An overview of the Freshwater Cladoceran*Daphnia magna* (Straus, 1820) and its Application in Fish Larviculture

Abstract

Over the last three decades, aquaculture has become increasingly important, leading to the commercial viability of various shellfish and finfish species. The production of live feed is gaining popularity as a way to enhance the nutritional quality of species raised in aquaculture.Daphnia is a type of small crustacean belonging to the Brachiopoda family, commonly found in freshwater environments. *Daphnia spp*. serves as an excellent natural food source for tropical fish fry and has emerged as an alternative to traditional fish feeds. Utilizing Daphnia in aquaculture offers benefits such as low cost and ease of cultivation. This study addresses the identification of Daphnia, its reproduction and life cycle, nutritional value, significance in aquaculture, and methods of cultivation.

Introduction

In the past thirty years, aquaculture has gained significant importance, with numerous shellfish and finfish species becoming commercially viable. This growth has resulted in the establishment of effective methods for breeding, reproduction, and the management of broodstock in captivity. Live food organisms are crucial as they supply necessary nutrients such as carbohydrates, proteins, amino acids, lipids, fatty acids, vitamins, and minerals, earning them the title of "living capsules of nutrition" [1]. However, the high price of Artemia nauplii cysts has led aquaculturists to explore alternative, suitable zooplankton options like Daphnia magna, Moina, rotifers, infusoria, termites, and bloodworms, which can be produced in large quantities. While feeding preferences differ among species, many require high-protein live food to improve growth performance, reproductive success, and survival rates [1].

The nutrition of fish is essential in aquaculture production because the survival and growth rates of cultured species, ultimately determining the industry's financial viability [2]. This aspect is particularly vital during the early larval stages, where mortality rates are elevated due to the significant nutritional requirements for growth and development, which are compounded by their underdeveloped digestive enzyme activity, making it difficult for them to absorb nutrients from inert food sources. Moreover, research indicates that

commercial diets often lack the necessary specificity and fail to meet the nutritional needs of all cultured species[3]. In response to this issue, the production of live feed is gaining popularity as a way to enhance the nutritional quality of species raised in aquaculture. Live food provides a natural source of proteins, lipids, carbohydrates, minerals, and vitamins. Additionally, it does not affect water quality(color and odour), and their constant movement,stimulate feeding in predators [4].

Cladocerans are zooplankton that belong to the class Crustacea within the phylum Arthropoda. These organisms primarily inhabit freshwater habitats, though they can also be found in brackish and marine environments. Their soft, non-thorny bodies make them an important food source for the larvae and juvenile stages of commercially important fish and prawn species. Consequently, are commonly used as an economical live food source in aquaculture hatcheries [5].Approximately 420 species have been recognized globally, with Daphnia being the most commonly cultivated species for the initial stages of finfish and shellfish feeds. This organism thrives in a range of habitats, from tropical areas to the Arctic, particularly in smaller ponds and larger freshwater lakes. While 50 species of Daphnia have been reported worldwide, only six are typically found in tropical zones [6].

The genera *Daphnia* and *Moina* are closely related and can be found globally, and are collectively referred to as *Daphnia* [7]. These organism´s serves a vital role as a live feed in freshwater aquaculture. Its distinctive appearance and erratic swimming patterns have earned it the nickname "water flea." This small crustacean ranges in size from 0.2 to 3.0 mm in length, with *D. pulex* and *D. magna* being the two primary species farmed for aquaculture purposes[7]. The lack of commercial feed options for the early stages of larval development underscores the importance of Daphnia as a key live food source in many freshwater fish hatcheries. Thus, advancements in Daphnia cultivation and a better understanding of its nutritional profile could significantly improve hatchery operations moving forward. This study focuses on the identification of Daphnia, its reproductive and life cycle, nutritional value, role in aquaculture, and cultivation methods.

Identification of*Daphnia*:

It has a large head with rostrum,thorax and abdomen covered by the carapace. The abdomen which is bent down ward is free of appendages. In cephalic appendages, second maxilla is absent. Paired eyes are fused in one. Five pairs of leaflike feet present on thorax [8].Daphnia have a body consisting of a head and a trunk. The antennae are the main means

of locomotion. Large compound eyes lie under the skin on the sides of the head. One of the major characteristics of daphnia is that the main part of the body, the trunk, is enclosed in an external skeleton (carapace). Periodically, they moult or shed their external shell. The brood pouch, where the eggs and embryos develop, is on the dorsal side of the female. In Daphnia, the brood pouch is completely closed [7].

