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Research Article

An Account on the Spatial Distribution and Diversity of Parasites on Commercial Fishes Caught from the Eastern Part of Andaman Waters, India

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Abstract

The coastal and marine ecosystems in an island is supported with a wide habitat range sustaining various ecological services. One of such services includes the fishing activities for commercial and recreational purposes. Since commercial importance of fishery resources is higher, regular studies in different aspects is important. The present study aims in contributing to such studies, particularly in the field of parasite infection. The distribution pattern of these parasites infecting different species of fishes were observed to be uniform in the waters around Andaman Islands. A total of 573 individuals of parasites including five species were recorded from four species of 183 individuals of fishes over a period of 6 months. The most abundant parasite species was observed to be *Hirudinella ventricosa* extracted from the gut of yellowfin tuna. Out of the 7 designated locations where the fishes were caught, location 4 (L-4) and 6 (L-6) were observed to have the maximum distribution and diversity. Similarity dendrogram also suggested alike results where the degree of similarity through clusters and vector directions favoured L-4 and L-6 locations. Analysis using ANOVA and other statistical parameters of the parasite and fish individuals resulted in data with no significant variation (p-value > 0.05). However, in terms of correlation through different correlation coefficient, it was observed to show a very high positive correlation. Thus, the result suggests strong unyielding association between the parasite and fish host which can be better understood with a long term spatial and temporal studies from the different regions of Andaman waters. This study serves as a baseline investigation for similar possible studies in the future.

Keywords: Copepod; Sailfish; MDS; Anisakis; Statistics; *Hirudinella*

Introduction

The general science of ecology is basically concerned with the interaction between organisms and the environment. However, parasites are different in this regard, since they have two environmental components; namely the microhabitat in the host at any stage of their life cycle and the macrohabitat in the environment where the host is present [1]. The interaction between parasite and the host comes with certain effects in several ways such as physical action, supply or withdrawal of certain substances, effect on immune response of the host, release of toxins or microorganism transfer. These effects may not be negative always, however, not much information is known from parasites of host populations from the open seas; as well as their ecological distribution.

The distribution of parasites are quite heterogenous and structured spatially within the host as well as the environment [2]. These distributions are not uniform or random in the population of the host species, but, rather a contagious or overspread distribution referred to as aggregated distribution. Aggregation in parasites have been studied theoretically to describe the distribution pattern with negative binomial being the most common method used [1]. There are certain conditions which leads to this aggregated and non-random pattern of distribution [3]. Some of these conditions are a wide series of host exposures, thereby, giving more chances of exposure, followed by the infective stage of their life cycle which is specific and the infection rate that is likely to enhance or decrease possibility of further infection. Further, such a distribution stabilizes the host-parasite interaction [4] and mortality occurs only in heavily infected individuals of the host species [5]. Thus, to better understand the occurrence of parasites in different geographical areas, the information on spatial distribution is important to avoid any outbreak of harmful diseases.

The fishes in pelagic region (both neritic and deep waters) of the marine environment are considered to be poor in terms of parasitic infestation [6]. Although, they have been used as biological tags in their host [7], studies on the infection dynamics and structural ecological distribution are scarce. In order to understand the spatial distribution, structures and other ecological processes, a number of statistical tools are present to approach and facilitate a better and improved comprehension of parasite distribution [8].

Andaman waters hold great potential for parasitic research as information present are mostly on records based on morphological and molecular characterization with no research on spatial or temporal distribution. Therefore, in this study, an attempt to draft the spatial distribution of different parasites from the various individual fish hosts was implemented. The present study aims to provide the first assessment from these waters using statistical analysis and highlight any possible pattern or trend of the distribution in parasites from their designated hosts from these areas.

Materials and Methods

Study site

The study area consists of different sites in the Andaman waters of the Andaman and Nicobar Archipelago. Oceanic commercial fishes including tunas, sharks, sword fish and sail fish were caught from eastern part of Andaman waters within Lat 10°-14°N and Long 92°-93°E (Figure 1). These fishes were hauled through regular fishing activities carried out onboard different fishing boats at the Junglighat Fish landing centre. These regions are mostly accessible for fish exploitation through operation using mechanised and motorised fishing vessel.

