



EFFECT OF BIOTIC AND ABIOTIC FACTORS ON THE COMPOSITION OF WADER BIRDS ASSEMBLAGE (CHARADRIIFORMES AND CICONIIFORMES) AT SHATT AL-ARAB ESTUARY .IRAQ, NW ARABIAN GULF.

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Abstract

Determining the influence of environmental factors on organism's assemblage is essential to understanding the relationships between these factors and distribution of organisms. This study aimed to identify the affecting of environmental variables as determinants on the wader birds assemblage composition at Shatt al-Arab estuary. A total of 37 species of wader birds belonging to 18 genera and five families have been recorded in Shatt al-Arab estuary from November 2017 to November 2018. The Canonical Correspondence Analysis (CCA) was used, to explain the relationship between biotic and abiotic factors with wader birds assemblage at Shatt al-Arab estuary. The most important factors that positively affected on the total number of species and individuals of wader birds in the estuary were dissolved oxygen, the density of invertebrates and total organic carbon (TOC). While, the most important factors that negatively influenced on population of wader birds were air and water temperature, pH, salinity, wind speed, water depth, turbidity, vegetation cover and vegetation height.

Keywords : Effect, biotic and abiotic, wader birds, Shatt al-Arab estuary, Iraq, NW Arabian Gulf.

Introduction

The Shatt al-Arab estuary effect by semidiurnal tide of the Arab Gulf accordingly, the salinity levels fluctuate on an hourly basis and freshwater discharge from Shatt al-Arab the salinity level varies throughout year. The Shatt al-Arab river considered as the main source of freshwater for daily consumption and agricultural activities. Agricultural land extends along the banks of river, with an extensive palm groves (Abdulah *et al.*, 2016). Decline of freshwater discharge from Tigris, Euphrates and Karun river led to reduced the discharge of freshwater from Shatt al-Arab to Arabian Gulf.

A various of human activities along the river and its tributaries cause water quality to deteriorate and increased of the salinity concentration over time. In addition, led a decline in quantity of freshwater drained into the estuary consequently increase of salt water intrusion to the Shatt al-Arab (flow the seawater into the river) its known as the salt wedge at present. This situation was further magnified by reduction of Karun discharge, since available information on discharge of Karun river is limited and unclear (Salarijazi *et al.*, 2012).

Shatt al-Arab form an extensive estuary characteristics by vast mudflats which inaccessible to fisherman these mudflats are a major refuge for wader birds, small fish and various of invertebrates (Jones, 1985; Harrington, 2003). Previous studies in the estuary were limited, Al-Shaban (1996) concludes that the productivity of Shatt al-Arab mudflat were mesotrophic to eutrophic. Hussain *et al.* (1999) studied the temperature and salinity stratification of the estuary. Mohamed *et al.* (2001) published a checklist of fish of the estuary. Al-Shaheen (2016) studied the taxonomical and ecological of Diatoms communities of Shatt al-Arab river and its estuary. There is no previous studies about the birds assemblage in Shatt al-Arab estuary.

The study of interaction between biotic and abiotic factors becomes necessary to understand the community structure and composition of an ecosystem (Dunson and

Travis 1991). It is important to know the relationship between water characteristics in estuary and wader birds composition. As animals rely on directly or indirectly on vegetations and vegetation in turn rely on water chemistry, wader birds distribution can be prospective to change with the changes in water chemistry (Thapa and Saund, 2012). The aim of this study to account the occurrence and abundance of wader birds at the mudflat of Shatt al-Arab estuary beside of determining environmental factors (biotic and abiotic) which effects on wader birds assemblage.

Material and Methods

Study area

The Shatt al-Arab river is located at southern Iraq. The total length of Shatt al-Arab river is approximately 198 km in the south-east direction, emptying its waters in Arabian Gulf at Faw town (Abdullah, 1990). Consequently the estuary receives freshwater from four main tributaries mainly Tigris and Euphrates rivers. The others are Seewab and Karun rivers (Abdulah *et al.*, 2016).

Three stations were chosen, all located on the western bank of the estuary on the Iraqi territories, while the eastern bank represents the Iranian borders (figure 1). The first station was Al-Najaa (N: 29 58' 45.17"; E: 48 28' 46.40") this region considered as the marina of fishing boats of all sizes, this region characterized by the variety of human activities included movement of boats and pedestrians for entertainment due to near by the park of Faw town and characterized by a largest discharge of sewage drained from town.

