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Ecological indices of key biological groups in Southern Iraqi marshland during 2005-2007

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Abstract - Yearly values of ecological indices were calculated for several key biological groups include macrophytes, macroinvertbrates, fishes and waterfowls during the period 2005-2007 in Huwaiza, West Hammar and East Hammar marshes in Southern Iraq. Ecological indices increase for the studied key biological groups in 2006 in the three monitored marshes in comparison with that of 2005. Ecological indices of macrophytes and waterfowls assemblages increase steadly from 2005 towards 2007. On the contrary macroinvertebrates and fishes suffer severe decline in 2007 mainly due to reduced water level. Continuous improvement in ecological indices of macrophytes and waterfowls in two of the restored marshes indicated that reduced water level was less harsh to them than to the other two groups. In spite of the slow recovery in ecological indices in the monitored marshes, diversity and richness values fluctuated between poor to moderate status and semi-integrated to disturbed, respectively. Cases of poor status and disturbed were more common and limited good ones were noticed. Most evenness values indicated absence of dominance cases, except two below the acceptable limit (0.5) were scored both were during 2007. What is clear is that the yearly hydrological period plays a major role in manipulating the biodiversity and repercussion ecological indices in the Southern restored marshes. Lower values of ecological indices indicated that the environment of Southern marshes still disturbed and need more time and care to be fully restored.

Introduction

Wetlands of Southern Iraq consisted of different types of marshes which differ substantially in number of species and individuals they support (Maltby, 1994; Partow, 2001; Evans, 2002 and Alwash and Alwash, 2004). The prevailing environment of these marshes differ according to the controlling limiting factors like water temperature, salinity, hydro period, nutrients availability and level of the functions of these marshes like primary production, decomposition and major elements cycles (Richardson *et al.*, 2005; Richardson and Hussain, 2006). Consequently the Southern marshes could be categorized into freshwater non-tidal marsh like Huwaiza, Oligosaline non-tidal marsh West Hammar and mesosaline tidal marsh East Hammar (UNEP, 2004; Hussain *et al.*, 2010). Huwaiza marsh gets its water from Tigris River, characterized by low salinity and high nutrients load. West Hammer get its water from Euphrates River recognizes by moderate

salinity and moderate nutrients load. East Hammer gets its water mostly from Shatt Al-Arab river known by moderate salinity and high nutrients concentration, and is affected by semidiurnal tide.

No previous studies were traced on ecological indices before the catastrophic desiccation during the nineties of last century. Studies on the biodiversity of the Southern marshes were resuming after the inundation of marshes in 2003. Recent published research papers and reports dealt mostly with one group of organisms in one type of the Southern marshes, like Al-Obaidi (2006) on phytoplankton, Ali *et al.* (2007) on macroinvertebrates, Habeeb (2008) on waterfowls, Mohamed *et al.* (2008; 2012), Hussain *et al.* (2008, 2009) on fishes, Al-Abbawy (2009) on macrophytes, Qazar (2009) on gastropod and Abd (2010) on phytoplankton and fishes and Salman *et al.* (2010) on zooplankton. Few comprehensive reports of IMRP (2006), ARID (2006) and IMET (2006) dealt with several main biological groups performed in three major Southern marshes or more.

Dudgeon *et al.* (2006) indicated that water flow modifications was one of five reasons affected freshwater biodiversity including over exploitation, water pollution, habitat degradation and invasion of alien and exotic species which repercussion ecological indices in wetlands. Abel (2002) illustrated the importance of ecological indices to monitor effect of pollution on biological community and counted ten of most important of them. Izsák and Papp (2000) highlighted importance of ecological indices and their sensitivity to monitor the abundance of different species. While Matthews and Marsh-Matthews (2003) discussed the usage of ecological indices to monitor the spatial and temporal effect of drought and reduced water level on the fish assemblages in freshwater habitat.

