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ECTOPARASITIC COMMUNITY ECOLOGY OF FRESHWATER FISHES OF RIVER PENNA, YSR KADAPA DISTRICT, ANDHRA PRADESH, INDIA

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Abstract: A total of 18 freshwater fish species (n= 859) belonging to 10 families from River Penna, Andhra Pradesh were examined for metazoan ectoparasites from July 2017 to June 2019, of which only 12 fish species were infected with at least one parasitic species. The mean prevalence of infection was 63.9%, the average abundance was 13.9 parasites per fish due to very heavy infestation of some parasites. Prevalence of infection in these 12 infected fishes ranged from 98.9% *(Wallago attu*) to 30% (*Salmostoma bacaila*) and mean intensity from 44.3 (*Oreochromis niloticus*) to 1.0 (*Glossogobius giurus*). The infra and component communities of parasites were fairly peculiar. The dominance pattern of the major taxa was in the order Monogenea > Copepoda > Isopod. Siluridae (*W. attu*) showed the richest parasite fauna (n=5) followed by Bagridae (*M. vittatus*, n= 3) and Cichlidae (*O. niloticus*, n= 3) whereas 09 infected fish species showed very poor fauna. The parasite fauna of *W. attu* was the most heterogeneous while the remaining fish species were the most homogenous. The results specify that the freshwater fishes of River Penna harbour a poor and less diverse species. The results also put forward the fact that the lesser scales on the body of carnivorous fishes enable the ectoparasites to penetrate the skin and gills more easily.

Keywords: Dominance index, Ectoparasites, Jaccard index, Penna River, Richness index.

INTRODUCTION

Fishes are exclusively aquatic animals with streamlined body and rich in different types of nutrients (Kumar *et al.,* 2020; Verma and Prakash, 2020, Syed *et al.,* 2020). They get infection from various kinds of parasites frequently. Parasite fauna of marine fishes of the East coast of India is well studied (Madhavi and Rukmini, 1992; Vankara *et al.,* 2006, 2007a, 2007b; Madhavi and Sairam, 2000; Gudivada and Vankara, 2010; Madhavi, 2011; Madhavi and Lakshmi, 2012; Kritsky *et al.,* 2012; Gudivada *et al.,* 2013). But only a handful of work is contributed on parasites of freshwater fishes from different fresh water bodies such as Godavari River (Vankara and Chikkam, 2009, 2010, 2015a, 2015b, 2017; Vankara *et al.,* 2011, 2014, 2016; Gudivada and Vankara, 2017; Vankara, 2018a), Penna River (Modi and Vankara, 2018, 2019, 2021) and Yamuna River etc. (Prakash and Verma, 2017, 2020). Marine fishes are usually thought to harbour more diverse and richer parasite fauna than freshwater fishes (Sindermann, 1990; Rohde, 1993). Parasite fauna of omnivorous/ carnivorous fishes are reported to be richer and more diverse than that of herbivorous fishes (Zaman and Leong, 1987; Wierzbicka, 1991; Kennedy, 2009; Beevi and Radhakrishnan, 2012;

Gudivada and Vankara, 2017; Vankara, 2018b). Earlier surveys from River Penna have focused mainly on Icthyofaunal diversity and taxonomy (Indra *et al.,* 2011). At present, very few records of parasitic helminths in the study area were documented (Modi and Vankara 2018, 2019, 2021). The present study is an attempt to carry out the community characteristics of the ectoparasite fauna of 18 species of freshwater fish of river Penna, YSR Kadapa, Andhra Pradesh (A.P.) which would definitely add an informative data in the field of fishery research.

MATERIALS AND METHODS

Study Area

Penna River is a seasonal river flowing through YSR district and is gifted with many tributaries such as Chitravathi, Kunderu, Papaghni, Sagileru and Cheyeru. The Penna basin extends an area of 55,213 sq km and covers areas in the states of Karnataka and Andhra Pradesh. The 597 km long river spans about 61 km are in Karnataka and 536 km is in Andhra Pradesh. The fishes were entirely procured from local fishermen from the three sampling sites of River Penna *i.e.,* Site 1: Mylavaram Reservoir across the Penna River in Mylavaram village (Lat.14° 0' 150"N 78° 20 40" E longitude), located in YSR Kadapa District of Andhra Pradesh; Site 2: Aadinimmayapalle Dam across the Penna River in Chennur Village (Lat.14"34'0.12"N, 78"48' 0"E longitude), YSR Kadapa District and Site 3: Backwaters of Somasila reservoir across the Penna River in Somasila village (14°29'22" N 79°18'19"E) SPSR Nellore, near Vontimitta Village, YSR Kadapa District.

