ABUNDANCE AND DIVERSITY STATUS OF SOME CEPHALOPOD ALONG CHAUNGTHA COASTAL AREA, AYEYARWADY REGION

Thida Soe[1], Thein Soe[2], Lei Lei Oo[3], Mu Mu Aung Soe[4]

Abstract

The present study was to assess the abundance and species diversity of cephalopods along Chaungtha coastal area. It was conducted from December 2018 to November 2019. Identification was followed after Jereb and Roper (2005) and Jereb *et al*. (2010,2014).The key of species richness index, Simpson's index of diversity and Shannon-Wiener's diversity index were used in this research. A total of 14 cephalopod species, belonging to six genera, four families under four orders were recorded within the study area. Maximum number of cephalopod individuals was recorded in cold season. The highest number of individual was also observed for the species *Uroteuthis duvauceli*. The second highest number of individual was examined in the hot season. The least number was in the wet season. Fourteen species were recorded in all season. According to Shannon index the highest value (1.828295) was in wet season while the lowest value (1.708776) was in cold season. According to Simpson's index the highest value (0.250587) was recorded in cold season and the lowest value (0.22207) was observed in wet season. The output was expected to promote the cephalopod fishery in future fishery sector of coastal region in Myanmar.

Keywords: Cephalopod species, abundance, diversity, Chaungtha coastal area

Introduction

Cephalopod is the most morphologically and behaviorally complex class in phylum Mollusca. They are a very diverse and abundant group inhabiting all marine environments of the world, from surface waters to more than 5000 m depth (Jereb and Roper 2005). Cephalopods are an important component of many marine ecosystems from the tropics to the poles (Jackson and O'dor, 2002). The coastal and marine environs comprise some of the high biodiversity area (Khan *etal*., 2005). Cephalopods are a diverse group of species. There are over 800 extant species of cephalopod in the world. Four groups of cephalopods are squid, cuttlefish, octopus and chambered nautilus (Roper *et al*.1984, Jereb and Roper, 2005). Three major orders; Octopoda, Sepioidea, Teuthoidea live in the continental shelf (Boyle and Daly, 2000). These species are abundant and ecologically important (Duysak,*etal*., 2008). In common with many marine animal groups, the highest diversity of the octopus occurs in the tropical Indo-West Pacific region, particularly the Indo-Malayan Archipelago (Jereb *et al*., 2014).

Cephalopods are a worldwide commercial interest with several fisheries providing significant quantities for human consumption, animal feed and fishing bait (Pierc and Guerra, 1994). Cephalopods are .most commonly eaten in Southeast Asia and Southern Europe (Mouritsen, 2018). Cephalopods started gaining importance in India and neighbor countries such as Myanmar, with the development of export markets and consequent are cepholopods fauna. Myanmar is rich in natural resources along coastal area including diverse cephalopods fauna (Wye, 2003). In coastal area, cephalopods dwell in sandy, rocky and muddy area. *Sepia, Loligo* and *Octopus* are edible mollusks and economically importance of Myanmar marine ecosystem (Khin Myat Myat Tun, 2000).

Ayeyarwady Region is abundant of coastal area and fishery; it produces million viss of fishes and prawns. Chaungtha beach is a part of Rakhine coast on the Bay of Bangal. Fishery sector

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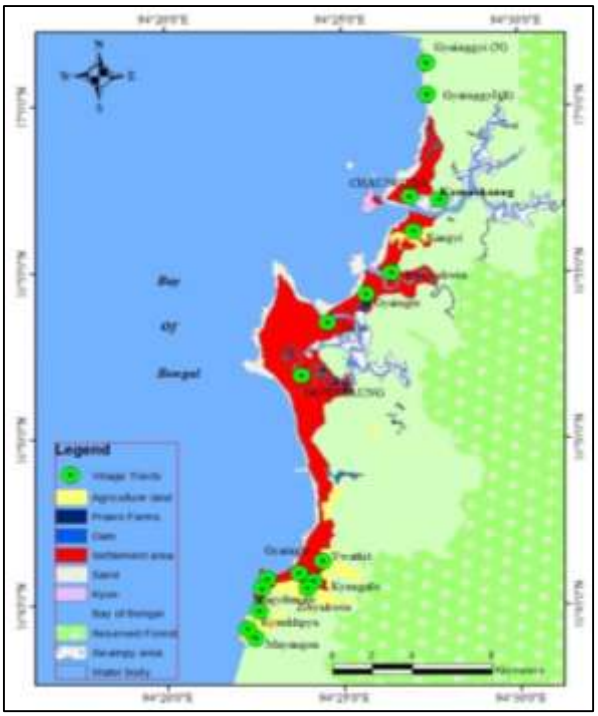
is the most important for local people because it provides the socio economic importance for local fisher families and fishery industry. The general aims of this research are:

