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The effects of salinity on the survival, growth and haemolymph osmolality of early juvenile blue swimmer crabs, *Portunus pelagicus*

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Abstract

The blue swimmer crab, *Portunus pelagicus*, is an emerging aquaculture species in the Indo-Pacific. Two experiments were performed to determine the effects of salinity on survival, growth and haemolymph osmolality of early juvenile *P. pelagicus* crabs. The salinities tested for the first experiment were 10, 15, 25 and 40 ppt, and for the second experiment 5, 20, 30, 35 and 45 ppt. Each salinity experiment was triplicated, with each replicate consisting of 10 stage 4 juveniles. Each experiment lasted 45 days. Mortalities and incidence of "molt death syndrome" were recorded daily, while the intermolt period, carapace length, carapace width and wet weight were measured at each molt. At the end of the experiments the haemolymph osmolality and dry weights were measured.

Results demonstrate that salinity significantly affects both the survival and growth of early *P. pelagicus* juveniles. Mortality was significantly higher ($p<0.01$) for juveniles cultured at salinities ≤ 15 ppt and at 45 ppt. At a salinity of 5 ppt a complete mortality occurred on day 20. In all salinity treatments, the majority of mortalities were due to "molt death syndrome". In experiment 1, immediate effects of salinity on growth and development were seen at 10 ppt as the intermolt period was significantly longer ($p<0.01$) and the mean carapace size increase was significantly less ($p<0.01$) at the first molt compared to the other treatments. Meanwhile, the specific growth rates (carapace length, width and wet weight) were significantly lower ($p<0.05$) at high salinities (≥ 40 ppt) due to longer intermolt periods and significantly lower ($p<0.05$) carapace size or wet weight increases.

The haemolymph osmolality exhibited a positive linear relationship with the culture medium with an isosmotic point of 1106 mOsm/kg, equal to a salinity of approximately 38 ppt. Based on the osmolality graph, high metabolic cost for osmoregulation due to increased hyper- and hypo-osmotic stress appeared to cause lower survival and specific growth rates of the crabs. The results demonstrate that a salinity range of 20–35 ppt is suitable for the culture of early juvenile *P. pelagicus*.

Keywords: Salinity; Survival; Growth; Osmolality; *Portunus pelagicus*; Early juveniles

1. Introduction

Blue swimmer crabs, *Portunus pelagicus*, also known as sand crabs are native throughout the Indo-West Pacific region (Xiao and Kumar, 2004). Their harvests support important commercial fisheries in the region and their popularity is growing fast with

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estimated landings increasing from 947,000 tonnes in 1990 to 1,500,000 tonnes in 1998 (Otto et al., 2001). Apart from the traditional sale as hard-shell crabs there has been a substantial increase in their utilisation for pastuerised canned crabmeat and for the production of soft-shell crabs. For example, exportation of pasteurised blue swimmer crab meat to the United States, Japan and Singapore reportedly generates a multi-million dollar revenue for Indonesia annually (Muna, 2005; Setyadi and Susanto, 2005). To meet the increasing market demands for soft-shell crabs, *P. pelagicus* crabs, have been individually held in compartments within a recirculating system to produce soft-shell crabs in Australia. The efficient and expedient harvesting of newly molted soft-shell crabs is made possible by a periodic robotic monitoring system (O'Neill, 2003). In addition, lined ponds have also been proposed for the free-range production of soft-shell *P. pelagicus* where recently molted crabs are removed via periodic observation (Walker, 2006). Currently, blue swimmer crabs are largely sourced from fisheries which is unreliable and seasonal (Otto et al., 2001). Therefore the aquaculture interest of this species is growing due to their relative ease of hatchery production (Walker, 2006) and fast growth rates (Josileen and Menon, 2005).

As the aquaculture potential for this species increases, an understanding of the basic culture conditions is necessary to optimise production. Salinity is one of the most important abiotic factors in aquaculture and while many crustacean species exhibit some degree of euryhalinity (Pequeux, 1995), optimal salinity levels for growth, survival and production efficiency are often species-specific (Rouse and Kartamulia, 1992; Bray et al., 1994; Kumlu and Jones, 1995; Kumlu et al., 2001; Soyel and Kumlu, 2003; Ruscoe et al., 2004). Furthermore, osmotic stress has been reported to elicit physiological responses such as increased dissolved oxygen consumption (Chen and Chia, 1996; Spanopoulos-Hernández et al., 2005) and ammonia excretion (Chen and Lin, 1994b; Lemos et al., 2001; Silvia et al., 2004) that may substantially alter the culture environment in a closed culture system.

Presently, there is no published information on the salinity tolerance and optimal salinity levels for early *P. pelagicus* crabs (Lestang et al., 2003a), although their natural distribution appears to be dependent on salinities (Kangas, 2000; Lestang et al., 2003b). It has also been reported that blue swimmer crab juveniles emigrate in mass numbers preceding seasonal salinity reductions in Western Australian estuaries (Potter et al., 1983). These reports suggest that early juvenile blue swimmer crabs are sensitive to either salinity fluctuations or low salinity levels. Experiments were designed and conducted to obtain information on the effects of salinity on the survival and growth of the early *P. pelagicus* juveniles and to investigate the underlying physiological mechanisms. Such knowledge has significant implications in aquaculture as it can be used for farm site selection as well as the manipulation of salinity in a recirculating system to maximise productivity. The information will also enhance our understanding on juvenile habitat preferences and migration of *P. pelagicus* juveniles.

2. Materials and methods

2.1. Source of experimental crabs

Blue swimmer crab broodstock were caught from estuaries in Townsville, north Queensland, Australia, using baited traps. All broodstock were labeled and maintained in outdoor 1000-l oval recirculating tanks (temperature maintained at 28±2 °C and salinity at 32± 2 ppt) at the Marine and Aquaculture Research Facility Unit (MARFU), James Cook University. Each day, the broodstock were fed to satiation on an alternation of prawns, mussels and squid. When a berried female was found it was disinfected in a static formalin bath (concentration 50 μl l^{-1}) for 6 h.

After disinfection, the berried female was transferred indoors and individually held in a 300-l tank for hatching at a temperature of 26±1 °C and salinity of 34±1.5 ppt. The tank water was aerated and continually circulated through three cartridge filters (10, 5 and 1 μm) and a UV steriliser. The berried female was not fed and faeces and discarded eggs were siphoned daily from the tank, accompanied with about a 10% water exchange.

The juvenile crabs used in the first and second salinity experiments came from fifth and sixth consecutive spawns of the same female. Upon hatching, the aeration was turned off and the active larvae were siphoned from the hatching tank. Larvae were stocked at approximately 500 larvae l^{-1} and cultured at a salinity of 25 ppt at 29±1 °C. Newly hatched larvae were initially fed rotifers (*Branchionus* sp.) at 20–40 individuals ml^{-1} and the rotifer density was maintained by daily additions of microalgae *Nannochloropsis* sp. From the Zoea II stage onwards, *Artemia* (*INVE*, *AAA*) nauplii were hatched and added daily to the larval tanks, without enrichment, and the *Artemia* density was successively increased from an initial 1–2 individuals ml^{-1} to 3–5 individuals ml^{-1} by the time the megalopa stage was reached. Daily