Fish collection and identification

Fishes collected from the River Penna and various fish markets in and around the river in different seasons during July, 2017 - June, 2019 using various varieties of 'Nets and Gears' with the help of local fishermen folk were scrutinized for ectoparasites. Fishes were systematically washed, photo-graphed in fresh condition and preserved in 9-10% formalin solution (Jayaram, 1999) for further identification. However, the abdomen of the larger fishes was dissected to remove the gut contents before preservation. Reference books were followed to identify the fish species (Talwar and Jhingran, 1991; Jayaram, 1999; Nath and Dey, 2000).

Ectoparasitofauna analysis

External surface of the fish was clearly examined using a hand lens for ectoparasitic species and crustaceans. Smear of scrapings from the skin, fins and gills were also examined for ectoparasites. Voucher specimens of fish and parasites were deposited in the Department of Zoology, Yogi Vemana University, Kadapa, Andhra Pradesh, India.

Data interpretation:

Qualitative and quantitative analysis of the data using various bio statistical parameters (prevalence, mean intensity, mean abundance, dominance value, proportion and dominance index) were done for total parasites, parasitic groups and also for individual parasitic genus. Statistical analyses were performed based on the various formulae provided by Leong and Holmes (1981).

1. Prevalence of infection (P) = Percentage of fish infected
2. Mean intensity of infection (MI) = Average number of parasite per infected fish
3. Abundance (A) = Percentage of each taxon of parasite per host species
4. Proportion (P) = Total no. of parasites in a host species (100 infected fishes/total number of parasite from all host fishes, calculated as Total MI × 100/(Σ Total MI × 100)
5. Dominance Value (DV) = No. of parasites in each major taxon in a host species or family/Total No. of parasites in that host species or family × 100)
6. Total number of parasites (N)
7. Number of species (S) and number of major taxonomic group (major taxa = K) of parasites.
8. Dominance index (DI) = $\Sigma (DV_i/100)^2$
9. Richness Index (RI) = $(S-1)/\log_e N$
10. Shannon Index of Diversity = SI = H = $\{(n\log_e n)-(\Sigma f_i \log_e f_{i)}\}$, where $n = \Sigma f_i$; f_i = DV of parasite taxa in a host species/family
11. Evenness Index (EI) = (Homogeneity = Relative Diversity) = $H/\log_e$, where H = Shannon Index of Diversity

12. Jaccard Index of species overlap (J) = {(100c)/(a+b)-c}, where, a = No. of species of parasites in host A; b = No. of species of parasites in host B; c = No. of species of parasites shared by hosts A and B.

RESULTS

The various fish species of different families examined, infected and the total number of fish examined and infected in each species are provided in Table 1. Tables 2, 3 and 4 exemplify the list of parasites and their distribution in host fishes and families. Tables 5 and 6 showed the general nature of ectoparasitic infection in different species and families of freshwater fishes. Tables 7 and 8 depicted the community characteristics of the ectoparasite fauna in different species and families of fishes respectively. Tables 9 and 10 correspondingly represented the parasite species overlap (= similarity of the parasite fauna) in different species and families of fishes. Ectoparasites occurred in only 12 species of the total 18 species of examined fishes. Of the 859 fishes examined, 63.9% harboured ectoparasites with an average of 14 ectoparasites per fish. Prevalence of infection was the highest in *Wallago attu* (98.9%) and the lowest in *Salmostoma bacaila* (30%).

On the whole, the carnivorous and omnivorous fish prevalence of infection was comparatively higher than in the predominantly herbivorous species. The highest MI of ectoparasites was noted in *Oreochromis niloticus* (44.3) and *Wallago attu* (34.1) and the lowest in *Glossogobius giurus* (1.00). Proportion of metazoan parasites registered the maximum in *O. niloticus* (0.2604) and *W. attu* (0.2004) and the least in *Glossogobius giurus* (0.0058) and *Labeo dyocheilus* (0.0094) (Table 5). Of the 12 species of fishes infected, monogeneans (74.2%) dominated the

Table 1: Catalogue of host fish species and families examined and number of fish infected during the study period, July 2017- June 2019 from River Penna, YSR Kadapa District.

