978; Esch, 1982; Esch *et al*., 1988; Poulin, 2004). Though a number of chemical and physical factors are known to affect a wide range of aquatic vertebrate and invertebrate life cycles, the effect of biotic factors on the abundance and the prevalence of parasites has been the main focus of several research efforts. The ecological relationship between hosts and parasites are usually influenced by the organism's intra and inter-specific interactions with biotic and abiotic components of the environment (Williams and Jones, 1994). For instance, temperature is recognized as the most important factor influencing the abundance and distribution of worms, yet temperature vary according to seasons of the year at various latitudes and longitudes and at varying depths (Williams and Jones, 1994).

Materials and Methods

A comprehensive literature search was made from the Internet and serial materials from Nnamdi Azikiwe Library, University of Nigeria Nsukka, various journal articles, proceedings of learned societies of fisheries and parasitology, Food and Agricultural Organization (FAO) of United Nation publications and textbooks were consulted vis-à-vis of the prevalence, intensity and abundance of parasites in freshwater fishes. Data obtained from consulted sources were collated and presented in tables.

Results and Discussion

Host age and size: Generally, standard length of fish is directly related to age (Shotter, 1973) and fish body size. Age has often been found to be positively associated with the prevalence and/or intensity of parasitic infection (Betterton, 1974; Madhavi and Rukmini, 1991; Chandler *et al*., 1995) (Table 1). Poulin (2000) stated that in fish population, parasitic infection tends to increase with increasing host age and size. He argued that older fish have longer time to accumulate parasites than younger ones and may provide more internal and external space for parasite establishment and therefore tend to have heavier worm burdens because they eat more parasitized prey and offer large surface area for skin-attaching parasites. Muňoz and Cribb (2005) reported that larger host had higher parasites richness, abundance and intensity than smaller ones. They argued that this pattern might be explained by combination of resources, time and prey. In general, large hosts have more space, more flux of energy (i.e. food) and microhabitats for parasites than small hosts. Furthermore, large fish are older than smaller individuals of the same species so that they have more opportunities to become infected (Rhode, 1993; Muňoz *et al.,* 2002).

During fish ontogenetic development, various changes may occur in the behavior and in its biology, in particular, with regard to diet and physiological conditions. All these changes may have considerable influence on parasitic fauna, especially parasite species that utilize various organisms as intermediate hosts (Takemoto and Pavanelli, 2000). Those parasites acquired trophically, uses the fish's diet as their intermediate host (Takemoto *et al*., 1996). Brickle *et al.* (2003) reported that larval acanthocephalan *C. bullosum* showed a significant increase in abundance with increasing host length, suggesting that parasite accumulates more with host length/age (Table 1). Takemoto and Pavanelli (1994) found species of proteocephalid cestodes in the upper Paraná River, with positive correlation between prevalence,

Table 1: Positive correlation between parasitic infection and age/length of fish hosts

Fish host	Parasite	Source
Genypeterus bransiliensis	*Acanthocolpus bransilieensis*	Alves *et al.* (2002)
Genypeterus bransiliensis	*Contracaecum sp*	Alves *et al.* (2002)
Genypeterus bransiliensis	*Cucullanus genypteri*	Alves *et al.* (2002)
Pseudoplatystoma corruscans	*Nomimoscolex sodobim*	Machado *et al*. (1994)
***Dissostichus eleginoides* (Toothfish)**	*Neopovlosskioides georgianus*	Brickle *et al.* (2006)
***Dissostichus eleginoides* (Toothfish)**	*Larval acanthocephala*	Brickle *et al.* (2006)
***Dissostichus eleginoides* (Toothfish)**	*Carynosoma bullosum*	Brickle *et al.* (2006)
***Dissostichus eleginoides* (Toothfish)**	*Neolepidapedon magnatestis*	Brickle *et al.* (2006)
Cottus cognatus	*Echinorhynchus salmonis*	Muzzal and Bowel (2002)
Cottus cognatus	*Diplostomum species*	Muzzal and Bowel (2002)
Cottus cognatus	*Tetracotyle species*	Muzzal and Bowel (2002)
Clarias gariepinus and C. anguillaris	*Eustrongylides afrcanus larvae*	Ibiwoye et al. (2004)
Tilapia mariae	*Clinostomum tilapiae*	Olurin and Somorin (2006)
Bluehead Catfish	*Phyllodistomum pawlovskii*	Li *et al.* (2006)
Goat fish	*Contracaecun species*	Luque *et al.* (2002)
Goat fish	*Anisakis species*	Luque *et al.* (2002)
***M. aeglefinus* (Whiting)**	*Ceratomyxa arcuata*	Mackenzie *et al.* (2005)
Sorubim lima	*Spatulifer maringaensis*	Takemoto and Pavnelli (2000)
Sorubim lima	*Nupelia portoriquensis*	Takemoto and Pavnelli (2000)
***Hippoglossina macrops (*Bigeye Flounder)**	*H. chilensis*	González *et al*. (2001)

Table 2: Negative correlation with increase in host age/length

Fish host	Parasite	Source
Genypeterus bransiliensis	*Lacistorhynchus* sp	Alves *et al.* (2002)
***Dissostichus eleginoides* (Toothfish)**	Larval trpanorhynch	Brickle *et al.* (2006)
***Dissostichus eleginoides* (Toothfish)**	*Elytrophalloides oates*	Brickle *et al.* (2006)
Cottus cognatus	*Neoechinorhynchus pungitius*	Muzzal and Bowel (2002)
Whiting	*Leptotheca informis*	Mackenzie *et al.* (2005)
Saithe	*Myxidium gadii*	Mackenzie *et al.* (2005)
Sword fish	*Tristoma coccinema*	Matticci *et al.* (2005)
***Hippoglossina macrops* (Bigeye Flounder)**	*Floridosentis* sp	González *et al.* (2001)
***Dissostichus eleginoides* (Toothfish)**	*Tetraphyllidean plerocercoids*	Brickle *et al.* (2006)

Table 3: Highest rate of infection at intermediate age/length of hosts

Fish host	Parasite	Source
Genypeterus bransiliensis	*Polymorphus* sp	Alves *et al.* (2002)
Chrysichthys nigrodigitatis	*Henneguya chrysichthys*	Obiekezie *et al.* (1988)
Haddock	*Leptotheca longipes*	Mackezie et al (2005)
Stegastes nigricans	*Lecithaster* sp (D)	Lo *et al.* (1998)
Stegastes nigricans	*Aponurus* sp (D)	Lo *et al.* (1998)
***Sparus aurata* (Gilthead Sea Bream)**	*Cryptosporidium molnari*	Sitjà-Bobadilla *et al.* (2005)

