汽水性カイアシ類Sinocalanus tenellusの種々の水温,塩分条件下における成長特性

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Growth Characteristics of a Brakish-water Calanoid Copepod *Sinocalanus tenellus* in Relation to Temperature and Salinity[1) 2), 3)]

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Abstract

The growth characteristics of a brackish-water calanoid copepod *Sinocalanus tenellus* (Kikuchi) were investigated in relation to temperature and salinity. Egg hatching and postembryonic development were successful over a wide range of temperature (6.6-31.3°C and 6.2-27.1°C, respectively) and salinity (2.5-35.0‰ and 5.0-30.0‰, respectively). The time required after egg-laying to reach any developmental stage increased with the decrease of temperature. The effect of salinity on the development time was not so marked as that of temperature. The stage duration was shortest in NI, nearly constant from NII to CIII, and somewhat prolonged in CIV and CV. Males developed faster than females. Body length of *S. tenellus* decreased with increasing temperature for each developmental stage except for NI. Salinity did not appear to affect the body size significantly except for CV and CVI, where the size became largest at 15‰. The daily specific growth rate increased exponentially with increasing temperature, and was highest at a salinity of 15‰. The present study indicates that *S. tenellus* is a eurythermal and euryhaline copepod with a high growth potential.

Most planktonic copepods have 13 life history stages, i.e. egg, 6 naupliar and 6 copepodite stages (the last copepodite, CVI, is the adult). Information on the development time of these respective stages is needed to assess the population dynamics and production of copepods. Temperature is one of the most important factors influencing the development rate (HEINLE 1969, MCLAREN 1978, THOMPSON 1982). Food abundance is also important (HARRIS & PAFFENHÖFER 1976, PAFFENHÖFER & HARRIS 1976), but to a much less degree. In estuaries of temperate regions, not only temperature and food but also salinity is an important factor affecting the physiological rates of zooplankton.

Copepods of the genus *Sinocalanus* (Calanoida: Centropagidae) are distributed in estuaries and brackish-water systems of the Far East (CHEN & ZHANG 1965, BRODSKY 1967, MIZUNO 1984), among which two species, *S. tenellus* (Kikuchi) and *S. sinensis* (Poppe), are present in Japan (KIKUCHI 1928, MIZUNO 1984). Since either species is often dominant in estuaries (TANAKA & MATSUMIYA 1982) and brackish-water ponds (HADA et al. 1986), they may play

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[3)] 汽水性カイアシ類 *Sinocalanus tenellus* の種々の水温，塩分条件下における成長特性
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an important role in food webs of these brackish-water environments.

In the present study, we have investigated the effects of temperature and salinity on the embryonic and postembryonic development and growth of *S. tenellus* under controlled laboratory conditions. As far as we know, there are only two published papers (MATSUDAIRA 1957, WATANABE 1961) which report the effects of environmental factors on the physiology of *S. tenellus*, except for our recent paper (HADA et al. 1986). MATSUDAIRA (1957) first attempted to rear *S. tenellus* in the laboratory and described the developmental stages and gave some biological information on this species. WATANABE (1961) also cultivated *S. tenellus* more intensively to estimate the energy budget of laboratory populations. The techniques for culturing copepods and for measuring the biomass, however, have been much improved since these two pioneering works. We will report here the growth characteristics of *S. tenellus* in more detail.

Materials and Methods

Zooplankton was collected by horizontal hauls of a cylinder-conical net (30 cm diameter, 100 μm mesh opening) at a brackish-water pond in Fukuyama (HADA et al., 1986). The contents of the cod-end were transferred into 2 l plastic bottles containing pond water, and brought back to the university laboratory. The time for transportation was ca. 30 min. About 500-1,000 adult females and males of *Sinocalanus tenellus* were isolated and introduced to 1 l glass beakers containing a standardized culture medium. The medium was prepared by diluting the glass-fiber (Whatman GF/C) filtered coastal seawater (salinity: ca. 30‰) with distilled water to adjust to 10‰, approximate salinity of the pond water. Cultured *Isochrysis galbana* and *Thalassiosira weissflogii* were suspended in the medium at densities of ca. 5×10^4 and 5×10^3 cells ml^{-1}, respectively. These beakers were incubated in a temperature controlled room (20.5 ±0.5°C, 12L-12D photoperiod). Eggs produced within 1 h were used for the experiments to study the effects of temperature and salinity on egg hatching. Eggs laid during 4-24 h were used for the experiment on postembryonic development.

Effect of Temperature

Two hundred eggs were introduced into each glass evaporating dish (75 mm diameter, 30 mm deep) containing approximately 50 ml filtered water (salinity: 10‰), and incubated at 9 different temperatures ranging from 6.6 to 34.9°C. Hatched nauplii were counted hourly for the first 2 days and at 4-24 h intervals thereafter. Illumination was not controlled, although direct sun light was avoided; daytime light intensity in the laboratory was 100-500 lx. To determine the growth rate of *S. tenellus*, 1,000 to 3,000 eggs were introduced into glass beakers containing approximately 1 l of standardized culture medium, and incubated at different temperatures. Photoperiod was controlled at 12L-12D except for beakers incubated at 34.7, 9.9 and 6.2°C, where light was not specifically controlled. At 0.5-3 d intervals, 25 to several hundred individuals were subsampled with a large-mouthed pipette and preserved with formalin. At the same time, half of the medium was replaced with freshly prepared medium.