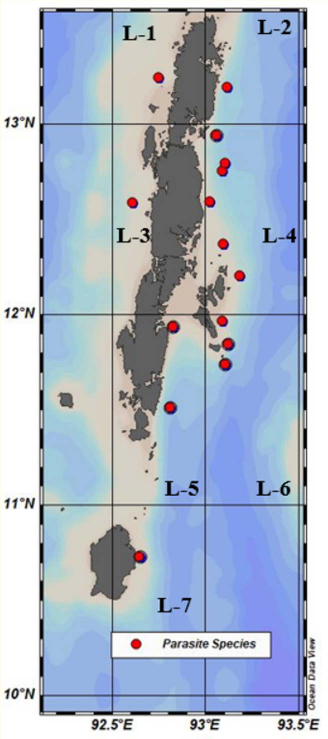

Figure 1: Map showing the sites where specimens were collected.

Sampling

Parasite samples were collected from different species of fishes which landed at the Junglighat fish landing centre from the mentioned locations from the month of March to August 2023. Detailed sampling was carried out following the protocols laid by [9]. Since the GPS location given by the fishermen were not consistent, the indication of study sites was narrowed down to the respective grid of latitude and longitude and the sites were named as L-1 (13°N; 92°E), L-2 (13°N; 93°E), L-3 (12°N; 92°E), L-4 (12°N; 93°E), L-5 (11°N; 92°E), L-6 (11°N; 93°E) and L-7 (10°N; 92°E). The parasite sampling and the number of samples collected were completely opportunistic and greatly depended on the catch composition through fishing activities. The fish species were identified using proper taxonomic identification keys [10,11]. Both ectoparasites and endoparasites were considered for the study. Ectoparasites were carefully removed from the body surface of the fish using fine forceps and transferred to containers with 70% ethanol. Similarly, endoparasites were removed from the stomach of the organisms after dissection and preserved in ethanol for further analysis. The parasite samples were then brought to the laboratory for through examination under stereo microscope for proper identification. The parasites were then identified following the works of [12] and [13]. The number of parasites in each infected fish specimen were counted for distribution studies.

Data analysis

For data analysis, the abundance data is shown in tabular representation. Distribution and diversity for both alpha and beta diversity were made through ecological indices and dendrogram using requisite software. Single factor ANOVA was also analysed for the different study sites with respect to fishes and parasites. All the values derived from the software after analysis were represented in tabular and graphical forms. The statistical assessment was performed using MS excel, SPSS version 23 [14] and PRIMER version 6.2 developed by the Plymouth Marine Laboratory, UK [15]. The representation of the study site was achieved using Ocean Data View (ODV) 5.6.5 [16].

Results and Discussion

The present study indicates some interesting observation of different parasitic groups found in fishes within a set geographic location. From the study, a total of 573 individuals of parasites from 183 individuals of fishes were noted during the study period of 6 months. These parasites include copepods; which are ectoparasitic copepods as well as nematodes and trematodes; which are endoparasitic worms. A total of 5 species were identified from 4 oceanic fishes and their name along with the details of host and the area of infection is given in table 1. Maximum number of parasites extracted with 252 individuals were from 162 individuals of yellowfin tuna followed by 162 individuals of parasites from 12 individuals of pelagic shark, 99 individuals of parasites from 3 individuals of sword fish and 60 parasite individuals from 6 individuals of sail fish. The microscopic images of each parasite were taken and presented in figure 2.

Sl No.	Name of Parasite	Host Name	No of Fishes	No of Parasites	Area of Infection
1	*Hirudinella ventricosa*	Yellowfin Tuna	162	252	Gut (attached)
2	*Gloiopotes huttoni*	Sail Fish	6	60	Head region
3	*Dinemoura discrepan*	Pelagic Shark	8	59	Pectoral fin
4	*Echtrogaleus denticulatus*	Pelagic Shark	12	103	Cloacal region
5	*Anisakis sp.*	Sword Fish	3	99	Gut (free living)

Table 1: Details of Parasites obtained from different hosts.