The second station was Al-Qishla (N: 29 57' 11.1"; E: 48 31' 54.7") is an area prone to many human activities as it passes fishing boats, its one of the most areas where the activities of fishing by fixed gill nets its proximity of residential areas inhabited by fishermen, as well as presence of Pedestrian and recreational trips coming from residential regions to the banks of the river.

The third station was Saffy (N: 29 56' 20.8"; E: 48 35' 31.1"), which is located in the southernmost of Faw town (Ras al- Bisha), characterized by a passage of fishing boat, thus less prone to human activities. It is also characterized as

an open area of vast costal wetland with dense dry vegetations mainly *Phrygmities australis* as well as *Salicornicum herbaacea* and *Suaeda* spp. which is one of the most suitable areas for Herons, as well as other wader birds.



Fig. 1 : Map of Shatt al- Arab estuary ,Iraq NW Arabian Gulf showing of the study stations.

**Data Collection
Birds Watching**

The line transect method as described by Bibby *et al.* (2000) and Sutherlan *et al.* (2004) was adopted for the survey according to the nature and topographic of this area. The survey was conducted from November 2017 to November

2018. Birds survey was performed during a height of bird activity from 7 am to 1 pm. The survey was carried out under wind speed was less than 6 m/s and non rainy and clear weather to avoid conditions of low birds delectability (Bibby *et al.*, 2000; Johannesdottir, 2013). The movement during the survey conducted by boat. Used during the birds watching

binocular Opticron 8 x 42 and a professional camera Canon EOS 7D with sigma lens 50–500 mm. Birds were identified using field guide (Porter *et al.*, 1996).

Macro-invertebrates estimation

The macro-invertebrates samples collected from sediments by using quadrat 30 × 30 cm in all stations with three replicates during the lower tide period. The sediment samples were collected at a 10 cm in depth depending on the length of bills of some wader birds. The invertebrates samples were sieved through different mesh sizes 2mm and 0.5 mm respectively. Benthic were isolated with their impurities and placed in nylon bags and brought to the laboratory. Invertebrates were isolated by forceps and assisted by a magnifying glass and were placed in plastic containers of different sizes, then the sample of invertebrates were preserved in 70% alcohol (George *et al.*, 2009; Khalaf, 2016). Identification of macro-invertebrates was done by using following keys, Timm (2009) for identified Annelids, Baloch *et al.* (2012) for identified mollusks, while insects were identified by Edmondson (1979) and crustaceans were identified by Al-Adhub and Hamza (1987).

Vegetation cover

Calculated by dividing the percentage of vegetation cover (emergent vegetation) by the number of quadrates, three samples were taken per station per month (Khedr and Doust, 2000). Also vegetation height was measured.

Environmental variables

Nine environmental variables were measured during present study include, Air temperature (At C°), Water temperature (Wt C°), pH, Dissolved oxygen (DO mg/L), Salinity (Sal.‰), Turbidity (Tur. NTU), Total organic carbon (TOC %), Wind speed (Ws m/sec.), and Water depth (Wd cm). All the parameters measured in the field except TOC. Various devices were used in measured these parameters.

Statistical analysis

Results of biotic and abiotic factors at all stations were treated by using SPSS program (version 21) to test the significance of differences between estuary stations, months

Table 1 : Environmental parameters were recorded at Shatt-al Arab estuary during the period from November 2017 to November 2018.

Parameters	Maximum values			Minimum values			Significant level	
	Values	Stations	Months	Values	Stations	Months	Between stations	Between months
At C°	41.6	Al-Najaa	Jul.	14.1	Saffy	Feb.	P • 0.05	P • 0.05
Wt C°	32.2	Al-Najaa	Sep.	12.2	Saffy	Feb.	P • 0.05	P • 0.05
pH	8.7	Al-Najaa	Sep.	7.5	Al-Najaa	Nov. 2017	P • 0.05	P • 0.05
DO mg/L	9.2	Saffy	Jan.	5.9	Al- Qishla & Saffy	Aug.	P • 0.05	P • 0.05
Sal. ‰	43.7	Saffy	Sep.	9.6	Saffy	Nov. 2017	P • 0.05	P • 0.05
Tur. (NTU)	794	Al- Qishla	Jun.	9.4	Saffy	Mar.	P • 0.05	P • 0.05
Ws m/sec.	11.5	Al- Qishla	Jun.	0.5	Al- Qishla	Jan.	P • 0.05	P • 0.05
Wd cm	12.3	Al- Qishla	May	4.3	Al-Najaa & Saffy	Nov. 2017	P • 0.05	P • 0.05
TOC %	16.21	Saffy	Feb.	6.39	Saffy	Nov. 2017	P • 0.05	P • 0.05

