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Evaluation of the growth performance of common carp Cyprinus carpio L. fry after adding a powdered mixture of some insects to their diets

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Abstract

This study was conducted to test the effect of adding an insect powder mixture on the performance of common carp fry which had initial body weight attained (16.65±0.01) g. A total of 72 fish they were randomly distributed into 4 treatments with 3 replicates (6 fish per replicate). A commercial Ferdaneh diet with a crude protein content of 30% and a gross energy 412 kcal/g was used. A commercial insect powder mixture (grasshopper and mealworms) was added to the diets at the following experimental levels: T0 was the control treatment without any addition. And it was added to T1, T2, and T3 at levels of 1%, 2%, and 3%, respectively. Fish performance was tested after 60 days of the experiment, based on weight gain, daily growth rate, relative growth rate, specific growth rate, feed conversion ratio, feed conversion efficiency, and protein efficiency ratio. The results of the statistical analysis showed that all addition treatments significantly exceeded on the control treatment, in the following order: T3 then T2, followed by T1, for all studied parameters hence, we conclude that common carp fry showed the best growth performance after adding the insect powder mixture at the above-mentioned levels to their diet, particularly at 3%.

Keywords: Evaluation, juveniles, common carp, growth performance, insect powder mixture.

I. Introduction

The increasing demand for fishmeal and its price volatility have placed tremendous pressure on fisheries, jeopardizing marine ecosystems and global fish stocks (Lalander *et al*. 2015). Several studies have shown that plant proteins can be an alternative to fishmeal in fish feed. Some of the nutritional problems associated with plant proteins, such as nutrient deficiencies and poor absorption of certain nutrients, are often associated with their use as a primary food source for humans (Gai *et al*. 2012). Since the main group of fish species used in aquaculture are either carnivorous or omnivorous, it is essential to search for sustainable and environmentally friendly protein sources that are readily available, cost-effective, and capable of energy conversion, such as insect protein (Xiao *et al*., 2018). Insects are a promising solution to the challenge of sustainable feeds in aquaculture, and their use offers several unique advantages (Röthig *et al*., 2023), such as their high nutritional value, as they are rich in proteins, essential amino acids, and nutrients necessary for fish growth and development (Llagostera *et al*., 2019). Therefore, insects are considered a sustainable and environmentally friendly alternative to aquaculture feeds (Mousavi *et al*., 2020). In recent years, insects have received significant attention as a viable and sustainable alternative to aquaculture feeds. Insects offer a range of benefits that make them an attractive option for sustainable feed production (Freccia *et al*., 2020). Many insect species have a protein content comparable to traditional feed sources such as fish meal. Furthermore, insects are rich in vitamins, minerals, and fatty acids essential for the growth and development of cultured organisms (Bingqian *et al*., 2023). Therefore, this study aims to evaluate the growth performance of juvenile common carp after adding a powdered mixture of certain insects to their diet.

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II. Materials and Methods

Experimental Fish

A total of 72 fish of common carp fry were brought from a private hatchery in Al-Mahawil District, Babil Governorate, with an average weight of 16.65±0.01 g. Upon arrival at the experimental site, the fish were gradually thermally acclimated. The experimental fish were then placed in a 0.3% saline bath for 5 minutes to eliminate any pathogens that might affect the experiment. They were then placed in storage tanks until they were distributed to the glass tanks.

Environmental Measurements

The following physicochemical properties of the water were measured during the experiment:

