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DEVELOPMENT, GROWTH, AND SURVIVAL IN THE JUVENILE CARIBBEAN KING CRAB *MITHRAX SPINOSISSIMUS* (LAMARCK) REARED IN THE LABORATORY

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ABSTRACT

Two comparative growth studies were performed on spawns from the Caribbean king crab *Mithrax spinosissimus* (Lamarck). These studies lasted for 181 and 142 days, respectively. Crabs that exhibited long intermolt periods and a low increase in carapace length at molt during early development, because of a low water temperature and/or early lack of food, later caught up in both respects, compared to individuals raised under more favorable conditions during early development. The growth rate (carapace length) at molt (crab stages 3–12) varied between approximately 22 and 40%, and the corresponding mean weight (live wet weight) increase varied between approximately 90 and 135% (stages 7–12). Pronounced allometric growth was recorded concerning the two parameters of carapace length and width. The carapace of young crabs was considerably longer than wide, while the L/W ratio for adults was close to 1. The abdominal length and width measurements indicated that it should be possible, by visual observations, to distinguish between the sexes at a carapace length of approximately 12–15 mm, i.e., in this study, at crab stage 10 or 11, or at an age of approximately 120–140 days. In early stages prolonged intermolt periods led to a proportionally lower increase in carapace length at molt. A positive relationship was recorded between a low increase in carapace length at molt and a high mortality rate. The length of the intermolt period had, however, no significant effect on the mortality rate.

The Caribbean king crab *Mithrax spinosissimus* is one of the largest crabs inhabiting coral reefs and rocky outcrops of the western Atlantic Ocean. It is found in shallow water to a depth of approximately 180 m, and the known range is from the Carolinas to the Bahamas, the Florida Keys, Nicaragua, and through the West Indies to Barbados and Venezuela (Rathbun, 1925; Williams, 1984). In the Florida Keys it is common nearshore in canals where it remains in hiding during the day, but ventures several meters from its ledge at night to browse on benthic algae and associated epifauna (Bohnsack, 1976). The sexes are dimorphic. The males reach a greater size, and their chelipeds attain massive proportions compared to those of the females. Due to its large size, nonaggressive behavior, omnivorous feeding, and market acceptability, this species has in recent years stimulated several research programs in the region (Adey, 1985, unpublished; Bernard and Bernard, 1985, unpublished; Creswell and Tunberg, in press; Creswell *et al.*, 1989). Brownell *et al.* (1977) first reported the potential for the mariculture of *M. spinosissimus*. Yet little is known about the biology of this species, particularly the growth, development, and behavior, which is critical information for its commercial culture. The aim of this study was primarily to determine molting frequency, growth, and survival in early crab stages. The development and mortality during the first 30 days of the life cycle have, however, been described in an earlier paper (Tunberg and Creswell, 1988).

MATERIALS AND METHODS

The treatment and hatchery design have been thoroughly presented in earlier papers (Tunberg and Creswell, 1988; Creswell and Tunberg, in press).

The berried females of *Mithrax spinosissimus* were collected by divers in the Florida Keys on 9 August (GS1) and 8 October 1986 (GS3). Another growth study (GS2) covering only the first 30 days of the life cycle has, together with GS1 and GS3, been presented in Tunberg and Creswell (1988). The experiments were carried out at the Indian River Marine Science Research Center (IRMSRC) in Vero Beach, Florida. Hatches of swimming zoeae for the studies were obtained on 2 September and 11 October. The experiments were performed on large, shallow water-tables (equipped with drain stand pipes) each supplied with approximately 8 l min^{-1} filtered sea water (30 μm nominal filtration).

Growth Study 1 (GS1).—All swimming zoeae were siphoned into a 300-mm diameter screen (with a constant supply of sea water) placed on a water table. Ten days after hatching, 42 randomly selected crabs were transferred to 106-mm diameter screens, with 8 stage

Table 1. *Mithrax spinosissimus.* Water temperature (°C) (15-day intervals) during experiments GS1 and GS3. dah = days after hatching, N = number of observations, SD = standard deviation. A one-way ANOVA was used to compare the temperatures of the two studies. *** = $P < 0.001$. ** = $P < 0.01$. * = $P < 0.05$. NS = $P > 0.05$.

Period (dah)	N	GS1		GS3		Significance level
		Mean	SD	Mean	SD	
1–15	12	28.0	0.5	26.4	1.8	**
16–30	13	28.3	0.6	26.8	0.3	***
31–45	12	28.6	0.7	26.5	0.4	***
46–60	10	26.0	0.8	24.9	1.2	*
61–75	13	26.8	0.3	25.3	1.2	***
76–90	12	26.3	0.3	24.0	1.0	***
91–105	13	24.5	0.8	24.8	0.6	NS
106–120	8	24.8	1.5	24.8	0.6	NS
121–135	9	24.7	0.5	25.9	1.3	*
136–142	3	25.4	0.2	26.9	0.6	***
121–142	12	24.9	0.5	26.2	1.2	**
1–142	105	26.5	1.6	25.6	1.4	***

1 crabs on each of 4 screens and 10 stage 2 crabs on 1 screen. All screens were suspended on a water table, with no water supplied to individual screens. On 12 October (39 days after hatching) the number of screens was doubled (10), with 3 crabs on 2 screens and 4 on the others. On 17 October (44 days after hatching) the number of screens was doubled again (to 20), with a maximum of 2 crabs on each screen. On 14 November (73 days after hatching), the 32 survivors were placed on individual screens. The GS1 individuals were fed filamentous diatoms during the first 10 days; thereafter the diet was supplemented with small pieces of macroalgae (*Enteromorpha* spp., *Gracilaria* spp., and *Ulva* sp.). *Thalassia testudinum* and fish pellets (see below) were later added to the diet. This experiment was terminated 181 days after hatching.

