ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 8, Issue, 10, pp. 21051-21060, October, 2017

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

COMMUNITY STRUCTURE OF METAZOAN PARASITES OF FRESHWATER FISHES OF VIZIANAGARAM DISTRICT, ANDHRA PRADESH, INDIA

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DOI: http://dx.doi.org/10.24327/ijrsr.2017.0810.1006

ARTICLE INFO

Article History:

Received 15th July, 2017
Received in revised form 25th August, 2017
Accepted 23rd September, 2017
Published online 28th October, 2017

Key Words:

Community ecology, metazoan parasites, freshwater fishes, Vizianagaram District.

ABSTRACT

The present study is the first documentation of the metazoan parasitofauna of freshwater fishes in Vizianagaram district of Andhra Pradesh state. The study was conducted for a period of two years i.e. June 2014 to May 2016. The Prevalence and mean intensity of metazoan parasitic infection and various community characteristics, together with the qualitative similarity of metazoan parasites among species and families of the fishes were determined of the 15 fish species of freshwater fishes of Vizianagaram District, Andhra Pradesh belonging to nine different families. Metazoan parasite fauna of this geographical area is very less diverse with only 23 species of parasites belonging to 5 major taxa: three species of monogeneans, 15 digenea of which 8 adult digeneans and 7 larval trematodes, 2 cestodes, 2 copepods and one acanthocephalan. Prevalence of infection ranged from 13.3% (*Wallago attu*) to 34.3% (*Clarias batrachus*) and mean intensity from 1.17 (*M. aculeatus*) to 3.0 (*G. giurus*). The infra and component communities of parasites were somewhat characteristic/ peculiar. The dominance pattern of the major taxa was in the order Digenea > Monogenea > Cestodes = Copepods > acanthocephalans. *Mastacembelus armatus*, *Macrognathus aculeatus* and *Mastacembelus pancalus* showed the richest parasite fauna whereas *Catla catla, Cyprinus carpio, Notopterus notopterus, M. pancalus* and *Heteropneustus fossilis* showed least rich fauna and *Cirrhinus mrigala* marked none. The parasite faunas of *M. armatus*, *M. aculeatus* and *M. pancalus* and that of *M. vittatus* and *S. seenghala* and *C. punctatus* and *G. giurus* were similar. However, in spite of taxonomic nearness and the similarity of habits and habitats of 4 species of cyprinids (*C. catla*, *C. mrigiala*, *L. rohita* and *C. carpio*), their parasite fauna were qualitatively dissimilar of the 3 species of parasites encountered in them only one was shared by the 2 host species.

INTRODUCTION

Parasitology has traveled a long way, and covered a wide area to secure its place today as a distinct scientific discipline. What is more, its ever-expanding frontier continues to bear an eloquent testimony to its vibrant viability. During the long process of growth and evolutionary run, however it has accommodated a diverse flow of contributions from many other disciplines, which in their turn have provided nourishment, enrichment and at times embellishment. Parasitology in its literal sense may go to encompass a wide canvas and parasites like many other organisms have made suitable models for valuable studies on what may be called fundamental biology. However it should be admitted, that all the information's thus obtained have not always lent them to be exploited meaningfully to answer the needs and problems of parasitology with its conventional and pragmatic connotation. Sanction of usage demands that we look at the parasites and usage with respect to their involvement and responsibility for diseases and disabilities in man and animals. Parasitic diseases continue to be a cause of major concern to human and animal health in several parts of the globe including India, causing high morbidity, mortality and economic losses. Many worms infection prevail in animal hosts, which in turn, may become natural reservoirs of infection to human host. The nature and extent of worm types that occur in food giving animals like fishes, poultry and livestock mammals depend on, and are influenced by the ambient environmental factors and socio-cultural practices prevailing in a region.

Helminths are the most common and abundant parasites of fishes. They are occurring as endoparasites usually in the gut and associated organs of fishes. Taxonomic studies on helminth parasites of fishes were initiated in the early 19th century itself

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by scientists, but they received momentum in the 20th century. To date around 30,000 species of helminth parasites were recorded from freshwater fishes. The present investigation deals with the ecological aspects of metazoan parasites of freshwater fishes of Vizianagaram, Andhra Pradesh.

India is endowed with many freshwater resources, rich fish genetic biodiversity (2,200 fish species) and ranks 9th in terms of freshwater mega diversity (Miltermeier *et al*., 1997). Nevertheless, a significant portion of the freshwater fish production in India is still based on the harvest from wild population (Sarkar *et al*., 2008). In tropical regions, parasites are major concern to freshwater and marine fishes (Iyaji and Eyo, 2008; Bichi and Dawaki, 2010; Ekanem *et al*., 2011). They constitute a major limiting factor to the growth of farmed fish (Bichi and Yelwa, 2010). They play a vital role in devaluation of nutrients (Hassan *et al*., 2010); alteration of biology and behaviour (Lafferty, 2008); inducing blindness and in decreasing immunity (Echi *et al*., 2009 a, b); reduction of growth and fecundity, increasing mortality and morbidity (Nmor *et al*., 2004) and they also cause mechanical injuries based on number and site of infection (Echi *et al*., 2009 a, b). Moreover, parasites may also control host population dynamics and manipulate community structure (Malan *et al*., 1997; Marcogliese, 2004; Hatcher *et al*., 2006; Vignon and Sasal, 2010).

Parasitology is an ever going discipline in research. The host parasite associations are unique in the sense that of the two organisms it is only the parasites that is benefited while the host suffers. The valuable information pertaining to the ecological aspects of freshwater fishes was contributed by several parasitologists of national and international status (Kennedy, 1976; Holmes, 1973; Dogiel, 1964, William and Jones, 1994; Khalil and Polling, 1997; Pérez-Ponce de Leon *et al*., 2000; Nelson and Dick, 2002; Johnson *et al*., 2004; Madhavi and Rukmini, 1992; Muralidhar, 1989; Satyanarayana, 1982; Madhavi and Sairam, 2000; Dhole *et al*., 2010; Alves and Luque 2001; Salgado-Maldonado *et al*., 2001, 2004; Luque *et al*., 2003; Takemoto *et al*., 2005, Avenant-Oldewage and Knight, 2008; Mwita and Nkwengulila, 2008; Zetlmeisl, 2011; Vankara and Chikkam, 2013; Vankara *et al.,* 2014, 2015, 2016; Gudivada *et al.,* 2012, 2017).

