

Helminth Community of *Catla catla* (Hamilton, 1822) in River Indus at Jamshoro, Sindh, Pakistan: Taxonomy, Prevalence, and Zoonotic Significance of Parasitic Helminths

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ABSTRACT

Background: Helminthic parasites present a significant risk to fish health, commercial fisheries and food security in South Asia. Although *Catla catla* (Hamilton, 1822), one of the most commercially important freshwater carps in the region, was economically important, the helminth fauna of the Indus River in Sindh province had been virtually unrecorded before this work. **Methods:** A total of 26 *Catla catla* samples were taken in the River Indus at Jamshoro, Sindh, Pakistan, between January 2018 and January 2020. Typical parasitological methods such as dissection, teasing, staining (borax carmine), and microscopic analysis were used. Morphotaxonomic identification was done by the use of known taxonomic keys. **Findings:** Nine out of 26 hosts (34.6) had helminth parasites. It was possible to identify six helminth taxa: three trematodes: *Thaparotrema pedicellatum* Verma, 1927; *Isoparorchis trisimilitubis* Southwell, 1913; *Echinochasmus* Dietz, 1909; two nematodes: *Procamallanus* (*Spirocamallanus*) sp. and *R*. All taxa are new host or locality records. The prevalence of trematodes was 23.07, nematodes 7.69 and acanthocephalans 3.84. **Conclusions:** This paper is the first detailed morphotaxonomic description of the helminth community of the *Catla catla* in the Indus River at Jamshoro and presents six new records of hosts and locality in Pakistani parasitology. The zoonotic potential of *Echinochasmus* and the ill-known acanthocephalan *Dispirin* highlights the importance of scaled-up parasitological surveillance in Pakistani freshwater fisheries.

Keywords: Catla catla; Helminthology; Trematoda; Nematoda; Acanthocephala; Indus River; Parasitology; Pakistan; Zoonosis; Fish parasites

1. Introduction

Fish forms one of the most important sources of dietary protein in the world and especially in developing countries like Pakistan where it is both a food and economic purpose. Indus river system is among the longest and ecologically important rivers of south Asia sustaining a rich diversity of freshwater fish that are the foundation of the lives of millions of fishermen and their families (Laghari, 2021; Sheikh et al., 2017). One of these species, Catla catla (Hamilton, 1822) also known as the major carp or catla, holds a special position due to its huge body size, high rate of growth, palatability, and high level of aquaculture exploitation in India, Bangladesh, Nepal, Myanmar, and Pakistan.

Although Catla catla has a commercial and nutritional significance, the health of wild fish in Pakistan is becoming more and more impaired by helminthic parasitic infections. The most common, and economically most destructive, endoparasites in freshwater fisheries throughout the world are known as helminths a taxonomically diverse group of parasitic worms that includes trematodes (flukes), cestodes (tapeworms), nematodes (roundworms), and acanthocephalans (spiny-headed worms) (Poulin, 20). They cause direct damage by damaging tissues, causing inhibited growth and development, reproductive dysfunction, and death, and can also act as vectors of zoonotic diseases that humans can contract by eating poorly cooked fish (Laghari, 2021).

Inland waters in Pakistan have been included in haphazard helminthological studies of genera including Channa, Labeo, Rita, Mystus and Wallago, but systematic parasitological description of Catla catla - especially in the Sindh province - has been a large gap in the literature. Until the current research, there was only one report of Neoechinorhynchus in Catla catla in Haleji Lake, Sindh (Laghari, 2021). There was no detailed morphotaxonomic description of the helminth community of this species in the River Indus.

The current paper summarizes the results of the M.Phil. thesis study by Laghari

(2021) at the University of Sindh, Jamshoro to present a comprehensive morphotaxonomic, ecological, and zoonotic study of the helminth community of *Catla catla* in the River Indus at Jamshoro. The six taxa of helminths are outlined and explained with reference to their taxonomy, location of infection, host specificity, prevalence and general public health concerns. The findings address a urgent gap in the Pakistani parasitology and serve as a much-needed foundation of future epidemiological and molecular studies.

1.1 Objectives of the Study

The present study was designed with the following specific objectives:

1. To examine freshwater fish *Catla catla* collected from the River Indus at Jamshoro for helminth parasites.
2. To conduct morphotaxonomic studies of recovered helminths and establish their taxonomic identities.
3. To calculate prevalence indices for each helminth group and document site-specificity of infection.
4. To assess the zoonotic significance of identified parasites and their implications for fisheries management in Pakistan.

