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The Distribution of *Ceratophyllum demersum* L. in Relation to nvironmental Factors in Restored Al-Mashb marsh, Hor Al-Hammar, Southern Iraq.

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Abstract

After extensively drained of Mesopotamian wetlands, southern Iraq in 1990s *Ceratophyllum demersum* L. reappeared as response to re-flooding. This investigation was conducted to study distribution of *Ceratophyllum demersum* in Al-Mashb marsh, Hor Al-Hammar, and the physical-chemical properties of its habitat, Water depth (WD), light penetration (LP), water temperature (WT), water salinity (Sal.), pH, dissolved oxygen (DO), calcium (Ca^{+2}), magnesium (Mg^{+2}), nitrite, nitrate, and phosphate were seasonally determined during 2008. Its vegetation cover percentage was 85 % with its peak in summer, while the lowest value was 35 % in winter. CANOCO ordination program (CCA) was used to analyze the data. Statistically, Positive relationships for WT, pH, Ca^{+2}, Mg^{+2}, nitrite, nitrate, and phosphate with the vegetation cover percentage were observed. However, negative relationships for Sal, WD, LP, and DO with the vegetation cover percentage were observed. *Myriophyllum spicatum* L. and *Hydrilla verticillata* (L.f.) Royle were recorded as associated species with *C. demersum* community in this study.

Keywords: Restoration. *Ceratophyllum demersum* . Mesopotamian. Marshes. Iraq

1- Introduction

An environmental disaster had been happened after the destroying of Mesopotamian marshes in southern Iraq, many of aquatic macrophyte species and communities were changed to xerophyte communities. Re-flooding to Mesopotamian plain were done after the fall of the Iraqi government in 2003(Richardson et al. 2005; Hamdan et al. 2010; Hassan et al. 2011) and many aquatic macrophytes reappeared in Mesopotamian plain in southern Iraq.

C. demersum which locally called shinblan سنبلان distributed in large areas of the world in Europe, Asia, and Northern Africa (Cronk and Fennessy, 2001). Concern over the invasion of non-indigenous plants into natural areas is rapidly increasing, as the number of studies showing the prevalence and effects of such invasions rises (Thompson, 1991). Larson *et al.* (2001) showed that the ability of alien plant species to invade a region depends not only on the attributes of the plants, but also on the characteristics of the invaded habitat. Aquatic plant habitat is threatened by changes in wetland hydrology, eutrophication, the invasion of exotic plants, and other human-induced disturbances such as agriculture and development (Wisheu and Keddy, 1994).

Within the last few years, major hydrological engineering activities in and around the area of Lower Mesopotamia have resulted in the drying out of vast areas of wetlands in the Central Marches and Al-Hammar, and could eventually lead to the disappearance of these systems (Richardson *et al.*, 2005). Currently, less than 10% of the marshlands in Iraq remain as fully functioning wetlands because of the extensive drainage and upstream agricultural irrigation programs on the Tigris and Euphrates rivers (Partow, 2001). Now, restoration by re-flooding of drained marshes is proceeding in the Central and Al-Hammar marshlands (Lawler, 2005; Hamdan *et al.* 2010; Hassan et al.,2011).

One of these Iraqi marshes is Al-Mashb marsh, southern Iraq, which is the largest part of Al-Hammar marsh (figure 1), large part of it have been lost mainly as a results of drainage and damming in 1990s. In 2003, the restoration process of Iraqi marshes was started by removing the dams, which were established on the Tigers and Euphrates Rivers. So after reflooding these marshes many plant species disappeared, while in contrast another exotic species appeared and spread out such as *H. verticillata*.

The current study was conducted to identify the prevailing macrophyte communities in Al-Masheb marsh after reflooding, with some of general features of its habitat and discussed the environmental variables that led to its growth and distribution in the study marsh.

2- Materials and Methods

Floristic Study

The studied macrophytes were identified in the Herbarium of College of Science in the University of Basrah Townsend and Quest (1980). Vegetation Cover percentage is defined as the area of ground within the quadrate ($1m^2$), which is occupied aboveground parts of each species when viewed from above (Kent and Coker, 1992). However, stratification or multiple layering of vegetation will often result in total cover values of well over 100 percent.

