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Status of fish diversity and fishing gears in the fishery of Nanthikadal Lagoon, Mullaitivu, Sri Lanka

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Abstract – The Northern coast of Sri Lanka is home to a larger number of lagoons, totalling up to 804 km^2. Nanthikadal lagoon is a significant lagoon that exists in the coastal zone of the Mullaitivu District between 9° 17' N and 80° 48'E. Species occurrences and their types are good indicators to express the health status of the lagoon ecosystem. The present investigation was carried out for the first time to record the finfish and shellfish diversity, diversity indices and the fishing gears used to capture these fishes in the Nanthikadal lagoon by collecting monthly samples from the fish landing centres from September 2017 to August 2019. Collected species were identified using FAO species identification field guide. During the field survey, the number of organisms caught from all species were also counted. Diversity indices such as Dominance, Simpson, Shannon and Evenness were calculated by using PAST software. Fish numbers were graphically compared through cluster analysis by Unweighted Pair Group Method with Arithmetic mean (UPGMA). Fishing gears used and details on mesh size of nets were collected by using questionnaire and face to face interview with the fishermen. Seventeen finfish and five shellfish species belonging to seventeen families were identified during the study period. *Tilapia mossambica* made the highest percentage contribution (29.34%). The minimum contribution was reported by species such as *Portunus pelagicus*, *Scylla serrata*, *Scatophagus argus*, *Lutjanus johnii*, *Tricanthus biaculeatus* and *Chanos chanos* (<1%). The highest and lowest abundance was found in post-monsoon and pre-monsoon periods respectively. Simpson index and Shannon index were high in the monsoon season. *Strongylura strongylura* and *Gerres abbreviates* showed a close relationship based on month-wise cluster analysis. Cast net was the most commonly used, and legal fishing gear. Part-time fishermen actively participated in shrimp capturing from brackish water. In the present study, the important components of the lagoon fishery such as fish and usage of fishing gears were analyzed to determine the present status of Nanthikadal lagoon fishery. These findings will be helpful for stakeholders in this region for sustainable fishery management and ultimately supporting the Ministry of Fisheries and Aquatic Resource Development by providing required fundamental information to develop a lagoon management plan in the future.

Keywords: Nanthikadal lagoon, Diversity indices, Finfish, Shellfish

1. INTRODUCTION

1.1 Coastal Lagoons

Coastal and marine ecosystems play a complex and essential role in supporting economic prosperity and social welfare in Sri Lanka. The diverse coastal habitats of Sri Lanka include estuaries and lagoons, coral reefs, mangroves, seagrass beds and salt marshes, support rich biodiversity (Bertness, 2007).

Coastal lagoons are bodies of water, with a depth of no more than 5m, which have been completely or partly separated from the ocean by sand or shingle deposited during wave action (spits or barriers). Coastal lagoons are usually found enclosed between the different types of coral reefs and land (Silva *et al*., 2013). Coastal lagoons are susceptible to chemical and physical changes due to wind, tidal, and rainfall factors (Miththapala, 2013; Silva *et al*., 2013).

Lagoons cover approximately 13% of the world's coastline and are found in all continents, except for Antarctica. Africa has the largest percentage cover of lagoons, covering an estimated 18% of its coastline. North America is close behind with 17.6% cover. In Asia, coastal lagoons are said to cover approximately 13.8% of their coastline (Miththapala, 2013).

Lagoons along the coast are highly productive ecosystems that can compete with rainforests and coral reefs (Miththapala, 2013). As a result of their support for a variety of habitats, such as salt marshes, sea grasses, and mangroves, they help to increase the overall productivity of coastal waters. They provide habitat and nursery grounds for commercially and recreationally important finfish and shellfish (Bertness, 2007). Reefs, mangroves, wetlands and tidelands act as the nursery and feeding areas for many marine species, help recycle nutrients, and provide a buffer for storm protection and control erosion. Disturbances caused due to natural calamities and the adverse impact of human settlements threatens these important ecosystems. The existence of coastal marsh is being severely endangered due to increasing development, land subsidence, erosion and sea level rise. In some areas, invasive species have displaced native species, threatening commercially important biological resources by altering the habitat and productivity of the marsh. An increase in suspended solids and the growth of algae affect water clarity, inhibiting the growth of submerged aquatic vegetation.

In Sri Lanka, coastal lagoons are typically shallow, and some are even ephemeral, maintaining water in the lagoon basin only during the wet season while having wide dry beds during the dry season (Silva *et al*., 2013).

