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SHORTER CONTRIBUTION

Dry Weight and Elemental Composition (C and N) of the Cast Moults of the Larvae of the Pink Shrimp *Pandalus borealis* KRØYER

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Abstract

Cast moults of *Pandalus borealis* larvae (stage I-VII) and postlarvae were collected and dry weights and carbon and nitrogen contents were determined. Dried moults accounted for 3.7-9.3% of dried post-moulted larvae. Carbon and nitrogen in dried moults were 20.8% and 3.8%, respectively. These results were used to complete carbon budgets of the larvae growing from stage I to the postlarvae of *P. borealis* porposed previously by SAOTOME and IKEDA (1990). Overall effect of the use of new moult data on the carbon budget was found to be very small.

Key words *Pandalus borealis*, larvae, moult, carbon, nitrogen

The pink shrimp *Pandalus borealis* in the Japan Sea is an important commercial species, but its numbers have been declining since 1982 (ISHIKAWA FISHERIES EXPERIMENTAL STATION 1988). Since 1983, the Japan Sea-Farming Association at Notojima has been raising *P. borealis* larvae for release, as an effort to boost the natural population size of this shrimp in the Japan Sea. To establish an economical and reliable method for raising the larvae, SAOTOME and IKEDA (1990) investigated oxygen consumption rates and body composition (water, ash, carbon and nitrogen) of each larval stage (I to VII) and the post larvae, and established a carbon budget for the larvae growing from stage I to postlarvae. In their calculation, SAOTOME and IKEDA (1990) did not measure moulting loss at each larvae stage, but assumed a 2% loss of body carbon at each moulting from literature data. The aim of the present study was to provide this previously unmeasured data in the carbon budget of SAOTOME and IKEDA (1990).

The larvae were raised from eggs at the Japan Sea-Farming Association at Notojima during the period January through February 1989. General methods for raising the larvae were similar to those in SAOTOME and IKEDA (1990). To obtain moults, 5-6 larvae at each stage were isolated individually in small vials (25ml capacity) and observed daily for moults. The moults collected were de-salted in distilled water. Special caution was paid to remove seawater from inside the moult, which was achieved by gentle, repeated squeezing of the moult with forceps in distilled water. De-salted moults were placed individually on microscope cover glasses. Post-moult larvae were rinsed briefly with distilled water and kept in plastic vials. Both cover glasses with moult and post-moult larvae were dried in a desiccator over silica-gel. Weighing of dried moults and larvae were made with a Mettler ultra-micro balance (model M3) which was accurate to 1 μg.

Moult dry weight of stage I larvae was 0.014mg (mean) and increased with the development, reaching 0.257mg (mean) at the post-

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larval stage (Table 1, column (1)). The dry weights of the post-moult larvae increased also from 0.264 to 2.793mg in the course of the development (Table 1, column (2)). Moult dry weights accounted to 3.7 to 9.3% of the dry weights of post-moult larvae, and no consistent trend was evident with the development of the larvae (Table 1, column (3)). A variance analysis revealed a signifficant difference among eight mean percentages of the dried moult weights to the dried larva weights ($F=3.505$, $df=7,34$, $p<0.05$). Further analyses between paired means with a LSD-test (cf. SNEDECOR and COCHRAN 1967) indicated that there was no signifficant differences among the means of stage I to VII ($p>0.05$) and only the mean of postlarvae (9.3%) was signifficantly greater than the rest of seven means ($p<0.05$). From these results a grand mean of 5.2% (±1.8) was computed as the percentage of the dried moult weight to the dried larva weight for the stage I through stage VII. It is noted that post-moult larvae of each stage in Table 1 correspond to pre-moult larvae of the next stage; e.g. post-moult stage 1 larva is stage II larva in SAOTOME and IKEDA (1990). However, dry weight of the larvae obtained in this study is less than that of SAOTOME and IKEDA (1990) due to the use of 0 day-old specimens in this study in contrast to the use of 3 to 6 day-old specimens by SAOTOME and IKEDA (1990). In crustaceans the increase in body length is limited by moulting, but dry weight increases continuously between moultings (cf. ANGER 1989).

Moult samples obtained in this study were insufficient for measuring the elemental composition of each larval stage. For this purpose, all moult samples obtained in this study were pooled and the elemental composition (carbon and nitrogen) was analyzed with a Yanaco CHN Corder (MT-3) using antipyrine as a standard. The analyses demonstrated that carbon and nitrogen contents were 20.8 (±0.1, N=2) and 3.8% (±0.0, N=2), respectively, of dry weight. From these elemental composition data and dry weight data in Table 1, the total amount of cast moults for the larvae growing from stage I to the postlarvae is estimated as 0.356mg dry weight, or 74μg carbon ($0.356\times0.208\times1000$). The previous indirect estimate of the total cast moults by SAOTOME and IKEDA (1990) was 102μg carbon, which was derived from the assumption of a 2% loss of body carbon at each moulting.

