Voyage Journal of Scientific Research and Exploration (VJSRE) *Vol 2. Issue 1*
ISSN (Online): **3007-3898**, ISSN (Print): **3007-388X**, April to September 2025

DIVERSITY, LENGTH-WEIGHT CORRELATION AND HEAVY METAL UPTAKE IN SEA CUCUMBER COLLECTED FROM BULEJI, PAKISTAN.

[1]Kanwal Nazim, [2]Vaitheeswaran Thiruvengadam, [1]Moinuddin Ahmed and [3]Wazir Ali Metlo

[1]Services for Environment & Mangrove Protection, Pakistan
[2]International University of East Africa, Kampala, Uganda
[3]Shaheed Benazir Bhutto University, Nawab Shah
Author's e-mail: sempwa.20@gmail.com

Abstract

Sea cucumber is one of the marine resources which takes crucial importance for the ecology and the economy. Buleji was selected to observe the qualitative and quantitative seasonal variations of sea cucumbers throughout the year, 2023 using a linear transect quadrate. Length- weight correlation and diversity were calculated using ecological methods. Some physico-chemical parameters were also analyzed. The data suggests that the water quality parameters are influenced by seasonal changes, particularly the monsoon. The monsoon season brings about dilution effects, leading to lower salinity, conductivity, and TDS levels, while also increasing dissolved oxygen. The pH levels remain relatively stable, indicating a consistent alkaline nature of the water across the seasons. During study a total five species viz., *Holothuria pardalis, Holothuria arenicola, Holothuria atra, Ohshimella ehrenbergi and Holothuria verrucosa* belonging to 03 orders and 02 families were recorded from study site. The maximum diversity (1.32±0.26) and equitability (0.97 ± 0.23) was recorded in monsoon whereas the minimum diversity with higher dominance (0.68±0.01) was recorded in post-monsoon season. The graph of correlation analysis presents a strong positive linear relationship between the length and weight of *all holothurians species* where the weight increases proportionally with the length, and the linear model is a good fit for the data. The heavy metal results disclosed that the iron and manganese were found higher peaks with seasonal fluctuations. It is hoped that this research will add to our knowledge pertaining to the distribution and diversity of sea cucumbers in marine ecosystem.

Key Words: Sea cucumber, Buleji, sediments, diversity, length-weight, heavy metals

Introduction

Sea cucumbers are generally large worm like echinoderms, distributed in all oceans, usually live near corals, rocks or sea weeds in warm shallow waters (Ridzwan, 2007; Zulfigar *et al.*, 2008).The family Holothuriidae includes a great number of species, includes five genera (Escandon et al., 2011), of which Holothuria is the most diverse (Oliveria and Christoffersen, 2012). According to Pawson, (2007) and Paulay, (2003) about 1716 species of holothurians belonging to six orders *Aspidochirotida, Elasipodida, Molpadiida, Apodida, Dendrochirotida* and *Dactylochirotida* are known globally while Beirni *et al*., (2001) stated that holothurians include more than 1100 species of marine organisms worldwide. Holothurians are the most important components of the marine ecosystem comprise 90% of the total mass of the macrofauna (Purcell *et al*., 2016). They are distributed in all oceans the world over, generally living near corals, rocks or sea weeds in warm shallow waters (Ridzwan, 2007 and Higgins, 2000). They serve a useful role in the marine ecosystem as they help recycle nutrients, breaking down detritus and other organic matter after which bacteria can continue the degradation process (Du *et al.*, 2012).

Holothurians have become a superior aquaculture commodity with high economic value nowadays, due to the high nutritional content. The dry weight of sea cucumber contains 82% protein, 1.7% lipid, 8.9% water, and 4.8% of fiber (Martoyo *et al*., 2006).They play an important role as a large-scale detritus feeder and cycle up to 90% benthic biomass in ocean. Though sea cucumbers are very abundant in marine habitat but their numbers have recently been observed to be declining. Anthropogenic activities, such as marine tourism, and environmental induced changes are the major causes of their declining. They are presently overexploited worldwide for export of the dried product *Bêche-de-mer* (or trepang) consumed by Asiatic populations (Conand, 1981, 2004, 2006; Toral-Granda *et al*., 2008; Purcell *et al*., 2013). The holothurian fisheries in the Indian Ocean have been described (Conand, 2008) and their poor management has been pointed out (Conand and Muthiga, 2007; FAO, 2013; Muthiga and Conand, 2014).Clark and Rowe recorded twelve species of Holothuriidae from west India and Pakistan in 1971 subsequently twelve species belonging to three families (six species of family Holothuriidae, four species of family Cucumariidae and two species of family Synaptidae) were recorded by Tahera and Kazmi, (2004) from Pakistan coast. Given the worldwide overexploitation of holothurians, it is important to know their present status diversity and distribution in distant areas (Conand et al., 2013). Length-weight relationship is also an important tool in fishery (Garcia et. al., 1989; Haimovici and Velasco, 2000). It is essential to estimate the average weight at a given length group and also useful to convert growth-in-length data to growth-in- weight in stock assessment models (Beyer, 1987).

Buleji is located at 24° 8499' N 66° 89418' E on the northeastern border of the Arabian Sea. The rocks of Buleji were laid in post tertiary period covering an area of 1.5 Km. These rocks are rough and hard, the rocky ledge is gradually sloping move or less triangular platform which protrudes out in the Arabian Sea. The site may be classified as exposed wave beaten rocky coast, with slightly uneven profile consisting of slightly elevated and depressed areas. Therefore, part of the shores, which exposed to direct wave action, is somewhat elevated compared to the hinder part where small and large pools of water are created at low tides. Boulders of various sizes can be seen scattered on the rocky ledge but mostly high-water mark. Buleji coastal site was selected to collect the current knowledge of holothurians, as this site comprises different habitats as sandy, rocky, pools and muddy so considered as ideal place for biota (Nazim et al., 2012). The major objectives of this study were to determine the seasonal diversity and length-weight correlation along the accumulation of heavy metals of sea cucumber at Buleji coast. It is hoped that the current study will add our knowledge related seasonal distribution and over exploitation due to pollution.

Materials and Methods

For qualitative analysis 05 plots were selected at Buleji coast during January to December, 2023, five quadrats ($1x1m^2$) were set up in each plot to detect the distribution and diversity of sea cucumbers, Total numbers of sea cucumbers were counted and preserved for later identification. For identification, the specimens were anaesthetized by magnesium chloride at concentration of 5% to extend the tentacles following Samyn *et al.*, (2006). For further taxonomic studies specimens, ossicles were taken from three positions i.e. dorsal body wall, ventral body wall, and tentacles. The slides of the spicules were prepared by placing a small piece of skin on a slide and adding a few drops of 3.5% bleach. The slides were then dried, rinsed with a drop of distilled water, mounted in Canada balsam and examined under microscope (10 x10 magnifications).

