Heliyon 10 (2024) e34332

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Ecological dynamics of Al-Chibayish marshes in southern Iraq: Insights into water quality, fish genetic affinity, and conservation implications

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ARTICLE INFO

Keywords:
Al-Chibayish
Fish diversity
Phylogenetic classification
Water quality

ABSTRACT

The aim of this paper is to comprehensively investigate and analyze the ecological dynamics of the Al-Chibayish Marsh. The study focuses on key environmental factors, aims to gain insight into the diversity and abundance of fish populations within the marsh, identifies dominant fish families, and assesses monthly changes in species composition. Two locations were chosen from among the Al-Chibayish marshes for this study, and three water samples were collected every month at every site, starting from March 2020 to February 2021. The mean water temperature recorded was 23.66 °C, while the salinity content exhibited variation over the study period. In July, the salinity content measured 4.34 g/l. Moreover, the pH ranged from 7.4 to 8.5. Dissolved oxygen levels exhibited seasonal variation, with an average value of 7.65 mg/l. The mean alkalinity value was 155.25 mg/l. *Planiliza abu* is the predominant species in terms of relative abundance, constituting 25.99 % of the total catch. Its percentages varied from 12.13 % in May to 46.74 % in December, with *Alburnus sellal* accounting for 19.07 % of the catch, with variations between 5.10 % in May and 30.99 % in June. *Oreochromis aureus* comprised 15.98 % of the total and fluctuated from 11.17 % in March to 20.27 % in January. Other notable species include *Carassius auratus* (13.10 %), *Coptodon zillii* (10.49 %), and *Carasobarbus luteus* (3.80 %). The H index exhibited variation over time, with values ranging from 1.25 in March to a peak of 2.99 in October. On the other hand, the J index also displayed temporal variability, with values ranging from 0.65 in April to 0.86 in August, while the D index showed changes as well, with values differing from 1.66 in March to 3.79 in January. Finally, based on these data, the ecosystem in the study area can be considered a fragile system.

1. Introduction

Nestled within a vast floodplain formed by an intricate network of Tigris and Euphrates rivers, the swamps of southern Iraq are an ecological wonder and the largest wetland in Southwest Asia. In addition, based on the research of [1], comprising an area of over 15, 000 square kilometers and containing a full 44 % of Iraq's freshwater bodies, these swamps are not simply geographical features. In fact, they are ecosystems of subtle balance that teem with life.

According to the scope of the study [2], this ecosystem has precedents and parallels elsewhere in the world. This area's plant and

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https://doi.org/10.1016/j.heliyon.2024.e34332
Received 12 February 2024; Received in revised form 2 June 2024; Accepted 8 July 2024
Available online 9 July 2024
2405-8440/

animal life has been examined in some detail. The swamps of southern Iraq are the subject of this ecological investigation. The purpose is to probe into the nature of these changing ecosystems. Over time, researchers have carefully studied the marshes of Hawr Ad Dalmaj, Al Shafi, Al Huwyzah, and Zachery from many perspectives to gain an understanding of the different varieties and dynamics of local fish populations. Together, these studies make up a patchwork, revealing multifarious connections between factors and the countless fish that depend on these wetlands [3–7].

In addition, investigations over time have shown these biomes to be in flux. For example, they checked the temperature, salinity, and pH of water at low and high levels and all levels in between; fluctuation in water depth was also examined. Among the consequences are the examined marshland fish communities [8–10]. Outside of the scholarly realm, this marshland is also a vital source of wealth for local communities. In terms of activity and tourist destinations, these swamps provide not just entities but lively sources of life that provide significant benefits to local inhabitants. These morasses, which are sites for tourists to visit and sources of social and economic fabric in the countryside, have a profound significance. People there have been using them for generations as a proper country and workshop [2].

The purpose of these studies goes beyond the mere ecology and aptitude of the swamps of southern Iraq. They also sound like an unusual warning for humankind. They tell us that life will not go on indefinitely in the general sense that these wetlands support. We need to practice environmental conservation and management if we want to improve our prospects and those of high-value ecosystems. These wetlands are natural wonders and, at present, significant hothouses. Thus, this paper aims to study and analyze the dynamics of the Al Chiba Marsh; in particular, it will focus on critical environmental factors such as water temperature, salinity, dissolved oxygen, and alkalinity. A survey was established to see just how many kinds of fish and how large a fish population exists in such a spot. We hope that we can gain insight into ecosystem health and resilience by calculating and studying these indices. Plus, we hope this survey will provide clues about what is happening in the marsh population and offer us the knowledge to help us develop strategies for protecting its ecological character.