Environmental variables

The water environmental variables were measured according to APHA (2003). Five water samples were taken at each season. The water temperature, water salinity, and water pH were measured directly in the field by digital portable multi meter (model 340i/SET, Germany). The water depth was calculated by using ironic ruler (its scale from 0-400 cm.), and Secchi disk (with a diameter 30 cm) was used for light penetration measurement. Dissolved oxygen was measured by Azide-modification of Winkler method. Calcium and magnesium ions concentration were calculated by titration against standard EDTA (0.01 M). While, the nutrients (NO_2^{-1}, NO_3^{-1}, and PO_4^{-3}) were measured by colorimetric methods.

Data analysis

Mean and standard error for water environmental variables were used. The CANOCO 4.5 was used to analyze the data (Ter Braak, 1986) as well as Canonical Correspondence Analysis (CCA) method.

3-Results

Floristic results

The identified plant in this study is *C.demersum.* Its vegetation cover percentage was measured, seasonally. The lowest percentage (35%) was in winter. While, its growth reaches to the peak (85%) in summer (figure 2). *Myriophyllum spicatum* and *Hydrilla verticillata* appeared as associated species with *C. demersum* community.

Environmental variables results

The seasonal fluctuation of environm-ental variables was showed in the figure 3. The seasonal variation in the water depth value was clear, the lowest level (57 cm) was recorded in summer season, while the highest level (105 cm) was in spring season. The light penetration reached to the bottom during all the study period, it followed water depth, usually. The seasonal water temperature variations was clear, when the lowest value (9.75°C) was in winter, while the highest value (26.65 °C) was in summer. The lowest salinity value (2.7 ppt.) was recorded in spring, while the highest value (5.1 ppt.) in summer season. The seasonal pH and dissolved oxygen were calculated, their lowest values were 7.15 and 2.2 mg/l in summer season respectively. Their higher values were 8.82 and 9.3 mg/l in winter respectively. The calcium and magnesium concentrations were ranged from 105.9 to 265.7 mg/l and from 63.5 to 92.7 mg/l in spring and autumn. The seasonal variations in nutrients concentrations (NO_2^{-1}, NO_3^{-1}, and PO_4^{-3}) were clear during the study period, the low values (0.51 µg/l), (1.02 µg/l), and (0.93 µg/l) recorded in summer respectively, while their high values (1.66 µg/l), (3.39 µg/l), and (2.09 µg/l) were in winter, respectively (figure 3). These environmental variables were analyzed to know their means and standard errors (table 1). As well as, the correlation (r) between environmental variables to each other was done (table 2).

Also, the relationships between environmental variables and species were concluded, statistically by CCA method, whereas positive relationships were observed between vegetation cover percentage for *C. demersum* and the values of water temperature, pH, calcium ion, magnesium ion, reactive nitrate, reactive nitrite, and reactive phosphate, their correlation (r) values were 0.853, 0.557, 0.939, 0.919, 0.746, 0.702, and 0.663, respectively. While, negative relationships were observed between vegetation cover percentage for *C. demersum* and the values of the other environmental variables, which are salinity, dissolved oxygen, and water depth. Their correlation (r) valves were -0.980, -0.624, and -0.575, respectively. On the other hand, light penetration reached to the bottom during the study period, totally. So that its correlation (r) value with vegetation cover percentage for *C. demersum* followed water depth, it is -0.575 (figure 4 and table 2).

During the current investigation, we noticed two associated species with *C. demersum* community; these species are *Myriophyllum spicatum* and *Hydrilla verticillata*.

