J.Univ.Ruhuna 2013 ***1****(2):9-17*
Volume 1 Number 2, December 2013
ISSN 2345-9387

RESEARCH ARTICLE

Evaluation of changes in zooplankton community and water quality parameters in the Polhena reef ecosystem observed during November 2010 to February 2011

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Abstract: This study provides baseline information on physico-chemical parameters and the zooplankton community at the Polhena reef, from November 2010 to February 2011, the months of the second inter monsoon to north east monsoon. Water samples were collected from seven stations at 15 day intervals for measurement of physico-chemical parameters and identification and quantification of zooplanktons. The results were; average salinity 28.8 - 35.4ppt, total dissolved solids 29.56 - 39.23 g/L, dissolved oxygen 7.35 - 10.36 mg/L, biological oxygen demand 0.32 - 1.95 mg/L, total hardness 5012 - 5816 mg/L and pH 8. Highest average phosphate concentration was recorded in the dry season as 0.8 mg/L. Highest average nitrite concentration was recorded as 0.063 mg/L in mid December. Though no significant changes were recorded in average DO levels, water temperature, BOD levels, salinities, TDS, TSS and TH levels, pH, and NO_2^- and PO_4^{3-} concentrations at different stations, their temporal changes at each site were significant. The highest average total zooplankton abundance was recorded as 45,638.14 individuals/m^3 on February 01, 2011 and that of the lowest was recorded as 6,507.71 individuals/m^3 on December 01, 2010. The zooplankton community was identified to occupy 17 groups, dominated by copepods, crustacean nauplii and foraminiferans. Their relative abundances were calculated as percentages and copepods made up to about 96% at station 3 in February which was the highest of any group at any station. Nauplii stages, foraminiferans and veliger larvae, peaked at different stations.

Keywords: Zooplankton, Relative abundance, Physico-chemical parameters, Temporal change

Introduction

Zooplankton is an essential faunal group in a reef ecosystem, as it provides food for corals and reef fish communities (Randall, 1967). Its biomass is a fertility index of an area (Zafar, 2007). The information of zooplankton ecology is important to implement strategies for coastal zone management. Their relationships with physico-chemical parameters are important for the management strategies of aquatic ecosystems (Edward and Ugwumba, 2010). Changes of these parameters may indicate some alterations of the prevailing conditions of the eco system. Physico-chemical parameters may change due to several environmental incidences and it may affect the biota including the zooplankton community. These alterations may give rise to issues related to food supply for consumers in the higher trophic levels. But data of its related zooplankton community and its variation with other environmental factors are rare. Thus, very little information on zooplankton is available for the management of marine habitats. The objective of this study was to provide baseline information on the water quality and the changes of zooplankton community structure at the Polhena reef area, from inter monsoon to dry season.

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Materials and Methods

Polhena area receives southwest monsoonal rains from mid May to October and has a dry climate during the northeast monsoon from December to March. Inter monsoonal period prevails in October and November. Seven (7) sampling stations were tracked using GPS on the basis of the proximity to the reef and the land. Also, the influence of freshwater runoff entering the site from the river (Figure 1) was studied. Collection of zooplankton and water samples was carried out for four months from November 2010 to February 2011, once every 15 days during daytime. Physical parameters (depth, Secchi depth, salinity), chemical parameters (dissolved oxygen (DO), pH, total dissolved solids (TDS), total suspended solids (TSS), total hardness, nitrite (NO_2^-) and phosphate (PO_4^{3-}) concentrations) and biological parameters (biological oxygen demand (BOD), zooplankton abundance) were determined. Zooplanktons were collected using a 100µm mesh sized circular zooplankton net with 100cm length and 25cm diameter. Vertical hauls from known depth were taken at each station. Collected planktons were fixed with 4% neutralized formalin. They were sub sampled, identified into groups and counted as individuals/ml (Omori and Ikeda, 1984). One way Analysis of Variance (ANOVA) was performed at 0.05 significance level with physico-chemical parameters and average total zooplankton abundance as dependant variables. The factors, “sampling dates” (5 factors) and “stations” (7 factors) were used as independent variables.