2. The Host Fish: Biology and Significance of *Catla catla*

Catla catla (Hamilton, 1822) belongs to the family Cyprinidae, subfamily Cyprininae. It is classified under: *Kingdom: Animalia* | *Phylum: Chordata* | *Class: Actinopterygii* | *Order: Cypriniformes* | *Family: Cyprinidae* | *Genus: Catla* | *Species: C. catla*

Catla catla is a large, deep bodied fish with morphological features of broad, large head, strongly upturned mouth, greyish scales over the dorso-lateral body surface and a whitish ventral abdomen. It is a rapidly expanding freshwater fish in South Asia, which can grow up to 182 cm long and 38.6 kg in body mass under optimum conditions (Laghari, 2021; FAO, 2021). It has stratified feeding patterns by age with juvenile forms being phytoplankton and zooplankton feeders and adults feeding mainly on zooplankton. This feeding pattern of surface and midwater enhances their exposure to intermediate hosts of different helminth parasites.

One of the basics of aquaculture in South Asia is *catla catla*. It adds billions of rupees yearly to the fisheries sector of the Pakistan economy, and supplies vital animal

protein to millions of low-income families. Catla catla fish proteins are nutritionally better than most other sources of animal protein in terms of amino acid profile, digestibility and quality of fats (Laghari, 2021). The species is grown in polyculture in the Punjab and Sindh provinces of Pakistan and also found in natural water bodies, such as the Indus River.

Catla catla have parasitic infections which pose a direct threat to these economic outputs. Helminthiasis slows down the growth of fish, affects its reproductive ability, destroys organ systems and in extreme cases leads to death, which is then translated into economic losses in the fishery sector (Laghari, 2021; Vijaysundardeva et al., 2018). In addition, a number of helminth genera reported in this research have been reported to have a zoonotic potential, which creates a high concern on food safety.

The longest river in Pakistan and one of the most productive freshwater ecosystems of Asia is the River Indus which has a total drainage area of 1,165,000 km². It has its origin in the Tibetan Plateau close to the lake Mansarwar, and passes through Ladakh, GilgitBaltistan, Punjab, Khyber Pakhtunkhwa, and Sindh and empties in the Arabian Sea at Thatta (Laghari, 2021). The river is strengthened by a number of great tributaries, the Chenab, Jhelum, Ravi, Sutlej, Beas (vice Panjnad), Gomol, Kabul, Gilgit and Kurram which sustain a significant discharge during the year.

The Jamshoro reach of the Indus, located below the Kotri Barrage, is described as containing moderately warm, turbid, freshwater with rich benthic and pelagic invertebrate communities which are intermediate and paratenic hosts to helminth parasites. The Catla catla population at this locality has a steady population that is readily available through net-trapping techniques and is in good body condition thus making the locality ecologically representative to conduct a parasitological survey (Laghari, 2021).

3. Materials and Methods

The samples of Catla catla (n=26) were collected in the River Indus (Jamshoro, Sindh, Pakistan) using a systematic net-trapping technique during two years (January 2018 to January 2020). Live fish was shipped to the Department of Zoology,

Parasitology Laboratory, University of Sindh, Jamshoro, in ice-cooled boxes to preserve tissue integrity. The identification of the host was done with routine morphological keys including confirmation of the typical broad head, upturned mouth, greyish dorso-lateral scales, and whitish ventral coloration.

The host fish was cut in longitudinal ventral incision on a standard dissecting tray starting at the anus, up to the mouth. All visceral organs liver and gall bladder, swim bladder, body cavity, stomach, intestine and esophagus were moved separately to labeled Petri dishes with isotonic normal saline. The fine-pointed scissors and needles were used to carefully tear open the soft organs and examined through zero-size brushes under a dissecting microscope (Amscope trinocular dissecting microscope) to observe the contents of the organs in the case of helminth parasites (Laghari, 2021; Garcia and Ash, 1979; Schmidt, 1988).

The parasites recovered were initially immersed into distilled water (to relax alive) followed by fixation in warm 70% ethanol to straighten the bodies and to expel eggs. Trematodes and acanthocephalans were put through a series of ethanol (20, 30, 40, 50, 70) to dehydrate gradually, put between glass slides and stained with borax carmine (10-15 minutes). Any excess stain was washed off in 70% alcohol, and the specimen was dried progressively in absolute alcohol (80, 90, 100 percent), cleared in clove oil, washed in xylene and finally permanently mounted in Canada balsam. Slides were allowed to dry at 55°C overnight. Nematodes and acanthocephalans did not need to be stained, as they were maintained in 70% ethanol in labeled glass vials (Laghari, 2021; Schmidt, 1988).

