Community ecology of the metazoan parasites of the Indian mackerel *Rastrelliger kanagurta* (Scombridae) from the coast of Visakhapatnam, Bay of Bengal

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Abstract One hundred and eighty four specimens of the mackerel *Rastrelliger kanagurta* collected from fish landings at Visakhapatnam coast, Bay of Bengal, between January 2006 and 2007, were examined for analysis of their metazoan parasite community structure at infra and component community levels and study the effects of season and host body length on these communities. Fifteen species of metazoan parasites were collected including 3 spp. Monogenea, 7 spp. Digenea and 5 spp. Copepoda. All the fish were parasitized by one or more metazoan parasite species. A total of 2,004 parasites were collected with a mean of 10.9. The majority were digeneans accounting for 42.4% of total number of parasites collected and the hemiurid *Lecithocladium angustiovum* is found to be the most dominant species. Mean values of species richness (3.0 ± 1.5), abundance (12.4 ± 9.3) and diversity ($H' = 0.92$) were within ranges observed for most of the metazoan parasite communities of marine fish from temperate and tropical countries. Seasonally, the mean diversity and parasite species richness of infracommunities were high during December and January and low during September–October. No correlation was found between host total length and any of the community descriptors. Most of the parasites i.e., 12 out of 15 species of parasites collected were host specialists. Only one species *Aponurus laguncula* was a host generalist. All taxa of metazoan parasites showed a typical over-dispersed pattern of distribution. The dominance of the core species in all the infracommunities and the high degree of host specialization of the parasite species resulted in the predictable component in the

infracommunities to be high, each infra community comprising a core species accompanied by a few secondary species.

Keywords Metazoan parasites communities · Indian mackerel · *Rastrelliger kanagurta* · Bay of Bengal · Infracommunities · Component communities

Introduction

In recent years, investigations dealing with analysis of marine fish parasite communities are receiving much attention. Several species of marine fish occurring in different zones in the sea, differing widely in their food habits, reproductive behavior, migratory movements, and belonging to different geographic regions have been subjected to the study. We have a fairly vast knowledge on the organization of marine fish parasite communities as well as the role of various host and ecological factors as determinants of the community organization of these parasites. Many review articles on dependence of parasite communities of marine fish on factors such as host body size (Poulin, 2000), productivity of the habitat (Poulin 2003), and host ecology and phylogeny (Lile, 1998) have also been published. However, much of this knowledge is an outcome of the investigations undertaken in temperate regions and a few tropical areas of Atlantic and Pacific. There is a profound dearth of information on marine fish parasite communities from Indian region, although Bay of Bengal and Arabian Sea along east and west coasts of India support rich fish fauna and the parasite fauna of these fishes is well documented. The only relevant studies are those of Biju kumar (1996) and Madhavi and Sairam (2000). To fill this gap in our knowledge, an investigation was undertaken

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during 2005–2007 on metazoan parasite communities of common food fishes of Visakhapatnam coast. The present communication deals with metazoan parasite communities of the Indian mackerel, *Rastrelliger kanagurta* at infra and component community levels and examines the patterns of these communities associated with season and host size.

The scombroid fish, *Rastrelliger kanagurta* (Cuvier) popularly known as the Indian mackerel, is widely distributed in Indo-west Pacific region and forms an important fishery along east and west coasts of India. It is a schooling pelagic fish, inhabits the shallow coastal waters, migrates from coastal waters to deeper areas during monsoon season (July, August) for spawning purpose (Pradhan, 1956; Jayashankar et al. 2004). Being a planktivorous, the mackerel occurs predominantly in regions rich in plankton. It serves as a potential host for many species of metazoan parasites and several taxonomic papers have been published dealing with parasites of this fish. Recently, Madhavi and Triveni Lakshmi (2011) in an account on the metazoan parasite fauna of the fish from Visakhapatnam coast, Bay of Bengal, discussed its role as a host for different species of metazoan parasites and also provided information on the relevant literature. So far, there are no studies dealing with quantitative aspects of metazoan parasite communities of the mackerel.