Figure 1. Sampling locations at Polhena reef area.
(Image source: 2011 Geoeye, Courtesy of Google Earth ™ Mitsubishi inc.)
Accessed on 10 October 2011

Results and discussion

Table 1. Temporal changes of average physico-chemical parameters ± SE at Polhena reef area between November, 2010 and February, 2011.

Physico-chemical parameter	Nov. 29	Dec. 14	Dec. 29	Jan. 13	Feb. 01
Temperature ^oC)*	28.6±0.6	29±0	27.9±0.4	28.7±0.5	27.7±0.5
pH	8.60±0.02	8.50±0.34	8.51±0.33	8.47±0.26	8.64±0.21
Salinity (ppt)*	28.86±4.41	31±0	32.14±1.57	35.43±0.98	35.43±0.78
Total suspended solids (mg/L)*	113.43±8.80	56.85±18.46	54.45±4.29	48.74±5.97	40.46±3.66
Total dissolved solids (g/L)*	29.56±5.60	33.02±2.85	34.49±1.60	35.04±0.6	39.23±2.31
Dissolved oxygen (mg/L)*	7.54±0.24	6.03±1.08	7.71±0.99	10.36±0.68	9.40±0.97
Biological oxygen demand (mg/L)*	0.32±0.16	0.85±0.69	0.56±0.26	1.44±0.81	1.95±1.14
Total hardness as $CaCO_3$(mg/L)*	5012.00±516.77	5610.57±99.25	5629.14±121.66	5588.43±38.05	5816.27±76.25
Phosphate (mg/L)*	0.23±0.02	0.06±0.05	0.04±0.02	0.14±0.24	0.80±0.90
Nitrite (mg/L)	0.05±0.03	0.06±0.02	0.05±0.02	0.04±0.01	0.04±0.02

* Average values of the physico-chemical parameter are significant at 0.05 probability level ($P < 0.05$) at least between two sampling dates.

Table 2. ANOVA table, proving variations at different stations and temporal variations of average physico-chemical parameters-Polhena reef area.

Physico-chemical parameter	Variations at different stations				Temporal variations			
	SS	df	F	P	SS	df	F	P
Temperature (C^o)	1.3	6	446	841	8.471	4	9.883	0.000*
pH	0.614	6	1.572	0.192	0.148	4	0.483	0.748
Salinity (ppt)	44.743	6	0.678	0.669	229.429	4	12.191	0.000*
Total suspended solids (mg/L)	840.242	6	0.153	0.987	23555.969	4	60.618	0.000*
Total dissolved solids (g/L)	115.315	6	1.033	0.425	343.223	4	8.758	0.000*
Dissolved oxygen (mg/L)	7.113	6	0.352	0.903	80.606	4	28.382	0.000*
Biological oxygen demand (mg/L)	5.642	6	1.199	0.336	12.430	4	6.149	0.001*
Total hardness (mg/L as $CaCO_3$)	369102.743	6	0.429	0.853	25.901	4	10.829	0.000*
Phosphate (mg/L)	1.129	6	0.758	0.609	2.767	4	3.902	0.011*
Nitrates (mg/L)	0.005	6	2.036	0.094	2.767	4	0.692	0.11

* Average value of the physico-chemical parameters significant at 0.05 probability level ($P < 0.05$)
SS – Sum of Squares   df – degree of freedom   n – Number of observations.   F – Significance   P – probability