- to identify the cephalopods species in Chaungtha coastal area
- to investigate the seasonal abundance of cephalopods species
- to assess the diversity of cephalopods species recorded from the study area

Materials and Methods

Study area and Study period

Chaungtha beach is located in the northwest of Pathein Township, Ayeyarwady Region. It is situated at latitude 16˚ 57' N and longitude 94˚ 30' E (Fig.1). The study period lasted from December, 2018 to November, 2019.



(**Source:** Department of Geography, Pathein University)

Figure 1 Map of Chaungtha environs

Data collections

Monthly data collection was carried out in study site. Cephalopod species and individuals were recorded and noted. Interview survey was made with local fishermen and depots, dealing with catch number, commercial status and fishing gear for cephalopod fishery. Spawning season of finfish and shell fish was investigated from fishery department of Ngwe Saung Township. The morphological and taxonomic characters, from fresh specimens were taken photographs. Then, they were preserved in 10% formaldehyde solution.

Species identification

Specimens were identified by distinctive characters and texture, colouration, proportion of carapace, shape of mantle, rows of sucker, tentacles shapes and photo key according to Jereb and Roper (2005), and Jereb *et al*., (2010,2014).

Estimates of species diversity

Three indices of species diversity, Dominant index, Shannon index, Simpson index, and its evenness were used to assess species diversity of cephalopods. Index value of each cephalopods species collected from study sites and seasons were compared (Krebs, 2001, and Stiling, 1999).

The formula of Dominant index is as:

$$\text{Dominant index} = \frac{n}{N} \text{ x100}$$

Where n is the number of individuals in each species and N is the total population number.
The formula of Richness index as:

$$\text{Richness index} = n + (n-1)/n$$

Where n is the number of individuals in each species.
The formula of the Simpson index of the species diversity is as:

$$D_s = \sum_{i=1}^{s} \frac{(n_i(n_i - 1))}{(N(N-1))}$$

The formula of the Shannon index of species diversity is as:

$$H' = -\sum P_i \text{ Ln } P_i$$

$$\text{Evenness} = H' / \text{Ln}$$

Where, S is total number of species. Evenness is usually range between 0 and 1.0.

Results

A total of 14 species of cephalopods belonging to six genera of four families under four orders were recorded during the study period. (Table.1, Plate.1)

Species Composition

. A total of 14 species belong to six genera of four families under four orders of class cephalopods were recorded. The recorded cephalopods include under four orders of Sepiida, Sepiolida, Teuthida and Octopoda.

The order Sepiida included the highest number of species and percent (seven species, 50 percent of recorded cephalopods) among the collected cephalopods. The second highest number of species (three species, 22 percent of recorded cephalopods) was observed in Octopoda, and the least number of species (two species, 14 percent recorded cephalopods) in the order Teuthida and Sepiolida. (Table.1,Fig. 2)