Name of the host	No. of fishes examined	No. of fishes infected	Families
1. *Channa punctata* (Bloch,1793)	20	-	Channidae
2. *Cirrhinus cirrhosus* (Bloch, 1975)	15	-	Cyprinidae
3. *Cirrhinus ariza* (Buchmann, 1807)	40	38	Cyprinidae
4. *Glossogobius giurus* (Hamilton, 1822)	12	5	Gobidae
5. *Labeo calbasu* (Hamilton, 1822)	122	92	Cyprinidae
6. *Labeo catla* (Hamilton, 1822)	55	40	Cyprinidae
7. *Labeo rohita* (Hamilton, 1822)	57	39	Cyprinidae
8. *Labeo dyocheilus* (McClelland, 1839)	25	16	Cyprinidae
9. *Macrognathus aculeatus* (Bloch, 1786)	25	-	Mastacembelidae
10. *Mastacembelus armatus* (Lacepede, 1800)	45	41	Mastacembelidae
11. *Mystus vittatus* (Bloch, 1794)	70	54	Bagridae
12. *Notopterus notopterus* (Lacepede, 1800)	15	-	Notopteridae
13. *Oreochromis niloticus* (Linnaeus, 1758)	133	91	Cichlidae
14. *Piaractus brachypomus* (Cuvier, 1818)	10	-	Serrasalmidae
15. *Puntius sarana* (Hamilton, 1822)	40	33	Cyprinidae
16. *Salmostoma bacaila* (Hamilton, 1822)	20	6	Cyprinidae
17. *Wallago attu* (Bloch and Schneider, 1801)	95	94	Siluridae
18. *Xenentodon cancila* (Hamilton, 1822)	60	-	Belonidae
Total	**859**	**549**	

Table 2: Host-ectoparasite list collected during the study period, July 2017- June 2019.

Name of fish	Name of the ectoparasites	No. of parasites collected
1. *Channa punctata* (Bloch,1793)	-	-
2. *Cirrhinus cirrhosus* (Bloch, 1975)	-	-
3. *Cirrhinus ariza* (Buchmann, 1807)	*Dogeilus catlaius* (Jain, 1961) Gusev, 1976	385
4. *Glossogobius giurus* (Hamilton, 1822)	*Dactylogyrus pennari* n.sp	5
5. *Labeo calbasu* (Hamilton, 1822)	*Dactylogyrus fotedari* (Jain, 1960) Gusev, 1978	1623
6. *Labeo catla* (Hamilton, 1822)	*Dactylogyrus fotedari* (Jain, 1960) Gusev, 1978	401
	Dogeilus catlaius (Jain, 1961) Gusev, 1976	208
7. *Labeo rohita* (Hamilton, 1822)	*Paradactylogyrus catlaius* Thapar, 1948	256
8. *Labeo dyocheilus* (McClelland, 1839)	*Dactylogyrus lamellatus* Achmerow, 1952	25
9. *Macrognathus aculeatus* (Bloch, 1786)	-	-
10. *Mastacembelus armatus* (Lacepede, 1800)	*Mastacembelocleidus* bam (Tripathi,1959) Kritsky et al., 2004	14
	Ergasilus malnadensis Venkateshappa, Seenappa and Manohar, 1998	951
11. *Mystus vittatus* (Bloch, 1794)	*Cornudiscoides vittati* Dubey, Gupta and Agarwal,1992	119
	Bifurcohaptor indicus Jain, 1958	90
	Lamproglena hospetensis Manohar, Seenappa and Venkatappa, 1992	29
12. *Notopterus notopterus* (Lacepede, 1800)	-	-
13. *Oreochromis niloticus* (Linnaeus, 1758)	*Cichlidogyrus sclerosus* Paperna and Thurston, 1969	2245
	Cichlidogyrus tilapiae Paperna, 1960	725
	Scutogyrus longicornis (Paperna and Thurston, 1969) Pariselle and Euzet, 1995	1058
14. *Piaractus brachypomus* (Cuvier, 1818)	-	-
15. *Puntius sarana* (Hamilton, 1822)	*Dactylogyrus mrigali* Gusev, 1976	128
16. *Salmostoma bacaila* (Hamilton, 1822)	*Ancyrocephalus goshi* Gusev, 1976	14
17. *Wallago attu* (Bloch and Schneider, 1801)	*Thaparocleidus indicus* (Kulkarni, 1969) Lim, 1996	688
	Thaparocleidus wallagonia Jain, 1952	405
	Mizelleus indicus Jain, 1957	03
	Ergasilus malnadensis Venkateshappa, Seenappa and Manohar, 1998	2096
	Alitropus typus Milne-Edwards, 1840	10
18. *Xenentodon cancila* (Hamilton, 1822)	-	-
	Total	**11978**

Table 3: Distribution of ectoparasites in 18 species of freshwater fishes of River Penna, YSR Kadapa (√-Present).