Preserved specimens were staged and their body length, i.e. from the front border to the base of the caudal spine for nauplii and from the head to the end of the prosome for copepodites, was measured using an eyepiece micrometer. Live specimens of each developmental stage were subsampled from the cultures, and their organic carbon content was measured by a total carbon analyzer (Oceanography International Co., Model 524).

Effect of Salinity

Egg development was examined at 13 different salinities between 0 and 40.0‰ by incubating 200 eggs in evaporating dishes, and larval development was investigated at 6 different salinities between 5 and 30‰ using cultured *I. galbana* and *T. weissflogii* (their concentration was the same as the standardized medium) as food. In both experiments, temperature was fixed to 20.2±0.5°C. The other procedures were essentially the same as in the experiments to determine the effect of temperature.

Results

Effect of Temperature

1. *Egg Hatching*

The hatching success and the time required for hatching of 50% of viable eggs of *Sinocalanus tenellus* at various temperatures are shown in Fig. 1. The eggs hatched at all the temperatures tested, and the hatching success was higher than 70% at temperatures between 6.6 and 31.3°C. At 34.9°C, hatching success was as low as 16%.

The time to hatching was dependent on temperature, shortened exponentially with increasing temperature up to 31.3°C, beyond which it was slightly prolonged. A Bělehrádek's

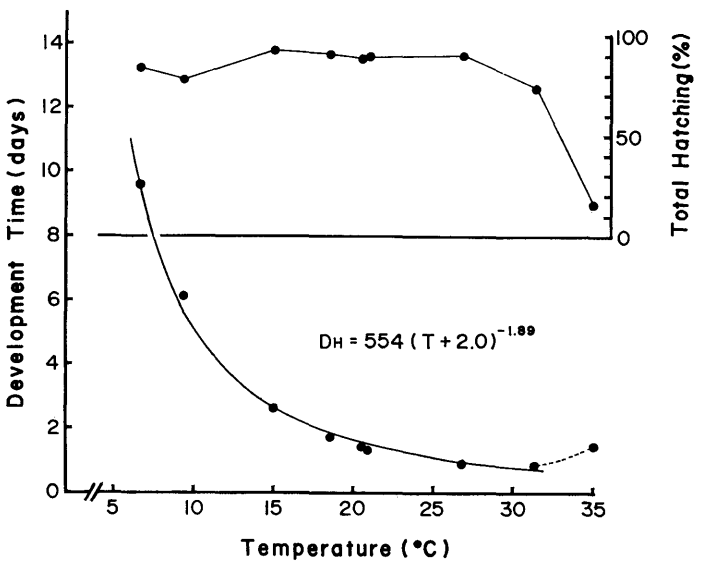


Fig. 1. Effect of temperature on the hatching success and development time of eggs of *Sinocalanus tenellus*.

temperature function, which has been commonly used to describe the relationship between the egg development time and temperature (McLaren 1965, 1966, McLaren et al. 1969), was applied to the present species. By fitting the data between 6.6 and 31.3°C, the following equation was obtained:

$$DH=554\,(T+2.0)^{-1.89} \quad (r=-0.995)$$

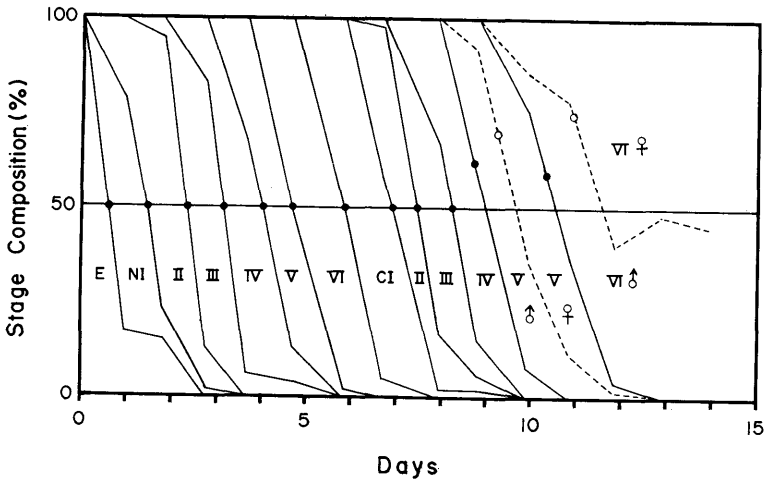


Fig. 2. Stage succession of *Sinocalanus tenellus* at 20.3°C.