Due to the confusion and difficulty in differentiating lagoon and estuaries, the total number of lagoons in Sri Lanka is differing in its history. Earlier studies denoted that the number is 45, however, another study conducted in 2013 by the International Water Management Institute identify up to 82 lagoons out of which, over 75% are found in the dry zone. The northern coast is home to the largest number of lagoons (17), totalling up to 804 km^2 (80,400 ha). The largest lagoon is the Jaffna lagoon with a surface area of 441 km^2 (44,100 ha) (Silva *et al*., 2013). Another significant lagoon in the northern coastal zone is Nanthikadal lagoon situated in the Mullaitivu District.

1.2 Fish species diversity

Finfish and shellfish are the most important aquatic organisms in lagoons in terms of biomass and commercial importance. For some fish species, estuaries, lagoons, and nearby shorelines make great nurseries where they can acquire food for growth and protection from predators. It appears that the majority of Sri Lanka's seasonal, small tidal lagoons are not productive in terms of the growth of fish and shellfish. Nonetheless, many big lagoons are abundant in finfish and shellfish species from the sea, estuaries, and freshwater. The lagoons are home to a wide variety of fish species, many of which are commercially significant and have sizable populations that enable subsistence fishing.

A diversity index is a quantitative measure that reflects how many different types (such as species) that are in the dataset, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among these types. The value of a diversity index increases along with the variety of types and degree of evenness. The value of the diversity index is greatest when there are an equal number of species in each category (Rosenzweig, 1995). Generally, diversity indices take the relative abundances of different species into account in addition to the species richness (number of species present) when describing the composition of a community. This data supports the notion that diversity indices depend on both species richness and the degree to which individuals are distributed fairly among various species (Magurram, 1988).

The value of a diversity index also increases both when the number of types increases and when evenness increases. For a given number of types, the value of the diversity index is maximized when all types are equally abundant (Rosenzweig, 1995). This is an index applied to biological systems derived from a mathematical formula used in the communication area by Shannon in 1948 (Mandaville, 2002). It's the most preferred index among the other diversity indices. The index values are between 0.0 – 5.0. Results are generally between 1.5 and 3.5, and it exceeds 4.5 very rarely (Kocataş, 1992). The values above 3.0 indicate that the structure of the habitat is stable and balanced; the values under 1.0 indicate degradation of habitat structure (Gencer and Nilgun, 2010).

1.3 Fishing gears

An understanding of fishing gears is necessary for fishery management. The effectiveness of various fishing gear types, their ability to be used in different environments, and their suitability for various tasks vary greatly. The structure, materials used, principles of capture, and operational techniques of fishing gears differ widely. Fishermen can employ a variety of gears and techniques depending on the species, the surrounding environment, and the type of terrain. On the basis of the principles of capture, design, technical aspects, and operating procedures, numerous categorization systems for fishing gear have been devised (Boopendranath, 2012).

Although species occurrences and their types are good indicators of the present status of the lagoon ecosystem, the available information reveals that knowledge of fish fauna in Sri Lankan lagoons is scarce. No complete information is available on the diversity, abundance and population densities of fish fauna of northern coastal lagoons. In the years prior to or following the civil war, no study was carried out in the Nanthikadal lagoon. In order to better understand the finfish and shellfish diversity, diversity indices and the fishing gears used to capture these fishes, the present study was designed to report it as a baseline data for the first time.

2. Materials and Methods

Nanthikadal lagoon is located on North East coast of Sri Lanka in Mullaitivu District, between 9° 17' N and 80° 48'E. The area and periphery of the lagoon are 75.05 km^2 and 90.3 km respectively. It opens up to the Indian Ocean via only one inlet. The marine entrance is 0.34 km. Nanthikadal is connected with a fresh water source (Per aru) from Muthuiayankadu kulam (Fig. 1).

Figure 1: Map of Nanthikadal Lagoon (Surveying Department, Sri Lanka)

Preliminary survey along the lagoon was performed from June 2017 to August 2017 in order to identify the landing sites. Data collection was carried out from September 2017 to August 2019 through monthly field visits to each chosen landing site. Finfish and shellfish species were collected from fishermen from their small-scale fishery. The colouration of body and markings were recorded in fresh condition. Collected fish samples were brought directly to the laboratory of the Department of Fisheries, University of Jaffna for detailed analysis and identification. Identification of species was carried out according to the published literature by examining their morphological characters (De Bruin *et al*., 1994).