Parasite species/ Group	*Channa punctatus*	*Cirrhinus cirrhosus*	*Cirrhinus ariza*	*Glossogobius giurus*	*Labeo calbasu*	*Labeo catla*	*Labeo robita*	*Labeo dyocheilus*	*Macrognathus aculeatus*	*Mastacembelus*	*Mystus vittatus*	*Notopterus*	*Oreochromis niloticus*	*Piaractus brachypomus*	*Puntius sarana*	*Salmostoma bacaila*	*Wallago attu*	*Xenentodon cancila*
MONOGENEA																		
Dogeilus catlaius			✓			✓												
Dactylogyrus pennari n.sp.				✓														
Dactylogyrus fotedari					✓	✓												
Paradactylogyrus catlaius							✓											
Dactylogyrus lamellatus								✓										
Mastacembelocleidus bam										✓								
Cornudiscoides vittati											✓							
Bifurcohaptor indicus											✓							
Cichlidogyrus sclerosus													✓					
Cichlidogyrus tilapiae													✓					
Scutogyrus longicornis													✓					
Dactylogyrus mrigali															✓			
Ancyrocephalus goshi																✓		
Thaparocleidus indicus																	✓	
Thaparocleidus wallagonia																	✓	
Mizelleus indicus																	✓	
COPEPODA																		
Ergasilus malnadensis										✓							✓	
L.hospetensis											✓							
ISOPODA																		
Alitropus typus																	✓	

ectoparasitic communities of these fishes, followed by Copepods (25.6%) and isopods (0.083%). The dominance pattern of the major taxa of metazoan parasites in freshwater fishes of this region was in the order, Monogenea> Copepoda> Isopoda (Table 3). Results of the family-wise comparison of parasitic infection (Table 6) showed that the highest prevalence of ectoparasitic infection was in Siluridae (98.9%) and the lowest in Gobidae (41.7%). Prevalences of infection in the other 4 families were Cyprinidae (70.6%), Mastacembelidae (58.6%), Bagridae (77.1%) and Cichlidae (68.4%) however, the other 4 families Channidae, Notopteridae, Serrasalmidae and Belonidae showed no infection. The highest MI was noted in Cichlidae (44.3) and the lowest in Gobiidae (1.0). In the other families MI varied between 4.4 and 34.1. The highest proportion of metazoan parasites was recorded in Cichlidae (0.3670) followed by Siluridae (0.2825), Mastacembelidae (0.1947), Cyprinidae (0.1110) and Bagridae (0.0365). The lowest proportion was noted in Gobiidae (0.0083).

Community structure of metazoan parasite fauna in different species of fishes:

Each host species had a characteristic assemblage or community of parasites, which differed in

Table 4: Distribution of ectoparasites in 10 families of freshwater fishes of River Penna, YSR Kadapa (√-present).

Parasite species/ Group	Channidae	Cyrinidae	Gobidae	Mastacembelidae	Bagridae	Notopteridae	Cichlidae	Serrasalmidae	Siluridae	Belonidae
MONOGENEA										
Dogeilus catlaius		✓								
Dactylogyrus pennari n.sp			✓							
Dactylogyrus fotedari		✓								
Paradactylogyrus catlaius		✓								
Dactylogyrus lamellatus		✓								
Mastacembelocleidus bam				✓						
Cornudiscoides vittati					✓					
Bifurcohaptor indicus					✓					
Cichlidogyrus sclerosus							✓			
Cichlidogyrus tilapiae							✓			
Scutogyrus longicornis							✓			
Dactylogyrus mrigali		✓								
Ancyrocephalus goshi		✓								
Thaparocleidus indicus									✓	
Thaparocleidus wallagonia									✓	
Mizelleus indicus									✓	
COPEPODA										
Ergasilus malnadensis				✓					✓	
L.hospetensis					✓					
ISOPODA										
Alitropus typus									✓	

several respects among the host species (Table 7). Of the 12 infected host species, *Wallago attu* harboured the maximum of 5 parasite species and in rest of the host fishes, the number of parasite species varied between one to three. *Mystus vittatus* and *Oreochromis niloticus* harboured three parasite species each. Most of the host species harboured only one parasitic taxa i.e., Monogenea (*Glossogobius giurus, Cirrhinus ariza, Labeo calbasu, L. rohita, L. dyocheilus, Puntius sarana, Salmostoma bacaila* and *Oreochromis niloticus*). The parasite fauna of *Mystus vittatus* and *Mastacembelus armatus* (Copepoda and Monogenea) was constituted by two major taxa of parasites. Similarly, only *W. attu* showed infection with all the three parasitic taxa (Copepoda, Monogenea and Isopoda). *M. armatus* (0.970) and *M. vittatus* (0.7859) showed the highest DIs whereas other hosts showed DI between 0.0026-0.113. The parasite fauna was the richest in *W. attu* (RI= 0.798), which harboured 5 species of parasites belonging to four genera, closely followed by *M. vittatus* (RI= 0.402) and *O. niloticus* (RI= 0.265) with three parasite species, *M. armatus* (RI= 0.101) with two parasite species and *Labeo calta* (RI= 0.108) only one species of parasites respectively. Of the 12 species of fish, only 5 species of fish portrayed the

Table 5: Prevalence (P= %), Mean Intensity (MI), Abundance (A), Dominance value (DV) and proportion of ectoparasites in different species of freshwater fishes of River Penna, YSR Kadapa.