Table 1. *Pandalus borealis*. Dry weights (DW) of cast moult and of post-moult larvae, and percentages of cast moult to post-moult larvae in terms of dry weight. Means ±1SD of N replicates. PL= postlarva

Larval stage	N	(1) Moult DW (mg)	(2) Post-moult larva DW (mg)	(3) (1)/(2) (%)
I	5	0.014±0.002	0.264±0.022	5.3±1.1
II	5	0.025±0.017	0.526±0.042	4.8±3.3
III	5	0.025±0.007	0.658±0.067	3.7±0.9
IV	5	0.051±0.014	0.862±0.197	6.1±1.8
V	6	0.061±0.018	1.141±0.479	5.6±0.9
VI	5	0.079±0.019	1.411±0.244	5.6±1.4
VII	5	0.101±0.039	2.169±.0632	5.3±3.2
PL	6	0.257±0.055	2.793±0.481	9.3±3.3

Using this new moult carbon data, the carbon budget of the larvae growing from stage I to the postlarvae of SAOTOME and IKEDA (1990) was re-calculated in Table 2. Carbon allocation for growth and metabolism are unchanged, but assimilated carbon decreased from 3220 μg to 3192 μg. Due to the reduction of assimilated carbon, ingested carbon changed from 4025 μg to 3990 μg, net growth efficiency from 56.5% to 57.0%, and net growth efficiency from 45.2% to 45.6%. Overall, the use of the new moult data on the entire carbon budget thus produce only very small effects.

Among marine crustaceans, a single moult accounts for 2.6-12.8% of body dry weight in various euphausiids (IKEDA and DIXON 1981, and literatures therein), 13% in a mysid *Metamysidopsis elongata* (CLUTTER and THEILACKER 1971), 6.8% in a hyperiid amphipod *Themisto japonica* (IKEDA unpublished data). Present results of the percentages of dried moult to dried post-moult larvae of *P. borealis* (3.7-9.3%) fall into the range of these reported values by previous workers on other marine pelagic crustaceans (2.6-23.8%). The higher percent of moult loss (9.3% of body dry weight) seen in the postlarvae of *P. borealis* as compared with younger larvae (3.7-6.1% of body dry weight) may be related to the transition from planktonic life to benthic life of the larvae. ANGER (1989) observed also a similar phenomenon for the larvae of helmit crab *Pagurus bernhardus*, in which moult loss of 4-5% of body dry weight seen at zoea stages increased suddunly to 24% at megalopa stages and the first juveniles.

With regard to elemental composition of dried moults, IKEDA and DIXON (1982) reported that carbon and nitrogen constituted 23.7% and 4.4%, respectively, in a euphausiid *Euphausia superba*. In other euphausiids, carbon and nitrogen composition of dried moults was 26.4% and 5.2% respectively in *Thysanoessa inermis* (DALPADADO and IKEDA 1989), and 17.0% and 2.5% respectively in *Euphausia pacifica* (LASKER 1966). Dried moults of *M. elongata* contained carbon 23.5% of dry weight (CLUTTER and THEILACKER 1971). The moult of *T. japonica* contained carbon and nitrogen 23.7% and 4.2%, respectively, of dry weight (IKEDA unpublished). Thus, moults of *P. borealis* larvae are similar also to those of other marine planktonic crustaceans in terms of carbon and nitrogen contents.

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Table 2. *Pandalus borealis*. Carbon budget of the larvae growing from stage I to postlarvae at 8 °C estimated by SAOTOME and IKEDA (1990), and that revised using new data for moults in this study.

	SAOTOME and IKEDA (1990)	This study
(1) Growth:	1820 μgC	1820 μgC
(2) Moult:	102 μgC	74 μgC
(3) Metabolism:	1298 μgC	1298 μgC
(4) Assimilation: (1)+(2)+(3)	3220 μgC	3192 μgC
(5) Ingestion: (4)/0.8	4025 μgC	3990 μgC
(6) Net growth efficiency: (1)/(4)×100	56.5%	57.0%
(7) Gross growth efficiency: (1)/(5)×100	45.2%	45.6%

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ホッコクアカエビ（*Pandalus borealis* KRØYER）幼生の脱皮殻の乾重量と炭素・窒素含量

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実験室で採卵・孵化・飼育されたホッコクアカエビの幼生全期（Ⅰ～Ⅶ）および後幼生期について脱皮殻の乾重量とその炭素・窒素含量を測定した．その結果，脱皮殻の乾重量は幼生乾重量の3.7～9.3％であり，脱皮殻に含まれる炭素・窒素量はそれぞれ脱皮殻乾重量の20.8％，3.8％であることが判った．この結果より，SAOTOME and IKEDA（1990）が計算した本種幼生がⅠ期から後期幼生に成長する際の炭素収支について若干の修正を行った．