Table -1- Mean and Standard Error for Water Environmental Variables

Mean and Standard Error for Water Environmental Variables											Season
PO_4±SE	NO_3±SE	NO_2±SE	Mg±SE	Ca±SE	DO ±SE	pH±SE	Sal±SE	WT ±SE	LP±SE	WD±SE	
2.09±0.04	3.39±0.31	1.66±0.11	86.2±5.15	194.2±13.12	9.3±0.15	8.82±0.03	3.5±0	9.75±0.24	92.5±0	92.5±6.5	**Winter**
1.21±0.09	1.42±0.09	0.87±0.06	63.5±4.72	105.9±8.29	7.3±0.3	8±0.1	2.7±0	11.75±0.15	104±0	105±4.7	**Spring**
0.93±0.05	1.02±0.11	0.51±0.09	78.4±3.03	172.2±11.06	2.2±0.2	7.15±0.05	5.1±0	26.65±0.55	57±0	57±3.5	**Summer**
1.77±0.06	2.99±0.02	1.28±0.03	92.7±5.57	265.7±15.01	4.9±0.4	7.7±0	4.7±0	18.9±0.2	66.5±0	66.5±5.1	**Autumn**

Table.2. The correlation (r) between environmental variables and vegetation cover (percentage) for *Ceratophyllum demersum.* Also, between environmental variables to each other.

Myr spi	PO4	NO2	NO3	Mg	Ca	DO	pH	Sal.	WT	LP	WD	
											1.000	**WD**
										1.000	1.000	**LP**
									1.000	-0.378	-0.378	**WT**
								1.000	0.824	0.026	0.026	**Sal.**
							1.000	-0.864	-0.922	0.480	0.480	**pH**
						1.000	0.973	-0.869	-0.986	0.708	0.708	**DO**
					1.000	-0.413	-0.403	-0.085	0.544	-0.934	-0.934	**Ca**
				1.000	0.969	-0.236	-0.270	-0.247	0.503	-0.961	-0.961	**Mg**
			1.000	0.195	0.369	-0.998	-0.979	0.894	0.977	-0.379	-0.379	**NO3**
		1.000	0.971	-0.020	0.181	-0.965	-0.912	0.945	0.960	-0.153	-0.153	**NO2**
	1.000	0.991	0.994	0.108	0.297	-0.991	-0.955	0.918	0.980	-0.285	-0.285	**PO4**
1.000	**0.663**	**0.702**	**0.746**	**0.919**	**0.939**	**-0.624**	**-0.624**	**-0.980**	**0.853**	**-0.575**	**-0.575**	***Cerdem***

