EVALUATION OF DIET AND FUNCTIONAL TRAITS OF *CYPRINUS CARPIO* IN THE THIRD RIVER/ CENTRAL IRAQ

Kadhim J. L. Al- Zaidy
Assist. Prof.
Branch of pathology and clinical disease of poultry
Coll. Veterinary medicine, University of Kerbala
kadum.jwad@qu.edu.iq

Giuliana Parisi
Prof.
Agriculture Food Environment and Forestry
Forestry University of Florence, Italy
giuliana.parisi@unifi.it

ABSTRACT

This study was conducted in the Third River for the extended period from January 2022 to December 2022. A total of 327 *Cyprinus carpio* fish were collected. The measurements were carried out to show the monthly changes in food selection, some of the functional traits that influence feeding were also measured. The results showed that the highest rate of stomach values containing food was found in the months of May and July, while the highest level of feeding intensity was recorded in November. The results of the study suggested that the standard length for tested fish was 342.5±88.5.mm. Head length, and head depth were 77.91± 18.12 mm and 64.91± 15.03 mm consecutively. The study concluded that the functional traits exhibited by common carp improved their ability to adapt to their environment and that their status is not sensitive in the study area.

Keywords: Nutrition, Functional diversity, ecosystem health, Main Outfall Drain, trophic interactions, life below water

تقييم النظام الغذائي والسمات الوظيفية لاسماك *Cyprinus carpio* في النهر الثالث/وسط العراق

كاظم جواد لفته
أستاذ مساعد
قسم الامراض وامراض الدواجن والاسماك
كلية الطب البيطري ، جامعة كربلاء

جوليانا باريسي
أستاذ
قسم التغذية الزراعية والبيئة
جامعة فلورنسا ، ايطاليا

المستخلص:

أجريت هذه الدراسة في النهر الثالث للفترة الممتدة من يناير 2022 إلى ديسمبر 2022. تم جمع 327 سمكة *Cyprinus carpio*وتم قياس بعض الصفات الوظيفية التي تؤثر على طبيعة التغذية وكذلك تقييم نظام الغذائي للأسماك المختبرة شهريا. أظهرت النتائج أن أعلى قيمة عددية للمعد المحتوية على غذاء كان في شهري ايار وتموز، بينما سُجل أعلى مستوى لشدة التغذية في شهر تشرين الثاني. أشارت نتائج الدراسة أيضا أن معدل الطول القياسي للأسماك المختبرة بلغ 342.5 ± 88.5 ملم. في حين بلغت قيم طول الرأس وعمق الرأس 77.91 ± 18.12 ملم و 64.91 ± 15.03 ملم على التوالي. خلصت الدراسة إلى أن السمات الوظيفية التي أظهرتها أسماك الكارب الشائع قد حسنت من قدرتها على التكيف مع بيئتها وأن وضعها غير حساس في منطقة الدراسة.

الكلمات المفتاحية: التغذية، التنوع الوظيفي، صحة النظام البيئي، المصب العام، التفاعلات الغذائية، الحياة تحت الماء.

Received: 27/2/2025, Accepted:4/6/2025, Published: August.

INTRODUCTION

Aquatic ecosystems provide a wide range of habitats for fish communities, and each one of these habitats has a unique role in regulating biodiversity and controlling its resilience and stability (41). The common carp species (*Cyprinus carpio*) is considered a freshwater fish, they are also the first fish species to be unnaturally propagated on a large scale, and it is known that it is classified as the second-most common species of fish (45). Despite this widespread prevalence, this species often has detrimental effects on ecosystems (1,3,32). Including causing water turbidity and high levels of phosphorus. More recently, the detrimental effect of these species has been quantified by the functional redundancy of these species (25,23). Functional redundancy is defined as the presence of several species in a given environment that fulfill the same functional role (11,35). One of the most effective ways to learn about the functional role of species is to determine their feeding behaviour (6). Understanding the feeding habits of fish helps to assess the processes that affect fish communities as well as determine the frequency of roles for individuals within a fish community (4, 7, 10,24). From the functional perspective, body traits such as mouth size, body shape, and eye position, are expected to state the feeding strategies adopted by those species (2, 19).Can also provide information about the species' ecological specialization. Can also provide information about the species' ecological specialization, as well as how core resources are used. Can also provide information about the species' ecological specialization, as well as how core resources are used (2, 5). The Main Outfall Drain (MOD), or the Third River, expands from north of Baghdad city in the middle of Iraq to the city of Basra, which is located in southern Iraq, with a total length of approximately 565 km. It is geographically detailed into three sections (North, Central, and South), the central sector (the one in which the current study was conducted), it's considered the most sensitive part from a biological point of view, because it is the only and exclusive source of water to feed the Hawr Ad Dalmaj Marsh region (3). Despite the great importance of this part of the main estuary. Yet, there is a notable lack of studies on its biological characteristics. The current study aims to understand some aspects of the feeding of common carp fish in this body of water, as well as studying some of the functional traits associated with the functional diversity of these faunas.

