熱帯海産遊泳エビAcetes sibogae australisの脱皮間隔と成長に関する予備的研究
Preliminary Studies on the Intermoult Period and Growth of the Pelagic Shrimp *Acetes sibogae australis* from a Tropical Sea$^{1),2}$

TSUTOMU IKEDA$^{3), 4)}$ and J.K.B. RAYMONT$^{5), 6)}$

*Australian Institute of Marine Science,*

_P.M.B. No. 3, Townsville, M.S.O.,*

_Queensland 4810, Australia_

**Abstract**

Locally caught specimens of *Acetes sibogae australis* were maintained at 22°C in the laboratory for up to 64 days, providing *Artemia* nauplii as food. For specimens with 5 to 25 mm body length (BL), intermoult period (IP) ranged from 3 to 5 days, and growth in BL between consecutive moults (ΔBL), from 0.00 to 0.51 mm. Observed daily growth rate (ΔBL/IP) was 0.00 to 0.14 mm·d$^{-1}$, but potential daily growth rate as high as 0.20 mm·d$^{-1}$ was indicated. Some conditions which may govern productivity of *Acetes* in the field are discussed.

**Introduction**

The sergestid shrimp genus *Acetes* has 14 species, and is distributed mainly in estuaries and coastal waters of tropical and subtropical regions (OMORI 1975). Detailed accounts on morphology and development of larvae have been reported on *Acetes japonicus* (SOEJIMA 1926), *A. erythraeus* (MENON 1933) and *A. sibogae australis* (MORRIS 1948). Information on life history and reproduction of *Acetes* shrimps is currently limited to *A. japonicus* distributing around the coast of western Japan (YASUDA et al. 1953, IKEMATSU 1953), South Korea (YOSHIDA 1949) and China (LEI 1984), and *A. chinensis* inhabiting central western waters of Korea (KIM 1974).

IKEMATSU (1953) made a laboratory study on the growth of *A. japonicus*, but paucity of experimental data on pelagic decapod shrimps in general (see OMORI 1974 for review) contrasts with the wide variety of laboratory experiments on other crustacean orders, such as euphausiids, in accumulating important biological data (Ross 1982, IKEDA 1985, IKEDA et al. 1985, IKEDA & THOMAS 1987).

The present study aims at the determination of the intermoult period of

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2) 熱帯海産遊泳エビ *Acetes sibogae australis* の脱皮間隔と成長に関する予備的研究
3) 池田 魁・J.K.B. レイモント, オーストラリア海洋科学研究所
4) Present address: Japan Sea Regional Fisheries Research Laboratory, 1 Suido-cho, Niigata 951, Japan (現在: 日本海区水産研究所)
5) Present address: C/O Department of Oceanography, the University, Southampton, SO9 2NH, UK (現在: サウサンプトン大学)
Acetes sibogae australis in the laboratory as a basis to estimate their potential growth in the field.

Materials and Methods
Specimens of various sizes (5.3–24.6 mm body length) were collected with a hand net from off the beach near the Australian Institute of Marine Science, Townsville, Queensland, during the period September to November 1979. Specimens were brought back to a laboratory aquarium and sorted into three arbitrarily defined body length (BL) groups (5–10, 10–20 and >20 mm body length). No separation of sex was made. Specimens were then transferred individually to 4 liter (>20 mm group), 1.5 liter (10–20 mm group) and 1 liter (5–10 mm group) Pyrex beakers filled with natural seawater. Each beaker was covered with a plastic sheet. Experiment was run at 22°C under simulated natural light–dark cycles.

Natural detritus collected from the same sampling site with a 20 µm mesh net and newly hatched Artemia nauplii were used as food. Both types of food were frequently given to animals in order to maintain a continuous feeding regime. Specimens were transferred to beakers filled with new seawater when accumulation of feces and uneaten food was observed on the bottom of beakers.

Beakers with specimens were checked every morning for moults. Collected moults were preserved with a few drops of formalin for later measurement of uropod length under a dissecting microscope. Uropod length (UL mm) was converted to body length (BL mm; from the tip of rostrum to the distal end of telson) using an equation BL = 1.51 + 5.02 UL (n = 59, r = 0.985, p<0.01) established with both fresh and formalin preserved specimens (no effect of formalin preservation was observed). BL may be converted to body wet weight (WW, mg) using an equation log_{10} WW = -2.069 + 2.985 log_{10} BL (n = 40, r = 0.997), and WW to dry weight multiplying by 0.230 (±0.010, n=10).