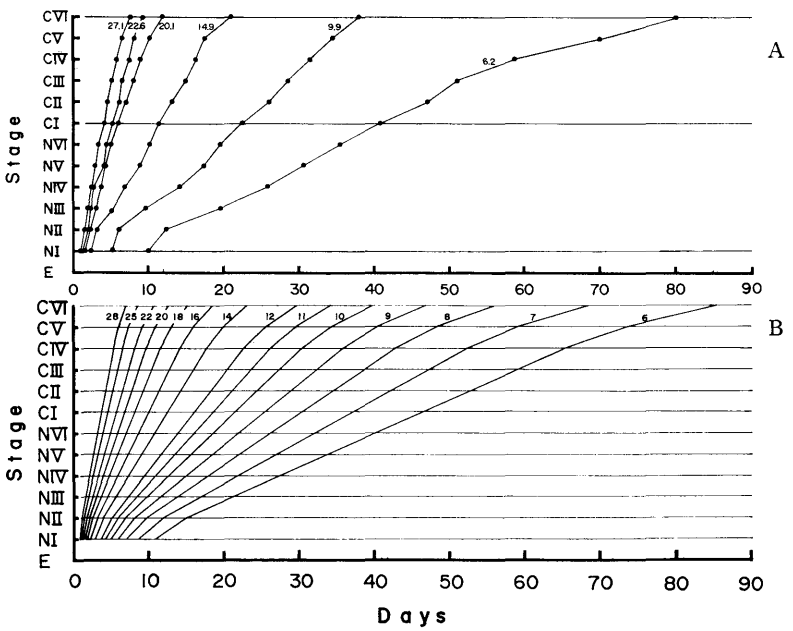


Fig. 3. Postembryonic development of *Sinocalanus tenellus* at different temperatures. A: Development at 6 different experimental temperatures. Each point is the time required for 50 % of individuals to molt into each stage. B: Schematic pattern of development at temperatures from 6 to 28°C.

where DH is the time to hatching in days and T is temperature in °C.

2. *Larval Development*

Composition of each developmental stage was traced as shown in Fig. 2, in order to know the progress of stage succession of *S. tenellus*. The time of the beginning of each stage was defined graphically by the time when 50% of the individuals had molted into that stage. Since males developed significantly faster than females in CIV and CV, the stage was determined separately by sex. In the experiment at 20.3°C (Fig. 2), the stage duration from NI to CIV was nearly isochronal (mean duration: 0.84 d), but it was slightly prolonged in CV. Males (0.58 and 1.58 d) had shorter duration than females (1.00 and 1.75 d) in CIV and CV.

The progresses of stage succession at 6 different temperatures are shown in Fig. 3A. In this case, the durations for egg development are included. At lower temperatures, the duration for NI was significantly shorter than the other stages and the development tended to become slower in later copepodite stages. The total development time from egg-laying to CVI was calculated as 80.2, 38.0, 21.2, 11.9, 9.3 and 7.5 d at 6.2, 9.9, 14.9, 20.1, 22.6 and 27.1°C, respectively.

TABLE 1. TIME REQUIRED FOR EMBRYONIC AND POSTEMBRYONIC DEVELOPMENT OF *Sinocalanus tenellus* AT VARIOUS TEMPERATURES.

Temperature (°C)	Stage duration (days) Egg* A	NI B	NII-CIII C	CIV D		CV E		B/A	C/A	D/A		E/A	
6.2	10.4	2.3	5.76	11.3	M11.6	9.9	M 7.5	0.22	0.56	1.09	M1.12	0.96	M0.72
					F10.7		F11.1				F1.03		F1.07
9.8	5.3	1.8	2.95	—		—		0.35	0.56	—		—	
9.9	5.1	0.9	3.18	3.0	M 3.0	3.6	M 3.1	0.18	0.62	0.58	M0.58	0.70	M0.60
					F 3.0		F 4.2				F0.59		F0.82
14.8	2.7	0.8	1.59	3.4	M 3.4	3.5	M 2.6	0.29	0.59	1.25	M1.25	1.29	M0.97
					F 3.3		F 4.0				F1.50		F1.50
14.9	2.7	0.7	1.64	1.2	M 1.0	3.5	M 3.4	0.27	0.62	0.46	M0.46	1.32	M1.27
					F 1.6		F 3.6				F0.58		F1.35
20.1	1.6	—	—	1.2	M 1.1	1.8	M 1.8	—	—	0.78	M0.71	1.10	M1.15
					F 1.4		F 1.7				F0.80		F1.04
20.3	1.6	0.9	0.85	0.8	M 0.6	1.6	M 1.6	0.56	0.54	0.51	M0.37	1.01	M1.01
					F 1.0		F 1.8				F0.64		F1.12
20.4	1.6	0.4	0.90	1.4	M 1.3	1.2	M 1.0	0.27	0.58	0.87	M0.85	0.75	M0.64
					F 1.4		F 1.4				F0.87		F0.87
22.6	1.3	0.9	0.65	0.6	M 0.5	1.3	M 1.4	0.61	0.50	0.49	M0.37	0.99	M1.05
					F 0.9		F 1.1				F0.67		F0.84
22.7	1.3	—	0.85	1.3	M 1.2	1.8	M 1.9	—	0.66	0.99	M0.93	1.42	M1.43
					F 1.4		F 1.9				F1.07		F1.45
27.1	0.9	0.6	0.53	0.7	M 0.6	1.1	M 1.0	0.61	0.55	0.72	M0.65	1.14	M1.09
					F 0.7		F 1.1				F0.78		F1.14
							mean	0.37	0.58	0.77	M0.73	1.07	M0.99
							±S.D.	±0.17	±0.04	±0.27	±0.31	±0.23	±0.27
											F0.86		F1.12
											±0.28		±0.25

* Calculated from $DH=554\ (T+2.0)^{-1.89}$

M: male, F: Female.

