STUDIES ON THE DIGENETIC TREMATODES OF THE PISCIVOROUS BIRDS IN MALABAR, KERALA

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By

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CERTIFICATE

This is to certify that this thesis is an authentic record of the research work done by **Mr. Subair, K. T.** from December 2000 to July 2011 under my supervision and guidance and that no part thereof has been presented before for any other degree.

Dr. K.P. Janardanan

DECLARATION

I hereby declare that the present work is original and has not been published or submitted in part of full for any degree or prize.

Calicut University
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Dedicted to

My Parents

Contents

INTRODUCTION

Kerala, with its tropical climate, evergreen vegetation, heavy rainfall and water bodies like lakes, rivers, streams and wetlands, has the ideal ecological conditions for a rich resident and migratory avifauna. As a post-graduate student specializing in wildlife biology at the department of Zoology, Farook College, Calicut, I happened to examine wild birds in the laboratory and became interested in the digenetic trematodes infecting them. Information on the morphology and biology of digenetic trematodes is important, since it is an essential pre-requisite for formulating effective control measures against digenean infections. A review of literature showed that the digeneans infecting birds of Kerala have not been the subject of any comprehensive investigation, though birds form an important component of India's fast-dying wildlife. The available information is limited to the systematics and biology of a few digeneans by Roopa and Janardanan (2001), Nambiar and Janardanan (2001), Vasandakumar and Janardanan (2002), and Sheena *et al.* (2007). The present investigation was undertaken with a view to throwing more light on the systematics and biology of

digeneans infecting piscivorous birds in the Malabar region of Kerala. Since the knowledge of digenean fauna can contribute much toward avian parasitology and bird conservation, the present investigation has scientific importance and intimate bearing on the welfare and preservation of the Indian wildlife.

During the present study 101 birds belonging to 16 species representing 15 genera and 12 families, collected from various localities in Malabar from June 2001 to April 2009, were examined for digenetic trematodes. Of these, 65 birds belonging to 9 species were found to be infected with adult trematodes. Altogether 24 species, including 3 new species, belonging to 20 genera were recovered and studied. The new species are, *Echinochasmus* sp.1 n. sp. from *Phalacrocorax niger, Stephanoprora* sp.I n. sp. from *Alcedo atthis,* and *Uvulifer* sp.1 n. sp. from *Halcyon smyrnensis*. The remaining 21 species are, *Nephrostomum ramosum, Parallelotestis tarai, Paryphostomum horai, Petsiger variospinosus, Echinochasmus bagulai, Ignavia breviovarica, Pegosomum egretti, Psilorchis indicus, Basantisia ramai, Nigerina hardoiensis, Centrocestus formosanus,*

Stellantchasmus falcatus, Haplorchis taichui, Clinostomum complanatum, Euclinostomum heterostomum, Mesostephanus indicum, Subuvulifer halcyonae, Uvulifer denticulatus, U. stunkardi, U. cochlearis, and *Apharyngostrigea ramai.* The life cycles were established for 2 species, *Mesostephanus indicum* and *Uvulifer* sp. I n. sp.. Detailed descriptions are furnished for the 3 new forms, and all the known species are redescribed. Data on prevalence and intensity of digenean infection among piscivorous birds in Malabar have been collected and presented. Host-specificity, mixed infections and other aspects of host-parasite relations of digeneans infecting birds have been discussed in the light of available information. New host and geographical records have been presented in the thesis.

HISTORICAL REVIEW

Digenetic trematodes belonging to 20 genera have been recovered from 9 species of piscivorous birds in Malabar during the course of the present investigation. These include *Nephrostomum* Dietz, 1909, *Parallelotestis* Belopol'skaia, 1954, *Paryphostomum* Dietz, 1909, *Petasiger* Dietz, 1909, *Echinochasmus* Dietz, 1909, *Stephanoprora* Odhner, 1902, *Ignavia* Freitas, 1948, *Pegosomum* Ratz, 1903, *Psilorchis* Thapar and Lal, 1935, *Basantisia* Pande, 1938, *Nigerina* Baugh, 1958, *Centrocestus* Looss, 1899, *Stellantchasmus* Onji and Nishio, 1916, *Haplorchis* Looss, 1899, *Clinostomum* Leidy, 1856, *Euclinostomum* Travassos, 1928, *Mesostephanus* Lutz, 1935, *Subuvulifer* Dubois, 1952, *Uvulifer* Yamaguti, 1934 and *Apharyngeostrigea* Ciurea, 1927. A brief review of literature of all these genera is presented here.

Genus *Nephrostomum* Dietz, 1909

The genus *Nephrostomum* was established by Dietz (1909) with *Nephrostomum ramosum* (Sonsino, 1895) as its type, which was reported by Sonsino (1895) as *Echinostomum ramosum* from the cattle egret, *Bubulcus ibis*

in Nile delta, Morocco. Since then, 12 species have been added to this genus from birds in different parts of the world*: N. garzettae* (MacCallum, 1904) from *Garzetta nigriceps*; *N. limai* Travassos, 1922 from *Syrigma sibilatrix*; *N. australe* (Johnson, 1928) Mendheim, 1943 from *Gallinula tenebrosa*; *N. bicolanum* Tubangui, 1933 from *Herodias timoriensis*; *N. robustum* Vigueras, 1944 from *Columbus dominicus dominicus; N. skrjabini* Kasimov, Vaidova and Feizullaev, 1959 from *B. ibis*; *N. sinchirocai* Ibanez, 1966 from *Leucophoyx thula; N. legonum* Ukoli, 1967 from *B. ibis*; *N. reticulatum* Karyakarte, 1969 from *B. ibis; N. chandigarhensis* Gupta and Mehrotra, 1970 from *Dissurus episcopa episcopa, N. dubashi* Kaikabad and Bilquees, 1972 from *B. ibis,* and *N. guptai* Gupta, 1985 from *B. ibis.* Odhner (1910) synonymised *N. garzettae* with *N. ramosum*. Prudhoe (1944) synonymised *N. bicolanum* Tubangui, 1933 with *N. ramosum,* and Srivastava (1982) considered *N. chandigarhensis* as a synonym of *N. ramosum.* Gupta and Singh (1985) agreed with the arrangement made by Odhner (1910), Prudhoe (1944) and Srivastava (1982). Sahay and Verma (1987), after a critical study, synonymised *N. reticulatum* Karyakarte, 1969 with *N. ramosum.* Thus, among the species of the genus

Nephrostomum described by various workers, only nine species are valid. Of these, *N. ramosum* and *N. guptai* are reported from India.

The characters of the genus *Nephrostomum* Dietz, 1909, as given by Kostadinova (2005), are: Body elongate-oval (BW = 16-31%), with maximum width at mid-uterine level. Forebody very short (FO = 7-20%). Collar large, with wide ventral notch and shallow dorsal depression. Collar-spines very small, conical, 32-50, in single row interrupted dorsally; angle spines 2 x 4, similar in size to lateral spines; spines at dorsal depression smallest. Testes small, elongate-oval, smooth or indented, in third quarter of body (T = 26-35%). Ovary transversely oval, smooth, irregular or lobed, median, equatorial. Uterus long (U = 22-36%), with numerous intercaecal loops between ovary and ventral sucker. Stem of excretory vesicle with lateral diverticula; pore subterminal. In intestine of birds (Ardeidae); Africa, Asia, South America, Australia. Cercariae in Planorbidae; metacercariae in tadpoles (exp.) Type-species *N. ramosum* (Sonsino, 1895) Dietz, 1909.

Genus *Parallelotestis* Belopol'skaia, 1954

Belopol'skaia (1954) erected the genus *Parallelotestis* with *P. horridus* from the egret, *Egretta alba modesta* as its type species. Srivastava (1958) proposed a new genus *Proechinocephalus* and designated *P. tarai* from *Bubulcus ibis coromandus* as its type and in 1960 added a new species, *P. egretti* to it from the same host. Beverly-Burton (1960), while describing *Parallelotestis kafuensis* from *Egretta alba melanorhyncha,* synonymised *Proechinocephalus* Srivastava, 1958 with *Parallelotestis.* Gupta and Gupta (1964) described *Parallelotestis indicus* from *B. ibis coromandus* and agreed with Beverly-Burton in synonymising *Proechinocephalus* with *Parallelotestis.* Kaushal (1970) suppressed *P. egretti* (Srivastava, I960) Beverly-Burton, 1960 and *P. indicus* Gupta and Gupta, 1964 as a synonym of *P. tarai.* Later, Jahan (1973) added *P. garzettai* from *E. garzetta,* and Gupta and Gupta (1980) added *P. bubulcusi* from *B. ibis* to the genus. But Srivastava (1982) suppressed *P. garzettai* Jahan, 1973 as a synonym of *P. tarai.* Thus the genus *Parallelotestis* at present has 4 valid species, *P. horridus* Belopolskaia, 1954, *P. kafuensis* Beverly-Burton, 1960*, P. tarai* (Srivastava, 1958)*,* and *P. bubulcusi* Gupta and Gupta, 1980, of which the latter 2 are from Indian birds.

The characters of the genus *Parallelotestis* Belopol'skaia, 1954, as given by Kostadinova (2005), are: Body medium to large, lanceolate (BW = 33-50%), dorsoventrally flattened, with maximum width at level of testes, tapered bluntly at both ends. Forebody very long (FO = 28-33%). Entire tegument armed with very large spines (c.50 % of maximum angle spine length). Collar small, reniform; ventral ridge distinct. Collar-spines 27; dorsal spines in double row; lateral spines in single row; angle spines 2 x 4, longer than marginal spines. Oral sucker small, spherical. Ventral sucker muscular, in second quarter of body. Prepharynx short or absent. Pharynx usually larger than oral sucker. Oesophagus comparatively long, with or without lateral diverticula. Intestinal bifurcation in posterior third of forebody. Testes symmetrical or somewhat oblique, sub-globular, smooth, in third quarter of body (T = 27-41%). Cirrus-sac elongate or transversely oval, almost entirely anterior to ventral sucker. Internal seminal vesicle saccular. Pars prostatica well developed. Cirrus massive, armed with large spines. Ovary oval, dextral or median, just pre-equatorial. Mehlis' gland diffuse. Uterus very short (U = 3-10%), with few loops; metraterm short; eggs numerous.

Vitelline fields reach anteriorly to level of anterior margin of ventral sucker or genital pore, confluent in post-testicular field; follicles small. Excretory pore terminal. In gall-bladder and bile-ducts of birds (Ardeidae); Africa and Asia. Type-species *P. horridus* Belopol'skaya, 1954.

Genus *Paryphostomum* Dietz, 1909

Dietz (1909) proposed the genus *Paryphostomum* to receive *P. radiatum* (Dujardin, 1845) as its type species. Mukherjee and Ghosh (1968) reviewed the status of the genus and synonymised it with *Echinostoma*, but Yamaguti (1971) revived the generic name *Paryphostomum.* Till date, over 25 nominal species have been added to the genus *Paryphostomum* by several workers from different parts of the world. Of these, 9 species are from India: *P. testitrifolium* Gogate, 1934 from *Phalacrocorax niger; P. pentalobum* Verma, 1936 from *Capella galenago; P. horai* Baugh, 1950 from *Anas poecilorhynca*; *P. dollfusi* Agarwal, 1958 from *Bubulcus ibis; P. giganticum* Rai and Agarwal, 1961 from *Porphyrio poliocephalus*; *P. srivastavi* Chishti and Thanveer, 1993 from *Gallus gallus* and *Phalacrocorax niger; P. siddiqui* Gupta and Singh, 1986 from *Anas acuta; P. agarwali* Gupta

and Singh, 1986 from *Ardeola ibis,* and *P. mukhtarensis* Ahmed, 2000 from *Phalacrocorax carbosinensis.*

The characters of the genus *Paryphostomum* Dietz, 1909, as given by Kostadinova (2005), are: Body small to medium, elongate to elongate-oval (BW = 14-31%), with nearly parallel margins and maximum width at level of testes. Forebody short (FO = 15-20%). Tegument armed with small spines. Collar well developed, reniform; ventral incision deep; ventral ridge present. Collar-spines 27, large; lateral spines in single row; dorsal spines in double row; angle spines 2 x 4, considerably larger than marginal spines. Oral sucker spherical. Ventral sucker cup-shaped, with deep cavity, between first and second quarters of body. Prepharynx short. Pharynx sub-globular, similar in size to oral sucker. Oesophagus short. Intestinal bifurcation at significant distance anterior to ventral sucker. Testes tandem, large, deeply lobed, contiguous or slightly separated; anterior testis usually equatorial (T = 23-45%). Cirrus-sac elongate-oval, anterior to or extending to mid-level of ventral sucker dorsally. Internal seminal vesicle voluminous, bipartite. Pars prostatica well developed. Cirrus large, spined. Ovary small,

spherical, dextral, pre-equatorial. Mehlis' gland compact, larger than ovary. Uterine seminal receptacle conspicuous. Uterus very short to short (U = 0-11 %), with few coils. Metraterm muscular, long. Eggs not numerous. Vitelline fields between posterior margin of ventral sucker and posterior extremity, non-confluent, approach median line posteriorly to testes; follicles large. Arms of excretory vesicle with lateral diverticula; pore terminal. In intestine mainly of Phalacrocoracidae in Europe, Asia, Africa, Australia, North and South America and Ciconidae [or Cathartidae?] and Sulidae in South America. Cercariae in Planorbidae and Lymnaeidae; metacercariae in cyprinid fishes and tadpoles. Type-species *P. radiatum* (Dujardin, 1845) Dietz, 1909.

Genus *Petasiger* Dietz, 1909

The genus *Petasiger* was proposed by Dietz (1909) with *P. exaertus* from the cormorants, *Phalacrocorax carbo* and *P. pygmaeus* in England and USSR as its type species. Since then 33 nominal species have been described in this genus. Bashkirova (1941) erected 2 subgenera based on the location of the testes; the subgenus, *Neopetasiger* to accommodate the species with symmetrical or oblique testes, and the

subgenus *Petasiger* to include the species with tandem testes. In an independent analysis of the genus, Mendheim (1943) proposed a new genus, *Navicularia* to include the species which have oblique or parallel testes smaller than the ovary, acuminate body and collar spines of similar length. He retained in *Petasiger* those species having testes larger than the ovary, a compact body and collar spines with different lengths. Skrjabin and Bashkirova (1956) considered *Navicularia* as a synonym of *Neopetasiger.* Yamaguti (1971) and Kostadinova (2005) did not agree with these actions. Faltynkova *et al.* (2008), based on a comparative morphological study of the nominal species of *Petasiger,* reassessed the status of all the species in the genus, recognised only 17 species as valid and added one new species to it. Further, they revised the generic characters of *Petasiger* and presented a key to the 18 recognised species reported till then. As far as is known, only one species of *Petasiger, Petasiger variospinosus*, is recorded from India.

The characters of the genus *Petasiger* Dietz*,* 1909*,* as given by Faltynkova *et al*. (2008), are: Body small, spindle-shaped, broadly oval to elongate; maximum width at ventral

sucker or testicular level. Tegument armed with small sharp spines which are especially dense in forebody. Forebody long (FO/TOT = 25-55%), with somewhat constricted 'neck region' posterior to collar. Oral sucker subspherical. Ventral sucker prominent, spherical, usually in mid-body. Prepharynx usually distinct, occasionally apparently absent or short. Pharynx oval to elongate-oval, smaller than oral sucker, muscular. Oesophagus short to long. Intestinal bifurcation well anterior to ventral sucker; caeca reach close to posterior extremity. Collar well developed, kidney-shaped, with distinct ventral ridge. Collar-spines 19-27; lateral spines in a single row; dorsal spines in double row; angle spines 2 x 3-4, longer than marginal spines. Testes two, tandem, oblique or symmetrical, contiguous, sub-globular to elongate-oval sometimes transversely oval, smooth or slightly lobed, usually in mid-hindbody (Post-testicular field 10-35% of body length). Cirrus-sac large, elongate to broadly oval, between intestinal bifurcation and ventral sucker or reaching back dorsally to its mid-level. Internal seminal vesicle bipartite, large. Pars prostatica usually well developed. Genital pore usually median, at level of or posterior to intestinal bifurcation. Cirrus tubular or bulb-like, unarmed (except in *P. combesi*). Ovary

spherical to ovoid, dextral, post equatorial but close to ventral sucker. Mehlis' gland usually compact, larger than ovary. Uterine seminal receptacle distinct. Uterus short, restricted to few intercaecal loops between anterior testis, ovary and ventral sucker, contains few to numerous eggs. Metraterm short. Vitellarium follicular; follicle small to large, form lateral fields; fields extend into forebody as far as anterior margin of ventral sucker, genital pore or intestinal bifurcation, converge towards median line or confluent in post-testicular field and may be confluent in forebody. Excretory vesicle Y-shaped; stem with lateral diverticula; pore terminal. In intestine of fish-eating birds (Anhingidae, Phalacrocoracidae, Phoenicopteridae, Podicipedidae, occasionally Anatidae and Laridae); cosmopolitan. Cercacariae in Planorbidae; metacercariae in oesophagus or pharynx of freshwater teleosts. Type-species *P. exaeretus* Dietz, 1909.

Genus *Echinochasmus* Dietz, 1909

Dietz (1909) erected the genus *Echinochasmus* with *E. coaxatus* from the birds, *Colymbus crystatus, C. griseigena, C. nigrocollis, C. caspicus, Ciconia ciconia* and *Anas platyrhyncha,* as its type. Till date more than 70 nominal

species have been reported in the genus *Echinochasmus* from different parts of the world. Of these, 12 species are from India: *E. perfoliatus* (Ratz, 1908) Dietz, 1909 from man, dog and cat*; E. Japonicus* Tanabe, 1926 from *Egretta intermedia*, *Milvus migrans, Bucephala clangula* and *Nycticorax nycticorax; E. bagulai* Verma, 1935 from *Ardeola grayii* and *N. nycticorax; E. ruficapensis* Verma, 1935 from *Podiceps ruficollis; E. narayani* Mudaliar, 1938 from *M. migrans govinda; E. megavitellus* Lal, 1939 from *A. grayii; E. antigonus* Gupta, 1953 from *Antigone antigone; E. minutus* Karyakarte, 1970 from *M. migrans; E. vindhianae* Vasudev, 1973 from *Aquila rapax vindhiana*; *E. megadermi* Salem, 1975 from *Megadermi lira; E. papillosai* Gupta and Jahan, 1979 from *Pseudibis papillosa,* and *E. premvatii* Sharma, 1988 from *Fulica atria .*

The characters of the genus *Echinochasmus* Dietz, 1909, as given by Kostadinova (2005), are: Body small, elongate-oval (BW = 17-50%) with maximum width at level of testes. Forebody typically long (FO = 25-50%). Tegument armed with scale-like spines (length 30-50% of maximum collar-spine length) in alternating rows to level of testes. Tegumental

spines may be present on dorsal depression of collar and on dorsal surface of oral sucker. Collar well developed, with ventrolateral edges curved medially. Collar-spines 20-24 or 30-34 in single row; angle spines 2 x 2-3, somewhat smaller than marginal spines. Oral sucker small, spherical. Ventral sucker in second quarter of body. Prepharynx long. Pharynx large. Oesophagus long. Intestinal bifurcation just anterior to ventral sucker. Caeca blind. Testes tandem, large, smooth, irregular or lobed, contiguous, post equatorial, in mid-hindbody (T = 15-30%). Anterior testes typically larger, transversely oval; posterior testes rounded-triangular, ovoid or semicircular in outline. Cirrus sac muscular, large, elongate-oval, between intestinal bifurcation and ventral sucker or extending dorsally to its posterior margin. Internal seminal vesicle saccular, bipartite. Pars prostatica small, indistinct. Cirrus short, unarmed. Ovary small, dextral or submedian, close posterior to ventral sucker, usually equatorial. Mehlis' gland median or sinistral, conspicuous. Uterus very short (U = 0-10%), with few eggs. Metraterm short, thin walled. Vitelline fields confluent in post-testicular region; anterior limits between ventral sucker and pharynx; fields may be confluent in forebody; follicles small. Stem of

excretory vesicle chambered or not; arms with prominent lateral diverticula; pore terminal. In intestine of wide range of fish-eating birds, rarely in mammals and occasionally in bursa Fabricii of birds; cosmopolitan. Cercariae lacking collar-spines, in various prosobranch gastropods (*Blythynia, Semisulcospira, Digoniostoma, Viviparus, Pyrgophorus, Pomacea, Amnicola, Bulimus*); metacercaria with collar-spines in or on gills, oesophagus or intestinal mesenteries of freshwater teleosts, occasionally in snails and tadpoles.Type-species *E. coaxatus*, Dietz, 1909.

Genus *Stephanoprora* Odhner, 1902

Odhner (1902) established the genus *Stephanoprora* and designated *S. ornata* from crocodiles in Sudan, Egypt and Congo as its type. Dietz (1909) created two new genera, *Mesorchis* and *Monilifer,* in which the vitellaria are distributed in the same pattern as they are in *Stephanoprora* Odhner, 1902. Odhner (1911) synonymised both these genera with *Stephanoprora* based on the strong resemblances. Subsequently, several workers agreed with this arrangement but a few considered the genera *Mesorchis* and *Monilifer* as distinct. Yamaguti (1958) considered *Mesorchis* as a

synonym of the genus *Stephanoprora,* and *Monilifer* as a valid genus. Later, in 1971 he synonimysed *Monilifer* also with *Stephanoprora*. More than 30 nominal species have been added to the genus from different parts of the world. Among these, 20 species are from birds. Information on the genus *Stephanoprora* in India is limited to the description of 6 species, all from birds. These are, *S. reynoldi* Balerao, 1926 from *Corvus insolens*; *S. pennant* (Verma, 1936) Yamashita, 1937 from *Anhinga melanogaster*; *S. fusca* Lal, 1939 from *Totanus fuscus*; *S. gigantica* Gupta, 1962 from *Xenorhynchus asiaticus,* and *S. nigerica* Gupta, 1963 from *Phalacrocorax niger*.

The characters of the genus *Stephanoprora* Odhner, 1902, as given by Kostadinova (2005), are**:** Body small to large, fairly elongate with maximum width at level of ventral sucker or elongate-oval with maximum width at level of anterior testis. Forebody short or very long. Tegument armed with scale-like spines (length *c.* 30-50% of maximum collar-spine length) in alternating rows to level of gonads posteriorly. Tegumental spines or smaller dot-like spines may be present on anterior margin of oral sucker. Collar well

developed, with 22 collar-spines (26 in type-species only) in single row; angle spines, 2 x 2, smaller than marginal spines. Oral sucker spherical. Prepharynx long. Pharynx large. Oesophagus short. Intestinal bifurcation halfway between pharynx and ventral sucker or just anterior to ventral sucker. Caeca blind. Testes tandem, large, elongate-oval, smooth, rarely irregular, contiguous, equatorial, pre-equatorial or just post equatorial. Cirrus-sac oval, between intestinal bifurcation and ventral sucker or extending dorsally to mid-level of ventral sucker. Internal seminal vesicle saccular, bipartite. Pars prostatica short. Cirrus small, unarmed. Ovary small, round, median, separated from ventral sucker or fairly close to it. Mehlis' gland conspicuous, median. Uterus moderately long or extremely short, with few loops. Metraterm short, thin-walled. Eggs few. Vitelline fields between level of anterior testis and posterior extremity, spreading in post-testicular field but not confluent; follicles small. Stem of excretory vesicle chambered or not, with lateral diverticula; pore terminal. In intestine of wide range of fish-eating birds, mammals and reptiles (*Crocodilus, Caiman*); cosmopolitan. Cercaria lacking collar-spines, in prosobranch (*Hydrobia, Marsa, Pomacea, Juga*) and pulmonate (*Biomphalaria*)

gastropods; metacercaria with collar-spines, on gill or inner surface of oesophagus of freshwater, euryhaline or marine teleosts. Type-species *S. ornata* Odhner , 1902.

Genus *Ignavia* Freitas, 1948

Freitas (1948) erected the genus *Ignavia* with *I. venusta* from *Casmerodius albus egretta* and *Leucophoyx thula thula* in Brazil as its type species. Since then 8 nominal species have been added to this genus by several workers from different parts of the world. Of these, *Ignavia breviovarica* reported by Gupta (1962) from *Ardea purpurea* in Lucknow is the only species reported from lndia.

The characters of the genus *Ignavia* Freitas, 1948, as given by Kostadinova (2005), are: Body remarkably elongate (BW = 4-7%), with almost uniform width. Forebody very short (FO = 8-15%). Tegument armed; spines dense in forebody. Collar very small, reduced dorsally; ventral ridge absent. Collar-spines fairly small, 20, 22 or 24, in single row with wide dorsal interruption. Oral sucker large. Ventral sucker close to anterior extremity. Prepharynx long. Pharynx well developed. Oesophagus relatively long, sinuous, thick-walled, irregular in outline. Intestinal bifurcation just anterior to ventral sucker.

Caeca blind, narrow. Testes tandem, contiguous or separated, smooth, irregular or lobed, pre-equatorial (T = 51-66%). Cirrus-sac very small, oval, anterodorsal to ventral sucker, reaches its mid-level. Internal seminal vesicle bipartite. Pars prostatica short. Cirrus small, unspined. Genital pore median, just postbifurcal. Ovary transversely oval, median, pre-equatorial. Mehlis' gland diffuse, larger than ovary. Uterine seminal receptacle distinct. Uterus very short (U = 8-13%); metraterm indistinct; eggs not numerous. Vitellarium in two lateral extracaecal non-confluent fields of large follicles, between ventral sucker or mid-uterine level and posterior extremity. Stem of excretory vesicle very long; pore on terminal papilla. In ureter and urinary tubules of kidneys of birds (Ciconiiformes, Pelecaniformes, occationally Falconiformes); cosmopolitan. Type-species *I. venusta* Freitas, 1948

Genus *Pegosomum* Ratz, 1903

Ratz (1903) proposed the genus *Pegosomum* and designated *P. saginatum* (Ratz, 1897), from *Ardea alba* in Europe as its type. Since then more than 10 species have been added to this genus from different parts of the world.

Among these, 4 species are reported from India, all infecting the cattle egret, *Bubulcus ibis*: *P. egretti* Srivastava, 1957, *P. indicum* Saxena, 1960, *P. kulbehri* Dwivedi, 1967, and *P. lucknowensis* Pandey, 1975. Pandey (1975) transferred *P. indicum* to the genus *Episthmium* and named it as *E. indicum* (Saxena, 1960). Srivastava (1982) expressed doubt regarding the validity of *P. lucknowensis* and *P. kulbehri* and stated that all the Indian species of the genus *Pegosomum* from *B. Ibis* are one and the same showing wide range of variation. Thus, *P. egretti* is the only valid Indian species in the genus *Pegosomum*.

The characters of the genus *Pegosomum* Ratz, 1903, as given by Kostadinova (2005), are: Body medium to large, muscular, leaf like, with maximum width at level of ventral sucker (BW = 30-40%). Forebody very long (FO=25-45%). Entire tegument armed. Collar poorly developed, with 25 or 27 spines with blunt rounded ends in double row uninterrupted dorsally; angle spines 2 x 4, subcylindrical, longer than marginal spines. Oral sucker absent or rudimentary. Ventral sucker small, in the second quarter of body. Pharynx large, muscular. Oesophagus long, straight or

undulating, with or without lateral diverticula. Intestinal bifurcation in mid-forebody or slightly posterior. Caeca blind, sinous, undulating. Testes tandem, large, transversely oval, smooth, indented or lobed, postequatorial occupy most of the posterior half of body (T = 20%), in mid hindbody (T = 10-20%). Cirrus-sac large, oval, thin-walled, anterior to ventral sucker. Internal seminal vesicle tubular, bipartite, curved. Pars prostatica prominent. Muscular ‘fastening apparatus’ (‘verschlussapparat’) between seminal vesicle and ejaculatory duct present. Cirrus massive, muscular, smooth. Genital pore midway between ventral sucker and intestinal bifurcation. Ovary oval to transversely oval, smooth, indented or lobed, dextral, just pre-equatorial. Mehlis’ gland distinct, median. Uterus very short with few intercaecal loops (U=0-10%). Metraterm fairly muscular, slightly longer than cirrus-sac. Vitellarium follicular, reticulate or dendritic in two wide lateral fields between level of pharynx or mid-oesophagus and posterior extremity or either anterior or posterior testis; fields confluent in forebody anteriorly to cirrus-sac. Excretory pore terminal. In bile-duct or gall-bladder of birds (Ardeidae); Europe, Asia, North America, Africa. Type-species *P. saginatum* (Ratz, 1897) Ratz, 1903.

Genus *Psilorchis* Thapar and Lal, 1935

Thapar and Lal (1935) established the genus *Psilorchis* with *P. indicus* from the birds, *Halcyon smyrnensis, Psittacula krameri* and *Alcedo atthis insipida* in Lucknow as its type species. Altogether 17 species of *Psilorchis* have been reported from different hosts from various parts of the world. Of these, 11 are from Indian birds: the type species*, P. indicus* Thapar and Lal, 1935*; P. ajgainis* Lal, 1938 from *Nettion crecca; P. halcyoni* Chatterji, 1948 from *H. smyrnensis*; *P. thapari* Baugh, 1949 from *Athene brama indica*; *P. mehrai* Gupta, 1956 from *A. insipida*; *P. ketupai* Chatterji, 1956 from *Ketupa zeylonensis*; *P. seekhpari* Jain, 1968 from *Anas acuta*; *P. lucknowensis* Pandey, 1975 from *H. smyrnensis; P. udaipurensis* Sharma, 1977 from *Tadorna ferrugine; P. atkinsoni* Sharma, Lal and Lata, 1984, from *Anas penelope,* and *P. ranchiensis* Sahay, Sahay and Verma, 1990 from *Ardeola grayi* . Mehra (1980) synonymised six Indian species, *P. ajgainis, P. halcyoni, P. thapari, P. mehrai, P. ketupai* and *P. seekhpari,* with *P. indicus.* Srivastava (1982) treated *P. lucknowensis* Pandey, 1925 and *Indopseudoechinostomum udaipurensis* described by Sharma

(1977) from *H. smyrnensis* as synonym of *P. indicus.* Kostadinova (2005) transferred *P. udaipurensis* to genus *Hypoderaeum* Dietz, 1909 and considered *P. ranchiensis* as an echinostome having 44 collar spines. Thus out of the 11 species of the genus *Psilorchis* reported from Indian birds only two species, *P. indicus* and *P. atkinsoni*, are valid.

The characters of the genus *Psilorchis* Thapar and Lal, 1935, as given by Kostadinova (2005), are: Body small to medium, elongate (BW = 14-23%), with almost parallel margins and maximum width at mid-level of uterus. Forebody notably short (FO = 11-12%). Tegument unarmed?. Oral sucker small, subspherical, and much smaller than ventral sucker. Ventral sucker large, spherical, in first quarter of body. Pharynx small, elongate-oval, comparable in size to or larger than oral sucker. Oesophagus very short. Intestinal bifurcation just post-pharyngeal. Testes elongate-oval, smooth or indented, contiguous or separated, in third quarter of body (T = 21-26%). Cirrus-sac small, elongate-oval, entirely anterior to ventral sucker. Internal seminal vesicle simple, occupies almost entire cirrus-sac. Pars prostatica indistinct. Genital pore dextral (?), halfway between intestinal

bifurcation and ventral sucker. Ovary small, sub-globular, submedian, equatorial or just postequatorial. Mehlis' gland diffuse, submedian, contiguous with ovary and anterior testis. Uterus long (U = 25-31%), coiled. Metraterm long. Eggs < 130 µm long. Vitelline fields non-confluent; anterior limits at some distance posterior to ventral sucker; follicles small. Arms of excretory vesicle with numerous ramifications; pore terminal. In intestine of birds (Alcedinidae); India. Type-species *P. indicus* Thapar & Lal, 1936.

Genus *Basantisia* Pande, 1938

The genus *Basantisia* was established by Pandey (1938) with *Basantisia ramai* from the kingfisher, *Ceryle rudis leucomelanura* in North India as its type. Later, Murhar (1960) reported the same species from the domestic pegion, *Columba domestica* in Nagpur. Since then, 11 nominal species have been were added to this genus from various parts of the world*: B. queenslandensis* Deblock and Pearson, 1968 from *Dacelo gigas*; *B. halcyonae* Oshmarin, Alexiev and Smetanina, 1969 from *Halcyon sancta* ; *B. prolecithum* (Oschmarin 1963) Deblock, 1973 from *Alcedo atthis*; *B. sabahensis* (Fischthal & Kuntz 1973) from *Copsychus saularis*;

B. aequabilis Ke, Liu and Huang, 1985 from *Halcyon smyrnensis*; *B. badzrii* Pearson and Deblock, 1986 from *Pelargopsis capensis*; *B. bidaii* Pearson and Deblock, 1986 from *Halcyon pileata*; *B. forcipulata* Pearson and Deblock, 1986 from *H. chloris*; *B. labidomeda* Pearson and Deblock 1986 from *H. chloris*; *B. pearsonorum* Pearson and Deblock, 1986 from *H. chloris,* and *B. ridwani* Pearson and Deblock, 1986 from *H. chloris.* Of the 12 species, only the type species is reported from Indian birds.

The characters of the genus *Basantisia* Pande, 1938, as given by Deblock (2008), are: Body fusiform, linguiform or pyriform if contracted; medium-sized to large (300-1000µm). Oral sucker generally larger than ventral. Ventral sucker embedded in parenchyma or not. Oesophagus short or medium-sized. Caeca short and in forebody or medium and at level of ventral sucker, more or less divergent, partly marginal or not; deep prominent gastrodermis may occur. Testes in mid-hindbody, slightly asymmetrical. Vesiculoprostatic pouch horse-shoe shaped, encircling ventral sucker or not; seminal PI 2 plate present. Elasmocotyle with three rather voluminous pieces, more or less sclerotized;

dorsal piece short. Genital musculature more or less developed. Genital atrium dextral, simple, present. Genital pore dextrally posterolateral to ventral sucker. Ovary sinistral to ventral sucker, slightly posterior to vesiculoprostatic pouch. Uterine coils postcaecal with extratesticular loops or not. Uteroterm present. Vitellarium composed of two clusters of about ten rounded follicles, postcaecal, anterior to testes, not marginal; vitelline ducts pretesticular, transverse, medium-sized. Excretory vesicle short, intertesticular, I-shaped. In intestine of birds (mainly Coraciiformes); Indian area, Eastern Asia, Australia. Type-species *B. ramai* Pande, 1938.

Genus *Nigerina* Baugh, 1958

Baugh (1958) created the genus *Nigerina* and designated *Nigerina hardoiensis* as its type, which was collected from the liver and gall bladder of the little cormorant, *Phalacrocorax niger* in Hardoi, Uttar Pradesh. *Amphimerus interruptus* reported by Braun (1901) from *Casmerodius albus* in Mexico was later shifted to the genus *Nigerina* by Scholz (2008). Thus, the genus at present has two

valid species: *Nigerina hardoiensis* Baugh, 1958 and *N. interruptus* (Braun, 1901) Scholz, 2008.

The characters of the genus *Nigerina* Baugh, 1958, as given by Scholz (2008), are**:** Body elongate, slightly widened posteriorly, with ruffled lateral margins forming conical lateral projections with concentration of muscle fibers. Tegument unspined. Oral sucker well developed, terminal or subterminal. Ventral sucker smaller than oral sucker, in anterior third of body. Prepharynx absent. Oesophagus short. Intestinal bifurcation near anterior extremity. Caeca reach posterior extremity. Testes round, diagonal, near posterior extremity. Ovary median, oval, pretesticular. Seminal receptacle posterolateral to ovary. Laurer's canal present. Uterus intercaecal, between ovary and ventral sucker. Vitellarium poorly developed; follicles in lateral fields of hind-body (postequatorial), reach posteriorly as far as to posterior testis. Excretory vesicle with sigmoid stem, passes between testes; pore terminal. In gall-bladder, liver and intestine of piscivorous birds; Asia (India) and the Americas. Type-species *N. hardoiensis* Baugh, 1958.

Genus *Centrocestus* Looss, 1899

Looss (1899) proposed the genus *Centrocestus* and designated *C. cuspidatus* from the kite, *Milvus parasiticus* in Egypt as the type species which was described by him in 1896 as *Distomum cuspidatum.* Leiper (1913) described *C. cuspidatus caninus* which was considered a synonym of *C. cuspidatus* by Ransom (1921). Tanabe (1922) established the genus *Stamnosoma* to receive *S. armatum* which was closely similar to *Centrocestus.* Nishigori (1924a) added another species, *S. formosanum,* to the genus *Stamnosoma.* Faust and Nishigori (1926) considered *C cuspidatus caninus* as a synonym of *Stamnosoma formosanum.* But Chapin (1926), Fuhrmann (1928), Witenberg (1929), Price (1932), and Stiles and Baker (1934) treated *Stamnosoma* as a synonym of *Centrocestus.* Later, Faust (1937) suppressed the genus *Stamnosoma* in favour of *Centrocestus.* Among the species of *Centrocestus* described by various authors, Chen (1942) recognised only 3 species as valid: *C. cuspidatus* (Looss, 1896) Looss, 1899; *C. armatus* (Tanabe, 1922) Price, 1932, and *C. formosanus* (Nishigori, 1924) Price, 1932. Of these, only one species, *C. formosanus* has been reported from India.

The characters of the genus *Centrocestus* Looss, 1899*,* as given by Pearson (2008), are: Body scaly, < 1.00 mm long. Oral sucker with dorsal lip demarcated by inner transverse groove, with two circles of spines. Ventral sucker with axis dorsoventral or inclined anteriorly. Testes two, opposite. Seminal vesicle bipartite. Gonotyl absent. Ventrogenital sac facultative; genital part thick-walled and eversible. Ovary entire. Seminal receptacle canalicular. Eggs 30-40 x 15-19 µm. In birds and mammals; Africa, Eurasia, Indonesia, Phillippines, Japan, Hawaii. Type-species *C. cuspidatus* (Looss, 1896) Looss, 1899.

Genus *Stellantchasmus* Onji and Nishio, 1916

Onji and Nishio (1916) established the genus *Stellantchasmus* and designated *S. falcatus,* recovered from cats experimentally fed with the mullet, *Mugil cephalus* harboring the metacercariae, as its type species. Of the 7 nominal species described in the genus *Stellantchasmus,* Pearson and Ow-Yang (1982) treated only 4 species as valid. These are *S. falcatus* Onji and Nishio, 1916, *S. aspinosus* Pearson, 1964, *S. batillans* Pearson, 1964 and *S. gallinae* (Oshmarin, 1971). The Indian report of the genus is limited to

the description of metacercariae of *S. falcatus* from fishes by Rekharani and Madhavi (1985).

The characters of the genus *Stellantchasmus* Onji and Nishio, 1916, as given by Pearson (2008), are: Body pyriform. Tegument scaly. Ventral sucker sucker-like with axis inclined antero-sinistrally, unarmed or armed with minute spines or single sclerite. Distal chamber of seminal vesicle an expulsor. Gonotyl unarmed. Male and female pores separate, not on gonotyl. Testes two and symmetrical or tandem; or one and sinistral. Ventrogenital sac permanent. Seminal receptacle canalicular. Eggs 23 x 12 µm. In birds and mammals; Eurasia, Australasia, Hawaii. Type-species *S. falcatus* Onji and Nishio, 1916.

Genus *Haplorchis* Looss, 1899

In 1899 Looss created the genus *Haplorchis* and designated *Haplorchis pumilio* from the bird, *Pelecanus onocrotalus* in Egypt as the type species, which was described by him in 1896 as *Monostomum pumilio.* Since then, over 25 nominal species have been added to this genus from different parts of the world. As far as is known, only 3 valid species are reported from Indian birds and mammals. These are,

Haplorchis pumilio (Looss, 1896), Looss, 1899 from *Bubulcus ibis* and *Ardeola* grayii; *H. taichui* Nishigori, 1924 from *Vulpus bengalensis, Sus scrofa* and *Canis familiaris,* and *H. yokogawai* (Katsuta, 1932) Chen, 1936 from *Buteo rufinus* and *Milvus migrans.*

The characters of the genus, *Haplorchis* Looss, 1899, as given by Pearson (2008), are: Body pyriform. Tegument scaly. Ventral sucker with reduced cavity, with axis inclined anteriosinistrally, bilaterally symmetrical or asymmetrical, armed with spines or toothed sclerites. Testis single. Ventrogenital sac permanent; dorsal pocket unarmed or armed with spines and spiny plates. Gonotyle absent. Seminal vesicle bi- or tripartite, thin-walled. Seminal receptacle canalicular, dextral to ovary. Eggs 24-30 x 13-16 µm. In birds and mammals; Africa, Eurasia, Australia, Hawaii. Type-species *H. pumilio* (Looss, 1896) Looss, 1899.

Genus *Clinostomum* Leidy, 1856

The genus *Clinostomum* was proposed by Leidy (1856), and Braun in 1899 designated *Clinostomum complanatum* as its type species. Since then over 40 nominal species have been added to the genus from various parts of the world.

Southwell and Prashad (1918) described the metacercaria of *C. piscidium* from *Trichogaster fasciatus* and *Nandus nandus*; this forms the first record of the genus from India.

