



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

COMMERCIAL PRODUCTION AND UTILIZATION OF LIVE FEED (COPEPODS RICH) AT THE NURSERY LEVEL IN BANGLADESH

¹Zahirul Haque Bhuiyan, ^{2,*}Md. Khaled Rahman,
³Fanindra Chandra Sarker, ⁴Tanjira Tasnim Munia

¹Fishzone Agro Fisheries, Ballavdikanda, Araihaazar, Narayanganj, Bangladesh.

²Bangladesh Fisheries Research Institute, Riverine Sub-station, Rangamati-4500, Bangladesh.

³Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

⁴Department of Fisheries and Marine Resource Technology, Khulna University, Khulna, Bangladesh.

*Corresponding author

DOI: <https://doi.org/10.51193/IJAER.2023.9401>

Received: 02 Jun. 2023 / Accepted: 10 Jun. 2023 / Published: 31 Jul. 2023

ABSTRACT

Live feed on hatcheries is essential for many aquaculture species and this situation is predicted for the future. Therefore, a two-year study (March 2020 to February 2022) was performed in Ballavdikanda, Bangladesh, for commercial production as live feed for fish farms. Live feed was produced/decimal/m water depth by a mixture (with live feed creator 10gm, NaHCO₃ 100gm, wheat flour 200gm, rice polish 300gm, water 3 liters and fermented for 3 days) in the nursery pond. Live feed's production cost (BDT) significantly achieved 189.50% profit. This mixture was applied directly to nursery ponds and a large number of zooplanktons germinated after 3-4 days of application for consumption by fish fry *Cirrhinus cirrhosis*, *Oreochromis niloticus*, *Anabas testudineus*, *Ompok pabda*, *Cyprinus carpio* and *Macrobrachium rosenbergii*. The live feed significantly decreased 20% feed cost and raised the fry survival rate upto 85%-90% with improved physical appearance, attractive body color and strength, whereas the survival rate in the control treatment was 50%-60%. It is suggested that the Copepod can be used as a live feed to produce commercially important fish. We concluded and suggested that the authority expand the scope of this live feed production and commercialization at the farmer level throughout the country.

Keywords: Beneficiary Zooplankton; Commercial Utilization; Copepods; Live Feed Creator; Nursery Stage

1. INTRODUCTION

The glorious fish production of Bangladesh is 4.621 million metric tons, where 85% of freshwater fish and the rest comes from marine (DoF, 2022). Among the freshwater fish, 57% come from culture fisheries and 28% from capture fisheries (DoF, 2022). Bangladesh placed first in total hilsha (*Tenualosa ilisha*) catch, including almost 85% of the world, and has a Geographical Index (GI) certificate (2016). Bangladesh also placed third in capture fisheries, fourth in the world and also third in Asia by *Oreochromis niloticus* production, and fifth in aquaculture (FAO, 2020). Annual carp hatchling production in our country is 6,83.15 metric tons, of which only 2.152 metric tons are from natural sources and 680.99 metric tons from 1056 artificial farms or hatcheries; hence, 99.68% of hatchlings are produced artificially (DoF, 2022). The total amount of Post Larvae (PL) production in Bangladesh is 723.41 crores including *Macrobrachium rosenbergii* and *Paneaus monodon* combined from 77 hatcheries (27 Govt & 50 private), with 723.04 crores from private hatcheries (6 *Macrobrachium rosenbergii* and 44 *Paneaus monodon* hatcheries) and the remaining 0.37 crore from government hatcheries (only 27 *Macrobrachium rosenbergii* hatcheries) (DoF, 2022). The government hatcheries produced 12.193 metric tons (MT) of hatchlings. Of these, Indian major carp 7.44, exotic carp 2.56, *Pangasianodon hypophthalmus* 0.033, *Barbonymus gonionotus* 0.89, *Labeo bata* 0.77, *Heteropneustes fossilis* 0.005, and others 0.144. Similarly, production (in MT) from private sources is Indian major carp - 259.33, exotic carp -183.71, *Pangasianodon hypophthalmus* 28.44, *Barbonymus gonionotus* 30.75, *Labeo bata* 35.13, *Anabas testudineus* 11.81, *Heteropneustes fossilis* 39.63, and others 67.83 of the total 656.63. *Oreochromis niloticus* juvenile production (Lac) from government hatcheries is 4699, whereas the production from private hatcheries is 49497 (DoF, 2021).

