Journal of Applied and Natural Science
14(1), 268 - 282 (2022)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Description of six new species of the genus *Cornudiscoides* Kulkarni, 1969 (Monogenoidea: Dactylogyridae) from two catfish, *Mystus*, Scopoli, 1777 and *Sperata* Holly, 1939, with a note on its biodiversity

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Article Info
https://doi.org/10.31018/jans.v14i1.3352
Received: February 4, 2022
Revised: March 10, 2022
Accepted: March 15, 2022

How to Cite
Verma, J. *et al.* (2022). Description of six new species of the genus *Cornudiscoides* Kulkarni, 1969 (Monogenoidea: Dactylogyridae) from two catfish, *Mystus*, Scopoli, 1777 and *Sperata* Holly, 1939, with a note on its biodiversity. *Journal of Applied and Natural Science*, 14(1), 268 - 282. https://doi.org/10.31018/jans.v14i1.3352

Abstract
The genus *Cornudisoides* Kulkarni, 1969 is a specialist monogenoid reported from two fish host, *Mystus* and *Sperata.* Despite their ecological importance, *Cornudiscoides* diversity remains unexplored, and the taxonomic description of nominal species is inadequate. The present study was performed to chart the biodiversity of the genus *Cornudiscoides* and defined the characters to identify their species quickly and efficiently using unambiguous characters. Examination of fish hosts collected from different localities of Uttar Pradesh revealed 12 known and 6 new species of *Cornudiscoides.* Since the original description of known species lacked some salient features, the present study has redescribed them and added new host records. The new species are described: *C. tripathii* sp. nov., *C. lucknowensis* sp. nov., *C. speratai* sp. nov., *C. indicus* sp. nov., *C. kulkarnii* sp. nov. and *C. falcatum* sp. nov. They have distinct copulatory complexes and vaginal armatures. A detail of the species diversity of *Cornudisoides*, their type host, new host record type locality, additional localities and major distinguishable characters would be helpful to understand the diversity of these parasites.

Keywords: Biodiversity, *Cornudiscoides*, *Mystus*, Monogenoideans, River Gomati, *Sperata*

INTRODUCTION

Aquaculture is an important industry where fish can be bred in captivity under controlled environmental conditions. They are good sources of protein and minerals (Mishra, 2021). Monogenoideans mainly cause mass mortality of baby fishes, i.e., fry and fingerlings during heavy or secondary infections caused by viruses and bacteria. They mainly feed on blood, epithelial tissue and mucus of fish hosts and induce respiratory and osmoregulatory dysfunctions, destruction of gill epithelium, hyperplasia and asphyxiation. (Ogawa, 2015; Stoskopf, 2015), resulting in detrimental effects on fish populations and poor growth of fish and thus resulting in economic losses to fish cultures. (Cribb *et al.,* 2002; Bakke *et al*., 2007). The present study is based on a single monogenoidean genus, *Cornudiscoides,* established by Kulkarni (1969), with *C. heterotylus* (type species), *C. microtylus* and *C. megalorchis* from *Mystus tengara* (Hamilton, 1822). The parasite is a specialist (Agrawal *et al.,* 2016) and infects two fishes, *Mystus*, Scopoli, 1777 and *Sperata* Holly, 1939 (Agrawal *et al.,* 2020), the two economically important genera (Verma *et al.,* 2017). The genus *Mystus* comprises 44 species (Jayaram & Anuradha, 2003), of which 14 species are found in the Indian subcontinent. The widely distributed fishes in India are *M. vittaus*, *M. tengara*, *M. bleekerai*, *M. cavasius*, *M. gulio*, and *M. menoda* (Jayaram and Anuradha, 2003); the first four are commonly found in Lucknow and other districts of Eastern Uttar Pradesh (Srivastava, 1980). *M. aor* (Hamilton, 1822) and *M. seenghala* (Sykes, 1839) are now placed under a separate genus *Sperata* Holly, 1939. It is restricted in Southern Asia, ranging from Afghanistan to Thailand, along with two more species, *Sperata acicularis* (Ferraris and Runge, 1999) and *S. aorella* (Blyth, 1858). The aim of the present study was to chart the biodiversity of the genus *Cornudiscoides* and define the characters to identify their species quickly and efficiently using unambiguous characters.

MATERIALS AND MRTHODS

Fish samples (commonly available freshwater fish for which ethical clearance is not required) were collected from rivers and ponds and purchased from the fish market from 2014-2018 from various localities of Uttar Pradesh (26°8'N 80°9'E). The hosts were collected from River Gomati (Lucknow), Betwa River (Jhasi), Ramgarh Taal (Gorakhpur), pond in Mati (Barabanki) with the help of several types of nets and local fishermen. Fishes were also purchased from fish markets such as the Kaiserbagh fish market, Daliganj market, Dubbaga fish market of Lucknow, Malihabad fish market and Sitapur fish market. Live hosts were kept in battery-operated plastic coolers, brought to the laboratory, and maintained in glass aquaria.

Fishes were identified with the help of Fish base (Froese & Pauly, 2014-2018) and Jayaram (1955). Freshly dead fish hosts were preserved in 10% formalin glass jars for further study. The gills of the fish were excised and fixed in lukewarm 4% formalin for morphometric study. The live hosts were sacrificed; the body surface, fins, nasal cavity and buccal cavity of the piscine hosts were screened under a binocular microscope for monogenoidean parasites. Gills were surgically removed and transferred into Petri dishes containing saline (0.8%) water. Living worms were observed under a stereomicroscope (Leica EZ). Parasites were placed in a drop of saline water on the slide under the coverslip and studied live under a phase contrast microscope (Olympus CX41, Tokyo Japan). Composite Camera lucida diagrams of relaxed specimens were made and identified using “An Encyclopedia of Indian Monogenoidea” by Pandey and Agrawal (2008). The method of Kristsky *et al*. (1986) was followed for staining, mounting and illustration of parasites. The numbering of hooks was counted according to Kulwiec (Kulwiec, 1927; Gusev, 1976). Glycerin mounts were also made, sealed with a sealant (nail enamel) and used for the study of hard parts. Measurements were taken in µm using Image-Pro Express 6.0 software (for image analysis). Means were followed by the range and number (n) of specimens measured in parentheses. Holotype and voucher specimens are deposited in the Helminthological Collection of Zoology Department, University of Lucknow, Uttar Pradesh.

RESULTS

Cornudiscoides tripathii sp. nov.
(Figs 1-2, Plate 1)
Type host: *Mystus bleekeri* (Hamilton, 1822)
Type locality: River Gomati, Lucknow (U.P.)
Additional locality: Barabanki (U.P.)
Site of infection: Gills
Etymology: This species is named in honors of Prof. Y.R. Tripathi in recognition of his contribution to the field of Monogenoideans.

Description

Body elongated, dorso-ventrally flattened, 363 (316-457, n=10) long (excluding haptor), maximum width 97 (74-132, n=10) in middle region. Cephalic region well developed; cephalic lobes 2 pairs; head organs conspicuous, 4 pairs. Eye spots 2 pairs, posterior pair larger. Accessory granules were sometimes observed. Pharynx spherical, 25 (21-29, n=10) in diameter. Intestinal caeca confluent at posterior one-third of body. Haptor bilobed, 78 (54-89, n=10) long, 109 (84-137, n=10) wide. Anchors two pairs, unequal, dorsal pair larger. Dorsal anchor large, arcuate, with roots, shaft curved, elongate point, extending past level of the base of shaft, inner length 41 (39-42, n=10), outer length 33 (31-34, n=10), recurved point 24 (23-25, n=10) long. Dorsal patch triangular, 14 (13-17, n=10) long. Ventral anchor in two separate lobes, with shorter outer root, weakly curved shaft and straight point, inner length 19 (18-21, n=10), outer length 17(16-18, n=10), point 21 (20-22, n=10) long. Dorsal bar transversely elongated, slightly bent, 30 (29-31, n=10) long. Paired stick-shaped ventral bar 32 (30-34, n=10) (one piece) long, ligament not observed. Hooks seven pairs, of two types, larval, 14 (13-14, n=10) long, larger third pair, 32 (31-33, n=10) long, near the ventral anchors. Testis single, pyriform, 64 (60-78, n=10) long, 56 (47-64, n=10) wide; vas deferens ascends along dorsal side, to ventral side of body, looping left intestinal caecum and dilating to form a single blind sac like seminal vesicle, 31 (28-35, n=10) long, which opens at the base of copulatory tube. Prostatic reservoir single, 19 (18-20, n=10) long, opening at the base of copulatory tube. The copulatory complex consists of a short, weakly curved, sclerotized copulatory tube of 25(24-26, n=10) long, which is blunt at the distal end, articulating with a small rod-like accessory piece, 20(19-21, n=10) long. Ovary single, round to oval, intercaecal, 62 (52-72, n=10) long, maximum width 51(40-60, n=10), in the middle third of body. Vagina sinistral, sclerotized, vaginal opening funnel like, connected by a short vaginal tube to open into oval seminal receptacle. Vitellaria dense throughout the trunk, except in the region of reproductive organs.

Remarks

C. tripathii sp. nov. chiefly differs from known species of the genus *Cornudiscoides* in having small stick-shaped accessory pieces and copulatory tubes that are blunt at the distal end.

Cornudiscoides lucknowensis sp. nov.

(Figs 3- 4, Plate 2)
Type host: *Mystus cavasius*
Type locality: River Gomti, Lucknow
Site of infection: Gills
Etymology: The specific name is named after Lucknow, the type locality.