MATERIALS AND METHODS

Samples were gathered from two sites within the central sector of the Main Outfall Drain (MOD). The first site is within the point (32°26'58.0" N, 45°06'17.3" E). The second position in the orbit of the point (32°11'12.5"N, 45°19'33.9"E) is southeast of the first site. It represents the only place to supply water to the Hawr Ad Dalmaj Marsh region (Fig. 1). Fish were caught monthly for the duration of the one-year trial, from January to December 2022. By using different fishing methods. Bag nets, gill nets, and cast nets from the two sites were used. The gillnets were erected for one night and then removed the next morning, the caught fish were placed on the ice until they reached the laboratory; it is one of the recommended methods to send sample fish for scientific research. As soon as the trapped samples arrived at the laboratory, the total length and the rest of the studied morphological traits were recorded, also, the weights of the studied samples were taken, and the data were rounded to the nearest millimeter and milligram, respectively. In this experiment, nine traits of function were measured, namely: Standard length (SL), Head length (HL), Head depth (HD), Oral gape (OG), and Mouth position (MP). Also Eye diameter (ED), Snout Length (SnL), Gut length (Glst), and Gill raker length (GRlst) are shown in Table 1.

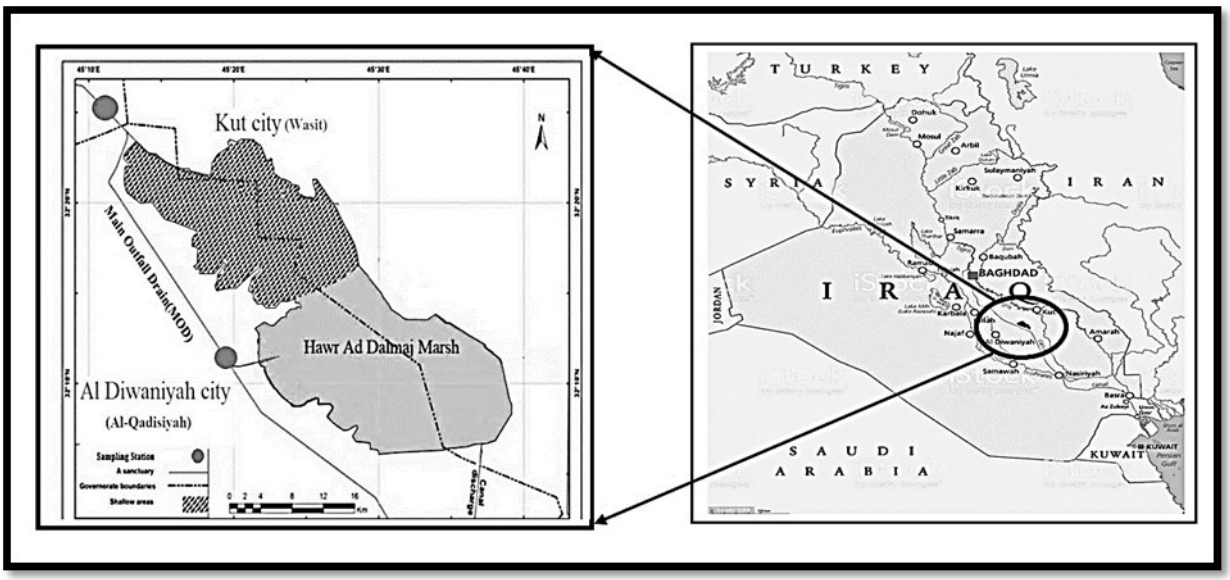

Figure 1. Map of the study area from the general estuary project in the center of Iraq

Table 1. The functional traits used for *Cyprinus carpio* fish assemblages with measurement methodology in the study