Fish species/Family	Number examined	Number infected	Number of parasites	Total	Monogenes	Copepods	Isopods	Proportion
Family: Channidae								
Channa punctatus	20	0	0	-	-	-	-	-
Family: Gobiidae								
Glossogobius giurus	12	5	5	P 41.7	41.7			0.0058
				MI 1.0	1.0			
				A 0.4	0.4			
				DV 0.04	0.04			
Family: Cyprinidae								
Cirrhinus cirrhosus	15	0	0	-	-	-	-	-
Cirrhinus ariza	40	38	385	P 95	95			**0.0593**
				MI 10.1	10.1			
				A 9.6	9.6			
				DV 3.21	3.21			
Labeo calbasu	122	92	2123	P 75.4	75.4			**0.1358**
				MI 23.1	23.1			
				A 17.4	17.4			
				DV 17.72	17.72			
Labeo catla (Catla catla)	**55**	**40**	**609**	**P 72.7**	72.7			**0.0893**
				MI 15.2	15.2			
				A 11.1	11.1			
				DV 5.08	5.08			
Labeo robita	**57**	**39**	**256**	**P 68.4**	68.4			**0.0388**
				MI 6.6	6.6			
				A 4.5	4.5			
				DV 2.14	2.14			
Labeo dyocheilus	**25**	**16**	**25**	**P 64.0**	**64.0**			**0.0094**
				MI 1.6	1.6			
				A 1.0	1.0			
				DV 0.21	0.21			
Puntius sarana	**40**	**33**	**128**	**P 82.5**	**82.5**			**0.0229**
				MI 3.9	3.9			
				A 3.2	3.2			
				DV 1.07	1.07			
Salmostoma bacaila	**20**	**6**	**14**	**P 30.8**	30.8			0.0135
				MI 2.3	2.3			
				A 0.7	0.7			
				DV 0.12	0.12			

Family: Mastacembelidae								
Macrognathus aculeatus	25	0	0	-	-	-	-	-
Mastacembelus armatus	45	41	965	P 91.1 MI 23.5 A 21.4 DV 8.06	22.22 1.4 0.311 1.45	91.11 23.19 21.13 98.5		
Family: Bagridae								
Mystus vittatus	70	54	238	P 77.1 MI 4.4 A 3.4 DV 1.99	75.71 3.94 2.98 87.81	17.14 2.14 0.414 12.18		**0.0258**
Family: Notopteridae								
Notopterus notopterus	15	0	0	-	-	-	-	-
Family: Cichlidae								
Oreochromis niloticus	133	91	4028	P 68.4 MI 44.3 A 30.3 DV 33.63	68.4 44.3 30.3 33.63			0.2604
Family: Serrasalmidae								
Piaractus brachypomus	10	0	0	-	-	-	-	-
Family: Siluridae								
Wallago attu	95	94	3202	P 98.9 MI 34.1 A 33.7 DV 26.73	64.2 18.0 11.5 9.15	96.8 22.8 22.1 17.5	9.5 1.1 0.1 0.08	0.2004
Family: Belonidae								
Xenentodon cancila	60	0	0	-	-	-	-	-
TOTAL	**859**	**549**	**11978**	**P 63.9** MI 21.8 A 13.9 DV 100	68.2 18.3 12.5 74.24	69.0 21.2 14.6 25.68	9.5 1.1 0.1 0.08	

distribution of parasites of which, the parasite fauna of *L. catla* (EI= 0.92±0.65), *M. vittatus* (EI= 0.892±0.631), *O. niloticus* (EI= 0.809±0.573), *W. attu* (EI= 0.413±0.292) and *M. armatus* (EI= 0.354±0.25) was the most unevenly distributed or the most heterogenous (Table 7). Diversity of parasite fauna was the maximum for *O. niloticus* (H= 0.759) with 3 species of monogenean parasites was homogenously distributed to some extent (EI= 0.809). However, *L. catla* (H= 0.637, EI= 0.92), *W. attu* (H= 0.492, EI=0.413), *M. vittatus* (H= 0.472, EI= 0.892) and *M. armatus* (H= 0.245, EI= 0.354) showed infection with 2, 5, 3 and 2 species of parasites respectively. Qualitative resemblance of the parasite fauna of the host fishes showed that there was reasonably elevated likeness between the parasite fauna of *L. catla* and *C. ariza* (JI = 100) with only one monogenean species, *Dogeilus catlaius* shared by the two hosts (Table 9). Those of *L. calbasu* – *L.*

Table 6: Prevalence (P= %), Mean Intensity (MI), Abundance (A), Dominance value (DV) and proportion of ectoparasites in different families of freshwater fishes of River Penna, YSR Kadapa.