Materials and methods

From January 2005 to 2006, a total of 184 specimens of *R. kanagurta* ranging in size from 118 to 250 mm and collected from fish landings at fishing harbor, Visakhapatnam were subjected to the study. Fish samples were available during all the months of the year except during July and August when probably the fish migrated to off-shore waters for breeding activity. For each fish, the total body length was measured and all the viscera and gills were examined for parasites. The metazoan parasites found were identified and enumerated. Data on individual parasite species were analyzed for prevalence, mean intensity and abundance according to the definitions of Bush et al. (1997). The diversity of parasite fauna was determined from an estimation of the community descriptors including Mean total parasite abundance, species richness, and Shannon–Wiener diversity index (H' calculated using natural log). Dominance was evaluated by the Berger–Parker index. Aggregation was calculated using Dispersion index (s^2/x). To determine the relationship between host length and community parameters, the host fishes ranging in size from 118 to 250 mm were partitioned into four length groups, <151, 151–180, 181–210, and >210. The values of diversity parameters in different host length groups were compared using ANOVA. Pearson's correlation coefficient

(r) was used to determine the possible relationship between host total length and the community descriptors. Wherever necessary the values were normalized by log transformation ($\log x + 1$).

Results

Component communities

All the 184 *R. kanagurta* examined were infected with one or more parasite species and a total of 2,004 parasite individuals were collected. The overall prevalence and mean intensity were 100% and 10.9, respectively. The metazoan parasite fauna comprised of 15 species including 3 spp. of monogeneans, 7 spp. of digeneans, and 5 spp. of copepods. Digeneans were the most dominant members of the parasite spectrum and accounted for 42.2% of the total parasite individuals encountered. Data on the prevalence, mean intensity to infection with various metazoan parasite species (Table 1) revealed that among the digeneans the hemiurid, *Lecithocladium angustiovum* was the most dominant species with a dominance index of 0.25–0.66 (mean 0.44) and highest dominant frequency of 1.0 being the dominant member in all the infracommunities. It is the only core species in the parasite spectrum. Next in dominance was the didymozoid, *Renodidymocystis yamagutii*. All the five species of copepods and the digenean *Phyllodistomum* sp. occurred with a prevalence less than 10% and constituted the so called 'satellite species'. The remaining species namely the three species of monogeneans, the digeneans *O. bacillaris*, *P. orientalis*, *P. waltirensis*, and *A. laguncula* showed infections of a moderate nature representing the secondary species in the parasite community. The values of dispersion index suggest an aggregated distribution for all taxa (Table 1). The dispersion index was highest for *L. angustiovum* and lowest for *Phyllodistomum* sp. As regards frequency of occurrence of hosts with single or multiple infections with species, 18% hosts were infected by one parasite species and 24, 20, and 23% hosts had multiple infections with 2, 3, and 4 parasite species, respectively (Fig. 1).

Infracommunities

The number of parasite species in a host ranged from 1 to 7 with a mean of 3.0 ± 1.5 , majority of the hosts harbored 2–4 parasite species (Fig. 1) and the parasite abundance ranged from 1 to 51 with a mean of 12.4 ± 9.3 . The value of Shannon Wiener's Diversity index (H') ranged from 0.16 to 2.47 with an average of 0.92. The evenness ranged from 0.22 to 1.0 with an average of 0.78. The frequency distribution of H' in the infracommunities (Fig. 2) revealed

Table 1 Prevalence, mean intensity, and relative density to infection with various parasite species in *R. kanagurta*

Parasite species	Prevalence %	Mean intensity $\pm$ sd	Mean abundance	Diversity index $s^2/\bar{x}$
Monogenea				
<i>Eylavera typica</i>	5.4	1.2 $\pm$ 0.3	0.06	0.07
<i>Pseudoanthocotyle jagannath</i>	20	2.0 $\pm$ 1.4	0.40	0.98
<i>Kuhnia sprostonae</i>	16.3	2.3 $\pm$ 1.6	0.38	1.11
Digenea				
<i>Opechona bacillaris</i>	33.1	3.4 $\pm$ 5.2	1.14	7.9
<i>Prodistomum orientalis</i>	32.1	4.1 $\pm$ 1.6	1.3	0.62
<i>Prodistomum waltirensis</i>	15.8	2.0 $\pm$ 3.2	0.30	5.1
<i>Phyllodistomum</i> sp.	2.7	1.8 $\pm$ 0.9	0.05	0.45
<i>Renodidymocystis yamaguti</i>	45.6	6.5 $\pm$ 7.0	2.9	7.5
<i>Lecithocladium angustiovum</i>	88.5	5.4 $\pm$ 4.6	4.82	3.9
<i>Aponurus laguncula</i>	16.8	2.6 $\pm$ 2.4	0.45	2.2
Copepoda				
<i>Orbitocolax aculeatus</i>	1.1	1.0 $\pm$ 0.34	0.01	0.11
<i>Nothobomolochus kanagurta</i>	1.1	1.0 $\pm$ 0.18	0.01	0.03
<i>Caligus kanagurta</i>	4.7	1.1 $\pm$ 0.43	0.05	0.16
<i>Lernanthropus kanagurta</i>	2.2	1.0 $\pm$ 0.24	0.02	0.05
<i>Peniculus scomberi</i>	4.11	1.4 $\pm$ 0.6	0.05	0.25

