Effect of Tidal Zones on Some Aspects of Fish Biodiversity in East Hammar Marsh, Basrah, Iraq

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Abstract

The current study describes the movements of nine fish species in the tidal and intertidal areas of East Hammar Marsh during different seasons of the year. The study was conducted at three stations in East Hammar tidal marsh; Al-Sallal station LLW (subtidal zone), Al-Mansory station MHW (intertidal zone) and Al-Burka station HHW (tidal zone). The results indicated that Al-Sallal station was characterized by dominating species of (O. aureus, O. niloticus, P. latipinna, C. auratus, P. abu, T. ilisha, T. whiteheadi), Al-Mansury station by (O. aureus, O. niloticus, P. latipinna , C. auratus, P. abu, T. whiteheadi), and Al-Burka station by (O. aureus, O. niloticus, P. latipinna, C. zillii, C. auratus, P. abu, T. whiteheadi). The native species S. triostegus prevailed in both subtidal during winter and intertidal zones during all other seasons. In contrast, P. abu showed a migration into the subtidal zone in all seasons with returning in autumn into the subtidal and tidal zones. In all seasons, the marine species T. ilisha was migrated densely from the subtidal zone into the tidal zone, unlike B. fuscus which dominates the subtidal zone. However, the marine species T. whitheadi dominated the intertidal zone at all the seasons except winter when it migrates into the subtidal and tidal zones. The exotic species C. zillii populated the tidal zone zone all over the year, while C. auratus migrates into the tidal zone at spring and summer but in autumn and winter it migrates into the intertidal zone. On the other hand, O. aureus dominated the subtidal zone during winter and summer, and the tidal zone at summer and autumn, while O. niloticus migrates into the intertidal zone in winter and spring but at summer it migrates into the tidal zone then at autumn it returns back to the subtidal zone. It was concluded that most fish species in this marsh have seasonal migrations into the intertidal from tidal and subtidal zones and vice versa. The zonation patterns were significantly affected by several factors including evading predators, food availability, salinity, spawning site and avoiding seasonal fluctuations of temperature.

Keywords: *East Hammar Marsh, fish assemblage, biodiversity, zonation, tidal zones.*

INTRODUCTION

The freshwater bodies inside Iraqi lands are covering between 600 000 to 700 000 ha, including lakes (39%), marshes (44%), reservoirs and dams (13 %), and rivers with their branches (3.5 %) [1]. The southern part of Iraq has the largest wetlands and marshes that covers about 15000 km2 and are considered as the largest in the region of southwest Asia [1]. In the near past, the southern marshes were rich in all forms of biodiversity due to its favorable conditions and ecosystem, while its natural richness and geographical location allowed it to be a resting place or a major transit point for millions of migratory birds from Siberia to South Africa [2].

Globally, most of the upper parts of estuaries are occupied by tidal of freshwater wetlands and these areas are highly experiencing obvious tidal activity one to two times a day. The tidal front appears in the interface between the river and the upper area of the brackish part of the estuary [3]. In spite of the fact that the tidal freshwater wetlands do not have numerous restricted or endemic species, they are characterized by the appearance of a large extents of habitat diversity and species occurrence, Organisms that live in the intertidal zone tend to form their own assemblages across the zone's elevation gradient. Anything living in the intertidal zone must be able to survive changes in moisture, temperature, and salinity and withstand strong waves. Intertidal zones of rocky shorelines host sea stars, snails, seaweed, algae, fish, and crabs. The downstream estuary and upstream riverine ecosystems are separated from each other due to the buffering zones that raise from the activity of the freshwater tidal marshes, whereas a high diversity of macrophytes will occur in the same place [4]. These macrophyte dominating areas will distinct a zonation patterns, whereas a high rate of decomposition process and primary production will concur in this area [5, 6]. Indicated [7] that changes in the tidal flow pattern have an effect on the movement of plants and their colonization to other areas. These locations could be used as a valuable habitat for wildlife and fish communities, while acting simultaneously as sinks for heavy metals and nutrients [8].

Fishing activities could be affected by climate parameters mainly winds and tides, whereas sea-level fluctuations and water velocity have an effect on fish occurrence, abundance and also the fishing methods [9].

Many previous researches on fish that conducted on East Hammar marsh were dealt with fish species compositions, nature of fish communities, migration of marine species from Arabian Gulf, seasonal changes in species existence and the abundance of exotic species [10, 11, 12,13,14.15.16].

Alhsan [16] published the first study on fish zonation at East Hammer marsh which explained how the tidal movement have an important effect on the occurrence and distribution of fish. Whereas the communities of coastal fish in the shallow water could be highly affected by the tidal cycle and this is very important to the environmental management in order to study the occurrence of the fish, it was found that the movement of waves has effects on the distribution of different species of fish, as they differ temporally and spatially in the distribution As well as the size and shape of the body determines the species that has the ability to deal with currents and tidal movement [17]

Typically, the amplitude of tides and currents affects the ecological functions and the

formation of fish assemblage and pattern, which needs to be continuously studied.

This study aims to investigate the seasonal patterns of zonation by some fish species of different origins at intertidal (Al-Burka station), tidal (Al-Mansory station), and subtidal (Al-Sallal station) zones of East Hammar marsh, as well as to determine the relationships of water temperature, salinity, and depth with fish origin of the nine selected species to explain zonation patterns.