The aim of present work is to coordinate ecological indices of key trophic groups including macrophytes, macroinvertebrate, fishes and waterfowls in three of the Southern marshes in an attempt to understand the pattern of yearly changes in ecological indices of these important groups precisely.

Materials and Methods

Row data were obtained from the reports of IMRP (2006) and ARID (2006) to calculate the ecological indices (diversity by Shanon and Wiener (1949), richness by Margalef (1968), evenness by Pielou (1977) for macrophytes, macroinvertebrates, fishes and waterfowls.in the Southern marshes. Other related data were employed from Habeeb (2008), Qazer (2009) and Al-Abbawy (2009). Shatt Al-Arab river discharges during the years 2005, 2006 and 2007 were obtained from Hassan (2009).

Rating of ecological indices levels were adapted from Jorgensen *et al.* (2005) for ecological indices and modified to suit the ranges of ecological indices of Southern marshes (Table 1).

Table 1. Rating ranges and values, for diversity, richness and evenness used to evaluate ecological indices of Southern Iraqi marshes.

Diversity Shannon & Wiener index		Margalef Richness index		Evenness Pielou index	
Range	0-5	Range	0->5	Range	0-1
High status	>4-5	integrated	>5	balanced	>0. 8-0.9
Good status	>3-4	semi disturbed	>2.05-5	semi- balanced	>0.5-0.8
Moderate status	>2-3	disturbed	≤2.05	unbalanced	≤0.5
Poor status	>1-2				
Bad status	0-1				

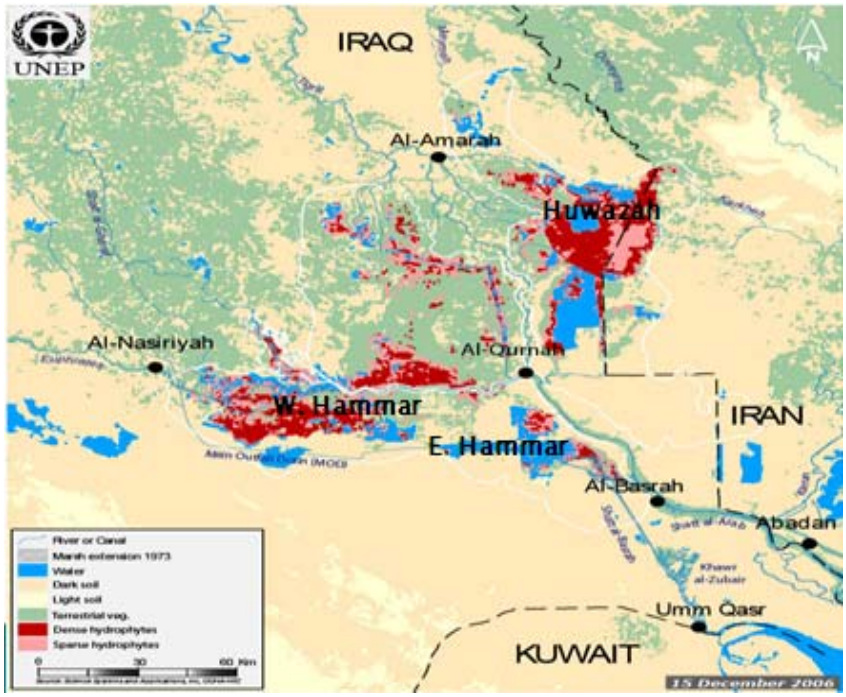

Figure 1. Map of Southern Iraqi marshland, showing Huwaiza, West Hammar and East Hammar marshes.