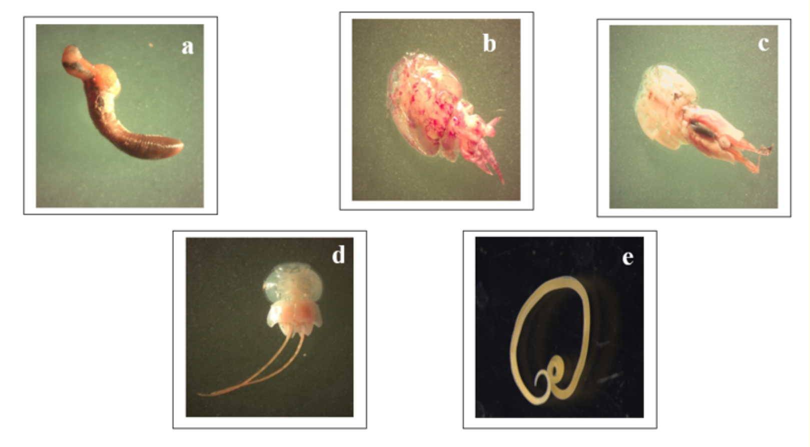

Figure 2: a) *Hirudinella ventricosa* isolated from gut of yellowfin tuna; b) *Gloiopotes huttoni* isolated from snout region of sail fish; c) *Dinemoura discrepans* isolated from clasper of pelagic shark; d) *Echtrogaleus denticulatus* isolated from pectoral fin of pelagic shark; e) Anisakis sp. isolated from Sword fish gut.

Distribution pattern

Parasites were observed to have a varied distribution with great abundance as seen in this case. The different locations are being designated along with the detailed distribution in the number of fishes and parasites respectively (Table 2). Since yellowfin tuna was the dominant catch, the number of parasites associated are also high and spread in almost all the locations of the study sites. Site 4 (L-4) was seen to have the maximum distribution of fishes with 69 individuals as well as for parasites with a total of 345 individuals of parasites comprising of 84 number of trematodes, 99 number of nematodes, 42 and 77 numbers for two species of Pandaridae copepods and 43 individuals of Caligidae copepods. Site 4 was the most abundant site followed by site 6 which showed about 153 individuals of parasites from 63 individuals of fishes. This site was observed to have the maximum number of trematode parasites with 93 individuals along with 17 and 26 individuals of Pandaridae copepods and 17 individuals of Caligidae copepods. A visual representation of the parasite distribution with respect to the fishes is shown in figure 3 with a linear trendline.

Sl No.	Site Name	Coordinates	No of Fishes	Fish Species	No of Parasites
1	L-1	10°N;92°E	9	YFT	15
2	L-2	10°N;93°E	12	YFT	15
3	L-3	11°N;92°E	3	YFT	6
4	L-4	11°N;93°E	54 + 3 + 9 + 3	YFT + SW+SH + SF	84 + 99 + 119 + 43
5	L-5	11°N;94°E	6	YFT	9
6	L-6	12°N;93°E	57 + 3 + 3	YFT + SH + SF	93 + 43 + 17
7	L-7	12°N;94°E	21	YFT	30

Table 2: Parasite distribution in geographic location and designated fishes.

Note: YFT: Yellowfin Tuna; SW: Swordfish; SH: Shark; SF: Sailfish

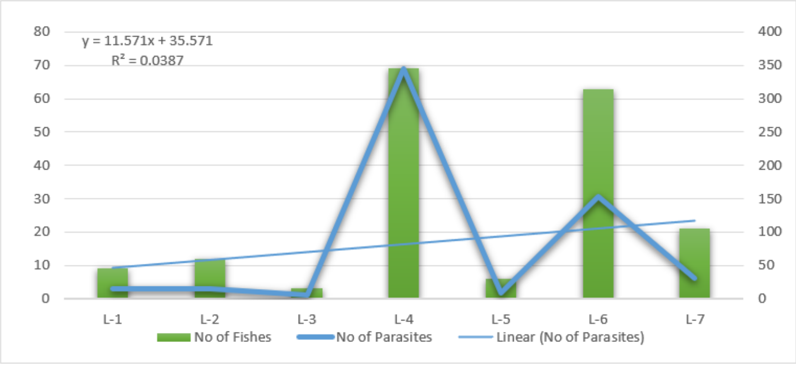

Figure 3: Graph showing distribution of parasites with respect to fishes in different sites.

Diversity analysis

Ecological aspects of parasites includes both Alpha and Beta diversity of these groups in various geographical areas considered for the present study. Alpha diversity is attained using ecological indices such as Number of species (S), Number of individuals (N), Margalef's Species Richness (d), Pielou Evenness (J'), Shannon-Weiner Diversity (H'), and Simpson's Index (1-λ). Beta diversity was obtained by constructing Bray-Curtis dendrogram and Multidimensional scaling (MDS).