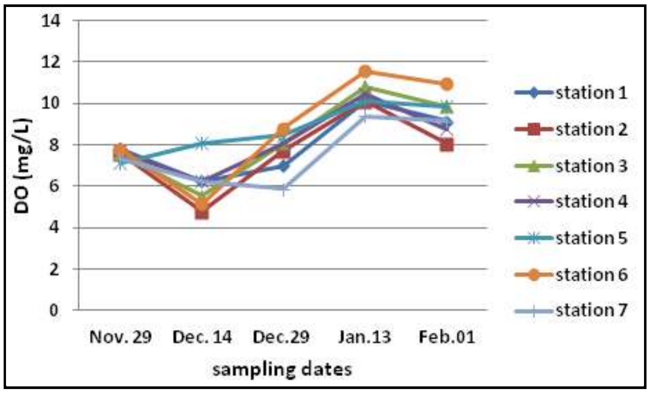

Figure 2. Average DO levels at seven stations

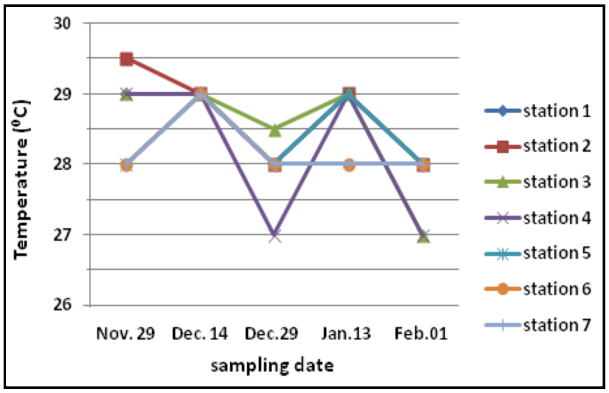

Figure 3. Average temperatures at the stations

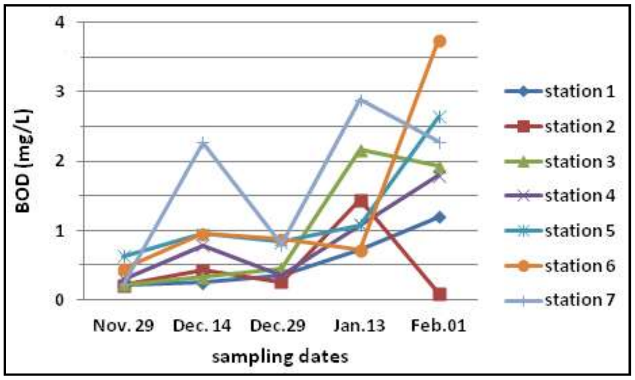

Figure 4. Average BOD levels

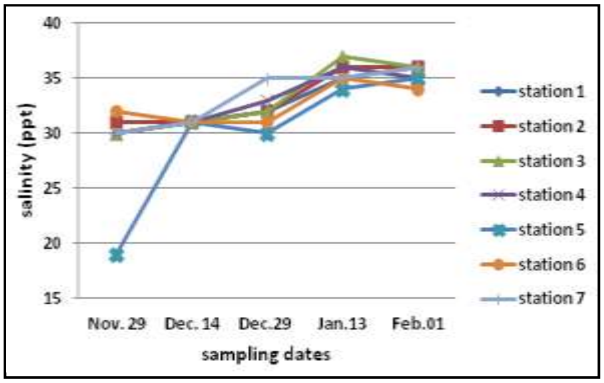

Figure 5. Average Salinity levels

There were no statistically significant differences ($P < 0.05$) in average DO levels, water temperature, BOD levels, salinities, TDS, TSS and TH levels, pH, and NO_2^- and PO_4^{3-} concentrations at different stations. But their temporal variations at the site were significant ($P < 0.05$). One way ANOVA showed a significant difference ($P < 0.05$) among the average DO levels of different sampling periods (Table 2). A minimum average of about 6 mg/L was recorded for DO in the area on December 14, 2010 and then increased with time. The highest average of 10.3mg/L has been recorded for DO on January 13, 2011. Station 6 had the highest recorded DO of 11.55 mg/L whereas station 2 had the lowest DO of 4.77 mg/L (Figure 2). A significant difference ($P < 0.05$) among the average water temperatures were seen at different sampling sessions (Table 2). The highest average water temperature was recorded as 29ºC on 14th December, and the lowest was recorded as 27ºC on 01st February. Station 2 possessed the highest Temperature of 29.5 ºC and the two stations, 3 and 4 showed lowest temperature as 27 ºC (Figure 3).

One way ANOVA proved that there was a significant difference among average BOD levels taken on different sampling dates (Table 2). The average BOD increased significantly with the time, even though it a lower value was recorded on 29th December. The highest average BOD in the study area was recorded as 1.95 mg/L on February 01 and the lowest average was recorded as 0.32 mg/L on 29th November. Station 6 possessed the highest BOD of 3.74mg/L and station 2 possessed the lowest BOD of 0.09 mg/L (Figure 4). A significant difference among average salinities were found from one way ANOVA, at different sampling dates as shown in Table 2. This revealed that the average salinity of the study area was increased with time. The lowest average salinity in the area of 28.8ppt was recorded on 29th November. On February 01, 2011, the highest average salinity of about 32.5ppt was recorded in the reef area. There was a uniform salinity of 31ppt at all the seven stations on the 14th December (Figure 5). Station 3 showed the highest salinity of 37 ppt and station 5 possessed the lowest salinity of 19 ppt.