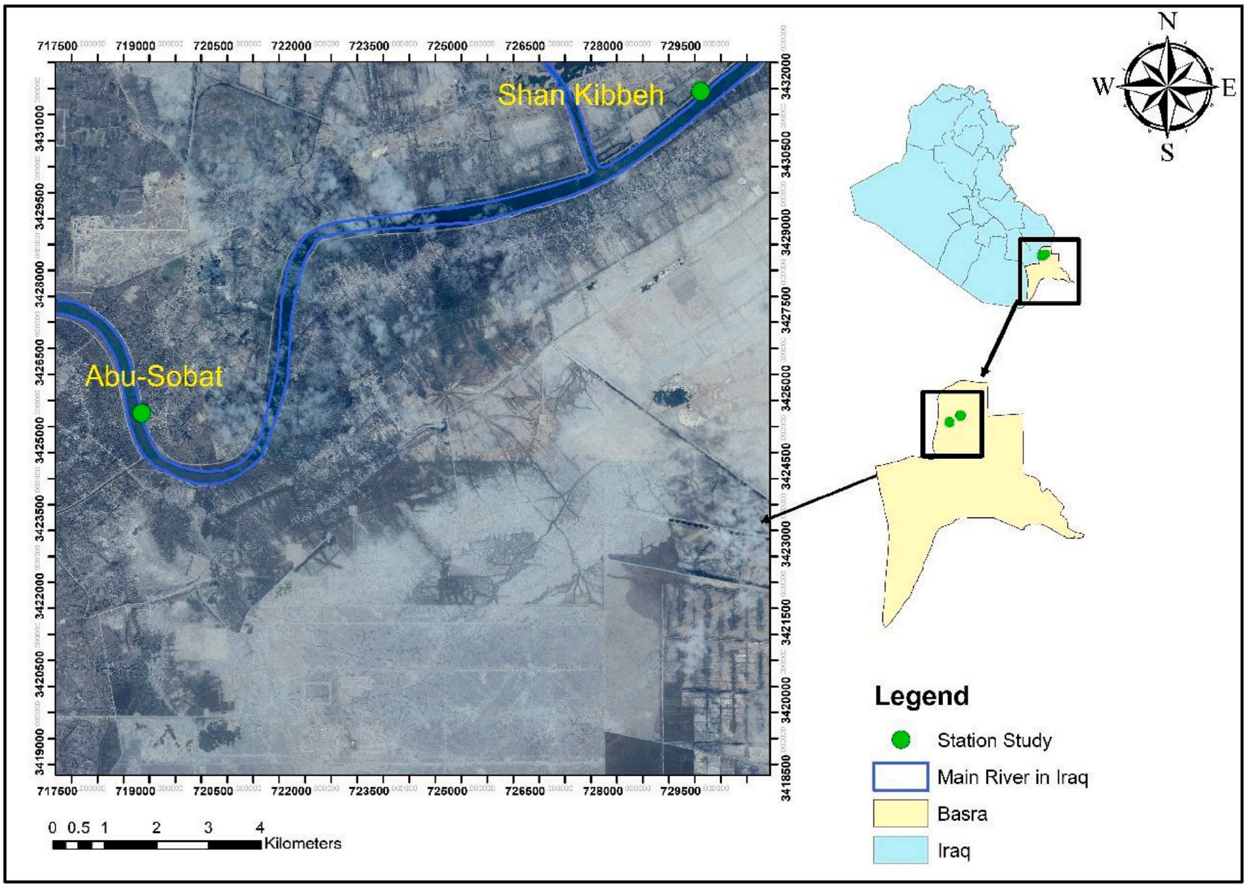

Fig. 1. Study area.

2. Materials and methods

2.1. Study area and sampling sites

Two locations were chosen from among the Al-Chibayish marshes for this study. Al-Chibayish marshes are located in Dhi Qar Governorate, southern Iraq. These marshes are considered part of the Great Marshes of Iraq, which are located between the Tigris and Euphrates rivers. It covers an area of about 700 mi^2 (1,800 km^2). Their biological diversity and unique ecosystem distinguish these marshes. It is home to a variety of plant and animal species. These marshes receive their water from the Tigris and Euphrates rivers, in addition to several smaller rivers. According to the Geographic Information System (GIS) for the coordinates, the first station chosen in our study is Abu Sobat, which is located at coordinates N 30° 56′ 26″ and E 47° 17′ 27″.

In contrast, the second station is (Shan Kibbeh) east of the first station. It lies 11 km away and has coordinates N 30° 59′ 39″ and E 47° 24′ 17″ (Fig. 1), depending on the swamp region and time, with a depth ranging from approximately 1 m–3.5 m at the main tributary area. This area is characterized by an abundance of plants: *Typha domengensis* and *Phragmites communis*.

2.2. Sampling regimen

Three water samples were collected every month at every swamp over the research period, starting from March 2020 to February 2021. The physicochemical variables, including water temperature (°C), salinity (g/l), and total alkalinity, were assessed using YSI556 MPS models in 2005. While, dissolved oxygen (mg/l) was assessed using the method [11].

2.3. Fish sampling

Standardized measurement methods were used throughout the study to ensure accuracy and reliability in measuring Catch Per Unit Effort (CPUE). The effort expended in fishing was recorded regularly throughout every fishing session. The number of catches collected was documented with the same reliability and accuracy. Unified standards were utilized for analyzing the CPUE data. The environmental factors surrounding the fishing samples were considered. From the middle of March 2020 to February 2021, fish samples were gathered from each study area at a constant catch rate utilizing the following net types.

1. Gill net (1×60 m^2 with a 15 mm mesh size), three times
2. Cast net (4 m with a 1.5 cm mesh size) six times
3. Hand net for small fish, six times

The classification of fish species was carried out in accordance with the taxonomic references of [12–14]. We also relied on information from the International GenBank® using the National Center for Biotechnology Information (NCBI) databases to study the genetic affinity between the identified species.

