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POPULATION DYNAMICS OF ZOOPLANKTON IN MERBOK ESTUARY, KEDAH, MALAYSIA IN RELATION TO SOME WATER QUALITY PARAMETERS

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Key words: Zooplankton density, Distribution, Merbok estuary

Abstract

In the present investigation, Station 5 located in the downstream of the Merbok estuary showed higher density of zooplankton (132×10^3 ind/m^3) but it was lowest (83×10^3 ind/m^3) was at Station 2 (upstream). The highest and lowest zooplankton density was observed in May and November, respectively. Twenty groups of zooplankton were recorded and copepod was the dominant group at all sampling stations during the sampling period. Months and stations were statistically significant (Kruskal-Wallis H test; $p < 0.05$) factors that affect the density of zooplankton, temperature, salinity and nutrients. Mann-Whitney U test showed that temperature, NO_2 and zooplankton density were significantly different between seasons ($p < 0.01$). Significant correlation among zooplankton density, chl *a* concentration and nutrients ($p < 0{\cdot}01$) were observed.

Introduction

Zooplankton are heterotrophic and usually consist of copepods, tintinnids and larval molluscs. They constitute an important food item for many aquatic species(1) and play an important role both as a consumer of phytoplankton by transferring food energy to higher trophic levels(2). The Merbok estuary is one of the recognized mangrove reserves, which is located in the north-west Peninsular Malaysia. It flows into the Straits of Malacca after passing through paddy fields on its freshwater route and mangroves on its estuarine route. Merbok river is an enormous source of fisheries. It serves also as an important breeding and nursery ground for estuarine fishes. Local inhabitants are dependent on the Merbok river for their livelihood via fishing(3). However, a few investigations have been carried out on zooplankton from estuaries(4-6) in Malaysia. Therefore, the present research was undertaken to study the population dynamics of zooplankton in the Merbok estuary in relation to its water quality.

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Materials and Methods

In the present investigation, samples of zooplankton were collected at monthly interval from January to December, 2011 from six sampling stations in the Merbok estuary (Fig. 1). Station 1 (Lalang river) and 2 (Semeling river) were located on the upper reaches of the estuary while Station 3 (Jagung river) and 4 (Teluk Wang) at the middle, and Station 5 (Gelam River) and 6 (Derhaka river) were on the downstream (Fig. 1). Horizontal towing of plankton net below 50 cm of surface was done to collect zooplankton samples in each sampling station. Towing was done for 18 min by using plankton net (0.13 m in diameter) made up of bolting silk (mesh size 150 μm). For each tow, the volume (m^3) of filtered water was measured using mouth area of the net and distance of towing. After collection, the samples were immediately preserved in 4% buffered formalin and used for quantitative and qualitative analysis. Three sub-samples of each sample were taken for the identification and counting[7, 8].

