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Survival and growth of Mud crab, *Scylla serrata*, juveniles subjected to removal or trimming of chelipeds

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ABSTRACT

The effects of removing or trimming the chelipeds at various molt stages on regeneration, molt interval (MI) and specific growth rate (SGR) were determined in mud crab *Scylla serrata*. These strategies in combination with provision of shelters and food were tested in relation to survival and growth.

Hatchery-reared *S. serrata* juveniles (1.3–2.2 g body weight) in the postmolt, intermolt, and premolt stages were subjected to autotomy of two chelipeds, and trimming of dactylus and pollex. Intact crabs served as the control group. Interval from stocking to first molt was significantly longer in crabs autotomized at intermolt or premolt than in trimmed or intact crabs, but was similar to intact crabs when autotomy was done at postmolt. However, MI from first to second molts was longer compared to intact crabs when chelipeds were removed or trimmed at premolt.

After the first molt, autotomy and not trimming caused significant decrease in SGR. The SGRs at the end of the test were similar to intact crabs (postmolt: 7.90 ± 0.39, intermolt: 5.64 ± 0.50) when trimming of chelipeds was done at postmolt (8.01 ± 0.75) or intermolt (4.38 ± 0.40). However, SGR was lower when premolt crabs were subjected to autotomy (4.11 ± 0.67) and trimming (5.29 ± 1.40) than when chelipeds were intact (9.45 ± 0.47). A two-factor experiment was conducted in the second phase where intermolt crabs with autotomized or trimmed chelipeds (factor A) were either fed or starved but provided with shelters or fed but without shelters (factor B). After 10 days, higher survival was obtained in crabs with autotomized (95.55 ± 2.94%) or trimmed chelipeds (93.33 ± 3.33%) than in intact crabs (73.33 ± 6.67%). Survival was not affected by factor B, but higher final mean body weights were attained in fed crabs with (0.78 ± 0.04 g) or without shelters (0.74 ± 0.04 g) than unfed ones (0.48 ± 0.04 g). A third experiment was conducted to verify these results. Crabs with trimmed or intact chelipeds were either fed or unfed. No shelters were provided. Crabs with trimmed chelipeds (88.57 ± 0%) had higher survival than intact crabs (59.76 ± 7.56%) regardless of whether they were fed or starved; and fed crabs (0.82 ± 0.04 g) had higher mean body weight than unfed crabs (0.61 ± 0.07 g) regardless of whether chelipeds were intact or trimmed. These results indicate that trimming or total removal of chelipeds are effective strategies in reducing cannibalism.

1. Introduction

Mud crab (*Scylla* spp.) seed stocks for farming are obtained from the wild and recently from the hatchery in commercial scale, specifically in the Philippines, Vietnam and China. A nursery system has been developed to grow either megalopa or crab instar to the size of 1.5–4.0 cm carapace width (CW) for farming to market size (Quinitio et al., 2009; Quinitio and Parado-Estepa, 2008). The nursery period is 3–4 weeks depending on the desired size. Since crab juveniles molt frequently, cannibalism and conspecific encounters are the major causes of mortality in the communal culture system. The intensity of cannibalism in crustaceans can be affected by several factors such as availability of refuge (Kurihara and Okamoto, 1987; Luppi et al., 2001; Moksnes et al., 1998), substrate or shelter type or preference (Day and Lawton, 1988; Pottle and Elner, 1982; Ut et al., 2007), density (Rodriguez et al., 2007; Ut et al., 2007), prey size and availability (Dutil et al., 1997; Thomas et al., 2003), body intactness (Karplus et al., 1989), or molt stage (Lipcius and Herrnkind, 1982).

The chelipeds of brachyuran crabs are utilized to capture and manipulate prey and their loss or damage could reduce predation or foraging success (Juanes and Smith, 1995; Smith and Hines, 1991). The loss of chela results in reduced fitness, affecting both feeding behavior (Smith and Hines, 1991) and growth rates (Norman and Jones, 1991; Smith, 1990). Likewise, a male crab lacking chelae may become handicapped when mating (Abello et al., 1994).

Crustaceans have the ability to regenerate lost limbs. The regeneration of lost limbs to its original size depends on the age/size (Mariappan et al., 2000), the molt stage in which the limbs were lost (Hopkins, 1982), and the number of limbs removed (Fingerman and Fingerman, 1974; Skinner and Graham, 1972; Smith, 1990). Limbs

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can be replaced only by molting. The loss of limbs hastens the onset of the next molt (Hopkins, 1982).

Providing sufficient food and shelters, reducing stocking density and size grading are the common strategies that could mitigate the high level of cannibalism in the mud crab nursery phase (Quinitio and Parado-Estepa, 2008). Crabs provided with sufficient refuge showed reduced aggressive activity (Marshall et al., 2005). Chelotomy or autotomy, dactylotomy and immobilization of dactylus have been shown to reduce the degree of cannibalism in the lobsters *Homarus americanus* (Kendal et al., 1982) and in *Macrobrachium rosenbergii* (Diaz et al., 1990; Karplus et al., 1989). In the Philippines, the present practice of mud crab collectors is to remove both chelipeds during transport of juveniles from the source to the farms to reduce fighting and cannibalism (Triño et al., 1999). In the hatchery, trimming and removal of both chelipeds have been tested and gave promising results in improving the survival of crab juveniles. However, the consequences of cutting or trimming on molt interval, growth and behavior of crabs of such practice are not fully understood.