The ratios of stage duration of NI, each stage of NII–CIII, CIV and CV, to the duration for embryonic development, were nearly constant in spite of a difference of temperature (Table 1), although considerable variations were observed in some cases. Hence, the time required after egg-laying to reach any developmental stage can be calculated from the Bělehrádek's temperature function by proper multiplication of proportional constant for embryonic development (CORKETT & MCLAREN 1970), as follows:

$$DS=554\times M(T+2.0)^{-1.89}$$

where DS is the development time in days from egg-laying to a given stage, T is temperature in °C and M is a multiplyer (Table 2). From this equation, the development of *S. tenellus* at various temperatures between 6 and 28°C is given schematically in Fig. 3B.

TABLE 2. MULTIPLIER (M) IN THE BELĚHRÁDEK'S TEMPERATURE FUNCTION, $DS=554\times M(T+2.0)^{-1.89}$, USED TO CALCULATE THE TIME REQUIRED FROM EGG-LAYING TO VARIOUS DEVELOPMENTAL STAGES OF *Sinocalanus tenellus*.

DS	D_{NI}	D_{NII}	D_{NIII}	D_{NIV}	D_{NV}	D_{NVI}	D_{CI}	D_{CII}	D_{CIII}	D_{CIV}	D_{CV}	D_{CVI}
M	1	1.37	1.95	2.53	3.11	3.68	4.26	4.84	5.42	6.00	6.77	7.84
											M6.73	M7.72
											F6.86	F7.98

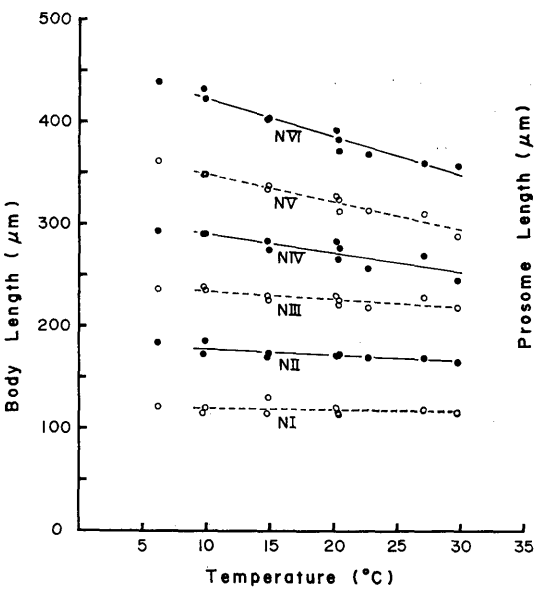


Fig. 4. Effect of temperature on the body length of *Sinocalanus tenellus* nauplii. Each point is the mean body length at a given temperature.

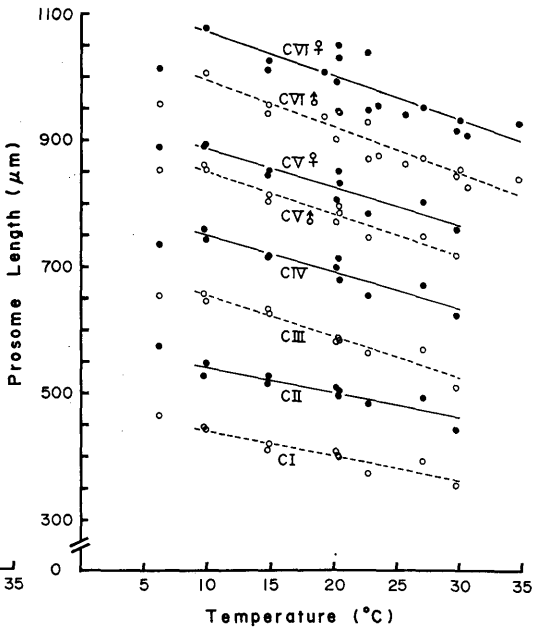


Fig. 5. Effect of temperature on the prosome length of *Sinocalanus tenellus* copepodites and adults. Each point is the mean prosome length at a given temperature.

TABLE 3. CONSTANTS (a AND b) IN THE REGRESSION EQUATION, $L=a-bT$, USED TO CALCULATE THE PROSOME LENGTH OF VARIOUS DEVELOPMENTAL STAGES OF *Sinocalanus tenellus*. FOR EXPLANATION, SEE TEXT.

Stage	a	b
CVI F	1142	7.02**
CVI M	1068	7.37**
CV F	947	6.10**
CV M	917	6.73**
CIV	807	5.80**
CIII	720	6.55**
CII	581	4.02**
CI	480	3.99**
NVI	460	3.73**
NV	376	2.72**
NIV	309	1.88**
NIII	241	0.76**
NII	183	0.58**
NI	121	—