A drawing tube was appended to an Olympus CH20 microscope to give drawings. The photomicrographs were taken using the OMAX Digital Trinocular LED Microscope (10MP camera) and Nikon P700 digital microscope. Calibrated ocular micrometers were used to determine all the morphological measures in micrometers (μm) unless otherwise indicated. This was achieved through cross-reference of morphometric data with published taxonomic keys and monographs such as Yamaguti (1961, 1963, 1971), Soulsby (1968), Garcia and Ash (1979) and Schmidt (1988). Prevalence (%) was determined as follows: (Number of hosts infected/ Number of hosts checked) $\times$ 100.

4. Results

4.1 Overall Infection Parameters

Among the 26 samples of catla catla investigated, 9 (34.6) were found to be harboring at least one helminth taxon. A total of 63 recovered helminths represented six taxa: three trematodes, two nematodes and one acanthocephalan. The taxa are new host or locality records of Pakistan. The most common group was trematodes (23.07%), followed by nematodes (7.69%), and acanthocephalans (3.84%). Tables 1 and 2 summarize the data.

Table 1: *Prevalence of Helminth Groups Recorded from Catla catla, River Indus, Jamshoro, Pakistan (n = 26)*

Helminth Group	Hosts Examined	Hosts Infected	Specimens Recovered	Prevalence (%)
Trematoda	26	6	28	23.07%
Nematoda	26	2	28	7.69%
Acanthocephala	26	1	7	3.84%
Total	26	9	63	34.61%

Source: Laghari (2021), University of Sindh, M.Phil. Thesis

Table 2: *Helminth Taxa Recorded from Catla catla with Site of Infection and Taxonomic Status*

Class	Species / Genus	Site of Infection	Specimens Recovered	Status
Trematoda	<i>Thaparotrema</i>	Gall bladder	7 9 12	New record
	<i>pedicellatum</i> Verma, 1927	Body cavity / swim		
	<i>Isoparorchis</i>	bladder		
	<i>trisimilitubis</i>	Intestine		
	<i>Southwell</i> , 1913			
	<i>Echinochasmus</i> sp.			
	<i>Dietz</i> , 1909			
Nematoda	<i>Procamallanus</i>	Stomach	7 21	First record
		Intestine		

(*Spirocamallanus*) *sp.*

Rhabdochona *sp.*

Railliet, 1916

Acanthocephala *Dispirin sp.* Stomach 7 New record
(Pakistan)

Source: Laghari (2021)

4.2 Trematoda (Flukes)

4.2.1 *Thaparotrema pedicellatum* Verma, 1927

Family: Opisthorchiidae Braun, 1901 | Site of infection: Gall bladder | Hosts infected/examined: 2/26 | Specimens recovered: 7

This species was characterized by a tubular body, tapering at the rear, tegumental spines on the anterior part (lost post-testicularly), long oral sucker, long ventral sucker, short prepharynx, oval pharynx, and bifurcated esophagus. Testes were round and big; ovary was round and was situated in front of the anterior testis. The small vitelline follicles were found between the ovary and ventral sucker, laterally. Intercecally a large oval round seminal vesicle was seen.

The general body plan of *T. pedicellatum* in *Hemibargus nemurus* (Thailand) was congruent with morphometric comparison to the previously described specimen, with significant differences in the shape of the pharynx (oval in present specimens), the location of the excretory bladder in relation to the testes, and the tightness of uterine coils (Laghari, 2021; These characteristics attest to *T. pedicellatum*. It is a genus first reported in *Catla catla* in Pakistan.