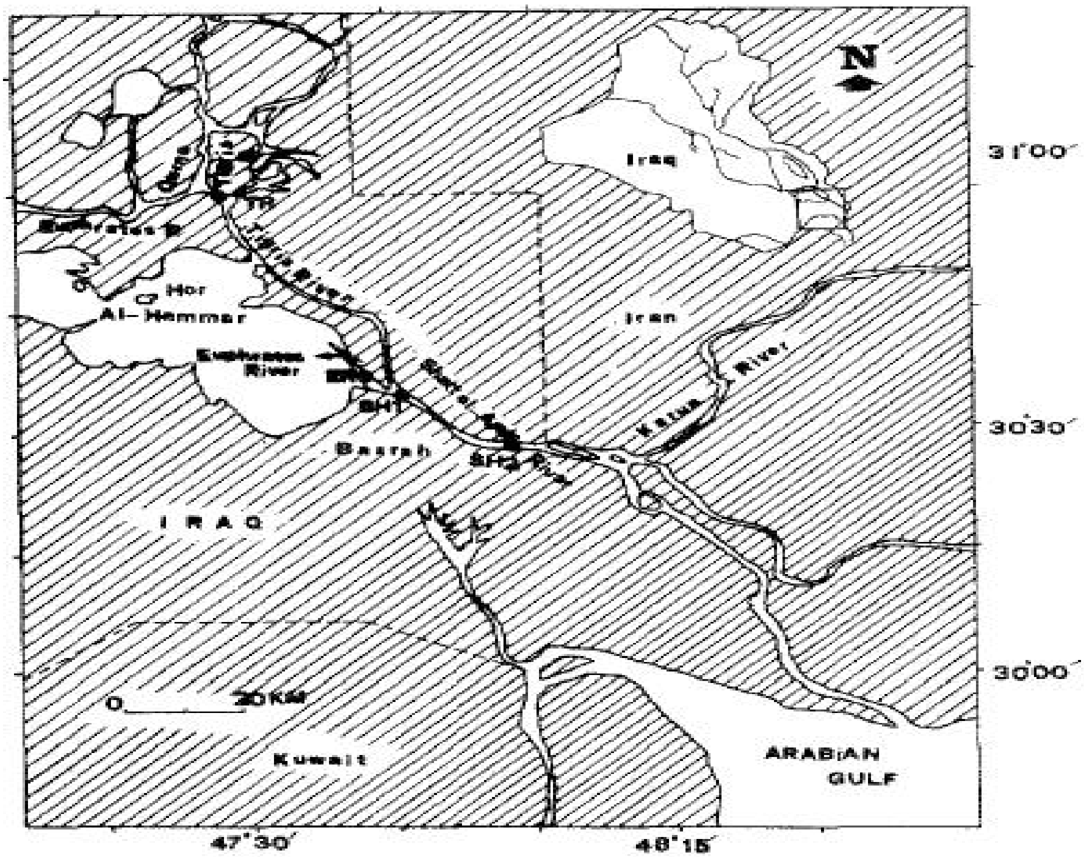

Fig.1. Map of the studied location.