Results

1- Yearly changes in Ecological indices:

Diversity:

Macrophytes diversity values slightly increased in Huwaiza and East Hammar during 2007 in comparison to those of 2006. Diversity values of macroinvertebrates of the three marshes were in the same ranges during 2005 with slight improvement in 2006 and a decline in East Hammar in 2007. Fishes diversity were similar in 2005 and 2006 with the exception of

East Hammar, which had higher values in 2005, followed by decline in all the three marshes in 2007. Waterfowls scored highest diversity value in East Hammar in 2007, values of the other two marshes were in the same level in 2005 and 2006 and lower values in Huwaiza were obtained in 2007 (Fig. 2). In general diversity values of the three groups increased during 2006 in comparison with those of 2005, except for waterfowls in Huwaiza and fishes in East Hammar. In 2007 noticeable decrease in diversity of the three groups, except waterfowls in East Hammar were observed. Macrophytes diversity exhibited steady increase from 2005 to 2007 (Table 2 and Fig.2).

Richness:

Macrophytes richness values moderately increased in Huwaiza and East Hammar in 2007 in comparison to those of 2006. Richness of macroinvertebrates in the three marshes were slightly higher in 2005 in comparison with those of 2006, especially in West and East Hammar and then declined radically in East Hammar 2007. Fishes showed higher richness in 2006 in all the marshes, especially in West Hammar, and then declined in 2007 in all the marshes. Higher waterfowls richness were recorded in 2007 in Huwaiza and East Hammar with a peak value recorded in the last marsh (5.7) (Table 2). In general higher richness values for macrophytes, fishes and waterfowls were recorded in 2006 than in 2005 (Fig. 3).

Evenness:

Macrophytes evenness values slightly increased in Huwaiza and moderately so in East Hammar in 2007 in comparison to those of 2006. Values of macroinvertebrates evenness in 2005 were better than those of 2006 i.e. match between number of species and individuals, but severely declined in 2007 in the East Hammar. Higher fishes evenness was recorded in the three marshes in 2006 than in 2005, followed by decline in 2007. In general fishes scored moderate evenness in the three marshes. Waterfowls exhibited higher evenness values in 2005 and 2006 with slight decline in 2007. East Hammar recorded higher score in 2006 and 2007 than the other two marshes. In 2005 West Hammar showed better evenness than Huwaiza and East Hammar marshes (Fig.4). Evenness exhibit higher scores in 2006 in comparison to those of 2005, except three cases with slight decrease in 2007. All groups showed marked decrease in evenness values. It seems that 2006 had better ecological indices records than 2005 and 2007 (Table 2).

2- Yearly changes in Southern marshes:

Huwiza marsh:

Macrophytes ecological indices increased steadily from 2006 to 2007. Macroinvertebrates exhibited similar pattern of changes of ecological indices

for the years 2005, 2006 and 2007, except an increase in diversity in 2006. Fishes diversity showed the same levels in 2005 and 2006, but with small decline in 2007, richness exhibited higher value in 2006 and than in 2007. Evenness recorded the same values in 2005, 2006 and decreased in 2007. Waterfowl's diversity recorded the same values in 2005, 2006 and decreased in 2007. Richness had the same values in 2005, 2006 with small increase in 2007. Evenness showed the same values in 2005, 2006 with sharp decline in 2007 (Table 2).

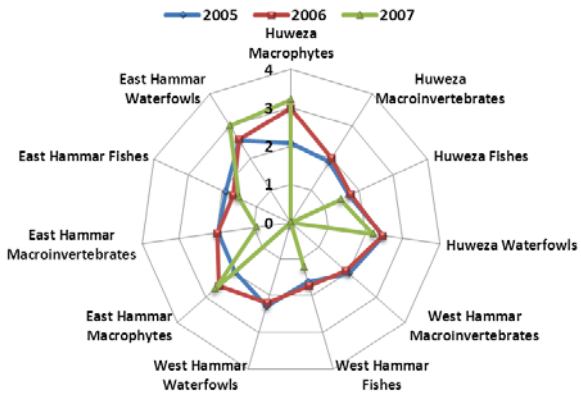

Figure 2. Diversity of macrophytes, macroinvertebrates, fishes and waterfowls in Huwaiza, West Hammar and East Hammar marshes during 2005, 2006 and 2007.

