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# Toleration of *Moina* sp. towards Salinity and Food Types as the Prominent Factors in Determining *Moina* sp. Abundance: A Review

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## Review Article

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**ABSTRACT**

In hatchery, an adequate supply of live food for first feeding fish larvae is essential and nutritional quality of live food organisms can be improved through nutrient enrichment. The use of live food organisms, especially at first feeding, is a requisite for most marine fish larvae. In ocean, freshwater fish larvae primarily feed on *Moina* sp., but the production protocols for *Moina* sp that are able to tolerate with brackish environment together with an appropriate feed types are still underdeveloped in hatchery. As the food ingestion and the digestive system of cladocerans are different from other live food organisms (e.g., rotifers), the nutrition enrichment procedures with emulsion oil used in rotifers is not effective on cladocerans. This review focuses on the potential of producing a salt tolerate zooplankton species of *Moina* sp. and the importance of feeding types in *Moina* sp. production. Specifically, we discuss the relationship between the salinity and food availability in *Moina* sp. The review links nutrient supply to *Moina* sp. and the change of nutrition in *Moina* sp. and suggests ways to improve cladocerans nutrition in hatcheries.

## INTRODUCTION

Cladoceran which is commonly known as water fleas is a small planktonic crustacean. Cladoceran is one of the important groups of zooplankton in aquatic ecosystems due to its role in energy and nutrient transfer to other organisms [1]. The studies about cladocerans are widely spread due to their ecological importance, sensitivity towards environmental changes and easy to handle [1]. Most of the species of cladoceran live exclusively in the freshwater environment especially the genus from Moina and Daphnia [2]. In natural conditions, Moina and Daphnia live in fresh and low saline water ponds, tanks, lakes puddle and some sewage lagoon [3].

Nowadays temperature and salinity in the water environment were increased due to human activities [4] and significantly affecting the freshwater animals especially the crustaceans that are not able to migrate [5]. This situation can give an impact on growth and reproduction of cladocerans species in response to their original habitat. The increase of salinity in ponds and lakes had become an environmental perturbation [6]. It had also caused a serious environmental problem in aquatic environments [6]. Furthermore, other important environmental factors that can affect the cladocerans population are the quantity and quality of food [7]. Herbivores cladocerans usually graze on algae and the composition of algae will influence this grazers' survival [8].

## CURRENT ENVIRONMENTAL PROBLEMS

Industrial and urbanization have caused many negative impacts on the aquatic ecosystem, especially in freshwater ecosystems. The salt concentrations of freshwater habitat have increased because of the activities of industrial and urbanization and freshwater animal are being affected [5]. Besides, the increase of the sea water levels and coastal erosion were among the reasons why the salinity of the freshwater ecosystem has tremendously changed. Many freshwater ecosystems had transformed into a saline condition especially in the coastal and semi-arid region because of these human activities which are urbanization, industrialization, deforestation and other activities that can harm the freshwater environment [9]. Salinity is a serious menace to the freshwater ecosystems and it became more serious matter to the aquatic habitat especially in freshwater environment [9].

Changes of the salinity on the freshwater ecosystem can cause many problems to occur especially in decreasing the zooplankton communities. The abundance and diversity of zooplankton have been affected because of the increases of salinity in the freshwater environment. The increases of salt had caused the changes of zooplankton community structure [4]. The decrease of zooplankton species has been reported due to the increases in salinity in the freshwater environment [9]. The increase of salinity also can change the original taxa on the freshwater ecological process, such as primary productivity, decomposition, nutrient cycles and food webs [10]. Salinity rises in freshwater have the potential to reduce freshwater zooplankton richness especially the cladocerans community and thus changes the freshwater species to a more salt tolerate species [9].

Cladocerans are a very important group in zooplankton that most of the species live in the freshwater environment with salinities lower than 1ppt [5]. This is due to their osmoregulation adaptations that only allow them to tolerate in lower salinity [11]. Cladocerans freshwater species also can get the impact from the changes of salinity. However, there are a few species from cladocerans that can live in saline environment; mostly from brackish water species which are able to tolerable towards salinity ranges (up to 13 ppt); such as *Daphnia pulex*, *Daphnia thomsoni* and *Daphnia magna* [11]. *Moina* sp. is a genus of cladocerans that mostly inhibit in the freshwater environment. The high concentration of *Moina* sp. appears in ponds, pools, lakes, ditches, and swaps that most are from the environment with low salinity levels [12]. Changes of salinity in the freshwater habitat can give an impact to this water fleas whether on their distribution or on their community's structure.

Other than zooplankton, phytoplankton that presence in the first level of food web as a primary producer also can get the impact of this situation. The structure of the planktonic primary producers might be affected due to these salinity changes [13]. The abundance of phytoplankton in freshwater habitat will be changed in accordance with their toleration towards salinity ranges. According to Cui et al. [14], the phytoplankton compositions were significantly changed after incubation in different salinity. Changes in phytoplankton communities are also related to the changes of zooplankton abundance since algae, bacteria, and detritus serve as food for zooplankton [15].