Materials and Methods

Study area

The study was carried out on East Hammar Marsh which is located at the northern part of Basrah governorate, Iraq (figure 1). This marsh also extends westward to Dhi Qar governorate [1]. It is bordered to the east and north-east by Shatt al-Arab, from the north by Euphrates River and Western Hammar Marsh to the west. Three stations have been selected to study from East Hammar Marsh, considering these three stations as tidal areas rather than coastal and semi-coastal areas [16]. Where their exact location was determined by a GPS device as shown in table (1).

Table (1): Coordination of study stations in East Hammar Marsh.

Station No.	Station Name	Coordination
1	Al-Sadda or Al-Sallall station Represented the lowest tidal (LLW)	N:300 360 470 E:470 400 15 0
2	Al-Mansory station Represented the mean higher tidal (MHW)	N: 300 400 260 E:470 370570
3	Al-Burka station Represented the highest tidal (HHW)	N: 470 330 20 E:300 410 440

The southeastern part of the locality is affected by the tidal phenomenon, whereas the tidal activity originates from the Arabian Gulf. This makes it distinct from the rest of the southern marshes by the presence of some marine fish that enter the marsh for the purpose of nursery, feeding or breeding in addition to the endemic species [18].

- Station one (Al-Sadda or Al-Sallal)

Al-Sallal regulating dam was built to cut the supplying source of Al-Hammar marsh during the 1990s, but it was removed after 2003 by the locals in order to refill the dried region again with water. The depth of this zone ranges from 7-9 m.

- Station two (Al- Mansory)

It is called the channel marsh, where the depth is ranged between 5-7 m. The area is highly affected by the tides and was highly suffered from draught previously.

- Station three (Al-Burka)

It is an open marsh which characterized by a large and shallow area. The depth is ranging only between 1-3 m. which supporting the wide distribution of floating and submerged plants

Figure (1): Map of East Hammar marsh, showing the three selected stations, Al- Burka (intertidal zone), Al-Mansory (tidal zone) and Al-Sallal (subtidal zone).

Field work

Water and fish samples were collected from the study stations on a monthly basis during the period from November 2020 to October 2021.

The multi-parameter device (WTW Multi 350i) was used for measuring; water temperature and salinity. The depth was measured by the Fishfinder-X25B.

Field Work on Fish Samples

Fish samples were collected on a specific day seasonally during the low tide period at the three studied stations. A number of fishing methods were used, according to the nature of the study area, like Seine nets, a cast net, and the electrical method of fishing finally Floating gill net.

Laboratory work

Fish were classified according to species according to the books of a number of researchers

(19, 20 and 21)

Fish Origin

Fish species were divided according to their origin into three categories 1- Native 2-Exotic 3- Marine

Relative abundance:

- The relative abundance of each species was calculated according to Krebs (1974) [22]

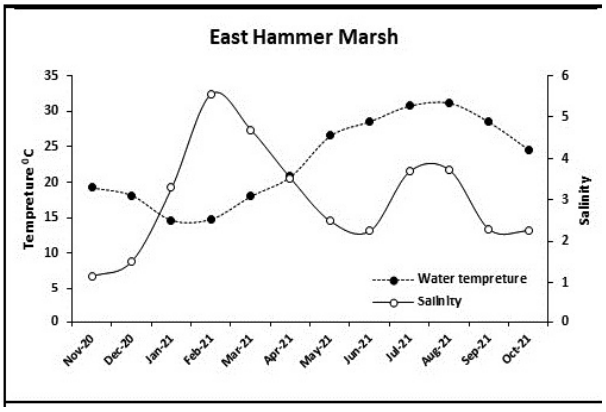
Statistical analysis

Using The SPSS program (version 20) for statistical analyses of the collected data

Results and Discussions

Environmental parameters of East Hammar Marsh

Figure (2): Monthly variations of water temperature and salinity at East Hammar Marsh



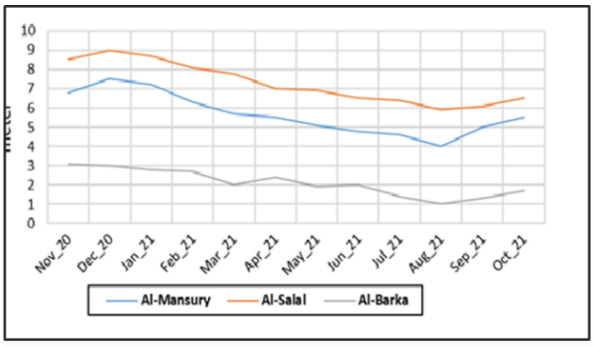
The illustration of water temperature and salinity in the above graph (figure 2) showed that the minimum temperature was 13.8 0C in February 2021 and the maximum temperature was 33 0C in July with an average of 22.8 0C at the East Hammar Marsh. The minimum salinity was 1 in November 2020 and the maximum was 5.8 in March 2021 with an average of 3.1 at the East Hammar Marsh, which was much lower than earlier study made during 2018-2019 which varied between 3.2 in Al-Sada station at minimum and 14.2 at maximum in the Al-Burka station [23].

A significant positive correlation (r=0.7, p-value=<0.05) was between water temperature with the total catch of fish individuals while the salinity showed a very week negative correlation (r= -0.2, p-value=<0.05) with the total catch of fish individuals

The depth varied in all the stations during the investigation period (Figure 3). At Al-Mansory station the maximum depth was 7.5 m in December 2020 and the lowest was 4 m in August 2021 with an average of 5.7. The maximum was 9 in December 2020 and the lowest was 5.9 m in August 2021 with an average of 7.3 at Al-Sallal station and in the Al-Baraka station the maximum depth was 3.1 m in November 2020 and the lowest was 1 m at August 2021 with an average of 2.1 m.

