Species diversity of the genus *Thelohanellus* Kudo, 1933 (Myxozoa: Bivalvulida) parasitizing fishes in Indian subcontinent

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Abstract A synopsis of 52 nominal species of the genus *Thelohanellus* Kudo, 1933 reported to infect freshwater fishes in India is presented. These species infect various organs such as gills, fins, scales, skin, muscles, gall bladder, kidney etc. The diagnostic features of the genus include tear-shaped myxospores with smooth shell valves and single polar capsule. The members are histozoic in their nature of parasitism infecting fresh water fishes. The present manuscript is aimed to compile the list of reported species in India along with essential information on morphometrics of vegetative stage, host, organ preference and pathogenic effects if any. Maximum number of species are recorded from state of West Bengal (25) followed by 23 in Punjab (out of which 8 were already reported from other states of India), Andhra Pradesh (7), Orissa (3), Manipur (1) and Haryana (1). Majority of the species have been recorded to infect major and minor carps (43 species) and 9 species in cat fishes. Out of 43 species infecting Indian major carps, *T. batae* infected the epithelial lining of gill filament of *Labeo bata* and also the wall of the duodenum and pectoral fin of *Wallago attu* in Harike Wetland (Punjab). Organ distribution of the species belonging to the genus *Thelohanellus* indicated that the plasmodia of 27 species were located in the gills, 14 species in the fins, 7 species in the gall bladder, 4 species in muscles and 3 species in kidney, 2 each in scale and skin on the head region and 1 species each in brain, eye, spleen, liver and

wall of the duodenum. Recent studies conducted by the authors and also by few earlier studies in West Bengal have documented many species of *Thelohanellus* to cause serious gill haemorrhagic disease and dermal lesions. Histological studies on the gills of cultured carps in Punjab infected with members of *Thelohanellus* have indicated that these parasites cause 15–20 % damage to respiratory surface leading to localized loss of function.

Keywords *Thelohanellus* · Fresh water fishes · Gills · Indian major carps

Introduction

Thelohanellus Kudo, 1933 is the second most prevalent genus after *Myxobolus* Butschli, 1882 infecting freshwater fishes in natural and cultured habitat in India. In general, these are mostly histozoic (within the tissues) and rarely coelozoic (in body cavities). The identification of the genus is based on the morphology and morphometrics of myxospores which is a propagative life cycle stage enclosed in pseudocyst/plasmodium. The myxospores typically have single polar capsule placed anteriorly within the tear shaped body (pyriform to broadly ellipsoidal in valvular view, being more slender in sutural view). Members of the genus *Thelohanellus* Kudo, 1933 are characterized in having shell with smooth valves and single polar capsule. So far 108 nominal species have been recorded throughout the world (Zhang et al. 2013). Lifecycle of only 2 species have been elucidated, *T. hovarkai* and *T. nokolskii* (Yokoyama 1997, 1998; Székely et al. 1998; Liyanage et al. 2003). The former species has been reported to cause a serious disease, haemorrhagic thelohanellosis in *Cyprinus carpio* (Yokoyama et al. 1998). Anderson et al. (2000)

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confirmed the transmission and production of actinospores in experimentally infected alternate oligochaete host. According to Molnar (1994) some *Thelohanellus* species possess very strict host and tissue specificity than others and some species occur exclusively in carp fishes (Akhmerov 1955, 1960). Rhee et al. (1990a, b) demonstrated the therapeutic effect of fumagillin dicyclohexylamine salt for the treatment and prevention of *T. kitauei*. More recently, real-time quantitative PCR have been used by Cavander et al. (2004) and Kelley et al. (2006) to identify and rapid assessment of the exposure of *Myxobolus cerebralis* to sentinel fish. Griffin et al. (2009) also applied real-time PCR assay for detection of *Henneguya ictaluri* infecting commercial channel catfish ponds. A unique feature was recorded as the presence of macro and micro myxospores in some plasmodia in *T. jiroveci* (Kundu and Haldar 1981). The present synopsis presents data on 52 nominal species belonging to the genus *Thelohanellus* infecting fresh water fishes in different states of India (up to 2015). Also, provides information on the state-wise distribution, organ specificity and organ location. Clinical symptomatology and pathogenicity caused by this group of parasites has been documented as per the original description. Globally, there are 108 nominal species of the genus *Thelohanellus* and is the sixth most speciose myxozoan genus after *Myxobolus*, *Myxidium*, *Henneguya*, *Ceratomyxa* and *Chloromyxum* (Zhang et al. 2013).