Results
Survival: Specimens fed natural detritus lived shorter (3–17 days) than those fed Artemia nauplii (11–64 days) (Table 1). Because of poor survival the data of specimens fed natural detritus were omitted, and only data from specimens fed Artemia nauplii were analysed and discussed. One major problem was that some animals jumped out of the water and adhered to the sides of the beaker or cover. Mortality due to this factor was highest in the 5–10 mm size group (60%) followed by 10–20 mm size group (21%) and lowest (7%) in >20 mm size group. Another cause of death was failure to moult.

Intermoult period (IP): IP data being divided into four BL length groups (5–10, 10–15, 15–20 and >20 mm) showed a wide variation (2–8 days) in each size group (Fig. 1). Since the IP data were not normally distributed, median instead of mean was used in the following analyses. Median IP was 3 days for smaller groups (5–15 mm BL) and 4–5 days for larger size groups (>15 mm BL).
TABLE 1. *A. sibogae australis*. SURVIVAL OF THREE SIZE GROUPS FED NEWLY HATCHED *Artemia* NAUPLII AND NATURAL DETRITUS

<table>
<thead>
<tr>
<th>BL (mm)</th>
<th>Food</th>
<th>N</th>
<th>Mean±1SD</th>
<th>Range</th>
<th>Death due to jumping out of water (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5–10</td>
<td><em>Artemia</em></td>
<td>10</td>
<td>29±8</td>
<td>11–39</td>
<td>60</td>
</tr>
<tr>
<td>10–20</td>
<td><em>Artemia</em></td>
<td>7</td>
<td>53±12</td>
<td>35–64</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Detritus</td>
<td>12</td>
<td>8±5</td>
<td>3–17</td>
<td>0</td>
</tr>
<tr>
<td>&gt;20</td>
<td><em>Artemia</em></td>
<td>6</td>
<td>29±14</td>
<td>15–47</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Detritus</td>
<td>8</td>
<td>11±4</td>
<td>5–16</td>
<td>0</td>
</tr>
</tbody>
</table>

Fig. 1. *A. sibogae australis*. Relative frequencies of intermoult period (IP), increment of BL between moults ($\Delta$BL), and daily increment of BL ($\Delta$BL/IP) of four BL size groups (5–10, 10–15, 15–20 and >20 mm) fed *Artemia* nauplii.
Growth (ΔBL, ΔBL/IP): As IP, the increment of BL between consecutive moults (ΔBL) scattered widely among four size groups. Median ΔBLs for smaller size groups (5–15 mm BL) were 0.40–0.51 mm and larger size groups (>15 mm BL), 0.10–0.00 mm BL, showing the decrease with in the increase of BL (Table 2).

Daily growth rate in BL can be calculated from ΔBL divided by IP. Thus obtained median daily growth rates were 0.13, 0.14, 0.02 and 0.00 mm for 5–10 mm, 10–15 mm, 15–20 mm and >20 mm BL groups, respectively (Table 2).

<table>
<thead>
<tr>
<th>BL (mm)</th>
<th>N</th>
<th>ΔBL (mm)</th>
<th>ΔBL/IP (mm·d⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5–10</td>
<td>55</td>
<td>0.48±0.62</td>
<td>0.15±0.19 0.13</td>
</tr>
<tr>
<td>10–15</td>
<td>38</td>
<td>0.53±0.54</td>
<td>0.17±0.17 0.14</td>
</tr>
<tr>
<td>15–20</td>
<td>21</td>
<td>−0.03±0.99</td>
<td>−0.08±0.29 0.02</td>
</tr>
<tr>
<td>&gt;20</td>
<td>61</td>
<td>0.05±0.33</td>
<td>0.01±0.09 0.00</td>
</tr>
</tbody>
</table>

Discussion

IKEMATSU (1953) observed moulting in Acetes japonicus in the laboratory and found that of 78 specimens tested, 50% moulted in 3 days and 94% in 7 days. Most specimens died within 10 days and no specimen moulted twice. If one assumes a random moulting of specimens, IKEMATSU’s (1953) results suggest IP of 6–7 days for A. japonicus, which is much longer than 3–5 days observed in A. sibogae australis of this study.

IP of crustaceans is known to vary depending on endogenous (size, sex, maturity etc.) as well as exogenous factors (temperature, light, food supply etc., see Hartnoll 1982 for review). Neither size nor temperature are likely causes for differences in IPs of Ikematsu’s A. japonicus (BL: 11–33 mm, temperature: 10–25 °C) and our A. sibogae australis (BL: 6–25 mm, temperature: 22°C). While Artemia nauplii were used as food in this study, IKEMATSU (1953) fed chopped fresh Acetes to his specimens. The effect of these different foods on the IP is difficult to assess, but considered not to be the major cause. Higher mortality of animals recorded in IKEMATSU’s experiment may reflect some unfavorable conditions for experimental animals, possibly resulting in longer IPs of his animals. Artemia nauplii have been successfully used as a food for growth experiment of pelagic shrimps such as Neomysis intermedia (Murano 1966), Metamysidopsis elongata (Clutter & Theilacker 1971), Lucifer chacei (Zimmerman, 1973), Sergia lucens (Omori 1971) and Sergestes similis (Omori 1979). The IP of 3–5 days observed on A. sibogae australis in this experiment is consistent with 3–4 days for the larvae of caridean shrimp Palaemon serratus which have similar BLs (4–9 mm), fed Artemia nauplii and maintained at 22°C (Reeve 1969).

