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ANIMAL SCIENCE

Using decapsulated local brine shrimp cysts on feeding common carp larvae in hatcheries

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Abstract: The current study aims at using non-hatchable artemia eggs of local origin and making use of these eggs by decapsulating and presenting them as food for the larvae of the *Cyprinus carpio* as a source of animal protein with high nutritional value instead of throwing them away. The results showed that the second parameter (A2) was highly significant at the level (P≤0.05) in the growth rates of the larvae that were fed on decapsulated artemia eggs alone, and it was better than the two control parameters (A1), in which the larvae were fed with feed designated for *Cyprinus carpio* fish. It also outperformed the third parameter (A3), in which the feed was mixed with artemia eggs with 50% decapsulation, which also outperformed the control parameter with high significance at the same level (P≤0.05).

Key words: Animal protein source, crustaceans, decapsulated eggs, growth rate, live food.

INTRODUCTION

Artemia is a crustacean specimen with high economic importance, particularly for fish breeders, as a source of animal protein (Watanabe et al. 1980). It can be used as a natural food for various types of fish, whether wet or dry (Stappen 1996). After rearing artemia larvae in controlled conditions, especially salinity, temperature, and nutrition, they are also used in their complete form after hatching or as adults in the nutrition of several species of fresh and saltwater fish, table fish, as well as ornamental fish. (Granvil 2000, Lim et al. 2002, Marc et al. 2015, Nemat et al. 2022).

Artemia has been used in most aquaculture facilities as food for many aquatic organisms such as shrimp, lobster, and other economic crustaceans (Laviña & Figueroa 1978, Gonzalez et al. 2008, Kouba et al. 2011). The production and farming of artemia were becoming common in some Arab countries that were interested in the breeding and production of artemia, such as Egypt, Tunisia, Libya, and the UAE (El-Bermawi 2003, El-Magsodi et al. 2005, Hachem et al. 2008, Al Dhaheri & Saji 2013, Hasan 2016). Artemia is a type of crustacean that can survive in harsh and changing environmental conditions, like temperature changes and drought. Moreover, it also has the ability to reproduce and survive, even though it has a relatively short lifespan. (Camara 2020).

The species was first documented in 1921 in the Karmat Ali area in Basra Governorate, southern Iraq. It is commonly found in highly saline inland water bodies (Gurney 1921). Nonetheless, it attracted the attention of Iraqi researchers who were interested in rearing and developing breeding systems for the local artemia, which is widespread in several Iraqi regions, particularly the center and the south. Moreover, the various life stages of artemia were adopted to feed the larvae of fish farming in Iraq, especially *Cyprinus carpio* and grass carp (Alubaydi 2005, 2012, Alubaydi et al. 2013).

The aim of the current study is to exploit neglected local natural resources into feed materials with high nutritional value for fish in Iraq under local conditions. Hence, the idea of using artemia eggs, which are non-hatching, has emerged provided that they are free of mold and fungi, and exploiting them after decapsulating with simple parameters to feed local fish, especially *Cyprinus carpio*, specifically in hatcheries to meet the larvae's need for live food. artemia eggs are a type of live food that is important for the early growth stages of fish and crustacean larvae in hatcheries. The decapsulated eggs have high nutritional values, particularly as a source of animal protein.

MATERIALS AND METHODS

Experiment

Three hundred *Cyprinus carpio* larvae were used and distributed randomly into three parameters, with 100 larvae per parameter: The first parameter was a control parameter (A1), in which the larvae were fed on commercial fish feed; the second parameter (A2) was represented by decapsulated local Artemia eggs; and the third parameter (A3) was a mixture of commercial feed with 50% decapsulated local artemia eggs. The average weight of the larvae at the beginning of this study was 0.75 ± 0.4 g, and the average length of the primary larvae was 1.17 ± 0.1 cm. The fish were fed 5% of their body weight for the duration of the experiment, which lasted 45 days immediately after the acclimation period, which lasted three weeks. These larvae were reared in circular plastic basins with a capacity of 150 liters, equipped with a highly efficient filtration system, in addition to using an automatic heater to set the temperature to 24 ± 0.5 degrees Celsius, which is the optimal temperature for the growth of *Cyprinus carpio* fish. The water temperature was measured using a regular mercury thermometer, and the pH was measured using a Hanna pH meter, in addition to measuring the percentage of dissolved solids in the water and the degree and concentration of ammonia. Furthermore, these measurements were taken every 15 days. A home air compressor was also used to distribute oxygen equally to all three experimental basins: A1, A2, and A3. The larvae were weighed every 15 days, and the total weight gain was calculated according to the equation mentioned by Alubaydi (2005).

