Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(3): 109 – 118 (2025)
www.ejabf.journals.ekb.eg

Pathogenic Bacteria Influencing the Common Carp (*Cyprinus carpio* L.) Farming in Floating Cages in Dayla Province

Safaa H. Alloul[1], Sarmad J. JaliI[2], Sabah M. Al-Shammari[3]
[1]Department of Biotechnology, College of Sciences, University of Diyala, Iraq
[2]Department of Histology and Anatomy, College of Veterinary Medicine, Shatrah University, Iraq
[3]Department of Pathology and Poultry Diseases, College of Veterinary Medicine. Diyala University, Iraq
***Corresponding Author:** dr.sabahmahmoud@uodiyala.edu.iq

ARTICLE INFO

Article History:
Received: Feb. 12, 2025
Accepted: April 28, 2025
Online: May 3, 2025

Keywords:
Cyprinus carpio L.,
Aquaculture,
Microbial pathogens,
Sensitivity tests,
Antibiotics

ABSTRACT

Bacterial infections that arise naturally in the environment of fish present a major challenge for fish farming in Iraq and globally. The objective of this study was to isolate pathogenic bacteria from common carp that are raised in floating cages and subsequently sold in the local market of Diyala Province. The local examination involved counting 100 fish and collecting samples from them. A dissection was conducted on each fish in the laboratory, isolating bacterial strains from different regions including the skin, gills, liver, spleen, kidney and intestines. Bacteria were identified through microscopic examinations and biochemical tests to pinpoint potential isolates, subsequently confirmed using the API® 20 E system for each strain. Bacteria isolated from all targeted organs revealed the presence of potential pathogenic species, including *Escherichia coli*, *Aeromonas hydrophila*, *Pseudomonas aeruginosa*, and *Staphylococcus* spp. In carp from this study, *E. coli* was found in the highest numbers, particularly in the skin and spleen, while *P. aeruginosa* and *Staphylococcus* spp. were detected in lower quantities. The maximum bacterial count in fish organs is found in the skin and spleen (3.27 × 106), while the minimum count is observed in the gills and kidneys (1.91 ± 0.14) ×106. The effect of different antibiotics was illustrated on the isolated bacteria. The antibiotics used include Chloramphenicol (C30), Ceftazidime (KF30), Cefoxitin (ZOX30), Ticarcillin (TI30), Oxacillin (OX30), Doxycycline (DO20) and Amikacin (AK30). In this research, the pathogenic bacteria impacting the common carp in floating cages within Diyala Governorate, Iraq, were investigated. Sensitivity tests indicated significant resistance rates to commercial broad-spectrum antibiotics, underscoring their prevalence, impact on fish health, and implications for management strategies.

INTRODUCTION

Bacteria in aquaculture result in significant economic losses **(Sánchez *et al*., 2022)**. Seasonal variations in water quality and stock conditions induce recurrent infections in common carp **(Alrudainy & Jumma, 2016; Hossain *et al*., 2022)**. Fish are vulnerable to multiple bacterial infections, some of which are thought to be saprophytic and can induce disease **(Dinev *et al*.,**

2023). Microbes are found in diverse environments, including the gills, skin, and internal organs **(Alam *et al*., 2023; Hussein & Jumma, 2024)**. The efficacy of antibiotics in treating bacterial infections guides treatment strategies **(Al-Bayati *et al*., 2020; Milijasevic *et al*., 2024)**. The excessive use of antibiotics can lead to bacterial resistance, complicating treatment. Additionally, antibiotics may harm fish livers, alter fish tank ecology, and reduce essential bacteria necessary for ecosystem health **(Oday *et al*., 2024; Dhyani *et al*., 2025)**. Prior to the application of antibiotics in aquaculture, it is essential to assess the associated risks and to implement measures to mitigate their overuse **(Imtiaz *et al*., 2024)**. Additionally, antibiotic residues in fish meat pose risks to food safety and consumer health **(Alwan & Al-Bayati, 2020; Dhyani *et al*., 2025)**.