**: $p<0.01$

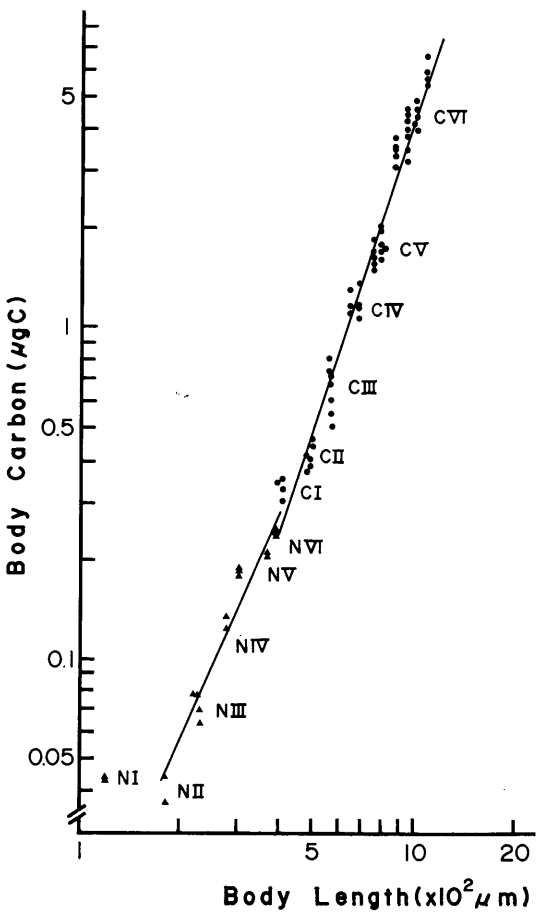


Fig. 6. Length-carbon weight relationship of *Sinocalanus tenellus*.

3. *Body Size*

Body length of *S. tenellus* was negatively related to temperature between 9.8 and 29.7°C, but in NI, it remained unchanged over the temperature range tested (Figs. 4 and 5). At 6.2°C, the prosome length became smaller beyond CII. Females were significantly larger than males in CV and CVI. The difference of adult body size was both ca. 1.2-fold between 9.9°C (mean prosome length: 1,078 and 1,006 μm for females and males, respectively) and 29.7°C (914 and 842 μm, respectively). The relationship between temperature (T, °C) and body length (L, μm) was described by $L=a-bT$. The constants of a and b for each developmental stage are listed in Table 3.

4. *Growth Rate*

The length-weight relationship of *S. tenellus* was first determined (Fig. 6). The body carbon weight (C, μg) increased exponentially with the increase of body length (L, μm), expressed as:

$$\log C=2.332\log L-6.621 \quad (r=0.980)$$

for nauplii, and

$$\log C=3.126\log L-8.735 \quad (r=0.985)$$

for copepodites including adults. However, body carbon weight decreased during NI, since the yolk was consumed until the start of feeding in NII.

Table 4 shows the daily growth rate of each stage for animals reared at 20.3°C. The

TABLE 4. DAILY GROWTH RATE OF VARIOUS DEVELOPMENTAL STAGES OF *Sinocalanus tenellus* AT 20.3°C.

Stage	Body length (μm)	Body carbon* (μg C)	Weight increment (μg C)	Duration** (days)	Daily growth rate (μg C d^{-1})	Daily specific growth rate (d^{-1})	Mean specific growth rate (d^{-1}, ± S.D.)
NI	116	0.043	—	0.58	—	—	
NII	172	0.039	0.031	0.90	0.034	0.879	
NIII	221	0.070	0.038	0.90	0.042	0.601	
NIV	266	0.108	0.063	0.90	0.070	0.645	
NV	324	0.171	0.080	0.90	0.089	0.518	for nauplii
NVI	382	0.251	0.0	0.90	0.0	0.0	0.529±0.325
CI	400	0.251	0.240	0.90	0.266	1.058	
CII	496	0.491	0.345	0.90	0.382	0.777	
CIII	588	0.836	0.691	0.90	0.764	0.914	
CIVM	713	1.527	0.627	1.14	0.550	0.360	
CV M	796	2.154	1.541	1.56	0.990	0.460	
CVIM	946	3.695	—	—	—	—	
CIVF	713	1.527	1.127	1.35	0.835	0.547	
CV F	851	2.654	2.466	1.75	1.408	0.530	for copepodites
CVIF	1050	5.120	—	—	—	—	0.740±0.252

* Calculated from Fig. 6

** Calculated from Table 1

calculated growth rate increased as the stage progressed, i.e. the larger the size, the larger the growth increment per day. However, the daily specific growth rate varied depending on the developmental stage. The overall mean for nauplii (NII to NVI) was 0.529, but the growth was negligible in NVI, probably due to a larger energy expenditure for metamorphosis or a considerable error in calculation of weight of NVI and CI using different equations. The mean daily specific growth rate for copepodites (CI to CV) was 0.740, being higher than that for nauplii.

The daily specific growth rate (G) was calculated for animals at other temperatures and plotted in Fig. 7. It increased exponentially with the increase of temperature (T, °C), expressed as:

$$G=0.00257\ (T+2.0)^{1.72} \quad (r=0.998)$$

for nauplii, and

$$G=0.00128\ (T+2.0)^{2.03} \quad (r=0.998)$$

for copepodites.