Table 3: *Morphometric Measurements of Thaparotrema pedicellatum Verma, 1927*

Organ / Body Part	Measurement (µm)
Entire Body	4347–4530 × 759–810
Oral Sucker	230–280 × 184–200
Ventral Sucker	115–135 × 138–150
Prepharynx	460–500
Pharynx	550–600
Esophagus	161–182

Cirrus Sac	184–195 × 920–950
Anterior Testis	368–390 × 253–260
Posterior Testis	322–328 × 391–396
Ovary	230–260 × 184–187
Seminal Vesicle	115–120 × 920–970
Seminal Receptacle	920–980 × 161–165

Source: Laghari (2021) — measurements in μm

4.2.2 *Isoparorchis trisimilitubis* Southwell, 1913

Family: Isoparorchidae Travassos, 1922 | Site of infection: Body cavity and swim bladder | Hosts infected/examined: 2/26 | Specimens recovered: 9

Isoparorchis is a monotypic genus described by Southwell (1913), most of the species occurring in the air bladder of siluriform fishes in Asia and Australia (Bashirullah, 1972). The specimens obtained in this work were small, anteriorly tapering and flattened, the oral sucker being subterminal and globular, the pharynx being round, and the esophagus being broad and short. There was evidence of two pair of round posterolateral testes (left larger than the right) and a long curved cirrus sac, posteromedian tubular ovary and dendritically branched tubular vitellaria. The uterus ran out of the ventral sucker to the posterior edge of the ovary.

The obtained specimens were compared with *I. trisimilitubis* by body sizes, sucker morphology, the shape of the testicles, the location of the ovaries, and the distribution of the vitellaria (Laghari, 2021; Bashirullah, 1972). It is a new host (*Catla catla*) and locality (River Indus, Sindh) record in Pakistan.

4.2.3 *Echinochasmus* sp. Dietz, 1909

Family: Echinostomatidae Dietz, 1909 | Site of infection: Intestine | Hosts infected/examined: 3/26 | Specimens recovered: 12

Echinochasmus genus are typical of a type of trematodes that infect not only the birds and the mammals that feed on fish, but also do it globally. It is characterized by a strange collar on the crown, of spines - in our specimens 24 spines, in one row. Other distinctive characteristics included big oral sucker, short prepharynx, well-developed pharynx, a ventral sucker in the second quarter of the body (three times larger than oral sucker) and submedian oval ovary and laterally positioned vitellaria.

Eggs were golden-colored and measured $56-70 \times 32-44 \mu\text{m}$ (Laghari, 2021; Verma, 1935).

It is known on the genus level; a molecular analysis will be applied in order to distinguish a species level (Laghari, 2021). It was also discovered that the *Echinochasmus* species were also known to induce echinocasmiasis in humans owing to consumption of the metacercariae in uncooked fish (Laghari, 2021). This was the first record of this genus of the catla catla of the Indus River.

Table 4: *Morphometric Measurements of Echinochasmus sp. Dietz, 1909*

Organ / Body Part	Measurement (mm)
Body Length $\times$ Width	$0.78-1.61 \times 0.21-0.416$
Head Collar	$0.068-0.102 \times 0.90-0.166$
Oral Sucker	$0.032-0.083 \times 0.039-0.083$
Prepharynx Length	$0.030-0.083$
Pharynx	$0.045-0.098 \times 0.03-0.071$
Ventral Sucker	$0.106-0.227 \times 0.090-0.189$
Anterior Testis	$0.079-0.227 \times 0.090-0.212$
Posterior Testis	$0.109-0.090 \times 0.204$
Ovary	$0.030-0.090 \times 0.026-0.106$
Egg Size (μm)	$56-70 \times 32-44$

Source: Laghari (2021)

4.3 Nematoda (Roundworms)

4.3.1 Procamallanus (Spirocamallanus) sp.

Family: Camallanidae Railliet and Henry, 1915 | Site of infection: Stomach | Hosts infected/examined: 1/26 | Specimens recovered: 7

This nematode has a deep-brown, medium-sized, striated body, the widest at the esophageal level. The buccal capsule was long and square in outline with 1314 bands in a spiral in the male and 1214 bands in a female - the characteristic feature of the subgenus *Spirocamallanus* (Olsen, 1952). Other characteristics were two thickened lateral ridges, four median oral papillae, two amphids, cervical basal ring, bearing two knob-like structures, and bipartite esophagus (muscular and glandular parts). There were two unequal spicules and caudal alae in males and a postequatorial vulva

and muscular uterus containing oval ova in females (Laghari, 2021; Moravec and Van As, 2015).

It was not possible to identify the specimen to the species level because of uncharacterized diagnostic features; molecular analyses are advised (Laghari, 2021). It is the first record of this subgenus of *catla catla*.