MATERIALS AND METHODS

Sampling

A total of 100 *Cyprinus carpio* (common carp) samples were collected from floating cage culture systems in Diyala Province between January and February 2024. The samples were immediately transported to the Pathology Laboratory at the College of Veterinary Medicine, Diyala University. Fish were aseptically dissected, and samples were taken from the skin, gills, liver, spleen, kidneys, and intestines. For microbiological analysis, an inoculating loop of broth culture was streaked onto various media—including brain-heart infusion broth, blood agar, MacConkey agar, and mannitol salt agar—and incubated at 37°C for 24 hours.

Bacteria identification

Gram's staining, phenotypic features (colonial morphology, microscopic appearance) and biochemical tests were used to identify bacteria using identification keys from **Mondal *et al*. (2010)** research. Pure bacterial isolates were characterized using biochemical methods based on the principles outlined in Bergey's Manual of Systematic Bacteriology **(Garrity *et al*., 2001)**. To confirm the identity of each strain, the API® 20E system was used.

Study susceptibility testing using 7 antibiotics

The susceptibility or resistance of the isolates to antibiotics was determined based on measuring the diameter of the growth inhibition zone (mm) around the disc. The measurements were made accurately and the results were extracted for comparison with the approved standards **(Ataee *et al*., 2011)**.

Zone of inhibition

This measurement reflects the effectiveness of each antibiotic against the bacteria tested, with a larger zone indicating greater antibacterial activity.

RESULTS AND DISCUSSION

1. Bacteria identification

The analysis demonstrates the bacterial diversity present in various regions of the examined fish, as illustrated in Table (1). *Aeromonas hydrophila* is the primary bacterium linked to skin

infections, accounting for 60% of positive cultures, indicating a significant risk for these infections. *Pseudomonas aeruginosa* shows a prevalence of 33%, alongside a notable occurrence of *Staphylococcus* spp. at 55%. *E. coli* was detected in the gills at a rate of 20%, whereas in liver *E. coli* was detected at a rate of 10%. The spleen demonstrates a varied bacterial composition, comprising *E. coli* (12%), *Aeromonas hydrophila* (22%), *Pseudomonas aeruginosa* (15%), and *Staphylococcus* spp. (12%). The intestines show a notable prevalence of *Aeromonas hydrophila* (75%) and *Pseudomonas aeruginosa* (55%), alongside *E. coli* (33%) and *Staphylococcus* spp. (22%). The current investigation confirmed the results of **Tesfaye *et al*. (2018)**, demonstrating that *Pseudomonas* spp. was recovered from the skin and gut, while *E. coli* was recovered from the skin, gills, and intestine of common carp. Aquaculture quality is influenced by numerous chemical and bacteriological parameters, as water quality directly impacts fish productivity and health **(Hildah *et al*., 2019)**. The aquatic environment ultimately receives a multitude of contaminants due to the discharge of industrial, agricultural, and municipal waste, leading to alterations in water quality and the presence of sewage **(Al-Shammari *et al*., 2024)**.
Table (1) shows that bacteria primarily affect the intestines and the gills demonstrate a modest infection rate.

Table 1. The analysis of percentage of bacteria % in different organs of the examination fish

Organ	Percentages of bacteria %			
	E. coli	*Aeromonas hydrophila*	*Pseudomonas aeruginosa*	*Staphylococcus* spp.
Skin	10	60	33	55
Gills	20	30	10	22
Liver	10	15	14	45
Spleen	12	22	15	12
Kidney	11	55	12	15
Intestines	33	75	55	22

2. Total count of bacteria

Maintaining sterile conditions is essential to prevent contamination. Samples were obtained from several parts of the fish, including skin, gills, and internal organs. The total bacterial count in 1ml of the sample was determined by utilizing the colony count and the inverse dilution ratio. The bacterial colonies were enumerated using a bacterial counting apparatus, which recorded the total number of colonies, resulting in the total bacterial count per milliliter **(Andrews, 1992)**.
Table (2) illustrates the total number of bacteria (CFU/ml) × 10^6 in various organs.

