Seasonal Ecological Study for Community of *Hydrilla Verticillata* in Al-Masehb Marsh, Southern Iraq.

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Abstract

This study was performed in Al-Masehb Marsh, Southern Iraq after its restoration processes during 2007, seasonally. *Hydrilla verticillata* was identified for the first time in this marsh, then its standing crop biomass and vegetation cover percentage were studied. In addition to some physical and chemical water properties. Whereas, its standing crop biomass was with its peak in summer, its value was 213.5 gm/m^2, while the lowest value was 42.7 gm/m^2 in winter. Also, the vegetation cover percentage was with its peak in summer, its value was 80 %, while the lowest value was 20 % in winter. T-test program was applied to study the significant differences in the growth between seasons at significance levels (P-value < 0.01) and (P-value < 0.05). Pearson's product moment correlation coefficient (r) was done to study the relationships between the growth and the studied environmental variables. Statistically, significant differences were shown in the growth between some seasons (winter and summer, winter and autumn, spring and summer; thus spring and autumn). Positive relationships for water temperature and salinity with the growth were observed, while negative relationships were observed for water depth, calcium, magnesium, nitrite, nitrate, and phosphate with *Hydrilla verticillata* growth.

Keywords: *Hydrilla verticillata*. Biomass. Vegetation Cover. Iraqi Marshes.

Introduction

Iraqi marshes ultimately drain southeast wards into the Gulf via the Shatt Al-Arab waterway [1] Iraq's very limited coastal zone consists mainly of intertidal mudflats flanked by bare silt flats, often with an intervening narrow strip of date palm gardens [2]. Floodplain wetlands, riverbanks and lakeshores are utilized for the cultivation of cereals, rice or vegetables, while rivers and lakes themselves support freshwater fisheries. In the vast reed-beds of Mesopotamia, marsh-dwelling communities are almost totally dependent on reeds for their construction needs. In Mesopotamia, large numbers of waterfowl are captured and sold each year, providing a livelihood for hundreds of people [3]. One of the most serious threats to the wetlands in Iraq has been the drainage and diversion of water, as typically supply for agricultural purposes, but also in recent years, for military reasons [1].

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 [4]. 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 [1]. Now, restoration by re-flooding of drained marshes is proceeding in the Central and Al-Hammar marshlands [5].

One of these Iraqi marshes is Al-Masehb marsh, southern Iraq, which is one parts of Al-Hammar marsh that was destroyed by prevent water flow to it during 1990s by dames and applying the water regime for the water amounts, which reach to the south of Iraq. Then at 2003, the restoration process of Iraqi marshes was started by removing the dams, which established on the Tigers and Euphrates Rivers, in addition to increasing the water amounts, which reach to southern areas from Iraq. So that the water reflooded to these areas and the life in these marshes started again, therefore, many flora Iraqi species disappeared, and at the same time, there are new species appeared, which are considered new species in Iraq.

