Endoparasites of some economically important food fishes of River Jhelum, Kashmir (India)

Taqdees Farooq · Imran Khan · Irfan-ur-Rauf Tak · Shoaib Ali Dar · A. R. Yousuf

Received: 22 August 2014 / Accepted: 3 October 2014 / Published online: 18 October 2014
© Indian Society for Parasitology 2014

Abstract During the present study endo-parasitic fauna of fish at different sites of River Jhelum were analysed. Four different species of endoparasites were recovered from *Schizothorax* species which include *Adenoscolex kashmirensis* Mehra, 1930, *Bothriocephalus acheilognathi* Yamaguti, 1934, *Echinorhynchus* sp., *Pomphorhynchus kashmirensis* Kaw, 1941, belong to Phylum Platyhelminths and Phylum Acanthocephala. Prevalence and generation time were inversely proportional to each other. Prevalence and mean abundance were highest at Qamarwari. Diversity was more at Tengpora. Cestodes including *Adenoscolex kashmirensis* and *Bothriocephalus acheilognathi* were more dominant than *Pomphorhynchus kashmirensis* and *Echinorhynchus* sp.

Keywords Endoparasites · *Schizothorax* · Kashmir · Jhelum

Introduction

Nearly everyone has some experience with parasites and knows in general terms what they are. All living beings including fishes fall prey to large number of diseases

caused by different types of parasites. Because of the importance of animal protein provided by fishes, various aspects of its production and conservation is studied and study of parasitology is one of the important aspects since parasites are responsible for various pathogenic diseases resulting in their death, particularly in younger stages. Effect of parasitism results in the destruction of hosts tissues, either by mechanical action due to migration of parasites or their larvae or their multiplication in organs or tissues, or by insertion of attachment organs of parasites (hooks, suckers) etc. into tissues as anchors.

Asian tapeworm can be attributed to its ability to infect a wide variety of fish and copepod hosts (Korting 1975; Dove and Fletcher 2000) and also because this parasite requires only a couple of weeks to complete its development in the intermediate host Korting (1975). It has been reported by various workers that *Bothriocephalus acheilognathi* completes its life cycle in almost 1 year (Korting 1975; Hoffman 1976; Mitchell and Hoffman 1980; Paperna 1996). Asian tapeworm has reportedly caused considerable mortality in hatchery ponds (Liao and Shih 1956; Korting 1975).

Helminth parasites are the most important and common among various fish parasitic diseases affecting the fish in different ways. Fishes fall prey to the infection of parasites in their larval stages, for example choking of gills in fingerlings is caused by monogenetic treaties which affect their respiratory activity causing their mortality.

To increase fish production, stress has to be laid on their health and growth. In this context it is necessary to study their pathogens or parasites which cause diseases in them and as a result hamper their growth pace as well as affect their quality and quantity. Therefore a Knowledge of the local parasite fauna of fish and their morphology at tissue level is of vital importance. It is in this direction that a brief

T. Farooq · I. Khan · A. R. Yousuf
Department of Environmental Science, University of Kashmir,
Srinagar, India

Irfan-ur-Rauf Tak · S. A. Dar (✉)
Center of Research for Development, University of Kashmir,
Srinagar, India
e-mail: darshoaib786@gmail.com

S. A. Dar
Department of Zoology, Punjabi University, Patiala, India

study was conducted on the fish parasites in Jhelum River during 2011.

Materials and methods

In the present study we analysed the endo-parasite fauna of fish at different sites of River Jhelum with the main objectives of, Identifying the Endoparasites, Assess the distribution of endoparasites among various species of fishes and determining differences in infection indices (prevalence, MI, MA) among different sites.

Sampling sites

Site I (Marwal 33°58'45.4"N;74°54'16.5"E)

It was located about 32 km from the main city centre (Lal Chowk) in District Pulwama at Marvel. The average depth at the site was about 1.6 m.