During the field visits, the number of organisms caught was counted for all species. Four major biodiversity indices namely Dominance, Simpson, Shannon and Evenness were used to know the discrepancy between aquatic communities and populations. However, to know the status of fish community structure and assembly, data were monthly collected and traced. Diversity indices were calculated by using PAST (Paleontological Statistics) software (Hammer *et al*., 2001). Fish abundance of each species was graphically compared through cluster analysis by Unweighted Pair Group Method with Arithmetic mean (UPGMA) in PAST (Paleontological Statistics) software. Studies such as cluster analysis and diversity indices analysis were done month-wise and season-wise based on the data gathered over two years. For season-wise analysis, the season was classified as monsoon (October – December), post-monsoon (January - March), dry season (April - June) and pre-monsoon (July – September).

The indices, Shannon diversity index (H) (Shannon and Weiner, 1949), Simson's index (D) (Simpson, 1949), Evenness (E) (Odum, 1971), and Dominance (C) (Odum, 1971), were calculated using the following formula:

$$H = -\sum_i p_i \log p_i$$

$$C = \sum_i p_i^2$$

$$E = \frac{H}{H_{max}}$$

$$D = \frac{1}{C}$$

$$p_i = \frac{n}{N}$$

Where, n is the individuals of a given species, N represents the total number of individuals in a community, and $H_{max} = \log S$. S represents the number of species found.

In addition, types of fishing gears, mesh size of fishing nets and details of collected species were recorded. Those data were collected by providing questionnaires and conducting face-to-face interviews with the fishermen.

3. RESULTS

Twenty-two finfish and shellfish species belonging to seventeen families were identified during the study period. Among them, seventeen species are finfishes, and the rest comprise shellfish representing shrimps and crabs (Table 1).

During the present study, the highest number of finfish species was recorded under family Cichlidae. Shellfish species were mainly reported under family Penaeidae. Of these, *Penaeus monodon* and *Metapenaeus monoceros* are mainly contributing to the lagoon catches. *Scylla serrata*, *Portunus pelagicus* and *Thalamita crenata* are the three identified crab species belonging to family Portunidae. Table 4 shows the percentage contribution of dominant fish and shellfish species to the lagoon fish catches. *Tilapia mossambica* made the highest percentage contribution (29.34%), followed by *Metapenaeus monoceros* (25.74%), *Gerres abbreviatus* (5.99%), *Penaeus monodon* (5.76%), and *Arius jella* (5.25%). The minimum contribution was reported by species such as *Portunus pelagicus*, *Scylla serrata*, *Scatophagus argus*, *Lutjanus johnii*, *Tricanthus biaculeatus* and *Chanos chanos* (<1%). Penaeidae made the highest percentage contribution (31.5%) among the families identified.

The highest species richness was found from December 2017 to April 2018 and November 2018 to March 2019. The lowest richness was found in September 2018 and August 2019 (Table 2). The highest Abundance was found in January and February 2018 and 2019. The lowest abundance was found in September 2017 (Table 2). The highest species richness was found in January to May, November and December. The lowest richness was found in August. The highest Abundance was found in February and the lowest was found in September (Fig. 2). The lowest richness was found in pre-monsoon. The highest Abundance was found in post-monsoon and the lowest was found in pre-monsoon (Fig. 3).

Table 1: Details of finfish and shellfish species reported in the Nanthikadal lagoon during the study period from September 2017 to August 2019.

Group	Family	Species	Symbol used in Cluster analysis	Number of fishes	%
Shrimps	Penaeidae	*Penaeus monodon*	C1	832	5.76
		Metapenaeus monoceros	C2	3720	25.74
Crabs	Portunidae	*Portunus pelagicus*	N1	130	0.90
		Scylla serrata	N2	37	0.26
		Thalamita crenata	N3	327	2.26
Fin fishes	Clupeidae	*Nematalosa nasaus*	D1	256	1.77
		Sardinella longiceps	D2	311	2.15
		Sardinella gibbosa	D3	93	0.64
	Belonidae	*Strongylura strongylura*	A	425	2.94
	Scatophagidae	*Scatophagus argus*	B	142	0.98
	Sciaenidae	*Johnius caronua*	E	375	2.59
	Leiognathidae	*Leiognathus fasciatus*	F	154	1.07
	Terapontidae	*Terapon jarbua*	G	289	2.00
	Gerreidae	*Gerres abbreviatus*	H	866	5.99
	Lutjanidae	*Lutjanus johnii*	I	82	0.57
	Triacanthidae	*Tricanthus biaculeatus*	J	127	0.88
	Engraulidae	*Stolephorus indicus*	K	523	3.62
	Ariidae	*Arius jella*	L	759	5.25
	Paralichthyidae	*Psedorhombus elevatus*	M	260	1.80
	Labridae	*Chanos chanos*	O	35	0.24
	Cichlidae	*Tilapia mossambica*	P	4240	29.34
	Mugilidae	*Mugil cephalus*	Q	470	3.25

Table 2: Diversity Indices of fishes collected from Nanthikadal Lagoon from September 2017 to August 2019.

