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EFFECT OF DIFFERENT SALINITY LEVELS ON GROWTH PERFORMANCE, HEMATOLOGICAL PARAMETERS AND PROXIMATE COMPOSITION OF *CYPRINUS CARPIO*

MUHAMMAD OWAIS[1], RIAZ-UD-DIN QURESHI[1], MUHAMMAD IRFAN[1], SIKANDAR JAMIL[1], RIFFAT YASIN[2], SUMRANA RAMZAN[3], IRISH ATIQ[3], SEHRISH ASHRAF[3], INAYAT ULLAH MALIK[3], KHIZAR SAMIULLAH[3], RANA MEHROZ FAZAL[3*]

[1]Department of Fisheries, Saline Water Aquaculture Research Center (SWARC), Muzaffargarh, Punjab, Pakistan
[2]Faculty of Veterinary Sciences, MNS, University of Agriculture, Multan, Punjab, Pakistan
[3]Department of Zoology, Ghazi University, Dera Ghazi Khan

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Cyprinus carpio, Salinity levels Growth performance, Hematological parameters, Proximate composition.

ABSTRACT

The current study was conducted to evaluate the effect of different salinity levels on the growth performance, proximate composition, and hematological parameters of Common carp (*Cyprinus carpio).* The experiment was designed under Laboratory conditions with twice replica as five treatments: T0: 0-ppt, (control); T1: 2-ppt, T2: 4-ppt, T3: 6-ppt and T4: 8-ppt and fish were randomly stocked (5 fish /aquarium). The *C. carpio* were fed 5% (commercial diet CP-30%) of their body weight and water was replaced regularly after every alternate day. The present study describes the significant changes ($p<0.05$) in growth parameters (viz; final weight, weight gain, feed intake and feed conversion ratio) with poor feeding behavior and stress were observed with further increase in salinity. Furthermore, body composition (Protein, fat, moisture, and ash contents) also showed significant changes ($p<0.05$). The crude protein and moisture contents were significantly decreased while crude fat and ash contents were increased with the increase of salinity respectively. The results of hematological parameters also decrease with the increase of salinity and found significant changes ($p<0.05$). The results of this study indicate that *C. carpio* exhibits a great degree of adaptability and resistance to salinity stress. This study serves as a basis for developing strategies to optimize the rearing conditions and welfare of common carp in different salinity regimes. Further research is warranted to elucidate the molecular and cellular mechanisms involved in the observed responses, enabling more precise management practices for the sustainable cultivation of *C. carpio*.

1. INTRODUCTION

Salinity is an abiotic factor that affects body composition, growth performance and hematological parameters of aquatic organisms (Moffett *et al.,* 2023). It is considered as an important factor that impact on osmosis, physiological functions, hormones, enzymes, immune metabolism and survival of fish (Wang & Zhu, 2002; Akhtar *et al.,* 2010).

*Corresponding Author**:** rfazal@gudgk.edu.pk

High salinity causes mortality, low reproductive rates and in some freshwater species reproductive failure is also reported (Hintz & Relyea, 2019). In the worldwide, natural waters are exposing to continuous rise in salinity levels due to human activities such as the use of salt or desalination of plants and uneven rainfall (Al-Faiz *et al.,* 2009; Fazio *et al.,* 2013; Hintz & Relyea, 2019). Therefore, climatic conditions of Pakistan do not sustain and changed into underground brackish and saline water (Jarwar, 2014; Khan *et al.,* 2016).

Aquaculture plays an important role in solving worldwide crises such as salinity, famine and malnutrition by the production of fish in intensive and non-intensive culture systems. In aquaculture practices some organisms have evolved to fully adapt to tolerate a wide range of high salinity levels, such as the common carp (*Cyprinus carpio*) (Triantaphyllopoulos *et al.*, 2020). *C. carpio* belongs to Family Cyprinidae considered as potential candidate live in freshwater habitat, although it can tolerate to some salinity and has been testified to improves growth and survival, but higher levels of salinity seem to be injurious (Barus *et al.*, 2001; Mangat & Hundal, 2014). It is known as a potential candidate for profitable aquaculture worldwide (Eurasia) due to its high adaptive capabilities (Parkos & Wahl, 2014; Tessema *et al.*, 2020). The common carp is stenohaline fish that can tolerate various environmental conditions such as extreme salinity and resistance to pathogens. It can adjust the hematological characteristics, allied with immune response display physiological status which effects on growth and physical appearance (Akinrotimi *et al.*, 2012). In aquaculture, common carp is a familiar fish due to its fabulous taste and its excellent market demand (Nedoluzhko *et al.*, 2021).