Subsequently, 17 species were described in the genus from India either as metacercariae and/or adults. These are: *C. prashadi* Bhalerao, 1942, *C. dasi* Bhalerao, 1942, *C. gydeoni*, Bhalerao, 1942, *C. indicum* Bhalerao, 1942, *C. anusi* Wesley, 1944, *C. kalappahi* Bhalerao, 1947, *C. shizothoraxi* Kaw, 1950, *C. deccanum* Jaiswal, 1957, *C. demiegretta* Jaiswal, 1957, *C. hyderbadensis* Jaiswal, 1957, *C. singhi* Jaiswal, 1957, *C. macrosomum* Jaiswal, 1957, *C. mastacembali* Jaiswal, 1957, *C. progonum* Jaiswal, 1957, *C. giganticum* Agarwal, 1959, and *C. orientale* Mukherjee, 1968. Siddiqui and Nizami (1982) and Firdaus (1984, 1988) reported the metacercaria of *Clinostomum complanatum* (Rudolphi, 1819) Braun, 1899 from freshwater fishes in India.

Due to high degree of morphological variability within the same species, *Clinostomu*m has been subjected to several taxonomic revisions. Ukoli (1966a), in a revisionary study of the species described the genus *Clinostomum*, synonymised 20 species including 18 Indian species with *C. complanatum,*

and recognised 13 valid species. Subsequent to Ukoli's work some of the Indian species were treated as valid by a few workers. These are, *C. piscidium* by Pandey and Baugh (1969) and Singh and Verma (1978), *C. dasi* by Jain and Deepchandra (1979), *C. indicum* by Nama (1980), *C. Shizothoraxi* by Dhar and Majdah (1988), and *C. macrosomum* by Karyakarte and Yadav (1972), and *C. giganticum* by Baugh and Pandey (1969), Chakraborti (1974) and Sinha *et al*. (1988). However, no justification was given by the authors for validating these species. Yamaguti (1971) partly accepted the revision made by Ukoli (1966a) and listed a total of 26 valid species among which 16 were described on the basis of adults, 7 only as metacercariae and 3 occasionally isolated as adults from the mouths of cats. Feizullaev and Mirzoeva (1983) reviewed the systematic history of Clinostomoidea and agreed with Ukoli. Mattews and Cribb (1998) revalidated *C. hornum* Nicoll, 1914 and *C. australiense* Jonston, 1917 which were treated as synonyms of *C. complanatum* by Ukoli (1966a), and added a new species *C. wilsoni*. They indicated the need for a revision of the genus using molecular techniques. Dzikowski (2004) recognized *C. complanatum* and *C. marginatum* (Rudolphi,

1819) as distinct taxa based on 18s rRNA sequences. Nolan and Cribb (2005) also stressed the importance of applying diagnostic molecular approach to Clinostome systematics. In the light of these suggestions, it is not reasonable to determine the total number of recognized species in the genus. By virtue of various synonymies, *C. complanatum* has emerged as the cosmopolitan species widely distributed in most of the countries of the world, and is considered as the only valid species of the genus reported in India.

The characters of genus *C. complanatum* (Rudolphi, 1819) Braun, 1899, *as* given by Kanev *et al.* (2002), are: Body medium to large, linguiform, stout, convex dorsally and concave ventrally. Oral sucker surrounded by collar-like fold when retracted. Ventral sucker muscular well developed. Caeca long, simple, with more or less sinuous wall, especially in anterior half of body, but without long lateral branches or diverticula. Testes smooth or irregular in shape, in posterior half of body. Cirrus-sac and genital pore pretesticular or lateral to anterior testis. Ovary intertesticular, submedian. Vitelline follicles in lateral fields between posterior extremity and level of ventral sucker. Uterus intercaecal, between

Mehlis' gland and ventral sucker. Cosmopolitan. Type-species *C. complanatum* (Rudolphi, 1819) Braun.

Genus *Euclinostomum* Travassos, 1928

Rudolphi (1809) described *Distoma heterostomum* from the purple heron, *Ardea purpurea* in Europe, and Braun (1899) transferred it to the genus *Clinostomum* Leidy, 1856 and named it *Clinostomum hetrostomum*. Travassos (1928) created the genus *Euclinostomum* for clinostomes with long caecal diverticula and shifted *C. heterostomum* to the new genus as its type and renamed it *E. heterostomum* (Rudolphi, 1809). Subsequently, 12 nominal species have been described in this genus either as metacercariae and/or adults from different parts of the world. Of these, 5 are recorded from India: *E. heterostomum* (Rudolphi, 1809) Travassos, 1928; *E. indicum* Bhalerao, 1942, *E. heptacaecum* Jaiswal, 1957; *E. bagavantami* Jaiswal , 1957, and *E. channai* Jaiswal, 1957. Ukoli (1966b) considered all Indian species of the genus as synonyms of *E. heterostomum* and regarded only two species of the genus, *E. heterostomum* (Rudolphi, 1809) Travassos, 1928 and *E. multicaecum* Tubangui and Masilungan, 1935, as valid. This view was accepted by Dennis

and Sharp (1973). Jansilakshmibai and Madhavi (1997) also accepted this view and considered 2 more species *E. minutus* Zaidi and Khan, 1975 and *E. ardeolae* El. Naffar and Khalifa, 1981, as valid. Thus, this genus at present has 4 recognised species.

The characters of the genus *Euclinostomum* Travassos, 1928, as given *by* Kanev *et al*. (2002), are: Body stout, linguiform. Oral sucker may or may not be surrounded by collar-like fold. Ventral sucker well-developed, relatively close to oral sucker. Caeca long, with numerous lateral diverticula branching from lateral walls between level of ventral sucker and posterior extremity. Testes irregular in shape, in posterior half of body. Cirrus-sac small, oval, pretesticular. Genital pore immediately pretesticular, median or submedian. Ovary intertesticular, submedian, oval. Vitelline fields well developed, extend from posterior end of body to ventral sucker; follicles surround caecal branches in hindbody. Uterus reaches forward to ventral sucker. In buccal cavity and oesophagus of piscivorous birds. Europe, Asia, Africa, America. Type-species *E. heterostomum* (Rudolphi, 1809) Travassos, 1928.

Genus *Mesostephanus* Lutz, 1935

Price in 1934 described *Prohemistomum fajardensis* from *Sula brasiliensis* and *S. leucogaster* in Brazil. Lutz (1935) created the genus *Mesostephanus*, shifted *P. fajardensis* to the new genus, renamed it *Mesostephanus fajardensis*, and designated it as the type. Since then over 15 valid species have been reported under the genus *Mesostephanus* from different parts of the world. Of these, 3 are from Indian birds: *M. milvi* Yamaguti, 1939 from *Milvus migrans* (Syn. *M. indicus* Vidyarthi, 1948); *M. indicum* Mehra, 1947 from *Buteo rufinus rufinus,* and *M. neophroni* Baugh, 1958 from *Neophron percnopterus giganus*.

The characters of the genus *Mesostephanus* Lutz, 1935, as given by Niewiadomska (2002), are: Body oval or linguiform, foliiform or cochleariform, with ventral concavity in posterior part of body and small dorsoterminal appendage at end of body. Oral sucker, ventral sucker and pharynx moderately developed; oesophagus rather short; caeca reaching close to posterior extremity. Ventral sucker at about middle of body. Holdfast organ protrusible, small or medium

in size, round, with median slit or central cavity. Testes subspherical or oval, tandem. Cirrus-sac well developed. Genital pore terminal. Ovary round, posterior or posterolateral to anterior testis, opposite cirrus sac. Vitellarium of large follicles, posterior to ventral sucker, surrounding holdfast organ and gonads but not confluent posteriorly. Vaginal sphincter ellipsoidal, sometimes indistinct but always present. In birds and mammals. Cosmopolitan. Metacercariae of 'prohemistomulum' type, in fishes or amphibians. Cercariae with flame-cell formula 2[(3+3+3) + (3+3+[3])] = 36. Type-species *M. fajardensis* (Price, 1934) Lutz, 1935.

Genus *Subuvulifer* Dubois, 1952

Gogate (1940) reported *Procrassiphiala halcyonae* from the white-breasted kingfisher, *Halcyon smyrnensis.* Dubois in 1952 erected the genus *Subuvulifer* and shifted *P. halcyonae* to the new genus as its type species and named it *Subuvulifer halcyonae* (Gogate, 1940). In 1964 Dubois synonymised *Allodiplostomum fuscai* Chatterji, 1956 from *H. smyrnensis*, *Choanochenia hawanensis* Yang, 1959 from *H. smyrnensis* and *C. stomospinosa* Yang, 1959 from *H. pileatus* with *S. halcyonae*. Subsequently, 2 species*, S. sabahensis* (Fischthal

et Kuntz, 1973) Dubois, 1977 and *S. glandulaxiculus* Pearson and Dubois, 1985 were added to the genus *Subuvulifer.*

The characters of the genus *Subuvulifer* Dubois, 1952, as given by Niewiadomska (2002), are: Body bipartite; forebody oval, cochleariform; hindbody subcylindrical, about two to three times longer than forebody; pseudosuckers present. Holdfast organ round, small, one-quarter to one-third of forebody length. Ventral sucker larger than oral sucker; pharynx rather small. Testes tandem, massive, lobed, similar in size. Ovary spherical or ellipsoidal, median, pretesticular, near middle of hindbody. Vitellarium in hindbody, penetrates forebody to level of holdfast organ, but less densely distributed than in hindbody. Seminal vesicle large, without ejaculatory pouch. Copulatory bursa encloses genital cone, which is surrounded ventrolaterally at its base by prepuce-like fold. Hermaphroditic duct opens terminally on genital cone. In Alcedines. Asia. Type-species *S. halcyonae* (Gogate, 1940) Dubois, 1952.

Genus *Uvulifer* Yamaguti, 1934

Yamaguti (1934a) erected the genus *Uvulifer* with *U. gracilis* from the king fisher, *Ceryle lugubris* in Japan as its

type species. Although the species resembled the members of the genus *Crassiphiala* Van Haitsma, 1925, the new genus differed in the presence of a well developed ventral sucker which is smaller than oral sucker and in having a dorsoterminal sucker-like genital atrium which terminated in a uvula-like muscular appendage. Yamaguti (1934b) established another genus *Pseudodiplostomum* distinguishing it from *Uvulifer* in that its acetabulum is larger than oral sucker and the uvula-like muscular appendage in the genital atrium is absent. Harwood (1936) synonymised *Uvulifer* and *Pseudodiplostomum* with *Crassiphiala* and transferred the type species of the two genera to *Crassiphiala*. Dubois (1938), after a comprehensive study, recognized the validity of *Uvulifer* and *Pseudodiplostomum* and treated the two genera as valid. Yamaguti (1971) listed 9 species under the genus *Uvulifer*. Since then, 8 species have been added to this genus by several workers all over the world. Of the valid 17 species, 6 are reported from Indian birds. These are, *U. ceryliformes* (Vidyarthi, 1938) Bhalerao, 1942 from *Ceryle rudis leucomelaneura*; *U. stunkardi* (Pande, 1938) Bhalerao, 1942 from *Halcyon smyrnensis fusca*; *U. cochlearis* (Verma, 1936) Dubois, 1944 from *Alcedo atthis insipida U. mehrai*

Chatterji, 1956 from *H. smyrnensis*; *U. giriencis* Mishra and Gupta, 1980 from *Ceryle lugubris,* and *U. chandigarhensis* Mishra and Gupta, 1980 from *H. smyrnensis*.

The characters of the genus *Uvulifer* Yamaguti, 1934, as given by Niewiadomska (2002), are: Body distinctly bipartite; forebody oval, cochleariform; hindbody claviform, much longer than forebody. Pseudosuckers absent; ventral sucker smaller than oral; pharynx small. Holdfast organ round, small, 15-30% of body length. Testes round, tandem, in posterior region of hindbody. Ovary ellipsoidal or spherical, pretesticular. Vitellarium in hindbody often confined to posterior region. Seminal vesicle followed by muscular ejaculatory pouch situated dorsally. Copulatory bursa moderate or large, with protrusible genital cone half enclosed by ventrolateral preputial fold. Hermaphroditic duct opens at apex of cone. In Alcedines. Holarctic, Neotropical and Oriental regions. Metacercariae of 'neascus' type, in fishes. Cercariae with rudimentary caeca, three pairs of penetration glands arranged in rows and flame-cell formula 2[1+1+1) + (1+1+1 + [2])] = 16. Type-species *U. gracilis* Yamaguti, 1934.

Genus *Apharyngeostrigea* Ciurea, 1927

Ciurea (1927) proposed the genus *Apharyngostrigea* and designated *Apharyngostrigea cornu* as the type species, which was described by Zeder in 1800 as *Distoma cornu.* As far as is known, more than 15 recognised species have been reported in the genus *Apharyngostrigea*, and among these only two are reported from Indian birds. These are, *A. egretti* Verma, 1936 from *Bubulcus coramandus* and *B. ibis,* and *A. ramai* (Verma, 1936) Vidyarthi, 1937 from *Nycticorax nycticorax, Ardeola grayi, B. ibis, Ardea cineria, Egretta alba, N. nycticorax,* and *Pelicanus philippinus.*

The characters of the genus *Apharyngostrigea* Ciurea, 1927, as given by Niewiadomska (2002), are**:** Body bipartite; forebody oval, pyriform or calyciform, lacking lateral expansions; hindbody cylindrical to claviform, curved dorsally, with constriction near region of copulatory bursa. Oral and ventral suckers feebly developed. Pharynx absent. Testes multilobed. Ovary reniform, near middle of hindbody. In forebody, vitellarium extends into dorsal and lateral body wall and into holdfast organ (mainly dorsal lobe); in hindbody, it reaches copulatory bursa. Genital cone more or less distinctly delimited from body parenchyma. Muscular ring surrounding

genital cone feebly developed or indistinct. Hermaphroditic duct opens at apex of genital cone. In ardeids. Cosmopolitan. Metacercaria of ‘tetracotyle’ type in fishes. Cercariae with flame-cell formula 2[(2+2) + (2+2 [2])] = 20, two excretory commissures, one anterior and one posterior to ventral sucker, two groups of seven or four penetration glands anterior and lateral to ventral sucker. Type-species *A. cornu* (Zeder, 1800) Ciurea, 1927.

MATERIALS AND METHODS

Collection and maintenance of Bird hosts

Birds used for the present investigation were collected from Iruvetty and Puthurpallikkal in Malappuram and Ramanattukara and Cheruvady in Kozhikkode districts of Kerala. Collections were made during a period of 7 years and 11 months, from June 2001 to April 2009. Sixteen species of birds (Plates 1 and 2) were collected mainly from the roosting sites and from the premises of water bodies. A classified list of birds collected, with their localities, period of collection and number examined, is presented here.

List of birds examined for digenetic trematodes

Classification and name of birds	No. of birds examined	Locality of collection	Period of collection
Family: Ardeidae			
Ardeola grayii Sykes	16	Iruvetty and Puthurpallikkal in Malappuram, and Cheruvady and Ramanattukara in Kozhikkode districts	March 2002-December 2008

Classification and name of birds	No. of birds examined	Locality of collection	Period of collection
Egretta garzetta Linnaeus	8	Iruvetty, Puthur pallikkal and Cheruvady	October 2002-February 2009
Bubulcus ibis Linnaeus	12	Iruvetty, Puthur pallikkal, Ramanattukara and Cheruvady	January 2002-March 2009
Family:Ciconiidae			
Anastomus ocitans Boddaert	1	Cheruvady	August 2005
Family:Phalacrocoracidae			
Phalacrocorax niger Vieillot	13	Iruvetty, Puhurpallikkal Ramanattukara and Cheruvady	September 2003-August 2008
Family : Strigidae			
*Athene brama*Temminck	1	Iruvetty	December 2003
Family : Dacelonidae			
Halcyon smyrnensis Linnaeus	16	Iruvetty, Puthur pallikkal and Cheruvady	March 2004-April 2009
Family : Alcedinidae			
Alcedo atthis Linnaeus	7	Iruvetty and Puthur pallikkal	June 2001-April 2004
Family :			

Classification and name of birds	No. of birds examined	Locality of collection	Period of collection
Sturnidae			
Acridotheres tristis Linnaeus	4	Iruvetty and Cheruvady	June 2002-March 2003
Family : Corvidae			
Corvus splendens Vieillot	5	Iruvetty and Ramanattukara	March 2004-May 2006
Corvus macrorhyncus Wagler	4	Iruvetty and Ramanattukara	June 2002-March 2003
Family : Rallidae			
Amourornis phoenicurus Pennant	4	Iruvetty	September 2006-April 2008
Family : Charadridae			
Vanellus indicus Boddaert	1	Iruvetty	September 2002
Family :Accipitridae			
Accipiter badius Gmelin	2	Iruvetty	February 2006 and December, 2007
Milvus migrans Boddaert	3	Cheruvady	March 2006 - March 2007
Family: Phasianidae			
Gallus gallus Linnaeus	4	Puthurpallikkal	March 2009

Birds were brought to the laboratory either alive or dead. Dead birds were immediately dissected and examined for digenetic trematodes, while live specimens were maintained in clean cages and fed occasionally with infection free insects, fishes or frogs.

Recovery and study of digenetic trematodes

The live birds were killed later using chloroform for the recovery of trematodes. Buccal cavity and pharynx of the birds were thoroughly examined for parasites. The internal organs like stomach, intestine, rectum, urinary bladder, lungs, kidney, heart, liver and pancreas were dissected out from each bird, placed in separate petridishes containing 0.75% saline, teased apart and examined under a dissecting microscope for parasites.

The trematodes when present were carefully removed and collected in 0.75% saline taken in a petridish. The flukes were transferred into a drop of saline taken on a glass slide, covered with a No.l cover glass, and observed under a phase contrast research microscope with or without supravital staining to study their structural details. Vital stains like neutral red, Nile blue sulphate or methylene blue were used as 0.1% solution diluted to 0.01% in saline. The cuticular and collar spines were studied by staining with 0.01% Lugol's iodine solution. Gravid flukes were allowed to lay eggs by keeping them overnight in saline. The eggs were then transferred on to a slide with a drop of water and observed

under oil-immersion objective of the phase-contrast microscope. Observations were also made on fixed and stained specimens. For permanent whole mounts the trematodes were fixed in 5% formalin or AFA under slight cover glass pressure, and stained in alum carmine, following the procedure outlined by Cantwell (1981). Data on prevalence and intensity of infection by trematodes were collected. The ecological terms, prevalence, intensity and site used here are in accordance with the definition of Margolis *et al.* (1982).

Experimental infection studies

Experiments were conducted in the laboratory to trace the life-cycle, from cercariae to egg-producing adults, of *Uvulifer* sp. 1 n. sp. infecting *Halcyon smyrnensis*. Freshwater snails*, Lymnea luteola, Bellamya dissimilis* and *Paludomus transcharicus* were collected from the water bodies of the area from where infected birds were collected. The snails were kept in beakers containing tap water, screened for infection with furcocercous cercariae. *Indoplanorbis exustus* was the only snail found releasing furcocercous cercariae. The infected snails were isolated and the shed cercariae were

studied alive, with or without vital staining, under a phase-contrast microscope. Genital primordium was observed in lacto acetic carmine stained cercaria. Measurements were taken from heat-killed cercariae. Intramolluscan stages of development were studied by crushing the infected snails.

The water bodies where infected snails inhabit were searched for the suspected second intermediate hosts of the trematode. Tadpoles and adults of *Euphlyctis cyanophlyctis* and *Hoplobatrachus tigerinus* and the fishes like *Rasbora daniconius, Puntius sophore* and *Aplocheilus lineatus* were collected from these water bodies and examined for natural infection with metacercariae. The black pigmented metacercariae, suspected to be that of *Uvulifer* species, were found only in tadpoles and adults of *E cyanophlyctis.* For experimental infection studies, infection-free tadpoles of *E. cyanophlyctis* were collected from a pond in the Calicut University campus and maintained in aquarium tanks in the laboratory.

Furcocercous cercariae shed by *I. exustus* were used in experimental infection studies. Tadpoles were exposed to cercariae and sacrificed periodically to follow the course of

the development of metacercariae. To obtain the adult flukes experimentally, infective metacercariae from natural infections or from experimentally infected tadpoles were fed to 6 laboratory born, 1-week old nestlings of *H. smyrnensis*. The development of adult flukes was followed by sacrificing the fed birds periodically. The metacercariae and the adults were observed with or without supravital staining.

Photographs, measurements and sketches

Photomicrographs of the live/stained trematodes were taken under the phase contrast objectives of Carl Zeiss Axioscop two plus trinocular research microscope. Measurements were taken with the aid of a calibrated ocular micrometer; measurements are in micrometres (µm); the range is followed by the mean values in parentheses. Descriptions are based on measurements of a minimum of 10 specimens where the number of recovered specimens exceeded 10, whereas in others based on measurements of all the specimens recovered are used. Sketches were made with the aid of camera lucida and details added free hand from observations made on live specimens.

RESULTS

Family: Echinostomatidae Poche, 1925.

Genus: *Nephrostomum* Dietz, 1909

Nephrostomum ramosum (Sonsino, 1895) Dietz, 1909

Natural infections with the adults of the present fluke were found in the intestine of the cattle egret, *Bubulcus ibis* collected from Iruvetty and Puthurpallikkal during April and May of 2004 and 2006. Four birds were positive for this fluke. The intensity of infection varied from 1 to 3. In one bird the present fluke was found along with *Pegosomum egretti* and in another it was found with *P. egretti* and *Clinostomum complanatum.*

Description (Fig. 1; Table 1; Plate 4):

Body large, elongate, aspinose, with maximum width at the middle; 11904-16375 (14140) x 2637-3625 (3130). Forebody 916-1960 (1536) long, 8-11 (10)% of body length. Head collar conspicuous, reniform, 1325-1817 (1721) wide, armed with 48 spines. Spine arrangement: 4 small angle spines on each ventrolateral lappet, 2 oral and 2 aboral,

(27 x 13); 16 lateral on each side in single row, (33 x 18), and 8 dorsal spines (22 x 8) in a single row. Oral sucker ovoid, 231- 246 (239) x 360-339 (349). Ventral sucker large, cup

Table 1. Measurements (µm) of adults of *Nephrostomum ramosum* (Sonsino, 1895) Dietz, 1909

Character	Range	Mean
Body size	11904-16375 x 2637-	14140 x 3130
Forebody	3625	1536
Collar width	916-1960	1721
Oral sucker	1325-1817	239 x 349
Ventral sucker	231-246 x 360-339	1640 x 1434
Prepharynx	1408-1872 x 1152-	85
Pharynx	1716	293
Oesophagus	39-131	427
Anterior testis	231-308	972 x 814
Posterior testis	316-539	921 x 629
Cirrus sac	539-1404 x 692-936	656 x 412
Ovary	516-1326 x 400-858	497 x 803
Eggs	454-858 x 277-546	45 x 25
	400-593 x 670-936	
	43-46 x 23-26	

shaped, in anterior quarter of body; 1408-1872 (1640) x 1152-1716 (1434). Sucker width ratio 1: 4.22-6.29 (5.25). Prepharynx 39-131 (85) long. Pharynx globular, 231-308 (293) in size. Oesophagus 316-539 (427) long. Intestinal bifurcation 468-546 (494) anterior to ventral sucker. Caeca slender, terminate blindly 234-312 (281) from posterior end of body.

Testes two, median, tandem, lobate, post-equatorial; anterior testis 539-1404 (972) x 692-936 (814); posterior testis 516-1326 (921) x 400-858 (629). Post-testicular region 2418-5304 (4095) long. Cirrus sac small, 454-858 (656) x 277-546 (412), overlapping anterior margin of ventral sucker. Seminal vesicle bipartite, measured 270-508 (389) x 162-262 (212). Pars prostatica long, surrounded by a large number of prostatic gland cells. Cirrus small, protrusible. Laurer’s canal present. Genital pore anterior to ventral sucker, slightly sub median.

Ovary pre-testicular, ovoid, transversally elongated, 400-593 (497) x 670-936 (803) in size. Ventral sucker to ovary distance 4197-5460 (4815). Vitellarium follicular, mostly extracaecal, extending from mid level of ventral

sucker to caecal ends. Vitelline reservoir present. Uterus preovarian, intercaecal, with 16-17 coils. Eggs numerous, yellow, operculate, embryonate; 43-46 (45) x 23-26 (25). Excretory vesicle I- shaped.

Definitive host	:	*Bubulcus ibis* Linnaeus
Site	:	Intestine
Locality	:	Iruvetty and Puthurpallikkal, Malappuram district, Kerala
Period of collection	:	January 2002-March 2009
Prevalence	:	Four out of 12 *B. ibis* examined were found to be infected
Intensity	:	1-3

Remarks

Two species of *Nephrostomum, N. ramosum* and *N. guptai* are known from birds in India. The trematode encountered in the present study in the intestine of *Bubulcus ibis* is similar to *N. ramosum* in body dimensions, sucker width ratios, position, shape and size of testes and ovary, and in the extend of vitellaria. However, there is difference in the measurements of eggs which are smaller in the present worm. This difference is not by itself significant enough to differentiate the two forms. Therefore, the present fluke is identified and reported here as *Nephrostomum ramosum* (Sonsino, 1895). This forms the first report of the species from South India.

Genus: *Parallelotestis* Belopol'skaia, 1954

Parallelotestis tarai (Srivastava, 1958) Beverly-Burton, 1960

Natural infection with the present fluke was found in the liver and bile duct of the cattle egret, *Bubulcus ibis* collected from Iruvetty on 26 December 2005. One bird was infected with 8 adults of this fluke and was found simultaneously infected with the adults of *Clinostomum complanatum.*

Description (Fig. 2; Table 2; Plate 4):

Body lanceolate, attenuated toward both ends, attaining maximum width at middle of body; 6300-9126 (7713) x 1625-2652 (2139). Forebody 2217-3080 (2798) long, 28-38 (33)% of body length. Oesophageal region swollen and flexed ventrally. Tegument uniformly covered with cutaneous spines, 53-56 (54) x 12-15 (14) in dimensions. Head collar small, weakly developed, 331-549 (439) wide, armed with 27 spines. Spine arrangement: 4 large bluntly pointed angle spines on each ventrolateral lappet, 2 oral and 2 aboral, 145-146 (146) x 22-24 (23) in size; 5 lateral on each side in single row, 91-92 (92) x 21-24 (23); 9 dorsal, 4 oral and 5 aboral, 75-78 (77) x

13-14 (14) in measurements. Oral sucker ovoid, sub-terminal; 200-234 (217) x 175-218 (197). Ventral sucker large, nearly round, muscular, pre-equatorial; 1000-

Table 2. Measurements (µm) of adults of *Parallelotestis tarai* (Srivastava, 1958) Beverly-Burton, 1960.

Character	Range	Mean
Body size	6300-9126 x 1625-2652	7713 x 2139
Forebody	2217-3080	2798
Collar width	331-549	439
Oral sucker	200-234 x 175-218	217 x 197
Ventral sucker	1000-1264 x 950-1248	1132 x 1049
Prepharynx	50-86	68
Pharynx	200-308 x 150-270	254 x 210
Oesophagus	750-936	843
Left testis	468-500 x 500-624	484 x 562
Right testis	421-435 x 425-671	426 x 548
Cirrus sac	875-1232 x 468-500	1054 x 484
Ovary	250-312 x 325-359	281 x 342
Eggs	85-100 x 46-62	92 x 54

1264 (1132) x 950-1248 (1049). Sucker ratio 1: 5.52-5.6 (5.54). Prepharynx 50-86 (68) long. Pharynx prominent, muscular; 200-308 (254) x 150-270 (210). Oesophagus 750-936 (843) long, bifurcating 650-671 (661) in front of ventral sucker. Caeca slender up to testicular level, dilate thereafter and end blindly, 347-375 (361) from hind end of body.

Testes two, symmetrical, ovoid to spherical, intercaecal, post-equatorial; left testis 468-500 (484) x 500-624 (562); right testis 421-435 (426) x 425-671 (548). Post-testicular region 2625-3000 (2860) long. Cirrus sac large, 875-1232 (1054) x 468-500 (484), anterior to ventral sucker; cirrus spined. Laurer's canal present. Genital pore post-bifurcal, slightly sub-median.

Ovary pre-testicular, slightly dextral, ovoid, 250-312 (281) x 325-359 (342). Ventral sucker to ovary distance 425-644(362). Vitellarium follicular, extend from level of ventral sucker to posterior end of body, confluent in post-testicular field. Uterus preovarian. Eggs numerous, tanned, ovoid, non-operculate; 85-100 (92) x 46-62 (54).

Definitive host : *Bubulcus ibis* Linnaeus

Site : Liver and bile duct

Locality	:	Iruvetty, Malappuram district, Kerala
Period of collection	:	January 2002-March 2009
Prevalence	:	One of 12 *Bubulcus ibis* examined was found to be infected
Intensity	:	8

Remarks

The present fluke recovered from the liver and bile duct of *Bubulcus ibis* has head collar with 27 spines, pre-equatorial ventral sucker, symmetrical testes, cirrus armed with large spines and pre-equatorial ovary. Based on these characters, it is included in the genus *Parallelotestis* Belopol'skaia, 1954. As far as is known, only 4 valid species have so far been reported in the genus *Parallelotestis* from birds all over the world. These are, *P. horridus* Belopol'skaia, 1954, *P. tarai* (Srivastava, 1958) Beverly-Burton, 1960, *P. kafuensis* Beverly-Burton, 1960 and *P. bubulcusi* Gupta and Gupta, 1980. The present fluke agrees fully with *P. tarai* in shape and size of body, position, shape and size of testes and ovary, distribution of vitellaria, and shape and size of eggs. A comparison of characters of the present form with that of the other 3 species revealed that it is distinct from them. Hence,

it is identified and reported here as *P. tarai* (Srivastava, 1958) Beverly-Burton, 1960. Recovery of this species from *B. ibis* at Iruvetty in Malappuram district of Kerala forms a new geographical record.

Genus: *Paryphostomum* Dietz, 1909

Paryphostomum horai Baugh, 1950

Adults of the present fluke were recovered from the domestic fowl*, Gallus gallus* collected from Puthurpallikkal on 9 March 2009. One of 4 birds (25%) examined was found to be infected with 5 flukes in its intestine.

Description (Fig. 3; Table 3; Plate 4):

Body elongate, tapering at ends, 4435-6712 (5925) long, 812-1560 (1250) wide, with maximum width at the middle of body. Forebody 1251-1412 (1375) long, 21-24 (23.2)% of body length. Tegument spinose, spines in anterior half distributed densely, in posterior half sparsely. Head collar well-developed, 450-616 (512) wide, armed with 39 spines. Spine arrangement: 5 angle spines on each ventrolateral lappet, 3 oral, 60-66 (62) x 12-16 (15), and 2 aboral, 65-73 (69) x 12-16 (15) in size; 6 lateral in a single row, 66-75 (69) x 12-16 (15); 17 dorsal, 9 oral and 8 aboral, 61-65 (62) x 12-16 (15). Oral sucker sub-terminal, round, 180-248 (231). Ventral sucker large, round, muscular; 521-596 (568). Sucker ratio 1: 2.31-2.48 (2.43). Prepharynx 172-201 (193) long. Pharynx

muscular, ovoid, 121-194 (165) x 156-180 (170). Oesophagus 485-534 (501) long, bifurcating in posterior region of forebody, 212-271 (246)

Table 3. Measurements (µm) of adults of *Paryphostomum horai* Baugh, 1950.

Character	Range	Mean
Body size	4435-6712 x 812-1560	5925 x 1250
Forebody	1251-1412	1375
Collar width	450-616	512
Oral sucker	180-248	231
Ventral sucker	521-596	568
Prepharynx	172-201	193
Pharynx	121-194 x 156-180	165 x 170
Oesophagus	485-534	501
Anterior testis	212-254 x 396-440	231 x 424
Posterior testis	412-476 x 437-470	462 x 462
Cirrus sac	351-402 x 212- 254	385 x 231
Ovary	211-261 x 294-321	231 x 308
Eggs	116-123 x 62-69	120 x 66

from anterior margin of ventral sucker. Caeca long, narrow, terminate blindly 261-312 (293) from posterior extremity.

Testes two, post-equatorial, tandem, trilobate; anterior testis 212-254 (231) x 396-440 (424); posterior testis 412-476 (462) x 437-470 (462). Post-testicular region 1452-1586 (1500) long, 24- 27 (25)% of body length. Cirrus sac 351-402 (385) x 212 254 (231), between intestinal bifurcation and anterior margin of ventral sucker. Seminal vesicle bipartite, measured 254-312 (293) x 98-124 (116). Laurer's canal present. Cirrus coiled. Genital pore post-bifurcal, median.

Ovary ovoid, pre-testicular, 211-261 (231) x 294-321 (308), at a distance of 1114-1389 (1250) from ventral sucker. Vitellarium follicular, in lateral fields, extracaecal, extending from middle level of ventral sucker to caecal ends. Uterine coils pre-testicular, in intercaecal space between anterior testis and ventral sucker. Eggs numerous, yellow, ovoid, operculate; 116-123 (120) x 62-69 (66).

Definitive host : *Gallus gallus* Linnaeus

Site : Intestine

Locality : Puthurpallikkal, Malappuram district, Kerala

Period of collection : March 2009

Prevalence : One of 4 *Gallus gallus* examined were found to be infected

Intensity : 5

Remarks

Baugh (1950) described *Paryphostomum horai* from the domestic duck *Anas poecylorhyncha* in Allahabad. The present fluke recovered from the intestine of *Gallus gallus* resembles *P. horai* Baugh, 1950 in body dimensions, sucker width ratios, position, shape and size of testes and ovary, and distribution of vitellaria. The present fluke has a prepharynx which was not observed by Baugh in his specimens. This is not by itself significant enough to differentiate the two forms. Therefore, it is identified and reported here as *Paryphostomum horai* Baugh, 1950. Recovery of this species from *Gallus gallu*s in Malappuram district of Kerala forms a new host and geographical record.

Genus: *Petasiger Dietz,* 1909

Petasiger variospinosus **(Odhner, 1910) Yamaguti, 1933**

Numerous adult flukes were recovered from the intestine of the little cormorant, *Phalacrocorax niger,* collected from Iruvetty, Puthurpallikkal, Ramanattukara and Cheruvady from September 2003 to August 2008. Eleven out of 13 birds (84.6%) collected were found to be infected with the adults of the present form. The intensity of infection varied from 15 to 100. Triple infection with *Echinochasmus* sp.1 n. sp., *Nigerina hardoiensis* and the present form was found in one bird. Four birds exhibited double infections; two with the present form and *Echinochasmus* sp.1 n. sp. and the other two with *N. hardoiensis* and the present form.

Description (Fig. 4; Table 4; Plate 4):

Body slender, elongate, tapering toward ends with maximum width at level of ventral sucker; 1560-3071 (2211) long, 328-610 (437) wide. Forebody 255-828 (561) long, 15.44-27.54 (23.03)% of body length. Tegument spinose, with spines distributed densely up to the level of ventral sucker, and sparsely behind the sucker. Head collar well-developed, 270-338 (318) wide, armed with 27 spines. Spine

arrangement: 4 angle spines on each ventrolateral lappet, 2 oral and 2 aboral, 83-111 (97) x 14.6-17.38 (14.69); 5 lateral on each side in single row, 64-88 (71) x 10; 9 dorsal, 4 oral and 5 aboral, 63-76 (71) x 12. Oral sucker sub-terminal, round, 62-140 (102). Ventral sucker nearly round, 177-427 (331) x 255-371 (318), pre-equatorial. Sucker ratio 1: 2.9-3.4 (1: 3). Prepharynx 36-72 (58) long. Pharynx ovoid, muscular; 46-94 (75) x 41-91 (65). Oesophagus 234-421 (331) long, slender. Intestinal bifurcation 185-263 (214) anterior to ventral sucker; caeca get slightly

Table 4. Measurements (µm) of adults of *Patasiger variospinosus* (Odhner, 1910) Yamaguti, 1933.

Character	Range	Mean

Body size	1560-3071 x	2211 x 437
Forebody	328-610	561
Collar width	255-828	318
Oral sucker	270-338	102
Ventral sucker	62-140	331 x 318
Prepharynx	177-427 x 255-	58
Pharynx	371	75 x 65
Oesophagus	36-72	331
Anterior testis	46-94 x 41-91	93 x 109
Posterior testis	234-421	84 x 116
Cirrus sac	55-107 x 80-141	349 x 130
Ovary	47-109 x 62-169	102 x 106
Eggs	265-509 x 99-	76 x 58
	188	
	70-159 x 94-169	
	73-81 x 53-63	

enlarged toward posterior end and terminate blindly 50-187 (112) from posterior extremity.

Testes two, equatorial, intercaecal, ovoid, smooth, obliquely tandem, contiguous or slightly overlapping; anterior testis 55-107 (93) x 80-141 (109); posterior testis 47-109 (84) x 62-169 (116). Post-testicular region 702-1581 (1082) long, 39-51 (44)% of body length. Cirrus sac large, 265-509 (349) x 99-188 (130), contains bipartite seminal vesicle, small pars prostatica, ductus ejaculatorius and protrusible cirrus. Cirrus elongated, coiled, 229-246 (234) long. Laurer's canal present. Genital pore median, post-bifurcal.

Ovary pre-testicular, dextral, nearly round, 70-159 (102) x 94-169 (106), at a distance of 13-73 (51) from ventral sucker. Vitellarium follicular, in lateral fields; follicles extend from posterior margin of ventral sucker to posterior end of body; fields converge in post-testicular region. Uterus short, intercaecal, pre-testicular. Eggs 1-11; 73-81 (76) x 53-63 (58) in size.

Definitive host : *Phalacrocorax niger* Vieillot

Site : Intestine

Period of collection : September 2003-August 2008

Locality	:	Iruvetty and Puthurpallikkal, Malappuram district; Ramanattukara and Cheruvady, Kozhikkode district, Kerala
Prevalence	:	Eleven out of 13 *Phalacrocorax niger* examined were found to be infected
Intensity	:	15-100

Remarks

Flatynkova *et al.* (2008) revised the characters of the genus *Petasiger* Dietz, 1909 and recognized 18 species as valid. *P*etasiger *variospinosus* (Odhner, 1910) Yamaguti, 1933 from *Phalacrocorax auritus* in Egypt is the only species known from India. Nath (1973) described the metacercaria of *P. variospinosus* from *Channa punctatus* and *Rana cyanophlyctis* in Uttar Pradesh. Vasandakumar and Janardanan (2002) reported the adult of *P. variospinosus* from *Phalacrocorax niger* in Kerala and this formed the first and only report of this species from India. They also established the complete life cycle of the species. The description of *P. variospinosus,* given Vasandakumar and Janardanan, corroborates well with the description of the trematode presented here. Therefore, the

present form is identified and reported as *Petasiger variospinosus* (Odhner, 1910) Yamaguti, 1933.

Genus: *Echinochasmus* Dietz 1909

Echinochasmus bagulai Verma, 1935

Twelve out of 16 pond heron, *Ardeola grayii* collected (75%) from Iruvetty, Puthurpallikkal, Ramanattukara and Cheruvady during March 2002-December 2008 were found to be infected with the adults of the present fluke. The intensity of infection varied from 50 to 200. A total of 7 infected birds were found simultaneously infected with other trematode species in different combinations. The other species involved were: *Clinostomum complanatum, Centrocestus formosanus* and *Apharyngostrigea ramai* in one bird; *C. complanatum* in 4 birds; *Ignavia breviovarica* in one bird, and *A. ramai* in another.

Description (Fig. 5; Table 5; Plate 4): Body elongate, 702-1014 (872) long, 234- 312 (260) wide, with maximum width at level of testes. Forebody 294-343 (322) long, 34-36 (35)% of body length. Tegument spinose, spines densely distributed in anterior half, sparsely in the posterior region. Head collar well-developed, 123-211 (153) wide, armed with 24 collar spines in dorsally interrupted alternating double rows. Spine arrangement: 4 angle spines on each ventrolateral lappet, 2

oral and 2 aboral, 24-27 (25); 3 lateral on each side, 24-28 (26); 5 dorsal on each side, 3 oral and 2 aboral, 25-27 (26). Oral sucker sub-terminal, round, 46-77 (60). Ventral sucker large,

Table 5. Measurements (µm) of adults of *Echinochasmus bagulai* Verma, 1935

Character	Range	Mean
Body size	702 -1014 x 234 -	872 x 260
Forebody	312	322
Collar width	294 - 343	153
Oral sucker	123- 211	60
Ventral sucker	46 - 77	145
Prepharynx	123 -187	45
Pharynx	27- 54	60
Oesophagus	54- 69	85
Anterior testis	62-115	63 x 113
Posterior testis	54 - 69 x 85 - 132	98 x 122
Cirrus sac	77 - 116 x 77 - 154	95 x 51
Ovary	68 - 132 x 34 - 62	59 x 61
Eggs	50 - 68 x 50 -77	64 x 46
	61 - 69 x 39 -53	

muscular, round, pre-equatorial; 123-187 (145). Sucker ratio, 1: 2.3-2.8 (2.43). Prepharynx 27-54 (45) long. Pharynx muscular, globular, 54-69 (60). Oesophagus 62-115 (85) long, bifurcating 34-94 (68) from anterior margin of ventral sucker. Caeca narrow terminate, blindly 48-85 (62) from posterior end of body.