Fig. 1 Frequency of metazoan parasite species per host in the sample of *R. kanagurta*

that in more than 49% of individuals of hosts the H' values were greater than 0.9. The frequency of 'E' values skewed to right with over 53% of hosts showing values between 0.8 and 1.0 (Fig. 3). It is evident that diversity of parasite fauna is not high but evenness is high which means that in the infracommunities, the various parasite species are more or less uniformly distributed.

Seasonal changes

The mean parasite burden during different months ranged from 3.0 in November to 18.4 in December when most of parasite species recorded highest prevalence. It was low during September and November (Table 2). Similarly the mean species richness ranged from 1.3 to 3.7, the diversity values varied from 0.15 during October to 1.05 during

Fig. 2 Frequency distribution of H' values of metazoan parasite infracommunities in *R. kanagurta* **Fig. 3** Frequency distribution of 'E' values of metazoan parasite infracommunities in *R. kanagurta*

June. The evenness values ranged from 0.7 to 0.87. The values of all the three descriptors were at minimum during September–November and remained more or less uniform during rest of the year. Although seasonal changes were not pronounced, it is evident from the data that the recruitment

Table 2 Seasonal changes in species richness, mean abundance, diversity, and evenness in the metazoan parasite communities of *R. kanagurta*

Month	Species richness	Mean abundance	H'	Evenness
Jan 06	2.8	7.7	0.81	0.87
Feb	2.6	10.3	0.68	0.75
Mar	3.2	10.9	0.88	0.81
Apr	3.4	9.4	0.92	0.86
May	3.3	12.96	0.78	0.78
June	3.7	16.6	1.05	0.79
Sep	1.6	8.1	0.91	0.85
Oct	1.3	8.1	0.15	0
Nov	2.0	3.0	0	0
Dec 06	3.2	18.4	0.72	0.71
Jan 07	2.9	17.0	0.70	0

for most of the parasites commences during the months of September and October; the infection builds up over the next few months and disappears in June, to reappear again in September.

Host length

Values of correlation coefficient the '*r*' statistic revealed no correlation between host body length and species richness ($r = -0.153$), parasite burden ($r = -0.197$), H' ($r = -0.155$), and E ($r = -0.046$).

Data on the mean values of community descriptors in different sizes groups of the fish is presented in (Fig. 4). No significant differences were found between host size and species richness ($F = 1.9656$; $P \leq 0.05$) and mean abundance ($F = 1.9656$; $P \leq 0.05$).

Host specialization

Twelve of the 15 species of metazoan parasites including all the three species of monogeneans, 6 out of 7 species of digeneans and three species of copepods were narrowly specific to *R. kanagurta*. Only one species *A. laguncula* was host generalist. The core species *L. angustiovum* showed some degree of specificity to scombroid fishes (Gibson and Bray, 1986). Similarly *O. bacillaris* and *O. orientalis*, have been recorded from scombroid fish from different geographic regions, indicating selectivity to this group of fish.

Discussion

Results of the present study on the metazoan parasite communities of *R. kanagurta* revealed that the infracommunities are characterized by fairly high values of species richness, abundance and diversity. The values of

Fig. 4 Values of species richness, mean abundance and diversity among different size groups of *R. kanagurta*

infracommunity parameters are within the ranges reported for metazoan parasite communities of other species of marine fish from tropical and subtropical regions. The predominance of digeneans in the parasite spectrum noted here was also seen in many other marine fish species (Thoney, 1993; Campos and Carbonell, 1994; Biju Kumar, 1996; Lile, 1998; Zander et al. 1999; Madhavi and Sairam, 2000; Silva et al. 2000; Alves and Luque, 2001; Alves et al. 2003). *L. angustiovum* was found to be the most dominant species in the parasite assemblage of *R. kanagurta*. Such domination by a single species of digenean has also been reported in the parasite communities of many other species of marine fish (Alves et al. 2003).