Water samples were collected in pre-washed acidified bottles and preserved in refrigerator for further analysis. The five physical parameters i.e. pH, dissolved oxygen (mg/L), conductivity (mS/cm), total dissolved solids (g/L) and salinity (ppt) were recorded monthly basis using multiparameter (model Sension TM [105]) The sediment samples were collected and kept in cleaned plastic bags, labeled and transported to the laboratory for heavy metals analysis. The sediment samples were dried at 105 ºC, ground, sieved and digested with a mixture of conc. H_2O_2, HCl and HNO_3 following Page *et al.*, (1982) and preserved in a refrigerator till analysis. The tissue samples of different collected species of sea cucumbers were chopped into small pieces, ground and calcinated at (450^{o}C) for 4-5 hours. Ash sample of each specimen were weighed (g), dissolved with HCL (0.1 M) and further treated with Hydrogen per oxide (H_2O_2) (30%) until clear solutions were formed then diluted with water (Hashmi *et al.*, 2002). The Whatman filter papers 0.45µm were used for the filtration purposes. Eight heavy metals (Cd, Cu, Co, Cr, Fe, Mn, Pb and Zn) were analyzed on Atomic Absorption spectrophotometer. Species diversity was measured following Shannon and Weiner's, (1963) method. Species richness was measured using the index proposed by Menhinick, (1964). The equitability index was estimated by the Pielou's, (1969) method and the concentration of dominance was calculated by Simpson's, (1949) method**.**

Results and Discussion

Physical-Chemical Analysis of water

Table 1 presents an analysis of various water quality parameters across three distinct periods: pre-monsoon, monsoon, and post-monsoon. These parameters include temperature, salinity, conductivity, total dissolved solids (TDS), dissolved oxygen (DO), and pH. Water temperature fluctuates throughout the year, with the highest temperature recorded during the pre-monsoon period (23.85°C) and the lowest during the post-monsoon period (19.91°C). This is a typical seasonal variation, as temperature generally decreases after the monsoon season. Salinity levels are highest during the pre-monsoon season (40.17‰) and slightly lower during the monsoon (38.48‰) and post-monsoon (38.83‰) seasons. The higher salinity during the pre-monsoon could be due to increased evaporation and reduced freshwater input. Conductivity, which indicates the presence of ions in the water, shows a significant decrease from the pre-monsoon period (23461.11±1151.34 µS/cm) to the monsoon period (5894.61±131.56 µS/cm), followed by a slight increase in the post-monsoon period (6111.83±145.76 µS/cm). This fluctuation could be due to the dilution effect of rainwater during the monsoon season and subsequent concentration as the monsoon recedes. TDS levels follow a similar trend to conductivity, with the highest value in the pre-monsoon period (11917.1±107.45 mg/l) and lower values during the monsoon (2912.72±121.23 mg/l) and post-monsoon (3216.17±113.34 mg/l) seasons. This is because TDS measures the total amount of dissolved substances in water, which is also affected by dilution and concentration processes. Dissolved oxygen levels are lowest during the pre-monsoon period (0.74±0.08 mg/l) and peak during the monsoon season (1.53±0.06 mg/l), decreasing again in the post-monsoon period (0.31±0.04 mg/l). DO levels are influenced by temperature; with lower temperatures generally leading to higher DO levels. The pH values are slightly alkaline across all three periods, ranging from 7.53±0.4 to 8.63±0.22 during monsoon to post-monsoon periods respectively. pH is an important indicator of water quality, and these values suggest that the water is within an acceptable range, though seasonal variations are noticeable as reported by Khan *et al*., (2022).

Table 1. Analysis of various water quality parameters across three distinct seasons.

Months	Temperature (°C)	Salinity (‰)	Conductivity (µS/cm)	TDS (mg/l)	Do (mg/l)	Ph
Pre monsoon	23.85±2.23	40.17±9.87	23461.11±1151.34	11917.1±107.45	0.74±0.08	8.19±0.54
Monsoon	21.25±1.44	38.48±4.56	5894.61±131.56	2912.72±121.23	1.53±0.06	7.53±0.4
Post Monsoon	19.91±1.34	38.83±6.67	6111.83±145.67	3216.17±113.34	0.31±0.04	8.63±0.22

Sediment Texture

The pie chart illustrating the composition of sediment types during all seasons. The chart shows the percentage distribution of different sediment sizes, ranging from gravel to silt or clay. By comparing the composition of sediment in different seasons: pre-monsoon, monsoon and post-monsoon. The charts break down the sediment into categories: gravel, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, and silt or clay. During pre-monsoon silt or clay constitutes the majority of the sediment (64.13%), followed by very fine sand (18.70%). The other categories are present in smaller percentages. In monsoon silt or clay remains the largest component but decreases to 58.51%. There is an increase in the proportion of fine sand (9.82%) and medium sand (6.09%) compared to the pre-monsoon season. While in post-monsoon silt or clay decrease further to 40.22%. Fine sand (13.90%) and very fine sand (21.56%) increase significantly, becoming the second and third largest components respectively. There is also a noticeable increase in coarse sand (8.30%) (Fig. 1). This distribution suggests that the sediment in the studied area is predominantly composed of fine-grained materials (silt and clay), with lesser amounts of sand and gravel. This type of sediment composition is typical of environments with low energy conditions, such as floodplains or coastal areas with minimal wave action. Overall, the comparison reveals a shift in sediment composition across the seasons. The pre-monsoon timing is relevant as it represents a period before significant rainfall and runoff, which can alter sediment distribution patterns. Silt or clay is dominant in the pre-monsoon period but decreases during and after the monsoon, while the proportion of sand fractions, especially fine and very fine sand, increases. This change could be attributed to the monsoon season's influence on sediment transport and deposition.

Voyage Journal of Scientific Research and Exploration (VJSRE) *Vol 2. Issue 1*
ISSN (Online): 3007-3898, ISSN (Print): 3007-388X, April to September 2025

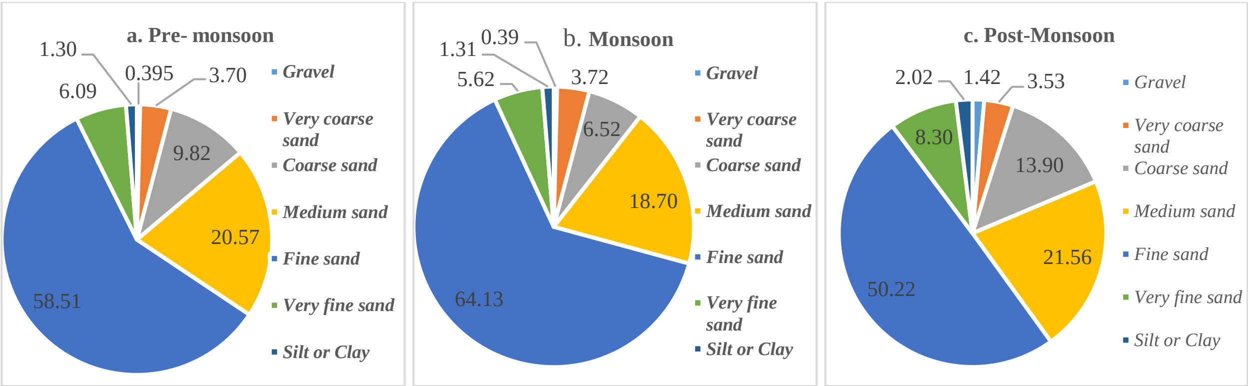


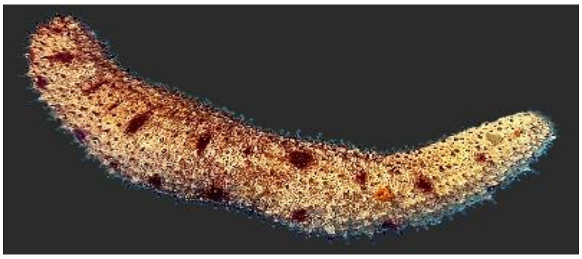
Figure 1. Texture analysis of the Sediment collected from Buleji in three seasons.