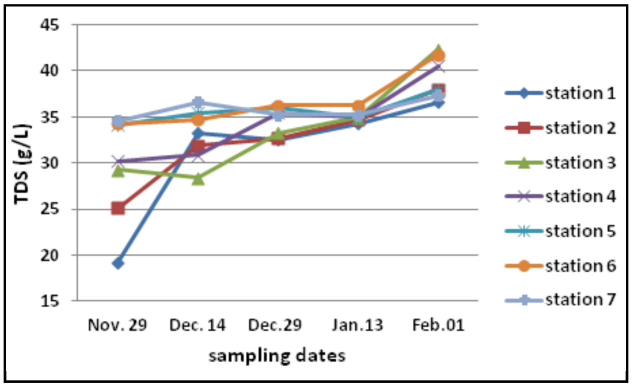

Figure 6. Average TDS levels at seven stations

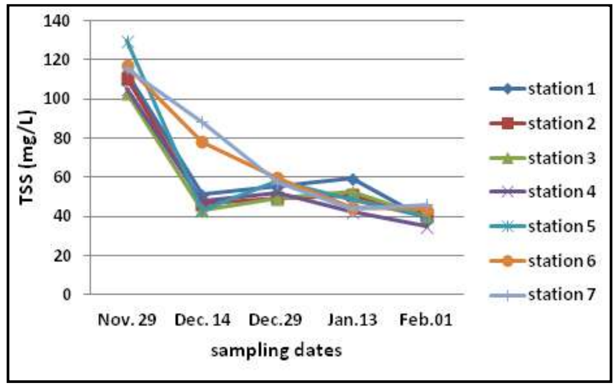

Figure 7. Average TSS levels at seven stations

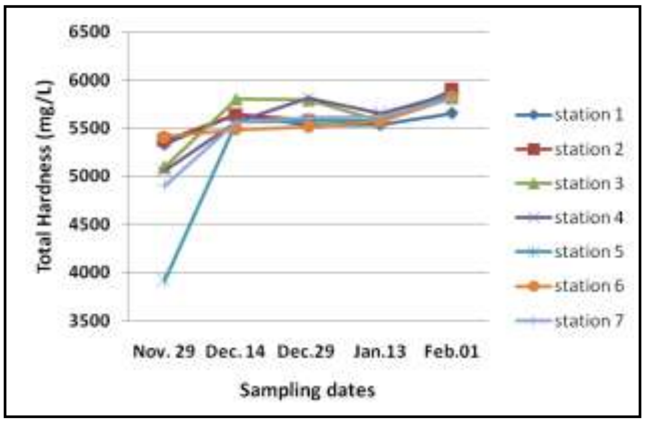

Figure 8. Average TH levels at the stations

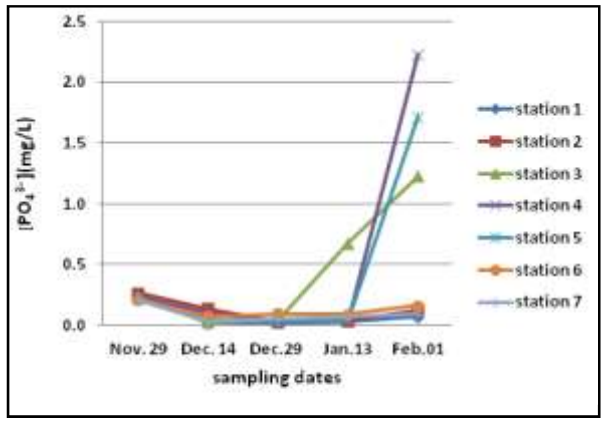

Figure 9. Average phosphate concentrations

Results from one way ANOVA shows that there is a significant difference among the average TDS levels in the area taken on different sampling dates (Table 2). There was a clear increment of the average TDS levels from beginning to end of the sampling period. The lowest mean of about 29.5 g/L was recorded on 29th November with the highest variability whereas the highest mean of about 39.2 g/L was recorded on 01st February 2011 (Figure 6). A significant difference among average TSS levels was seen at the stations taken on different sampling dates (Table 2). The highest average TSS level was recorded on 29th November as 113 mg/L and the lowest was recorded on 01st February as 40.45 mg/L. The highest variation around the mean had been recorded on 14th December. Average TSS levels at the site have decreased, in general, with time (Figure 7).