Previous surveys from Vizianagaram have focused mainly on Icthyofaunal diversity and taxonomy (Rao *et al*., 2013; Ramaneswari and Sridhar, 2015). At present, very few records of parasitic helminths in the study area were documented (Sujana and Shameem, 2015; Mani *et al*, 2017). The present study was an attempt at bringing out the community characteristics of the metazoan parasite fauna of 15 species of freshwater fish of Vizianagaram district.

Study Area

Vizianagaram is located at 18.12°N 83.42°E. It has an average elevation of 74 metres (242 feet). The district is bounded on the east by Srikakulam District on the west and south by Visakhapatnam district, on the south east by the Bay of Bengal and North West by Odisha state. The major rivers flowing in the study area are Nagavali, Janjavathi, Suvarnamukhi, Vegavathi, Champavathi and Gosthani. Apart from rivers there are many ponds, tanks, ditches, streams and few stagnant watery areas. The main tanks in Vizianagaram are Dwarapudi, Bondapalli, Nelivada, Konisa, Devupalli, Gollupalem, Dharmapuri, Gajularega, Ayyannapeta, Kanapaka, Jonnavalasa, Gajapathinagaram, Garbham etc. and reservoirs at Gadigedda, Tatipudi, Andra and Thotapalli. There are many medium irrigation projects covering an area of 43,984 Hectares. Generally fish captured from 7 reservoirs and 203 village tanks and culture fisheries yield 0.7 tons in Vizianagaram district (FAO Corporate Document Repository).

MATERIALS AND METHODS

Fish Collection and Identification

Fishes were collected from the above reservoirs, rivers and tanks in different seasons by using different types of 'Nets and Gears' with the help of local fishermen. Fishes caught were thoroughly washed, photographed in fresh condition and preserved in 9-10% formalin solution (Jayaram, 1999). For larger fishes an incision on the abdomen was done and the gut contents were removed before preservation. The collections were made once in a month from June 2014 to May 2016. The fishes were identified with help of standard books (Talwar and Jhingran, 1991, Jayaram, 1999 and Nath and Dey, 2000).

Parasitofauna analysis

External surface of the fish was grossly examined using a hand lens for ectoparasitic species and crustaceans. Smear of scrapings from the skin, fins and gills were also examined for ectoparasites. The fish were sectioned and the alimentary canal, liver, kidney, swim bladder and spleen examined for endoparasites. The excised gastrointestinal tract was carefully sectioned into portions such as oesophagus, intestine and rectum and each portion was then cut open, washed in Petri dish with 0.1% sodium chloride solution and examined thoroughly for the endoparasites namely, digeneans, cestodes, nematodes and acanthocephalans. These endoparasites were collected and preserved in A.F.A (Alcohol-85 ml, Formalin-10 ml and Acetic acid-5 ml) which acts as an ideal fixative for the whole mount preparations and processed for further studies. Trematode cysts from the muscle were manually teased to release the metacercariae, which were fixed in hot alcohol-formal-acetate (AFA) and preserved in 70% ethyl alcohol. Digenean trematode metacercariae were stained in Haematoxylin and Eosin (Paperna, 1996). Figures were drawn with the aid of camera lucida and measurements were taken with the aid of an ocular micrometer. Measurements are given in millimetres unless otherwise mentioned. Microphotographs were taken and scale is provided accordingly. Voucher specimens of fish and parasites were deposited in the Department of Zoology, Maharajah's College (Autonomous), Vizianagaram, Andhra pradesh, India.

Data analysis

Different biostatistical parameters like prevalence, mean intensity, mean abundance, dominance value, proportion and dominance index were calculated for total parasites, parasitic groups and also for individual parasitic genus were applied for qualitative and quantitative analysis of the data. Biostatistical books by the Snedecor and Cochran (1967), Sundara Rao and Richard (1996), Daniel (1998) and formulae from Leong and Holmes (1981) were followed for statistical analysis.

RESULTS

The different species and families of fishes examined, infected and the total number of fish examined and infected in each species are shown in Table 1.

Table 1 List of host fish species and families examined and number of fish infected during the study period, June 2014 - December 2015

Name of the host	No. of fish examined	No. of fish infected	Families
1. *Catla catla* (Hamilton)	150	24	Fam: Cyprinidae
2. *Cirrhinus mrigala* (Hamilton)	54	-	"
3. *Labeo rohita* (Hamilton)	140	18	"
4. *Cyprinus carpio* (Linnaeus)	79	16	"
5. *Notopterus notopterus* (Pallas)	22	04	Fam: Notopteridae
6. *Mastacembelus armatus* (Lacepede)	132	42	Fam: Mastacembelidae
7. *Macrognathus aculeatus* (Bloch)	128	35	"
8. *Macrognathus pancalus* (Hamilton)	44	12	"
9. *Wallago attu (*Bloch & Schneider)	120	16	Fam:Siluridae
10. *Mystus vittatus* (Bloch)	125	25	Fam:Bagridae
11. *Sperata seenghala* (Sykes)	140	20	"
12. *Heteropneustus fossilis* (Bloch)	22	06	Fam: Saccobranchidae
13. *Clarias batrachus* (Linnaeus)	70	24	Fam: Clariidae
14. *Channa punctatus* (Bloch)	162	45	Fam: Ophiocephalidae
15. *Glossogobius giurus* (Hamilton)	65	16	Fam: Gobiidae
Total	1453	303	

The list of parasites and their distribution in host fishes and families are presented in Tables 2 and 3.

Parasite species overlap (= similarity of the parasite fauna) in different species and families of fishes is given in Tables 8 and 9 respectively. Metazoan parasites occurred in almost 14 species of fishes except in *Cirrhinus mrigala*. Of the 1453 fishes examined, 20.9% harboured metazoan parasites and the average number of parasites was 1.83 per fish. Prevalence of infection was the highest in *C. batrachus* (34.29%) and the lowest in *L. rohita* (12.86%). On the whole, in the carnivorous and omnivorous fishes prevalence of infection was comparatively higher than in the predominantly herbivorous species. The highest MI of metazoan parasites was noted in *G. giurus* (3.0) and the lowest in *M. pancalus* (1.17); the former a predominantly carnivore (particularly larvivore) and the latter an herbivore. As with prevalence, MI was also slightly higher in the carnivorous species than in the herbivorous. Proportion of metazoan parasites registered the maximum in *C. punctatus* (0.2) and the lowest in *N. notopterus* (0.011) (Table 4).

