Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(2): 693 – 700 (2025)
www.ejabf.journals.ekb.eg

Effect of Feeding Tation Turbidity on the Population Growth of *Moina* sp.

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ARTICLE INFO
Article History:
Received: Nov. 29, 2024
Accepted: Jan. 27, 2025
Online: March 14, 2025

Keywords:
Moina sp.,
Turbidity,
Baker's yeast,
Population density

ABSTRACT

Moina sp. were cultured with varying concentrations of feeding rations to find the optimal feed turbidity for population growth.. Baker's yeast (*Saccharomyces cerevisiae*) was added to the culture tanks until the water reached the desired feed turbidities (20, 25, 30, 35, and 40cm) corresponding to five treatment levels; each treatment was performed in triplicate. The results show that feed turbidity does affect the growth and population density of *Moina* sp. At turbidities of 20–25cm, the density reached a maximum of 860 individuals (ind.)/L on day 4; at 30cm, the maximum density was 1,017 ind./L on day 6; and at turbidities of 35–40cm, the maximum population density was over 1,300 ind./L on day 9 of the experiment. The findings reveal that the highest *Moina* biomass was attained with the tubidity from 35-40cm.

INTRODUCTION

Moina sp. is an important food source for larval freshwater fish and shrimp because of its small size (400–1000µm) **(Alam *et al.*, 1993)**, high protein content (>50%), and high lipid content (20–25%) **(Hasan *et al.*, 2023)**. In addition, this species has a high concentration of digestive enzymes **(Dhert, 1996)**. However, the harvest of wild *Moina* is increasingly limited and cannot meet the demand of freshwater aquaculture hatcheries. Furthermore, *Moina* is often harvested from farming sites that use animal waste as a food source; as such, there are concerns that contamination from pathogenic bacteria may infect the reared animals.

Due to the high demand for pathogenic-free *Moina* sources, there have been many studies on raising *Moina* in tank systems such as earthen ponds. Since *Moina* are non-selective, filter-feeding zooplankton, producers can use a variety of feeds of different sizes for biomass farming. Food source plays an important role in *Moina* quality **(Sayali *et al.*, 2009, Hasan *et al.*, 2023)**. Moreover, studies have examined the effects of different foods such as *Chlorella* sp. **(Mangas-Ramires *et al.*, 2002; Aswazi *et al.*, 2022)**, red yeast (*Rhodotorula glutinis)* **(Kushniryk *et al.*, 2015; Khudyia *et al.*, 2018)**, and rice bran combined with fish meal **(Mubarak *et al.*, 2017)**.

Baker's yeast (*Saccharomyces cerevisiae*) is a widely-available, low-cost food source that has been used successfully for *Moina* biomass production **(Khudyia *et al.*, 2018)**. However, indoor *Moina* biomass production using baker's yeast for feed with feeding rations, is difficult to apply to large-scale biomass production in aquatic hatcheries. To optimize the diet of *Moina* for maximum population growth and provide recommendations for biomass farmers, this study examined the biomass yield of *Moina* raised with five different feed concentrations of baker's yeast measured by turbidity.

MATERIALS AND METHODS

Experimental setup

Moina sp. stock was provided by the College of Aquaculture & Fisheries at Can Tho University. *Moina* sp. samples were reared indoor in a 150L conical glass fiber tanks containing 100L of chlorine-free fresh water (0‰ salinity), with an initial stocking density of 200 individuals/L. Baker's yeast was used as the feed. Dry baker's yeast (produced in China) was mixed with freshwater at 50g/ L, then the yeast solution was grounded for two minutes with a blender and provided to *Moina* twice a day (at 8:00 am and 4:00 pm). *Moina* were raised on five different feed concentrations, which were determined by using a Secchi disc while adding the baker's yeast solution into each culture tank to measure the turbidity in the tank. There were a total of five turbidity treatment levels: 20, 25, 30, 35, and 40cm. Each treatment was performed in triplicate. Tanks were aerated slightly for the duration of the experiment, and water was changed by 30% every three days using a 50µm mesh filter to remove the old water before adding new water. The cultures were exposed in housing under the natural light.

Sample collection and data analysis

Physio-chemical parameters

Temperature and pH were measured twice a day (at 8:00 am and 4:00 pm) using a temperature and pH meter (Hanna HI 98128). Total ammonia nitrogen (TAN) and nitrite (NO_2^-) concentrations in the culture water were measured every three days at 8:00 am. Water samples were collected, stored at 4ºC, and then analyzed according to the **APHA (1999)** standard methods for the examination of water.

Biological parameters

Population density (ind./L) and percentage of egg-carrying females (%) were calculated by collecting daily aliquots (250mL) from each culture starting on day 2. Samples were fixed with 5% formalin, and then the number of *Moina* and egg-carrying *Moina* were counted under a microscope at 4× magnification. These numbers were used to calculate the density and percentage of egg-carrying *Moina*.