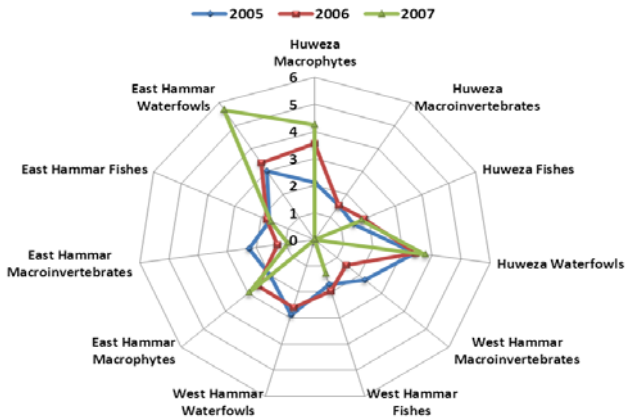

Figure 3. Richness of macrophytes, macroinvertebrates, fishes and waterfowls in Huwaiza, West Hammar and East Hammar marshes during 2005, 2006 and 2007.

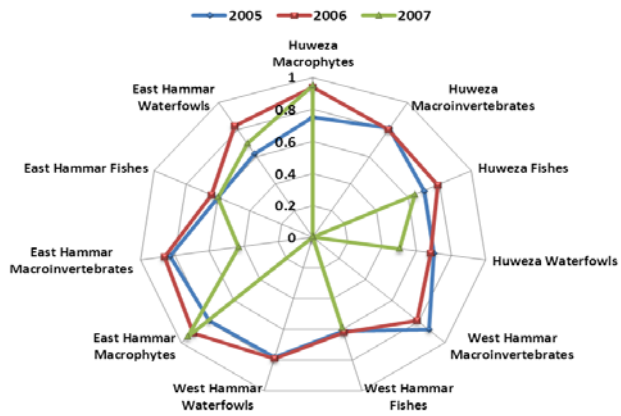

Figure 4. Evenness of macrophytes, macroinvertebrates, fishes and waterfowls in Huwaiza, West Hammar and East Hammar marshes during 2005, 2006 and 2007.

West Hammar marsh:

In West Hammar diversity of macroinvertebrate declined in 2006 in comparison with that of 2005. Richness scored an exceptionally higher value in 2005 and decreased in 2006, the same is true for evenness with a slight drop in 2006. Fishes diversity increased in 2006 and decreased sharply in 2007, richness followed the same pattern. Evenness showed the same level in 2005 and 2006 and with small drop in 2007. Waterfowl's diversity and richness showed the same pattern of increase in 2005, 2006 and 2007. Evenness in Huwaiza decreased from 0.7 in 2005 to 0.5. Evenness in East and West Hammar reached a peak in 2006 and then a decline in 2007 (Table 2).

East Hammar marsh:

Macrophytes ecological indices sharply increased from 2005 to 2007. Macroinvertebrates diversity in East Hammar acquired about the same level in 2005, 2006 with one fold drop in 2007. Richness scored higher values in 2005 and gradually decreased in 2006 and with a drop in 2007. Evenness secured its levels in 2005 and 2006 with a noticeable decrease in 2007.

Diversity of fishes exhibited gradual decrease in values from 2005 towards 2007. Richness and evenness scored the highest values in 2006 in comparison with 2005 and 2007. On the contrary waterfowls diversity showed gradual increase from 2005 toward 2007. Richness showed the same pattern and reached highest value (5.7) in 2007. Evenness reached the maximum in 2006 and then slightly decreased in 2007 (Table 2).

Table 2. Ecological indices (diversity, richness and evenness) of macrophytes, macroinvertebrates, fishes and waterfowls in Huwaiza, West Hammar and East Hammar marshes, Southern Iraq, during 2005, 2006 and 2007.