P = Protozoan; M = Monogenean; D = Digenea, C = Cestoda, (Tapeworms), N=Nematoda (Roundworms), Co = Copepoda; A = Acanthocephala (Thorny-headed worms) intensity and standard length of host. While studying the parasite fauna of the carnivorous “pintado”, of the floodplain of upper Paraná River, Machado *et al*. (1994) found a positive correlation between prevalence of proteocephalid cestodes, *Nomimoscolex sudobim* and standard length of *Pseudoplatystoma corruscans* (Table 1). Furthermore, positive correlation between infection intensity and standard length of hosts has been reported for fish infected with cestodes *Nomimoscolex sudobim, Megathylacus travassosi* (Pavanelli and Machado dos Santos, 1991) and *H. kaparari*. It has also been found that in *Pseudoplatystoma luetkeni* and *P. corruscans*, as well as in *Sorubim lima*, an increase in the size and age of fish means a significant increase in the levels of parasitism (Takemoto and Pavanelli, 1994; Machado *et al*., 1994) (Table 1).

The occurrence of negative correlations, i.e. an increase in the host’s size with a reduction in levels of parasitism has been reported (Zdzitowiecki, 1988; Oliva *et al*., 1990) (Table 2). Negative correlation may be due to changes in the feeding habit (the fish may give up feeding on a certain item which functions as an intermediate host in the adult phase) or to the development of the immunity reaction that occurs in older fish (Adams, 1985).

In similar studies on marine and freshwater fish ectoparasites, Shotter (1973), Hanek and Fernando (1978 a, b), Fernandez (1985), Valtonen *et al*. (1990) and Roubal (1990) found higher levels of parasitism in hosts with intermediate lengths and suggested that fish acquired the parasites in their youth phase which are eliminated in the fish’s adult phase suggesting the possibility of the development of immunological resistance in adults. Obiekezie *et al.* (1988) reported heaviest parasite burden in the adult *C. nigrodigitatus 50* cm total length for the *Henneguya chrysichthyi* and *Ergasilus latus* parasites (Table 2). The worm burden increased with fish length up to 50 cm. Chapman *et al*. (2000) found that parasite prevalence increased with host body size only up to 700 mm; larger individuals showed lower prevalence. Such a pattern they argued could reflect the premature mortality of infected older individuals (Pennycuick, 1971; Anderson and Gordon, 1982; Gordon and Rau, 1982) or the lower prevalence in larger individuals may be due to the development of immunity with age.

Host size and parasite size: Several studies found a positive correlation between total parasite length and host body size (Table 3) (Morrand *et al*., 1996; Sorci *et al*., 1997; Sasal *et al*., 1998; Lo *et al.,* 1998; Morrand, 2000). This positive relationship was explained by a selective advantage for increasing fecundity through large size in larger hosts because large body size is correlated with high fecundity (Morrand and Sorci, 1998). It may also be due to a costly adaptation to host environment (Sasal *et al*., 1998) arising from the necessity to develop large attachment organs in larger hosts (Sasal *et al*., 1998, Morrand, 2000). In another report, larger fish subject ectoparasites to stronger water currents and have large gill area per unit body weight (Hughes, 1966). Parasites living on larger hosts have to adapt their hooking system to the gill filament in order to remain attached (Sasal *et al*., 1998; Morrand, 2000). The factors controlling the growth of helminth parasites in their host are of current interest (Barber 2005). Parker *et al*. (2003) suggested that the size attained by larval cestodes might reflect either host-imposed resource constraints on growth, or arise as a result of evolved life history strategies. Barber (2004) observed that the growth of *Solidus plerocercoids* in stickleback host was consistent with the view that parasite growth was limited by host resources. Others suggested that plerocercoid growth might also be related to the diversity of the host’s major histocompatibility complex (MHC) (Milinski, 2003; Kurtz *et al*., 2004).

Host specificity: Host specificity differs widely among parasite groups (Poulin, 1998; Sasal e*t al*., 1998). Monogenean species are considered to be highly host specific in comparison to other parasitic groups of fish (Bauer, 1959; Noble and Noble 1982; Sasal *et al*., 1998). Rhode, (1978, 1989) explained differences in host specificity between monogenean and other parasitic species in relation to their life cycle. It has been suggested that parasites with simple life cycles such as monogeneans are more host specific than parasites with complex life cycles such as the digeneans (Morrand, 1996). Sasal *et al*. (1998) also pointed out that ectoparasitic copepods that are directly transmitted are not highly host specific (Table 4).

Seasonality: Obiekezie *et al.* (1988) reported the gill myxozoan *Henneguya chrysichthyi* exhibited marked seasonality in prevalence and intensity. Both parameters reached peaks of *76*% and *100*% per host respectively in the late rainy season month of October in *C. nigrodigitatus* from Cross river estuary, Nigeria (Table 5). For the monogenean, *Protancylodiscoides chrysichthes* (Paperna, 1979), infections were consistently above 70% with low intensity during the heavy rain months of July-October. The larval nematode *Hysterothylacium* occurred in *C. nigrodigitatus* throughout the year with no defined peak of intensity, (Obiekezie *et al.,* 1988). The Sciaenid fish *Pseudotolithus elongatus* showed *100*% all year round infection with the same larval *Hysterothylacium sp*. The crustacean copepod, *Ergasilus latus* occurred throughout the year with mean monthly prevalence of *31*% and a mean intensity of 4.1 (Paperna, 1979). Gee and Davey (1986) reported seasonal variation in infection of *Mytilicola intestinalis* in blue mussels with higher intensity of infection in late autumn. This was associated with occurrence of egg production in *Mytilicola intestinalis* between June and August. Eggs hatched in summer and produce larvae that become infective adults during the autumn and could result in increase in the intensity during the autumn (Gee and Davey, 1986). Studies on four species of clariids (Ezenwaji and Ilozumba, 1992) in Nigeria, and on *Channa punctata* (Bloch) in India (Gupta *et al.*, 1984) indicated a higher abundance of parasites in the dry months before the rainy season. It has been suggested that this is due to an increase in host density and greater overlap of