Site II (Aramwari near Zero bridge 34°04'9.2"N;74°50'20.88"E)

It was located about 1.2 km from the Srinagar city near Zero bridge. All along its course from Marwal to Srinagar the river receives significant quantities of domestic wastes

from human settlements and army cantonment areas. The average depth at the site was about 2 m.

Site III (Qamarwari 34°05'35.9"N;74°46'45.4"E)

It was located about 10 km from main city centre at Qamarwari. The site was having both the commercial activities and residential settlements along both banks, which directly release the sewage and other solid wastes directly into the river. The average depth at the site was about 1.2 m.

Fig. 1 Study area and sampling sites

Table 1 Biological aspects of different species collected at different sampling sites during (June–November 2011)

Name of the host	Total length (mm)	Total weight (gm)	Condition factor (K)
<i>S. plagiostomus</i>	274.62	205.26	0.99
<i>S. curvifrons</i>	258.32	222.02	1.29
<i>S. esocinus</i>	262.28	207.51	1.15
<i>S. niger</i>	298.83	214.25	0.86

Bar graph showing biological aspects of *S. plagiostomus*, *S. curvifrons*, *S. esocinus*, *S. niger*

Fig. 2 **a** Microphotograph of *B. acheilognathi*,
b Microphotograph of *B. acheilognathi*,
c *Bothriocephalus acheilognathi* infection in *Schizothorax*

Fig. 3 Cestode parasite (*Adenoscolex kashmirensis*)

Fig. 4 **a** Microphotograph of *P. kashmirensis*,
b Microphotograph of *P. kashmirensis*

Site IV (Tengpora 34°7'47.1"N;74°43'11"E)

It was located about 26 km from main city centre at Tengpora. The site is characterized by the dense vegetation of *populous*, *Salix* and other plants. All along the banks the land was used for the agricultural purposes (Fig. 1).

Methods

Collection of fish/host

The Piscine hosts, belonging to different fish species were collected from the river Jhelum with the assistance of local fishermen. The hosts were brought alive to the Limnology

Fig. 5 *Echinorhynchus* sp.

laboratory of the Centre and Research Development (CORD) in large carry bags/plastic containers. However, fresh dead fishes, which could not survive the transportation up to the laboratory, were also used. It was

interestingly found that parasites recovered from these fishes were alive.

Laboratory techniques employed

Post-mortem examination of fishes for parasites Fishes were identified, and weighed one by one, and the parameters like total length, standard length and width were noted. Fishes were autopsied as soon as possible to prevent migration of helminthes or their decay. The viscera was removed from the host and placed in separate petri dishes containing normal saline (0.75 % NaCl) and body cavity was examined carefully for any parasite or an abnormal or doubtful structure. Sex of the fish was determined by examining the gonads. In case of cestodes, whose rostellum was deeply anchored to the mucosa, a few menthol crystals

Table 2 Endoparasites of fishes at Marwal (site I)

Name of Host	Sample size	<i>Adenoscolex kashmirensis</i>	<i>Pomphorynchus kashmirensis</i>	<i>Bothriocephalus acheilognathi</i>
<i>S. plagiostomous</i>	35	+	+	—
<i>S. curvifrons</i>	30	+	—	—
<i>S. esocinus</i>	23	—	+	+
<i>S. niger</i>	2	—	—	—

Table 3 Endoparasites of fishes at Aramwari (site II)

Name of Host	Sample size	<i>Adenoscolex kashmirensis</i>	<i>Pomphorynchus kashmirensis</i>
<i>S. plagiostomous</i>	30	+	+
<i>S. curvifrons</i>	25	+	—
<i>S. esocinus</i>	20	+	+
<i>S. niger</i>	10	—	—

Table 4 Endoparasites of fishes at Qamarwari (site III)