Species diversity of the genus *Thelohanellus* in Indian fishes

Earlier, Lom and Dykova (1992) had listed 39 species under the genus, *Thelohanellus*, recently Zhang et al. (2013) gave synopsis of 108 species all over the world and 40 in Indian fishes. Basu et al. (2006) and Kalavati and Nandi (2007) had listed 32 Indian species. Most recently, Basu et al. (2015) gave summarized compilation of 32 species in India. The present synopsis consists of an account of 52 species infecting Indian fishes.

Prevalence

Singh and Kaur (2012d) reported 55.7 % infection with myxozoans, out of which 16 species of *Thelohanellus* infecting freshwater fishes in wetlands of Punjab with highest prevalence rate in *Cirrhinus mrigala* in Kanjali wetland of Punjab. Kaur (2014) reported infestation rate of 34.7 % in wetlands and 26.28 % in aquaculture. The present synopsis on a prominent myxosporean genus would be second in series after one on the genus *Myxobolus* by Kaur and Singh (2012). Although, many reports of pathogenic species have been made in the past in India, however, no apparent pathogenicity has been seen due to thellohanelloid

species by workers in various states of India. Dermal lesion by *Myxobolus* and *Thelohanellus* were recorded to be common in the states of Andhra Pradesh and Karnataka (Kalavati and Nandi 2007). The most recent study by Kaur and Katoch (2016) have reported 3 gill infecting *Thelohanellus* species (*T. bifurcata*, *T. dykovi*, *T. filli*), 1 infecting liver (*T. wallagoi*) and 2 species infecting fins (*T. boggoti*, *T. kalavatae*). The studies conducted by Basu and Haldar (1998, 2003) have shown that hybrid carps were more susceptible to myxozoan infestation and in many instances they prove to be more prone to pathogenic effects leading to heavy mortality in culture systems.

Pathogenicity: In Punjab, as many as 3 species of *Thelohanellus* *T. bifurcata* Basu and Haldar (1999); *T. dykovi* Kaur et al. (2014a); *T. filli* Kaur et al. (2014b) infecting gills have been recorded to be highly pathogenic in cultured major carps (Kaur and Katoch 2014). All the three species were reported to have large-sized pseudocysts occupying most of the gill lamellae thereby causing total destruction of the respiratory surface (Kaur et al. 2014a, b). Mondal et al. (2014) recorded 12.5 % fin infection in *L. rohita* with *T. caudatus* (Pagarkar and Das 1993; Kaur et al. 2015). Recently, Kaur and Katoch (2016) recorded 3 gill infecting *Thelohanellus* species in two locations i.e. gill lamellae (LV3 type) and gill filament (FV1 type), causing mild to severe histopathological changes.