Table 2. Total count of bacteria × 106 (CFU/ml) in different organs of the examination fish

Organ	Total count of bacteria× 10`			
	E. coli	***Aeromonas hydrophila***	***Pseudomonas aeruginosa***	***Staphylococcus* spp.**
Skin	3.27±0.4Aa	0.68±0.4Ab	0.07±0.03Ac	1.3±0.29Ab
Gills	1.91±0.14Ba	0.23±0.11Ab	0.03±0.005Ab	0.02±0.01Bb
Liver	2.4±1.01Ca	0.45±0.09Abc	0.08±0.04Ac	0.73±0.05Ab
Spleen	3.27±0.4Aa	0.68±0.4Ab	0.07±0.03Ac	1.3±0.29Ab
Kidney	1.91±0.14Ba	0.23±0.11Ab	0.03±0.005Ab	0.02±0.01Bb
Intestines	2.4±1.01Ca	0.45±0.09Abc	0.08±0.04Ac	0.73±0.05Ab
LSD 0.05	0.68			

The bacterial counts (mean ± SD, log CFU/g) isolated from different organs of *Cyprinus carpio* are summarized as follows:

- **Skin**: *E. coli* (3.27 ± 0.40), *Aeromonas hydrophila* (0.68 ± 0.40), *Pseudomonas aeruginosa* (0.07 ± 0.03), *Staphylococcus* spp. (1.30 ± 0.29)
- **Gills**: *E. coli* (1.91 ± 0.14), *Aeromonas hydrophila* (0.23 ± 0.11), *Pseudomonas aeruginosa* (0.03 ± 0.005), *Staphylococcus* spp. (value not provided)
- **Liver**: *E. coli* (2.40 ± 1.01), *Aeromonas hydrophila* (0.45 ± 0.09), *Pseudomonas aeruginosa* (0.08 ± 0.04), *Staphylococcus* spp. (0.73 ± 0.05)
- **Spleen**: *E. coli* (3.27 ± 0.40), *Aeromonas hydrophila* (0.68 ± 0.40), *Pseudomonas aeruginosa* (0.07 ± 0.03), *Staphylococcus* spp. (value not provided)
- **Kidneys**: *Aeromonas hydrophila* (0.23 ± 0.11), *Pseudomonas aeruginosa* (0.03 ± 0.005), *Staphylococcus* spp. (0.02 ± 0.01); *E. coli* not detected
- **Intestines**: *E. coli* (2.40 ± 1.01), *Aeromonas hydrophila* (0.45 ± 0.09), *Pseudomonas aeruginosa* (0.08 ± 0.04), *Staphylococcus* spp. (0.73 ± 0.05)

Among all sampled organs, *E. coli* was the most abundant bacterium, particularly in the skin and spleen.

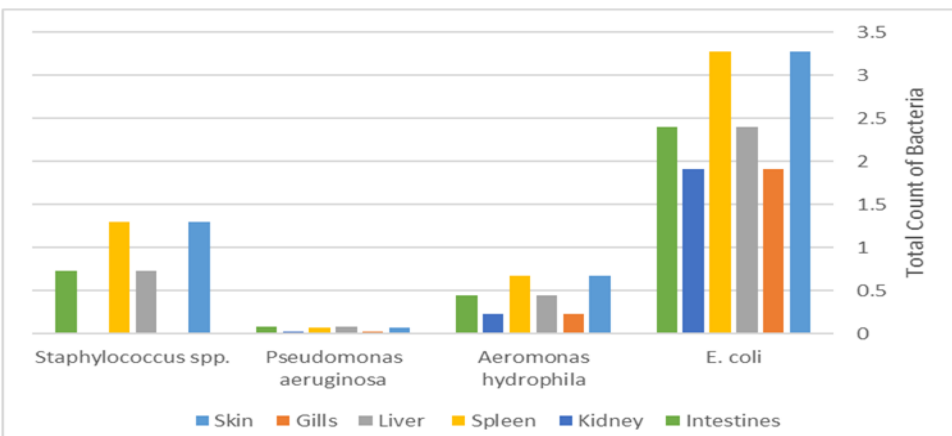

Fig. 1. Total number of different bacteria × 10^6 (CFU/ml) in the fish's body organs, with each type represented by a different color

The maximum bacterial count in fish organs is found in the skin and spleen (3.27 × 106), while the minimum count is observed in the gills and kidneys (1.91 ± 0.14) ×106. Fish diseases may arise from microbial pollution in freshwater or contamination during harvesting activities **(Raufu *et al*., 2024; Bashar *et al*., 2025)**. Human illnesses result from organisms conveyed from fish **(Robinson, 2014)**. **Mohammed (2024)** documented the bacterial isolates (Table 2) of their study on the isolation and identification of harmful bacteria from fresh fish tissues. Additionally, previous reports have highlighted the presence of various pathogenic bacterial isolates in fish from local markets, which may reduce the quality and safety of fish available for consumer use.