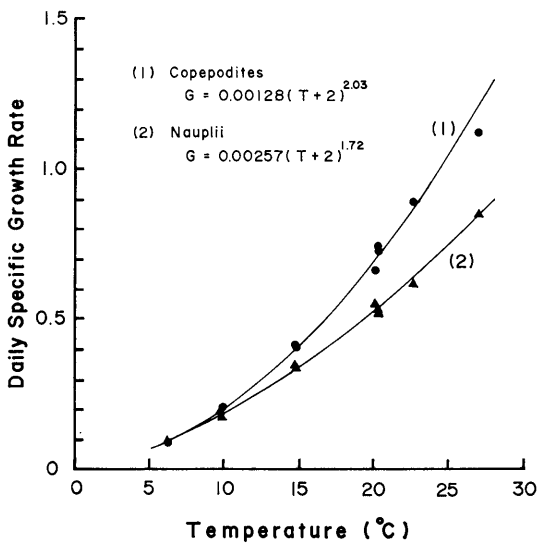


Fig. 7. Relationship between temperature and the mean daily specific growth rate in nauplii (triangles) and copepodites (circles) of *Sinocalanus tenellus*.

Effect of Salinity

1. *Egg Hatching*

The range of salinity in which eggs could hatch was between 2.5 and 35.0‰ (Fig. 8). Although hatching success was generally lower than that of the experiment to test the effect of temperature, it was higher than 50% within the range from 2.5 to 25.0‰. The time to hatching was shortest at 10‰ (1.4 d), while it was slightly prolonged at salinities above and

below this level.

2. *Larval Development*

The development time from egg-laying to CI and CVI at various salinities is shown in Fig. 9. The time from egg-laying to CVI was shortest at 15‰ (10.8 d) and slightly prolonged at other salinities. At salinities between 5 and 30‰, the larvae were able to develop to the adult stage and produce a second generation.

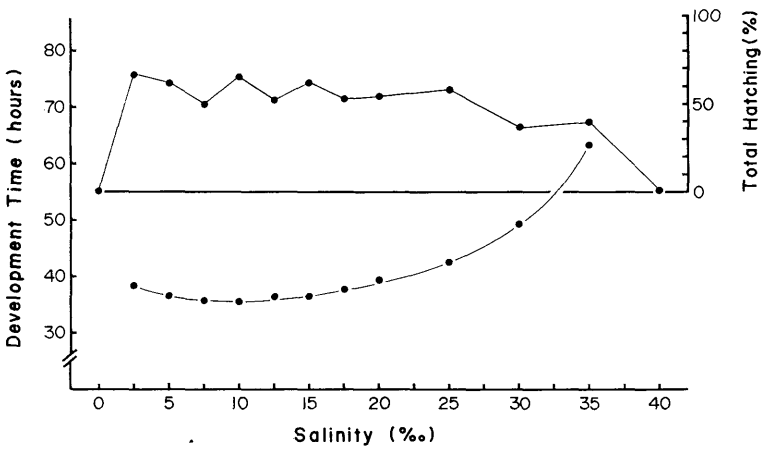


Fig. 8. Effect of salinity on the hatching success and development time of *Sinocalanus tenellus* at 20.2°C. The curve is drawn freehand.

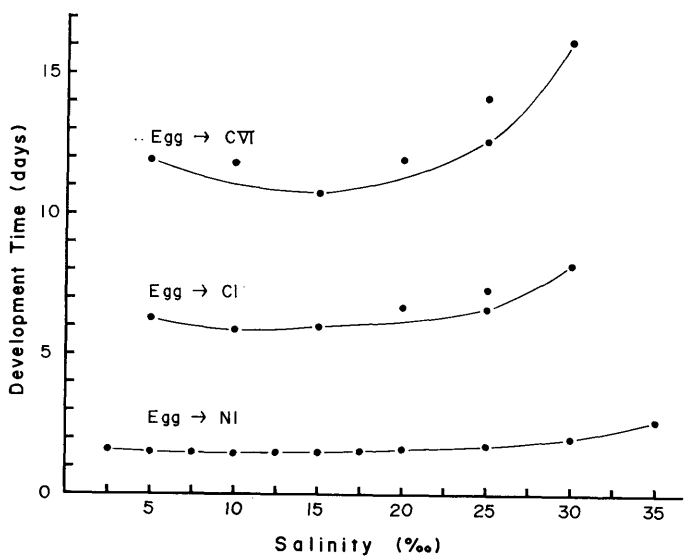


Fig. 9. Effect of salinity on the development time of *Sinocalanus tenellus* at 20.2°C from egg-laying to NI, CI and CVI. The curves are drawn freehand.

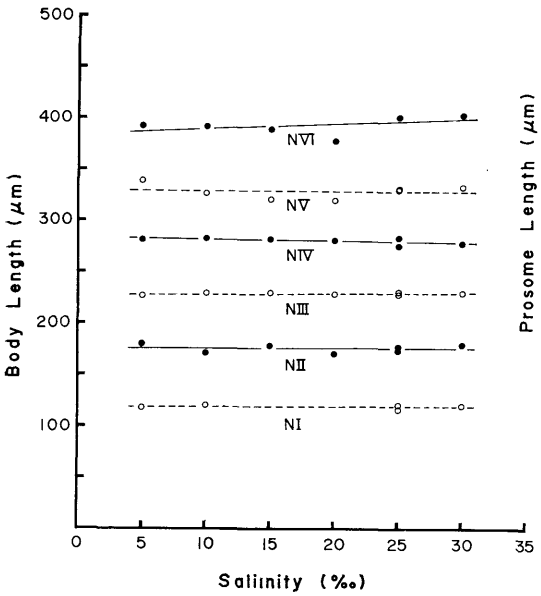


Fig. 10. Effect of salinity on the body length of *Sinocalanus tenellus* nauplii at 20.2°C. Each point is the mean body length at a given salinity.