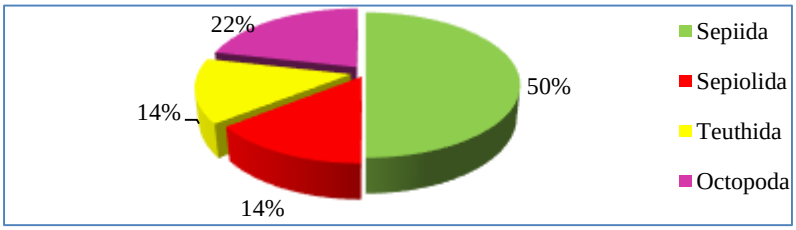


Figure 2 Species composition in different orders by percentage

Table 1 Species composition of cephalopods along Chaungtha coastal area

Order	Family	Scientific name	Connom name	Local Name
1. Sepiida	Sepiidae	*Sepia braggi*	Slender cuttlefish	Yay Kyat
		S . esculenta	Goldencuttlefish	Yay Kyat
		S . prabahari	Small strip cuttlefish	Yay Kyat
		S . aculata	Needle cuttlefish	Yay Kyat
		S. pharaonis	Pharaoh cuttlefish	Yay Kyat
		S . recurvirostra	Curve spine cuttlefish	Yay Kyat
		Sepiella inermis	Spineless cuttlefish	Yay Kyat
2.Sepiolida	Sepiolidae	*Euprymna hyllebergi*	Bobtail squid	Sin Na Ywet
		Euprymna moresi	Mimika bobtail squid	Sin Na Ywet
3.Teuthida	Loliginidae	*Uroteuthis duvauceli*	Indian squid	Kin Mon
		U.chinensis	Mitre squid	Kin Mon
4.Octopoda	Octopodidae	*Octopus dollfusi*	Marble octopous	Yay Myuk
		Amphioctopus aegina	Webfoot octopus	Yay Myuk
		A.neglectus	Webfoot octopus	Yay Myuk

Seasonal abundance of cephalopods

A total of 14 species of cephalopod were recorded at the study area in all season. Maximum number of cephalopod's individuals was observed in cold season. The highest catch number of individuals was also observed for the species *Uroteuthis duvauceli*. The second highest catch number of individuals was examined in hot season. The least number was in the wet season (Table.2, 3).