Table 4: Host Specificity of fish parasites

Fish species	Parasite	Prevalence	Source
Vimba vimba tenella	*Dactylogyrus cornu* (M)	100%	Ozer and Ozturk (2005)
Stegastes nigricans	*Haliotrema* sp (M)	94.4%	Lo et al (1998)
***Xiphias gladius* (Swordfish)**	*Pennella instructa* (Co)	100%	Mattiucci et al (1998)
***Xiphias gladius* (Swordfish)**	*Fistulicola plicatus* (C)	88.9%	Mattiucci *et al* (1998)
***Xiphias gladius* (Swordfish)**	*Hysterothylacium* sp (N)	94.6%	Mattiucci *et al* (1998)
***Solea solea* (Soleidae)**	*Entobdella soleae* (M)	77.3%	Whittington *et al* (2000)

M= Monogenean; C=Cestoda, N=Nematoda; Co= Copepoda

Table 5: Influence of seasons on prevalence of fish parasite

Fish host	Parasite	Season						Source
		Dry	wet	Sp	Su	Au	Wi	
Chrysichthys nigrodigitatus	*Henneguya chrysichthys*	34	76%	-	-	-	-	Obiekezie *et al* (1987)
Pygocentrus nattereri	*Branchiurans* sp (Cr)	74.63%	38.24%	-	-	-	-	Carvallo et al (2003)
Serrasalmus spiloplenra	*Branchiurans* sp (Cr)	21.67	11.43	-	-	-	-	Carvallo et al (2003)
Serrasalmus marginatus	*Branchiurans* sp (Cr)	16.67	11.76	-	-	-	-	Carvallo et al (2003)
Semotilus atromaculatus	*Allocreadium lobatum*	33%	2%	-	-	-	-	Willis (2001)
Vimba vimba	*Dactylogyrus cornu*	-	-	10%	60%	45%	0%	Öztürk and Altunel (2006)
Blicca bjoerkna	*Dactylogyrus sphyrna*	-	-	1.%	40%	80%	1%	Öztürk and Altunel (2006)
Rutilus rutilus	*Dactylogyrus crucifer*	-	-	80%	1%	50%	40%	Öztürk and Altunel (2006)
Scardinius erythrophthalmus	*Dactylogyrus difformis*	-	-	0%	100%	0%	0%	Öztürk and Altunel (2006)
***Sparus aurata* (Gilthead Sea Bream)**	*Cryptosporidium molnari*	-	-	*P* < 0.001).	-	-	-	Sitjà-Bobadilla et al (2005)
***Dissostichus eleginoides* (Toothfish)**	*Neopavlovskioides georgianus (M)*	-	-	-	-	-	P< 0.01	Brickle *et al* (2006)
***Dissostichus eleginoides* (Toothfish)**	*Gonocerca phycidis (M)*	-	-	-	-	-	P< 0.01	Brickle *et al* (2006)
***Dissostichus eleginoides* (Toothfish)**	*Elytrophalloides oatesi*	-	-	-	P < 0.01	-	-	Brickle *et al* (2006)

Sp= Spring; Su= Summer; Au= Autumn; Wi= Winter, P=Protozoan; M= Monogenean; D=Digenea, C=Cestoda, (Tapeworms), Cr = Crustacea; N=Nematoda (Roundworms), Co= Copepoda; A=Acanthocephala (Thorny-headed worms)

Table 6: Influence of Sex on prevalence of parasite

Fish host	Parasite	Prevalence		Source
		Male	Female	
Hippoglossina macrops	*H. chilensis (Co)*	*		González *et al* (2001)
Centropomus undecimaltis	*Acanthlochus unisagittatus*	95.7%	81.5%	Tavarse and Luque (2004)
Salmon	*Ichthyophonus*	25.9%	32.5%)	Kocan *et al* (2004)
Semotilus atromaculatus	*Allocreadium lobatum*		p > 0.01	Willis (2001)
Hemisorubim platyrhynchos	*Goezeella paranaensis (C)*		p > 0.01	Guidelli *et al* (2003)
Hemisorubim platyrhynchos	*Mariauxiella piscatorum (C)*		p > 0.01	Guidelli *et al* (2003)

C = Cestoda, Co = Copepoda

intermediate and definitive hosts as water bodies shrink (Ezenwaji and Ilozumba, 1992) or due to pre-spawning congregation of hosts (Gupta *et al*., 1984), both of which facilitate transmission. In contrast, Zaman (1985) and Zaman and Seng (1989) found increases in parasite abundances of two species of clariid catfish coincided with increase in rainfall in Malaysia, but the parasites of one species, *C. batrachus*, showed an additional peak in the dry month of January in one of the two locations surveyed. Although Akhtar *et al*. (1992) stated that the comparatively higher rate of infestation *in Heteropneustes fossilis* (Bloch) was observed in the rainy season, their data also indicated that a number of helminth species increased in prevalence and intensity during the dry months between November and March, with marked oscillations in abundance through the year. Brickle *et al.* (2006)

reported that out of the parasites examined for seasonality, four species showed significant differences in seasonal prevalence of parasites. Monogenean, *N. georgianus* and cyst of unknown etiology (CUE) had their highest prevalence in winter, while *G. phycidia* and *E. oatesi* were more prevalent in winter with lower prevalence in summer and spring. Choudhury *et al.* (2004) observed seasonal patterns of infection with *B. acheilognathi*. They reported that there was a general trend of low abundance in summer months with significant higher abundance in the following fall (September). The seasonal patterns were attributed to temperature related dynamics in line with finding of earlier studies (Granath and Esch, 1983; Marcogliese and Esch, 1989a, b) that demonstrated the effect of temperature related dynamics on prevalence of *B. acheilognathi.* Chubb (1977) had identified temperature as the most important single factor controlling the seasonal prevalence of occurrence of Dactylogyrids and Gyrodactylids. Obiekezie *et al*. (1988) opined that as warm temperature would hasten the generation time, the absence of seasonal fluctuation in temperature would suggest a dynamic equilibrium of the parasite population with constant infection and maturation.