Functional traits	Trait definition	Functional category	Reference
Maximum standard length	It is the distance calculated from the beginning of the snout to the beginning of to the commencement of the foundation of the caudal peduncle.	Feeding, habitat use	[15]
Head length	Distance from the tip of the jaw to the posterior edge of the operculum	Feeding	[18]
Head depth	Vertical distance from dorsum to ventrum passing through the pupil	Feeding	[10]
Oral gape	Vertical distance measured inside of fully open mouth at tallest point	Nature/size and method of items captured	[10, 36]
Mouth position	The angle between an imaginary line connecting the tips of the open jaws with a straight imaginary line that lies between the center of the pupil on one side and the posterior vertebra on the other side. (e.g. 90 representing a terminal mouth)	Feeding, habitat use	[26]
Eye diameter	Horizontal distance from eye margin to eye margin	Vision for feeding	[37]
Snout length	Distance from the pupil to the tip of the upper jaw with mouth shut	Feeding	[40]
Gut length	Length of gut from the beginning of the esophagus to the anus (extended without stretching)	Feeding (residence time of food)	[17]
Gill raker length	Length of the longest gill raker	Filter feeding ability or the size of items retained	[16, 14]

To perform the analysis of the food items in the gut, an incision was made longitudinally at the end of the fish's body from the abdomen side; the alimentary canal was then excised and immersed in 5% formalin to preserve it. Due to the absence of a true stomach for Cyprinidae species. Each stomach was assessed by giving it a fullness score according to the point method (13). Its contents were then emptied into Petri dishes and classified using a microscope. Two methods were employed. The first method involves assigning points (P%) to each food item. As for the second method, it is dependent on the frequency or occurrence (F%) of each food item. The value of the Index of Relative Importance (IRI) evaluated according to (20). Feeding activity rate (%) and feeding intensity rate were evaluated according to (22).

RESULTS AND DISCUSSION

A total of 327 individuals of common carp fish were collected; only the gut components of fish with distended and full guts were analyzed. The mean of the standard length of fish sampled for their stomach content analysis was 231.08±72.11, the highest numerical value of guts containing food was in May and July, where 32 stomachs containing food were identified. Out of a total of 36 fish examined in May and 38 in July, the lowest numerical value for entrails containing food was in November; their number reached 13 fish out of

a total of 15 fish examined. As shown in Table No. 2. The incidence values of feeding activity, feeding intensity, and the vacuity index (%VI) for common carp differed significantly during the study period. The highest value for feeding activity was 91.3 and was recorded during February; the lowest value was noted in September, which was 84. Similarly, there was notable variability observed in feeding intensity throughout the study. The highest level was recorded in the month of November. The lowest was in the month of August with two values of 15.46 and 9.59, respectively (table 2). The manifestations of the values representing the percentage of the Vacuity index differed. The highest percentage was in October (15.15) and the lowest in February (8.7), as shown in Table2

Table 2. Shows Feeding activity, Feeding intensity, and Vacuity index for species of common carp during the study period

Month	examined stomachs	stomach contains food	Empty stomachs	Feeding activity	Feeding intensity	Vacuity index (%VI)
January	17	15	2	88.26	13.67	11.77
February	23	21	2	91.3	13.1	8.7
March	35	30	5	85.71	11.03	14.29
April	26	23	3	88.46	14.52	11.54
May	36	32	4	88.89	15.031	11.11
June	27	23	4	85.19	12.26	14.82
July	38	32	6	84.21	8.41	15.79
August	31	27	4	87.1	9.59	12.9
September	25	21	4	84	11.71	16
October	33	28	5	84.85	13.14	15.15
November	15	13	2	86.67	15.46	13.33
December	21	18	3	85.71	11.83	14.29

These results are in agreement with what was found by (30). When they studied the feeding habits of common carp species in the Naogaon region of Bangladesh. The coefficient of vacuity index (%VI) of the stomach of common carp fish ranged between 8.7% and 15.79%. During the two months of February and July, respectively. In addition, vacuity index values (% VI) appear to be closely related to the reproductive cycle of common carp fish, especially in the female species of it. Tessema et al (42) confirmed that the monthly fluctuations of the coefficient of stomach vacuity index of common carp fish are intimately linked with the sexual cycle. Furthermore, Manam & Quraishi (28) provided evidence to support this idea. They demonstrated that during the mating season, common carp fish had lower values of the stomach vacuity index; this was confirmed by Al-Zaidy (3) when he indicated that the highest level of gonadosomatic index (GSI) of common carp fish in the Main Outfall Drain/middle Iraq was in February. Meanwhile, the lowest values recorded for (GSI) were in July and August. Feeding intensity in fish increases before and after the spawning period, probably due to the high-energy cost required to obtain food, as metabolic activity decreases as spawning approaches (42). Based on the examination of the gut contents of the samples tested. The main food components in the feeding of common carp fish were plants, seeds, organic debris, and algae. As well as crustaceans, diatoms, aquatic insects, and zooplankton. Each of the plants and seeds, organic crumbs, algae, and aquatic insects, received the highest percentages of the Index of Relative Importance (IRI). Plants and seeds topped the list of *Cyprinus carpio's* main dietary components with 42.95%. Followed by organic crumbs at 22.7 %. Then followed algae and aquatic insects with close percentages. Wherein they amounted to 10.38% and 10.09%, respectively as shown in table 3. Among the nutrients, plants and seeds accounted for the largest proportion during the study months for all lengths of common carp but the largest proportion of this food component was recorded for fish that were ≥40 cm long. Common carp diversified the types of food items that which was eaten according to his height in relative terms (Figure 2). The contribution of plants and seeds and mollusca were the highest during the