4.3.2 *Rhabdochona sp. Railliet, 1916*

Family: Rhabdochonidae Skrjabin, 1946 | Site of infection: Intestine | Hosts infected/examined: 2/26 | Specimens recovered: 21

Rhabdochona is a giant, cosmopolitan genus of nematodes, which comprises about 100 species, and is a pathogen of freshwater fishes in all zoogeographical areas (Moravec, 2010). The recovered specimens had diagnostic features that included a strong body with a mouth orifice containing pseudolabia, a funnel-shaped prostom with longitudinal teeth, a long slender mesostom, bifurcated simple derids, no lateral alae, a large number of preanal papillae, 5-7 pairs of postanal papillae, a conical tail with a rounded end, and a mid-body. The embryos of the eggs were embryonated with shells (Laghari, 2021).

Identification to the species level was not done until molecular corroboration, as suggested by Moravec (2010). The number of 21 specimens obtained out of the two hosts implies that there was a high level of infection among the infected individuals. This is the earliest record of *Rhabdochona* of *Catla catla*.

4.4 *Acanthocephala* (Spiny-Headed Worms)

4.4.1 *Dispirin sp.*

Family: Dispirin | Site of infection: Stomach | Hosts infected/examined: 1/26 | Specimens recovered: 7

The acanthocephalan found in the study had a small muscular body with transverse striations. The proboscis was invaginated and had 12 longitudinal rows of hooks that had 2-3 hooks each row. The receptacle of the proboscis was bigger than the proboscis. The second body quarter had two tandem, overlapping testes observed, above the cement gland, which was above the saferen pouch. There was an invaginated bursa (Laghari, 2021).

There was only one male specimen that was retrieved. The acanthocephalan

taxonomy generally needs both sexes to be certain, and thus, the specimen is temporarily assigned a generic rank and name as *Dispirin* sp. (Laghari, 2021; Yamaguti, 1963). It is the first record of this genus in *Catla catla* and in Pakistan, which is a new host and locality record of significant scientific interest.

5. Discussion

The total number of 34.6% of helminthic prevalence in this study is comparable to other related surveys of *catla catla* and other cyprinids in South Asia. A study of *catla catla* in West Bengal, India, by Dash et al. (2015) also documented mixed infections of trematodes, nematodes, and acanthocephalans in a large percentage of hosts studied. A helminth assemblage reported by Gudivada and Vankara (2017) in the major carps of Andhra Pradesh showed various helminth. The present paper generalizes them to the Indus River drainage basin in Pakistan, an area that was virtually uncharted in this respect.

The prevalence of trematodes (23.07) in the helminth community of *Catla catla* can be ecologically explained. Trematodes are usually complex multi-host life cycle parasites with aquatic snails as first intermediate hosts, other invertebrates or fish as second intermediate hosts, and vertebrates as definitive hosts. The support of large molluscan communities is linked with the Jamshoro reach of the Indus River and, therefore, offers the required intermediate hosts to accomplish the life cycles of trematodes (Laghari, 2021). The surface and mid-water *catla catla* grazing behavior also helps in the ingestion of cercariae parasites released by snail intermediate hosts. The reduced infection with nematodes (7.69%), and the isolated acanthocephalan infection (3.84) is probably due to the disparity in intermediate host and life cycle features. The genera *Rhabdochona* and *Procamallanus* (*Spirocamallanus*) are usually parasites of aquatic insects (mayflies, caddisflies), and the acanthocephalans of crustaceans. The diversity and relative abundance of these invertebrate groups within the Jamshoro part of the Indus would directly affect the dynamics of presence of parasites.

It is interesting to note that *Rhabdochona* sp. produced the largest number of specimen (n=21) with the least number of hosts (n=2) indicating that when the infection is established, it can be very intense. This is consistent with the existing

literature, which has reported cases of Rhabdochona infection in cyprinid fishes with dozens to hundreds of worms per fish (Moravec, 2010; Rafique, 2002).

Each of the six reported helminth taxa in the study are new host or locality records, which are a significant addition to the helminthological biodiversity of Pakistan. *Thaparotrema* (family *Opisthorchiidae*) was previously reported in Pakistan in *Rita rita* by Soofi et al. (2015, 2016), but its occurrence in *Catla catla* of the Indus at Jamshoro is completely novel. The morphological resemblance to *T. pedicellatum* Verma, 1927 - which comprises the typical pre-equatorial ventral sucker, oval pharynx and compact vitelline follicles - is convincing but molecular confirmation would be additional to the identification.