The results indicate the change in beach profiles due to change in wave action in monsoon season results in the deposition of the coarser sediments at the high tide level thus increasing the steepness of the beach (Farooq and Nazia, 2021). The gentle movement of water before SW monsoon promotes the deposition of very fine sand fraction at the studied site.

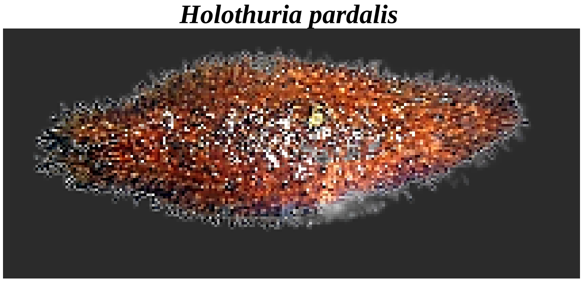
Species Composition

A total of 05 species viz., *Holothuria pardalis, Holothuria arenicola, Holothuria atra, Ohshimella ehrenbergii* and *Holothuria verrucosa* (Plate 1) belonging to 03 orders; Holothuriida, Aspidochirotida and Dendrochirotida and 02 families including Holothuriidae and Sclerodactylidae were recorded from study site.

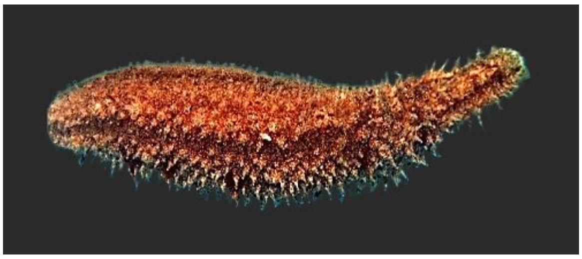
Holothuria pardalis



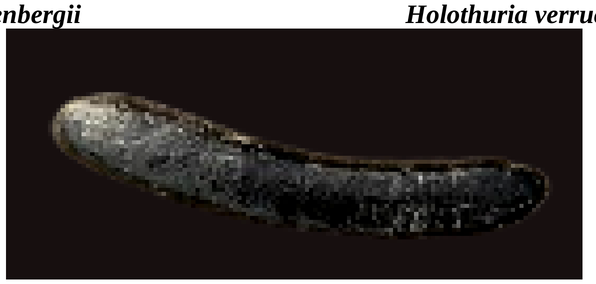
Holothuria arenicola



Ohshimella ehrenbergii



Holothuria verrucosa



Holothuria atra

Plate 1. Showing the collected holothurians from the study site.

ISSN (Online): 3007-3898, ISSN (Print): 3007-388X, April to September 2025

Table 2. Scientific/common names of recorded holothurians with their colors, habitats and global distribution.

Order	Family	Scientific name	Common name	Color	Habitat	Distribution
Holothuriida	Holothuriidae	*Holothuria pardalis (Selenka, 1867)*	Leopard sea cucumber	Yellowish white ventral to pink dorsal	Rocky, sandy and muddy bottoms in shallow to deeper waters including crevices, coral reefs, exposed sandy areas at depth 10 to 20 feet.	From Western Central Pacific to the Hawaiian Islands, Asia and the Africa and Indian Ocean region. Also found on Pacific Coast of Central America.
Aspidochirotida	Holothuriidae	*Holothuria arenicola (Semper, 1868)*	Sand fish sea cucumber	Tan to brown cream to rusty, some found in orange	Sandy or muddy bottoms near coral reef, seagrass beds and other fixed habitat.	Western Pacific, parts of Asia, Indian Ocean, including the Red Sea and the Comoros. Reported along the Pacific coast of Central America.
Holothuriida	Holothuriidae	*Holothuria atra (Jaeger, 1833)*	Lolly fish black sea cucumber	Black, greyish black	on sea bed in shallow water on reefs and sandflats and in grass meadows at depth up to 20m.	Indo-Pacific. East Africa, Madagascar, Red Sea, Mascarene Islands, Southeast Arabia, Persian Gulf, Maldives, Sri Lanka, Bay of Bengal, India, North Australia, Philippines, China, Southern Japan, South Sea Islands, Hawaiian Islands. Galápagos islands, Panama region, Clipperton Island and Mexico.
Dendrochirotida	Sclerodactylidae	*Ohshimella ehrenbergii (Selenka, 1868)*	Ashy sea cucumber	Greyish brown	In rock crevices or under stones, crevices between boulders.	Red Sea, Somalia, South Africa (Natal), Madagascar, Seychelles (Mahé), Maldive Islands, Chagos Archipelago (Diego Garcia), Persian Gulf, Sri Lanka, Indonesia (Sulawesi), China (Xisha Islands).
Aspidochirotida	Holothuriidae	*Holothuria verrucosa (Selenka, 1867)*	Warty sea cucumber	Deep chocolate-brown with an upper surface often suffused with orange, ventral side yellowish	Shallow to moderately deep water, often near coral reefs, buried in sand, sea grasses and rubble	Indian Ocean, Eastern Africa including Aldabra, Madagascar, Comoros, the Mascarene Basin, the Red Sea, Seychelles, and Tanzania. It is also distributed in Sandwich Is., East Indies, north Australia, Indonesia, Philippines, south Pacific Is. and Hawaiian Island, China and Australia.

Table 2 describes the common names, habitats and the global distribution of all the recorded species. The most distributed species was *H. pardalis* (64 %) ranked first, *H. verrucosa* (16 %) ranked second, *H. arenicola* (14 %) ranked third while *H. atra* and *O. ehrenbergii* both comprised the remaining proportion in same ratio (Fig 2a). The highest percent of holothurians were recorded following this pattern monsoon> pre monsoon>post monsoon as 50%, 44% and 6% respectively (Fig 2b).

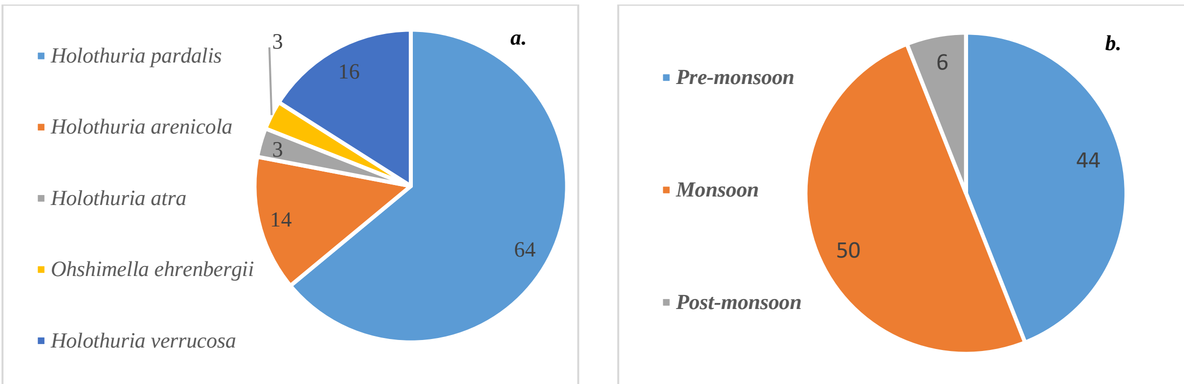


Figure 2. Showing the a. Frequency % & b. seasonal distribution % of holothurians collected from Buleji.