Decapsulating and preserving Artemia eggs

The non-hatched eggs were soaked for one hour in order to hydrate and soften to get rid of floating impurities stuck to the eggs. The eggs were placed in 2-liter plastic conical bottles equipped with an air chamber to create internal currents that stirred the eggs in order to facilitate the decapsulation process. 50g of unhatched artemia eggs and 150 ml of sweetener (sodium hypochlorate) were added at a concentration between 5.25% and 3 ml of sodium hydroxide (NaOH). Moreover, the parameter took into consideration controlling the temperature, monitoring proper ventilation for turning, and noting the change in color of the decapsulated eggs, turning them from brown and dark brown to light orange (Alubaydi 2005).

The air was turned off and the eggs were left for 5 minutes to settle, whereas the decapsulated eggs were removed with a siphon and washed well with running water in a fine-mesh cloth (150 microns) until the strong chlorine smell was eliminated from the minor substance (sodium hypochlorite). A saturated salt solution was prepared to preserve the decapsulated eggs until using and presenting them to *Cyprinus carpio* larvae after washing them well with running water to get rid of the salts attached to these eggs as a result of preservation with the saturated salt solution (Campton & Busack 1989).

Statistical analysis

The statistical program Statistical Analysis System (SAS) (2018) was used to analyze the data to study the effect of various parameters on the studied characteristics according to a complete random design (CRD). Moreover, the significant differences between the means were compared with the Duncan (1955) multinomial test.

Mathematical Model:

Yij = μ + Ti + eij Since:
Yij: the value of the j view of transaction i.
μ: the general average of the studied trait.
Ti: effect of fish type i.
eij: Random error that is normally distributed with a mean equal to zero and a variance of σ2e.

RESULTS AND DISCUSSION

The results of the water assays, which included temperature, pH, carbon hardness (KH), and ammonia concentration (NH3), and dissolved calcium (GH) in addition to the total dissolved solids (TDS) of fish farming water, were illustrated in Table I.

The water assays, especially the pH, were appropriate for the growing conditions throughout the experiment Table I. pH values were changing within degrees suitable for the livelihood of *Cyprinus carpio*, as illustrated by Hapher (1988). It indicated that the appropriate pH for *Cyprinus carpio* growth was between 6.7 and 8.2. As for carbon hardness (KH), it was also suitable for rearing *Cyprinus carpio* fish, as explained by Al-Salman (1990) and FAO (1981).

It was also noted that the total dissolved solids (TDS) and ammonia concentration (NH3) and dissolved calcium (GH) from the same table above, which was represented by the percentage, was suitable for rearing (FAO 1984).

Table II shows the analysis of the nutritional elements of decapsulated Artemia eggs after keeping them in a salt solution and presenting them to fish larvae.

The control parameter (A1), represented by egg yolk emulsion, was superior to parameters A2 and A3 in terms of the increase in larval weight after 15 days of the experiment. The second parameter (A2), which consisted of an equal mixture of egg yolk emulsion and decapsulated Artemia eggs, was secondly ranked, followed by the parameter of decapsulated Artemia eggs alone (the third parameter, A3) Table III.

The discrepancy between these parameters can be attributed to the higher consumption and rapid digestion of the egg yolk emulsion, as well as the feeding of the carp larvae for a longer period of acclimation to it compared to the capsulated artemia eggs. This may be due to the weight increases that began to decrease

Table I. Analysis of the experimental rearing water.

Water analysis	Measurements every 15 days until the end of the experiment			
Temperature Celsius	30	29	25	26
pH	8.5	7.8	7.9	8.2
KH ppm	143.2			
GH ppm.	322.2	340.2	451	451
NH3 mg / L	0.25			
TDS ppm.	348	347	406	416

in the control parameter as the experiment progressed, compared to the second and third parameters, in which decapsulated artemia eggs were used mixed with egg yolk. The reason for the decrease in growth in the control parameter may be attributed to the differences appearing after 15 days of rearing. Furthermore, using decapsulated artemia eggs alone or mixed with egg yolk increases the energy content due to their high protein content. Fish larvae use protein as a source of energy by using available free amino acids during the first two weeks of hatching (Stappen 1996). Correct water characteristics and standards were provided, especially the optimum temperature for the growth of *Cyprinus carpio* larvae. These inferences are consistent with Alubaydi et al. (2013), Alubaydi (2005) and Francis et al. (2002). This diversity of feed materials gives a high readiness for protein deposition and good growth of fish larvae. This is consistent with the opinion of Atack et al. (1979), who explained that diets with a diverse protein composition of animal origin meet the needs of *Cyprinus carpio* fish more than diets with a single specialty protein of animal origin. The results of this study are consistent with those reported by Yaqub et al. (1997). Live food is also important in feeding *Cyprinus carpio* larvae at the beginning of their lives because of their high readiness and ease of digestion (Alubaydi 2005).