Testes two, tandem, contiguous, in posterior third of body; anterior testis transversely elongated with slightly indented margins, 54-69 (63) x 85-132 (113); posterior testis large, 77-116 (98) x 77-154 (122). Post-testicular region 123-193 (149) long, 14-19(16)% of body length. Cirrus sac large, thin walled, between intestinal bifurcation and ventral sucker, 68-132 (95) x 34-62 (51) in size, encloses bipartite seminal vesicle and a short cirrus. Laurer’s canal present. Genital pore post-bifurcal, submedian.

Ovary pre-testicular, dextral, ovoid, 50-68 (59) x 50-77 (61), at a distance of 82-109 (96) from ventral sucker. Vitellarium follicular, in lateral fields; follicles extend from posterior level of ventral sucker to posterior end of body, overlap caeca dorsally, confluent posterior to testis. Uterine coils preovarian, in intercaecal space between ovary and

ventral sucker. Eggs 4-5; yellow, ovoid, operculate; 61-69 (64) x 39-53 (46).

Definitive host	:	*Ardeola grayii* Sykes
Site	:	Intestine
Locality	:	Iruvetty and Puthurpallikkal, Malappuram district; Cheruvady and Ramanattukara, in Kozhikkode district, Kerala
Period of collection	:	March 2002-December 2008
Prevalence	:	Twelve out of 16 birds examined were found to be infected
Intensity	:	50-200

Remarks

The present fluke recovered from the intestine of *Ardeola grayii* has dorsally interrupted double row of 24 collar spines, post-equatorial tandemly placed testes, densely arranged tegumental spines in the fore-body and caeca reaching to posterior end of body. Based on these characters, it is included in the genus *Echinochasmus* Dietz 1909. As far as is known, 12 species have been reported in the genus from India. The present fluke has 24 collar spines arranged in

dorsally interrupted double rows, a character present in *Echinochasmus bagulai* Verma, and 1935. A comparison of characters of the present form with that of *E. bagulai* shows that they are identical in morphological characters and metric details. Hence, the present form recovered from the intestine of *A. grayii* is identified and reported as *Echinochasmus bagulai* Verma, 1935; this forms a new geographical record.

***Echinochasmus* sp.1 n.sp.**

Natural infections with the adults of the present fluke were found in the intestine of the little cormorant, *Phalacrocorax niger* collected from Iruvetty, Ramanattukara and Cheruvady during September-October 2003 and August 2008. Four birds were infected with the present worm. The intensity of infection varied from 20 to 100. One of the birds infected with the present fluke exhibited triple infection by harbouring the adults of two other flukes, *Petasiger variospinosus* and *Nigerina hardoiensis.* Two birds were found infected with *P. variospinosus* along with the present fluke.

Discription (Fig. 6; Table 6a, 6b; Plate 4):

Body elongate oval, tapering gradually toward anterior end; 554-896 (662) long, 172-296 (228) wide, with maximum width at level of testes. Forebody 198-476 (337) long, 30-55 (41)% of body length. Tegument spinose, spines densely distributed up to the level of ventral sucker and sparsely behind the sucker. Head collar small, 46-79 (60) wide, armed with 18 collar spines in dorsally interrupted single row. Spine arrangement: 3 angle spines on each ventro lateral lappet; 3 lateral on each side: 3 dorsal on each side; spines more or less equal in length, (12.54-13.2), except the second angle spine (16-17.25). Oral sucker sub-terminal, ovoid, 39-62 (50) x 26-39 (27). Ventral sucker equatorial, muscular, round, 71-106 (94). Sucker

Table 6a. Measurements (µm) of adults of *Echinochasmus* sp.1 n. sp.

Character	Range	Mean
Body size	554-896 x 172-296	662 x 228
Forebody length	198-476	337
Collar width		60

Oral sucker	46 -79	50 x 27
Ventral sucker	39-62 x 26-39	94
Prepharynx	71-106	45
Pharynx	30-66	35 x 26
Oesophagus	31-37 x 24-32	250
Anterior testis	210-270	75 x 112
Posterior testis	56 -88 x 83 - 122	72 x 112
Cirrus sac	60-84 x 81-115	106 x 47
Ovary	99 -112 x 43 -50	53 x 40
Eggs	36 - 69 x 33 - 46	71 x 50
	69-73 x 46-53	

Table 6b. Comparison of characters of *Echinochasmus dietzvi* Issaitschikoff, 1927, *E. narayani* Mudaliyar, 1938, *E.megavitellus* Lal, 1939 and *Echinochasmus* sp.I n. sp.

Character	*E. dietzevi*	*E. narayani*	*E. megavitellus*	*Echinochasmus* sp. 1 n. sp.
Body size	1130-1470 x 396-550	1500-1800 x 600-620	1050 x 450	554-896 (662) x 172-296 (228)
Forebody	380	450-540	380	198-476 (337)
Forebody length as percentage of body length	29	30	36	30-55 (41)
Collar width	319	225-270	170	46-79 (60)
Collar spines	20, first ventral spine, 34; second, 47; and others, 55-60	24, larger towards sides, except last three at either side, 30-60	24, uniform; 25	18, second angle spine, 16-17.5; others, 12.54-13.2
Oral sucker	Nearly round; 55-60	Round; 20-29 x 31-36	Ovoid; 60 x 50	Ovoid; 39-52 (50) x 26-39 (27)
Ventral sucker	Round; 220-248 x 198-220	Nearly round; 140-180	180 x 170	Round; 71-106 (94)
Sucker width ratio	1 : 36	1 : 2.8-3	1 : 34	1 : 3.2-3.6 (3.4)
Prepharynx	110	80-120	75	30-56 (45)

Character	***E. dietzevi***	***E. narayani***	***E. megavitellus***	***Echinochasmus* sp. 1 n. sp.**
Pharynx	110	80-120	90 x 100	Round; 31-37 (35) x 24-32 (26)
Oesophagus	264-308	180	53.8	210-270 (250)
Anterior testis	Transversely elongated; 143-165 x 187-231	Transversely elongated; 350-400 x 160-200	Transversely elongated; 200 x 110	Transversely elongated; 56-88 (75) x 83-122 (112)
Posterior testis	187-209 x 187-231	Round posterior margin; 300-350 x 210-250	Round posterior margin; 170 x 112	Round posterior margin; 60-84 (72) x 81-115 (112)
Post testicular region	420	365-438	161.46	96-124 (108)
Post testicular region as percentage of body length	32	24	15.3	10.86-14.58 (12.9)
Ovary	Transversely oval; 77-86 x 77-99	Dextral round; 100-120	Dextral, ovoid; 80 x 70	Dextral, ovoid; 36-69 (53) x 33-46 (40)
Distance between ventral sucker and	40	55-60	89.7	12-20 (15)

Character	***E. dietzevi***	***E. narayani***	***E. megavitellus***	***Echinochasmus* sp. 1 n. sp.**
ovary				
Eggs	A few; 81-86 x 43-47	A few; 60-48	A few; 70 x 50	One; 69-73 (71(x 46-53 (50)
Hosts	*Ardea cinerea, A. comata, A. purpurea, Botaurus stellaris, Bubulcus ibis, Circaetus gallicus* and *Circus cyaneus*	*Milvus migrans govinda*	*Ardeola grayii*	*Phalacrocorax niger*

ratio 1: 3.2-3.66 (3.42). Prepharynx small, 30- 66 (45) long. Pharynx ovoid, 31-37 (35) x 24-32 (26). Oesophagus 210-270 (250) long, bifurcating 36-60 (45) anterior to ventral sucker. Caeca narrow, terminate blindly, 26-36 (32) from posterior end of body.

Testes two, tandem, contiguous, in posterior third of body; anterior testis transversely elongated, 56-88 (75) x 83-122 (112); posterior testis with round posterior margin, 60-84 (72) x 81-115 (112) in size. Post-testicular region 96-124

(108) long, 10.86-14.58 (12.9)% of body length. Cirrus sac thin-walled, between intestinal bifurcation and ventral sucker, partly overlapping the anterior margin of ventral sucker; encloses bipartite seminal vesicle and short cirrus; measured 99-112 (106) x 43-50 (47). Laurer's canal present. Genital pore submedian, post-bifurcal.

Ovary pre-testicular, ovoid, 36-69 (53) x 33-46 (40), at a distance of 12-20 (15) from ventral sucker. Vitellarium follicular, in lateral fields; follicles extend from middle level of ventral sucker to posterior end of body, overlap caeca dorsally, confluent posterior to testis. Uterine coils short, pre-testicular, with one egg. Eggs large, yellow, ovoid, operculate; 69-73 (71) x 46-53 (50).

Type-host	:	*Phalacrocorax niger* Linnaeus
Site	:	Intestine
Type-locality	:	Iruvetty, Malappuram district, Kerala, India
Additional localities	:	Cheruvady and Ramanattukara, Kozhikkode district, Kerala, India
Period of collection	:	Sept

Prevalence : Four of 13 *Phalacrocorax niger* examined were found to be infected

Intensity : 20-1

Holotype : To be deposited in the parasite collections, Parasitolgy Laboratory, Department of Zoology, University of Calicut, Kerala, India.

Remarks

The present fluke can be undoubtedly included in the genus *Echinochasmus* Dietz, 1909 since it has head collar with dorsally interrupted single row of spines, post-equatorial, tandemly placed testes and vitelline follicles extending from middle level of ventral sucker to posterior end of body and confluent in post-testicular field. Till date over 70 recognised species have been reported in this genus from different parts of the world. Of these, the present form resembles *E. dietzevi* Issaitschikoff, 1927 , *E. narayani* Mudaliyar, 1938 and *E. megavitellus* Lal, 1939 in general body form, arrangement of collar spines, extend of caeca, shape of testes, and distribution of vitellaria. A comparison of characters of the present fluke with that of the above 3 species presented in

Table 6a shows that it is different from the others in body measurements, size of head collar, number and size of collar spines, size of suckers and their ratios, measurements of pharynx, testes and ovary and in the size and number of eggs. Further, these species infect different hosts also. The present fluke is thus distinct from all the known species of *Echinochasmus*, and is reported here as a new species and named *Echinochasmus* sp.1 n.sp.

Genus*: Stephanoprora* Odhner, 1902

***Stephanoprora* sp.I n.sp.**

Natural infections with the adults of the present fluke were found in the intestine of the small blue kingfisher, *Alcedo atthis collected* from Iruvetty and Puthurpallikkal from June 2001 to April 2004. Six out of 7 birds collected were positive for this fluke. The intensity of infection varied from 1 to 4. Four birds exhibited mixed infections with the present fluke and *Uvulifer denticulatus.*

Description (Fig. 7; Table 7a, 7b; Plate 5):

Body elongate, slender, maximally wide at ventral sucker level; 2824- 5148 (3671) long, 421-530 (473) wide. Forebody 402-548 (461) long, 10.6-

16.5 (13)% of body length. Tegument spinose; spines densely set in anterior region up to ventral sucker and diminishing in density toward posterior end. Head collar reniform, 198-267 (233) wide, armed with 22 spines arranged in a single dorsally interrupted row; spines almost equal in size; 36-38 (37) x 10-12 (11).

Oral sucker nearly round, 63-78 (73) x 78-94 (83), sub-terminal. Ventral sucker nearly round, 187-250 (204) x 187-250 (224), situated at end of anterior fourth of body. Sucker width ratio I: 2.44-3.27 (2.76). Prepharynx 27-39 (38) long . Pharynx elliptical, 77- 85 (80) x 54-69 (62). Oesophagus 120-193 (169) long, bifurcating 62-103 (82) anterior to ventral sucker. Caeca narrow, widening posteriorly, terminate blindly 26-100 (63) from posterior end of body.

Testes two, tandem; anterior testis pre-equatorial, transversely elongated, 101-265 (I79) x 296-343 (322); posterior testis post-equatorial, nearly round, 312-374 (334) x 250-437 (326). Post- testicular region 1248-1526 (1290) long, 35-54 (39)% of the body length. Cirrus sac large, saccular, 296-374 (316) x 109-161 (132); extending near to posterior level of ventral sucker overlapping its margin dorsally.

Laurer's canal present. Seminal vesicle bipartite, 125-187 (156) x 78-109 (94). Genital pore median, anterior to ventral sucker.

Table 7a. Measurements (µm) of adults of *Stephanoprora* sp. I n. sp.

Character	Range	Mean
Body size	2824- 5148 x 421-	3671 x 473
Forebody	530	461
Collar width	402-548	233
Oral sucker	198-267	73 x 83
Ventral sucker	63-78 x 78-94	204 x 224
Prepharynx	187-250 x 187-250	38
Pharynx	27-39	80 x 62
Oesophagus	77-85 x 54-69	169
Anterior testis	120-193	179 x 322
Posterior testis	101-265 x 296-343	334 x 326
Cirrus sac	312-374 x 250-437	316 x 132
Ovary	296-374 x 109-161	101 x 187
Eggs	78-140 x 156-218	81 x 51
	79-83 x 49-53	

Table 7b. Comparison of characters of *Stephanoprora reynoldi* Bhalerao, 1926, *S. nigerica* Gupta,1962 and *Stephanoprora* sp.I n. sp.

Character	*S. reynoldi*	*S. nigerica*	*Stephanoprora* sp.1 n.sp.
Body size	4200 x 699	2683-4010 x 450-551	2824-5148 x 421-530
Forebody	699	672-1024	402-548
Forebody length as percentage of body length	16.6	25-26	10.6-16.5
Collar spine	22, 2 angular spines, 25x9; other spines, 40 x 19	22, equal in length; 41-49 x 5-7	22, equal in length, 36-38 x 10-12
Oral sucker	Ovoid; 21 x 68	Round; 59-109 x 56-102	Nearly round; 63-78 x 78-94
Ventral sucker	Nearly round; 326 x 279.6	Nearly round; 180-218 x 164-233	Nearly round; 187-250 x 187-250
Sucker width ratio	1 : 4.1	1:2.28 – 2.92	1:2.44 – 3.27
Prepharynx	15	45-64	27-39
Pharynx	Elliptical; 125 x 100	Elliptical; 65-90 x 47-63	Elliptical; 77-85 x 54-69
Oesophagus	200	341-591	120-193
Distance between intestinal bifurcation and ventral sucker	46.6	168-256	62-103
Anterior testis	Oval; 380 x	255-368 x	Transversely

Character	***S. reynoldi***	***S. nigerica***	***Stephanopr ora* sp.1 n.sp.**
	333	306-454	elongated; 101-265 x 296-343
Posterior testis	Ovoid; 500x330	Ovoid; 419-551 x 282-436	Globular; 312-374 x 250-437
Post testicular region	1631	1365-2080	1248-1326
Cirrus sac	279 x 184	198-326 x 108-135	296-374 x 109-161
Ovary	Ovoid; 150 x 115	Ovoid; 113-141	Ovoid; 78-140 x 156-218
Distance between ventral sucker and ovary	419	21-32	235-638
Vitellaria	Posterior end of anterior testis to hind end of body	Anterior boarder of posterior testis to hind end of body	Posterior level of posterior testis to hind end of body
Eggs	56-89 x 31-49	68-76 x 50-54; 2-8 no.	79-83 x 49-53; 5-30
Host	*Corvus insolens* Hume	*Phalacrocora x niger* Vieillot	*Alcedo atthis* Linnaeus

Ovary ovoid, median, 78-140 (101) x I56-218 (187), anterior to anterior testis, at a distance of 235-638 (398) from ventral sucker. Vitellarium follicular, follicles transversely elongate, extending in lateral fields from posterior level of posterior testis to posterior end of body, more or less confluent at middle region. Uterus pre-testicular, intercaecal, forming 4-5 coils. Eggs 5-30, ovoid, yellow, operculate; 79-83 (81) x 49-53 (51). Excretory pore terminal; excretory vesicle I-shaped

Type-host : *Alcedo atthis* Linnaeus

Site : Intestine

Type-locality : Iruvetty, Malappuram district, Kerala, India

Additional locality : Puthurpallikkal, Malappuram district, Kerala, India

Period of collection : June 2001-April 2004

Prevalence : Six out of 7 *A. atthis* examined were found to be infected

Intensity : 1-4

Holotype : To be deposited in the parasite collections, Parasitolgy Laboratory,

Department of Zoology, University of Calicut, Kerala, India.

Remarks

The present fluke recovered from the intestine of *Alcedo atthis* is characterized by the presence of well-developed head collar with 22 spines in single dorsally interrupted row, tandemly placed testes in equatorial region, pre-testicular ovary and vitellaria in post-testicular field, and therefore, it is included in the genus *Stephanoprora* Odhner, 1902. Of the 30 valid species of *Stephanoprora* reported till date, 6 are from India. The present form is comparable to *S. reynoldi* Bhalerao, 1926 and *S. nigerica* Gupta, 1962 in general body form, number and arrangement of collar spines, extend of caeca, position of testes and in the position of cirrus sac and genital pore. But it is different from *S. reynoldi* in body measurements, size of oral and ventral suckers and their ratios, size of angle spines, testes and in the anterior extend of vitellaria. The present fluke is different from *S. nigerica* in the length of forebody, prepharynx, oesophagus, distance from intestinal bifurcation to ventral sucker, ventral sucker to

ovary, size of testes, and in the anterior extend of vitellaria. A comparison of characters of *S. reynoldi*, *S. nigerina* and of the present form given in Table 7b showes that the 3 species are different from each other. Further, they infect different hosts also. Therefore, the present fluke is reported as a new species and named *Stephanoprora* sp.I n. sp.

Genus: *Ignavia* Freitas, 1948

Ignavia breviovarica Gupta, 1962

Natural infection with the present fluke was found in the kidney of the pond heron, *Ardeola grayii* collected from Puthurpallikkal. A single specimen of *A. grayii* collected on 3rd February 2007 harboured 3 adult flukes. The bird was found simultaneously infected with the adults of *Echinochasmus bagulai.*

Description (Fig. 8; Table 8; Plate 5):

Body elongate, with broadly round anterior and somewhat pointed posterior ends; 6300-7800 (6800) long, 511-710 (647) wide. Forebody 1260-2142 (1850) long, 28.6-33.9 (30.35)% of body length. Tegument spinose; spines become sparse posteriorly. Head collar 250-325 (312) wide,

armed with 22 small, stout spines interrupted dorsally. Spines more or less equal in size, measured 21-29 (25) x 11-12 (11); angle spines four on each ventrolateral lappet in alternate rows, others in a single row. Oral sucker terminal, round, 194-251 (218). Ventral sucker muscular, round, 324-361 (349), in anterior third of body. Sucker ratio 1: 1.4-1.61 (1.57). Prepharynx 175 long. Pharynx muscular, spherical, 137-163 (159). Oesophagus 502-671 (624) long with lateral outgrowths, bifurcating 103-141 (125) anterior to

Table 8. Measurements (µm) of adults of *Ignavia breviovarica* Gupta, 1962,

Character	Range	Mean
Body size	6300-7800 x 511-	6800 x 647
Forebody	710	1850
Collar width	1260-2142	312
Oral sucker	250-325	218
Ventral sucker	194-251	349
Prepharynx	324-361	175
Pharynx	175	159
Oesophagus	137-163	624
Anterior testis	502-671	131 x 193
Posterior testis	122-159 x 162-235	123 x 216
Cirrus sac	102-146 x 209-245	109 x 78
Ovary	98-118 x 64-92	154 x 216
Eggs	143-168 x 201-251	105 x 74
	100-108 x 69-77	

ventral sucker. Caeca long, narrow, terminate blindly 62-83 (76) from posterior end of body.

Testes two, tandem, broader than long; anterior testis 122-159 (131) x 162-235 (193); posterior testis 102-146 (123) x 209-245 (216). Post-testicular region 2865-3149 (3012) long, 41-47.6 (44.12)% of body length. Cirrus sac anterior to ventral sucker, pear shaped, measured 98-118 (109) x 64-92 (78). Genital pore median, post-bifurcal. Seminal vesicle bipartite, 109-149 (131) x 41-59 (46). Pars prostatica and ejaculatory duct short.

Ovary dextral, pre-testicular, ovoid, 143-168 (154) x 201-251 (216) in size, at a distance of 596-716 (671) from ventral sucker. Vitellarium follicular, extracaecal; follicles extend from posterior level of ventral sucker to caecal ends. Uterine coils preovarian, in intercaecal space between ovary and ventral sucker. Eggs 20-48 in number, yellow, ovoid, 100-108 (105) x 69-77 (74).

Definitive host	:	*Ardeola grayii* Sykes
Site	:	Kidney
Locality	:	Puthurpallikkal, Malappuram district, Kerala

Period of collection : March 2002-December 2008

Prevalence	:	One of 16 *Ardeola grayii* examined were found to be infected
Intensity	:	3

Remarks

Gupta (1962) described *Ignavia breviovarica* from the purple heron, *Ardea purpurea* in Lucknow and Hardoi of Uttar Pradesh, and this forms the only species in the genus so far known from India. The present fluke recovered from the kidney of *Ardeola grayii* is identical with *I. breviovarica* in body measurements, sucker ratios, position, shape and size of testes and ovary, distribution of vitelline follicles and in the size of eggs. The present specimens have 22 dorsally interrupted collar spines whereas Gupta observed only 21 spines in his specimens. Variations in the number of collar spines in a single species of echinostome has been reported previously by different workers. This may be due to loss of one or more spines during the preparation of the specimens for examination. Therefore, this difference in the number of spines cannot be considered as a valid character warranting the creation of a new species. Hence, the present form is identified and reported here as *Ignavia breviovarica* Gupta.

1962. Recovery of this fluke from *A. grayii* in Malappuram district forms a new host and geographical record for *I. breviovarica.*

Genus: *Pegosomum* Ratz, 1903

Pegosomum egretti Srivastava, 1957

Adults of the present worm were found in the liver and bile duct of the cattle egret, *Bubulcus ibis* collected from Iruvetty, Puthurpallikkal and Cheruvady from January 2002 to March 2009. Four birds were found positive for this fluke. The intensity of infection varied from 3 to 20. Mixed infections were observed in two birds. Of these, one exhibited triple infection with *Nephrostomum ramosum*, *Clinostomum complanatum* and the present form, and the other showed co-infection with *N. ramosum.*

Description (Fig. 9; Table 9; Plate 5):

Body elongate, maximally wide at level of ventral sucker, tapering toward both ends; 8192-8986 (8570) long, 2304-2816 (2577) wide. Forebody 2517-3080 (2798) long, 28-38 (33)% of body-length. Tegument covered with conspicuous

spines, which are closely set anterior to ventral sucker. Head collar small, poorly developed, 294-297 (295) wide, armed with 27 collar spines in dorsally uninterrupted double rows. Spine arrangement: four bluntly pointed angle spines on each ventrolateral lappet, 2 oral and 2 aboral, 92-116 (104) x 23 in size; 6 lateral on each side, 62-77 (75) x 15-16

Table 9. Measurements (µm) of adults of *Pegosomum egretti* Srivastava, 1957

Character	Range	Mean
Body size	8192-8986 x 2304-2816	8570 x 2577
Forebody	2517-3080	2798
Collar width	294-297	295
Oral sucker	84-89 x 100-123	85 x 112
Ventral sucker	794-1203 x 717-947	1041 x 810
Pharynx	116-234 x 116-156	175 x136
Oesophagus	1123-1757	1342
Anterior testis	896-1357 x 1280-1536	1126 x 1408
Posterior testis	896-1229 x 1024-	1063 x 1137
Cirrus sac		697 x 362

Ovary Eggs	1250 493-900 x 297-425 461-512 x 204-410 109-116 x 73-77	486 x 384 113 x 75

(15), and 7 dorsal, 3oral and 4 aboral, 69-77 (73) x 15-16 (15). Oral sucker very small, terminal, nearly round, 84-89 (85) x 100-123 (112). Ventral sucker large, ovoid, muscular, immediately pre-equatorial; 794-1203 (1041) x 717-947 (810). Sucker width ratio 1: 7.3-10.4 (9.4). Pharynx muscular, ovoid, 116-234 (175) x 116-156 (136). Oesophagus 1123-1757 (1342) long, bifurcating 624-1326 (912) anterior to ventral sucker. Caeca long, extend up to hind end of body.

Testes two, tandem, transversely elongated, post-equatorial; anterior testis larger, slightly crescentic, 896-1357 (1126) x 1280-1536 (1408); posterior testis smaller, wedge-shaped, 896-1229 (1063) x 1024-1250 (1137). Post-testicular region 1404-2315 (1626) long, 16-21 (17)% of body length. Cirrus sac 493-900 (697) x 297-425 (362) in size, situated in front of ventral sucker, slightly curved round on the left side. Cirrus muscular, protrusible. Seminal vesicle small. Laurer's canal present. Male genital pore anterior to ventral sucker; post-bifurcal.

Ovary pre-testicular, dextral, slightly ovoid, 461-512 (486) x 204-410 (384). Vitellarium dendritic, extending from behind pharynx to middle of posterior testis or slightly

beyond, confluent in front of cirrus sac. Uterine coils between ventral sucker and anterior testis, opens at female genital pore near male genital pore. Eggs numerous, yellow, ovoid, operculate; 109 -116 (113) x 73-77 (75). Excretory bladder 'Y' shaped.

Definitive host	:	*Bubulcus ibis* Linnaeus
Site	:	Liver and bile duct
Locality	:	Iruvetty and Puthurpallikkal, Malappuram district; Cheruvady and Ramanattukara, Kozhikkode district, Kerala
Period of collection	:	January 2002-March 2009
Prevalence	:	Four out of 12 *Bubulcus ibis* examined were found to be infected
Intensity	:	3-20

Remarks

Pegosomum egretti Srivastava, 1957 infecting *Bubulcus ibis* is the only valid species in the genus known from an Indian bird. The characters of the present fluke recovered from the liver and bile duct of the same bird host agrees fully with the description of *P. egretti* suggesting its identity with *P.*

egretti. However, the present specimens have 27 collar spines whereas *P. egretti* has only 25 spines. This difference in the number of collar spines may be due to loss of 2 collar spines at the time of preparation of the specimens for examination by Srivastava. Therefore, the present fluke is identified and reported here as *P. egretti* Srivastava, 1957. This report forms a new geographical record for *P. egretti.*

Family: Psilostomidae Loss, 1900

Genus: *Psilorchis* Thapar and Lal, 1935

***Psilorchis indicus* Thapar and Lal, 1935**

Natural infections with this fluke were found in the intestine of the white-breasted kingfisher, *Halcyon smyrnensis,* collected from Iruvetty and Puthurpallikkal from March 2004 to April 2009. Seven birds were found to be infected with the adults of the present fluke, and the intensity of infection varied from 1 to 10. All the 7 birds were found concurrently infected with other species of flukes in different combinations. The other species were, *Subuvulifer halcyonae*, *Uvulifer stunkardi*, *U. cochlearis,* in one bird; *Basantitia ramai*,

Uvulifer sp.1 n.sp. in two birds; *Uvulifer* sp. 1 n.sp. in 3 birds, and *B. ramai* in one bird.

Description (Fig. 10; Table 10; Plate 5):

Body elongate, spinose with broadly round anterior and narrow posterior ends; 5023- 8315 (6578) x 484-1076 (732). Forebody 374-702(496) long, 5-12 (8)% of body length. Head collar small, rudimentary, 331-370 (351), with minute spines scattered all over it. Oral sucker sub-globular, sub-

Table 10. Measurements (µm) of adults of *Psilorchis indicus* Thapar and Lal, 1935

Character	Range	Mean
Body size	5023-8315 x 484-	6578 x 732
Forebody	1076	496
Collar width	374-702	351
Oral sucker	331-370	124 x 138
Ventral sucker	94-156 x 109-172	537
Prepharynx	359-716	73
Pharynx	62-100	105 x 91
Oesophagus	86-109 x 62-109	117
Anterior testis	109-125	640 x 275
Posterior testis	437-811 x 203-406	652 x 277

Cirrus sac	343-858 x 125-421	297 x 160
Ovary	234-390 x 125-203	256 x 238
Eggs	203-312 x 156-312	116 x 66
	116 x 66	

terminal; 94-156 (124) x 109-172 (138) in measurements. Ventral sucker round, pedunculate, muscular; 359-716 (537). Sucker width ratio 1: 3.42- 4.39 (3.96). Prepharynx 62-100 (73) long. Pharynx, muscular, ovoid, 86-109 (105) x 62-109 (91) in size. Oesophagus 109-125 (117) long, bifurcating 154-202 (182) anterior to ventral sucker. Caeca narrow, run along lateral sides and terminate blindly 125-269 (217) from posterior end.

Testes two, tandem, elongate oval, lobate with irregular margins, post-equatorial; anterior testis 437-811 (640) x 203-406 (275); posterior testis 343-858 (652) x 125-421 (277). Post-testicular region 1170-1716 (1380) long. Cirrus sac anterior to ventral sucker, partially overlapping its anterior margin; 234-390 (297) x 125-203 (160). Cirrus massive, protrusible. Laurer’s canal present. Seminal vesicle single, 131-218 (183) x 46-94 (78), with long ejaculatory duct. Genital pore median.

Ovary pre-testicular, nearly spherical, 203-312 (256) x 156-312 (238). Ventral sucker to ovary distance 1341-3123 (2065). Vitellarium follicular, extending from posterior level of ventral sucker to posterior end of body, extracaecal, but

reaching inner border of caeca in the posterior end. Uterus intercaecal, pre-testicular with many coils. Ootype round. Eggs numerous, yellow, ovoid, operculate; 116 x 66. Excretory vesicle small, Y- shaped.

Definitive host	:	*Halcyon smyrnensis* Linnaeus
Site	:	Intestine
Locality	:	Iruvetty and Puthurpallikkal, Malappuram district, Kerala, India
Period of collection	:	March 2004-April 2009
Prevalence	:	Seven out of 16 birds examined were found to be infected
Intensity	:	1-10

Remarks

In India the genus *Psilorchis indicus* Thapar and Lal, 1935 is represented by 2 species*: P. indicus* and *P. atkinsoni*. The present fluke recovered from the intestine of *Halcyon smyrnensis* is identical with *P. indicus* reported from the same host species in body dimensions, nature of digestive system, shape and position of ovary, testes and cirrus sac, and in the distribution of vitellaria. It is, therefore, readily identified and reported here as *P. indicus* Thapar and Lal, 1935. Recovery of this species at Iruvetty and Puthurpallikkal in Malappuram district forms a new geographical record.

Family: Microphallidae Travassos, 1920

Genus: *Basantisia* Pande, 1938

Basantisia ramai Pande, 1938

Natural infections with this fluke were found in the intestine of the white-breasted kingfisher, *Halcyon smyrnensis,* collected from Iruvetty and Puthurpallikkal during March 2004-April 2009. Five birds were found positive for the present fluke. Intensity of infection varied from 1 to 3. Of the 5 birds, 2 exhibited triple infections with the present fluke and the adults of *Uvulifer* sp. 1 n. sp. and *Psilorchis indicus*; 2 showed double infection with the present fluke and *Uvulifer* sp. 1 n.sp. and the other with *P. indicus* .

Description (Fig. 11; Table 11; Plate 5):

Body pyriform, 431-1001 (619) long, 200-429 (304) wide. Forebody 159-417 (257) long, 33-56 (41)% of body length. Tegument armed with minute scales. Oral sucker sub-terminal, nearly round, 40-76 (53) x 53-100 (65). Ventral sucker round, 33-112 (67) in size. Sucker ratio 1: 0.96-1.19 (1.07). Prepharynx short, 3-20 (9) in length. Pharynx ovoid, 36-46 (42) x 17-35 (23) in measurements. Oesophagus 33-94 (46) long, bifurcating 57-148 (108) from anterior margin of

ventral sucker. Caeca saccular, extend up to level of ventral sucker, terminate blindly 214-617 (390) from posterior end of body.

Table 11. Measurements (µm) of adults of *Basantisia ramai* Pande, 1938

Character	Range	Mean
Body Size	431-1001 x 200-429	619 x 304
Forebody	159-417	257
Oral sucker	40-76 x 53-100	53 x 65
Ventral sucker	33-112	67
Prepharynx	3-20	9
Pharynx	36-46 x 17-35	42 x 23
Oesophagus	33-94	46
Right testis	50-127 x 66-117	88 x 85
Left testis	73-147 x 66-118	112 x 84
Cirrus sac	111-323 x 35-54	295 x 47
Ovary	63-118 x 39-106	86 x 70
Eggs	16.5 x 9.9	16.5 x 9.9

Testes two, nearly round, almost symmetrical, located in middle of hind body; right testis 50-127 (88) x 66-117 (85); left testis 73-147 (112) x 66-118 (84). Post-testicular region 83-176 (126) long, 17-19 (19)% of body length. Vesiculoprostatic pouch horseshoe shaped, encircling ventral sucker. Elasmocotyle with three rather voluminous pieces, more or less sclerotized, measured 111-323 (295) x 35-54 (47) in size. Seminal vesicle large, tubular, 135-149 (141) x 26-40 (33) in size. Cirrus coiled. Genital pore dextral, immediately posterior to ventral sucker.

Ovary nearly round, 63-118 (86) x 39-106 (70), just behind right caecal end at a distance of 50-66 (60) from ventral sucker. Vitellarium forming almost symmetrical bunches of follicles anterior to testes. Uterus voluminous, occupies most of the space between caeca and posterior end of body. Eggs numerous, yellow, ovoid, operculate; 16.5 x 9.9.

Definitive host : *Halcyon smyrnensis* Linnaeus

Site : Intestine

Locality : Iruvetty and Puthurpallikkal, Malappuram district, Kerala

Period of collection : March 2004-April 2009

Prevalence	:	Five of 16 birds examined were found to be infected
Intensity	:	1-3

Remarks

The genus *Basantisia* was established by Pande (1938) with *B. ramai* from the birds, *Ceryle rudis leucomelanura* and *Columba domestica* as the type species. This is the only species of the genus known so far from India. The present fluke infecting *Halcyon smyrnensis* agrees fully with *B. ramai*, in body dimensions, sucker width ratios, position, shape and size of testes and ovary, size of eggs, and in the distribution of vitellaria. Therefore, the present fluke is identified and reported here as *Basantisia ramai* Pande, 1938. Recovery of this fluke from *H. smyrnensis* in Malappuram district forms a new host and geographical record for the species.

Family: Opisthorchiidae Braun, 1901

Genus: *Nigerina* Baugh, 1958

***Nigerina hardoiensis* Baugh, 1958**

Natural infections with the adults of the present fluke were found in the liver and bile duct of the little cormorant,

Phalacrocorax niger collected from Cheruvady in September 2003 and Ramanattukara in March 2008. Three birds were found positive for this infection and the intensity of infection varied from 1 to 3. One bird exhibited triple infection with the present fluke, *Petasiger variospinosus* and *Echinochasmus* sp. 1 n. sp., and the other two birds showed double infection with the present form and *P. variospinosus.*

Description (Fig. 12; Table 12; Plate 5):

Body elongate, slightly widened posteriorly, with ruffled lateral margins forming conical lateral projections; 8580-13104 (10019) long, 578-811 (707) wide. Forebody 936-1747 (1326) long, 10.52-15.09 (13)% of body length. Tegument unspined. Oral sucker terminal, bowl-shaped, 193-316 (265) x 270-601(419). Ventral sucker round, slightly smaller than oral sucker, located in first quarter of body; 270-385 (326). Sucker ratio 1: 0.84-1.2 (0.9). Pharynx well developed, 193-216 (201) x 154-193 (172). Oesophagus short, bulbous; 23-39 (28). Intestinal bifurcation 780-1170 (917) from anterior margin of ventral sucker. Caeca long, terminate blindly 78-156 (117) from posterior end of body.

Testes two, ovoid, smooth, oblique, near posterior end of body; anterior testis 218-281 (260) x 250-296 (276); posterior testis 234-281 (260) x 203-328 (281). Post-testicular region 624-733 (634) long, 7-8.54 (7.78)% of body length. Seminal vesicle convoluted, immediately behind ventral sucker.

Table 12. Measurements (µm) of adults of *Nigerina hardoiensis* Baugh, 1958

Character	Range	Mean
Body size	8580-13104 x 578-811	10019 x 707
Forebody	936-1747	1326
Oral sucker	193-316 x 270-601	265 x 419
Ventral sucker	270-385	326
Pharynx	193-216 x 154-193	201 x 172
Oesophagus	23-39	28
Anterior testis	218-281 x 250-296	260 x 276
Posterior testis	234-281 x 203-328	260 x 281
Cirrus sac	169-254 x 85-139	212 x 109
Ovary	68-89 x 82-103	71 x 92
Eggs	23-26 x 13.2	24.5 x 13.2

Cirrus sac 169-254 (212) x 85-139 (109) in size. Cirrus absent. Laurer's canal present. Genital pore anterior to ventral sucker, median.

Ovary small, nearly round, 68-89 (71) x 82-103 (92), pre-testicular, submedian, at a distance of 4856-7854 (6402) from ventral sucker. Vitellarium follicular; follicles distributed in lateral fields of posterior quarter of body, reaching below the level of posterior testis. Uterine coils preovarian, in intercaecal space between ovary and ventral sucker. Eggs numerous, small, yellow, non-operculate; 23-26 (24.5) x 13.2. Excretory pore terminal.

Definitive host : *Phalacrocorax niger* Linnaeus

Site : Liver and bile duct

Locality : Cheruvady and Ramanattukara, Kozhikkode district, Kerala

Period of collection : February 2003-March 2008

Prevalence: Three out of 13 *Phalacrocorax niger* examined were found to be infected

Intensity : 1-3

Remarks

The present fluke recovered from the liver and bile duct of *Phalacrocorax niger* fully agrees with *Nigerina hardoiensis* Baugh, 1958 reported from the same host species in body dimensions, position, shape and size of testes and ovary, distribution of vitellaria, and in shape and size of eggs. As *N. hardoiensis* is the only species of the genus so far recorded from India, the present worm is identified and reported here as *Nigerina hardoiensis* Baugh, 1958. Recovery of the trematode from the same bird host in Kerala forms a new geographical record for the species.

Family: Heterophyidae odhner, 1914

Genus: *Centrocestus* Looss, 1899

***Centrocestus formosanus* (Nishigori, 1924) Price, 1932**

Three pond herons, *Ardeola grayii* collected from Puthurpallikkal during March-April 2007 and one pariah kite, *Milvus migrans* collected from Cheruvady on 29 March 2007 were found to be infected with the adults of the present fluke. The intensity of infection in *A. grayii* was 6 in two birds and 7 in the other. *M. migrans* was infected with 9 flukes. In *A.*

grayii, the present fluke was found along with the adults of *Echinochasmus bagulai*, *Clinostomum complanatum*, and *Apharyngostrigea ramai* in one bird, and with *A. ramai* in another one. In *M. migrans* the one bird infected with the present fluke was found simultaneously infected with adults of *Mesostephanus indicum*.

Description (Fig. 13; Table 13; Plate 6)

Body elongate oval, flattened, with narrow anterior and broad posterior ends, maximally wide at level of ovary; 381-460 (432) long, 171-200 (181) wide. Forebody 214-251(238) long, 54-56 (55)% of body length. Tegument spinose, spines densely distributed in anterior half and sparsely in posterior. Oral sucker funnel-shaped, terminal, 40-66 (50) x 24-34 (30) in size. Circum-oral spines 30, in two alternating rows. Ventral sucker 32-41 (46) x 32-56 (41) in size. Sucker width ratio 1: 1.12-1.6 (1.37). Prepharynx 21-27 (25) long. Pharynx sub-globular, muscular; 27-41(35) x 21-36 (28) in size. Oesophagus 20-28 (22)) long, bifurcating 61-91(75) from anterior margin of ventral sucker. Caeca extend up to the level of ovary and terminate blindly 122-129 (125) from posterior end of body.

Testes ovoid, symmetrical on either side of excretory bladder; right testis 41-59 (50) x 35-62 (41); left testis 52-60 (57) x 41-96 (71). Post-testicular region 37-49 (41) long, 8-13 (9.05)% of body length. Seminal vesicle large, sac-like, bipartite, opens in front of ventral sucker.

Table 13.Measurements (µm) of adults of *Centrocestus formosanus* (Nishigori, 1924) Price, 1932.

Character	Range	Mean
Body Size	381-460 x 171-200	432 x 181
Forebody	214-251	238
Oral sucker	40-66 x 24-34	50 x 30
Ventral sucker	32-41 x 32-56	46 x 41
Prepharynx	21- 27	25
Pharynx	27-41 x 21-36	35 x 28
Oesophagus	20-28	22
Right testis	41-59 x 35-62	50 x 41
Left testis	52-60 x 41-96	57 x 71
Ovary	22-34 x 31-44	28 x 38
Eggs	24-32 x 14-16	25 x 15

Ovary ovoid, 22-34 (28) x 31-44 (38), pre-testicular, at a distance of 55-84 (75) from ventral sucker. Seminal vesicle large, sac-like, opens in front of ventral sucker. Vitellarium follicular; follicles lying scattered along the lateral body margins from pharyngeal level to posterior end of body, confluent at level of caecal bifurcation. Uterine coils occupy the space between ventral sucker and testes, contain 20-40 eggs. Eggs ovoid, yellowish brown, operculate; 24-32 (25) x 14-16 15). Excretory bladder x-shaped, between testes.