The seasonal distribution of holothurian species apparent a patchy nature. *H. pardalis* and *H. arenicola* were the species found throughout the seasons, *H. atra* was only recorded in pre-monsoon while *O. ehrenbergii* and *H. verrucosa* were only found in post-monsoon (Fig. 3). The fluctuations in number of species may be partially explained in term of the substrata availability but the physical factors affecting growth obviously important. Sandy substrate provides better place to survive Holothurians, they may inhabit on sand which provides favorable resources for better growth and survival. When the results were analyzed with respect to the species, *Holothurian pardalis* ranked first with 64% throughout the seasons in study area, is likely influenced by various factors including habitat, food availability and potentially most probable due to competitive interactions with other species (Amaral et al., 2015).

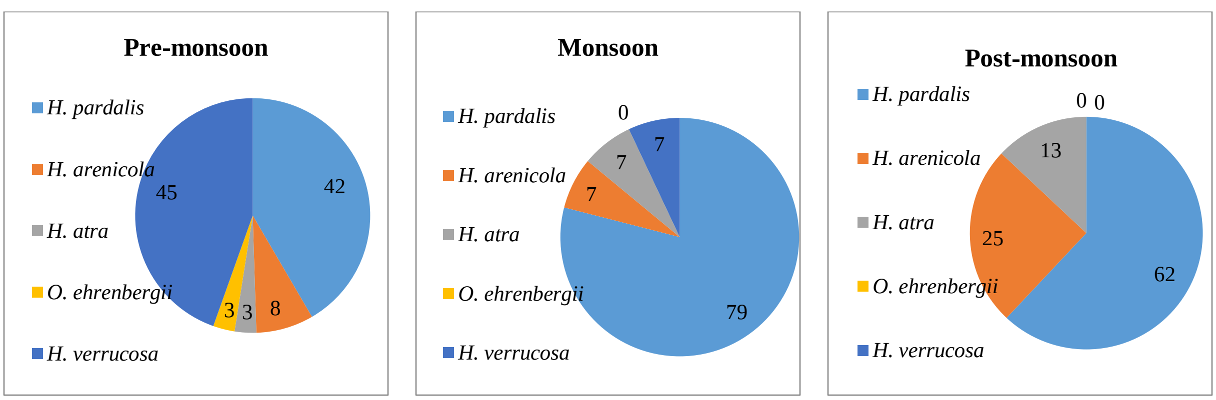


Figure 3. Seasonal distribution of collected holothurians from Buleji coast.

Diversity index

The bar chart illustrates the diversity indices across different seasons: pre-monsoon, monsoon, and post-monsoon. The chart compares four metrics: diversity, equitability, species richness, and dominance (Fig. 4).

A diversity index is a quantitative measure reflecting the number of different species in a dataset and their evenness; generally, it is used to assess biodiversity in an area. The overall species diversity shows that the maximum diversity (1.32±0.26) and equitability (0.97±0.01) of holothurians were recorded during monsoon while relatively lower in the pre-monsoon however least were found in post-monsoon periods. Species richness was highest (0.89±0.23) during the pre-monsoon, suggesting a greater variety of species at this time. Dominance appears to be inversely related to the other metrics, with lower dominance during the monsoon. The chart indicates that the pre-monsoon and monsoon are associated with higher biodiversity and a more even distribution of species compared to post-monsoon which shows lower diversity and potentially higher dominance (0.68±0.01) by certain species (Fig. 4).
The maximum diversity during monsoon might be due lower values of salinity, conductivity, total dissolved solids, pH and higher value of dissolved oxygen (Yuniarga *et al*., 2021). All these factors inevitable will cause a change in the variation of sea cucumber status in this area.

The results demonstrated that diversity of species may be ultimately determined by high population size, tolerance to extremes of physical conditions and higher range of potential habitats. This may be concluded that *Holothuria pardalis* were found abundantly on the Buleji coast whereas *Ohshimella ehrenbergii* was rarely rare species of this site. The *H. pardalis* could be preventing other species to be found effectively within the same habitat. So, there is a need to study holothurians on large scale. Overall, the species diversity of sea cucumbers is comparatively higher in study site compared to the results conducted in southern coastal zone of Sri Lanka reported by Kumara *et al*., (2021).

The proposed diversity of the holothurians can help in assessing the abundance of holothurian species in different substrate varied from silt, silty sand, sandy gravel, and coral fracture. Though this area is prohibited for visitors but fishing practice with locals has been conducted for a quite long time with no regulation on fishery management. The number of local populations in this area also increases with the consequence of high pollution risk at Buleji coast.

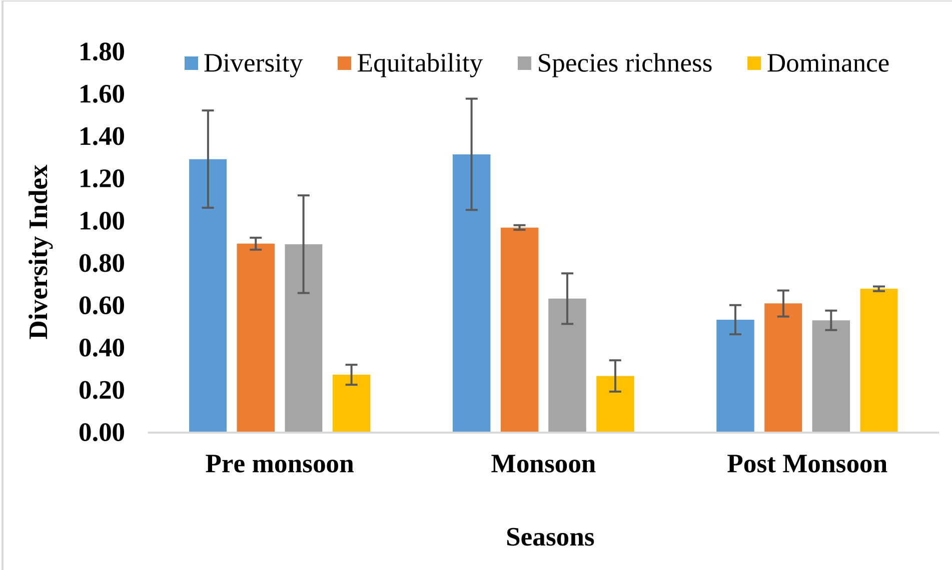


Figure4. Overall seasonal species diversity, richness, evenness and dominance of collected holothurians.