Indices		Diversity Shannon-wiener Range 0 - 5			Richness Margalef index Range 0 - > 5			Evenness Pielou Range: 0 - 1		
Marshes	groups / Years	2005	2006	2007	2005	2006	2007	2005	2006	2007
Huwaiza	Macrophytes	2.07	2.98	3.22	2.11	3.54	4.23	0.75	0.94	0.95
	Macroinvertebrates	1.88	2.01	-	1.52	1.5	-	0.81	0.80	-
	Fishes	1.7	1.74	1.45	1.43	1.84	1.75	0.7	0.79	0.64
	Waterfowls	2.47	2.46	2.49	3.43	3.45	3.8	0.7	0.68	0.5
West Hammar	Macroinvertebrates	2.03	1.94	-	2.25	1.41	-	0.88	0.79	-
	Fishes	1.62	1.73	1.24	1.71	1.95	1.31	0.61	0.62	0.59
	Waterfowls	2.28	2.19	-	2.88	2.58	-	0.78	0.79	-
East Hammar	Macrophytes	1.98	2.53	2.68	2.01	2.57	2.94	0. 79	0.91	0.95
	Macroinvertebrates	1.95	1.98	0.93	2.26	1.27	0.91	0.83	0.86	0.43
	Fishes	1.91	1.69	1.52	1.7	1.79	1.63	0.6	0.64	0.60
	Waterfowls	2.55	2.57	3.0	3.02	3.37	5.7	0.62	0.83	0.70

3 - The relationship between water discharge (flow) of Shatt Al-Arab River and ecological indices in East Hammar marsh:

Figure (3) illustrates the relationship between diversity and richness of macrophytes, macroinvertebrates, fishes and waterfowls in East Hammar marsh with water discharge of Shatt Al-Arab river in 2005, 2006 and 2007. Lower water discharge (water flow and level) in 2007 have no effect on diversity and richness of macrophytes and waterfowls, on the contrary it have negative effects on those of macroinvertebrates and fishes.

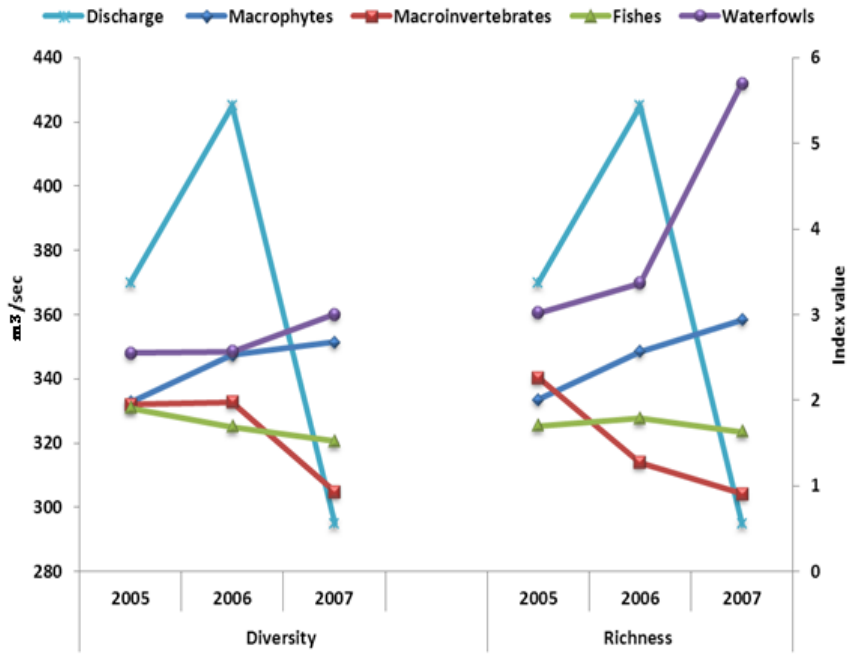

Figure 3. The relationship between water discharge (flow) of Shatt Al-Arab river and ecological indices (diversity and richness) of macrophytes, macroinvertbrates, fishes and waterfowls in East Hammar marsh.

