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# TREMATODES INFECTING DUCKS OF GENUS *AYTHYA* BOIE, 1822 (ANSERIFORMES: ANATIDAE) IN SINDH, PAKISTAN

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## ABSTRACT

The present study covers a part of the trematode diversity in a variety of ducks migratory birds mainly including pochards found in the water bodies of Sindh, Pakistan. In the present study, the birds were collected from different water bodies using the mist nest with the help of local bird catchers. Birds were dissected for their helminthes. The treaded parasites were processed for permanent mounting in Canada balsam and for further microscopic examination. In total, 70 birds belonging to three species of pochards of Genus *Aythya* (Anatidae: Anseriformes), *A. ferina*, *A. fuligula* and *A. nyroca* were collected from different water bodies during 2019-2020. The results showed five species of digenean trematodes including *Psilochasmus singhi* Jaiswal and Humayun, 1971, *Psilochasmus oxyurus* (Creplin, 1825), *Catatropis pakistanensis* Shafi *et al.,* 1982, *Echinochasmus amphibolus* Kotlan, 1922 and *Notocotylus attenutus* (Rudolphi, 1809). All species were identified on the basis of their generic and specific characters including, body shape and size, position of oral sucker, cirrus pouch, genital pore, cecca, number of uterine loops, shape position of testes and ovaries. This is the first parasitological study on trematodes infecting the genus *Aythya* from Sindh, Pakistan.

**Keywords:** new records, Pakistan, pochards, Sindh, trematoda

## INTRODUCTION

The water fowls of genus *Aythya* Boie, 1822 (Anatidae: Aythyini) are generally known as pochard or diving ducks, are gregarious birds that eat mainly aquatic vegetation, small invertebrates, and small fishes, which become a main source of trematode infection in them (Silveira and Amato, 2010; Stunkard and Uzmann, 2016; Roy and St-Louis, 2017; Akhmetov, 2020). There are about 12 species of pochards known in the world in which only five species migrate to southern part of the country during winter season; in which only four species of pochards are observed in Sindh province (IUCN, 2004; Mirza, 2007; Jobling, 2010; Dickinson and Remsen, 2013). Pochards have been studied for their parasitological and epidemiological aspects; the rate of infection of trematodes in pochards observed in high number, causes mortality of the host in some cases (Roy and St-Louis, 2017). The prevalence and intensity of trematode infection in anatid birds may be influenced by several factors; due to feeding on the intermediate host, their rate of infection, number of parasite eggs and larvae may vary. It was also observed that the age and gender can also play a role in harboring the helminthic infection. The trematodes mature into adults in the gut of waterfowl, sexually reproduce, and then the eggs are excreted into the water. The heavy infections may cause quick death in few days (Huffman and Roscoe, 1989; Mucha and Huffman, 1991).

In addition to direct transmission of disease, birds can also be of indirect economic importance to man by the disseminating disease to livestock herds and poultry flocks (Ernest *et al.,* 2007; Sandland *et al.*, 2014; Ashraf *et al.,* 2015). These are the edible birds, may cause a basic source of transmission of some poisonous metallic compounds of lead, chromium and arsenic etc. put an adverse impact on human health in local nearby population (Johansen *et al.,* 2004; Pain *et al.,* 2010; Dalton, 2014). Considering the environmental factors, destruction of habitats, human involvements that creating unhygienic conditions, global warming and unhealthy dietary components of game birds, they harbor a variety of parasites with their

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bodies, causing them some serious diseases (Dalton, 2014).

At present, there is a very little attention being given to the helminth fauna and epidemiological study in ducks generally and pochards particularly (Birmani *et al*., 2016; Buriro *et al.,* 2016; Thebo *et al*., 2019), hence the present study has been planned to record the helminths of pochards and their interaction in Sindh, Pakistan.

## MATERIALS AND METHODS

A total of 70 birds were captured in which 22 were dead and 48 were live, by using over-water mist nets (Smith *et al.,* 2015), during November 2019 to February 2020 from the local ponds and river (Table 1). The birds were captured using the mist nets, floated over the surface of water bodies in the evening after dusk, where birds were found entangled in the nets and were removed in the early morning with the help of local fishermen. Each bird was isolated in separate cage; they were identified with the help of avian keys (Robert, 1991; Clement, 2021).

Their pre-section examination like body weight, size and health condition was carried out in the field. For the collection of trematodes, autopsy of each bird was carried out according to the avian ethics and international standard practice, subjected to the law of the Animal Ethical committee, University of Sindh, Jamshoro. A detailed examination of each organ was undertaken using stereo microscope (Optika Lab 20). A variety of helminths were recovered from different organs, including cestodes, nematodes and trematodes. All parasites were preserved in 80% ethanol in the separate collection tubes, whereas the trematodes were mostly recovered from intestines of their hosts and were further processed for the permanent mount, in order to complete the purposed study. The trematodes were prepared for the permanent mounting in Canada balsam following the standard method by Garcia and Ash (1979).

The line diagrams of the specimens were made using Olympus UDA drawing tube attached with Olympus CH20 microscope; inked with black pointer on the white tracing papers; measurements were taken with the help of ocular micrometer in millimeter and micrometer in case of eggs. The trematodes specimens were identified using taxonomic keys by Yamagucchi (1971) and Gibson (2002). All the specimens of trematodes were labeled and stored in the Advanced Parasitology Research Laboratory-Museum of Parasitology (APRLMP), Department of Zoology, University of Sindh, Jamshoro.