One way ANOVA showed a significant difference among the average TH levels, taken at different sampling dates (Table 2). The lowest average TH of 5012 mg/L was recorded on 29th November and the highest TH of 50816 mg/L was recorded on 01st February. A slight increment of the mean TH with time has been revealed (Figure 8). Average PO_4^{3-} concentrations seen were significantly different from one sampling date to the other (Table 2). Highest average PO_4^{3-} concentration of about 0.91mg/L was recorded on 01st February whereas the lowest value of about 0.04mg/L was recorded on 29th December. From November to late December, the mean PO_4^{3-} concentration has been decreased, but it has increased sharply during January and February at several stations as seen in Figure 9. Months of November and December recorded minimum variations of PO_4^{3-} concentrations around their mean while the maximum variation of PO_4^{3-}concentrations occurred on 01st February followed by 13th January.

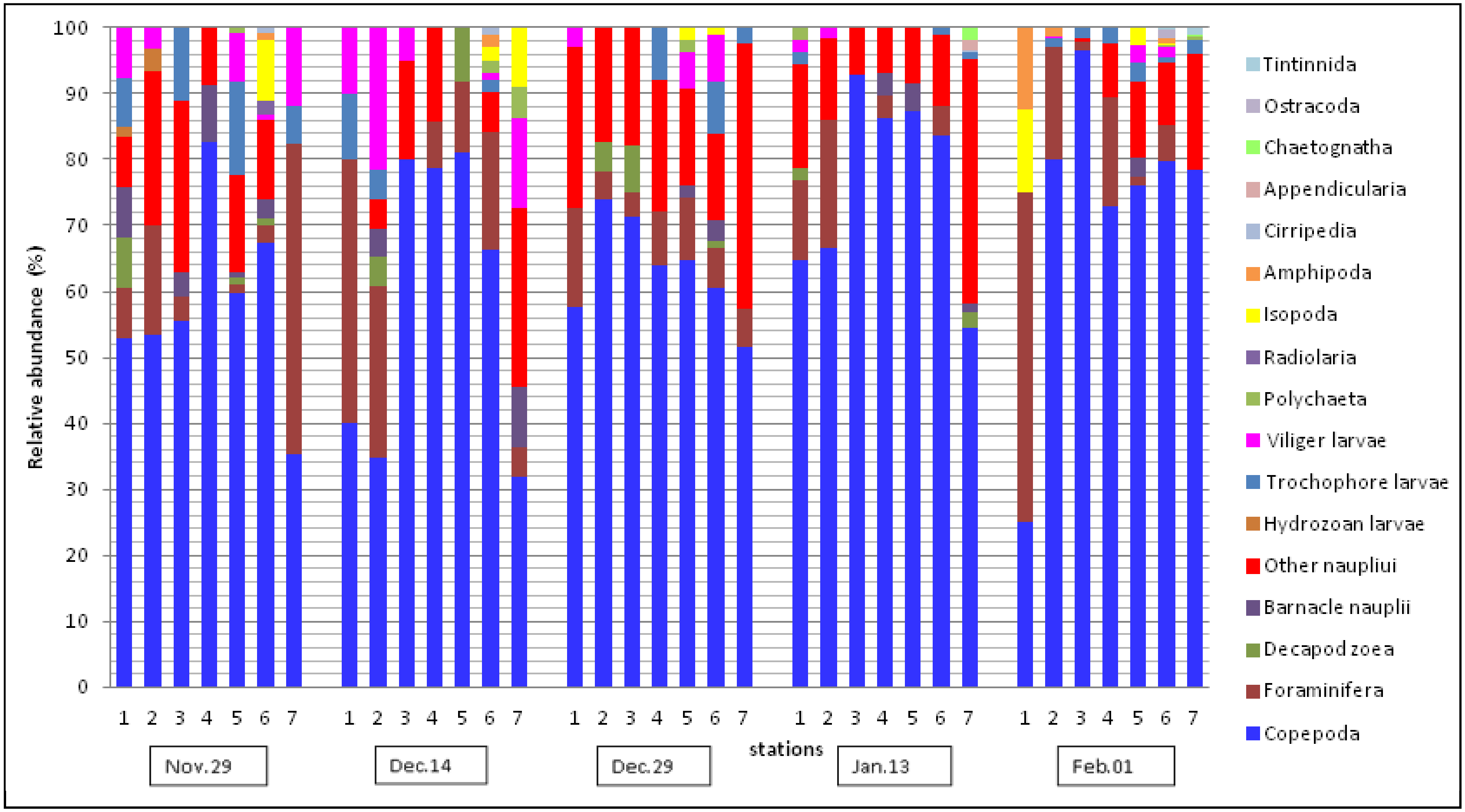

Figure 10. Relative abundance (%) by number of individuals of different zooplankton groups at the sampling stations (1 to 7) in Polhena Reef area