Fish species/Family	Number examined	Number infected	Number of parasites	Total	Monogenes	Copepods	Isopods	Proportion
Family: Channidae	**20**	**0**	**0**	**-**	**-**	**-**	**-**	**-**
Family: Gobidae	**12**	**5**	**5**	**P 41.7**	**41.7**			**0.0083**
				MI 1.0	1.0			
				A 0.4	0.4			
				DV 0.04	0.04			
Family: Cyprinidae	**374**	**264**	**3540**	**P 70.6**	**70.6**			**0.1110**
				MI 13.4	13.4			
				A 9.5	9.5			
				DV 29.55	29.55			
Family: Mastacembelidae	**70**	**41**	**965**	**P 58.6**	14.3	58.57		0.1947
				MI 23.5	1.4	23.19		
				A 13.8	0.2	13.58		
				DV 0.86	1.45	98.5		
Fam: Bagridae	**70**	**54**	**238**	**P 77.1**	75.71	17.14		0.0365
				MI 4.4	3.94	2.14		
				A 3.4	2.98	0.414		
				DV 1.99	87.81	12.18		
Family: Notopteridae	**15**	**0**	**0**	**-**	**-**	**-**	**-**	**-**
Family: Cichlidae	**133**	**91**	**4028**	**P 68.4**	68.4			0.3670
				MI 44.3	44.3			
				A 30.3	30.3			
				DV 33.63	33.63			
Family:Serrasalmidae	**10**	**0**	**0**					
Family: Siluridae	**95**	**94**	**3202**	**P 98.9**	64.2	96.8	9.5	0.2825
				MI 34.1	18.0	22.8	1.1	
				A 33.7	11.5	22.1	0.1	
				DV 26.73	9.15	17.5	0.08	
Family: Belonidae	**60**	**0**	**0**	**-**	**-**	**-**	**-**	**-**
TOTAL	**859**	**549**	**11978**	**P 63.9**	**55.8**	**57.5**	**9.5**	
				M I 21.8	**13.6**	**16.14**	**1.1**	
				A 13.9	**9.14**	**12.03**	**0.1**	
				DV 100	**26.9**	**42.72**	**0.08**	

catla (JI= 50) which also shared one monogenean species, *Dactylogyrus fotedari*. Similarly, *W. attu – M. armatus* (JI=16.6) also shared only one copepod species, *Ergasilus malndensis* (Table 9).

Community ecology of metazoan parasite fauna in different families of fishes:

The highest prevalence of metazoan parasitic infection was in Siluridae (98.9%) with highest number of species (n= 5) and parasite taxa (n=3)

Table 7: Community characteristics of ectoparasites of 18 species of freshwater fishes of River Penna, YSR Kadapa.

Parameters	Channidae	Gobiidae	Cyprinidae																TOTAL
	Cp	*Gg*	*Cc*	*Ca*	*Lc*	*L.cat*	*Lr*	*Ld*	*Ps*	*Sb*	*M.ac*	*M.ar*	*Mv*	*N.not*	*On*	*Pb*	*Wa*	*Xc*	
Number examined	20	12	15	40	122	55	57	25	40	20	25	45	70	15	133	10	95	60	859
Number infected	-	5	-	38	92	40	39	16	33	6	-	41	54	-	91	-	94	-	549
Total no. of parasites(N)	-	5	-	385	2123	609	256	25	128	14	-	965	238	-	4028	-	3202	-	11978
No. of species of parasites(S)	-	1	-	1	1	2	1	1	1	1	-	2	3	-	3	-	5	-	19
No. of taxa of parasites(K)	-	1	-	1	1	1	1	1	1	1	-	2	2	-	1	-	3	-	3
Prevalence (%)	-	41.7	-	95	75.4	72.7	68.4	64.0	82.5	30.8	-	91.1	77.1	-	68.4	-	98.9	-	63.9
Mean Intensity (MI)	-	1.0	-	10.1	23.1	15.2	6.6	1.6	3.9	2.3	-	23.5	4.4	-	44.3	-	34.1	-	21.8
Abundance (A)	-	0.04	-	9.6	17.4	11.1	4.5	1.0	3.2	0.7	-	21.4	3.4	-	30.3	-	33.7	-	13.9
Proportion of parasites	-	0.006	-	0.059	0.136	0.089	0.039	0.009	0.023	0.014	-	0.138	0.0258	-	0.2604	-	0.2004	-	
Dominance index (DI)	-	0	-	0	0	0.0026	0	0	0	0	-	0.970	0.7859	-	0.113	-	0.0389	-	
Richness Index on S (RI)	-	0	-	0	0	0.108	0	0	0	0	-	0.101	0.402	-	0.265	-	0.798	-	
Richness Index on K (RI)	-	0	-	0	0	0	0	0	0	0	-	0.101	0.127	-	0	-	0.272	-	
Evenness Index on S (EI)	-	0	-	0	0	0.920 ±0.65-	0	0	0	0	-	0.354 ±0.25	0.892 ±0.631	-	0.809 ±0.573	-	0.413	-	
Shannon Index (H)	-	0	-	0	0	0.637 ±0.451-	0	0	0	0	-	0.245 ±0.173	0.472 ±0.478	-	0.759 ±0.537	-	0.492 ±0.333	-	