2.4. Environmental indices

Monthly assessments of environmental indices for fish composition in the Al-Chibayish Marsh were executed following the methodologies of [15] for relative abundance [16], for diversity (H) [17], for evenness (J), and [18] for richness (D).

2.5. Fish species categorization

Based on the monthly sampling occurrences, fish species were categorized into three groups following the criteria established by Tyler [19]. Additionally, the proportion of the three most dominant species (Dominance (D3)) in terms of presence was determined according to Ref. [20].

2.6. Statistical analysis

In order to statistically evaluate the research results, appropriate statistical analysis was performed using SPSS Ver. 20 at the significance level of 0.05.

3. Results

3.1. Ecological factors

3.1.1. Water temperature, salinity content, dissolved oxygen, and alkalinity

The mean water temperature recorded was 23.66 °C, with a standard deviation of 7.01. The lowest recorded water temperature, 13 °C, was observed in February, while the highest, 34.5 °C, was recorded in July. The salinity level fluctuated in the course of the research. The salinity was 2.12 g/l in January and rose to 4.34 g/l in July, yielding an average value of 3.22 g/l with a standard deviation of 0.6. Moreover, the pH ranged from 7.4 to 8.5. Dissolved oxygen levels exhibited seasonal variation, with an average value of 7.65 mg/l and a standard deviation of 0.79. In August, the dissolved oxygen level was 6.9 mg/l, while in February, it measured 8.8 mg/l (Fig. 2). Alkalinity levels remained consistently alkaline throughout the study. The mean alkalinity value was 155.25 mg/l. The range of alkalinity values ranged from 125 mg/l in December to 180 mg/l in September (Fig. 3).

3.1.2. *Fish diversity and dominant fish families*

Four thousand one hundred thirty-seven fish were collected from the research region, representing a diverse array of species across six orders, 11 families, 13 genera, and 17 species. Within this diversity, nine species were native to the region, while eight were identified as alien species. The Cyprinidae family and Leuciscidae family emerged as the most dominant, comprising three species for each family and accounting for 17.64 % of all individuals. It was closely followed by the Cichlidae family, which had two species, representing 11.76 % of the total, while the remaining families each featured one species, 5.88 % (Figs. 4 and 5).

3.1.3. *Monthly variation in species*

The number of fish species in the two study stations exhibited monthly fluctuations, as depicted in Fig. 6. At the first station, the range of species varied from 10 in August to 15 in October, totaling 16 species. In the second station, 14 species were documented, with the range oscillating between eight in June and 13 in December. Significant differences ($P < 0.05$) in the number of species were observed between the two study stations.

3.1.4. *Total fish population*

According to the total fish population, the statistical analysis confirmed statistical differences between the two stations studied (Table 1). Fig. 7 illustrates the total number of fish individuals in the research region. In the first station, the number of fish individuals reached 2,357, fluctuating from 102 in November to 321 in February. In the second station, 1,780 fish individuals were counted, ranging from 107 in January to 244 in February.

Planiliza abu is the predominant species in terms of relative abundance, constituting 25.99 % of the total catch. Its percentages varied from 12.13 % in May to 46.74 % in December, followed by *Alburnus sellal* accounting for 19.07 % of the catch, with variations between 5.10 % in May and 30.99 % in June. *Oreochromis aureus* comprised 15.98 % of the total and fluctuated from 11.17 % in March to 20.27 % in January. Other notable species include *Carassius auratus* (13.10 %), *Coptodon zillii* (10.49 %), and *Carasobarbus luteus* (3.80 %).