Density of *Moina*

The density of *Monia* was calculated as follows:

Density of *Moina* (ind./L) = count of individuals × 4

Percentage of egg-carrying *Moina*

The percentage of egg-carrying *Moina* was calculated as follows:

Percentage of egg-carrying *Moina* (%) = number of egg-carrying *Moina*/total number of *Moina* in the sample x 100

Statistical analysis

Differences in *Moina* population density, growth rate, and percent of egg-carrying females among feed concentrations were analyzed using one-way ANOVA and the Tukey HSD test in STATISTICA 7.0 software. Results were considered significant at $P<0.05$.

RESULTS AND DISCUSSION

1. Physio-chemical parameters

Temperature and pH

The average pH values among cultures ranged from 7.1 to 7.5 (Table 1), which falls within the appropriate range for the growth of *Moina* **(Dhert, 1996)**. The pH in the culture did not change significantly over the course of a day.

Water temperatures during the experiment ranged from 26.5 to 29.6ºC (Table 1). According to **Rottmann *et al.* (1992)**, acceptable temperatures for the growth and development of *Moina* range from 24 to 31ºC. Therefore, the temperature in the current experiment falls within the acceptable range for *Moina*'s population development.

TAN (ammonia/ammonium ion) concentrations

TAN concentrations fluctuated widely from 1.2 to 26.8mg/ L over the course of the experiment (Table 1). The increasing waste from *Moina* increased the amount of TAN in the water throughout the experimental period. The amount of ammonia (NH_3)

and ammonium ions (NH_4^+) present in the water depends on water pH. NH_3 content is high when the pH changes from an acid to a base. When the concentration of NH_3 passes a certain threshold, it has negative effects on the diversity and population density of Cladocera **(Sarma *et al.*, 2003)**. According to **Heng (1983)**, *Moina* can tolerate NH_3 concentrations from 35–50mg/ L, while **Mangas-Ramirez *et al*. (2002)** reported that the LC50 (the lethal concentration for 50% of the population) after 24h of exposure to NH_3 is up to 232mg/ L for *Moina macrocopa*. In the final days of this experiment, TAN concentrations in treatments 1 and 2 (20 and 25cm; T1 and T2) fell within the acceptable range for population development but approached the limits that *Moina* can tolerate. In the remaining treatments, TAN concentrations stayed at suitable levels for the development of *Moina*.

Table 1. Culture parameters

Treatment	Temperature (°C)		pH		TAN (mg/L)	$N\text{-}NO_2$ (mg/L)
	8:00	14:00	8:00	14:00		
T1 (20cm)	27,1±0,4	28,3±0,6	7,3±0,2	7,3±0,2	15±8,3	0,06±0,04
T2 (25cm)	27,1±0,4	28,2±0,6	7,3±0,1	7,3±0,2	12,3±6,9	0,07±0,04
T3 (30cm)	27,3±0,7	28,1±0,6	7,3±0,2	7,3±0,2	9±5,2	0,08±0,03
T4 (35cm)	27,1±0,4	28,1±0,6	7,3±0,1	7,3±0,2	6,7±4,9	0,07±0,04
T5 (40cm)	27,2±0,4	28,1±0,6	7,3±0,1	7,3±0,1	4,2±2,5	0,06±0,04

NO_2^- concentration.

The NO_2^- concentrations in the cultures increased gradually over the course of the experiment and reached a maximum value of 0.16mg/ L (Table 1). According to **Xiang *et al*. (2010)**, *Daphnia similoides* can tolerate high levels of $N\text{-}NO_2^-$; the 24h LC50 ranges from 40–150mg/ L, depending on the age of the *Daphnia*. Therefore, the $N\text{-}NO_2^-$ concentrations in the experiment stayed within the acceptable range for the growth of *Moina*.

2. Biological parameters

Moina population density

Moina population density fluctuated throughout the culture period (Table 2). The density gradually increased from day 1 to day 3 of culture. At that point in time, density did not differ between treatments. By day 4, the density had increased from 2.7 to 4.3 times the initial stocking density; populations were the highest in treatments T1 and T2, which were significantly higher ($P \geq 0.05$) than the other treatments, with the exception of T3. However, from day 5 onwards, the density in treatments T1 and T2 gradually decreased, while the population density of the remaining treatments continued to increase. Treatment T3 had the highest density on day 5; it was significantly higher than the remaining treatments at 853 ind./L. The density of T3 continued to increase until day 6, when it reached an average of 1,017 ind./L (five times higher than the initial density), then began to decrease from day 7 onwards.

From day 7 onwards, *Moina* density was highest in treatments T4 and T5. T5 had the highest density on days 7 (1,014 ind./L) and 8 (1,321 ind./L), which was significantly higher than all other treatments. By day 9, the density of the T5 treatment reached its highest peak at 1,389 ind./L (nearly seven times higher than the initial stocking density), which was significantly higher than all of the other treatments, with the exception of the T4 treatment. The population began to decrease in treatments T4 and T5 on day 10.