In recent decades, the number of cultured fish species and the feed cost have increased considerably, but the price of fish has not increased proportionally, which is a warning sign for aquafarmers in Bangladesh. From 2016 to 2022, pangas *Pangasianodon hypophthalmus*, *Oreochromis niloticus*, *Heteropneustes fossilis*, and *Macrobrachium rosenbergii* feed prices exhibited an upward tendency, according to field research. Tilapia nursery feed costs (BDT) increased from 60 to 135 while starter, grower, and finisher feed prices increased from 45 to 65. At the same time, pangas, shing, and shrimp feed exhibit a more or less identical growth propensity. As a result of decreasing sales prices, some farmers are changing the species of fish they cultivate. In the early first-feeding or start-feeding phase, there aren't many restrictions on the proper feed selection and use. Because of this, it may not come as a surprise that one of the

main obstacles impeding the complete commercialization of many farmed fish and shellfish species is larval nutrition, particularly that of the delicate first-feeding larvae. The major nursing period of fish larvae culture still significantly relies on natural live feeding, despite significant efforts to adopt artificial feeds. To acquire a satisfactory yield from hatchery rearing of fish and shellfish larvae, they should be fed nutrient-rich live food. Therefore, a steady supply of low-cost live food is reliable for commercial fish production (Payne and Rippingale, 2001). Freshwater copepods that live in the wild are usually less than 0.5 mm to 2 mm long. However, some species, like cyclopoids such as *Macrocylops fuscus* and *Megacyclops gigas*, and calanoids in quite a few genera, including *Heterocope*, *Epischura*, *Limnocalanus*, and *Hesperodiaptomus* can grow to be 3–5 mm long (Reid and Williamson, 2010), making them ideal live feed for numerous financially important fish, prawn, shrimp, and mollusks larvae (Mehraj-Ud-Din *et al.*, 2009). Copepods have a high nutritive value (Evjem *et al.*, 2003), having 71.2% protein and 9.7% fat on a dry basis without egg sacs, but these statistics increased somewhat when egg sacs were included (Miliou *et al.*, 1992) and fed to commercially important finfish and crustaceans during the critical first-feeding period, dramatically boosting larval growth and survival rates (Payne and Rippingale, 2001). Copepods are essential for the rapid development of aquaculture sectors, and including copepods in aquaculture will boost farmed fish species' production (Støttrup, 2000; Payne *et al.*, 2001). Copepod farming has already become widespread, supplying the aquaculture trade with high-quality live feed (Engell-Sørensen *et al.*, 2004; Evjemo *et al.*, 2003; Olivotto *et al.*, 2008; Rajkumar, 2006; Sørensen *et al.*, 2007; Toledo *et al.*, 1999; Van der Meeren *et al.*, 2008). The cultivation and production of appropriate nutritive live food organisms is regarded as the hatchery's heart for long-term seed production (Tidwell *et al.*, 1997). However, producing nutritious live food is a challenge for hatcheries to operate in a sustainable manner. And, due to challenges in their intensive culture, copepods are projected to be more used in marine fish culture in abroad with the advancement of copepod culture techniques in recent years (Milione and Zeng, 2007; Camus *et al.*, 2009; Alajmi *et al.*, 2014, 2015), but copepods are hardly used as live feed in commercial hatcheries in Bangladesh. The objectives of this study were (i) to reduce the fish feed cost (ii) to increase the survival rate of fish and crustacean larvae, and (iii) to minimize the production cost following profit maximization.

2. MATERIALS AND METHODS

2.1. Site Selection

This study was conducted from March 2020 to February 2022 in 'FishzoneAgro Fisheries' situated in Ballabhdikanda (23.751550°, 90.635685°), Araihasar, Narayanganj, Bangladesh.

2.2. Commercial copepods production

The round tank (22'x22') was prepared on one decimal area by using a tarpaulin sheet (0.75mm) in the sunlight place and filled up with water up to the one-meter depth (35000 L) and set up the aeration system by LP100 (LP-100 Low Noise Aquarium Air Pump) (100 watts).