Statistical analysis indicated that there was a significant difference between stations and between seasons ($p < 0.05$).

Figure (3) the variation of depth at the three studied stations in East Hammar Marsh



Relative abundance of selected fish species in East Hammar Marsh

The origin of fish species in the marsh (table 2) was characterized by the large relative abundance of exotic species (65.5 %) with 11 species, while the native species was (15.4 %) for 12 species and the marine species was (19 %) for 20 species. On the other hand, Al-Sallal station was characterized by the highest relative abundance of exotic species (60.78 %) for 10 species, while the native species was (15.81 %) for 11 species and the marine species was (23.41 %) for 20 species. The relative abundance of exotic species in Al-Mansury station was (66 %) for 11 species, native species was (16.23 %) for 10 species, and marine species was (17.8 %) for 20 species. In Al-Burkha station the relative abundance exotic species was (69.4 %) for 9 species, native species was (14.6 %) for 12 species, and marine species was (16 %) for 18 species.

Table (2): Table showing the relative abundance of fish origin in the three stations

	Al-Sallal station		Al-Mansury station		Al-Burkha station	
Fish origin	Relative abundance	Number of species	Relative abundance	Number of species	Relative abundance	Number of species
Native	15.81	11	16.23	10	16.63	12
Exotic	60.78	10	65.97	11	69.42	9
Marine	23.41	20	17.8	20	15.9	18

Tables (3, 4 and 5) indicate the relative abundance of nine fish species in the three station belong to three origins; two of them were native species (Silurus triostegus, Planiliza abu) three of them were marine species (Bathygobius fuscu, Thryssa whiteheadi, Tenualosa ilisha) finally four exotic species (Oreochromis aureus, Oreochromis niloticus, Coptodon zillii, Carassius auratus).

The (figure 4) showed that the abundance of native fish species was not affected by the variation of the depth, which was appeared in all the stations within the marsh while the marine fish species have highest abundance in the deepest area of the Al-Sallall station, then decreased to the lowest abundance in the shallowest areas of Al-Mansury and Al-Burka station. The exotic species in the diagram showed that these species have the highest abundance in the shallows area in the Al Barkha station.

Table (3): Seasonal variation in the relative abundance (%) of 9 fish species in Al-Sallal station LLW (November 2020 - October 2021).

Species	Relative abundance Autumn 2020	Relative abundance Winter 2021	Relative abundance Spring 2021	Relative abundance Summer 2021	Average	Origin
O.niloticus	20.17	19.13	23.50	13.70	22.3	Exotic
O.aureus	15.77	23.80	24.17	13.00	19.18	Exotic
C.auratus	5.8	15.6	12.7	12.8	12.33	Exotic
P.abu	8.8	12.4	7.1	10.7	9.97	Native
T.ilisha	9.1	4.8	2.7	10.6	6.96	Marine
T.whit headi	5.98	4.08	6.9	6.86	6.06	Marine
C.zillii	0.95	0.92	3.6	3.2	2.4	Exotic
S.triostegus	0.31	2.7	2.5	0.09	1.42	Native
B.fuscus	0.25	0.02	0.39	0.55	0.33	Marine

Table (4): Monthly variations in relative abundance (%) of fish species in Al-Mansury station MHW (November 2020 - October 2021).

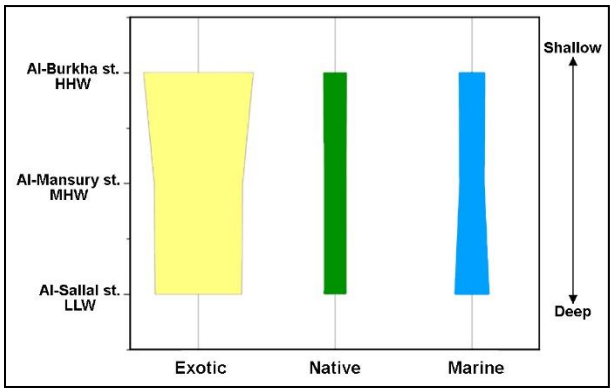
Species	Relative abundance Autumn 2018	Relative abundance Winter 2019	Relative abundance Spring 2019	Relative abundance Summer 2019	Average	Origin
O.niloticus	19.8	30.4	28.06	14.9	23.3	Exotic
O.aureus	14.7	16.5	20.6	18.8	17.67	Exotic
C.auratus	10.9	17.8	11.7	10.7	12.79	Exotic
P.abu	7.8	13.3	8.01	11.7	10.56	Native
T.whit headi	7.6	2.4	10.1	9.1	7.48	Marine
T.ilisha	5.6	2.1	1.4	4.2	3.27	Marine

C.zillii	1.7	0.80	2.3	2.9	2.07	Exotic
S.triostegus	0.23	3.7	1.5	0.03	1.39	Native
B.fuscus	0.44	0.27	0.18	0.76	0.44	Marine

Table (5): Monthly variations in relative abundance (%) of fish species in Al-Burkha station HHW (November 2020 - October 2021).

Species	Relative abundance Autumn 2020	Relative abundance Winter 2021	Relative abundance Spring 2021	Relative abundance Summer 2021	Average	Origin
O.aureus	18.3	13.1	21.6	19.7	18.23	Exotic
O.niloticus	18.3	12.9	17.6	16.4	15.76	Exotic
C.zillii	3.6	21.5	11.5	5.33	10.66	Exotic
C.auratus	9.4	11.9	10.7	7.7	9.85	Exotic
P.abu	9.3	12.9	5.1	8.4	8.93	Native
T.whit headi	5.3	3.9	8.4	3.8	5.26	Marine
T.ilisha	5.1	0.51	0.55	2.2	1.86	Marine
B.fuscus	0.59	0.42	0.65	1.4	0.83	Marine
S.triostegus	0.16	0.39	0.094	0.035	0.18	Native

Figure (4): Kite diagram representing the fish origins of exotic, native, and marine species abundance in the three stations during the study period.