1- Water temperature

2- Dissolved oxygen in the water

3- pH

4- Salinity

5- Total hardness

Rearing System

The growth experiment was conducted in the animal house Lab which followed of Al-Qadisiyah University/College of Education/Department of biology from March 17, 2025 to May 15, 2025 by using 12 glass aquariums with dimensions 50 cm x 50 cm x 50 cm, with a volume of 0.125 cm3 and a capacity of 125 liters. The tanks were arranged in a U-shape and covered with plastic mesh covers to prevent fish from jumping out of the its. Each glass aquarium was equipped with a 25-watt aeration pump and a 50-watt water heater. Water was supplied to each aquarium through a 3/4-inch diameter pipe, which was closed at one end and connected at the other. A 1/2 horsepower water pump connected to a 500-liter plastic water tank filled with water and left for more than 8 hours to remove chlorine from the water. Another 1,000-liter tank is filled with tap water and used to store and supply the other tank. Water is drained from the glass aquariums via a hand pump into 1-inch diameter pipes that pass alongside the glass aquariums and connect to a 1-inch diameter main pipe, which in turn ends in a drain outside the experimental site. The experimental site was equipped with an electrical inverter to ensure continuous electricity during a national power outage.

The experimental feed used in the experiment

A ready-made floating diet, Fardaneh type, of Iranian origin, was used, prepared from the local market. Table (1) shows its chemical composition:

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Table (1) the chemical composition of Fardaneh diet*

Elements	Unit
Dry matter (%)	88
Crude protein (%)	30
Fat (%)	18
Crude fiber (%)	9
Ash (%)	9
Nitrogen free extract (%)	22
Phosphor (%)	1.5
Vit. C (mg)	250
Vit. E (mg)	200
Vit. D3 (I.U.)	2000
Vit. A (I.U.)	8000
Gross energy (Kcal/g)**	412

* Chemical composition according to the label affixed to the product by the manufacturer.

**Total energy = (% protein x 5.4) + (% fat x 9) + (% nitrogen-free extract x 4) (Jauncey and Ross, 1982)

Powder of insect mixture

Quantities of dried locusts and mealworms were obtained from the local market and used in feeding ornamental birds and fish. They were then mixed in equal quantities and continuously to ensure homogeneity. They were finely ground, and samples were sent to laboratories affiliated with the Ministry of Science and Technology to determine their chemical composition. They were then stored until used in preparing experimental feeds. Table (2) shows the chemical composition of the insect powder.

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Table (2) Powder of insect mixture

Element	Percentage (%)
Dry matter	93.26
Crude protein (N*6.25)	41.26
Fat	12.06
Crude fiber	7.15
Ash	3.65
Nitrogen free extract	29.14
Total	100%

Preparing of experimental diets

The Fardana floating diet was grinded into a very fine powder and a 10 kg was weighed to each experimental treatment, and insect powder was added according to the levels determined by the experimental design, as follows: T0: Control feed without any addition ; T1: Fardana floating feed powder + 1% insect powder. ; T2: Fardana floating feed powder + 2% insect powder ; T3: Fardana floating feed powder + 3% insect powder.Then, each diet was mixed well with the added amount of insect powder according to the levels determined in the study in order to distribute it homogeneously. Then, water was added to it at a rate of 350-400 ml per 1 kg until it became a solid paste. Then, the mixture was placed inside a National type grinding machine with 2-3 mm holes to form it into feed threads, which after drying will be used as feed pellets. Then, the diets were air-dried and exposed to sunlight after shaping until they were completely dry. After that, they were stored inside special bags to preserve them until they were used in the experiment.

Growth parameters

Weight gain = Final Weight- Initial Weight

Daily growth rate = Final Weight- Initial Weight/ ΔT (Schmalhousen ,1926).

Relative Growth Rate = Final Weight*Initial Weight/ Initial Weight (Uten,1978).

Specific growth Rate = Ln Final Weight- Ln Initial Weight **/** ΔT (Brown,1957).

Feed Conversion Ratio = weight of food intake / weight gain of fish (Uten,1978).

Feed conversion efficiency = weight gain of fish **/** weight of food intake *100 (Uten,1978).

Protein Efficiency Ratio = Weight gain / protein intake (Gerking,1971).

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Statistical analysis

The statistical program SPSS version (26) was used to analyze the data according to the Complete Randomized Design (CRD) ,significant differences between means were tested by using (Duncan,1955) multiple range test, at a significance level of (0.05).