Growth Study 3 (GS3).—The swimming zoeae were transferred to twenty 106-mm diameter screens, with a maximum density of 60 individuals per screen. Each screen was supplied with a constant flow of sea water through 4.5-mm diameter aquarium tubing. Sixteen days after hatching 60 crabs were transferred to individual screens (51-mm diameter) suspended on a water table. These screens did not have a separate water supply. On 17 December (67 days after hatching) the 23 survivors were placed on larger screens (106-mm diameter). The GS3 individuals were not fed until the seventh day after hatching. They were thereafter given the same type of food as the individuals in GS1. This experiment was terminated 142 days after hatching.

Separate water supply to all experimental screens was installed on 23 January, i.e., 143 days after hatching for GS1 and 104 days after hatching for GS3. Feeding all crabs in both experiments with fish pellets, in addition to algal food, was started on 6 January 1987.

Crab exuviae were removed daily, preserved in 70% ethanol, and later measured with a stereomicroscope equipped with an ocular micrometer. Carapace length (CL) was measured from the anterior margin (between the rostral spines) to the posterior margin of the carapace, and carapace width (CW) was measured over the widest portion of the carapace. The abdominal length measurement comprised the distance from the tip of the telson to the division line between the fifth and sixth somite. The width was measured at this division line.

Results

Temperature.—The mean water temperatures of 15-day intervals during the two studies are presented in Table 1. As shown in Table 1, there were significant temperature differences between the two studies, except for days 91–105 and 106–120; the temperature during days 1–90 was significantly higher in GS1, while it was significantly higher in GS3 during days 121–142. For the whole study period, the temperature was significantly higher ($P < 0.001$) in GS1.

Intermolt Period.—The intermolt periods (stage duration) of crab stages 3–12 are presented in Fig. 1. In GS1 individual stage duration was not recorded up to stage 6. Only the number of crabs that reached the respective stage at each date (days after hatching) was recorded. The stage duration for stages 3–6 in GS1 were therefore calculated from the differences between the mean total number of days to reach each stage (days after hatching) (Table 2), and therefore do not include standard deviations. The intermolt periods were longer in GS3 than in GS1 during early development, but shorter after stage 4. As shown in Table 2, the total number of days (days after hatching) to reach the different stages was lower in GS1 up to stage 9. The duration up to stage 10 was similar in both studies, but stage 11 was, however, reached somewhat faster in GS3 than in GS1. A one-way

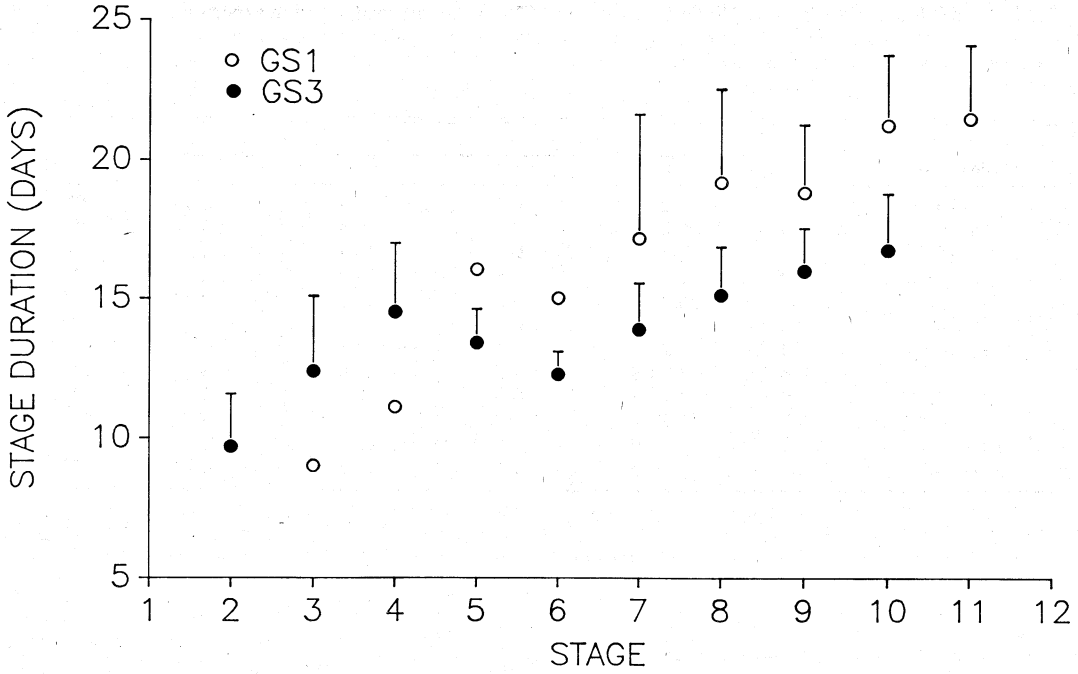

Fig. 1. Intermolt periods (stage duration) of the different crab stages of *Mithrax spinosissimus*; mean number of days, + standard deviation, to reach each stage. Stages 3–6 in GS1 were calculated differently, and do not include standard deviation values (see text).

ANOVA confirmed that the total number of days (days after hatching) to reach each stage (3–11) was significantly different ($P < 0.001$) between the two studies, except for stages 10 and 11 ($P > 0.05$).

Length at Stage.—Table 3 shows the mean carapace length of the different crab stages. When comparing the carapace lengths of the different stages (4–11) between the two growth studies (one-way ANOVA), significant differences were recorded for stages 4–7 (larger in GS1) and stage 11 (larger in GS3). The percentage increase in carapace length at molt is presented in Table 4. The percentage values in parentheses were calculated from the difference in the mean length of each stage, not as the mean percentage growth for all individuals, as was the case with the other calculations. In GS3

Table 2. Time to reach the respective crab stages (days after hatching) of *Mithrax spinosissimus*. N = number of observations, SD = standard deviation. A one-way ANOVA was used to compare the results of the two studies. *** = $P < 0.001$. NS = $P > 0.05$.