Definitive hosts : *Ardeola grayii* Sykes and *Milvus migrans* Boddaert

Site : Intestine

Period of collection : March 2002-December 2008

Locality : *A. grayii:* Iruvetty and Puthurpallikkal, Malappuram district; Cheruvady and Ramanattukara, Kozhikkode district, Kerala

M. migrans: Cheruvady, Kozhikkode district, Kerala

Prevalence : Three of 16 *A. grayii,* and one of 3 *M. migrans* examined were found to be infected

Intensity : 6 and 7 in *A. grayii*; 9 in *M. migrans*

Remarks

Nishigori (1924a) described *Stamnosoma formosanum* from the night heron, *Nycticorax nycticorax* but Price (1932) shifted it to the genus *Centrocestus* Looss, 1899 and renamed it *C. formosanus.* Only 3 valid species of *Centrocestus* have so far been reported from birds all over the world. These are, *C. cuspidatus* (Looss, 1896) Looss, 1899, *C. armatus* (Tanabe, 1922) Price, 1932, and *C. formosanus* (Nishigori, 1924) Price, 1932. The species under discussion comes close to *C. formosanus* in body dimensions, sucker ratios, position, shape and size of testes and ovary, distribution of vitellaria, and in the size of eggs. As *C. formosanus* is the only species of *Centrocestus* so far reported from India, the present fluke is identified and reported here as *Centrocestus formosanus* (Nishigori, 1924) Price, 1932.

Genus: *Stellantchasmus* Onji and Nishio, 1916

***Stellantchasmus falcatus* Onji and Nishio, 1916**

Infection with the present trematode was found in the intestine of the pariah kite, *Milvus migrans* collected from Cheruvady on 16 April 2006. One of 3 birds (33%) examined was found to be infected. The bird harboured more than 200 worms and it exhibited mixed infection with the adults of *Mesostephanus indicum* and *Haplorhis taichui .*

Description (Fig. 14; Table 14; Plate 6):

Body pyriform, with maximum width at middle of body; 462-657 (555) long, 205-314 (267) wide. Forebody 205-241 (226) long, 36-50 (41)% of body length. Tegument covered with backwardly directed, scale like spines. Spines densely distributed in anterior half, sparsely in posterior. Oral sucker sub-terminal, round, 36-50 (47). Ventrogenital sac pre-equatorial slightly shifted to right side and contains ventral sucker. Ventral sucker, small, round, 10-14(12), enclosed in genital atrium; armed with two lateral groups of spines on the lip. Sucker ratio 1: 0.37-.42(0.4). Prepharynx 8-20 (14) long. Pharynx globular, 26-30 (29). Oesophagus narrow, 89-116 (106) long, bifurcates in posterior region of forebody, 33-43 (36) anterior to ventral sucker. Caeca run laterally on either side, terminate blindly 129-198 (169) from posterior end.

Testes two, symmetrical, in posterior region of hindbody; right testis 139-179 (161) x 66-76 (69); left testis 149-198 (168) x 66-96 (76). Post-testicular region 17-33 (25) long, 0.03-.06 (0.04)% of body length. Seminal vesicle ovoid, connected by a short tube to a relatively large, ovoid, muscular expulsor located in left side of middle region of body. Pars prostatica weakly developed. Ejaculatory duct opens to genital atrium along with uterus. Cirrus absent.

Table 14. Measurements (µm) of adults of *Stellantchasmus falcatus* Onji and Nishio, 1916

Character	Range	Mean
Body size	462-657 x 205-314	555 x 267
Forebody	205-241	226
Oral sucker	36-50	47
Ventral sucker	30-35	31
Prepharynx	8-20	14
Pharynx	26-30	29
Oesophagus	89-116	106
Right testis	139-179 x 66-76	161 x 69
Left testis	149-198 x 66-96	168 x 76
Ovary	69-99	85
Eggs	26-32 x 20-23	29 x 21

Ovary submedian, round, 69-99 (85), located between ventral sucker and right testis, 126-156 (147) from ventral sucker. Vitellarium follicular; follicles extend from level of ventral sucker to posterior end of body. Uterine coils fill the space between intestinal bifurcation and posterior end of body. Eggs numerous, yellow, operculate; 26-32 (29) x 20-23 (21).

Definitive host : *Milvus migrans* Boddaert

Site : Intestine

Period of collection : March 2006-March 2007

Locality : Cheruvady , Kozhikkode district, Kerala

Prevalence : One of 3 *Milvus migrans* examined were found to be infected

Intensity : > 200

Remarks

Stellantchasmus falcatus Onji and Nishio, 1916 was reported from cats experimentally fed with the mullet, *Mugil cephalus* harbouring the metacercariae. The Indian report of the genus is limited to the description of metacercariae of *S. falcatus* from fishes by Rekharani and Madhavi (1985).

Recovery of the present fluke from the intestine of *Milvus migrans* is thus the first report of the adults of the genus from India. A comparison of the characters of the present form with that of the known species in the genus revealed that it is identical with *S. falcatus* in body dimensions, sucker ratios, position, shape and size of testes and ovary, and in the distribution of vitellaria. But the eggs in the present worm are slightly larger in size. This difference in the egg size alone cannot be taken as a character significant enough for assigning a species status to the present worm. Therefore, it is reported here as *Stellantchasmus falcatus* Onji and Nishio, 1916. Recovery of *S. falcatus* from *M. migrans* in Cheruvady forms the first report of the adults of the species from India and from the present host.

Genus *Haplorchis* Looss, 1899

Haplorchis taichui (Nishigori, 1924) Witenberg, 1929

Adults of the present fluke were recovered from the intestine of the pariah kite, *Milvus migrans,* collected from Cheruvady on 14 March 2006 and 16 April 2006. Two out of 3 birds (66.6%) examined were found to be infected with the present worm. Intensity of infection was 30 and 45. One bird

was found simultaneously infected with the adults of *Mesostephanus indicum* and *Stellantchasmus falcatus* and the other with *M. indicum.*

Description (Fig. 15; Table 15; Plate 6):

Body pyriform, flattened, with narrow anterior and broad posterior ends, maximally wide at level of ovary; 540-940 (731) long, 364-635 (494)

Table 15. Measurements (µm) of adults of *Haplorchis taichui* (Nishigori, 1924) Witenberg, 1929.

Character	Range	Mean
Body size	540-940 x 364-635	731 x 494
Forebody	216-380	310
Oral sucker	46-82	65
Ventro-genital complex	61-110 x 52-90	82 x 74
Prepharynx	7-13	11
Pharynx	33-56 x 21-36	35 x 32
Oesophagus	51-90	82
Testis	158-240 x 141-229	201 x 204
Ovary	90-157 x 60-115	131 x 97
Eggs		25 x 15

	24-28 x 10.5-16.5	

wide. Forebody 216-380 (310) long, 39-42 (40)% of body length. Tegument covered with backwardly directed, scale-like spines, closely set in pre-testicular region and widely in post-testicular region. Oral sucker sub-terminal, round, 46-82 (65). Ventro-genital complex 61-110 (82) x 52-90 (74) in size, located below intestinal bifurcation, contains genital sac, ventral sucker and genital pore. Ventral sucker armed with 14-16 large spines, 8-28 (21) in length, arranged in a fan-like form, and 4-5 smaller spines on either side of the larger spines. Prepharynx small, 7-13 (11) long. Pharynx, muscular, ovoid, 33-56 (35) x 21-36 (32). Oesophagus 51-90 (82) long, bifurcating 72-126 (111) from anterior margin of ventro-genital complex. . Caeca reach posterior level of testis, terminate blindly 126-220 (187) from posterior end of body.

Testes single, nearly round, 158-240 (201) x 141-229 (204), in posterior part of body. Post-testicular region 108-192 (161) long. Seminal vesicle bipartite with proximal part 14-25 (20) x 14-25 (21) and distal part 43-74 (51) x 40-71 (46) in size. Ovary ovoid, pre-testicular, adjacent to ventrogenital complex; 90-157 (131) x 60-115 (97) in size. Vitellarium follicular; follicles extending from anterior level of

ovay to posterior end of body. Uterus contains numerous eggs. Eggs ovoid, operculate; 24-28 (25) x 10.5-16.5 (15).

Definitive host	:	*Milvus migrans* Boddaert
Site	:	Intestine
Period of collection	:	March 2006-March 2007
Locality	:	Cheruvady, Kozhikkode district, Kerala
Prevalence	:	Two out of 3 *M. migrans* were found to be infected
Intensity	:	35-45

Remarks

Nishigori (1924b) described *Monorchotrema taichui* from the night heron, *Nycticorax nycticorax* in Taiwan. Witenberg (1930) synonymised the genus *Monorchotrema* Nishigori, 1924 with *Haplorchis* Looss, 1899 and shifted *M. taichui* to *Haplorchis* and renamed it *H. taichui*. The present worm recovered from the intestine of *Milvus migrans* fully agrees with *H. taichui* (Nishigori, 1924) in body dimensions, position, shape and size of testis and ovary, size of eggs, structure of ventrogenital complex, and in the pattern of arrangement of spines on ventral sucker. Therefore, the present fluke is

readily identified and reported here as *Haplorchis taichui* (Nishigori, 1924). Recovery of the fluke from *Milvus migrans* in Kozhikkode district forms a new geographical record for the species.

Family: Clinostomidae Luhe, 1902

Genus: *Clinostomum* Leidy, 1856

Clinostomum complanatum (Rudolphi, 1819) Braun, 1899

Adults of the present fluke were recovered from the buccal cavity and pharynx of 5 *Ardeola grayii*, collected from Iruvetty, Puthurpallikkal, Cheruvady and Ramanattukara, 2 *Egretta garzetta* from Iruvetty, 4 *Bubulcus ibis* from Iruvetty, Puthurpallikkal and Cheruvady, and one *Anastomus ocitans* from Cheruvady. The intensity of infections varied from 10 to 75. Mixed infections with other flukes in different combinations were observed in all the *A. grayii* infected with the present fluke. In one bird the other flukes recovered were *Echinochasmus bagulai, Centrocestus formosanus* and *Apharyngostrigea ramai,* and in 4 birds it was *E. bagulai.* In *B. ibis* mixed infections were observed in 3 of 4 infected birds. Triple infection with *Nephrostomum ramosum, Pegosomum egretti* and the present fluke was found in one bird. Double infections were observed in 2 birds, one with *Parallelotestis tarai* and the other with *A. ramai.*

Description (Fig. 16; Table 16; Plate 6)

Body stout, linguiform; 3138-6000 (4225) long, 1248-1872 (1487) wide, with maximum width at middle of body. Forebody 546-1250 (811)

Table 16 . Measurements (µm) of adults of Clinostomum complanatum (Rudolphi, 1809) Braun, 1899.

Character	Range	Mean
Body size	3138-6000 x 1248-	4225 x 1487
Forebody	1872	811
Oral sucker	546-1250	248 x 287
Ventral sucker	187-296 x 265-312	660
Oesophagus	499-795	178
Anterior testis	125-296	365 x 516
Posterior testis	312-468 x 390-624	388 x 599
Cirrus sac	312-468 x 515-702	225 x 173
Ovary	150-292 x 102-200	183 x 130
Eggs	94-250 x 94-203	90 x 68
	89-91 x 66-69	

long, 16.8-18.9(16.6)% of body length. Tegument aspinose. Oral sucker sub-terminal, 187-296 (248) x 265-312 (287) in size. Ventral sucker round, 499-795 (660), highly muscular, in anterior third of body. Sucker ratio 1:1.9-.3.2 (2.48). Pharynx absent. Oesophagus 125-296 (178) long, bifurcating 156-375 (297) from anterior margin of ventral sucker. Caeca long, sinuous, with numerous closely set pouches from posterior level of ventral sucker up to caecal ends, terminate blindly, 78-200 (133) from posterior end of body.

Testes two, tandem, lobed, roughly triangular with their biconcave bases facing each other; anterior testis 312-468 (365) x 390-624 (516), in middle third of body; posterior testis 312-468 (388) x 515-702 (599), in posterior third of body. Post-testicular region 515-1000 (799) long. Cirrus sac oval to elliptical, 150-292(225) x 102-200(173), located between right margin of anterior testis and ovary; encloses a coiled seminal vesicle, long coiled ejaculatory duct and highly muscular, claviform, eversible cirrus. Cirrus 109 in length. Genital pore at level of right lateral margin of anterior testis.

Ovary ovoid, 94-250 (183) x 94-203 (130), intertesticular, located beneath the cirrus sac. Ventral sucker

to ovary distance 1200-2125 (1358). Vitellarium consists of small follicles extending from posterior margin of ventral sucker to posterior end of body. Uterus runs round left margin of anterior testis and makes a loop before opening into uterine sac, a short distance in front of anterior testis. Eggs numerous, ovoid, operculate; 89-91 (90) x 66-69 (68).

Definitive hosts	:	*Ardeola grayii* Sykes, *Bubulcus ibis* Linnaeus, *Egretta garzetta* Linnaeus, and *Anastomus ocitans* Boddaert
Site	:	Buccal cavity and pharynx
Locality	:	Iruvetty and Puthurpallikkal, Malappuram district; Ramanattukara and Cheruvady, Kozhikkode district, Kerala
Period of collection	:	January 2002-March 2009
Prevalence	:	Five of 16 *Ardeola grayii*; two of 8 *Egretta garzetta*, 4 of 12 *Bubulcus ibis* and 1 *Anastomus ocitans* examined were found to be infected.
Intensity	:	8-75

Remarks

Clinostomum complanatum (Rudolphi, 1819) Braun, 1899 is a cosmopolitan species widely distributed in most of the countries of the world. After various synonymies *C. complanatum* became the only valid species known from India. The present fluke recovered from the buccal cavity and pharynx of *Ardeola grayii, Egretta garzetta, Bubulcus ibis* and *Anastomus ocitans* collected from Malappuram and Kozhikkode districts agrees fully with *C. complanatum* in morphological features and metric details. Hence, it is readily identified and reported here as *C. complanatum* (Rudolphi, 1819) Braun, 1899. Recovery of this fluke from Malappuram and Kozhikkode districts forms new geographical record for the species. `

Family: Clinostomidae Luhe, 1901

Genus: *Euclinostomum* Travassos, 1928

***Euclinostomum heterostomum* (Rudolphi, 1809)**

Travassos, 1928

The present fluke was recovered from the buccal cavity of the cattle egret, *Bubulcus ibis,* collected from

Puthurpallikkal on 6 December 2008. Only one bird was found infected and it harboured 6 adult flukes.

Description (Fig. 17; Table 17; Plate 6)

Body stout, linguiform; 4800-9820 (7440) long, 1840-3220 (2580) wide, with distinct lateral constriction at level of ventral sucker. Forebody 992-1712 (1500) long, 17.45-22.3 (20)% of body length. Tegument smooth, unarmed. Oral sucker sub-terminal, ventral, sub-globular, 192-304 (257) x 224-352 (295) in size. Ventral sucker highly muscular, large, round, 960-1344 (1157), in anterior third of body. Sucker width ratio 1: 4-4.7 (4.2). Pharynx absent. Oesophagus 90-160 (120) long, bifurcating 349-425 (377.3) from

Table 17. Measurements (µm) of adults of Euclinostomum heterostomum (Rudolphi, 1809) Travassos, 1928

Character	Range	Mean
Body size Forebody	4800-9820 x 1840-3220	7440 x 2580

Oral sucker	992-1712	1500
Ventral sucker	192-304 x 224-352	257 x 295
Oesophagus	960-1344	1157
Anterior testis	90-160	120
Posterior testis	540-960 x 560-	695 x 923
Cirrus sac	1376	622 x 686
Ovary	416-864 x 432-896	139 x 103
Eggs	109-172 x 62-125	183 x 130
	94-250 x 94-203	90 x 68
	89-91 x 66-69	

anterior margin of ventral sucker. Caeca broad in anterior region of ventral sucker, becoming narrower thereafter. Behind ventral sucker each caecum gives off branches from the outer margins. The right caecum gives off 8 to 10 unequal branches and the left gives off 8 to 11 branches.

Testes two, tandem, large, lobed, intercaecal, in posterior third of body; anterior testis, ‘U’ shaped with a shallow deep concavity, 540-960 (695) x 560-1376 (923); posterior testis trilobed, 416-864 (622) x 432-896 (686). Post-testicular region 880-1832 (1232) long. Cirrus sac ovoid, 109-172 (139) x 62-125 (103), located between arms of anterior testis and ovary; encloses a coiled seminal vesicle, leading into a short ejaculatory duct and highly muscular, eversible cirrus. Cirrus 109 long. Genital pore at level of anterior margin of anterior testis.

Ovary sub-spherical, 94-250 (183) x 94-203 (130) inter-testicular, shifted to right of median line. Ventral sucker to ovary distance 1437-3125 (2358). Seminal receptacle 47-140 (98) x 39-47 (43) in size. Vitellarium in small follicles, extending from posterior margin of ventral sucker to the posterior end of body. Uterine sac long, tubular, not reaching

ventral sucker. Eggs numerous, ovoid, operculate; 89-91 (90) x 66-69 (68).

Definitive host : *Bubulcus ibis* Linnaeus

Period of collection : Janu

Locality : Puth Kerala

Site : Buccal cavity

Prevalence : One of 12 *Bubulcus ibis* examined was found to be infected.

Intensity : 6

Remarks

The genus *Euclinostomum* Travassos, 1928 at present has 4 recognised species, *E. heterostomum* Rudolphi (1809), *E. minutus* Zaidi and Khan, 1975, *E. multicaecum* Tubangui and Masilungan, 1935 and *E. ardeolae* El. Naffar and Khalifa, 1981. *E. heterostomum* is the only species of the genus known from India. A comparison of the characters of the present fluke with that of *E. heterostomum* revealed that in general body form, structure of caeca, position of testes and

ovary, nature of cirrus sac, distribution of vitellaria, size of eggs, and sucker width ratios it is identical with *E. hetrostomum* Therefore, it is identified and reported here as *E. heterostomum* Rudolphi (1809) Travassos, 1928. Recovery of this species from *B. ibis* collected at Puthurpallikkal forms a new locality record.

Family: Cyathocotylidae Muhling, 1898

Genus *Mesostephanus,* Lutz 1935

***Mesostephanus indicum* Mehra, 1947**

Adults of the present fluke were recovered from the intestine of the pariah kite, *Milvus migrans,* collected from Cheruvady in Kozhikkode district during March 2006-March 2007 (Plate 6). All the 3 birds examined were found to be infected with the present worm. Intensity of infection varied from 30 to 45. Triple infection with *Stellanthchasmus falcatus* and *Haplorchis taichui* and the present fluke was found in one bird. Two birds exhibited double infections; one with *Centrocestus formosanus,* and the other with *H. taichui.* The life-cycle of *Mesostephanus indicum* has already been worked out and published (Parasitol. Res. (2007), 101: 1015-1018). A copy of the publication is included under Appendix I.

Family: Diplostomidae Poirier, 1886

Genus: *Subuvulifer* Dubois, 1952

***Subuvulifer halcyonae* (Gogate, 1940) Dubois, 1952**

Adult flukes were recovered from the intestine of two white-breasted kingfishers, *Halcyon smyrnensis* collected

from Iruvetty on 10 April 2004 and from Puthurpallikkal on 30 May 2007. One bird was infected with 6 flukes and the other with 8. One infected bird exhibited mixed infection with the adults of *Psilorchis indicus, U. stunkardi* and *Uvulifer cochlearis,* and the other with *Uvulifer cochlearis* and *Uvulifer* sp l. n.sp.

Description (Fig. 18; Table 18; Plate 7)

Body distinctly bipartite, 2621-3030 (2757) in length. Forebody oval, cochleariform, 468-780 (640) x 468-749 (614); hindbody long, sub cylindrical, 1950-2250 (2117) x 328-600 (471). Ratio of forebody length to hind body length 1: 2.88-4.6 (3.46). Oral sucker sub-terminal, round, 40-73 (67). Ventral sucker larger than oral sucker, 54-76 (65) x 59-116 (86) in size, just anterior to middle of forebody. Distance between oral sucker and ventral sucker 109- 274 (192). Sucker width ratio 1: 1.07-1.53 (1.22). Pseudosuckers smaller than oral sucker, measured 46-54 (49) x 31-43 (38). Ratio of oral sucker length to pseudosucker length 1: 0.68-0.93 (0.83). Holdfast organ nearly round with a median slit; immediately posterior to ventral sucker, measured 154-308 (220) x 108-347 (218). Ratio of body length to holdfast organ length 1:

0.06- 0.101 (0.07). Ratio of forebody length to holdfast organ length 1: 0.23-0.42 (0.34). Proteolytic gland at the junction of fore- and hindbody. Prepharynx small; pharynx small, round, 39-59 (47); oesophagus 30-39 (33) long; intestinal caeca reach into post-testicular region. Ratio of oral sucker length to pharynx length 1: 0.62-0.76 (0.71).

Table 18. Measurements (µm) of adults of Subuvulifer halcyonae (Gogate, 1940) Dubois, 1952

Character	Range	Mean
Forebody	468-780 x 468-749	640 x 614
Hindbody	1950-2250 x 328-	2117 x 471
Oral sucker	600	67
Ventral sucker	40-73	65 x 86
Pseudosucker	54-76 x 59 - 116	49 x 38
Holdfast organ	46-54 x 31-43	220 x 218
Pharynx	154-308 x 108-347	47
Oesophagus	39 - 59	33
Anterior testis	30-39	318 x 303
Posterior testis	154-462 x 193-462	293 x 283
Seminal vesicle	231-362 x 231-347	152 x 160
Ovary	148-156 x 99-200	121
Eggs	92-154	83 x 57
	73-92 x 50-62	

Testes tandem, massive, lobed, located just posterior to middle of hindbody; anterior testis 154-462 (318) x 193-462 (303); posterior testis 231-362 (293) x 231-347 (283). Seminal vesicle large, 148-156 (152) x 99-200 (160), posterior to testis, without ejaculatory pouch. Copulatory bursa encloses a protrusible genital cone. Prepuce-like fold around genital cone present. Ovary round, immediately pre-testicular; 92-154 (121). Hermaphroditic duct opens terminally on genital cone. Vitellarium follicular; follicles distributed densely from posterior level of holdfast organ to posterior end of hindbody. Uterus with 11-13 (12) eggs. Eggs yellow, ovoid, operculate; 73-92 (83) x 50-62 (57).

Definitive host	:	*Halcyon smyrnensis* Linnaeus
Site	:	Intestine
Locality	:	Iruvetty and Puthurpallikkal, Malappuram district, Kerala
Period of collection	:	April 2004-June 2008
Prevalence	:	Two of 16 *Halcyon smyrnensis* examined were found to be infected
Intensity	:	6-8

Remarks

Subuvulifer halcyonae (Gogate, 1940) Dubois, 1952 reported from *Halcyon smyrnensis* is the only valid species of the genus known from India, and therefore, the present form recovered from the same host species needs a comparison with it. A comparative study revealed that the present fluke is identical with *S. halcyonae* in morphological features. But in metric details there are minor differences between the two flukes. This may be due to the difference in the methods of the preparation of the worms for detailed studies. As *S. halcyonae* is the only valid species reported from India, the present fluke is identified and reported here as *Subuvulifer halcyonae* (Gogate, 1940) Dubois, 1952. This forms the first report of *S. halcyonae* from South India.

Genus: *Uvulifer* Yamaguti, 1934

Uvulifer denticulatus (Rudolphi, 1819) Dubois, 1937

Infections with the adults of the present fluke were found in the intestine of the small blue kingfisher*, Alcedo atthis* collected from Iruvetty and Puthurpallikkal during June 2001-April 2004. Five out of 7 birds (71.4%) examined were

found to be infected with this fluke. The intensity of infection varied from 1 to 3. Four birds infected with the present fluke exhibited mixed infections with adults of *Stephanoprora* sp. 1 n.sp.

Description (Fig. 19; Table 19; Plate 7):

Body distinctly bipartite, spoon-shaped, 2354-4454 (3640) in length. Forebody cochleariform, concave ventrally, 468-693 (561) x 281-423 (373); hindbody exceedingly long, narrow at anterior and broader at posterior ends; 1872-3865 (3079) x 265-437 (356). Ratio of forebody length to hindbody length 1: 3.95-8.25 (5.66). Oral sucker terminal, round, 46-114(74), larger than ventral sucker. Ventral sucker round, 35-62 (54), almost at the middle of forebody just anterior to holdfast organ. Distance between oral sucker and ventral sucker 173-205 (189). Sucker ratio 1:0.53-0.9 (0.84). Holdfast organ round, lobed, with a median longitudinal slit; immediately posterior to ventral sucker; 162-200 (179) x 116-193 (163). Ratio of body length to holdfast organ length 1: 0.042-0.069 (0.051). Ratio of forebody length to holdfast organ length 1: 0.244-0 .69 (0.327). Prepharynx very small; pharynx ovoid, muscular; 77-83 (79) x 36-54 (45);

oesophagus short, narrow, 45-62 (56) in length; intestinal caeca narrow, terminate blindly, 249-302(280) from posterior end of body. Ratio of oral sucker length to pharynx length 0.9-1.42 (1.3).

Table 19. Measurements (µm) of adults of *Uvulifer denticulatus* (Rudolphi, 1819) Dubois, 1937

Character	Range	Mean
Forebody	468-693 x 281-423	561 x 373
Hindbody	1872-3865 x 265-	3079 x 356
Oral sucker	437	74
Ventral sucker	46-114	54
Holdfast organ	35-62	179 x 163
Pharynx	162-200 x 116-193	79 x 45
Oesophagus	77-83 x 36-54	56
Anterior testis	45-62	262 x 289
Posterior testis	131-347 x 193-462	271 x 308
Seminal vesicle	116-377 x 208-470	179 x 168
Ovary	100-216 x 69-293	136 x 169
Egg	77-184 x 115-269	83 x 57
	83-84 x 56-57	

Testes nearly round, tandem, in middle third of hindbody; anterior testis 131-347 (262) x 193-462 (289); posterior testis 116-377 (271) x 208- 470 (308). Seminal vesicle saccular, 100-216 (179) x 69-293 (168), behind posterior testis, slightly overlapping its posterior margin, opens into a muscular ejaculatory pouch. Copulatory bursa with a protrusible genital cone, half enclosed by a prepuce like fold. Hermaphroditic duct opens at the apex of genital cone.

Ovary ovoid, 77-184 (136) x 115-269 (169), pre-testicular, just behind middle of hindbody. Ootype round. Laurer's canal present. Mehlis' gland complex and vitelline reservoir intertesticular. Vitellarium follicular, in lateral fields extending from anterior region of hind body to the level of caecal ends. Uterus with 8-11 eggs. Eggs ovoid, yellow, operculate; 83-84 (83) x56-57 (57).

Definitive host : *Alcedo atthis* Linnaeus

Site : Intestine

Locality : Iruvetty and Puthurpallikkal, Malappuram district, Kerala

Period of collection : June 2001-April 2004

Prevalence : Five of 7 *A. atthis* examined were found to be infected

Intensity : 1-3

Remarks:

The present fluke recovered from the intestine of *Alcedo atthis* has a distinctly bipartite body, ventral sucker which is smaller than the oral sucker, copulatory bursa with a protrusible genital cone half enclosed by a preputial fold and vitellaria confined to hindbody. These characters justify beyond doubt its inclusion in the genus *Uvulifer* Yamaguti, 1934. A comparison of characters of the present fluke with that of the 17 known species in the genus revealed that it comes close to *U. denticulatus* (Rudolphi, 1819) Dubois, 1937 reported from the same host species in shape of body, sucker width ratios, position, shape and size of testes and ovary, distribution of vitellaria, and shape and size of eggs. Therefore, it is identified as *U. denticulatus* (Rudolphi, 1819) Dubois, 1937 and reported here accordingly. This forms the first record of *U. denticulatus* from India.

***Uvulifer stunkardi* (Pande, 1938) Bhalerao, 1942**

Natural infection with this fluke was found in the intestine of the white-breasted kingfisher, *Halcyon smyrnensis* collected from Puthurpallikkal on 11 May 2007. Only one bird was found positive and 6 adults were recovered from it. The bird was simultaneously infected with the adults of *Psilorchis indicus, Subuvulifer halcyonae* and *Uvulifer cochlearis*

Description (Fig. 20; Table 20; Plate 7)

Body distinctly bipartite, 725-810 (754) in length. Forebody cochleariform, 220-261 (231) x 136-209 (164); hindbody long, sub cylindrical, 494- 612 (523) x 196-234 (208). Ratio of forebody length to hindbody length 1: 2-2-2.32 (2.26). Oral sucker terminal, nearly round, 60-85 (54) x 43-53 (46). Ventral sucker nearly round, 20-29 (26) x 31-36 (32), almost in middle of forebody just anterior to holdfast organ. Distance between oral sucker and ventral sucker 45-60 (54). Sucker width ratio 1: 0 .75-0.93 (0.83). Holdfast organ nearly round, with a median longitudinal slit; immediately posterior to ventral sucker, measured 43-60 (54) x 55-73 (69). Ratio of body length to holdfast organ length 1: 0. 06-0.074 (1.071). Ratio of forebody length to holdfast organ length 1:

0.21-0 .244 (0.233). Prepharynx very small; pharynx globular, 20-29(23); oesophagus short, narrow, 13-19 (15) long; intestinal caeca reach into post-testicular region. Ratio of oral sucker length to pharynx length 1: 0.5- 0.7 (0.6).

Testes tandem, in the middle third of hindbody near right margin; anterior testis 59-66 (62) x 80-109 (92); posterior testis 54-71 (62) x 102-125

Table 20. Measurements (µm) of adults of *Uvulifer stunkardi* (Pande, 1938) Bhalerao, 1942

Character	Range	Mean
Forebody	220-261 x 136-209	231 x 164
Hindbody	494-612 x 196-234	523 x 208
Oral sucker	60-85 x 43-53	54 x 46
Ventral sucker	20-29 x 31-36	26 x 32
Holdfast organ	43-60 x 55-73	54-69
Pharynx	20-29	23
Oesophagus	13-19	15
Anterior testis	59-66 x 80-109	62 x 92
Posterior testis	54-71 x 102-125	62 x 116
Seminal vesicle	43-55 x 61-76	50 x 66
Ovary	40-51 x 49-59	46 x 54

Eggs	75-77 x 54-56	77 x 54

(116). Seminal vesicle saccular, 43-55 (50) x 61-76 (66), behind posterior testis, slightly overlapping its posterior margin, opens into a muscular ejaculatory pouch. Copulatory bursa with a protrusible genital cone, half enclosed by a prepuce like fold. Hermaphroditic duct opens at the apex of genital cone.

Ovary ovoid, immediately pre-testicular, 40-51 (46) x 49-59 (54). Mehlis' gland complex and vitelline reservoir inter-testicular. Vitellarium follicular, distributed in two lateral fields extending from anterior region of hindbody to posterior end of body. Uterus with 3-5 eggs. Eggs yellow, ovoid, operculate; 75-77 (77) x 54-56 (54) in size.

Definitive host	:	*Halcyon smyrnensis* Linnaeus
Site	:	Intestine
Locality	:	Iruvetty, Malappuram district, Kerala
Period of collection	:	March 2004-April 2009
Prevalence	:	One of 16 *H. smyrnensis* examined were found to be infected
Intensity	:	6

Remarks

The present fluke infecting *Halcyon smyrnensis* resembles *Uvulifer stunkardi* (Pande,1938) Bhalerao, 1942 reported from the same host species in shape and size of body, sucker width ratios, ratio of forebody length to hindbody length, position and shape of testes and ovary , distribution of vitellaria, and in the number, shape and size of eggs. However, this fluke shows slight variations from *U. stunkardi* in measurements of body, testes and ovary. These minor variations exhibited by the present worm cannot be considered significant enough to differentiate the two forms. Therefore, the fluke is readily identified and reported here as *Uvulifer stunkardi* (Pande, 1938) Bhalerao, 1942. This forms the first report of the species from South India.

***Uvulifer cochlearis* (Verma, 1936) Dubois, 1944**

Uvulifer cochlearis was found in the intestine of *Halcyon smyrnensis* collected from Iruvetty and Puthurpallikkal during March 2004-April 2009**.** Three birds collected were positive for this fluke. Six flukes were recovered from 2 birds and 8 from one bird. All the three birds infected with the present fluke were found infected with other flukes in the following

combinations: *Psilorchis indicus, Subuvulifer halcyonae*, and *U. stunkardi* in the first bird; *S. halcyonae* and *Uvulifer* sp. I n. sp. in the second, and *Uvulifer* sp. 1 n. sp. in the third.

Description (Fig. 21; Table 21; Plate 7)

Body distinctly bipartite, spoon-shaped, 847-2029 (1300) in length. Forebody cochleariform, concave ventrally, 231-470 (312) x 172-331 (220); hindbody elongate, narrow at anterior and broader at posterior ends, 616-1560 (989) x 156-281 (203). Ratio of forebody length to hindbody length 1: 2.66-3.43 (3.15). Oral sucker terminal, nearly round, 31-94 (46) x 62- 77 (65). Ventral sucker round, 17-54 (40), almost at middle of forebody just anterior to holdfast organ. Distance between oral sucker and ventral sucker 69-146 (106). Sucker width ratio 1: 0.267- 0.75 (0.61). Holdfast organ nearly round, lobed, with a median longitudinal slit; immediately posterior to ventral sucker, measured 40-131 (79) x 50-116 (80). Ratio of body length to holdfast organ length 1: 0.046- 0.067 (0 .059). Ratio of forebody length to holdfast organ length 1: 0.17-0.3 (0.249). Prepharynx very small; pharynx muscular, ovoid 23-39 (32) x 23-46 (31); oesophagus short, narrow, 14-23 (21); intestinal caeca reach

into post-testicular region. Ratio of oral sucker length to pharynx length 1: 0 .41- 0 .82 (0.71).

Testes tandem; anterior testis 115-400 (185) x 100-231 (144), located near right margin of hindbody; posterior testis, 108-231 (139) x 123-308 (174), intercaecal in position in hindbody. Seminal vesicle saccular, 92-108 (100) x 69-169 (105), behind posterior testis, slightly overlapping its posterior

Table 21. Measurements (µm) of adults of *Uvulifer cochlearis* (Verma,1936) Dubois, 1944

Character	Range	Mean
Forebody	231-470 x 172-331	312 x 220
Hindbody	616-1560 x 156-281	989 x 203
Oral sucker	31-94 x 62-77	46 x 65
Ventral sucker	17-54	40
Holdfast organ	40-131 x 50-116	79 x 80
Pharynx	23-39 x 23-46	32 x 31
Oesophagus	14-23	21
Anterior testis	115-400 x 100-231	185 x 144
Posterior testis	108-231 x 123-308	139 x 174
Seminal vesicle	92-108 x 69-169	100 x 105

Ovary	62-108	77
Eggs	77-92 x 46-62	83 x 52

margin, opens into a muscular ejaculatory pouch. Copulatory bursa with a protrusible genital cone, half enclosed by a prepuce like fold. Hermaphroditic duct opens at the apex of genital cone.

Ovary round, 62-108 (77), immediately pre-testicular, just anterior to middle of hindbody. Ejaculatory duct opens into sucker like genital atrium. Mehlis' gland complex and vitelline reservoir intertesticular. Vitellarium follicular, distributed in two lateral fields, extending from anterior region of hindbody to posterior end of body. Uterus with 3-5 eggs. Eggs yellow, ovoid, operculate; 77-92 (83) x 46-62 (52).

Definitive host	:	*Halcyon smyrnensis* Linnaeus
Site	:	Intestine
Locality	:	Iruvetty, Malappuram district, Kerala
Period of collection	:	March 2004-April 2009
Prevalence	:	Three of 16 *H. smyrnensis* examined were found to be infected.
Intensity	:	1-6

Remarks

A comparison of the characters of the present fluke recovered from *Halcyon smyrnensis* with that of the 17 known species of the genus revealed that it is identical with *Uvulifer cochlearis* (Verma, 1936) Dubois, 1944 in body dimensions, sucker width ratios, position, shape and size of testes and ovary; distribution of vitellaria and in shape and size of eggs. Therefore, the present form is reported here as *Uvulifer cochlearis* (Verma, 1936) Dubois, 1944. Recovery of this species from *H. smyrnensis* from Malappuram district of Kerala forms a new geographical record.

***Uvulifer* sp.1 n.sp.**

Natural infections with this fluke were found in the intestine of the white-breasted kingfisher, *Halcyon smyrnensis* collected from Iruvetty, Puthurpallikkal and Cheruvady during March 2004-April 2009. Twelve out of 16 birds (75%) collected from these areas were found to be infected by this fluke. The present fluke exhibited mixed infection with the adults of *Uvulifer stunkardi* in one bird; a few birds were infected with the present fluke along with the adults of *Uvulifer cochlearis*, *Basantisia ramai* and *Psilorchis indicus*.

Description: (Fig. 22a; Table 22a; Plate 7): Body distinctly bipartite, 790-1669 (1139) in length. Forebody cochleariform, 323- 468 (387) x 312-390 (352); hindbody long, sub-cylindrical, 770-1248 (963) x 343 -501 (413). Ratio of forebody length to hindbody length 1: 2.2-2.96 (2.51). Body unarmed, serrated. Oral sucker terminal, round, 56-99 (77). Ventral sucker round, 33-50 (39), anterior to middle of forebody. Distance between oral sucker and ventral sucker 55-122 (83). Sucker width ratio 1:0 .46-0-0.58 (0 .51). Holdfast organ nearly round, 76-116 (103) x 85-149 (113), lobed, with a median longitudinal slit; located immediately posterior to ventral sucker. Ratio of body length to holdfast organ length 1:0 .06-0.09 (0.08). Ratio of forebody length to holdfast organ length 1: 0.19-0.35 (0.27). Prepharynx very small, 3-8 (6) in length; pharynx ovoid, muscular, 33-50 (37) x 26-43 (35); oesophagus short, narrow, 13-50 (28) long; intestinal caeca long, extend up to the hind end of body. Ratio of oral sucker length to pharynx length 1:0.33-0.6 (0 .47).

Testes tandem, at the middle third of hindbody; anterior testis dorsoventrally elongated, assymmetrical, 70-193 (130)

x 109-270 (176); posterior testis transversely elongated, 76-246 (148) x 177-231(198). Seminal vesicle posterior to testis, saccular; 77-231(184) x 100-184 (122), opens into the muscular ejaculatory pouch. Copulatory bursa with a protrusible genital cone half enclosed by a prepuce-like fold. Hermaphroditic duct opens at the apex of the genital cone.

Ovary median, pre-testicular, ovoid, 69-100 (84) x 96-139 (122). Laurer's canal present. Mehlis' gland complex and vitelline reservoir inter-testicular. Vitellarium follicular, in lateral fields; follicles extend from anterior region of hind body to posterior end of body. Uterus with one egg.

Table 22a. Measurements (µm) of adults of *Uvulifer* sp. I n.sp.

Character	Range	Mean
Forebody	323-468 x 312-390	387 x 352
Hindbody	770-1248 x 343-	963 x 413
Oral sucker	501	77
Ventral sucker	56-99	39
Holdfast organ	33-50	103 x 113
Prepharynx	76-116 x 85-149	6

Pharynx	3-8	37 x 35
Oesophagus	33-50 x 26-43	28
Anterior testis	13-50	130 x 176
Posterior testis	70-193 x 109-270	148 x 198
Seminal vesicle	76-246 x 177-231	184 x 122
Ovary	77-231 x 100-184	84 x 122
Eggs	69-100 x 96-139	96 x 69
	92-99 x 59-73	

Table 22 b. Comparison of the characters of *Uvulifer stunkardi* (Pande, 1938) Bhalerao, 1942, *U. cerylou* Dollfus, 1950, *U. chandigharensis* Mishra and Gupta, 1980 and *Uvulifer* sp.I n. sp.