The raw materials and doses (g/decimal) for the primary core mixer were live feed creator (multi-stain probiotics mixture) 40, NaHCO₃ 400, rice polish 1200, wheat flour 800, and water 12 liter/decimal. The aforementioned materials were fermented in another plastic drum for 48 to 72 hours, and then the fermented mixture was dispersed across the pond. Then, copepods germinated within 48-72 hours and were ready for harvesting around one kilogram of copepods one week after the application of the fermented mixture; this process was repeated for up to 12 weeks. A 100-micron glass nylon cloth was used to harvest copepods. After seven days, the second dose was applied at 1/2 of the first dose, and the third dose was delivered at 1/4 of the first dose at seven-day intervals from the second dose. The third dose was continued up to the 12th week of zooplankton culture. In order to maintain the Phyto-zooplankton balance in the experimental pond, one-fourth of the water volume was replaced every month. The water was changed at both the bottom and the surface for improved outcomes. At three-month intervals, every arrangement was reconfigured for improved results. During the culture period, temperature, pH, and dissolved oxygen were kept within the limits of 25-30°C; 7.0-8.5; and 5.5-7.5 ml/l, respectively. Finally, 250g live copepods were packaged in 2-3 liters of water with double the volume of oxygen in a polybag for sale.

2.3. Nursery management with copepods

For nursery management with copepods, the following steps were maintained-

- a) Pond preparation: Three replications and a control pond were selected for every species. All pond dikes were repaired, mud from the concerning pond bottom was removed and made the bottom plain. The ponds were exposed to dry in the sun for 7 days. Then, it was filled with water up to one meter depth and liming was done at the rate of 1 kg per decimal after 3 days of water filling. A mixer with live feed creator 10gm, sodium bicarbonate 100gm, rice polish 300gm, wheat flour 200gm, and water 3 liters was allowed to keep in a plastic drum and lead it to ferment for 3 days. Then the fermented mixer was broadcast into the pond and copepods were germinated within 72 hours (in 1st week of Table 1).
- b) Stocking management: Six species like *Macrobrachium rosenbergii* 20000 PL/decimal, *Ompok pabda* 100/decimal, *Anabas testudineus* 50/decimal, *Cirrhinus cirrhosus* 10/decimal, *Oreochromis niloticus* 1000 juvenile/decimal, *Cyprinus carpio* 10/decimal were stocked at the favorable temperature and sunny day (morning or afternoon).

- c) Post-stocking management: After stocking, normal feeding was provided at the prescribed ratio of body weight. In the case of fish fry juvenile nursing with copepods, the core ingredients doses were sequentially continued from the 2nd to 6th week by following Table 1 with all required activities.

Table 1: Core materials used for copepod production in the nursery ponds.

Sl.	Ingredients	Week					
		1 st	2 nd	3 rd	4 th	5 th	6 th
1	Live feed creator (g)	10	5	2.5	2.5	2.5	2.5
2	Sodium bicarbonate (g)	100	50	25	25	25	25
3	Rice polish (g)	300	150	75	75	75	75
4	Wheat flour (g)	200	100	50	50	50	50
5	Water (ml)	3000	1500	750	750	750	750

2.4. Data Analysis

The calculation was done by using the following formulas:

Total production cost (BDT) = Sum of all ingredients and activities cost (Live feed creator + NaHCO_3 + Rice polish + Wheat flour+ Lease value + Labor wage+ Electricity charge + Depreciation cost of tank & equipment),

Profit (BDT) = Sale Price - Production cost

% Profit (BDT) = (Sale Price - Production cost) x100/ Production cost

Lease Value/week/Decimal (BDT) = (Per decimal lease value for one year/365) x 7

DCTE (BDT) = (Total Cost of Tanks and equipment)/20/365x7 (Considered tanks and equipment sustainable for 20years),

Survival rate (%) = (Final harvested fry number - Initial stocked fry number) x100/Initial stocked fry number, and

student t-test was used for significant differences ($P < 0.05$).