Name of Host	Sample size	<i>Adenoscolex kashmirensis</i>	<i>Pomphorynchus kashmirensis</i>	<i>Bothriocephalus acheilognathi</i>
<i>S. plagiostomous</i>	20	+	+	+
<i>S. curvifrons</i>	37	+	—	+
<i>S. esocinus</i>	28	+	+	+
<i>S. niger</i>	18	—	—	+

Table 5 Endoparasites of fishes at Tengpora (site IV)

Name of Host	Sample size	<i>Adenoscolex kashmirensis</i>	<i>Pomphorynchus kashmirensis</i>	<i>Bothriocephalus acheilognathi</i>	<i>Echinorhynchus</i> Sp.
<i>S. plagiostomous</i>	20	—	+	+	—
<i>S. curvifrons</i>	37	—	+	+	+
<i>S. esocinus</i>	18	—	+	+	+
<i>S. niger</i>	18	—	+	+	+

Table 6 Infection indices of endoparasites of fishes at Marwal (site I)

Name of Host	Sample size	Number of fish infected	No. of parasites	Prevalence (%)	MI	MA
<i>S. plagiostomous</i>	35	6	43	17.14	7.16	1.22
<i>S. curvifrons</i>	30	5	25	16.66	5	0.83
<i>S. esocinus</i>	23	2	10	8.69	5	0.43
<i>S. niger</i>	2	0	0	0	0	0

Graph showing infection indices of fish endoparasites at Marwal (site I)

were add to the normal saline containing the parasites adhered to the intestinal wall. Acanthocephalans which bore their proboscis into gut wall were freed carefully by splitting the gut wall with the help of a pair of fine needles.

Examination of living helminthes

The parasites collected were transferred to fresh normal saline, and were thoroughly studied before killing and fixing, by using neutral red and methylene blue. They were observed under microscope and counting of hooks was made by mounting the proboscis in glycerin. It made the counting easier. In living specimens, excretory system was also observed under microscope.

Preparation of permanent slides

Preparation In a tube containing 0.75 % NaCl, the worms collected were shaken vigorously. Cold or luke warm water was also used. Afterwards, the digenetic trematodes and cestodes were put in distilled water for sometime. This resulted to relax the specimens further and in some species, caused them to eggs, which otherwise

obscure much of the discharge most of the intestinal anatomy (Meyer and Olson 1975).

Killing and fixing Tapeworms were killed by pouring them in a flask containing saline heated to 60–80° C (depending upon size) and shaking vigorously for about 20 s. The cestode specimens were then fixed on clean slides under the cover glass or slide depending upon their thickness. These were then transferred to fresh fixative and kept from half-hour to 2 h, depending upon size. (Meyer and Olson 1975 and Cable 1977). A drop of chloroform was added to a saline in a dish containing Acanthocephalans to necrotize them. Specimens were kept for sometime in this solution till the proboscis was fully everted in case of *Neoechinorhynchus*. In the present study, Carnoy's fixative was generally used as it gave good results with all material. Permanent slides were made from the preserved material to study some specimens.

Results and discussion

The present study was aimed at studying the endoparasites of fishes in river Jhelum ecosystem. For this purpose five

Table 7 Infection indices of endoparasites of fishes at Aramwari (site II)

Name of Host	Sample size	Number of fish infected	No. of parasites	Prevalence (%)	MI	MA
<i>S. plagiostomus</i>	30	6	30	20	5	1
<i>S. curvifrons</i>	25	4	45	16	11.25	1.8
<i>S. esocinus</i>	20	3	15	15	5	0.75
<i>S. niger</i>	10	0	0	0	0	0

Bar-graph shows the infection indices of fish endoparasites at Aramwari (site II)

species of fishes including *Schizothorax plagiostomus* Heckel 1838, *Schizothorax curvifrons* Heckel 1838, *Schizothorax esocinus* Heckel 1838, *Schizothorax niger* Heckel 1838 were studied at four sites along the course of river Jhelum from June 2011 to November 2011. The data collected on different aspects of fish are described in the following pages under different sub-heads:

- (1) Biological aspects of *Schizothorax* species
- (2) Endoparasites of fishes
- (3) Infection indices of fish endoparasites
- (4) Monthly variation of helminth parasites

Biological aspects of *Schizothorax* species

The biological aspects of fish that were calculated in the present study include its total length, total weight and condition factor (K). Total length was calculated by using measuring board, total weight by digital balance and condition factor or Ponderal Index was calculated by using formula:

$$K = W/L^3 \times 10^5$$

where 'W' is weight in gm and 'L' is length in mm.