According to **Rasdi and Qin (2018)**, *Moina* rapidly increased in number when fed with algae, bacteria, and animal waste (suitable feeding rations), but population growth decreased when there was an excessive amount of food in the habitat. The results of the current experiment showed that population density increases in low feed turbidities during the initial days of culture, but later on, the population density gradually decreases. Flocs formed quite early on day 4, and the number of flocs increased with culture time. *Moina* stuck to the flocs, which caused the population to gradually decrease during the farming process. In contrast, *Moina* raised at high turbidities increased slowly in number during the initial days of culture but reached a high peak later. This result suggests that the feed concentration is important for *Moina* population development. Therefore, to support a growing population, it is necessary to increase feed turbidity when the population density begins to increase. This will ensure an adequate food supply for continued population growth.

Percentage of egg-carrying *Moina*

The percentage of egg-carrying *Moina* increased or decreased with feed turbidity. The percentage of egg-carrying *Moina* was significantly higher in one treatment on days 6 (T1) and 7 (T4) (Table 3). On the other days, there was no statistical difference among treatments. The percentage of egg-carrying *Moina* ranged from 13–40%, with the highest percentage observed in treatment T1 on day 6 and the lowest percentage in treatment T2 on day 2. These results suggest that feed concentration does not have a strong effect on the percentage of egg-carrying *Moina* in the population. **Rodmongkoldee and Taparhudee (2020)** reported that food concentrations had effects on the number of offspring per brood and the total number of offspring per female of *Moina micrura*, but the different concentration of food in present study did not produce significant difference in percentage of egg-carrying *Moina*. The nutritional supplement from low food concentration in the present study may have enough for nutrient requirment of *Moina*.

Table 2. *Moina* population density (ind./L)

Treatment	Population density (ind./L)									
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
T1 (20cm)	200±0	297±45[a]	532±72[a]	866±62[b]	475±92[a]	436±97[a]	378±107[a]	351±121[a]	168±43[a]	158± 10[b]
T2 (25cm)	200±0	296±64[a]	508±39[a]	863±68[b]	599±28[a]	415±153[a]	593±64[ab]	393±90[a]	269±111[ab]	197± 11[b]
T3 (30cm)	200±0	304±41a	442±86[a]	629±127[ab]	853±69[b]	1017±81[b]	643±108[ab]	524±124[a]	424±68[b]	331± 30[a]
T4 (35cm)	200±0	289±51[a]	480±30[a]	524±189[a]	430±21[a]	517±25[a]	714±56[b]	884±76[b]	1340±101[c]	423± 68[a]
T5 (40cm)	200±0	278±38[a]	421±113[a]	537±68[a]	581±96[a]	706±169[a]	1014±141[c]	1321±165[c]	1389±49[c]	447± 76[a]

For each column, the superscript letter indicates statistical differences ($P \geq 0.05$); groups marked with the same letter are not significantly different.

Table 3. Percentage (%) of egg-carrying females in the *Moina* population

Treatment	Percentage (%) of egg-carrying females									
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
T1 (20cm)	20±3[a]	22± 3[a]	25± 6[a]	24± 3[a]	23± 3[a]	26± 7[b]	18± 3[a]	20± 3[a]	21± 7[a]	18± 2[a]
T2 (25cm)	21±4[a]	19± 3[a]	16± 3[a]	20± 5[a]	23± 3[a]	21± 4[ab]	19± 2[ab]	17± 3[a]	18± 3[a]	19± 2[a]
T3 (30cm)	19±3[a]	22± 6[a]	19± 3[a]	23± 5[a]	22± 3[a]	22± 4[ab]	22± 3[ab]	18± 2[a]	22± 3[a]	22± 4[a]
T4 (35cm)	22±2[a]	22± 4[a]	22± 4[a]	23± 4[a]	21± 4[a]	19± 6[ab]	26± 4[b]	20± 1[a]	18± 2[a]	18± 2[a]
T5 (40cm)	21±4[a]	18± 4[a]	20±2[a]	22± 4[a]	18± 3[a]	17± 3[a]	19± 3[ab]	18± 5[a]	21± 4[a]	19± 4[a]

For each column, the superscript letter indicates statistical differences ($P \geq 0.05$); groups marked with the same letter are not significantly different.

CONCLUSION

Feed turbidity affects the growth of *Moina* sp. The population density also differs with turbidity; the peak densities at low feed turbidities occurred days earlier than the peak densities at higher turbidities. At turbidities of 20–25cm, the density peaked on day 4 at 866 ind./L; at a turbidity of 30cm, it reached 1,017 ind./L on day 6; and at turbidities of 35–40cm, density peaked at 1,300 ind./L on day 9. Feed turbidity does not have a strong effect on the percentage of egg-carrying *Moina*.

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