The development of aquaculture during the last decade have resulted in much greater attention paid to problems posed by parasites and their impact on the fish health leading to constraints in the productivity (Kennedy 1994). In Punjab (India) fish culture is an upcoming industry having 8285 ponds practicing polyculture and myxozoan parasites have been recorded to be as the major pests (Kaur et al. 2013a, b, Kaur et al. 2014a, b, Kaur et al. 2015, Kaur and Katoch 2014, 2016). This synopsis has been compiled in order to emphasis on the 52 Indian thellohanelloid species infesting major and minor carps, and pin pointing the pathogenic ones and symptomatology as per respective studies (Table 1). In India, the genus *Thelohanellus* (52 species) is the second most speciose after *Myxobolus* with 138 species as indicated in a synopsis by Kaur and Singh (2012). Out of 52 species 43 have been reported to infect Indian major and minor carps and 9 species from the catfishes (Tables 2, 3). *T. batae* was reported in the gill filaments of *Labeo bata* has also been reported from the wall of the duodenum and pectoral fin of *Wallago attu* in Harike Wetland of Punjab (Table 3; Fig. 1).

Organ distribution

The plasmodia of 27 species were located in gills, 14 species in fins, 7 in gall bladder, 4 species in muscles and 3

Table 1 A summary of *Thelohanelius* spp. infecting Indian fishes

Species	Host	Site of infection	Locality	Myxospore	Polar capsule	Number of coils	Parietal folds	Symptomatology/Pathogenicity	Reported by
1. <i>T. andhrae</i>	<i>Labeo fimbriatus</i>	Gills	AP, KR	12.8 × 5	7.0 × 2.2	10–11	5	Not apparent	Qadri (1962a)
2. <i>T. anilae</i>	<i>Labeo rohita</i>	Gills	WB	33.3 × 12.8	17.5 × 5.3	10–11	×	Not apparent	Hemananda et al. (2010a, b)
3. <i>T. auerbachii</i>	<i>Tachysurus plastystomus</i>	Gill bladder	WB	14.8 × 5.3	8.0 × 3.7	5–6	×	Not apparent	Sarkar (1987)
4. <i>T. avijiti</i>	<i>L. rohita</i> , <i>L. bata</i>	Dorsal fin	WB, PB	14.0 × 9.7	6.0 × 4.0	6–8	×	Not apparent	Basu and Haldar (2003)
5. <i>T. batae</i>	<i>L. bata</i> , <i>Wallago attu</i>	Gill filament, Wall of duodenum, Pectoral fin	AP, PB	12.3 × 6.2	7.7 × 3.0	4–6	×	Not apparent	LalithaKumari (1969)
6. <i>T. bengalensis</i>	<i>Catla catla</i>	Gill bladder	WB	10.9 × 6.5	5.4 × 3.4	3–4	×	Not apparent	Sarkar and Raychaudhuri (1986)
7. <i>T. bifurcata</i>	<i>L. rohita</i> × <i>C. catla</i> <i>L. rohita</i> (Cultured)	Gills	WB, PB	34.8 × 9.2	23.3 × 6.6	15–20	×	Mucous laden and pale gills, Necrosis of Intralamellar and intrafilamental tissue	Basu and Haldar (1999)
8. <i>T. boggoti</i>	<i>L. boggoti</i> , <i>C. catla</i>	Gill lamellae	AP, PB	11.5 × 6.75	6.25 × 3.8	10–11	×	Mucous laden gills	Qadri (1962b)
9. <i>T. calbasui</i>	<i>L. calbasu</i>	Scales	WB	9.9 × 7.2	5.4 × 3.4	–	×	Not apparent	Tripathi (1952)
10. <i>T. caudatus</i> (Acc. No. KC865607)	<i>L. rohita</i> , <i>L. calbasu</i>	Between the rays of caudal fin anal fin and Caudal fin	WB, PB	13.8 × 9.0	6.99 × 5.32	6–7	×	Not apparent	Pagarkar and Das (1993)
11. <i>T. catlae</i>	<i>C. catla</i>	Branchiae	WB	20.3 × 11.0	12 × 11	9–10	×	Not apparent	Chakravarty and Basu (1948)
12. <i>T. chandannagarensis</i>	<i>C. catla</i>	Gill filament	WB	12.5 × 6.7	5.1 × 3.1	8–10	×	Not apparent	Basu and Haldar (2003)
13. <i>T. chelae</i>	<i>Chela bacaila</i>	Gill bladder	WB	9.8 × 5.5	4.9 × 2.8	5	×	Not apparent	LalithaKumari (1969)
14. <i>T. chilkinsis</i>	<i>L. rohita</i>	Gill bladder	OD	26.7 × 8.7	17.5 × 7.0	6	×	Not apparent	Kalavati and Vaidehi (1991)
15. <i>T. chrysopomati</i>	<i>Barbus chrysopoma</i>	Gill contents	AP	12.4 × 5.4	6.5 × 2.7	9–10	×	Not apparent	LalithaKumari (1969)
16. <i>T. coeli</i>	<i>Tachysurus tenuispinis</i>	Gill bladder	WB	12.7 × 7.1	7.13 × 3.2	6–8	×	Not apparent	Sarkar and Mazumdar (1983)
17. <i>T. deri</i>	<i>L. dero</i>	Caudal fin	PB	10.0 × 5.0	5.4 × 3.6	6–7	×	Not apparent	Singh and Kaur (2012a, b, c, d)
18. <i>T. dykovi</i>	<i>L. rohita</i> (Cultured)	Gills	PB	10.7 × 4.0	6.4 × 2.0	18–20	×	Necrosis of Intrafilamental tissue	Kaur (2014)
19. <i>T. endodermitis</i>	<i>L. rohita</i>	Under surface of scales	WB	13.6 × 5.3	7.1 × 3.0	8–12	×	Not apparent	Mukhopadhyay and Haldar (2004)