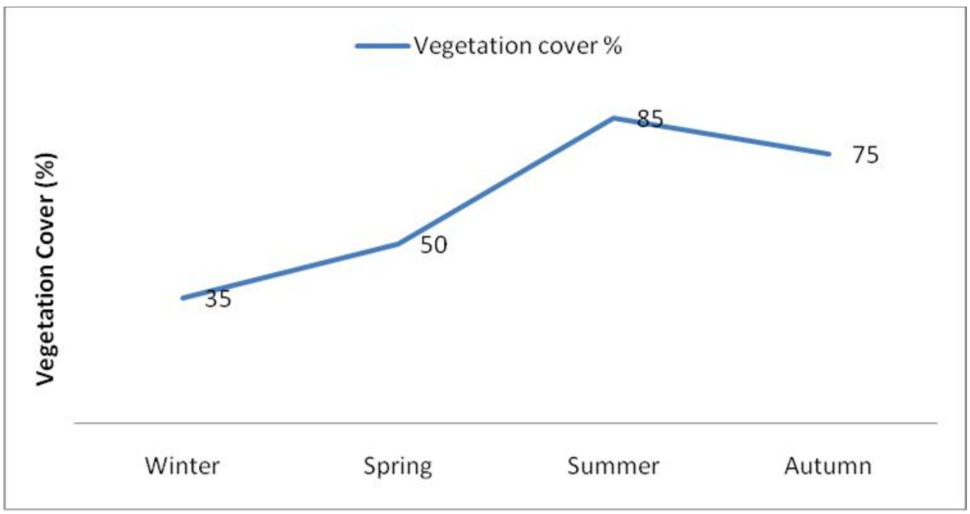

Fig.2. Seasonal vegetation cover percentage for *Ceratophyllum demersum.*

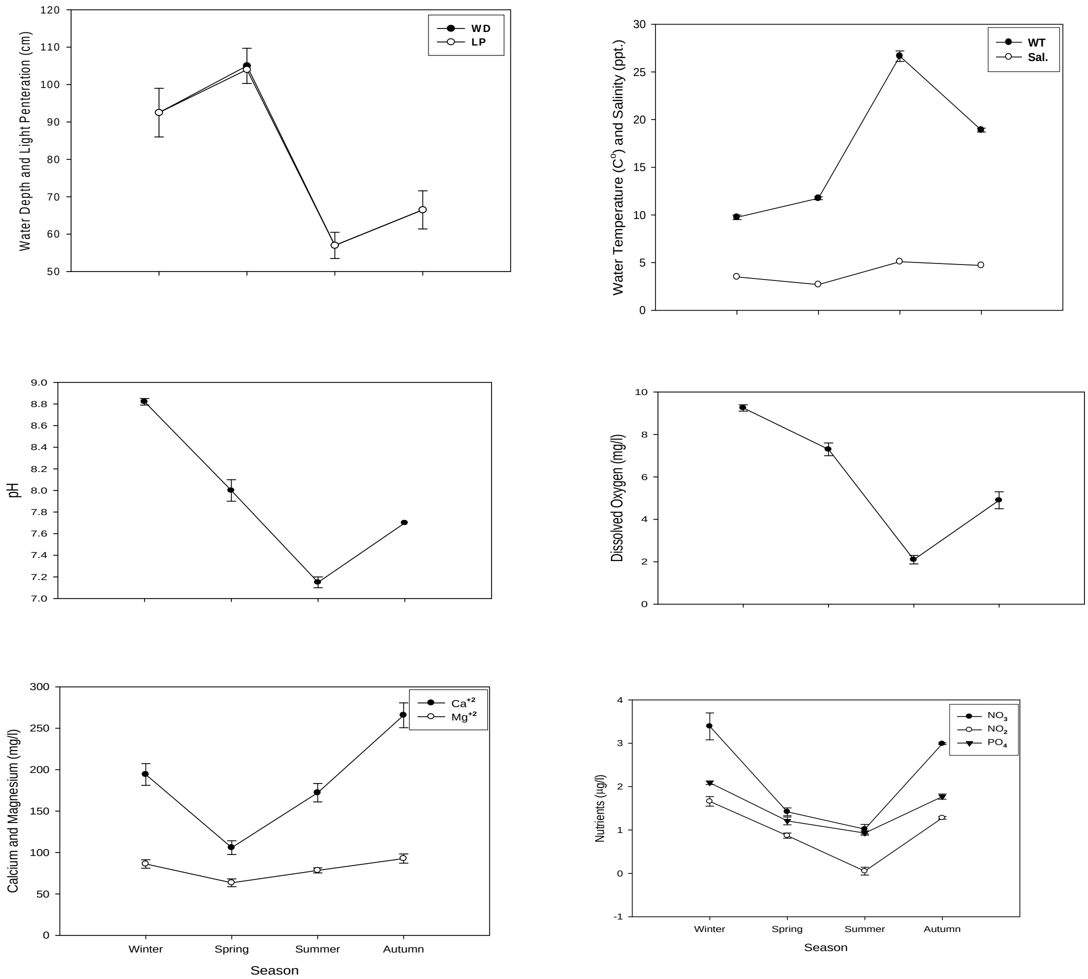

Fig.3. Seasonal variations with standard error for some environmental variables.

