

**CULTURE OF A PLANKTONIC CYCLOPOID,
APOCYCLOPS DENGIZICUS (LEPESHKIN, 1900) AND ITS
SUITABILITY AS LIVE FEED FOR THE POSTLARVAE OF
GIANT BLACK TIGER SHRIMP, *PENAEUS MONODON*
FABRICUS (1798)**

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By

OMIDVAR FARHADIAN

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Doctor of Philosophy**

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Dedication

I dedicate this dissertation to my wife Mohtaram Mohammad Soltan

Babadi and my son Ebrahim Farhadian

Who from early on gave me curiosity and a respect for science, and

without whose encouragement I never would have come this far

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

CULTURE OF A PLANKTONIC CYCLOPOID, *APOCYCLOPS DENGIZICUS* (LEPESHKIN, 1900) AND ITS SUITABILITY AS LIVE FEED FOR THE POSTLARVAE OF GIANT BLACK TIGER SHRIMP, *PENAEUS MONODON* FABRICIUS (1798)

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Copepods form an important link between phytoplankton and higher trophic levels such as fish and shrimp. In aquaculture industry, some species of copepods are used as live feed for fish and shrimp larvae. In this study the suitability of a copepod *Apocyclops dengizicus* as a live food was investigated. For establishment of successful culture protocol, the biology (feeding, reproduction, and growth) and environmental requirements (salinity, temperature, light intensity, and photoperiod) of *A. dengizicus* were studied.

Apocyclops dengizicus can reproduce in salinity levels from 5 through 35 ppt. The salinity level of 20 ppt gave maximum production (535.3 ± 30 ind./female). At temperature levels between 20 °C to 35 °C, the mean maximum production (386.3 ± 60.3 ind./female) was obtained at 35 °C. Culture of *A. dengizicus* at different light intensity levels (from 33.3 to $162.1 \mu\text{mol}/\text{m}^2/\text{s}$), showed that the mean maximum production (523 ± 37.4 ind./female) was observed at $33.3 \mu\text{mol}/\text{s}/\text{m}^2$. In different photoperiods, the mean maximum production (647.5 ± 144 ind./female) was attained at continuous light exposure.

Feeding rates of *A. dengizicus* varied from nauplius to adult ($p < 0.01$). The best feed for all stages of *A. dengizicus* were *Tetraselmis tetrathele*, *Chaetoceros calcitrans*, *Isochrysis galbana* and *Nannochloropsis oculata* respectively. The algal species and their densities showed significant effects on the growth rates of *A. dengizicus* population ($p < 0.01$). Of different algal diets tested, copepod fed with *Tetraselmis tetrathele* and its combination with other microalgae gave fastest development, maximum offspring production, and maximum production.

Nutritional analysis of *A. dengizicus* revealed that it has 23-60 % protein, 18-20 % lipid, and 4-10 % carbohydrate. Phenylalanine and leucine had the highest concentrations ranging from 12.4 to 26.3 % and 11.3 – 12.2 % respectively. Saturated fatty acids (SFA) constituted the major part of the fatty acids (40.54 ± 5.97 %) followed by mono unsaturated fatty acids (MUFA) (20.67 ± 7.21 %) and highly unsaturated fatty acids (HUFA) (20.69 ± 4.90 %). The major SFA, MUFA, and HUFA for *A. dengizicus* were C14:0 (30.47 ± 4.61 %), C18:1n-7 plus C18:1n-9 (14.23 ± 4.96 %) and C22 : 6n-3 (10.54 ± 3.14 %) respectively. Considerable increase in n-3/n-6 and DHA/EPA ratios for *A. dengizicus* compared to newly hatched *Artemia* nauplii make it as suitable nutritious prey for fish and shrimp larvae.

This study showed that the best ingestion rates for *Penaeus monodon* larvae were 41.5 ind./day for PL3-6 fed on *Apocyclops* and 101.6 ind./day for PL9-12

for *Artemia*. The shrimp larvae could also ingest selectively *Apocyclops* better than *Artemia*.

Experiments on the survival and growth rates of *P. monodon* larvae fed with different diets showed that survival and growth rates of *P. monodon* were maximum (56.3%, 14.24 %/day) in mixed diet of *A. dengizicus* + *Artemia* nauplii. The n-3/n-6 ratios of larvae increased from 1.88 to 2.56 when fed with *Apocyclops*, 2.46 with *Artemia*, and 2.40 with *Apocyclops* and *Artemia*.

This study illustrated that *A. dengizicus* has high potential as live feed for *P. monodon* and could partially replace the imported *Artemia* cyst.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doctor Falasafah

**PENGKULTURAN CYCLOPOID PLANKTONIK *APOCYCLOPS*
DENGIZICUS (LEPESHKIN, 1900) DAN KESESUAIANNYA SEBAGAI
MAKANAN HIDUP UNTUK PASCA-LARVA UDANG HARIMAU,
PENAEUS MONODON FABRICIUS (1798)**

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Kopepod membentuk hubungan yang penting antara fitoplankton dan organisma di aras trofik yang lebih tinggi seperti ikan dan udang. Dalam industri akuakultur, beberapa spesies kopepod digunakan sebagai makanan hidup untuk ikan dan udang. Dalam penyelidikan ini, kesesuaian kopepod *Apocyclops dengizicus* sebagai makanan hidup dikaji. Untuk mencapai kejayaan dalam protokol pengkulturan, biologi (pemakanan, pembiakan dan pertumbuhan) serta keperluan persekitaran (saliniti, suhu, keamatan cahaya, dan fotokala) untuk *A. dengizicus* dikaji.