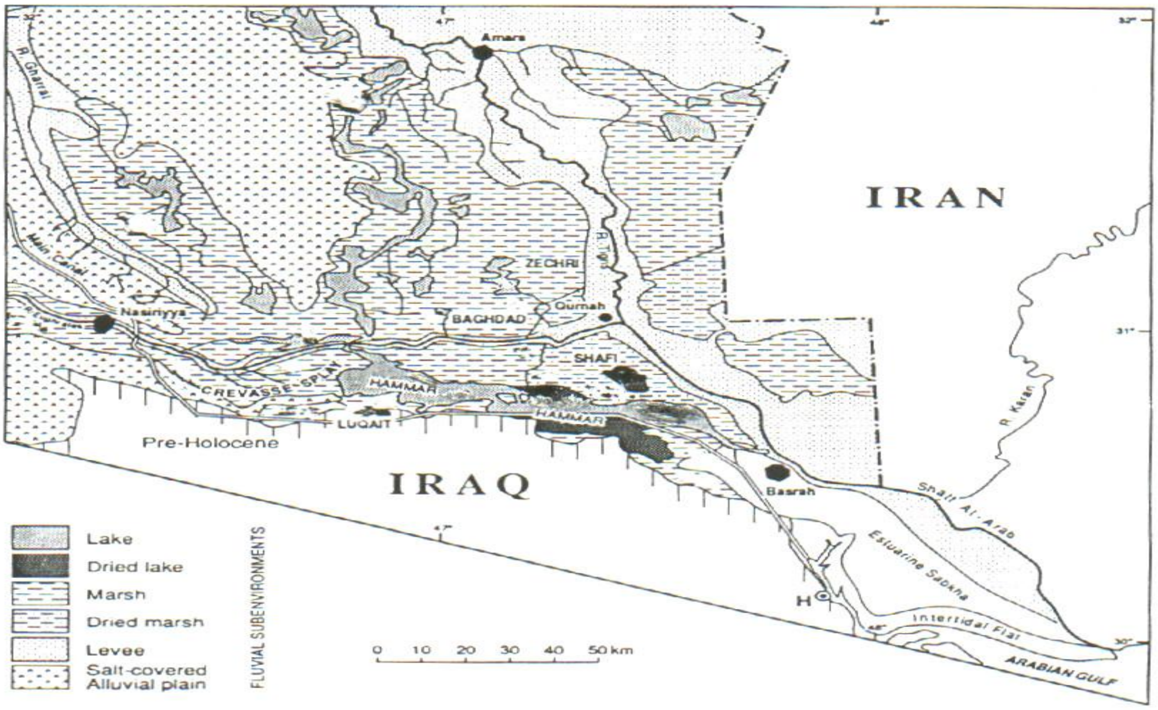


Fig. (1) Location Map (١).

Hydrilla verticillata is a native of Southeast Asia. It is a noxious invasive in many states of the U.S. including most of the Atlantic and Gulf Coast states and the western states, Arizona, California, and Washington [6]. It is also considered an invasive in Europe, Central America, and elsewhere [7]. By the mid-1960s, *H. verticillata* had become a nuisance species and it has been the most abundant submerged plant in Florida since 1983 [8]. Once established in a water body, *H. verticillata* spreads very quickly, for example, in a south central Florida lake (11,332 ha) *H. verticillata* covered approximately 14 % of the lake’s total area in 1987, a year later, it covered 70% of the lake [9].

In Iraq, *H. verticillata* is considered as new species, when it was recorded for the first time in Abu-Zirig marsh, southern Iraq at 2004 after restoration process of Iraqi marshes [10]. So that, when we observed it in Al-Masehb Marsh, Southern Iraq, We decided to identify it, scientifically. In addition, Study the environmental variables that were available to its growth and distribution in this marsh. Moreover, study the amount of its growth (vegetation cover and standing crop biomass) in this marsh, seasonally.

Materials and Methods

The studied macrophyte species was identified in the herbarium of college of science in the University of Basrah according to [11].

Vegetation Cover percentage is defined as the area of ground within the quadrate, which is occupied aboveground parts of each species when viewed from above. Cover was estimated usually as a percentage. Whereas area of the quadrate is one m^2, where both its length and its width are divided to 100 cm, so that its length has 10 small quadrates, the area of each small quadrate is 100 cm^2, its width has too [12].

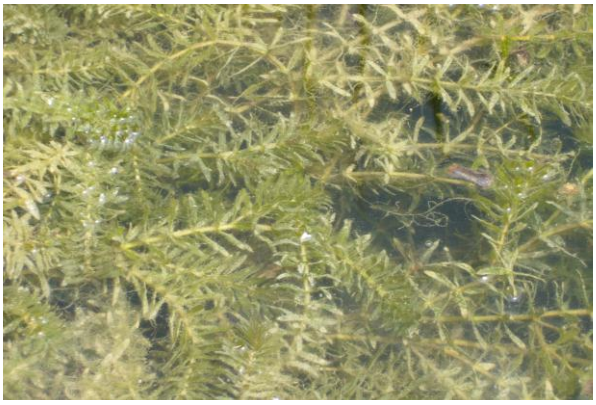
Standing Crop Biomass includes live parts and dead parts of live plants, which are still attached [13, 14]. To obtain the standing crop, the harvesting technique was used, whereas the plant parts inside the quadrate (1 m^2) was clipped at sediment level using sickle, and then the harvested plants are sorted, cleaned from sediments and periphyton, and dried in the oven at 70 C° to a constant weight [15].