The parasitological data was analyzed statistically using basic quantitative parameters manually including prevalence (%), mean intensity of the infection (mean±S.E), rate of infection and frequency (*f*) to enumerate the parasitic population among the anatid birds (Bush *et al.,* 1997; Musa *et al.,* 2012; Naz *et al.,* 2021).

## RESULTS AND DISCUSSION

Out of 70 birds, 44 were found infected by trematodes with 62.85% of prevalence. At present, five species of trematodes were recovered, including *Psilochasmus singhi* Jaiswal and Humayun, 1971, *Psilochasmus oxyurus* (Creplin, 1825), *Catatropis pakistanensis* Shafi *et al.,* 1982, *Echinochasmus amphibolous* Kotlan, 1922 and *Notocotylus attenutus* (Rudolphi, 1809). The host species-wise prevalence of birds was calculated 67% in *Aythyaferina*, 63% in *Aythya fuligula* and 55% in *Aythya nyroca*; with the highest mean intensity of *N. attenutus* (6±0.631) was found in *A. ferina*, which is absent in other two species of host; following the *E. amphibolous* (5.4±0.455). *P. oxyurus* was found in all host species during the present study with higher mean intensity (4.8±0.331) in *A. fuligula* whereas lower (1.8±0.28) in *A. nyroca*. The frequencies (*f*) were also calculated separately to check out the higher parasitic infection caused by the trematodes among the host birds (Table 2).

***Psilochasmus oxyurus* (Creplin, 1825)**
(Digenea: Psilostomidae: Psilostominae)

**Materials examined**
N=51, ex. *Aythya ferina* (n=05)*, Aythya fuligula* (n=05)*, Aythya nyroca* (n=06); intestine (ileum); 26-xii-2019; District Thatta, District Qambar Shahdad Kot, District Jamshoro; stored in APRLMP, Department of Zoology, University of Sindh, Jamshoro.

**Status New record for host**
Body muscular, elongated, with rounded anteriorly and tapering posteriorly Figure 1a, 1b, measuring 0.36 × 0.08, fore body measures 0.166 long Figure 1c, hind body measures 0.195 long Figure 1d; oral sucker muscular, sub-terminal, rounded, measures 0.073 × 0.075; pre-pharynx short wider than long, measuring 0.011× 0.015; esophagus long, diverticula into

intestinal cecae that run through lateral sides of the body and ends in between posterior testis and posterior extremity; ventral sucker measures 0.048 × 0.051; testes tandem, median, contiguous, rounded to oval, anterior and posterior testes measure 0.028 × 0.02 and 0.031 × 0.022 respectively; cirrus sac long, tubular, measuring 0.066 × 0.022; vitellaria situated at lateral sides of the body, commencing from posterior margins of ventral sucker reaching up to the post-testicular region, not confluent posteriorly; ovary median, pre-testicular, rounded, measures 0.015 × 0.02; distance between ovary and ventral sucker measures 0.017 and from ventral sucker to post-testicular space measures 0.044 (Table 3).

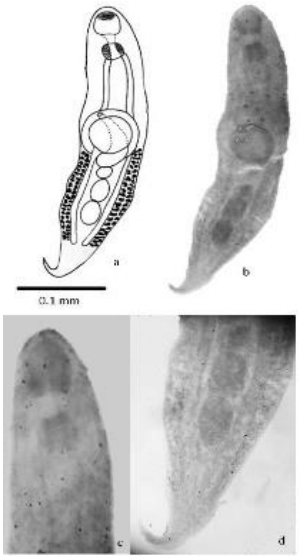


**Figure 1.** *Psilochasmus oxyurus,* a. Entire worm; b. Microphotograph (40×); c. Anterior portion enlarged (100×); d. Posterior portion enlarged (100×)

## Remarks

The genus *Psilochasmus* was described by Lühe (1909) from different species of waterfowls. The genus was first reported in Sindh region by Buriro *et al*. (2016) from the domestic ducks; however, it is the first time recovered from a pochard of genus *Aythya*in the region.

The present specimens resemble with *P. oxyurus* (Creplin, 1825) but it is varied in distribution of vitellaria, situated in lateral sides of the body, commencing from posterior margins of ventral sucker leading to the post testicular region, not confluent posteriorly and other minor characteristics. Based on these similarities, present specimens were identified as *P. oxyurus*.

## ***Psilochasmus singhi* Jaiswal and Humayun 1971**

(Digenea: Psilostomidae: Psilostominae)

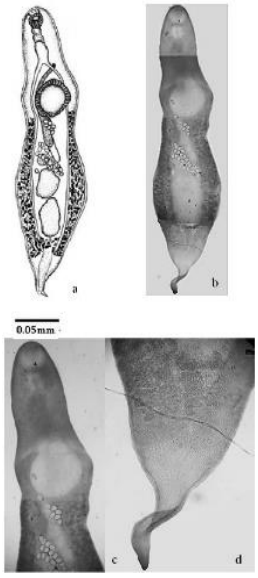


**Figure 2.** *Psilochasmussinghi,* a. Entire worm; b. Microphotograph (40×); c. Anterior portion (100×); d. Posterior portion enlarged (100×)

## Material Examined

N=32; ex. *Aythya fuligula* (n=06); intestine (ileum); 25-ii-2020; District Jamshoro; stored in APRLMP, Department of Zoology, University of Sindh, Pakistan.