Table 1 continued

Species	Host	Site of infection	Locality	Myxospore	Polar capsule	Number of coils	Parietal folds	Symptomatology/Pathogenicity	Reported by
20. <i>T. filii</i>	<i>L. rohita</i> (Cultured)	Gills	PB	27.0 × 10.5	16.6 × 8.2	12–14	×	Mucous laden gills and Necrosis of Intrafilamental tissue	Kaur et al. (2014b)
21. <i>T. gangeticus</i>	<i>Chela bacaila</i> , <i>Puntius vittatus</i> , <i>L. calbasu</i>	Muscles, Brain tissue, Gill lamellae	WB, KR, PB	16.8 × 5.4	7.2 × 2.5	9	×	Mucous laden gills	Tripathi (1952)
22. <i>T. globulosa</i>	<i>Cirrhinus reba</i>	Caudal fin	PB	11.7 × 7.9	5.3 × 4.8	4–5	×	Not apparent	Singh and Kaur (2012a, b, c, d)
23. <i>T. habibpuri</i>	<i>L. rohita</i>	Pectoral fin	WB	13.9 × 8.5	6.0 × 4.9	3–4	×	Not apparent	Acharya and Dutta (2007)
24. <i>T. haldari</i>	<i>C. reba</i>	Caudal fin	PB	12.6 × 6.2	7.0 × 4.8	3–4	×	Not apparent	Singh and Kaur (2012a, b, c, d)
25. <i>T. imphalensis</i>	<i>L. rohita</i>	Gills	MN	21.2 × 9.3	10.8 × 3.8	7–8	×	Not apparent	Hemananda et al. (2010b)
26. <i>T. jiroveci</i>	<i>L. bata</i>	Gills	WB	Macro: 35.0 × 12.4 Micro: 16.3 × 6.8	Macro: 18.4 × 7.0 Micro: 7.3 × 4.1	10–12	×	Not apparent	Kundu and Halder (1981)
27. <i>T. kalavatae</i>	<i>C. reba</i>	Caudal fin	PB	11.5 × 5.0	5.2 × 3.3	5–6	×	Not apparent	Singh and Kaur (2014)
28. <i>T. kalbensi</i>	<i>L. calbasu</i>	Gill lamellae	PB	9.5 × 4.9	4.8 × 3.2	5–6	×	Mucous laden gills	Singh and Kaur (2014)
29. <i>T. kanjalensis</i>	<i>C. catla</i>	Skin of snout	PB	11.7 × 6.6	7.5 × 3.3	4–6	×	Not apparent	Singh and Kaur (2012a, b, c, d)
30. <i>T. lamelliformis</i>	<i>C. catla</i>	Gill lamellae	PB	10.2 × 4.9	3.8 × 2.6	6–7	×	Mucous laden gills	Singh and Kaur (2015)
31. <i>T. mrigalae</i>	<i>C. mrigala</i> , <i>C. catla</i>	Skin on the head, Head muscles	WB, PB	11.4 × 6.7	6.3 × 4.3	6–7	×	Not apparent	Tripathi (1952)
32. <i>T. muscularis</i> (NCBI unpublished, Acc. No. KT387308)	<i>Labeo rohita</i>	Head muscles	PB	9.2 × 4.0	5.8 × 3.10	5–6	×	Cystic appearance of muscles	Kaur et al. (2015)
33. <i>T. narasimhamurtius</i>	<i>Amblypharyngodon mola</i>	Internal lamellae of gill filament	WB	9.6 × 3.3	6.5 × 2.2	9–10	×	Necrosis of Interlamellar tissue	Sarkar (1994)
34. <i>T. neocyprini</i> (NCBI unpublished, Acc. No. KP792568)	<i>C. catla</i>	Gill filament	PB	34 × 9.0	18.5 × 5.8	10–14	×	Highly symptomatic	Kaur et al. (2015)
35. <i>T. ophthalmicus</i>	<i>Glossogobius giuris</i>	Internal musculature and sclera of eye	WB, KR	12.5 × 7.5	6.5 × 3.2	6–7	×	Not apparent	Halder et al. (1983)
36. <i>T. orissae</i>	<i>C. mrigala</i>	Gills	OD	Macro: 13.8 × 4.8 Micro: 7.2 × 3.1	Macro: 6.3 × 2.3 Micro: 3.7 × 2.3	6	×	Not apparent	Halder, Samal and Mukhopadhyay (1997)