3. Antibiotic sensitivity

Table (3) demonstrates antibiotic inhibition zones against *E. coli*, *Aeromonas hydrophila*, *Pseudomonas aeruginosa*, and *Staphylococcus* spp. The antibiotics are Chloramphenicol (C30), Ceftazidime (KF30), Cefoxitin (ZOX30), Ticarcillin (TI30), Oxacillin (OX30), Doxycycline (DO20), and Amikacin (AK30). For the distribution of inhibition zones, Amikacin (AK30) and Doxycycline (DO20) were recorded as the most effective antibiotics since they have extensive inhibition zones against all types. The less effective antibiotics are Chloramphenicol (C30) and Cefoxitin that (ZOX30), as they do not suppress bacterial strains. *E. coli* and *Aeromonas hydrophila* show significant inhibition, while *Staphylococcus* spp. and *Pseudomonas aeruginosa* show varying inhibition with more powerful antibiotics. The results are consistent with the findings of **Kane *et al*. (2024)**, who reported that antibacterial treatments are commonly administered to fish through medicated feed. However, contamination of the external environment with these antibacterials often occurs due to the leakage of uneaten feed and fish feces. Furthermore, curative practices in aquaculture may contribute to the development of antibacterial resistance in both fish pathogens and the surrounding environment **(Al-Shammari *et al*., 2019)**. Antibacterial resistance in freshwater fish culture systems is increasingly reported, although it remains poorly understood **(Al-Shammari *et al*., 2024)**. At present, several diseases affecting farmed fish stocks also pose a threat to wild fish populations **(Hiba *et al*., 2020; Jumma, 2024)**.

Table 3. Zone of inhibition (mm) of *Pseudomonas aeruginosa*, *Aeromonas hydrophila*, *E. coli* and *Staphylococcus* spp. to antibiotics

Type of antibiotic	Zones of inhibition (mm)			
	E. coli	*Aeromonas hydrophila*	*Pseudomonas aeruginosa*	*Staphylococcus* spp.
Amikacin AK30	15± 0.74Aa	9.1 ± 0.33Db	14 ± 0.50 Ca	18 ± 0.20 Aa
Doxycycline DO20	15 ± 0.32Ab	22.5 ± 0.13Aa	20 ± 0.70 Ab	24 ± 0.40 Aa
Oxacillin OX30	11 ± 0.58Bb	12.3± 0.10Ba	9 ± 0.15 Dd	15 ± 0.33 Bb
Ticarcillin TI30	9 ± 0.01Cb	10 ± 0.05Ca	11 ± 0.12 Cc	12 ± 0.25 Bb
Cefoxitin ZOX30	4 ± 0.22Ea	0 ± 0.08Fb	2 ± 0.10 Ef	5 ± 0.12 Ea
Ceftazidime KF30	8 ± 0.00Da	3.3 ± 0.16Eb	6 ± 0.05 Ef	7 ± 0.19 Da
Chloramphenicol C30	0.7± 0.10Ea	0.11 ± 0.41Fa	0.7 ± 0.05 Ga	0.8 ± 0.30 Fa
LSD(P<0.05)	0.82			

Statistical Significance: The LSD (P<0.05) value indicates the least significant difference, which is useful for determining if differences between the means of groups are statistically significant.

It is noted in Table (3) the sensitivity of *Pseudomonas aeruginosa*, *Aeromonas hydrophila*, *E. coli* and *Staphylococcus* spp. to various antibiotics, as measured by inhibition zones (in mm) and statistically significant differences (LSD, *P*< 0.05).