Water environmental variables were measured according to [16]. 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, which is made in Germany), in addition the water depth by ironic ruler that is divided from 0-400 cm and light penetration by Secchi disk (30 cm in diameter). Dissolved oxygen was measured by Azide-modification of Winkler method. Calcium ion concentration was measured by titration against standard EDTA (0.01 M). While, the nutrients (NO_3, NO_2, and PO_4) were measured by colorimetric methods.

Pearson's Product Moment Correlation Coefficient (r) was used to determine the effect of environmental variables on the growth (significant or non-significant). The statistical significance of differences for data among seasons was assessed using t-test. *P*-value less than the point 0.01 and 0.05 level of significance were considered statistically significant [17].

Results

The studied species was identified that is *Hydrilla verticillata*, it is shown in the picture (1). It is a monocotyledon in the Hydrocharitaceae. It is a rooted, submerged perennial with leaves from 5 to 15 mm long and 2 to 4 mm wide, arranged in pairs on the lower nodes and in whorls of 3 to 10 leaves on the upper nodes. Its stems are varied in length from a few centimeters to several meters and either erect, horizontal, or subterranean.



Picture (1) Hydrilla verticillata.

Vegetation cover percentage for it ranged between (20 % – 80 %), when the lowest value was in winter, while the highest value was in summer. Fig.(2).

Standing crop biomass for this species ranged between (42.7 gm/m^2 – 213.5 gm/m^2), when the lowest value was in winter, while the highest value was in summer. Fig.(3).

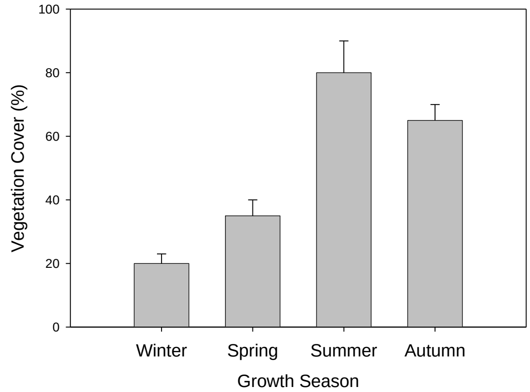


Fig.(2)Seasonal vegetation cover (%) for Hydrilla verticillata community.

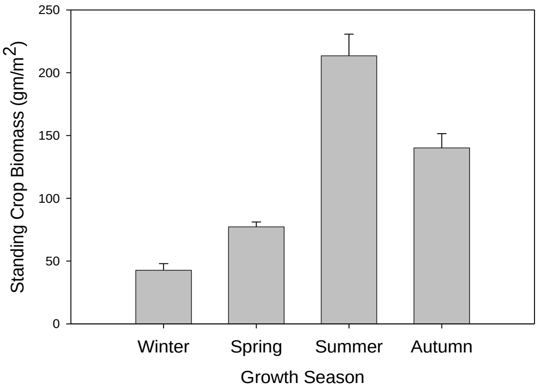


Fig.(3) Seasonal standing crop biomass (gm/m^2) for Hydrilla verticillata community.

The environmental variables are clear in the Table (1). Whereas the seasonal variation in the water depth value is clear, see Fig.(2), when the lowest level was at summer season (59 cm), while the highest level was at spring season. The light penetration reached to the bottom during all the study period, this is clear in the Fig.(5), it followed water depth, usually. The seasonal water temperature variations was clear, Fig.(6), when the lowest value was at winter (9.75 C°), while the highest value was in summer (26.65 C°). Salinity changed during the seasons, clearly, Fig.(7), its low value (2.7 ppt.) was in spring, while its high value (5.1 ppt.) was in summer. The seasonal pH variations were clear, Fig.(8), when its low value (7.15) was in summer, while the highest value (8.82) was in winter.