The effects of seasonal patterns on the fish zonation:

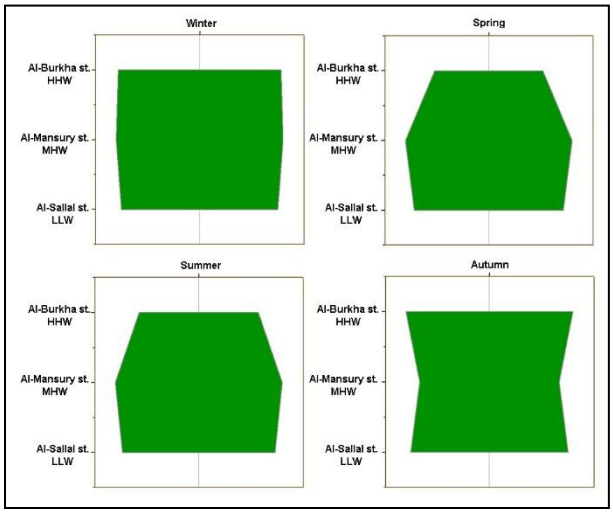
- Zonation pattern of native species

1- Planiliza abu

The (figure 5) showed the seasonal zonation for the species P. abu. It seems that this species was available in all the stations during the winter season with a slight decrease in Al-Sallal station (LLW). The population of P. abu concentrated in the Al-Mansury station (MHW) during spring and summer seasons while the appearance of P. abu dispersed at tidal zone (Al-Burkha stations) during spring and summer seasons. During autumn season, the appearance of P. abu was at the highest in the subtidal and tidal zones (Al-Burkha and Al-Sallal stations) respectively, while a few species retreat into the intertidal zone (Al-Mansury station).

The migration of P. abu in East Hammar marsh between the deep subtidal zone and the shallow intertidal zone illustrates the response to seasonal variation in salinity ($r = -0.6$, P-value= <0.05).

Figure (5): The zonation pattern of Planiliza abu at Al-Sallal station (LLW), Al-Mansoury station (MHW), and Al-Burkha station (HHW), during the period from winter 2020 to Autumn 2021 in East Hammar marsh.



2- Silurus triostegus

The individuals of S. triostegus was more abundant in the subtidal zone (Al-Sallal station) during the seasons of spring, summer, and autumn (figure 6). However, in the winter season the species of S. triostegus was highly migrated to the intertidal zone (Al-Mansury station). Limited migration of S. triostegus was observed into Al-Burkha station (tidal zone) during all the seasons. The migration of S. triostegus species could be controlled mainly by the appearance of its preys at the subtidal zone and The predatory fish is prefer the deep area, as these areas provide a more stable environment for large size fish (24).

- Zonation pattern of marine species

1- Tenualosa ilisha

The marine species of T.ilisha is anadromous migratory species, in the spawning period it moves to the East Hammar marsh to spawn. During the investigation period, the main population of T.ilisha was existing in the tidal zone (Al-Burkha station) in all the seasons, that can be for feeding on abundant phytoplankton and zooplankton, while there was a limited movement into the subtidal zone (Al-Sallal station) in all the seasons (figure 7).

Figure (6): The zonation pattern of Silurus triostegusat in Al-Sallal station (LLW), Al-Mansoury station (MHW), and Al-Burkha station (HHW), during the period from winter 2020 to autumn 2021 in East Hammar marsh.

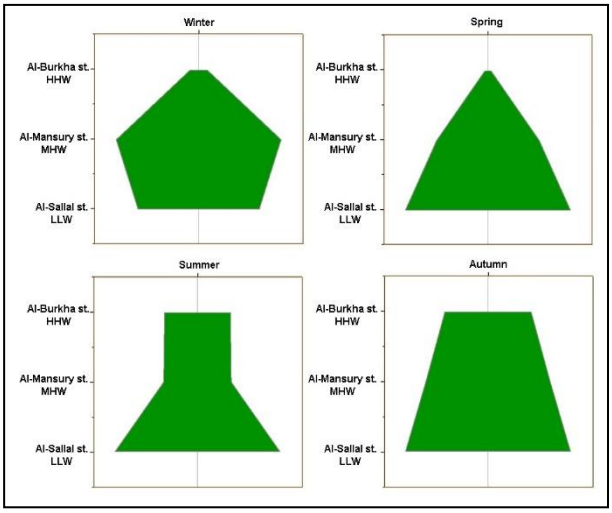
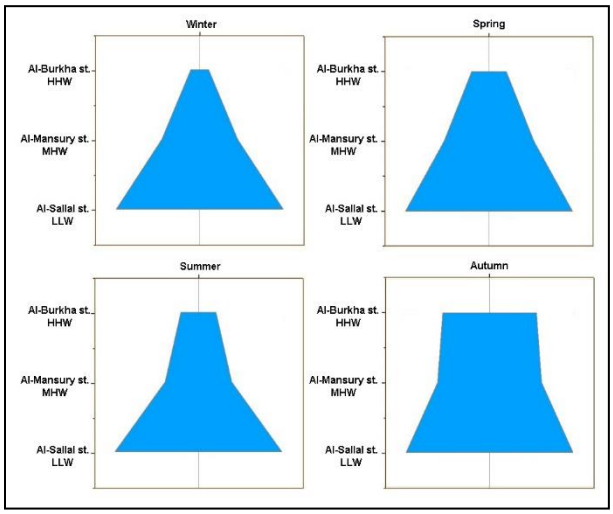