## TOLERATION OF *Moina* sp. TOWARDS SALINITY

The original habitats of the most *Moina* sp. are in freshwater environment with normal salinity, which is 0 ppt. The habitat of *Moina* sp. will be affected if the normal salinity started to rise. Based on previous study, zooplankton that originally from the freshwater environment cannot tolerates high salinity environment. Organisms become osmoconformers if they did not have any physical adaptive mechanisms that can balance the higher ionic concentrations that present outside of their body [16]. Generally, cladocerans are considered as osmoconformers, but there is a certain level of salinities that they can tolerate with [16]. Most of the cladocerans species that inhibit in freshwater are also able to tolerate in low salinity which is less than 2 ppt [17]. If the salinity of water increases, the survival rate of organisms will eventually have decreased [5]. Therefore, when the salinity of water increases, the *Moina* sp. survival rate might be decreased. The highest salinity that has been previously studied for *Daphnia* sp. is 12 ppt and the result indicated that the optimum growth of *Daphnia* sp. is below than 5 ppt [4]. If the salinity is higher than 5 ppt, the survival of *Daphnia* sp. will be affected. *Daphnia* sp. normally can reproduce and grow in salinity below than 4 ppt. When the salinity for cultivation is 11 ppt and 12 ppt, the *Daphnia* sp. can only survive around 1 to 2 hours [4]. The growth rate population started to decline when the salinity reaches 8 ppt and above [6]. The growth and fecundity of freshwater cladocerans decreased as an increase of salt concentration in the freshwater environment [11]. If the salinity remains above their toleration, it will affect the reproduction and survival of species and can have drastic implication on species composition [4].

## *Moina* sp. FEED ON MICROALGAE

### Microalgae and their nutritional value

Microalgae are a highly diverse group of unicellular organisms that have been used directly or indirectly as a live feed in aquaculture [3]. Zooplankton usually will feed on microalgae to suffice its nutrient composition for later to be used to feed fish larvae. In the natural, *Moina* sp. plays an important role as a primary consumer in the food web of ecosystems. *Moina* sp. can feed on a various group of bacteria, yeast, phytoplankton, and detritus and a population of *Moina* sp. grow rapidly when feeding on adequate amount of phytoplankton [12]. *Moina* sp. has the ability to live on phytoplankton and organic waste environment. Most cladoceran species are filters feeders and feed on algae because microalgae are suitable in terms of size, motility and nutritional value [18]. *Moina* sp. can multiply very fast when feeding on algae, bacteria and organic debris [3]. Even though *Moina* sp. can grow rapidly when feeding on algae, the optimum concentration of algae must be suitable for feeding to *Moina* sp. If the concentration is too high, *Moina* sp. will be overfed since high algae densities will cause overfeeding and death of animals [19-21]. In contrast, if the concentration is too low, *Moina* sp. might not get enough nutrients for their growth. One of the most important and vital factors for cladocerans growth and reproduction are food density whether subjected to field or under laboratory conditions. The rate of the population increased when the food density increased. The population density of cladocerans increases as the increases of algae density to the optimal level of algae concentration [7].

### *Moina* as a Live Feed

Cladocerans became one of the most used organisms in the aquaculture industry [22]. They are suitable as one of the live feed sources due to their abundance, tolerance to environmental conditions, high nutritional quality of protein (50% of dry weight), ease of handling and suitable in size for feeding fish larvae [2]. Cladocerans have been used as a successful tool for feeding fish larvae [23,24] and preferred to be eaten by most fish larvae [25,24] in the aquaculture sector. *Moina* sp. is really suitable to feed on newly-hatched freshwater fish fry because fishes at these stages are able to ingest young *Moina* sp. as their initial food [12]. *Moina* sp. can use as a live food for fish and prawn larvae because they are rich in protein and other nutrients compared to other types of live foods [26,27]. Recently, *Moina* sp. is widely used as a replacement to *Artemia* sp. and previous studies have indicated that *Moina* sp. can be a good replacement of *Artemia* sp. in live food culture. The used of *Artemia* sp. as a live feed is very costly for aquaculture sector and *Artemia* sp. are also not suitable to use for feeding on freshwater organisms because its natural habitat are from marine environment [27]. Therefore, by replacing *Artemia* sp. with *Moina* sp., it can reduce the production cost because the cultivation of *Moina* sp. is much cheaper compared to other live feed species especially *Artemia* sp. [26,27]. Moreover *Moina* sp. can be cultivated under variable environmental conditions and it is also at the ease of culture [28].