Apocyclops dengizicus boleh membiak dalam julat saliniti antara 5 hingga 35 ppt. Pembiakan maksimum (535.3 ± 30 ind./betina) diperolehi pada 20 ppt. Pada suhu antara 20 °C hingga 35 °C, min pembiakan maksimum (386.3 ± 60.3 ind./betina), diperolehi pada suhu 35 °C. Pengkulturan *A. dengizicus* pada

keamatan cahaya yang berbeza ($33.3 \mu\text{mol}/\text{m}^2/\text{s}$ hingga $162.1\mu\text{mol}/\text{m}^2/\text{s}$), menunjukkan min pembiakan maksimum ($523 \pm 37.4 \text{ ind./betina}$) diperolehi pada $33.3 \mu\text{mol}/\text{s}/\text{m}^2$. Pada fotokala yang berlainan, min pembiakan maksimum ($647.5 \pm 144 \text{ ind./betina}$), diperolehi pada cahaya yang berterusan.

Kadar pemakanan *A. dengizicus* berbeza daripada nauplius hingga dewasa ($p < 0.01$). Pemakanan yang paling baik untuk semua peringkat *A. dengizicus* adalah *Tetraselmis tetrathele*, *Chaetoceros calcitrans*, *Isochrysis galbana* dan *Nannochloropsis oculata* masing-masing. Spesies dan kepadatan alga menunjukkan kesan yang signifikan ke atas kadar pertumbuhan populasi *A. dengizicus* ($p < 0.01$). Untuk diet alga berbagai yang diuji, kopepod yang diberi makan *T. tetrathele* serta pemberian pemakanan secara kombinasi menghasilkan perkembangan yang cepat, bilangan nauplius yang maksimum, serta penghasilan yang maksimum.

Analisis nutrisi menunjukkan *A. dengizicus* mempunyai 23-60 % protein, 18-20 % lipid, dan 4-10 % karbohidrat. Phenylalanine dan leucine mempunyai kepekatan tertinggi terjulat dari 12.4 hingga 26.3% dan 11.3 – 12.2% masing-masing. Asid lemak tepu (SFA) merangkumi sebahagian besar asid lemak ($40.54 \pm 5.97 \%$), diikuti oleh asid lemak mono tak tepu (MUFA) ($20.67 \pm 7.21 \%$) dan asid lemak tak tepu (HUFA) ($20.69 \pm 4.90 \%$). SFA, MUFA dan HUFA major untuk *A. dengizicus* adalah C14:0 ($30.47 \pm 4.61\%$), C18:1n-7 serta C18:1n-9 ($14.23 \pm 4.96\%$) dan C22 : 6n-3 ($10.54 \pm 3.14\%$). Peningkatan nisbah n-3/n-6 dan DHA/EPA untuk *A. dengizicus* berbanding nauplius *Artemia* yang

baru menetas, menjadikan ia sebagai pembekal nutrisi yang sesuai untuk larva ikan dan udang.

Kajian ini menunjukkan kadar penghadaman paling baik adalah 41.5 ind./hari untuk PL3-6 yang memakan *Apocyclops* dan 101.6 ind./hari bagi PL9-12 untuk *Artemia*. Larva udang ini juga boleh menghadam *Apocyclops* lebih baik berbanding *Artemia*.

Eksperimen ke atas kemandirian dan pertumbuhan larva *Penaeus monodon* yang diberi makan dengan diet yang berbeza menunjukkan kemandirian dan pertumbuhan *P. monodon* adalah maksimum (56.3%, 14.24 %/hari) dalam diet campuran *A. dengizicus* + nauplius *Artemia*. Nisbah n-3/n-6 untuk larva bertambah dari 1.88 kepada 2.56 apabila diberi makan dengan *Apocyclops*, 2.46 dengan *Artemia*, dan 2.40 dengan diet campuran *Apocyclops* dan *Artemia*. Kajian ini menunjukkan bahawa *A. dengizicus* mempunyai potensi yang tinggi sebagai makanan hidup untuk *P. monodon* dan berkemungkinan boleh mengurangkan penggunaan sista *Artemia* yang diimport.

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I certify that an Examination Committee has met on 29th May 2006 to conduct the final examination of Omidvar Farhadian on his Doctor of Philosophy thesis entitled “Culture of a Planktonic Cyclopoid, *Apocyclops dengizicus* (Lepeshkin, 1900) and its Suitability as Live Feed for the Postlarvae of Giant Black Tiger Shrimp, *Penaeus monodon* Fabricius (1798)” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

OMIDVAR FARHADIAN

Date:

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