Character	*U. stunkardi*	*U. cerylou*	*U. chandigharensis*	*Uvulifer* sp.I n.sp.
Body length	725-810	690	1950-2520	790-1669 (1139)
Forebody	220-261 x 126-169	150-210 x 160-260	580-720 x 300-470	323-468 x 312-390
Hindbody	494-612 x 196-234	380-520 x 130-212	1360-1800 x 320-430	770-1248 x 343-501
Oral sucker	Sub globular, 60-90 x 90-120	Sub-spherical; 33-38 x 38-58	Sub-spherical, elongated; 45-65 x 60-98	Round; 56-99
Ventral sucker	Nearly round; 20-29 x 31-36	Sub-spherical; 11-18 x 20-29	Sub spherical; 45-65 x 60-98	Nearly round; 33-46 x 26-50
Sucker width ratio	1:0.75-.93	1:0.5-0.52	1:0.53	1:0.46-0.58
Hold-fast organ	Round; lobed; 43-60 x 55-75	Nearly round, lobed; 52-61 x 100	Round; 80-144 x 85-160	Round lobed; 76-116 x 85-149
Body length: hold-fast organ length	1:0.06-0.074	1:0.13	1:0.052	1:0.06-0.09
Forebody length: Hold-fast	1:0.21-0.24	1:0.30-0.35	1:0.2-0.24	1:0.19-0.35

Character	***U. stunkardi***	***U. cerylou***	***U. chandigharensis***	***Uvulifer* sp.I n.sp.**
organ length				
Pharynx	Round; 20-29 x 21-24	Round; 16-21 x 14-19	Round; 30-45 x 30-48	Ovoid; 33-50 x 26-43
Oesophagus	Short; 13-19	Short; 18-36	100	Short; 13-50
Anterior testis	Doso-ventrally elongated; 59-66 x 80-109	Dorso-ventrally elongated; smaller; 96x142-165	Dorso-ventrally elongated, larger; 315-355 x 275-325	Doro-ventrally elongated; 70-193 x 109-270
Post4erior testis	Transversely elongated, 54-71 x 102-125	Transversely elongated; 40-65 x 70-200	Transversely elongated; 320-355 x 325-350	Transversely elongated; 77-231 x 100-184
Ovary	Round; 40-51 x 49-59	Ovoid; 36-42 x 47-63	Elliptical to round; 129-145 x 132-145	Ovoid; 69-100 x 96-139
Eggs	3-5; 75-77 x 54-56	79-91 x 51-62	3-4; 45-50 x 20-30	0-1; 92-99 x 59-73
Hosts	*Halcyon smyrnensis*	*Ceryle rudis*	*Halcyon smyrnensis*	*Halcyon smyrnensis*

Life cycle (Plate 3):

Egg (Fig. 22a): Eggs ovoid, yellowish brown, operculate; 92-99 (96) X 59-73 (69). Attempts made to develop miracidia were not successful.

Sporocyst (Fig. 22b): Sporocysts developed in the hepatopancreas of *Indoplanorbis exustus*. Body reddish brown, elongate, thread-like; 33-46 (43) x 26-50 (39) in size, contain 8-9 cercariae and a few germ balls at different stages of development.

Cercaria (Fig. 22b): Natural infections with the cercariae were found in 30 of 1400 (2.14%) *I. exustus* collected from Iruvetty, Puthoorpallikkal and Cheruvady during March 2007-September 2008. Cercariae emerged during night hours. Cercariae exhibited characteristic swimming behavior with prolonged resting phase followed by brief swimming period. During resting, the cercariae remained suspended in the water column with the body directed downward, tail stem turned upward and the furcae diverged at an angle of about 60° to the tail stem.

Description: Longifurcate, pharyngeate, ocellate, distome cercaria. Body elongate-oval, (116-159) x (53-69), with a pear shaped anterior organ. Tail stem aspinose, (175-242) x (18-40), provided with 14 pairs of long sensory hairs. Furcae (165-198) x (23-40) in size, with longitudinal rows of spines; two short sensory hairs on each furca. Anterior organ highly muscular, (32-46) x (20-32) with 8-11 rows of prominent, backwardly directed spines in its anterior half. Cephalic glands two, on either side of oral cavity in anterior organ. Pre-oral spines 11, in three transverse rows; first row near mouth with 3 spines, and second and third rows with 4 spines each. Two bands of densely distributed spines encircling the body present at the posterior end of anterior organ; spines in between the bands sparsely distributed . Rest of body devoid of spines. Ventral sucker rudimentary, at the end of middle two third of body. A pair of non-pigmented eyespots present at mid region of body.

Mouth sub-terminal; prepharynx short; pharynx globular, (11-15) in diameter; oesophagus and caeca not discernible. Penetration glands 3 pairs, on either side of ventral sucker; each gland with finely granular contents and large nucleus;

ducts of penetration glands on each side form a bundle, take a forward course, pass over anterior organ, and open at anterior margin through 3 pores guarded by spines. Cystogenous glands numerous, beneath the tegument. Genital primordium represented by a conical mass of cells located just in front of excretory bladder. Excretory bladder oval, at posterior end of body. Flame cell formula: 2 (2) + (2+2+2) + (2) =20, with posterior 2 pairs in anterior third of tail stem. Caudal excretory duct runs through tail stem, bifurcates and runs into each furca and opens out mid-furcally.

Metacercaria (Fig. 22c): Natural infections with the metacercariae were found frequently below the skin of tadpoles and adults of the frog, *Euphlyctis cyanophlyctis,* collected from the same aquatic habitat where the infected snails were present. Intensity of infection varied from 25 to 40. Infection could be established experimentally in tadpoles of *E. cyanophlyctis.*

In the laboratory, the tadpoles were exposed to newly emerged cercariae. Cercariae actively penetrated the skin of tadpoles within 1 hour after exposure. Metacercariae

enclosed in a thin transparent cyst wall were observed after 24 hours. The larva lies folded in the cyst cavity. Cysts round. On the 10th day post-exposure, the cysts enlarged in size, became ovoid, and measured (285-320 X 169-250). Twenty-two days old cysts were fully formed and were found to be infective. All the tadpoles exposed to cercariae were infected, and as many as 90 cysts could be obtained from a single tadpole. These metacercariae resembled infective metacercariae obtained from natural infections.

Description (Based on naturally infected metacercariae): Cysts brownish-black, round to ovoid, 231-374(275) X 218-262 (237) in size. Cyst wall two- layered, with an outer, black-pigmented layer and an inner, thin, tough, hyaline layer. Metacercaria lies folded inside the cyst cavity. Metacercarial body bipartite, 501-593 (547) long, divisible in to a distinct foliaceous fore-body, 301-362 (329) x 208-231 (214), and a conical hindbody, 193-231(214) X 172-207 (198). Oral sucker ovoid, terminal, 70-92 (83) X 54-83 (77) in size. Ventral sucker round, 31-46 (39) in diameter. Hold-fast organ round, 77-93 (85) immediately posterior to ventral sucker. Pre-pharynx very small; pharynx globular, muscular, 31-45 (37);

oesophagus 35-77(58) long; intestinal caeca slender, extend up to the level of anterior margin of excretory bladder. Developing testes two, tandem, round to oval, at the posterior end of hindbody; anterior testis 31-51(42); posterior testis 28-55 (45). Ovary in the form of a group of cellslocated anterior to testis. Excretory bladder V-shaped. Reserve excretory system extensively developed.

Development of adults

Development of the flukes was observed in experimentally infected birds. Tadpoles with infective metacercariae were fed to the nestlings of *H. smyrnensis.* Excysted metacercariae were observed in the intestine within 12 hours post-infection and was without any marked changes from metacercariae in structural organization. On the second day post-infection, immature adult showed a slight increase in the size of hindbody, (312-335 x 172-217). Immature adults on the fourth day showed slight increase in the size of fore-body (314-342 x 281-307), hindbody (328-351 X 200-245), oral sucker (77-100 X 68-96), pharynx (33- 40 X 24-27), holdfast organ (100-108 X 72-85), anterior testis, (50-86 X 66-80) , posterior testis (52-73 X 64-66) and ovary (40-48 X 20-

23)) . On the sixth day increase in size was observed in the size of hindbody (424-539 X 231-315), anterior testis (67-87 x (80-106), posterior testis (89-106 x 63-86) and ovary (54-73 x 46-100). On the 10 day, flukes became fully mature and contained one egg in its uterus. Eggs measured 92-99 X 59-73 in size. The experimentally developed flukes were identical with those recovered from naturally infected birds.

Type-host	:	*Halcyon smyrnensis Linnaeus*
Site	:	Intestine
Type-locality	:	Iruvetty, Malappuram district, Kerala, India
Additional localities	:	Puthurpallikkal, Malappuram district; Cheruvady, Kozhikkode district, Kerala, India
Period of collection	:	March 2004-April 2010
Prevalence	:	Twelve out of 16 *Halcyon smyrnensis* examined were found to be infected
Intensity	:	50-200
Snail host	:	*Indoplanorbis exustus* Deshayes
Site	:	Hepatopancreas

Locality	:	Iruvetty and Puthurpallikkal, Malappuram district; Cheruvady, Kozhikkode district, Kerala
Period of collection	:	March 2007-September 2008.
Prevalence	:	Thirty out of 1400 (2.14%) snails examined
Second intermediate host	:	*Euphlyctis cyanophlyctis* Schneider
Site	:	Below the skin of abdomen and thigh
Type- locality	:	Iruvetty in Malappuram district, Kerala, India.
Other localities	:	Puthurpallikkal, Malappuram; Cheruvady in Kozhikkode district, Kerala, India
Prevalence	:	33 of 50 (66%) *E. cyanophlyctis* examined
Intensity	:	3-8
Holotype	:	To be deposited in the parasite collections, Parasitolgy Laboratory, Department of Zoology, University of Calicut, Kerala, India.

Remarks

The present fluke recovered from the intestine of *Halcyon smyrnensis* has a distinctly bipartite body, ventral sucker which is smaller than the oral sucker, copulatory bursa with a protrusible genital cone half enclosed by a preputial fold and vitellaria confined to hindbody. These characters justify beyond doubt its inclusion in the genus *Uvulifer* Yamaguti, 1934. Among the 17 species of *Uvulifer* known till date, the present form superficially resembles *U. cerylou* Dollfus, 1950 from *Ceryl rudis* in Belgium Congo and *U. chandigarhensis* Mishra and Gupta, 1980 from *Halcyon smyrnensis* in India. A comparison of characters presented in Table 23a clearly shows that the species under discussion is distinct from *U. cerylou* in having comparatively larger body, testes and ovary, round suckers, and vitellaria confined to lateral fields. Further, it is infecting a different host. *U. chandigharensis* is different from the present form in the size and shape of body and in having larger testes and ovary, relatively long oesophagus, and uniform distribution of vitellaria in the hindbody. It has more than three eggs in its

uterus whereas the present form has only one egg which is larger in size also.

Based on the differences of the present fluke with its closely related forms it would appear reasonable to treat the fluke as a new species of *Uvulifer,* and it is named *Uvulifer* sp.1 n.sp.

The life cycle of only one species of *Uvulifer, U. ambloplitis* (Hughes, 1927) Dubois, 1938, has been elucidated so far (Hunter and Hunter, 1930, 1934; Hoffman and Putz, 1965). It exhibited a three-host life cycle with *Heliosoma trivolvis* and *H. companulatum* as the snail hosts, the fishes, *Eunemacacanthus obesus* and *Lepomis macrochirus* as the second intermediate hosts and the belted kingfisher, *Megaceryl alcyon alcyon* as the definitive host. The life cycle from egg to egg-producing adults took 140 days to complete: miracidium came out of the eggs in 3 weeks; cercariae emerged from the snails in 42 days; metacercariae took 22-27 days in fish hosts to become infective, and developed into mature adults in 50 days in the intestine of the definitive host. The present fluke also has a three-host life cycle pattern showing differences with regard to the hosts involved and the

structural details of different stages in the life cycle. The longifurcate cercariae shed by the planorbid snails, *Indoplanorbis exustus* encysted below the skin of the tadpoles of *Euphlyctes cyanophlyctis.* Metacercariae became infective in 22 days and took only 10 days to become mature adults in the intestine of *Halcyon smyrnensis.*

Cercariae recovered during the present study from *I. exustus* agree fully with *Cercaria* sp. VIII Malabar, described by Vasandakumar and Janardanan (2006) from the same snail host from Kannur district in morphology and morphometry. As the two cercariae are similar in their structural organization and are infecting the same species of snail, they are identical. Other snail species of the habitat were found to be free from infection with the cercariae. The metacercariae of the present fluke has not been reported previously. It is infecting the tadpoles and adults of *E. cyanophlyctis* only. Other suspected intermediate hosts collected from the water bodies where infected snails inhabited were negative to metacercarial infection. Adult flukes were found only in the intestine of the bird*, H. smyrnensis*, and all other bird species of this area were negetive to the infection. This suggests that *Uvulifer*

sp.1 n.sp. exhibits strict specificity at the level of first and second intermediate hosts and definitive host.

Family: Strigeidae Ciurea, 1927

Genus: *Apharyngostrigea* Ciurea, 1927

***Apharyngostrigea ramai* (Verma, 1936) Vidyarthi, 1937**

The present flukes were recovered from the intestine of the pond heron, *Ardeola grayii,* and the cattle egret, *Bubulcus ibis* collected from Puthurpallikkal from January 2002 - March 2009 Three *A. grayii* and 2 *B. ibis* were found to be infected. The intensity of infection varied from 3 to 6 in both cases. *A. grayii* infected with the present worm exhibited mixed infections with other species of trematodes in different combinations: *Echinochasmus bagulai*, *Centrocestus formosanus, Clinostomum complanatum* and the present fluke in one bird; *E. bagulai* and the present fluke in one bird, and *Centrocestus formosanus* and the present fluke in one bird. In *B. ibis* one bird was found concurrently infected with *C. complanatum* .

Description (Fig. 23; Table 23; Plate 7):

Body bipartite, 2954-4134 (3744) long. Forebody cup-shaped with broad anterior end, 1092-1482 (1287) x 889-1150 (1108); hindbody cylindrical, elongate, with blunt posterior end; 2262-2652 (2457) x 499-530 (515). Ratio of forebody length to hindbody length 1:1.79- 2.07 (1.93). Tegument smooth. Oral sucker sub-terminal, round, 94-140 (117). Ventral sucker round, larger than oral sucker, 187-290 (225) in size, anterior to middle of forebody. Sucker width ratio 1:1.78-2 (1.89). Holdfast organ well developed, immediately posterior to ventral sucker, measured 546-624 (585) x 515-624 (569). Ratio of body length to holdfast organ length 1: 0.13-0.19 (0.16). Ratio of forebody length to holdfast organ length, 1: 0.37- 0.57 (0.47). Proteolytic gland large, at the junction of fore- and hindbody. Oesophagus 125-234 (179) long. Intestinal caeca terminate near posterior end of body.

Testes, tandem, lobed, post-equatorial, extend transversely; anterior testis 500-640 (601) x 490-740 (670); posterior testis 530-790 (721) x 518-800 (615). Seminal vesicle post-testicular. Ovary pre-testicular, ovoid, 203-324

(238) x 187-234 (211). Laurer's canal present. Copulatory bursa posterioterminal. Vitelline reservoir intertesticular. Vitellarium follicular, distributed in lateral fields of fore- and hindbody. Uterus with 20-50 eggs. Eggs yellow, ovoid, operculate; 86-92 (90) x 53-76 (64).

Table 23. Measurements(µm)of adults of *Apharyngostrigea ramai* (Verma, 1936) Vidyarthi, 1937

Character	Range	Mean
Forebody	1092-1482 x 889-	1287 x
Hindbody	1150	1108
Oral sucker	2262-2652 x 499-	2457 x
Ventral sucker	530	515
Holdfast organ	94-140	117
oesophagus	187-280	225
Anterior testis	546-624 x 515-624	585 x 569
Posterior testis	125-234	179
Ovary	500-640 x 490-740	601 x 670
Eggs	530-790 x 518-800	721 x615
	203-324 x 187-234	268 x 211
	86-92 x 53-76	90 x 64

Definitive host	:	*Ardeola grayii* Sykes and *Bubulcus ibis* Linnaeus
Site	:	Duodenum and ileum
Period of collection	:	March 2002-December 2008
Locality	:	Puthurpallikkal in Malappuram district, Kerala
Prevalence	:	Three of 16 *Ardeola grayii* and 2 of 12 *Bubulcus ibis* examined were found to be infected.
Intensity	:	3-6

Remarks

Verma (1936) erected the genus *Ridgeworthia* with *R. ramai* from the night heron, *Nycticorax nycticorax* as its type-species. Vidyarthi (1937) while describing two species of *Apharyngostrigea* synonymised *Ridgeworthia* Verma, 1936 with *Apharyngostrigea* Ciurea, 1927 and renamed *Ridgeworthia ramai* as *A. ramai***.** Verma in 1936 also reported *A. egretti* from *Bubulcus coramandus.* Dubois (1966, 1968) synonymised 4 species of *Apharyngeostrigea* reported from Indian birds with *A. ramai***:** *A. ardeolina* Vidyarthi, 1937, *A. indiana* Vidyarthi, 1937, *A. simplex* Bhalerao, 1942, and *A.*

joanae Gupta, 1963. Thus, there are only two valid species of *Apharyngostrigea, A. ramai* and *A. egretti* reported from India. The present fluke recovered from the intestine of *Ardeola grayii* and *Bubulcus ibis* resembles *A. ramai* (Verma, 1936) Vidyarthi, 1937 in morphological features. In metric details there are minor differences. These differences can be attributed to the difference in the methods of preparation of the worms for examination, and is not by itself significant enough to differentiate the two forms. The present fluke is, therefore, identified and reported as *A. ramai* (Verma, 1936) Vidyarthi, 1937**.** This forms the first record of a species of *Apharyngostrigea* from South India.

DISCUSSION

Birds are known to host a variety of digenetic trematodes and trematodes infecting wild birds of Kerala have not been a subject of any comprehensive investigation. Since the piscivorous birds form an important component of fast-dying wildlife in the state, as a wildlife biology student, I could realize the significance of a study on the digenean fauna of these birds and its scientific importance. The present investigation is a preliminary attempt to study the digenetic trematodes infecting a few piscivorous birds in Malappuram and Kozhikkode districts of Kerala. Due to restriction for collection of birds under Wildlife protection Act, it was not possible to conduct an extensive investigation, and therefore, it is limited to a small number of fish eating birds in a few localities of the two districts.

During the course of the present investigation, 101 birds belonging to 16 species representing 15 genera and 12 families, collected from Iruvetty and Puthurpallikkal in Malappuram and Cheruvady and Ramanattukara in Kozhikkode districts, were examined for trematodes. The

collections were made during the period from June 2001 to April 2009. The species of digeneans recovered, their hosts and prevalence of infections are summarized in the Table 24. Sixty-five birds belonging to 9 species, *Ardeola*

Table 24. Summary of digenetic trematodes recovered, their hosts and prevalence of infection

No.	Parasite	Host	Site	No. of hosts		Prevalence (%)
				Examined	Infected	
	Family: Echinostomatidae Poche, 1925					
1	*Nephrostomum ramosum* (Sonsino, 1895) Dietz, 1909	*Bubulcus ibis*	Intestine	12	4	33.33
2	*Parellelotestis tarai* (Srivastava, 1958) Beverly-Burton, 1960	*Bubulcus ibis*	Liver and bile duct	12	1	8.33
3	*Paryphostomum horai* Baugh, 1950	*Gallus gallus*	Intestine	4	1	25
4	*Petsiger variospinosus* (Odhner, 1910) Yamaguti, 1933	*Phalacrocorax niger*	Intestine	13	11	84.6
5	*Echinochasmus bagulai* Verma, 1935	*Ardeola grayii*	Intestine	16	12	75
6	*Echinochasmus* sp. I n. sp.	*Phalacrocorax niger*	Intestine	13	4	30.7
7	*Stephanoprora* sp.I n.sp.	*Alcedo atthis*	Intestine	7	6	85.7
8	*Ignavia breviovarica* Gupta, 1962	*Ardeola*	Kidney	16	1	6.25

No.	Parasite	Host	Site	No. of hosts		Prevalence (%)
				Examined	Infected	
		grayii				
9	*Pegosomum egretti* Srivastava, 1957	*Bubulcus ibis*	Liver and bile duct	12	4	33
	Family: Psilostomidae Loss, 1900					
10	*Psilorchis indicus* Thapar and Lal, 1935	*Halcyon smyrnensis*	Intestine	16	7	43.7
	Family: Microphallidae Travassos, 1920					
11	*Basantisia ramai* Pande, 1938	*Halcyon smyrnensis*	Intestine	16	5	31
	Family: Opisthorchiidae Braun, 1901					
12	*Nigerina hardoiensis* Baugh, 1958	*Phalacrocorax niger*	Intestine	13	3	23
	Family: Heterophyidae Odhner, 1914					
13	*Centrocestus formosanus* (Nishigori, 1924) Price, 1932	*Milvus migrans*	Intestine	3	1	33

No.	Parasite	Host	Site	No. of hosts		Prevalence (%)
				Examined	Infected	
		Ardeola grayii	Intestine	16	2	12.5
14	*Stellantchasmus falcatus* Onji and Nishio, 1*915*	*Milvus migrans*	Intestine	3	1	33
15	*Haplorchis taichui* (Nishigori, 1924) Witenberg , 1929	*Milvus migrans*	Intestine	3	2	66
	Family: Clinostomidae Luhe, 1901					
16	*Clinostomum complanatum* (Rudolphi, 1819) Braun, 1899	*Ardeola grayii*	Buccal cavity and pharynx	16	5	31.2
		Egretta garzetta	Buccal cavity and pharynx	8	2	25
		Bubulcus ibis	Buccal cavity	12	4	33.3
		Anastomus ocitans	Buuccal cavity	1	1	100
17	*Euclinostomum heterostomum* (Rudolphi, 1809) Travassos, 1928	*Bubulcus ibis*	Buccal cavity	12	1	8.33

No.	Parasite	Host	Site	No. of hosts		Prevalence (%)
				Examined	Infected	
	Family: Cyathocotylidae Muhling, 1898					
18	*Mesostephanus indicum* Mehra, 1947	*Milvus migrans*	Intestine	3	2	66.6
	Family: Diplostomidae Poirier, 1886					
19	*Subuvulifer halcyonae* (Gogate, 1940) Dubois, 1952	*Halcyon smyrnensis*	Intestine	16	2	12.5
20	*Uvulifer denticulatus* (Rudolphi,1819) Dubois, 1937	*Alcedo atthis*	*Intestine*	7	5	71.4
21	*Uvulifer stunkardi* (Pande, 1938) Bhalerao, 1942	*Halcyon smyrnensis*	Intestine	16	1	6.25
22	*Uvulifer cochlearis* (Verma, 1936) Dubois, 1944.	*Halcyon smyrnensis*	Intestine	16	3	18.75
23	*Uvulifer* sp.1. n.sp.	*Halcyon smyrnensis*	Intestine	16	12	75
	Family: Strigeidae Ciurea, 1927					

No.	Parasite	Host	Site	No. of hosts		Prevalence (%)
				Examined	Infected	
24	*Apharyngostrigea ramai* (Verma, 1936) Vidyarthi, 1937	*Ardeola grayii*	Intestine	16	3	18.75
		Bubulcus ibis	Intestine	12	**2**	16.6

grayii, Egretta garzetta, Bubulcus ibis, Anastomus ocitans, Phalacrocorax niger, Halcyon smyrnensis, Alcedo atthis, Milvus migrans, and *Gallus gallus,* were found to be infected with adult trematodes. The other 7 species of birds were free from digenean infection. Altogether 24 species of trematodes belonging to 20 genera were recovered from the 9 species of birds. Of these, 3 have been described as new species. These are, *Echinochasmus* sp.1 n. sp. from *Phalacrocorax niger*; *Stephanoprora* sp.I n. sp. from *Alcedo atthis*, and *Uvulifer* sp.1 n. sp. from *Halcyon smyrnensis.* The remaining 21 are known species. Of these, 3 species, *Petasiger variospinosus* Odhner (1910) Yamguti, 1933, *Centrocestus formosanus* (Nishigori, 1924) Price, 1932 and *Mesostephanus indicum* Mehra, 1947, have already been reported from Kerala (Roopa and Janardanan, 2000; Vasandakumar and Janardanan, 2002; Sheena *et al*., 2007). The remaining 18 species, *Nephrostomum ramosum* (Sonsino, 1895) Dietz, 1909, *Parallelotestis tarai* (Srivastava, 1958) Beverly-Burton, 1960, *Paryphostomum horai* Baugh, 1950, *Echinochasmus bagulai* Verma, 1935, *Ignavia breviovarica* Gupta, 1962, *Pegosomum egretti* Srivastava, 1957, *Psilorchis indicus* Thapar and Lal, 1935, *Basantisia ramai* Pande, 1938, *Nigerina hardoiensis*

Baugh, 1958, *Stellantchasmus falcatus* Onji and Nishio, 1916, *Haplorchis taichui* (Nishigori, 1924) Witenberg, 1929, *Clinostomum complanatum* (Rudolphi, 1809) Braun, 1899, *Euclinostomum heterostomum* (Rudolphi, 1809) Travassos, 1928, *Subuvulifer halcyonae* (Gogate, 1940) Dubois, 1952, *Uvulifer denticulatus* (Rudolphi, 1819) Dubois, 1937, *Uvulifer stunkardi* (Pande, 1938) Bhalerao, 1942, *Uvulifer cochlearis* (Verma, 1936) Dubois, 1944, and *Apharyngostrigea ramai* (Verma, 1936) Vidyarthi, 1937, have been redescribed.

Among these, report of *Stellantchasmus falcatus* from *Milvus migrans,* and *Uvulifer denticulatus* from *Alcedo atthis* forms the first record of these species from India. Recovery of *Paryphostomum horai* from *Gallus gallus, Ignavia breviovarica* from *Ardeola grayii*, *Haplorchis taichui* from *Milvus migrans* and *Basantisia ramai* from *Halcyon smyrnensis* form new host records.

Discussions on the systematics of individual species have been made while describing them in the thesis. However, a general discussion on biology and certain aspect of host-parasite relations of digeneans recovered during the present study is given here.

Life cycles of 2 species of trematodes have been successfully established in the laboratory and their natural hosts also have been recovered. One is the life cycle of *Mesostephanus indicum* Mehra, 1947 infecting the pariah kite, *Milvus migrans*. The furcocercous cercariae liberated by the gastropod, *Bellamya bengalensis* (identical with *Cercariae pendulata* Baugh, 1954 reported from the same snail host) encysted in the muscle tissue of *Rasbora daniconius*, *Puntius sophore, Mystus malabaricus, Hetropneustes fossilis*, *Aplocheilus lineatus*, *Etroplus maculates*, *E. suratensis* and *Pseudophromenus cupanus.* The prohemistomulum-type metacercariae became infective within 30 days in fish hosts, and developed into mature adults in 7 days in the bird host. (An article on the life cycle was published by Sheena *et al.* (2007). A copy of the paper is included under Appendix I.).

The other is the life cycle of *Uvulifer* sp. I n. sp., which was found infecting the white-breasted kingfisher, *Halcyon smyrnensis.* As far as is known, the life cycle of only one species of *Uvulifer, U. amploplitis* (Hughes, 1927) Dubois, 1938 was established (Hunter and Hunter, 1933, 1934; Hoffman and Putz, 1965). The new species also exhibited a

three host life cycle pattern. The furcocercous cercariae liberated by the gastropod, *Indoplanorbis exustus* (identical with C*ercariae* sp. VIII. Malabar Vasandakumar and Janardanan, 2006 reported from the same snail host) encysted below the skin of tadpoles and adults of the frog, *Euplyctis cyanophlyctis.* The metacercariae became infective within 22 days and developed to mature adults in 10 days in the bird host.

Prevalence of infection

Although I have collected 16 species of birds, only 9 species were found to be infected with one or more species of digenetic trematodes. Out of a total of 80 birds (belonging to 9 species) examined, as many as 65 were found infected, indicating an overall prevalence of 81.2% (Table 26). The prevalence of trematode infection is apparently very high in the study area. Comparable data on prevalence of infection is not available, and the reason for this high prevalence is not understood. This may be attributed to the hosts' diet as well as the abundance of first and second intermediate hosts of the flukes in the habitat. In addition, conditions most congenial for successful transmission and completion of life

cycles of these parasites may also be available in the habitats studied.

Host-specificity

The 24 species of trematodes showed different levels of host specificity ranging from narrow to wide. Twenty-one are species specific, each having its own bird as host. Two species, *Centrocestus formosanus and Apharyngostrigea ramai,* infected two species of birds each, and one species, *Clinostomum complanatum* infected 4 bird species. *C. complanatum* is a cosmopolitan species widely distributed in most of the countries of the world. As *C. complanatum* infected 4 species of birds, there appears to be a lack of recognizable host-specificity for this fluke. The wide geographical distribution, high infection rates and large number of fish acting as intermediate hosts might be related to a wide range of birds acting as

Table 25. Host range of digenetic trematodes recorded from birds of Malabar

No.	Parasite	Host								
		Ardeola grayii	*Egretta garczetta*	*Bubulcus ibis*	*Anastomus ocitans*	*Phalacrocorax niger*	*Halcyon smyrnensis*	*Alcedo atthis*	*Milvus migrans*	*Gallus gallus*
1	*Nephrostomum ramosum* (Sonsino, 1895) Dietz, 1909			+						
2	*Parellelotestis tarai* (Srivastava, 1958) Beverly-Burton, 1960			+						
3	*Paryphostomum horai* Baugh, 1950									+
4	*Petsiger variospinosus* (Odhner, 1910) Yamaguti, 1933					+				
5	*Echinochasmus bagulai* Verma, 1935	+								
6	*Echinochasmus* sp.1 n.sp.					+				

No.	Parasite	Host								
		Ardeola grayii	*Egretta garczetta*	*Bubulcus ibis*	*Anastomus ocitans*	*Phalacrocorax niger*	*Halcyon smyrnensis*	*Alcedo atthis*	*Milvus migrans*	*Gallus gallus*
7	*Stephanoprora* sp.I n.sp.							+		
8	*Ignavia breviovarica* Gupta, 1962	+								
9	*Pegosomum egretti* Srivastava, 1957			+						
10	*Psilorchis indicus* Thapar and Lal, 1935						+			
11	*Basantisia ramai* Pande, 1938						+			
12	*Nigerina hardoiensis* Baugh, 1958					+				
13	*Centrocestus formosanus* (Nishigori, 1924) Price, 1932	+							+	
14	*Stellantchasmus falcatus* Onji and Nishio, 1915								+	

No.	Parasite	Host								
		Ardeola grayii	*Egretta garzetta*	*Bubulcus ibis*	*Anastomus ocitans*	*Phalacrocorax niger*	*Halcyon smyrnensis*	*Alcedo atthis*	*Milvus migrans*	*Gallus gallus*
15	*Haplorchis taichui* (Nishigori, 1924) Witenberg, 1929								+	
16	*Clinostomum complanatum* (Rudolphi, 1819) Braun, 1899	+	+	+	+					
17	*Euclinostomum heterostomum* (Rudolphi, 1809) Travassos, 1928			+						
18	*Mesostephanus indicum* Mehra, 1947								+	
19	*Subuvulifer halcyonae* (Gogate, 1940) Dubois, 1952						+			
20	*Uvulifer denticulatus* (Rudolphi, 1819) Dubois, 1937							+		

No.	Parasite	Host								
		Ardeola grayii	*Egretta garczetta*	*Bubulcus ibis*	*Anastomus ocitans*	*Phalacrocorax niger*	*Halcyon smyrnensis*	*Alcedo atthis*	*Milvus migrans*	*Gallus gallus*
21	*Uvulifer stunkardi* (Pande, 1938) Bhalerao, 1942						+			
22	*Uvulifer cochlearis* (Verma, 1936) Dubois, 1944.						+			
23	*Uvulifer* sp.1 n.sp.						+			
24	*Apharyngostrigea ramai* (Verma, 1936) Vidyarthi, 1937	+		+						

definitive hosts for this worm (Ukoli, 1966a; Aohagi *et al*., 1992; Jansilakshmi bai, 1995). There are several examples in which one species of digenean is found infecting either a single host species or more than one. These types of specificity have been previously reported by several workers. The factor(s) responsible for different levels of host-specificity exhibited by digeneans recovered during the present study is/ are not understood. This aspect is open for future investigations

Another interesting observation was that all the nine infected hosts were not equally preferred by digenetic trematodes. The most preferred hosts were *Bubulcus ibis* and *Halcyon smyrnensis* with 6 species of flukes infecting them. Next to this was *A. grayii* with 5 flukes followed by *M. migrans* (4), *Phalacrocorax niger* (3), and *Alcedo atthis* (2) (Table 25). Example for one species of host getting infected with more than one parasite is not rare. Such instances were reported previously (Bhalerao, 1936; Verma, 1936; Lal, 1939; Srivastava, 1982, Abd-al-aal *et al.,* 2008). Because of the variations in the number of host species examined, no

justifiable explanation could be given to this pattern of host preference.

Mixed infections

During the present study, I came across naturally acquired mixed infections in 6 species of birds: *Ardeola grayii, Bubulcus ibis, Phalacrocorax*

Table 26. Incidence of mixed infections with digenetic trematodes in birds examined

Host	No. examined	No. infected	No. of mixed infections
Ardeola grayii	16	14	8
Egretta garzetta	8	2	0
Bubulcus ibis	12	11	4
Anastomus ocitans	1	1	0
Phalacrocorax niger	13	12	5
Halcyon smyrnensis	16	14	11
Alcedo atthis	7	7	4
Milvus migrans	3	3	3
Gallus gallus	4	1	0
Total	80	65	35

niger, Milvus migrans, Halcyon smyrnensis and *Alcedo atthis* (Table 26). Out of the 16 *A. grayii* collected, 14 were found to be infected, and a total of 5 species of trematodes were recovered from them. Eight birds were found simultaneously infected with more than one species: 7 with 2 species in different combinations and the other with 4 species. The combination between *Echinochasmus bagulai* and *Clinostomum complanatum* was found in 4 birds and that between *E. bagulai* and *Ignavia breviovarica*, *E. bagulai* and *Apharyngostrigea ramai*, and *Centrocestus formosanus* and *A. ramai* in one bird each. Infection with 4 species of flukes in one bird involved C*. complanatum, E. bagulai, A. ramai* and *C. formosanus.*

Eleven out of 12 *Bubulcus ibis* examined were found to be positive for trematodes and altogether 6 species of flukes were recovered from them. Of these, 3 birds exhibited different combinations of double infections and one served as host for triple infection. The combinations of double infections were between *Nephrostomum ramosum* and *Pegosomum egretti*, *A. ramai* and *C. complanatum,* and *Parallelotestes*

tarai and *C. complanatum.* The bird with triple infection harboured *N. ramosum, P. egretti and C. complanatum.*

In *Phalacrocorax niger,* 12 out of the 13 birds examined were found to be infected with trematodes, and only 3 species could be collected from them. Four cases of double and a single case of triple infections were observed. In double infections the combinations between *Petasiger variospinosus* and *Echinochasmus* sp.1 n.sp. were found in two birds and that between *P. variospinosus* and *Nigerina hardoiensis* were found in the other two birds. All the three species, *P. variospinosus, Echinochasmus* sp.1 n.sp. and *N. hardoiensis,* infecting *P. niger* were found in the intestine of one bird.

Among the kingfishers collected, 14 of 16 *Halcyon smyrnensis* served as hosts for a total of 6 species and all the 7 *Alcedo atthis* as hosts for one or two species of trematodes. Seven *H. smyrnensis* exhibited double infections in different combinations, 3 showed triple infections and one was found infected with 4 different trematodes. Concurrent infection with *Psilorchis indicus* and *Uvulifer* sp.1 n. sp. was observed in three birds, that with *Basntisia ramai* and *Uvulifer* sp.1 n. sp. in two and *P. indicus* and *B. ramai,* and *U. cochlearis* and

Uvulifer sp.1 n.sp. in one each. Triple infections with *P. indicus*, *B. ramai,* and *Uvulifer* sp.1 n. sp. were found in two birds and that with *Subuvulifer halcyonae, U. cochlearis* and *Uvulifer* sp.1 n. sp. in one bird. Infection with four species of flukes in one bird involved *P. indicus, S. halcyonae, U. cochlearis* and *U. stunkardi*. In *A. atthis,* the two flukes recovered, *Stephanoprora* sp.1 n. sp. and *Uvulifer denticulatus,* co-existed in the intestine of four birds.

Four species of trematodes were recovered from *Milvus migrans* collected during the present investigation. All the three birds collected exhibited concurrent infections in different combinations. One bird showed triple infection with *Stellantchasmus falcatus, Haplorchis taichui* and *Mesostephanus indicum,* and the other two birds carried double infections in the following combinations: *Centrocestus formosanus* and *M. indicum*, and *H. taichui* and *M. indicum*.

Sixty-five birds out of a total of 80 (belonging to 9 species) examined were infected. Altogether 24 species of trematodes were recovered from them. Among the 65 birds infected as many as 35 exhibited mixed infections in different combinations. Thus the incidence of mixed infections is very high (53.85%) in the limited number of birds examined. The mechanism of simultaneous infections by 2 or more trematodes and the effects of such infections among birds are not well known. The problem of interrelationship between various trematodes in one bird host is of particular interest to vertebrate pathologists.

SUMMARY

The present investigation was aimed at studying the systematics and biology of digenetic trematodes infecting some piscivorous birds in Malabar, Kerala. Sixteen species of birds belonging to 15 genera, collected from Iruvetty and Puthurpallikkal in Malappuram and Cheruvady and Ramanattukara in Kozhikkode districts, during a period of 7 years and 11 months (from June 2001 to April 2009), were subjected to parasitological studies. Altogether 24 species of adult trematodes, including three new species, were recovered from 9 species of birds. All the digeneans recovered have been described and illustrated in the thesis.

The new species include *Echinochasmus* sp. 1 n. sp. from *Phalacrocorax niger*, *Stephanoprora* sp. I n. sp. from *Alcedo atthis* and *Uvulifer* sp.1 n. sp. from *Halcyon smyrnensis.* Three species were recovered from more than one host. These are, *Clinostomum complanatum* from *Ardeola*

grayii, Bubulcus ibis, Egretta garzetta and Anastomus ocitans; Centrocestus formosanus from *A. grayii* and *Milvus migrans,* and *Apharyngostrigea ramai* from *B. ibis* and *A. grayii.*

The remaining 18 species include, *Psilorchis indicus, Basantisia ramai, Subuvulifer halcyonae*, *Uvulifer stunkardi,* and *U. cochlearis* from *Halcyon smyrnensis*; *Nephrostomum ramosum, Parellelotestis tarai, Pegosomum egretti,* and *Euclinostomum heterostomum* from *Bubulcus ibis; Stellantchasmus falcatus, Haplorchis taichui* and *Mesostephanus indicum* from *Milvus migrans; Echinochasmus bagulai* and *Ignavia breviovarica* from *Ardeola grayi; Petasiger variospinosus* and *Nigerina hardoiensis* from *Phalacrocorax niger*; *Paryphostomum horai* from *Gallus gallus,* and *U. denticulatus* from *Alcedo atthis.*

Life cycles of 2 species, *Mesostephanus indicum* and *Uvulifer* sp.1 n. sp., have been successfully established in the laboratory, and their natural hosts have been recovered.

M. indicum exhibited a three host life cycle pattern with *Bellamya bengalensis* as the snail host, the fishes, *Rasbora daniconius*, *Puntius sophore, Mystus malabarica*, *Hetropneustes fossilis, Aplocheilus lineatus*, *Etroplus*

maculates, *E. suratensis* and *Pseudophromenus cupanus* as the second intermediate hosts and *Milvus migrans* as the definitive host. The furcocercous cercariae liberated by the snails encysted in the muscle tissue of the fishes and the metacercariae developed into mature adults in the final host. (A paper on the life cycle was published in 2007; Parasitol. Res., 101:1015-1018).

Uvulifer sp. I n. sp. also exhibited a typical three host life cycle pattern with *Indoplanorbis exustus* as the snail host, tadpoles and adults of the frog, *Euphlyctis cyanophlyctis* as the second intermediate hosts and *Halcyon smyrnensis* as the definitive host. The furcocercous cercariae liberated by the snail encysted below the skin of tadpoles and frogs, and the metacercariae became mature adults in the bird host.

Data on prevalence and intensity of infections have been collected and presented. Host specificity, mixed infections and other aspects of host-parasite relations of digeneans infecting piscivorous birds have been discussed in the light of available information. New host and geographical records have also been presented in the thesis.

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Table 1. Measurements (µm) of adults of *Nephrostomum ramosum* (Sonsino, 1895) Dietz, 1909

Character	Range	Mean
Body size	11904-16375 x 2637-	14140 x 3130
Forebody	3625	1536
Collar width	916-1960	1721
Oral sucker	1325-1817	239 x 349
Ventral sucker	231-246 x 360-339	1640 x 1434
Prepharynx	1408-1872 x 1152-	85
Pharynx	1716	293
Oesophagus	39-131	427
Anterior testis	231-308	972 x 814
Posterior testis	316-539	921 x 629
Cirrus sac	539-1404 x 692-936	656 x 412
Ovary	516-1326 x 400-858	497 x 803
Eggs	454-858 x 277-546	45 x 25
	400-593 x 670-936	
	43-46 x 23-26	

Table 2. Measurements (µm) of adults of *Parallelotestis tarai* (Srivastava, 1958) Beverly-Burton, 1960.

Character	Range	Mean
Body size	6300-9126 x 1625-2652	7713 x 2139
Forebody	2217-3080	2798
Collar width	331-549	439
Oral sucker	200-234 x 175-218	217 x 197
Ventral sucker	1000-1264 x 950-1248	1132 x 1049
Prepharynx	50-86	68
Pharynx	200-308 x 150-270	254 x 210
Oesophagus	750-936	843
Left testis	468-500 x 500-624	484 x 562
Right testis	421-435 x 425-671	426 x 548
Cirrus sac	875-1232 x 468-500	1054 x 484
Ovary	250-312 x 325-359	281 x 342
Eggs	85-100 x 46-62	92 x 54

Table 3. Measurements (µm) of adults of *Paryphostomum horai* Baugh,1950.