Specifically, there is acanthocephalan *Dispirin* sp. which is of special taxonomic interest. This genus is not well known in the rest of the world, and little host-range information is recorded. Its recovery in *Catla catla* in Pakistan opens new perspectives of the systematics of this group and indicates the necessity of specific acanthocephalological surveys of the Pakistani freshwater ecosystems. The limitation of only one male specimen recovered highlights the value of the continuation of collecting in the next series of surveys.

Echinostomatidae (*Echinochasmus*), a species found in the intestine of *Catla catla*, has a special scientific and public health interest. The genus is known to transmit echinostomiasis to people through consumption of raw or undercooked fish, as a result of which people have intestinal inflammation, diarrhea, and in severe cases, malabsorption and wasting (Laghari, 2021; Verma, 1935). The identification of this parasite in a popular food fish in Sindh indicates an unappreciated zoonotic risk route in the area.

The available helminthological literature on the freshwater fishes in Pakistan is still developing. Previously, Bilqees and colleagues had described trematodes, cestodes and acanthocephalans in Sindh waters; Khan et al. had described nematodes in a variety of species and Soofi, Birmani, and others in Jamshoro. The given work is the continuation of these studies as it pays special attention to *Catla catla* - one of the species that has not been mentioned extensively in the Pakistani parasitological literature, although it dominates the market.

Neoechinorhynchus in catla was first recorded in Haleji Lake, Sindh (Bilqees et al., 2021) - the only previous record in this host in Pakistan. The six new records reported herein significantly augment this body of knowledge in terms of three helminth phyla and a variety of organ systems (gall bladder, swim bladder, body cavity, stomach, intestine), and this is the first multi-organ multi-group helminthological profile of *Catla catla* in Pakistan.

The cascading effects of helminthic infections in *Catla catla* include effects on fisheries productivity, ecosystem functionality, and human health. On the population scale, high-intensity infections could reduce growth rates and fecundity, and quantifiable effects on the stock recruitment and commercial yield. Pollution in polyculture pond systems, which are prevalent in the Sindh and Punjab provinces of Pakistan can be reinforced by the introduction of wild-caught *Catla catla* with helminth parasites that can infect other species, further increasing losses.

As a public health issue, the discovery of *Echinochasmus* in a commercially marketed food fish in Sindh is an issue that should attract the attention of the fisheries and health departments of Pakistan. Consumer habits - especially the eating of semi-cooked or dried fish - provide conceivable pathways of metacercarial infection. It is highly recommended to use educational interventions, focused on fishing communities and fish traders about the significance of thorough cooking, and periodical parasitological monitoring of marketed fish (Laghari, 2021).

Future research must consider histopathological evaluation of the parasitized organs to estimate tissue damage and relate intensity of infection with host condition indices (hepatosomatic index, gonadosomatic index). The other high-priority research area is seasonal change in helminth prevalence along the Indus River, which is associated with changes in temperature, rainfall, and the density of invertebrate hosts.

6. Comparative Analysis: Host Range and Geographic Distribution

Table 5 presents a comparative overview of the helminth taxa identified in this study in relation to their previously documented host range and geographic distribution, contextualized against the present findings.

Table 5: Comparative Host Range and Geographic Distribution of Helminth Taxa Recovered from *Catla catla*, Jamshoro

Parasite	Reported Host(s)	Region	Reference
<i>Thaparotrema</i>	Hemibargus	Thailand, India	Laghari, 2021;
<i>pedicellatum</i>	nemurus, Rita rita		Soofi et al., 2016
<i>Isoparorchis</i>	Siluriform fishes	Asia, Australia	Bashirullah, 1972;
<i>trisimilitubis</i>	(catfishes)		Laghari, 2021
<i>Echinochasmus sp.</i>	Fish-eating birds,	Worldwide	Laghari, 2021;
	mammals, fishes		Verma, 1935
<i>Procamallanus</i>	Freshwater fish	Cosmopolitan	Laghari, 2021;
<i>(Spirocamallanus) sp.</i>	(various)		Moravec, 2015
<i>Rhabdochona sp.</i>	Freshwater fish	Cosmopolitan	Laghari, 2021;
	(various)		Rafique, 2002
<i>Dispirin sp.</i>	Catla catla (new host)	Pakistan (new locality)	Laghari, 2021

Source: Compiled from Laghari (2021) and cited references

Table 5 highlights the novelty of all the six helminth records in the current study. Although a few genera (*Thaparotrema*, *Isoparorchis*, *Echinochasmus*, *Rhabdochona*, *Procamallanus*) are cosmopolitan or well-known in other areas, none has been recorded anywhere in the Indus River system in the Sindh province before. Most taxonomically unusual finding is the acanthocephalan *Dispirin* as the genus is not well documented across the world.