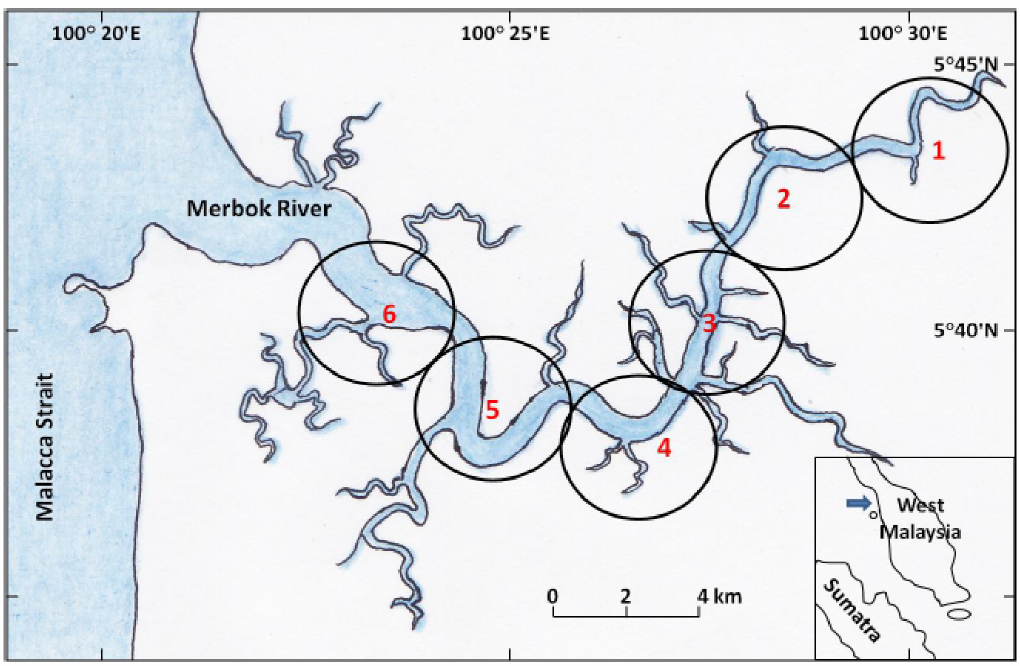

Fig. 1. Location map of sampling stations of Merbok estuary.

The density of the zooplankton from the sub-samples were standardized into the number of individuals per cubic meter (ind/m^3) according to Postel *et al.*[9]. Rainfall data were obtained from the Meteorological Department of Kedah, Malaysia and seasonal classification used by MMD (Malaysian Meteorological Department) was adopted for grouping the data into dry and wet seasons. Rainfall above 200 mm is considered as criteria for wet season (March, April, May, August, September and November) and 0 - 200 mm is considered as dry season (January, February, June, July, October, December). Three replicates of temperature and salinity were made by using Hydro lab Surveyor 3 Data Logger (Model no SVR3-DL, USA). Chlorophyll *a*, nitrite and nitrate nitrogen were measured according to the method of Strickland and Parsons(10) and ammonia was determined after Adams(11). Non-parametric tests (Kruskal-Wallis H test, Mann-Whitney U test) and Spearman's rank correlation were performed to find the relationship between zooplankton and water quality data(12). Mann-Whitney U test was used to determine the significant differences between the dry and wet season.

Results and Discussion

Maximum temperature was recorded at Station 3 (midstream) whereas minimum at Station 1 (upstream). Higher salinity values were found at Station 5 (downstream) and this could be due to the increase of positive ions in the downstream station (Table 1). Lower value was observed at Station 1 (upstream) because of freshwater discharge. NO_3^-, NO_2^- and NH_3 were higher in Station 1 (upstream) compared with other downstream stations indicating domestic wastewater discharge from upstream human settlement. Point and non-point source of pollution and erosion effects may be responsible for nutrient concentration(13). The highest concentration of chlorophyll *a* was found upstream, and then decreased in the middle, finally increased again in the downstream (Table 1). This may be due to combined effects of light, shallow depth, and mechanical processes like turbulent mixing. This observation was similar with the previous studies(14). Temperature and chlorophyll *a* was significantly different between the sampling months (Kruskal Wallis H test; $p < 0.05$) whereas, temperature and chlorophyll

Table 1. Some water quality parameters of the studied stations (mean ± Sd).

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Temp. (ºC)	29.46 ± 0.915	29.64 ± 0.86	29.71 ± 0.94	29.68 ± 0.90	29.66 ± 0.91	29.68 ± 0.96
Salinity (ppt)	13.74 ± 4.26	20.43 ± 5.55	22.81 ± 8.42	23.49 ± 8.14	24.66 ± 7.96	23.35 ± 6.67
NO_3^- (mg/l)	0.21 ± 0.12	0.15 ± 0.08	0.09 ± 0.04	0.07 ± 0.04	0.07 ± 0.03	0.05 ± 0.03
NO_2^-(mg/l)	0.19 ± 0.06	0.17 ± 0.10	0.14 ± 0.07	0.13 ± 0.08	0.13 ± 0.07	0.10 ± 0.07
NH_3 (mg/l)	1.18 ± 0.69	0.30 ± 0.21	0.17 ± 0.12	0.13 ± 0.10	0.10 ± 0.08	0.10 ± 0.07
Chl *a* (µg/l)	1.14 ± 1.31	0.49 ± 0.35	0.46 ± 0.39	0.48 ± 0.41	0.45 ± 0.30	1.78 ± 1.66