This table shows the biological aspects including total length, total weight & condition factor of different *Schizothorax* sp. (Table 1). The total length, total weight and condition factor follows the trend as:

Total length: *S. niger* (298.38) > *S. plagiostomus* (274.62) > *S. esocinus* (262.28) > *S. curvifrons* (258.32)

Total weight: *S. curvifrons* (222.02) > *S. niger* (214.25) > *S. esocinus* (207.51) > *S. plagiostomus* (205.26)

Condition factor (K): *S. curvifrons* (1.25) > *S. esocinus* (1.15) > *S. plagiostomus* (0.99) > *S. niger* (0.86)

Description about endoparasites

Bothriocephalus acheilognathi Yamaguti, 1934 (Asian Tapeworm) (Fig. 2)

B. acheilognathi, also known as the Asian tapeworm, is a freshwater fish parasite that originated from China and Russia. It is generalized parasite that affects a wide variety

Table 8 Infection indices of endoparasites of fishes at Qamarwari (site III)

Name of Host	Sample size	Number of fish infected	No. of parasites	Prevalence (%)	MI	MA
<i>S. plagiostomous</i>	20	4	33	20	8.25	1.65
<i>S. curvifrons</i>	37	9	60	24.32	6.66	1.62
<i>S. esocinus</i>	28	6	35	21.42	5.83	1.25
<i>S. niger</i>	18	5	23	27.77	4.6	1.27

Bar-graph shows the infection indices of fish endoparasites at Qamarwari (site III)

of fish hosts, particularly Cyprinids, contributing to its overall success. It has a fleshy scolex (head region) with an undeveloped terminal disc and two long attachment grooves called bothria positioned dorsoventrally. The scolex is distinctively shaped like an inverted heart or an arrowhead. Its ribbon like body consists of flattened segments called proglottids.

In 1934, the Japanese helminthologist Satyu Yamaguti first described specimens from Ogura lake, Japan. He named them as two different species—*B. acheilognathi*, *B. opsariichthydi*. In 1955, the Chinese helminthologist Liang-Sheng Yeh described more specimens recovered from grass carp (*Ctenopharyngodon idella*) in South China as *B. gowkongensis*.

Adenoscolex kashmirensis Mehra, 1930 (Fig. 3)

It has a creamy white or pale pink colour and an elongated body. Body is divided into scolex, neck and posterior body segments (proglottids). The scolex bears suckers and hooks. Neck is short and narrow, not clearly demarcated from the rest of the body. Neck is followed by immature, then mature and finally gravid proglottids.

Pomphorhynchus kashmirensis Kaw, 1941 (Fig. 4)

It has a small body mostly yellowish in colour. Its main characteristic is the presence of protrusible, armed proboscis at the anterior terminal which is followed by an unarmed neck. A digestive tract is completely lacking in them and absorb nutrients through the body surface. The proboscis bears rows of hooks and spines. *Pomphorhynchus kashmirensis* is digenic having two hosts an intermediate host (*Gammarus pulex*) and a definitive host (fish).

Echinorhynchus sp. (Fig. 5)

The parasite is yellow in colour, having small body. Life cycle of *Echinorhynchus* requires one intermediate host (*Echinogammarus pungens*) an amphipod and one definitive host.