Table 1 continued

Species	Host	Site of infection	Locality	Myxospore capsule	Number of coils	Parietal folds	Symptomatology/Pathogenicity	Reported by
37 <i>T. parastromataei</i>	<i>Parastromataeus</i>	Gall bladder	OD	11.1×9.4	–	×	Not apparent	Narasimhamurti et al. (1990)
38 <i>T. potaili</i>	<i>L. potail</i>	Fin	AP	13.0×8.2	4	×	Not apparent	LalithaKumari (1969)
39 <i>T. pyriformis</i>	<i>Tinca tinca</i> , <i>Rutilus rutilus</i> , <i>Leuciscus idus</i>	Gills, Muscles kidney, Spleen, Liver	HR (Elsewhere: France, Russia, South East Asia)	17.1×7.0	6	×	Massive hypertrophy of the endothelial cells	Thelohan (1892), Kudo (1933)
40 <i>T. qadrii</i>	<i>L. potail</i>	Gill filaments	AP	14.7×5.4	13–18	×	Not apparent	LalithaKumari (1969)
41 <i>T. rodgii</i>	<i>L. calbasu</i>	Gills	WB	34.3×11.7	–	×	Not apparent	Hagargi, Kundu and Halder (1979)
42 <i>T. rohi</i>	<i>L. rohita</i>	Caudal fin	PB	14.5×7.7	4–5	×	Not apparent	Singh and Kaur (2015)
43. <i>T. rohita</i>	<i>L. rohita</i> , <i>L. bata</i>	Gills	WB	31.5×11.5	6	×	Not apparent	Southwell and Prashad (1918)
44 <i>T. sanjibi</i>	<i>Mystus gulio</i>	Kidney	WB	12.5×8.2	4–5	×	Not apparent	Sarkar and Ghosh (1990)
45 <i>T. seni</i> (Southwell and Prashad)	<i>C. catla</i>	Branchiae	WB	$13.78 \times .5$	6	×	Not apparent	Chakravarty and Basu, 1948 (Syn. <i>Myxobolus seni</i> Southwell and Prashad, 1918)
46 <i>T. shortii</i>	<i>L. fimbriatus</i>	Fin	AP	12.5×6.9	3–4	×	Not apparent	Qadri (1967)
47 <i>T. sp</i> (NCBI unpublished, Acc. No. KU516661,	<i>Labeo dero</i>	Gills Caudal fin	PB	9.7×3.85	5–6	×	Not apparent/ Necrosis of gill lamellae	Kaur et al. (2015)
48 <i>T. sudevi</i>	<i>A. mola</i>	Kidney	WB	14.0×5.8	4–5	×	Not apparent	Sarkar and Ghosh (1990)
49 <i>T. thaili</i>	<i>C. catla</i> , <i>L. bata</i>	Gill lamellae	PB	11.6×7.2	4–5	×	Mucous laden gills	Singh and Kaur (2012a, b, c, d)
50 <i>T. theinensis</i> (NCBI unpublished, Acc. No KT387307	<i>L. bata</i>	Gill lamellae	PB	8.3×4.4	5–6	×	Mucous laden gills	Kaur et al. (2015)