study, where these percentages were increasing with the increasing length of fish. In contrast to diatoms and algae, which were decreasing with the increasing length of tested fish. Mollusca was recorded as the lowest food component for fish with lengths less than 20 cm. Whereas, diatoms were the lowest food component of fish that is a length greater than (or equal) to 40 cm in length (fig. 2)

Table 3. Shows two methods of analysis of gut content and Relative Importance (IRI%) for common carp during the study period

Food items	Point method		Frequency of occurrence		IRI%
	No	%	No	%	
Algae	556	13.01	197	58.98	10.38
plants and seeds	1426	33.38	318	95.21	42.95
Diatoms	112	2.63	74	22.16	0.78
Organic crumbs	894	20.93	268	80.24	22.7
Aquatic insects	538	12.59	198	59.28	10.09
Crustacean	235	5.5	143	42.81	3.18
Mollusca	460	10.77	185	55.27	8.93
Zooplankton	51	1.19	20.51	6.13	0.99

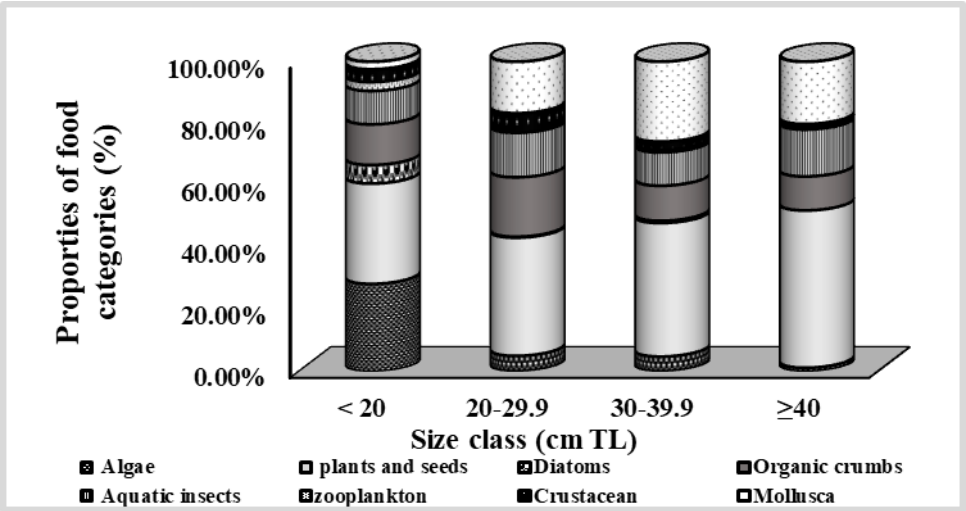

Figure 2. The percentage Index of Relative Importance (IRI) of prey organisms consumed by (n=327) *Cyprinus carpio* at different size classes during the study period

Fish dietary habits, based primarily on analyses of the composition of food consumed, are widely used within aquatic ecology as an effective means of investigating the course of trophic relationships within aquatic organisms. In this study, common carp species were found to feed items on a specific set of food items. Including food from plant origins such as aquatic plants and seeds, diatoms, and algae. As well as food from animal origins. Such as crustaceans, aquatic insects, zooplankton, and mollusca, as per Table 3. The fish samples tested showed that their feeding behavior was omnivorous; also, they have exhibited a notable inclination towards plant-origin food items over animal-origin nutrients. This preference included all specimens tested, regardless of the lengths of these individuals. The logical explanation for the high abundance of these items in the diets of these species. Due to the high availability of these nutritional components in this part of the Third River. These results of the nutrient ratios were similar and comparable to those reported by (43). The highest percentage of food items consumed by common carp were aquatic plants and seeds. According to the points method and frequency of occurrence. Therefore, the value of the digestibility coefficient of the Index of Relative Importance (IRI) was 42.95%. The results of this study differ from what Sahtout et al (38) found. During their study of the feeding habits of *Cyprinus carpio* fish at Foum El-Khanga Dam, Algeria. Where it was noted that crustaceans had the highest rate in the Index of Relative Importance. These differences are probably due to variances in the nutrients available to fish (34,8). The

