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Numerical and Descriptive Assessment of the Fish Assemblage at East Hammar Marsh, Basra, Iraq

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Abstract - The fish assemblage at the East Hammar Marsh (EHM) was dominated by alien species instead of native species. Alien species were successfully established in the EHM over a relatively short time period. Continuous increase in salinity altered the aquatic environment from freshwater/oligohaline to mesohaline/estuarine in EHM. The degree of disturbance of the fish assemblage invaded by alien species was quantified on the basis of native species number and their individuals to the total number of species and total individuals present. Formulas were applied to quantify the ratios of occurrence and abundance of both native and alien species. The highest number of species recorded at EHM was 44 in 2012 and the lowest 21 in 2024. Data on the occurrence and abundance of native fish components in the assemblages were 18.2% (very disturbed) and 3.2% (totally upset). A noticeable decrease in the ratio of native species to alien species and vice versa was accompanied by an increase in salinity during one decade from 2009 to 2024. The highest native species occurrence rate was 56% in 2013 and the lowest was 20%. In 2019 The highest abundance score of the native species was 44% and the lowest was 20%. The highest turnover rate index was 43.39 and the lowest was 8.19. As the turnover index value increased, as more alien species occurred at EHM.

التقييم العددي والوصفي لتجمعات الأسماك في هور الحمار الشرقي، البصرة، العراق

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المستخلص - شهد مجتمع الأسماك في هور الحمار الشرقي تغيرات بيئية واضحة خلال السنوات الأخيرة، تمثلت بزيادة ملحوظة في هيمنة الأنواع الغازية على حساب الأنواع المحلية، سواء من حيث عدد الأنواع أو كثافة اعدادها. ويبدو أن هذه الأنواع الغازية تمكنت من التكيف والاستقرار بسرعة داخل النظام البيئي للهور. تعزى هذه التغيرات في المقام الاول إلى الارتفاع التدريجي في ملوحة المياه، والذي أدى إلى تحول طبيعة البيئة من عذبة أو قليلة الملوحة إلى بيئة شبه مصبية. وقد انعكس ذلك سلباً على الأنواع المحلية، حيث لوحظ تراجع مستمر في تواجدها ووفرتها مع مرور الزمن. تم تقييم درجة اضطراب مجتمع الأسماك باستخدام مؤشرات كمية تعتمد على نسب الأنواع المحلية إلى اجمالي اعدادها، بالإضافة الى مقارنة وفرتها مع الأنواع الغازية. وأظهرت النتائج أن المجتمع السمكي يعاني من مستويات عالية من الاضطراب، مع حالات تصل إلى اختلال شبه كامل في بعض الفترات . أظهرت البيانات أن حالة تجمعات الأسماك من حيث التكرار والوفرة للأنواع المحلية كانت مضطربة جدًا بنسبة 18.2% ومختلة تمامًا بنسبة 3.2%. كما لوحظ انخفاض واضح في نسبة الأنواع المحلية إلى الدخيلة (والعكس صحيح) بالتزامن مع ارتفاع الملوحة خلال فترة الدراسة من عام 2009 إلى 2024. بلغ أعلى عدد للأنواع المسجلة في الهور 44 نوعًا في عام 2012، بينما كان أدنى عدد 21 نوعًا في عام 2024. وسجل أعلى معدل تواجد للأنواع المحلية 56% في عام 2013، وأدنى معدل 20% في عام 2019. كما سجلت أعلى نسبة وفرة للأنواع المحلية 44% وأدناها 20%. في المقابل، بلغت أعلى نسبة للأنواع الدخيلة 80%. سُجلت معدلات أعلى لتواجد ووفرة الأنواع المحلية في محطة مدخل الهور (السدة) مقارنة ببقية مناطق هور الحمار الشرقي. وبلغ أعلى مؤشر لمعدل التغير Turnover Index 43.39 أدناه 8.19، حيث يدل ارتفاع هذا المؤشر على زيادة ظهور الأنواع الدخيلة.

