The Open Access Israeli Journal of Aquaculture – Bamidgeh

As from **January 2010** The Israeli Journal of Aquaculture - Bamidgeh (IJA) will be published exclusively as **an on-line Open Access (OA)** quarterly accessible by all AquacultureHub (http://www.aquaculturehub.org) members and registered individuals and institutions. Please visit our website (http://siamb.org.il) for free registration form, further information and instructions.

This transformation from a subscription printed version to an on-line OA journal, aims at supporting the concept that scientific peer-reviewed publications should be made available to all, including those with limited resources. The OA IJA does not enforce author or subscription fees and will endeavor to obtain alternative sources of income to support this policy for as long as possible.

Editor-in-Chief
Dan Mires

Editorial Board

Sheenan Harpaz	Agricultural Research Organization Beit Dagan, Israel
Zvi Yaron	Dept. of Zoology Tel Aviv University Tel Aviv, Israel
Angelo Colorni	National Center for Mariculture, IOLR Eilat, Israel
Rina Chakrabarti	Aqua Research Lab Dept. of Zoology University of Delhi
Ingrid Lupatsch	Swansea University Singleton Park, Swansea, UK
Jaap van Rijn	The Hebrew University Faculty of Agriculture Israel
Spencer Malecha	Dept. of Human Nutrition, Food and Animal Sciences University of Hawaii
Daniel Golani	The Hebrew University of Jerusalem Jerusalem, Israel
Emilio Tibaldi	Udine University Udine, Italy

Copy Editor
Ellen Rosenberg

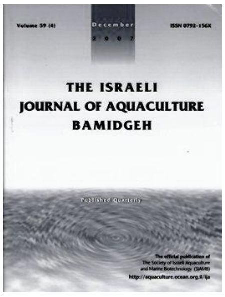
Published under auspices of
The Society of Israeli Aquaculture and Marine Biotechnology (SIAMB),
University of Hawaii at Manoa Library
and
University of Hawaii Aquaculture Program in association with
AquacultureHub
http://www.aquaculturehub.org

ISSN 0792 - 156X

© Israeli Journal of Aquaculture - BAMIGDEH.

PUBLISHER:
Israeli Journal of Aquaculture - BAMIGDEH -
Kibbutz Ein Hamifratz, Mobile Post 25210,
ISRAEL
Phone: + 972 52 3965809
http://siamb.org.il

The Israeli Journal of Aquaculture - Bamidgeh, IJA_64.2012.704, 6 pages



Efficiency of Shelters in Reducing Cannibalism among Juveniles of the Marine Blue Swimmer Crab, *Portunus pelagicus*

Raghunath Ravi* and Mary K. Manisseri

*Marine Biodiversity Division, Central Marine Fisheries Research Institute,
Post Box No. 1603, Kochi 682 018, Kerala, India*

(Received 7.3.11, Accepted 3.5.11)

Key words: *Portunus pelagicus*, cannibalism, shelters, hide-outs, crab juveniles

Abstract

Portunus pelagicus is an important crab species for aquaculture in India. Cannibalism during the megalopa and juvenile stages is a major constraint in standardizing the hatchery technology of this species. The present study evaluates the efficiency of various types of shelters in curbing cannibalism in juvenile *P. pelagicus*. Larvae from eggs of berried females collected from the wild were reared to first crab instars under controlled conditions. They were stocked in 200-l tanks at a density of 10/l with shelters of different materials: (a) nylon mesh netting, (b) seagrass, (c) seagrass and sand, and (d) without any material as shelter. At the end of the experimental period (15 days), the mean survival rates of the juveniles in each treatment were subjected to one-way ANOVA and pairs that significantly differed ($p<0.01$) were traced using Fisher's LSD. The seagrass and sand treatment produced the highest mean survival (88±3%); the lowest (24.67±2.52%) was obtained in the treatment where no material was provided as a shelter.

---

* Corresponding author. Fax: +91-0484-2394909, e-mail: raghunathravi@yahoo.com

Introduction

In crustacean hatchery production, cannibalism is one the most serious issues influencing the final survival rate. In crabs, cannibalism starts in the zoeal stages and becomes more pronounced during the megalopa stage. Concentration of juvenile crabs in the nursery leads to intra and inter-cohort competition for space and food (Iribarne et al., 1994).