nutritional composition of fish is influenced by spatial variation. As well as fluctuations in water quality and other factors (33,45). Taking into consideration that when there is no animal food available. Common carp species will be compelled to consume seeds and aquatic plants, according to Mohammed et al. (31,29). This explains the relatively low proportion of crustaceans and molluscs in this study. In the present study, eggs or parts of fish were not encountered in the diet of common carp. These results contrast with the findings of Hanaa and Manal (21). Where they recorded the presence of eggs in the guts of carp fish in the Al-Iatifiyah region of central Iraq. This result may be due to the unavailability of fish eggs in sufficient proportions in the study area. Especially since the Main Outfall Drain does not directly connect to the Tigris or Euphrates River, Which leads to a shortage of fish supplies (3). In addition, no fish body parts were found in the guts of the tested fish in this study. This is in contrast to what Saikia and Das found (39). This may be due to the availability of piscivorous fish in the study region. Such as *Leuciscus vorax* and *Silurus triostegus*, which are by nature more competitive than common carp fish. The analysis of the data from the current study showed. The nutrients consumed by common carp species vary depending on the season and the length of those fish. The most noticeable change was in the small fish (less than 20 cm SL). Where algae and diatoms comprised a high proportion of their diet. Adult fish (≥40 cm SL) were mainly fed on the plants and seeds. In addition to the aquatic insects throughout the study period. Juveniles of the common carp species are usually preferred for their diet. Shallow plant parts, benthic invertebrates, and algae (27). Also, the low percentage of these components in the diet of juvenile common carp fish could be due to unfavorable environmental conditions. Which led to its limited availability in this environment. During the study, it was also found that the mouth of the studied specimens of common carp had occupied a terminal position. It was also noted that the mouth cavity of the studied samples was devoid of any teeth. Table 4 shows the means of functional traits ± standard deviation (mm) for the captive fish. Where it shows that, the standard length was 342.5±88.5. The head length, head depth, eye diameter, and snout length were 77.91± 18.12; 64.91± 15.03; 5.93± 0.64; and 24.79±6.19 consecutively. The values of oral gape, gut length, and gill raker length were 2.94±1.81; 602.77±131.09; and 0.371±0.067, respectively.

Table 4. Average rates of morphometric observations for functional traits (in mm) for species of *Cyprinus carpio* during the study period

Functional traits	Code	Mean ±SD. (mm)
Standard length	**SL**	**231.08±72.11**
Head length	**HL**	**77.91± 18.12**
Head depth	**HD**	**64.91± 15.03**
Eye diameter	**ED**	**5.93± 0.64**
Snout length	**SnL**	**24.79±6.19**
Oral gape	**OG**	**2.94±1.81**
Gut length	**Glst**	**602.77±131.09**
Gill raker length	**GRlst**	**0.371±0.067**

According to the findings, the mouths of the common carp fish specimens studied had a terminal position. This is pointed out by Bakhtiyar et al (9), they clarified that the type of nourishment is mostly determined by the mouth's size. As well as its location on the external, structure. The same author added. Omnivorous fish that have bottom feeding usually have small mouths; these fish also have a terminal, or lower, mouth. This is consistent with the results of the current work. Where the rate of oral gape was 2.94 ± 1.81 for the studied carp fish during the experimental period. Mouth size is not the only factor associated with prey size. A wider range of prey sizes can only be consumed if feeding behavior is not size-selective. Also, the case if prey of different sizes is abundant (9). During the study, it was found that the common carp species lacks any teeth in the mouth cavity. Compensation was made for those teeth with sophisticated pharyngeal teeth. Which are situated in the back of the pharynx, upper the pharyngeal bone. Also, the

current results displayed the mean of the snout length, which was 24.79±6.19 mm. Gill rakers length and head length were 0.371±0.067 mm and 77.91± 18.12 mm, respectively. Also, eye diameter and head depth were 5.93 ± 0.64 and 64.91 ± 15.03 mm, respectively. Body shape is viewed as the dominant factor determining the feeding behavior of the fish (40).Waterways with low flows typically harbor fish with large eyes and large gills that exhibit filter feeding behavior (12). In common carp species, suction feeding is the predominant feeding method. In this type of feeding, the distance between the prey and the mouth is reduced. At the same time, the buccal cavity is expanded. As a result, a water current is generated that pulls the prey into the fish's mouth. Accordingly, this process cannot be completed successfully. Without synchronizing the characteristics of the head and mouth as required. The results of the current study showed that the mean gut length was 602.77 ± 131.09 mm. Also, it was observed that the gut length was greater than the total length of the fish that were examined. In slow-moving bodies of water, most fish populations are made up of species with lengthy intestines and terminal or subterminal mouths. The reason is due to the abundance of nutritional components of plant origin. In general, most of the studies that dealt with the nature of the relationship between dietary habits and gut morphology concluded that there is an important relationship between the length of the gut and the nature of nutrition (44, 46). Adaptation to habitat and food selectivity leads to differences in gut morphology. Besides feeding strategies between fish species or among fish of the same species. The results show that the diverse functional traits displayed by common carp fish have improved their capacity to adapt to their environment. This, in turn, increases their ability to effectively coexist with their external surroundings. The third river shows mostly variable chemical and physical characteristics. Assuming that it flows through agricultural areas and urban industrial areas. Thus, it can be considered that the studied common carp fish have a good chance to continue in this body of water.