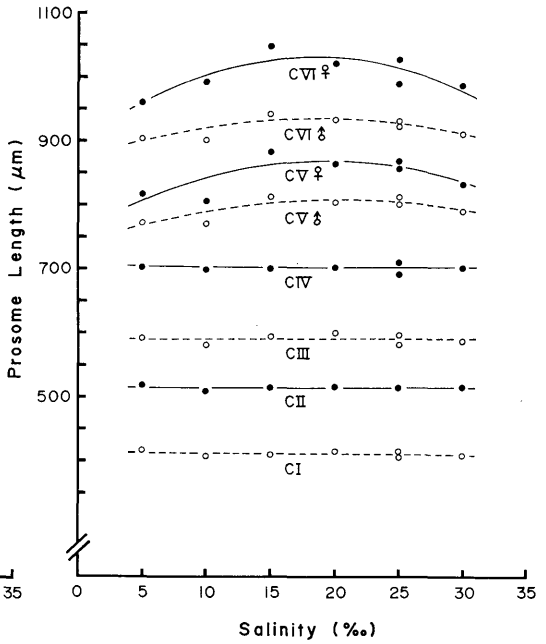


Fig. 11. Effect of salinity on the prosome length of *Sinocalanus tenellus* copepodites and adults at 20.2°C. Each point is the mean prosome length at a given salinity.

3. *Body Size*

The relationship between salinity and body size for nauplii and copepodites are shown in Figs. 10 and 11, respectively. Body size of each developmental stage from NI to CIV was almost similar over the salinity range tested. However, the difference in body size was apparent beyond CIV; mean prosome length of both CVI females (1,048 μm) and males (942 μm) was largest at 15‰ and slightly shorter at other salinities. The relationship between adult prosome length (L, μm) and salinity (S, ‰) was described by a quadratic equation:

$$L=-0.384\,(S-18.5)^2+1{,}030$$

for females, and

$$L=-0.185\,(S-19.1)^2+933$$

for males.

4. *Growth Rate*

The daily specific growth rate of each stage was also calculated for animals reared at each salinity. Mean specific growth rate was highest at 15‰ for both nauplii and copepodites (Fig. 12). Their growth rate (G) in relation to salinity (S, ‰) was described by:

$$G=-0.00080\,(S-14.1)^2+0.585$$

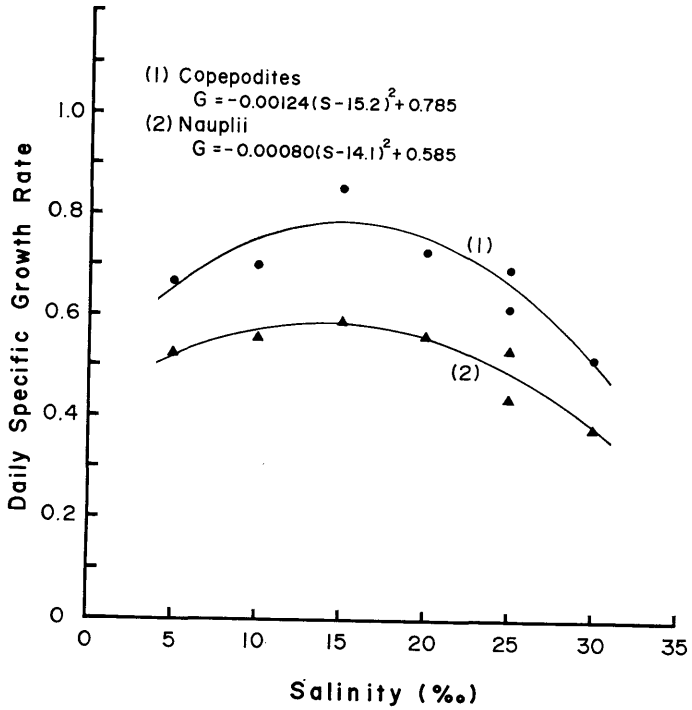


Fig. 12. Relationship between salinity and the mean daily specific growth rate in nauplii (triangles) and copepodites (circles) of *Sinocalanus tenellus* at 20.2°C.

for nauplii, and

$$G = -0.00124\,(S-15.2)^2+0.785$$

for copepodites.

Discussion

For the examination of the effect of temperature, salinity was fixed to 10‰, and when examining the effect of salinity, temperature was maintained at 20.2°C; in both experiments food was always in excess. Hence, the effect of temperature or salinity on the development and growth of *Sinocalanus tenellus* was isolated, whereas the effect of combinations of these two parameters was not investigated. Our results show that the effect of temperature is much more marked than that of salinity on the development and growth rates of *S. tenellus*.