Of the 14 species of fishes infected, 78.6% harboured digeneans, 35.1% harboured monogeneans. The other major taxa of metazoan parasites Cestoda, Acanthocephala and Copepoda were harboured by equal number of host fishes =14.3% each. The dominance pattern of the major taxa of metazoan parasites in freshwater fishes of this region was in the order, Digenea > Monogenea> Cestoda = Acanthocephala = Copepoda (Table 2). The most dominant group of parasites was Digenea (DV = 34.71%) and the least were Cestoda and Copepoda (DV = 5.75%) (Tables 2, 3 & 4).

Results of the family-wise comparison of parasitic infection (Table 5) showed that the highest prevalence of metazoan parasitic infection was in Clariidae (34.3%) and the lowest in Siluridae (13.3%) and Cyprinidae (13.7%).

Table 2 Distribution of metazoan parasites in 15 species of freshwater fishes of Vizianagaram, Andhra pradesh (√-present)

Parasite species/ Group	Fish species														
	Catla catla	*Cirrhinus mrigala*	*Labeo rohita*	*Cyprinus carpio*	*Notopterus notopterus*	*Mastacembelus armatus*	*Macrognathus aculeatus*	*Macrognathus pancalus*	*Wallago attu*	*Mystus vittatus*	*Sperata seenghala*	*Heteropneustes fossilis*	*Clarias batrachus*	*Channa punctatus*	*Glossogobius giurus*
Monogenea															
D.catalius	√		√												
B.wallagonia									√						
T. tengra										√	√				
Digenea															
Genarchopsis goppo														√	
Opecoelus mehrii						√									
Opecoelus beliyai															√
Asymphylodora tincae				√											
Haplorchoides macrons										√	√				
Allocreadium aculeatum							√								
Allocreadium handiai													√		
Isoparorchis hypselobagri					√										
Larval Trematodes															
Metacercaria *Clinostomum mastacembeli*							√	√							
Metacercaria *Clinostomum dasi*												√			
Metacercaria														√	
Euclinostomum heterostomum															
Metacercaria *Isoparorchis hypselobagri*														√	
Tetracotyle glossogobii															√
Tetracotyle sp-I						√	√								
Metacercaria *Ascocotyle nana*						√	√								
Cestodes															
Lytocestus indicus													√		
Circumonchobothrium shindei						√									
Acanthocep-hala															
Pallisentis ophiocephali														√	√
Copepoda															
Ergasilus malnadensis									√						
Argulus siamensis			√												

The overall nature of metazoan parasitic infection in different species and families of freshwater fishes is given in Tables 4 and 5 respectively. The community characteristics of the parasite fauna in different species and families of fishes are presented in Tables 6 and 7 respectively.

Prevalences of infection in the other six families were, Mastacembelidae = 29.3%, Ophiocephalidae = 27.8%, Saccobranchidae = 27.3%, Gobiidae = 24.6%, Notopteridae = 18.2% and Bagridae= 17.0%. The highest MI was noted in Gobiidae (3.0) and the lowest in Saccobranchidae (1.33).

Table 3 Distribution of metazoan parasites in 9 families of freshwater fishes of Vizianagaram, Andhra pradesh (√-present)

Parasite species/ Group	FISH FAMILY								
	Cyprinidae	Notopteridae	Mastacembelidae	Siluridae	Bagridae	Saccobranchidae	Clariidae	Ophiocephalidae	Gobiidae
Monogenea									
D.catalius	√								
B.wallagonia				√					
T. tengra					√				
Digenea									
Genarchopsis goppo								√	
Opecoelus mehrii			√						
Opecoelus beliyai									√
Asymphylodora tincae	√								
Haplorchoides macrones					√				
Allocreadium aculeatum			√						
Allocreadium handiai							√		
Isoparorchis hypselobagri		√							
Metacercaria *Clinostomum mastacembeli*			√						
Metacercaria *Clinostomum dasi*						√			
Metacercaria								√	
Euclinostomum heterostomum									
Metacercaria *Isoparorchis hypselobagri*								√	
Tetracotyle glossogobii									√
Tetracotyle sp-I			√						
Metacercaria *Ascocotyle nana*			√						
Cestodes									
Lytocestus indicus							√		
Circumonchobothrium shindei			√						
Acanthocephala									
Pallisentis ophiocephali								√	√
Copepoda									
Ergasilus malnadensis				√					
Argulus siamensis	√								

Table 4 Prevalence (P= %), Mean Intensity (MI), Abundance (A), Dominance value (DV) and proportion of metazoan parasites in different species of freshwater fishes of Vizianagaram, Andhra Pradesh

Fish species/Family	Number examined	Number infected	Number of parasites	Total	Monogenea	Digenea	Larval Trematode	Cestoda	Acanthocephala	Copepod	Proportion
Fam: Cyprinidae											
Catla catla	150	24	32	P 16 MI 1.33 A 0.21 DV 5.76	16 1.33 0.21 100						0.057
Cirrhinus mrigala	54	-	------	P MI A DV							
Labeo rohita	140	18	38	P 12.86 MI 2.11 A 0.27 DV 6.83	5.71 2.25 0.06 47.37					11.42 1.25 0.14 52.63	0.068
Cyprinus carpio	79	16	26	P 20.25 MI 1.63 A 0.33 DV 4.68		20.25 1.63 0.33 100					0.046
Fam: Notopteridae											
Notopterus notopterus	22	04	06	P 18.18 MI 1.50 A 0.27 DV 1.08		18.18 1.50 0.27 100					0.011
Fam: Mastacembelidae											
Mastacembelus armatus	132	42	63	P 31.81 MI 1.50 A 0.48 DV 11.33		16.67 1.18 0.20 41.27	15.15 1.25 0.19 39.68	7.58 1.20 0.09 19.05			0.113
Macrognathus aculeatus	128	35	67	P 27.34 MI 1.91 A 0.52 DV 12.05		17.19 1.64 0.28 53.73	15.63 1.56 0.24 46.27				0.121
Macrognathus pancalus	44	12	14	P 27.27 MI 1.17 A 0.32 DV 2.52			27.27 1.17 0.32 100				0.025
Fam:Siluridae											
Wallago attu	120	16	30	P 13.33 MI 1.88 A 0.25 DV 5.40	8.33 1.80 0.15 60.0					5.0 2.0 0.10 40.0	0.054
Fam:Bagridae											
Mystus vittatus	125	25	39	P 20.0 MI 1.56 A 0.31 DV 7.01	12.0 1.46 0.18 56.41	9.60 1.42 0.14 43.59					0.070
Sperata seenghala	140	20	33	P 14.29 MI 1.65 A 0.24 DV 5.94	2.86 3.75 0.11 45.45	12.14 1.06 0.13 54.55					0.059
Fam: Saccobranchidae											
Heteropneustes fossilis	22	06	08	P 27.27 MI 1.33 A 0.36 DV 1.44			27.27 1.33 0.36 100				0.014