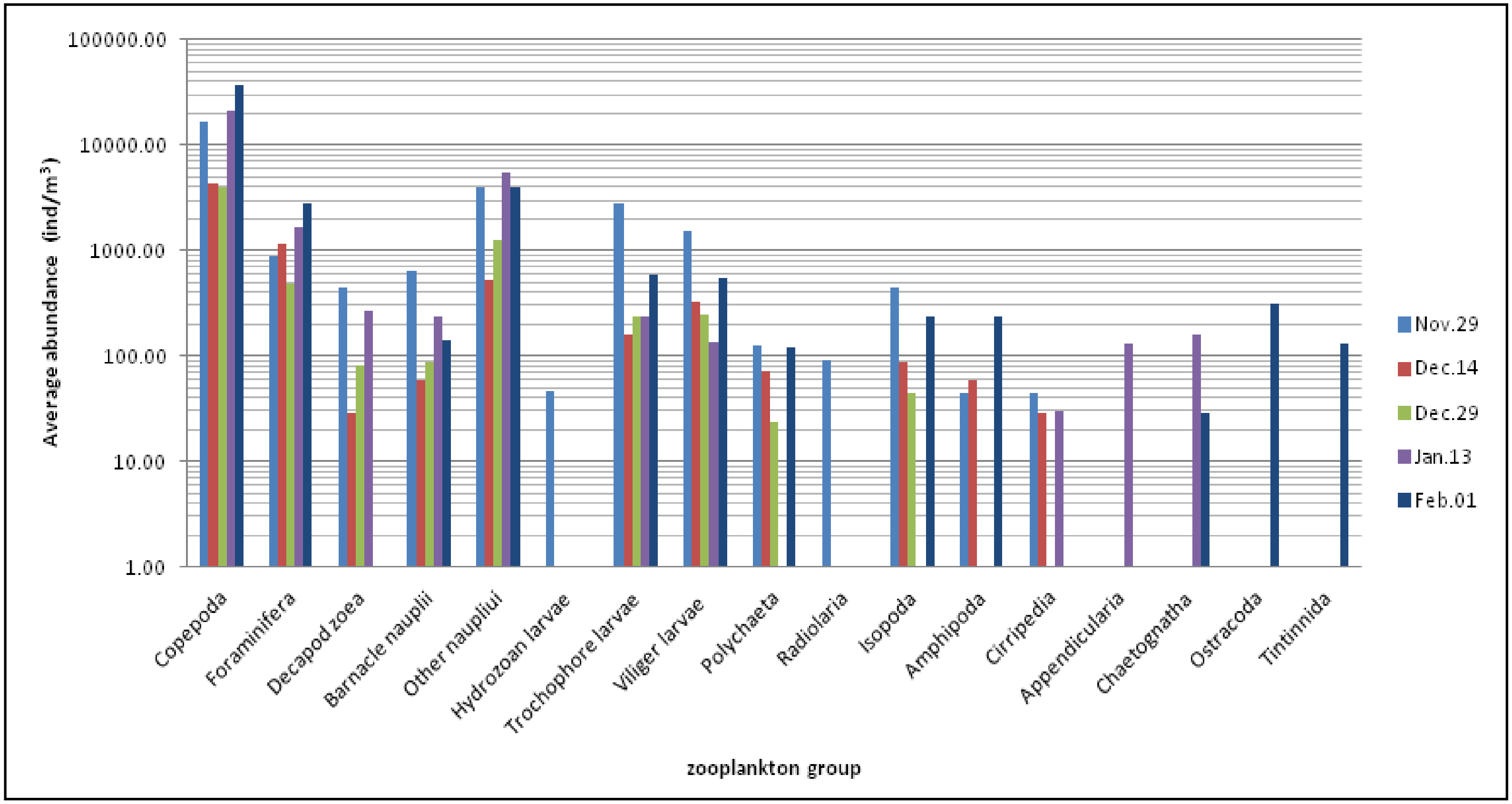

Figure 11. Average abundance of zooplankton groups recorded during the study period at Polhena reef area.

During the dry season, higher average DO and BOD levels, increased salinity, TDS and TH levels, decreased water temperature and TSS levels were detected. One way ANOVA showed that there were no significant spatial differences or temporal differences in average total zooplankton abundance recorded. The average total zooplankton abundance increased in the dry season. The highest was recorded as 45,638.14 ind / m^3 on Feb.01 and the lowest was recorded as 6,507.71 ind / m^3 on Dec.01. Copepods were the dominant group which recorded as 36500 ind/m^3 in the dry season which was followed by Crustacean nauplii and Foraminiferans, respectively. Station 6 has been identified as a critical place which influenced the abundance of the zooplankton community in the area. It is frequently subjected to fresh water discharge. Some investigations showed that the variations in total zooplankton abundance are due to the dilution by flushing effects of inland fresh water discharge (Diaz-Zebella and Gaudy, 1996). Same theory could be applied here.

Number of zooplankton groups was higher in inter monsoonal period than dry season. But Average abundance of Copepods had doubled in size during this period. Therefore, it formed much denser total zooplankton community during the dry season. Bednarski and Ramírez, 2004 stated that the Copepods are more tolerant to the salinity changes when they are fed. Moreover, lower temperatures help to increase their survival rate than higher temperatures over broad range of salinity changes. Supporting this finding, the average water temperature was found to have decreased from November to February followed by the increasing salinity, which was ideal for copepods. Copepods, nauplii stages of Crustaceans, Foraminiferans, Trochophore stages, Veliger stages dominated the