Egg hatching and postembryonic development of *S. tenellus* were successful over a wide range of temperature (6.6-31.3°C and 6.2-27.1°C, respectively), and the development time increased exponentially with the decrease of temperature. CORKETT & MCLAREN (1970), LANDRY (1975) and UYE (1980a, b) examined the development time of eggs and larval stages of neritic calanoid copepods in relation to temperature, and demonstrated that under excess food, the time required to reach any stage was proportional to the time for the eggs to hatch at a given temperature. This has been called "equiproportional development" by

CORKETT (1984). The same growth rule was found in *S. tenellus*. This allowed us to calculate the development time to any stage or the duration of any stage at any temperature (Fig. 3B) from proper multiplications (Tables 1 and 2) of the egg development times throughout the copepod's temperature range. Upper and lower critical temperatures for the larval development of *S. tenellus* were not critically defined in the present study. In spite of the prolonged hatching time and reduced hatching success at 34.9°C (Fig. 1), a few individuals developed up to the adult at such a high temperature, indicating that ca. 35°C may be the upper limit for the embryonic and larval development of this species. Natural populations of *S. tenellus* almost disappear from the plankton at much lower temperatures (ca. 25°C) in the brackish-water pond in Fukuyama (HADA et al. 1986), where the present specimens were collected.

To our knowledge, *Acartia tonsa* has the fastest development rate among planktonic copepods. HEINLE (1966) reported that *A. tonsa* required the time from egg to egg of 7, 9 and 13 d at 25.5, 22.4 and 15.5°C, respectively. Because of a time lag from molting into CVI before starting egg production, the time from egg to adult is slightly shorter than those given above. The development time of *S. tenellus* may be one of the shortest; it took 7.5 d from egg-laying to adult at 27.1°C. However, at lower temperatures, the development time of this species was moderate. At 15°C, it took 21 d, the same time (19–21 d) as reported by LANDRY (1983) for ecologically dominant copepod species. The molting pattern of *S. tenellus* was nearly isochronal, as found by MILLER et al. (1977) for *Acartia* spp., but NI was shorter and CIV and CV were longer than the other stages. It was often observed that the first feeding stage took longer than the other stages (UYE 1980b, LANDRY 1983), but the duration of the first feeding stage (NII) of this species was not significantly longer.

The specific growth rate in each developmental stage is the product of a relative increase of body weight and a duration within the stage. A temperature increment made the former parameter smaller (Figs. 4 and 5), but the latter parameter shorter (Fig. 3B). The resultant specific growth rate increased exponentially with the increase of temperature (Fig. 7). At 27.1°C, the mean specific growth rate was 1.12 d^{-1} and 0.85 d^{-1} for copepodites and nauplii, respectively. The fitted equation of Fig. 7 indicates that the specific growth rate of *S. tenellus* copepodites is higher than 1.0 d^{-1} at temperatures higher than 25°C. A similar relationship between the specific growth rate and temperature was found in *A. tonsa* (HEINLE 1969, fig. 10), but the highest rate read from the figure was ca. 0.85 d^{-1} at 30°C. Specific growth rates higher than 1.0 d^{-1} were only reported by DURBIN & DURBIN (1981, table 6) for natural population of *A. tonsa* in Narragansett Bay, U.S.A.; the highest value was 1.28 d^{-1} at 22.9°C.

As observed for several species of *Acartia* (UYE 1980a, UYE & FLEMINGER 1976), the eggs of *S. tenellus* could hatch over a wide salinity range (2.5–35.0‰). The most conspicuous thing is that the postembryonic development of this species was also successful over a wide salinity range (5–30.0‰). This may indicate *S. tenellus* has a greater degree of osmoregulation as reported by BRAND & BAYLY (1971) for some Australian brackish-water copepod species. The salinity effect on body size of *S. tenellus* was negligible in younger stages,

whereas beyond CIV, the size became smaller at lower and higher salinities than 15‰ (Fig. 11). A similar effect of salinity on body length was reported by KATONA (1970) for *Eurytemora herdmani*. At 14°C, female *E. herdmani* showed a linear size increase with decreasing salinity from 33‰ to 15‰, but the salinity effect was not investigated at salinities lower than 15‰. The rates of embryonic and postembryonic development of *S. tenellus* was reduced at lower and higher salinities, but the influence was more marked at salinities higher than 20‰ (Figs. 8 and 9). As a consequence, the specific growth rate was highest at 15‰, and was reduced at lower and higher levels (Fig. 12), indicating that *S. tenellus* may be best adapted to salinities around 15‰. Unsuitable salinities may cause some physiological stress or energy loss due to osmoregulation or respiration, which results in a suppression of growth rate. In a backish-water pond in Fukuyama, where a very dense population of *S. tenellus* was seen, the average salinity of the pond water was 12.6‰ (HADA et al. 1986). In our study, the effect of salinity was investigated only at one temperature (20.2°C). Since the influence of salinity on the physiology of copepods is often dependent on temperature (LANCE 1963, 1964), it is necessary to investigate the effects of temperature-salinity combinations for understanding this situation in more detail.

From the results of the present investigation, it is concluded that *S. tenellus* is a eurythermal and euryhaline copepod, and is more adapted to a mixomesohaline (salinity: 5–18‰, according to the Venice System, cf. SMAYDA 1983) environment. The growth potential of this species is one of the largest among planktonic copepods. This is advantageous for a quick establishment of its population in the variable environments of estuaries and brackish-water ponds. Considering these highly advantageous biological characteristics, *S. tenellus* can be listed as one of the more promising copepod species for future mass cultivation as food for larval fishes, as already mentioned by OMORI (1973).

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