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Fish zonation patterns in East Hammer tidal marsh /Basrah-Iraq

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Abstract

Zonation patterns of nine fish species belong to five origins, two native species *Planiliza abu*; *Silurus triostegus*, three marine species (*Tenualosa ilisha*,*Bathygopius fuscus* ; *Thyressa whitheadi*) ,two exotic species (*Coptodon Zillii*,*Carassius auratus*), one ornamental species (*Pocilia latipinna*) and one invader species *Hemiculter leuciscuius*, were studied in East Hammer tidal marsh in three stations (Al-Sada ,Al-Mansoury ; Al-Burkha), during four seasons from autumn 2018 to summer2019. Patterns were different according to the species needs. Native species *P.abu* tend to migrate to the intertidal zone during the primary productivity bloom, native predators *S.triostegus* deployed seasonal patterns nearby the intertidal zone ambushing small prey. Marine anadromus *T.ilish* migrate to the tidal zone of East Hammer for spawning, While another two species, *T.whitheadi* and *B.fuscus* depend on the marsh as a feeding ground. Exotic species *C.zillii* and *C.auratus* made a shuttle migration between tidal and intertidal drive-by food performance. Ornamental species *P. latipinna* and invader species *H.leciscuius* both made a noticeable seasonal migration between subtidal and intertidal zones, affected water temperatures and food availability. Most of these species express seasonal migration to the intertidal zones from subtidal and tidal zones and visa versa. Significant factors affect zonation patterns, including food availability, protection from predators, spawning site, and avoiding seasonal temperature fluctuations.

Keywords: Fish Zonation, intertidal fish. tidal marsh, East Hammer marsh, Spatio-temporal zonation.

Introduction

Tidal freshwater wetlands occupy the most upper part of estuaries globally and experience tides of up to several meters in amplitude once or twice a day. They occur at the interface between the upper brackish zone in the estuary and the river (Barendregt et al. 2006). Although tidal freshwater wetlands do not include many endemic or restricted species, they are characterized by high species occurrence and habitat diversity. Freshwater tidal marshes act as buffer zone between upstream riverine ecosystems and the downstream estuary. They display high macrophyte diversity (van der Valk 2006) and distinct macrophytes zonation patterns. Primary production and decomposition proceed at high rates (Mitsch and Goosling 2000). They serve as habitat for fish and other wildlife and may act as sinks for

nutrients and heavy metals (Batzer and Sharitz,2006).

Most previous studies on East Hammer fishes dealt with the nature of the fish assemblages, species compositions, seasonal changes species existence, migration of marine species from Arabian Gulf, and abundance of exotic species (CIMI,2006, Hussain, et al. (2008b and 2009), Lazem (2009), Mohamed, et al., (2009,2014 a; b) and Hameed (2014).

No previous studies were traced concerned with the fish zonation in the East Hammer tidal marsh. The current account's major aim is to highlight the seasonal pattern of species zonation of different origins at intertidal, tidal, and subtidal zones of East Hammer marsh.

Materials and Methods :

East Hammer marsh is situated to the north of Basrah city and extended to the west to reach Thi Qir province. The marsh is affected by the Arabian Gulf's semi-diurnal tide via the Shatt Al-Arab River (Hussain and Taher,2007). The dominant weather is hot temperate characterized by short winter and long extremely hot summer extended to 8-9 months. The marsh Covered by emerge aquatic plants, mainly *Phargmites australesis Typha demoningesis* . During spring, several marine fish migrate to East Hammer marsh, mainly *Tenaulosa ilish* , *Planiliza subviridis* , *P. klunzingeri*, and Penaeidae shrimps *Metapeanus affinis*, for spawning and feeding.

East Hammer marsh, an extensive tidal and intertidal zone extended approximately 30 km from southern sub tidal edge to the most upper intertidal reaches and connected easterly by discharge channel called Karmet Ali river. Three stations were selected to represent a different gradient of the marsh. These stations were exposed to tidal water of various amplitude during days of the lunar month. East Hammer is a tidal marsh; we used intertidal and tidal zones expression instead of littoral and sublittoral zone.

1- Al-Sadda station: Represent the marsh's actual entrance with water depth -ranged from 6 to 7.5 meters at ebb and tide, respectively. It represents the subtidal zone of the marsh, refer as tidal status Low Water Tide (LWT), with co-ordination (N:30o 360 470) (E:470 400 15 0).

2- Al-Mansoury station: Represent the marsh's actual water residence with a mean water depth of 4.5- 6.5 meters at ebb and tide, respectively. It represents the actual tidal zone, refer as tidal status Mean Water Tide (MWT), with co-ordination (N: 300 400 260)(E:470 370 570).