a was insignificant between stations ($p > 0.05$). Kruskal Wallis H test showed that nutrients (nitrate, nitrite and ammonia), salinity were significantly different between the sampling months and stations ($p < 0.05$) whereas, Mann-Whitney U test result found that nitrate, ammonia, salinity, and chlorophyll *a* was insignificant ($p > 0.05$) between dry and wet seasons except nitrite and temperature ($p < 0.01$).

Mean zooplankton abundance peaked in May (361× 10^3 ind/m^3 and the lowest value were recorded in November (88 × 10^3 ind/m^3) (Fig. 2). The density of zooplankton varied from 83 × 10^3 ind/m^3 at Station 2 (upstream) to 132 × 10^3 ind/m^3 at Station 5 (downstream) (Fig. 3). Kruskal Wallis H test showed significant temporal and spatial variation ($p < 0.01$) on the mean zooplankton abundance/density. The density was higher at the downstream stations than stations located upstream. A study conducted on the Arabian sea, found higher number of copepods species to be correlated with higher zooplankton density[15].

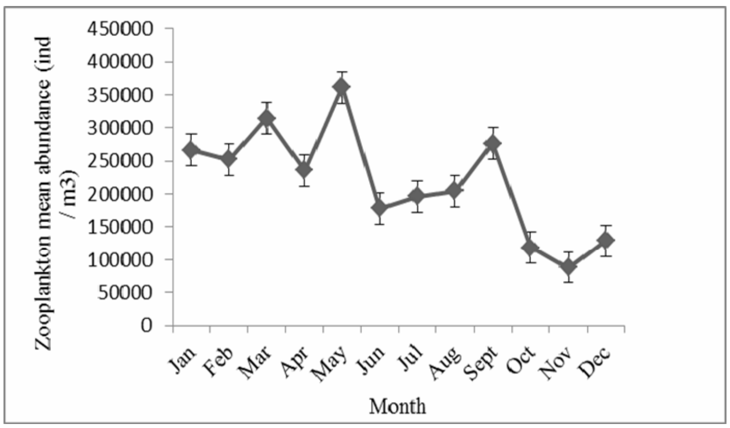

Fig. 2. Population dynamics of zooplankton in Merbok estuary from January to December, 2011(mean ± SE).

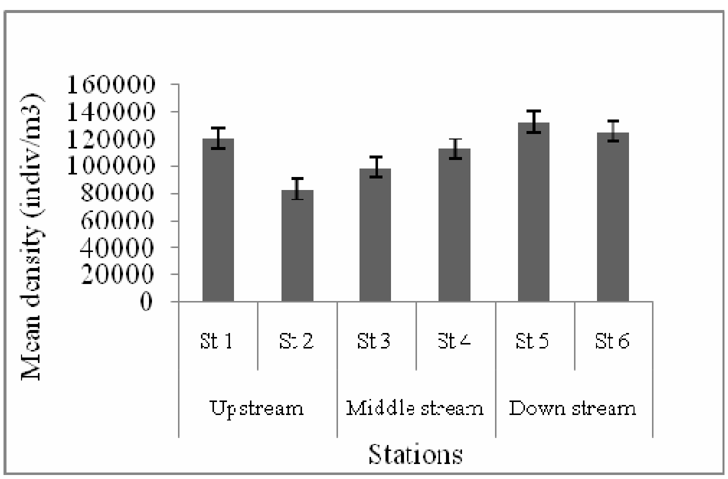

Fig. 3. Station wise mean zooplankton density in the Merbok estuary (vertical bars represent the standard errors) during January to December, 2011.