Fam: Clariidae													
Clarias batrachus	70	24	42	P 34.29 MI 1.75 A 0.60 DV 7.55		18.57 1.69 0.31 52.38		22.86 1.25 0.29 47.62				0.085
Fam: Ophiocephalidae													
Channa punctatus	162	45	110	P 27.78 MI 2.44 A 0.68 DV 19.78		12.35 1.60 0.20 29.09	9.26 2.33 0.22 31.82		19.75 1.34 0.27 39.09			0.198
Fam: Gobiidae													
Glossogobius giurus	65	16	48	P 24.61 MI 3.0 A 0.74 DV 8.63		12.31 1.25 0.15 20.83	6.15 4.50 0.28 37.50		9.23 3.33 0.31 41.67			0.086
TOTAL	1453	303	556	P 20.9 MI 1.83 A 0.38 DV ----	4.198 1.72 0.07 18.88	9.22 1.44 0.13 34.71	5.29 1.70 0.09 23.56	1.789 1.23 0.02 5.76	2.62 1.66 0.04 11.33	1.51 1.45 0.02 5.76		--------

Table 5 Prevalence (P=%), Mean Intensity (MI), Abundance (A), Dominance value (DV) and proportion of metazoan parasites in different families of freshwater fishes of Vizianagaram, Andhra Pradesh

Fish species/Family	Number examined	Number infected	Number of parasites	Total	Monogenea	Digenea	Larval Trematode	Cestoda	Acanthocephala	Copepoda	Proportion
Cyprinidae	423	58	96	P 13.7 MI 1.66 A 0.23 DV 17.27	7.57 1.56 0.12 52.08	3.78 1.63 0.06 27.08				3.78 1.25 0.05 20.83	0.17
Notopteridae	22	04	06	P 18.2 MI 1.5 A 0.27 DV 1.08		18.2 1.5 0.27 100					0.01
Mastacembelidae	304	89	144	P 29.3 MI 1.62 A 0.47 DV 25.9		14.47 1.41 0.20 43.06	17.11 1.35 0.23 48.61	3.29 1.20 0.04 8.33			0.26
Siluridae	120	16	30	P 13.3 MI 1.88 A 0.25 DV 5.40	8.33 1.8 0.15 60.0					5.0 2.0 0.10 40.0	0.05
Bagridae	265	45	72	P 17.0 MI 1.60 A 0.27 DV 12.95	7.17 1.95 0.14 51.39	10.94 1.21 0.13 48.61					0.13
Saccobranchidae	22	06	08	P 27.3 MI 1.33 A 0.36 DV 1.44			27.3 1.33 0.36 100.0				0.01
Clariidae	70	24	42	P 34.3 MI 1.75 A 0.6 DV 7.55		18.57 1.69 0.31 52.38		22.86 1.25 0.29 47.62			0.08
Ophiocephalidae	162	45	110	P 27.8 MI 2.44 A 0.68 DV 19.78		12.35 1.6 0.20 29.09	9.26 2.33 0.22 31.81		19.75 1.34 0.27 39.09		0.20
Gobiidae	65	16	48	P 24.6 MI 3.0 A 0.74 DV 8.63		12.31 1.25 0.15 20.83	6.15 4.50 0.28 37.50		9.23 3.33 0.31 41.67		0.09
TOTAL	1453	303	556	P 20.9 MI 1.83 A 0.38 DV ----	4.20 1.72 0.07 18.88	9.22 1.44 0.13 34.71	5.30 1.70 0.09 23.56	1.79 1.23 0.02 5.76	2.62 1.66 0.04 11.33	1.51 1.45 0.02 5.76	

Table 6 Community characteristics of metazoan parasites of 15 species of freshwater fishes of Vizianagaram district, Andhra Pradesh

Parameters	Fish Families/species																		Grand Total
	Cyprinidae					Notopteridae	Mastacembelidae			Siluridae			Bagridae		Sacco-branchidae	Clariidae	Ophio-cephalidae	Gobiidae	
	Cc	Cm	Lr	Cy.c	Total	Nn	Ma	Mac	Mp	Total	Wa	Mv	Ss	Total	Hf	Cb	Cp	Gg	
Number examined	150	54	140	79	423	22	132	128	44	304	120	125	140	265	22	70	162	65	1453
Number infected	24	-	18	16	58	04	42	35	12	89	16	25	20	45	06	24	45	16	303
Total no. of parasites(N)	32	--	38	26	96	06	63	67	14	144	30	39	33	72	08	42	110	48	556
No. of species of parasites (S)	01	-	02	01	03	01	04	04	01	06	02	02	02	02	01	02	04	03	23
No. of taxa of parasites (K)	01	-	02	01	03	01	02	01	01	02	02	02	02	02	01	02	02	02	05
Prevalence (%)	16	-	12.9	20.3	13.7	18.2	31.8	27.3	27.3	29.3	13.3	20	14.3	17.0	27.3	34.3	27.8	24.6	20.9
Mean Intensity(MI)	1.33	-	2.11	1.63	1.66	1.5	1.5	1.91	1.17	1.62	1.88	1.56	1.65	1.60	1.33	1.75	2.44	3.0	1.83
Abundance (A)	0.21	-	0.27	0.33	0.23	0.27	0.48	0.52	0.32	0.47	0.25	0.31	0.24	0.27	0.36	0.6	0.68	0.74	0.38
Proportion of parasites	0.06	-	0.07	0.05	0.17	0.01	0.11	0.12	0.03	0.26	0.05	0.07	0.06	0.13	0.01	0.08	0.20	0.09	
Dominance index (DI)	1.0	-	0.50	1.0		1.0	0.37	0.50	1.0		0.52	0.51	0.50		1.0	0.50	0.34	0.36	

Cc C.catla Cm C.mrigala Lr L.rohita Cyc.Cy.carpio Nn N.notopterus Ma M.armatus Mac M.aculeatus Mp M.pancalus Wa W.attu Mv M.vittatus Ss S.seenghala Hf H.fossilis Cb C.batrachus Cp C.punctatus Gg G.giurus

In the other families MI varied between 2.44 and 1.5. The highest proportion of metazoan parasites was recorded in Mastacembelidae (0.26) followed by Ophiocephalidae (0.20), Cyprinidae (0.17) and Bagridae (0.13). The lowest proportion was noted in Notopteridae (0.01) and Saccobranchidae (0.01). In Gobiidae it was 0.09, in Clariidae 0.08 and in Siluridae 0.05.