Dissolved oxygen changed clearly during study period, Fig.(9), when the lowest value (2.1 mg/l) was in summer, while the highest value (9.2 mg/l) was in winter. The seasonal variations for calcium and magnesium concentrations were clear, Fig.(10) and (11), when their low values (102.6 mg/l), (62.8 mg/l) respectively were in spring, while their high values (268.4 mg/l), (94.2 mg/l), respectively were in autumn. The seasonal variations in nutrients concentrations (NO_2, NO_3, and PO4) were clear during the study period, Figs. (12), (13), and (14), when their low values (0.52 µg/l), (1.06 µg/l), and (0.96 µg/l), respectively were in summer, while their high values (1.7 µg/l), (3.42 µg/l), and (2.07 µg/l), respectively were in winter.

Table (1)
Mean and Standard Error for Water Environmental Variables.

Site-Season	*Mean and Standard Error for Water Environmental Variables*										
	WD±SE	*LP±SE*	*WT ±SE*	*Sal.±SE*	*pH±SE*	*DO ±SE*	*Ca±SE*	*Mg±SE*	*NO_2±SE*	*NO_3±SE*	*PO_4±SE*
Al-Masehb-Winter	92.5±6.5	92.5±0	9.75±0.24	3.5±0	8.82±0.03	9.25±0.15	194.2±13.12	86.2±5.15	1.7±0.11	3.42±0.31	2.07±0.04
Al-Masehb-Spring	104±4.7	104±0	11.75±0.15	2.7±0	8±0.1	7.3±0.3	102.6±8.29	62.8±4.72	0.87±0.06	1.42±0.09	1.21±0.09
Al-Masehb-Summer	59±3.5	59±0	26.65±0.55	5.1±0	7.15±0.05	2.1±0.2	172.2±11.06	78.4±3.03	0.52±0.09	1.06±0.11	0.96±0.05
Al-Masehb-Autumn	66.5±5.1	66.5±0	18.9±0.2	4.7±0	7.7±0	4.9±0.4	268.4±15.01	94.2±5.57	1.28±0.03	2.99±0.02	1.77±0.06

Pearson's product moment correlation coefficient (r) showed that there are correlations between the growth of *Hydrilla verticillata* and the environmental variables, whereas *r* value between *Hydrilla verticillata* growth and water depth is -0.941, as well as light penetration reached to the bottom and its value followed the water depth. There is positive correlation between growth and water temperature, whereas its r value is 0.963. The correlation r between the growth and salinity value is 0.708. The negative correlation between the growth and pH was observed, its value is -0.974. Also, negative correlation was observed between the growth and dissolved oxygen, its value is -0.919. Thus, negative correlation between the growth and calcium concentration was observed, its value is -0.692. The correlation between the growth and magnesium concentration is negative, its value is -0.659. In addition, the correlations between the growth and nutrients concentrations (NO_2, NO_3, and PO_4) are negative, whereas their *r* values were (-0.941, -0.973, and -0.965), respectively. The t-test program showed that there are significant differences in the growth between some seasons by *P*-value at significance levels less than 0.01 and 0.05, these results are clear in the Table (2).

Table (2)
A summary of t-test results showing the significant differences for growth of Hydrilla verticillata community by P-value at significance levels less than 0.01 and 0.05, among the seasons.

The seasons	*P-value for growth of Hydrilla verticillata community*
Winter and Spring	-
Winter and Summer	0.002**
Winter and Autumn	0.011*
Spring and Summer	0.019*
Spring and Autumn	0.037*
Summer and Autumn	-

* The difference at significance level 0.05.
** The difference at significance level 0.01.
- There is no significant difference.