CONCLUSION

This study was conducted in the Third River (Main Outfall Drain). Extending within the boundary of the Province of Al-Qadisiyah, central Iraq. From January 2022 to December 2022. The study aims to prove the monthly changes in the food selection of *Cyprinus carpio* fish. As well as understanding the dietary habits of this species. A study revealed the common carp were omnivorous. With tendencies for items of food of plant origin more than nutrients of animal origin. In addition, suction feeding is the predominant feeding method in common carp fish. From this, it can be concluded that the quantity and quality of food consumed by the tested fish varies depending on the length of the fish and the season of the year. The studied functional traits enhanced the ability of common carp to adapt to the environment of the Third River.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

REFERENCES

1. Al-Hilali, H., Lozovskiy, A., and M. Al-Khshali, 2025. The Natural Food Base of Nursery Ponds and the Diet of the Common Carp Fry in Iraq. Egyptian Journal of Aquatic Biology and Fisheries, 29(1), 1023-1046.

2. Alkhshali, M.Sh. and H.A. Al- Hilalli, 2017. Effect of gradual salinity increasing on some stress parameters (glucose,totalprotein,lactate) in blood plasma of common carp Cyprinus carpio L. Iraqi Journal of Agricultural Sciences, 48(2): 573-581. https://doi.org/10.36103/ijas.v48i2.424

3. Al-Zaidy, K. J. 2021. Study of some Reproductive Characteristics of *Cyprinus Carpio* (L., 1758) from Main Outfall Drain in Al-Qadisiyah City, Iraq. In IOP Conference Series: Earth and Environmental Science (Vol. 735, No. 1, p. 012075). IOP Publishing.

4. Al-Noori, A. A., A. J. Abuelheni, and M.S.Al-Khshali. 2024. Effect of adding natural and nano zinc oxide to the dite on some growth parameters of Cyprinus carpio L. Iraqi Journal of Agricultural Sciences, 55(5):1612-1619. https://doi.org/10.36103/gz903610