Salinity also can impact on hematological parameters which are assessed as indicators, play vital roles in maintaining physiological functions and overall health of organisms (Kim & Kang, 2016; Ahmed *et al.*, 2020). The alterations in blood parameters are thought to be adaptive responses to changes in the osmotic balance caused by variations in salinity. The increase in salinity levels inspiring to decrease in red blood cell counts, suppress immune responses, leading to decrease in the number of white blood cells and a compromised immune system (Soegianto *et al.*, 2017; Ramesh *et al.*, 2018). Such immunosuppression can render the fish more susceptible to various diseases and infections in brackish or seawater environments (Jackson *et al.*, 2020).

The aim of this scientific study is to investigate the impact of varying salinity levels on growth performance, hematological parameters and proximate composition of *Cyprinus carpio* to provide valuable insights into the species' adaptability and optimize their husbandry in diverse aquatic environments.

2. MATERIALS AND METHODS

The Common carp (*Cyprinus carpio*) were collected from pond of fish hatchery, Saline Water Aquaculture Research Centre (SWARC) Muzaffargarh and transported to Laboratory. Fish were acclimatized for 7 days in freshwater glass aquaria before the experiment began. The experiment was designed into five treatments (T1: 2-ppt, T2: 4-ppt, T3: 6-ppt and T4: 8-ppt) respectively and control group (T0: 0-ppt). Each treatment had two replicas and 5 fish/aquarium were randomly stocked in each treatment. Fish were fed 5% of their body weight with Commercial diet CP-30% and water was exchanged regularly after every alternate day. The aquariums were properly equipped, and continuous aeration was provided to maintain dissolved oxygen. All of the physicochemical parameters were maintained by using Apera 8500 EC meter, Apera 8500 pH meter and P-512 dissolved oxygen meter on daily basis. The salinity of the treatments were gradually maintained by increases of salt and tested by Salinity meter on daily basis. Detritus and uneaten feed were removed on daily basis by siphoning out.

Growth performance

Growth parameters viz; Final weight, weight gain, feed intake, growth rate and FCR were recorded by following formulas:

Weight gain = Final weight- Initial weight
FCR= feed given (g)/ Weight gain (g)
Growth Rate (%); WG (g)/ WI (g) X 100
Feed Intake; FCR × Weight gain (g)

The following measurements were taken (Owais *et al.*, 2023)

Proximate composition

The proximate inspection of desiccated fish meat was supported by procedures of Association of Analytical Chemist (AOAC, 1984). Samples were weighted at 105°C to determine moisture. Protein content was determined by measuring nitrogen (N×6.25) using the Kjeldahl method. Fat was confirmed by ether extraction using Soxhlet method. Crude ash was calculated following combustion at 550 °C for 6h (Owais *et al.*, 2023).

Blood sampling

The blood samples of experimental and control group fish were taken at the end of the experiment. It was collected by using a 5 ml disposal syringe. From each fish 1 ml of blood was collected into blood count test tubes that contain anticoagulant EDTA solution. The hematological parameters (Hemoglobin: Hb, Platelet count: PLT, Red blood cell: RBC, mean corpuscular volume: MCV, Hematocrit: HCT and Mean corpuscular hemoglobin: MCH) were tested by using a fully automated blood cell counter machine.

Statistical Analysis

SPPS (ver. 22, USA) was used for statistical analysis of the data. Data were subjected to one-way ANOVA and Duncan's multiple range tests to determine the significant differences between the means.

3. RESULTS AND DISCUSSION

The results of growth performance revealed that decrease in Final weight (g), Weight gain (g), Feed intake (g), Growth rate (%) while feed conversion ratio increased when salt concentrations gradually rose from 0-ppt to 8-ppt. The statistical analysis shows significant differences ($P \geq 0.05$) in treatments. Results of growth parameters show weight gain (g); T0: 0-ppt (11.28±0.28), T1: 2-ppt (10.34±0.38), T2: 4-ppt (9.02±0.17), T3: 6-ppt (8.52±0.27) and T4: 8-ppt (7.64±0.26) respectively. Feed intake (g); T0: 0-ppt (14.58±0.37), T1: 2-ppt (14.47±0.42), T2: 4-ppt (12.95±0.12), T3: 6-ppt (12.26±0.36) and T4: 8-ppt (12.38±0.51) respectively. Growth Rate (%); T0: 0-ppt (95.72±0.93), T1: 2-ppt (87.39±1.75), T2: 4-ppt (81.52±2.95), T3: 6-ppt (73.54±2.51) and T4: 8-ppt (69.73±3.33) respectively. Feed conversion ratio; T0: 0-ppt (1.27±0.01), T1: 2-ppt (1.39±0.01), T2: 4-ppt (1.40±0.03), T3: 6-ppt (1.41±0.02) and T4: 8-ppt (1.65±0.05) respectively (Table 1, Figure 1).