Al-Burkha station: It represents the most upper part of the marsh intertidal zone, the upper high water limit reach by the tide with a water depth of 1.5 -3 meters during the ebb and tide respectively, with co-ordination (N 470 330 20) (E:300 410 440), Figure (1).

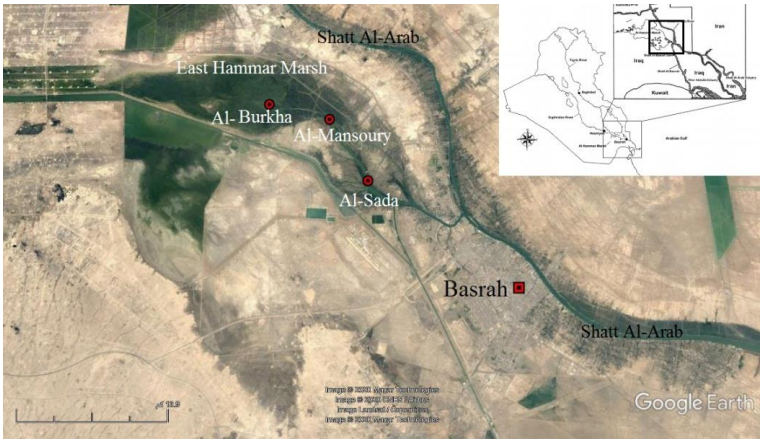

Fig (1) Map of East Hammer marsh, showing the three selected stations, first Al- Burkha (intertidal zone) , second Al-Mansoury (tidal zone) and third Al-Sada (subtidal zone).

Fish collection:

Fishes were collected seasonally from Autumn 2018 to summer 2019, from three stations designated using four fishing methods 1-Seine net 2-Cast net 3-Floating gill net 4- Electrical fishing technique, besides recording other fishermen fish species catch. The fish samples were collected during ebb for six to eight hours.

Fish classification:

Cached Fish species were classified after Al-Faisal *et al*. (2014) and Froese and Pauly (2017).

Fish Origin:

Different fish species were categorized according to their origin into five categories 1-Native 2-Exotic 3-Orenmental 4- Marine migratory 5-Freshwater Invader.

Environmental variables :

Three environmental variables were used to determined fish zonation tidal level fluctuation, seasonal temperature, and station water depth.

kite diagrams:

kite diagrams were modified from Abdalhsan (2019) applied by using auto cad program to draw the zonation patterns of the nine species belong to five fish origins, in an attempt to draw their seasonal dispersals patterns, in three zones 1- HWT in high water tide (Al- Burkha station) 2- MWT mean water tide (Al-Mansoury station) 3- LWT low water tide (Al-Sada station), during four seasons from Autumn 2018 to summer 2019.

Relative abundance :

Relative abundance was calculated after Odum (1971).

Results:

Relative abundance of fish species with different origins:

Nine fish species belong to five origins were studied, two native species *Planiliza abu*; *Silurus triostegus*, three marine species (*Tenualosa ilisha*,*Bathygopius fuscus* ; *Thyressa whitheadi*) , two exotic species (*Coptodon Zillii*,*Carassius auratus*) ,one ornamental species (*Pocilia latipinna*) and one invader species *Hemiculter leuciscuius* . These species choose to display their relative abundance in three stations at East Hammer tidal marsh.

Tables 1, 2, and 3 display the relative abundance of the nine fish species with different origin collected from the three stations at East Hammer marsh during Autumn 2018 to Summer 2019. The relative abundance of exotic and ornamental species was the highest actually, dominated the catch. On the other hand, native species have very low relative abundance reflected the disturbing status of fish assemblage at East Hammer marsh .

According to their relative abundance at Al-Sada station, the first three dominant species were ornamental *P.latipinna*, the second was exotic species *C.zillii* and third was marine species *T.whitheadi*.

In Al-Mansory station, the first three dominant species according to their higher relative abundance were, first ornamental species *P.latipinna* ,second was marine species *T.whitheadi*, and third was exotic species *C.zillii* .

According to their higher relative abundance at Al-Burkha station, the first three dominant species were ornamental species *P.latipinna*, the second was marine species *T.whitheadi* and third was exotic species *C.auratus*.

Generally the nonnative species were dominant in the shape of freshwater ornamental, exotic and marine ones.

Table(1): Seasonal variation in the relative abundance of different fish origins (exotic, marine, native, ornamental; invader), collected from Al-Sada station at East Hammer tidal marsh during the period from autumn 2018 to summer 2019.