and the lowest in Gobidae (41.7%) with only one species of monogenean parasitic taxa. However, Cyprinidae harboured 6 species of the parasite taxa Monogenea. Bagridae harboured 3 species of two parasite taxa and Cichlidae harboured 3 species of parasites of monogenean parasite taxa. Similarly, Mastacembelidae harboured 2 species of parasites belonging to two major taxa. Mean intensity recorded the highest in Cichlidae (44.3) followed by Siluridae (34.1), Mastacembelidae (23.5) and lowest in Gobiidae (1.00). In the other families, Cyprinidae and Bagridae, MI varied between 13.4 and 4.4 (Tables 5 and 8). The richest parasite fauna was that of Siluridae (RI= 0.797) followed by Bagridae (RI= 0.4016) and Cichlidae (RI= 0.2646) (Table 8). RI was 0.398 in Siluridae (5 species representing 3 major taxa) and Mastacembelidae showed least RI of 0.100 as Gobidae, Cyprinidae and Cichlidae harboured only one parasite taxa each and there is no parasite diversity in these families. Dominance index recorded high for Mastacembelidae (0.9704) and Bagridae (0.7859) while the DI of other families ranged from 0.00000016-0.1183 (Table 8). The parasite fauna of Bagridae was the most heterogeneous (EI = 0.892) followed by Siluridae (0.413) and Mastacembelidae (0.354). Diversity of parasite fauna was the greatest in Siluridae (H = 0.492) followed by Bagridae (0.472) were dominated by monogeneans. The lowest diversity index was recorded for Mastacembelidae (0.245) (Table 8). Analysis of parasite species overlap in different host families (Table 10) showed that only the parasite species of Mastacembelidae and Siluridae (J = 16.66) were qualitatively very less similar. Of the 7 species of parasites recorded from these two host families, only one species was shared by both the fish families (Table 10).

DISCUSSION

The higher prevalence and mean intensities of interspecific and interfamilial similarity of ectoparasitic fauna in carnivorous/omnivorous species/families signifies their body texture with fewer scales on body. The lesser scales on the body of carnivorous fishes enable the ectoparasites to penetrate the skin and gills more easily. The diversity of parasitic fauna of class mammal and aves was poor than that of freshwater fishes and that species richness and mean intensity of parasites of freshwater fishes is

Table 8: Community characteristics of ectoparasites of 10 families of freshwater fishes of River Penna, YSR Kadapa.

Parameters	Channidae	Gobiidae	Cyprinidae	Masta cembelidae	Bagridae	Noto pteridae	Cichlidae	Serr asalmidae	Siluridae	Belonidae	Total
Number examined	20	12	375	70	70	15	133	10	95	60	859
Number infected	0	5	264	41	54	0	91	0	94	0	549
Total no. of parasites (N)	0	5	3540	965	238	0	4028	0	3202	0	11978
No. of species of parasites (S)	0	1	6	2	3	0	3	0	5	0	19
No. of taxa of parasites (K)	0	1	1	2	2	0	1	0	3	0	3
Prevalence (%)	0	41.7	70.6	58.6	77.1	0	68.4	0	98.9	0	63.9
Mean Intensity (MI)	0	1.0	13.4	23.5	4.4	0	44.3	0	34.1	0	21.8
Abundance (A)	0	0.4	9.5	13.8	3.4	0	30.3	0	33.7	0	13.9
Proportion of parasites	0	0.0083	0.1110	0.1947	0.0365	0	0.3670	0	0.2825	0	
Dominance index (DI)	0	0.00000016	0.0873	0.9704	0.7859	0	0.1130	0	0.0389	0	
Richness Index on S (RI)	0	0	1.09	0.1009	0.4016	0	0.2646	0	0.7977	0	
Richness Index on K (RI)	0	0	0	0.1009	0.2008	0	0	0	0.3988	0	
Evenness Index on S (EI)	0	0	0	0.354 ±0.250	0.892 ±0.631	0	0	0	0.413 ±0.292	0	
Shannon Index (H)	0	0	0	0.245 ±0.173	0.472 ±0.478	0	0	0	0.492 ±0.333	0	

less than its marine counterparts (Kennedy *et al.*, 1986). The present study was in total concurrence with these two disagreements as only 19 ectoparasitic species encountered from the 18 species of examined fish species as against more than thousand species from different species of marine fishes (Gudivada *et al.,* 2010; Madhavi, 2011; Kritsky *et al.,* 2012; Gudivada and Vankara, 2017) from the same geographical area. In this perspective, it is to be noted that the component community (=local parasite fauna) is discriminatory by several factors and there could be even temporal differences in the nature of compound communities (Holmes, 1990). According to Esch *et al.* (1988), Kennedy (1993), Beevi and Radhakrishnan (2012) and Gudivada *et al.* (2017) parasitic communities of freshwater fishes are principally stochastic groups dogged by events like chance prologue, colonization and extinction of parasites in a given area. Carnivorous forms of the family Siluridae, Cichlidae, Mastacembelidae, Bagridae harboured richer parasite faunas than predominantly herbivorous forms. Gobiidae in spite of being carnivorous in nature showed very poor ectoparasitic fauna which might be due to their