Reproduction and Life Cycle of *Daphnia*

However, parthenogenesis reproduction is common in these organisms. The female produces an amictic eggs-a clutch of parthenogenetic eggs-and keep them in brood pouch. The developmental manner takes place in brood pouch and after completion of development in 3 days the smaller younger ones immediately released from the mother brood pouch. The produced daphnia seems plenty much like their mother, like a clone however without a brood pouch [9]. After six molting stages, the young *Daphnia* obtain maturity and produce the egg for first time – primiparestage. In general, it takes 5-10 days to attain the primipare level but, the duration is highly temperature based. once in 3-4 days interval, the adult daphnia releases the eggs which retain until her death. lifestyles span of daphnia under captive conditions is about 2 months [9].

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Factors, such as change in water temperature or food deprivation as a result of population increase, may induce the production of males. These males have one or two gonopores, which open near the anus and may be modified into a copulatory organ. The male clasps the female with the first antennae and inserts the copulatory processes into the single, median female gonopore [9]. The fertilized eggs are large, and only two are produced in a single clutch (one from each ovary), and are thick-shelled: these resting or dormant eggs being enclosed by several protective membranes, the ephippium. In this form, they are resistant to desiccation, freezing and digestive enzymes, and as such play an important role in colonizing new habitats or in the re-establishment of an extinguished population after unfavourable seasonal conditions.

Nutritional quality of *Daphnia*

Among zooplankton species, *D. magna* has excellent nutritional content that is recommended for use in feeding of fish larvae[10].*Daphnia sp.* is highly nutritious live food containing high protein content ranging from 45-72 % and the fat ranges from 6.5-8 % of its dry weight. Furthermore, its linoleic and linolenic fatty acids contents are 7.5 % and 6.7 %, respectively [11,12, 13].

Importance of Daphnia in Aquaculture

Daphnia is one of the most popular live feeds for aquaculture fishes. It is a frequently used food source in the fresh water larviculture (ie, for different carp species). They have been used extensively to rear larvae and fry [14,15]. Daphnia includes several species, the largest of which is *D. magna*, shows high reproductively. *D. magna* is mainly used, alive or preserved as food for fish in aquaculture [16,17].

D. magna comprises several digestive enzymes like proteases, peptidases, amylase, lipase, and cellulase which act as exoenzymes in the gut of fish. Being larger in size than Moina, it serves as live food for advanced stages of fish [18]. *D. magna* contains added protein and consequently, is a good replacement for Artemia nauplii in aqua hatcheries. *D. magna* has also been extensively utilized as a live-food source in various hatcheries and in the care and culture of aquarium fishes of commercial importance [19]. *D. magna* has the advantage of high reproduction rates, wide temperature tolerance, and the ability to thrive on phytoplankton and organic wastes. This enrichment of food with *D. magna* is accomplished with a basis of DHA, which helps the fish to make immune resistance against gill and water fouling problems [18, 20].Recently, Daphnia meal is successfully used as a fish meal replacer in the diet of *Pelteobagrusfulvidraco*[21]. Moreover, *D. magna* can be used as a bioencapsulation of probiotics during fish larvae feeding, as indicated by [22] who reported that Persian sturgeon (*Acipenserpersicus*) larvae fed with bioencapsulated *D. magna* with *Saccharomyces cerevisiae*had higher growth performance and better feed utilization.

The bioencapsulation of *D. magna* using the commercial probiotic *Bacillus*sp.bacteria (Protexin Aquatic) has been shown to enhance the resilience of *Acipenserpersicus* larvae to various stressors[23]. Munirasu[24]investigated the bio enrichment of live *D. magna* as a means to improve the survival and growth of the freshwater fish *Catlacatla*. Vivi [25] reported on the mass cultivation of *D. magna* Straus, 1820 in a fermented medium, which served as feed to enhance the nutrient quality and growth performance of Nile tilapia larvae (*Oreochromis niloticus*, Linnaeus, 1758). Rameshwar [26] explored the production of Daphnia for the nursery rearing of cultivable freshwater fish species. Abo [27] examined the impact of using *D. magna*(Straus, 1820) as a substitute for fish meal, assessing its effects on the growth, feed efficiency, histological condition, and economic viability of grey mullet (*Mugil cephalus*, Linnaeus 1758). Manjit [1] conducted experiments with *D. magna* (Straus,

1820) as an alternative live feed for *Pterophyllumscalare*, focusing on its potential for commercialization. Kethavath[8] studied Daphnia culture and evaluated its role in the growth and development of molly fish.