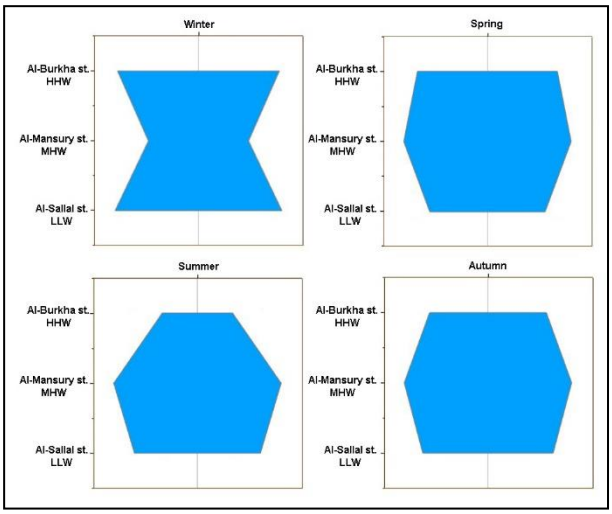
Fig (7): The zonation pattern of Tenualosa ilisha in Al-Sallal station (LLW), Al-Mansoury station (MHW), and Al-Burkha station (HHW), during study period.



2- Thryssa whitheadi

The species of T. whitheadi was migrated to the intertidal zone (Al-Mansury station) during three seasons; spring, summer, and autumn, while T. whitheadi individuals were dispersed at winter in the same location (figure 8). During summer period there was a limited movement into the subtidal zone (Al-Sallal station). The presence of the T. whitheadi is mainly depends on their diet main components such as the shrimp Metapenaeus affinis this confirms the importance of the eastern Hammar Marsh as a ground for feeding a [25].

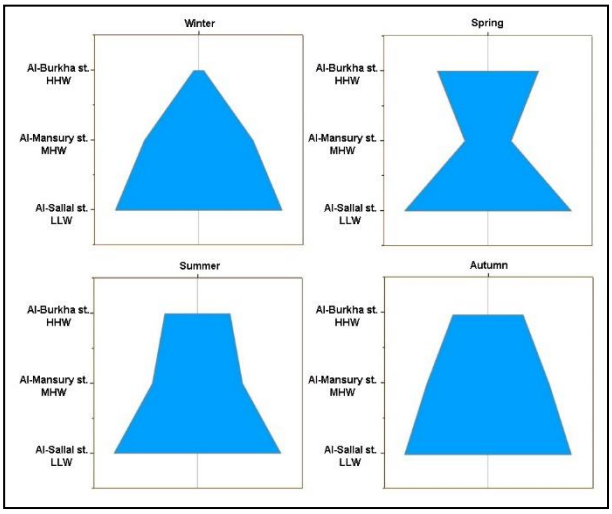
Figure (8): The zonation pattern of Thryssa whitheadi in Al-Sallal station (LLW), Al-Mansoury station (MHW), and Al-Burkha station (HHW), during study period.



3- Bathygobius fuscus

The individuals of B. fuscus were more abundant in the subtidal zone (Al-Sallal station), whereas a few species migration to the tidal zone (Al-Burkha station) during all the seasons of study period (figure 9).

Figure (9): The zonation pattern of Bathygobius fuscus in Al-Sallal station (LLW), Al-Mansoury station (MHW), and Al-Burkha station (HHW), during study period.



- Zonation pattern of exotic species

1- Coptodon zillii

The individuals of C. zillii are seems to be migrating from the subtidal zone (Al-Sallal station) to the tidal zone (Al-Burkha station) during all the seasons (figure 10). The shallow and warm waters are good conditions for most tilapia species [26].

2- Oreochromis niloticus

Nile tilapia O. niloticus seems to dominate the intertidal zone (Al-Mansury station) during winter but during spring it migrates into the intertidal zone from the tidal zone (figure 11). However, in summer there was returning to the tidal zone from the subtidal zone where the numbers of O. niloticus individuals increased in the Al-Sallal station (subtidal zone).

3- Oreochromis aureus

During winter and spring O. aureus was migrating into the subtidal zone from the tidal zone (figure 12). During summer, O. aureus tends to reverse its migration and dominating at the tidal zone but in autumn the species migrates into the subtidal and tidal zones from intertidal zone.

Figure (10): The zonation pattern of Coptodon zillii in Al-Sallal station (LLW), Al-Mansoury station (MHW), and Al-Burkha station (HHW), during study period.

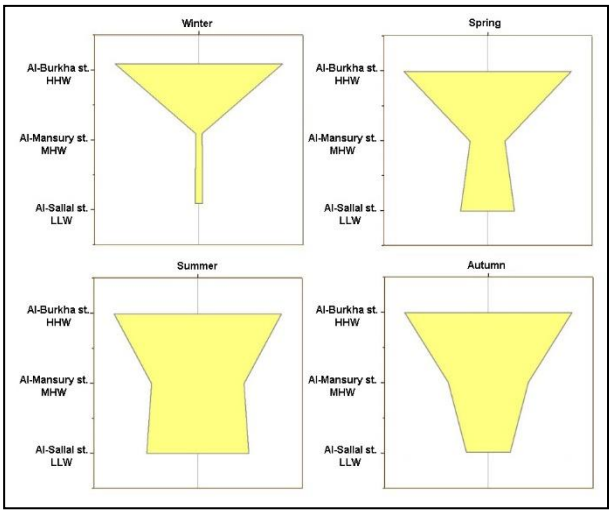


Figure (11): The zonation pattern of Oreochromis niloticusin Al-Sallal station (LLW), Al-Mansoury station (MHW), and Al-Burkha station (HHW), during study period.