Stage	GS1			GS3			Significance level
	N	Mean	SD	*N*	Mean	SD	
2	—	—	—	29	21.9	2.7	—
3	41	18.6	1.9	44	31.2	3.1	***
4	39	27.6	2.2	36	43.0	4.1	***
5	35	38.8	4.5	27	57.3	4.8	***
6	33	54.8	5.9	23	70.0	4.2	***
7	31	69.8	5.2	23	82.2	4.2	***
8	26	88.2	7.1	23	96.8	3.8	***
9	20	106.9	6.0	23	111.4	5.9	***
10	18	126.5	8.1	23	127.1	6.7	NS
11	17	144.7	14.6	8	138.3	4.9	NS
12	15	165.4	11.3	—	—	—	—

Table 3. Carapace length (CL, mm) of the different crab stages of *Mithrax spinosissimus*. N = number of observations, SD = standard deviation. A one-way ANOVA was used to compare the results of the two studies. * = $P < 0.05$, *** = $P < 0.001$. NS = $P > 0.05$.

Stage	GS1			GS3			Significance level
	N	Mean	SD	N	Mean	SD	
4	36	3.22	0.18	35	2.71	0.20	***
5	34	4.02	0.30	27	3.38	0.30	***
6	32	4.99	0.45	23	4.11	0.38	***
7	29	6.13	0.57	23	5.35	0.50	***
8	21	7.55	0.83	23	7.09	0.80	NS
9	19	9.70	1.27	22	9.23	1.25	NS
10	18	12.66	1.77	23	12.99	1.86	NS
11	17	16.35	2.45	8	19.19	3.06	*
12	15	22.53	3.40	–	–	–	–
13	2	27.45	0.07	–	–	–	–

no significant difference ($P > 0.05$) in carapace length was found in a comparison between sexes (stages 1–11). The same analysis for GS1 (stages 7–12) showed, however, that the females were significantly larger in stage 8 ($P < 0.05$), 9 ($P < 0.01$), and 10 ($P < 0.05$).

Length at Age.—The length-age relationship was calculated by combining the results from GS1 and GS3 (Fig. 2). Ten points were available for GS1 (stages 3–12) and GS3 (stages 2–11). The best curve fit was accomplished by using an exponential curve:

$$Y = 1.6247e^{0.0163X} \qquad (r = 0.9736)$$

Length–Width.—The carapace length–width relationship of the stages is presented in Fig. 3. The L/W ratio declines with successive molts. Young crabs are considerably longer than wide, while this ratio decreases at later stages. The straight line in Fig. 3 reads:

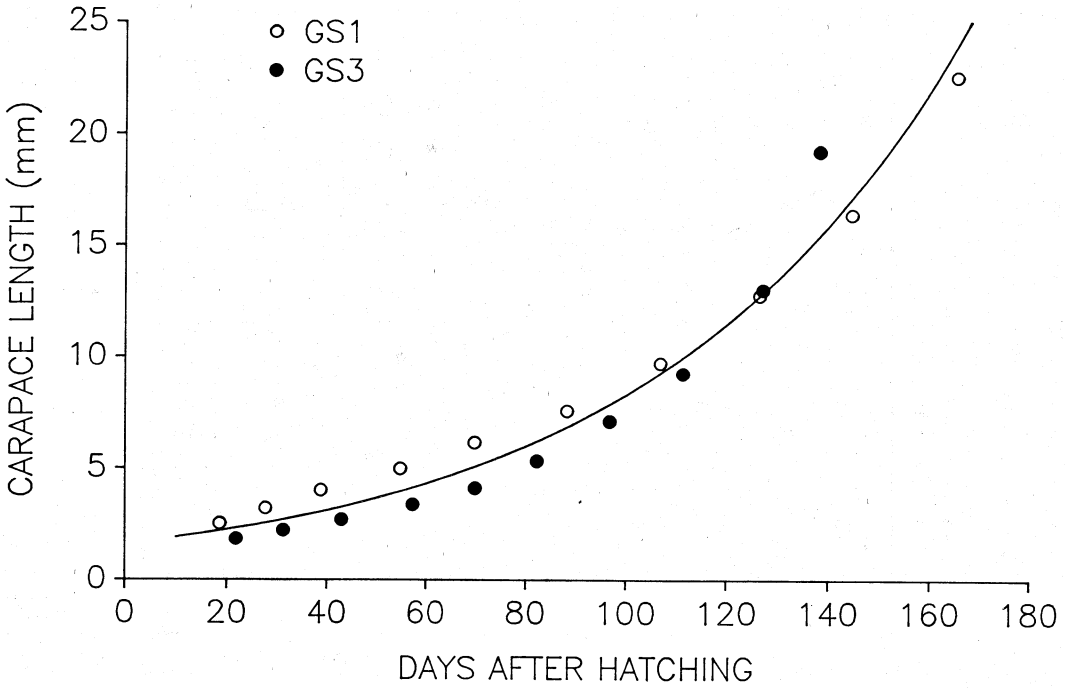

Fig. 2. Growth (carapace length) of young specimens of *Mithrax spinosissimus*. The points represent the mean CL at each stage (Y-value) and the mean number of days to reach each stage (X-value). The corresponding curve was calculated from these values.

Table 4. Percentage increase in carapace length (CL) at molt of the different crab stages of *Mithrax spinosissimus*. N = number of observations, SD = standard deviation. The figures in parentheses were calculated differently (see text).