Results of hematological studies revealed that decrease in blood counts like red blood cells (RBC), hemoglobin (Hb), mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), hematocrit (HCT) and platelet count (PLT) when the salt concentrations gradually rose to 0-ppt to 8-ppt. The statistical analysis showed significant differences ($P \geq 0.05$) in treatments. The RBC $10^6 \times mm3$ counts as in treatments; T0: 0-ppt (0.42±0.09), T1: 2-ppt (0.38±0.05), T2: 4-ppt (0.33±0.06), T3: 6-ppt (0.29±0.06) and T4: 8-ppt (0.23±0.01) respectively. Hb g/dl**;** T0: 0-ppt (3.33±0.07), T1: 2-ppt (3.28±0.07), T2: 4-ppt (2.62±0.21), T3: 6-ppt (2.22±0.01) and T4: 8-ppt (2.17±0.01) respectively. MCH pg; T0: 0-ppt (78.70±0.45), T1: 2-ppt (75.86±0.39), T2: 4-ppt (73.68±0.19), T3: 6-ppt (70.62±0.33) and T4: 8-ppt (65.00±0.59) respectively. MCV μm3**;** T0: 0-ppt (76.68±0.43), T1: 2-ppt (73.30±0.48), T2: 4-ppt (69.24±0.53), T3: 6-ppt (65.06±0.39) and T4: 8-ppt (59.14±1.34) respectively. HCT %; T0: 0-ppt (3.34±0.03), T1: 2-ppt (3.25±0.06), T2: 4-ppt (2.83±0.02), T3: 6-ppt (2.68±0.02) and T4: 8-ppt (2.35±0.01) respectively. PLT 10^9/l; T0: 0-ppt (717.40±1.02), T1: 2-ppt (710.60±1.12), T2: 4-ppt (670.00±7.07), T3: 6-ppt (654.20±1.52) and T4: 8-ppt (562.00±2.67) respectively (Table 2, Figure 2).

The results of proximate composition revealed that decrease in Crude Protein and Moisture with the increase of salinity while Crude fat and Ash content increase with the increase of salinity. The significant differences are found in the treatments. The values of Crude Protein %; T0: 0-ppt (17.44±0.16), T1: 2-ppt (16.48±0.08), T2: 4-ppt (15.42±0.15), T3: 6-ppt (14.24±0.10) and T4: 8-ppt (13.64±0.12) respectively. Crude fat %; T0: 0-ppt (9.38±0.08), T1: 2-ppt (11.44±0.23), T2: 4-ppt (13.44±0.16), T3: 6-ppt (14.32±0.11) and T4: 8-ppt (15.28±0.08) respectively. Moisture %; T0: 0-ppt (80.44±0.14), T1: 2-ppt (77.74±.049), T2: 4-ppt (73.92±0.54), T3: 6-ppt (71.18±0.46) and T4: 8-ppt (65.16±0.98) respectively. Ash %; T0: 0-ppt (1.46±0.02), T1: 2-ppt (1.74±0.05), T2: 4-ppt (2.68±0.08), T3:6-ppt (2.86±0.09) and T4: 8-ppt (3.60±0.07) respectively (Table 3, Figure 3).

The present study was conducted to the Effect of different salinity levels on growth performance, Hematological parameters and proximate composition of Cyprinus carpio. The findings of the study revealed that no mortality on different salinity regime between 0 to 8-ppt. The growth parameters revealed that decrease in Final weight (g), Weight gain (g), Feed intake (g), Growth rate (%) while feed conversion ratio increased with the increased of salinity. Mylonas *et al.*, (2009) revealed that regime in salinity 0-ppt to 8-ppt affects the growth rate, feed conversion and feed intake. However, fish was perfectly able to normalize body functioning such as osmoregulatory process and metabolic rate. The high level of salinity increases metabolic rate because of new osmotic conditions leads to control necessary ions through osmoregulation and to maintain the internal stability (homeostasis) which needs high energy cause reduction in growth rate and effects the feed conversion ratio and feed intake. Abo- Hegab & Hanke, (1982) describe changes in feed conversion rate of common carp with the increase of salinity upto15-ppt. DeBoeck *et al.* (2000) studied common carp (*Cyprinus carpio*) at 10-ppt salinity and found negatively impact on feed conversion rate, weight gain and feed intake while Laiz-Carrión *et al.* (2005) describes the effect of salinity on fish reported poor growth performance depends on species and duration of exposure. Barman *et al.* (2005) entitled that decline in growth parameters viz; feed conversion and feed intake of grey mullet (*Mugil cephalus*) on high salinity. Luz *et al.*, (2008) studied the goldfish *Carassius auratus* and reported low feed conversion rate at 8-ppt. Furthermore, Xia *et al.*, (2010) studied grass carp *Ctenopharyngodon Idella* at different salinity levels and reported low feed conversion rate at 10-ppt.