Species	Relative abundance Autumn 2018	Relative abundance Winter 2019	Relative abundance Spring 2019	Relative abundance Summer 2019	Average	Origin
P.latipinna	45.8	57.9	31.2	24.1	39.7	ornamental
C.zillii	20.1	7.6	20.5	4.5	13.1	Exotic
T.whit headi	2.3	0.7	14.3	3.6	5.3	Marine
C.auratus	0	12.4	0.3	7.3	5	Exotic
P.abu	0.4	7.1	0	4.5	3	Native
B.fuscus	0.4	0	6.1	2.6	2.2	Marine
S.triostegus	0	0	0.3	0	0.07	Native
H.leucisculus	0.1	0.2	0	0	0.07	Invader
T.ilisha	0	0	0.1	0.2	0.07	Marine

Table(2): Seasonal variation in the relative abundance of different fish origin (Exotic, Marine, Native, Ornamental; Invader), collected from Al-Mansoury station at East Hammer tidal marsh the period from autumn 2018 to summer 2019.

Species	Relative abundance Autumn 2018	Relative abundance Winter 2019	Relative abundance Spring 2019	Relative abundance Summer 2019	Average	Origin
P.latipinna	33.3	89.4	22.1	22.1	40.6	ornamental
T.whitheadi	8.5	1.1	67.9	67.9	19.7	Marine
C.zillii	22.7	1.9	3.8	3.8	8.8	Exotic
C.auratus	0	1.19	0.1	0.1	2.2	Exotic
B.fuscus	2.7	0.2	0.5	0.5	2.3	Marine
P.abu	0	0.1	0.1	0.1	2.4	Native
S.triostegus	0	0	0.3	0.3	0.1	Native
H.leucisculus	0.2	0	0	0	0.07	Invader
T.ilisha	0	0	0.1	0.1	0.04	Marine

Table(3) : Seasonal variation in the relative abundance of different fish origin (Exotic, Marine, Native, Ornamental; Invader), collected from Al-Burkha station at East Hammer tidal marsh the period from autumn 2018 to summer 2019. .

Species	Relative abundance Autumn 2018	Relative abundance Winter 2019	Relative abundance Spring 2019	Relative abundance Summer 2019	Average	Origin
P.latipinna	29.7	68.6	5.0	34.1	34.3	ornamental
T.whitheadi	15.2	2.9	56.2	1.0	18.8	Marine
C.auratus	0	7.3	27.0	3.0	9.3	Exotic
C.zillii	18.1	3.8	0.7	8.0	7.6	Exotic
B.fuscus	8.2	0.4	0.7	3.2	1.7	Marine
P.abu	0	0.4	0	4.0	1.1	Native
S.triostegus	0	0.4	0.1	0.09	0.1	Native
H.leucisculus	0.7	0	0	0.09	0.1	Invader
T.ilisha	0	0	0.3	0.03	0.08	Marine

Seasonal temperatures :

Seasonal variations in water temperature were obvious in the three studied stations (Al-Sada, Al-Mansoury and Al-Burkha in East Hammer marsh) in the East Hammer marsh. The lowest

values were recorded in winter2019,14.0,15.5, and 15. 0 C^0 and the highest values were recorded in summer, 30.0, 31.0, and 33.0 C^0 respectively in Al-Sada, Al-Mansoury, and Al-Burkha stations. Statically analysis showed a significant difference between stations and seasons ($p<0.05$).

Table(1) Minimum and Maximum water temperatures recorded in three stations (Al-Sada, Al-Mansoury, and Al-Burkha)in East Hammer marsh during the autumn 2018 to summer 2019.

	Minimum temp. C^0	Maximum temp. C^0
Stations	Winter 2019	Summer 2019
Al-Sada	15.0	30.0
Al-Mansoury	15.5	31.0
Al-Burkha	14.0	33.0
East Hammer marsh	15.0	33.0

Water depth and distances between sampling stations :

Clear variations occurred in water depth between the seasons and between stations. Statistical analysis indicated a significant difference between stations and between seasons ($p<0.05$). Lower values were recorded in autumn (6 meters, meter 4.5 and 1.5 meters)) , higher values were recorded in Summer (7,5 meter 7.0 meter and 3.0 meter) in Al-Sada, Al-Mansory, and Al-Burkha stations, respectively (4).

Distance between stations was calculated from Google map. Table (4) and fig (2) explain the relief topography of the sampling area, showing that the gradient decrease and water depth toward Al-Burgha station in comparison with the other two stations (Al-Sada and Al-Mansoury) . Table (4) showed the difference in water depth during ebb and tide at the three stations. In general, the water level fluctuated about 1.0 - 1.5 meters during tide and ebb.

