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**EFFECTS OF FISH CAGE AQUACULTURE ON THE
ZOOPLANKTON IN A MALAYSIAN MANGROVE ESTUARY**

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ABSTRACT

A study on the effects of fish cage aquaculture on the zooplankton was carried out in the Matang mangrove estuary, Perak, Malaysia. Investigations consisting of 4-month study and 12-hour study were conducted. Zooplankton were sampled inside and away from floating fish cage culture areas in Sangga Besar (SSB) river and in an adjacent non-aquaculture river, Sangga Kecil (SSK), in order to examine the effect of fish cage culture on zooplankton abundance. Zooplankton populations varied both spatially (being more abundant towards the river mouth) and temporally (being more abundant at certain months, e.g. in December). In SSB, fish cage culture had a significant effect on the zooplankton abundance; cage sites compared to non-cage sites were significantly more abundant in zooplankton ($p < 0.01$). The higher zooplankton abundance was likely due to increased availability of food resulting from increased phytoplankton production and leftovers of mashed trash fish used as food for cultured fish. Fish cage aquaculture also had an impact on the zooplankton community in SSB where common zooplankton found dominating the fish cage area were *Pseudocalanus* spp., *Acartia* spp. *Oithona* spp., cirripede nauplii, amphipods and brachyuran zoeae. The Multidimensional Scaling (MDS) and Principal Component Analysis (PCA) indicated spatial and temporal variabilities in zooplankton species abundance where two clusters of samples were separable by their month of sampling: (1) December (1999), January and Early March (2000) and (2) late March and April (2000). The diurnal phytoplankton peak in the fish farms in SSB during mid-afternoon appeared not limited by dissolved nutrients and was superseded by a peak in zooplankton abundance. When the phytoplankton abundance fell during night, zooplankton abundance also fell but remained at a level that was much higher than observed in the morning. The dissolved oxygen (DO) concentrations inside and outside of the cage farm area in SSB varied diurnally. The DO levels inside the fish farm area were significantly lower than away from fish farm during night attributable to the higher rates of oxygen consumption by zooplankton, bacterioplankton and cultured fish, and the lack of tidal flushing inside the fish farm area. In SSK, where there is no aquaculture, the density of zooplankton was significantly higher than in SSB. There were more nauplii of cirripedes and copepods, cypris larvae and harpacticoid copepods, *Microsetella* spp., which increased in abundance towards the mouth of the river. The diurnal cycle of phytoplankton abundance in SSK appeared nutrient-limited, peaking earlier and dropping soon after but never reached the peak level as observed inside the fish farm area in SSB. Diel and tidal phases did not play any significant role in the abundance of zooplankton. All these observations suggest a change in the structure of the zooplankton community in SSB possibly due to environmental changes brought about by the aquaculture activity. The results therefore support the stated hypothesis on the impact of cage fish aquaculture.

