Culture of the Caribbean King Crab on Grand Turk, Turks and Caicos Islands, BWI

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ABSTRACT

For several years, the Marine Systems Laboratory, Smithsonian Institution, has investigated the feasibility of culturing Caribbean king crab (*Mithrax spinosissimus*) on cultured algal turfs. Culture techniques consisted primarily of holding crabs in field cages and rotating screens covered with algal turf into the cages at rates suitable to the cage's crab biomass. The primary disadvantage of this system was high rates of density dependent mortality. Laboratory studies showed the probable cause of the mortality was agnostic encounters among the crabs. In several experiments that held crabs at different densities, the highest density treatment had the highest fraction of deaths attributable to aggressive encounters. Increasing habitat complexity or supplementing the crab's diet with meat (conch slop) did not alter the proportion of aggression-related deaths.

A potential solution to this problem is rearing crabs in individual containers in a land-based system. Both container size and diet affected growth of individually reared crabs, although container size had the stronger effect. Ninety-day-old crabs grew best when held in large (15 cm diameter) rings and fed meat supplemented macroalgae. The slowest growth rates occurred when crabs were held in small (7.5 cm) rings and fed either algal turf or macroalgal diets.

INTRODUCTION

For several years, the Smithsonian Institution's Marine Systems Laboratory (MSL) has investigated the feasibility of basing commercial mariculture on filamentous algal (algal turf) diets. If successful, such a mariculture would benefit many Caribbean nations because algal turfs are a rapidly renewable resource in Caribbean waters. Crustaceans and molluscs potentially suitable for export markets consume algal turfs, thus turf based mariculture could become a source of hard-currency for underdeveloped Caribbean nations. The Caribbean king crab, *Mithrax spinosissimus* (hereafter referred to as *Mithrax*), is a candidate for turf based mariculture, based upon growth rates of young crabs, potential markets, and accessibility of suitable seedstock (*i.e.*, newly hatched larvae metamorphose into benthic post larvae in less than 48 hours).

A *Mithrax* mariculture based on cultured algal turfs encompasses two primary elements: (1) the economic mariculture of *Mithrax* independent of food source, and (2) the potential role of algal turfs in such an industry. The latter hypothesis does not examine whether algal turfs are the best diet for culturing *Mithrax*, but merely a sufficient diet. An advantage to an algal turf-based mariculture is low food costs, an essential characteristic if mariculture will succeed in underdeveloped Caribbean nations. Entrepreneurs countries may find other diets maximize economic yield, but MSL did not intend to address this more general question. During the past few years, MSL and the Harbor Branch Oceanographic Institute (HBOI), Ft. Pierce, Florida, have independently studied the feasibility of *Mithrax* mariculture, however only MSL extensively focused on algal turf technologies.

The time required to raise a marketable product is an important mariculture element because of its effect on production costs. For *Mithrax*, HBOI (Ryther *et al.*, 1987) and MSL have defined marketable crabs as those exceeding 125 mm CL (1000 g). Under this definition, *Mithrax* growth models, independently produced by MSL and HBOI, suggest 2.5-4.0 years are required to grow marketable crabs.

Additional aspects of *Mithrax* biology, however, complicate this issue. Majid crabs typically stop molting after they attain maturity (*i.e.*, the pubertal molt is a terminal molt). HBOI (Ryther *et al.*, 1988) has cultured mature Florida *Mithrax* in 1.5 years, but these crabs were considerably smaller then the projected market size. In Florida *Mithrax* populations, adults rarely exceed 110 mm CL, whereas Grand Turk *Mithrax* commonly exceed 150 mm CL. Further, the sizes of Grand Turk juvenile *Mithrax* and adult Florida *Mithrax* are equivalent after 1.5 years, suggesting maturation occurs earlier (*i.e.*, at a smaller size) in Florida crabs. Preliminary surveys by MSL of other Caribbean *Mithrax* populations show considerable variation in adult size ranges, further suggesting maturation age varies geographically. Thus, if a terminal molt is characteristic of *Mithrax*, some populations should not be considered as a source of seedstock. Nonetheless, maturation occurs beyond the projected market size in some populations (*e.g.*, Grand Turk, Antigua, and Dominican Republic) and considerably short of the marketable size in others (*e.g.*, Florida and possibly South Caicos).