5. Al-Zaidy, K. J., and G. Parisi, 2025. The diet and feeding habits of leuciscus vorax fish in the main outfall drain middle Iraq. Iraqi Journal of Agricultural Sciences, 56(Special), 303-310. https://doi.org/10.36103/2n8vc846
6. Al-Zaidy, K. J., Parisi, G., and M. J. Y. Al-Amari, 2019. The fish community and food habits of fish species in hawr ad dalmaj marsh. Biochemical & Cellular Archives, 19.
7. Al-Khshali, M.S. 2019. Effect of different ratio of addition of NaCl to the diets on some growth traits in grass carp ctenopharyngodon idella. Plant Archives, 19: 908–911.
8. Artioli, L. G. S., and C. B. Fialho, 2024. Spatial variation in abiotic conditions and fish diversity in coastal lagoons, Southern Brazil. Acta Limnologica Brasiliensia, 36, e25.
9. Bakhtiyar, Y., Nissar, S., Arafat, M. Y., and R. Mushtaq, 2023. Feeding Ecology of Fishes-A Mini Review. Bulletin of Pure & Applied Sciences-Zoology, (1).
10 Bi, L., Huang, P., Huang, T., Liang, Z., Guo, D., and J. Zheng, 2024. Research on feeding behaviour of fish by using spatial and temporal features of depth images. International Journal of Bio-Inspired Computation, 23(2), 125-134.
11. Biermann, G., and J. Geist, 2019. Life cycle assessment of common carp (*Cyprinus carpio* L.)–A comparison of the environmental impacts of conventional and organic carp aquaculture in Germany. Aquaculture, 501, 404-415.
12. Bunnell, D. B., Ludsin, S. A., Knight, R. L., Rudstam, L. G., Williamson, C. E., Höök, T. O., and M. A. Koops, 2021. Consequences of changing water clarity on the fish and fisheries of the Laurentian Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences, 78(10), 1524-1542.
13. Das, S. K. 2024. Archer Fish Biology. CRC Press.
14. de Lima, D. E. P. C., and A. L. M. Pessanha, 2024. Changes in the food selectivity of zooplanktivorous fishes related to the effects of nutrient enrichment in an urban tropical estuary. Marine Pollution Bulletin, 209, 117146.
15. Ding, H., Zhong, T., Yang, Y., Ge, D., Wen, J., Zhao, C., and Z. Zhang, 2023. Length-Weight Relationships and Growth Patterns of Eight Indigenous Fish Species from Lancang River, Southwest China. Journal of Applied Ichthyology, 2023(1), 1629923.
16. do Nascimento, C. P., Dos Santos, N. C., Dal Vesco, B. M., and L. C. Gomes, 2020. Trophic morphology features allow Astyanax endemic species coexistence in a Neotropical river system. Journal of Fish Biology, 97(3), 776-784.
17. Duque-Correa, M. J., Clements, K. D., Meloro, C., Ronco, F., Boila, A., Indermaur, A., and M. Clauss, 2024. Diet and habitat as determinants of intestine length in fishes. Reviews in fish biology and fisheries, *34*(3), 1017-1034.
18. Endo, C. 2024. Feeding selectivity and a functional trade-off in a benthic fish with a continuous morphological variation: an experimental test. BMC zoology, 9(1), 5.
19. Everard, M. 2025. *Crucians (Carassius Carassius):* Biology, Ecology, Angling and Culture. CRC Press.
20. Gauzens, B., Kalinkat, G., Antunes, A. C., Boy, T., O'Gorman, E. J., Jacob, U., ... & Brose, U. (2024). Quantitative description of six fish species' gut contents and prey abundances in the Baltic Sea (1968–1978). *Scientific data*, *11*(1), 236.
21. Hana, H. M., and M. A. Manal, 1988. Limnological investigation on the Al-Iatifiyah common carp (*Cyprinus carpio*) pond (Baghdad-Iraq) and food and feeding habits of *Cyprinus carpio* L. 1758. Environmental Science and Health, 23(6), 513-524.
22. Hardy, R. W., Kaushik, S. J., Mai, K., and S. C. Bai, 2022. Fish nutrition—History and perspectives. In Fish nutrition (pp. 1-16). Academic Press.
23. Harikrishnan, M., Syanya, F. J., Khanna, A. N., Mumina, P., and W. M. Mathia, 2024. Ecological implications of unintentional aquaculture escapees: an overview of risks, remediation strategies and knowledge gaps in the aquaculture sector of India and riparian East African countries. Marine & Fishery Sciences (MAFIS), 37(4), 1.
24. Henderson, C. J., Gilby, B. L., Olds, A. D., Mosman, J., Connolly, R. M., Hyndes, G., and T. A. Schlacher,2022. Connectivity shapes functional diversity and maintains complementarity in surf zones on exposed coasts. Estuaries and Coasts, 45(6), 1534-1544.

25.Kajgrová, L., Blabolil, P., Drozd, B., Roy, K., Regenda, J., Šorf, M., and J. Vrba, 2022. Negative effects of undesirable fish on common carp production and overall structure and functioning of fishpond ecosystems. Aquaculture, 549, 737811.

26. Kroboth, P. T., Stahlschmidt, B. H., and D. C. Chapman, 2024. Black Carp *Mylopharyngodon piceus* (Richardson, 1846) Mouth Gape and Size Preference of a Bivalve Prey. Journal of Applied Ichthyology, 2024(1), 5551187.

27. Lee, T. M., Saif, U. M., Man, Y. B., and M. H. Wong, 2025. Growing Invasive Fish in Sewage-Fed Ponds to Improve Water Reuse and Food Security. In Sustainable Management of Invasive Species (pp. 473-506).

28. Manam, V. K., and M. A. Quraishi, 2024. Comprehensive review on Indian major carps: An integrated approach to pond cultivation, nutrition, and health management for sustainable aquaculture. International Journal of Fisheries and Aquatic Studies, 12(1), 01-12.

29. Mangalo, H. H., and M. M. Akbar, 1988. Limnological investigation on the Al-Latifiyah common carp (*Cyprinus carpio*) pond (Baghdad-Iraq). II pood and feeding habits op *Cyprinus carpio* L. Journal of Environmental Science & Health Part A, 23(6), 513-524.

30. Manon, M. R., and M. D. Hossain, 2011. Food and feeding habit of *Cyprinus carpio* var. specularis. Journal of Science Foundation, 9(1-2), 163-169.