Host diet: Diet plays a major role in the composition of parasite communities in the fish gut (Dogiel, 1961). Examination of the diet of different species of subtropical and tropical freshwater fish and comparison with the richness and characteristics of the parasite community indicated that the richest enteric helminth fauna was found in fish with mixed carnivorous diets (invertebrates and fish) e.g. some clariid and mochokid catfish, followed by invertebrate feeders e.g. *Citharinus citharus* while many algal feeders and herbivores as well as some zooplankton specialist had poor enteric helminth fauna e.g. some *Alestes* species, *Tilapia* species and *Labeo* species (Bashirullah, 1973; Choudhury and Dick, 2000). Guidelli *et al*. (2003) observed that host feeding habit and diet were important in helminth acquisition while Dogiel (1970) commented that the habitat from which the main bulk of food is obtained was as important as the diet in parasite fauna composition. McClain *et al.* (1996) studied food preferences of juvenile and adult sculpins using length as the criteria for classification into juvenile and adult and reported that juvenile sculpins (up to 50 mm in length) consume small invertebrates such as copepods while adults (above 50 mm in length) shift to larger prey such as isopods, opossum shrimps *Mysis relicta,* Loven, 1861, snails and fish fry. Muzzal and Bowen (2002) examined the differences in the endohelminths among the host size classes to study how the shift in food preferences with host size affected the changes in acquisition of helminth parasite infracommunities. They reported higher prevalence, mean intensity, and mean abundance of *N. punititus* in small sculpins, whereas, higher prevalence, mean intensity, and mean abundance of *E. salmonis* were observed in large sculpins.

Host sex: Reimchem and Nosil (2001) pointed out that there are theoretical, experimental and field evidence to suggest that males are to be more heavily infected than females (Table 6), possibly due to the cost of sexual selection (Batra, 1984; Folstad *et al*., 1989; Folstad and Karter, 1992; Poulin, 1996; Wedekind and Jacobson, 1998) It has been argued that competition for mates extract costs on reproductive males and consequently, males may be operating closer to their physiological limits than females (Trivers, 1972; Zuk, 1990; Clutton-Brock and Parker, 1992). Cost of reproduction for males may be especially high for fishes where males provide all the parental care and exhibit all the territorial defense (van den Assem, 1967; Fitzgerald *et al*., 1989; De-Fraipont *et al*, 1992; Baker, 1994). This can result in higher levels of stress and reduced immunocompetence in males relative to females (Herbert and Cohen, 1993). Sex-biased parasitism can result from differences in immunocomptence with males predicted to bear a greater cost of sexual selection and immunosuppressive effects of testosterone production (Folstad *et al*., 1989; Folstad and Karter, 1992; Clutton-Brock and Parker, 1992; Zuk, 1990) and thus to become more susceptible to parasitic infection than females.

However, differences in parasitic infection between genders might also arise ecologically. For example, niche partitioning involving habitat or diet (Grant, 1975; Reimchem, 1980; Grant, 1985; Shine, 1989; Raymond *et al.,* 1990; Houston and Shine, 1993; Selander, 1996) can result in differential exposure to parasites unrelated to the unequal costs of reproduction (Tinsley, 1989). Such an ecological origin of parasitism would predict that either males or females could exhibit excess parasitism dependent on their probability of encountering the parasite and that excess parasitism in males may not be as a result of reduced immunocomptence. Kennedy (1975) had argued that quantitative differences in parasite infection between sexes can be expected and may be explained as a consequence of different habitat occupied by males and females, differences in the diet and/or physiology.

However, several researchers found no consistent pattern of infection in terms of prevalence and intensity between males and females (Oliva *et al.*, 1990). In a study of flat fish, *Paralichthys adspersus*, (Pleuronectiformes) they found that sex affects mean abundance and prevalence for only six out of twenty five parasites, all of which are trophically transmitted parasites. They observed that this means that differences are due mainly to diet and or physiology, but no differences in habitat could be expected for male and female flatfishes, as suggested by the absence of differences in monoxenic parasites. Moreover, Kong *et al.* (1995) were unable to find differences in diet of male and females of *P. adspersus*. Thus, differences in some ecological parameters of the infectious process could be a consequence of differential physiology of male and female flatfishes. Guidelli *et al.* (2003) reported that out of forty- one females and eighty-seven males of *Hemisorubim platyrhychos* studied, there was a significant relationship between host sex and prevalence with the females being more infected.

Environmental factors: It has been pointed out that certain habitat characteristics either physical or chemical may facilitate the establishment and proliferation of parasite in particular host population (Bagge *et al.,* 2004). In fish hosts for instance variables such as lake size, water pH or distance from other lakes have been associated with either the number of parasite species per host population or with abundance of given parasites (Kennedy, 1978; Marcogliese and Cone, 1991; Hartvigsen and Halvorsen, 1994; Karvonen *et al*., 2003). Saariem and Taskiem (2004) reported that stagnant waters were optimal habitat for *P. rylovi* whereas the flowing waters of rivers provide suboptimal environment. Gee and Davey (1986) reported lower levels of infection by copepod *Mytilicola intestinalis* in blue mussels *Mytilus edulis* in turbulent regions as compared with calm regions. The differences in the rate of infection, they argued, may be due to infection process of the parasitic species. The parasites that infect fish hosts slowly e.g. via filtration are likely to have lower infection rate in flowing rivers as larvae may be washed away before they become infective in flowing rivers (Gee and Davey, 1986; Saarinem and Taskiem, 2004).

References

Adams, A. M. (1985). Parasites on the gills of the Plains Killifish, *Fundulus kansae*, in the South Platte River, Nebraska. *Transactions of the American Microscopical Society,* 104: 278 – 284.

Akhtar, H. K., Zaman, Z and Begum, N. (1992). Metazoan parasites of *Heteropneustes fossils* (Bloch). *Bangladesh Journal of Zoology*, 20: 103 – 122.

Alves, D. R., Luque, J. L., Paraguassu, A. R. (2002). Community Ecology of the Metazoan parasites of Pink Cusk-eel, *Genypterus brasiliensis* (Osteichthyes: Ophidiidae), from the coastal zone of the State of Rio de Janeiro, Brasil. *Mem Oswaldo, Rio de Janeiro*, 97(5): 683 – 689.

Anderson, R. and Gordon D. (1982). Processes influencing the distribution of parasite numbers within host populations with special emphasis on parasite induced host mortalities. *Parasitology,* 8: 373 – 398.