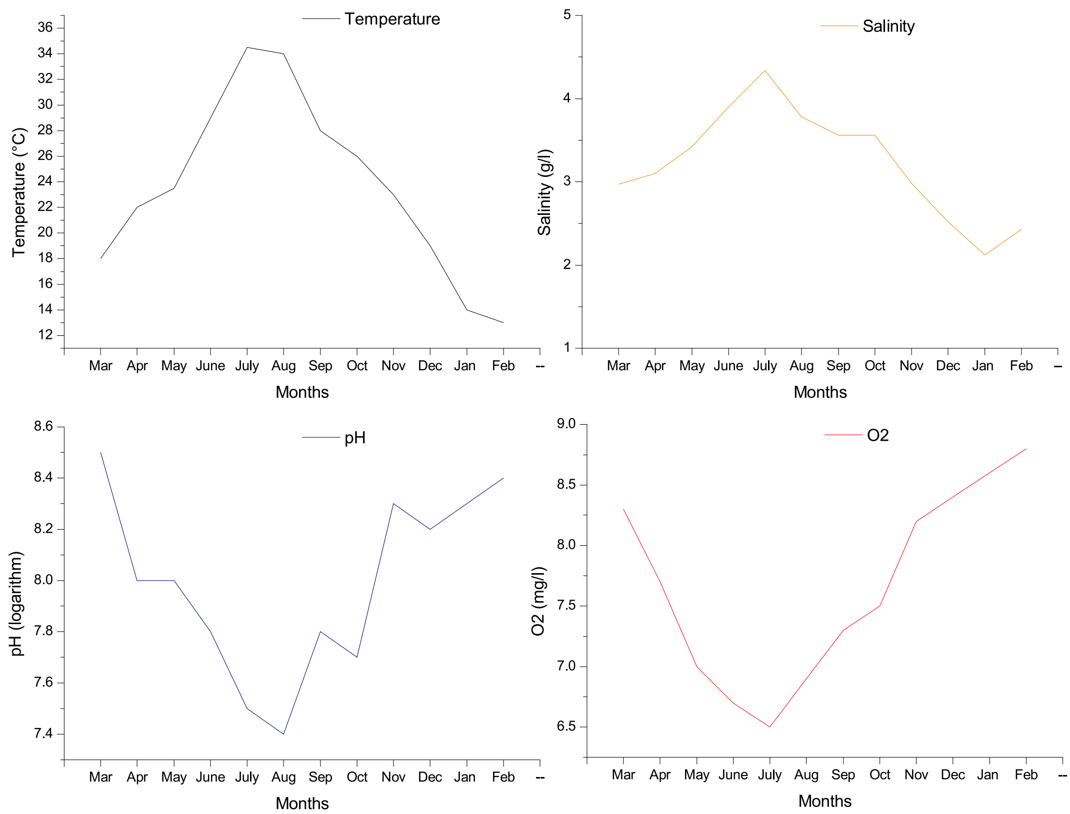

Fig. 2. Environmental factors measured in the study area.

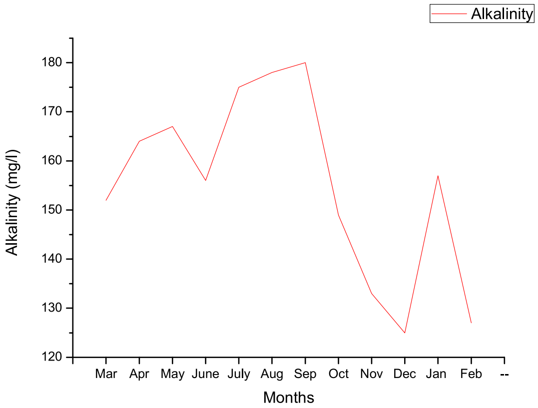

Fig. 3. Alkalinity levels in the study area.

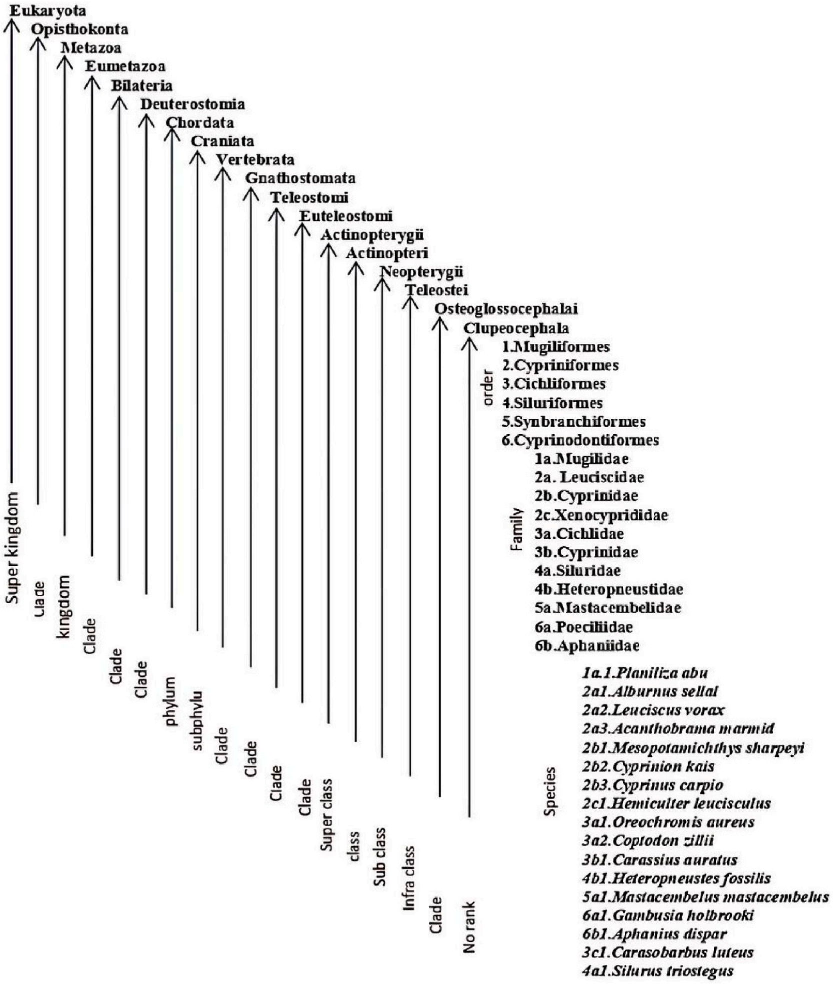

Fig. 4. Classification of species in the study area based on taxonomy ID using NCBI databases.