During the last one decade, several studies have investigated the determinants of species diversity in parasite communities of marine fish (Sasal et al. 1997; Morand, 2000; Luque et al. 2004). All the studies have attempted to explain parasite species richness as the product of external environmental factors and host traits. The number of parasite species per host species has been related to a range of host ecological and life history traits such as body size, life span, population density, or geographic range. A relationship between productivity and diversity in parasite communities has also been suggested (Poulin 2003). The fairly

rich parasite fauna of *R. kanagurta* is evidently a reflection of its planktivorous diet and the abundance in the coastal waters of the macrobenthos that serve as intermediate hosts for helminth parasites (Dogiel, 1961; Kennedy and Hartvigsen, 2000). Other factors such as the occurrence of dense populations of the mackerel in the coastal waters, the shoaling behaviour, the long life span (4 yr) and the wide geographical range also contribute to the development of species rich parasite community in *R. kanagurta*.

The present investigation is the only study dealing with metazoan parasite communities of *R. kanagurta*. However, information is available on parasite communities of other species of scombroid fish (Abdallah et al. 2002; Alves et al. 2003; Alves and Luque, 2006). An investigation comparable to the present one was undertaken by Alves et al. (2003) on *Scomber japonicus* from Rio de Janeiro. However, in *S. japonicus* the values of species richness (4.8) and mean abundance (70.6) were slightly higher compared to those in *R. kanagurta*. These differences may have been caused by differences in the ecological characteristics of the habitat and also the food preferences of the two species of hosts.

Alves et al. (2003) compared their results with those reported by earlier workers for *S. japonicus* from different regions, such as Rio de Janeiro (Rego and Santos, 1983), Brazil (Rohde et al. 1995), Argentina (Cremonte and Sardella, 1997) and suggested that differences that occurred between different geographical areas could serve as indicators of possible latitudinal gradient of parasitization in marine fishes from South American and Atlantic regions, in accordance with the hypothesis of a higher biodiversity in the regions nearer to equatorial line (Rohde, 1999). On the other hand, Cremonte and Sardella (1997) stated that qualitative differences between the component communities of *S. japonicus* from Brazil and Argentina might be explained by the presence of different population stocks in both regions. Similar studies on populations of *R. kanagurta* from different geographic regions need to be undertaken to find support to the above hypothesis of latitudinal differences in the parasite communities of parasites proposed by Rohde (1999) for ectoparasites of marine fish and also to determine the existence of different population stocks of *R. kanagurta*.

Traditionally, parasite communities have been viewed as forming a continuum between two extremes: At one end of the spectrum there are isolationist communities characterized by low rates of colonization, low densities, weak interactions, and low species richness. At the other extreme, there are interactive communities which experience high rates of colonization, high densities, strong interspecific interactions such as competition and higher species richness (Holmes and Price, 1986; Sousa, 1994). In the present case, the gut is colonized by two species of

hemiuroids and three species of Lepocreadiids. The three species of lepecreadiids, *O. bacillaris*, *P. orientalis*, and *P. waltirensis* co-occur, and concurrent infections with two or all the three spp. or any two of these were quite frequently encountered. Although the possibility exists that these three spp. may be sharing the same second intermediate host, there is no evidence for the existence of any interspecific interaction or competition between them. Overall, the parasite communities of *R. kanagurta* seem to be isolationist in nature, at the same time fairly species rich and diverse. The diversity of metazoan parasites also followed a seasonal pattern with peak during the months December–May and minimum during September–November. It is assumed that host feeding habits, its breeding cycle and the local ecological factors have a direct bearing on the parasite communities of *R. kanagurta*.

The present study revealed no correlation between host length and any of the parasite community descriptors. *R. kanagurta* is predominantly a planktivorous fish, both juveniles and adults feed on planktonic organisms (Kuthalingam, 1959) and all the digeneneas, the predominant members of the parasite fauna use planktonic organisms as intermediate hosts. The observed pattern is probably a reflection of the lack of demographic changes in the feeding pattern and behavior of mackerels.

Much debate exists as to whether parasite communities are predictable, or not. According to Caswell (1978) and Hanski (1982) the parasite infracommunities consist of dominant, predictable core species surrounded by subordinate unpredictable satellite species. Several studies dealing with marine fish parasite communities have supported the view that parasite assemblages are structured by factors that lead to a predictable species composition. The situation in *R. kanagurta* supports this concept in that majority of the parasites are host specialists and one of these constitutes the core species. These characteristics resulted in the predictability of parasite fauna to be high in each infra community, the fauna being comprised of the predictable core species accompanied by nonpredictable secondary or satellite species.

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