Length-weight analysis

The graph illustrates the relationship between the length and weight of *H. pardalis*, R-squared value ($R^2 = 0.937$) are displayed on the graph appears to be a positive correlation between length and weight, as indicated by the upward slope of the trendline. This suggests that as the length of *H. pardalis* increases, its weight tends to increase as well. The equation V = 1.4822x indicates the linear relationship between length (x) and weight (V). The slope of 1.4822 suggests that for every 1 cm increase in length, the weight increases by approximately 1.48 grams. The R-squared value of 0.937 indicates that the trendline explains 93.7% of the variability in the data. This suggests a strong fit, meaning the linear model is a good representation of the relationship between length and weight for different samples of *H. pardalis (*Fig. 5a). The points are clustered relatively close to the trendline, further supporting the strong correlation. Fig. 5b illustrates the relationship between the length and weight of *H. arenicola*, a species of marine worm. The equation of the trendline is y = 1.3273x, where y is the weight and x is the length. This equation suggests that for every centimeter increase in length, the weight increases by approximately 1.3273 grams. The R-squared value, 0.9326, indicates that the trendline fits the data well, explaining 93.26% of the variability in weight based on length. This high R-squared value suggests a strong linear relationship between the length and weight of *H. arenicola* within the measured range. The Fig. 5c shows a scatter plot with a trend line, displaying a correlation between two variables length and weight in *H. atra*. The top left corner displays the equation of the trend line (y = 1.0161x) and the R-squared value ($R^2 = 0.9468$). The R-squared value suggests a strong positive correlation between the variables Kumara *et al*., (2021). Fig. 5d provides equation y = 0.9635x and $R^2 = 0.9965$ describe the relationship between length (x) and weight (y) of *O. ehrenbergii*, along with the strength of that relationship. y = 0.9635x**. This is a linear equation where 0.9635 represents the slope. It suggests that for every 1 cm increase in length, the weight of *O. ehrenbergii* increases by approximately 0.9635 grams. $R^2 = 0.9965$: This is the coefficient of determination, a statistical measure of how well the regression line approximates the real data points. It ranges from 0 to 1, where values closer to 1 indicate a stronger relationship. An R^2 of 0.9965 suggests that the linear model explains 99.65% of the variance in the data, indicating a very strong correlation between length and weight. In simpler terms, the equation allows for predicting the weight of *O. ehrenbergii* given its length, and the R^2 value confirms that this prediction will likely be highly accurate.

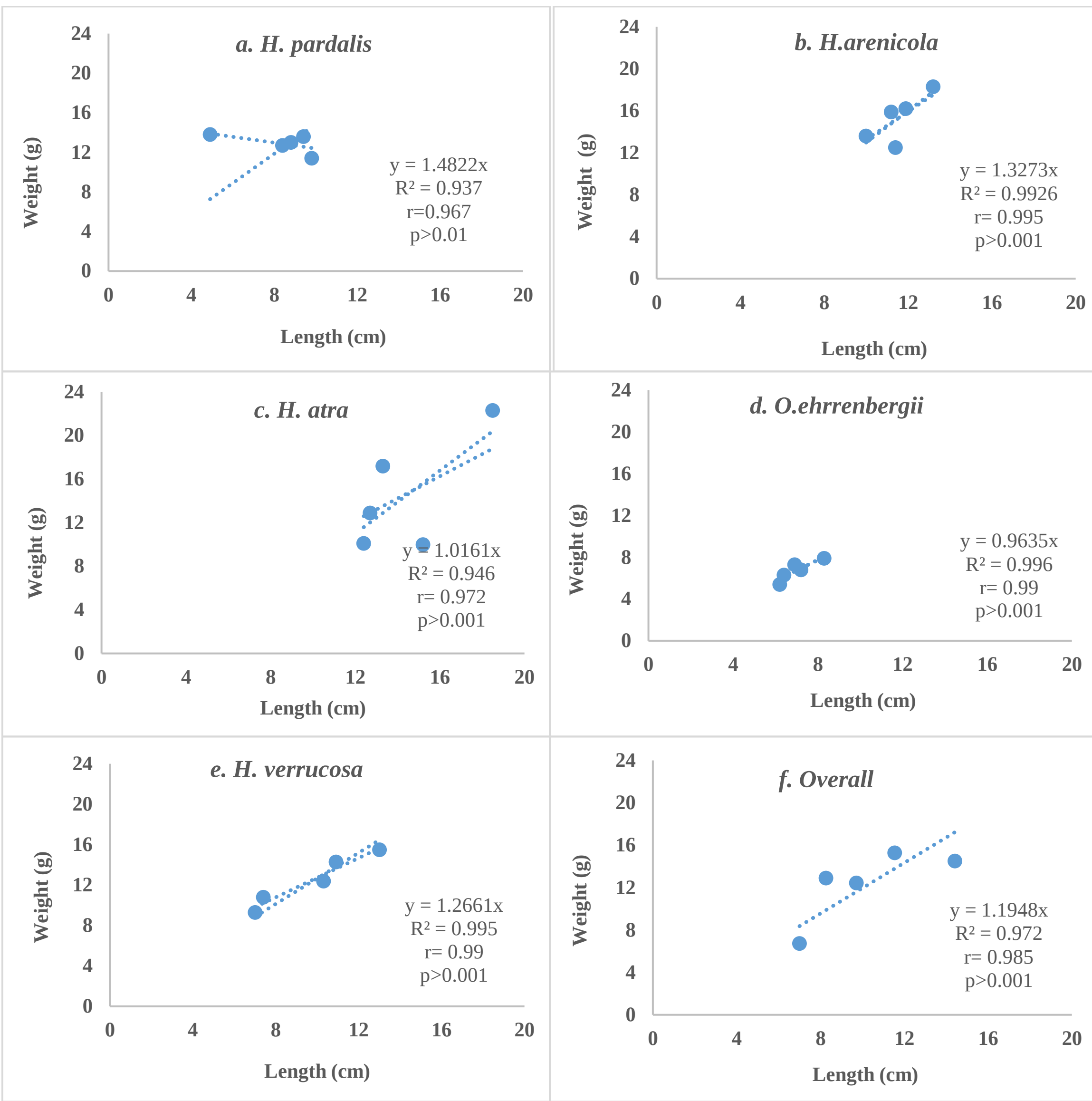


Figure 5. Length weight correlation of five different holothurians species and as whole.

Fig. 5e illustrates the relationship between the length and weight of *H. verrucosa.* The data points show a positive correlation, indicating that as the length of *H. verrucosa* increases, its weight also tends to increase. A trend line is fitted to the data points, with the equation y = 1.2661x and an R^2 value of 0.9952. The R^2 value, close to 1, suggests a strong fit of the linear model to the data, meaning that the length of *H. verrucosa* is a good predictor of its weight. Fig. 5f showing the relationship between length and weight of overall species. The equation for this line is y = 1.1948x, with an R^2 value of 0.97 indicates a positive linear relationship between length and weight. Equation y = 1.1948x indicates a strong positive correlation, meaning the model fits the data well. A value close to 1 suggests that the length is a good predictor of weight. The values were significantly lower from the hypothetical value of 3, showing a negative allometric growth pattern as reported by Froese, (2006) & Pauly, (1980). This finding signifies the more elongated body of sea cucumbers as a distinctive morphological character by emphasizing that the rate of length increment is lower than that of the weight increase of sea cucumbers in the study site, further, this growth pattern emphasizes that all the sea cucumbers species are likely to be gaining weight in the sampling site as stated by Veronika et al., (2018).