Description

Body elongated, dorso-ventrally flattened, 275 (250-290, n=10) long (excluding haptor), maximum width 64 (50-70, n=10) in middle region. Cephalic region well developed; cephalic lobes 2 pairs; head organs conspicuous, 4 pairs. Eye spots 2 pairs, posterior pair larger. Pharynx spherical, 23 (22-24, n=10) in diameter. Intestinal caeca jointed at one-third of the body.

Haptor bilobed, 58 (52-66, n=10) long, 70 (65-75, n=10) wide. Anchors two pairs, unequal, dorsal pair larger. Dorsal anchor large, arcuate, with roots, shaft curved, point, elongated, extending past level of the base of shaft, inner length 53 (50-55, n=10), outer length 47(45 -50, n=10), recurved point 30 (28-32, n=10) long. The dorsal patch stretched as a claw at the anterior end, 13 (13-14, n=10) long. Ventral anchor in two separate lobes: each with a short inner and outer roots, weakly curved shaft and straight point, inner length 15 (15-16, n=10), outer length 13 (13-14, n=10), point 16 (16-17, n=10) long. Dorsal bar transversely elongated, slightly bent, 32 (30-34, n=10) long. Paired stick shape ventral bar, 22 (20-24, n=10) (one piece) long, ligament not observed. Hooks seven pairs, of two types, larval type, 12 (11-12, n=10) long, larger third pair, 18 (17-19, n=10) long, near the ventral anchors.

Testis single, pyriform, 43 (40-45, n=10) long, 36 (34-38, n=10) wide; vas deferens ascends along dorsal side, looping left intestinal caecum, dilating to form a single blind, sac-like seminal vesicle, 24 (22-26, n=10) long, which opens at the base of copulatory tube. Prostatic reservoir single, opening at the base of copulatory tube. The copulatory complex consists of a long sclerotized copulatory tube that is 235 (230-240, n=10) long (through the coil) and has a massive irregular accessory piece that is 33 (32-34, n=10) long. The middle part of the accessory piece has a groove, guiding the copulatory tube. Ovary single, round to oval, intercaecal, 54 (50-57, n=10) long, maximum width 43 (40-45, n=10), in the middle third of body. Vagina sinistral, sclerotized, vaginal opening funnel shaped, connected by a vaginal tube, usually contains a single coil and gives a snake-like appearance, open to an oval seminal receptacle. Vitellaria dense throughout the trunk, except in the region of reproductive organs.

Remarks

C. lucknowensis sp. nov.chiefly differs from all the species of *Cornudiscoides* in having a massive, irregular accessory piece of copulatory complex and funnel-shaped vagina with a coiled vaginal tube.

Cornudiscoides speratai sp. nov.
(Figs 5-6, Plate 3)
Type host: *Sperata aor* (Hamilton, 1822)
Type locality: River Gomti, Lucknow
Site of infection: Gills
Etymology: The species is named after *Sperata aor*, the type host.

Description

Body elongated, dorso-ventrally flattened, 556 (458-650n=10) long (excluding haptor), maximum width 86 (74-96, n=10) in middle region. Cephalic region well developed; cephalic lobes 2 pairs; head organs conspicuous, 4 pairs. Eye spots 2 pairs, posterior pair larger. Accessory granules were sometimes observed. Pharynx spherical, 38 (36-40, n=10) in diameter.

Haptor bilobed, 82 (66-99n=10) long, 61 (45-78, n=10) wide. Anchors two pairs, unequal, dorsal pair larger. Dorsal anchor large, arcuate, with roots, shaft curved, elongate point, extending past level of the base of shaft, inner length 42 (41-42, n=10), outer length 30 (29-30, n=10), recurved point 25 (24-26, n=10) long. Dorsal patch triangular, 15 (14-16, n=10) long. Ventral anchor in two separate lobes: each with moderate inner and small outer roots, weakly curved shaft and point, inner length 25 (23-27, n=10), outer length 19 (18-19, n=10), point 17 (16-18, n=10) long. Dorsal bar transversely elongated, slightly bent, 37(36-39 n=10) long. Paired stick shape ventral bar, 35 (34-36, n=10) (one piece) long, joint together by a thick contractile ligament. Hooks seven pairs, of two types, larval type, 13 (12-14, n=10) long, larger third pair30 (30-31, n=10) long, near the ventral anchors. Testis single, pyriform, 57 (54-62, n=10) long, 45 (39-50, n=10) wide; vas deferens ascends along dorsal side, to ventral side of body, looping left intestinal caecum and dilating to form a single blind sac like seminal vesicle, 42 (30-50, n=10) long, which opens at the base of copulatory tube. Prostatic reservoir single, large, oval, 62 (56-64 n=10) long, opens at the base of copulatory tube. The copulatory complex consists of a small tubular highly sclerotized copulatory tube that is 93 (90-96 n=10) long and small, a siphon-like accessory piece that is 29 (28-30, n=10) long, a groove, and a guiding copulatory tube. Ovary single, round to oval, intercaecal, 62(55-68, n=10) long, maximum width 48 (42-53, n=10), in the middle third of body. Vagina sinistral, sclerotized, vaginal opening small, funnel shaped, connected by a small vaginal tube to an oval seminal receptacle. Vitellaria dense throughout the trunk, except in the region of reproductive organs.

Remarks

C. speratai new species chiefly differs from other species of *Cornudiscoides* in having a siphon-like accessory piece.

***Cornudiscoides indicus* sp. nov.**

(Figs. 7-8, Plate 4)

Type host: *Sperata aor* (Hamilton, 1822)

Type locality: River Gomti, Lucknow

Site of infection: Gills

Etymology: The species is named after the country from which it has been described.

Description

Body elongated, dorso-ventrally flattened, 649(382-790, n=10) long (excluding haptor), maximum width 48 (40-55, n=10) in middle region. Cephalic region well developed; cephalic lobes 2 pairs; head organs conspicuous, 4 pairs. Eye spots 2 pairs, posterior pair larger. Pharynx spherical, 23 (23-24, n=10) in diameter. Intestinal caeca jointed at the posterior one-third of the body. Haptor bilobed, 85 (49-126, n=10) long, 89 (72-116, n=10) wide. Anchors two pairs, unequal, dorsal pair larger. Dorsal anchor large, arcuate, with roots, shaft curved, point, elongated, extending past level of the base of shaft, inner length 38 (35-40, n=10), outer length 32 (28-33, n=10), recurved point 22 (20-24, n=10) long. The dorsal patch stretched as a claw at the anterior end, 11 (10-12, n=10) long. Ventral anchor in two separate lobes: each with long inner and short outer roots, curved shaft and point, inner length 24 (21-26, n=10), outer length 21 (19-24, n=10), point 17 (16-20, n=10) long. Dorsal bar transversely elongated, rod-like, 37 (35-39, n=10) long. Paired stick shape ventral bar, 34 (32-35, n=10) (one piece) long, joint together by a thick contractile ligament. Hooks seven pairs, of two types, larval type, 12 (11-12, n=10) long, larger third pair, 26 (25-28, n=10) long, near the ventral anchors.

Reproductive organs are present in one-third of the body. Testis single, pyriform, 42 (40-45n=10) long, 34 (34-36, n=10) wide; vas deferens ascends along dorsal side, looping left intestinal caecum, dilating to form a single blind, sac like seminal vesicle, 27 (25-28, n=10) long, which opens at the base of copulatory tube. Prostatic reservoir single, 25 (24-26, n=10) long, opening at the base of copulatory tube. The copulatory complex consists of a small sclerotized copulatory tube that is 71 (63-74, n=10) long and a thin circular membranous accessory piece that is 24 (24-27, n=10) long and has a groove guiding the copulatory tube. A copulatory tube with an accessory piece together gives an umbrella-like appearance. Ovary single, round to oval, intercaecal, 49(32-57, n=10) long, maximum width 38 (28-47, n=10), in the middle third of body. However, vaginal armature was not observed. Vitellaria dense throughout the trunk, except in the region of reproductive organs.

Remarks

C. indicus sp. nov.chiefly differs from all other species of *Cornudiscoides* in the body length and structure of the copulatory complex.

***Cornudiscoides kulkarnii* sp. nov.**

(Figs 9-10, Plate 5)

Type host: *Sperata aor*

Type locality: River Gomti, Lucknow

Site of infection: Gills

Etymology: The specific name in honor of Prof. Tukaram Kulkarmai for his contribution to the field of monogenoideans.

Description

Body fusiform, dorso-ventrally flattened, 448 (395-500, n=10) long (excluding haptor), maximum width 83 (65-100, n=10) in middle region of body. Cephalic region well developed; cephalic lobes 2 pairs; head organs conspicuous, 4 pairs. Eye spots 2 pairs, posterior pair larger. Pharynx spherical, 26(26-38, n=10) in diameter. Intestinal caeca confluent at the posterior third of the body. Haptor bilobed, 105(90-116, n=10) long, 92(82-109, n=10) wide. Anchors two pairs, unequal, provided with wings, dorsal pair larger. Dorsal anchor large, arcuate, with long root, shaft curved, elongate point, extending past level of the base of shaft, inner length 43 (42-44, n=10), outer length 33(33-34, n=10), recurved point 23 (22-25, n=10) long. Dorsal patch somewhat triangular, 12(11-13, n=10) long. The ventral anchor was placed in two separate lobes: each with a long inner root, short outer root, curved shaft and point arcuate, inner length 26 (24-29, n=10), outer length 22 (21-23, n=10), and point 17 (15-17, n=10). Dorsal bar wide, U-shaped, 36 (34-38, n=10) long. Paired ventral bar, 43(41-46, n=10) (one piece) long, jointed by a thick contractile ligament. Hooks seven pairs, of two types, larval type, 14 (13-15, n=10) long, larger third pair, 35 (34-36, n=10) long, near the ventral anchors. Testis single, round to oval, 52 (51-64, n=10) long, 44 (46-53, n=10) wide; vas deferens arises from anterior end of testis, running anteriorly to loop left intestinal caecum and dilating to form a single, blind sac like seminal vesicle, 42 (40-45, n=10) long, which opens at the base of copulatory tube via a short duct. Prostatic reservoir single, 48 (45-50, n=10) long, opening at the base of copulatory tube. Copulatory complex sclerotized copulatory tube small, 152(150-155, n=10) long, accessory piece bulb shaped, 49 (45-53, n=10) long, having a flap-like structure and a groove at its proximal end, guiding copulatory tube. Ovary single, pyriform, intercaecal, 64 (51-72, n=10) long, maximum width 40 (35-40, n=10) in the middle third of body. Vagina sinistral, tube like, vaginal opening small, simple, funnel shaped, connected by a small, vaginal tube to seminal receptacle. Vitellaria dense throughout the trunk, except in the region, occupied by reproductive organs.

