

**DYNAMICS AND TROPHIC ROLE OF ZOOPLANKTON  
COMMUNITY IN THE MATANG MANGROVE ESTUARIES  
AND ADJACENT COASTAL WATERS (PENINSULAR  
MALAYSIA), WITH SPECIAL EMPHASIS ON COPEPODS**

**CHEW LI LEE**

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## ABSTRACT

Dynamics and trophic role of zooplankton community were studied in the Matang mangrove estuaries and adjacent coastal waters, Malaysia. Monthly zooplankton samples collected from May 2002 to October 2003 at five stations located from the upper estuary (7 km upstream) to 16 km offshore showed highest biomass and abundance of zooplankton at nearshore waters. Both standing stocks decreased towards upstream and offshore waters. Copepods (62% of total zooplankton abundance) dominated the zooplankton, followed by larvae of cirripede (18%) and polychaete (4%). Copepod abundance was higher during the wetter northeast (NE) monsoon and inter-monsoon (IN) period as compared to the drier southwest (SW) monsoon. Multivariate analyses revealed that the structure of the zooplankton community in the upper reaches of Matang was distinctively different from that of the adjacent coastal waters which was attributed to the spatial and temporal variations in environmental conditions. Salinity, food availability and quality, and predation were the main factors influencing zooplankton abundance and composition.

Twenty-four hour samplings of surface and bottom zooplankton in the lower estuary, encompassing four consecutive lunar phases in July 2003 (dry period) and November 2003 (wet period), showed that the adults of four dominant copepod species (*Acartia spinicauda*, *Parvocalanus crassirostris*, *Bestiolina similis* and *Oithona simplex*) and mysids were significantly more abundant during night than day. This diel pattern was less obvious for meroplanktonic larvae of cirripedes, brachyurans and polychaetes, although they were consistently more abundant during ebb than flood tide. More cirripede and polychaete larvae were sampled during neap tide compared to spring tide, especially during the dry period. The neap tide zooplankton community during the wet period was dominated by the estuarine copepod *A. spinicauda*. The demersal copepod *Pseudodiaptomus annandalei* occurred in high numbers during the wet spring tide period. *P. crassirostris* and brachyuran zoeae were about equally abundant during the dry and wet period, although consistently more abundant during spring than neap tide. The implications of short-term zooplankton variability, the potential mechanisms of zooplankton response to short-term environmental variations and the significance of their adaptive mechanisms were evaluated.

The trophic role of zooplankton in the mangrove and adjacent coastal water food web was elucidated. Stomach contents of 2183 juvenile fish belonging to 26 species revealed significant consumption of zooplankton food. Copepods were the most

important zooplankton food consumed by fish followed by *Acetes*, mysids, cirripede larvae and amphipods. The copepod species, *P. annandalei*, was the most important species, being consumed by most small-sized fishes. The dominant copepods *Acartia* and *P. crassirostris* were mainly exploited by ambassids and engraulids. The hyperbenthic shrimps, *Acetes* spp. and mysids, were fed by various economically-important fish species. Stable isotope analysis indicated high dependency of zooplankton on phytoplankton rather than mangrove carbon in the estuary, with assimilation of benthic microalgae in nearshore waters. The range of  $\delta^{15}\text{N}$  values indicated at least four trophic levels, with zooplankton at the second and third trophic level.

## ABSTRAK

Penyelidikan dan kajian dinamik dan peranan trofik zooplankton telah dikendalikan di kawasan perairan hutan simpanan bakau Matang, Perak Malaysia dan perairan pantai sekitarnya. Sampel zooplankton diambil pada setiap bulan dari Mei 2002 hingga Oktober 2003 bagi lima stesen; bermula dari kawasan hulu sungai yang berjarak 7 km dari muara hingga ke 16 km jauh kawasan perairan laut. Kawasan perairan pantai bersebelahan muara mencatat min biojisim dan kelimpahan zooplankton tertinggi. Kedua-dua ukuran tersebut mengurang secara beransur-ansur apabila semakin menuju ke arah hulu dan laut. Kopepod adalah zooplankton yang paling dominan diikuti oleh larva cirripede dan larva polychaete. Peningkatan kelimpahan kopepod yang ketara berlaku semasa bulan perantaraan monsun dan monsun timur laut (NE). Kelimpahan larva polychaete sebaliknya meningkat semasa monsun barat. Kelimpahan larva cirripede tidak jauh berbeza antara musim monsun. Analisis multivariate menunjuk perbezaan struktur komuniti zooplankton di antara perairan paya bakau dan perairan pantai dan laut. Ini adalah disebabkan oleh perbezaan faktor persekitaran dari segi ruang dan tempoh masa. Kemasinan air, bekalan makanan yang cukup dan berkualiti serta pemangsaan merupakan faktor-faktor penting yang mempengaruhi komposisi dan struktur komuniti zooplankton.