	GS1			GS3		
Stage	N	Mean	SD	N	Mean	SD
1, 2	—	(30.31)	—	36	21.34	4.36
2, 3	—	(26.27)	—	42	21.59	5.38
3, 4	—	(27.13)	—	34	21.55	5.74
4, 5	—	(24.94)	—	27	22.46	3.88
5, 6	—	(23.80)	—	23	22.83	4.42
6, 7	—	(23.30)	—	22	29.28	3.63
7, 8	21	23.45	5.36	23	33.16	4.96
8, 9	18	28.54	5.40	22	30.75	4.84
9, 10	18	30.16	5.18	22	39.31	4.32
10, 11	17	29.67	4.58	8	37.69	2.61
11, 12	15	36.59	3.66	—	—	—

$$Y = 1.4495 - 2.6284 \times 10^{-2}X$$
$$(r = 0.9684),$$

where X equals stage number and Y equals the L/W ratio.

Weight at Stage.—Weight measurements (live wet weight) were taken on 6 occasions between 9 December 1986 and 2 March 1987 in GS1 and on one occasion (2 March) in GS3. The weights of the different stages are presented in Table 5. A one-way ANOVA showed that there was a significant weight difference between GS1 and GS3 stage 10 crabs ($P < 0.01$), but not in the stage 11 crabs ($P > 0.05$). No significant weight difference ($P > 0.05$) was found between sexes in the different stages of GS1. In GS3, however, stage 10 females were significantly ($P < 0.01$) heavier than the males.

Table 5. Total body weight (g wet weight) of the different crab stages of *Mithrax spinosissimus*. N = number of observations, SD = standard deviation.

	GS1			GS3		
Stage	N	Mean	SD	N	Mean	SD
7	2	0.13	0.05	—	—	—
8	28	0.25	0.08	—	—	—
9	20	0.48	0.18	—	—	—
10	11	1.12	0.40	16	0.77	0.23
11	13	2.30	1.07	7	2.83	1.06
12	14	4.81	2.26	—	—	—
13	2	8.65	0.14	—	—	—

Weight at Age.—The weight-age relationship is presented in Fig. 4. The corresponding power curve reads:

$$Y = 3.3121 \times 10^{-11}X^{4.9429}$$
$$(r = 0.9967),$$

where Y equals live wet weight in g and X equals number of days after hatching. The

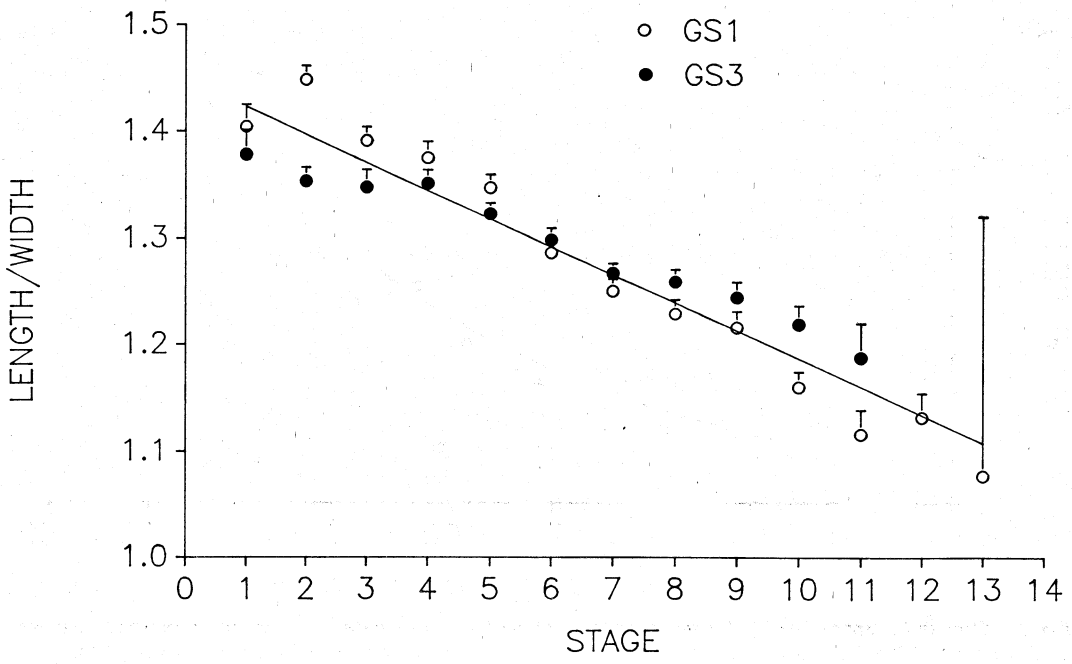

Fig. 3. Carapace length–width relationship, + standard deviation, at each crab stage of *Mithrax spinosissimus*.