This study determined the effects of removing or trimming the chelipeds during different molt stages on regeneration, molt interval and growth in mud crab, *Scylla serrata*. Because the ultimate goal is to reduce cannibalism in the nursery phase, these strategies, coupled with provision of shelters and food were tested in relation to survival and growth performance.

2. Materials and methods

2.1. Molt stage

Newly molted mud crabs were held individually in perforated plastic containers (14 L × 10 W × 6D cm) and were examined daily until the next molt to establish the molt stages. The last walking leg of each individual was observed and monitored to determine molt stages based on the appearance of the membranous layer at the edge or the evidence of epidermal retraction of the swimming (paddle) limbs. Softness of the exoskeleton was also noted. Classification of molt stages according to Drach and Tchernigovtzeff (1967), Freeman et al. (1987), and Diaz and Petriella (1990) was slightly modified as follows:

Postmolt: Early postmolt (A) - crab soft, slippery and weak; poorly developed setal base
Late potsmolt (B) - crab with papery shell; integument harder; setal wall thickened
Intermolt: Early intermolt (C_1) - integument firm to hard; crab active
Late intermolt (C_2) - integument hard; separation of epidermis from cuticle begins
Premolt: Beginning premolt (D_0) - epidermis has withdrawn from the cuticle showing a gap between the cuticle and epidermis
Early premolt (D_1) - scalloped epidermis is apparent
Middle premolt (D_2) - parallel channels are formed
Late premolt (D_3) - new setae are formed into the channels
Final premolt (D_4) - new setae at the base of old ones evaginate

2.2. Experiment 1 - regeneration of chelipeds

Sibling hatchery-reared crabs of 1.3–2.2 g body weight (1.7–2.3 cm carapace width) maintained in 10-ton concrete tanks were selected based on the molt classification established earlier by cutting a small portion at the edge of the swimming leg: postmolt (A), intermolt (C_2), and premolt (D_2). In each group of molt stage, crabs were randomly assigned into three groups. In the first group, autotomy was induced by crushing the merus of the chelipeds (removed at the breakage plane of the limb's base from crabs). The dactylus and pollex of the chelipeds were trimmed in the second group and the chelipeds were left intact in the third group (control). Each treatment used eight crabs (replicates) which were held individually in compartments of perforated plastic containers (14 L × 10 W × 6D cm). Containers of different treatments were distributed in aerated fiberglass tanks containing seawater of 26 ppt salinity. A total of 72 crabs were used in this experiment. Ambient temperature was 28–29 °C. A net shelter (Quinitio and Parado-Estepa, 2008) was provided for each crab. About 50% of the water volume was changed daily. Crabs were provided finely chopped fish and mussel alternately at 12–15% of biomass.

Regeneration of the limbs, molting and mortality were monitored daily while body weight and carapace width (CW) and length (CL) were taken at the start of the experiment prior to removal and trimming of chelipeds and two days after each molt to ensure that crabs were at the intermolt stage during weighing. CW was measured as the distance across the carapace between the bases of the 8th and 9th lateral spines. CL was determined as the distance from the area between the bases of the two middle anterior front lobe spines to the carapace margin just before the first abdominal segment (Keenan et al., 1998). Percent specific growth rate (SGR) was calculated as (ln final weight − ln initial weight) / duration × 100, where ln = natural logarithm. Growth of the regenerating limb buds was observed daily but measurement was not done to avoid excessive handling.

2.3. Experiment 2 - feeding and provision of shelters

A two-factor experiment was conducted in Experiment 2 to determine the effects of autotomy/trimming of chelipeds (factor A) and feeding/shelters (factor B) on survival and growth of juveniles. Intermolt juveniles with 1.7–2.3 cm CW were divided into three groups. Juveniles in the first group were subjected to autotomy following the method described in Experiment 1. The dactylus and pollex of the chelipeds in the second group were trimmed, while the third group served as control where chelipeds were left intact. In each group, juveniles were either fed and provided shelters, unfed and provided with shelters, or fed but no shelters were provided. Each of the nine treatments had five replicates, with each replicate comprising five crabs stocked in a 10-l container. Uneaten feeds and other sediments were siphoned out prior to water replacement of about 50% daily. Feeding and other culture conditions were the same as in Experiment 1. Survival and body measurements were determined after 10 days. Initial weight was determined before chelipeds were autotomized or trimmed.

2.4. Experiment 3 - confirmatory test on feeding and provision of shelters

Another two-factor experiment was conducted to confirm results, specifically for trimmed crabs, in the above test. Intermolt crabs of similar size as the previous experiments were either fed or starved and chelipeds were trimmed or left intact. Five crabs were stocked in each 10-l container without shelters, representing one replicate. Each treatment had five replicates. Survival and body weight were determined after 10 days.

2.5. Statistical analysis

The effects of treatments on the molt interval, growth rate and survival were evaluated by two-way analysis of variance (ANOVA). If interaction was significant, the Duncan's multiple range test was applied to determine significant differences among treatments (Sokal and Rohlf, 1994).

3. Results

3.1. Regeneration of limbs

Crabs trimmed at any molt stage grew their dactylus and pollex after molting. However, 50% of the crabs trimmed at the premolt had