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الكلمات المفتاحية: هور الحمار الشرقي، الأهوار العراقية، تواجد الأسماك المحلية، تواجد الأسماك الدخيلة، قياس الاضطراب

Introduction:

Vast marshes occupy southern Mesopotamia, characterized by unique flora and fauna, are considered valuable ecological oases surrounded by deserts. The southern marshes face a gradual decrease in freshwater supply mainly from the Tigris and Euphrates rivers. This is due to climate change, severe reduction in rainfalls in the Levant and the construction of several irrigation dams in Turkey, Iran, Syria and Iraq. This resulted in a large reduction in the freshwater influx to the southern marshes. At the time the East Hammer Marsh (EHM) received freshwater supply from the Shatt Al Arab River-Estuary continue only.

During the nineties of the last century, the fish assemblage at Hammer marsh consisted of freshwater, anadromous and seasonal migratory marine species as postulated by Hussain (2014). The study also suggested that no endemic or restricted species were present. The fish community in the marsh was derived mainly from the Tigris, Euphrates rivers and Shatt Al-Arab River-Estuary Continue.

Several efforts have been made to introduce exotic species into the Iraqi Rivers and the marshes to rectify inland fisheries and increase fishery yield. The first was in the eighties of the last century, when the common carp (*Cyprinus carpio*) was released into the Iraqi rivers and later invaded the southern marshes, followed by the accidental release of Prussian carp (*Carassius auratus*) into the Shatt Al-Arab River-Estuary continue and later expanded to occur in all Iraqi rivers and marshes (Al-Fasial and Mutlak, 2014). After 2003, the Euphrates River witnessed the occurrence of tilapia fish species in 2007 and then invaded all Rivers and the Southern marshes of Iraq. At that time exotic fish were considered the most abundant species in marshes. (Hussain and Reiss, 2018; Abdalhsan, 2019). However many ornamental fish escape from their culture ponds in southern Basrah to settle and occupy the sublittoral zone of the EHM.

Most previous studies on EHM fishes have dealt with the nature of the fish assemblages, species compositions, seasonal changes, migration of marine species from Shatt Al Arab River-Estuary Continue and abundance of exotic species (Hussain *et al.,* 2008; Hussain *et al.*, 2009; Lazem, 2009 ; Mohamed *et al.,* 2013 ;Al-Fasial and Mutlak, 2014; Hussain and Reiss, 2018; Abdalhsan *et al.,* 2019).

The current study aimed to investigate the disturbance score of the fish assemblage in the EHM due to marine migration, the release of ornamental species, and the introduction of many exotic species of different origins. In addition, we intended to implement a numerical and descriptive scale to estimate the status of disturbance of fish assemblages and calculate the turnover rate index of species at the EHM.

Materials and Methods:

Description of the Study Area:

EHM represents the southern part of the vast southern Iraqi marshes, situated to the northwest of Basrah city and expanded to the west to Thi Qar province. The marsh is affected by semidiurnal tides originating from the Arabian Gulf via the Shatt Al-Arab River-Estuary Continue. It is characterized by hot weather with short winters and long dry summers extending to 8-9 months (Raadi *et al*., 2022). The marsh was subjected to deliberate desiccation by Saddam regime during the nineties of the last century. After inundation in 2003, the marsh exhibited a return of its flora and fauna at different percentages (Richardson and Hussain, 2006). The marsh is covered by emerging aquatic plants mainly *Phragmites australesis, Typha demoningesis* and

Schinoplactus littoralis. During the spring and summer seasons several marine fish migrate to EHM mainly the anadromous species *Tenaulosa ilisha*, *Planiliza subviridis*, *P. klunzingeri* and Penaeidae shrimp *Metapeanus affinis*, for spawning, feeding or as nursery grounds.

Sampling Stations:

Usually, the four stations selected by the authors for fish sampling, represent different biotopes of the EHM. Three stations were at the main body of the marsh, Al-Sadda, Al-Mansouri and Al-Burkha represented different biotopes, and the fourth station Qarmat Ali at the outlet channel connected the entire marsh with the Shatt Al-Arab River-Estuary Continue, and their coordinates were determined using a GPS device.