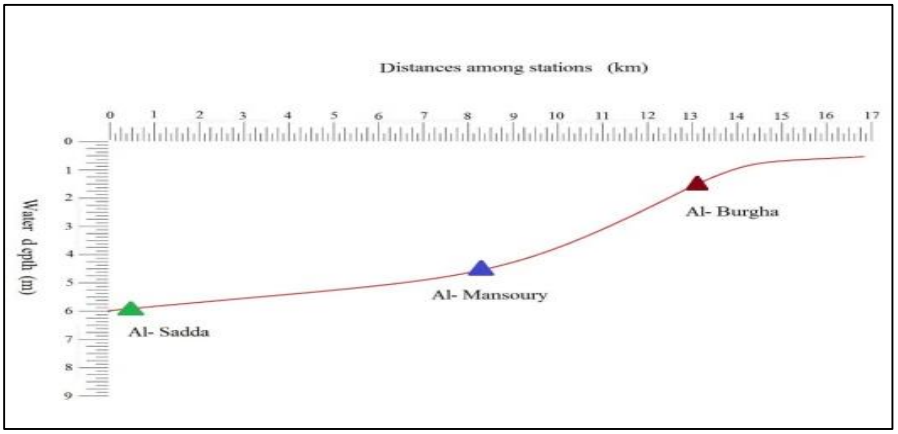

Figure (2): Represent the relation between water depth (meters) and distance (Km.) between the three sampling stations Al-Sada (subtidal), Al-Mansory (tidal), and Al- Burkha (intertidal) in East Hammer tidal marsh.

Table (4): Exhibited the distance (Km) between the sampling stations and their water depth (Meters).

Stations	Distance between stations (km)	Range of water depth at ebb and tide (Meters)
Al-Sada - Al-Mansory	8	6.0-7.5
Al-Mansory - Al- Burkha	5	4.5-7.0
Al-Burkha	-	1.5-3.0

Seasonal Patterns of fish zonation:

1-Zonation pattern of native species

1- ***Planiliza abu***

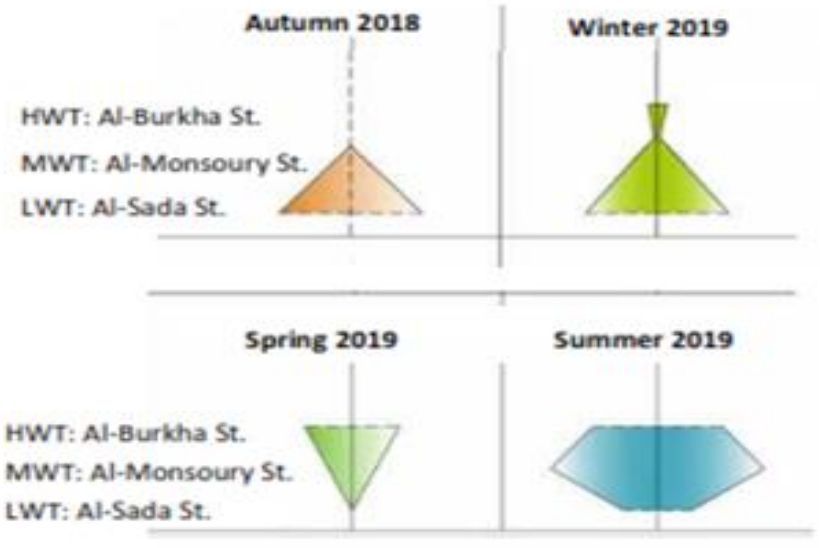

Fig (3): Represent the zonation pattern of *P.abu* at the Al-sada station (LWT),Al-Monsoury station(MWT), and Al-Burkha station (HWT), during the period from Autumn 2018 to Summer 2019, in East Hammer marsh

Figure (3) Showed the seasonal zonation of *P.abu* , it seems that *P abu* available in Al-Sada station (LWT) in autumn 2018 and winter 2019. In Spring 2019, *P.abu* population moved to Al-Burkha station (LWT)., while in summer 2019 *P abu* population disperses largely in both intertidal and tidal zones (Al-Burkha and Al-mansoury stations) with few individuals retreat to subtidal zone (Al-sada station).

Zonation of *P.abu* seemed to be controlled by two factors, seasonal water temperature and availability of detritus (CIMI,2006) present in shallow water station (Al-Burkha) as surplus product of primary production bloom in spring (Hassan *et. al*,2011; Ridee,2014). *P abu* population in East Hammer marsh express a shuttle migration between the shallow intertidal zone and deep subtidal zone in response to seasonal temperature prevail (fig.3) .

1-2- ***Silurus triostegus***

S.triostegus individuals were more abundant in Al-Burkha station (intertidal zone) during autumn 2018 due to the availability of small prey.

In summer 2019, limited retreat to the Al-Mansoury stations (tidal zone) chasing their prey.

Limited migration to Al-Sada station (subtidal zone) in winter 2019again following small preys (fig.4).The movement of *S.triostegus* population seems to be controlled mainly by the presence of its preys and their occurrence at the intertidal zone.