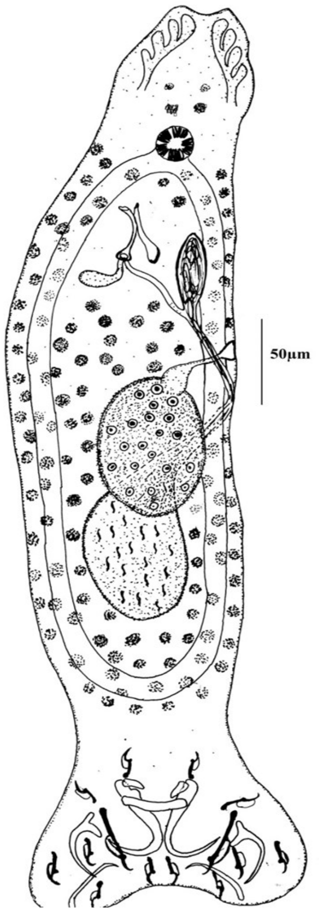

Fig. 1. *Cornudiscoides tripathii sp.nov. (Whole mount: ventral view)*

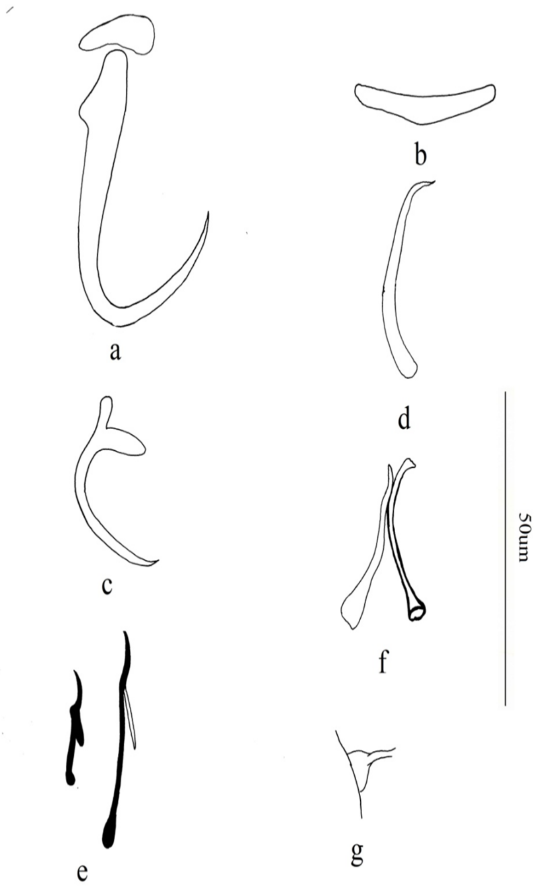

Fig. 2. *a- dorsal anchor with patch; b- dorsal bar; c- ventral anchor; d- ventral bar (one piece); e- hooks (small and large hook); f- copulatory complex; g- vaginal armature.*

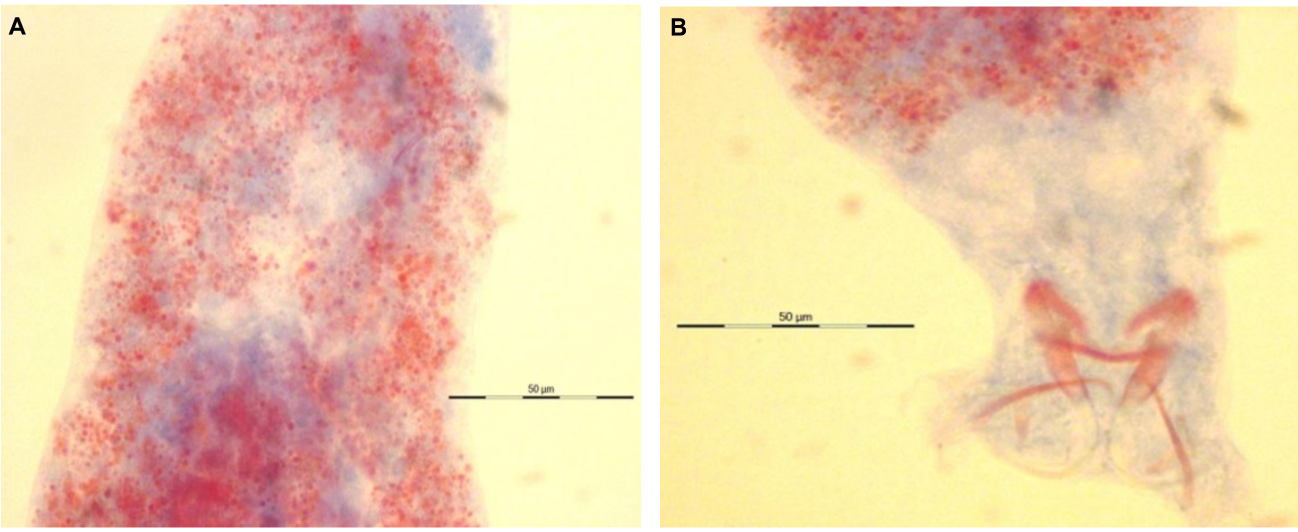

Plate 1. *Photomicrograph of C. tripathii sp. nov. showing copulatory complex (A) and haptor (B)*

Remarks

The new *species C. kulkarnii* species chiefly differs from all the species of *Cornudiscoides* in having bulb-shaped accessory pieces of copulatory organs and small copulatory tubes.

***Cornudiscoides falcatum* sp. nov.**

(Figs 11-12, Plate 6)

Type host: *Sperata aor* (Hamilton, 1822)

Type locality: River Gomti, Lucknow

Additional localities: Gorakhpur, Malihabad and Sitapur

Site of infection: Gills

Etymology: The specific name is from Latin (falcatus = sickle-shaped) and refers to a part of the accessory

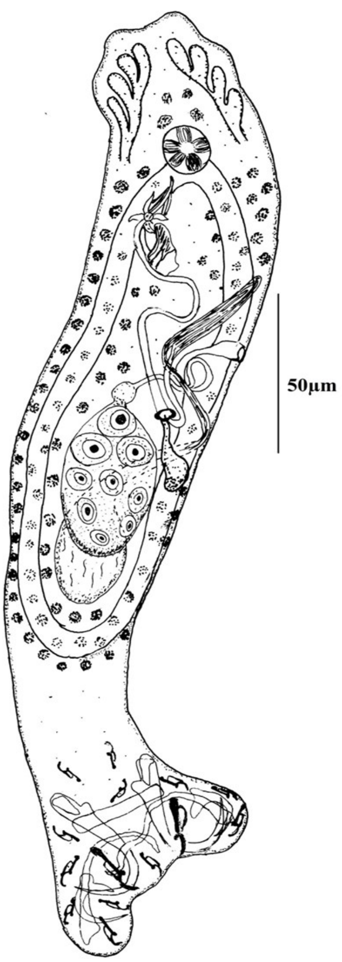

Fig. 3. *Cornudiscoides lucknowensis sp. nov. (Whole mount: ventral view)*

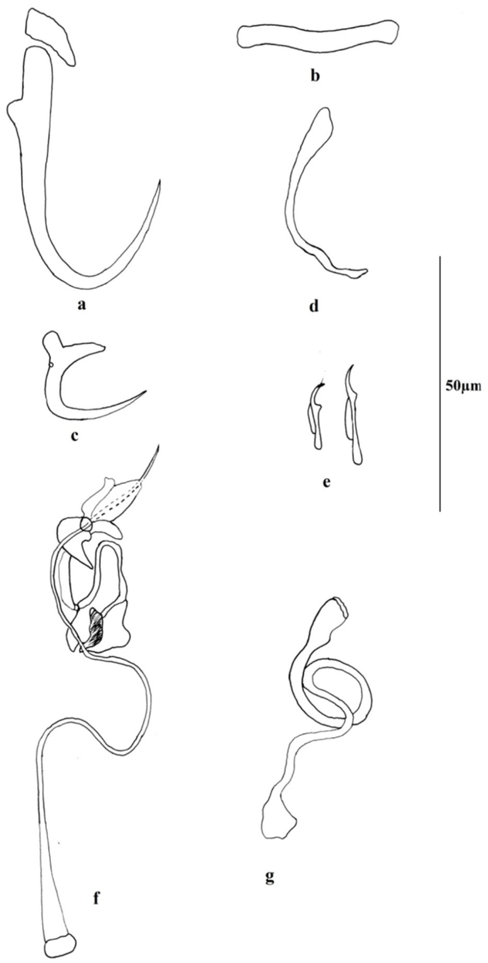

Fig. 4. *a- dorsal anchor with patch; b- dorsal bar; c- ventral anchor; d- ventral bar (one piece); e- hooks (small and large hook); f- copulatory complex; g- vaginal armature*