## Status new host and new locality record

Body elongated, measured 4.534 long, spindle-shaped with a bluntly rounded anterior end and a sharply marked off retractile tail at posterior extremity, forming a caudal spine Figure 2a, 2b; the oral sucker sub-terminal and spherical, measuring 0.244 × 0.244, oral sucker surrounds the mouth which communicates with the pharynx by means of a very short pre-pharynx; pharynx muscular, fairly large and elongated, measuring 0.232 × 0.174 Figure 2c; acetabulum strongly muscular and rounded in shape, measuring 0.604 × 0.581, nearly double the size of the oral sucker; esophagus measures 0.395 × 0.197, it bifurcates into two intestinal cecae, that pass along the lateral sides of the body, measuring 2.84, touching the inner margins of the vitelline follicles, terminating posteriorly and slightly above the level of the vitelline glands; excretory bladder is Y-shaped, opens through the

excretory pore placed at the base of the caudal spine Figure 2d; anterior testis measures 0.476 × 0.348, posterior testis measures 0.604× 0.348; cirrus sac remarkably elongate measuring 1.534; ovary slightly rounded, measuring 0.209 × 0.162; metraterm strongly developed; vitellaria follicular in structure and extra-cecal in position; eggs thick, shelled, measuring 0.068-0.109 × 0.1-0.090 and very few in number.

**Remarks**

This species was first reported infecting the intestine of a whistling teal *Dendrocygna javanica* from the Hyderabad, India (Jaiswal and Humayun, 1971).

At present, the specimens of *P. singhi* were observed similar to the previously known specimens in morpho-taxonomical detail; however, some differences were found in the body size, shape of esophagus, position of genital pore, size and position of ovaries and vitellaria. These differences may be due to the host and niche variations. Despite of the differences, the present specimens were closely resembled with the previously known *P. singhi*, hence it was identified as the same species (Table 4).

***Echinochasmus amphibolous* Kotlan, 1922**

(Digenea: Echinostomatidae: Echinostomatinae)

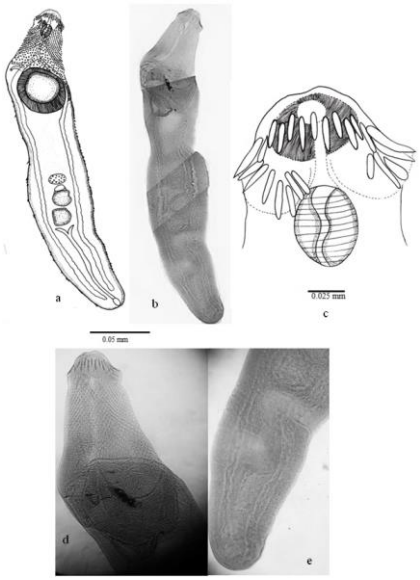

**Figure 3.** *Echinochasmus amphibolous,* a. Entire worm; b. Microphotograph (40×); c. Anterior portion enlarged (100×); d. Oral sucker with collar spines; e. Posterior portion enlarged (100×)

**Material examined**

N=27, ex. *Aythya ferina* (n=05); intestine (ileum); 26-xi-2019; district Larkana; stored in APRLMP, Department of Zoology, University of Sindh, Pakistan.

**Status new host and new locality record**

Body measures 3.26 long, anterior portion measures 0.573 in length Figure 3a, 3b; oral sucker terminal, measures 0.104 × 0.495, surrounded by 24 spikes, almost all spikes equal in size near the edges of the collar, interrupted ventrally Figure 3c; pre-pharynx narrow at the anterior and broader at the terminal, measuring 0.043; pharynx oval, measuring 0.121 × 0.104; esophagus greatly long, measuring 0.2, branching into two intimal caeca, extended along with the lateral sides of the body, reaching up to the posterior extremity Figure 3d; cirrus sac smaller in comparison to the body; cirrus pouch located at the center of the acetabulum (Figure 3e); genital pore located at the left intestinal branch; testes semi lobed, anterior testis tandem, measuring 0.182 × 0.165, posterior testis measures 0.173 × 0.173; ovary oval, measuring 0.104 × 0.130; vitellaria not clearly visible; uterine folds slightly visible in posterior region above the ovary; eggs also unclear.

**Remarks**

The present species is reported from *A. ferina,* as described above, is very much similar in the morphology and morphometry with the previously known species *E. amphibolus*. However, with the geographical and variations in the host, it is possible to have some differences in the general morphology. On the basis of the above characterization, it has been identified as the same species with the new host, reported from the study region for the first time.

The differences appear in the present species with that of previously described species are enumerated. Our specimens of *E. amphibolus* differ in size, and host interaction. Previously, *E. amphibolus* was recorded from *Phalacrocorax carbo, Ardea cinerea, Botaurus stellaris, Nycticorax*, from different part of the world (Brohi *et al.,* 2017). *E. amphibolus* was also reported from Pakistan by Bhutta and Khan (1975) from *Gallinula chloropus* from some of the northern parts; however, this is the first report of this species from pochards in the southern part of the country (Table 5).