The Number of Species (S) and Number of Individuals (N) was observed to be maximum in L-4 with all the 5 parasitic species and 345 individuals collectively present from the site. L-4 location was seen to be dominant for all the diversity indices mainly due to the maximum abundance in the site. Margalef's species richness with d value of 0.69 for L-4 followed by 0.60 for L-6; Pielou's Evenness with J' value of 0.96 for L-4 and 0.79 for L-6; Shannon-Weiner diversity index with H' value of 1.55 for L-4 and 1.09 for L-6 and lastly Simpson's diversity index with (1-λ) value of 0.78 for L-4 and 0.58 for L-6 was observed to be the analysed outcome.

Similarity analysis was done through Bray-Curtis dendrogram with the transformed data (Figure 4). Maximum similarity was seen between L-1 and L-2 with a similarity degree of 100% followed by 89.9% similarity between L-3 and L-5. S-7 was seen to have a similarity of 82.84% with the first cluster. The second and third cluster in turn shows a similarity of 77.02%. L-6 and L-6 showed 70.44% while the least similarity of 22.16% was seen between this formed cluster with the larger cluster.

Multidimensional Scaling (MDS) was also analysed and the plot (Figure 5) corresponds to the similarity as observed in Bray-Curtis dendrogram with the addition of vector in the form of different parasite species. The scaling was obtained by applying Kruskal stress formula with a value of 1 and the minimum stress employed was 0.01. The percentage variation observed for MDS1 was 85.5% and MDS2 14.4%. From the plot, it is clear that L-4 and L-6 are completely different from the rest of the sites with the corresponding parasite species indicating the vector direction towards the same.

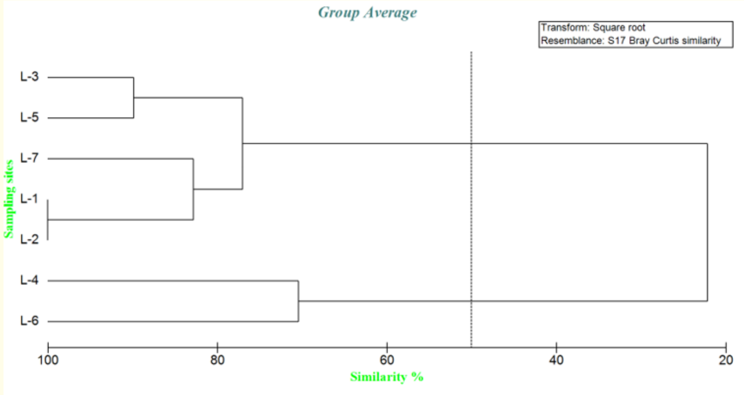

Figure 4: Bray-Curtis Similarity Dendrogram for different sites.

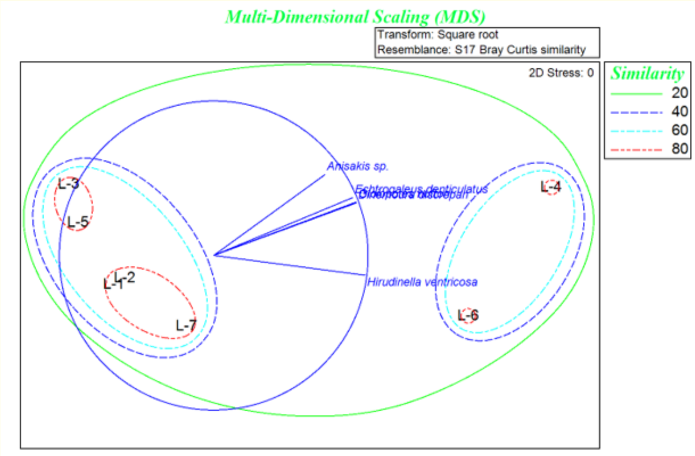

Figure 5: Multidimensional Scaling (MDS) of the sample sites with respect to parasite species.

Statistical analysis

The data obtained were analysed with various statistical parameters so as to observe for any significance, probable variation, and correlation among the number of fishes and parasites. These parameters along with other basic parameters are given in table 3. For a normal data distribution, the skewness is 0. A negative value indicates data to be skewed left and a longer left-tail (formed in a graphical representation), while a positive value indicates the data to be skewed right and the right tail is relatively long compared to left tail.