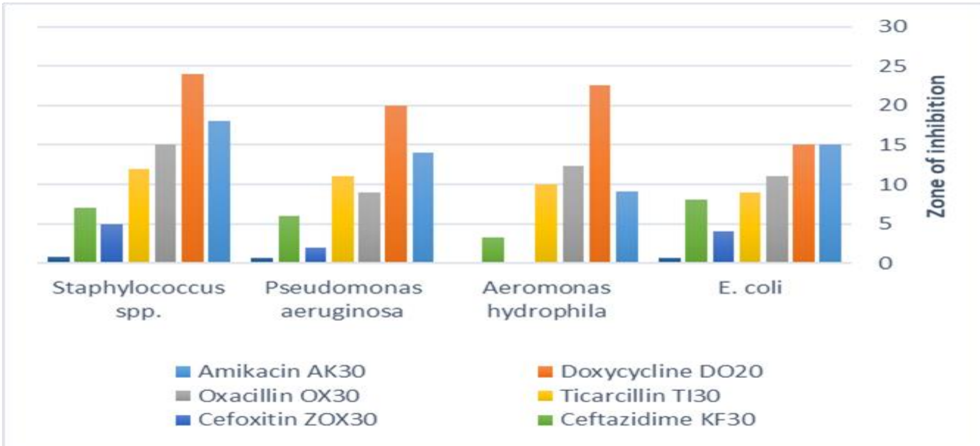

Fig. (2) shows that the largest inhibition zone was observed with Doxycycline (DO20) against *Staphylococcus* spp., measuring approximately 24mm. In contrast, the smallest inhibition zone—measuring 0 mm—was recorded with Cefoxitin (ZOX30) against *Aeromonas hydrophila*, indicating complete resistance and the antibiotic's ineffectiveness against this bacterium.

It is important to note that the interpretation of antimicrobial resistance can vary based on disciplinary perspectives. From a microbiological standpoint, a sensitive organism is one that lacks resistance-conferring mechanisms. Clinically, however, sensitivity is defined by whether a microorganism can be effectively treated with drug concentrations achievable in the body through standard therapeutic dosing **(Khalifa *et al.*, 2020; Shah *et al*., 2024)**. An organism is considered sensitive if the pharmacologically achievable concentration of an antibiotic is sufficient to suppress or eliminate the pathogen **(Abdullah *et al.*, 2024; Wani, 2024)**. **Wani (2024)** also noted that bacterial resistance to antibiotics was observed soon after their initial introduction and has been extensively studied. The steady increase in antibiotic resistance, coupled with a decline in the development of new antibiotics, suggests the potential onset of a "post-antibiotic era"—a period in which treating infections becomes increasingly difficult **(Shinu *et al.*, 2022; Aljoburi, 2024)**.

Aguiar *et al.* (2024) reported widespread resistance to Tetracycline among bacterial isolates, with the exception of two isolates that remained sensitive. These results are consistent with the findings of **Papaleo *et al.* (2022)**, who observed that most bacterial isolates were sensitive to Rifampicin but resistant to Ciprofloxacin, except for one antibiotic that was effective only against actively growing bacterial cells.

CONCLUSION

Pathogenic bacteria provide a considerable risk to the aquaculture of common carp in floating cages throughout Diayla Province. The research findings have indicated the necessity for efficient techniques to control fish health and avert bacterial infections in aquaculture. Antibiotics having limited potency, such as Cefoxitin and Chloramphenicol, are not advised for use against examined bacteria.

REFERENCES

Abdullah, S.A.; Al-Bayati, H.H.K.; Shihab, T.J., Sultan, M. and Jumaa, Q. S. (2024). Immunogenicity of culture filtrated proteins and whole-cell killed formalin of Listeria monocytogenes to induced cellular immune response in vivo. *Open veterinary journal, 14*(12), 3581–3598. https://doi.org/10.5455/OVJ.2024.v14.i12.40

Aguiar, S.; Debnath, F. and Kaushik, S. (Eds.). (2024). Reviews in Antibiotic Resistance and New Antimicrobial Drugs. *Frontiers Media SA*. https://www.frontiersin.org/research-topics/53219/reviews-in-antibiotic-resistance-and-new-antimicrobial-drugs/magazine