Hot season

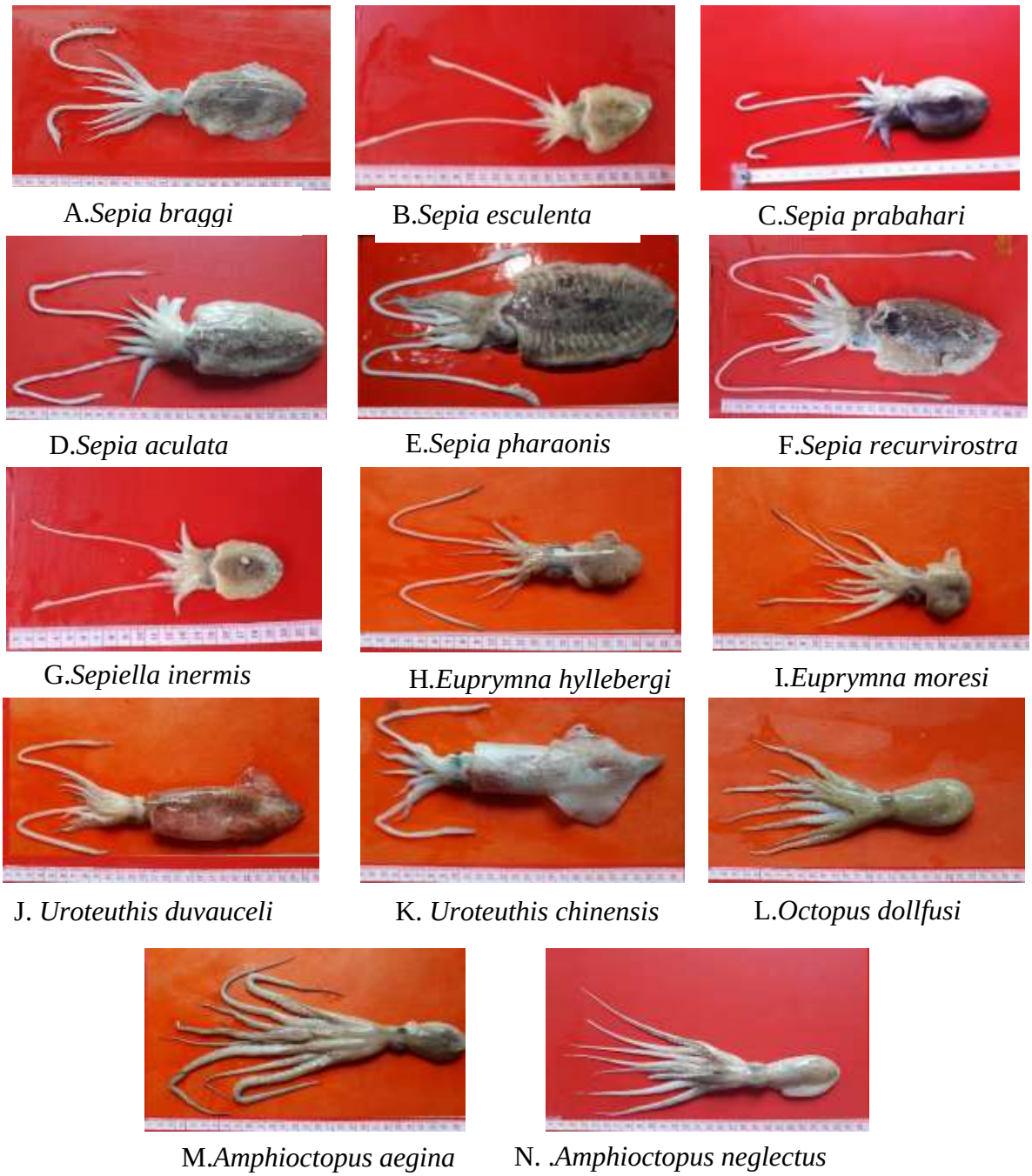
In hot season, 14 species and 582887individuals were observed from the study site. Among the recorded four orders in hot season, order Sepiida had the highest number of species (7 species) .The order Teuthida had the highest catch number of individuals (386580 individuals).The second highest number of species was recorded in order Octopoda (3 species) which was successively followed by order, Sepiolida and Teuthida (2 species). The order Sepiida had the second highest catch number of individuals (186717 individuals).Order Sepiolida had the least number of species and individuals (two species and 1049 individuals). In hot season *Uroteuthis duvauceli* was recorded to have the maximum number of individuals (193740 individuals) (Table.2 and Fig.3A).

Wet season

In wet season, 14 species and 263042 individuals were recorded in which the highest number of species (7 species) was observed in order Sepiida and the highest number of individuals (166500 individuals) was recorded in order Teuthida. The second highest number of individuals (91843 individuals) was observed in order Sepiida which was successively followed by order Octopoda (4390 individuals). The least number of species (two species) was observed in order Sepiolida and Teuthida, and order Sepiolida had the least number of species and individuals (two species and 309 individuals).The species *Uroteuthis duvauceli* was the maximum number of individuals in this season (87500 individuals) (Table.2 and Fig.3B).

Cold season

In cold season, 14 species and 1204830 individuals were collected. Among the recorded four orders, order Sepiida had the highest number of species (7species). The highest catch number of individuals (818324 individuals) was recorded in order Teuthida which was successively followed by order Sepiida including 370365 individuals and the order Octopoda was 14116 individuals. Two orders Teuthida and Sepiolida were observed to obtain two species. The least number of species and individuals (two species and 2025 individuals) was recorded for order Sepiolida Maximum number of individuals, 409612 individuals was observed for the species *Uroteuthis duvauceli* in this season (Table.2and Fig.3C).