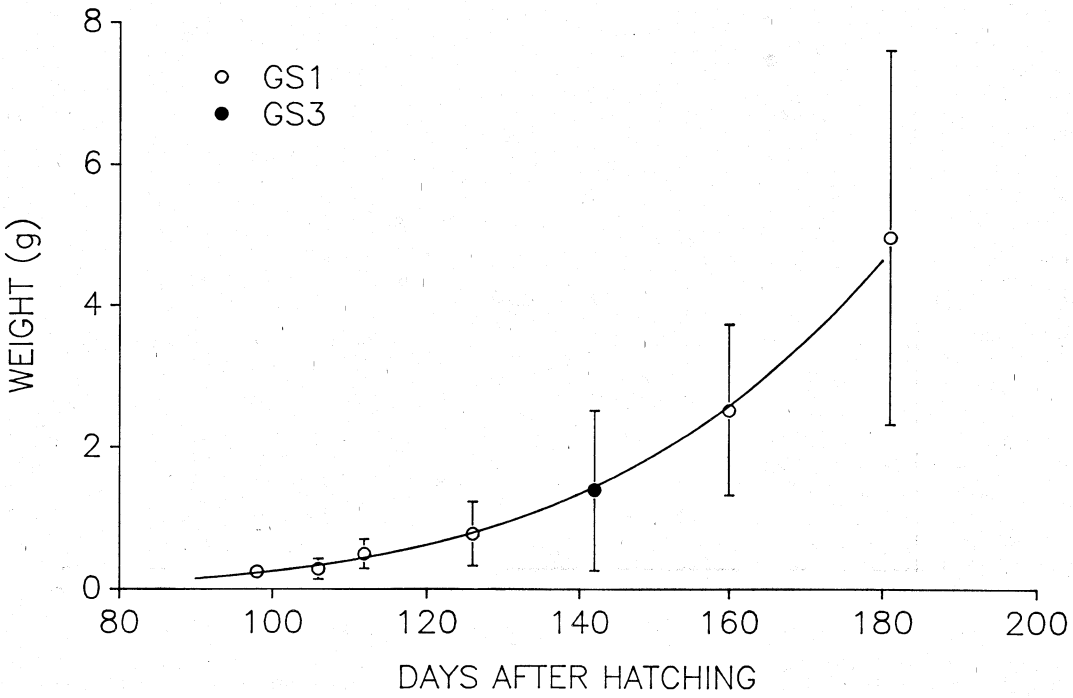

Fig. 4. Live wet weight in relation to age (days after hatching) in *Mithrax spinosissimus*. The points represent mean values at a certain date ± standard deviations.

curve was calculated from the mean values at each date (Fig. 4).

Length–Weight.—Due to the relatively short periods between weight measurements in GS1, many stages were measured more than once. When the length (X)–weight (Y) relationship was calculated, each stage was, however, included only once. All GS3 crabs weighed on 2 March were also included (Fig. 5). A linear relationship was found for log-transformed values:

$$\log Y = 2.6725 \log X - 2.9661 \quad (r = 0.9861)$$

A one-way ANOCOV on transformed data showed, however, that there was a significant difference ($P < 0.01$) between GS1 and GS3 in this respect. The calculated linear relationships read:

$$\text{GS1: } \log Y = 2.7283 \log X - 3.0012 \quad (r = 0.9908)$$

$$\text{GS3: } \log Y = 2.7596 \log X - 3.1576 \quad (r = 0.9925)$$

A comparison, one-way ANOCOV, was also done between the sexes in GS1 (log-transformed values) but no significant difference ($P > 0.05$) was found in this respect.

Intermolt Period–Molt Increment (CL).—A correlation analysis (Pearson R) was performed for the different stages (GS1: 8–12, GS3: 3–11) to elucidate any correlation between how many days a crab stayed at a certain stage (intermolt period) and the following percentage CL increase at molt (molt increment). No significant correlation was found in GS1 (stages 8–12) in this respect ($P > 0.05$). There were, however, significant negative correlations between these parameters in GS3 for stages 3–6 ($P < 0.01$ in stages 3–5 and $P < 0.05$ in stage 6) and in stage 8 ($P < 0.01$), but not in stages 7 and 9–11 ($P > 0.05$).

Temperature–Size (CL) and Intermolt Period.—In order to elucidate the effect of temperature on size (CL) and intermolt periods for the crabs in GS1 and GS3, the difference between the two studies concerning these parameters was plotted (Fig. 6). In spite of higher water temperature in GS1 up to stage 8, the GS3 crabs exhibited a greater molt increment (CL) from stage 7 and shorter intermolt periods from stage 5.

Onset of Sexual Dimorphism.—At the termination of growth experiments, an at-

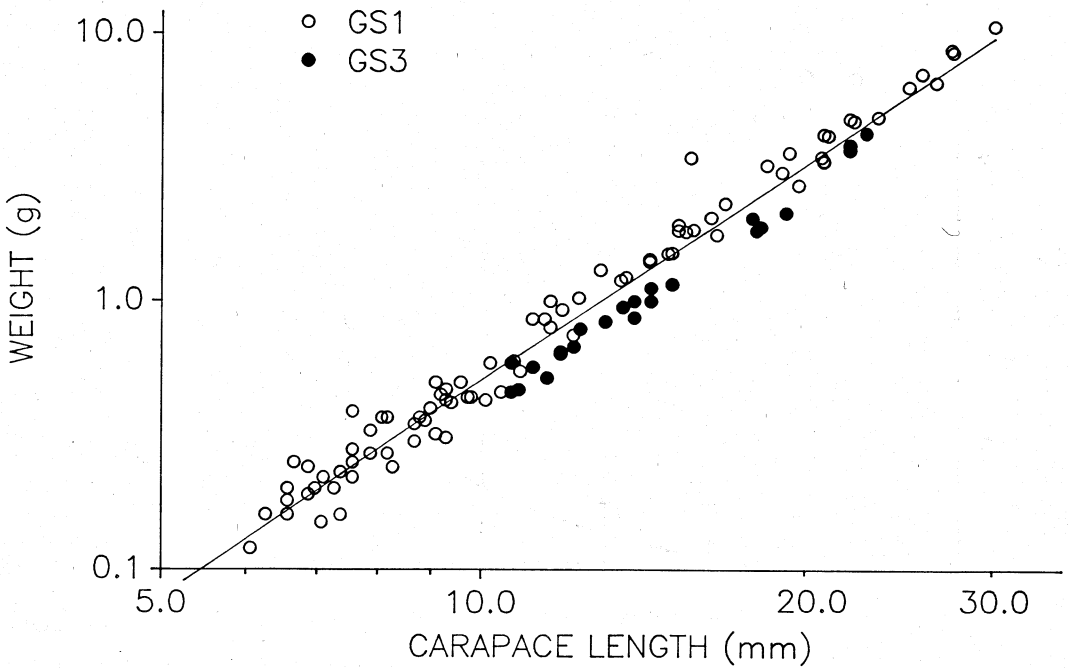

Fig. 5. Carapace length–live wet weight relationship in *Mithrax spinosissimus* presented on a log/log scale.