The current study results exhibited a significant effect of various salinity levels on hematological parameters decrease in haemoglobin content, RBCs and haematocrit in treated groups. These findings are in similar agreement with another researcher who found a significant effect of salinity on RBCs, HCT and Hb of different fish species and high salinity levels with the osmoregulatory dysfunction (Fazio *et al.*, 2013; Soltanian *et al.* 2016). McCormick, (2001) explained that blood parameters play a significant role in health status of fish and reported salinity influence on physiological changes which leads to decrease in blood parameters. *Cyprinus carpio* hematological parameters are found significantly decreases in blood parameters at high salinity.

Luz *et al.* (2008) explained that salinity is used as stress indicators for hematological and physiological parameters of the fish and reported that increase in salinity level affects the ion exchange mechanism. Al-Hilali & Al-Khshali, (2016) examined the impact of high salinity on the blood parameters of common carp and reported that salinity levels did influence certain hematological parameters. Elarabany *et al.* (2017) reported significant changes in hematological parameters of Nile tilapia (*O. niloticus*) at higher salinities levels. Mubarik *et al.* (2019) examined hematological parameters of *Cyprinus carpio* under different critical and chronic salinity regimes. It found significant effects on various blood parameters, including hemoglobin concentration. Murmu *et al.*, (2020) explained the effect of salinities on hematological parameters on Rohu fingerlings and explained the decreased in RBC counts at 6-ppt. Similarly, MCH and haemoglobin content are also drastically reduced in the fishes treated with high salinity. Salati *et al.* (2021) reported the impact of salinity levels in *C. carpio* and demonstrate variations in hematological parameters.

The proximate composition such as moisture, protein, lipid, and ash of common carp are affected by salinity. The result revealed significant differences among all of the treatments. The protein and moisture contents decreased with increase of salinity while minimum protein and moisture content were found at 8-ppt. Fat and ash contents increased with increase of salinity, maximum contents were found at 8-ppt respectively. Barman, (2012) studied milk fish proximate composition which shows significant reduction in level of moisture with increase in salinity from 0 to 15-ppt. Ljubojević *et al.* (2015) reported decreasing in protein content and the increasing in lipid contents in the *Lutjanus guttatus* and carp. Daudpota *et al.* (2016) studied body composition of *C. carpio* at higher salinities and reported changes in the protein, moisture, lipid, or ash contents because osmoregulation expenditure is required high energy contents. Rahim *et al.* (2017) studied the body composition of the common carp at higher salinity and found significantly higher fat content because fish store more energy to cope with the osmotic stress of salinity. Mandal *et al.* (2020) studied the proximate composition of *Pangasius* at different salinity levels, found protein and moisture contents decreased with the increase of salinity while Fat and ash contents increased with the increase of salinity.

4. CONCLUSION

This study summarized that growth performance, hematological parameters and proximate composition of common carp (*Cyprinus carpio*) are influenced by different salinity levels. *C. carpio* exhibits a great degree of adaptability and resistance to salinity stress, which can impact its overall health and physiological responses. These findings contribute to a profound understanding about ecological significance of salinity in aquaculture and natural aquatic environments. This study may serve as a basis for developing strategies to optimize the rearing conditions and welfare of common carp. Further research is warranted to elucidate the molecular and cellular mechanisms involved in the observed responses, enabling more precise management practices for the sustainable cultivation of this economically important fish. Overall, this scientific investigation sheds light on the intricate relationship between salinity levels, growth and physiological well-being of aquaculture industry and contributes to understanding of aquatic ecosystems.

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6. CONFLICT OF INTEREST

All authors have declared that there is no conflict of interests regarding the publication of this article.

REFRENCES

Abo-Hegab, S., & Hanke, W. (1982). Electrolyte changes and volume regulatory processes in the carp during osmotic stress. *Comp. Biochem. Physiol., 1A (2)*, 157-164.

Ahmed, I. (2020). The influence of endogenous and exogenous factors on hematological parameters in different fish species: a review. *Aquaculture International*, *28*, 869–899. https://doi.org/10.1007/s10499-019-00501-3

Akhtar, M. S., Pal, A. K., Sahu, N. P., Alexander, C., Gupta, S. K., Choudhary, A. K., & Jha, A. K. (2010). Stress mitigating and immunomodulatory effect of dietary pyridoxine in Labeo rohita (Hamilton) fingerlings. *Aquacult Res, 41*(7), 991–1002.

Akinrotimi, O. A., Agokei, E. O., & Aranyo, A. A. (2012). Changes in blood parameters of Tilapia guineensis exposed to different salinity levels. *Journal of Environmental Engineering and Technology*, *1*(2), 4-12.

Al-Faiz, N. A., Jabir, A. A., & Yesser, A. A. K. (2009). Variance salinity concentrations affect survival, growth and feeding of common carp (Cyprinus carpio) fingerlings. *Iraqi J. Aquacul.*, *6*(2), 59–70.