A.*Sepia braggi* B.*Sepia esculenta* C.*Sepia prabahari*

D.*Sepia aculata* E.*Sepia pharaonis* F.*Sepia recurvirostra*

G.*Sepiella inermis* H.*Euprymna hyllebergi* I.*Euprymna moresi*

J. *Uroteuthis duvauceli* K. *Uroteuthis chinensis* L.*Octopus dollfusi*

M.*Amphioctopus aegina* N. .*Amphioctopus neglectus*

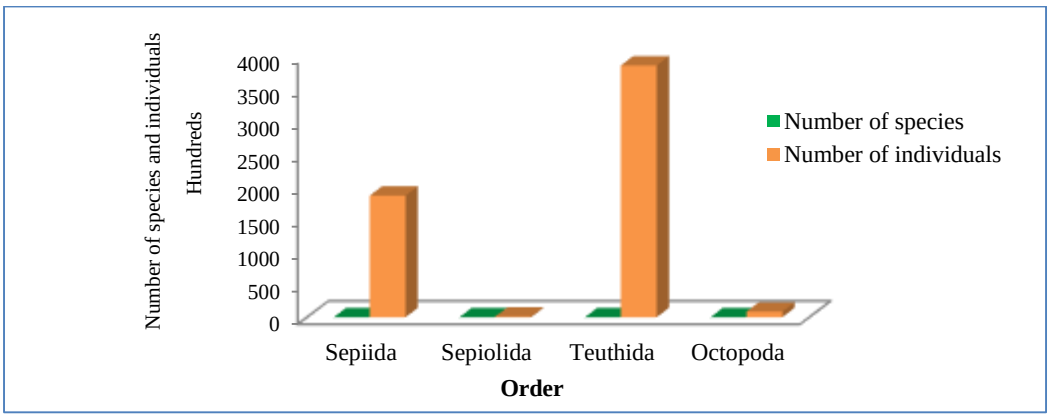
Plate 1 Recorded cephalopods belonging to order Sepiida, Sepiolida, Teuthida and Octopoda

Table 2 Seasonal abundance of cephalopods along Chaungtha coastal area

Order	No	Species	Hot	Wet	Cold	Total
1. Sepiida	1	*Sepia braggi*	27407	11450	44060	82917
	2	*S . esculenta*	25250	12870	45756	83876
	3	*S . prabahari*	27740	12100	45185	85025
	4	*S . aculata*	19821	11840	45073	76734
	5	*S. pharaonis*	6777	2583	10795	20155
	6	*S.recurvirostra*	59933	24450	137321	221704
	7	*Sepiella inermis*	19789	16550	42175	78514
Total			**186717**	**91843**	**370365**	**648925**
Sepiolida	8	*Euprymna hyllebergi*	522	145	1005	1672
	9	*Euprymna moresi*	527	164	1020	1711
Total			**1049**	**309**	**2025**	**3383**
3.Teuthida	10	*Uroteuthis duvauceli*	193740	87500	409612	690852
	11	*U.chinensis*	192840	79000	408712	680552
Total			**386580**	**166500**	**818324**	**1371404**
4. Octopoda	12	*Octopus dollfusi*	2865	1390	4456	8711
	13	*Amphioctopus aegina*	2836	1530	4775	9141
	14	*A.neglectus*	2840	1470	4885	9195
Total			**8541**	**4390**	**14116**	**27047**

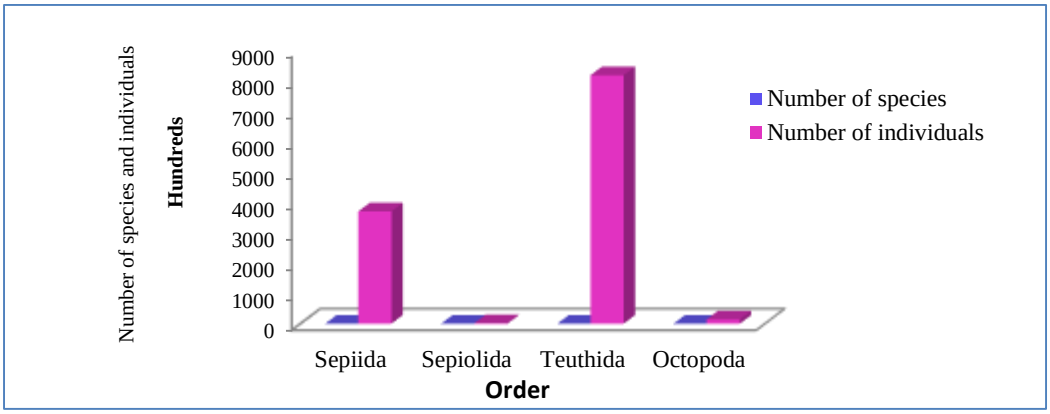
Table 3 Comparison seasonal abundance of cephalopods in three seasons