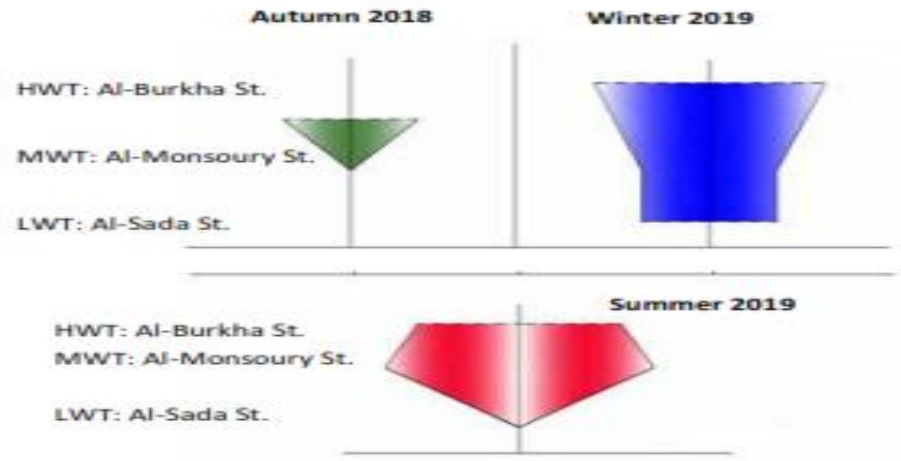

Fig (4) : Represent the zonation pattern of *S.triostegus* at the Al-sada station (LWT),Al-Monsoury station(MWT), and Al-Burkha station (HWT) during the period from Autumn 2018 to Summer 2019, in East Hammer marsh.

2-Zonation patterns of marine species

2-1-*Tenualosa ilisha*

T.ilish is anadromous marine migratory species, move to East Hammer marsh as a spawning ground. The main population existed in Al-Monsoury station (tidal zone MWT) ., with limited movements to the intertidal zone at Al-Burkha station during summer 2019 for feeding on zoo and phytoplankton **(fig. 5).**

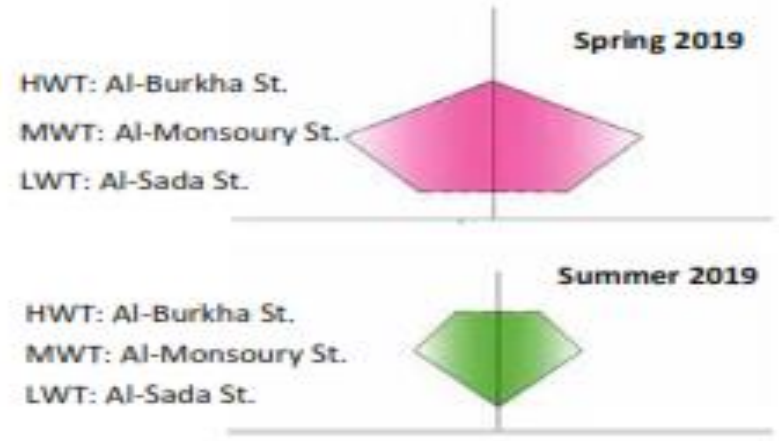

Fig (5) : Represent the zonation pattern of *T.ilish* at the Al-sada station (LWT),Al-Monsoury station(MWT), and Al-Burkha station (HWT), during the period from Spring 2019 to Summer 2019, in East Hammer marsh.

2-2- *Thryssa whitheadi*

Dispersal patterns of *T.whitheadi* individual seem more abundant in Al-Burkha station (intertidal zone) in three seasons (autumn 2018,winter2019 and spring 2019) with a partial move to Al-Sada station (subtidal zone) in summer 2019. The existence of *T.whitheadi* depends on the presence of their main diet, migratory shrimps *Metapenaeus affinis* (Salman et.al, 1990) **(fig.6)**.

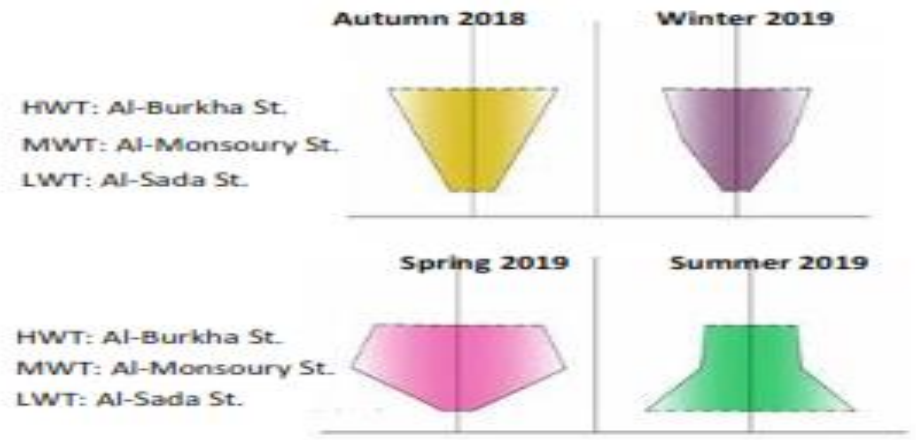

Fig (6): Represent the zonation pattern of *T.whitheadi* at the Al-sada station (LWT),Al-Monsoury station(MWT), and Al-Burkha station (HWT), during the period from Autumn 2018 to Summer 2019, in East Hammer marsh ..