3. RESULTS AND DISCUSSION

3.1. Commercial culture of copepods

The total production costs (BDT) for commercially cultured copepods were higher in the first week (840.18) than in the second (728.18) and third weeks (672.18). Notably, the expenditures on copepod production from the third to the twelfth week were equal to 672.18 BDT. (Table 2). The amounts and prices of the four culture elements for the second and third weeks were half and one-fourth of the first week respectively but the establishment costs were constant every week.

Table 2: Expenditure (BDT) on ingredients and activities to produce copepods for 3 subsequent weeks.

Ingredients & activities	1 st week			2 nd week			3 rd week		
	Qt/Kg	Unit price	Price	Qt/Kg	Unit Price	Price	Qt/Kg.	Unit price	Price
LFC	0.04	2400	96	0.02	2400	48	0.01	2400	24
WF	0.8	35	28	0.4	35	14	0.2	35	7
RP	1.2	25	30	0.6	25	15	0.3	25	7.5
SB	0.4	175	70	0.2	175	35	0.1	175	17.5
LV	7 d	2.49	17.43	7 d	2.49	17.43	7 d	2.49	17.43
Lbrw	-	525.26	229.8	-	525.26	229.8	-	525.26	229.8
Etyc	-	8.25	147	-	8.25	147	-	8.25	147
DCTE	7d	31.71	221.95	7d	31.71	221.95	7d	31.71	221.95
Total cost	-	-	840.18	-	-	728.18	-	-	672.18

* LFC=Live feed creator, WF=wheat flour, RP=Rice polish, SB=Sodium bicarbonate, LV=Lease value (BDT/decimal/day), Lbrw =Labor wage, Etyc=Electricity charge, DCTE=Depreciation cost of tank & equipment, d=day.

3.2. Cost-profit analysis on commercial copepods production and Sale

From 1 lot culture arrangement of copepods with their subsequent activities, production continued for up to 12 weeks, with the first, second, and third weeks of production costing (BDT) 840.18, 728.18, and 672.18. However, the weekly yield was 1 kg and the average sale price (BDT) remained constant from the first to the twelfth week. Therefore, the profits (BDT) for the first two weeks were 1159.82 and 1271.82, and the profits for the third to twelfth weeks were 1327.82. The percentage profit (BDT) in the first, second, and third to twelfth weeks was 138.04, 174.66, and 197.54, respectively. The average costs, sales, profits, and profit percentage (BDT) were 690.85, 2000.00, 1309.15, and 190.67, respectively (Figure 1). Student t-test showed a significant difference ($P < 0.05$) between production cost and the sale price of commercial copepods production.

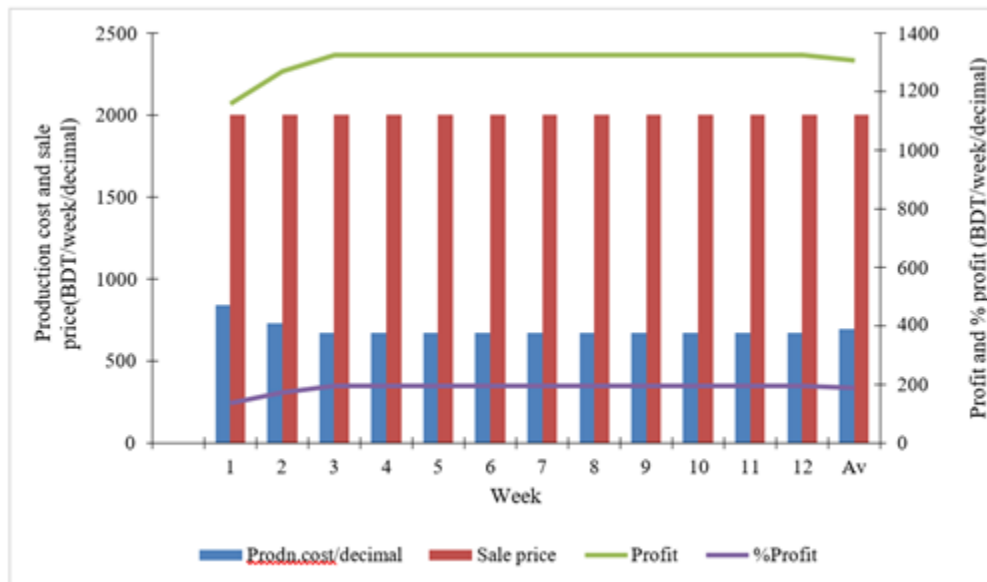


Figure 1: Cost-profit analysis of commercial copepods production.