3.1.5. *Relative abundance of fish species*

Table 2 presents the relative abundance of fish species in the sampling environment. *P. abu* emerged as the predominant species in terms of relative abundance, constituting 25.99 % of the total catch. Its percentages varied from 12.13 % in May to 46.74 % in December. *A. sellal* followed, accounting for 19.07 % of the catch, with variations between 5.10 % in May and 30.99 % in June.

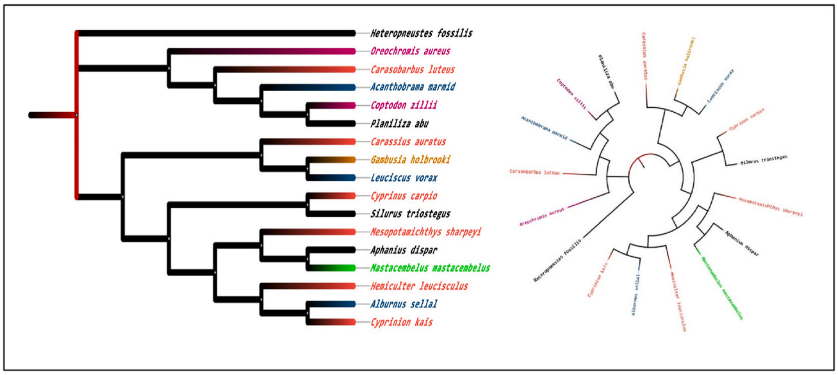

Fig. 5. A phylogenetic tree of species in the study area based on GenBank databases.

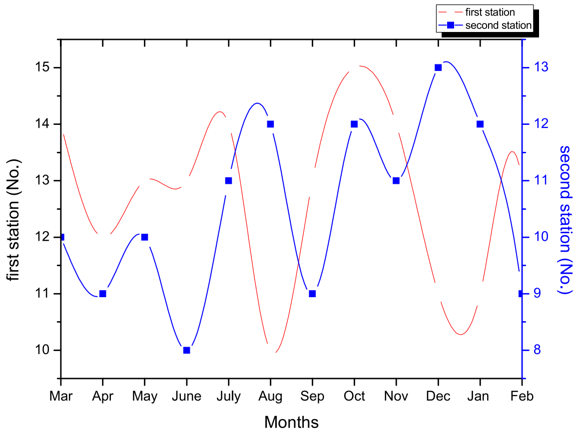

Fig. 6. Monthly variation in species based on two study stations.

Table 1
The statistical data for the total number of fish individuals between the two stations studied ($\bar{x}$,*mean; σ, standard deviation; σ $\bar{x}$,* standard error; x^2, mean square*; Sig, p-value; α, level of significance*).

Stations	Statistical parameters					
	$\bar{x}$	σ	$\sigma\bar{x}$	x^2	F-test	Sig.$^{\alpha 0.05}$
1	196.4167	58.96603	17.02203	13872.042	4.922	0.037
2	148.3333	46.46863	13.41434	2818.163		
Total	172.3750	57.43489	11.72385	–		

O. aureus comprised 15.98 % of the total and fluctuated from 11.17 % in March to 20.27 % in January. Other notable species include *C. auratus* (13.10 %), *C. zillii* (10.49 %), and *C. luteus* (3.80 %). The remaining fish species ranged from 3.60 % to 0.02 % of the total catch, each with its distinct profile (Fig. 8). On the other hand, the statistical data to study the correlation between fish abundance and parameters of water quality showed that there is no high correlation between fish abundance and the factors represented by water temperature, dissolved oxygen, salinity content, and alkalinity. In contrast, it was found that there is a good correlation between fish abundance and pH (Table 3). Furthermore, Fig. 9 shows the correlation relationship between environmental factors and the number of species recorded in the study area based on monthly fluctuations.

4. Ecological indices

4.1. Measurement of environmental indices

In the research region, ecological indices, including the diversity index (H), evenness index (J), and richness index (D), were calculated. Their values are depicted in Fig. 10. The diversity index (H) exhibited variation over time, with values ranging from 1.25 in March to a peak of 2.99 in October. These fluctuations reflect the changing composition and abundance of species in the ecosystem.

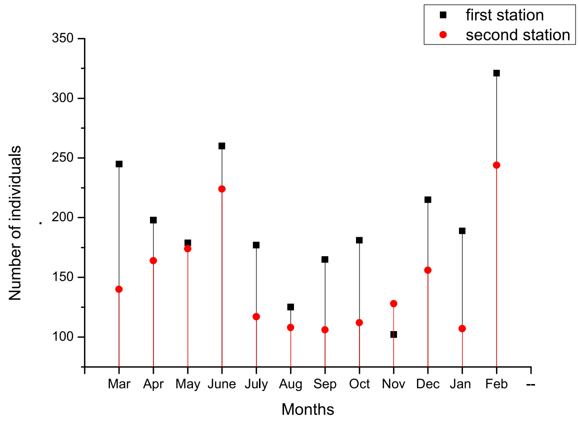

Fig. 7. Total fish population based on two study stations.

Table 2
Relative abundance of fish species based on monthly fluctuations.