*Moina* sp. has been reported to feed on various types of foods [29]. *Moina* sp. normally feeds on various groups of bacteria, phytoplankton, and detritus in nature. They feed by ingesting these particulate organic substances that are filtered from water [30]. The particles are gathered to the mouth by moving appendages located at the anterior part of body [29]. The ingested food that remains in the digestive tract can be observed by the naked eye if the organisms are appearing in large numbers or can be observed under a microscope. Based on previous study, yeast has been demonstrated in mass culturing of rotifer in fish farms and hatcheries [31], and now yeast is also widely used for *Moina* sp. cultivation. *Moina* sp. are one of few zooplanktons which also feed on the blue green algae *Microcystis aeruginosa*, and various groups of phytoplankton such as *Chlorella* sp., *Anabaena* sp., *Scenedesmus* sp., and *Staurastum* sp. other than using yeast as culture medium [32]. According to Lee et al., [33] rice bran, soya roughages, and ntennules grain powder are also suitable to be used for culturing *Moina* sp. in large numbers. Combinations of Chlorella vulgaris and yeast as culture media are able to produce large densities of *M. macrocopa* [32]. A recent study in India has also shown that animal waste products such as human urine can be utilized to maximize the reproduction of *M. micrura* [34].

### *Moina* sp. Enrichment

The enrichment should be done in order to produce the mass culture production of *Moina* sp. in the hatcheries even though *Moina* sp. already high in protein and nutrient content. Kang et al. [35] also found that the proportion of most essential amino acids in yeast-fed M. macrocopa was higher than *Artemia* and rotifers fed with the same diet. Moreover, the histidine and threonine contents of *Moina* sp. were even higher than that of rotifers or *Artemia* fed on microalgae and commercial diets. Therefore, according to He et al., [29], *Moina* sp. may provide essential amino acids such as methionine, histidine, and threonine for freshwater fish larvae.

### Microalgae

Microralgae can bioaccumulate a long chain of unsaturated fatty acids (UFAs), amino acids, carotene and store minerals from the cultured media of heterotrophic and/or mixotrophic condition [36-38]. There are some microalgae species, such as *Chlorella vulgaris*, *Haematococcus pluvialis*, *Dunaliella salina* and the *Cyanobacteria Spirulina* maxima, which already commercially available, and are used primarily as additives in animal feed and as nutritional supplements for humans [39]. Zooplankton, an important natural food for fish, and an excellent source of essential amino acids (EAAs) and polyunsaturated fatty acids (PUFAs) cannot accumulate these essential micronutrients in significant amounts but their concentrations can be increased through consumption of the right kind of algae [40]. However, cladoceran rich in nutrients making it an excellent live food for the good growth and development of fish and prawn larvae [41,26].

In this study, only one microalgae will be used which is Chlorella sp. to feed the *Moina* sp. In addition, *Chlorella* sp. provides protein (essential amino acids) and energy. Besides, they also provide other key nutrients such as vitamins, essential polyunsaturated fatty acids (PUFA), pigments and sterols, which are transferred through the food chain [42].

### Canola oil (CO)

High zooplankton growth rates could be attainable when direct dietary sources of HUFAs are available for fast-growing zooplankton [43]. Lipids have been reported to promote the growth of cladoceran species. Besides, inadequate lipid content in cultured fish diets can adversely affect the performance of larvae during the grow-out stage, since larvae often have low energy reserves and require substantial energy sources for their high somatic growth rates and development of their bodies [44]. Canola (Brassica napus), for instance, is a major oil producing crop, and the global production of rapeseed oil was over 22 million tons during 2009 to 2010, which is considered to be the third largest source of the vegetable oil supply [45]. Canola oil is of high nutritional value with high concentrations of unsaturated C18 fatty acids (>60%), and is known to contain high quantities of oleic, linoleic, and α-linolenic acids as well as vitamins E and K, which produces no peroxides up to 200°C [45]. These features have rendered canola oil as a suitable enrichment complement for diverse live feeds.

### Mixed diet

In fish and crustacean hatcheries, the live food enrichment by oil emulsion is commonly used. Commercial enrichment products and methodologies have been formulated for *Artemia nauplii* and rotifers [46] but not for *Moina* sp. It is anticipated that the combinations of *Chlorella vulgaris* and canola oil culture media are able to produce large densities of *Moina* sp. in accordance with previous studies on other types of zooplankton.

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## CONCLUSIONS

This review highlights the importance of using *Moina* sp. as live food in hatchery and emphasizes the need of using non-traditional way to enrich *Moina* sp. to meet the nutritional requirements in fish and crustacean larvae in aquaculture. Furthermore, it is also important to produce *Moina* sp. that can tolerate a wide range of salinities for further used in marine fish and crustaceans larval culture. *Moina* sp. are expected to be able to adapt towards saline environment and also serve as a bio-indicator in evaluating the impacts of increased salinity on the aquatic environment. It is vital to also evaluate how salinity have generally impacted the *Moina* sp. abundance since the ability of *Moina* sp. being cultured in high densities can assist the aquaculture sector by having an additional feeding substitute for the brackish larvae. This review clearly proves that any attempts towards developing a sustainable cultivation of *Moina* sp. are worthwhile and effective larval rearing can be done to overcome the problem faced by aquaculturists during larval fish growth and development.

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