III. Results and discussion

Environmental measurements

The water temperature ranged between 20-21°C, while the dissolved oxygen values in the water ranged between 7.4-7.1 mg/L, and the pH recorded values within the range of 7.1-7.23, and the salinity values ranged between 1.27-1.8 g/L, and the total hardness values of the water ranged between 455.2-450 mg/L. The environmental parameters recorded during the study period are considered suitable for the growth of common carp. According to Froese and Pauly (2011), common carp can tolerate a wide temperature range of 35-3°C. According to Salman (2000), the minimum dissolved oxygen level in water for carps is no less than 3 mg/L. Salman (1993) and others indicated that common carp can tolerate salinity levels as high as 14 g/L. The FAO (1981) indicated that the appropriate pH for common carp farming ranges from 6.5 to 9.5. Meanwhile, Al-Dubaikal (1996) indicated that total hardness, which reached 620 mg of calcium carbonate/L, is considered within the appropriate range for common carp. These results are consistent with some physical and chemical measurements by Jabbar and Salman (2023) and FAO (2009).

Growth parameters

A review of the statistical analysis results in Table (3) shows that all insect powder addition treatments (T1, T2, and T3), especially treatment T3, was exceeded on the control treatment of all studied parameters. T3 was exceeded and recorded the highest means of all mentioned parameters such as weight gain, daily growth rate, relative growth rate, specific growth rate, feed conversion ratio, feed conversion efficiency, and protein efficiency ratio. The exceeding of the addition treatments, especially treatment T3, may be attributed to the fact that insect powder is a promising alternative as a protein source in aquatic feeds due to its high protein content (35-61%) and fat content (13-33%), in addition to other factors that support and improve health, such as high energy, fat content, fiber, minerals, vitamins, chitin, and other major minerals (Ojha et al., 2021). Alternatively, the reason may be due to the insect mixture consisting of locusts and mealworms, and the unique combination of essential amino acids such as histidine, isoleucine, and leucine. Lysine, methionine, phenylenediamine, threonine, tryptophan, tyrosine, valine, and others, as well as some essential fatty acids such as oleic, linoleic, linolenic, lauric, myristic, palmitic, and stearic acids (Wu *et al*., 2020; Ahmed and İnal, 2024) improved the performance of T3 treatment fish for the above-mentioned criteria. This opinion was reinforced by what Belghit *et al*., (2019) indicated that insect meal contains large amounts of essential amino acids compared to fish meal and is characterized by a good balance between its basic components such as fats, proteins, minerals, and other micro- and macronutrients, which makes it an effective alternative in fish feed. Stenberg *et al*., (2019) also indicated that insect meal contains a diverse composition of fatty acids, the most important of which are omega-3 fatty acids. It also contains large amounts of antimicrobial substances and biologically active compounds that improve the health status of farmed fish. This opinion was also reinforced by what Alegbeleye *et al*., (2012) concluded in their study that partial substitution of 25% of the colored locust meal *Zonocerus variegatus* L. as an alternative to fish meal has beneficial effects on the performance of juvenile African gar *Clarias gariepinus* as they recorded the best values for the final average body weight, specific growth rate, feed conversion rate and protein efficiency ratio. Das (2024) also concluded that black mollies *Poecilia sphenops* can efficiently utilize mealworm meal when used at a 75% rate as a replacement for fish meal, as a significant improvement in growth efficiency and higher survival rate was recorded compared to the control treatment.