- Qarmat Ali station: A deep channel marsh connecting the main body of EHM with the Shatt with water depth fluctuating between 7- 8 meters and length of 10.5 Km. width of 280 meters, with co-ordination (30º 34'30.93'N) (47º 44' 38.87"E).
- Al Sadda station: The actual inlet zone to the marsh with water depth fluctuating during the semidiurnal tidal cycle, with co-ordination (30º 36' 49.16"N) (47º 40' 13.65"E).
- Al Mansouri station: Wide-channel marsh with water depth fluctuating during the tidal cycle, with coordination. (30º 40' 28.08"N) (47º 37' 42.79"E).
- Al Burkha station: Wide shallow openness marsh with water depth fluctuated 0.5-2.0 m during tidal cycle, with co-ordination (30º 41'18.97"N) (47º 35' 11.93"E).

Fish Collection:

Fish samples were collected seasonally (autumn, winter, spring and summer) from EHM at the four designated stations by using three main methods: 1-Seine net 2-Cast net, and 3- Electrical fishing, in addition to field recording of other fisherman, s catch.

Fish Classification:

Fish species were classified according to (Al-Fasial, 2020).

Fish Origin:

Different fish species were categorized according to their origin based on (Al-Fasial and Mutlak, 2014) into five categories: Native (N), Exotic (E), Ornamental (O), Marine (M) and Freshwater Invader (I)

Analysis of Fish Species Occurrence and Abundance in EHM:

Occurrence Ratio of Native Species to Total Fish Species in the Sample:

NO/TO *100

NO= Number of native species occurrences in the sample.
TO= Total occurrence of all species in the sample {native (N) + exotic (E) + marine (M) + ornamental (O) + invasive (I)}.

Occurrence Ratio of Alien Species to Total Number of Species in the Sample:

AO /TO *100

AO = Number of alien species in the sample {Exotic (E) + Marine (M) + Invader (I) + Ornamental (O)}

TO= Total occurrence of all species in the sample {native (N) + exotic (E) + marine (M) + ornamental (O) + invasive (I)}.

Abundance of Native Species to Total Number of Individuals in the Sample:

NA / TA *100

NA= Number of native species abundance (individuals) in the sample.
TA= Total abundance (individuals) of all species in the sample {native (N) + exotic (E) + marine (M) + ornamental (O) + invasive (I)}.

Abundance of Alien Species to the Total Number of Individuals in the Sample:

AA /TA *100

AA= Number of alien species individuals in the sample.
TA= Total number of individuals of all species in the sample.

Degree of Disturbance Score:

The method is formulated to described the disturbance in fish assemblage in mathematical formula easy to described and compare. To estimate the degree of disturbance in fish assemblages at EHM, we applied the following expression and equivalent number ranges to quantify each case separately as follows (Tables.1 and 2).
Status description: NO = Native species occurrence in the sample; TO=Total occurrence of all species in the sample.

Table1. Assessing disturbance score of native to total fish species occurrence.

Native species / Total fish species (NO /TO) score	Habitat* status description
90-100	Integrated
70-89	Fine
50-69	Moderate
30-49	Disturbed
29-10	Very disturbed
9-0	Totally disturbed

*Marshes biotopes.
NA= Native Species Abundance (individuals) in the sample.
TA= Total abundance of all species individuals in the sample.

Table 2. Assessing disturbance score of native to total alien species abundance.