Discussion

Bunn and Arthington (2002) pointed out the crucial role of the hydrology (periodicity and flow rate) on wetland biodiversity, they showed that the impact of flow regimes changes were manifest across broad taxonomic groups include aquatic plants, invertebrate and fish. Richardson (2010) concluded that water supply from Tigris and Euphrates will not be sufficient to fully restore all the Southern marshes, and pointed out future shortage of water flow to Iraqi marshland especially during dry years.

Mitsch *et al.* (2005) emphasis on the importance of the hydro-period and flow rate in his mathematical model for restoration of Iraqi marshland. Hamdan *et al.* (2010) in his study on macrophytes in central marshes indicated that the biomass and diversity were low, and seasonal fluctuation depends on quantity of water input from Tigris and Euphrates rivers.

What is clear in the Southern marshes, is that the yearly hydrological period plays a major role in manipulating the biodiversity and repercussion ecological indices. Macrophytes ecological indices increased steadily in values in Huwaiza and East Hammar from 2005 to 2007. Conceding with a four years (2004-2007) trend of increasing marsh vegetation recovery in the restored marshes of Iraq as shown along with water patterns (UNEP, 2007). Measurements of ecological indices in Southern marshes started after 2004 in attempt to elevate the restoration programs initiated by Iraqi government, international agencies and several private programs. These schemes and programs were not devoted to measure biodiversity for major functional groups like aquatic plants, algae, as a base for other main trophic levels in the restored marshes. The second set back was the absence of historical data and records to compare with.

Three indices were used: diversity of Shanon and Wiener (1949), Richness of Margalef (1968) and Evenness of Pielou (1977); represent the most basic ones used, even though there are several others exist could be more suitable to quantify the yearly changes in ecological indices. Even the Southern marshes are different in types or kind but still face the same major limiting factors like quality and quantity of freshwater received yearly, percentage of aquatic plant cover, available nutrients and degree of pollution disturbance. Richness scores showed no fixed pattern for the four major groups in 2005 and 2006 in the three studied marshes. In 2007 a major decline in richness values of macroinvertbrates and fishes and increase of macrophytes and waterfowls in Huwaiza and East Hammar.

It seems that 2006 had better records of ecological indices in comparison with those of 2005 and 2007 for fishes and waterfowls, especially in East Hammar and this is may be due to the migration of marine fish species and also due to migration of sea shore birds like sea gulls, terns and gray herons. Ecological indices in 2006 scored higher values in comparison with those of 2005 and this is probably due to higher water impulse to the Southern marshes which led to flourishing of aquatic plants and algae, again the decline in 2007 could be explain by low water discharge since it was consider as dry year (Hassan, in press).

The majority of diversity values recorded in Southern marshes were considered as poor status, few were in moderate status and rare ones in good status in Huwaiza, West Hammar and East Hammar, except macrophytes and waterfowls, the later exceed that limit, mainly due to the abundance of migratory birds in autumn-winter period (Habeeb, 2009).

Diversity values of less than 2 for fishes were recorded in the freshwater habitat because of the confined community, limited number of species and the lack of seasonal migration (Allen and Horn, 1975). In the Shatt Al-Arab river diversity, richness and evenness of fish assemblage were calculated during the eighties of the last century to be 3.06, 4.37 and 0.87, respectively and these were mainly due to the abundance of migratory marine species (Hussain *et al.*, 1989). Higher richness values of macroinvertebrates in 2005 could be due to the low abundance of predators mostly fishes and waterfowls. Effect of predation and low water level were obvious during 2006 and 2007 with low macroinvertebrates richness against higher richness of fishes and waterfowls. Waterfowls scored highest richness value (5.7) indicating that their community was integrated in the Southern marshes and these wetlands started to play their previous role as favorite places attracting autumn-winter migrating birds.