In species that exhibit cannibalistic behavior, early juveniles may be preyed upon by individuals of the same or older cohorts (Luppi et al., 2001). Cannibalism, particularly at the megalopa and juvenile stages, is the main cause of low survival during the hatchery production of *Scylla serrata* (Latiff and Musa, 1995). In several species of brachyuran crabs, cannibalism is an important factor affecting the year class strength and fishery recruitment through differential survival of successive cohorts (Fernández and Castilla, 2000).

Several methods have been tried by researchers to minimize cannibalism so as to improve the survival rate of larvae. Plastic pipe cuttings, plastic nets, and the seaweed, *Gracilariopsis bailinae*, distributed in tanks as shelters, improved the survival rate of megalopae of *S. serrata* (Quinitio et al., 2001). Size-grading of stock and trimming of claws were also successful in reducing cannibalism in the same study (Quinitio et al., 2001). Decreasing stocking densities and providing shelters in larvae tanks and ponds reduced cannibalism (Liong, 1992).

The settlement of postlarvae of *Portunus pelagicus, Alphaeus* sp., and caridean shrimp in seagrass habitats indicates their preference for habitats with food (Kenyon 1993) and shelter (Kenyon et al., 1995). In *Pseudocarcinus gigas* larvae, cannibalism was strongly influenced by lighting, which was manifested by greater damage to the dorsal spine in larvae kept in light than in those reared under continuous darkness (Gardner, 1996). Molting during night hours considerably reduces cannibalism in juveniles of *Chasmagnathus granulata* (Lopez and Rodriguez, 1998). *Portunus pelagicus* of less than 50 mm carapace length predominantly forage on shallow sand flats, whereas larger individuals are abundant in seagrass and unvegetated habitats further offshore (Edgar, 1990). In *Ranina ranina*, visual cues not only affect feeding but also augment cannibalism (Minagawa et al., 1994).

Photoperiod and light intensity are amongst the primary factors affecting cannibalism (Hecht and Pienaar, 1993) as in the case of *P. gigas* (Gardner, 1996). A genetic component has been suggested as instigating cannibalism in certain species (Dominey and Blumer, 1984). An increase in shelter density significantly improves the survival rate of *Callinectes sapidus* larvae (Zmora et al., 2005).

The marine blue swimmer crab, *P. pelagicus*, is a candidate species for aquaculture in India. Though there is no organized grow-out of this species, fattening is popular in several coastal areas of the country. Since there is no large-scale production of *P. pelagicus* seeds at present, farmers depend on the wild for juveniles or young ones for fattening. Non-availability of quality seeds is one of the major hindrances in establishing a systematic culture for this species. Efforts are on to develop and standardize technology for producing *P. pelagicus* seeds at a commercial level. Cannibalism during the larval and juvenile stages in the life history of this species is a major impediment to the success of such efforts. This paper studies the effectiveness of hide-outs in improving the survival rate of *P. pelagicus* by minimizing cannibalism during the juvenile stage, under laboratory conditions.

Materials and Methods

Collection and maintenance of animals. Three healthy females of mean carapace width 159.86±3.04 mm (±SD) with yellow berry were collected from the Gulf of Mannar off Mandapam, 9°09′N, 78°44′E. The animals were brought to the wet laboratory in battery-aerated containers and stocked in black oval 1-ton fiberglass reinforced plastic (FRP) tanks at the rate of one animal per tank. Animals were fed raw clam (*Meritrix meritrix*) and squid (*Sepia pharaonis*) meat at a ratio of 1:1, *ad libitum*. The animals were examined daily and, at dark grey berry stage, were transferred to 500-l cylindro-conical FRP tanks for hatching. Once the eggs were hatched, the most active larvae of the same brood were collected and stocked in 200-l rectangular FRP tanks at a density of 25/l, the stocking density that produced the best results in earlier trials. Dead larvae and feed waste were siphoned out prior to daily water exchange (60%). Temperature, salinity, pH, and photoperiod were maintained at 28±2.0°C, 35 ppt, 8.1±0.2, and 12 h light:12 h dark.

Larvae feeding protocol. Zoeae 1 and 2 were fed *Skeletonema costatum* and *Brachionus plicatilis* twice daily at densities of 50,000 and 25 cells/ml, respectively. The larvae were also fed formulated prawn feed (Frippak 2 CD, INVE, Belgium) at 0.5 g/ton, four times daily. Zoeae 3 and 4 were fed *S. costatum*, *B. plicatilis*, and formulated prawn feed at 50,000 cells/ml, 30 cells/ml, and 0.5 g/ton, respectively, four times daily. Megalopae were fed *Moina macrura* and newly hatched *Artemia* sp. nauplii once a day at 3 and 5 cells/ml, respectively. In addition, they were fed freshly prepared egg custard twice daily at 0.5 g/ton. Rotifers and *M. macrura* were collected from the wild using different sized nets and mass cultured in 1-ton FRP tanks on microalgae.