***Notocotylus attenutus* (Rudolphi, 1809)**
(Digenea: Notocotylidae: Notocotylinae)

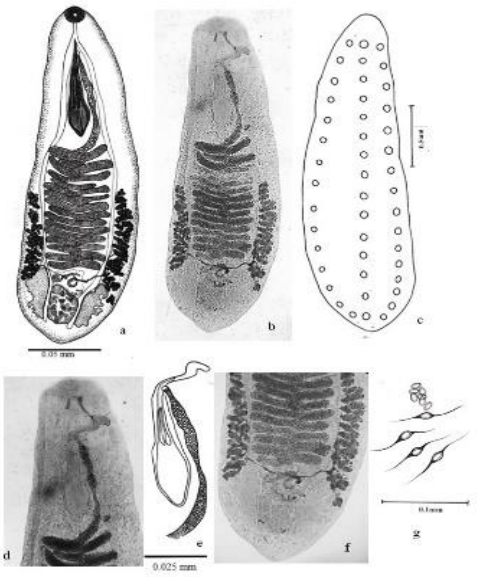

**Figure 4.** *Notocotylus attenutus,* a. Entire worm; b. Microphotograph (40×); c. Position of ventral glands; d. Anterior portion enlarged (100×); e. Cirrus sac in details; f. Posterior portion enlarged (100×)

**Material examined**
N=36, ex. *Aythya ferina* (n=06); intestine (ileum); 9-i-2020; district Thatta and district Jamshoro; stored in APRLMP, Department of Zoology, University of Sindh, Pakistan.

**Status New locality record**
Body elongated slightly curved anteriorly and rounded posteriorly Figure 4a, 4b, measuring 2.74 long; cuticle covered with numerous fine spines; ventral papillae or glands present in three rows, sixteen gland in each lateral rows and 15 glands in the median row Figure 4c, present throughout the body except antero-laterally; oral sucker terminal, rounded 0.142 × 0.584; ventral sucker absent; esophagus relatively shorter (0.116); caeca long 2.36, reaching up to posterior extremity; pharynx absent; genital pore slightly behind the bifurcation of intestine; cirrus pouch elongated (0.805) Figure 4d, 4e; prasprostica cylindrical; seminal vesicle convoluted; testes lobulate, situated at the posterior extremity in side by side, lateral to the caeca, right testes measures 0.396 × 0.155 and left testes measures 0.428 × 0.103; ovary slightly larger than testes, measures 0.285 × 0.207, inter-testicular in position; vitellaria extra caecal, extending slightly behind the mid body, reaching up to testes; uterus possesses ascending limbs, having 16-17 uterine loops, folded between the ovary and cirrus pouch, occupy all space between the caeca Figure 4f; eggs polar, filamentous, 0.012 × 0.025 to 0.012 × 0.019 in size Figure 4g; metraterm present.

**Remarks**
The present specimens of *N. attenutus* differs with previously known species in the shape and size of the body that differs in maximum width of posterior and anterior extremities, shape and location of ovary and the distribution papillae on ventral sucker and number of papillae are differing from present specimens. However, the morpho-taxonomical features share the similarities in the body shape and size, spinous cuticle, arrangement of the glands and numbers of papillae, esophagus, ceca, size and position of ovary and testes, numbers of uterine loops are also similar in position, position of genital pore is also similar with the previously known specimens of the species. Hence, on the major similarities, the present specimens were identified as *N. attenutus* (Table 6).

***Catatropis pakistanensis* Shafi *et al.,* 1982**
(Digenea: Notocotylidae: Notocotylinae)

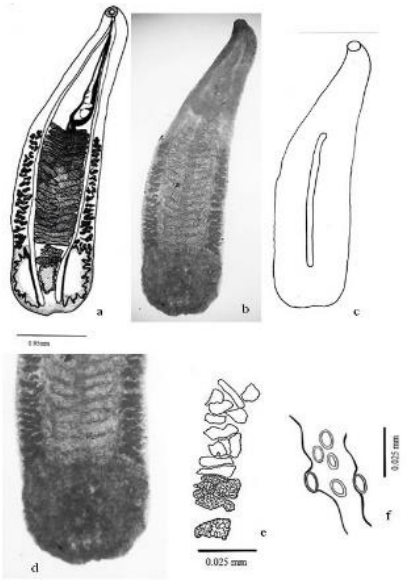

**Figure 5.** *Catatropis pakistanensis,* a. Entire worm; b. Microphotograph (40×); c. Position of ventral central ridge; d. Posterior body enlarged (100×); e. Vitellaria; f. A portion of eggs

**Material examined**
N= 42, ex. *Aythya fuligula* (n=06) and *Aythya nyroca* (n=05); intestine (ileum); 13-ii-2020;

district Badin and district Qambar Shahdad Kot, follow (Naz *et al*., 2021). Specimens stored in APRLMP, Department of Zoology, University of Sindh, Pakistan.