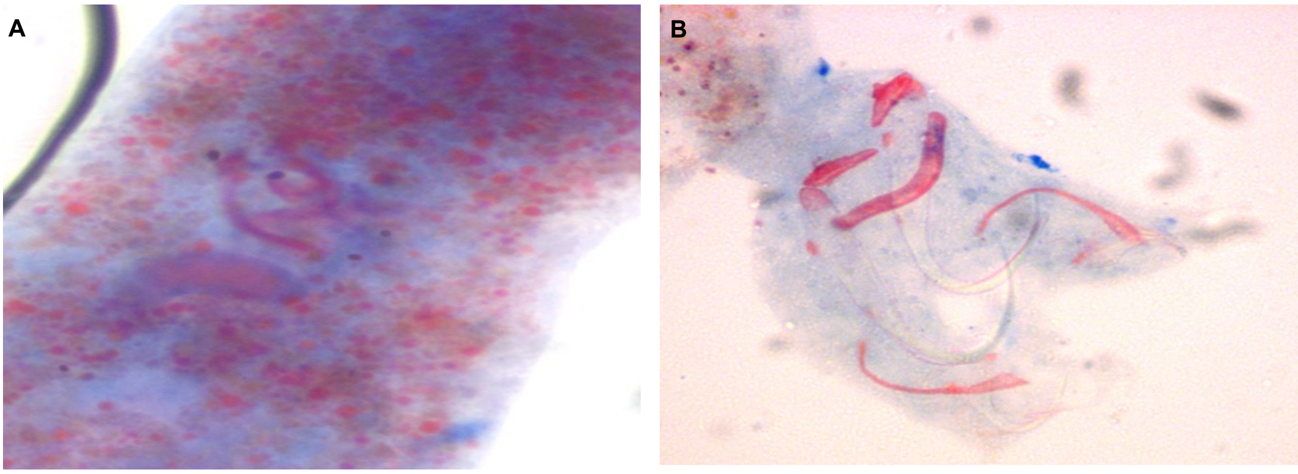

Plate 2. *Photomicrograph of C. lucknowensis sp. nov. showing copulatory complex (A) and haptor (B)*

piece of the copulatory complex.

Description

Body elongated, dorso-ventrally flattened, 413 (340-500, n=10) long (excluding haptor), maximum width 94 (80-122, n=10) in middle region. Cephalic region well developed; cephalic lobes 2 pairs; head organs conspicuous, 4 pairs. Eye spots 2 pairs, posterior pair larger. Accessory granules were sometimes observed. Pharynx spherical, 29 (28-30, n=10) in diameter. Intestinal caeca confluent at the posterior third of the body. Haptor bilobed, 89 (80-102, n=10) long, 78 (61-98, n=10) wide. Anchors two pairs, unequal, dorsal pair larger. Dorsal anchor large, arcuate, with roots, shaft

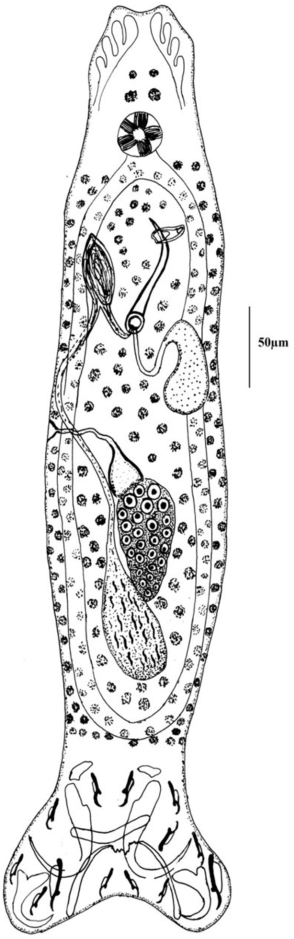

Fig. 5. *Cornudiscoides speratai n. sp. (Whole mount: dorsal view)*

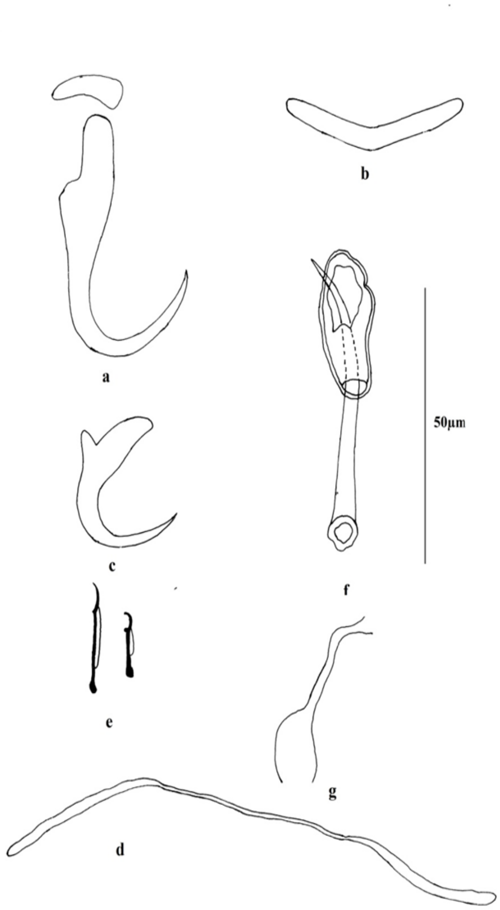

Fig. 6. a- *dorsal anchor with patch; b- dorsal bar; c- ventral anchor; d- ventral bar (one piece); e- hooks (small and large hook); f- copulatory complex; g- vaginal armature*

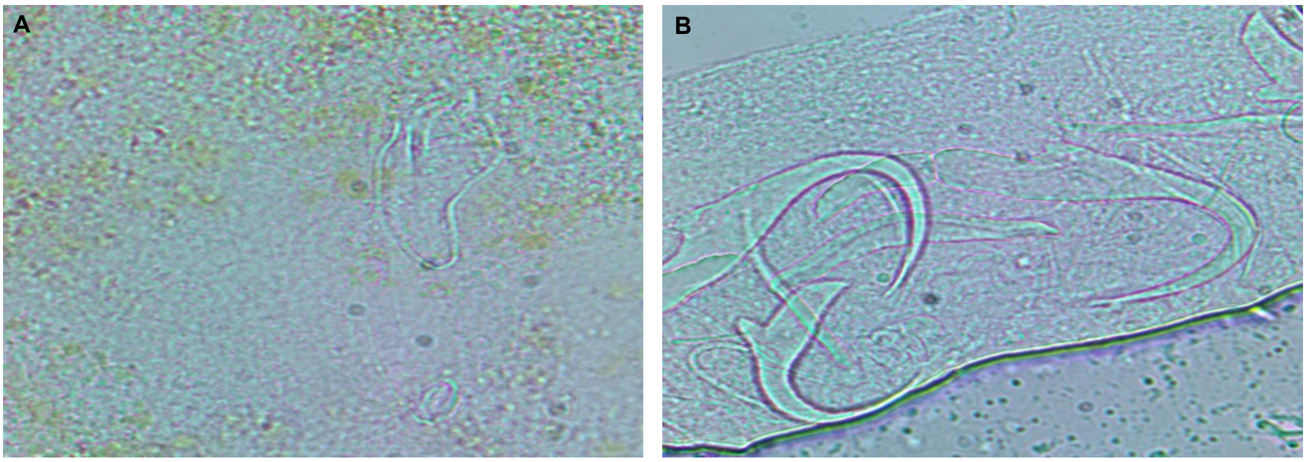

Plate 3. *Photomicrograph of C. speratai showing copulatory complex (A) and haptor (B)*

curved, elongate point, extending past level of the base of shaft, inner length 46 (40-49, n=10), outer length 34 (31-38, n=10), recurved point 26 (22-29, n=10) long. Dorsal patch somewhat triangular, nail-like patch 22 (20-24, n=10) long. Ventral anchor in two separate lobes: each with moderate inner and short outer roots, weakly curved shaft and arcuate point, inner length 27 (25-30, n=10), outer length 25 (22 -28, n=10), point 15 (11-17, n=10) long. Dorsal bar transversely elongated, rod shaped, 41(40-43, n=10) long. Paired stick shape ventral bar, 35 (32-38, n=10) (one piece) long, joint together by a thick contractile ligament. Hooks seven pairs, of two types, larval type, 13 (12-14, n=10) long, larger third pair, 30 (29-31,