Bagge, A. M., Poulin, R. and Valtonen, E. T. (2004). Fish population size and not density as the determining factor of parasite infection. A case study. *Parasitology,* 128: 305 – 313.

Baker, T. M. (1994). Evolution of aggressive behaviour in threespine stickleback. Pages 345 – 379. *In:* Bell M. A. and Foster, S. A. (Eds.). *The Evolutionary Biology of the Threespine stickle spine.* Oxford University Press, Oxford.

Barber, I. (2005). Parasites grow larger in faster growing fish hosts*. International Journals for Parasitology,* 35: 137 – 143.

Bashirullah, A. K. M. (1973). A brief survey of the helminth fauna of certain marine and freshwater fishes of Bangladesh. *Bangladesh Journal of Zoology,* 1: 63 – 81.

Batra, V. (1984). Prevalence of helminth parasites in three species of cichlids from Man made lake in Zambia. *Zoological Journal of Linnaean Society*, 82: 319 – 333.

Bauer, O. (1959). The influence of environmental factors on the reproduction of fish parasite. *Vapr. Ekoi (Izdat, Kiev University)*, 3:132 – 141.

Betterton, C. (1974). Studies on the host specificity of the eye fluke, *Diplostomum spathaceum*, in brown and rainbow trout. *Parasitology,* 69: 11 – 29.

Brickle, P., Buxton, N. G. and Villalon, E. (2003). Infection of *Sphyrion laevigatum* (Copepod: Sphyriidae) on *Genypterus blacodes* (Pisces: Ophidiidae) from the Falkland Islands, South Atlantic. *Parasitology,* 89(2): 242 – 244.

Brickle, P., MacKenzie, K. and Pike, A. (2006) Variations in the parasite fauna of the Patagonian Toothfish, *Dissostichus eleginoides* with Length, Season and Depth of habitat around the Falkland Islands. *Journal of Parasitology,* 92(2): 282 – 291.

Carvallo, L. N., De-Claro, K and Takemoto, R. M. (2003). Host Parasite interaction between *Branchiurans* (Crustacean: Argulidae) and *Pirans* (Osteichthyes: Serrsalminae) in the Pantaland wetland of Brazil. *Environmental Biology of Fishes,* 67: 289 – 296.

Chandler, M., Chapman, L. J. and Chapman, C. A. (1995). Patchiness in the abundance of metacercariae parasitizing *Poecilia gillii* (Poeciliidae) isolated in pools of an intermittent tropical stream*. Environmental Biology of Fishes,* 42: 313 – 321.

Chapman L. J., Lanciani, C. A. and Chapman, C. A. (2000). Ecology of a diplozoon parasite on the gills of the African cyprinid *Barbus neumayeri*. *African Journal of Ecology,* 38: 312 – 320.

Choudhury, A. and Dick, T. A. (2000). Richness and diversity of helminth communities in tropical freshwater fishes: empirical evidence. *Journal of Biogeography*, 27: 935 – 956.

Choudhury, A., Hoffnagle, T. L. and Cole, R. A. (2004). Parasite of native and nonnative fishes of the Little Colorado River. Grand Canyon, Arizona. *Parasitology,* 90(5): 1042 – 1053.

Chubb, J. C. (1970). The parasite fauna of British freshwater fish. Pages 119 – 144. *In: Aspects of fish parasitology*. Taylor, A. E. R. and Muller, R. (Eds.). Blackwell Scientific Publications, Oxford, United Kingdom.

Chubb, J. C. (1977). Seasonal occurrence of helminths in freshwater fishes: Monogenea. *Advances in Parasitology,* 15: 133 – 199.

Clutton-Brock, T. H. and Parker, G. A. (1992). Potential reproductive rates and the operation of sexual selection. *Quarterly Review of Biology,* 67: 437 – 455.

De-Fraipont, M., Fitzgerald, G. J. and Guderley, H. (1992). Femme fatale: the case of the threespine stickleback. *Ethology,* 91: 147 – 152.

Dogiel, V. A. (1961). *Obshchaya Parazitologiya* (English translation: General Parasitology). Academy Press, New York.

Dogiel, V. A. (1970). Ecology of the parasites of freshwater fishes. Pages: 1 – 47. *In:* Dogiel, V. A., Petrushevski G. K. and Polyansky, Y. I. (eds.), *Parasitology of fishes.* Olivier and Boyd, London.

Esch, G. W. (1982). Abiotic factors: an overview. Pages 279 – 288. *In:* Mettrick, D. F. and Desser, S. S. (Eds.) *Parasites; their world and ours. Proceedings of the Fifth International Congress of Parasitology Toronto, Canada,* 7-14 August, 1982. Elsevier Biomedical Press, Amsterdam.

Esch, G. W., Kennedy, C. R., Bush, A. O. and Aho, J. M. (1988). Patterns in helminth communities in freshwater fish in Great Britain: Alternative strategies for colonization. *Parasitology,* 96: 519 – 532.

Ezenwaji, H. M. G and Ilozumba, P. C. O. (1992). Helminth fauna of four West African small *Clarias* species (Osteichthyes: Clariidae) from Nigeria*. Journal of African Zoology,* 106: 391 – 400.

Fernandez, B. J., (1985). Estudio parasitológico de *Merluccius australis* (Hutton, 1872) (Pisces: Merluccidae): aspectos sistemáticos, estadisticos zoogeograficos. *Boletin de la Sociedod de Biologia de Concepción, Chile*, 56: 31 – 41.

Fitzgerald, G. J., Guderley, H. and Piscard, P. (1989). Hidden reproductive costs in threespined stickleback *Gasterosteus aculeatus*. *Experimental Biology,* 48: 295 – 300.

Folstad, I. and Karter A. J., (1992). Parasite, bright males, and the immunocompetence handicap. *American Naturalist,* 139: 603 – 622.

Folstad, I., Nilseen, A. C., Halvorsen, O. and Andersen, J. (1989). Why do male Reindeer (*Rangifer t. tarandus*) have higher abundance of second and third instar larvae of *Hypoderma tarandi* than females? Oikos, 55: 87 – 92.

Gee, J. M., and Davey, J. T. (1986). Experimental studies on the infestation of *Mytilus edulis* (L.) by *Mytilicola intestinalis* Steuer (Copepoda, Cyclopoida). *Journal du Conceil, Conceil International pour* 19 *Exploration de la Mer,* 42: 265 – 271.