Community structure of metazoan parasite fauna in different species of fishes

The results are shown in Table 6. Each host species had a characteristic assemblage or community of parasites, which differed in several respects among the host species. Of the 15 host species, three (*M. armatus, M. aculeatus* and *C. punctatus*) harboured four parasite species each and *C. mrigala* harboured none.

Table 7 Community characteristics of metazoan parasites of nine families of freshwater fishes of Vizianagaram district, Andhra Pradesh

Parameters	Cyprinidae	Notopteridae	Mastacembelidae	Siluridae	Bagridae	Saccobranchidae	Clariidae	Ophiocephalidae	Gobiidae	Total
Number examined	423	22	304	120	265	22	70	162	65	1453
Number infected	58	04	89	16	45	06	24	45	16	303
Total no. of parasites (N)	96	06	144	30	72	08	42	110	48	556
No. of species of parasites (S)	03	01	06	02	02	01	02	04	03	23
No. of taxa of parasites (K)	03	01	02	02	02	01	02	02	02	05
Prevalence (%)	13.7	18.2	29.3	13.3	17.0	27.3	34.3	27.8	24.6	20.9
Mean Intensity (MI)	1.66	1.5	1.62	1.88	1.60	1.33	1.75	2.44	3.0	1.83
Abundance (A)	0.23	0.27	0.47	0.25	0.27	0.36	0.6	0.68	0.74	0.38
Proportion of parasites	0.17	0.01	0.26	0.05	0.13	0.01	0.08	0.20	0.09	
Dominance index (DI)	0.39	1.00	0.43	0.52	0.50	1.00	0.50	0.34	0.36	

In the other hosts species, the number of parasite species varied between one and three. Most of the host species harboured two parasite species. In *L. rohita* and *W. attu* (Monogenea, Copepoda) *M. armatus* and *C. batrachus* (Digenea, Cestoda), *M. vittatus* and *S. seenghala* (Monogenea, Digenea) *C. punctatus* and *G. giurus* (Digenea, Acanthocephala) the parasite fauna was constituted by two major taxa of parasites.

C. catla, C. carpio, *N. notopterus, M. pancalus* and *H. fossilis* which harboured only one species of parasite, dominance index was the highest (1.0). In the above host species digeneans were a very dominant component constituting 78.6% of the total number of parasites except in *C. catla* where monogeneans dominated. DI was almost similar in *L. rohita* (0.50), *M. aculeatus* (0.50), *W. attu* (0.52), *M. vittatus* (0.51), *S. seenghala* (0.50) and *C. batrachus* (0.50). In *L. rohita* and *W. attu* ectoparasites, in *M. aculeatus*, *M. vittatus*, *S. seenghala* and *C. batrachus* digeneans dominated in the parasite fauna.

In *M. armatus, G. giurus* and *C. punctatus* DI recorded comparatively low values (0.37, 0.36 and 0.34 respectively) and in these species the parasite fauna were comparatively homogeneous.

Qualitative similarity of the parasite fauna of the host fishes (Table 8) showed that there was relatively high similarity between the parasite fauna of *M. vittatus* and *S. seenghala* (Jaccard index = 100) as also between those of *C. catla* and *L. rohita* (Jaccard index = 50.0). Of the two species of parasites encountered in *M. vittatus* and *S. seenghala* two were shared by the two hosts. Similarly, one species of parasites harboured by *C. catla* and *L. rohita* was shared by them. Only relatively lesser similarity was noted in the parasite fauna of the *M. aculeatus* and *M. pancalus* (Jaccard Index = 25.0), though four species of parasites were encountered in them only one species was shared by them.

Table 8 Parasite species overlap in different species of freshwater fishes of Vizianagaram district, Andhra Pradesh

Fish Species		S	Lr	Cy.c	Nn	Ma	Mac	Mp	Wa	Mv	Ss	Hf	Cb	Cp	Gg
Catla catla	(Cc)	1	1 (50.0)	0	0	0	0	0	0	0	0	0	0	0	0
Labeo rohita	(Lr)	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprinus carpio	(Cyc)	1		0	0	0	0	0	0	0	0	0	0	0	0
Notopterus notopterus	(Nn)	1			0	0	0	0	0	0	0	0	0	0	0
Mastacembelus armatus	(Ma)	4				0	2 (33.3)	0	0	0	0	0	0	0	0
Macrognathus aculeatus	(Mac)	4					0	1 (25.0)	0	0	0	0	0	0	0
Macrognathus pancalus	(Mp)	1						0	0	0	0	0	0	0	0
Wallago attu	(Wa)	2							0	0	0	0	0	0	0
Mystus vittatus	(Mv)	2								0	2 (100)	0	0	0	0
Sperata seenghala	(Ms)	2									0	0	0	0	0
Heteropneustes fossilis	(Hf)	1										0	0	0	0
Clarias batrachus	(Cb)	2											0	0	0
Channa punctatus	(Cp)	4												0	1 (16.6)
Glossogobius giurus	(Gg)	3													0

Table 9 Parasite species overlap in different families of freshwater fishes of Vizianagaram district, Andhra Pradesh

Fish Family	No. of species of parasites (S)	Cyprinidae	Notopteridae	Mastacembelidae	Siluridae	Bagridae	Saccobranchidae	Clariidae	Ophiocephalidae	Gobiidae
Cyprinidae	03		0	0	0	0	0	0	0	0
Notopteridae	01			0	0	0	0	0	0	0
Mastacembelidae	06				0	0	0	0	0	0
Siluridae	02					0	0	0	0	0
Bagridae	02						0	0	0	0
Saccobranchidae	01							0	0	0
Clariidae	02								0	0
Ophiocephalidae	04									1 (16.6)
Gobiidae	03									

Community ecology of metazoan parasite fauna in different families of fishes

The highest prevalence of metazoan parasitic infection was in Clariidae (34.3%) and the lowest in Siluridae (13.3%). However, the highest number of species of parasites was recorded in Mastacembelidae (6 belonging to two major taxa) and the lowest in Notopteridae and Saccobranchidae (1). Ophiocephalidae harboured four species of parasites belonging to two major taxa, Cyprinidae was infected with three species belonging to three major taxa, Gobiidae with three species belonging to two major taxa, Siluridae, Bagridae and Clariidae harboured two species belonging to two major taxa. In Mastacembelidae, the parasite fauna was predominated by adult and larval Digeneans (five species), whereas the most assorted fauna of parasites was in Cyprinidae. Mean intensity recorded the highest in Gobiidae (3.0) followed by Ophiocephalidae (2.44), Saccobranchidae recorded the lowest MI (1.33). In the other families MI varied between 1.5 and 1.88 (Table 5). Dominance index recorded high for Notopteridae and Saccobranchidae (1). In these cases adult Digenea (DV = 100%) and larval trematodes (100%) only occurred. No other taxa of parasites recorded (Table 7). Analysis of parasitie species overlap in different host families showed that the parasite species were qualitatively less similar in Ophiocephalidae and Gobiidae (Jaccard index = 16.6) (Table-9).