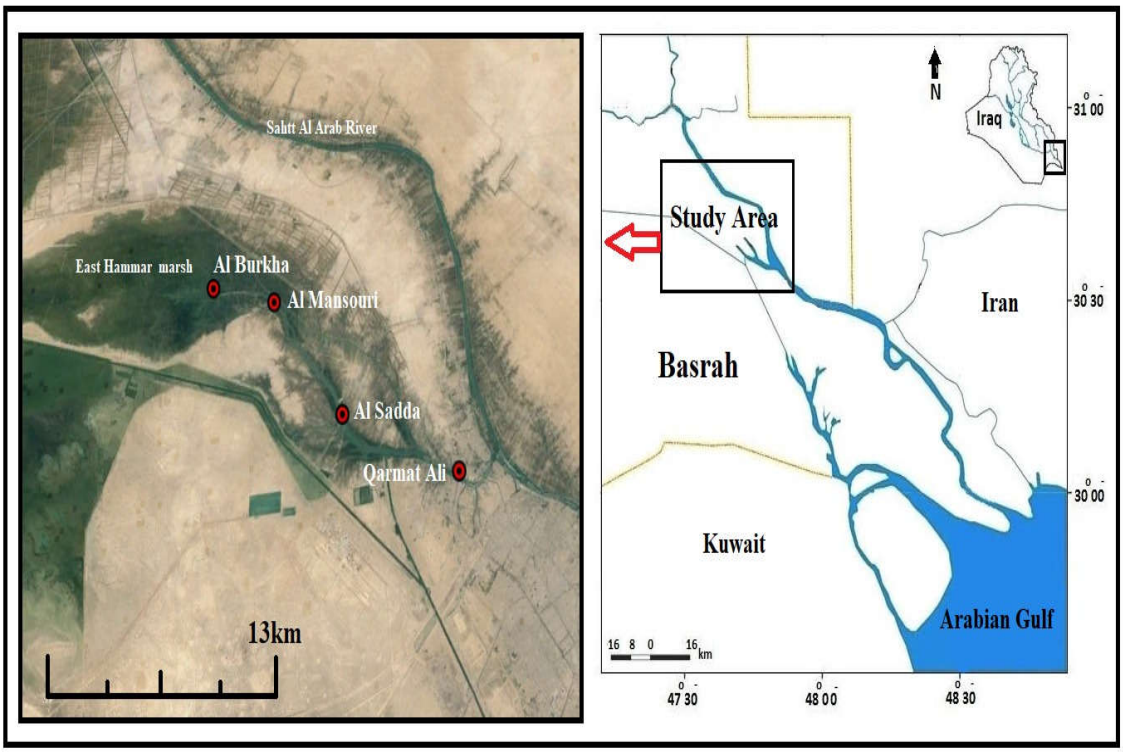
Disturbance score of number of native species Abundance (Individuals / total individuals abundance (NA/TA %)	Habitat* status description
90-100	Incorporated
70-89	Average
50-69	Medium
30-49	Upset
29-10	Very upset
9-0	Totally upset

*Marshes biotopes.

Turnover Rate Index (Yu *et al*., 2025).
$T = L + G / S_2 + S_1$……(Simplified version from the original equation by Yu *et al.,* 2025.)
T: Turnover rate index.
L: Number of lost (disappear) species.
G: Number of Gain (introduce) species.
S_1+S_2 = Number of species (Richness) in two areas or periods.

Supplementary fish data on occurrence and abundance in EHM were obtained from previous published studies accordingly:

Map (1) of East Hammer Marsh:



Map1. East Hammer marsh located at the north and north west of Basrah city, showing four major stations from east to west: Garmat Ali represent a canal marsh and outlet connection with Shatt Al Arab Estuary. Inlet station at Al-Sadaa connecting between EHM and Qarmat Ali station. The third wide shallow channel is marsh station at Al-Mansouri, the fourth Al –Burkha which represent extensive openness marsh.

Results:
Occurrence Ratio of Native and Alien Species at EHM:

The highest number of species recorded at EHM was 44 by (Mutlak, 2012) and the lowest (21) by (Mohammed, 2024). The peak of native species was 14 registered by 13 and the least was 5 by 14 and17. The highest alien species obtained was 30 by 13 and the minimum was 14 by 5 (Table.3).

Table 3. Display native and alien species ratio as recorded by previous studies on fish assemblage of EHM during the period from 2009 to 2024.