51. <i>T. tripurensis</i>	<i>Labeo calbasu</i> , <i>Labeo bata</i> , <i>Labeo gonius</i> and <i>Cirrhinus reba</i>	Gill filaments	Tripura	17.4×10.1	5–6	×	Not apparent	Madhavan, Bandyopadhyay and Santosh (2012)
52 <i>T. wallagoi</i>	<i>Wallago attu</i>	Gall bladder, Gill	WB, PB	9.2×4.8	4–5	×	Mucous laden gills	Sarkar (1987)

AP Andhra Pradesh, HA Haryana, MN Manipur, OD Orissa, PB Punjab, KR Kerala, WB West Bengal

Table 2 Showing list of species recorded

S. no.	Host fish	Parasite recorded
1	<i>Catla catla</i> vern. thail	<i>T. bengalensis</i> ; <i>T. catlae</i> ; <i>T. chanadannagarensis</i> ; <i>T. ophthalmicus</i> ; <i>T. seni</i> ; <i>T. lamelliformis</i> ; <i>T. kanjalensis</i> ; <i>T. thaili</i>
2	<i>Cirrhinus reba</i> vern. mori	<i>T. kalavatae</i> ; <i>T. globulosa</i> ; <i>T. haldari</i> ; <i>T. tripurensis</i>
3	<i>Cirrhinus mrigala</i> vern. mrigal	<i>T. disporomorphus</i> ; <i>T. mrigalae</i> ; <i>T. orissae</i>
4	<i>Labeo bata</i> vern. bata	<i>T. batae</i> ; <i>T. jiroveci</i> ; <i>T. rohita</i> ; <i>T. thaili</i> ; <i>T. theinensis</i> ; <i>T. tripurensis</i>
5	<i>Labeo calbasu</i> vern. kalbans	<i>T. calbasui</i> ; <i>T. kalbensi</i> ; <i>T. rodgii</i> ; <i>T. tripurensis</i>
6	<i>Labeo dero</i> vern. gid	<i>T. deri</i>
7	<i>Labeo rohita</i> vern. rohu	<i>T. anilae</i> ; <i>T. caudatus</i> ; <i>T. chilkensis</i> ; <i>T. dykovi</i> ; <i>T. endodermitus</i> ; <i>T. filli</i> ; <i>T. habibpuri</i> ; <i>T. rohi</i> ; <i>T. imphalensis</i> ; <i>T. avijiti</i> ; <i>T. rohita</i> ; <i>T. bifurcata</i> ; <i>T. muscularis</i>
8	<i>Labeo potail</i> vern. hoobli	<i>T. potaili</i> ; <i>T. qadri</i>
9	<i>Labeo fimbriatus</i> vern. tambir, rachu	<i>T. andhrae</i> ; <i>T. shortii</i>
10	<i>Labeo boggot</i> vern. boggut	<i>T. boggoti</i>
11	<i>Labeo rohita</i> x <i>L. bata</i> (hybrid)	<i>T. rohita</i> ; <i>T. thaili</i> ; <i>T. bifurcata</i>
12	<i>Amblypharyngodon mola</i> vern. molacarpel	<i>T. narasimhamurtius</i> ; <i>T. sudevi</i>
13	<i>Tinca tinca</i> vern. golden tench	<i>T. pyriformis</i>