Experimental design. After larval rearing, the most active first crab instars were stocked at 10/l in 200-l rectangular FRP tanks for the experiment. The experimental set-up consisted of three treatments and a control, all carried out in triplicate. In treatment T1, twenty pieces of 500 μ nylon mesh netting (20 × 15 cm) were introduced into the rearing tanks. A few pieces were placed at the bottom with weights and the remaining pieces were allowed to float in the water column. In treatment T2, seagrass (*Cymodocea rotundata*) was planted in small cups and suspended in the water column. Treatment T3 was provided with a 4-cm thick bottom of clean beach sand and seagrass was planted in cups on the bottom and suspended as in treatment T2. Treatment T4 (control) tanks were not provided any material for shelter.

The instars were fed minced clam meat (*M. meritrix*) twice daily, *ad libitum*. Dead larvae and feed waste were siphoned out prior to daily water exchange (70%). Temperature, salinity, pH, and photoperiod were maintained at 28±2.0°C, 35 ppt, 8.1±0.2, and 12L:12D. pH was adjusted by adding 1N sodium carbonate or 1N hydrochloric acid, as required. The tanks were covered with black sheets after the photophase and aerated continuously throughout the experiment. Juveniles in each tank were collected and counted at the end of the experimental period (15 days) to calculate the final survival rate.

Data analysis. The data were statistically analyzed using one-way ANOVA to determine if there were significant differences ($p<0.01$) in mean survival rates amongst treatments. The survival rates, which showed significant differences, were identified by subjecting the data to post hoc test of multiple comparison (Fisher's Least Significant Difference Test) using SYSTAT version 7.0.1.

Results

In treatment T1 (nylon mesh netting), average survival was 57±9.54% (Fig. 1). Average survival in treatment T2 (seagrass) was slightly higher, 59.67±3.79%. The highest average survival (88±3%) was obtained in treatment T3 (sand and seagrass); in this treatment, even the tank with the lowest survival (85%) exceeded survival in tanks with the highest survival in the other treatments. The lowest average survival (24.67±2.52%) was recorded in the control tanks (no shelter). One-way ANOVA showed significant differences ($p<0.01$) in survival rates between treatments; Post Hoc Test using Fisher's LSD identified significantly different pairs (Table 1).

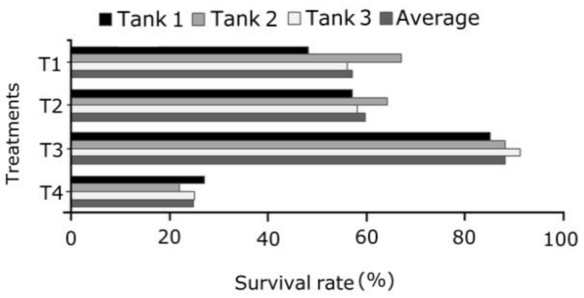


Fig. 1. Survival of *Portunus pelagicus* juveniles raised in different shelters: T1 = nylon mesh netting, T2 = seagrass, T3 = seagrass & sand, T4 = without shelter.

Table 1. Fisher's LSD Matrix of pair-wise comparison probabilities for different treatments.

Treatment	*T1*	*T2*	*T3*	*T4*
T1	1.000	-	-	-
T2	0.569	1.000	-	-
T3	0.000	0.000	1.000	-
T4	0.000	0.000	0.000	1.000

T1 = nylon mesh netting, T2 = seagrass, T3 = seagrass & sand, and T4 = without shelter

Discussion

Several factors including availability of refuge (Moksnes et al., 1997) and level of satiation (Luppi et al., 2001) influence the frequency and intensity of cannibalism among decapod crustaceans. In the present work, where experimental conditions were similar for all treatments, but for the nature of the substrata, we assumed that cannibalism would be the major reason for differences in mortality. In the red king crab, *Paralithodes camtschaticus*, survivorship was associated with the complexity of the habitat and the most important habitat characteristic appeared to be the relative availability of refuge space for the crab instars (Loher and Armstrong, 2000). Likewise, the reason for the better survival in T3 where two types of shelters were used simultaneously could be that the two materials provided refuge in different niches of the tank, i.e., sand at the bottom and seagrass in the water column. The use of two niches might have distributed the stock, decreasing the number of instars per unit area.