No.	Sources	No of Species	Native Species	Alien Species
1	Hussain *et al.,* (2009)	31	13	18
2	Mutlak(2012)	44	14	30
3	Mohamed *et al*., (2013)	25	11	14
4	Ahmed (2017)	22	5	17
5	Al- Najjar (2019)	35	7	28
6	Abdalhsan *et al.,* (2020)	23	5	18
7	Abdullah *et al.,* (2022)	32	10	22
8	Mohammed (2024)	21	5	16

Occurrence Score of Native Verses Alien Species at EHM:

The highest score was 44% (Mohamed *et al*., 2013), and the lowest 20% was recorded by (Al Najjar, 2019). In contrast, the highest score for alien species (A/T) is 80% as mentioned by (Al Najjar, 2019). (Table.4)

Table 4. Temporal disturbance score of native and alien species occurrence to total number of species occurrence at EHM. NO/TO= Number native species occurrence /total number of species occurrence, AO/TO=Number of alien species occurrence /total number of species. Occurrence. Data were calculated from previous studies.

No.	**Sources**	**Native occurrence / Total occurrence (NO/TO %)**	**Alien occurrence / Total occurrence (AO/TO %)**	**Native occurrence disturbance status**
1	Hussain *et al*., (2009)	42%	58%	Disturbed
2	Mutlak(2012)	32%	68%	Disturbed
3	Mohamed *et al*., (2013)	44%	56%	Disturbed
4	Ahmed (2017)	23%	77%	Very disturbed
5	Al- Najjar (2019)	20%	80%	Very disturbed
6	Abdalhsan *et al.,* (2020)	22%	78%	Very disturbed
7	Abdullah *et al.,* (2022)	31%	69%	Disturbed
8	Mohammed (2024)	24%	76%	Very disturbed

Occurrence score of native species (NO) to total occurrence of species (TO) as calculated from previous studies. The highest score was 44% (Mohamed *et al*., 2013), and the lowest 20% was recorded by (Al Najjar, 2019). In contrast, the highest score for alien species is 80% as mentioned in (Al Najjar, 2019). (Table.4).

Abundance Score of Native Verses Alien Species at EHM:

Abundance score of native species (NA) to total abundance of species (TA) ,was calculated from previous studies. The highest score of native abundance percentage was 56.1% by (7) and the lowest was (2.4) recorded by (Ahmed, 2017). On contrary the highest score of alien species was 85.2% as mention by (Al Najjar, 2019). and the minimum was 43.8 by (7) (Table .5).

Table 5. Temporal disturbance score of native and alien species abundance to total number of species abundance as calculated from previous studies at EHM. NA/TA=number of native abundance /total number of species abundance, AA/TA=Number of alien species abundance /total number of species abundance. (The references used here in the table is part of the table contents to explain the case, other wise it will obscure and lost effect of time series.

Sources	Total number of individuals	Native individuals %	Alien individuals %	Native abundance disturbance Status
Hussain *et al*., (2009)	16199	56.1	43.8	Upset
Mutlak(2012)	151489	44.8	55.1	Medium
Mohamed *et al*., (2013)	4913	52.2	47.7	Upset
Ahmed (2017)	1624	17.05	82.8	Very upset
Al- Najjar (2019)	38653	14.7	85.2	Very upset
Abdalhsan *et al.,* (2020)	11529	21.8	78.2	Very upset
Abdullah *et al.,* (2022)	5767	6.47	93.42	Totally upset

Spatial Impact on Fish Assemblage Composition:

Native occurrence and abundance data indicated that the EHM fish assemblages were very disturbed and totally upset respectively (Tables 4 and 5). Disturbance scores differed among stations. The Al-Sadda (inlet marsh) station score was higher than the other two stations for both native occurrence and native abundance scores. In other words, the number of native species occurred and the number of individuals collected from Al-Sadda station was higher than that from Al-Mansouri (Channel marsh) and Al-Burkah (Openness marsh) stations (Figure 1).