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The best feed conversion rate and efficiency was recorded of T3, followed by treatment T2, and then treatment T1, which they exceeded on T0. The reason for the exceeding of the addition treatments in general, and especially T3, may be attributed to the fact that both insect powders contain a diverse composition of essential amino acids and some fatty acids, as previously mentioned (Ahmed and İnal, 2024). These are considered attractive substances (Jannathulla *et al*., 2021), which are used in the field of fish farming as attractive factors that lead to improving the taste of food by fish and stimulating fish to eat food significantly (Polat and Beklevik 1999), which improves the feed conversion rate with high feed conversion efficiency. This is what Zou *et al*. (2017) indicated that adding attractive substances such as amino acids and others to the food of Nile tilapia *Oreochromis niloticus* The taste of food will be improved by incorporating chemical molecules into the food components, which increases the palatability and food intake of fish, increases their weight, and the absorption of nutrients, which in turn improves the feed conversion rate. This view is supported by what Zlaugotne et al. (2022) indicated, that the attractants in fish food increase the palatability of fish food and thus improve the feed conversion rate. This was recorded in this study by adding insect powder in varying proportions to the experimental treatments, the highest of which was in treatment T3. Consequently, this proportion of the two insect powders added a quantity of amino and fatty acids, previously indicated as attractants in fish food, thus improving the rate and efficiency of food conversion consumed by fish. Alternatively, the amino acids in insect powder, previously indicated as attractants (Jannathulla *et al*., 2021), may target the chemical signals of the senses of taste and smell in fish, which strongly attract fish to the provided food, thus increasing the feeding rate. It affects the amount of feed consumed and thus affects the performance of fish (Morais, 2016) or it works to simulate the taste of natural prey, thus activating the taste and smell receptors that stimulate the fish's response to feeding (Morais, 2017). As for the protein efficiency ratio, it is noted from reviewing the results in Table (3) that the addition treatments T1, T2 and T3 were significantly exceeded T0, and the lead was for the fish of treatment T3, as it exceeded on all experimental treatments and recorded the highest values for the aforementioned criterion. The reason for the exceeding of the addition treatments T1 and T2 in general, and the best-performing treatment T3 in particular, may be attributed to the composition of the experimental diets and the percentages of insect powder rich in crude protein added to them, which was reflected in the improvement of the composition of the experimental diets and according to the added percentages, as they were the highest in treatment T3, which had the best performance for this criterion and other studied criteria, or perhaps the reason is attributed to the content of the added insect powder from Essential amino acids (Ahmed and İnal, 2024) represent the building blocks of protein in the fish body, which results in high protein deposition in the fish muscles. This opinion was reinforced by what Sánches-Muros *et al* (2015) indicated that adding mealworms to the feed of Nile perch increased the final body weight, daily growth rate, protein efficiency ratio, and food conversion rate by increasing the level of mealworm addition. This opinion was agreed upon by what Tsado *et al* (2021) reached, that adding locust powder to the feed of the African grebe *Clarias gariepinus* resulted in an improvement in the growth and production of these fish.

Table (3) Some studied growth parameters (mean ± standard error) of common carp fry fed on mixture of insect powder during the duration of the experiment.

Studied parameters	Experimental treatments				Significant level
	T0	T1	T2	T3	
Initial weight (g)	0.05±16.62	0.006±16.65	0.03±16.64	0.005±16.69	N.S
Final weight (g)	0.01±38.96 d	0.15±40.23 c	0.06±41.74 b	0.21±45.15 a	0.05

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Weight gain (g)	0.04±22.23 d	0.15±23.7 c	0.09±25.09 b	0.23±28.27 a	0.05
Daily growth rate (g/day)	0.00±0.37 d	0.002±0.39 c	0.001±0.41 b	0.003±0.47 a	0.05
Relative growth rate (%)	0.68±132.93 d	0.93±141.54 c	0.87±150.74 b	1.85±167.55 a	0.05
Specific growth rate (%/day)	0.009±1.40 d	0.006±1.46 c	0.005±1.53 b	0.01±1.64 a	0.05
Food intake (g)	0.13±51.18 d	0.02±51.91 c	0.02±52.87 b	0.10±54.58 a	0.05
Feed conversation rate (g)	0.01±2.30 a	0.01±2.20 b	0.009±2.10 c	0.01±1.93 d	0.05
Feed conversation efficiency (%)	0.19±43.44 d	0.28±45.41 c	0.20±47.46 b	0.37±51.80 a	0.05
Protein efficiency ratio	0.006±1.44 d	0.009±1.50 c	0.006±1.55 b	0.01±1.67 a	0.05

*Different letters indicate significant differences between experimental treatments within the same row according to Duncan's multiple range test (Duncan, 1955).

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