DISCUSSION

Overall nature of parasitic infections

Interspecific and interfamilial comparisons of metazoan parasitic fauna revealed that both prevalence and mean intensity were higher in carnivorus/omnivorus species/families indicating the importance of feeding habit in determining the parasitic fauna in them. Carnivorous fishes more prone to parasitic infections as they have high probability of acquiring parasites, particularly heteroxenous forms than the herbivorous forms, which because of the restriction in food, do not have chances of acquiring more infections nor more varied fauna of parasites.

Community ecology of metazoan parasite fauna

Compared to the parasite fauna of birds and mammals, species richness and mean intensity of parasites in freshwater fishes is more diverse but their parasite diversity is less compared to their marine counterparts (Kennedy *et al.,* 1986). The present study is in total agreement with these 2 contentions as only 23 species were encountered from these 14 species of fishes as against more than thousand species from different species of marine fishes (Madhavi, 2011) from the same geographical area. In this context, it is to be noted that the component community (=local parasite fauna) is influenced by several factors and there could be even temporal differences in the nature of compound communities (Holmes, 1990). According to Esch *et al.,* (1998); Hartvigsen and Kennedy, (1993); Kennedy, (1993); Beevi and Radhakrishnan (2012) who showed that parasitic communities of freshwater fishes are basically stochastic assemblages established by events like chance introduction, colonization and extinction of parasites in a given region. Carnivorous forms of the family Mastacembelidae, Ophiocephalidae, Saccobranchidae harboured richer parasite faunas than predominantly herbivorous forms. Moreover, distribution of parasite species was somewhat homogenous than in herbivorous. Predominance of helminthic infection in the parasitic communities was observed by Radhakrishnan and Nair (1980) and Biju Kumar (1996a) and the present study concur with their views showing 86.9% of helminthic infection in the freshwater fishes of Vizianagaram district.

Qualitative similarity of parasite fauna

High qualitative similarity of the parasite fauna has been noticed for the two herbivorous species, *C. catla* and *L. rohita,* for the two bagrids, *S. seenghala* and *M. vittatus* which support the fact that the feeding habits of the host species plays a very crucial role in shaping the parasite fauna of the host. However, the parasite fauna of closely related species, *M. aculeatus*, *M. armatus* and *M. pancalus* and *Ophiocephalus punctatus* and *Glossogobius giurus* showed very less resemblance in their parasite fauna and the causes for the observed variation of the parasitic fauna of closely allied host species are beyond comprehension. This observation is supporting the views of Biju Kumar (1996b) who also reported the variation in species composition between the two closely related Asian cichilids, *Etroplus suratensis* and *E.maculatus*.

CONCLUSION

Metazoan parasite fauna of the freshwater fishes of Vizianagaram District is very poor and less diverse which might be due to geographical variations in a given area. The present study gives a better picture of the community ecology of the metazoan parasites in the freshwater fishes by providing a host-parasite database to the future taxonomists.

Conflict of Interest

The authors declare that they have no conflict of interest related to the work.

Acknowledgements

The First author, G. Mani is grateful to UGC for providing the financial assistance as Principal investigator for Minor Research Project F.No.4-4/2013-14(MRP-SEM/UGC-SERO) dt.17.03.2014.

Author's Contribution

The first author, GM was involved in collecting the fish samples and parasites, literature collection while the second author, APV was involved in conducting statistical analysis, write-up and drafting of the manuscript.

Significance Statement: This study discovers the fact that the parasitic community structure of the freshwater fish species of the Vizianagaram, District, Andhra Pradesh showed less species diversity and strong similarity of species composition among the closely related fish species. However, the species diversity in freshwater fishes was very less compared to their marine counterparts. This study will help the future researchers to analyze the parasitic community structure of these freshwater fishes in detail.