	Taxa	Individuals	Dominance	Simpson	Shannon	Evenness
Sep-17	18	150	0.2434	0.7566	2.075	0.4424
Oct-17	20	263	0.3423	0.6577	1.805	0.3039
Nov-17	21	448	0.2274	0.7726	2.147	0.4077
Dec-17	22	750	0.1636	0.8364	2.383	0.4924
Jan-18	22	1215	0.1854	0.8146	2.191	0.4065
Feb-18	22	1263	0.2010	0.7990	2.118	0.3778
Mar-18	22	993	0.2065	0.7935	2.114	0.3763
Apr-18	22	753	0.2133	0.7867	2.087	0.3663
May-18	21	505	0.1944	0.8056	2.212	0.4349
Jun-18	20	329	0.1498	0.8502	2.415	0.5597
Jul-18	18	262	0.1545	0.8455	2.376	0.5980
Aug-18	18	225	0.1491	0.8509	2.390	0.6061
Sep-18	17	195	0.1496	0.8504	2.351	0.6177
Oct-18	19	180	0.1202	0.8798	2.506	0.6449
Nov-18	22	417	0.1125	0.8875	2.533	0.5725
Dec-18	22	998	0.1888	0.8112	2.206	0.4127
Jan-19	22	1306	0.1973	0.8027	2.182	0.4030
Feb-19	22	1286	0.2075	0.7925	2.117	0.3774
Mar-19	22	944	0.1686	0.8314	2.252	0.4320
Apr-19	21	750	0.1953	0.8047	2.123	0.3980
May-19	21	496	0.1849	0.8151	2.209	0.4338
Jun-19	20	297	0.1979	0.8021	2.189	0.4461
Jul-19	18	240	0.2089	0.7911	2.104	0.4557
Aug-19	17	188	0.1457	0.8543	2.333	0.6062

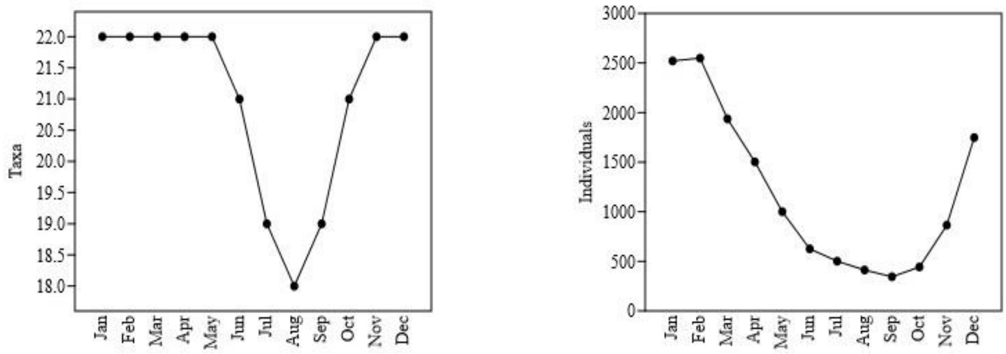

Figure 2: Month-wise species richness and abundance of fishes collected from Nanthikadal Lagoon.

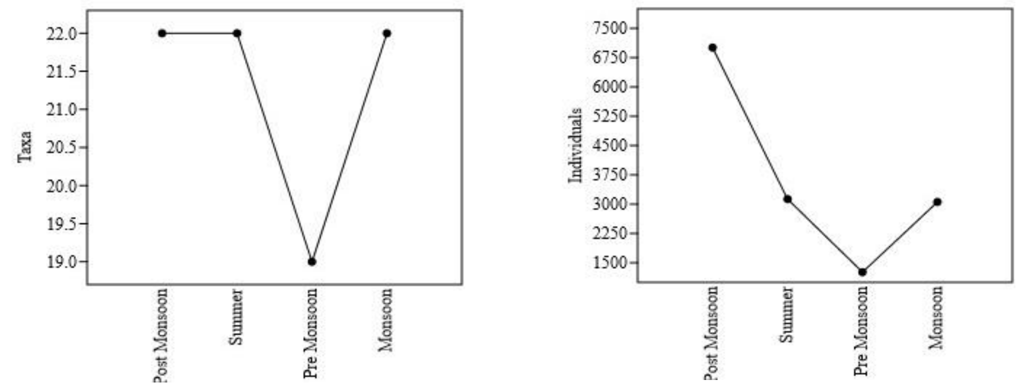

Figure 3: Season-wise species richness and abundance of fishes collected from Nanthikadal Lagoon.