Heavy metal concentration in sediments, water and sea cucumbers

Table 3 presents a comparison of mean ± standard Error of heavy metal concentrations of Cadmium, Copper, Cobalt, Chromium, Iron, Manganese, Lead, and Zinc in sediments, water, and sea cucumbers. The Concentrations of Cadmium are relatively low across all three matrices, with water showing a slightly higher concentration (2.08 ± 0.65) compared to sediments (1.98 ± 0.18) and sea cucumbers (0.36 ± 0.07). Water exhibits the highest concentration of copper (19.90 ± 2.7), while sediments have a lower concentration (4.35 ± 0.88) and sea cucumbers have the lowest (0.98 ± 0.12). Sediments and water have relatively similar cobalt concentrations (30.85 ± 9.13 and 36.59 ± 6.435, respectively), whereas sea cucumbers show a much lower concentration (0.18 ± 0.04). Sediments have the highest chromium concentration (33.10 ± 0.42), followed by water (16.50 ± 1.95), with sea cucumbers having the lowest (1.55 ± 0.09). Iron concentrations are significantly higher than other metals, with water having the highest concentration (330.90 ± 19.9), followed by sediments (172.37 ± 26.49), and sea cucumbers showing a lower concentration (44.83 ± 4.75). Water has the highest manganese concentration (372.42 ± 21.77), while sediments have a considerably lower concentration (139.62 ± 5.27), and sea cucumbers have the lowest (4.66 ± 0.43). Water shows a higher lead concentration (52.70 ± 10.64) compared to sediments (29.49 ± 5.81), and sea cucumbers have the lowest concentration (0.45 ± 0.08). Water has a higher zinc concentration (27.20 ± 2.49) than sediments (21.55 ± 6.98), while sea cucumbers have the lowest (8.97 ± 0.40). Overall, the results indicate that heavy metal concentrations vary significantly among sediments, water, and sea cucumbers. Water generally has the highest concentrations of most heavy metals, followed by sediments, with sea cucumbers typically showing the lowest concentrations. This suggests that sea cucumbers do not accumulate these heavy metals to the same extent as sediments or the surrounding water.

Table 3. Mean±SE concentration of heavy metals recorded in sediments, water and sea cucumber.

Heavy Metals	Sediments	Water	Sea cucumber
Cd	1.98±0.18	2.08±0.65	0.36±0.07
Cu	4.35±0.88	19.90±2.7	0.98±0.12
Co	30.85±9.13	36.59±6.435	0.18±0.04
Cr	33.10±0.42	16.50±1.95	1.55±0.09
Fe	172.37±26.49	330.90±19.9	44.83±4.75
Mn	139.62±5.27	372.42±21.77	4.66±0.43
Pb	29.49±5.81	52.70±10.64	0.45±0.08
Zn	21.55±6.98	27.20±2.49	8.97±0.40

Figure 6 (a-c) illustrates the concentration of heavy metals include: Cadmium (Cd), Copper (Cu), Cobalt (Co), Chromium (Cr), Iron (Fe), Manganese (Mn), Lead (Pb), and Zinc (Zn) in sediments, water and sea cucumber during pre-monsoon, monsoon, and post-monsoon periods. Table 3 shows the mean ±Standard Error concentration of heavy metals in all samples, the concentration levels of all metals were measured in parts per million (ppm).

Fig. 6a shows that Fe has the highest mean concentration (172.37±26.49) among all metals, particularly during the pre-monsoon and monsoon seasons, with a notable decrease in the post-monsoon period. Manganese (Mn) also exhibits relatively high concentrations (139.62±5.27), with a similar trend to iron. Other metals show comparatively low concentrations across all seasons. It is evident, with most metals showing peak concentrations during the pre-monsoon or monsoon seasons and lower levels in the post-monsoon period. This suggests a potential influence of rainfall and water flow on metal concentrations in sediments.

The graph indicates that iron and manganese are the most abundant heavy metals in the sediment samples, with their concentrations varying significantly across different seasons. The other metals are present in much lower concentrations and exhibit less seasonal fluctuation. This analysis suggests a dynamic interaction between environmental factors and heavy metal distribution in the coastal sediment ecosystem (Michel et al., 2006).

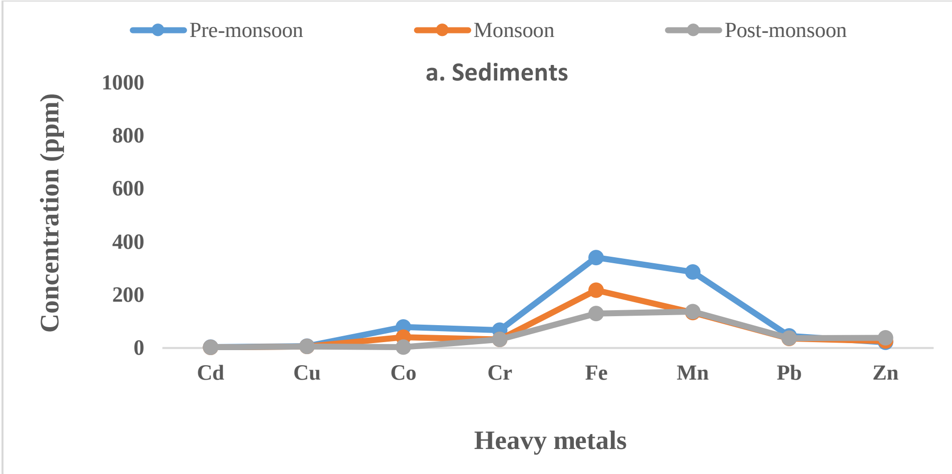


Figure 6a. Seasonal uptake of heavy metal in sediment samples collected from Buleji.

In Fig. 6b graph shows significant peaks for Iron and Manganese, particularly during the pre-monsoon season. Manganese reaches the highest mean concentration (372.42±21.77) ranked first followed by iron (330.86±19.90) among all metals, with a notable drop during the monsoon and post-monsoon periods, but is still high. The concentrations of other metals remain relatively low across all three seasons. There are minor fluctuations, but they are not as significant as those observed for Iron and Manganese. The high levels of Iron and Manganese, particularly during the pre-monsoon season, could be attributed to various factors such as industrial discharge, natural weathering of rocks, or agricultural runoff. The decrease in metal concentrations during the monsoon season likely results from the dilution effect of increased rainfall and surface runoff, which reduces the concentration of pollutants in the water. The stabilization of metal concentrations in the post-monsoon season suggests a return to more normal conditions, though the levels of Iron and Manganese remain comparatively high.

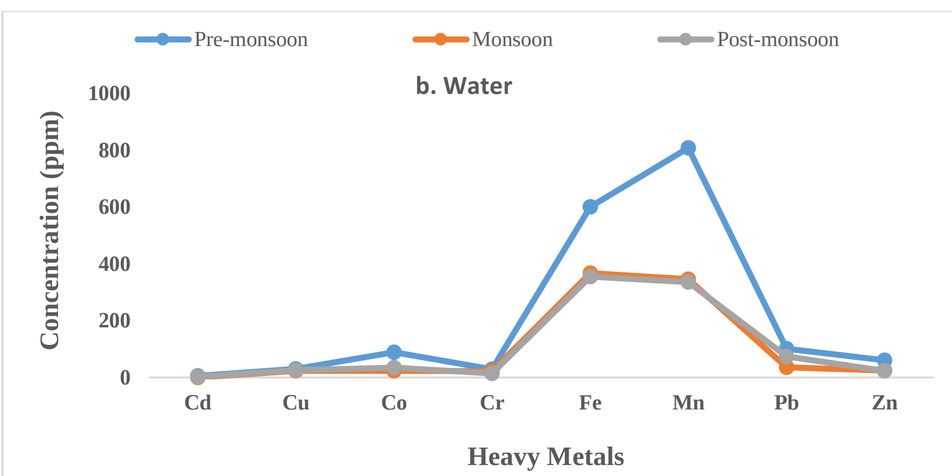


Figure 6b. Seasonal uptake of heavy metal in water samples collected from Buleji.