2-3-*Bathygobius fuscus*

Appear that individuals of *B.fuscus* were more abundant in Al-Burkha station (intertidal zone) in three seasons (autumn 2018,winter2019, and summer 2019) and migrate to Al-Sada station (subtidal zone) in spring 2019 (fig.7). The abundance of *B.fuscus* in intertidal could be related to the availability of plants and small animals associated since this species is omnivores.

Fig (7): Represent the zonation pattern of *B.fuscus* at the Al-sada station (LWT),Al-Monsoury station(MWT), and Al-Burkha station (HWT), during the period from Autumn 2018 to Summer 2019, in East Hammer marsh

3-Zonation pattern of exotic species

3-1- *Coptodon zillii*

C.zillii individuals seem to make a shuttle movement between the intertidal zone (Al-Burkha station) and subtidal zone (Al-Sada station) . Abundant at Al-Burkha station in summer 2019 and migrate to the subtidal zone (Al-Sada station) in spring 2019. *C.zillii* individuals disperse in the three zones with marginal abundance in deep water (LWT) in autumn and winter (fig.8).

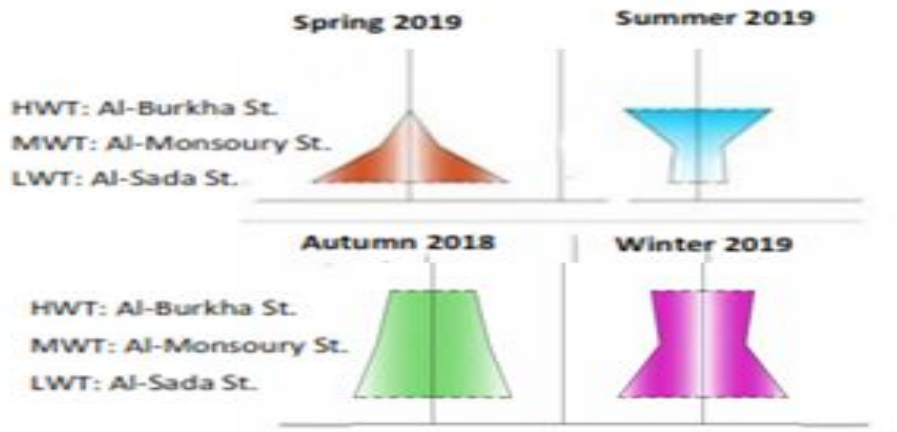

Fig (8): Represent the zonation pattern of *C.zillii* at the Al-sada station (LWT),Al-Monsoury station(MWT), and Al-Burkha station (HWT), during the period from Autumn 2018 to Summer 2019, in East Hammer marsh

3-2- *Carassius auratus*

In autumn 2018, the major part of the population of *C.auratus* abundant at subtidal zone (Al-Sada station) and a minor part at the intertidal zone (Al-Burkha station), the division of population could be due to separation according to size performance, since old specimens prefer different food item from the young of the year. During winter 2019, the population of *C.auratus*. migrated to the intertidal zone for feeding. In summer 2019, the population *C.auratus* spread in the three zones (fig.9).

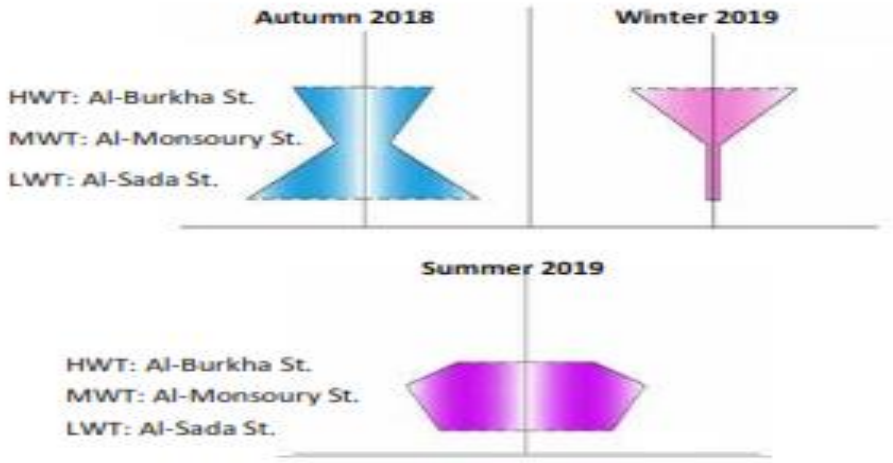

Fig (9): Represent the zonation pattern of *C.auratus* at the Al-sada station (LWT),Al-Monsoury station(MWT), and Al-Burkha station (HWT), during the period from Autumn 2018 to Summer 2019, in East Hammer marsh.