	Hot	Wet	Cold
Number of species	14	14	14
Number of individuals	582887	263042	1204830



(A) Hot Season

(B)Wet Season



(C) Cold Season

Figure 3 Seasonal abundance of cephalopods from study area

Species diversity

Species diversity of three seasons represented by different indies was found to vary as follows;

Hot Season

In hot season, *Uroteuthis duvauceli* Indian squid under the order Teuthida had the highest value of species diversity, richness index (193741.00), Shannon index (-0.366109), Simpson's index (0.110476). *Uroteuthis chinensis* of the order Teuthida was the second highest diverse species which had the highest index value of species richness (192841.00), Shannon index (-0.365948), Simpson'sindex (0.109452). The species *Euprymna hyllebergi* had the least value of species diversity, richness index (522.9980843), Shannon index (0.006285), Simpson's index (0.000001).

Wet season

In wet season, the highest value of species richness was (87500.99999), that of Shannon index (-0.366136), that of Simpson's was (0.110653) in the species *Uroteuthis duvauceli*, Indian squid of order. The second highest value of species diversity, richness index (79000.99999), Shannon index (-0.361259), Simpson's index (0.090199) was observed for the species *Uroteuthis chinensis* mitre squid of order Teuthida , The species *Euprymna hyllebergi* was the lowest value of species diversity richness was (145.9931034), Shannon index(-0.004136), Simpson's index (0.000000).

Cold season

In cold season**,** the highest value of species diversity, richness index (409613.00), Shannon index (-0.366793), Simpson's index (0.0115583) was recorded for the species *Uroteuthis duvauceli*, Indian squid of the order Teuthida. *Uroteuthis chinensis*, mitre squid had the second highest value of species diversity, richness index (408713.00), Shannon index (-0.366734), Simpson's index (0.115075).The species *Euprymna hyllebergi* was the lowest value of species diversity richness index (1005.999005), Shannon index (-0.005913), Simpson's index (0.000001).

Table 5 Diversity indies of cephalopods during hot season

Sr No	Species	n	Richness n+(n-1)/n	Dominance index n/N*100	Shannon index Pi Ln Pi	Simpson's index n(n-1) /N(N1)
1	*Sepia braggi*	27407	27407.99996	4.70194	-0.143747	0.002211
2	*S . esculenta*	25250	25250.99996	4.33189	-0.135985	0.001876
3	*S . prabahari*	27740	27740.99996	4.75907	-0.144919	0.002265
4	*S.aculata*	19821	19821.99995	3.40049	-0.114979	0.001156
5	*S.pharaonis*	6777	6777.999852	1.16266	-0.051790	0.000135
6	*S.recurvirostra*	59933	59933.99998	10.28210	-0.233894	0.010572
7	*Sepiella inermis*	19789	19789.99995	3.39500	-0.114848	0.001153
8	*Euprymna hyllebergi*	522	522.9980843	0.08955	-0.006285	0.000001
9	*Euprymna moresi*	527	527.9981025	0.09041	-0.006337	0.000001
10	*Uroteuthis duvauceli*	193740	193741.00	33.23800	-0.366109	0.110476
11	*U.chinensis*	192840	192841.00	33.08360	-0.365948	0.109452
12	*Octopus dollfusi*	2865	2865.999651	0.49152	-0.026126	0.000024
13	*Amphioctopus aegina*	2836	2836.999647	0.48654	-0.025911	0.000024
14	*A.neglectus*	2840	2840.999648	0.48723	-0.025941	0.000024
	Total	**582887**	**582900.9947**	**100.00000**	**-1.762821**	**0.239369**