Character	Range	Mean
Body size	4435-6712 x 812-	5925 x 1250
Forebody	1560	1375
Collar width	1251-1412	512
Oral sucker	450-616	231
Ventral sucker	180-248	568
Prepharynx	521-596	193
Pharynx	172-201	165 x 170
Oesophagus	121-194 x 156-180	501
Anterior testis	485-534	231 x 424
Posterior testis	212-254 x 396-440	462 x 462
Cirrus sac	412-476 x 437-470	385 x 231
Ovary	351-402 x 212- 254	231 x 308
Eggs	211-261 x 294-321	120 x 66
	116-123 x 62-69	

Table 4. Measurements (µm) of adults of *Patasiger variospinosus* (Odhner, 1910) Yamaguti, 1933.

Character	Range	Mean
Body size	1560-3071 x	2211 x 437
Forebody	328-610	561
Collar width	255-828	318
Oral sucker	270-338	102
Ventral sucker	62-140	331 x 318
Prepharynx	177-427 x 255-	58
Pharynx	371	75 x 65
Oesophagus	36-72	331
Anterior testis	46-94 x 41-91	93 x 109
Posterior testis	234-421	84 x 116
Cirrus sac	55-107 x 80-141	349 x 130
Ovary	47-109 x 62-169	102 x 106
Eggs	265-509 x 99-	76 x 58
	188	
	70-159 x 94-169	
	73-81 x 53-63	

Table 5. Measurements (µm) of adults of *Echinochasmus bagulai* Verma, 1935

Character	Range	Mean
Body size	702 -1014 x 234 -	872 x 260
Forebody	312	322
Collar width	294 - 343	153
Oral sucker	123- 211	60
Ventral sucker	46 - 77	145
Prepharynx	123 -187	45
Pharynx	27- 54	60
Oesophagus	54- 69	85
Anterior testis	62-115	63 x 113
Posterior testis	54 - 69 x 85 - 132	98 x 122
Cirrus sac	77 - 116 x 77 - 154	95 x 51
Ovary	68 - 132 x 34 - 62	59 x 61
Eggs	50 - 68 x 50 -77	64 x 46
	61 - 69 x 39 -53	

Table 6a. Measurements (µm) of adults of *Echinochasmus* sp.1 n. sp.

Character	Range	Mean
Body size	554-896 x 172-296	662 x 228
Forebody length	198-476	337
Collar width	46 -79	60
Oral sucker	39-62 x 26-39	50 x 27
Ventral sucker	71-106	94
Prepharynx	30-66	45
Pharynx	31-37 x 24-32	35 x 26
Oesophagus	210-270	250
Anterior testis	56 -88 x 83 - 122	75 x 112
Posterior testis	60-84 x 81-115	72 x 112
Cirrus sac	99 -112 x 43 -50	106 x 47
Ovary	36 - 69 x 33 - 46	53 x 40
Eggs	69-73 x 46-53	71 x 50

Table 6b. Comparison of characters of *Echinochasmus dietzvi* Issaitschikoff, 1927, *E. narayani* Mudaliyar, 1938, *E.megavitellus* Lal, 1939 and *Echinochasmus* sp.I n. sp.

Character	*E. dietzevi*	*E. narayani*	*E. megavitellus*	*Echinochasmus* sp. 1 n. sp
Body size	1130-1470 x 396-550	1500-1800 x 600-620	1050 x 450	554-896 (662) x 172-296 (228)
Forebody	380	450-540	380	198-476 (337)
Forebody length as percentage of body length	29	30	36	30-55 (41)
Collar width	319	225-270	170	46-79 (60)
Collar spines	20, first ventral spine, 34; second, 47; and others, 55-60	24, larger towards sides, except last three at either side, 30-60	24, uniform; 25	18, second angle spine, 16-17.5; others, 12.54-13.2
Oral sucker	Nearly round; 55-60	Round; 20-29 x 31-36	Ovoid; 60 x 50	Ovoid; 39-52 (50) x 26-39 (27)
Ventral sucker	Round; 220-248 x 198-220	Nearly round; 140-180	180 x 170	Round; 71-106 (94)
Sucker width ratio	1 : 36	1 : 2.8-3	1 : 34	1 : 3.2-3.6 (3.4)
Prepharynx	110	80-120	75	30-56 (45)
Pharynx	110	80-120	90 x 100	Round; 31-37 (35) x 24-32 (26)
Oesophagus	264-308	180	53.8	210-270 (250)

Character	***E. dietzevi***	***E. narayani***	***E. megavitellus***	***Echinochasmus* sp. 1 n. sp**
Anterior testis	Transversely elongated; 143-165 x 187-231	Transversely elongated; 350-400 x 160-200	Transversely elongated; 200 x 110	Transversely elongated; 56-88 (75) x 83-122 (112)
Posterior testis	187-209 x 187-231	Round posterior margin; 300-350 x 210-250	Round posterior margin; 170 x 112	Round posterior margin; 60-84 (72) x 81-115 (112)
Post testicular region	420	365-438	161.46	96-124 (108)
Post testicular region as percentage of body length	32	24	15.3	10.86-14.58 (12.9)
Ovary	Transversely oval; 77-86 x 77-99	Dextral round; 100-120	Dextral, ovoid; 80 x 70	Dextral, ovoid; 36-69 (53) x 33-46 (40)
Distance between ventral sucker and ovary	40	55-60	89.7	12-20 (15)
Eggs	A few; 81-86 x 43-47	A few; 60-48	A few; 70 x 50	One; 69-73 (71(x 46-53 (50)
Hosts	*Ardea cinerea, A. comata, A. purpurea, Botaurus stellaris, Bubulcus ibis, Circaetus gallicus*	*Milvus migrans govinda*	*Ardeola grayii*	*Phalacrocorax niger*

Character	***E. dietzevi***	***E. narayani***	***E. megavitellus***	***Echinochasmus* sp. 1 n. sp**
	and *Circus cyaneus*			

Table 7a. Measurements (µm) of adults of *Stephanoprora* sp. I n. sp.

Character	Range	Mean
Body size	2824- 5148 x 421-	3671 x 473
Forebody	530	461
Collar width	402-548	233
Oral sucker	198-267	73 x 83
Ventral sucker	63-78 x 78-94	204 x 224
Prepharynx	187-250 x 187-250	38
Pharynx	27-39	80 x 62
Oesophagus	77-85 x 54-69	169
Anterior testis	120-193	179 x 322
Posterior testis	101-265 x 296-343	334 x 326
Cirrus sac	312-374 x 250-437	316 x 132
Ovary	296-374 x 109-161	101 x 187
Eggs	78-140 x 156-218	81 x 51
	79-83 x 49-53	

Table 7b. Comparison of characters of *Stephanoprora reynoldi* Bhalerao, 1926, *S. nigerica* Gupta,1962 and *Stephanoprora* sp.I n. sp.

Character	*S. reynoldi*	*S. nigerica*	*Stephanoprora* sp.1 n.sp
Body size	4200 x 699	2683-4010 x 450-551	2824-5148 x 421-530
Forebody	699	672-1024	402-548
Forebody length as percentage of body length	16.6	25-26	10.6-16.5
Collar spine	22, 2 angular spines, 25x9; other spines, 40 x 19	22, equal in length; 41-49 x 5-7	22, equal in length, 36-38 x 10-12
Oral sucker	Ovoid; 21 x 68	Round; 59-109 x 56-102	Nearly round; 63-78 x 78-94
Ventral sucker	Nearly round; 326 x 279.6	Nearly round; 180-218 x 164-233	Nearly round; 187-250 x 187-250
Sucker width ratio	1 : 4.1	1:2.28 – 2.92	1:2.44 – 3.27
Prepharynx	15	45-64	27-39
Pharynx	Elliptical; 125 x 100	Elliptical; 65-90 x 47-63	Elliptical; 77-85 x 54-69
Oesophagus	200	341-591	120-193
Distance between intestinal bifurcation and ventral sucker	46.6	168-256	62-103
Anterior testis	Oval; 380 x 333	255-368 x 306-454	Transversely elongated; 101-265 x 296-343
Posterior testis	Ovoid; 500x330	Ovoid; 419-551 x 282-436	Globular; 312-374 x 250-437

Character	***S. reynoldi***	***S. nigerica***	***Stephanopr ora* sp.1 n.sp**
Post testicular region	1631	1365-2080	1248-1326
Cirrus sac	279 x 184	198-326 x 108-135	296-374 x 109-161
Ovary	Ovoid; 150 x 115	Ovoid; 113-141	Ovoid; 78-140 x 156-218
Distance between ventral sucker and ovary	419	21-32	235-638
Vitellaria	Posterior end of anterior testis to hind end of body	Anterior boarder of posterior testis to hind end of body	Posterior level of posterior testis to hind end of body
Eggs	56-89 x 31-49	68-76 x 50-54; 2-8 no.	79-83 x 49-53; 5-30
Host	*Corvus insolens* Hume	*Phalacrocora x niger* Vieillot	*Alcedo atthis* Linnaeus

Table 8. Measurements (µm) of adults of *Ignavia breviovarica* Gupta,1962,

Character	Range	Mean
Body size	6300-7800 x 511-	6800 x 647
Forebody	710	1850
Collar width	1260-2142	312
Oral sucker	250-325	218
Ventral sucker	194-251	349
Prepharynx	324-361	175
Pharynx	175	159
Oesophagus	137-163	624
Anterior testis	502-671	131 x 193
Posterior testis	122-159 x 162-235	123 x 216
Cirrus sac	102-146 x 209-245	109 x 78
Ovary	98-118 x 64-92	154 x 216
Eggs	143-168 x 201-251	105 x 74
	100-108 x 69-77	

Table 9. Measurements (µm) of adults of *Pegosomum egretti* Srivastava, 1957

Character	Range	Mean
Body size	8192-8986 x 2304-2816	8570 x 2577
Forebody	2517-3080	2798
Collar width	294-297	295
Oral sucker	84-89 x 100-123	85 x 112
Ventral sucker	794-1203 x 717-947	1041 x 810
Pharynx	116-234 x 116-156	175 x136
Oesophagus	1123-1757	1342
Anterior testis	896-1357 x 1280-1536	1126 x 1408
Posterior testis	896-1229 x 1024-1250	1063 x 1137
Cirrus sac	493-900 x 297-425	697 x 362
Ovary	461-512 x 204-410	486 x 384
Eggs	109-116 x 73-77	113 x 75

Table 10. Measurements (µm) of adults of *Psilorchis indicus* Thapar and Lal, 1935

Character	Range	Mean
Body size	5023-8315 x 484-	6578 x 732
Forebody	1076	496
Collar width	374-702	351
Oral sucker	331-370	124 x 138
Ventral sucker	94-156 x 109-172	537
Prepharynx	359-716	73
Pharynx	62-100	105 x 91
Oesophagus	86-109 x 62-109	117
Anterior testis	109-125	640 x 275
Posterior testis	437-811 x 203-406	652 x 277
Cirrus sac	343-858 x 125-421	297 x 160
Ovary	234-390 x 125-203	256 x 238
Eggs	203-312 x 156-312	116 x 66
	116 x 66	

Table 11. Measurements (µm) of adults of *Basantisia ramai* Pande, 1938

Character	Range	Mean
Body Size	431-1001 x 200-429	619 x 304
Forebody	159-417	257
Oral sucker	40-76 x 53-100	53 x 65
Ventral sucker	33-112	67
Prepharynx	3-20	9
Pharynx	36-46 x 17-35	42 x 23
Oesophagus	33-94	46
Right testis	50-127 x 66-117	88 x 85
Left testis	73-147 x 66-118	112 x 84
Cirrus sac	111-323 x 35-54	295 x 47
Ovary	63-118 x 39-106	86 x 70
Eggs	16.5 x 9.9	16.5 x 9.9

Table 12. Measurements (µm) of adults of *Nigerina hardoiensis* Baugh, 1958

Character	Range	Mean
Body size	8580-13104 x 578-811	10019 x 707
Forebody	936-1747	1326
Oral sucker	193-316 x 270-601	265 x 419
Ventral sucker	270-385	326
Pharynx	193-216 x 154-193	201 x 172
Oesophagus	23-39	28
Anterior testis	218-281 x 250-296	260 x 276
Posterior testis	234-281 x 203-328	260 x 281
Cirrus sac	169-254 x 85-139	212 x 109
Ovary	68-89 x 82-103	71 x 92
Eggs	23-26 x 13.2	24.5 x 13.2

Table 13.Measurements (µm) of adults of *Centrocestus formosanus* (Nishigori, 1924) Price, 1932.

Character	Range	Mean
Body Size	381-460 x 171-200	432 x 181
Forebody	214-251	238
Oral sucker	40-66 x 24-34	50 x 30
Ventral sucker	32-41 x 32-56	46 x 41
Prepharynx	21- 27	25
Pharynx	27-41 x 21-36	35 x 28
Oesophagus	20-28	22
Right testis	41-59 x 35-62	50 x 41
Left testis	52-60 x 41-96	57 x 71
Ovary	22-34 x 31-44	28 x 38
Eggs	24-32 x 14-16	25 x 15

Table 14. Measurements (µm) of adults of *Stellantchasmus falcatus* Onji et Nishio, 1915

Character	Range	Mean
Body size	462-657 x 205-314	555 x 267
Forebody	205-241	226
Oral sucker	36-50	47
Ventral sucker	30-35	31
Prepharynx	8-20	14
Pharynx	26-30	29
Oesophagus	89-116	106
Right testis	139-179 x 66-76	161 x 69
Left testis	149-198 x 66-96	168 x 76
Ovary	69-99	85
Eggs	26-32 x 20-23	29 x 21

Table 15. Measurements (µm) of adults of *Haplorchis taichui* (Nishigori, 1924) Witenberg, 1929.

Character	Range	Mean
Body size	540-940 x 364-635	731 x 494
Forebody	216-380	310
Oral sucker	46-82	65
Ventro-genital complex	61-110 x 52-90	82 x 74
Prepharynx	7-13	11
Pharynx	33-56 x 21-36	35 x 32
Oesophagus	51-90	82
Testis	158-240 x 141-229	201 x 204
Ovary	90-157 x 60-115	131 x 97
Eggs	24-28 x 10.5-16.5	25 x 15

Table 16 . Measurements (µm) of adults of Clinostomum complanatum (Rudolphi, 1809) Braun, 1899.

Character	Range	Mean
Body size	3138-6000 x 1248-	4225 x 1487
Forebody	1872	811
Oral sucker	546-1250	248 x 287
Ventral sucker	187-296 x 265-312	660
Oesophagus	499-795	178
Anterior testis	125-296	365 x 516
Posterior testis	312-468 x 390-624	388 x 599
Cirrus sac	312-468 x 515-702	225 x 173
Ovary	150-292 x 102-200	183 x 130
Eggs	94-250 x 94-203	90 x 68
	89-91 x 66-69	

Table 17. Measurements (µm) of adults of Euclinostomum heterostomum (Rudolphi, 1809) Travassos, 1928

Character	Range	Mean
Body size	4800-9820 x 1840-	7440 x
Forebody	3220	2580
Oral sucker	992-1712	1500
Ventral sucker	192-304 x 224-352	257 x 295
Oesophagus	960-1344	1157
Anterior testis	90-160	120
Posterior testis	540-960 x 560-	695 x 923
Cirrus sac	1376	622 x 686
Ovary	416-864 x 432-896	139 x 103
Eggs	109-172 x 62-125	183 x 130
	94-250 x 94-203	90 x 68
	89-91 x 66-69	

Table 18. Measurements (µm) of adults of Subuvulifer halcyonae (Gogate, 1940) Dubois, 1952

Character	Range	Mean
Forebody	468-780 x 468-749	640 x 614
Hindbody	1950-2250 x 328-	2117 x 471
Oral sucker	600	67
Ventral sucker	40-73	65 x 86
Pseudosucker	54-76 x 59 - 116	49 x 38
Holdfast organ	46-54 x 31-43	220 x 218
Pharynx	154-308 x 108-347	47
Oesophagus	39 - 59	33
Anterior testis	30-39	318 x 303
Posterior testis	154-462 x 193-462	293 x 283
Seminal vesicle	231-362 x 231-347	152 x 160
Ovary	148-156 x 99-200	121
Eggs	92-154	83 x 57
	73-92 x 50-62	

Table 19. Measurements (µm) of adults of *Uvulifer denticulatus* (Rudolphi, 1819) Dubois, 1937

Character	Range	Mean
Forebody	468-693 x 281-423	561 x 373
Hindbody	1872-3865 x 265-	3079 x 356
Oral sucker	437	74
Ventral sucker	46-114	54
Holdfast organ	35-62	179 x 163
Pharynx	162-200 x 116-193	79 x 45
Oesophagus	77-83 x 36-54	56
Anterior testis	45-62	262 x 289
Posterior testis	131-347 x 193-462	271 x 308
Seminal vesicle	116-377 x 208-470	179 x 168
Ovary	100-216 x 69-293	136 x 169
Egg	77-184 x 115-269	83 x 57
	83-84 x 56-57	

Table 20. Measurements (µm) of adults of *Uvulifer stunkardi* (Pande, 1938) Bhalerao, 1942

Character	Range	Mean
Forebody	220-261 x 136-209	231 x 164
Hindbody	494-612 x 196-234	523 x 208
Oral sucker	60-85 x 43-53	54 x 46
Ventral sucker	20-29 x 31-36	26 x 32
Holdfast organ	43-60 x 55-73	54-69
Pharynx	20-29	23
Oesophagus	13-19	15
Anterior testis	59-66 x 80-109	62 x 92
Posterior testis	54-71 x 102-125	62 x 116
Seminal vesicle	43-55 x 61-76	50 x 66
Ovary	40-51 x 49-59	46 x 54
Eggs	75-77 x 54-56	77 x 54

Table 21. Measurements (µm) of adults of *Uvulifer cochlearis* (Verma,1936) Dubois, 1944

Character	Range	Mean
Forebody	231-470 x 172-331	312 x 220
Hindbody	616-1560 x 156-281	989 x 203
Oral sucker	31-94 x 62-77	46 x 65
Ventral sucker	17-54	40
Holdfast organ	40-131 x 50-116	79 x 80
Pharynx	23-39 x 23-46	32 x 31
Oesophagus	14-23	21
Anterior testis	115-400 x 100-231	185 x 144
Posterior testis	108-231 x 123-308	139 x 174
Seminal vesicle	92-108 x 69-169	100 x 105
Ovary	62-108	77
Eggs	77-92 x 46-62	83 x 52

Table 22a. Measurements (µm) of adults of *Uvulifer* sp. I n.sp.

Character	Range	Mean
Forebody	323-468 x 312-390	387 x 352
Hindbody	770-1248 x 343-	963 x 413
Oral sucker	501	77
Ventral sucker	56-99	39
Holdfast organ	33-50	103 x 113
Prepharynx	76-116 x 85-149	6
Pharynx	3-8	37 x 35
Oesophagus	33-50 x 26-43	28
Anterior testis	13-50	130 x 176
Posterior testis	70-193 x 109-270	148 x 198
Seminal vesicle	76-246 x 177-231	184 x 122
Ovary	77-231 x 100-184	84 x 122
Eggs	69-100 x 96-139	96 x 69
	92-99 x 59-73	

Table 22 b. Comparison of the characters of *Uvulifer stunkardi* Pande (1938) Bhalerao, 1942, *U. cerylou* Dollfus, 1950, *U. chandigharensis* Mishra and Gupta, 1980 and *Uvulifer* sp.I n. sp.

Character	***U. stunkardi***	***U. cerylou***	***U. chandigharensis***	***Uvulifer* sp.I n.sp**
Body length	725-810	690	1950-2520	790-1669 (1139)
Forebody	220-261 x 126-169	150-210 x 160-260	580-720 x 300-470	323-468 x 312-390
Hindbody	494-612 x 196-234	380-520 x 130-212	1360-1800 x 320-430	770-1248 x 343-501
Oral sucker	Sub globular, 60-90 x 90-120	Sub-spherical; 33-38 x 38-58	Sub-spherical, elongated; 45-65 x 60-98	Round; 56-99
Ventral sucker	Nearly round; 20-29 x 31-36	Sub-spherical; 11-18 x 20-29	Sub spherical; 45-65 x 60-98	Nearly round; 33-46 x 26-50
Sucker width ratio	1:0.75-.93	1:0.5-0.52	1:0.53	1:0.46-0.58
Hold-fast organ	Round; lobed; 43-60 x 55-75	Nearly round, lobed; 52-61 x 100	Round; 80-144 x 85-160	Round lobed; 76-116 x 85-149
Body length: hold-fast organ length	1:0.06-0.074	1:0.13	1:0.052	1:0.06-0.09
Forebody length: Hold-fast organ length	1:0.21-0.24	1:0.30-0.35	1:0.2-0.24	1:0.19-0.35
Pharynx	Round; 20-29 x 21-24	Round; 16-21 x 14-19	Round; 30-45 x 30-48	Ovoid; 33-50 x 26-43

Character	***U. stunkardi***	***U. cerylou***	***U. chandigharensis***	***Uvulifer* sp.l n.sp**
Oesophagus	Short; 13-19	Short; 18-36	100	Short; 13-50
Anterior testis	Doso-ventrally elongated; 59-66 x 80-109	Dorso-ventrally elongated; smaller; 96x142-165	Dorso-ventrally elongated, larger; 315-355 x 275-325	Doro-ventrally elongated; 70-193 x 109-270
Post4erior testis	Transversely elongated, 54-71 x 102-125	Transversely elongated; 40-65 x 70-200	Transversely elongated; 320-355 x 325-350	Transversely elongated; 77-231 x 100-184
Ovary	Round; 40-51 x 49-59	Ovoid; 36-42 x 47-63	Elliptical to round; 129-145 x 132-145	Ovoid; 69-100 x 96-139
Eggs	3-5; 75-77 x 54-56	79-91 x 51-62	3-4; 45-50 x 20-30	0-1; 92-99 x 59-73
Hosts	*Halcyon smyrnensis*	*Ceryle rudis*	*Halcyon smyrnensis*	*Halcyon smyrnensis*

Table 23. Measurements(µm)of adults of *Apharyngostrigea ramai* (Verma, 1936) Vidyarthi, 1937

Character	Range	Mean
Forebody	1092-1482 x 889-	1287 x
Hindbody	1150	1108
Oral sucker	2262-2652 x 499-	2457 x
Ventral sucker	530	515
Holdfast organ	94-140	117
oesophagus	187-280	225
Anterior testis	546-624 x 515-624	585 x 569
Posterior testis	125-234	179
Ovary	500-640 x 490-740	601 x 670
Eggs	530-790 x 518-800	721 x615
	203-324 x 187-234	268 x 211
	86-92 x 53-76	90 x 64

Table 26. Incidence of mixed infections with digenetic trematodes in birds examined

Host	No. examined	No. infected	No. of mixed infections
Ardeola grayii	16	14	8
Egretta garzetta	8	2	0
Bubulcus ibis	12	11	4
Anastomus ocitans	1	1	0
Phalacrocorax niger	13	12	5
Halcyon smyrnensis	16	14	11
Alcedo atthis	7	7	4
Milvus migrans	3	3	3
Gallus gallus	4	1	0
Total	80	65	35

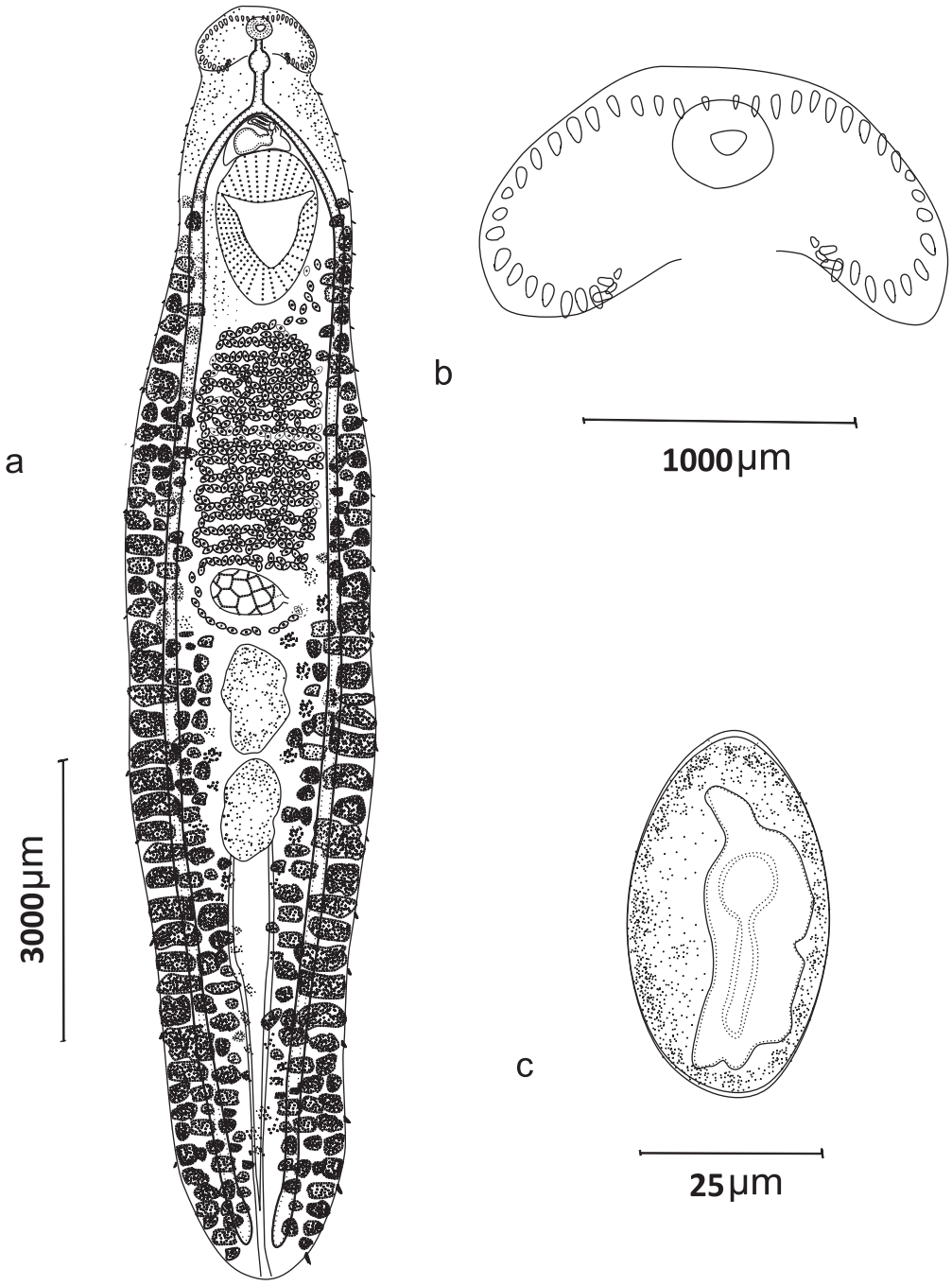


Fig. 1 . ***Nephrostomum ramosum*** **(Sonsino, 1895) Dietz,1909**
a. Mature adult; b. Collar with collar spines; c. Egg

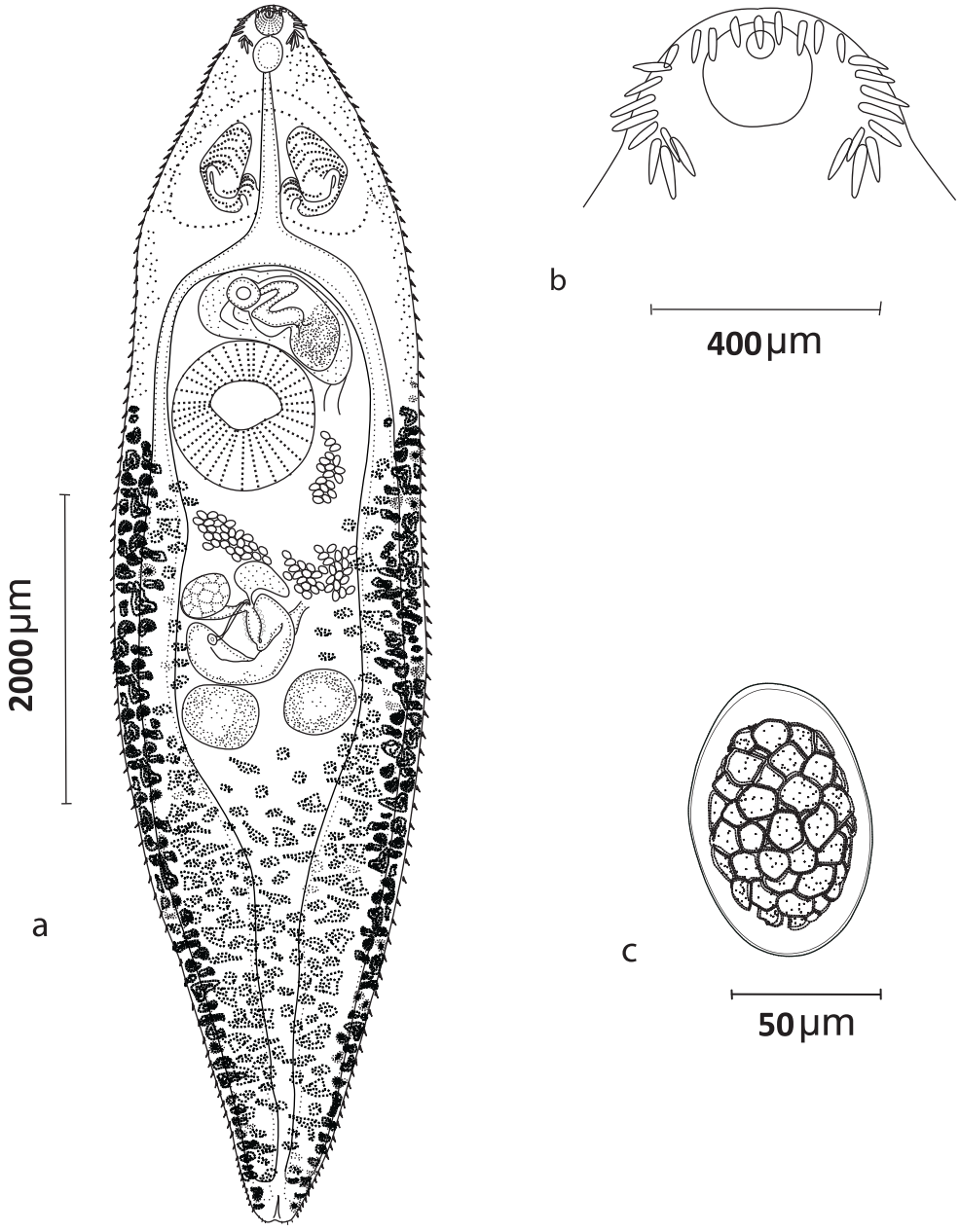


Fig. 2 . *Parallelotestis tarai* (Srivastava, 1958) Beverly-Burton,1960
a. Mature adult; b. Collar with collar spines; c. Egg

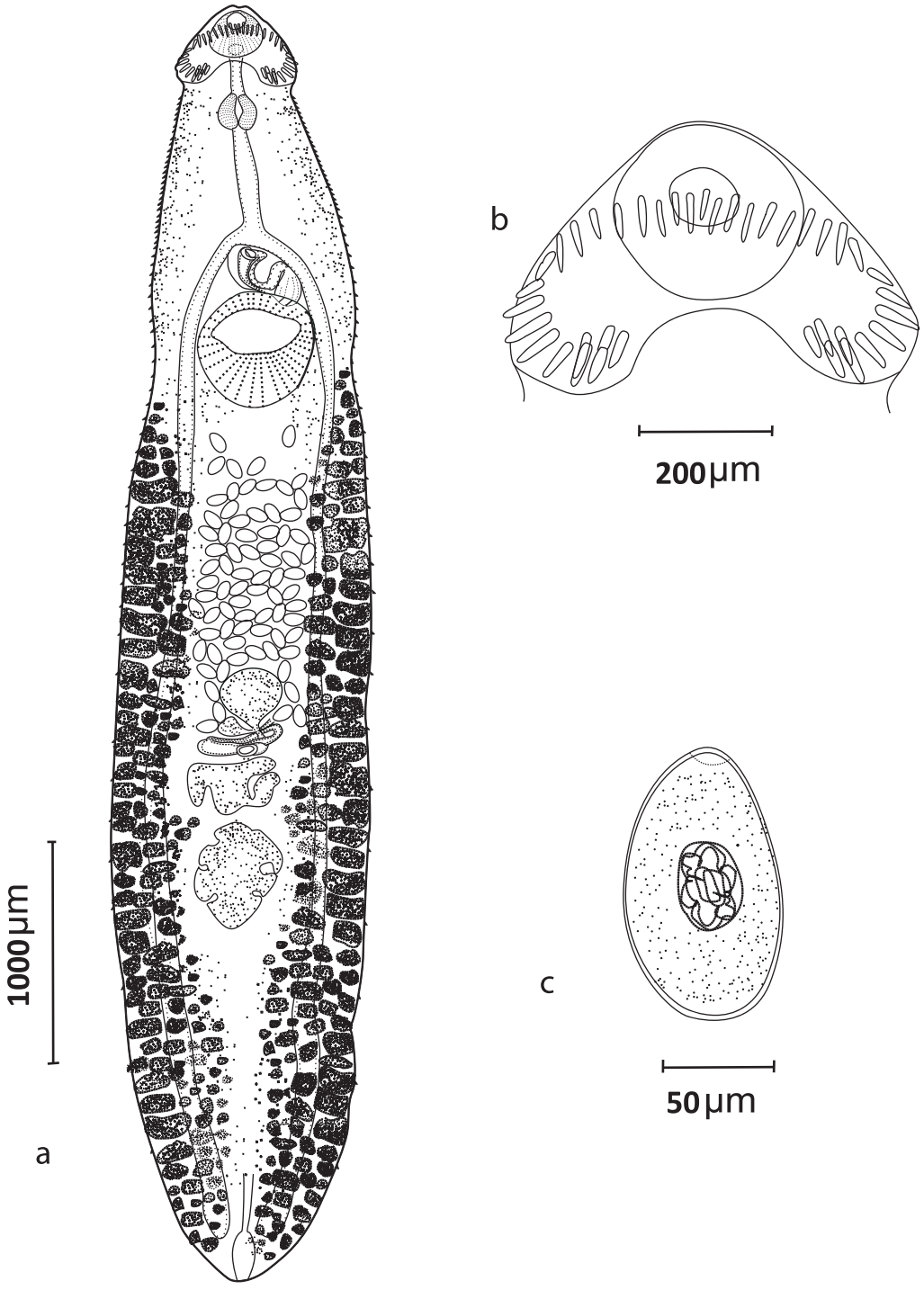


Fig. 3 . ***Paryphostomum horai*** **Baugh, 1950**
a. Mature adult; b. Collar with collar spines; c. Egg

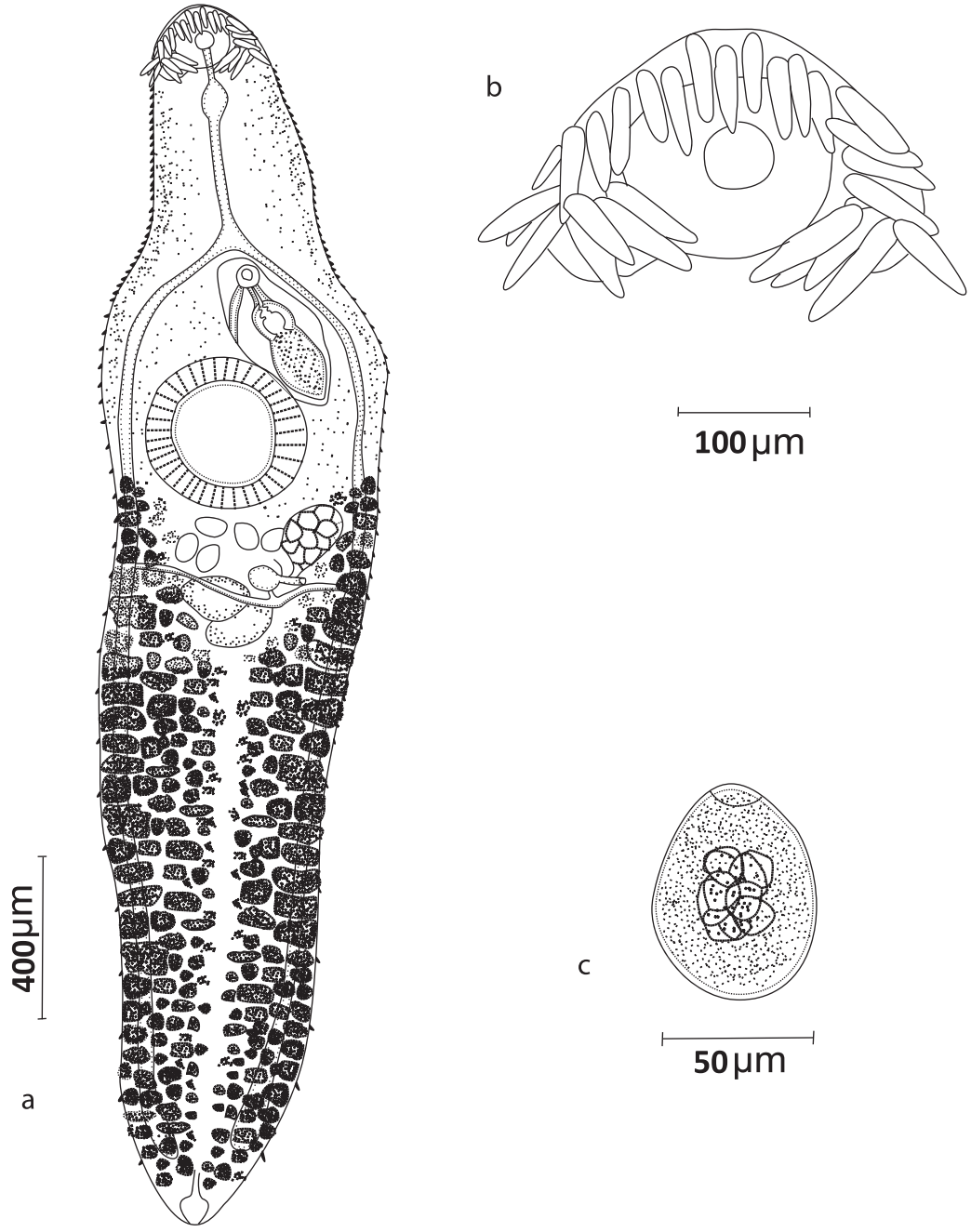


Fig. 4 . ***Petasiger variospinosus*** **(Odhner, 1910) Yamaguti, 1933**
a. Mature adult; b. Collar with collar spines; c. Egg

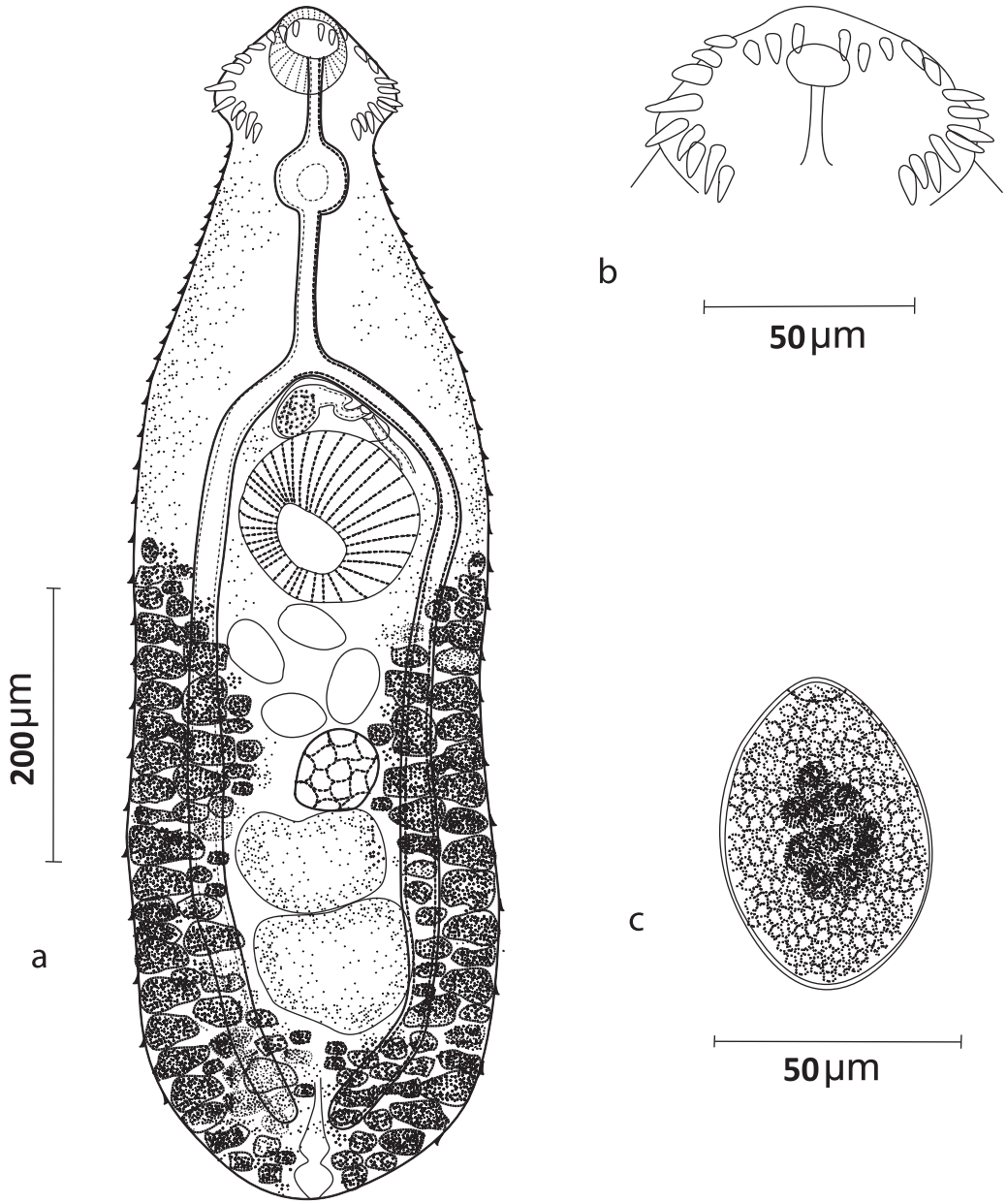


Fig. 5 . ***Echinochasmus bagulai*** **Verma, 1935**
a. Mature adult; b. Collar with collar spines; c. Egg