References

1. Miltermeier, R.A., Robles-Gil, P and Miltermeier, C.G. (1997). Megadiversidad los paises biologicamente mas ricos del mundo. CEMEX, Mexico.
2. Sarkar, U.K., Pathak, A.K and Lakra, W.S. (2008). Conservation of freshwater fish resources of India: New approaches, assessment and challenges. *Biodiversity and Conservation,* 17: 2495-2511 pp.
3. Iyaji, F.O and Eyo, J.E. (2008). Parasites and their freshwater fish host. Bio-Research, 6 (1): 328-338.
4. Bichi, A.H., Dawaki, S.S. (2010). A survey of the ectoparasites on the gills, skin and fins of *Oreochromis niloticus* at Bagauda fish farm, Kano, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 3 (1): 83-86.
5. Ekanem AP, Eyo VO and Sampson AF. (2011). Parasites of landed fish from great Kwa River, Calabar, Cross River State, Nigeria. *International Journal of Fisheries and Aquaculture*, 3 (12): 225-230.
6. Bichi, A.H and Yelwa, S.I. (2010). Incidence of piscine parasites on the gill and gastrointestinal tract of *Clarias gariepinus* (Teugels) at Bagauda fish farm, Kano. *Bayero Journal of Pure and Applied Sciences*, 3 (1): 104-107.
7. Hassan, A.A., Akinsanya, B and Adegbaju WA. (2010). Impacts of helminth parasites on *Clarias gariepinus* and *Synodontis clarias* from Lekki Lagoon, Lagos, Nigeria. Reports and Opinions, 2 (11): 42-48.
8. Echi, P.C., Eyo, J.E and Okafor, F.C. (2009 a). Co-parasitism and morphometrics of three clinostomatids (Digenea: Clinostomatidae); in *Sarotherodon melanotheron* from a tropical freshwater lake. *Animal Research International,* 6 (2): 982-986.
9. Echi, P.C., Okafor, F.C and Eyo, J.E. (2009 b). Co-infection and morphometrics of three clinostomatids (Digenea: Clinostomatidae); in *Tilapia guinensis* Bleeker, 1862 from Opi lake, Nigeria. Bio-Research, 7 (1): 432-436.
10. Nmor, J.C., Egwunyenga, A.O and Ake, J.E.G. (2004). Observation of the intestinal helminth parasites of cichlid in the upper reaches of River Orogodo, a freshwater body in Delta State, Southern Nigeria. Tropical Freshwater Biology, 13: 131-136.
11. Malan, F.S., Horak, I.G., De Vos, V and Van Wyk, J.A. (1997). Wildlife parasites: Lessons for parasite control in livestock. *Veterinary Parasitology*, 71: 137-153. CrossRef, PubMed.
12. Marcogliese, D.J. (2004). Parasites: small players with crucial roles in the ecological theatre. EcoHealth, 1: 151-164.
13. Hatcher, M.J., Dick, J.T.A and Dunn, A.M. (2006). How parasites affect interactions between competitors and predators. *Ecol. Letters*, 9: 1253-1271.
14. Vignon, M and Sasal P. (2010). Fish introduction and parasite in marine ecosystems: A need for information. *Environmental Biology of Fishes* 87: 1-8.
15. Kennedy, C.R. (1976). Ecological aspects of parasitology. North Holland Publ. Co., Amsterdam.
16. Holmes, J.C. (1973). Site selection by parasitic helminthes. Interspecific interactions, site segregation and their importance to the development of helminth communities. *Can. J. Zool*., 51: 333-347.
17. Dogiel, V.A. (1964). General Parasitology. Leningrad University Press, Oliver and Boyd, London.
18. Williams, H and Jones, A. (1994). Parasitic worms of fish, Taylor and Francis, Bristol, UK 593.
19. Khalil, L.F and Polling, K. (1997). Checklist of the Helminth Parasites of African Freshwater Fishes. Uni. of the North Department of Zoology. Republic of South Africa, 184.
20. Pe´rez-Ponce de Leo´n, G and Choudhury, A. (2005). Biogeography of helminth parasites of freshwater fishes in Mexico: the search for patterns and processes. *Journal of Biogeography*, 32: 645-659.
21. Nelson, P.A and Dick, T.A. (2002). Factors shaping the parasite communities in trout-perch, *Percopsis omiscomaycus* Walbaum (Osteichthyses: Percopsidae), and the importance of scale. *Canadian Journal of Zoology*, 80: 1986-1999.
22. Johnson, M.W., Nelson, P.A and Dick, T.A. (2004). Structuring mechanisms of yellow perch (*Perca flavescens*) parasite communities: host age, diet and local factors. *Canadian Journal of Zoology*, 82: 1291-1301.
23. Madhavi, R and Rukmini, C. (1992). Population biology of *Posthodiplostomum glayii* (Verma, 1936) (Trematoda: Diplostomidae) in the larvivorous fish, *Aplocheilus panchax. Acta Parasitologica*, 37 (4): 183-188.
24. Muralidhar, A. (1989). Seasonal variation of helminth parasites in marine fishes at East coast of India. *Ind. J. Helminthol,* 41(1): 1-4.
25. Satyanarayana, M.C. (1982). Incidence of trematode parasite *Paraplerurus sauridae*, in relation to season, sex and length of the marine fish, *Saurida undosquamis*. *Ind. J. of the Mar. Sci,* 11(2): 188-189.
26. Madhavi, R and Sairam, B.K. (2000). Community structure of helminth parasites of the tuna, *Euthynnus affinis* from the Visakhapatnam coast, Bay of Bengal. *J. of Helminthol,* 74: 337-342.
27. Dhole, J., Jawale, S., Waghmare, S and Chavan, R.R. (2010). Survey of helminth parasites in freshwater fishes from Marathwada region, MS, India. *Journal of Fisheries and Aquaculture*, 1 (1): 01-07.
28. Alves, D.R and Luque, J.L. (2001). Community ecology of the metazoan parasites of white croaker, *Micropogonias furnieri* (Osteichthyes: Sciaenidae) from coastal zone of Rio de Janeiro, Brazil. Memoras do Institute Oswaldo Cruz. , 96 (2): 145-153.
29. Salgado-Maldonado, G., Cabañas-Carranza, G., Caspeta-Mandujano, J.M., Soto-Galera, E., Mayen-Pena, E., Brailovsky, D and Baezvale, R. (2001). Helminth parasites of freshwater fishes of the Balsas river drainage basin of southwestern Mexico. Comparative Parasitology, 68: 196-203.
30. Salgado-Maldonado, G., Mercado-Silva, N., Cabañas-Carranza, G., Caspeta- Mandujano, J., Aguilar-Aguilar, R and Iñiguez-Dávalos, I. (2004). Helminth Parasites of Freshwater Fishes of the Ayuquila River, Sierra de