Culture Methods of *Daphnia*

Daphnia is a very good source of live feed in freshwater aquaculture industry.Cultivation of this species is not difficult as it can feed wide varieties of unused food residues. Herawati [12] mentioned that rice bran has high nutritional value and enhances the growth of *D. magna*. Additionally, it has widespread overall freshwater bodies. It is characterized as a suitable size for the mouth opening of many fish larvae and fry, and it has a high nutritional composition [28]. Its nutrient content varies according to the culture medium and the degree of availability of phytoplankton[12]. These are herbivores which mainly fed on micro algae. The herbivorous zooplankton growth rates are sometimes strongly correlated with the mineral and biochemical composition of the phytoplankton they consume reported that food nutrient content influenced the growth rate of *D. magna* even at very low food levels [29]. The best foods for culturing *Daphnia* are microalgae and yeast. For culturing, the algal feeds such as *Azollapinnata, Chlorella vulgaris*and the yeast (*S. cerevisiae*) are used. The advantages of algae as a food are that, algal feeds are easy to culture and it is an excellent feed for the growth of *Daphnia*. Yeast is easy to acquire, and there is a minimum of fuss while preparing it for the culture[29, 30]. The most critical environmental factor to successfully culture *Daphnia* is temperature, which should remain close to 20 °C (68 °F). Higher temperatures may be fatal to Daphnia and lower temperatures slow reproduction. It has a short generation time (9-11 days at 20°C), but total life span is longer (> 60 days at 20°C, up to one year at colder temperatures[30]. Daphnia can be cultured using various techniques, including batch culture, continuous culture, and recirculating systems.

Freshwater zooplankton, specifically Daphnia magna, can be cultured using different combinations of feed.Castro [31] investigated the laboratory cultivation of *D. magna* (Straus 1820) using microalgae and active dry yeast as feed. In a similar vein, Munirasu[5] explored how various feeds, including *C. vulgaris*, *A.pinnata*, and yeast, influenced the population growth of *D. magna*, which is commonly found in freshwater environments. Herman[32] examined the culture of *Daphnia sp*. and analysedthe impact of different manure types on growth, fertility, and mortality rates. Furthermore, Monowar[33] assessed the culture of freshwater zooplankton *D. magna* in Bangladesh, focusing on the effects of various feeding

combinations.Daphnia can be easily enriched with various compounds via a bio-enrichment process that enhances the nutritional quality of these live feed organisms. The materials that can be used for enriching *Daphnia*include microencapsulated diets, baker's yeast, and vitamins, which can be applied through feeding [9].

Conclusion

Daphnia is totally a vital Cladocera crustacean and it is taken into consideration as healthful and dietary food in aquaculture. Smaller length of daphnia and their rapid-transferring nature entice the fish larvae to seek them. Moreover, the simple rearing strategies and smaller rearing unit making them as crucial stay feed in freshwater hatcheries. *Daphnia* have large quantity of exoenzyme like proteinases, amylases, lipases and cellulase these are beneficial inside the digestion and boom of the growing fish larvae which exoenzymes aren't that much available in the other live feed.

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References

1. Monjit Paul, Mukti Chanda, Joydeep Das, Priyanka Maity, Sudip Mondal, Asim Kumar Giri. *Daphnia magna* (Straus, 1820)– an alternative live fish food for *Pterophyllumscalare* and its commercialization. TIJER - International Research Journal. 2023;10(7): 770-776.

2. Lazo JP. Conocimiento Actual y Nuevas Perspectivas en el Desarrollo de Dietas para Larvas de Peces Marinos. Cruz-Suárez LE, Ricque-Marie D, Tapia-Salazar M, Golvera-Novoa MA, Civera-Cerecedo R. (Eds). AvancesenNutriciónAcuícola V. 2000;300-312.