Endoparasites of fishes at different sites

Table 2 shows the endoparasites of fishes at Marwal (site I). Three endoparasites including *Adenoscolex kashmirensis*, *Pomphorhynchus kashmirensis* and *Bothriocephalus*

Table 9 Infection indices of endoparasites of fishes at Tengpora (site IV)

Name of Host	Sample size	Number of fish infected	No. of parasites	Prevalence (%)	MI	MA
<i>S. plagiostomous</i>	20	3	13	15	4.33	0.65
<i>S. curvifrons</i>	37	4	19	10.81	4.75	0.51
<i>S. esocinus</i>	28	5	15	17.85	3	0.53
<i>S. niger</i>	18	3	9	16.66	3	0.5

Bar-graph showing the infection indices of fish endoparasites at Tengpora (site IV)

Table 10 Overall infection indices of endoparasites at different sites in River Jhelum

Name of sites	Sample size	Number of fish infected	No. of parasites	Prevalence (%)	MI	MA
Marwal	90	13	78	14.44	6.0	0.86
Aramwari	85	13	90	15.29	6.92	1.05
Qamarwari	103	24	151	23.30	6.29	1.46
Tengpora	103	15	56	14.56	3.73	0.54

Bar-graph shows the overall infection indices of endoparasites at Marwal (site I), Aramwari (site II), Qamarwari (site III) and Tengpora (site IV)

Table 11 Monthly variation of helminth parasites at Marwal (site I)

Month	June	July	October	November
Prevalence (%)	19	20	15.5	10
MI	2.1	2.5	0.9	0.5
MA	0.47	0.5	0.4	0.3

Graph showing monthly variation of helminth parasites at Marwal (site I)

Table 12 Monthly variation of helminth parasites at Aramwari (site II)

Month	June	July	October	November
Prevalence (%)	20	14.2	10	8.2
MI	2	4.5	1	1.9
MA	0.4	0.43	0.2	0.4

Graph showing monthly variation of helminth parasites at Aramwari (site II)

acheilognathi were recovered from five species of *Schizothorax*. *Adenoscolex kashmirensis* was present in *S. plagiostomus* and *S. curvifrons*. *Pomphorhynchus kashmirensis* was present in *S. plagiostomus* and *S. esocinus*. *Bothriocephalus acheilognathi* was present only in *S. esocinus*. None of the three endoparasites were present in *S. niger*.

Table 3 shows the endoparasites at Aramwari (site II). Here only two endoparasite one belonging to Phylum Platyhelminths (i.e.; *Adenoscolex*) and other belonging to

Phylum Acanthocephala (i.e. *Pomphorhynchus kashmirensis*) was found. At this site *Adenoscolex kashmirensis* was present in three *Schizothorax* species including *S. plagiostomus*, *S. curvifrons* and *S. esocinus* while *Pomphorhynchus kashmirensis* was present in *S. plagiostomus* and *S. esocinus*. Both endoparasites were absent in *S. niger*.

Table 4 shows the presence of endoparasites of fishes at Qamarwari (site III). Here three endoparasites including *Adenoscolex kashmirensis*, *Pomphorhynchus kashmirensis* & *Bothriocephalus acheilognathi* were recovered. All of

Table 13 Monthly variation of helminth parasites at Qamarwari (site III)

Month	June	July	October	November
Prevalence (%)	28.57	28.6	12.8	10
MI	1.5	3.5	2	1.9
MA	0.5	1	0.4	0.8

Graph showing monthly variation of helminth parasites at Qamarwari (site III)

Table 14 Monthly variation of helminth parasites at Tengpora (Site IV)

Month	June	July	October	November
Prevalence (%)	20	20	10	9.8
MI	2	3.5	3.7	4.2
MA	0.4	0.7	1.5	0.8

Graph showing monthly variation of helminth parasites at Tengpora (Site IV)

the three endoparasites were present in *S. plagiostomus* and *S. niger* while only *Bothriocephalus acheilognathi* was present in *S. niger*.