González, M. T., Acuña, E. and Oliva, M. E. (2001). Metazoan parasite fauna of the Bigeye Flounder, *Hippoglossina macrops*, from Northern Chile. Influence of host age and sex. *Mem Inst Oswaldo Cruz, Rio de Janeiro,* 96(8): 1049 – 1054.

Gordon, D. M. and Rau, M. E. (1982). Possible evidence for mortality induced by the parasite, *Apatemon gracilis* in a population of brook sticklebacks, *Culea inconstans*. *Parasitology,* 84: 41 – 47.

Granath, W. O. and Esch, G. W. (1983). Seasonal dynamics of *Bothriocephalus acheilognathi* in ambient and thermally altered areas of North Carolina cooling reservoir. *Proceedings of the Helminthological Society of Washington*, 50: 205 – 218.

Grant, P. R. (1975). The classic case of character displacement. *Evolutionary Biology,* 8: 237 – 337.

Grant, P. R. (1985). Selection on bill characters in a population of Darwin's flinches in *Geospiza conirostris* on Isla Genovesa, Galapagos. *Evolution,* 39: 523 – 532.

Guidelli, G. M., Isaac, A., Takemoto, R M. and Pavanelli, G. C. (2003). Endoparasite infracommunities of *Hemisorubim platyrhychos* (Valenciennes, 1840) (Pisces: Pimelodidae) of the Baía river, upper Panama. *Brazilian Journal of Biology*, 63(2): 261 – 268.

Gupta, A. K., Niyogi, A., Naik, M. L. and Agarwal, S. M. (1984). Population dynamics of endohelminths of *Channa punctatus* at Raipur, India. *Japanese journal of Parasitology,* 33: *105-118*.

Hanek, G. and Fernando, C. H. (1978). The role of season, habitat, host age, and sex on gill parasites of *Lepomis gibbosus* (L.). *Canadian Journal of Zoology,* 56: *1247-1250*.

Hartvigsen, R. and Halvorsen, O. (1994). Spatial patterns in the abundance and distribution of parasites of freshwater fish. *Parasitology Today,* 10: *28-31.*

Herbert, C. and Cohen, S. (1993). Stress and immunity in humans: a meta-analytic review. *Psychosomatic Medicine,* 55: *364-379.*

Houston, D. and Shine R. (1993). Sexual dimorphism and niche divergence: feeding habits of the Arafura filesnake. *Journal of Animal Ecology,* 62: *737-748.*

Hughes, G. M. (1966). The dimensions of gill relation to their function. *Journal of Experimental Biology*, 45:177-195.

Ibiwoye, T. I., Balogun, A. M., Ogunsisi, R. A. and Agbontale, J. S. (2004). Determination of infection densities of Eustrongylides in Mudfish, *Clarias gariepinus* and Clarias anguillaris from Bida flood plain Nigeria. *Journal of Applied Sciences and Environmental Managemen*t, 8(2): 39 – 44.

Karvonen, A., Paukku, S., Valtonen, E. T. and Hudson, P. J. (2003). Transmission, infectivity and survival of *Diplostomum spathaceum* cercariae. *Parasitology,* 127: 217 – 224.

Kennedy, C. R. (1975). *Ecological animal Parasitology.* Blackwell Science Publishers, London.

Kennedy, C. R. (1978). An analysis of the metazoan parasitocoenoses of brown trout *Salmo trutta* from British lakes. *Journal of Fish Biology,* 13: 255 – 263.

Kennedy, C.R. (1995). Richness and diversity of macroparasite communities in tropical eels *Anguilla reinhardtii* in Queensland, Australia. *Parasitology*, 111: 233 – 245.

Kocan, R, Hershberger, P. and Winton, J. (2004). Effects of Ichthyophonus on Survival and Reproductive Success of Yukon River Chinook salmon. Final Report for Study 01-200 U.S. Fish and Wildlife Service Office of Subsistence Management Fisheries Resource Monitoring Program

Kong, I., Clarke, M. and Escribano, R. (1995). Alimentación de *Paralichthys adspersus* (Steindachner, 1867) en la zona norte de Chile. *Revista Brasileira de Biologia,* 30*:* 210 – 230.

Kurz, C.L., Chauvet, S., Andres, E., Aurouze, M., Vallet, I. and Michel, G.P. (2003). Virulence factors of the human opportunistic pathogen *Serratia marcescens* identified by *in vivo* screening. *EMBO Journal,* 22: 1451 – 1460.

Lo, C. M. Morand, S. and Galzina, R. (1998). Parasite diversity: host age and size relationship in three coral reef fishes from French Polynesia. *International Journal of Parasitology,* 28: 1695 – 1708.

Li, W. X., Wang, G. T., Yao, W. J. and Nie, P. (2005). Seasonal Dynamics and Distribution of Digenean *Phyllodistomum pawlovski* (Trematoda: Gorgoderidae) in the Blue head Catfish, *Pseudobagrus fulvidraco* in lake China. *Journal of Parasitology*, 9(4): 850 – 853.

Luque, J. L., Porrozzi F. and Alves, D. R. (2002). Community ecology of the metazoan parasites of Argentine Goatfish, *Mullus argentinae* (Osteichthyes: Mullidae), from the coastal zone of the state of Rio de Janeiro, Brazil. *Rev. Brasil. Parasitol. Vet.*, 11(1): 33 – 38.

Machado, M. H., Pavanelli, G. C. and Takemoto R. M. (1994). Influence of host's sex and size on endoparasitic infrapopulations of *Pseudoplatystoma corruscans* and *Schizodon borelli* (Osteichthyes) of the high Paraná River, Brazil*. Rev. Brasil. Parasitol. Vet.*, 3(2): 143 – 148.

MacKenzie, K., Kalavati, C., Gaard, M. and Hemmingsen, W. (2005). Myxosporean gall bladder parasites of the gadid fishes in the North Atlantic: Their geographical distribution and an assessment of their economic importance in fisheries and mariculture. *Fisheries Research*, 76: 454 – 465.

Madhavi, R. and Rukmini, C. (1991). Population biology of the metacercariae of *Centrocestus formosanus* (Trematoda: Heterophyidae) on the gills of *Aplocheilus panchax*. *Journal of Zoology*, 223: 509 – 520.