Evenness records showed that the number of individuals of different group were limited in 2005 and 2007 and this is may be due to shortage of food resources and shelter like aquatic plants and large algae and increase in numbers of predators, especially waterfowls, other unfavorable condition like low water level, high salinity and hardness. Most evenness values were ranged between 0.7 and over 0.9 indicating the absence of dominance, except two cases were below the acceptable limit (0.5) scored during 2007. The dominance of individuals of certain species in the assemblage of the waterfowls in Huwaiza marsh was due to the reduce of water level which led to the increase of waders (Al-Robaae and Habeeb, 2011) and the reduction in numbers of macroinvertebrates in the East Hammar marsh was due to reduce of water level and rise of salinity which led to massive decrease in individuals, as happened later in the Shatt Al-Arab River (Khalafe, 2011).

Lower diversity and richness of macroinvertebrates and fishes expresses that their communities in the three Southern marshes were disturbed and need more time and favorable hydrological conditions to reach their normal previous status. The values of diversity and richness fluctuated between poor to moderate and semi-integrated to disturbed, respectively. Cases of poor status and disturbed were more common and a few limited good ones were recorded. Macrophytes and waterfowls scored high ecological indices illustrated that their assemblages were progressing to approach integrated status better than fishes and macroinvertebrates.

Continuing improvement in ecological indices of macrophytes and diversity and richness of waterfowls in 2007 in the three marshes, contrary to those of macroinvertebrates and fishes indicating that reduced water level was less harsh to them than to the other two key biological groups. Phytoplankton ecological indices show no effect by low water level, as they return to their normal status in winter and summer 2007 after being disperse during summer 2005 and winter 2006 (Al-Obaidi, 2006).

Salman *et al.* (2010) recorded values of diversity and richness for zooplankton of the Southern Iraqi marshes of poor to moderate (1.0- 2.79 and 0.11- 2.94) and from disturbed to integrated (1.61- 7.65 and 0.3-8.01) in Huwaiza and East Hammar, respectively. In general values of ecological indices of zooplankton increased in 2006 with comparison to 2005 in Huwaiza and East Hammar, respectively. Based on lower values of ecological indices, it could be concluded that the environment of the Southern marshes was not fully recovered and need time and care for full restoration.

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الأدلة البيئية لمفتاح المجاميع الحياتية للأهوار الجنوبية في العراق خلال الاعوام 2005-2007

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المستخلص - حسبت التذبذبات السنوية في الأدلة البيئية (التنوع والغنى والتكافؤ) للنباتات المائية واللافقريات الكبيرة والأسماك والطيور المائية في أهوار الحويزة وغرب وشرق الحمار خلال الفتره من 2005-2007. إرتفعت الأدلة البيئية في كل الأهوار في 2006 بالمقارنة مع 2005 وللنباتات المائية والطيور خصوصا في 2007. إرتفعت الأدلة البيئية باطراد لمجتمعات النباتات المائية والطيور المائية إعتباراً من 2005 وحتى 2007. وبالعكس من ذلك انخفضت الادلة البيئية للافقريات الكبيرة والأسماك في 2007. بالرغم من التحسن في الأدلة البيئية فان قيم التنوع والغنى تراوحت ما بين فقيرة إلى معتدلة ونصف متكاملة إلى مضطربة على التوالي. غالبية القيم للتنوع والغنى فقيرة ومضطربة والأقلية جيدة. دلت قيم التكافؤ على عدم وجود حالات سيادة للأنواع ما عدا حالتين كانت أقل من الحد المقبول (0.5) سجلت خلال عام 2007. لوحظ أن لإنخفاض التصريف النهري السنوي تأثير على التنوع الحياتي ثم على إنخفاض الأدلة البيئية في 2007 في أهوار الحويزة وشرق الحمار. ويستنتج من قيم الأدلة البيئية المنخفضة أن الأهوار الجنوبية التي أعيد غمرها بالماء لازالت مضطربة بيئياً وتحتاج إلى مزيد من الوقت والعناية لإكتمال تعافيها بيئياً.