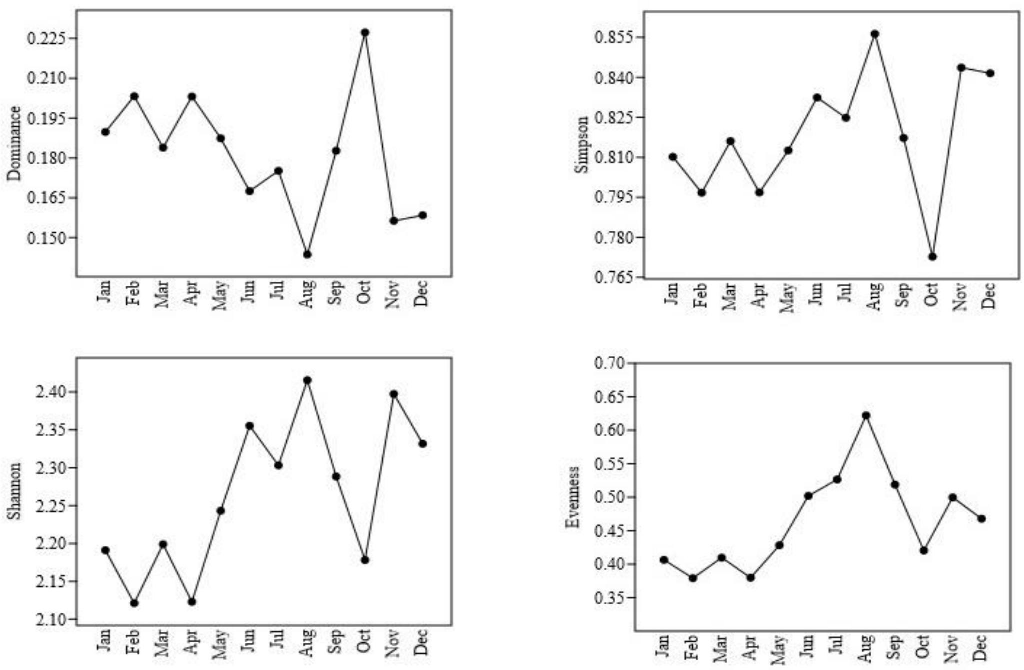

Figure 4: Month-wise Dominance, Simpson index, Shannon index and Evenness of fishes collected from Nanthikadal lagoon