tempt was made to determine the sex by the shape of the abdomen on GS1 crabs (visual observation) before checking the pleopods. GS1 consisted of three stage 11 crabs, 14 stage 12 crabs, and one stage 13 crab (plus two where the stage was unknown). All these crabs were easily and successfully sexed by the shape of the abdomen. Abdominal length and width measurements were taken on crabs and molts from GS1 and GS3, and on four other crabs of unknown stage. These L/W ratios (Y) were plotted against CLs (X) (Fig. 7). The resulting linear relationships read:

$$\text{females: } Y = 1.4008 - 1.4825 \times 10^{-2}X \quad (r = 0.8528)$$

$$\text{males: } Y = 1.3909 + 9.5294 \times 10^{-3}X \quad (r = 0.5455)$$

The abdominal L/W ratio for each stage is presented in Table 6. These ratios were calculated by combining abdominal L/W measurements from the GS1 and GS3 crabs. One-way ANOVAs showed that there were no significant differences ($P > 0.05$) between GS1 and GS3 in this respect, except for stage 11 females ($P < 0.05$) and stage 10 males ($P < 0.001$), i.e., in GS1 stage 11 females and stage 10 males had a higher abdominal L/W ratio than those in GS3. Significant differences ($P < 0.001$) were found between sexes in all stages that were investigated (7–12).

Survival.—The survival rate during the two studies is presented in Fig. 8. As shown, survival was lower in GS3 during the first 67 days. No GS3 individuals died after that, and 16 specimens (26.7%) of the original 60 survived the whole study period of 142 days. Survival was higher in GS1 in the beginning, but mortality continued for a longer period and 19 individuals (45.2%) of the original 42 survived the whole study period of 181 days.

Reasons for Mortality.—Twenty crabs from GS3 that died between stages 2 and 5 were used for this study. A correlation analysis (Pearson R) was used to elucidate possible relationships between five parameters: (1) Deviation from mean percentage molt increment (CL) to last stage, (2) Days after molt when mortality occurred, (3) Difference between the mean number of days (days after hatching) when next molt occurred for the stage and the mortality date of the crab, (4) Deviation in number of days after molt when the crab died from the mean intermolt period of the stage, (5) Percentage deviation

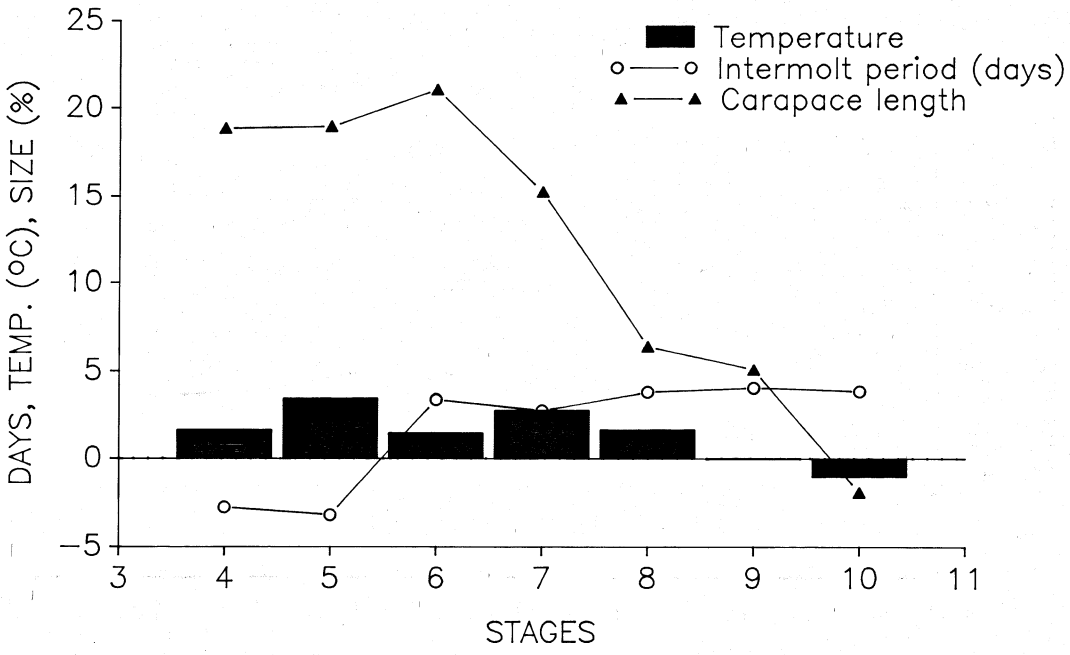

Fig. 6. Difference between GS1 and GS3 of *Mithrax spinosissimus* concerning three variables. Temperature: difference in mean temperature during the respective stage period (positive values = GS1 temperature higher). Intermolt period (days): difference in mean stage duration (positive values = GS1 periods longer). Carapace length (size): percentage difference in mean size at each stage (positive values = GS1 larger).