Avifauna of Shatt al-Arab estuary Species composition

A total of 37 species of wader birds belonging 18 genera and five families have been recorded in Shatt al-Arab

and temporal and spatial variations in number of wader birds species and abundance were applied using the General Linear model (GLM). All these tests were performed at probability of 0.05.

The Canonical Correspondence Analysis (CCA, version 4.5) was applied to explain the relationships between environmental factors and the number of species and abundance of wader birds at different stations.

Results

Macro- invertebrates

Macro- invertebrates that collected from the Shatt-al Arab estuary included two subclass: Polychaeta and Oligochaeta and five orders: Diptera, Amphipoda, Decapoda, Gastropoda and Bivalvia. Polychaeta recoded a highest relative abundance among the macro- invertebrates groups that reached to 70.58 % in Al-Najaa station, while Gastropoda recorded the lowest relative abundance that reached 0.15 %. The highest density of macro- invertebrates was 340.7 individuals per m² in February 2018 was recorded in saffy station, while the lowest density was 22.2 individuals per m² in June 2018 at Al-Najaa station. The results of statistical analysis showed significant differences (p < 0.05) between stations and months.

Vegetation cover

The highest percentage of vegetation cover was 90% in September 2018 was recorded in the Saffy station, whereas the lowest percentage that reached 7.3% in November 2018 at Al-Najaa station. A significant differences that showed between stations and months (P 0.05). On the other hand, the highest value of the height vegetation that reached 131 cm in September 2018 at Saffy station, while the lowest value that reached 51.6 cm in November 2018 at Al-Najaa station. The result of the statistical analysis exhibit significant differences between stations (P 0.05), while no significant differences were observed between months (P 0.05).

Environmental variables

The results of environmental parameters of Shatt-al Arab estuary were represented in Table 1.

estuary from November 2017 to November 2018. These species are to (17, 19, 24) in Al-Najaa, Al-Qishla and Saffy respectively (Table 1).

Table 1 : Present / absence of wader birds species (Charadriiformes and Ciconiiformes) in Shatt al-Arab estuary stations from November 2017 to November 2018 .

Order	Family	Common name	Scientific name	Al- Najaa	Al- Qishla	Saffy
Charadriiformes	Charadriidae	White-tailed Lapwing	<i>Chettusia leucura</i>	-	-	+
		Red-wattled Lapwing	<i>Vanellus indicus</i>	+	-	+
		Kentish plover	<i>Charadrius alexandrinus</i>	+	+	+
		Greater sand plover	<i>C. leschenaultii</i>	+	+	+
		Eurasian Dotterel	<i>C. morinellus</i>	-	-	+
	Scolopasidae	Common Redshank	<i>Tringa totanus</i>	+	+	+
		Common Greenshank	<i>T. nebularia</i>	+	+	+
		Marsh Sandpiper	<i>T. stagnatilis</i>	-	-	+
		Common Sandpiper	<i>Actitis hypoleucos</i>	+	+	+
		Terek Sandpiper	<i>Xenus cinereus</i>	+	+	-
		Dunlin	<i>Calidris alpina</i>	+	+	+
		Little Stint	<i>C. minuta</i>	+	-	+
		Black-tailed Godwit	<i>Limosa limosa</i>	+	+	+
		Bar-tailed Godwit	<i>L. lapponica</i>	-	-	+
		Eurasian Curlew	<i>Numenius arquata</i>	+	+	+
		Wimbrel	<i>N. phaeopus</i>	-	+	+
		Ruddy Turnstone	<i>Arenaria interpres</i>	+	+	+
		Recurvirostridae	Pied Avocet	<i>Recurvirostra avosetta</i>	+	+
	Black-winged Stilt		<i>Himantopus himantopus</i>	+	+	+
	Dromadidae	Crab Plover	<i>Dromas ardeola</i>	-	-	+
Ciconiiformes	Ardeidae	Grey Heron	<i>Ardea cinerea</i>	+	+	+
		Purple Heron	<i>A. purpurea</i>	-	-	+
		Western Reef Heron	<i>Egretta gularis</i>	+	+	+
		Little Egret	<i>E. garzetta</i>	+	+	+
		Western Cattle Egret	<i>Bulbucus ibis</i>	-	+	-
		Night Heron	<i>Nycticorax nycticorax</i>	-	+	+
		Squacco Heron	<i>Ardeola ralloides</i>	-	+	-