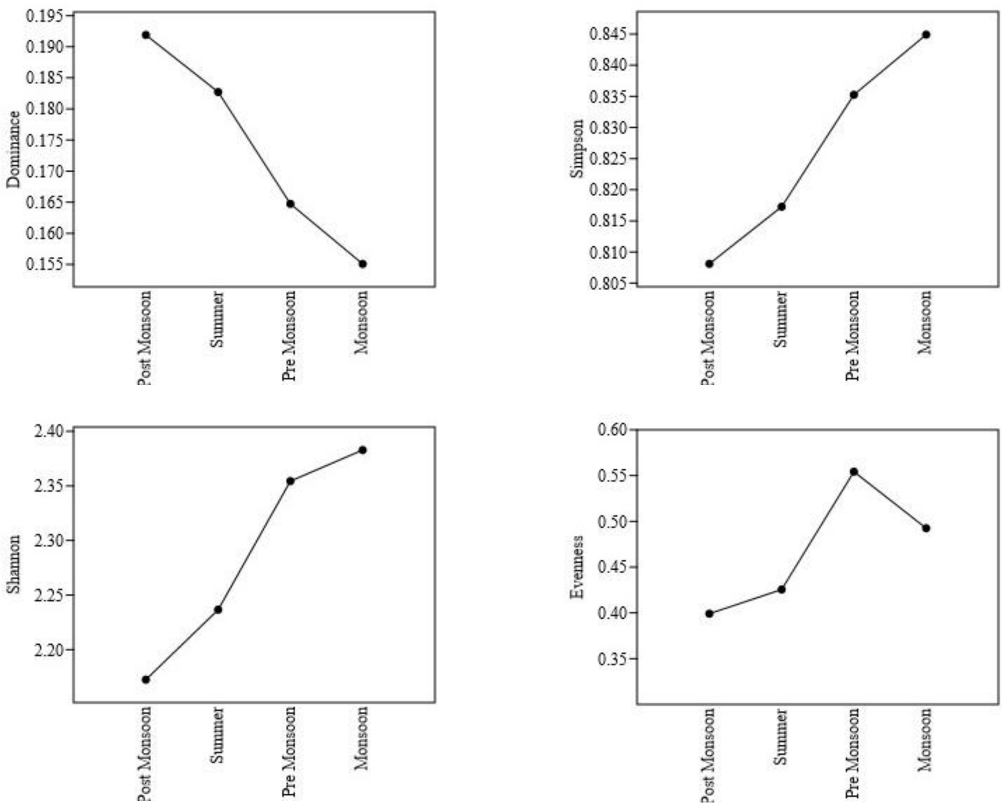

Figure 5: Season-wise Dominance, Simpson index, Shannon index and Evenness of fishes collected from the Nanthikadal Lagoon

Dominance was high in October 2017 and low in November 2018 (Table 2). Simpson index and Shannon index were high in November 2018 and low in October 2017 (Table 2). Evenness was high in October 2018 and low in October 2017 (Table 2). Dominance was high in October and low in August. Simpson index was high in August and low in October. Shannon index and Evenness were high in August and low in February and April (Fig. 4). Dominance was high in post- monsoon and low in monsoon. Simpson index and Shannon index were high in monsoon and low in post-monsoon. Evenness was high in pre-monsoon and low in post-monsoon (Fig. 5).

Based on the month-wise cluster analysis, two clusters were found. One cluster contained a small number of species such as *Sardinella gibbosa*, *Psedorhombus elevatus*, *Scatophagus argus* and *Johnius caronua*. In the other cluster, species *Chanos chanos* and *Thalamita crenata* showed a high difference from others in the same group. Species *Strongylura strongylura* and *Gerres abbreviates* showed a close relationship compared to others (Fig. 6). In year-wise analysis, two clusters were found. One cluster contained only two species such as *Sardinella gibbosa* and *Psedorhombus elevatus*. In the other cluster, species *Thalamita crenata* showed more difference from others. Here also species *Strongylura strongylura* and *Gerres abbreviates* showed a close relationship (Fig. 7). In season-wise analysis, two clusters were found. One cluster contained only two species such as *Sardinella gibbosa* and *Psedorhombus elevatus*. In the other cluster, species *Scatophagus argus* and *Schylla serrata* showed more differences with others. Species *Johnius caronua* and *Thalamita crenata* showed a very close relationship (Fig. 8).

Survey on fishing gears explained that fishing gears such as boats without engine, cast nets, gill nets and hoop nets are commonly used gears for fishing activities in the Narthikadal lagoon.

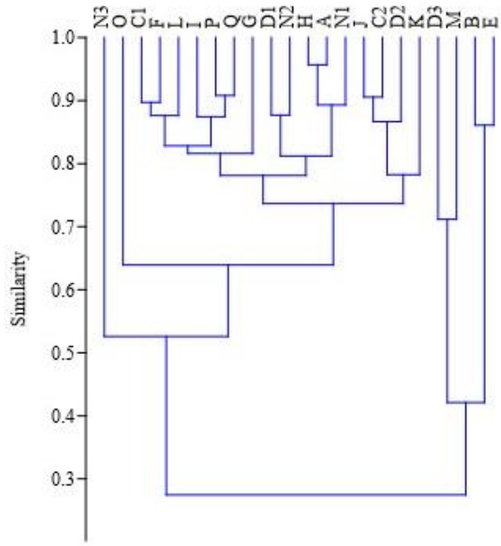

Figure 6: Cluster analysis of fish diversity (September 2017 - August 2019).

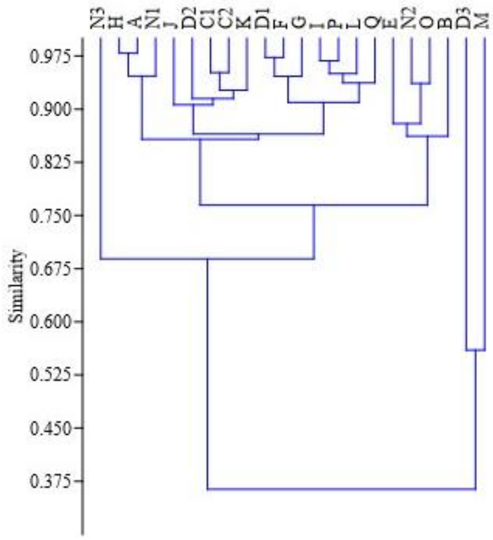

Figure 7: Month-wise Cluster analysis of fish diversity.