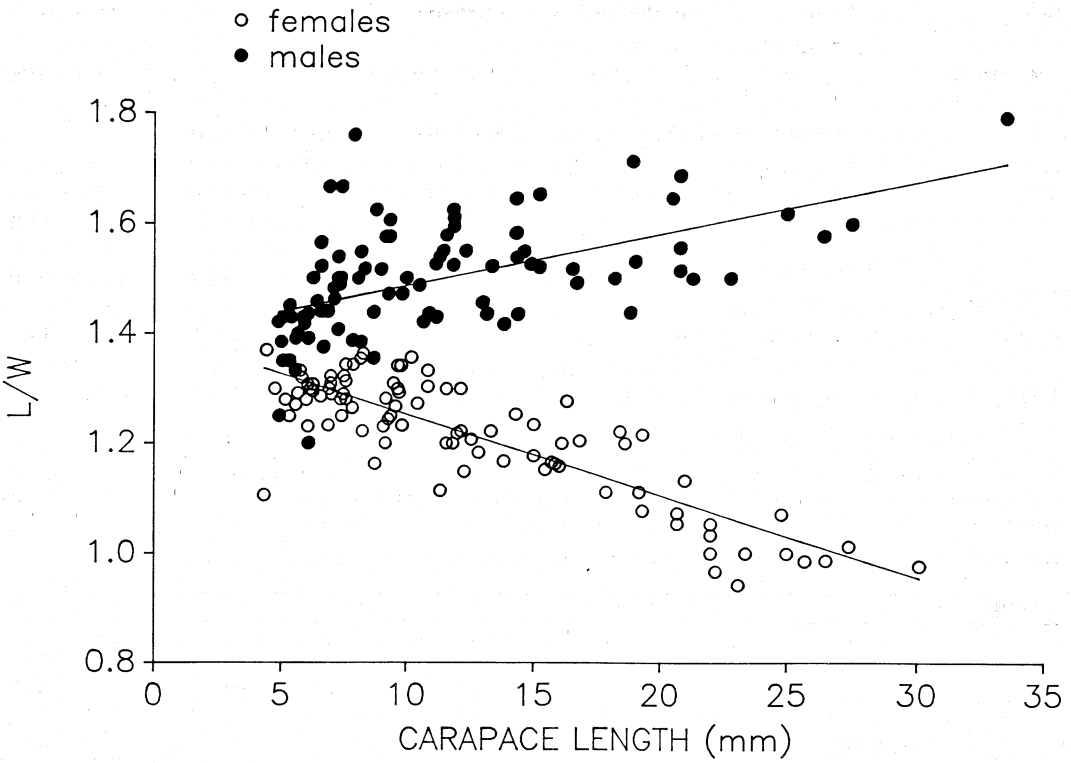

Fig. 7. Abdominal length–width ratios in *Mithrax spinosissimus*. The linear relationships for each sex are presented in the text.

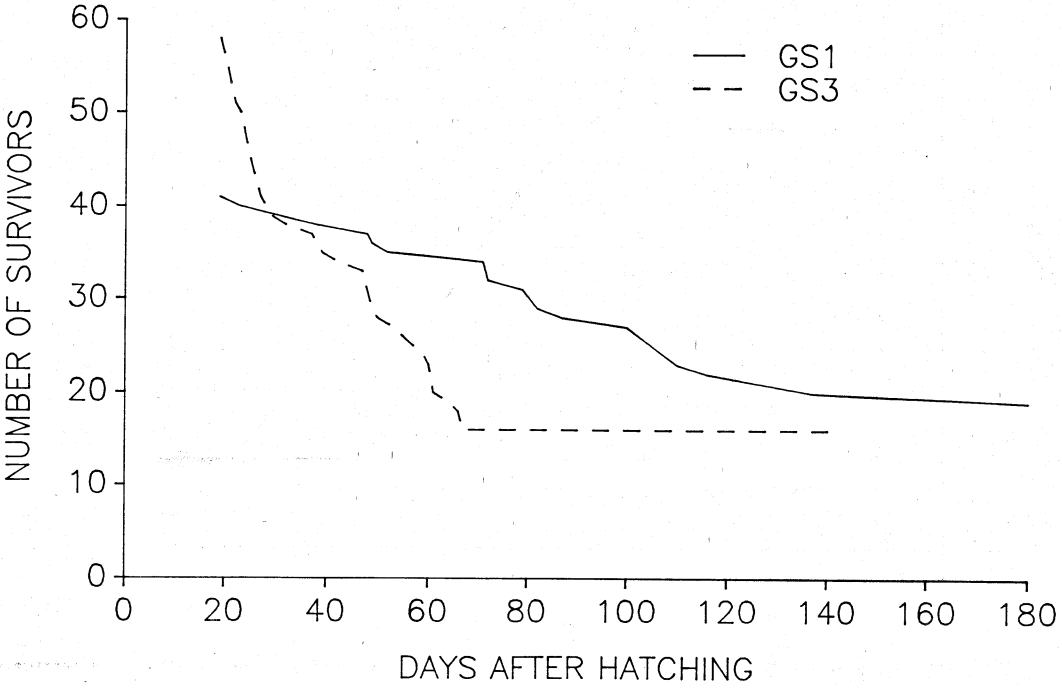

Fig. 8. Survival of *Mithrax spinosissimus* during the two growth study periods of 181 days (GS1) and 142 days (GS3).

in CL of the crab that died from the mean CL of the stage (Table 7). All comparisons are made to data from all individuals in GS3. Significant positive relationships ($P < 0.01$) were found between the following parameters: 1–2, 1–4, 2–5, and 4–5 (Table 7b). The basic statistics for these five variables are presented in Table 7A.

Discussion

As discussed in Tunberg and Creswell (1988), molting frequency is dependent upon temperature (Allen, 1972; Christiansen, 1973; Anger, 1984; Dawirs, 1985), diet, substrate, and water circulation (Roberts, 1972; Brick, 1974). We concluded that the lower temperature, and possibly also the early lack of food in GS3, compared to the two other growth studies (GS1 and GS2), had a negative effect not only on stage duration, but also on the size of crab stages 1–3 (Tunberg and Creswell, 1988). As shown in Fig. 1, the intermolt periods were longer in GS3 than in GS1 up to stage 4, and the GS1 crabs were significantly larger (CL) than those in GS3 up to stage 7 (Table 3). The GS3 crabs caught up rapidly in both respects in later stages and the GS3 stage 11 crabs

Table 6. Abdominal shape (L/W ratio), GS1 and GS3 of *Mithrax spinosissimus* combined. N = number of crabs measured, SD = standard deviation. A one-way ANOVA was used to compare the L/W ratios of the separate sexes. *** = $P < 0.001$. Data in parentheses are based on two observations only.