However, the results were completely different after 30 days of the start of experiment, as it was noted that the third parameter (A3) significantly outperformed the rest of the parameters, followed by the second parameter (A2) in the increase in growth of the experimental larvae. The control parameter (A1) declined clearly at the 30th day of the experiment, while the third parameter (A3) gave significant superiority at the level (P≤0.05). This gives evidence of the importance of live food, which is represented by decapsulated artemia eggs, as artemia eggs, their larvae, and even adults are excellent live food that can meet all the nutritional needs of fish larvae in the early stages of their lives. This is consistent with what was reported by Khaled et al. (2023): when mixing decapsulated artemia eggs or larvae with traditional feeds and presenting them to zebrafish, the results were good, and there was a clear increase in growth, even when they were fed with this mixture for a long period, as explained by Marc et al. (2015).

This result is consistent with the findings of the current study, as the second parameter (A2), which consisted of egg yolk emulsion

Table II. Chemical analysis of decapsulated artemia eggs.

Nutrients	%
Crude protein	50.45
Fats	10.38
Ashes	10
Humidity	2.34
Total energy	1650

Source: Central Laboratory/College of Agricultural Engineering Sciences.
Energy was calculated on the basis of 24 x the percentage of protein and 38 x the percentage of ether extract (kJ/g).

Table III. Average weight (g/live mass) of common carp larvae fed according to the experimental treatments.

Transactions	Initial weight	Day 15	Day 30	Day 45
A1	a 4.65 ± 0.00	a 5.13 ± 0.01	a 5.47 ± 0.01	a 5.83 ±0.01
A2	a 4.77 ± 0.00	a 4.89 ± 0.01	a 5.62 ± 0.01	a 6.32 ± 0.01
A3	a 5.13 ± 0.01	b 5.63 ± 0.01	b 6.58 ± 0.00	b 7.15 ± 0.00

Different letters horizontally indicate significant differences (P≤0.05).

and decapsulated artemia eggs, achieved good progress in the growth rate of *Cyprinus carpio* larvae. However, it did not overcome the growth rate in the third parameter (A3) when decapsulated artemia eggs were provided alone as live food for the larvae. Falahatkar et al. (2012) stated that egg yolk is also a good food that fish larvae could benefit from, whether on its own and for a limited time or when mixed with other live feed ingredients to give better results. Thus, the process of mixing decapsulated artemia eggs with traditional feed ingredients, such as emulsifiers, gives better results in improving the nutritional value of these feeds and improving growth (Alubaydi et al. 2013, Kamarudin et al. 2011) Table IV.

The growth rate values for *Cyprinus carpio* larvae were significantly higher (P≤0.05) for the third parameter (A3) from day 45 until the end of the experiment compared to both parameters A1 and A2. The latter, in turn, outperformed the control parameter also to a significant degree at the same level (P≤0.05), as shown in Table V, knowing that the weight increases were practically clear but did not appear when conducting the statistical analysis. In the third parameter (A3), decapsulated artemia eggs were relied entirely on to feed the *Cyprinus carpio* larvae, which gave clear evidence of the importance of animal protein sources in feeding the fish larvae, especially proteins that have a low percentage of fiber. This could provide high digestibility and a good representation of the nutrients provided to the fish larvae. Therefore, adult artemia, their larvae, and their capsulated eggs are almost completely lacking in complex fibers that require strong digestion. Decapsulated artemia eggs have high levels of protein, digestible energy, and large stores of fatty acids with high nutritional value, as indicated by Stappen (1996). This is clearly illustrated in Table II, which shows the analysis of the important nutritional components in decapsulated artemia eggs.

The values of the specific growth rate (SGR) and relative growth rate (RGR) did not change over the duration of the experiment Tables VI and VII, respectively, and no significant differences appeared between them in this study. It is possible that the stability of the specific growth rate (SGR) values or their decrease is due to the variation in the total weight. The specific growth rate (SGR) and relative growth rate (RGR) are also affected by the type of farming and the

Table IV. Average weight (g/fish) of common carp larvae fed according to the experimental treatments.