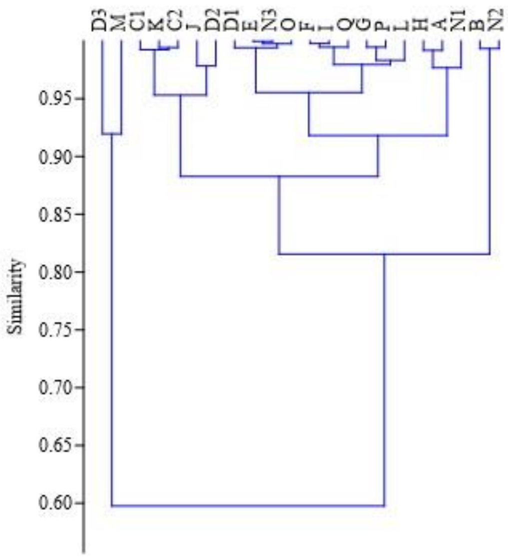

Figure 8: Season-wise Cluster analysis of fish diversity

The fishermen expressed that the Department of Fisheries and Aquatic Resources (DFAR) of Mullaitivu district allows only cast net fishing. Most of the fishermen use cast nets for their fishing activities. They use boats without engine mostly from November to April. However, fishermen use cast nets throughout the year. Hoop net is commonly used from November to April. Gill net is used from March to October. They use cast nets consisting of various mesh sizes such as 0.5, 0.75, 1.08, 1.25, 1.5, 2 and 2.5 inch. Likewise, they use gill nets consisting of various mesh sizes such as 1.5, 1.75, 2.00, 2.25, 2.5, 3, 3.5, 4, 4.5 and 7 inch. Hoop net is used only with one mesh size which is 0.5 inch. To capture the *Metapenaeus* shrimp cast nets consisting of 0.5 and 0.75 inch mesh size were commonly used. To capture the *Penaeus* sp. cast nets consisting of 1.08, 1.25 and 1.5 inch were commonly used. To capture the fin fish such as *Tilapia*, *Mugil* and *Gerres* cast nets consisting of 2.0 and 2.5 inch were used. To capture the shrimps and fin fishes, gill nets comprising of 2.0, 2.25, 2.5, 3.0 and 3.5 inch were used. To capture the finfish, gill nets comprising of 1.5 and 1.75 inch mesh size were used. To capture the crabs, 4.0, 4.5 and 7 inch mesh sized gill net is used. A hoop net with 0.5 inch mesh size net is used only for shrimp capturing.

4. DISCUSSION

In the present research, the value obtained for Shannon index was 1.805 - 2.533 and an average value was 2.225± 0.033. Based on the present results, lagoon shows generalized value but the structure of the habitat is not stable and unbalanced. Ulfah *et al.*, (2019) mentioned the diversity index criteria as follows: $H' \leq 1$ = Low diversity, $1 < H' \leq 3$ = Moderate diversity and $H' \geq 3$ = high diversity. According to this classification, Nanthikadal lagoon exhibited moderate fish diversity. The Simpson index is a diversity index derived by Simpson in 1949 (Mandaville, 2002) and is used to measure community diversity. Although it's commonly used to measure biodiversity, it can also be used to gauge diversity differences of populations. The range is from 0 to 1, where: high scores (close to 1) indicate high diversity. Low scores (close to 0) indicate low diversity. One of the more useful aspect of the index is to compare two sets of data to see which is more diverse. In the present analysis, the Simpson index was 0.6577 - 0.8875 and an average value was 0.8121 ± 0.009. This value is closer to one, so diversity is high in this lagoon. High diversity was observed in November 2018. Considering the season-wise analysis; monsoon season reports high diversity according to the Simpson index. Theoretical value evenness index ranges from 0-1. Furthermore, the evenness index is categorized as follows: $0 < E \leq 0.5$ = depressed community, $0.5 < E \leq 0.75$ = unstable community and $0.75 < E \leq 1$ = stable community (Krebs, 1989). The population uniformity will be smaller if the evenness index is small. It shows the distribution of the number of individuals of each species is not similar so there is a tendency for one species to dominate. The greater the uniformity value describes the number of organisms in each species remains the same or not much different exist. In the present study, evenness varied from 0.3039 to 0.6449 and the average value was 0.465±0.019. Based on the average value the community in the Nathikadal lagoon is termed as a depressed community. Uniformity index and small diversity indicates high dominance of a species against other species. Index values range from 0 – 1, it could be explained by the following categories: $0 < C < 0.5$ = Low Dominance, $0.5 < C \leq 0.75$ = Moderate Dominance and $0.75 < C \leq 1.0$ = High Dominance. Dominance index explains when there is only one biota or species that is more or dominating. The dominance index is inversely proportional to the diversity index. The higher the dominance value of water, the diversity value of water will decrease, and conversely, the higher the diversity value of water, the dominance value will decrease. The high and low diversity values, uniformity and dominance in waters will have an influence on physical chemical factors and availability of fish feed. It reveals that the other things that affect the Diversity index, Uniformity index, and Dominance index can also be affected in the data collection process (Bengen, 2000). The dominance index value of Nathikadal lagoon was 0.1125 - 0.3423 and the average value was 0.1878±0.009. Values of Dominance were less than 0.5 which indicates low dominance.