Manantlán Biosphere Reserve, West Central Mexico. *Comparative Parasitology*, 71 (2): 67-72.
31. Luque, J.L., Alves, D.R and Ribeiro, R.S. (2003). Community ecology of the metazoan parasites of Banded croaker, *Paralonchurus brasiliensis* (Osteichthyes: Sciaenidae), from the coastal zone of the state of Rio de Janeiro, Brazil. *Acta Scientiarum, Biological Science, Moringa*, 25 (2): 273-278.
32. Takemoto, R.M., Pavanelli, G.C., Lizama, M.A., Luque, J.L and Poulin, R. (2005). Host population density as the major determinant of endoparasite species richness in floodplain fishes of the upper Parana River, Brazil. *Journal of Helminthology*, 79: 75-84.
33. Avenant-oldewage, A and Knight, E. (2008). Aspects of the ecology of *Chonopeltis australis* Boxshall, 1976 in Boskop Dam, North West Province. *South African Journal of Wildlife Research*, 38 (1): 28-34.
34. Mwita, C and Nkwengulila, G. (2008). Determinants of the parasite community of Clariid fishes from Lake Victoria, Tanzania. *Journal of Helminthology.,* 82: 7-16.
35. Zetlmeisl, C. M. (2011). Host-parasite interactions in the European shore crab *Carcinus maenas* and their implications for the invasion success of this introduced species. Doctor of Science, Karlsruhe Institute of Technology, Karlsruhe, Germany.
36. Vankara, A.P and Vijayalakshmi, C. (2013). Population dynamics of cestode, *Circumonchobothrium shindei* (Cestoda: Pseudophyllidea Carus, 1863) in the freshwater eel, *Mastacembelus armatus* Lacèpéde 1800 from River Godavari, Rajahmundry. Online first publication in *Journal of Parasitic diseases* (July, 2013) Springerlink Journal.
37. Vankara, A.P and Chikkam, V. (2015). Community structure analysis metazoan parasites of *Channa punctatus* (Bloch, 1800) from Meghadrigedda Reservoir of Visakhapatnam District, Andhra Pradesh. *Journal of Advances in Parasitology,* 2 (3): 57-64, Nexus Academic Publications.
38. Vankara, A.P., Hemalatha, M., Srinivasa Kalyan, C and Vijayalakshmi, C. (2014). Metazoan parasite fauna of *Clarias batrachus* (Linn.) of River Godavari with description of a new species of digenean, *Phyllodistomum batrachii* sp.nov. *Acta Biologica Indica*, 3(1): 593-604, 2014. pISSN 2319-1244; eISSN 2279-0160.
39. Vankara, A.P., Gudivada, M and Vijayalakshmi, C. (2016). Lernaeid Copepod Parasitic on the Freshwater Fishes of Godavari River, Rajahmundry, Andhra Pradesh, India with description of a new Species, *Lernaea notopteri* n.sp. from *Notopterus notopterus*. Journal of Applied Life Sciences International, SCIENCEDOMAIN international, 9(3):1-13.
40. Vankara, A.P and Vijayalakshmi, C. (2015). Community structure analysis metazoan parasites of *Channa punctatus* (Bloch, 1800) from Meghadrigedda Reservoir of Visakhapatnam District, Andhra Pradesh. *Journal of Advances in Parasitology*, 2 (3): 57-64.
41. Gudivada, M., Anu prasanna, V and Vijayalakshmi, C. (2012). Population dynamics of metazoan parasites of marine threadfin fish, *Eleutheronema tetradactylum* (shaw, 1804) from Visakhapatnam coast, Bay of Bengal. *Cibtech Journal of Zoology* ISSN: 2319-3883 (Online) An Online International Journal Available at http://www.cibtech.org/cjz.htm 2012 Vol. 1 (1) May-Aug 12, pp.14-32.
42. Gudivada, M., Vankara, A.P and Chikkam, V. (2017). Metazoan ectoparasites of Edible Freshwater fishes of Vizianagaram District, Andhra Pradesh, India. Journal of Applied Life Sciences International, SCIENCEDOMAIN International, 10 (1): 1-10.
43. Rao, J.C.S., Simhachalam, G and Raju, C.S. (2013). A study on ichthyofaunal diversity, conservation status and anthropogenic stress of river Champavathi, Vizianagaram District (AP) India. *Asian Journal of Experimental Biological Sciences,* 4 (3): 418-425.
44. Ramaneswari, K and Sridhar, D. (2015). A typical study on fish faunal biodiversity of Thotapalli and Gotta reservoirs of Vizianagaram and Srikakulum districts of Andhra pradesh, India. *International Journal of Recent Scientific Research,* 6 (4): 3529-3533.
45. Sujana, M and Shameem, U. (2015). Monogenoidean parasites of some cyprinid fishes from North Coastal Andhra Pradesh. *International Journal of Recent Scientific Research*, 6 (3): 3147-3155.
46. Jayaram, K.C. (1999). The freshwater fishes of the Indian region. Narendra Publishing House, Delhi, pp. XXVII + 551.
47. Talwar, P.K and Jhingran, A.G. (1991). Inland Fishes of India and adjacent countries-Oxford and IBH publishing Co. Pvt. Ltd., N. Delhi, 2 volumes: XIX + 1158.
48. Nath, P and Dey, S.C. (2000). Fish and fisheries of North Eastern India (Arunachal Pradesh). New Delhi. Narendra Publishing House, pp. 217
49. Paperna, I. (1996). Parasites, infection and diseases of fishes in Africa-an update. CIFA Tech Paper, 31: 1-200.
50. Snedecor, W.G and Cochran, G.W. (1967). Biostatistical methods. 593pp, 6th edition, IOWA, IOWA State University press.
51. Sundara Rao, P.S.S and Richard, F. (1996). An introduction to Biostatistics. A manual for students in Health Sciences. Prentice- Hall of India Pvt. Ltd., New Delhi.
52. Daniel, W.W. (1998). Biostatistics: A foundation for analysis in the Health Sciences (VIII th Edition), John wiley & Sons Int., New York.
53. Leong, T.S and Holmes, J.C. (1981). Communities of metazoan parasites inopen water fishes of Cold Lake. Alberta J Fish Dis, 18: 693-713
54. Kennedy, C.R., Bush, A.O and Aho, J.M. (1986). Patterns in helminth communities: why are birds and fish different? *Parasitology*, 93: 205-215.
55. Madhavi, R. (2011). Checklist of digenean trematodes reported from Indian marine fishes. Systematic Parasitology, 78: 163-232. DOI 10.1007/S11230-010-92872.
56. Holmes, J.C. (1990). Helminth communities in marine fishes. In: Esch GW, Bush AO, Aho JM (eds) Parasite communities: patterns and processes. Chapman and Hall, London, pp 101-130.
57. Esch, G.W., Kennedy, C.R., Bush, A.O and Aho, J.M. (1988). Patterns in helminth communities in freshwater

fish in Great Britain: alternative strategies for colonization. *Parasitology*, 96: 519-532.
58. Hartvigsen, R and Kennedy, C.R. (1993). Patterns in the composition and richness of helminth communities in brown trout, *Salmo trutta*, in a group of reservoirs. *J Fish Biol,* 43: 603-615.
59. Kennedy, C.R. (1993). The dynamics of intestinal helminth communities in eels, *Anguilla anguilla*, in a small stream: long-term changes in richness and structure. *Parasitology*, 107: 71-78.
60. Beevi, M.R and Radhakrishnan, S. (2012). Community ecology of metazoan parasites of freshwater fishes of Kerala. *Journal of Parasitic Diseases*, 36 (2): 184-196.
61. Radhakrishnan, S and Nair, N.B. (1980). On the metazoan parasites associated with fishes along the South-west coast of India. *J Mar Biol Ass India*, 22: 21-38.
62. Biju kumar, A. (1996a). Studies on the metazoan parasite communities associated with the flatfishes (Order: Pleuronectiformes) of the southwest coast of India. *Riv Parassit*, 13: 251-269.
63. Biju kumar, A. (1996b). Comparison of the metazoan parasite faunas of *Etroplus suratensis* (Bloch) and *E. maculatus* (Bloch) in India. *Riv Parassit*, 13: 115-124.

How to cite this article:

Mani Gudivada and Anuprasanna Vankara.2017, Community Structure of Metazoan Parasites of Freshwater Fishes of Vizianagaram District, Andhra Pradesh, India. *Int J Recent Sci Res.* 8(10), pp. 21051-21060.
DOI: http://dx.doi.org/10.24327/ijrsr.2017.0810.1006

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