Al-Hilali, H. A., & Al-Khshali, M. S. (2016). Effect of water salinity on some blood parameters of common carp (Cyprinus carpio). *International Journal of Applied Research in Veterinary Medicine, 14*(3), 218-222.

Barman, U. K., Garg, S. K., & Bhatnagar, A. (2012). Effect of different salinity and ration levels on growth performance and nutritive physiology of milkfish, Chanos chanos (Forsskal)-field and laboratory studies. *Fisheries and Aquaculture Journal*, 1-12.

Barman, U. K., Jana, S. N., Garg, S. K., & Arasu, A. R. (2005). Effect of inland water salinity on growth, feed conversion efficiency and intestinal enzyme activity in growing of grey mullet, Mugil cephalus (L.): Field and laboratory studies. *Aquaculture International*, *13*, 41–256.

Barus, V., Peaz, M., & Kohlmann, K. (2001). *Cyprinus carpio* (Linnaeus, 1758). In Banarescu PM, Paepke HJ, editor. The freshwater fishes of Europe, v. 5/III; Cyprinidae 2/III, and Gasterosteidae. Germany: AULA-G GmbH Wiebelsheim; pp. 85–179.

Daudpota, A. R., Memon, M. A., & Memon, M. A. (2016). Effect of salinity on growth, body composition and biochemical profile of common carp (Cyprinus carpio). *Journal of Fisheries and Aquatic Sciences, 23*(1), 14-20.

DeBoeck, G., Vlaeminck, A., Linden, A., & Blust, R. (2000). The energy metabolism of common carp (Cyprinus carpio) when exposed to salt stress: an increase in energy expenditure or effects of starvation. *Physiol. Biochem. Zool.*, *73*(1), 102-111.

Elarabany, N., Bahnasawy, M., Edrees, G., & Alkazagli, R. (2017). Effects of salinity on some haematological and biochemical parameters in Nile tilapia, *Oreochromus niloticus*. *Agriculture, Forestry and Fisheries, 6*(6), 200-205.

Fazio, A., Marafioti, S., Arfuso, F., Piccione, G., & Faggio, C. (2013). Influence of different salinity on haematological and biochemical parameters of the widely cultured mullet, *Mugil cephalus*. *Marine and Freshwater Behaviour and Physiology*, *46*(4), 211–218.

Hintz, W. D., & Relyea, R. A. (2019). A review of the species, community, and ecosystem impacts of road salt salinization in fresh waters. *Freshwater Biology*, *64*(6), 1081-1097.

Jackson, L. K., White, J. M., & Anderson, D. L. (2020). Immunomodulatory effects of salinity in common carp (*Cyprinus carpio*). *Fish Pathology*, *12*(4), 289-297.

Jarwar, A. M. A. (2014). Using saline groundwater for aquaculture. *Daily Dawn Karachi, July 14, 2014.*

Khan, M. N., Shahzad, K., Chatta, A., Sohail, M., Piria, M., & Treer, T. (2016). A review of introduction of common carp (*Cyprinus carpio*) in Pakistan: origin, purpose, impact and management. *Croatian Journal of Fisheries, 74*(2), 71-80.*

Kim, J. H., & Kang, J. C. (2016). Changes in hematological parameters, plasma cortisol, and acetylcholinesterase of juvenile rockfish, *Sebastes schlegelii* supplemented with dietary ascorbic acid. *Aquacult. Rep.*, *4*, 80–85. https://doi.org/10.1016/j.aqrep.2016.07.001.

Laiz-Carrión, R., Sangiao-Alvarellos, S., Guzmán, J. M., Martín del Río, M. P., Soengas, J. L., & Mancera, J. M. (2005). Growth performance of gilthead sea bream *Sparus aurata* in different osmotic conditions: Implications for osmoregulation and energy metabolism. *Aquaculture, 250*, 849–861.

Ljubojević, D., Radosavljević, V., Puvača, N., Baloš, M. Z., Đordević, V., Jovanović, R., & Ćirković, M. (2015). Interactive effects of dietary protein level and oil source on proximate composition and fatty acid composition in common carp (*Cyprinus carpio* L.). *J. Food Compost. Anal.*, *37*, 44-50.

Luz, R. K., Martínez-Álvarez, R. M., De Pedro, N., & Delgado, M. J. (2008). Growth, food intake regulation and metabolic adaptations in goldfish (*Carassius auratus*) exposed to different salinities. *Aquaculture*, *276*(1-4), 171-178.

Mandal, S. C., Kadir, S., & Hossain, A. (2020). Effects of salinity on the growth, survival and proximate composition of pangas, *Pangasius hypophthalmus*. *Bangladesh Journal of Zoology*, *48*(1), 141-149.