**Status New locality and new host record**

Body elongated, oblong, muscular, 1.95 long, half of the anterior body measures 0.663 × 0.236, covered with minute rhomboid shaped spines Figure 5a, 5b, 5c, posterior body smooth, without spines, measures 0.990 × 0.436; oral sucker wider than long, sub terminal, slightly toward the left side in position, measuring 0.068× 0.436; esophagus long measures 0.063; intestinal caeca extended up to posterior extremity laterally to uterine loops passes through testes and ovary and terminate near the posterior margin of the testes, blind at the end of caecal wall, straight and smooth, measures 1.481 long Figure 5d; testes irregular, deeply lobed, elongated situated at posterior extremity, extra caecal, symmetrical, right testis measures 0.336 × 0.318, left testis measures 0.428 × 0.103; cirrus sac long, anteriorly narrow, elongated, measures 0.527; external seminal vesicles with two coils, genital pore median; ovary multi-lobed, inter-testicular; vitellaria thick, dense and along the mid lateral to posterior periphery of parenchyma Figure 5e; mehlis glands preovarian, measuring 0.163 × 0.090; uterine loops perivitelline with 16-17 loops; eggs polar Figure 5f, each pole contained single filament, ranging 0.009-0.013 × 0.022-0.020 in size.

**Remarks**

The present specimens were identified as the previously known species, *Ctatropis pakistanensis* which was first described in the region by Shafi *et al.* (1982), was recovered from rice rat *Bandicota bengalensis*. Later, it was reported from Pakistan infecting shovlers *Anas clypeata* by Schuster and Wibbelt (2012) described as new species. Both the species are described as new with the similar name *C. pakistanensis* but these species have some variations in their morphology, despite of that the two species cannot be designated as two different new species with same name, hence, the later species name can be designated as the 'homonym' of the former species.

Similarly, the present specimens of the same species were also bearing the structural variations. These variations may appear in morphology of these species due to the variety of the host and site of infection that may influence the physiological activities of the trematode, depicting the change in the external as well as internal body features (Sitko, 1993; Rzad *et al.,* 2020). The genus *Catatropis* hence, was observed infecting frequently in birds as compared to mammals, and in present it is reported from pochards for the first time from the same region, revealing that this species is surviving in waterfowls and other birds more successfully than mammals (Table 7).

The helminthic infection is common in wild waterfowls (Atkinson *et al*., 2008), that depends on the feeding habits of these birds. Throughout the world, there have many studies been conducted on the parasitological aspects in the migratory waterfowls, however, in Pakistan, it is still needed to investigate the various facets of parasitology. In province Sindh, a few parasitological studies on a variety of ducks were conducted generally (Buriro *et al*., 2016; Buriro *et al*., 2020). However, no significant studies were conducted on pochards particularly (Thebo *et al.,* 2019). The present work is hence, a continuation of parasitological studies on pochards in Sindh, Pakistan.

Amongst the helminthic infection, the prevalence and intensity of trematode infection have a strong relationship with their feeding habits; waterfowls are gregarious birds, eat every type of food ranging from aquatic weeds to invertebrates and small vertebrates like fishes, amphibians etc. hence, they carry a variety of parasitic infection, as the trematodes complete their life cycle within intermediate host which is generally an invertebrate and may flourish the parasitic infection in the water medium (Silveria *et al.*, 2010; Roy and St. Louis, 2017; Macklin and Hauck, 2019; Mayntz, 2021). In the present work, it was observed that among trematod species, *Psilochasmus oxyurus* was the most frequent in all the pochard species with the frequency of 27.12% following *Catatropis pakistanensis* (22.34%), *N. attenutus* (19.14%), *P. singhi* (17.02%) and *E. amphiboles* (14.36%). Among the pochard species, *Aythya ferina* were found highly prevalent with 67% of trematode infection followed by *A. fuligula* (63%) in the present study, whereas the least prevalence was found in *A. nyroca* (55%) (Table 1). This is the first helminthic study on pochards in the country, however, few literatures are available on the duck species of genus *Anas* undertaken in the region (Dharejo *et al.*, 2006; Birmani *et al.,* 2008; 2011; 2013; 2016; Buriro *et al.,* 2016; Khan *et al.,* 2017).

**Table 1.** Prevalence of infected birds from each district in Sindh province

| Districts Names | Coordinates | Birds Collected | | Total Examined birds | Infected birds | Prevalence |
|---|---|---|---|---|---|---|
| | | Dead Birds | Live Birds | | | |
| Jamshoro | (25.6251°N, 67.9524°E) | 05 | 14 | 19 | 15 | 78.94% |
| Qambar Shahdad Kot | (27.588505°N; 68.008937°E) | 06 | 13 | 19 | 12 | 63.15% |
| Thatta | (24.5457°N, 67.9524°E) | 04 | 09 | 13 | 08 | 61.53% |
| Larkana | (27.4993°N; 68.1908° E) | 04 | 07 | 11 | 06 | 54.54% |
| Badin | (24.6605°N; 68.7155°E) | 03 | 05 | 08 | 03 | 37.5% |

