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LETTER TO EDITOR
CLIMATE CHANGE AND THE CRAB AQUACULTURE INDUSTRY: PROBLEMS AND CHALLENGES

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Abstract: Studies on the climate change have attracted major scientific interests. The purpose of this editorial letter is to interpret recent issues related to the portunid crab aquaculture activities, and then to discuss the importance of crab aquaculture, and finally the challenges posed by climate change. It is well known that aquaculture is fast becoming the main source of seafood worldwide due to the depletion of wild fisheries. Achievements in various technologies play a vital role in the sustainability of highly commercial aquatic species such as the portunid crabs. Another challenges facing the aquaculture industry is the global climate change. The climate change-induce temperature-related process is the main interest in the future development of sustainable aquaculture industry. Significant increase in the number of studies related to climate change is expected to attract larger number of research related to be conducted. Thus, studies on the effects of climate change on aquaculture, especially temperature related, could provide important data for comparison with future research. Future efforts to understand the effects of a range of temperature changes should also be strongly encouraged, in order to act for better prediction and culture management.

Keywords: Nursery culture, sustainable aquaculture, temperature

Growth of the Aquaculture Industry and Its Economic Importance

In this century, aquaculture is fast becoming the main source of seafood worldwide, mainly due to the depletion of wild fisheries. From a production of less than 1 million tons in the past 65 years, the aquaculture industry has grown tremendously, with an increase of almost a thousand-fold and current production is more than 1 billion tons in 2016 (FAO, 2017). This situation highlights the increase in global demand, aquaculture has contributes to the emerging economies, as the annual global production of aquaculture has attained a farm gate value of more than USD160 billion. Crab fishery and aquaculture is dominated by a few species of the family Portunidae. Most captured or cultured portunid crabs are of relatively high commercial value and widely distributed (Romano & Zeng, 2017; Muhd-Farouk *et al.*, 2017; Azra & Ikhwanuddin, 2015; Ikhwanuddin *et al.*, 2009; 2010). In brief, global capture production based on crab species showed a decrease from 1,715,535t in 2014 to 1,677,266 t in 2015 (FAO, 2017). Global fishery landings of portunid crab are from five main species *Callinectes sapidus, Portunus pelagicus, Charybdis* spp., *P. trituberculatus* and *Scylla serrata* (FAO, 2017). Hatchery technology is a crucial component in aquaculture seed production, and plays an important role in the commercialization of this multi-million dollar industry. The development of culturing technology is important for increasing the production of targeted aquatic species in hatcheries and nurseries. Recent advances in commercial production, especially in crustacean species, have focused on artificial and biotechnological culture systems, stimulating reproduction in captive conditions, and introduction of various larval rearing protocols. Efforts to expand commercial practices for marine crustacean production have initially focused on species that have higher fecundity, shorter larval periods, and faster growth rates. These advances have been in part supported by hatcheries and nurseries that have led to continuous growth of the aquaculture industry. Nursery culture practices for commercial aquatic species are required to gain hatchery produced seed from the larvae and instar crablets to a suitable juvenile size for pond culture.

Challenges and Problems

Advances in seed production have often been a bottleneck because of lack of easy nursery techniques, as well as poor cultivation methods and technologies to maintain seed in each of the aquaculture phases. One of the main obstacles in aquaculture production, especially at the nursery stage, is the insufficiency of hatchery to produce seeds. Once advances in hatchery techniques and other aspects of nurseries culturing of instar larvae were made, growth would be improved, and commercial hatcheries would also be developed (Romano & Zeng, 2017). Portunid crabs are a promising crustacean group for the diversification of the Asian aquaculture industry, especially in Malaysia (Muhd-Farouk *et al.*, 2017; Ikhwanuddin *et al.*, 2009; 2010). The high meat quality of portunid crabs, good market demand, delicious taste, and profitable market price have made portunid crabs a species group with high potential for the Malaysian aquaculture industry. Recently, considerable research has been conducted on portunid crab broodstock and larval culture techniques, but less research had focused on instar stages (Azra & Ikhwanuddin, 2015; Azra & Ikhwanuddin, 2016). This is due to the fact that most of the seed used in portunid crab culture has been caught from the wild, and widely been collected and distributed. Due to these constraints, there is an even more pressure on natural populations of portunid crab species. With the unknown status of the seed (which is collected from the wild), it is difficult to determine their current stages and difficult to carry out a precise research effort. A lack of seed supplies, especially from instar larvae (in hatcheries), has obstructed the further expansion of the portunid crab industry (Waiho *et al.*, 2018; He *et al.*, 2017).

Climate-Induced Temperature

Based on the literature search from the ScienceDirect searching engine, the number of studies on the 'climate change' (indicated as keywords) were increased significantly from 15,225 articles in 2008 to 45,643 articles in 2017, with an increasing mean number of 3,000 articles per year. Significant increase in the number of studies related to climate change is expected to attract a larger number of researches related to be conducted. Links have been found between climate-induced temperature variability and certain life-cycle stages of marine invertebrates, with direct or indirect impacts on the culture process (Azra *et al.*, 2018; Lord *et al.*, 2017; Hoegh-Guldberg & Bruno, 2010). How these increases in temperature will affect aquaculture activities and aquatic animals in the future may cause to be problematic. Current efforts to assess how climate change affects aquatic organisms have been based on previously published literature and established knowledge (Gaitan-Espitia *et al.*, 2017; Paital & Chainy, 2014). Thus, studies on the effects of climate change on aquaculture, especially on temperature, could provide important data for comparison with future research. Future efforts to understand the effects of a range of temperature changes should also be strongly encouraged, for better prediction and culture management. In general, temperature affects virtually all reproductive activities of the portunid crabs. Water temperature has been considered as one of the most commonly discussed single environmental factor that affects the growth and development of the portunid crabs (Yuan *et al.*, 2017). However, less study were done on the effect of water temperature on the juvenile stages of portunid crabs. Establishment of the effects of water temperature on commercial aquatic species groups such as portunid crabs is important for further understanding of their potential for mass aquaculture commercialization.

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