32. Mohammed, H. H., Ebrahim, M., Youssef, M. I., Saleem, A. S. Y., and A. Abdelkhalek, (2024). Behavior and management of carp fish: A review. Open Veterinary Journal, 14(1), 1.

32. Mutethya, E., and E. Yongo, 2021. A comprehensive review of invasion and ecological impacts of introduced common carp (*Cyprinus carpio*) in Lake Naivasha, Kenya. Lakes & Reservoirs: Research & Management, 26(4), e12386.

33. Ouellet, V., Fullerton, A. H., Kaylor, M., Naman, S., Bellmore, R., Rosenfeld, J., and B. Sanderson, 2025. Food for fish: Challenges and opportunities for quantifying foods capes in river networks. Wiley Interdisciplinary Reviews: Water, 12(1), e1752.

34. Pinto, F. R., Duarte, A. M., Silva, F., Barroso, S., Mendes, S., Pinto, E., and M. M. Gil, 2022. Annual variations in the mineral element content of five fish species from the Portuguese coast. *Food Research International*, *158*, 111482.

35. Pombo-Ayora, L., Coker, D. J., Carvalho, S., Short, G., and M. L. Berumen**,** 2020. Morphological and ecological trait diversity reveal sensitivity of herbivorous fish assemblages to coral reef benthic conditions. Marine environmental research, 162, 105102.

36. Rajeeshkumar, M., Aneesh Kumar, K. V., Otero-Ferrer, J. L., Lombarte, A., Manjebrayakath, H., Saravanane, N., and V. M. Tuset, 2020. Differentiating morpho-functional patterns of the five most common deep-sea benthic anglerfishes (Lophiiformes) from Andaman and Nicobar Islands (eastern Indian Ocean).

37. Reynalte-Tataje, D. A., de Ávila-Simas, S., Lopes, C. A., da Silva, J. D. O., and E. Zaniboni-Filho, 2024. Guiding the path of larvae: The potential of light traps in Neotropical freshwater fish research. Environmental Advances, 16, 100516.

38. Sahtout, F., Boualleg, C., Kaouachi, N., Khélifi, N., Menasria, A., and M. Bensouilah, 2018. Feeding habits of *Cyprinus carpio* in Foum El-Khanga Dam, Souk-Ahras, Algeria. *AACL Bioflux,*, *11*(2.).

39. Saikia, S. K., & Das, D. N. (2009). Feeding ecology of common carp (*Cyprinus carpio* L.) in a rice–fish culture system of the Apatani plateau (Arunachal Pradesh, India). Aquatic Ecology, *43*, 559-568.

40. Șerban, D. A., Barbacariu, C. A., Burducea, M., Ivancia, M., and Ș. Creangă, 2024. Comparative Analysis of Growth Performance, Morphological Development, and Physiological Condition in Three Romanian *Cyprinus carpio* Varieties and Koi: Implications for Aquaculture. Life, 14(11), 1471.

41. Soengas, J. L., Comesaña, S., Blanco, A. M., and M. Conde-Sieira, 2025. Feed Intake Regulation in Fish: Implications for Aquaculture. Reviews in Fisheries Science & Aquaculture, 33(1), 8-60.

42. Tessema, A., Getahun, A., Mengistou, S., Fetahi, T., and E. Dejen, 2020. Reproductive biology of common carp (*Cyprinus carpio* Linnaeus, 1758) in Lake Hayq, Ethiopia. Fisheries and Aquatic Sciences, 23, 1-10.

43. Tynchenko, V., Kukartseva, O., Tynchenko, Y., Kukartsev, V., Panfilova, T., Kravtsov, K., and I. Malashin, 2024. Predicting Tilapia Productivity in Geothermal Ponds: A Genetic Algorithm Approach for Sustainable Aquaculture Practic-es. Sustainability, 16(21), 9276.

44. Wagaw, S., Enawgaw, Y., Wendimu, I., and H. Weldemichael, 2024. Seasonal Feeding Activity and Ontogenetic Dietary Shifts of the Common Carp (*Cyprinus carpio*) in Lake Arekit, a Small, Eutrophic Lake in Ethiopia. Aquaculture, Fish and Fisheries, 4(5), e70003.

45. Welsh, S.A**.** 2023. Hornyheads, Madtoms, and Darters: Narratives on Central Appalachian Fishes. Ohio University Press.

46. Whitlow, K. R., Ross, C. F., Gidmark, N. J., Laurence-Chasen, J. D., and M. W. Westneat, 2022. Suction feeding biomechanics of Polypterus bichir: Investigating linkage mechanisms and the contributions of cranial kinesis to oral cavity volume change. Journal of Experimental Biology, 225(3), jeb243283.