Table 5 shows the presence of four different endoparasites of fishes at Tengpora (site IV). These endoparasites include *Adenoscolex kashmirensis*, *Bothriocephalus acheilognathi* (belonging to Phylum Platyhelminths) & *Pomphorhynchus kashmirensis*, *Echinorhynchus kashmirensis* (belonging to Phylum Acanthocephala). *Adenoscolex* was absent at this site.

Infection indices of fish endoparasites

The level of parasite infection was quantified by using Prevalence, Mean intensity (MI), Mean abundance (MA) in accordance to the recommendations of Bush et al. (1997).

Table 6 shows the infection indices (Prevalence, MI and MA) of different *Schizothorax* sp. at Marwal (site I). The Prevalence, MI and MA were highest in *S. plagiostomus* (having values 17.14 %, 7.16, 1.22) followed by *S. curvifrons* (16.66 %, 5, 0.43) and then *S. esocinus* (8.69, 5, 0.43). The Prevalence, MI and MA were zero in *S. niger*.

Table 7 shows the infection indices (Prevalence, MI and MA) of different sp. of *Schizothorax* at Aramwari (site II) and the Prevalence was highest in *S. plagiostomus* (20 %) and zero in *S. niger*. While MI and MA were highest in *S. curvifrons* (11.25 and 1.8 respectively). The MI was same (i.e.; 5) for *S. plagiostomus*, *S. esocinus* and MA was least in *S. esocinus* (0.75).

Table 8 shows the infection indices (Prevalence, MI & MA) of fish endoparasites at Qamarwari (site III). The Prevalence was more in *S. niger* (27.77 %) & least in *S. plagiostomus* (20 %) whereas MI & MA were more in *S. plagiostomus* (8.25, 1.65 respectively). But MI was least in *S. niger* (4.6) and MA was least in *S. esocinus* (1.25).

Table 9 showing infection indices of fish endoparasites the Prevalence was highest in *S. esocinus* (17.85 %) and least in *S. plagiostomus* (15 %) while MI and MA shows different trend (MI highest in *S. curvifrons* (4.75) and same in *S. niger*, *S. esocinus* (3) and MA more in *S. plagiostomus* (0.65) and least in *S. niger* (0.5).

Overall infection indices of endoparasites at different sites in River Jhelum (Table 10)

The overall Prevalence, MI and MA shows the following trend:

Prevalence:	Qamarwari (23.30 %) > Aramwari (15.29 %) > Tengpora (14.56 %) > Marwal (14.44 %)
Mean intensity (MI):	Aramwari (6.92) > Qamarwari (6.29) > Marwal (6.0) > Tengpora (3.73)
Mean abundance (MA):	Qamarwari (1.46) > Aramwari (1.05) > Marwal (0.86) > Tengpora (0.54)

Monthly variation of helminth parasites at four sites

Monthly variation was recorded at four sites in terms of Prevalence, Mean intensity (MI) and Mean abundance (MA). In the present study monthly variation was recorded site wise

Table 15 Overall diversity profile of endoparasites at different sites in River Jhelum

Parasite group	Marwal	Aramwari	Qamarwari	Tengpora	Overall average
Cestoda	2	1	2	2	1.75
Acanthocephala	1	1	1	2	1.25
Nematoda	0	0	0	0	0
Total no. of Species	3	2	3	4

Bar-graph shows the over diversity profile of endoparasites at four sites (Marwal, Aramwari, Qamarwari, Tengpora)

as well as month wise with high prevalence of endoparasites in summer months and relatively low in autumn.

Table 11 shows the monthly variation of helminth parasites at Marwal (site I) using infection indices (Prevalence, MI, MA). The prevalence was more in July (20 %) and least in November (10 %). Similarly MI and MA (2.5 and 0.5 respectively) was also high in respective months.