3. Sanchez-Estudillo L. Alimento nutritivo, colorido y en movimiento: Los Cultivos de apoyo en Acuicultura. Ciencia. 2011;15(43):55-60.

4. Castro BT, De Lara AR, Castro MG, Castro MJ, Malpica SA. Alimento vivo en la Acuicultura. Contactos. 2003;48:27-33.

5. Munirasu S, Uthayakumar V, Arunkumar P Ramasubramanian V. The effect of different feeds such as *Chlorella vulgaris*, *Azolla pinnata* and yeast on the population growth of *Daphnia magna* commonly found in freshwater systems. International Journal of Fisheries and Aquatic Studies. 2016;4(6):05-10.

6. Delbare D, Dert P. Cladocerans, nematodes and trochophora larvae. Manual on the Production and Use of Live Food for Aquaculture. 1996;283-295.

7. Rottmann RW, Scott Graves J, Craig Watson, Roy PE,Yanong. Culture Techniques of Moina: The Ideal *Daphnia* for Feeding Freshwater Fish Fry. UF/IFAS Extension. University of Florida. CIR. 2017;1054.

8. KethavathMadhudeepika, Dharavath Ram kumar, Jagadeeshwarachari T. Daphnia culture and evaluating the role of *Daphnia* in Molly fish growth and development. International Journal of Research Publication and Reviews. 2024;5,(9):230-236.

9. Bhosle et al. Production of Daphnia for Freshwater Nursery Rearing of Cultivable Fishes. Biotica Research Today. 2020;2(11):1218-1221.

10. El-feky, MM, Abo-Taleb H. Effect of feeding with different types of nutrients on intensive culture of the water flea, *Daphnia magna* Straus, 1820. Egypt. J. Aquat. Biol. Fish. 2020;24,655–666.

11. Herawati VE, Hutabarat J, Radjasa OK. Growth and survival rate of tilapia (*Oreochromis niloticus*) larvae fed by *Daphnia magna* cultured with organic fertilizer resulted from probiotic bacteria fermentation. HAYATI J. Biosci. 2015;22,169-173.

12. Herawati VE, Nugroho RA, Pinandoyo,Darmanto YS, Hutabarat J. The effect of fermentation time with probiotic bacteria on organic fertilizer as *Daphnia magna* cultured medium towards nutrient quality, biomass production and growth performance enhancement. IOP Conference Series: Science. 2018;116:012089.

13. Macedo CF, Pinto-Coelho RM. Nutritional Status Response of *Daphnia laevis* and *Moinamicrura*from a tropical reservoir to different algal diets: *Scenedesmus quadricauda* and *Ankistrodesmusgracilis*. Brazilian J. Biol., 2001. 61: 555-562.

14. De Pauw N, Laureys P, Morales J. Mass cultivation of *Daphnia magna* (Straus) on ricebran. Aquaculture. 1981;25:141-152.

15. Tay SH, Rajbanshi VK, Ho WH, Chew J, Yap EA. Culture of Cladoceran*Moinamicrura*kurz using agro industrial wastes. In Proceedings of the Fourth Asian fish Nutrition Workshop (de silva, S.S., ed.), 1991;135-141.

16. Edwards P, Pullin RSV. Waste water-fed aquaculture. Proceedings of the International seminar on Waste water Reclamation and Reuse for Aquaculture, Calcutta, India, 6-9 December 1988. Asian Institute of Technology Bangkok, Thailand. 1990;1:295-299.

17. Sevrin-ReyssacJ, Prolux D, Watteau S, Chemillier J. Eauxuseesetlagunage. Plusqu'unexutoire. Aquac. Rev. 1994;54:14-32.

18. Reza R, Hadi J, Mahdieh JH. A Comparative Study on the Growth Rate of Persian Sturgeon, *Acipenserpersicus*, Larvae Fed with *Artemia nauplii*urmiana and *Daphnia magna*, Global Veterinaria. 2013;10(2):116-120.

19. Martin L, Fajardo J, Arenal A, Pimental E, Pacheco M, Garcia C, Hidalgo L, Santiesteban D. Complete and partial replacement of Artemia nauplii by *Moinamicrura* during early post-larval culture of white shrimp *Litopenaeusschmitt*. Aquacult. Nutr. 2006;12(2):89-96.