Mangat, H. K., & Hundal, S. S. (2014). Salinity tolerance of laboratory reared fingerlings of common carp, *Cyprinus carpio* (Linn.) during different seasons. *Int. J. Adv. Res.*, *2*(11), 491-496.

McCormick, S. D. (2001). Endocrine control of osmoregulation in fish. *American Zoologist, 41*, 781–794.

Moffett, E. R., Baker, H. K., Bonadonna, C. C., Shurin, J. B., & Symons, C. C. (2023). Cascading effects of freshwater salinization on plankton communities in the Sierra Nevada. *Limnology and Oceanography Letters, 8*(1), 30-37.

Mubarik, M. S., Asad, F., Zahoor, M. K., Abid, A., Ali, T., Yaqub, S., ... & Qamer, S. (2019). Study on survival, growth, haematology and body composition of *Cyprinus carpio* under different acute and chronic salinity regimes. *Saudi journal of biological sciences, 26*(5), 999-1002.

Murmu, K., Rasal, K. D., Rasal, A., Sahoo, L., Nandanpawar, P. C., Udit, U. K., ... & Sundaray, J. K. (2020). Effect of salinity on survival, hematological and histological changes in genetically improved rohu (*Jayanti*), *Labeo rohita* (Hamilton, 1822). *Indian Journal of Animal Research, 54*(6), 673-678.

Mylonas, C. C., Pavlidis, M., Papandroulakis, N., Zaiss, M. M., Tsafarakis, D., Papadakis, I. E., & Varsamos, S. (2009). Growth performance and osmoregulation in the shidrum (*Umbrina cirrosa*) adapted to different environmental salinities. *Aquaculture, 287*(1-2), 203-210.

Nedoluzhko, A. V., Gladysheva-Azgari, M. V., Shalgimbayeva, G. M., Volkov, A. A., Slobodova, N. V., Tsygankova, S. V., ... & Rastorguev, S. M. (2021). Genetic contribution of domestic European common carp (*Cyprinus carpio carpio*) and Amur carp (*Cyprinus carpio haematopterus*) to the wild Vietnamese carp population as revealed by ddRAD sequencing. *Aquaculture, 544*, 737049.

Owais, M., Fazal, R. M., Qureshi, R., Yasin, R., Irfan, M., Ameer, M. W., Malik, R. R., Sher, I., Malik, I. U., Samiullah, K., Ali, M., Sarwar, A. (2023). Evaluation of different salinity levels on growth performance and proximate composition of *Wallago attu*. *University of Sindh Journal of Animal Sciences, 7*(2), 44-49.

Parkos, J. J., Santucci, V. J. Jr., & Wahl, D. H. (2003). Effects of adult common carp (*Cyprinus carpio*) on multiple trophic levels in shallow mesocosms. *Canadian Journal of Fisheries and Aquatic Sciences*, *60*, 182–192.

Rahim, M., Memon, M. A., & Memon, M. A. (2017). Effect of salinity on growth, body composition and biochemical profile of common carp (*Cyprinus carpio*). *International Journal of Fisheries and Aquatic Sciences, 6*(2), 110-116.

Ramesh, M., et al. (2018). Antioxidant status, biochemical and hematological responses in a cultivable fish *Cirrhinus mrigala*, exposed to an aquaculture antibiotic sulfamethazine. *Aquaculture*, *491*, 10–19. https://doi.org/10.1016/j.aquaculture.2018.02.046.

Salati, A. P., Baghbanzadeh, A., Soltani, M., Peyghan, R., & Riazi, G. (2011). Effect of different levels of salinity on gill and kidney function in common carp *Cyprinus carpio* (Pisces: Cyprinidae). *Italian Journal of Zoology*, *78*(3), 298-303.

Soegianto, A., et al. (2017). Effect of different salinity on serum osmolality, ion levels and hematological parameters of East Java strain tilapia *Oreochromis niloticus*. *Mar. Freshw. Behav. Physiol.*, *50*, 105–113. https://doi.org/10.1080/10236244.2017.1333391.

Soltanian S, Vazirzadeh A, Fallahi R. (2016). Effects of sudden salinity changes on short-term hematological and biochemical responses in Mudskipper *Periophthalmus waltoni* Koumans 1941 (Gobiidae: Perciformes). *Iranian Journal of Ichthyology, 3*, 31-42.

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

Triantaphyllopoulos, K. A., Cartas, D., & Miliou, H. (2020). Factors influencing GH and IGF-I gene expression on growth in teleost fish: how can aquaculture industry benefit? *Reviews in Aquaculture*, *12*(3), 1637-1662.

Wang, Y. F., & Zhu, X. H. (2002). A review on the impact of salinity on patterns of fish ecophysiology. *Studia marina sinica*, *44*(5), 151-158.