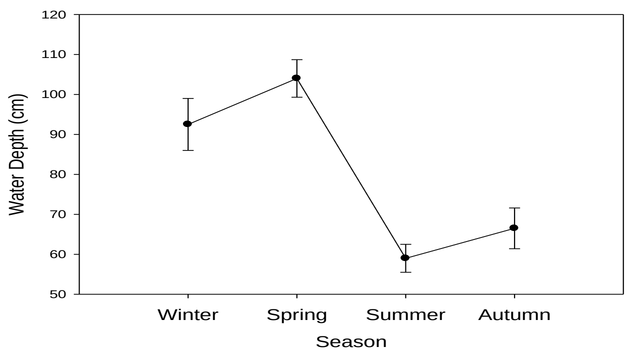


Fig.(4) Seasonal water depth variations with standard error.

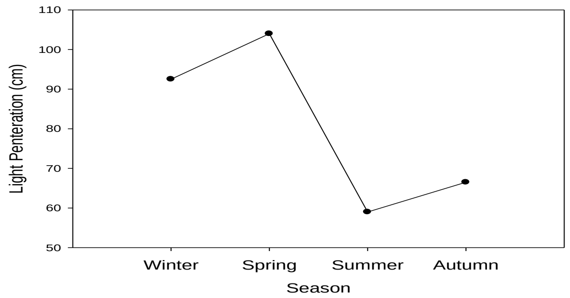


Fig.(5) Seasonal light penetration variations with standard error.

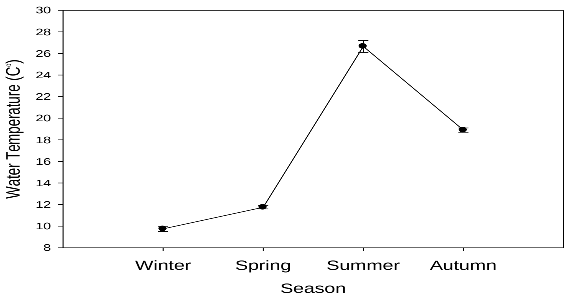


Fig.(6) Seasonal water temperature variations with standard error.

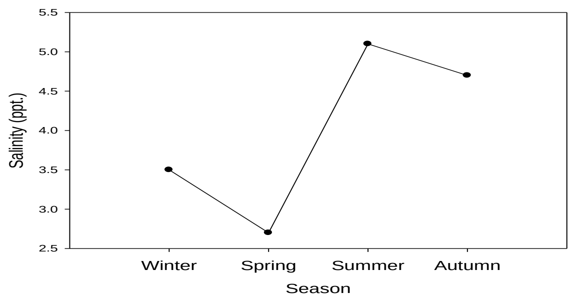


Fig.(7):Seasonal salinity variations with standard error.

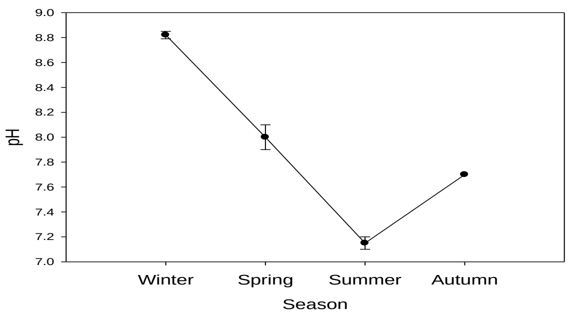


Fig.(8) Seasonal pH variations with standard error.

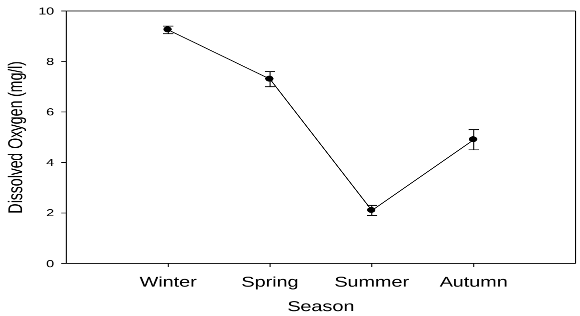


Fig.(9) Seasonal dissolved oxygen variations with standard error.