Species	Mar. 2020	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2021	Feb.	Total
	%												
Planiliza abu	20.00	26.24	46.74	30.17	22.11	13.73	28.78	25.60	16.96	12.13	17.91	36.28	25.99
Alburnus sellal	22.60	15.47	5.10	30.99	25.17	24.03	12.92	19.11	14.35	21.02	18.58	16.11	19.07
Oreochromis aureus	11.17	15.19	18.98	15.08	15.99	15.45	17.34	11.95	19.13	17.52	20.27	15.75	15.98
Carassius auratus	16.88	12.43	13.60	7.64	13.95	19.31	8.49	10.92	21.30	15.09	13.51	10.80	13.10
Coptodon zillii	9.61	9.67	9.07	9.71	11.90	8.15	12.92	9.22	5.65	12.13	11.49	13.27	10.49
Carasobarbus luteus	4.94	4.14	2.83	2.07	1.36	0.86	4.06	9.90	7.83	5.39	–	3.36	3.80
Leuciscus vorax	3.64	4.70	1.13	2.69	2.38	7.30	5.54	3.41	3.48	7.82	5.07	–	3.60
Cyprinus carpio	2.86	3.59	0.57	–	2.72	5.58	4.43	3.07	2.61	2.70	6.08	2.30	2.78
Silurus triostegus	4.42	4.97	1.13	–	3.06	4.29	–	4.10	6.96	2.43	0.68	1.59	2.56
Acanthobrama marmid	1.56	1.93	–	–	–	0.86	2.95	0.34	–	0.54	2.03	0.53	0.85
Mesopotamichthys sharpeyi	0.78	0.83	0.57	1.24	0.34	–	0.74	–	0.87	1.89	1.69	–	0.75
Hemiculter leucisculus	1.04	–	0.28	–	1.02	–	1.11	1.71	–	1.08	2.36	–	0.65
Heteropneustes fossilis	–	0.28	–	0.41	–	0.43	–	0.34	–	–	0.34	–	0.15
Cyprinion kais	–	0.28	–	–	–	–	–	–	0.87	0.27	–	–	0.10
Mastacembelus mastacembelus	0.52	–	–	–	–	–	0.37	–	–	–	–	–	0.07
Gambusia holbrooki	–	0.28	–	–	–	–	–	0.34	–	–	–	–	0.05
Aphanius dispar	–	–	–	–	–	–	0.37	–	–	–	–	–	0.02
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

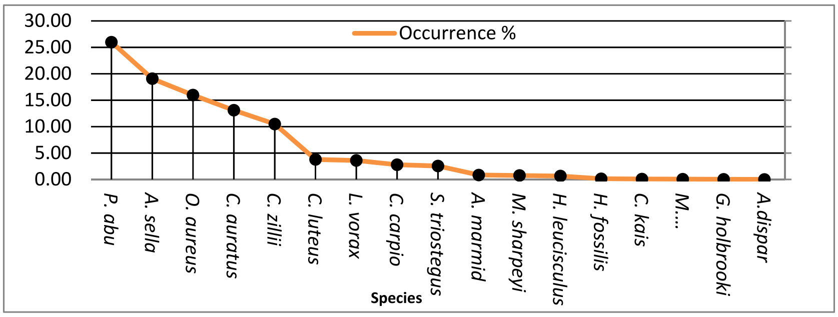

Fig. 8. Occurrence of fish species at the two stations.

Conversely, the evenness index (J) also displayed temporal variability, with values ranging from 0.65 in April to 0.86 in August. This variation in evenness suggests shifts in the relative distribution of species within the ecological community.

Meanwhile, the richness index (D) also showed changes, with values differing from 1.66 in March to 3.79 in January. These values provide insights into the number of unique species present in the ecosystem during specific months.

Despite these differences, statistical analyses to study the correlation between environmental factors and the H and J index showed

Table 3
Statistical data for relative abundance and environmental factors based on monthly fluctuations ($\bar{x}$,*mean; σ, standard deviation; Sig, p-value; α, level of significance; r, correlation*).

Statistical parameters	Factors				
	Temperature	Salinity	pH	Alkalinity	Oxygen
$\bar{x}$	23.66667	3.206667	7.991667	155.3333	7.658333
σ	7.014055	0.641452	0.357919	19.04699	0.790234
Sig.$^{α0.05}$	0.09	0.329	0.033	0.108	0.141
r	−0.50377	−0.30856	0.546028	−0.38534	0.33836

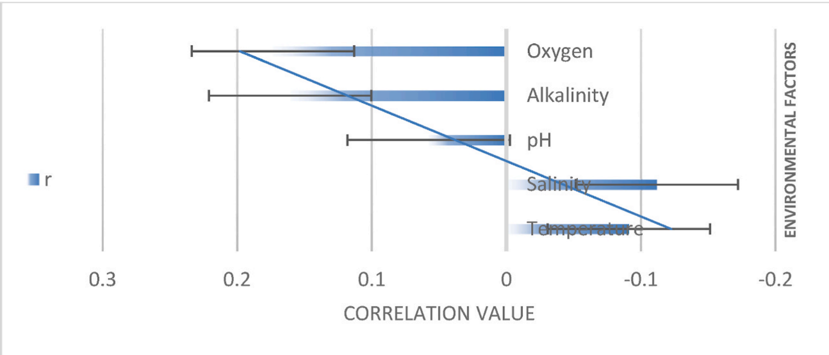

Fig. 9. Correlation value(*r*) relationship between environmental factors and number of species based on monthly fluctuations in the study area.