(+) Present (-) Absent

The number of species recorded in Shatt-al Arab estuary. Interestingly, the highest number of species was 16 recorded in November 2018 at Saffy station while, lowest number of species was three recorded in June 2018 at Al-Najaa station (figure 2). Statistical analysis appeared significant differences between stations and months ($P < 0.05$).

The highest number of individuals recorded was 729 in February 2018 was at the Saffy station whereas, lowest number 12 of individuals was found in June 2018 in Al-Najaa station (figure 3). The result of statistical analysis showed significant differences between stations and months ($P < 0.05$).

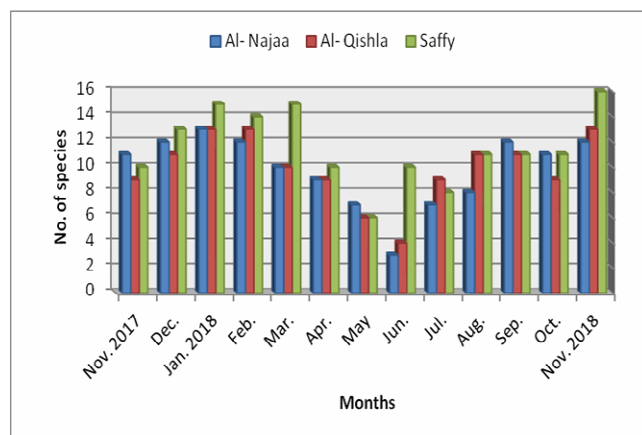


Fig. 2 : Monthly variations in number of species recorded in Shatt-al Arab estuary stations.

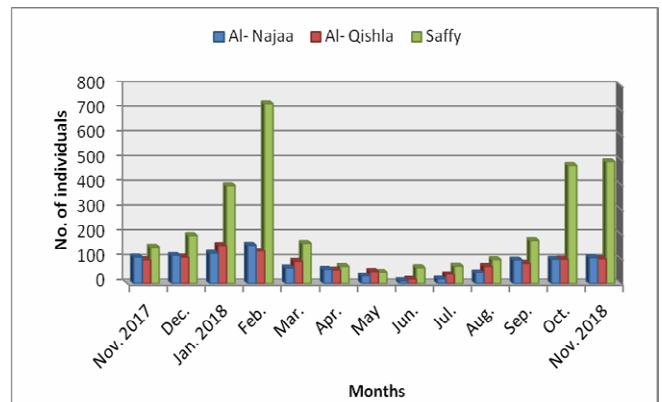


Fig. 3 : Monthly variations in number of species recorded in Shatt- al Arab estuary stations.

Status of birds recorded in the present study were ten resident species of wader birds of Shatt-al Arab estuary, including White tailed lapwing *C. leucura*, Red wattled lapwing *V. indicus*, Kentish plover *C. alexandrinus*, Pied avocet *R. avosetta*, Black winged stilt *H. himantopus*, Crab plover *D. ardeola*, Western reef heron *E. gularis*, Little egret *E. garzetta*, Western cattle egret *B. ibis* and Night heron *N. nycticorax*. Fourteen of winter visitors were recorded including, Greater sand plover *C. leschenaultii*, Eurasian dotterel *C. morinellus*, Redshank *T. toanus*, Greenshank *T. nebularia*, Marsh sandpiper *T. stagnatilis*, Common sandpiper *A. hypoleucos*, Terek sandpiper *X. cinereus*,

Dunlin *C. alpina*, Little stint *C. minuta*, Black tailed Godwit *L. limosa*, Bar tailed Godwit *L. lapponica*, Eurasian curlew *N. arquata*, Whimbrel *N. phaeopus* and Grey heron *A. cinerea*. Two species of summer visitors including Purple heron *A. purpurea* and Squacco heron *A. ralloides* and one passage migrant species include Ruddy Turnstone *A. interpres*.