waters of Polhena reef area during the study period respectively. Barnacle Nauplii, Zoeal stages of Decapods, Isopods and Polychaetes were the minor groups with far less average abundances compared to that of former mentioned groups. Besides this, Hydrozoan larvae, Radiolarians, Ostracods, Appendicularians, Cirripedians, Chaetognaths and Tintinnids were the groups, which were not only far less abundant, but appeared only once or twice during the study period. Hydrozoan larvae, Radiolarians and Cirripedians appeared in earlier sampling periods. Smaller percentages of Appendicularians, Ostarcods, Chaetognaths and Tintinnids appeared during dry season. Chaetognaths predate on crustacean nauplii and copepods (Todd et al., 1996). Thus, it is reasonable concluded that the populations of these organisms are needed to be controlled so that the predators would appeared. It was not possible to extend this study towards the rainy season. To visualize the exact patterns of the seasonal cycle of zooplankton abundance, the study should be extended for at least one complete year.

Conclusion

Weather pattern of southern Sri Lanka follows southwest monsoon rains in mid May to October and dry weather in northeast monsoons from December to March (Department of Meteorology, Sri Lanka, 2008). During inter monsoonal period from October to November, it experiences periodic squalls, tropical cyclones, overcast skies and rains (Department of Meteorology, Sri Lanka, 2008). In this study, measurements taken clearly demonstrates that, from inter monsoonal season to dry season, the average total zooplankton abundance in Polhena reef area has been increased. In the dry season, higher DO and BOD levels, increased salinity, TDS and TH levels, decreased water temperature and TSS level could be detected in the study area. These parameters seem to vary significantly in the inter monsoon season, in November.

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