Table 6 Diversity indies of cephalopods during wet season

Sr No	Species	n	Richness n+(n-1)/n	Dominance index n/N*100	Shannon index Pi Ln Pi	Simpson's index n(n-1)/N(N-1)
1	*Sepia braggi*	11450	11450.99991	4.35292	-0.136435	0.001895
2	*S. esculenta*	12870	12870.99992	4.89275	-0.147635	0.002394
3	*S. prabahari*	12100	12100.99992	4.60003	-0.141640	0.002116
4	*S.asculata*	11840	11840.99992	4.50118	-0.139574	0.002026
5	*S.pharaonis*	2583	2583.999613	0.98197	-0.045400	0.000096
6	*S.recurvirostra*	24450	24450.99996	9.29509	-0.220822	0.008640
7	*Sepiella inermis*	16550	16550.99994	6.29177	-0.174026	0.003958
8	*Euprymna hyllebergi*	145	145.9931034	0.05512	-0.004136	0.000000
9	*Euprymna moresi*	164	164.9939024	0.06235	-0.004601	0.000000
10	*Uroteuthis duvauceli*	87500	87500.99999	33.26465	-0.366136	0.110653
11	*U.chinensis*	79000	79000.99999	30.03323	-0.361259	0.090199
12	*Octopus dollfusi*	1390	1390.999281	0.52843	-0.027706	0.000028
13	*Amphioctopus aegina*	1530	1530.999346	0.58166	-0.029938	0.000034
14	*A.neglectus*	1470	1470.99932	0.55885	-0.028988	0.000031
	Total	**263042**	**263055.9841**	**100.00000**	**-1.828295**	**0.222070**

Table 7 Diversity indies of cephalopods during cold season

Sr No	Species	n	Richness n+(n-1)/n	Dominance index n/N*100	Shannon index Pi Ln Pi	Simpson's index n(n-1)/N(N-1)
1	*Sepia braggi*	44060	44060.99998	3.656947	-0.120992	0.001337
2	*S . esculenta*	45756	45756.99998	3.797714	-0.124215	0.001442
3	*S . prabahari*	45185	45185.99998	3.750322	-0.123135	0.001406
4	*S.aculata*	45073	45073.99998	3.741026	-0.122923	0.001399
5	*S.paraonis*	10795	10795.99991	0.895977	-0.042245	0.000080
6	*S.recurvirostra*	137321	137322.00	11.397542	-0.247529	0.012990
7	*Sepiella inermis*	42175	42175.99998	3.500494	-0.117346	0.001225
8	*Euprymna hyllebergi*	1005	1005.999005	0.083414	-0.005913	0.000001
9	*Euprymna moresi*	1020	1020.99902	0.084659	-0.005989	0.000001
10	*Uroteuthis duvauceli*	409612	409613.00	33.997493	-0.366793	0.115583
11	*U.chinensis*	408712	408713.00	33.922794	-0.366734	0.115075
12	*Octopus dollfusi*	4456	4456.999776	0.369845	-0.020711	0.000014
13	*Amphioctopus aegina*	4775	4775.999791	0.396321	-0.021919	0.000016
14	*A.neglectus*	4885	4885.999795	0.405451	-0.022332	0.000016
	Total	**1204830**	**1204843.997**	**100.00000**	**-1.708776**	**0.250587**

Table 8 Comparison of diversity indies of cephalopod species diversity in three seasons

	Seasons	Hot season	Wet season	Cold season
1	No of species	14	14	14
2	No of individuals	582887	263042	1204830
3	Species richness	582900.9947	263055.9841	1204843.997
4	Shannon index	1.762821	1.828295	1.708776
5	Shannon evenness	0.66797	0.69278	0.64749
6	Simpson index	0.239369	0.22207	0.250587

Comparison of species diversity in season

The value of two parameters of species diversity such as Shannon index and Simpson's index were compared for season.

Both indices of Shannon index and Simpson's index expressed the highest value of (1.828295) and (0.250587) were observed in the cephalopod species in wet and cold season. The least value of Shannon index (1.708776) was found in cold season while that of Simpson's index (0.22207) was also recorded in wet season (Table.4).

Discussion

A total of 14 species belong to six genera of four families under four orders of class cephalopods were recorded. The recorded cephalopods include under four orders of Sepiida, Sepiolida, Teuthida and Octopoda. Order Sepiida was represented by seven species, order Octopoda was represented by three species and two orders Sepiolida and Teuthida were represented by two species.