Kurtosis usually measures if the dataset is heavy-tailed or light-tailed compared to a normal distribution. Positive value indicates heavy-tailed and negative value indicates light-tailed. One way ANOVA gives us a more definite analysis as to the data being significant or not. The distribution in number of parasites is the same across different categories of sample sites with respect to the number of fishes, was assumed to be the null hypothesis. Since the p-value was determined to be more than the significance level ($p < 0.05$), the null hypothesis is retained. Other statistical parameters such as F-statistic and F-crit values were seen to compliment the significance values. Chi square test and the values of the different correlation coefficients considered for the present study with regards to the individual number of fishes and parasites resulted in values suggesting high correlation. The 'r' value was observed to be 0.917 whereas the 'ρ' value was seen to be the maximum being 0.991 indicating a very strong correlation.

The geographic distribution of parasites is influenced by the same factors observed in the distribution of other organisms. However, certain constraints regulate the distribution patterns of parasites, such as the availability of suitable hosts, sufficient numbers of hosts, and other external factors [17]. Therefore, this type of association is crucial for understanding the distribution of hosts and the environmental conditions in which they inhabit. In this study, an approach was taken to observe the spatial distribution of para-

Parameters	No of Fishes	No of Parasites
Mean	26.14	81.86
St. deviation	27.86	127.15
Variance	776.14	16166.14
Range (Min-Max)	3-69	6-345
Skewness	1.08 ± 0.79	1.93 ± 0.79
Kurtosis	-0.91 ± 1.59	3.40 ± 1.59
p value	0.28	
F statistic	1.28	
F-crit	4.75	
Chi-Square	0.714	
Pearson's correlation (r)	0.917	
Spearman's rho correlation coefficient (ρ)	0.991	
Kendall's tau correlation coefficient (τ_b)	0.976	

Table 3: Descriptive statistics for number of fishes and parasites.

sites attached to fish hosts in the Andaman waters. This approach aimed to gain a better understanding of their distribution patterns. The study was carried out with all regards to the fishermen for carrying regular fishing activities in the Andaman waters. The waters around the Andaman and Nicobar Islands serves as an unsullied ground for varied species of fishes. The identified fishery resources in shallow as well as deep waters are in immense numbers [18]. Among these vast range of species, majority of the fish species are bound with certain form of interaction with parasites. Thus, with this approach, initial sample was collected and based on the sample obtained from the first attempt, the species considered for the present study i.e., yellowfin tuna, sail fish, pelagic shark and sword fish were kept consistent.

Throughout the study period, a total of 183 individuals of the four species of fishes were recorded to contain 573 individuals of parasites. The maximum number of parasites recorded were 252 individuals of *Hirudinella ventricosa* from the gut of yellowfin tuna. This indicates that tuna landings were dominant in the landing centre and the commercial value is relatively higher. The study also explored the distribution pattern of the parasites through the location where the host species were caught. The results indicate a more dominant distribution and diversity in the fourth (L-4) and sixth (L-6) location (Figure 3). The probable reason for such a one direction results maybe due to the frequent visits of the fishermen in the same fishing grounds. The regular fishing in similar areas is employed mostly incase of harsh or extreme weather and sea conditions around the islands. None the less the results highlight the definite spatial distribution around the islands which shows the parasite distribution is uniform and not concentrated to one or specific area. Previous studies carried out by various researchers [19-22] focuses mainly on the occurrence of the recorded parasites, however the present study intends to present a wider knowledge on these obtained parasites. Further, similarity dendrogram and Multidimensional scaling (MDS) shows a strong affinity towards L-4 and L-6 being very similar and the other cluster consisting of the rest of the locations. Statistical analysis suggests no significant variation with p-value > 0.05. The different correlation coefficient analysed in the study shows a large positive correlation between the number of fishes and number of parasites.

Conclusion

Parasitic effects on the host population in the marine environment is less known due to the limited number of available studies. Scale of mortality or rapid widespread infection have not been reported in most cases. Thus, a heavy parasite load in comparison to the host species in a marine environment can lead to detrimental impact on the host [23]. Therefore, parasitic ecology studies should also be encouraged and carried out along with the studies of the host species, so as to keep a check and update of any possible negative outbreak. The present study provides a general idea and preliminary information on the distribution of parasites from host fishes which are of commercial importance in the Andaman and Nicobar Islands.

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Conflict of Interest

The authors declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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