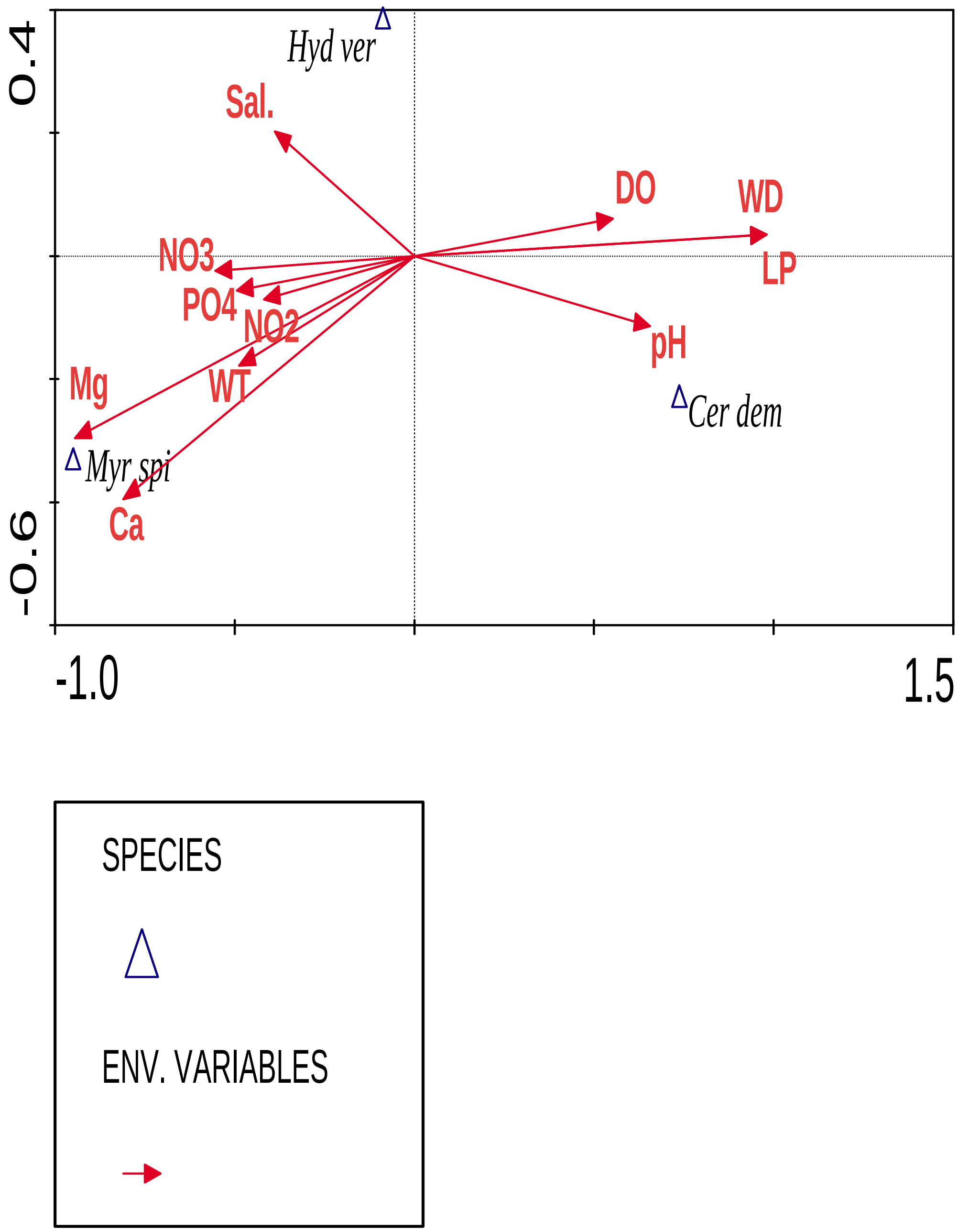

Fig.4. The relationships between environmental variables and species by CCA method.

Note: *Cer dem= Ceratophyllum dimerisum, Myr spi= Myriophyllum spicatum, Hye ver= Hydrilla verticellata*

4- Discussion

The fluctuation in the growth of *C. demersum* in the present study may be due to the physical and chemical conditions for its habitat (Menzie, 1979). Its large distribution may be due to the environmental changing in the marsh after restoration that leads to become appropriate habitat (Williamson, 1999).

C. demersum growth with its peak at summer may be attributed to the environmental conditions that should be changed to be more appropriate, while the environmental conditions are not suitable to growth of macrophytes at winter (Williamson, 1999).

Water depth is one of the important ecological factors in wetlands. In this study, the negative correlation between vegetation cover percentage for *C. demersum* and water depth may be because that increasing of water depth leads to decreasing of light penetration to submerged aquatic plants, which affects the photosynthesis (Terrados *et al.,* 2006). On the other hand the increasing of water level leads to dilute the nutrients which are required to growth of plants which agrees with (Herb and Stefan, 2006; Al-Kenzawi, 2007, 2009). Light penetration is very important factor for growth and distribution of the aquatic macrophyte, but this study showed there was negative correlation between light penetration and the growth that was attributed to the water in the studied site which was shallow so that light penetration followed water depth value and reached to the bottom during all the study period (Al-Kenzawi, 2007).

The positive relationship, which was observed between water temperature and vegetation cover percentage for *C. demersum* may be because the increasing of water temperature enhance evapo-transpiration, photosynthesis and microbial activity. The microbial organisms perform the degradation to dead bodies at warm season, so that the nutrients that are required by plants would be added to the ecosystem, so that temperature has positive effect on nutrients (Al-Kenzawi, 2009). Chlorophyll leaf concentration has positive correlation with temperature (Spencer and Ksander, 1990). Also, the peak of vegetation cover percentage for this species was at summer season, when the day lengths are more than others seasons, whereas increasing day length at summer season should result in increasing photosynthesis that should lead to more growth this agrees with other studies (Herb and Stefan, 2006; Al-Kenzawi, 2007).