The higher rate of cannibalism during the daytime in the present study agrees with observations in *Pseudocarcinus gigas* juveniles, where there was a directly proportional relationship between cannibalism and light hours (Gardner and Maguire, 1998). In *Scylla serrata* juveniles, cannibalism-related mortalities are often due to asynchronous molting and inadequate food (Rodriguez et al., 2001). Though food was provided *ad libitum* in all the tanks in the present study, molting was not uniform, which led to a difference in the size of the juveniles. This might have instigated cannibalism as suggested in the case of *S. serrata* juveniles. The main reason for the significant loss of zoeae due to cannibalism by megalopae in *Portunus trituberculatus* is the difference in size (Hamasaki, 1997). The availability of *Artemia* nauplii as an alternative food source helped reduce cannibalism of zoeae by megalopae in the mangrove crab *Ucides cordatus* (Ventura et al., 2008).

The likelihood of cannibalism increases when there is asymmetry between individuals in a interaction. Individuals in transition stages are at great risk of being cannibalized since they are either immobile or soft and virtually defenseless during and after ecdysis (Polis, 1981). In the present study, cannibalism was enormous when the crab juveniles were soft shelled (immediately after ecdysis). Cannibalism decreased when seaweed *G. bailinae* was distributed into megalopa tanks during hatchery production of *S. serrata* (Quinitio et al., 2001). In the present study, tanks with seagrass had better average survival (59.67±3.79%) than tanks without any shelter (24.67±2.52%). Cannibalism could have been the main reason for the decline in survival of early juveniles of the blue crab *C. sapidus* when reared large-scale in captivity (Zmora et al., 2005).

The present experiment illustrates the importance of shelters in curbing cannibalism among crab juveniles. The results of the study have significance both in hatchery production and also in understanding the larval biology of the species. It is possible to minimize cannibalism by providing adequate shelter using different materials. However, except for sand, the refuge materials used in this experiment, though simple, were not capable of providing complete protection to the animals. Provision of a sand bed is very helpful to crustaceans which have a natural tendency to remain buried, but the feasibility of such treatment in hatcheries is doubtful as sand is likely to cause difficulties during harvest. Numerous predator-prey studies have demonstrated that habitat complexity significantly reduces cannibalism. Therefore a combination of methods such as providing shelters, keeping low stocking density, size grading, provision of adequate supplementary and live feeds are suggested to curtail cannibalism and obtain better survival rates in crustacean seed production.

Acknowledgements

The authors wish to express their sincere thanks to Dr. G. Syda Rao, Director, Central Marine Fisheries Research Institute (CMFRI), Cochin, for his guidance and encouragement. Acknowledgement is also due to Dr. G. Gopakumar, Scientist-in-Charge, Regional Centre of CMFRI, Mandapam, for the facility provided.

References

Dominey J. and L.S. Blumer, 1984. Cannibalism in early life stages of fishes. pp. 43-64. In: G. Hausfater, S.B. Hardy (eds.). *Infanticide: Comparative and Evolutionary Perspectives.* Aldine, New York. 598 pp.

Edgar G.J., 1990. Predator-prey interactions in seagrass beds. II. Distribution and diet of the blue manna crab *Portunus pelagicus* Linnaeus at Cliff Head*,* Western Australia. *J. Exp. Mar. Biol. Ecol*., 139(1-2):23-32.

Fernández M. and J.C. Castilla, 2000. Recruitment of *Homolaspis plana* in intertidal habitats of central Chile and implications for the current use of management and marine protected areas. *Mar. Ecol. Prog. Ser.*, 208:157-170.

Gardner N.C., 1996. Behavioural basis of depth regulation in the first zoeal stage of the giant crab (*Pseudocarcinus gigas*, Brachyura, Xanthoidea, Oziidae). pp. 229-253. In: *High Latitude Crabs: Biology, Management, and Economics.* Alaska Sea Grant College Program Report No. 96-02, Univ. Alaska, Fairbanks. 720 pp.

Gardner C. and G.B. Maguire, 1998. Effect of photoperiod and light intensity on survival, development and cannibalism of larvae of the Australian giant crab *Pseudocarcinus gigas* (Lamark). *Aquaculture*, 165:52-63.