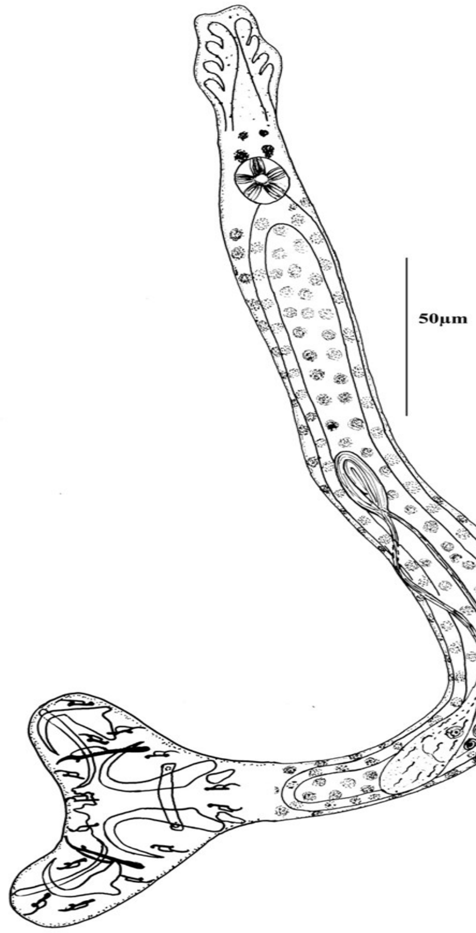

Fig. 7. *Cornudiscoides indicus sp. nov. (Whole mount: dorsal view)*

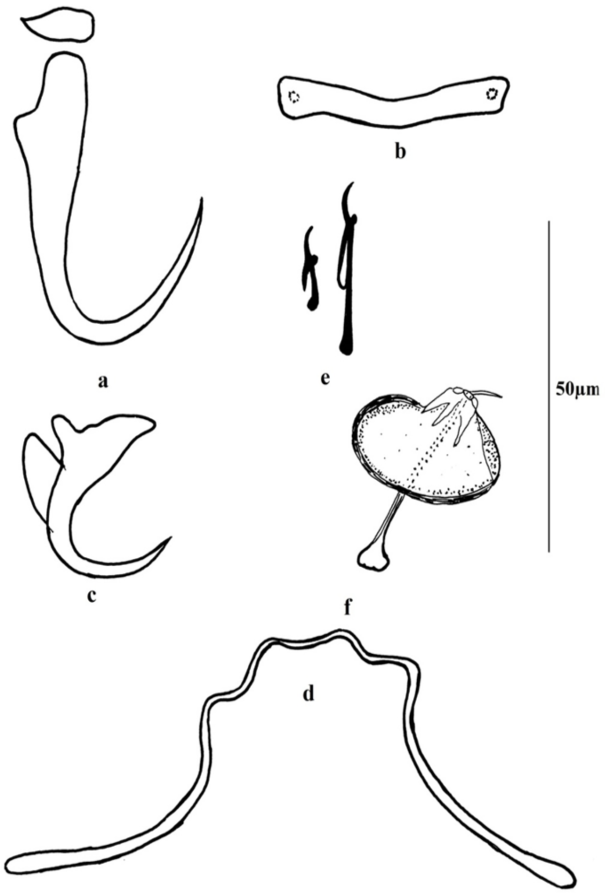

Fig. 8. *a– dorsal anchor with patch; b– dorsal bar; c– ventral anchor; d– ventral bar (one piece); e– hooks (small and large hook); f– copulatory complex; g– vaginal armature*

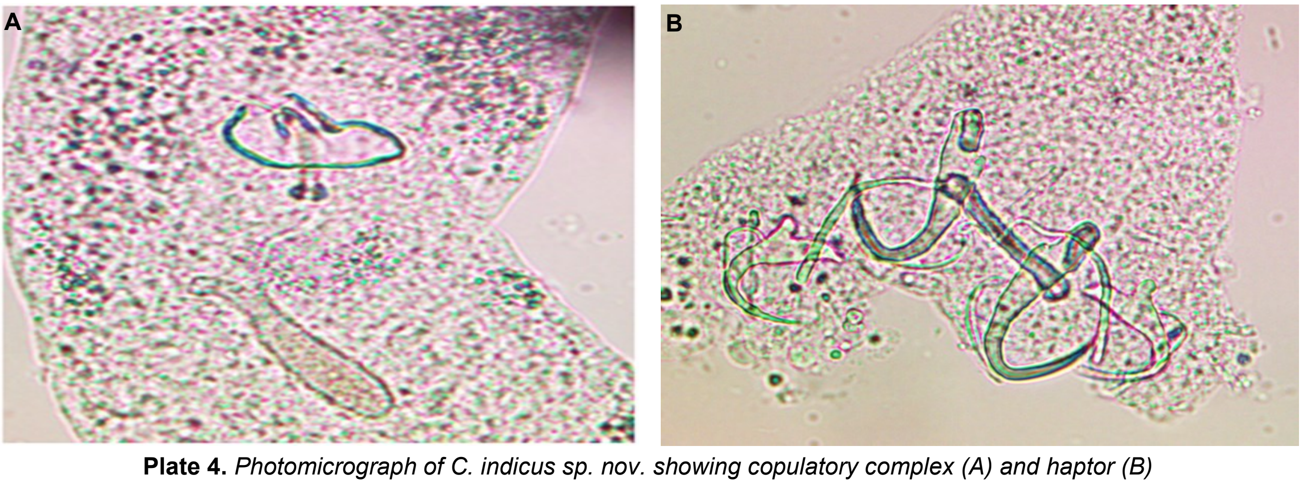

Plate 4. *Photomicrograph of C. indicus sp. nov. showing copulatory complex (A) and haptor (B)*

n=10) long, near the ventral anchors. Testis single, pyriform, 97 (95-102, n=10) long, 58 (52-63, n=10) wide; vas deferens ascends along dorsal side, to ventral side of body, looping left intestinal caecum and dilating to form a single, blind sac like seminal vesicle, 47 (41-53, n=10) long, which opens at the base of copulatory tube. Prostatic reservoir single, 42 (40-45, n=10) long, opens at the base of copulatory tube. The copulatory complex consists of a long sclerotized copulatory tube of 237 (203-245, n=10) long (through the coil), coil single, anticlockwise and thin membranous, broad accessory piece, 49 (36-61, n=10) long, one part of accessory piece is sclerotized, agricultural hand sickle shaped, has groove, guiding copulatory tube. Ovary single, round to oval, intercaecal, 84 (75-94, n=10) long, maximum width 62 (55-70, n=10), in the middle third of body.

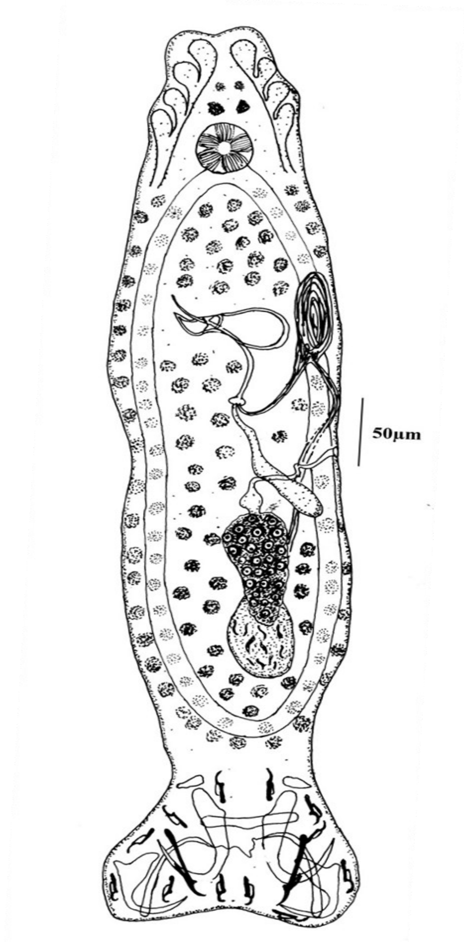

Fig. 9. *Cornudiscoides kulkarnii sp. nov. (Whole mount: ventral view)*

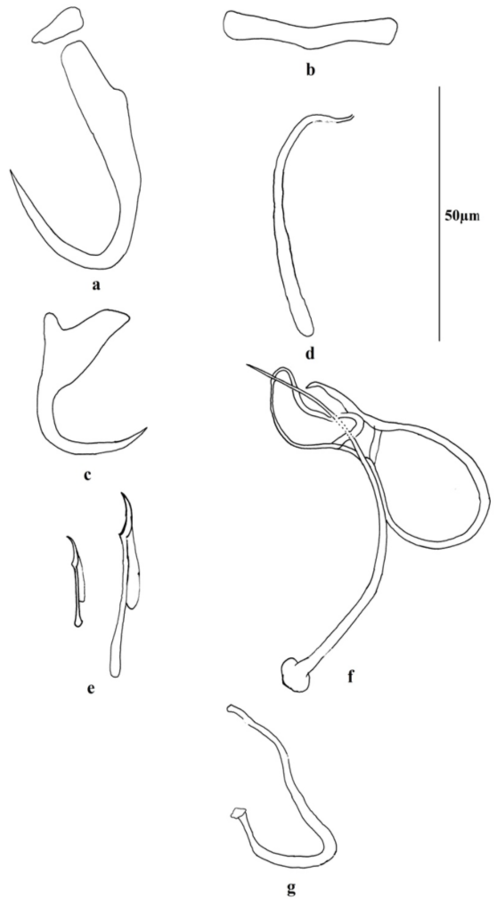

Fig. 10. *a- dorsal anchor with patch; b- dorsal bar; c- ventral anchor; d- ventral bar (one piece); e- hooks (small and large hook); f- copulatory complex; g- vaginal armature*

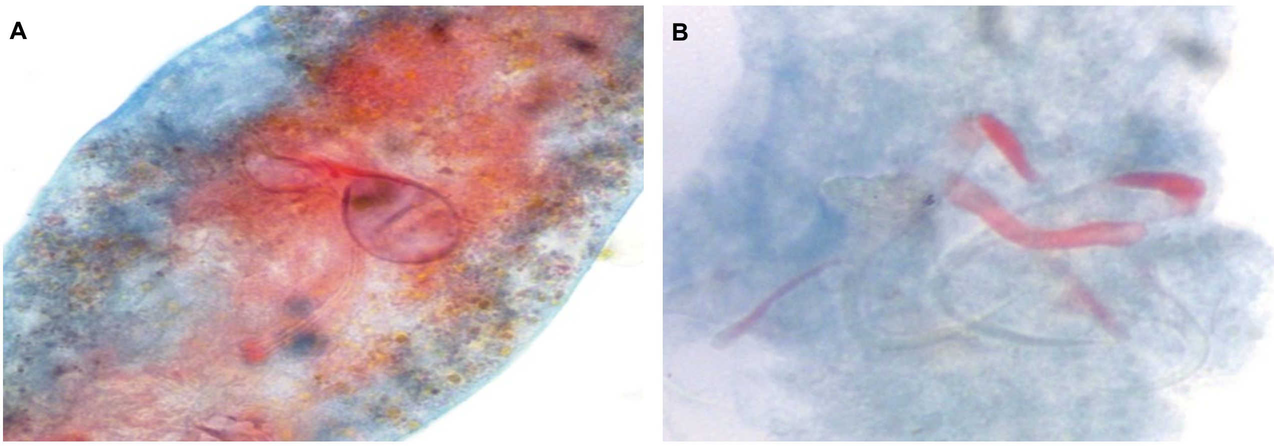

Plate 5. *Photomicrograph of C. kulkarnii sp. nov. showing copulatory complex (A) and haptor (B)*

Vagina sinistral, highly sclerotized, 39 (36-43, n=10) long, vaginal opening funnel shaped, vaginal tube with a blade-like accessory part connected to an oval seminal receptacle 45(40-50, n=10). Vitellaria dense throughout the trunk, except in the region of reproductive organs.