Table 9: Parasite species overlap in different species of freshwater fishes of River Penna, YSR Kadapa.

Fish Family	*S*	*Cp*	*Gg*	*Cc*	*Ca*	*Lc*	*L.cat*	*Lr*	*Ld*	*Ps*	*Sb*	*M.ac*	*M.ar*	*Mv*	*N.not*	*On*	*Pb*	*Wa*	*Xc*
Cp	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cc	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ca	1	0	0	-	0	1 100	0	0	0	0	0	0	0	0	0	0	0	0	0
Gg	1	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lc	1	0	0	1	1 100	0	-	1 50	0	0	0	0	0	0	0	0	0	0	0
L.cat	2	0	0	0	0	1 50	-	0	0	0	0	0	0	0	0	0	0	0	0
Lr	1	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0
Ld	1	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0
M.ac	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0
M.ar	2	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	1 16.66	0
Mv	3	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0
Nn	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0
On	3	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0
Ps	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0
Sb	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0
Wa	5	0	0	0	0	0	0	0	0	1 16.66	0	0	0	0	0	0	0	-	0
Xc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-

Table 10: Parasite species overlap in different families of freshwater fishes of River Penna, YSR Kadapa.

FISH FAMILY	No. of species of parasites (S)	Channidae	Gobidae	Mastacembelidae	Bagridae	Notopteridae	Cichlidae	Serrasalmidae	Siluridae	Belonidae	Belonidae
Channidae	**0**	-	0	0	0	0	0	0	0	0	0
Gobiidae	**1**	0	-	0	0	0	0	0	0	0	0
Cyprinidae	**6**	0	0	-	0	0	0	0	0	0	0
Mastacembelidae	**2**	0	0	0	-	0	0	0	0	1 (16.66)	0
Bagridae	**3**	0	0	0	0	-	0	0	0	0	0
Notopteridae	**0**	0	0	0	0	0	-	0	0	0	0
Cichlidae	**3**	0	0	0	0	0	0	-	0	0	0
Serrasalmidae	**0**	0	0	0	0	0	0	0	-	0	0
Siluridae	**5**	0	0	0	1 (16.66)	0	0	0	0	-	0
Belonidae	**0**	0	0	0	0	0	0	0	0	0	-

lesser availability. Furthermore, allocation of parasite species was somewhat heterogenous in carnivorous fishes than in herbivorous fishes. Diversity index of parasite species was also relatively higher in carnivorous forms than their herbivore counterparts. Holmes (1990), Rohde (1993) and Thoney (1993) projected that the marine fish generally have rich parasitic helminth communities than their freshwater counterparts. In convention with this proclamation Radhakrishnan and Nair (1980), Biju Kumar (1996), Madhavi and Lakshmi (2012), Gudivada and Vankara (2017) and Vankara (2018a, 2018b) also found that the parasitic communities of marine fishes were proportionately preponderated by helminths. The present results also however, showed helminth parasite fauna is very dominant (74.2% of helminths) which includes monogeneans. In the present study of the 19 ectoparasites recorded, 16 (84.2%) were helminths *i.e.,* monogeneans.

Qualitative similarity of ectoparasite fauna:
Qualitative similarity of the ectoparasite fauna has been conspicuous for *W. attu - M. armatus*, *L. catla - L. calbasu* and *L. catla – C. ariza* pairs which sustain the fact that their body texture with fewer scales on body enable the ectoparasites to penetrate the skin and gills more easily and is very crucial role in shaping the parasite fauna of the host.

CONCLUSIONS

The ectoparasitic fauna of freshwater fishes in this geographical area is less and very poor which might be attributed to the severe hot, dry and arid conditions in the study location. These types of studies are extremely useful in knowing parasite fauna of a particular niche or habitat. The present study is the first parasitological survey conducted in this river in which almost all the species are considered to be new geographical records a new monogenean species was reported from Gobiidae Family. This study has provided a database on host-ectoparasite association which would absolutely help the looming young researchers of this area to analyze the parasitic community structure of other freshwater fishes in a very classy manner.

CONFLICT OF INTEREST

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

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