Alam, S.; Afzal, G.; Siddique, A. B.; Hussain, R. and Mustafa, G. (2023). Incidence, transmission mechanisms and pathologic implications of bacterial zoonotic diseases of fish. Zoonosis, Unique Scientific Publishers, *Faisalabad*, *Pakistan*, 4, 625-645. https://doi.org/10.47278/book.zoon/2023.184

Al-Bayati, H.H.; Hussein, F.A.; Thamer, I.K. and Abdullah, B.A. (2020). Effects of Coconut oil and fusidic acid extract in alternative traumatic wound healing in RATS model. *Systematic Reviews in Pharmacy. 11*(11), 208–213. https://doi.org/10.31838/srp.2020.11.30

Aljoburi, A.; Jumma, Q. and Al-shammari, S. (2024). Effects of different vaccination methods against newcastle disease on immune response and some blood parameters in local chicken (gallus gallus domesticus) in shirqat city. *Assiut veterinary medical journal, 70*(183), 519-530. Doi: 10.21608/avmj. 2024.297170.1280

Alrudainy, A. J. and Jumaa, Q. S. (2016). Effect of Magnitized Water On Common Carp Cyprinus Carpio Rearing In Different Salinity Concentrations. Iraqi Journal Of Agricultural Sciences.47(2),.646-655. DOI: https://doi.org/10.36103/ijas.v47i2. 611

Al-Shammari, S.M.; Jumma, Q. and Ali, A. (2024). Oxidative Stress and Blood Parameters Affected by Carbaryl Insecticide in Cyprinus carpio. *Egyptian Journal of Aquatic Biology and Fisheries, 28*(6), 2195-2201. DOI: 10.21608/ejabf.2024.400585

Al-Shammari, S.M.; Sana, A.M. and Kane, A.M. (2019). Evaluation the Ozone Treatment To Control the Infection of Saprolegniasis in Cyprinus carpio L. *In Journal of Physics: Conference Series 12*(6), 062049. https://doi.org/10.1088/1742-6596/1294/6/062049

Alshumary, H.; jumma, Q.; Khorsheed, H. and alKaisi, B. (2024). Assessment of The toxic Effect of Environmental Pollution by 2 ,3 ,7 ,8 - Tetrachlorodibenzo-p-dioxin (TCDD) on The Female Reproductive System by Pathological and Biochemical Assay in Albino Female Rats. *Egyptian Journal of Veterinary Sciences, 55*(5), 1409-1415. https://doi.org/10.21608/ejvs.2024.254722.1721

Alwan, M.J. and Al-Bayati, H. (2020). Immunohistopathological and immunological evaluation of listeria nanoparticle vaccine during the first and third semester in the pregnancy rat model.

Plant Archives. 20 (2), 2016-2025. https://www.plantarchives.org/SPL%20ISSUE%2020-2/335

Andrews, S. (1992). Frequency and neighborhood effects on lexical access: Lexical similarity or orthographic redundancy. Journal of Experimental Psychology: *Learning, Memory, and Cognition, 18*(2), 234. https://doi.org/10.1037/0278-7393.18.2.234

Assane, I.M.; Gozi, K.S.; Valladão, G.M.R. and Pilarski, F. (2019). Combination of antimicrobials as an approach to reduce their application in aquaculture: Emphasis on the use of thiamphenicol/florfenicol against Aeromonas hydrophila. *Aquaculture.* 507, 238–245. https://doi.org/10.1016/j.aquaculture.2019.04.021

Ataee, R.A.; Mehrabi, T.A.; Hosseini, S.M.; Moridi, K. and Ghorbananli, Z.M. (2012). A method for antibiotic susceptibility testing: applicable and accurate. *Jundishapur J Microbiol. 5*(1):341-5. https://doi.org/10.5812/kowsar.20083645.2374

Bashar, S.N.; Qusai, S.J.; Muthanna, S.; Raghad, Z.S.; Khalid, A.H.; Ali, A.A. (2025). Preventive and Ameliorative Role of Lactoferrin in Improving Blood, Lipid and Liver Profiles Toward Immune Homeostasis in Lipopolysaccharides (LPS) Induced Dysregulation of Bio-Vital Parameters in the Common Carp (Cyprinus carpio). *Egyptian Journal of Aquatic Biology and Fisheries, 29*(2), 1173-1180. https://doi.org/10.21608/ejabf.2025.419336