7. Zoonotic Significance and Public Health Implications

Zoonotic potential of fish-borne helminth parasites represents an increasing global public health issue, especially in areas where fish is widely eaten, and food safety regulatory infrastructure is underdeveloped. Inland fisheries in Pakistan, such as the Indus River, provides fish to millions of consumers, many with limited access to food safety education or refrigeration. Identified helminth taxa in this study are different in terms of their zoonotic risk profiles, as they are discussed below.

The more zoonotic genera of helminths determined in the present study include *Echinochasmus* species (*Echinostomatidae*). Human beings become infected by

consuming uncooked metacercariae in uncooked fish meat. The clinical presentation of echinocasmiasis is characterized by abdominal pain, diarrhea, nausea, and malnutrition and wasting in severe or chronic infections (Laghari, 2021; Verma, 1935). Some *Echinochasmus* species have been reported in human infections in Southeast and East Asia and their presence in freshwater carps is regarded as a food safety threat (Laghari, 2021). The identification of a new zoonotic threat *Echinochasmus* of *Catla catla* - one of the most popular fish in the Sindh - which deserves immediate concern by the public health authorities.

Isoparorchis trisimilitubis is the major parasite of freshwater catfishes, and is not regarded as a pathogen of any importance to humans. But its recovery off the swim bladder of *Catla catla* - a surface-feeding carp - indicates a wider host plasticity than has been previously reported. *Opisthorchiidae* *Thaparotrema pedicellatum* is a member of a family that contains genera (e.g., *Opisthorchis*, *Clonorchis*) of extreme zoonotic significance. Although *T. pedicellatum* itself has not been directly associated with human disease, the mere fact that it belongs to this family needs to be monitored, particularly due to the low level of helminthological surveillance in Pakistan (Laghari, 2021; Soofi et al., 2015, 2016).

The genera *Rhabdochona* and *Procamallanus* (*Spirocamallanus*) of nematodes are predominant fish parasites that have no clearly documented direct zoonotic contribution. However, the presence of heavy infections in *Catla catla* is an indirect public health issue as it decreases the quality, palatability, and market value of fish, which has downstream impacts on food security and nutrition (Laghari, 2021; Moravec and Van As, 2015).

The group *Acanthocephalans* are infrequent zoonotic pathogens; certain species of the genus *Macracanthorhynchus* and others in the genus have been reported in human intestinal infections in Asia (Laghari, 2021; Yamaguti, 1963). The genus *Dispirin* has been so poorly described in the world that no definite conclusions can be made on its zoonotic potential. Its presence in the stomach of *catla catla* in Sindh is however worth considering in further surveillance measures of food safety screening.

8. Conclusion

This paper is the first morphotaxonomic investigation on the helminth community of the river Indus-catla (Hamilton, 1822) of the river Indus at Jamshoro, Sindh, Pakistan. Six taxa of helminthiidae - *Thaparotrema pedicellatum* Verma, 1927; *Isoparorchis trisimilitubis* Southwell, 1913; *Echinochasmus* sp. Dietz, 1909; *Procamallanus* (*Spirocamallanus*) sp.; *Rhabdochona* sp. Railliet, 1916; and *Dispirin* sp. - were detected in three helminth phyla in various organ systems of the host. All of the six taxa are new host or locality records in Pakistan.

The high prevalence of 34.6% and predominance of trematodes in the helminth community indicate the ecological factors of the Jamshoro reach of the Indus River such as presence of appropriate intermediate hosts. The discovery of *Echinochasmus*, a genus which has reported zoonotic potential, in a commonly consumed food fish highlights the importance of integrated fisheries health management and population health monitoring in the area.

Future research directions must incorporate seasonal prevalence studies in a series of Indus barrages, histopathological evaluation of the organ damage caused by helminths, molecular characterization of all taxa in order to resolve species-level identifications, and the protozoan parasites of *Catla catla* - a completely uncharted area in Pakistani parasitology. Together, these undertakings will contribute to the development of the strong scientific basis that will safeguard the health of fish and the safety of human food in one of the most ecologically and economically important river systems in South Asia.

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