3.3. Cost-profit analysis on nursery management and growth performance with and without copepods

Table 3 showed the nursery management costs (BDT) for 45 days per unit area (decimal) of experimented species treated with and without copepods where the use of copepods increased the cost of nursery management by very little. The seed, feed, labor, and other required materials costs (BDT) with and without copepods were more or less similar, but the treatment with copepods required an additional 121.25 BDT to include the live feed creator ingredients. Student t-test showed significant differences for all fry production costs (BDT) between with copepods and without copepods ($P < 0.05$).

Table 3: Nursery management Cost (Mean \pm SD) (per decimal) of with & without copepods.

Species	With copepods (BDT)	Without copepods (BDT)
<i>M. rosenbergii</i>	41483.25 \pm 300.00 ^a	41262 \pm 98.0 ^b
<i>O.pabda</i>	997.7 \pm 10.10 ^a	876.45 \pm 10.80 ^b
<i>A.testudineus</i>	1016.12 \pm 13.45 ^a	881.39 \pm 16.09 ^b
<i>C.cirrhosus</i>	1282.91 \pm 3.64 ^a	1161.7 \pm 18.80 ^b
<i>O.niloticus</i>	1458.20 \pm 1.0 ^a	1339.45 \pm 69.85 ^b
<i>C.carpio</i>	1081.20 \pm 10.00 ^a	959.95 \pm 17.35 ^b

Mean values with different superscripts in the same row differ significantly ($P < 0.05$)

Table 4 showed the production cost and production profits of fry (BDT) with and without copepods. The fry production cost and profit were significantly higher ($P < 0.05$) when using copepods. Lower fry production cost (per piece) was found for *Anabas testudineus* (0.29 ± 0.01) and higher for *Macrobrachium rosenbergii* PL (2.3 ± 0.05) and *Oreochromis niloticus* (2.02 ± 0.02). A higher profit was found for tilapia fry and Golda PL production (more than 85% for each species) per decimal area, whereas a lower profit was recorded for Koi fry production (58%) (**Figure 2**). Abate *et al.* (2016) conducted research on the cost-effectiveness of two alternative live feedstuffs used in juvenile turbot farming (copepods and artemia). The findings demonstrate that copepods are superior not just from a biochemical point of view but also from an economic point of view as a cost-effective supernumerary. Therefore, the commercial use of copepods will substantially reduce the production costs of turbot.

Table 4: Production cost and profit (Mean \pm SD) (BDT) of fry with and without copepods.

Species	Production cost of fry/piece		Fry production profit/decimal	
	With copepods	Without copepods	With copepods	Without copepods
<i>M. rosenbergii</i>	2.3 ± 0.05^a	4.13 ± 0.07^b	66516.75 ± 2700^a	18737.55 ± 3037.05^b
<i>O. pabda</i>	0.40 ± 0.01^a	0.49 ± 0.02^b	752.30 ± 69.21^a	383.55 ± 27.95^b
<i>A. testudineus</i>	0.29 ± 0.01^a	0.48 ± 0.04^b	1039.92 ± 82.85^a	881.39 ± 30.99^b
<i>C. cirrhosus</i>	0.44 ± 0.03^a	0.56 ± 0.04^b	1049.41 ± 141.83^a	486.78 ± 24.42^b
<i>O. niloticus</i>	2.02 ± 0.02^a	2.39 ± 0.09^b	330.80 ± 15.51^a	60.55 ± 9.75^b
<i>C. carpio</i>	0.40 ± 0.01^a	0.53 ± 0.03^b	1620.77 ± 52.98^a	840.05 ± 72.35^b

Mean values with different superscripts in the same row differ significantly ($P < 0.05$)