Relative abundance of wader birds species were recorded at the three stations of Shatt al-Arab estuary indicated that the highest relative abundance in the Al- Najaa station was recorded by Kentish plover *C. alexandrinus* that reached to 20.63 % and the lowest abundance was recorded by Black tailed Godwit *L. limosa* that reached to 0.09 %. The highest abundance in the Al-Qishla station was recorded by Kentish plover *C. alexandrinus* which reached to 17.89 % and the lowest abundance was recorded by Whimbrel *N. phaeopus* that reached to 0.09 %, while the Night heron *N. nycticorax* was recorded the highest relative abundance in the Saffy station which was 37.49 % and the lowest relative abundance recorded by Whimbrel *N. phaeopus* that reached to 0.03 %.

The Canonical Correspondence Analysis CCA was used to explain the relationship between environmental variables (biotic and abiotic) and number of species and individuals of wader birds. The results of CCA was showed that the most positive factors affecting on the total number of species and individuals of wader birds in the Shatt al-Arab estuary were: dissolved oxygen, invertebrates density and total organic carbon. Factors that negatively affected on the total number of species and individuals of these birds were: air temperature, water temperature, pH, salinity, wind speed, water depth, turbidity, vegetation cover and vegetation height (Figures 4,5 and 6). The results illustrated that the most affected species of air temperature, water temperature, pH, salinity, wind speed, water depth, turbidity, vegetation cover and vegetation height were of resident or summer visitors species such as *E. garzetta*, *E. gularis*, *C. alexandrinus*, *V. indicus*, *H. himantopus*, *D. ardeola* and *A. purpurea* and some individuals of passage migrants and winter visitors which delayed in summer such as *A. hypoleucos*, *T. totanus*, *T. nebularia*, *X. cinereus* and *A. interpres*. Others species of winter visitors, passage migrants and resident were negatively affected by these factors (Figure 4, 5 and 6).

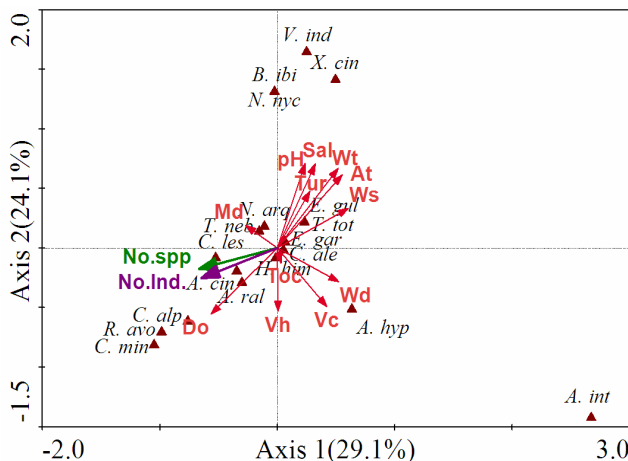


Fig. 4 : Canonical Correspondence Analysis CCA ordination plots showing the relationship among wader birds species and various environmental variables in the Al – Najaa station at Shatt al- Arab estuary

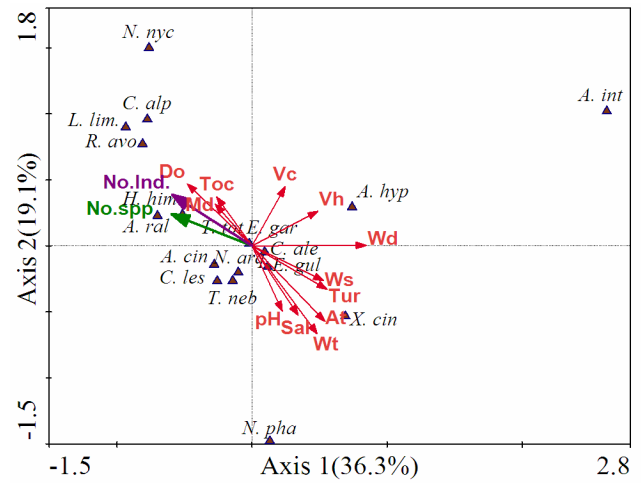


Fig. 5 : Canonical Correspondence Analysis CCA ordination plots showing the relationship among wader birds species and various environmental variables in the Al- Qishla station at Shatt al- Arab estuary