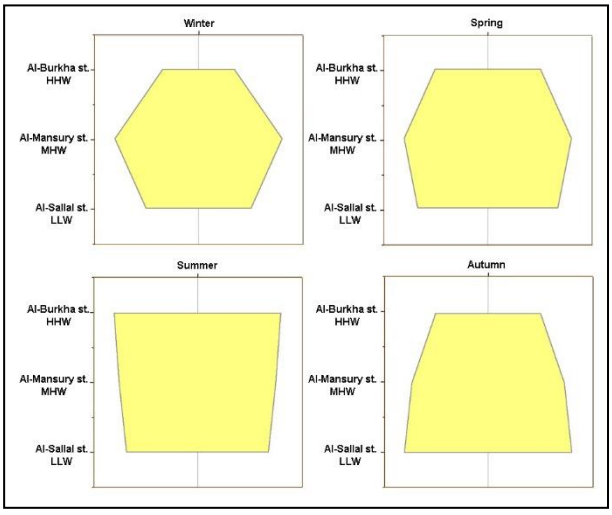
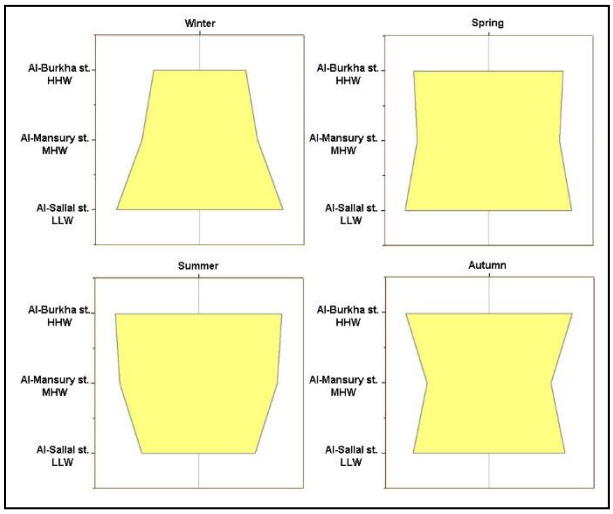


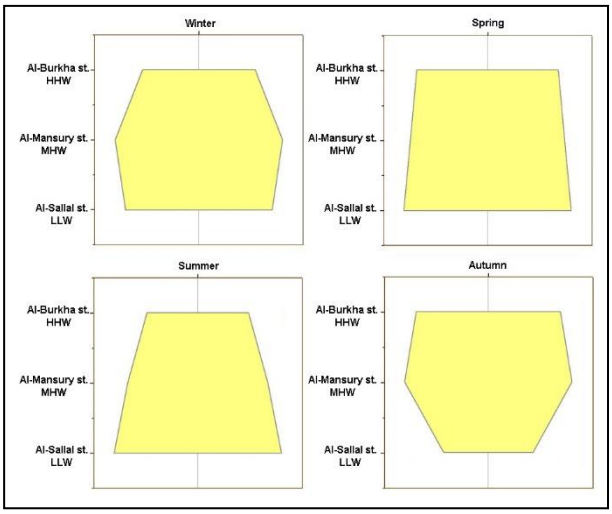
Figure (12): The zonation pattern of Oreochromis aureusin Al-Sallal station (LLW), Al-Mansoury station (MHW), and Al-Burkha station (HHW), during study period.



4- Carassius auratus

The major population part of C. auratus was settled at the tidal zone (Al-Burkha station) during spring and summer seasons (figure 13). During winter, the individuals of C. auratus migrate into the intertidal zone (Al-Mansury station) from the subtidal zone while during autumn the species migrates into the intertidal zone (Al-Mansury station) from the subtidal zone.

Figure (13): The zonation pattern of Carassius auratus in Al-Sallal station (LLW), Al-Mansoury station (MHW), and Al-Burkha station (HHW), during study period.



The tidal marsh of East Hammar has a big ecotone which act to separate between the deep water of Shatt Al-Arab River and the terrestrial semi desert terrain. The flora and fauna of the marsh have adapted to the fortnight or daily fluctuations of lunar tidal with the changes in mesohaline salinity (intermediate salinity). In spite of that, it forms a temporary or permanent habitat for a lot of plants and animals, and they obtain their remarkable ecological roles in this unique environment in the north-western Arabian Gulf and southern Iraq [27].

Many previous researchers [28,13,14,23] indicated that fish assemblages were changed a lot thoroughly between 2019 and 2006 by the dominance of marine, ornamental, and exotic species, which was a result of increasing salinity in addition to overfishing [29]. As a result, the patterns of original native fish zonation have changed significantly as a result of disappearance of many native species.

East Hammar marsh was considered a mesotrophic wetland (highly productive) as stated by [30,18,31], thus it could be a very important location for nursery and feeding ground for juveniles and adults of intruder marine and exotic species [10, 32].

Many emerged plants are present in the East Hammar tidal marsh which was pointed out by [33]. As a result of the relation between tidal amplitude and bottom elevation, a distinct zonation fauna and flora species in tidal marshes and freshwater was formed [4, 6].