In addition, 14 cephalopod species were found in all season. The highest catch number of individuals was observed in cold season (1204830 individuals). The second highest catch number of individuals was found in hot season (582887 individuals) and followed by wet season (263042 individuals). The least catch number was collected in wet season (263042 individuals).In all season, the highest catch number of individuals was recorded in the species *Uroteuthis duvauceli*.

The highest catch number of individuals was observed in cold season. It was agree with Thin Thin Maw (2009). She investigated the squid fishing and catch rate based on some fishery depots of Yangon environs. In her observed, the highest catch number was found in November December, January and February.

The least catch number was found in wet season. Zero catch number was observed in June, July and August. It may be assumed that the fishery department doesn't permit catching fish in these months of all coastal regions. Because June, July and August are spawning seasons of marine fish and prawn.

Fourteen cephalopod species were found in all season. This may be due to the fact that most cephalopods showed their continuous reproductive breeding period. Cephalopods have a rapid growth rate and short life spans. Spawning time and spawning vary among marine species; it's correlated with temperature, though cephalopods in shallow water spawn in cold months so that the offspring would hatch at warmer temperature. (Vidal, 2015)

Species diversity may be related with season. According to the different index value of species diversity, the Shannon index was weight to rare species which collected the least number while the Simpson's index was weight to common species. The value assess by Simpson's index for the least number (collected number is only one individual) of a particular species assessed value could not mentioned at all. Hence the former index should be suitable for the common species.

The species representing the highest value of cephalopod species diversity by Shannon index (-0.366109), Simpson's index (0.110476) was *Uroteuthis duvauceli*, which was followed by *Uroteuthis chinensis* Shannon index (-0.365948), Simpson's index (0.109452) in hot season. The species *Euprymna hyllebergi* had the lowest value of Shannon index (-0.006285), Simpson's index (0.000001).

The species evaluated as the highest value of cephalopod species diversity by Shannon index (-0.366136), Simpson's index (0.110653) was *Uroteuthis duvauceli*, which was followed by *Uroteuthis chinensis* Shannon index (-0.361259), Simpson's index (0.090199) in wet season. The species *Euprymna hyllebergi* had the lowest value of Shannon index (-0.004136), Simpson's index (0.000000).

The higest value of cephalopod species diversity by Shannon index (-0.366793), Simpson's index (0.0115583) was represented by *Uroteuthis duvauceli*, which was followed by *Uroteuthis chinensis* Shannon index (-0.366734), Simpson's index (-0.115075) in cold season. The species *Euprymna hyllebergi* had the lowest value of Shannon index (-0.005913), Simpson's index (0.000001).

It may be assumed that the highest value of species diversity may coincide with the breeding season of those species. The least value of species diversity may probably be due to the prebreeding season or may be the scarcity of those species in the natural habitat.

The present study was also agreed with Mae May Paw (2014). She observed the ecological aspects of cephalopod fauna from Chaungtha environs. She stated that the breeding of all cephalopod were in cool and dry season. Most ovigerous females were captured in cold season and dry season for all recorded species. It might be related to the period of after breeding season. Grist

and des Clers (1999) stated that temperature was also an important parameter incorporated into population dynamic models for short-lived animals.

Value of Shannon diversity index for real community is between1.5 to 3.5 (Krebs, 2001). In the present research, Shannon index ranges from 1.708776 to 1.828295 in seasonally. In the present study, the diversity of some cephalopods along Chaungtha coastal area revealed as the real community for the cephalopods species.

Conclusion

According to result, 14 cephalopod species found in three seasons. The highest catch number of individuals was observed in cold season. Analyzing to diversity indices, the highest diversity value was assessed in cold season. These findings indicate that cephalopods revealed as the real community along Chaungtha coastal area. Findings of the survey can provide cephalopod fauna. However, local people and fishery department should protect cephalopod species extinction as well as maintaining the fishery sector of coastal region. Because fishery sector is important for local people of Chaungtha beach, coastal region and our country.

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