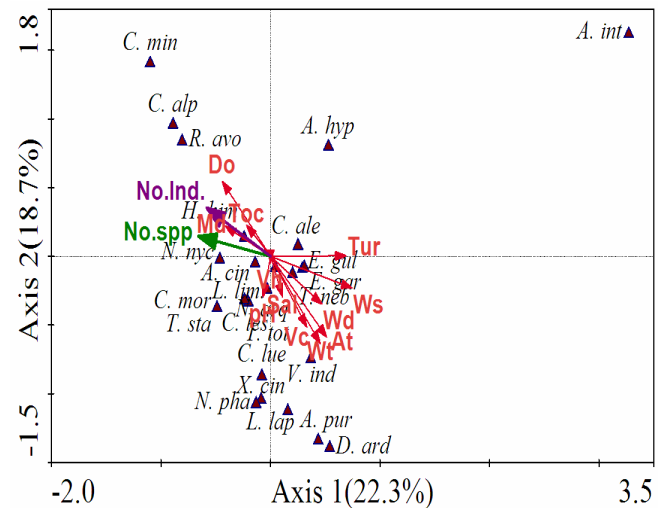


Fig. 10 : Canonical Correspondence Analysis CCA ordination plots showing the relationship among wader birds species and various environmental variables in the Saffy station at Shatt al-Arab estuary

Number of species (No. spp), Number of individuals (No. ind), Air temperature (At), Water temperature (Wt), pH, Dissolved oxygen (DO), Salinity (Sal.), Turbidity (Tur.), Total Organic Carbon (TOC), Wind speed (Ws), Water depth (Wd), Invertebrates density (Md), Vegetation cover (Vc) and Vegetation height (Vh).

C. alexandrinus (*C. ale*), *T. totanus* (*T. tot.*), *V. indicus* (*V. ind.*), *T. nebularia* (*T. neb*), *T. stagnatilis* (*T. sta.*), *A. hypoleucos* (*A. hyp.*), *C. alpina* (*C. alp.*), *C. minuta* (*C. min.*), *A. interpres* (*A. int.*), *H. himantopus* (*H. him*), *E. garzetta* (*E. gar.*), *A. cinerea* (*A. cin.*), *A. purpurea* (*A. pur.*), *B. ibis* (*B. ibi.*), *N. nycticorax* (*N. nyc.*), *A. ralloides* (*A. ral.*), *L. limosa* (*L. lim.*), *X. cinereus* (*X. cin.*), *C. morinellus* (*C. mor.*), *C. leshenaultii* (*C. les.*), *N. phaeopus* (*N. pha.*), *L. lapponica* (*L. lap.*), *E. gularis* (*A. gul.*), *D. ardeola* (*D. ard.*), *R. avosetta* (*R. avo.*), *C. leucura* (*C. leu.*) and *N. arquata* (*N. arq.*).

Discussion

Birds are one of the main and important links of the food chain in the environment and have an important and effective role in their habitats. This role is seen as a

reciprocal role. The components of environment provide a necessary factors for birds to survive and eventually reproduction, while birds contribute directly or indirectly in maintenance or modification of certain environment components, these birds as environmental modifiers (Ried, 1991 ; Block and Brennan 1993). In addition, birds are considered a good bio- indicators on habitat quality and the effectiveness of ecosystem, providing services to ecosystem and humans (Whelan *et al.*, 2008), as well as a good indicators of pollution degree and biodiversity. Birds considered as excellent communication tool to raise awareness of biodiversity issues in a way that many organisms can not do (Gregory and Strien, 2010).

Birds, such as other organisms, are affected by their occurrence, distribution and movement within their environment by a combination of environmental factors (Biota and abiota). The response of birds to their occurrence and distribution is governed by the environmental factors and conditions surrounding them as a whole, which are closely interrelated linked. Therefore, it is very difficult to link the presence of certain species to a specific environmental factor. In the current study the Canonical Correspondence Analysis (CCA) was used, to explain the relationship between biotic and abiotic factors with wader birds assemblage at Shatt al-Arab estuary. One of the most important benefits of this analysis is its ability to show all the components of the environment in a way that easy interpret (Alves, 2003). In other word, the CCA allows for a description of the relationship between different environmental factors and organisms (Ter Braak and Verdon Schot, 1995).