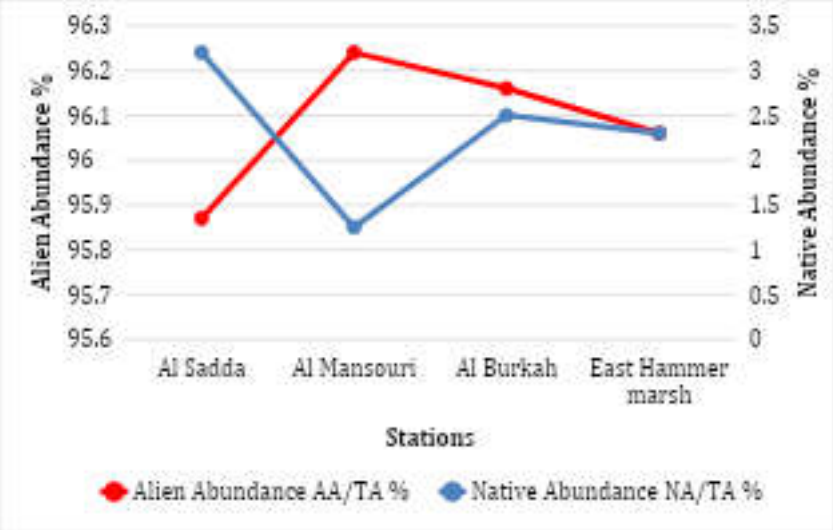


Figure 1. Spatial differences in ratio of native and alien abundance in EHM stations. (Abdalhsan, 2019).

Effect of Salinity Increase on Composition of Fish Assemblage:

A noticeable decrease in the ratio of native species to alien species(marine , exotic and ornamental) ratio and vice versa was accompanied by acontinuous increase in salinity during one decay period from 2008 to 2019. Salinity began to rise after 2012 (Mutlak, 2014) and peaked in 2020 (Raadi *et al*., 2022). (Figure 2)

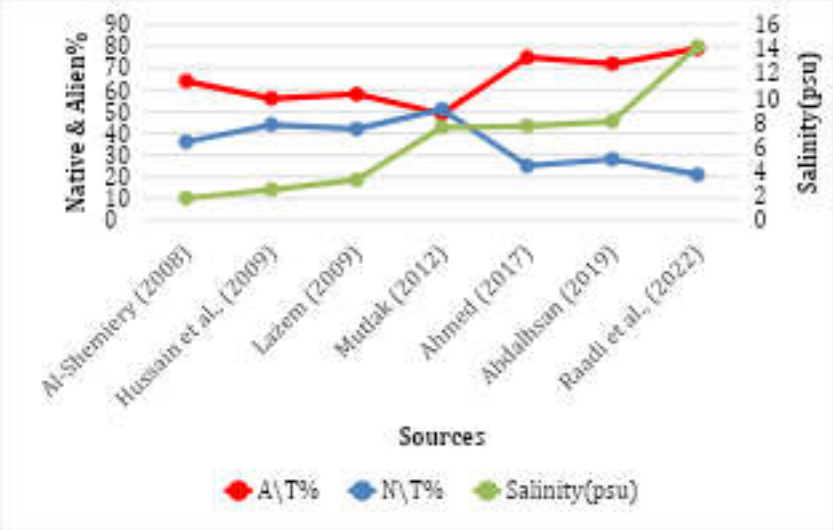


Figure 2. Illustrated continuous increase in salinity at EHM during the period from 2008 to 2019, with percentage of native and alien species. T= Total number of species, N= Number of native species, A = Number of alien species.

Ratio of Native and Alien Species Occurrence in Previous Studies:

During the period from 2009 to 2013, native species ratio score 42 to 44% (Mohamed *et al.,* 2013; Hussain *et al.,* 2009). Then a gradual decline to reach 20% only (Al Najjar, 2019). On the contrary alien species ratio reach the peak 80% in 2019 (Al Najjar, 2019), coinciding with peak salinity increase. This was followed by a slight decline to 69% in (Abdullah *et al*., 2022). In general the percentage of alien species has increased from 2017 to 2024 (Figure 3).