However, the central issue remains the time required to culture a marketable product. Producing a hardshell crab over two years old may be economically infeasible. It may be possible to grow crabs faster. Eyestalk ablation shortens the molt interval of most crustaceans and could become a useful mariculture technique if it does not cause excessive mortality while substantially reducing molt intervals. In contrast, production of softshell *Mithrax* may be more economically feasible. Softshell crabs should be marketable at 70 mm CL (125 g); softshell blue crabs, the mainstay of present softshell crab markets, are marketed at this weight. MSL and HBOI (Ryther *et al.*, 1988) have cultured *Mithrax* to this size in 9-11 months, suggesting the economics of softshell *Mithrax* production may be more favorable than hardshell production. MSL's present mariculture research focuses upon producing softshell *Mithrax*, however, the acceptance of *Mithrax* by softshell crab consumers has not been examined and requires study.

During the past few years, MSL's growout technique has focused on a high labor/low capital system (Porter *et al*., 1986). Briefly, this system consisted of rearing crabs in field cages (approximately 70 x 70 x 100 cm) and rotating screens covered with algal turf into the cages at rates suitable to the crab biomass within the cage. The principal disadvantage of this water-based culture system was excessive mortality, survivorship was often less than 25% per 100 days. During intermediate (approximately days 60 to 200) and late growout (beyond day 200), mortality was density dependent (*i.e*., holding more crabs within a cage increased the fraction of crabs dying). There is no data for early growout (less than day 60), but we assume similar processes occur.

Laboratory studies strongly suggest the principal cause of the mortality was agnostic interactions among crabs. In an experiment that held crabs at three densities (6, 10, and 18, eight mm CL crabs per 20 cm X 20 cm container, there were three replicates of each density, and the crabs were fed algal turf), 40% of the deaths were caused by aggressive interactions resulting in punctures near or through the mouthparts of the dead individual. Further, aggression-related mortality was most common in the high density treatment (60% of all deaths in that treatment), intermediate in the medium density treatment (30%), and lowest in the low density treatment (11%). In a similar experiment that offered habitat complexity to the crabs in the form of macroalgae (mixed species clumps of *Padina* sp., *Halimeda* spp., and *Dictyota* sp.), 41% of the deaths were associated with puncture wounds, and puncture-related deaths were relatively more common in the highest density treatment. Finally, in an experiment that held groups of four 18 mm CL crabs at different sex ratios (all male, all female, and 1:1) and two diets (macroalgae/turf algae and macroalgae/turf algae/conch slop, three replicates per treatment combination), 70% of the deaths in the all male groups were aggression related compared to 54% and 0% in the 1:1 and all female treatments, respectively. There was no effect of diet on survival.

The most workable solution to this impasse appears to be raising crabs individually in a land-based system, as is done in homarid lobster culture. The age at which crabs should begin to be reared individually is still under investigation. Because container size affects growth rates of individual homarid lobsters, we tested for a similar effect in *Mithrax*. Ninety-day-old crabs (10-12 mm CL) were grown for 126 days in individual rings (7.5 cm or 15.0 cm diameter) with three diets (algal turf, macroalgae, and macroalgae supplemented with conch slop); there were 22 crabs per treatment combination.

Both ring size and diet affected *Mithrax* growth, although ring size had the strongest effect. Crabs grew best when held in large rings and fed macroalgae and conch slop, attaining a mean size of 31.4 mm CL. In contrast, the mean sizes of crabs grown in small rings and fed either algal turf or macroalgae did not exceed 20 mm CL. These growth difference were caused by affecting the molt intervals rather than the molt increments. Details of the importance of protein supplements, however, are unclear. Studies by HBOI (Ryther *et al.*, 1987; 1988) of *Mithrax* yield in communal culture had high yields from cohorts fed Dyowa C pellets, which are distinctive because of their high protein content. However, another pellet used by HBOI that had a high protein content, Salmon Starter, had relatively low yields. Future research should address the importance of specific amino acids in diets as well as products not commonly found in algae (*e.g.*, cholesterol).

Relative to the water-based culture system originally pursued by MSL, a land based system should have lower labor costs, higher capital costs (principally a flow through seawater system), and higher yields. The economic feasibility of a land-based culture requires a pilot or demonstration study. Studies of market potential, market accessibility, and elasticities could begin immediately, however definitive studies of production costs need additional research or dietary and water requirements.

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