Table 12 shows the monthly variation of helminth parasites at Aramwari (site II) using infection indices (Prevalence, MI, MA). Here the Prevalence was more in June (20 %) and least in November (8.2 %), whereas MI and MA was more in July (4.5 and 0.43) and least in October (1 and 0.2).

Table 13 shows the monthly variation of helminth parasites at Qamarwari (site III) using infection indices (Prevalence, MI, MA). The Prevalence was high in July (28.6 %) and least in November (10 %). Likewise, MI and MA were also high in July (3.5 and 1) but least in June (1.5) and October (0.4) respectively.

Table 14 shows the monthly variation of helminth parasites at Tengpora using infection indices (Prevalence, MI and MA). The month of June and July shows same values of Prevalence (20 %), while November shows least Prevalence (9.8 %). The MI and MA values were highest in October (3.7 and 1.5) and least in June (2 and 0.4).

Overall diversity profile of endoparasites at four sites including Marvel (site I), Aramwari (site II), Qamarwari (site III) and Tengpora (site IV) in River Jhelum

Table 15 shows the overall diversity profile of endoparasites at different sites in River Jhelum. The diversity was more at Tengpora (4) and least at Aramwari (2).

Relative diversity of helminth parasites may be affected directly or indirectly by biotic and abiotic factors such as intermediate host availability and life cycle of parasite. In the present study the high diversity of endoparasites was high at Tengpora which may be correlated with the presence of intermediate host, immunological capability and feeding behavior of the fish. Our results are consistent with the results of Beer and German who described how environmental conditions increased the abundance of intermediate hosts.

Condition coefficient was found to be significantly lower in infected fish than in uninfected fish. It may be due to the fact that parasites may decrease the immune system of the hosts, which may lead to decreased growth of the fish. Decreased growth may lead to decrease in health condition of a fish (Khan and Thulin 1991 and Poulin 1992). However, our results are consistent with the findings of (Ondrackova et al. 2009) who concluded that no association between Fulton's condition factor and parasite infection was found.

References

- Bush AO, Lafferty KD, Lotz JM, Shostak AW (1997) Parasitology meets ecology on its own terms Margolis et al. revisited. *J Parasitol* 83:575–583
- Dove ADM, Fletcher AS (2000) The distribution of the introduced tapeworm *Bothriocephalus acheilognathi* in Australian freshwater fishes. *J Helminthol* 74:121–127
- Hoffman GL (1976) The Asian tapeworm, *Bothriocephalus gowkongensis*, in the United States and research needs in fish parasitology. *Proc. 1976 Fish Farming Conference and Annual Convention of the Catfish Farmers of Texas*. 2: 84–91

- Khan RA, Thulin J (1991) Influence of pollution on parasites of aquatic animals. *Adv Parasitol* 30:201–238
- Korting W (1975) Larval development of *Bothriocephalus* sp. (Cestoda: Pseudophyllidea) from carp (*Cyprinus carpio* L.) in Germany. *J Fish Biol* 7:727–733
- Liao H, Shih L (1956) Contribution to the biology and control of *Bothriocephalus gowkongensis* Yeh, a tapeworm parasitic in the young grass carp (*Ctenopharyngodon idellus* C. & V.). *Acta Hydrobiol Sin* 2:129–185
- Mitchell AJ, Hoffman GL (1980) Important tapeworms of North American freshwater fishes. United States fish and wildl service. Fish Dis Leaflet 59:1–18
- Ondrackova M, Davidova M, Blazek R, Gelnar M, Jurajda P (2009) The interaction between an introduced fish host and local parasite fauna: *Neogobius kessleri* in the middle Danube River. Paris, p 154
- Paperna I (1996) Parasites, infections and diseases of fishes in Africa—an update. Food and Agriculture Organisation of the United Nations, Rome. CIFA Technical Paper, No. 31. pp 220
- Poulin R (1992) Toxic pollution and parasitism in freshwater fish. *Parasitol Today* 31(19):919–993