Remarks

C. falcatum sp. nov. is characterized by its unique thin membranous, broad accessory piece with a sickle-shaped sclerotized part and vaginal armature with a blade-like accessory structure.

DISCUSSION

The genus *Cornudiscoides* is a potential biomarker (Agrawal *et al*., 2016) and performs the phenomenon of host specificity and infests only two bagarids, *Mystus*

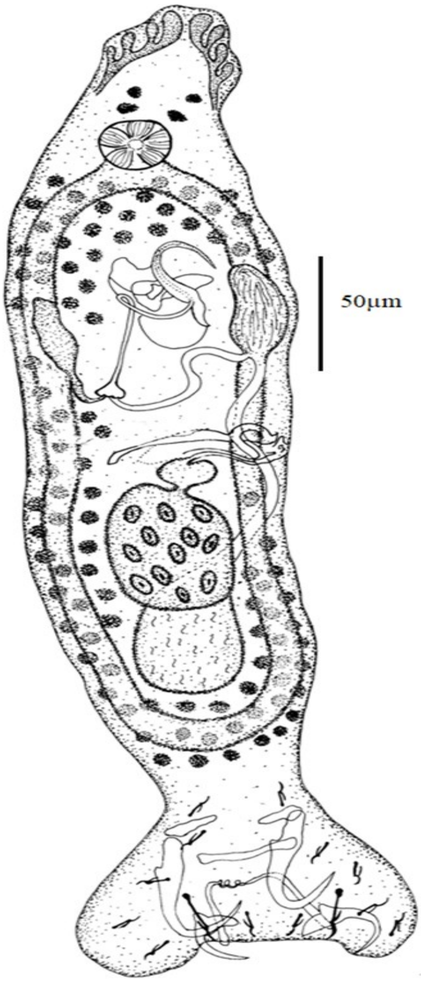

Fig. 11. *Cornudiscoides falcatum sp. nov. (Whole mount: ventral view)*

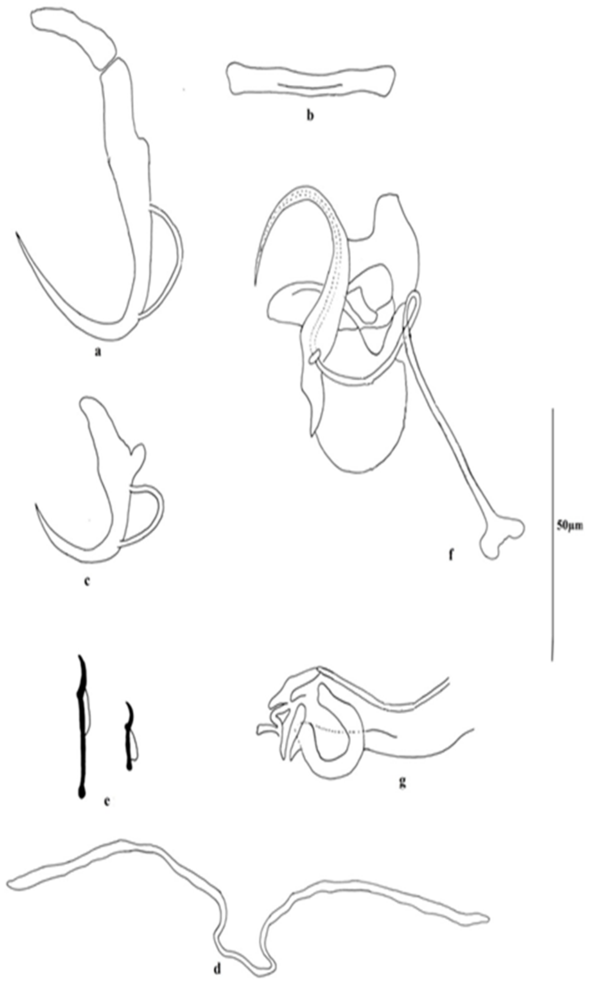

Fig. 12. *a- dorsal anchor with patch; b- dorsal bar; c- ventral anchor; d- ventral bar (one piece); e- hooks (small and large hook); f- copulatory complex; g- vaginal apparatus.*

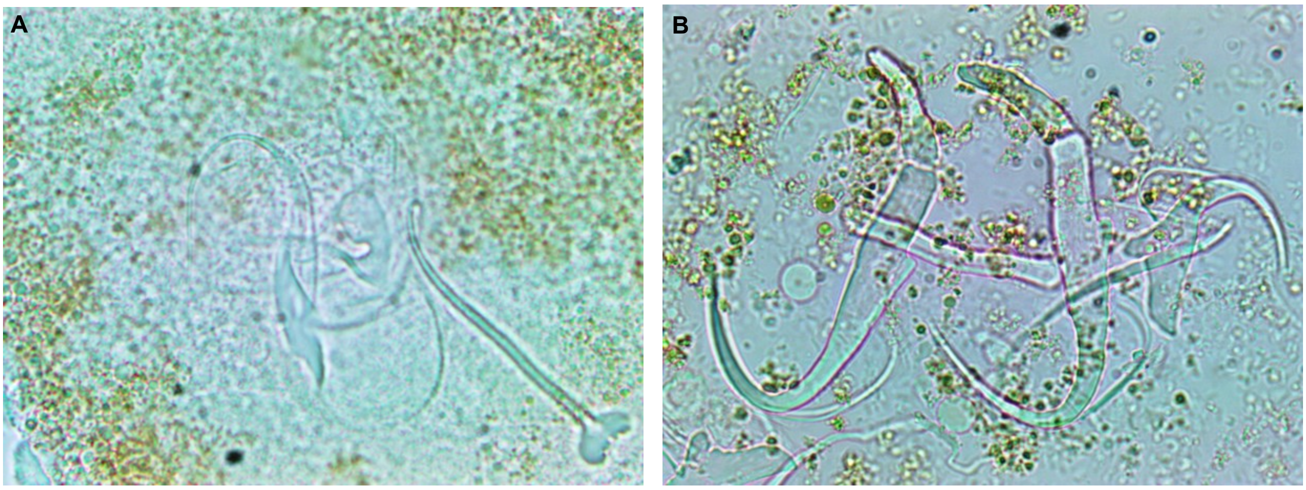

Plate 6. *Photomicrograph of C. falcatum sp. nov. showing copulatory complex (A) and haptor (B)*

and *Sperata*. The described new species are distinguished from each other on the basis of the morphology of hard parts.

C. tripathii sp. nov. chiefly differs from known species of the genus *Cornudiscoides* in having a small stick-shaped accessory piece and a copulatory tube blunt at the distal end. *C. tripathii* sp. nov. closely resembles *C. gomtiai* but differs in the size and shape of the copulatory tube and accessory piece (copulatory tube in *C. gomtiai* is larger and pointed at its distal). The ac-

Table 1. Different species of the genus *Cornudiscoides*, their host, locality and differences in their copulatory complex and ventral bar.