20. Jafaryan HM, Makhtomii, Mahdavi M. The effect of baker's yeast for better utilization of nutrient compositions of *Daphnia magna*larviculture of Persian sturgeon (*Acipenserpersicus*). Aquaculture Europe. Trondheim, Norway. 2009;282-283.

21. Zhang H, Wang Y, Wu X, Zeng X, Yang G, Zhang J, Zhu G, Bai D. Effects of *Daphnia magna* meal replacing fish meal on growth, biochemical indexes of *Pelteobagrusfulvidraco* and water quality indexes. Feed Ind. 2019;2,212-221.

22. Soltani M. Effects of bioencapsulated *Daphnia magna* with Saccharomyces cerevisiae on the growth and feeding performance of Persian sturgeon (*Acipenserpersicus*) larvae. Iran. J. Vet. Med. 2012;6,13-18.

23. Faramarzi M,Jafaryan H,Roozbehfar R, Jafari M, Rashidi Y, Biria M. Influences of probiotic bacilli via bioencapsulated *Daphnia magna* on resistance of Persian sturgeon larvae against challenge tests. Glob. Vet. 2012;8,421-425.

24. Munirasu S, Ramasubramanian V, Uthayakumar V, Muthukumar S. Bio enrichment of live feed *Daphnia magna* for the survival and growth of freshwater fish *Catlacatla*. Int J Cur Res Rev. 2014;05(08):20-26.

25. ViviEndarHerawati, Johannes Hutabarat, PinandoyoPinandoyo, NurmanitaRismaningsih, OckyKarnaradjasa. Mass culture of *Daphnia magna* Straus, 1820 in Fermented Medium as Feed to Enhance Nutrient Quality and Growth Performance of Nile Tilapia *Oreochromis niloticus* (Linnaeus, 1758) Larvae 2019;2,42-49.

26. Rameshwar V, Bhosle1, Stephen Sampath Kumar J, Somu Sunder Lingam. Production of Daphnia for Freshwater Nursery Rearing of Cultivable Fishes. Biotica Research Today. 2020;2(11):1218-1221.

27. Abo-Taleb HA, Ashour M,Elokaby MA, Mabrouk MM, El-feky MMM,Abdelzaher OF, Gaber A,Alsanie WF, Mansour AT. Effect of a New Feed *Daphnia magna* (Straus, 1820), as a Fish Meal Substitute on Growth, Feed Utilization, Histological Status, and Economic Revenue of Grey Mullet, *Mugil cephalus* (Linnaeus 1758). Sustainability 2021;13,7093. https://doi.org/10.3390/ su13137093

28. Bogut I,Adamek Z,Puskadija Z,Galovic, D. Nutritional value of planktonic cladoceran*Daphnia magna* for common carp (*Cyprinus carpio*) fry feeding. Croat. J. Fish. Ribar. 2010;68,1-10.

29. Sterner RW, Schulz KL. Zooplankton nutrition: recent progress and a reality check. Aquat. Ecol. 1998;32:261-279.

30. Stones CS, Mills DV. The use of live yeast and yeast culture products in aquaculture. International Aquaculture feed. 2004; (5):28-34.

31. Castro-Mejía Jorge, Ocampo-Cervantes Jose Antonio, Castro-Mejía German, Cruz-Cruz Irina, Monroy-Dosta Ma del Carmen, Becerril Cortes Dan. Laboratory production of *Daphnia magna* (Straus 1820) fed with microalgae and active dry yeast. Journal of Entomology and Zoology Studies 2016;4(2):548-553.

32. Herman H, Andriani Y, Sahidin A, Hidayat T, Herawati T. Culture of Daphnia sp. (crustacean-cladocera): the effect of manure variation on the growth, natality, and mortality. IOP Conf. Series: Earth and Environmental Science. 2018;2, 32-40. doi :10.1088/1755-1315/137/1/012018.

33. MonowarAsif Khan, Md. Mohibul Hasan, Kizar Ahmed SumonHarunur Rashid. Culture of freshwater zooplankton *Daphnia magna* fed with different feed combination. Bangladesh J. Fish. 2020;32(1):55-59.