Marcogliese, D. and Esch, G. W. (1989). Experimental and natural infection of planktonic and benthic copepods by the Asian tapeworm, *Bothriocephalus acheilognathi*. *Proceedings of the Helminthological Society of Washington,* 56: 151 – 155.

Mattiucci, S., Farina, V., Garcia, A., Santos, M. N., Mariniello, L. and Nascetti, G. (2005). Metazoan parasitic infections of Swordfish (*Xiphias gladius*) from the Mediterranean Sea and Atlantic Gibraltar waters: Implications for stock assessment. *Col. Vol. Sci. Pap. ICCAT*, 58(4): 1470 – 1482.

McClain, J. C., Bowen, C. and Hudson, P. (1996). Lake Trout rehabilitation in Lake Huron-1995 progress report on coded wire tag returns. Pages 1 – 18. *In: 1996 Annual Report of the Lake Huron Committee.* Great Lakes Fishery Commission, Ann Arbor, Michigan.

Milinski, M. (2003). The function of mate choice in sticklebacks: optimizing MHC genetics. *Journal of Fish Biology*, 63(Supp. A): 1 – 16.

Morrand, S. (1996). Biodiversity of parasites in relation with their life cycle. Pages 243 – 260. *In:* Hochberg M, Clobert, J. and Barbault, R. (Eds). *The genesis and maintenance of biological diversity*. Oxford University Press, Oxford.

Morrand, S. (2000). Wormy world: comparative tests of theoretical hypotheses on parasite species richness. Pages 63 – 79. *In:* Poulin, S., Morrand, S. and Skorping, A. (Eds.). *Evolutionary biology of host-parasite relationships: theory meets reality.* Elsevier Science, Amsterdam.

Morrand, S., Legendre, R., Gardner, S. L. and Hugot, J. R. (1996). Body size evolution of oxyurid parasites: the role of hosts. *Ecologia*, 107: 274 – 282.

Morrand, S. and Sorci, G. (1998). Determinants of life history evolution in nematodes. *Parasitology Today,* 14: 193 – 196.

Moravac, F., Gelner, M. and Rehulka, J. (1987). *Capillostrongyloides ancistri* n sp Nemetode: Cappillariidae, a new pathogenic parasite of aquarium fishes in Europe. *Folia Parasitologica,* 34: 157 – 161.

Munoz, G., Valdebenito, V. and. George-Nascimento, M. (2002). La dieta y la fauna de parásitos metazoos del torito *Bovichthys chilensis* egan 1914 (Pisces: Bovichthydae) en la costa de Chile centrosur: Variaciones geogra´ficas y ontogene´ticas. *Revista Chilena de Historia Natural*, 75: 661 – 671.

Munoz, G. and Cribb, T. H. (2005). Infracommunity structure of parasites of *Hemigymnus melapterus* (Pisces: Labridea) from Lizard Island, Australia: The importance of habitat and parasite body size. *Journal of Parasitology,* 91(1): 38 – 44.

Muzzall, P. M. and Bowen, C. A. (2002). Parasites of the Slimy Sculpin, *Cottus cognatus* Richardson, 1836, from Lake Huron, U.S.A. *Comparative Parasitology*, 69(2): 196 – 201.

Noble, E. R. and Noble, G. A. (1982). *Parasitology*. *The Biology of Animal Parasites*, 5th Edn. Lea and Febiger, Philadelphia.

Obiekezie, A. I., Moller, H. and Anders, K. (1988). Disease of the African estuarine catfish

Chrysichthys nigrodigitatus (Lacepede) from the Cross River estuary. *Nigeria Journal of Fish Biology, 32*: *207-221.*

Oliva, M., Luque, J. L. and Iannacone, J. A. (1990). The metazoan parasites of *Stellifer minor* (Tschudi, 1844): an ecological approach. *Revista Brasileira de Biologia*, 60(4): 577 – 584.

Olurin, K. B. and Somorin, C. A. (2006). Intestinal Helminths of the fishes of Owa stream, South-west Nigeria. *Research Journal of Fisheries and Hydrobiology*, 1(1): 6 – 9.

Öztürk, M. O. and Altunel, F. N. (2006). Occurrence of *Dactylogyrus* infection linked to seasonal changes and host fish size on four cyprinid fishes in lake Manyas, Turkey. *Acta Zoologica Academiae Scientiarum Hungaricae,* 52(4): 407–415.

Ozer, A and Ozturk, T. (2005).*Dactylogyrus cornu* Linstow, 1878 (Monogenea) infestations on Vimba (*Vimba vimba tenella* (Nordmann, 1840)) caught in the Sinop Region of Turkey in relation to the host factors. *Turk J Vet Anim Sci.,* 29: 1119 – 1123.

Paperna .I (1979). *Monogerea of inland water fish in Africa.* Annal. Mus Roy d. Afr. Cent. Tervum Belg, Ser IN-8 Science Zoologiques No 266.

Parker, G. A., Chubb, J. C., Roberts, G. N, Michaud, M., Milinski, M. (2003). Optimal growth strategies of larval helminths in their intermediate hosts. *Journal of Evolutionary Biology*, 16: 47-54.

Pavanelli, G. C. and Machado dos Santos, M. H. (1991). Proteocefalídeos parasitas de peixes, em especial pimelodídeos, do rio Paraná, Paraná. *Rev Unimar,* 13: 163-175.

Pennycuick, L. (1971). Differences in the parasite infections in three-spined Sticklebacks, *Gasterosteus aculeatus* L. of different sex, age and size. *Parasitology,* 63: 407 – 418.

Poulin, R. (1996). Sexual inequalities in helminth infections: a cost of being male? *American Naturalist,* 147: 287-295.

Poulin, R. (1998). *Evolutionary ecology of parasites: from individuals to communities.* Chapman and Hall, London.

Poulin, R. (2000). Variation in the intraspecific relationship between fish length and intensity of the parasitic infection: Biological and statistical causes. *Journal of Fish Biology,* 56: 123 – 137.

Poulin, R. (2004). Macroecological patterns of species richness in parasite assemblages. *Basic and Applied Ecology,* 5: 423 – 434.

Raymond, M., Robitaille, J. F., Lauzon, P. and Vaudry, R. (1990). Prey-dependent profitability of foraging behaviour of male and female ermine, *Mustela erminea*. *Oikos,* 58:323 – 328.