S. No.	*Cornudiscoides* spp.	Type host	New host record	Type Locality	Additional Locality	Copulatory complex: Accessory Piece	Copulatory complex: Copulatory tube	Ventral bar
1	*C. heterotylus* Kulkarni, 1969	*M. tengara*	*M. cavasius*	Hyderabad, A.P.	Lucknow, Barabanki	Accessory piece in two pieces (joined together at basal ends), first piece irregular in shape	Copulatory complex with simple tube (longer than accessory piece)	Ventral bar not joined by a thin median ligament
2	*C. microtylus* Kulkarni, 1969	*M. tengara*	-	Hyderabad, A.P.	-	-	-	-
3	*C. megalorchis* Kulkarni, 1969	*M. tengara*	-	Hyderabad, A.P.	-	-	-	-
4	*C. mystusi* (Rizvi, 1971), Dubey *et al*., 1992	*S. aor*		Sindh (now in Pakistan)	Lucknow, Jhansi, Sitapur,	Accessory piece, Urn-shaped	Copulatory complex with coiled and very long tube	Ventral bar joined by a very thin median ligament
5	*C. proximus* Gusev, 1976	*M. vittatus*	*M. tengara*	River Gomti, Lucknow	Basti Gonda, Jhansi,	Accessory piece claw-shaped	short tube more/less equal to accessory piece	Ventral bar joined by a very thin median ligament
6	*C. geminus* Gusev, 1976	*M. vittatus*	*M. tengara*	River Gomti, Lucknow	Gonda, Basti	Accessory piece Claw shaped	simple tube (longer than accessory piece)	Ventral bar joined by a very thin median ligament
7	*C. vittati* Dubey *et al*., 1992	*M. vittatus*	-	Water bodies near Raipur	-	Accessory piece clipper-shaped, two pieced (three segmented piece attached with basal piece	short tube more/less equal to accessory piece	Ventral bar joined by a very thin median ligament
8	*C. agrawali* Agrawal and Vishwakarma, 1996	*M. vittatus*	-	River Gomti, Lucknow	Barabanki	Copulatory tube distally attached with cigar-shaped accessory piece	Copulatory complex with simple and short tube (more/less equal to accessory piece	Ventral bar not joined by a thin median ligament
9	*C. tukarami* Agrawal and Vishwakarma, 1996	*M. bleekeri*	*M. cavasius*	River Gomti, Lucknow	Barabanki, Hyderabad	Accessory piece, massive	Copulatory complex with coiled and very long tube	Ventral bar joined by a very thin median ligament
10	*C. gussevi* Agrawal and Vishwakarma, 1996	*M. bleekeri*	*M. cavasius*	River Gomti, Lucknow	Barabanki	Accessory piece, two pieced, triangular, (one arm, attached with each other) and comparatively large dorsal bar	simple tube (longer than accessory piece)	Ventral bar joined by a very thin median ligament
11	*C. bleekerai* Agrawal and Vishwakarma, 1996	*M. bleekeri*	*M. cavasius*	River Gomti, Lucknow	Barabanki, Hyderabad	Three accessory pieces of different shape, are arranged in a linear fashion	Copulatory complex with Simple and very long tube	Ventral bar not joined by a thin median ligament

Contd….

Table 1. Contd...

12	*C. susanae* Agrawal and Vishwakarma, 1996	*M. bleekeri*	*M. cavasius*	River Gomti, Lucknow	Barabanki, Hyderabad	Massive irregular accessory piece	Copulatory complex with simple tube (longer than accessory piece)	Ventral bar not joined by a thin median ligament
13	*C. gomtiai* Agrawal and Vishwakarma, 1996	*M. vittatus*	-	River Gomti, Lucknow	-	Accessory piece wrench-shaped	short tube more/less equal to accessory piece	Ventral bar joined by a very thin median ligament
14	*C. sclerovaginalis* Devak and Pandey 2007	*M. cavasius*	-	Lucknow	Barabanki, Hyderabad	Accessory piece in two pieces, one is A shaped and second is conical shaped	Copulatory complex with simple tube (longer than accessory piece)	Ventral bar not joined by a thin median ligament
15	*C. longicirrus* Agrawal *et al.*, 2016	*S. aor*	-	Lucknow	-	Accessory piece, vase-shaped	Copulatory complex with coiled and very long tube	Ventral bar joined by a very thin median ligament
16	*C. aori* Agrawal *et al.*, 2016	*S.aor*	-	Lucknow	-	Accessory piece hallow sac like structure	simple tube (longer than accessory piece)	Ventral bar joined by a very thin median ligament
17	*C. tripathii* n. sp.	*M. bleekerai*	-	Lucknow	Barabanki	Copulatory complex stick like	short tube more/less equal to accessory piece	Ventral bar not joined by a thin median ligament
18	*C. lucknowensis* n. sp.	*M. cavasius*	-	Lucknow	-	Massive, irregular accessory piece and coiled copulatory tube	Copulatory complex with Simple and very long tube	Ventral bar not joined by a thin median ligament
19	*C. speratai* n. sp.	*S. aor*	-	Lucknow	-	Siphon like accessory piece accessory piece and tubular copulatory tube	simple tube (longer than accessory piece)	Ventral bar joined by a very thin median ligament
20	*C. indicus* n. sp.	*S. aor*	-	Lucknow	-	Accessory piece thin membranous circular flap structure	simple tube (longer than accessory piece)	Ventral bar joined by a very thin median ligament
21	*C. kulkarnii* n. sp.	*S. aor*	-	Lucknow	-	Accessory piece bulb shaped	Copulatory complex with simple tube (longer than accessory piece)	Ventral bar joined by a very thin median ligament
22	*C. falcatum* n. sp.	*S. aor*	-	Lucknow, Gorakhpur, Malihabad, Sitapur	-	Accessory piece, thin membranous, broad accessory piece with one sickle shaped part	Copulatory complex with coiled and very long tube	Ventral bar joined by a very thin median ligament

cessory piece in *C gomtiai* bifurcates distally, while in the present species, it is somewhat pointed. The dorsal bar is more or less straight in *C. gomtiai*, while it is slightly bent in the present species. The ventral anchor in *C. gomtiai* is connected by a thin median ligament, which is not observed in the present species. *C. gomtiai* was described from *M. vittatus,* while the present species is from *M. bleekeri*. *C. tripathii* sp. nov. also differs from *C. agarwali* in the structure of accessory piece (cigar shaped in *C. agarwali*, rod like an in present species), ventral bar (cephalated in *C. agarwali*), opening of vaginal armature (median in C. *agarwali* while marginal in present species) and length of large hook (third pair of hook larger in present species). The present species also differs from *C. heterotylus* in the structure of the ventral anchor (cephalated in *C. heterotylus*) and *C. proximus C. geminus*, *C. gussevi*, and *C. tukarami* in the presence of a thin median ligament, which is absent in the present species.

C. lucknowensis sp. nov. chiefly differs from all the species of *Cornudiscoides* in having a massive, irregular accessory piece of the copulatory complex and funnel-shaped vagina with a coiled vaginal tube. *C. lucknowensis* sp. nov. resembles *C. proximus* and *C. geminus* in the structure of dorsal and ventral anchors but differs in the shape and size of the ventral bar (in *C. proximus* and *C. geminus*, *the* paired ventral bar is pointed at one end and blunt at the other, jointed by a thin median ligament) and hook size (*C. proximus* has a larger third pair of hook species)

The present species also differs from *C agarwali* and *C. tripathii* sp. nov. in the ventral bar (cephalated in *C. agarwali* and stick shaped in *C. tripathii* sp. nov.), vaginal opening (median in *C. agawali*). *C. lucknowensis* sp. nov. further differs from *C. sclerovaginalis* in the structure of dorsal anchors (much larger in *C. sclerovaginalis*), from *C. heterotylus*, *C. susanai* and *C. bleekerai* in the structure of ventral anchors (cephalated in *C. heterotylus*, *C. susanai* and *C. bleekerai*), from *C. heterotylus, C. sclerovaginalis* and *C. gussevi* in the shape of dorsal bar (rod shaped in *C. heterotylus* and *C. sclerovaginalis*; and larger in the case of *C. gussevi*), from *C. susanai* and *C. tukarami* in the structure of ventral bar (median ligament observed in *C. susanai* and *C. tukarami*) and from *C. tripathii* sp. nov. in the size of large hooks (third pair of hooks larger in *C. tripathii* sp. nov.).

New *C. speratai* species chiefly differ from other species of *Cornudiscoides* in having a siphon-like accessory piece but closely resemble *C. mystusi*, *C. longicirrus* and *C. aori* in the structure of the dorsal anchor, ventral anchor and ventral bar but differ in the structure of the copulatory complex (Urn shaped in *C. mystusi*, vase shaped accessory piece in *C. longicirrus*; inverted, hollow, sac like in *C. aori* and siphon-like accessory piece in the present species).

C. speratai sp. nov. shows similarity with *C. aori* in the structure of vaginal armature, having a simple vaginal tube that is small but differs from *C. mystusi* and *C. longicirrus* (long coiled in *C. mystusi*; a blade-like accessory part in *C. longicirrus*). It also differs from *C. tripathii* n. sp. and *C. lucknowensis* n. sp. in the structure of the ventral anchor and absence of the median ligament (point of ventral anchors straight in *Tripathii* sp. nov. and *C. lucknowensis* sp. nov. and curved in the present species; the median ligament was absent in *Tripathii* sp. nov. and *C. lucknowensis* sp. nov. while present in present species).

C. indicus sp. nov. chiefly differs from all other species of *Cornudiscoides* in the body length and structure of the copulatory complex. It closely resembles *C. mystusi C. longicirrus*, *C. aori* and *C. speratai* sp. nov., in the structure of the dorsal anchor, ventral anchor and ventral bar but differs in the structure of the copulatory complex (Urn shaped in *C. mystusi*, vase shaped accessory piece in *C. longicirrus*; inverted, hollow, sac like in *C. aori* and siphon like accessory piece in *C. speratai* sp. nov. and position of reproductive organs (in *C. mystusi C. longicirrus*, *C. aori* and *C. speratai* sp. nov. is present in the middle region of the body, while in new species, it is present at one-third of the body.

The new *C. kulkarnii* species chiefly differs from all the species of *Cornudiscoides* in having bulb-shaped accessory pieces of copulatory organs and small copulatory tubes, except *C. mystusi*. It closely resembles *C. mystusi* in the shape of an accessory piece of copulatory complex but differs in size (in *C. mystusi,* the copulatory tube is large, single coiled, and anti-clockwise). The present species also resembles *C. aori* and *C. speratai* in the structure of vaginal armature and differs from *C. longicirrus* and *C. mystusi* in the structure of vaginal armature (vaginal tube long coiled in *C. mystusi*, with a blade-like accessory part in *C. longicirrus* and simple small tube with funnel-shaped opening in the present species). The new species also differs from *C. indicus* sp. nov. in the position of the copulatory complex (at one-third of the body while in the present species in the middle region of the body).