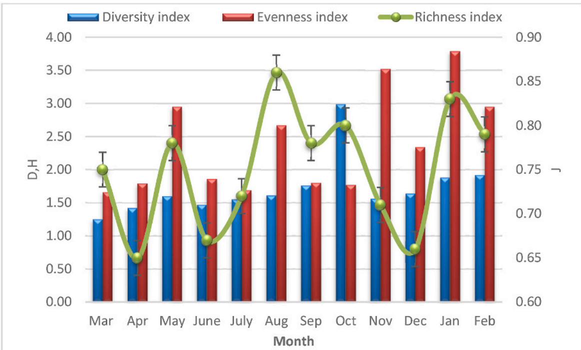

Fig. 10. Ecological indices in the study area.

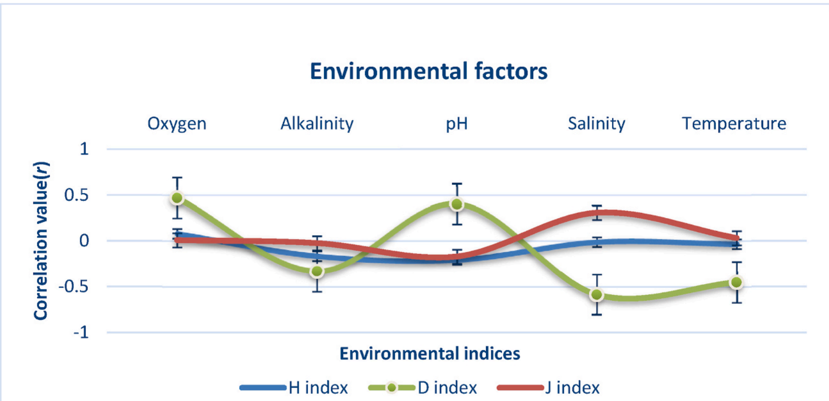

Fig. 11. Correlation value(*r*) relationship between environmental factors and ecological indices based on monthly fluctuations.

that there is no strong correlation between the H and J index and environmental factors. The discrepancies were more evident in the D index (Fig. 11).

4.2. Occurrence of fish species

Fig. 12. Provides insights into the presence and abundance of fish species in monthly samples. The identified species have been classified into three distinct groups based on their occurrence.

4.3. Common fish species

Common fish species represent the majority of the total catch, accounting for 96.47 % of the observed fish population. This group includes nine species: *P. abu*, *A. sellal*, *O. aureus, C. auratus, C. zillii, C. luteus, L. vorax, C. carpio, and S. triostegus.*

4.4. Seasonal fish species

Seasonal fish species, comprising *A. marmid, M. sharpeyi,* and *H. leuciscculus*, represent 2.25 % of the total species. These species exhibit variations in their presence throughout the year.

4.5. Occasional species

Occasional species constitute 0.39 % of the total species. This group includes *H. fossilis*, *C. kais*, *M. mastacembelus, G. holbrooki*, and *A. dispar*. Sporadic appearances in the ecosystem characterize these species. It is worth noting that, according to conservation implications, *A. dispar* has been listed on the IUCN (International Union for Conservation of Nature) Red List since 2014.

4.6. Dominance index (D3)

Regarding species dominance, three species, *P. abu*, *A. sella*, and *O. aureus,* collectively comprise 61.034 % of the total fish species count. Among these, *P. abu* holds a prominent position, forming 26.11 % of the total, per the dominance index (D3) illustrated in Fig. 10.

5. Discussion

The marshes are distinct habitats with a high degree of productivity and diversity; they are home to various living things, including plants and animals [21]. According to Ref. [22], they provide significant benefits to humans through social and economic value, biodiversity resources, suspended matter filtering and sedimentation, pollution capture, and tourism and recreational opportunities. Bio-geochemical processes support and organize the life cycles of species and the ecological system in marsh habitats [23].

Marshes are steady environments that offer sufficient food, cover from predators, and a suitable setting for species reproduction and ecosystem health preservation [24]. This research aims to reveal the parameters of the fish population in Al-Chibayish marshes and