Xia, J. H., Liu, F., Zhu, Z. Y., Fu, J., Feng, J., Li, J., & Yue, G. H. (2010). A consensus linkage map of the grass carp (*Ctenopharyngodon idella*) based on microsatellites and SNPs. *BMC Genomic, 11-13.*

Table 1. Showing growth performance (Mean ± SEM) of *Cyprinus carpio* at different salinity levels (0-ppt, 2-ppt, 4-ppt, 6-ppt and 8-ppt and) during the 60-days experiment.

Treatments	**Weight gain (g)**	**Feed intake (g)**	**Growth Rate (%)**	**FCR**
0-ppt	11.28±0.28d	14.58±0.37b	95.72±0.93a	1.27±0.01a
2-ppt	10.34±0.38c	14.47±0.42b	87.39±1.75b	1.39±0.01b
4-ppt	9.02±0.17b	12.95±0.12a	81.52±2.95b	1.40±0.03b
6-ppt	8.52±0.27b	12.26±0.36a	73.54±2.51c	1.41±0.02b
8-ppt	7.64±0.26a	12.38±0.51a	69.73±3.33c	1.57±0.05c

Means of the same raw with different letters are significantly different (p<0.05). Data was presented as (mean ± standard error).

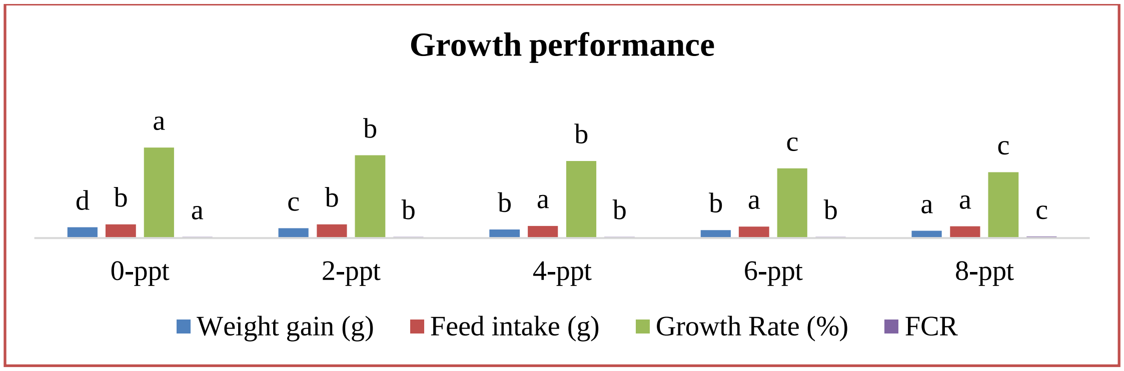

Figure 1. Clustered column bar graph showing growth performance of Cyprinus carpio at different salinity levels (0-ppt, 2-ppt, 4-ppt, 6-ppt and 8-ppt) during the 60-days experiment.

Table 2. Showing growth concentrations of hematological parameters (Mean ± SEM) of Cyprinus carpio at different salinity levels (0-ppt, 2-ppt, 4-ppt, 6-ppt and 8-ppt and) during the 60-days experiment.

Groups	**RBC10^6×mm3**	**Hb g/dl**	**MCH pg**	**MCV µm3**	**HCT %**	**PLT 10^9/l**
0-ppt	0.42±0.09e	3.33±0.07a	78.70±0.45e	76.68±0.43e	3.34±0.03d	717.40±1.02a
2-ppt	0.38±0.05d	3.28±0.07a	75.86±0.39d	73.30±0.48d	3.25±0.06d	710.60±1.12a
4-ppt	0.33±0.06c	2.62±0.21b	73.68±0.19c	69.24±0.53c	2.83±0.02c	670.00±7.07b
6-ppt	0.29±0.06b	2.22±0.01c	70.62±0.33b	65.06±0.39b	2.68±0.02b	654.20±1.52b
8-ppt	0.23±0.01a	2.17±0.01c	65.00±0.59a	59.14±1.34a	2.35±0.01a	562.00±2.67c

Means of the same raw with different letters are significantly different ($p<0.05$). Data was presented as (mean ± standard error).