Dhyani, V.; Dhyani, A. and Joshi, R. (2025). Antibiotic resistance: Pathophysiology, implications of overuse, and strategies for recovery. *Hazardous Chemicals*. 795-811. https://doi.org/10.1016/B978-0-323-95235-4.00021-9

Dinev, T.; Velichkova, K.; Stoyanova, A. and Sirakov, I. (2023). Microbial Pathogens in Aquaponics Potentially Hazardous for Human Health. *Microorganisms, 11*(12), 2824. https://doi.org/10.3390/microorganisms11122824

Eqbal, S.N.; Sabah, Al-Shammari, M.H. and Ali, M.K. (2020). Evaluation the Effects of Zingiber officinale L. as a feed Additive on Growth and Some Serum Biochemical Profiles of Cyprinus carpio L. (2020). *Indian Journal of Forensic Medicine and Toxicology. 14*(2), 1175-1180. https://doi.org/10.37506/ijfmt.v14i2.3065

Garrity, G.M. and Stanley, J.T. (2001). Bergey's Manual of Systematic Bacteriology: Volume One The Archaea and the Deeply Branching and Phototrophic Bacteria. D. R. Boone, and R. W. Castenholz (Eds.). *Springer New York.* https://link.springer.com/book/10.1007/978-0-387-21609-6

Hiba, A.S.; Siham, A.W.; Hassan, H. and Maythaem, A.I. (2020). Evaluation the effect and efficacy of lidocaine on healing of skin wound in rabbits. *Systematic Reviews in Pharmacy. 11*(12), 1368-1372. https://doi.org/10.31838/srp.2020.12.203

Hildah, J.; Josephine, M.; Emily, C.J. James, B.; James, W. and Christopher, S. (2022). Influence of Water Quality on Distribution Patterns and Diversity of Enteromius Fish Species in Small Water Bodies of Uasin Gishu County, Kenya. *African Journal of Education, 7*(2). https://doi.org/10.2022/ajest.v7i2.797

Hossain, M.A.; Hossain, M.A.; Haque, M.A.; Mondol, M.M.; Harun-Ur-Rashid, M. and Das, S. K. (2022). Determination of suitable stocking density for good aquaculture practice-based carp fattening in ponds under drought-prone areas of Bangladesh. Aquaculture, 547,737485. https://doi.org/10.1016/j.aquaculture.2021.737485

Hussein, A. and Jumma, Q. (2024). Diagnosis of Infectious Bronchitis Infection in Broiler Chicken Farms in Salah Al-Din Governorate. Egyptian Journal of Veterinary Sciences, 55(6), 1619-1626. https://doi.org/10.21608/ejvs.2024.262773.1780

Imtiaz, N.; Anwar, Z.; Waiho, K.; Shi, C.; Mu, C.; Wang, C. and Qingyang, W. (2024). A review on aquaculture adaptation for fish treatment from antibiotic to vaccine prophylaxis. *Aquaculture International*, *32*(3), 2643-2668. https://link.springer.com/article/10.1007/s10499-023-01290-6

Jumma, Q.S. (2024). Detection of ESBL E. coli That Carried STX1 and STX2 Form Common Carp (Cyprinus carpio) in Salhaldeen Province, Egypt. J. Vet. Sci. 55(4): 1165-1170. https://doi.org/10.21608/EJVS.2024.255648.1728

Kane, A. M.; Al-Darwesh, A. A.; Al-Shammar, S. M. and Abd Al-Ameer, I. S. (2024). Inhibitor Properties of Rue (Ruta graveolens L.) on Spermatogenesis in Guppy Poecilia reticulata Peters, 1859. *Basrah Journal of Agricultural Sciences*, *37*(1), 224-235. https://doi.org/10.37077/25200860.2024.37.1.17

Khalifa, S.Z.; Attee, R.S. and Al-Shammari, S.M. (2020). Some Properties Of Morphological And Relationship Weight – Length With Condition Factor Of The Coptodon Zillii (Gervais, 1848) In The Tigris River, Baghdad, Iraq. *Diyala Agricultural Sciences Journal. 12*(16), 194 – 205. https://doi.org/10.52951/dasj.20121018