In tissue samples of sea cucumber, iron shows the most significant fluctuation with highest mean value (44.83±4.75) across seasons, Fe gets a peak concentration during the pre-monsoon period, followed by a sharp decline in the monsoon and post-monsoon seasons. Zinc levels are relatively higher with mean value (8.97±0.40) compared to other metals, with a noticeable increase in the pre-monsoon and post-monsoon periods. The other metals; Cd, Cu, Co, Cr, Mn, Pb exhibit low concentrations across all seasons, with minimal fluctuations (Mohammadizadeha *et al.*, 2015). The seasonal comparison shows that pre-monsoon characterized by the highest concentrations of Fe and Zn, while other metals remain low, monsoon shows a marked decrease in Fe concentration but slight increases in other metals. During post-monsoon Fe levels remain low, while Zn and other metals show slight increases, indicating a potential accumulation or slower clearance during this period.

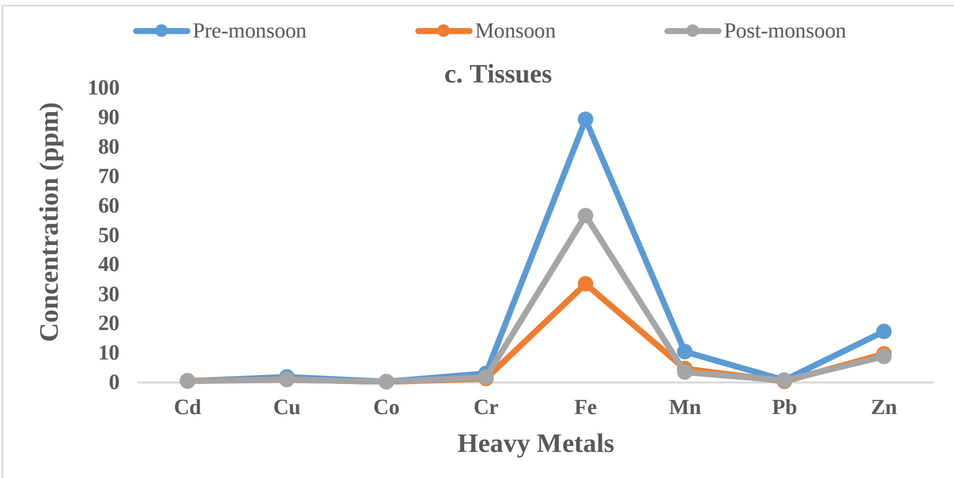


Table 6c. Seasonal uptake of heavy metal in holothurian tissue samples collected from Buleji.

Comparing the three graphs, it is noticeable that Fe consistently shows the highest concentration across all three matrices (sediments, tissues, and water), with a significant spike during the monsoon season. This suggests a strong influence of seasonal changes on Fe levels. In accordance with seasons, the monsoon season appears to have a notable impact on the concentrations of several heavy metals, particularly Fe and Mn, across all three matrices. This could be attributed to increased runoff and mobilization of metals during the rainy season. The concentration levels of heavy metals are different in each matrix. Tissues generally have lower concentrations compared to sediments and water. Fe dominates in all three; the relative concentrations of other metals differ. However, Mn is more prominent in water compared to sediments and tissues. The concentrations of other metals are relatively lower and show less variation across the seasons. The seasonal variations in heavy metal concentrations could be attributed to several factors, including changes in environmental conditions, biological activity, and pollution sources (Medina et al., 2004). The high levels of Iron during the pre-monsoon season might be linked to specific environmental processes or industrial activities prevalent during that time. The lower levels during the monsoon could be due to dilution effects from rainfall or changes in biological uptake and excretion rates. The consistent presence of Zinc, even at lower levels, suggests its essential role in biological processes or continuous exposure from environmental sources.

Conclusion

The current study provides valuable insights into the seasonal dynamics of sea cucumber diversity, length-weight correlation with heavy metals accumulation in tissues, highlighting potential environmental and biological influences. Though this research provides a baseline qualitative/quantitative analysis and seasonal pattern of holothurians dwelling on different habitats as; sandy and rocky beach with degrees of exploitation due to anthropogenic activities. Further research is needed to identify the specific sources and impacts of heavy metals, particularly Iron, Manganese and Zinc and to assess their implications for ecosystem health.

References

Amaral, M.K., Pellico-Netto, S., Lingnau, C. and Figueiredo, F. A. (2015). Evaluation of the Morisita index for determination of the spatial distribution of species in a fragment of Araucaria forest. Applied Ecology and Environmental Research, 13: 361-372.

Beyer, J.E. (1987). On length-weight relationship computing the mean weight of the fish of a given length class. Fish bytes. 5(10), 11-13.

Beirne, L., Fitzmier, K. and Miller, M. (2001). "Holothuroidea" (On-line). Biological Diversity 2001. Accessed January 28, 2005 .

Clark, A. M. and Rowe, F.W. (1971). Monograph of Shallow Water Indo-West Pacific Echinoderms. Trustees of the British Museum (Natural History); London, UK:171–209. Publication No. 690.

Conand, C. (1981). Sexual cycle of three commercially important holothurian species (Echinodermata) from the lagoon of New Caledonia. Bulletin of Marine Science, 31(3): 523-543.

Conand, C. (2004). Present status of world sea cucumber resources and utilization, an international overview: In: Lovatelli A., Conand, C., Purcell, S., Uthicke, S., Hamel, J.F. and Mercier, A. (eds). Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper (463): 13-23.

Conand, C. (2006). Harvest and trade: Utilization of sea sea cucumbers; cucumber fisheries; current international trade; illegal, unreported and unregulated trade; by-catch; socio economic characteristics of the trade in sea cucumbers: In Bruckner AW (ed) The Proceedings of the CITES workshop on the conservation of sea cucumbers in the families Holothuriidae and Stichopodidae. NOAA Technical Memorandum NMFS-OPR-34, USA: 51-73.

Conand, C. and Muthiga, N. (2007) Commercial sea cucumbers: A review for the Western Indian Ocean. WIOMSA Book Series No. 5, 66 pp

Conand, C. (2008). Population status, fisheries and trade of sea cucumbers in the Indian Ocean. In : Toral-Granda V, Lovatelli A, Vasconcellos M (eds) Sea cucumbers. A global review on fishery and trade. FAO Fisheries Technical Paper (516): 153-205.

Conand, C., Thierry, M. and Chabanet, P. (2013). Holothurian (Echinodermata) Diversity in the Glorieuses Archipelago (Eparses Islands, France, Mozambique Channel).*Western Indian Ocean J. Mar. Sci. Vol. 12, No. 1*, pp. 71-78

Du, H., Bao, Z., Hou, R., Wang, S., Su, H., Yan, J., Tian, M., Li, Y., Wei, W., Lu, W., Hu, X., Wang, S. and Hu, J. (2012). Transcriptome sequencing and characterization for the sea cucumber Apostichopus japonicas (Selenka, 1867). PLoS ONE, 7(3): e333111.

Escandon, M.H., Francisco A. S. and Alfredo L.F. (2011). Holothuria (Selenkothuria) carere, a new species of sea cucumber (Echinodermata: Holothuroidea) from the Mexican Pacific. Zootaxa, 2922:27-33.