Zooplankton density during wet and dry season ranged from 85 × 10^3 ind/m^3 (Station 2) - 153 × 10^3 ind/m^3 (Station 6) and 80 × 10^3 ind/m^3 (Station 2) - 133 × 10^3 ind/m^3 (Station 5), respectively. In the majority of stations, zooplankton density was higher during the wet season compared dry season (Fig. 4). During both seasons zooplankton density was highest in the downstream Stations 5 and 6 compared with the upstream (Stations 1 and 2). Mann Whitney U test showed that zooplankton density was significant between dry and wet season ($p < 0.01$). Previous study[16] showed the zooplankton abundance to increase at the beginning of each monsoon and gradually decreased towards the inter monsoon periods. In a mangrove estuary in Trinidad[17], the highest zooplankton population were observed following periods of rainfall (wet season) and the lowest during the dry season. Higher zooplankton densities during wet season are a common phenomenon in tropical mangrove estuaries[18].

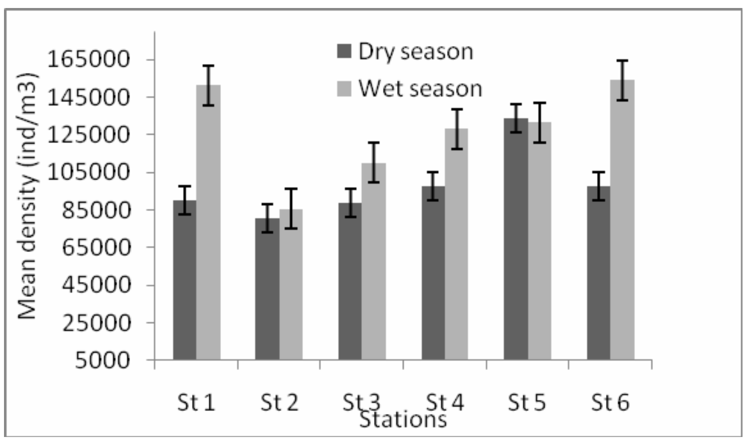

Fig. 4. Seasonal distribution pattern of zooplankton at all sampling stations in Merbok estuary during January to December, 2011 sampling period.

At Station 2, copepod formed the dominant group (66.18%) followed by copepod larvae (25.15%), cirripede larvae (5.66%), bivalve (0.443%), gastropod (0.218%), brachyuran larva (1.02%), amphipod (0.187%), chaetognaths (0.181%) and oikopleura (0.125%), Nematods (0.137%) and others group (0.249%). At Station 5 copepod was the dominant group (89.44%) followed by copepod larvae (6.05%), cirripede larvae (0.73%), bivalve (0.18%), gastropod (0.23%), brachyuran larva (1.20%), amphipod (0.10%), chaetognaths (0.98%), oikopleura (0.36%), lucifer (0.10%), polychaetes (0.18%) and other groups (0.18%) (Table 2). In this study, 20 groups of zooplankton were recorded with copepods dominance. Copepod showed variations from 66.18% (Station 2) to 91.36% (Station 6). Other researchers also observed copepods as the dominant group among zooplankton community of estuarine ecosystem[19, 20]. Thus the dominance of a particular

Table 2. Population density of zooplankton at different stations of Merbok estuary during January to December, 2011.