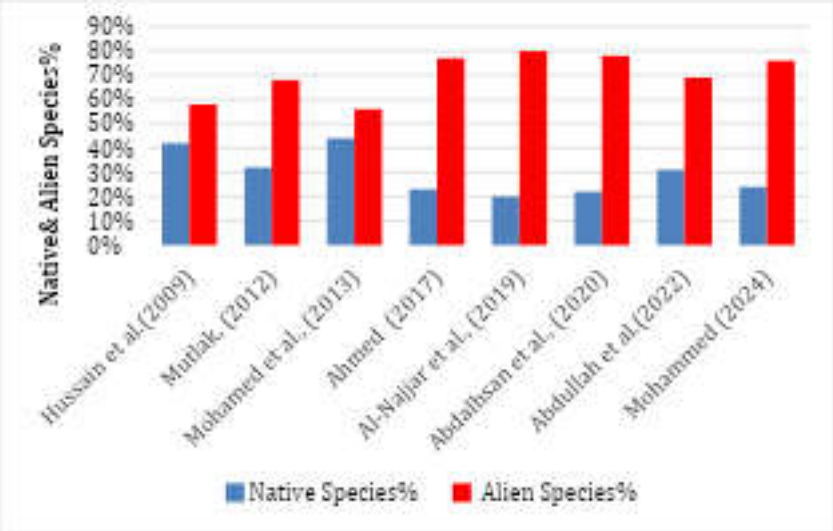


Figure 3. Showed the percentages of native and alien species ratio at EHM during the period from 2009 to 2024.

Turnover Rate Index of the Fish Assemblage at EHM

The highest turnover rate index was 43.39 recorded by (Abdalhsan *et al*., 2020) and lowest 8.19 by (Hussain *et al.,* 2009). As the value of turn over index increase indicated more alien species occurrence in EHM, in comparison with original status. Progressive decrease in native species in EHM, led to a decline in values of turnover rate index during the period 2009 to 2024 (Table 6).

Table 6. Turnover rate index of native and alien species recorded by previous studies at EHM during the period from 2009 to 2024.

Sources	Turnover Rate Index
Hussain *et al*., (2009)	8.19
Mutlak(2012)	22.58
Mohamed *et al*., (2013)	12.72
Ahmed (2017)	34.61
Al- Najjar (2019)	32.3
Abdalhsan *et al.,* (2020)	43.39
Abdullah *et al.,* (2022)	19.35
Mohammed (2024)	43.13

Discussion:

The occurrence and abundance of several exotic, ornamental and estuarine fish species in EHM led to fundamental changes in the nature of the fish assemblage, mainly to be dominated by Alien species instead of originally riverine native ones.

Steady increase in salinity in EHM, altered the marsh environment from oligohaline to be mesohaline or hypersaline and led to disappearance of most riverine native fish, since these species are strictly oligohaline and unable to tolerate saline habitat. Moreover, Aline exploited the mesohaline environment to flourish in the marsh and exerted fierce competition on available food resources (Castaldelli *et al*., 2013 and Gavioli *et al*., 2018) especially by the three aggressive tilapia fish species. African tilapia species were known to tolerate harsh environment conditions. Vicente and Fonseca-Alves (2013) concluded that the release of Nile tilapia into non-native aquatic ecosystems may result in competition for food and space, thereby damaging native species assemblage, reduce biodiversity and modify local fish assemblages ,through their wide environmental tolerance and high reproductive rate.

Tidal marshes are characterized by high biological productivity. Similarly, East Hammer is a semidiurnal tidal marsh that attracts many migratory organisms such as fish, birds and shrimps, consequently EHM has become an important feeding and nursery grounds especially for exotic, anadromous and migratory estuarine species. Recent studies on biological productivity by Habeeb, 2019; Hussain 2014) indicated that the EHM was eutrophic with a high Carlson's trophic State Index (CTSI) (Hussain and Sabbar, 2020).