**Table 2.** Quantitative parasitological parameters used to analyze the infection of trematodes in pochards of genus *Aythya* during the present studies

| Host (sample size) | Parasite species | No. of parasites recovered | Birds infected | Prevalence (%) | Rate of Infection | Frequency (%) | Intensity (Σ± SE) |
|---|---|---|---|---|---|---|---|
| *Aythya ferina* | *Notocotylus attenutus* | 36 | 6 | | 6.0 | 45.5 | 6±0.63 |
| (N= 28) | *Echinochasmus amphibolous* | 27 | 5 | 36.36% | 5.4 | 34.1 | 5.4±0.455 |
| | *Psilochasmus oxyurus* | 16 | 5 | | 3.2 | 20.25 | 3.2±0.331 |
| *Aythya fuligula* | *Psilochasmus oxyurus* | 24 | 5 | | 4.8 | 35.2 | 4.8±0.375 |
| | *Psilochasmus singhi* | 32 | 6 | | 5.3 | 47.05 | 5.33±0.305 |
| (N= 22) | *Catatropis pakistanensis* | 12 | 6 | 38.63% | 2.0 | 17.64 | 2±0.221 |
| *Aythya nyroca* | *Catatropis pakistanensis* | 30 | 5 | 55% | 6.0 | 73.17 | 5±0.491 |
| (N= 20) | *Psilochasmus oxyurus* | 11 | 6 | | 1.8 | 26.82 | 1.8±0.28 |

**Table 3.** Morphometric comparison of *Psilochasmus oxyurus* recovered from present host with that of other host birds

| Species Body parts | Recovered from present host | Recovered from Anas *platyrhynchos* | Recovered from *Himantopus melanurus* |
|---|---|---|---|
| Body | 3.813–0.894 | 3.0–4.484 × 0.695–0.878 | 2.643–3.286 × 0.893–0.929 |
| Oral sucker | 0.279 × 0.302 | 0.158–0.343 × 0.268–0.303 | 0.243–0.336 × 0.214–0.286 |
| Pre-pharynx | 0.127 | 0.068–0.070 × 0.120–0.125 | – |
| Pharynx | 0.209 × 0.255 | – | 0.157–0.164 × 0.129–0.164 |
| Ventral sucker | 0.651 × 0.686 | 0.378–0.728× 0.728–0.745 | 0.357–0.364 × 0.371–0.386 |
| Esophagus | Present | Present | – |
| Ceca | 2.813 | – | – |
| Cirrus Sac | 0.697 | – | |
| Ovary | 0.151 × 0.174 | 0.29–0.40 × 0.35–0.45 | – |
| Anterior Testes | 0.302 × 0.209 | 0.317–0.457 × 0.195–0.203 | Lobed testes |
| Posterior Testes | 0.325 × 0.209 | 0.414–0.440× 0.243–0.338 | Lobed testis |
| seminal vesicle | Present | Present | – |
| Uterus | Present | Present | – |
| Eggs | – | 84–86 × 24–26 | |
| Locality | Qambar Shahdad Kot, Jamshoro and Thatta | Qambar Shahdad Kot | Argentine |

**Table 4.** Morphometric comparison of *Psilochasmus singhis* recovered from the present host with that of other host birds

| Species body part | Recovered from *Aythya fuligula* | Recovered from *endrocygna javanica* |
|---|---|---|
| Body | 4.534 | 4.806–6.083 × 0.839–1.258 |
| Oral sucker | 0.244 × 0.244 | 0.303–0,322 × 0.296–0.303 |
| Pre-pharynx | – | 0.194–0.232 |
| Pharynx | 0.232 × 0.174 | 0.245–0.277 × 0.1680.187 |
| Ventral sucker | 0.604 × 0.581 | 0.477–0.658 × 0.465–0.580 |
| Esophagus | 0.395 × 0.197 | 0.439–0.568 × 0.1100.174 |
| Ceca | 2.837 | 0.503–0.774 |
| Cirrus Sac | 1.534 | – |
| Ovary | 0.209 × 0.162 | 0.1740.213 × 0.168–0.206 |
| Anterior Testes | 0.476 × 0.348 | 0.458–0.529 × 0.258–0.374 |
| Posterior Testes | 0.604 × 0.348 | 0.490–0.664 × 0.264–0.348 |
| seminal vesicle | Present | Present |
| Uterus | Present | Present |
| Eggs | 0.068–0.10 × 1.09–0.090 | 0.09–0.14 × 0.07–0.72 |
| Locality | Qambar Shahdad Kot | India |

**Table 5.** Comparative morphometry of *Echinochasmus amphibolous* with its closest allied species recovered from different host birds