Milijasevic, M.; Veskovic-Moracanin, S.; Milijasevic, J. B.; Petrovic, J. and Nastasijevic, I. (2024). Antimicrobial Resistance in Aquaculture: Risk Mitigation within the One Health Context. *Foods*, *13*(15), 2448. https://doi.org/10.3390/foods13152448

Mohammed, I. U. (2024). Isolation and identification of pathogenic bacteria from commercially marketed fish in Wukari, North-Eastern Nigeria. *European Journal of Microbiology and Infectious Diseases*, *1*(2), 66-66. https://doi.org/10.5455/EJMID.20240607073124

Mondal, S.; Roy, T. and Ray, A. K. (2010). Characterization and identification of enzyme-producing bacteria isolated from the digestive tract of bata, Labeo bata. *Journal of the World Aquaculture Society*, *41(*3):369-377. https://doi.org/10.1111/j.1749-7345.2010.00378.x

Oday, A. A.; Firas, A. H.; Qusai, S. J. and Marwa, A. H. (2024). Histological Investigation of the Skin Structure in the Common Carp (Cyprinus carpio) and the Catfish (Silurus triostegus): Aquatic Environment Adjustment". *Egyptian Journal of Aquatic Biology and Fisheries. 28*(6), 2219-2228. https://doi.org/10.21608/ejabf.2024.400587

Papaleo, S.; Alvaro, A.; Nodari, R.; Panelli, S.; Bitar, I. and Comandatore, F. (2022). The red thread between methylation and mutation in bacterial antibiotic resistance: How third-generation sequencing can help to unravel this relationship. *Frontiers in Microbiology*, 13, 957901. https://doi.org/10.3389/fmicb.2022.957901

Raufu, I. A.; Lawan, F. A.; Bello, H. S.; Musa, A. S.; Ameh, J. A. and Ambali, A. G. (2014). Occurrence and antimicrobial susceptibility profiles of Salmonella serovars from fish in Maiduguri, sub-Saharah, Nigeria. *The Egyptian Journal of Aquatic Research, 40*(1), 59-63. https://doi.org/10.1016/j.ejar.2014.01.003

Robinson, R. K. (2014). Encyclopedia of food microbiology. Academic press.

Sánchez, J. L.; Le Breton, A.; Brun, E.; Vendramin, N.; Spiliopoulos, G.; Furones, D. and Basurco, B. (2022). Assessing the economic impact of diseases in Mediterranean grow-out farms culturing European sea bass. *Aquaculture*, 547, 737530. https://doi.org/10.1016/j.aquaculture.2021.737530

Shah, S. N.; Bhat, M. A.; Bhat, M. A. and Jan, A. T. (2024). Antimicrobial Resistance: An Overview. Nanotechnology Based Strategies for Combating Antimicrobial Resistance, 1-44. https://www.sciencedirect.com/topics/immunology-and-microbiology/antimicrobial-resistance

Shinu, P.; Mouslem, A. K. A.; Nair, A. B.; Venugopala, K. N.; Attimarad, M.; Singh, V. A. and Deb, P. K. (2022). Progress report: Antimicrobial drug discovery in the resistance era. *Pharmaceuticals, 15*(4), 413. https://doi.org/10.3390/ph15040413

Tesfaye, K.; Kruseman, G.; Cairns, J. E.; Zaman-Allah, M.; Wegary, D.; Zaidi, P. H. and Erenstein, O. (2018). Potential benefits of drought and heat tolerance for adapting maize to climate change in tropical environments. *Climate risk management, 19*, 106-119. https://doi.org/10.1016/j.crm.2017.10.001

Wang, F.; Qin, Z. L.; Luo, W. S.; Xiong, N. X.; Huang, M. Z.; Ou, J. and Liu, S. J. (2023). Alteration of synergistic immune response in gut–liver axis of white crucian carp (Carassius cuvieri) after gut infection with Aeromonas hydrophila. *Journal of Fish Diseases, 46*(9), 917-927. https://doi.org/10.1111/jfd.13799

Wani, M. Y. (2024). Nanotechnology Based Strategies for Combating Antimicrobial Resistance. Springer Nature. https://link.springer.com/book/10.1007/978-981-97-2023-1