Introduction of three exotic Tilapia fish species (O. niloticus, C. zillii and O.aureus) to EHM after 2007 was accompanied by a steady increase in marsh salinity, which facilitated more migratory marine species to invade the marsh (Abdalhsan *et al*., 2020). These events led to fundamental changes in the nature of the fish assemblage to be dominated by ornamental, exotic and marine migratory species instead of the originally native freshwater fish (Al-Shemiery, 2008).

An increase in East Hammer marsh salinity during 2018 (Hussain and Reiss, 2018; Habeeb e*t al.,* 2023) indicated drastic habitat changes in biological productivity patterns, availability of food resources, and aquatic plant densities, in favor of exotic and marine migratory species against native freshwater ones, consequently altering the composition of fish assemblages (Abdalhsan, 2019). The native freshwater mullet *P.abu* lost its supremacy as a dominant species as recorded in 2009 to the ornamental *P.latipinna* in 2019 (Habeeb, 2019). In general, native species scored low ranks on the abundance list in 2019 compared with 2009 (Abdalhsan, 2019).

A decrease in freshwater inflow to the EHM from Tigris (>50m^3/sec), enhances further advancement of the salt wedge front from the Arabian Gulf. In the summer of 2018 a further decrease in freshwater flow to the marsh, led to a noticeable increase in salinity, which had never been experienced before (Al-Najjar *et al.,* 2020). The tidal saline current advanced further in the marsh, facilitating more marine species to migrate and become common in the marsh.

The steady increase in salinity in the East Hammer marsh from 2009 to 2019 altered the environment from oligohaline to mesohaline, resulting in the disappearance of most native fish, since these species are strictly freshwater and unable to tolerate saline habitats (Abdalhsan, 2019). Moreover, exotic and marine species exploited the mesohaline environment to flourish in the marsh and exerted competition on available food resources especially by the three exotic fish species. African Tilapia species are known to tolerate harsh environmental conditions (Hussain and Reiss, 2018; Habeeb *et al.,* 2023). Accordingly, there was a gradual decrease in the occurrence and abundance of native species owing to an increase in salinity and alien species.

Our results suggest that the assemblages of fish in the EHM were very disturbed and totally upset respectively, owing to the huge occurrence and abundance of alien species. The disturbance score of the East Hammer marsh varies sustainably in comparison to other Iraqi rivers and marshes. This result indicated that the fish assemblages suffered from intensive habitat disturbance, in terms of both the number of species and individuals. An increase in the number of alien individuals indicated tolerance to the distorted habitat and suitability for reproduction of offspring. The existence of exotic and marine migratory species illustrated the actual dominance rather than the temporary occurrence of alien species. Karr *et al*., (1986) stated that an increase in the number of alien species in the river indicated an increase in the environmental disturbance of that water body.

Continuous increase in salinity as result of low freshwater influx, indicated that EHM is no longer considered as tidal oligohaline wetland but became a tidal mesohaline/estuarine marsh. Consequently, EHM fish assemblages were very disturbed and totally upset respectively, due to huge intrusion of alien species including marine, exotic and ornamental species.

In general, data on occurrence and abundance disturbance ratios were a direct field indicators expressing the status of disrepute habitat to the local decision makers, environmental officers and local fishermen.

Conclusions:

Continuous salinity increases in EHM changed the status of the aquatic environment from freshwater/oligohaline to mesohaline/estuarine, resulting in structural changes in the fish assemblage. At that time the fish assemblage was dominated by alien species and their individuals. Alien species were successfully established in the EHM over a relatively short period.

Certain necessary and recommended steps need to be taken by local authorities to be implemented to alter the present environmental situation 1- Increase the freshwater quota to

EHM in order to alter the aquatic environment to be oligohaline again. 2-Relase native species fingerling to improve native fish stock in EHM 3-Exclusion of exotic species release in EHM.

The data of turnover rate index revealed that a progressive increase was notes in the number of alien species over native ones in EHM during the period from 2009 to 2024.

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