| Species body parts | Present species | E. Mazharuddin Ujjan *et al*., 2014 | E. Prakashi Gupta and Singh, 1988 | E. Japonicus Tanabe, 1926 | E. Bagulai Verma, 1935 | E. Ruficapensis Verma, 1935 | E. Jamshorensi Channa *et al*., 2009 | E. Mohiuddin Dharejo *et al*., 2007 | E. Accipeteri Bhutta and Khan, 1975 | E. passeri Dharejo *et al*., 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Body size | 3.51× 0.64 | 810-886× 395-421 | 0.97-1.62× 0.30-0.31 | 0.76× 0.19 | 1.0-1.75× 0.25-0.5 | 2.5-3.5× 0.4-0.6 | 0.43× 0.12 | 0.78-1.61× 0.21-41 | 2.2× 0.5 | 0.72× 0.28 |
| Fore body | 0.89× 0.59 | 277-291 | 0.28 | 0.4 | 0.29 | 0.91 | 0.18 | 0.46 | 0.48 | 0.25 |
| Hind body | 2.62× 0.52 | 386-404 | 0.60 | 0.29 | 0.44 | 1.6 | 0.18 | 0.89 | 1.42 | 0.36 |
| Spines | 24 | 28 | 22 | 24 | 24 | 24 | 24 | 24 | 24 | 26 |
| Oral sucker | 0.09× 0.12 | 76-86× 70-82 | 0.05-0.07× 0.06-0.07 | 0.10 | 0.05-0.07 | 0.15× 0.1 | 0.27× 0.02 | 0.03-0.08× 0.03-0.08 | 0.08× 0.04 | 0.04× 0.04 |
| Pre-pharynx | 0.07 | 8-11 | 0.05-0.09 | 0.06 | 0.05 | 0.15 | 0.05 | 0.03-0.08 | 0.02 | 0.01 |
| Pharynx | 0.12× 0.09 | 85-91× 65-76 | 0.07 | 0.05 | 0.05 | 0.14× 0.14 | 0.05× 0.02 | 0.04-0.09× 0.03-0.07 | 0.09× 0.08 | 0.05× 0.04 |
| Esophagus | 0.20 | 67-83 | 0.08×0.29 | 0.23 | 0.125 | 0.31 | 0.05 | 0.03-0.10 | 0.36 | 0.09 |
| Ventral sucker | 0.44× 0.41 | 160-186× 192-208 | 0.14-0.15× 0.18-0.19 | 0.08× 0.09 | 0.15-0.24 | 0.35 | 0.07× 0.07 | 0.10-0.22× 0.09-0.18 | 0.3× 0.33 | 0.10× 0.09 |
| Cirrus sac | – | 71-82× 45-52 | 0.09-0.12× 0.06-0.08 | 0.05 | 0.07× 0.06 | 0.17 | 0.06× 0.01 | 0.03-0.12× 0.04-0.07 | 0.17× 0.04 | 0.03× 0.03 |
| Ovary | 0.44× 0.41 | 73-82× 88-95 | 0.05-0.11× 0.05-0.08 | 0.02× 0.04 | 0.04-0.06 | 0.12×0.26 | 0.01× 0.02 | 0.03-0.09× 0.02-0.10 | 0.12× 0.1 | 0.05× 0.05 |
| Anteriortestis | 0.15× 0.15 | 101-121× 260-296 | 0.10-0.13× 0.14-0.17 | 0.05× 0.08 | 0.06-0.15× 0.76-0.19 | 0.18-0.22× 0.19-0.35 | 0.02× 0.04 | 0.07-0.22× 0.09-0.21 | 0.2× 0.29 | 0.06× 0.14 |
| Posteriortestis | 0.16× 0.16 | 127-143× 206-239 | 0.14-0.18× 0.13-0.20 | 0.05× 0.08 | 0.08-1.68× 0.08-0.17 | 0.18-0.25× 0.18-0.2 | 0.03× 0.04 | 0.10-0.28× 0.09-0.20 | 0.32× 0.26 | 0.10× 0.11 |
| Post testicular space | – | 122-139 | – | 0.115× 0.128 | – | 0.746 | 0.08 | 0.25 | 0.61 | 0.135 |
| Eggs | – | 73-100× 52-86 | 0.04-0.06× 0.03-0.05 | 0.075× 0.06 | 0.06-0.07× 0.05-0.05 | 0.07-0.08× 0.03-052 | – | 56-70× 32-44 | 0.04-0.06 | 36-43× 20-24 |
| Host | *Aythya ferina* | *Acridotheres ginginianus* | *Ardeola grayii* | *Anas platyrhynchos* | *Ardeola grayi* | *Podiceps ruficollis* | *Ardeola grayii* | *Ardeola grayii* | *Accipiter badius* | *Passer domesticus* |
| Location | Intestine | Gizzard | Intestine | Intestine | Intestine | Intestine | Intestine | Intestine | Intestine | Gall bladder |
| Locality | Pakistan | Pakistan | India | Korea | India | India | Pakistan | Pakistan | Pakistan | Pakistan |

**Table 6.** Comparative morphometry of *Notocotylus attenutus* with its closest allied species recovered from different host birds