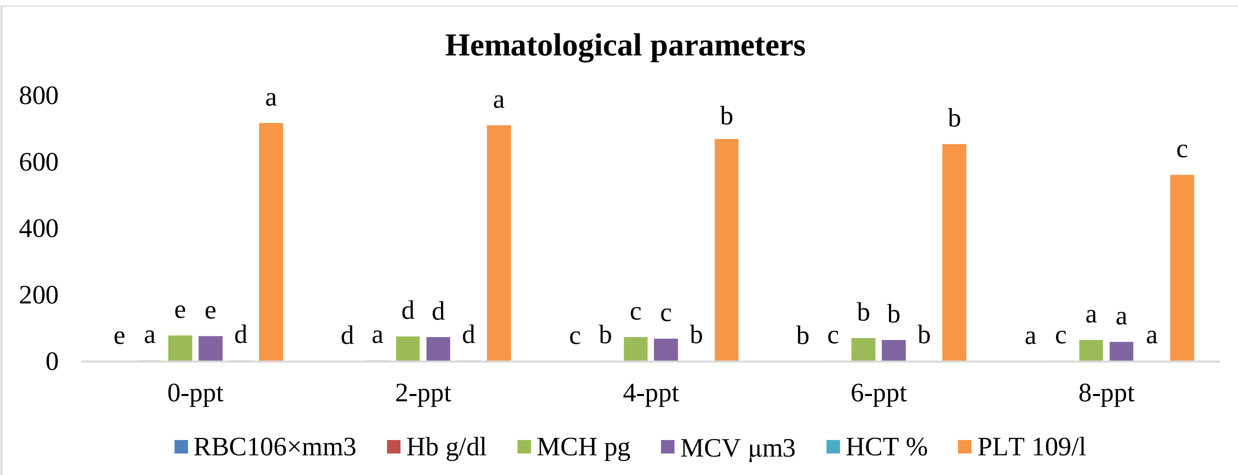

Figure 2. Clustered column bar graph showing hematological parameters of Cyprinus carpio at different salinity levels (0-ppt, 2-ppt, 4-ppt, 6-ppt and 8-ppt) during the 60-days experiment.

Table 3. Showing proximate composition (Mean ± SEM) of Cyprinus carpio at different salinity levels (0-ppt, 2-ppt, 4-ppt, 6-ppt and 8-ppt and) during the 60-days experiment.

Parameters	**Treatments**				
	0-ppt	**2-ppt**	**4-ppt**	**6-ppt**	**8-ppt**
Crude Protein %	17.44±0.16e	16.48±0.08d	15.42±0.15c	14.24±0.10b	13.64±0.12a
Crude fat %	9.38±0.08a	11.44±0.23b	13.44±0.16c	14.32±0.11d	15.28±0.08e
Moisture %	80.44±0.14e	77.74±.049d	73.92±0.54b	71.18±0.46b	65.16±0.98a
Ash %	1.46±0.02a	1.74±0.05b	2.68±0.08a	2.86±0.09c	3.60±0.07d

Means of the same raw with different letters are significantly different ($p<0.05$). Data was presented as (mean ± standard error).

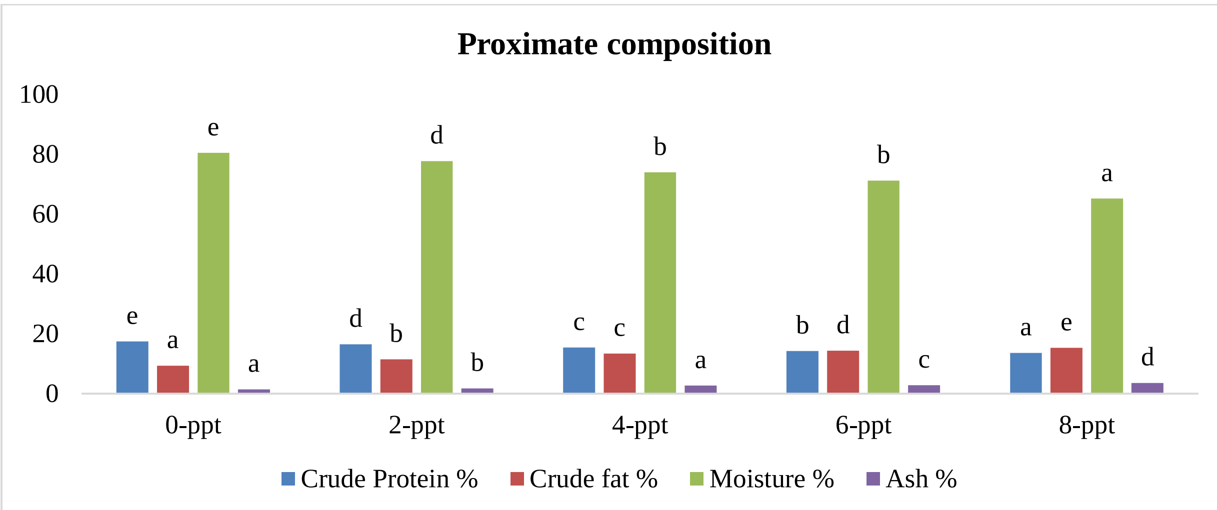

Figure 3. Clustered column bar graph showing proximate composition of *Cyprinus carpio* at different salinity levels (0-ppt, 2-ppt, 4-ppt, 6-ppt and 8-ppt) during the 60-days experiment.