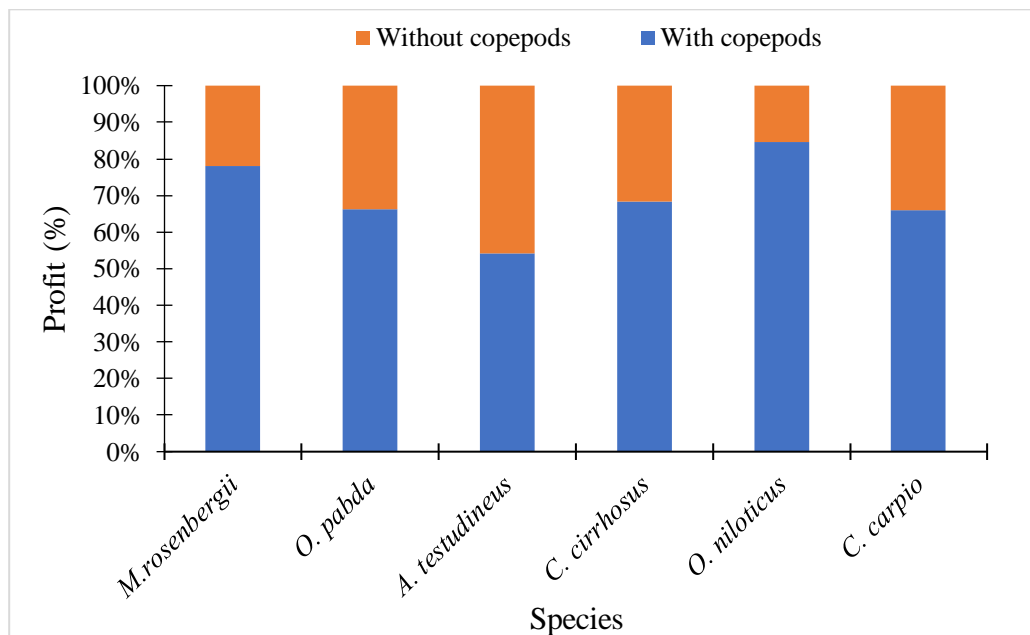


Figure 2: Fry production profit (BDT) per decimal with copepods and without copepods.

The FCR value of all species was significantly lower ($P < 0.05$) with copepods compared to without copepods except Tilapia. Lower FCR was found in *Oreochromis nilotica* (0.50 ± 0.01) and higher in *Ompok pabda* (1.0 ± 0.04) (Table 5). The survival rate per decimal for the same cases was also found significant variation ($P < 0.05$) between with copepods and without copepods (Table 5). Kadhar *et al.*, (2014) conducted research on the survival and growth of *Catla catla* fry using live feed and concluded that *Catla catla* fry showed significant increases in growth parameters, survival, SGR, FCR, and protein when fed with live feed such as Cyclopoid or in combination with Cyclopoid and Cladocera. Chhaba and Dabhade (2019) concluded Copepod feed shows a significant increase in growth lower FCR and a higher survival rate of *Catla catla*. A feeding experiment conducted by Janakiraman and Altaff (2015) using four different live feeds and a commercial pelletized feed revealed that the live feeds (rotifer 95%, copepod 90%, and Cladocera 85%) provided the best survival for young goldfish, indicating that the larvae utilized live feeds more effectively than the commercial pelletized feed. Sumithra *et al.* (2014) recorded a survival rate of 93.33% for fish-fed rotifer, followed by fish-fed pellet (6.63 %). Numerous studies have demonstrated that copepods considerably increase the survival rate of fish larvae (e.g., Shields *et al.* 1999; Toledo *et al.* 1999; Rajkumar, 2006; Wilcox *et al.* 2006). It is concluded that Copepods are the best feed source for growing commercial fish successfully.

Table 5: FCR and survival rate of commercially important fish (Mean±SD) with copepods and without copepods at the nursery levels.