| Species Body parts | Present species | *Notocotylus sindhensis* | *Notocotylus biomphalariae* | *Notocotylus fosteri* | *Notocotylus atlanticus* |
|---|---|---|---|---|---|
| Body size | 2.74 long | 1.49-1.64×0.42-0.46 | 1.573-2.059×801-1.03 | 2.705-3.125×0.955-1.095 | 2.20-3.65×0.8-1.1 |
| Ventral papillae/ glands | 15 | 19 | 15 | 32-37 | 16 |
| Oral sucker | Terminal, rounded 0.142×0.584 | terminal, small and muscular 0.088-0.092×0.09-0.094 | 122-144×134-161 | 129-167×154-179 | 0.15×0.12- |
| Pre-pharynx | Absent | - | Absent | - | - |
| Pharynx | Absent | short, 0.03-0.049 | Absent | - | - |
| Esophagus | relatively shorter 0.116 | esophagus long | 7-48 | 129-188 | Short |
| Ventral sucker | Absent | Absent | Absent | Absent | Absent |
| Cirrus sac | 0.805 | 0.10-0.12×0.05-0.06 | 422-643×98-144 | 565-770 | 0.028×0.6-0.84 |
| Caeca | Long, 2.36 | Long | - | 195-270 | - |
| Uterine loops | 16-17 | - | 12-16 | 15-18 | 12-16 |
| Ovary | 0.285×0.207 | 0.26-0.32×0.13-0.15 | 137-192×134-252 | 265-395×125-170 | 0.19-0.25×0.15-0.2 |
| Right testis | 0.396×0.155 | 0.25-0.29×0.10-0.13 | 250-336×163-221 | 540-775×270-365 | 0.28-0.48×0.16-0.26 |
| Left testis | 0.428×0.103 | 0.24-0.28×0.07-0.14 | 250-336×163-221 | 540-775×270-365 | 0.28-0.48×0.16-0.26 |
| Eggs | 0.012×0.019-0.025 | 0.01-0.014× 0.007-0.009 | 22-26×10-14 | 16-21×10-13 | 0.017-0.011 |
| Hosts | *Aythya ferina* | *Anas platyrhynchos* | *Anas* sp. (type-host) and *Gallus gallus domesticus* | Rice rat, *Oryzomys palustris* | Eider Ducks |
| Location | Thatta and Jamshoro | Tando Muhammad Khan | Fantasma Pond | Waccasassa Bay, Florida | - |
| Locality | Pakistan | Pakistan | Argentina | U.S.A. | - |

**Table 7.** Comparison of various species of genus *Catatropis* with present species with its closest allied species

| Name of organ | Present species | *C. pakistanensis* | *C. harwoodi* | *C. paceifera* | *C. johnstoni* | *C. fimbriata* | *C. indicus* |
|---|---|---|---|---|---|---|---|
| Body | 1.95×0.66 | 3.84-3.12× 0.85-1.18 | 2-3.5×0.5-0.8 | 1.0-3.1× 0.52-1.38 | 0.94-1.61× 0.31-0.57 | 2.2-3.3× 0.56-0.7 | 2.8×0.5 |
| Oral sucker | 0.06×0.43 | 0.1-0.13× 0.13-0.17 subterminal | 0.11-0.15 | 0.06-0.21 | 0.06-0.09× 0.07-0.12 | 0.07-0.09× 0.06-0.09 | 0.02 |
| Ventral sucker | Absent | Absent | Absent | Absent | Absent | Absent | Absent |
| Pharynx | Absent | Absent | Absent | Absent | Absent | Absent | Absent |
| Esophagus | 0.06 | 0.15-0.2 long | 0.11-0.15 | 0.05-0.14 | 0.06-0.16× 0.005-0.009 | 0.10-0.13 | Short |
| Caecum | 1.48 | Extend laterally to uterine coils | Long and cylinder | Ceca passes laterally | intestinal ceca extend posteriorly lateral to the uterine loops | intestinal ceca undulating, external to uterine coils | Caecum extend posteriorly |
| Papillae or glands | 9-10 | 9-10 | 7-9 | 4-11 | Absent | 12-13 | 12-13 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Testes | 0.33-0.42× 0.1-0.31 | 0.6-0.85× 0.3-0.38µm | 0.28-0.56× 0.15-0.28 | 0.11-0.38× 0.06-0.23 | 0.19-0.32× 0.08-0.15 | 0.19-0.26× 0.132-0.15 | – |
| Ovary | 0.16×0.09 | 0.22-0.4× 0.15-0.22 | 0.13-0.24× 0.1-0.15 | 0.14×0.16 | 0.09-0.16× 0.08-0.13 | 0.132× 0.105-0.11 | – |
| Cirrus sac | 0.527 long | 0.86 | 0.45-0.8× 0.03-0.05 | 0.23-0.8 | 0.43-64× 0.06-0.11 | – | – |
| Uterus | 16-17 loops | 14-19 | 17-22 | - | – | – | 15 |
| Host | *Aythya nyroca* and *Aythya fuligula* | *Anas platyrhynchos* | *Branta canadensis* | *Fulica americana* | Chicks | *Fiber zibethicus* | *Rattus norvigicus* |
| Locality | Badin, Qambar Shahdad Kot | – | Durham | Stockton, California | Newport beach, California | Nebraska | Cairo, Egypt |

## CONCLUSION

The present work has been carried out as a contribution towards the fauna of trematodes infection found in the migratory birds in the Pakistani water bodies. The present study put five species of trematodes infecting pochards of Sindh, Pakistan, that migrate from European region of our country. These trematode species included *Psilochasmus singhi* Jaiswal and Humayun, 1971, *Psilochasmus oxyurus* (Creplin, 1825), *Catatropis pakistanensis* Shafi *et al.,* 1982, *Echinochasmus amphiboles* Kotlan, 1922 and *Notocotylus attenutus* (Rudolphi, 1809). It is the first parasitological study being carriedout in the pochard of Sindh, Pakistan.

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## CONFLICT OF INTEREST

There is no conflict of interest between the authors before, during or after the publication of this work.

## AUTHOR'S CONTRIBUTION

**A. K. Thebo:** Generated the main idea of the work, written the first draft, illustrations were made

**S. Naz:** Finalized the manuscript, analyzed the data, determined the specimens

**N. A. Birmani:** Sample collection

**S. Siyal:** Experimental work and microscopy

**S. Khaskheli:** Sample preparation and review literature

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