The similarity is an amount that reflects the strength of the relationship between two data items; it represents how similar 2 data patterns are. Clustering is done based on a similarity measure between groups. The clusters are formed in such a way that any two data objects within a cluster have a minimum distance value and any two data objects across different clusters have a maximum distance value. In each of our analysis, two main clusters were found.

Metapenaeus monoceros lives in brackish to marine salinities as low as 5 and up to 30 ppt (Galil *et al*., 2002) which explains why they were captured abundantly. *Tilapia* sp is also characterized by a large tolerance to salinity and therefore, their abundance was also very high.

Cast net is the only allowed fishing gear in Nanthikadal lagoon by the Fisheries Department of Mullaitivu and they allowed fishermen to fish without boats. More than 85 mm mesh size is allowed for fishing. But fishermen used small size craft without engines for their fishing. Some of them use crafts. Others do their fishing activity on the border of the lagoon. Fishermen illegally used other types of nets such as gill nets and hoop nets. During the dry season, depth of water is low; at that time they do fishing without boats. Fishermen are active in the lagoon from January to March for shrimp fishing. Part-time fishermen were also involved in fishing during this time.

In the dry season fish production is low because most of the time fishermen do other jobs for their income. Young fishermen's number (30%) is too low because they get more income from other jobs. Most of the fishermen's families (75%) now do fishing to satisfy their daily needs, not for marketing.

5. CONCLUSION

Twenty-two finfishes and shellfishes species were found to be are the most common species of this Nanthikadal lagoon. Among them, only five are shellfish species comprise of two shrimps and three crab species. Five shellfish species are found in the lagoon. *Metapenaeus monoceros* and *Tilapia mossambica* are highly netted shellfish and finfish species respectively in the lagoon. Highest Abundance was found in February during post-monsoon season and the lowest was found in September during pre-monsoon season. The highest Abundance was found in post-monsoon and the lowest was found in pre- monsoon. Dominance was high in October and low in August. Simpson index was high in August and low in October. Shannon index and Evenness were high in August and low in February and April. In month-wise cluster analysis, two clusters were found. One cluster contains only two species such as *Sardinella gibbosa* and *Psedorhombus elevatus*. In the other cluster, *Thalamita crenata* was highly separated from the others. Here also *Strongylura strongylura* and *Gerres abbreviatus* showed a close relationship. The most common fishing gear applied is a cast net with a mesh size varied from 0.5-2.5 inches and other gears are illegally used. These illegally used gears should be thoroughly studied, analyzed, and considered for future lagoon management programmes. Species diversity was high in the monsoon season. In the present study, the important components of the lagoon fishery such as fish and fishing gears exist were analyzed to determine the present status of Nanthikadal lagoon fishery. These findings give a brief idea and baseline documentation to the stakeholders from this region for sustainable fishery management and provide ecosystem and economic stability for the local community. Further, this study can support the Ministry of Fisheries and Aquatic Resource Development by providing the required fundamental information to develop a Lagoon Management Plan in the future. No previous studies have been carried out on diversity of this lagoon and therefore present study will be a useful baseline documentation for researchers, government officers, fishery managers, and aqua culturists.

6. DECLARATION

The authors declare that they have no conflict of interest.

7. ACKNOWLEDGEMENTS

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