Table 3 Species of the Genus *Thelohanellus* Kudo, 1933 infecting non-major and minor carps in India

S. no.	Host fish	Parasite recorded
1	<i>Wallago attu</i> vern. mully	<i>T. batae</i> ; <i>T. wallagoi</i>
2	<i>Chela bacaila</i> vern. katari	<i>T. chala</i> ; <i>T. gangeticus</i>
3	<i>Barbus chrysopoma</i> vern. olive barb	<i>T. chrysopomati</i>
4	<i>Tachysurus tenuispinis</i> vern. etta	<i>T. coeli</i>
5	<i>Mystus gulio</i> vern. long whiskers catfish	<i>T. sanjibi</i>
6	<i>Parastromataeus niger</i> vern. black pomfret	<i>T. parastromataei</i>
7	<i>Tachysurus plastystomus</i> vern. flatmouth catfish	<i>T. auerbachii</i>

Fig. 1 Organ-wise distribution of the species of the genus *Thelohanellus* Kudo, 1933 in the fresh water fishes of India

species in kidney, 2 species each in scales and skin on head, 1 each in eye, brain, spleen, liver and wall of duodenum.

Molecular data on Indian species of *Thelohanellus*

The systematic of *Thelohanellus* spp. is primarily based on the morphology and morphometrics of the myxospore, type host and tissue location however recently molecular study based on partial amplification of SSU rDNA on 14 Indian species have been done as per the data in NCBI GenBank. These are- *T. caudatus* Acc. No. KM865607 (Mondal et al. 2014; publ), *T. habibpuri* KM252683 (Abraham et al. 2014-NCBI; unpubl.), *T. rohita* Acc. No. KM252682 (Abraham et al. 2014- NCBI; unpubl.), *T. catlae* Acc. No. KJ476881 (Abraham et al. 2014- NCBI; unpubl.), *T. jiroveci* Acc. No. KJ476885 (Abraham et al. 2014- NCBI; unpubl.), *T. seni* Acc. No. KJ476884 (Abraham et al. 2014-NCBI; unpubl.), *T. quadrii* Acc. No. KF170928 (Banerjee et al. 2015; publ), *T. bifurcata* Acc. No. KJ476886- NCBI; unpubl.), *T. dykovi* Acc. No. KR423868 (Attri and Kaur, 2015-NCBI; unpubl.), *T. neocyprini* Acc. No. KP792568 (Kaur et al. 2015- NCBI;

unpubl.), *T. filli* Acc. No. KR340464 (Kaur et al. 2015; publ.) and *T. theinensis* Acc. No. KT387307 (Kaur et al. 2015- NCBI; unpubl.), *T. muscularis* (Kaur et al. 2015- NCBI; unpubl.),

Thelohanellus sp. Acc. No. KU516661 (Kaur et al. 2015- NCBI; unpubl.).

Conclusions

This synopsis has been compiled in order to emphasis on the 52 Indian thelohanelloid species infesting major and minor carps, and pin pointing the pathogenic ones. In future, this data would form the basis of molecular identification of those species which are morphologically resemble closely recorded from same geographical area.

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Compliance with ethical standards

Conflict of interest No conflict of interest.

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