FAO. (2013). Report on the FAO Workshop on Sea Cucumber Fisheries: An Ecosystem Approach to Management in the Indian Ocean (SCEAM Indian Ocean), Mazizini, Zanzibar, the United Republic of Tanzania, 12-16 November 2012. FAO Fisheries and Aquaculture Report (1038): 92.

Farooq S. and Nazia, A. (2021). Sediment Characterization and Monsoonal Impact on Beach Morphology at the Three Beaches along the Karachi Coast, Pakistan.International Journal of Economic ans Environmental Geology 12(1) 81-85.

Froese, R. (2006). Cube law, condition factor and weight length relationships: History, meta-analysis and recommendations. 22, 241-253.

Kumara, L., Thiththagalle, G., Gajahin, G. N. T., Keerthi, S. S. A. and Hewa, K. R. S. K. (2021). Diversity, Length-Weight Relations, and Condition Factor of Sea Cucumbers in Three Coastal Areas Along the Southern Coast of Sri Lanka. Turk. J. Fish.& Aquat. Sci. 21(12), 575-588.

Garcia, C.B., Buarte, J.O., Sandoval, N., Von Schiller, D., Mello. and Najavas, P. (1989). Length-weight relationships of demersal fishes from the Gulf of Salamanca, Colombia. Fishbyte. 21, 30 - 32.

Haimovici, M. and Velasco, G. (2000). Length-weight relationship of marine fishes from southern Brazil. NAGA, ICLARM Quarterly. 23(1), 14-16

Higgins, M. (2000). Sea cucumbers in a deep pickle. Environmental News Network.30.

Hashmi, M.I., Mustafa, S., Nitisewojo, P. and Tariq, S.A. (2002). Distribution of heavy metals in seawater, sea sediments and sea cucumber (Holothuria scraba), and its implications for sea ranching in Sabah Malaysian Borneo. Science International, 14(1): 29-32.

Khan, M.U., Cai, L., Nazim, K., Ahmed, M., Zhao, X. and Yang, D. (2022). Effects of the summer monsoon on the polychaete assemblages and benthic environment of three mangrove swamps along the Sindh coast, Pakistan. Regional Studies in Marine Science. 56: 1-10

Martoyo, J., Aji, N. and Winanto, T. (2006). Sea Cucumber Cultivation (Ed). Revision. (Jakarta: PenebarSwadaya) p 69 (in Indonesian)

Medina, R.G., Carlos, Z.M., Manuel, C.B. and Roberto, P.C. (2004). Concentration of Cd, Cr, Cu and Pb in sediments and in three species of sea cucumber (Holothuroidea class) of the coasts of State of Yucatan, Mexico. Ingeniería; 8: 7-19. Spanish.

Menhinick, E. F. (1964). A comparison of some species individual's diversity indices applied to sample of field insects. *Ecology,* 45: 859-861.

Michel, W., Sandrine, D., Gilles, L., Alessia, M., Rodrigues, Y. and Philippe, D. (2006). Heavy metals in the sea cucumber *Holothuria tubulosa* (Echinodermata) from the Mediterranean Posidonia oceanic ecosystem: body compartment, seasonal, geographical and bathymetric variations. Environ Bio-indicators; 1: 268-85.

Muthiga, N.A. and Conand, C. (2014). Sea cucumbers in the western Indian Ocean: Improving management of an important but poorly understood resource. WIOMSA Book Series No. 14: 74.

Mohammadizadeha, M., Bastami, K.D., Ehsanpour, M., Afkhami, M., Mohammadizadeh, F. and Esmaeilzadeh, M. (2015). Heavy metal accumulation in tissues of two sea cucumbers, Holothuria leucospilota and Holothuria scabra in the northern part of Qeshm Island, Persian Gulf. Mar Pollut Bull; 103: 354-9.

Nazim, K., Moinuddin, A., Alia, A. and Muhammad, U. K. (2012). Quantitative description and multivariate analysis of flora and fauna of Buleji area of Karachi coast. FUUAST J. BIOL., 2(1): 117-123

Oliveira, J.P. and Christoffersen, M.L. (2012) Holothuria (Semperothuria) surinamensis Ludwig, 1875 (Echinodermata: Holothuroidea): Record of the species for the northeast coast of Brazil. Check List, 8 (4), 768–770.

Page, A. L., Miller, R. H. and Kenney, D. R. (editors). 1982. Heavy metals determination. In: Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties. American Society of Agronomy, Madison, WI, USA. 8 pp.

Paulay, G. (2003). The Asteroidea, Echinoidea, and Holothuroidea (Echinodermata) of the Mariana Islands. Micronesica 35–36: 563–583.

Pauly, D. (1980). A selection of simple methods for the assessment of tropical fish stocks.

Pawson, (2007) and Paulay, (2014) about 1716species of holothurians belonging to six orders *Aspidochirotida, Elasipodida, Molpadiida, Apodida, Dendrochirotida, and Dactylochirotida*

Pielou, E. C. (1969). Mathematical Ecology. John Wiley, New York.

Purcell, S.W., Mercier A., Conand, C., Hamel, J.F., Toral-Ganda, V., Lovatelli, A. and Uthicke, S. (2013) Sea cucumber fisheries: Global analysis of stocks, management measures and drivers of overfishing. Fish and Fisheries 14, Issue 1: 34–59.

Purcell, S., Conand, C., Uthicke, S., and Byrne, M. (2016). Ecological roles of exploited sea cucumbers. *Oceanogr. Mar. Biol. Annu. Rev.* 54, 367–386.

Ridzwan, B.H. (2007). Sea Cucumbers, A Malaysian Heritage. 1st ed. Research Centre of International Islamic University Malaysia (IIUM); Kuala Lumpur Wilayah Persekutuan, Malaysia: 1–15.

Samyn, Y., Vandenspiegel, D. and Massin, C. (2006). A new Indo-West Pacific species of *Actinopyga* (Holothuroidea: Aspidochirotida: Holothuriidae). Zootaxa; 1138, 53–68.

Shannon, C. E and Wiener, W. (1963). The Mathematical theory of communication. University of Illinois Press, Urbana. 117.

Simpson, E. H. (1949). The measurement of diversity. *Nature, 163:688*

Tahera, Q. (2004). An addition to the existing fauna of the family Cucumariidae (Holothuroidea; Echinodermata) from Pakistan. International Journal of Biology and Biotechnology. 1(2):

Toral-Granda, V., Lovatelli, A. and Vasconcellos, M. (2008). Sea cucumbers. A global review on fishery and trade. FAO Fisheries Technical Paper (516): 319.

Veronika, K., Edrisinghe, U., Sivashanthini, K., and Athauda, A. (2018). Length-weight relationships of four different sea cucumber species in North-East coastal region of Sri Lanka. Tropical agricultural research, 29, 212-217. doi: 10.4038/tar.v29i2.8290

Yuniarga, T.R., Satriyo, T.B. and Adharini, R.I. (2021). Community structure of sea cucumber on Harapan Island and East Penjaliran Island, Kepulauan Seribu National Park. IOP ConfSer: Earth EnvironSci919: 012025. DOI:10.1088/1755-1315/919/1/012025.

Zulfigar, Y., Kwang, S.Y., Shau-Hwai, A.T. and Shirayama, Y. (2008). Field Guide to the Echinoderms (Sea Cucumbers and Sea Stars) of Malaysia. 1st ed. Kyoto University Press; Kyoto, Japan: 9–61.