Reimchem, T. E. (1980). Spine deficiency and Polymorphism in a population of *Gastersteus aculeatus*: an adaptation to predators? *Canadian Journal of Zoology,* 68: 1232 – 1244.

Reimchem, T. E. and Nosil, P. (2001). Ecological causes of sex-biased parasitism in threespine stickleback. *Biological Journal of the Linnaean Society,* 73: 51 – 63.

Rhode, K. (1989). Simple ecological systems, simple solution to complex problems? *Evolutionary Theo*ry, 8: 305 – 350.

Rhode, K. (1993). *Ecology of marine parasites.* (2 ed.), University of Queensland Press,

Roubal, F. R., (1990). Seasonal changes in ectoparasite infection of juvenile yellowfin bream, *Acanthopagrus australis* (Günther) (Pisces: Sparidae), from a small estuary in Northern New South Wales. *Australia Journal of Marine and Freshwater Research*, 41: 411 – 427.

Saarinen, M. and Taskinen J. (2004). Aspects of the ecology and natural history of *Paraergasilus rylovi* (Copepod, Ergasildae) parasitic in Unionids of Finland*. Journal of Parasitology,* 90(5): 948 – 952.

Sasal, P., Desdevises, Y. and Morrand, S. (1998). Host-specialization and species diversity in fish parasites: phylogenetic conservatism? *Ecography,* 21: 639 – 643.

Selander, S. K. (1996). Sexual dimorphism and differential niche utilization in birds. *Condor,* 68: 113 – 151.

Sepu´lvedaa, F., Marı´nb, S. L. and Carvajala, J (2004) .Metazoan parasites in wild fish and farmed salmon from aquaculture sites in southern Chile. *Aquaculture,* 235: 89 – 100.

Sitjà-Bobadilla, A., Padrós, F., Aguilera, C. and Alvarez-Pellitero. P. (2005). Epidemiology of *Cryptosporidium molnari* in Spanish Gilthead Sea Bream (*Sparus aurata* L.) and European Sea Bass (*Dicentrarchus labrax* L.) cultures: from hatchery to market size. *Appl Environ Microbiol*. 71(1): 131–139.

Shine, R. (1989). Ecological causes for the evolution of sexual dimorphism: a review of the evidence. *Quarterly Review of Biology,* 64: 419 – 464.

Shotter, R. A. (1973). Changes in the parasite fauna of whiting *Odontogadus merlangus* L. with age and sex of host, season, and from different areas in the vicinity of the Isle of Man. *Journal of Fish Biology*, 5: 559 – 573.

Sorci, G., Morrand, S. and Hugot, L. P. (1997) Host-parasite coevolution: comparative evidence for covariation of life-history traits in primates and oxyurid parasites. *Proceedings of the Royal Society of London, Series* B, 264: 285 – 289.

Takemoto, R. M., Amato, J. F. R. and Luque, J. L. (1996). Comparative analysis of the metazoan parasite communities of leatherjackets, *Oligoplites palometa*, *O. saurus* and *O. saliens* (Osteichthyes: Carangidae) from Sepetiba Bay, Rio de Janeiro, Brazil. *Revista Brasileira de Biologia,* 56(4): 639 – 650.

Takemoto, R. M. and Pavanelli, G. C. (1994). Ecological aspects of Proteocephalidean cestodes parasites of *Paulicea luetkeni* (Steindachner)(Osteichthyes: Pimelodidae) from the Paraná river, Paraná, Brazil. *Rev. UNIMAR*, 16(Supl. 3): 17 – 26.

Takemoto, R. M. and Pavanelli, G. C. (2000). Aspects of the ecology of Proteocephalid cestodes parasites of *Sorubim lima* (Pimelodidae) of the Upper Paraná River, Brazil: I. Structure and influence of both size and sex. *Revista Brasileira de Biologia,* 60(4): 577- 584.

Tinsley, R. C. (1989). The effects of host sex on transmission success. *Parasitology Today,* 5: 190 – 195.

Trivers, R. L. (1972). Parental investment and sexual selection. Pages 136 – 179. In: Campell, B. (ed.) *Sexual selection and the Decent of Man*, 1871-1971. Aldine, Chicago.

Valtonen, E. T., Prost, M. and Rahkonen, R. (1990). Seasonality of two gill monogeneans from two freshwater fish from an oligotrophic lake in northeast Finland. *International Journal for Parasitology,* 20(1): 101 – 107.

Van den Assem, J. J. A. (1967). Territory in the threespined stickleback, *Gasterosteus aculeatus*. An experimental study in intra-specific competition. *Behavioural Supplements,* 36: 1 – 164.

Wedekind, C. and Jacobson, P. J. (1998). Male-biased susceptibility to helminth infections: an experimental test with a copepod. *Oikos,* 81: 458 – 462.

Williams, H. and Jones, A. (1994). *Parasitic Worms of Fish*. Taylor and Francis, United Kingdom.

Whittington, I. D., Cribb, B. W., Hamwood, T. E., Halliday, J. A.(200)Host-specicity of monogenean (platyhelminth) parasites: a role for anterior adhesive areas? *International Journal for Parasitology,* 30: 305 – 320.

Willis, M. S. (2001). Population Biology of *Allocreadium lobatum* Wallin, 1909 (Digenea: Allocreadiidae) in the Creek Chub, *Semotilus atromaculatus,* Mitchill (Osteichthyes: Cyprinadae), in a Nebraska Creek, *USA Mem Inst Oswaldo Cruz. Rio de Janeiro,* 96(3): 331 – 338.

Zaman, Z. (1985). Parasite fauna of Paddy field catfish (genus: Clarias) from Kedah and Perak, Peninsular Malaysia. PhD Thesis. University of Sains, Minden, Malaysia.

Zaman, Z. and Seng, L. T. (1989). The seasonal abundance of the parasite in *Clarias batrachus* and *C. macrocephalus* from two areas (Kedah and Perak) of Malaysia and its relationship to the maturity of the hosts. *Bangladesh Journal of Zoology*, 17: 47 – 55.

Zdzitowiecki, K. (1988). Occurrence of digenetic trematodes in fishes of South Shetlands (Antarctic*). Acta Parasitologica Polonica*, 33: 155 – 167.

Zuk, M. (1990). Reproductive strategies and disease susceptibility: an evolutionary viewpoint. *Parasitology Today,* 6: 231 – 233.