The current study indicated that the zonation of the fish assemblages in the East Hammar marsh depends on different biotic factors such as spawning sites, the availability of food, refugee sanctuary, aestivation or wintering habitats, and the human disturbance was on top of them. While the abiotic factors had a significant role such as fluctuation of seasonal temperature, tide amplitude, and the increase of salinity. Baumgartner [34] found that biotic and abiotic conditions could be influencing the distributions of fish within the wetland in a Brazilian reservoir.

Generally, various fish species (native, exotic, and marine) represent significantly the important biomass of the mesohaline East Hammar tidal marsh. Nevertheless, they tend to be distributed unequally right to the elevation gradient from the river of Garmat-Ali to the Al-Burkha station (intertidal zone).

However, the intertidal zone (Al-Burkha stations) seems to attract most of fish population specially the exotic species (figure 4), which could be related to their higher productivity [31, 35] and protection role due to their relative shallowness and blocking big predators from chasing small preys.

The predatory freshwater catfish S. triostegus has populated mostly in Al-Burkha station during Winter and Autumn seasons, as was stated by Hussain and Ali [32, 16], where in the case of high tide, predatory fish are allowed to enter shallow areas[36]

Similar abundance was noted by Hussain [16] on the native species P.abu in the autumn and winter in the subtidal zone, which was connected with the peak of the primary productivity of the East Hammar marsh. This result was in agreement with most studies, as the dominance of P.abu in the east Hammar [18]. Recognizing changes in fish communities by observing the density and distribution of local species is essential for the long-term conservation and management of biodiversity in coastal waters [37].

The marine species of T. whiteheadii which considered as carnivorous species was invaded Al-Burkha station (intertidal zone) similar to what noticed previously by Hussain [16], while the species of B. fuscus was exhibited at Al-sallal station (subtidal zone) in contrast to what was found in a previous work by Hussain [16]. Several studies suggested that fish abundance could be affected by changing water depth [17, 38].

We conclude that feeding is the primary function of fish migration in the Eastern Hammer marsh and thus energy transfer from the tidal zone to the subtidal zone and conversely, the spatiotemporal movements of the intertidal zone are closely related to the accessibility of resource-rich tidal habitats. The shallow intertidal zone provided an important nursery for juveniles, due to the low predation and almost absence of large fish.

Reference

Mohamed, A.R.M.; Hussain, N.A.; Al-Noor, S.S.; Coad, B.W.; Mutlak, F.M.; Al-Sudani, I. M.; Mojer, A. M. and Toman, A. J. (2008c). Species composition, ecological indices and trophic pyramid of fish assemblage of the restored Al-Hawizeh Marsh, Southern Iraq. Ecohydrology and Hydrobiology, 8 (2-4): 375-384.https://doi.org/10.2478/v10104-009-0029-5

Mohamed, A.R.; Hussein, S.A and Mutlak, F. M. (2014 b). Composition of fish assemblage in the East Hammar marsh, southern Iraq. Baghdad Sci J. 11(3). 1373-1381. https://bsj.uobaghdad.edu.iq/index.php/BSJ/article/view/2738

Barendregt, A.; Whigham, D. F.; Meire, P.; Baldwin, A. H.and Van Damme S. (2006). The Ecology of Freshwater Tidal Wetlands, BioScience, 33 (4).255–259.

Van der Valk, A. G. (2006). The biology of freshwater wetlands. Oxford university press.New York, 173 p.

Mitsch, W.J. and Gosselink, J.G. (2000). Wetlands,3rd ed. John weily,New York.920 pp

Yaqoob, M.M.; Berta, C.; Szabó, L.J.; Dévai, G.; Szabó, S.; Nagy, S.A.; Bácsi, I.; Simon, A.; Nagy, J.; Somlyai, I.; Ács, É.; Grigorszky, I. Changes in Algal Plankton Composition and Physico-Chemical Variables in a Shallow Oxbow Lake. Water 2021, 13, 2339. https://doi.org/10.3390/w13172339.

Boorman, L. A. Saltmarsh Review. An overview of coastal saltmarshes, their dynamic and sensitivity characteristics for conservation and management. JNCC Report 2003; No. 334

Batzer,D.P. and Sharitz R.R. (Eds) (2006).Ecology of freshwater and estuarine wetlands. University of California press, USA.568p.

Kuparinen, A.; Ohara, R. and BandMERIL, J. (2009). Lunar periodicity and the timing of river entry in Atlantic salmon Salmo salar. J Fish Biol 74: 2401-2408

CIMI (Canadian Iraqi Marsh Initiatives) (2006). Annual final fish report "Species composition, ecological indices, length frequencies and food habits of fish assemblages of the restored southern Iraqi marshes"byHussain,N.A.;Mohamed,A.R. M .;ALNoor,S.S.;Coad,B.,Mutlak, F.M.; ALSudani, I.M.; Mojer, A.M.;Toman, A.J. and Abdad,M.A . CIMI research group conference and field training session. October 2006.Damascus, Syria.114p.

Lazem, L.F. (2009).Structural composition of fish assemblages and their relation with biotic factors of karmet Ali River, south of Iraq. MSc thesis. Basrah University.90p. (Arabic).

Mohamed, A.R.M.; Hussain, N.A.; Al-Noor, S.S.; Coad, B.W. and Mutlak, F.M. (2009). Status of diadromous fish species in the restored East Hammar Marsh in Southern Iraq. J. Amer. Fish. Soc., 69: 577-588.

Mohamed,A.R.; Al- Sabonich.A.A.and Raadi,F.Kh.(2014a). Changes in fish composition of fish assemblages in East Hammar marsh, south of Iraq.J.King Abudal Al-Aziz for marine science.25 (2):159-182.