Species	FCRvalue		Survival(%)	
	Withcopepods	Withoutcopepods	Withcopepods	Withoutcopepods
<i>M. rosenbergii</i>	0.60±0.02 ^a	1.08±0.06 ^b	90.00±5.00 ^a	50.00±1.50 ^b
<i>O.pabda</i>	1±0.04 ^a	1.59±0.06 ^b	83.33±0.99 ^a	60.00±1.00 ^b
<i>A.testudineus</i>	0.60±0.04 ^a	1.1±0.14 ^b	83.78±1.91 ^a	45.45±0.68 ^b
<i>C.cirrhusus</i>	0.89±0.06 ^a	1.25±0.20 ^b	85.03±1.82 ^a	68.67±0.60 ^b
<i>O.niloticus</i>	0.50±0.01 ^a	0.64±0.08 ^b	92.2±0.80 ^a	56.00±0.35 ^b
<i>C.carpio</i>	0.60±0.01 ^a	0.9±0.10 ^b	90.07±0.63 ^a	60.00±2.50 ^b

Mean values with different superscripts in the same row differ significantly ($P<0.05$)

5. CONCLUSION

The nutritional quality of copepods is regarded as superior to that of the regularly used live food, artemia, for all fish larvae. With the exception of methionine and histidine, copepods have a decent profile of amino acids and a high protein content (44-52%). Copepod production is easier than that of any other commonly used live feed, and its biochemical contents enhance growth, reduce mal-pigmentation, and enable the successful farming of finfish species. Due to the escalating price of fish feed, the aquaculture industry is currently in a precarious position. As the copepod is a common live food for all types of fish, it can be used in all aquafarms to reduce feed costs and sustain aquaculture production. It can reduce mortality to an appreciable degree and enhance the overall production of fry, hence increasing the profit of food fish farms or fry nurseries. Therefore, the production and utilization of copepods can be expanded throughout Bangladesh, and relevant authorities can accept initiatives for these projects.

ACKNOWLEDGEMENTS

The authors acknowledged the “FishzoneAgro Fisheries” for funding the research.

REFERENCES

- [1] DoF. (2022). Year Book of Fisheries Statistics of Bangladesh, 2020-2021. Fisheries Resource Survey System (FRSS), Department of Fisheries: Ministry of Fisheries and Livestock. 2022. Volume 38:138p.
- [2] FAO. (2020). *The State of World Fisheries and Aquaculture 2020. Sustainability in action*. Rome.
- [3] DoF. (2021). sNational Fish Week 2021 Compendium (in Bangla), Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh, 160p.

- [4] Payne, M. F. & Rippingale, R.J. (2001). Intensive cultivation of the calanoid copepod *Gladioferens imparipes*. *Aquaculture*, 201, 329-342.
- [5] Reid, J. W., & Williamson, C. E. (2010). Copepoda. In Ecology and classification of North American freshwater invertebrates. Academic Press. pp. 829-899.
- [6] Mehraj-Ud-Din, W., Altaff, K., & Haniffa, M. A. (2009). Study on the growth and survival of *Channa striatus* (Bloch) postlarvae using live feed. *Bangladesh journal of fisheries research*, 13(2), 131-135
- [7] Evjemo, J.O., Reitan, K. I. & Olsen, Y. (2003). Copepods as live food organisms in the larval rearing of halibut larvae (*Hippoglossus hippoglossus* L.) with special emphasis on the nutritional value. *Aquaculture*, 227, 191-210.
- [8] Miliou, H., Moraitou-Apostolopoulou, M. & Argyridou, M. (1992). Biochemical composition of *Tisbe holothuriae* (Copepoda: harpacticoida) and its differentiation in relation to developmental stages. *Ophelia*, 36(2), 159-166.
- [9] Støttrup, J.G. (2000). The elusive copepods: their production and suitability in marine aquaculture. *Aquaculture Research*, 31, 703-711.
- [10] Payne, M. F., Rippingale, R.J. & Cleary, J.J. (2001). Cultured copepods as food for West Australian dhufish (*Glaucosoma hebraicum*) and pink snapper (*Pagrus auratus*) larvae. *Aquaculture*, 194, 137-150.
- [11] Engell-Sørensen, K., Støttrup, J. G., & Holmstrup, M. (2004). Rearing of flounder (*Platichthys flesus*) juveniles in semiextensive systems. *Aquaculture*, 230(1-4), 475-491.
- [12] Olivotto, I., Capriotti, F., Buttino, I., Avella, A.M. & Vitiello, V. (2008). The use of harpacticoid copepods as live prey for *Amphiprion clarkii* larviculture: effects on larval survival and growth. *Aquaculture*, 274, 347-352.
- [13] Rajkumar, M. (2006). Suitability of the copepod, *Acartia clausias* as a live feed for seabass larvae (*Lateolabrax japonicus* Bloch): compared to traditional live-food organisms with special emphasis on the nutritional value. *Aquaculture*, 261, 649-658.
- [14] Sørensen, T.F., Drillet, G., Engell-Sørensen, K., Hansen, B.W. & Ramløv, H. (2007). Production and biochemical composition of eggs from neritic calanoid copepods reared in large outdoor tanks (Limfjord, Denmark). *Aquaculture*, 263, 84-96.
- [15] Toledo, J.D., Golez, M.S., Doi, M. & Ohno, A. (1999). Use of copepod nauplii during early feeding stage of grouper *Epinephelus coioides*. *Fisheries Science*, 65, 390-397.
- [16] Van der Meeren, T., Olsen, R.E., Hamre, K. & Fyhn, H.J. (2008). Biochemical composition of copepods for evaluation of feed quality in the production of juvenile marine fish. *Aquaculture*, 274, 375-397.
- [17] Tidwell, J. H., Schulmeister, G., Mahl, C., & Coyle, S. (1997). Growth, survival, and biochemical composition of freshwater prawns *Macrobrachium rosenbergii* fed natural