It is interesting to note that in IKEMATSU (1954) experiment, the deaths
of 47 out of 78 specimens (i.e. 60%) were due to specimens jumping out of beakers and sticking on container wall, a phenomenon being rarely observed in the laboratory experiment on euphausiids and mysids. A similar problem, but to a lesser extent, was seen in *A. sibogae australis* in this study, especially for smaller specimens.

ΔBL was plotted against IP in Fig. 2. Median ΔBL tended to decrease with the increase of IP, but a regression analysis failed to find a significant relationship between these two variables (r=0.102, n=178, p>0.05). While no general rules have been found between ΔBL and IP in crustaceans (HARTNOLL 1982), shorter IP associated with greater ΔBL has been found in a euphasiid *Euphausia superba* (IKEDA et al. 1985, IKEDA & THOMAS 1987). Ecological advantage of this close association of greater ΔBL with shorter IP is a possible rapid growth of animals where food conditions are optimum in the field. If we assume that *A. sibogae australis* of all sizes could moult every two

Fig. 2. *A. sibogae australis*. Relationship between ΔBL and IP (pooled data of all sizes). Solid triangles indicate medians (IP>7 days omitted because of fewer data).
days and increase BL 0.40 mm at each molting (i.e., daily growth of 0.20 mm in BL), specimens with 0.5 mm BL could reach to 28 mm BL (the largest females found in this study) or 21 mm BL (the largest males found in this study) in 115 days and 80 days, respectively.

Among 14 Acetes species, information available on the life history is of *A. japonicus* and *A. chinensis*. From the examination of size frequency and maturation condition data collected from monthly sampling program, IKEMATSU (1953) considered that *A. japonicus* repeated two generations in a year in the coastal waters of western Japan; a winter generation living 9–10 months and a summer generation, 2.5–3 months. For *A. japonicus*, two generations per year were also confirmed in coastal waters of Guangdong Province, China (LEI 1984), but only one generation in a year in Korean waters (YOSHIDA 1949). The final size of *A. japonicus* varies in summer (female: 12–17 mm, male: 9–16 mm) and winter generations (female: 22–28 mm, male: 18–25 mm, IKEMATSU 1953, YASUDA et al. 1953). *A. chinensis* is a larger species than *A. japonicus* and repeats one generation in a year in central western waters of Korea (KIM 1974).

From size distribution data of field populations, growth rates of females and males of *A. japonicus* of summer generations were estimated to be 0.20–0.27 mm·d⁻¹ and 0.10–0.27 mm·d⁻¹, respectively (IKEMATSU 1953, LEI 1984). Using the same method, KIM (1974) concluded that the growth rate of *A. chinensis* was similar to that of *A. japonicus*. Potential growth rates as high as 0.20 mm·d⁻¹ as estimated for *A. sibogae australis* in the present study is close to these summer growth rates of *A. japonicus* and *A. chinensis* derived from field data analyses.

The shorter survival of *A. sibogae australis* fed natural detritus is puzzling, as their major habitat is coastal waters. HAMNER & HAMNER (1977) demonstrated an extreme chemosensory ability of *A. sibogae australis* in tracking scent trails of particular amino acids, suggesting that they are largely carnivores rather than detritus feeders in nature. Copepods and unidentified crustacean remains were found in the gut of *A. chinensis* (OMORI 1975) and *A. erythraeus* (LE RESTE 1970). It would appear that quality of food as well as quantity is important, and that detritus alone is not a suitable diet to maintain active growth in Acetes. HUDINAGA & KITAKA (1966) reported that the penaeid shrimp *Penaeus japonicus* required animal food for development beyond mysis stage.

Fishery statistics of *A. japonicus* indicate enormous variations in fishing season and catches (OMORI 1986). Such variations imply that successful recruitment and subsequent growth of this shrimp is largely under the control of natural environmental conditions which vary considerably from time to time in coastal regions. Precise information on spawning, larval survival, growth and maturation of Acetes under particular sets of environmental conditions is needed to predict their population dynamics in the field.

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**Literature Cited**