ABSTRAK

Satu kajian terhadap kesan akuakultur ikan ke atas zooplankton telah dijalankan di kawasan paya bakau muara sungai Matang, Perak, Malaysia. Kajian ini terdiri daripada penyampelan selama 4 bulan dan penyampelan intensif sepanjang 12 jam. Penyampelan zooplankton dilakukan di dalam dan luar (control) kawasan sangkar ikan terapung di Sungai Sangga Besar (SSB) dan juga di sungai tanpa aktiviti akuakultur, Sungai Sangga Kecil (SSK), bertujuan untuk mengkaji kesan akuakultur ikan ke atas kelimpahan zooplankton. Populasi zooplankton didapati berubah mengikut ruang (kelimpahan meningkat menuju ke arah laut) dan masa (kelimpahan bertambah pada bulan tertentu contohnya, Disember). Kawasan sangkar ikan di SSB menunjukkan kesan yang signifikan ke atas kelimpahan zooplankton di mana kawasan dalam sangkar ikan dibandingkan dengan kawasan luar sangkar ikan menunjukkan kelimpahan zooplankton yang signifikan lebih tinggi ($p < 0.01$). Kelimpahan zooplankton yang lebih banyak di dalam kawasan sangkar mungkin disebabkan oleh peningkatan sumber makanan yang didapati daripada pertumbuhan fitoplankton dan sisa-sisa ikan yang digunakan sebagai makanan ikan sangkar. Akuakultur ikan juga mempunyai kesan terhadap komuniti zooplankton di SSB di mana zooplankton yang dominan di dalam sangkar ikan adalah *Pseudocalanus* spp., *Acartia* spp., *Oithona* spp., nauplii cirripedia, amphipoda dan zoea brachyuran. Skala Multidimensi (MDS) dan Analisis Komponen Prinsipal (PCA) menunjukkan kepelbagaian ruang dan masa ke atas kelimpahan spesies zooplankton di mana dua kumpulan sampel dibahagikan mengikut bulan : (1) Disember (1999), Januari dan awal Mac (2000) dan (2) lewat Mac dan April (2000). Kelimpahan maksimum fitoplankton dalam sangkar ikan di SSB pada sebelah petang menunjukkan kehadiran nutrien terlarut yang tidak terhad dan digantikan oleh kelimpahan zooplankton yang maksimum. Apabila kelimpahan fitoplankton berkurang pada waktu malam, kelimpahan zooplankton juga berkurang tetapi berada pada paras yang lebih tinggi daripada yang diperhatikan pada waktu pagi. Oksigen terlarut (DO) di dalam dan di luar sangkar ikan berubah mengikut pasang surut harian. Paras DO di dalam sangkar ikan adalah signifikan lebih rendah daripada kawasan di luar sangkar ikan pada waktu malam. Ini mungkin disebabkan oleh pengambilan oksigen yang lebih tinggi oleh zooplankton, bakterioplankton dan ikan dalam sangkar, dan juga kekurangan peredaran air pasang surut di dalam sangkar ikan. Di SSK, (sungai yang tidak mempunyai aktiviti akuakultur), kelimpahan zooplankton adalah signifikan lebih tinggi dibandingkan dengan SSB. Terdapat lebih nauplii copepoda dan cirripedia, larva cypris dan copepoda harpacticoida, *Microsetella* spp. yang menunjukkan kelimpahan meningkat menuju ke arah laut. Dalam kitaran pasang surut harian, kelimpahan fitoplankton di SSK menunjukkan kehadiran nutrien terlarut yang terhad. Ia mencapai kelimpahan yang maksimum lebih awal dan berkurang selepas itu tetapi tidak mencapai paras maksimum seperti diperhatikan di dalam sangkar ikan di SSB. Kelimpahan zooplankton tidak bergantung kepada perubahan fasa siang malam dan pasang surut. Kesemua pemerhatian mencadangkan perubahan pada struktur komuniti zooplankton di SSB mungkin disebabkan oleh perubahan persekitaran yang disebabkan oleh aktiviti akuakultur. Keputusan ini menyokong hipotesis kesan akuakultur ikan.

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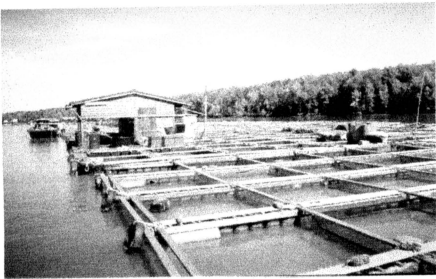
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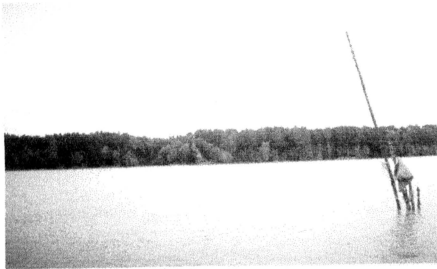
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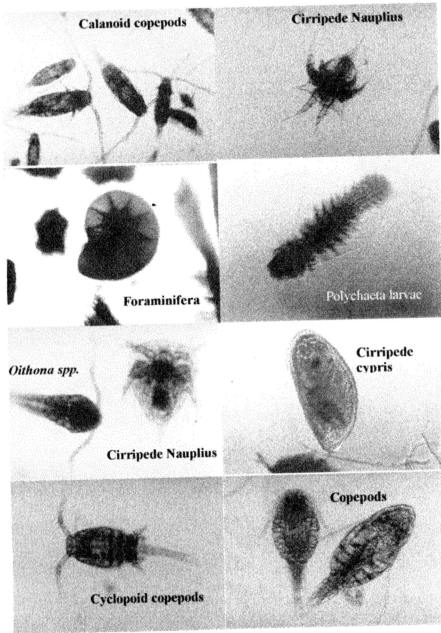
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