Stage	Females			Males			Significance level
	N	Mean	SD	N	Mean	SD	
7	19	1.30	0.06	19	1.40	0.06	***
8	20	1.29	0.05	20	1.48	0.12	***
9	17	1.26	0.07	16	1.50	0.07	***
10	18	1.22	0.06	19	1.51	0.07	***
11	14	1.15	0.09	8	1.56	0.06	***
12	9	1.01	0.04	7	1.57	0.06	***
13	—	—	—	(2	1.52	0.12)	—

Table 7. Mortality analysis in *Mithrax spinosissimus*. A, Basic statistics for 5 variables on 20 crabs from GS3 that died between stages 2 and 5; 1 = Deviation from mean percentage molt increment (CL) to last stage, 2 = Days after molt when mortality occurred, 3 = Difference between the mean number of days (days after hatching) when next molt occurred for the stage and the mortality date of the crab, 4 = Deviation in number of days after molt when the crab died from the mean intermolt period of the respective stage, 5 = Percentage deviation in CL of the crab that died from the mean CL of the stage. The comparisons are made to data from all individuals in GS3. SD = standard deviation, SE = standard error. B, Comparison (Pearson R correlation analysis) between the five variables presented above. ** = $P < 0.01$, NS = $P > 0.05$.

A				B		
Variable	Mean	SD	SE	Variable	Correlation	Significance level
1 (Percentage)	−3.46	6.62	1.48	1 versus 2	0.60	**
2 (Days)	11.25	7.64	1.71	1 versus 3	0.39	NS
3 (Days)	0.80	5.88	1.32	1 versus 4	0.61	**
4 (Days)	−2.06	7.86	1.76	2 versus 5	0.58	**
5 (Percentage)	−2.34	6.41	1.43	4 versus 5	0.57	**

were actually larger than those in GS1 (Table 3). This occurred even though the temperature was higher in GS1 up to stage 8 (Fig. 6). As shown in Fig. 6, the GS3 crabs caught up rapidly in size after stage 6. The same was observed concerning intermolt periods, which were shorter in GS3 from stage 5. Since the fish pellets were added to the diet on the same date in both experiments (6 January), GS1 crabs were given pellets after they reached stage 10 and GS3 crabs after they reached stage 7. As shown in Fig. 6, however, the intermolt periods were shorter and the carapace length increase at molt larger (percentage) in the GS3 crabs compared to GS1 crabs also before fish pellets were added. The diet can therefore not explain these differences in growth rate. This faster growth and molting rate in GS3 crabs can probably be explained as a "catching up" phenomenon because of a slower growth rate in the beginning of the life cycle. It is noteworthy, however, that the GS1 crabs were proportionally heavier than GS3 crabs (Fig. 5). This indicates that the "catching up" in CL among the GS3 crabs did not automatically lead to the same proportional increase in weight.

It is remarkable that the GS1 females, stages 8–10, were significantly larger (CL) than the males, especially since the adult males are considerably larger than the females. It is also noteworthy in this context that the GS3 stage 10 females were significantly heavier than the males of the same stage.

A considerably higher growth rate than the one presented in Fig. 2 has been reported from other studies on *M. spinosissimus* (e.g., Idyll and Caperon, 1986, unpublished; Porter *et al.*, 1986, unpublished). These latter studies were, however, performed under more natural conditions in the field, in comparison to our controlled individual studies in the laboratory. In the Smithsonian field studies there was undoubtedly cannibalism in the floating cages. This would provide an additional source of nutrition that may have enhanced growth in those studies at the expense of survival.

During certain periods of our experiments, the water temperature was probably too low for optimal growth to occur (see Table 1). Our observations in the laboratory indicate that a considerable drop in growth rate occurs at temperatures below approximately 25°C.

The results from the correlation analyses regarding intermolt period and molt increment, expressed as percentage increase in carapace length at molt, show that there is a negative correlation between these two parameters only in early crab stages, i.e., in early stages a prolonged intermolt period leads to proportionally lower increase in carapace length at molt.

GS3 crabs showed a much lower survival rate during the first 67 days after hatching than those in the GS1 experiment. No GS3 crabs died later, however, in comparison to GS1 crabs where mortality continued at a low rate throughout the experiment. The reason for these differences is possibly due to differences in the viability of separate spawns. The GS1 female spawned after 24 days in captivity, but the GS3 female after only 3 days in captivity. Handling stress of the latter female during advanced embryo

development possibly resulted in the lower survival rate in the GS3 experiment.

The abdominal L/W ratios (Table 6, Fig. 7) show that it should be possible to determine the sex of the crabs by visual observation at a carapace length of approximately 12–15 mm, i.e., in this study, at stages 10 or 11 or at an age of approximately 120–140 days.

Allometric growth concerning length and width of the carapace is pronounced (Fig. 3). A few measurements (5) on adult crabs showed that the carapace L/W ratio is close to 1.

Several observations provide some degree of predictability with regard to crab mortality. These variables and their interactions are summarized in Table 7. These data suggest that (a) crabs exhibiting molt increment increases that are significantly less than the mean are more likely to die sooner after molting, (b) mortality usually occurs close to the predicted end of the intermolt period for that stage, and smaller crabs are more likely to succumb than those at or above mean carapace length, and (c) mortality is not dependent on the time from hatching for a crab to reach a particular stage.

These analyses clearly illustrate that depressed growth is indicative of loss of vigor and subsequent high mortality. In the case of *Mithrax* this decline appears to be more associated with lower molt increments rather than with longer intermolt periods.

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