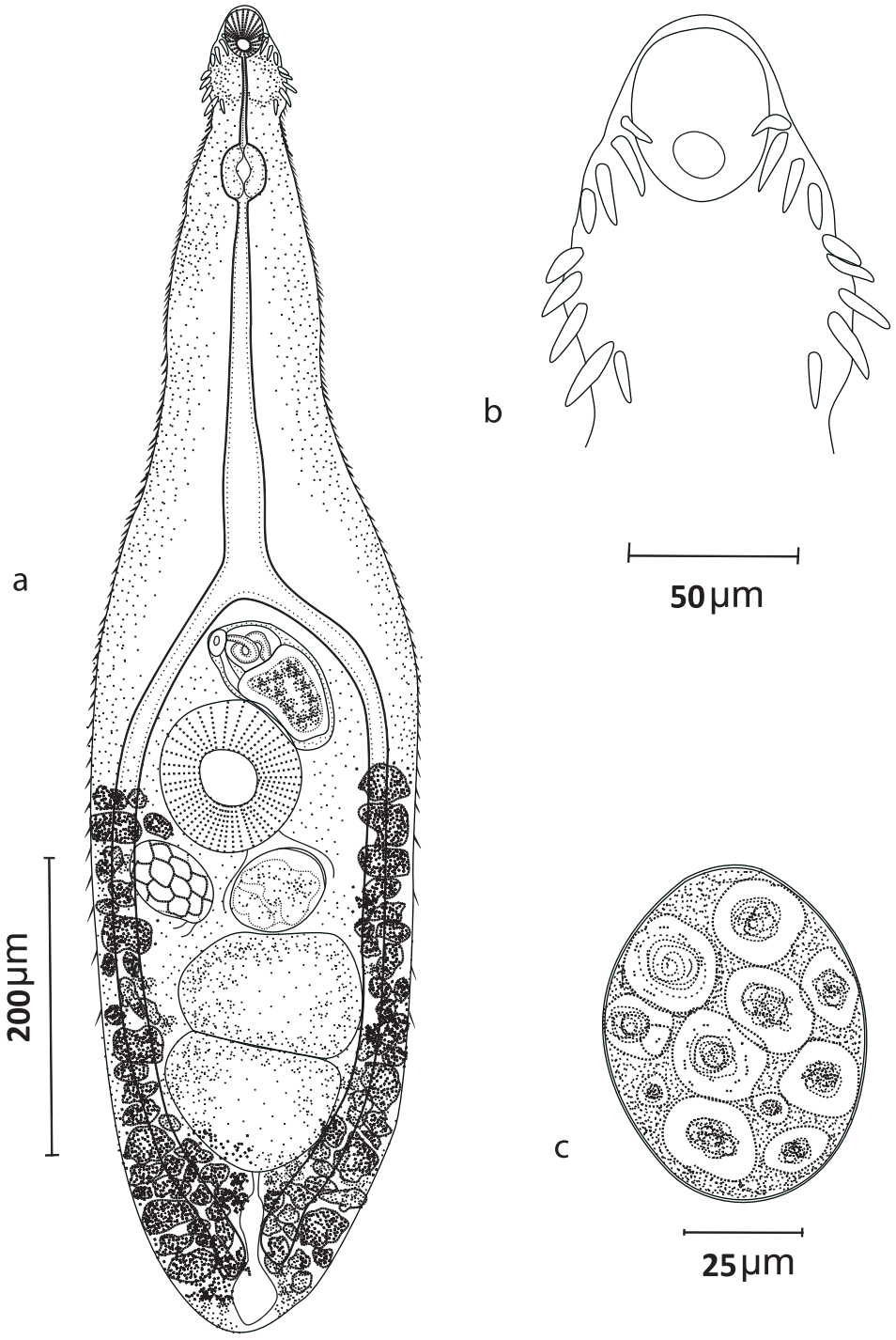


Fig. 6 . *Echinochasmus* sp. 1 n. sp.
a. Mature adult; b. Collar with collar spines; c. Egg

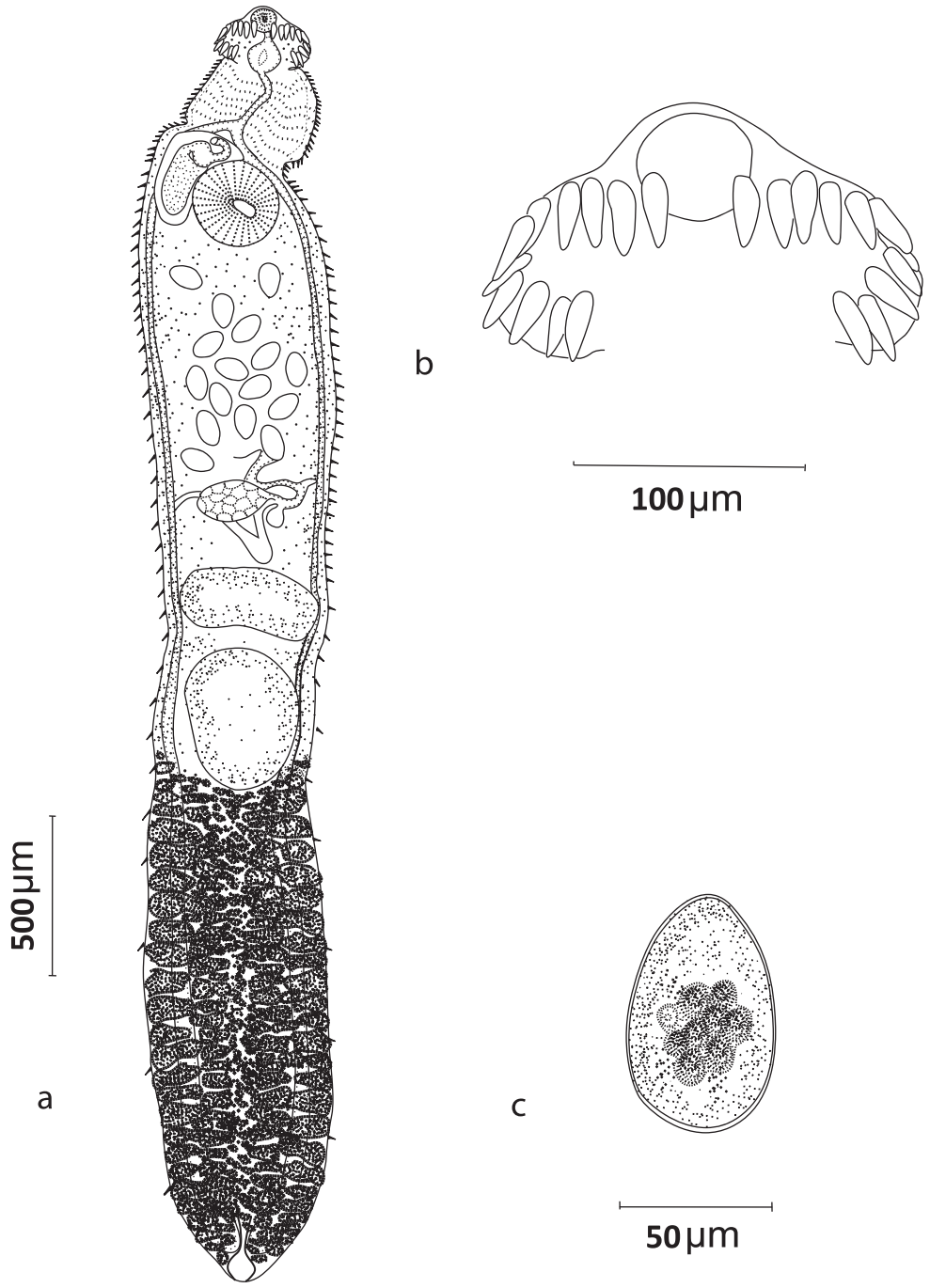


Fig. 7. *Stephanoprora* sp. 1 n. sp.
a. Mature adult; b. Collar with collar spines; c. Egg

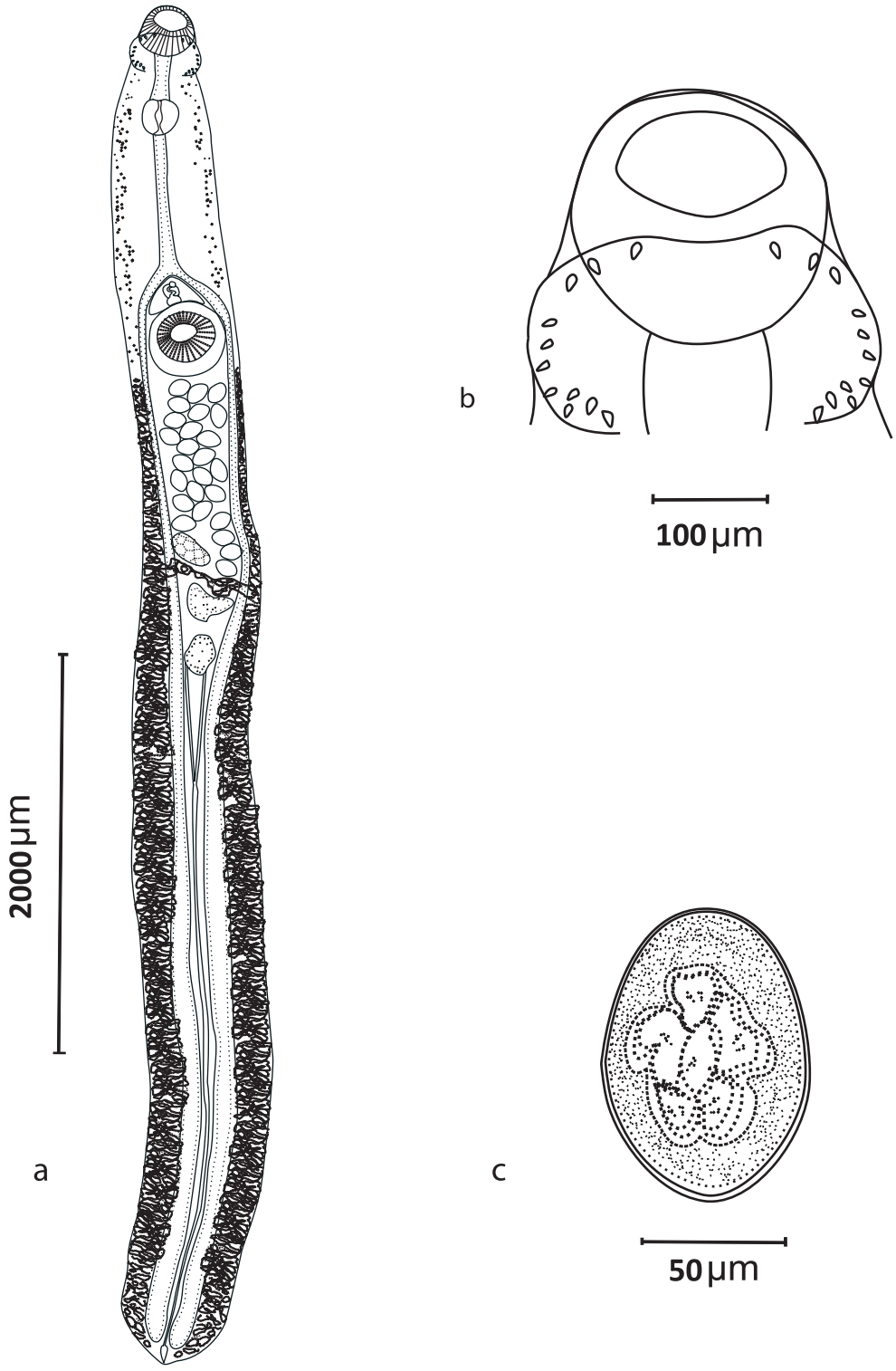


Fig. 8 . ***Ignavia breviovarica*** **Gupta, 1962**
a. Mature adult; b. Collar with collar spines; c. Egg

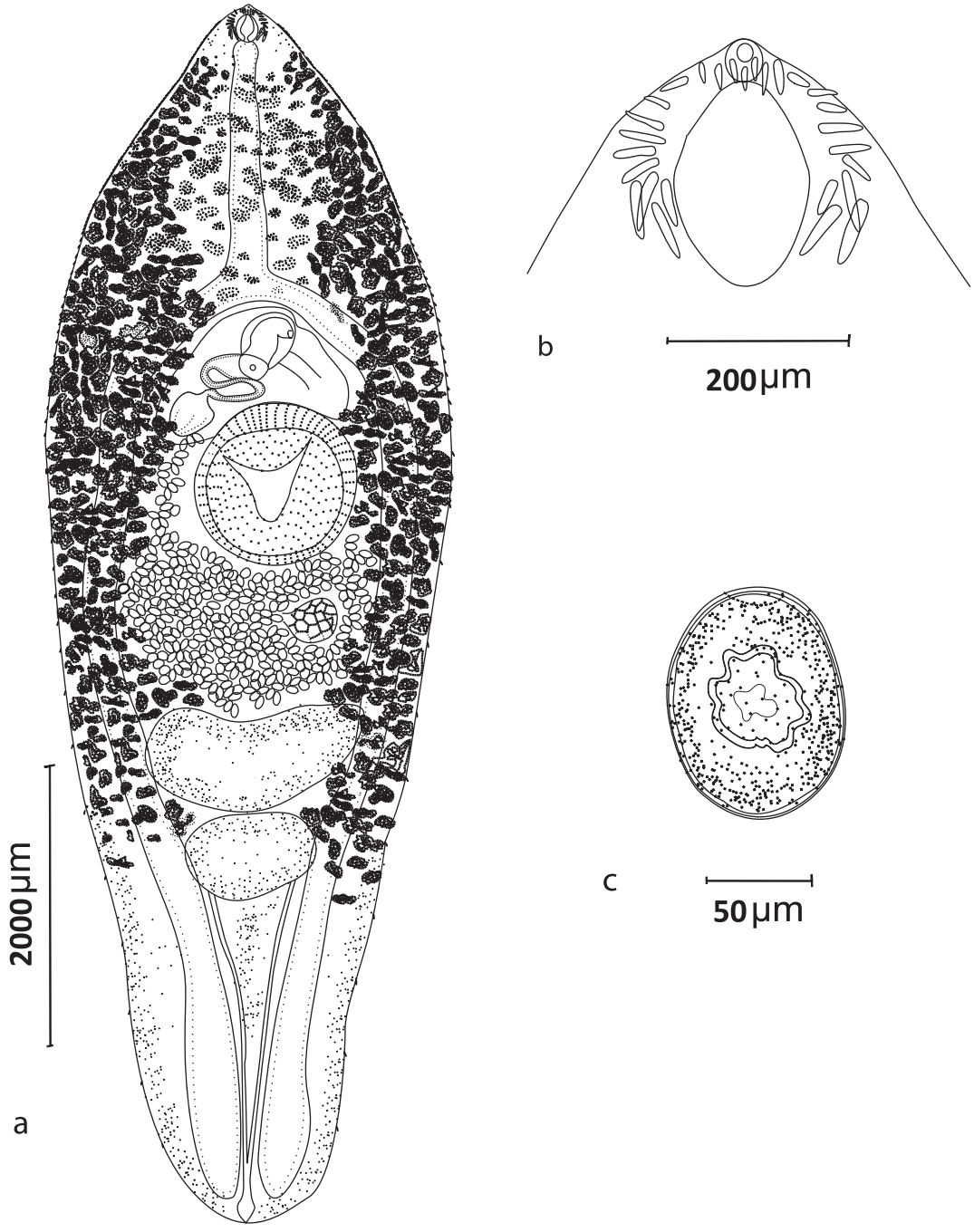


Fig. 9 . ***Pegosomum egretti*** **Srivastava, 1957**
a. Mature adult; b. Collar with collar spines; c. Egg

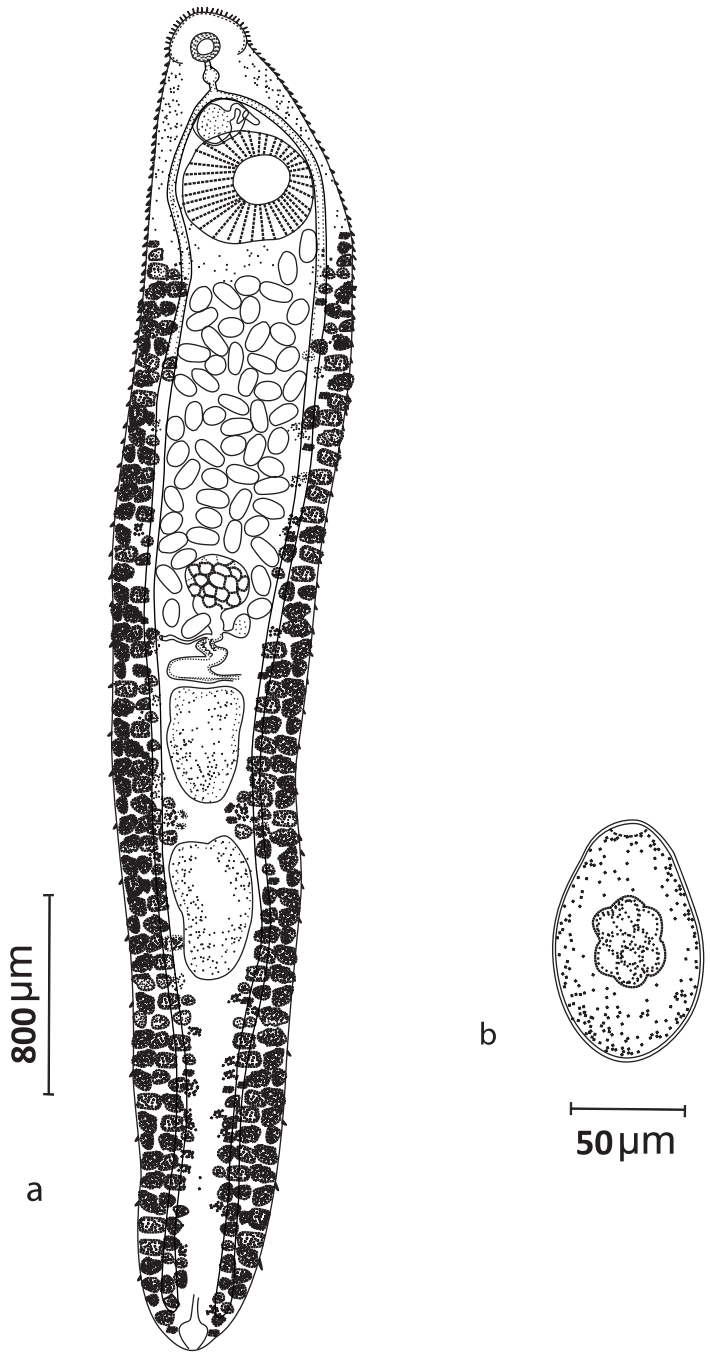


Fig. 10. *Psilorchis indicus* Thapar and Lal, 1935
a. Mature adult; b. Egg

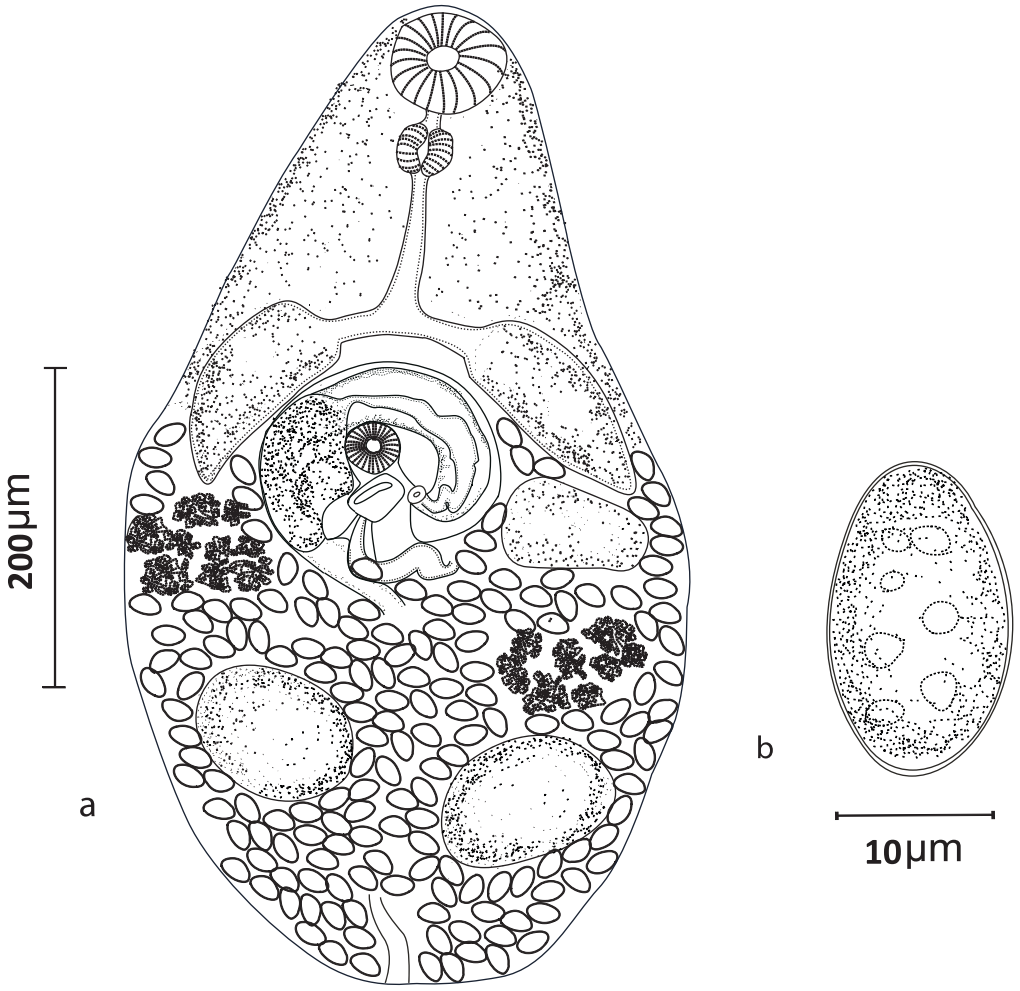


Fig. 11. *Basantisia ramai* Pande, 1938
a. Mature adult; b. Egg

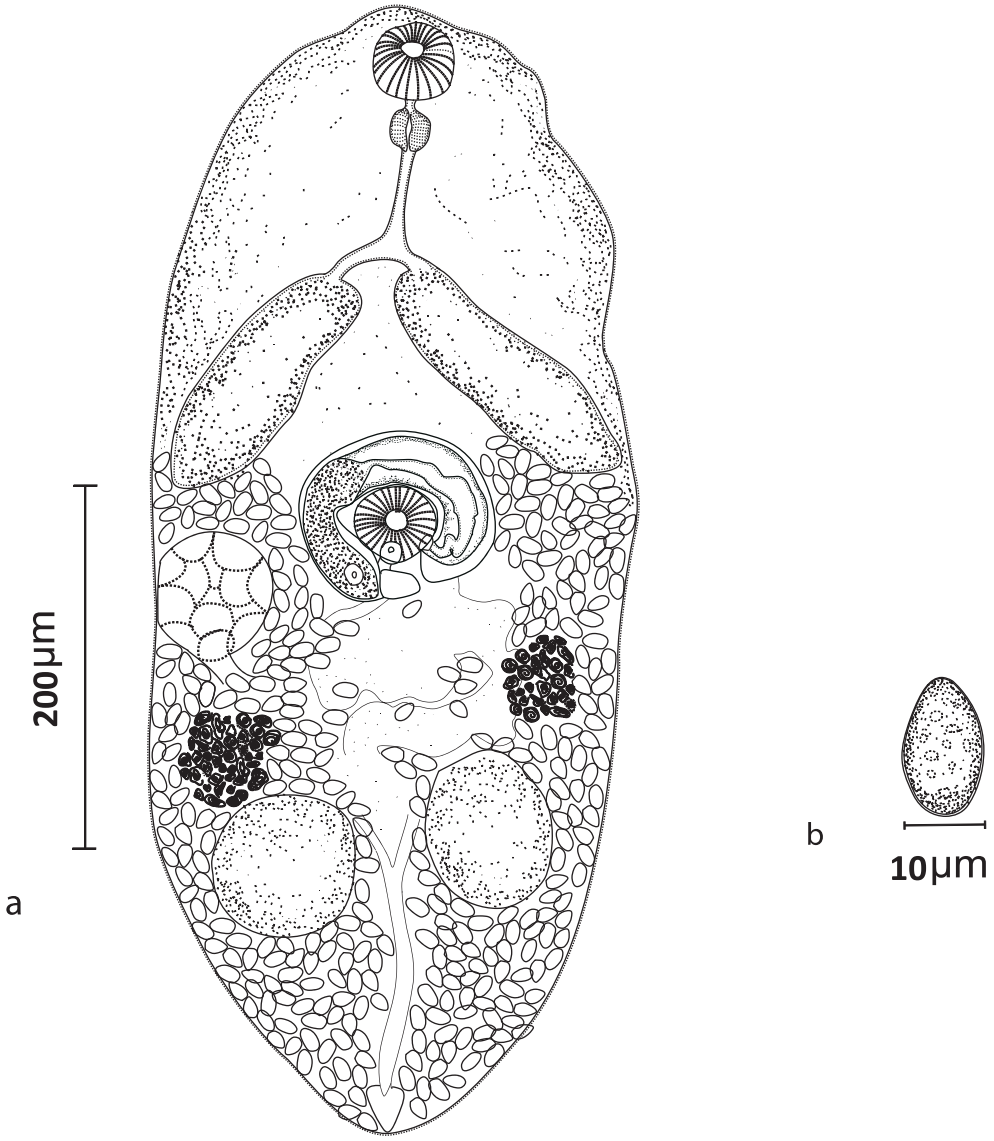


Fig. 11. *Basantisia ramai* Pande, 1938
a. Mature adult; b. Egg

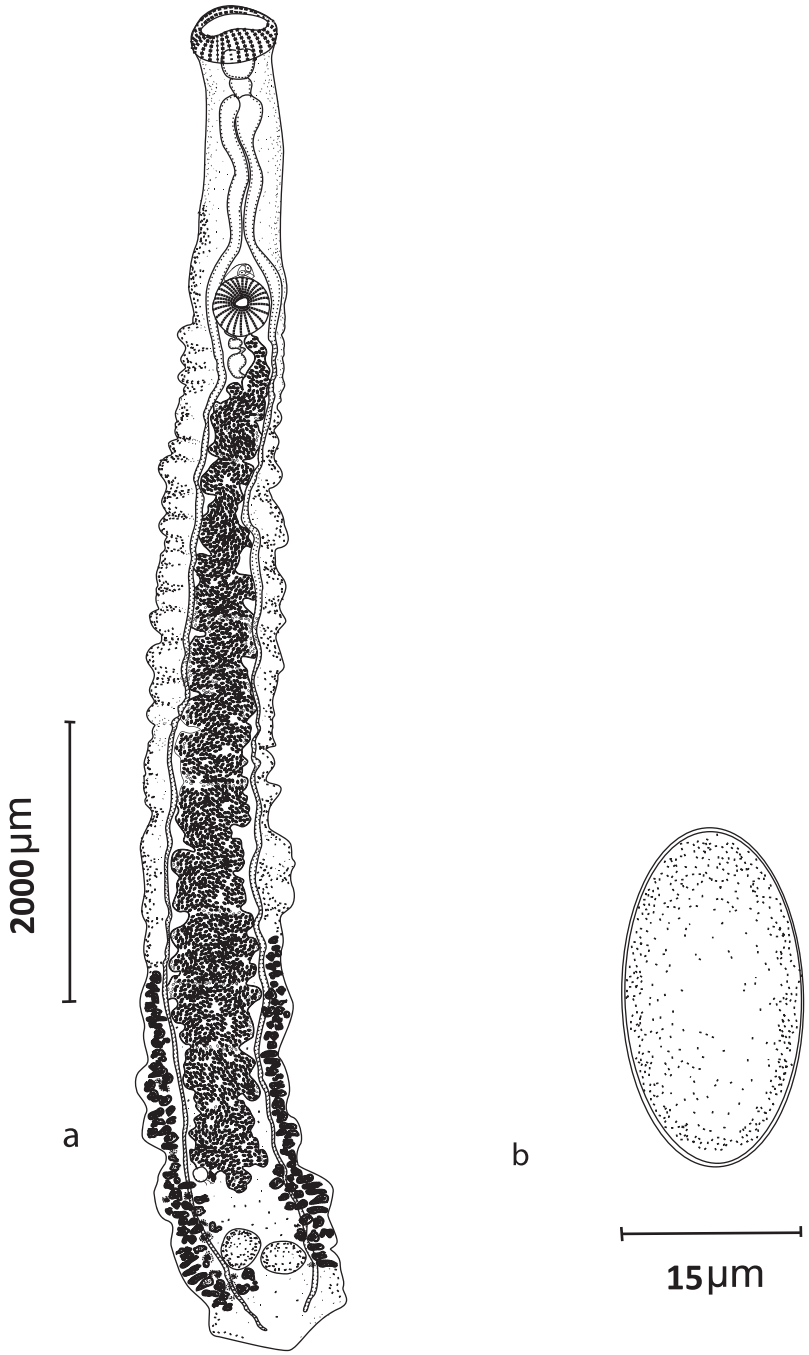


Fig. 12. *Nigerina hardoiensis* Baugh, 1958
a. Mature adult; b. Egg

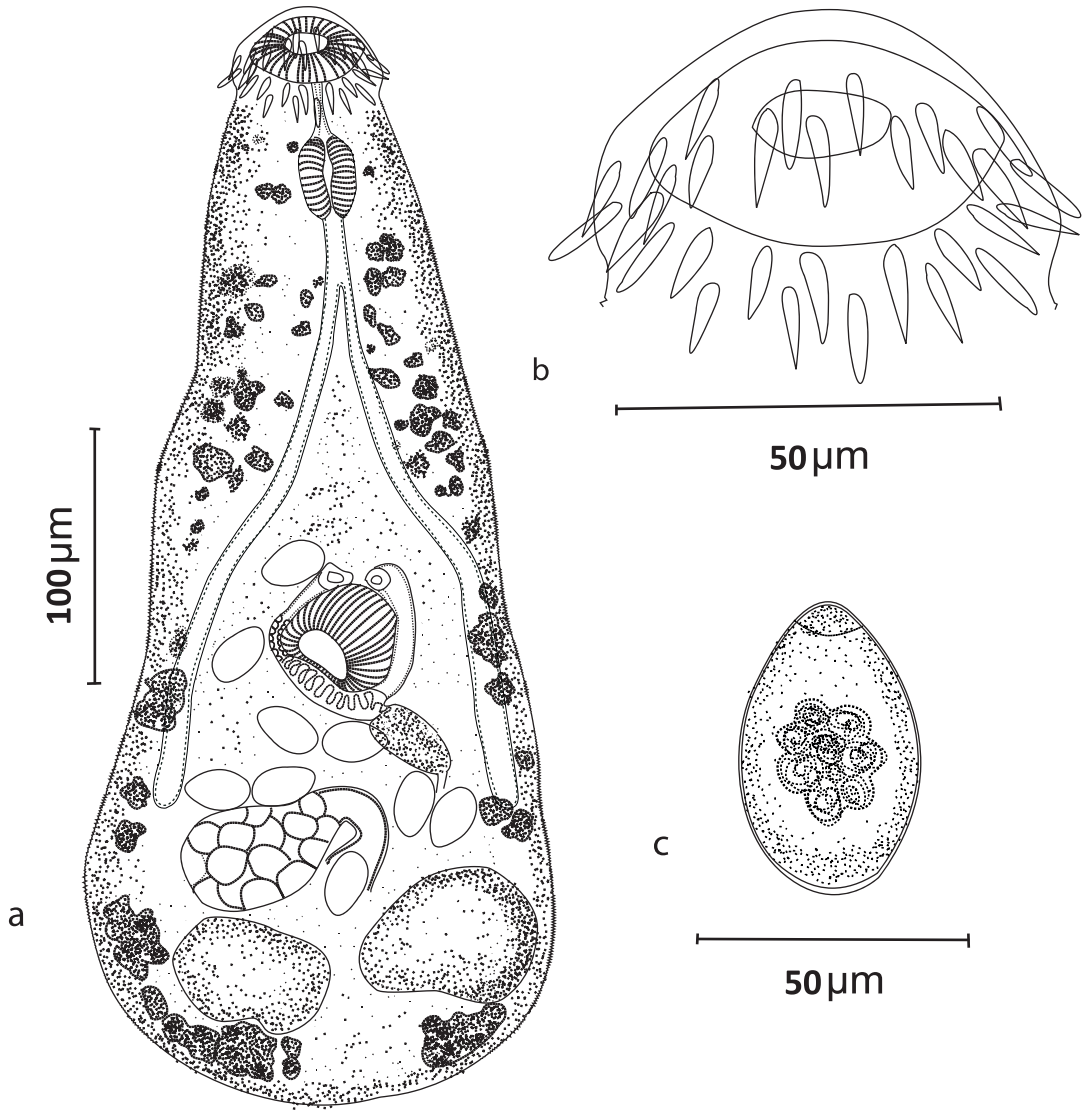


Fig. 13. *Centrocestus formasus* (Nishigori, 1924) Price, 1932
a. Mature adult; b. Circum oral spines; c. Egg

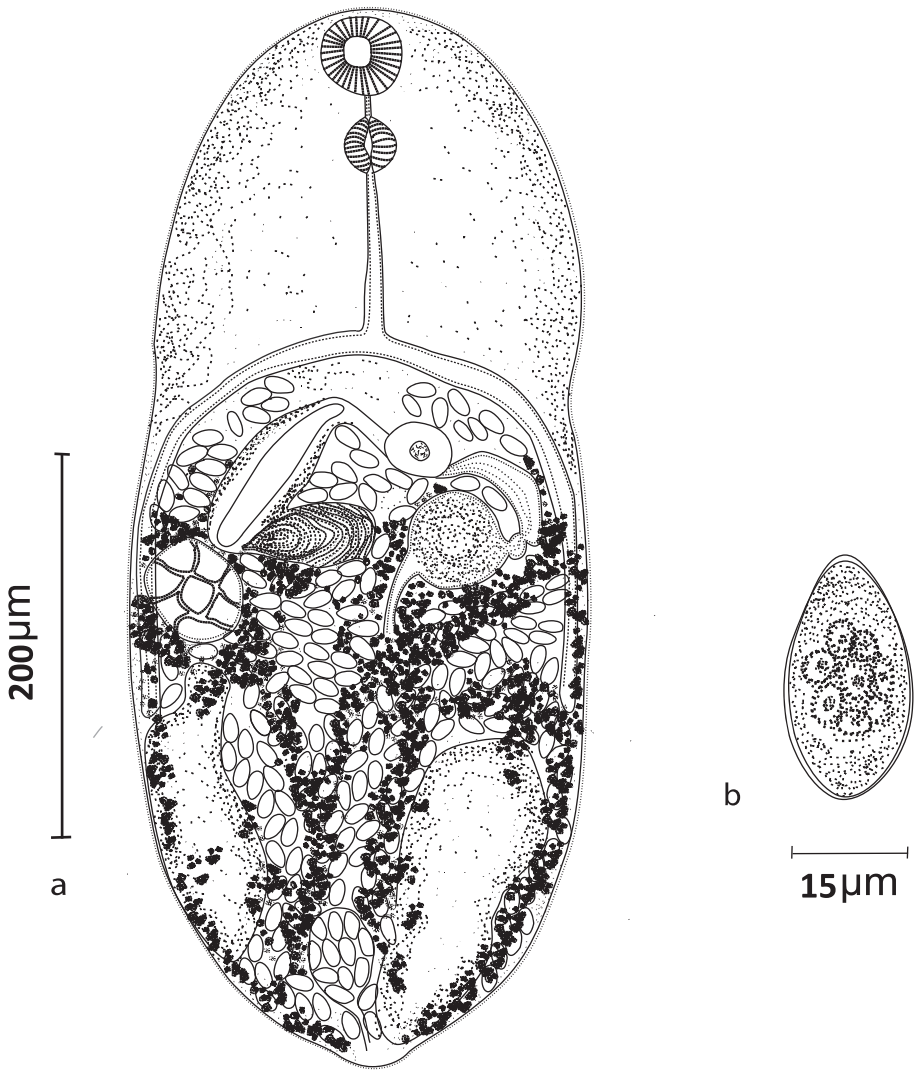


Fig. 14. *Stellantchasmus falcatus* Onji and Nishio, 1924
a. Mature adult; b. Egg

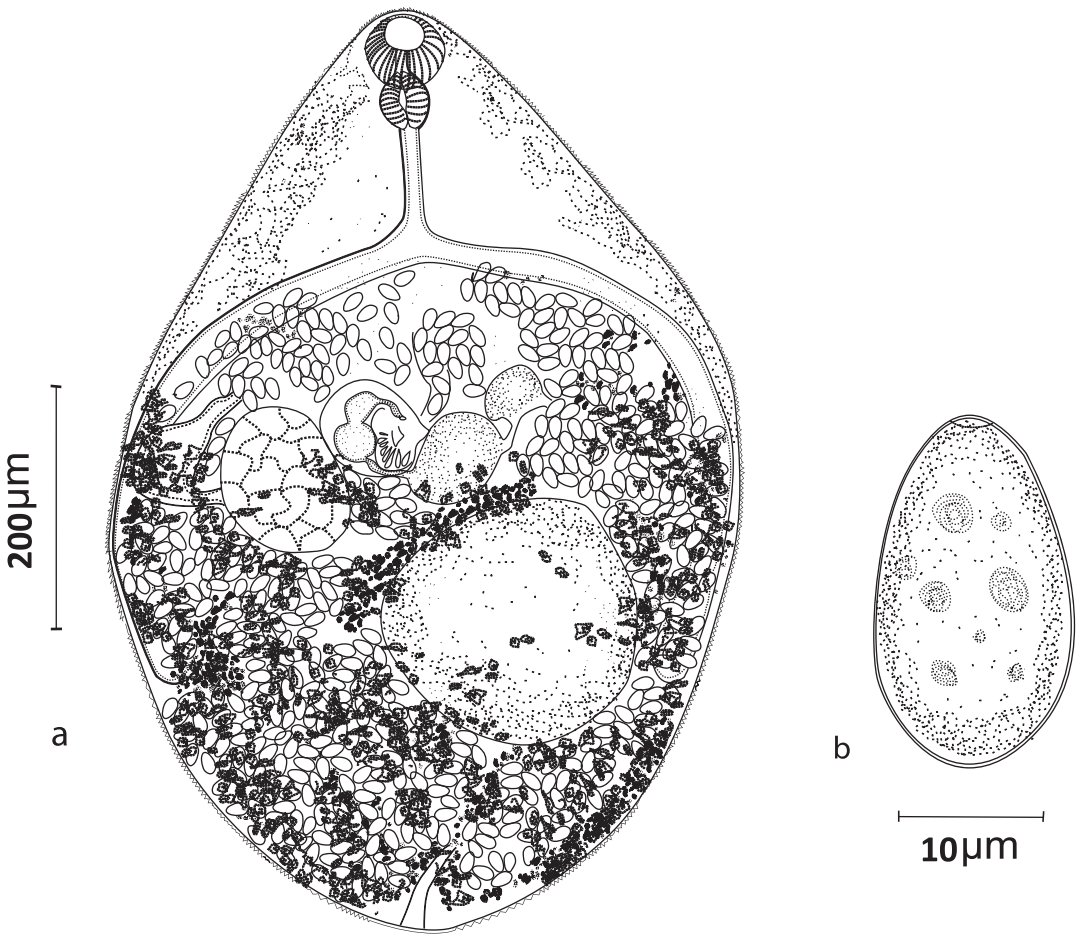


Fig. 15. *Haplorchis taichui* (Nishigori, 1924) Witenberg, 1929
a. Mature adult; b. Egg