Kutipan sampel zooplankton bagi kajian 24-jam merangkumi empat fasa bulan berturut-turut pada bulan Julai 2003 (musim kering) dan November 2003 (musim hujan). Sampel zooplankton dikutip pada bahagian permukaan dan dasar muara sungai setiap dua jam bagi tempoh 24 jam. Kopepod dewasa bagi dominan spesies (*Acartia spinicauda*, *Parvocalanus crassirostris*, *Bestiolina similis* dan *Oithona simplex*) serta udang mysid menunjukkan kelimpahan yang lebih tinggi pada waktu malam berbanding pada waktu siang. Tiada perbezaan jelas antara siang dan malam bagi sesetengah meroplankton yang penting (contohnya larva bagi cirripede, brachyuran dan polychaete). Namun, kelimpahan meroplankton tersebut mencatat kelimpahan yang lebih tinggi pada waktu surut berbanding pada waktu pasang. Larva cirripede dan polychaete menunjuk kelimpahan yang lebih tinggi pada air pasang mati khususnya pada musim kering. Pada air pasang mati bagi musim hujan, struktur komuniti zooplankton diwakili oleh kopepod *A. spinicauda*. Demersal kopepod *Pseudodiaptomus annandalei* menunjuk peningkatan kelimpahan yang ketara semasa air pasang besar bagi musim hujan. *P. crassirostris* dan larva brachyuran mencatatkan kelimpahan yang agak sama antara musim kering dan hujan tetapi lebih tinggi kelimpahannya pada air pasang besar berbanding pada air

pasang mati. Implikasi perbezaan jangka pendek komuniti zooplankton, mekanisma yang mungkin dipraktik oleh zooplankton ke atas variasi persekitaran serta signifikan mekanisma yang diadaptasi oleh zooplankton telah dibincangkan.

Trofik zooplankton dalam rangkaian makanan di kawasan perairan paya bakau dan perairan pantai sekitarnya juga dibincangkan. Kandungan perut ikan berjumlah 2138 daripada 26 spesis menunjuk pemakanan zooplankton yang signifikan oleh ikan. Kopepod adalah makanan zooplankton terpenting ikan diikuti udang *Acetes* dan mysid, larva cirripede dan ampipod. Spesis kopepod yang paling penting untuk makanan ikan kecil adalah *P. annandalei*. Kopepod dominan spesis *Acartia* dan *P. crassirostris* dieksploitasi oleh ikan ambassid dan engraulid. Udang *Acetes* spp. dan mysid merupakan makanan penting bagi spesis ikan yang bernilai komersil. Analisis stabil isotop menunjukkan bahawa fitoplankton dan mikroalga bentik adalah penting untuk nutrisi zooplankton tetapi kurang pentingnya sumber karbon yang berasal dari bakau. Nilai  $\delta^{15}\text{N}$  pengguna memapar sekurang-kurangnya rangkaian makanan bertingkat empat, di mana zooplankton terletak di trofik tingkat kedua dan ketiga.

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***'Man must be strong enough to know when he is weak, brave enough to encounter fear, proud and unbending in honest defeat, humble and gently in victory'***  
***~by Buddha~***

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## LIST OF ABBREVIATIONS

AITD	Average individual taxonomic distinctness
ANOSIM	Analysis of Similarities
ASTD	Average specific taxonomic distinctness
B	Niche breath
BC	Bray-Curtis
Bs	Levin's standardized niche breadth
chl. <i>a</i>	chlorophyll <i>a</i>
DO	Dissolved oxygen
DVM	Diel vertical migration
GPS	Geographic position system
IN	Inter-monsoon period
LE	Lower estuary
MDS	Non-metric multidimensional scaling
ME	Mid-estuary
MMFR	Matang Mangrove Forest Reserve
NE	Northeast monsoon
NS	Nearshore
OS	Offshore
PCA	Principle component analysis
PCs	Principal components
PDB	Peedee Belemnite
RDA	Redundancy analysis
SESMA	Scientific Expedition to the Seas of Malaysia
SPI	Standard precipitation index
SW	Southwest monsoon
TVM	Tidal vertical migration
UE	Upper estuary
VI	Vacuity index