Calcium and Magnesium ions are essential nutrient for plants, whereas they share in structure of the cell wall and chlorophyll. The positive relationships between vegetation cover percentage for *C. demersum* and these ions may be because these ions have effects on the microbial organisms, which perform the degradation for dead materials, that causes availability of nutrients which are required by aquatic plants, so that the growth of this species should be with the peak at the warm season (the growth season). These results agree with other studies (Serag and Khedr, 2001; Al-Kenzawi, 2007).

The positive relationships between vegetation cover percentage for *C. demersum* and nutrients (NO_2^{-1}, NO_3^{-2}, and PO_4^{-3}) may be because the high growth requires large amounts from nitrogen and phosphorous compounds to metabolic processes (Khedr and El-Demerdash, 1997).

On the other hand, at winter and autumn, when there was no growth, there was no taking up for nitrogen compounds by plants, in addition, the concentrations that are added by the rain and the degradation process for the dead materials, so that their concentrations should be increased at these seasons (Al-Kenzawi, 2007, 2009). The same case for phosphate concentration.

The negative correlation between pH value and vegetation cover percentage for *C. demersum* may be because that pH is affected by dissolved inorganic carbon, which is important for photosynthesis (Heegaard *et al.,* 2001). As well as, the variations in dissolved inorganic carbon availability may account for differences in the growth and distribution of *C. demersum* among low and high dissolved inorganic carbon locations.

The negative correlation between dissolved oxygen concentration and vegetation cover percentage for *C. demersum* may be due to gas exchange between the atmosphere and surface water during the growth season (summer) is controlled primarily by the gas concentration gradient and the boundary layer thickness (Serag and Khedr, 2001). As well as, aquatic macrophytes produce structural material (lignin, cellulose, and hemicelluloses), and this material decomposes relatively slowly, and at that time the microbial organisms consume more dissolved oxygen during the degradation process for these materials during the growth season, so that the dissolved oxygen will be decreased, and inverse this case at the winter season, this agrees with many studies (Khedr and El-Demerdash, 1997; Al-Kenzawi, 2007).

The present study noticed a considerable existence of *Hydrilla verticillata* in the studied marshes, there are no previous data recorded for this aquatic macrophyte in this marsh before desiccation of Mesopotamian wetlands. This invasive plant spreads in other Iraqi marshes after reflooding which may affect the appearance of the native macrophytes species in Mesopotamian marshes. Alwan (2006) recorded *Hydrilla* *verticillata* for the first time in Abu-Zirig marsh, southern Iraq in 2004. Hydrilla invaded many restored marshes in southern Iraq (Al-Abbawy and Al-Mayah, 2010) and other aquatic systems worldwide (Sousa, 2011), for this reason should the Iraqi government seeks to control this exotic species before this problem is aggravated.

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الخلاصة

استهدف البحث تحديد انتشار وتوزيع نبات الشمبلان *Ceratophyllum demersum* في هور المسحب ـ الحمار , والذي تاثر انتشاره بعد عملية تجفيف الاهوار في التسعينات واستعاد ظهوره بعد اعادة اغمارها بعد سقوط النظام السابق بالاضافة الى دراسة نسبة الغطاء النباتي والعوامل الفيزيائية والكيميائية لمعايير عمق الماء ونفاذية الضوء ودرجة حرارة الماء وملوحة الماء والاس الهيدروجيني والاوكسجين المذاب والكالسيوم والمغنسيوم والنتريت والنترات والفوسفات خلال عام 2008 واظهرت النتائج ان اعلى نسبة للغطاء النباتي كانت 85% في الصيف واقل نسبة 35% في الشتاء . وتبين من تحليلات CCA Coneco Ordination Program وجود علاقة موجبة بين الغطاء النباتي ودرجة الحرارة والحموضة والكالسيوم والمغنسيوم والنترات والنتريت والفوسفات ووجود علاقة سالبة مع الملوحة وعمق الماء والنفاذية والاوكسجين المذاب كما شوهد وجود نبات ذيل العتوي *Myriophyllum spicatum* والهيدرلا *Hydrilla verticillata* كانواع مصاحبة لمجتمع الشمبلان.