Zonation pattern of Ornamental species

Poecilia latipinna

The population of *P.latipinna* to be more in the deeper zone (subtidal zone), in autumn 2018 and move gradually to tidal zone (Al-Mansoury station) in winter 2019, with an appreciable portion of the population in both intertidal zone (Al-Burkha station) and deeper subtidal zone (Al-Sada station).In spring, the population retreat from the intertidal zone to tidal to sub-tidal zones. However, the population *P.latipinna* demonstrated the effect of water temperature on migrated to intertidal zone (Al-Burkha station) in summer and back to tidal and subtidal .zones in autumn and winter. Similar dispersal patterns during winter and spring and the opposite in autumn and summer (fig.10).

Zonation pattern of invader species

Hemiculter leucisculus

This invader species *H .leucisculus* seems to be common in intertidal zones(Al-Burkha station) during autumn 2018 and migrate to subtidal water in winter 2019 at Al-Sada station. During summer 2019, migrate to tidal and intertidal zones in Al-Mansoury and Al-Burkha stations, respectively. In winter 2019, *H .leucisculus* individuals retreat to the Al-Sada station's sub tidal zone (fig.11). Water temperature seems to the main control *H.lecucisculus* movement along the gradient, during hot seasons (autumn and summer)in intertidal zones and migrate to deep water in winter to avoid low temperature.

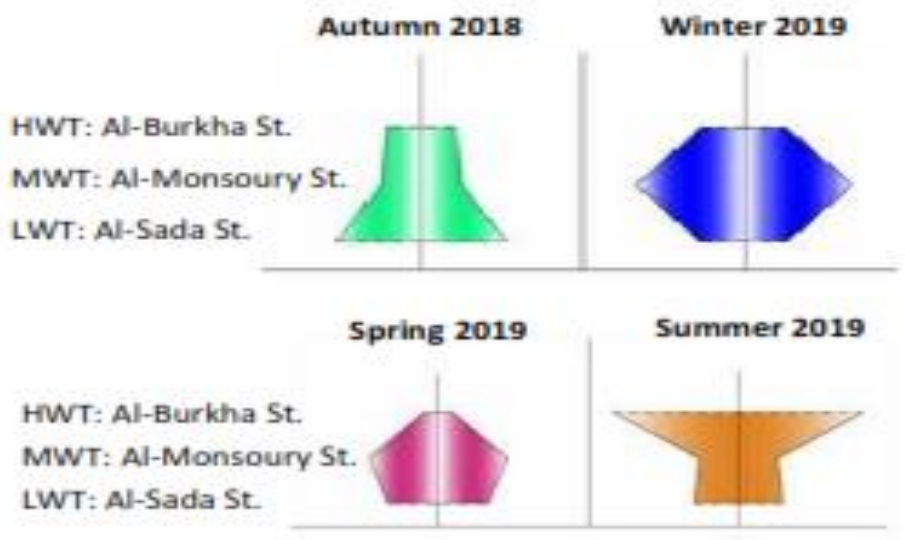

Fig (10): Represent the zonation pattern of *P. latipinna* at the Al-Sada station (LWT),Al-Monsoury station(MWT), and Al-Burkha station (HWT), during the period from Autumn 2018 to Summer 2019, in East Hammer marsh.

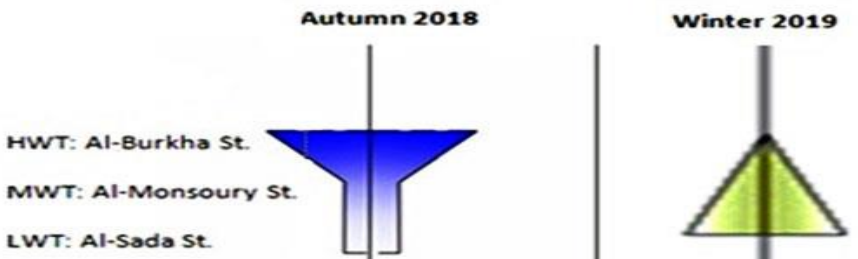

Fig (11): Represent the zonation pattern of *H .leucisculus* at the Al-sada station (LWT),Al-Monsoury station (MWT), and Al-Burkha station (HWT), during the period from Autumn 2018 to Summer 2019 in East Hammer marsh.