Transactions	Day 0	Day 15	Day 30	Day 45
A1	a 0.1860 ± 0.0085	a 0.2052 ± 0.0123	b 0.2188 ± 0.0115	b 0.2332 ± 0.0122
A2	a 0.1908 ± 0.0091	a 0.1956 ± 0.0110	b 0.2248 ± 0.0125	b 0.2528 ± 0.0129
A3	a 0.2052 ± 0.0130	a 0.2252 ± 0.0140	a 0.2632 ± 0.0080	a 0.2860 ± 0.0069

Different letters horizontally indicate significant differences (P≤0.05).

Table V. Weight gain of common carp larvae fed according to the experimental treatments.

Transactions	Day 15	Day 30	Day 45
A1	a 0.0192 ± 0.0150	a 0.0136 ± 0.0164	a 0.0144 ± 0.0078
A2	a 0.0048 ± 0.0153	a 0.0292 ± 0.0161	a 0.0280 ± 0.0170
A3	a 0.0200 ± 0.0204	a 0.0380 ± 0.0183	a 0.0228 ± 0.0092

Horizontally similar letters indicate no significant differences.

breeding method, as their rates increase in good breeding systems, especially those that are traditional and properly controlled. The values of the specific growth rate (SGR) and relative growth rate (RGR) decrease or are constant in uncontrolled rearing, despite the increase and development in fish growth (Kunindar et al. 2018, Halla et al. 2023).

Decapsulated artemia eggs or newly hatched artemia larvae are a valuable live food, especially for small fish larvae, whether these larvae are given decapsulated artemia eggs or fed with newly hatched Artemia larvae alike. If it was provided directly or mixed with egg yolk emulsion, it was evident in the second parameter (A2) of this study, which agrees with what was reported by (Nemat et al. 2022, Meshkini et al. 2010, Meshkini 2003). Decapsulated artemia eggs are also considered easily digestible food for fish larvae due to the presence of digestive enzymes. It is an important food source in hatcheries that are concerned with fish production and farming or other economic crustaceans such as shrimp and lobster. Although it is economically expensive, it provides high-quality food and results in high growth and food conversion for all aquatic organisms that are reared and produced in hatcheries. Furthermore, it is a crucial source of raw animal protein and essential fats for the growth of young fish and economically valuable crustaceans (Granvil 2000).

CONCLUSIONS

Artemia eggs are a valuable source of high-protein food for fish, whether they are used as decapsulated eggs, newly hatched larvae, or adults. They have a high nutritional value, particularly as a source of high-quality animal protein that is easy to digest because their bodies lack fiber. Furthermore, Artemia is able to survive in harsh environments and can reproduce even when its eggs are dried out and preserved for many years. However, it is expensive to obtain from high-quality sources, which is a challenge for fish breeders worldwide. There is ongoing research to find artemia strains that meet the needs of fish breeders at a lower cost. Thus, the highest levels of production of economical fish and crustaceans such as shrimp, oysters, and lobster are obtained, which feed on artemia larvae or eggs and even adults because they provide protein, beneficial fatty acids, and high-value digestive enzymes that give

Table VI. Relative growth rate % of common carp larvae fed according to the experimental treatments.

Transactions	Day 15	Day 30	Day 45
A1	a 9.990 ± 17.466	a 7.943 ± 14.904	a 10.037 ± 5.652
A2	a 9.638 ± 10.179	a 9.927 ± 22.437	a 10.448 ± 14.721
A3	a 9.376 ± 19.630	a 10.304 ± 30.518	a 5.868 ± 11.905

Horizontally similar letters indicate no significant differences.

Table VII. Specific growth rate (%/day) of common carp larvae fed according to the experimental treatments.

Transactions	Day 15	Day 30	Day 45
A1	a 0.235 ± 0.269	a 0.218 ± 0.218	a 0.111 ± 0.185
A2	a 0.221 ± 0.070	a 0.221 ± 0.389	a 0.221 ± 0.360
A3	a 0.275 ± 0.250	a 0.227 ± 0.558	a 0.095 ± 0.253

Horizontally similar letters indicate no significant differences.

high-quality growth. Therefore, using damaged and non-hatching eggs after decapsulating and preserving them instead of producing artemia as larvae offers a more economical option with lower costs compared to high-quality hatchable artemia eggs, which are somewhat expensive.

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Author contributions

TAGHREED S. ALUBAYDI: responsible for raising and producing Artemia in the laboratory, provided many sources and references related to this subject, prepared special emulsions for feeding Artemia in this article. MUHAMMAD I. GHAZWAN: worked on feeding Artemia in cooperation with Dr. Taghrid and collected many references that support this article, in addition to writing the texts of this article and continuous review.