C. falcatum sp. nov. is characterized by its unique thin membranous, broad accessory piece with a sickle-shaped sclerotized part and vaginal armature with a blade-like accessory structure.

It closely resembles *C. longicirrus*, *C. aori* and *C. mystusi* in the structure of dorsal anchor, ventral anchor and bar and differs in the structure of copulatory complex (Urn shaped in *C. mystusi*, vase shaped accessory piece and in *C. longicirrus*; inverted, hollow, sac like in *C. aori*, siphon like in *C. speratai* sp. nov., circular membranous accessory piece in *C. indicus* n. sp., and

bulb shaped in *C. kulkarnii* sp. nov.). The present species resembles *C. longicirrus* in the structure of the vaginal armature (vaginal tube with a blade-like accessory part in *C. longicirrus* and the present species) but differs from *C. mystusi*, *C. aori, C. speratai* n. sp. and *C. kulkarnii* sp. nov. (simple tube-like in *C. aori* and long coiled in *C. mystusi*, *C. speratai* sp. nov. and *C. kulkarnii* sp. nov.). These morphological variations present in a species are not only phenotypic but also present inside its genetic makeup and have been previously evaluated by additional parameters (molecular analysis, statistical analysis, etc.) by the present authors (Verma *et al.,* 2016; 2018; Agrawal *et al.,* 2020 and Verma and Agrawal, 2021), which supports the present analysis.
In terms of morphology and number, monogenoids are an ideal diversified group performing host specificity (Poulin, 2002). The genus *Cornudiscoides* is reported from India, Sri Lanka, Malaysia and Pakistan (Pandey and Agrawal, 2008). The parasites showed narrow host specificity and great biodiversity. Several species of the genus *Cornudiscoides* were subsequently added from various parts in India. However, in their monograph, Pandey and Agrawal (2008) recorded only 12 Indian species. Later, Agrawal *et al.* (2016) validated 16 species from India. Lim (1987) described six new species from Malaysia recovered from the gills of different species of *Mystus*. In the present study, sampling of fish hosts was performed in various localities in India and revealed two bagrid hosts (*Mystus* and *Sperata*) parasitized by 12 known and 6 new species of parasites. After Agrawal *et al*. (2016), the present study added six new species to the genus and now a total of 22 species under the genus *Cornudiscoides* considered valid in India and six species from Malaysia (Lim, 1987; Lim *et al.,* 2001). Out of 22 species, 15 species were reported from four species of *Mystus*, while 7 species were reported from *Sperata aor*. A comparative chart of known and new species, their type host , locality and characteristic differences in their hard parts is given to understand the diversity of the parasites more accurately (Table 1).

Conclusion

The present paper focused on the study of the genus *Cornudiscoides* Kulkarni, 1969, parasites of commercially important fish *Mystus* and *Sperata* to understand the species diversity of parasites from a morphological perspective and describe six new species, viz. *C. tripathii* sp. nov., *C. lucknowensis* sp. nov., *C. speratai* sp. nov., *C. indicus* sp. nov., *C. kulkarnii* sp. nov. and *C. falcatum* sp. nov. All *Cornudiscoides* species are similar at the generic level, but some structural differences are found in their copulatory complexes, which separate them at specific levels. A total of 22 species are considered valid under the genus *Cornudiscoides* from India and six species from Malaysia. A detailed description of species diversity, their type host , new host record type locality, additional localities and major distinguishable characters are summarized to understand the diversity of parasites.

Conflict of interest

The authors declare that they have no conflicts of interest.

REFERENCES

1. Agrawal, N., Rajvanshi, S. & Verma, J. (2016). Two new species of the genus Cornudiscoides Kulkarni, 1969 from naked catfish Sperata *aor* (Hamilton, 1822): Specialist or Generalist? *Pakistan Journal of Zoology*, 48 (6), 1687-1693.
2. Agrawal, N. Verma J. Rajvanshi, S. & Asthana, A. (2020). Application of two interesting statistical tools, used in differentiation of closely related species of *Cornudiscoides* Kulkarni, 1969 (Platyhelminthes: Monogenoidea: Dactylogyridae). *Uttar Pradesh Journal of Zoology*, 41(10), 143-156
3. Agrawal, N. & Vishwakarma, P. (1996). Six new species and redescription of two known species of the genus *Cornudiscoides* Kulkarni, 1969 (Monogenea) from Lucknow, U.P. *Indian Journal of Helminthology* (N.S.), 13, 10-31
4. Bakke, T. A. Cable, J. & Harris, P. D. (2007). The biology of Gyrodactylid monogeneans: the "Russian-doll killers". *Advances in parasitology* 64,161-460.
5. Cribb, T. H. Chisholm, L. A. & Bray, R. A. (2002). Diversity in the Monogenea and Digenea: does lifestyle matter?. *International Journal for Parasitology*, 32, 321-328.
6. Devak, A. & Pandey, K.C. (2007). A new species of *Cornudiscoides* Kulkarni, 1969 (Monogenoidea: Dactylogyridae) its locomotion, mode of attachment and distribution. *Indian Journal of Helminthology,* 25, 41-58.
7. Dubey, A. Gupta, A.K. & Agrawal, S.M. (1992). Studies on monogenean parasites in freshwater fishes at Raipur IX. Two new species of the genus *Cornudiscoides* Kulkarni a taxonomic discussion on species included in it. *Indian Journal of Helminthology,* 44, 109-115.
8. Froese, R. & Pauly, D. (2014-18). *Fish base*. https://www.fishbase.se/search.php [accessed 2014-2018]
9. Gusev, A.V. (1976). Freshwater Indian Monogenoidea. Principles of systematics, analysis of the world faunas and their evolution. *Indian Journal of Helminthology,* 25-26,1-241.
10. Jayaram, K. C. & Sanyal, A. (2003). A taxonomic revision of the fishes of the genus Mystus Scopoli (Family Bagridae) (No. 207). Zoological Survey of India.
11. Jyaram, K.C. (1955). Silurid fishes of India, Barma and Ceylon. XIV: Fishes of the genus *Mystus* Scopoli. *Record. Indian Museum.* (Culcutta), 51, 527-558.
12. Kritsky, D.C. Thatcher, V.E. & Boeger, W.A. (1986). Neotropical Monogenea 8. Reveision of *Urocleidoides* (Dactylogyridae, Ancyrocephalinae). *Procceding of helminthological. Society. Washington*, 53, 1-37.
13. Kulkarni, T. (1969b). Studies on the monogenetic trematodes of fishes found in Hyderabads Andhra Pradesh (India). Part I. *Riv di Parassitol* 30, 73-90

14. Kulwiec, Z. 1927. Untersuchungen an Arten des genus *Dactylogyrus* Diesing. *Bull*. *IoInt*. *Acad*. *Pon.Sci*. *Lett*., *Cl*. *Sci*. *Math*. *Nat*., *Ser*. *B: Sci*., 113-14.
15. Lim, L.H.S. (1987). Six new species of *Cornudiscoides* Kulkarni, 1969 (Monogenea: Ancyrocephalidae) from two *Mystus* species (Bagridae) of Peninsular Malaysia. *Folia Parasitologica,* 34,107-114.
16. Lim, L.H.S. Timofeeva, T. A. & Gibson, D.I. (2001). Dactylogyridean Monogeneans of the siluriform fishes of the old world. *Systematic Parasitology,* 50, 159-197. doi: 10.1023/A:1012237801974
17. Mishra, S.P. (2021). Studies on Infestations of Monogenean Ectoparasites on Indian Major Carps of District Sultanpur, Uttar Pradesh, India, *International Journal of Trend in Scientific Research and Development*, 5 (5), 2173- 2179,
18. Ogawa, K. (2015). Diseases of cultured marine fishes caused by Platyhelminthes (Monogenea, Digenea, Cestoda). *Parasitology*, 142(1), 178-195. doi: 10.1017/S0031182014000808.
19. Pandey, KC. & Agrawal, N. (2008). *An encyclopaedia of Indian Monogenoidea*, Vitasta Publishing Pvt. Ltd., New Delhi.
20. Poulin, R. (2002). The evolution of monogenean diversity. *International Journal for Parasitology*, 32(3), 245-54 doi: 10.1016/S0020-7519(01)00329-0
21. Rizvi, S.S.H. (1971). Monogenea of Pakistan fishes I. *Ancylodiscoides mystusi*, new species and *A. aori*, new species, from the gills of *Mystus aor* (Ham.). *Pakistan Journal Zoology,* 3, 87-92.
22. Stoskopf, M. K. (2015). Biology and management of laboratory fishes. In *Laboratory Animal Medicine* (pp. 1063-1086). Academic Press.
23. Verma, J. Agrawal, N. & Verma, A.K. (2017). The use of large and small subunits of ribosomal DNA in evaluating phylogenetic relationships between species of *Cornudiscoides* Kulkarni, 1969 (Monogenoidea: Dactylogyridae) from India*. Journal of Helminthology*, 91(2), 206-214. doi: 10.1017/S0022149X16000134
24. Verma, J. Rajvanshi, S. & Agrawal, N. (2018). Genetic characterization of three species of the genus *Cornudiscoides* Kulkarni, 1969 (Monogenoidea: Dactylogyridae), Parasitizing long whiskered cat fish *Sperata aor* (Ham) using ribosomal and mitochondrial DNA. *Journal of Zoological Sciences*, 6, 31-37.
25. Verma, J. & Agrawal, N. (2021). Molecular characterization of Indian species of the genus *Cornudiscoides* Kulkarni, 1969 (Monogenoidea: Dactylogyridae)*. Journal of Applied and Natural Science*, 13(1), 1 - 7. doi.org/10.31018/jans.v13i1.2434