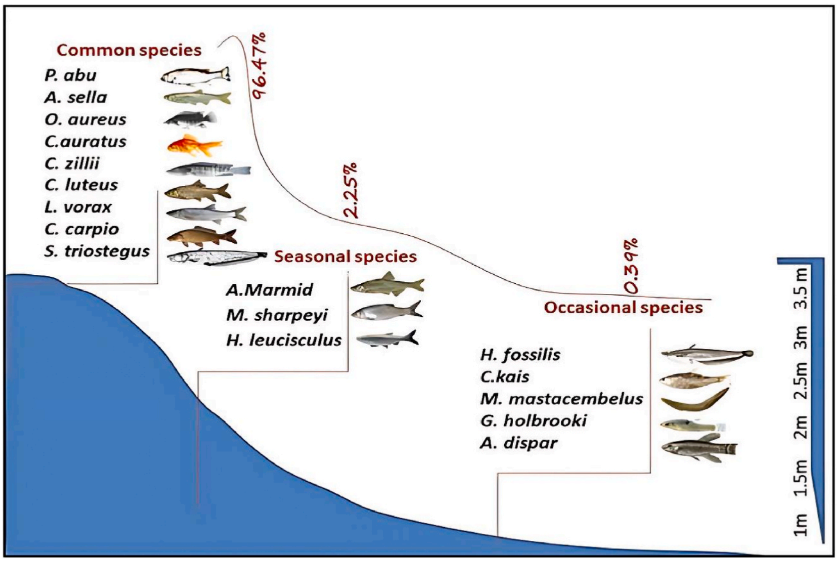

Fig. 12. Common, seasonal, and occasional species in the study area.

investigate how specific environmental factors influence where fish might be found. The ecological factors behind fish populations have never been studied here in these former salt flats, and now fertile grounds are developing back into a large marshland again. The current study may shed new light on the complex dynamics of this ecosystem. The findings derived involved many parameters. Water temperature, salinity, dissolved oxygen, alkalinity, fish diversity, and ecological indexes were all included. The average water temperature of the lakes is 23.66 °C, indicating that this marsh is a moderately warm locale. We recorded temperatures from 13 °C to 34.5 °C. Such a range of seasonal conditions could easily cause stress on aquatic organisms, affecting their physiological processes. These outcomes are consistent with the studies of Al-Zaidy et al. [25] and Abdullah [26].

It is not difficult to see that temperature is an excellent indicator of environmental change from winter to summer. Salinity is a reliable reference point for measuring variations in environmental conditions. In addition, changes in its magnitude and direction can shift the kinds of fish present and may also affect the composition of the fish community. On the other hand, seasonal variations in dissolved oxygen concentrations, which are at their maximum in August but lowest in February, reflect the combined effect of biological and physical factors. These fluctuations may be related to temperature changes [27], aquatic plant dynamics [28], and microbial activity [29].

Marshlands are consistently alkaline, with an average alkalinity rating of 155.25 mg/L, meaning that they can counteract acid rain deposition. This will help to stabilize the soil environment and rid it of its acidic state [30]. The ability to tolerate or soak up acidity from external sources is called buffering capacity. A change in the buffer system directly affects ecosystem health [31]. Abundant variety: 17 species of different orders and families. At least some Cyprinidae and Aromatidae inhabiting the region must have their unique ecological niches. Moreover, foreign species are present; people's damaging effects on indigenous species of wild fauna are thus clearly shown here [32].

A quantitative measure of ecosystem health and sustainability, based on a calculation in 1984 known as the Greene-Weiner index, can help guide management decisions for wetlands. These results demonstrate the dynamic nature of a swamp ecosystem: (1) temporal changes in diversity index (H), evenness index (J), and richness index (D); and (2) effects of changing water levels on these same trends expressed mathematically and graphically over time. The diversity peak in October shows a period of higher species richness that is non-monotonic in this 1-year data series. This diversity peak may be mainly due to the change in water levels and the increase or decrease in water depths in the study area. Despite the stability of the diversity peak in October, the two studied stations show statistical differences in the relative abundance of fish species based on monthly fluctuations which showed superiority for the first station (Abu Sobat), this may be partly due to near Abu Sobat station to the tributary of the Euphrates River, water depth, density of aquatic phytes, water quality parameters etc. Classifying fish species as common, seasonal, or episodic components can deepen our understanding of their ecological roles. The dominance index (D3) emphasizes the importance of a few key species in shaping the overall fish community structure [33].

It is an important habitat for the diverse fish community [33]. Al-Chibayish marsh ecosystems are extraordinarily sensitive to small changes in ecological parameters. In order to ensure the marsh keeps working and can recover from disruption, it is necessary to remain conscious of factors such as water quality, habitat diversity, and the status of key animals. Generally speaking, on the ecological variables and fish communities, this comprehensive study supports no other way to learn about such an amazing ecosystem than by going there to learn. This research helps conserve wetlands in light of continued environmental change and adds one further piece of knowledge to the scientific interpretation of marsh ecology.

6. Conclusion

Over the season, the observed range of ecological factors creates variations that may affect the physiological processes of aquatic organisms and indicate an environmental change entirely relying on their natural development conditions. When the H index changes with time, it finally reaches its highest point of 2.9 in October. At different periods, the fluctuations in species makeup and abundance come to a resolution in this value. Furthermore, the evenness J index also varied temporally. The observed changes in ecological parameters underscore the fragility of this particular ecosystem. Conservation efforts should keep proper water quality, habitat diversity, and fish protection as their primary aims in maintaining the resilience and function of the marsh.

Source of funding

None.

Disclaimer

None.

Data availability

Data will be made available on request.

CRediT authorship contribution statement

Sajad A. Abdullah: Writing – review & editing. **Kadhim F. Kadhim:** Writing – original draft, Data curation. **Yasser W. Ouda:**

Methodology, Data curation. **Salah N. Aziz:** Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

We would like to thank everyone who contributed to the success of our research, especially the University of Basrah, College of Education/Qurna, Department of Biology.

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