The results of the present study showed that the most important factors that positively affected on the total number of species and individuals of wader birds in the Shatt al-Arab estuary were dissolved oxygen, the density of invertebrates and total organic carbon (TOC). The effect of dissolved oxygen is significant on the density and diversity of invertebrates, which are usually high in density and diversity by increasing this factor, as was observed in all study station. Invertebrates are considered an important factor affecting on the abundance and distribution of wader birds as the main source of food for these birds (Thapa and Saund, 2012).

Invertebrates assemblages in the intertidal zones of the estuary are the most important aspect on wader birds feeding, on these assemblages are frequently affected by water levels changes. The results of current study explained that there is clear positive effect of invertebrates density on the number of species and individuals of wader birds, which is the main source of their food and is therefore present in the habitats have high densities of invertebrates. This agree with (Parta *et al.*, 2010; Thapa and Saund, 2012; Balapure *et al.*, 2013). A positive relationship was found between TOC and number of species and individuals of wader birds, this maybe attributed to high percentage of organic matter in sediments during the winter season, which is coincides with arrival of migratory species. Generally, wader birds are influenced by TOC indirectly, because organic content affecting on abundance and distribution of invertebrates, especially the Annelids (Khalef, 2016), which is the preferred food for many of waders.

The results illustrated that the most important factors that negatively influenced on population of wader birds

(species and individuals) in the Shatt al-Arab estuary were air and water temperature, pH, salinity, wind speed, water depth, turbidity, vegetation cover and vegetation height. Temperature is an significant factor for many environmental events. Changes in arrival times of migratory birds are associated with a decline in temperature, usually temperature restricts or changes from the distribution of migratory species (Sokos *et al.*, 2010).

The results indicated that there is a negative effect of air and water temperature on the wader birds (species and individuals). This maybe attributed to a moderate climate of Iraq during the winter season, which tempts many migratory birds from Siberia and western Europe to stay in their diverse environments (Al-Robaee, 2006). These results were agree with the results of (Habeb, 2008; Branco *et al.*, 2015; Bara and Segura, 2019). Where they found that there was an inverse relationship between temperature and number of species and abundance of wader birds.

There was a negative correlation between the pH, the number of species and abundance of wader birds in all stations. High and low in pH values can have an indirect impact on the population of wader birds, and this may have an effect on invertebrates, which are considered the main food of these birds (Thapa and Saund, 2012). Younos (2007) explained that excessive elevation (9) and the decrease (5) in degree of pH are stressful and can be lethal to aquatic organisms.

Salinity is an significant factor for wader birds habitats. In general, water of highly saline is harmful to wader birds (Ma *et al.*, 2010). The results of CCA explained that there was a negative impact of salinity on the population of wader birds (species and individuals) in all study sites. This agree with Rubega and Robinson (1997) explaining that wader birds usually avoid water of highly saline even for roosting due to salts reduce the waterproofing to feathers, which increase the energy cost of thermoregulation. In addition, water salinity determines the distribution of invertebrates and other aquatic animals and thus effects the use of foraging sites by wader bird (Ma *et al.*, 2010).

Turbidity affected negatively on wader birds assemblage in all study stations. The reason maybe that water turbidity may limit the ability of these birds to detected preys (Paton *et al.*, 2011). The results of CCA showed that there is a negative relationship between wind speed and number of species and individuals of the wader birds in Shatt al-Arab estuary. This maybe due to the directly influenced of birds activity when the wind speed increase and the high wind reduce a chance of seeing or hearing the birds and thus affect on the efficiency and reliability of data collection (Bibby *et al.*, 2000).

In the current study, there was a negative influence of water depth on the wader birds assemblage in all stations. This maybe due to the fact that the occurrence of these birds in foraging habitats requires shallow water, and their access to their food is limited to the depth of water (Ma *et al.*, 2010). In addition, it maybe difficult to detect prey in deep water, especially if the water is turbid, so these birds prefer water level less than 15 cm (Taft *et al.*, 2002).

The results of CCA showed an adverse impact of vegetation cover and its height on the wader birds population. This agreement with Darnell and smith (2004) who reported

that most wader birds except Rail and Bittern prefer unvegetated or short vegetations areas as foraging habitats. Colwell (1993) considered open habitats an significant variable affecting wader birds abundance.

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