- food organisms under controlled conditions. *Journal of the World Aquaculture Society*, 28(2), 123-132.
- [18] Milione, M., Zeng, C., 2007. The effects of algal diets on population growth and egg hatching success of the tropical calanoid copepod, *Acartiasinjiensis*. *Aquaculture*, 273, 656-664.
- [19] Camus, T., Zeng, C., McKinnon, D.A., 2009. Egg production, egg hatching success and population increase of the tropical paracalanid copepod *Bestiolinasimilis* (Calanoida: Paracalanidae) fed different microalgal diets. *Aquaculture* 297, 169-175.
- [20] Alajmi, F., Zeng, C., 2014. The effects of stocking density on key biological parameters influencing culture productivity of the calanoid copepod, *Parvocalanus crassirostris*. *Aquaculture*. 434, 201-207.
- [21] Alajmi, F., Zeng, C., 2015. Evaluation of microalgal diets for the intensive cultivation of the tropical calanoid copepod, *Parvocalanus crassirostris*. *Aquaculture Research*, 46, 1025-1038
- [22] Abate, T.G., Nielsen, R., Nielsen, M., Jepsen, P.M. & Hansen, B.W. (2016). A cost-effectiveness analysis of live feeds in juvenile turbot *Scophthalmus Maximus* (Linnaeus, 1758) farming: copepods versus Artemia. *Aquaculture Nutrition*, 22, 899-910.
- [23] Kadhar, A., Kumar, A., Ali, J. & John, A. (2014). Studies on the survival and growth of fry of *Catlacatla* (Hamilton, 1922) using live feed. *Journal of marine biology*, 2014.
- [24] Chhaba, S.G. & Dabhade, D. S. (2019). Effect of Copepods as A Live feed on The Protein Content of Fish *Catlacatla*. *International E- Research Journal*.
- [25] Sumithra, V., Janakiraman, A. & Altaff, K. (2014). Influence of Different Types of Feeds on Growth Performance in Black Molly, *Poeciliasphenops*. *International Journal of Fisheries and Aquatic Studies*, 1, 24- 26.
- [26] Shields, R.J., Bell, J.G., Luizi, F.S., Gara, B. & Bromage, N.R. (1999) Natural copepods are superior to enriched Artemia nauplii as feed for halibut larvae (*Hippoglossus hippoglossus*) in terms of survival, pigmentation and retinal morphology: relation to dietary essential fatty acids. *Journal of Nutrition*, 129, 1186-1.
- [27] Wilcox, J.A., Tracy, P.L. & Marcus, N.H. (2006) Improving live feeds: effect of a mixed diet of copepod nauplii (*Acartia tonsa*) and rotifers on the survival and growth of first-feeding larvae of the southern flounder, *Paralichthys lethostigma*. *Journal of the World Aquaculture Society*, 37, 113-12.