Zooplankton group	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Copepods	101584 (84.02%)	55482 (66.18%)	83556 (84.04%)	102249 (90.51%)	119843 (89.44%)	120120 (91.36%)
Copepod larvae	9595 (7.94%)	21080 (25.15%)	11391 (11.46%)	6140 (5.43%)	8103 (6.05%)	4078 (3.10%)
Cirriped larvae	3774 (3.12%)	4743 (5.66%)	2041 (2.05%)	1157 (1.02%)	974 (0.73%)	654 (0.50%)
Gastropod	455 (0.38%)	183 (0.22%)	188 (0.19%)	277 (0.25%)	303 (0.23%)	340 (0.26%)
Bivalve	345 (0.29%)	371 (0.44%)	303 (0.31%)	235 (0.21%)	235 (0.18%)	356 (0.27%)
Brachyuran larva	241 (0.20%)	853 (1.02%)	550 (0.55%)	942 (0.83%)	1607 (1.20%)	1822 (1.39%)
Oikopleura	126 (0.10%)	105 (0.13%)	115 (0.12%)	502 (0.44%)	481 (0.36%)	612 (0.47%)
Amphipod	63 (0.05%)	157 (0.19%)	68 (0.07%)	68 (0.06%)	131 (0.10%)	99 (0.08%)
Chaetognaths	94 (0.08%)	152 (0.18%)	440 (0.44%)	738 (0.65%)	1314 (0.98%)	1785 (1.36%)
Carridean larva	16 (0.01%)	26 (0.03%)	47 (0.05%)	47 (0.04%)	78 (0.06%)	162 (0.12%)
Lucifer	16 (0.01%)	10 (0.01%)	26 (0.03%)	68 (0.06%)	136 (0.10%)	319 (0.24%)
Tintinnids	4073 (3.37%)	99 (0.12%)	314 (0.32%)	141 (0.13%)	10 (0.01%)	21 (0.02%)
Cnidarians	26 (0.02%)	47 (0.06%)	21 (0.02%)	42 (0.04%)	63 (0.05%)	84 (0.06%)
Polychaetes	78 (0.06%)	52 (0.06%)	57 (0.06%)	131 (0.12%)	241 (0.18%)	555 (0.42%)
Ostracoda	110 (0.09%)	78 (0.09%)	31 (0.03%)	26 (0.02%)	47 (0.04%)	52 (0.04%)
Rotifera	26 (0.02%)	42 (0.05%)	58 (0.06%)	26 (0.02%)	42 (0.03%)	37 (0.03%)
Nematods	42 (0.03%)	115 (0.14%)	10 (0.01%)	26 (0.02%)	26 (0.02%)	78 (0.06%)
Fish larva	58 (0.05%)	5 (0.01%)	37 (0.04%)	42 (0.04%)	99 (0.07%)	99 (0.08%)
Fish egg	26 (0.02%)	21 (0.03%)	31 (0.03%)	26 (0.02%)	21 (0.02%)	10 (0.01%)
Others group	162 (0.13%)	209 (0.25%)	141 (0.14%)	89 (0.08%)	240 (0.18%)	198 (0.15%)
Total	120910	83830	99425	112972	133994	131481

group among the zooplankton can be due to the type of the ecosystem. Relative abundance of zooplankton particularly copepod was higher downstream compared with the upstream. It may be due to higher salinity downstream. Salinity is the most important water quality parameter which influences zooplankton distribution and abundance[21,22].

Results of Spearman's rank correlation analysis found that there were a significant correlation of zooplankton abundance between months and stations. Zooplankton abundance was negatively correlated with chlorophyll *a* ($r = -0.312$, $p < 0.01$). A significant relationship was found between zooplankton abundance and nitrate and ammonia except NO_2 ($r = -0.178$, $r = -0.220$, $p < 0.01$). This could be due to higher seasonal variability. Another reason is that organic detritus, which, derived from marsh plants may be an important food source for the zooplankton. Zooplankton may be food limited and the availability of organic detritus as a food may be the potential food resources in estuaries. Zooplankton are opportunistic feeder where zooplankton feed on the most abundant food. Several factors could be responsible for selective grazing on particular types of zooplankton, including differences in size, morphology and chemical composition of phytoplankton. Previous study conducted[23] reported that zooplankton grazing is an important factor controlling the density, species composition and size distribution of phytoplankton.

The result of this study showed differences of zooplankton abundance from up (Station 2) to downstream (Station 5) in the Merbok estuary. Zooplankton communities in this estuary are dominated by copepods. In the majority of stations, the highest zooplankton density/abundance was observed during the wet season compared to the dry season. It could be concluded that temperature, salinity and food availability of the estuary play a vital role for spatial and temporal changes in zooplankton abundance.

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