Hamasaki K., 1997. Larval survival. pp. 111-115. In: Y. Miyama, H. Nagayama, K. Oda, H. Murakami, H. Mizikure, M. Ichikawa, A. Yukutake, S. Matsumura, K. Kiyota, K. Ando, K. Hamasaki (eds.). *Seed Production of Swimming Crab: Principles and Practices*. Japan Sea-Farming Assoc., Tokyo.

Hecht T. and A.G. Pienaar, 1993. A review of cannibalism and its implications in fish larviculture. *J. World Aquacult. Soc.*, 24:246-261.

Iribarne O., Fernández M. and D. Armstrong, 1994. Does space competition regulate density of juvenile Dungeness crab *Cancer magister* Dana in sheltered habitats? *J. Exp. Mar. Biol. Ecol.*, 183:259-271.

Kenyon R.A., 1993. *Factors Affecting the Distribution and Abundance of Juvenile Tiger Prawns, Penaeus esculentus and Penaeus semisulcatus, at Groote Eylandt, Northern Territory*. Masters dissertation, Griffith Univ., Brisbane.

Kenyon R.A., Loneragan N.R. and J.M. Hughes, 1995. Habitat type and light affect sheltering behaviour of juvenile tiger prawns (*Penaeus esculentus* Haswell) and success rates of their fish predators. *J. Exp. Mar. Biol. Ecol.*, 192:87-105.

Latiff F.A. and C.U.C. Musa, 1995. *The Biology of Mud Crab and its Hatchery Production*. Bull. Perikanan, Department of Fisheries, Malaysia. 20 pp.

Liong P.C., 1992. The fattening and culture of the mud crab (*Scylla serrata*) in Malaysia. pp. 185-190. In: C.A. Angell (ed.). *The Mud Crab*. Proc. Seminar on Mud Crab in Surat Thani, Thailand, 5-8 November 1991. Bay of Bengal Program, Madras.

Loher T. and D.A. Armstrong, 2000. Effects of habitat complexity and relative larval supply on the establishment of early benthic phase red king crab (*Paralithodes camtschaticus* Tilesius, 1815) populations in Auke Bay, Alaska. *J. Exp. Mar. Biol. Ecol.*, 245:83-109.

Lopez L.S. and E.M. Rodriguez, 1998. Somatic growth in juveniles of the estuarine crab *Chasmagnathus granulata* Dana 1851 (Brachyura, Grapsidae), under laboratory conditions. *Invest. Mar.*, 26:127-135.

Luppi T.A., Spivak E.D. and K. Anger, 2001. Experimental studies of predation and cannibalism of the settlers of *Chasmagnathus granulata* and *Cyrtograpsus angulatus* (Brachyura: Grapsidae). *J. Exp. Mar. Biol. Ecol.*, 265:29-48.

Minagawa M., Chiu J.R., Kudo M. and F. Takashima, 1994. Male reproductive biology of the red frog crab, *Ranina ranina*, off Hachijojima, Izu Islands, Japan. *Mar. Biol.*, 118(3):393-401.

Moksnes P.O., Lipcius R.N., Pihl L. and J. van Montfrans, 1997. Cannibal-prey dynamics in young juveniles and postlarvae of the blue crab. *J. Exp. Mar. Biol. Ecol.*, 215:157-187.

Polis G.A., 1981. The evolution and dynamics of intraspecific predation. *Annu. Rev. Ecol. Evol. Syst.*, 12:225-251.

Quinitio E.T., Parado-Estepa F.D., Millamena O.M., Rodriguez E. and E. Borlongan, 2001. Seed production of mud crab *Scylla serrata* juveniles. *Asian Fish. Sci.*, 14:161-174.

Rodriguez E.M., Quinitio E.T., Parado-Estepa F.D. and O.M. Millamena, 2001. Culture of *Scylla serrata* megalops in brackishwater ponds. *Asian Fish. Sci.*, 14:185-189.

Ventura R., Da Silva U.A.T., Perbiche-Neves G., Ostrensky A., Boeger W.A. and M.R. Pie, 2008. Larval cannibalism rates in the mangrove crab *Ucides cordatus* (Decapoda: Ocypodidae) under laboratory conditions. *Aquacult. Res.*, 39:263-267.

Zmora O., Findiesen A., Stubblefield J., Frenkel V. and Y. Zohar, 2005. Large-scale juvenile production of the blue crab *Callinectes sapidus*. *Aquaculture,* 244(1-4):129-139.