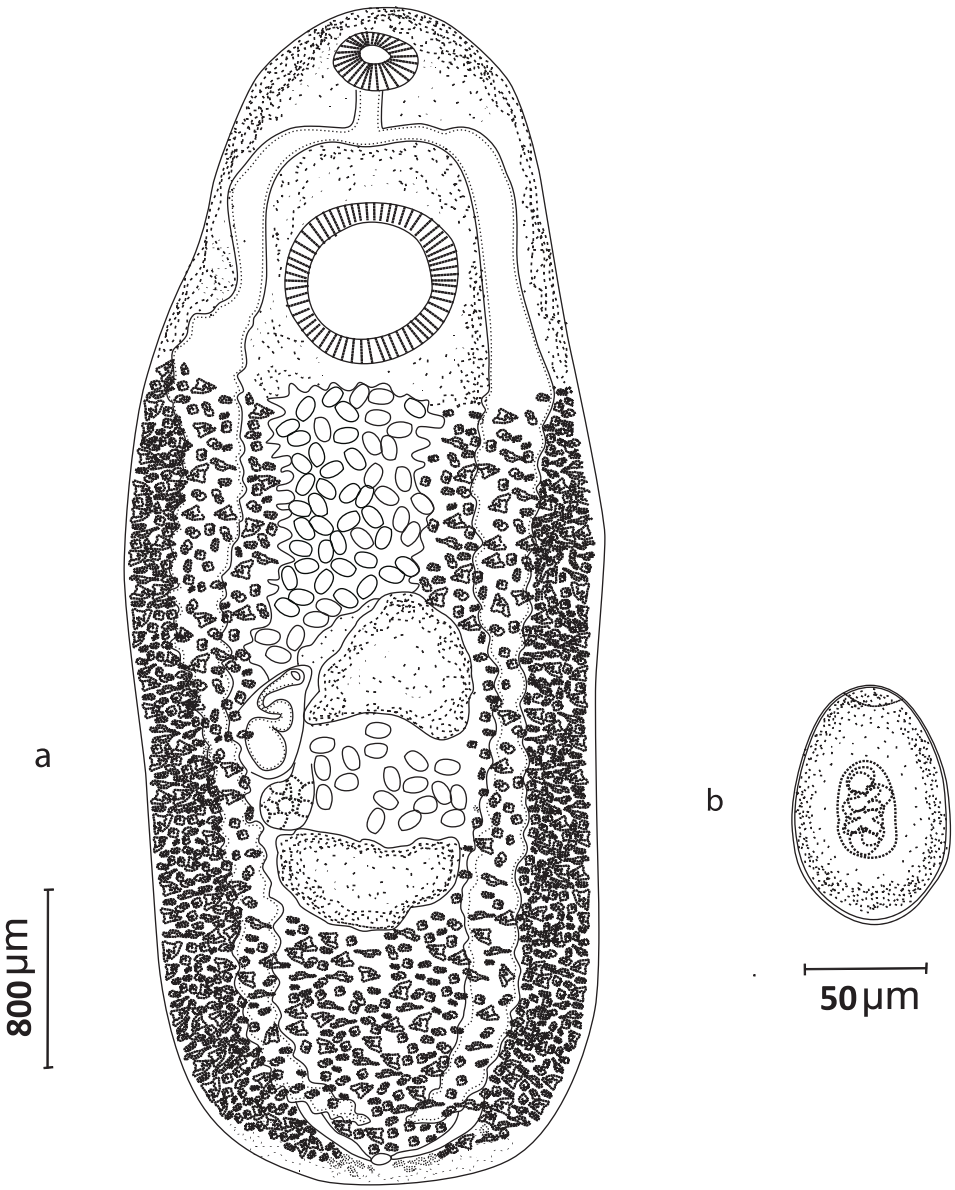


Fig. 16. *Clinostomum complanatum* (Rudolphi, 1819) Braun, 1899
a. Mature adult; b. Egg

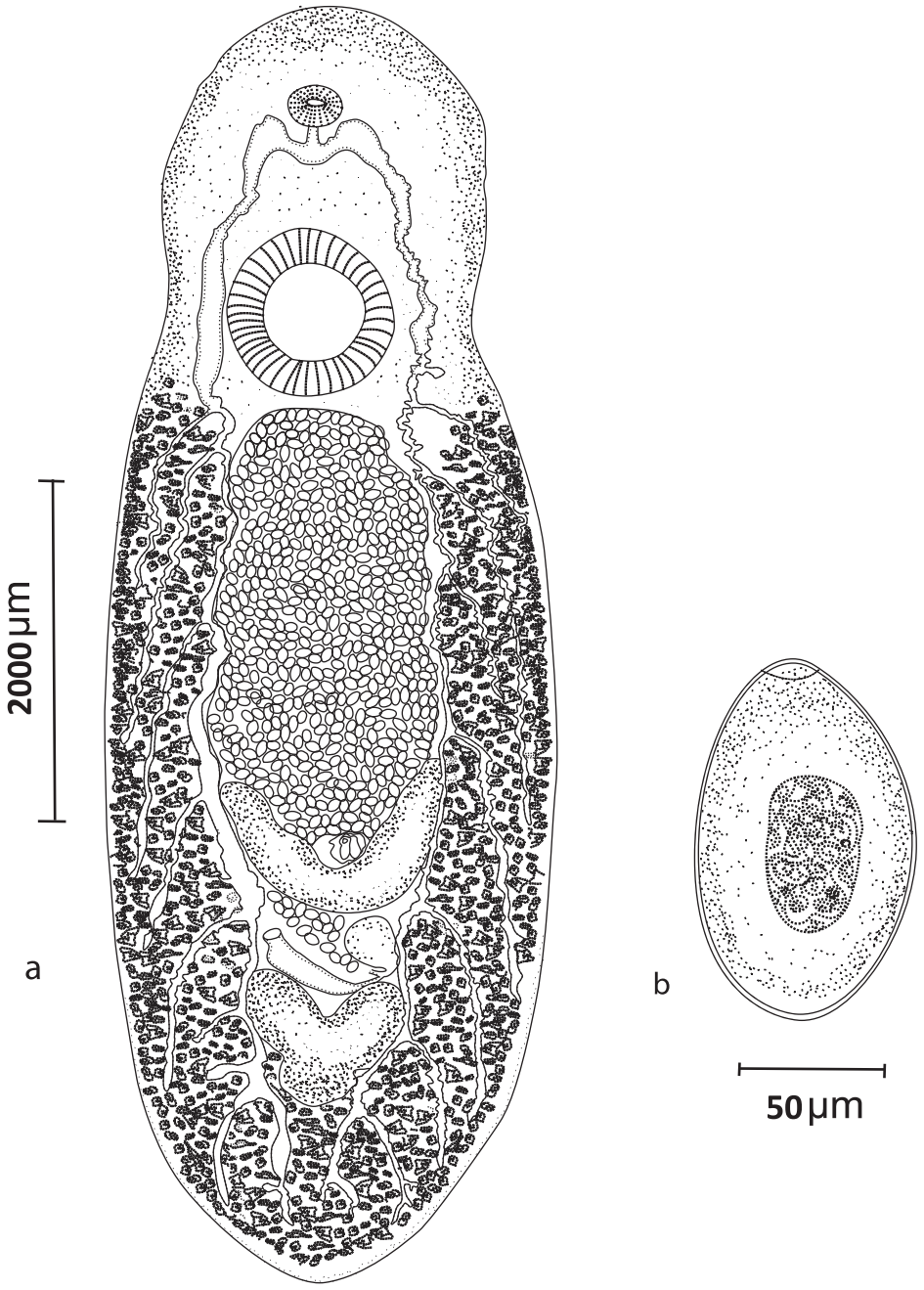


Fig. 17. *Euclinostomum heterostomum* (Rudolphi, 1809) Travassos, 1928
a. Mature adult; b. Egg

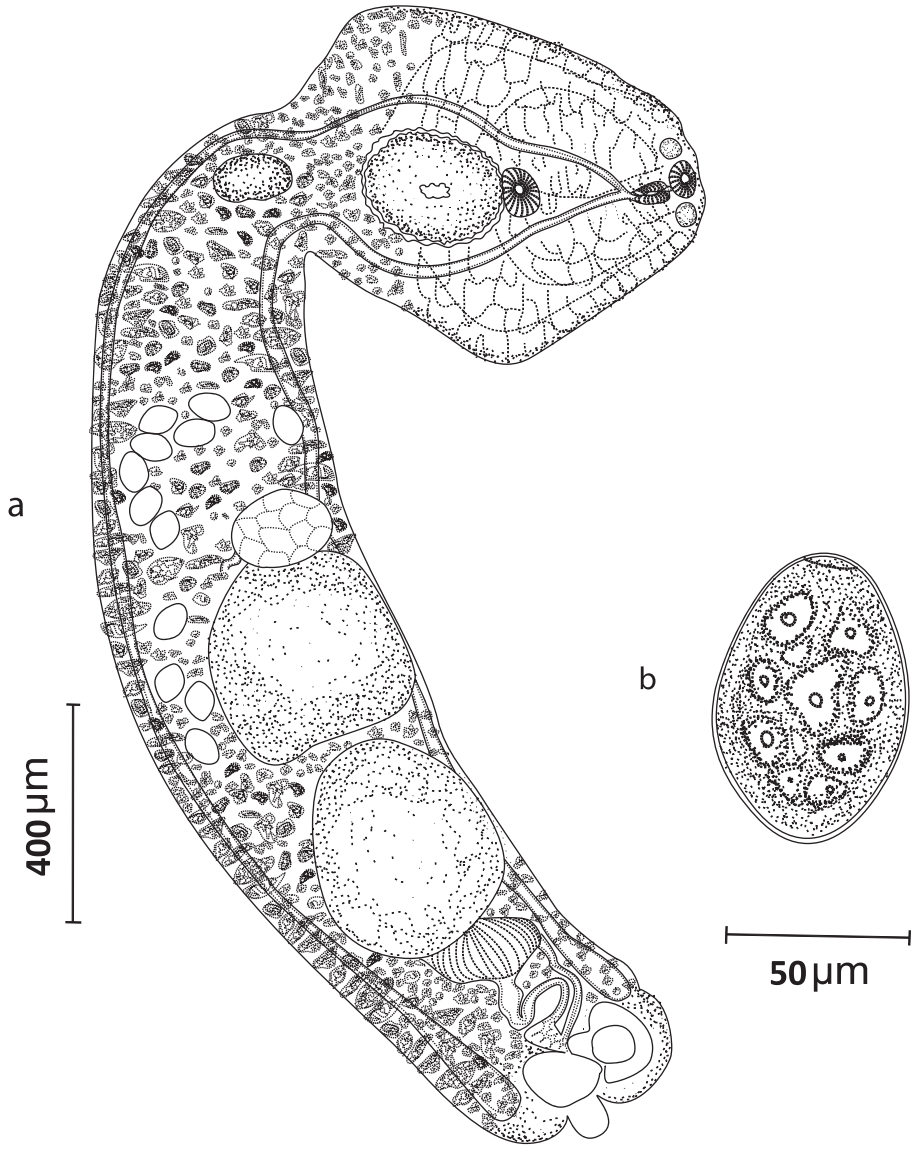


Fig. 18. *Subuvulifer halcyonae* (Gogate, 1940) Dubois, 1952
a. Mature adult; b. Egg

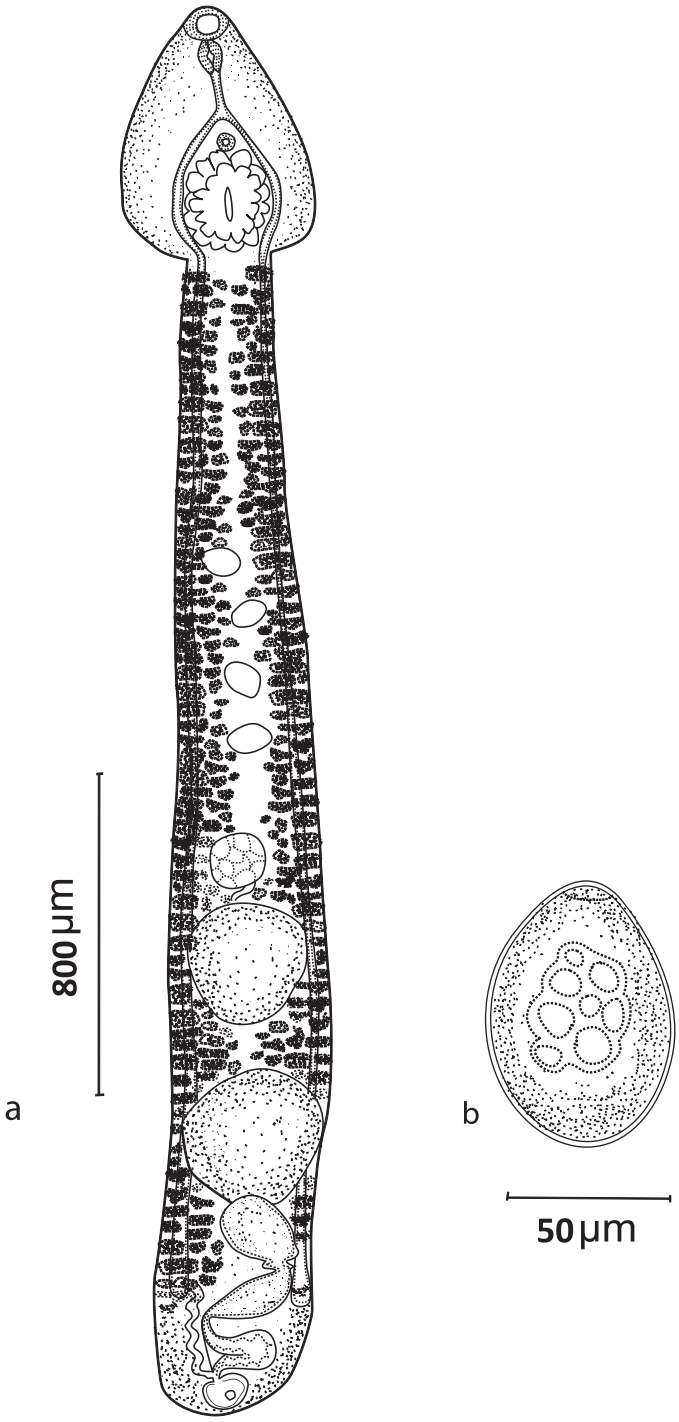


Fig. 19. *Uvulifer denticulatus* (Rudolphi, 1819) Dubois, 1937
a. Mature adult; b. Egg

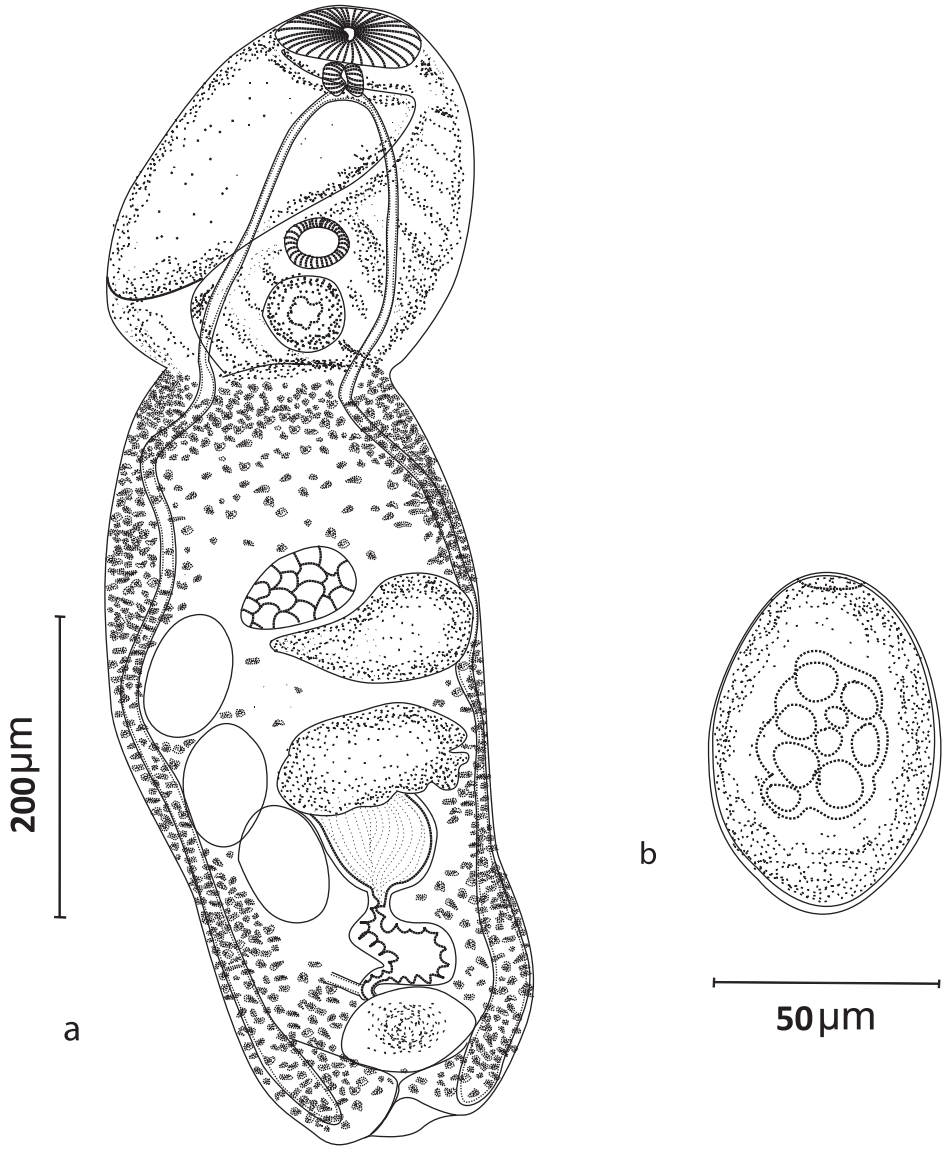


Fig. 20. *Uvulifer stunkardi* (Pande, 1938) Bhalerao, 1942
a. Mature adult; b. Egg

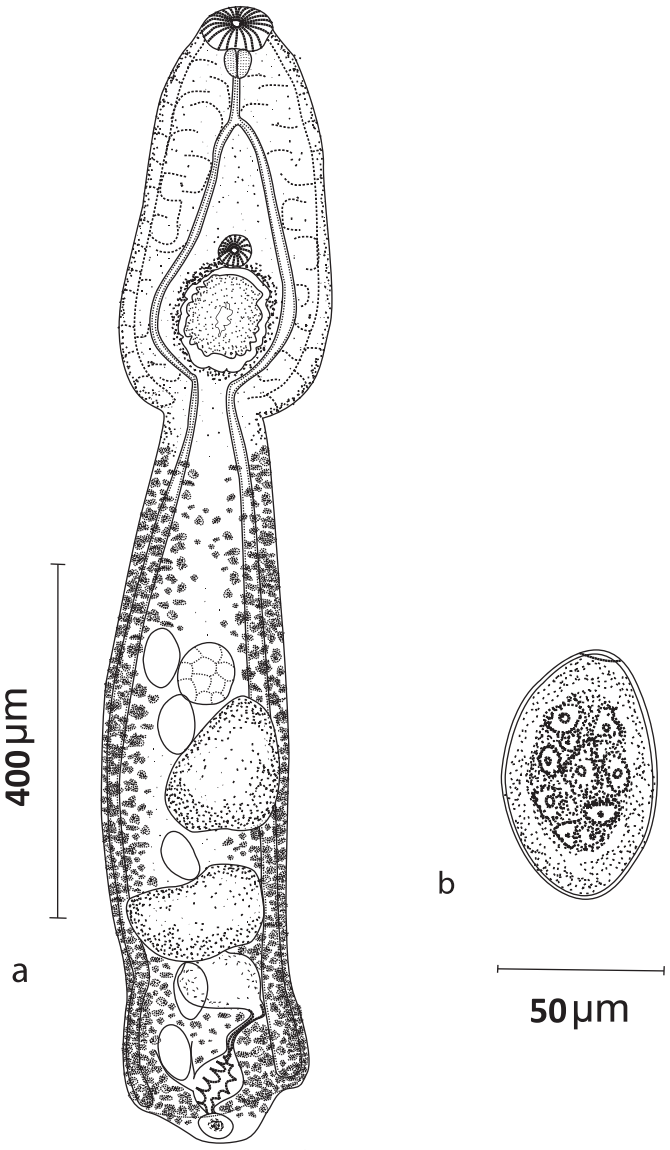


Fig. 21. *Uvulifer cochlearis* (Verma, 1936) Dubois, 1944
a. Mature adult; b. Egg

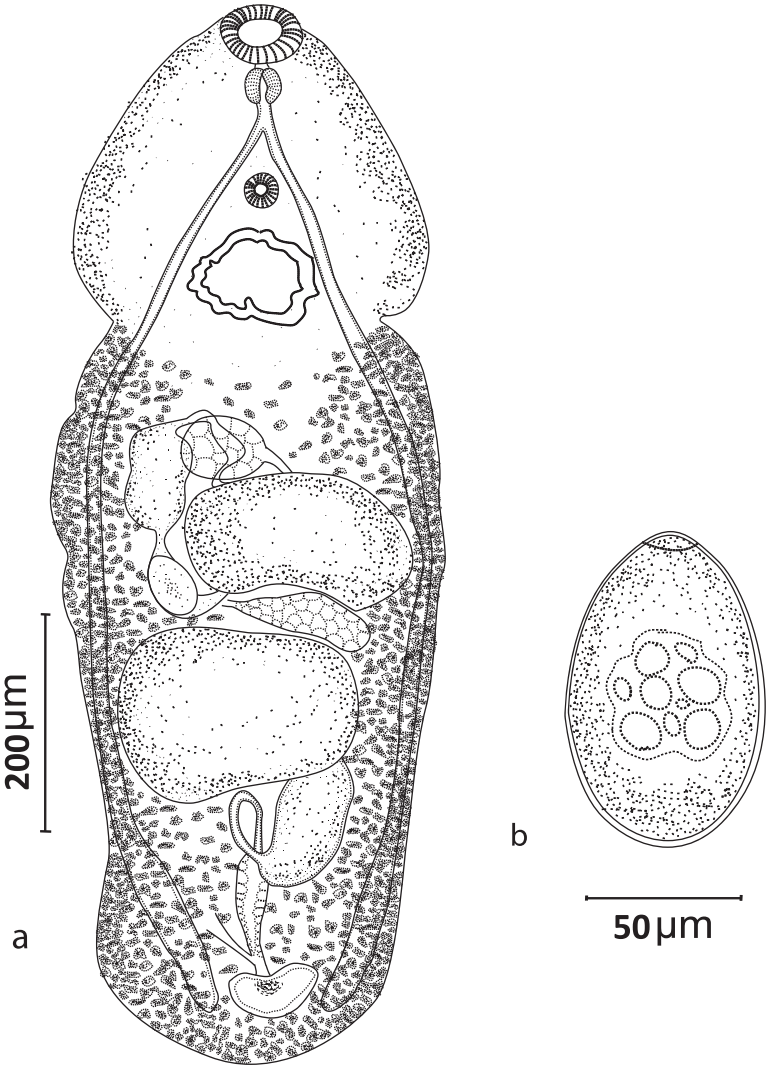


Fig. 22 a. *Uvulifer* sp. 1 n. sp.
a. Mature adult; b. Egg

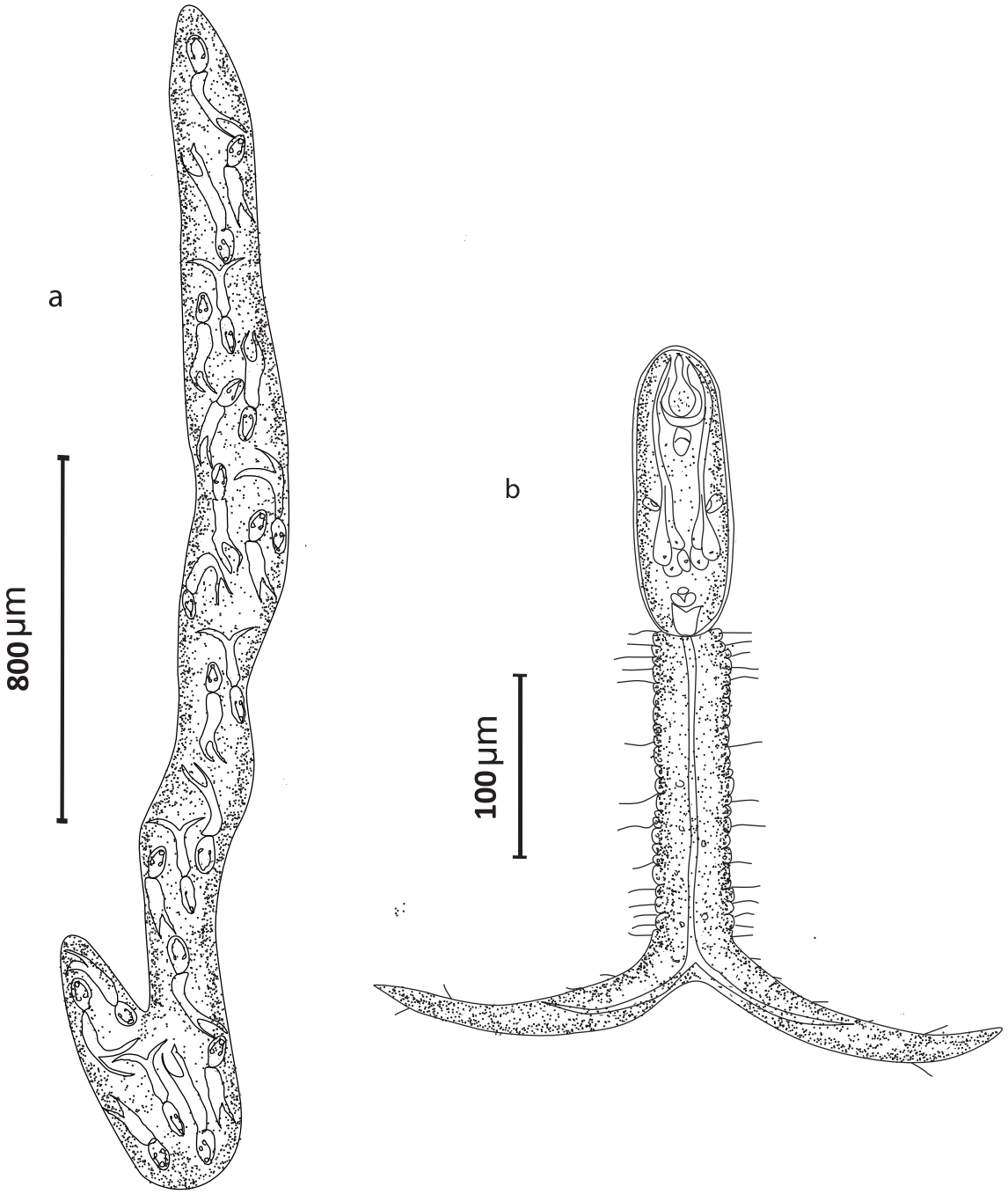


Fig. 22 b. *Uvulifer* sp. 1 n. sp.
a. Sporocyst; b. Cercaria

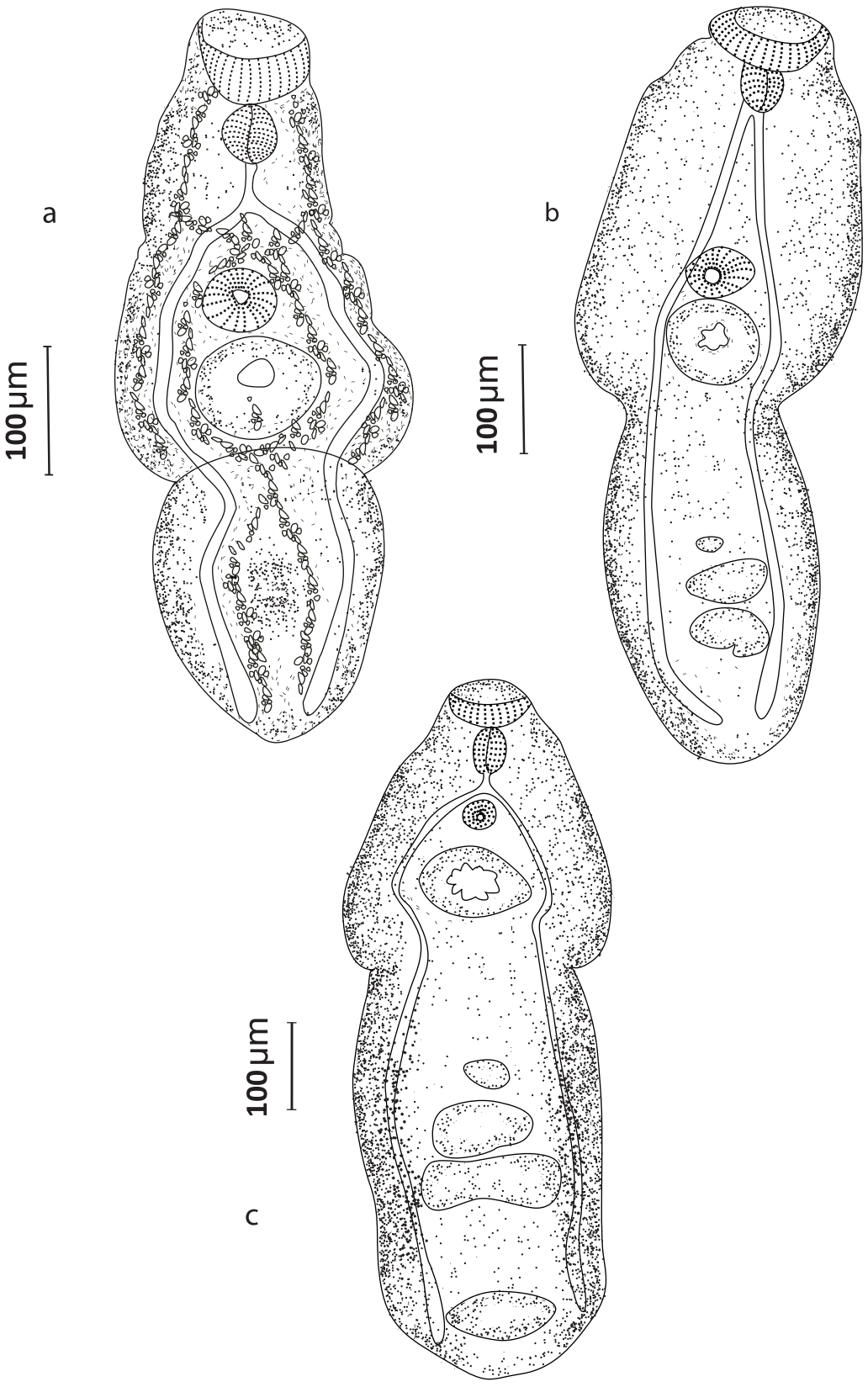


Fig. 22 c.*Uvulifer* sp. 1 n. sp.
a.Excysted metacercaria; b. 2-day-old adult; c. 6-day-old adult

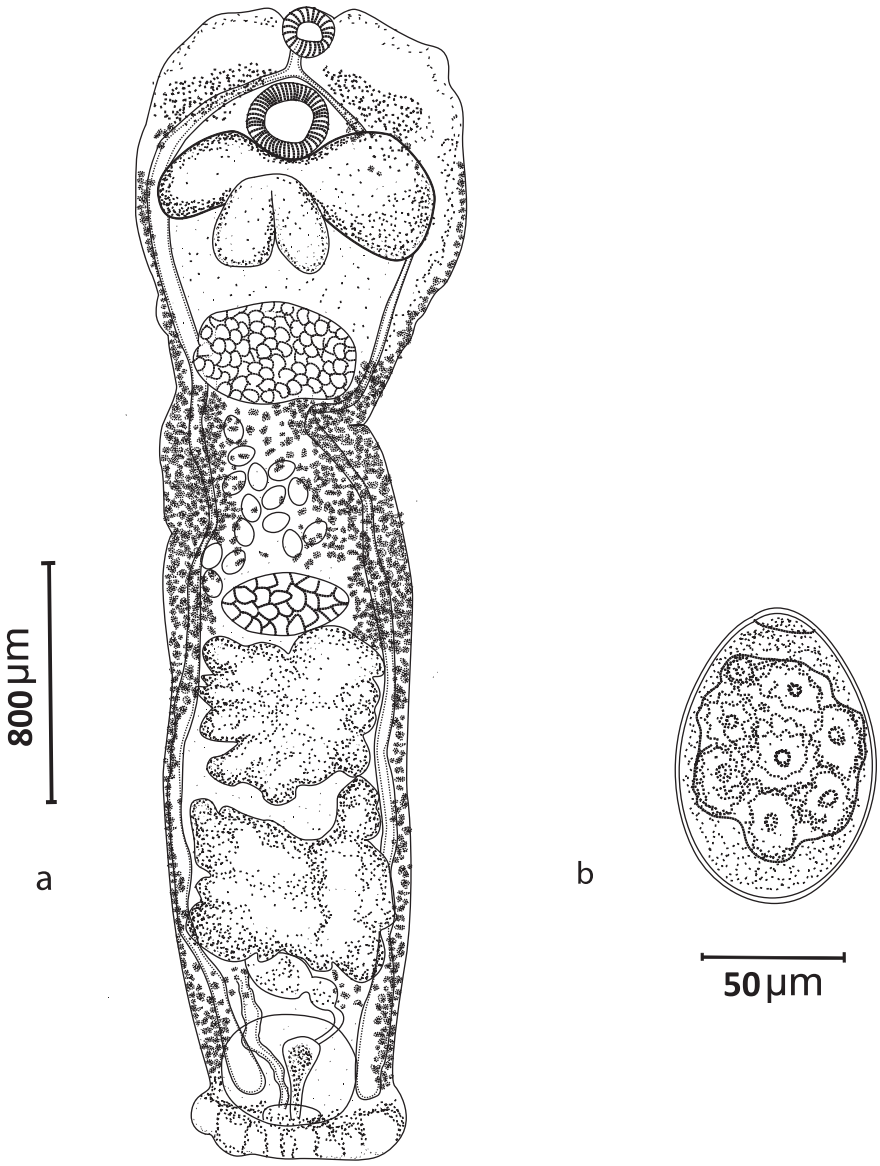


Fig. 23. *Apharyngostrigea ramai* (Verma, 1936) Vidyarthi, 1937
a. Mature adult; b. Egg

BIRDS EXAMINED FOR DIGENETIC TREMATODES

PLATE NO: 1

Ardeola grayii Sykes

Egretta garzetta Linnaeus

Bubulucus ibis Linnaeus

Anastomus ocitans Boddaert

Phalacrocorax niger Vieillot

Athene brama Temminck

Halcyon smyrnensis Linnaeus

Alcedo atthis Linnaeus

BIRDS EXAMINED FOR DIGENETIC TREMATODES

PLATE NO: 2

Acridotheres tristis Linnaeus

Corvus splendens Vieillot

Corvus macrorhyncus Wagler

Accipiter badius Gmelin

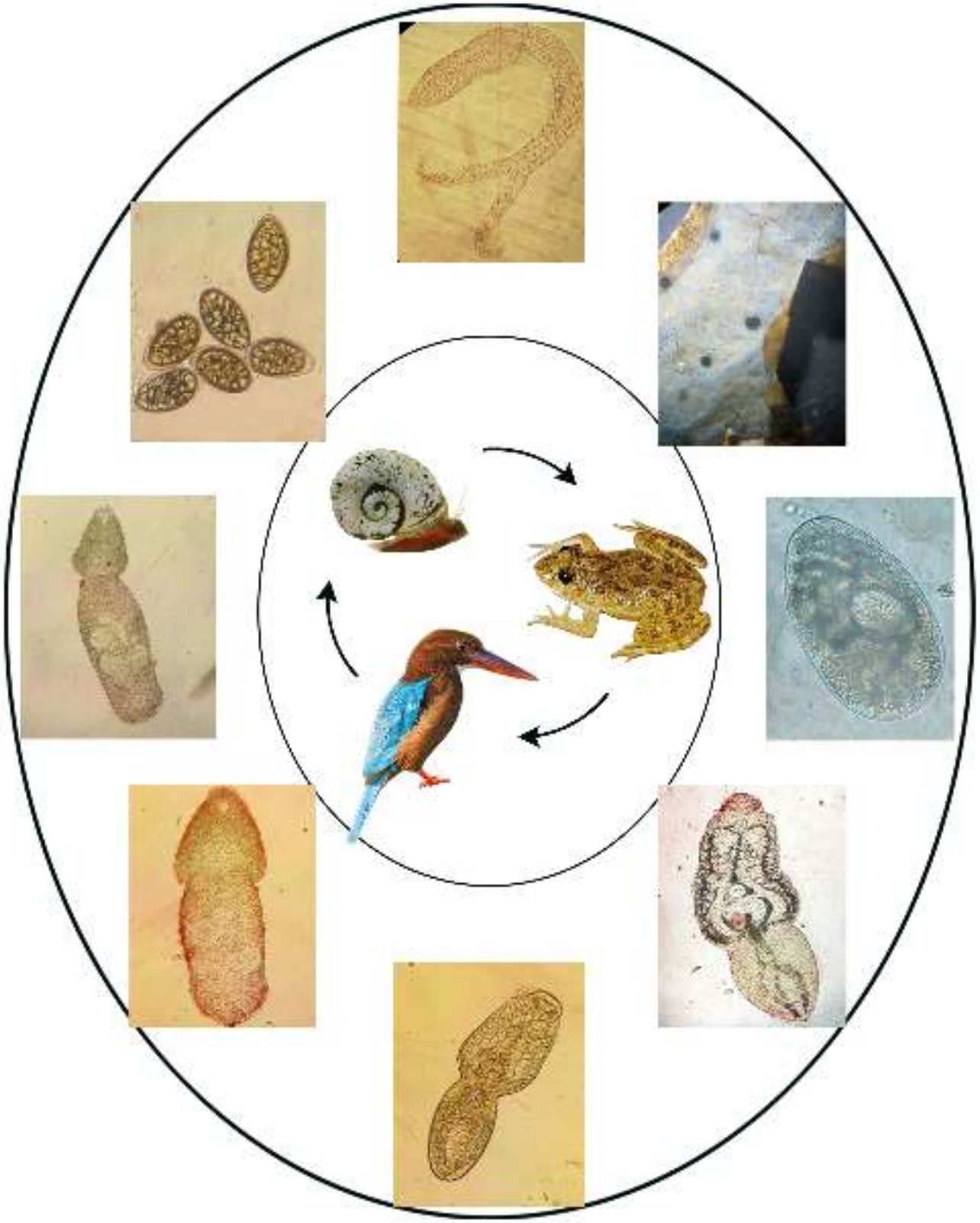
Milvus migrans Boddaert

Amourornis phoenicurs Pennant

Vanellus indicus Boddaert

Gallus gallus Linnaeus

Life-cycle of *Uvulifer* sp. 1 n. sp.



a.Egg; b. Cercaria; c and d.Cyst; e.Excysted metacercaria;
f. 2-day-old adult; g. 6-day-adult; h. Matured adult

DIGENETIC TREMATODES RECOVERED FROM BIRDS

Nephrostomum ramosum (Senaino, 1895) Dietz, 1905

Parallelotaelis farsi (Srivastava, 1958) Beverly-Burton, 1960

Paryphostomum farai Baugh, 1960

Petasiger variospinosus (Odhner, 1910) Yamaguti, 1933

Echinochasmus bagulai Verma,1935

Echinochasmus sp.I n. sp.

DIGENETIC TREMATODES RECOVERED FROM BIRDS

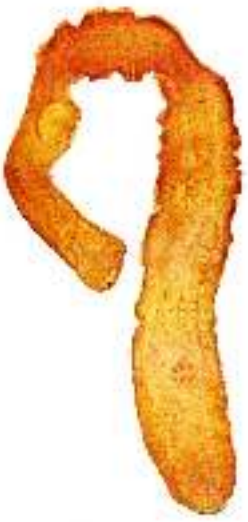
Stephanoprora sp. I n. sp.

Ignavia brevivarica Gupta, 1962

Pegosomum agrati Srivastava, 1957

Psilorchis indicus Thapar and Lal, 1935

Basantisia ramai Pande, 1939



Nigerina hardoiensis Baugh, 1958

DIGENETIC TREMATODES RECOVERED FROM BIRDS

Centrocestus formosanus (Nishigori, 1924) Price,1932

Stellantchasmus falcatus Onji and Nishi, 1924

Haplorchis taichui (Nishigori, 1924) Witenberg,1929

Clinostomum complanatum (Rudolphi, 1819) Braun, 1899

Euclinostomum heterostomum (Rudolphi, 1809) Travassos, 1928

Mesostephanus indicum Mehra, 1947

DIGENETIC TREMATODES RECOVERED FROM BIRDS

Subuvulifer halcyonae (Gogate, 1940) Dubois, 1952

Uvulifer denticulatus (Rudolphi, 1819) Dubois, 1937

Uvulifer shuhksdi (Pande,1538) Bhalerao, 1942

Uvulifer cochlearis (Verma, 1936) Dubois, 1944

Uvulifer sp. I n.sp.

Apharyngostrigea ramsi (Verma, 1936) Vidyarthi, 1937