Discussion :

East Hammer tidal marsh is considered a big ecoton between the terrestrial semi desert terrain and the deep water of Shatt Al-Arab river/ estuary. Accordingly, the fauna and flora of the marsh have adapted to the daily and fortnight lunar tidal fluctuations with mesosaline salinity changes. Despite that, it forms a permanent or temporary habitat for many animals and plants, and they fulfill their important ecological roles in this unique environment in southern Iraq and north-western Arabian Gulf (Hussain,2014).

Fish Zonation patterns in East Hammer marsh was neglected to be addressed previously, till the hydrological and ecological situation change fundamentally. The nature of fish assemblages was changed thoroughly between 2006 and 2019 by the dominance of exotic, ornamental, and marine species (Hussain et. al,2008, Mohamed *et al.*,2014 a; b and Abudalhsen,2019), facilitated by the steady increase of salinity (Hussain and Reiss 2018) deliberate release of new exotic Taliban species. Accordingly the original native fish zonation patterns change drastically as a result of the disappearance of native species.

East Hammer marsh was classified as a highly productive wetland (Mesotrophic) as stated by Hassan *et .al* ,(2011); Ridee (2014) and Salman *et. al* ,(2014), consequently act as an important feeding and nursery ground for adults and juveniles' of intruder exotic and marine fish species,(CIMI,2006, Hussain and Ali,2006; Hussain et al., 2009a)

Al-Abbawy (2009) pointed out the existence of emerged plants zonation in East Hammer tidal marsh. Even it's well known the formation of distinct zonation flora and fauna species in freshwater and tidal marshes, responding to the relationship between bottom elevation and tidal amplitude (Batzer and Sharitz 2006; van Der Valk 2006).

The present study indicated that fish zonation in East Hammer marsh depends on several biotic factors like food availability,spawning sites ,refugee sanctuary , habitat performance, wintering or aestivation habitats and on top of that, human disturbance. A biotic factors play an important role like tide amplitude , seasonal temperatures fluctuation ,salinity increase ,organic pollution and biological productivity. Baumgartner et. al,(2018) observed that abiotic and biotic conditions influencing fish

distributions within the wetland along vertical and horizontal gradients in Brazilian reservoir .

Resident fish species (exotic, marine, and native) contribute significantly to the standing biomass of tidal mesosaline East Hammer marsh. Still, they tend to be distributed unevenly along the elevation gradient from Karmet Ali river to the Al-Burkha intertidal station, intertidal zone (Al-Burkha station) seems to attracted most resident species due to their higher primary and secondary productivity (Rashed 2019 and Salman et. al,2014) and protection role due to their relative shallowness, hinder big predator from chasing small preys. On the other hand,, Al-Sada station plays an important role as a a deepwater reservoir for several species, resting station before their seasonal migration to Al-Burkha station or in their immigration back to Shatt Al- Arab river/estuary.

Marine carnivorous species like *T.whiteheadii* and *B.Fuscus* exhibited similar zonation patterns by invading the intertidal zone (Al Bukha station), chasing their prey of small fish and shrimps (CIMI ,2006 and Hussain et al,2009a). The same dispersal was noted for detritivorous *P.abu* to the intertidal zone in winter /spring, conceding with the peak of the East Hammer marsh's primary productivity.Again *S.triostegus* freshwater predator has a distinct zonation mostly in the Al-Burkha station, i.e. at the intertidal as feeding ground (Hussain and Ali,2006)

Fernandes *et, al.*(2010) indicated that the spatial patterns of fish assemblages in a seasonal tropical wetland was affected only by variable water depth; the same was noticed in East Hammer tidal marsh with daily and fortnights tidal level changed, effecting fish zonation and movement between stations/zones conceding with tidal depth.

Abdullah (2015) considered East Hammer tidal marsh as an available source of fisheries for both fin fishes and shrimps to the local inhabitants, with a 20% contribution of total annual Iraqi fisheries.

The steady increase in salinity of East Hammer tidal marsh facilitated the penetration more marine migratory species never been encounter previously in the marsh like stonefish (*Synanceia verrucosa*) and *Platycphalus indicus* and the tiger shrimp *Peauneus semiselectus* (Jodha,2019). However, our understanding of marine migratory fish using the East Hammer marsh is poor. *T. whitheadi* and *B.fuscus* became abundant around the year and becoming resident species than migratory ones, which could be due to the increase of salinity to reach a high level never encounter before (Hussain and Reiss 2018).

Juveniles and young of the year of exotic species like *C.zillii* tend to disperse in East Hammer marsh mainly for feeding and protection (Al-Okailee et al.,2017). Anadromus marine *T.ilish* use East Hammer marsh as spawning ground (Mohamed et al.,2009), these larvae and juveniles attracted other carnivorous species to invade the marsh. Consequently, East Hammer marsh plays an important ecological role as a nursery and feeding ground for many natives, exotic, and migratory marine fish species, especially the shallow intertidal zone at Al-Burkha station/area.

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