Mohamed, A.M; Hussein, S. And Mutlak F. M. (2014 b). Composition of fish assemblage in the East Hammar marsh, southern Iraq. Baghdad Sci J. 11(3). 1373-1381.

Hameed. E.K. (2017).Study of fish composition in Karmet Ali River, south of Iraq. MSc thesis,Basrah University 101p.(Arabic).

Hussain, N.A.; Abdalhsan, H.Th.and Abduijaleel, S. A. (2020). Fish zonation patterns in East Hammar tidal marsh /Basrah-Iraq. Marsh Bulletin.

Stefanoudis P.V., Gress E., Pitt J. M., Smith S.R., Kincaid T., Rivers M., Andradi-Brown D.A., Rowlands G., Woodall L.C. and Rogers A.D. (2019). Depth-Dependent Structuring of Reef Fish Assemblages from the Shallows to the Rariphotic Zone Frontiers in Marine Science, DOI=10.3389/fmars.2019.00307

Radee,F.Kh.(2014). Environmental Assessment for the East Hammar marsh and the possibility of establishment as a nature reserve.Basrah University. 131p (Arabic).

Carpenter, K.E.; Krupp, F. and Jones, D.A. (1997). Living marine resour-ces of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar and the United Arab Emirates. FAO of the United Nations Rome. 293p.

https://books.google.iq/books?id=ljk_BYW8oHMC&printsec=frontcover&hl=ar

Coad BW. Freshwater fishes of Iraq. Freshwater fishes of Iraq checklist. From: www.briancoad.com. Downloaded 05 April (2019).

Fricke R, Eschmeyer WN, Van der Laan R. Eschmeyer's Catalog of Fishes: Genera, Species, References. Electronic version accessed 10/ Feb/ 2020. From: http://researcharchive.calacademy.org/research/ ichthyology/ catalog/fishcatmain.asp

Krebs, C.J.K. (1974). Ecological Methodology. Harper and Row, USA 521p.

Abdalhsan, H.T. (2019). Study of zonation and ecological indices for fish assemblage in East Hammar marsh, Southern Iraq. Basrah University .129pp. (Arabic)

Lee, C.L.; Huang, Y.H.; Chung, C.Y.; Lin, H.J. Tidal variation in fish assemblages and trophic structures in tropical Indo-Pacific seagrass beds. Zool. Stud. 2014, 53, 56.

Hussain, N. A.; Mohamed, A. R. M. and Yousif, U. H. (2007). Dietary overlap of carnivorous in Iraqi marine waters, Northwest Arabian Gulf. Basrah J. Agric. Sci., 20 (2): 1-16.

Chapman, D. 2006. IUCN/SSC Invasive Species Specialist Group (ISSG): Oreochromis spp.Cited 12.03.2013 http://www.issg.org/database/species/ecology.asp?si=813&fr=1&sts=sss.&lang=EN

Hussain N.A. (2014). Biotopes of the Iraqi marshes. First Edition. Dhifaf publishing house, Basra, Iraq. 432pp. (Arabic).

Hussain, N.A., H.A. Saoud and Al Shami, E .J. (2008). Species composition and ecological indices of fishes in the restored marshes of the southern Mesopotamia. Marsh Bulletin, 3(1):17-31.

Hussain N.A, Reiss, P. (2018.). Exploring Program Sustainability and Impact. Twelve Years Later: USAID Iraq Marshlands Restoration Program (IMRP). DAI, Bethesda, Maryland.

Hassan, F.M., Al-Kubaisi, A.A., Talib, A.H.,Taylor. W.D. and Abdullah, D.S. (2011).Phytoplankton primary production in southern Iraqi marshes after restoration. Baghdad Sci. J.8 (1):519-530.

Salman,S.D.,Abbas.F.M.Ghazi,A.H.M.,Ahmed.H.K.Akash,A.N.,Ali,A.Z.,Warner ,B.G.and Asad.T.(2014).Seasonal changes in zooplankton in te re-flooded

Mesopomian wetlands,Iraq. J. Freshwater Eco.29, no3, 397-412.

Hussain,N.A. and T.S. Ali. (2006). Trophic nature and feeding relationships among Al- Hammar marsh fishes, southern Iraq. Marsh Bull. , 1(1):9-18

Al-Abbawy,D.A.H.(2009).Qualitative, quantitative and ecological study of aquatic macrophytes in southern Iraqi marshes during2006 and 2007 .Ph.D. thesis.Basrah University ,205pp.

Baumgartner, M. T.; Baumgartner, G. and Gomesa, L.C. (2018). Spatial and temporal variations in fish assemblage: testing the zonation concept in small reservoirs. Braz. J. Biol. 78(3) 487-500.

Rashed, S.S. (2019). Qualitative, quantitative study of planktonic and epiphytic diatoms in East Hammar marsh/southern Iraq, MSc thesis. Basrah University.121pp.

Krumme, U. (2004). Pattern in the tidal migration of fish in a north Brazilian mangrove channel as revealed by a vertical split-beam echosounder. Fish Res 70:1–15

Raffo, M.P; Russo, V.L and Schwindt, E. (2014). Introduced and native species on rocky shore microalga assemblages: zonation patterns, composition and diversity. Aquat Bot.; (112):57–65.

Krumme, U. (2009). Diel and tidal movements by fish and decapods linking tropical coastal ecosystems. In: Nagelkerken I (Ed) Ecological Connectivity among Tropical Coastal Ecosystems. Springer, Netherlands,yzssay`666 pp 271–324