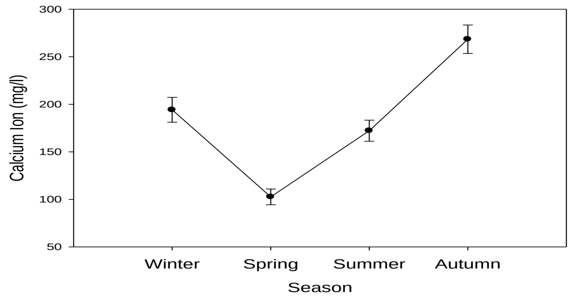


Fig.(10) Seasonal calcium ion concentration with standard error.

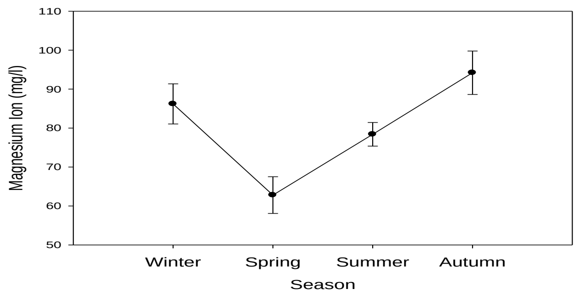


Fig.(11) Seasonal magnesium ion concentration with standard error.

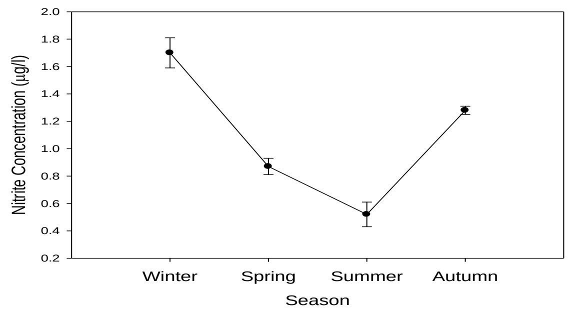


Fig.(12) Seasonal nitrite variations with standard error.

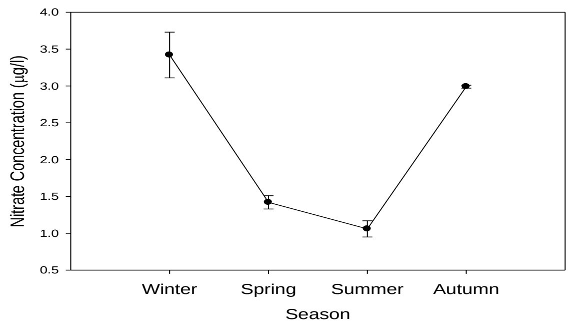


Fig.(13) Seasonal nitrate variations with standard error.

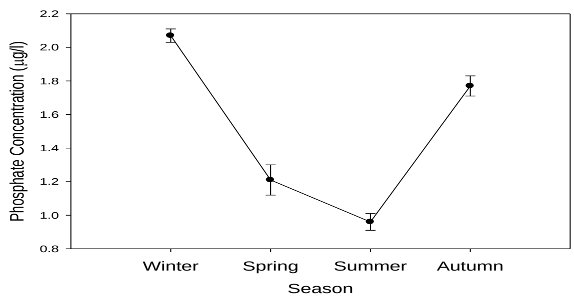


Fig.(14) Seasonal phosphate concentration variations with standard error.

Discussion

Hydrilla verticillata was recorded for the first time in Iraq after Iraqi marshes restoration process in Abu-Zirig marsh by Alwan (2006). Then, in this work, it was identified for the first time in Al-Masehb Marsh, Southern Iraq. So that, it is considered exotic species to Iraqi environment that may be due to changing of the marsh ecological conditions after restoration that should be led to become appropriate habitat for growth and distribution of new species [18].

The significant differences in the growth of *Hydrilla verticillata* among seasons that may be due to its growth seasons [19]. Whereas, at winter there was no growth that may be due to the environmental conditions are not suitable for growth of macrophytes, but at summer, the environmental conditions should be changed to be more appropriate [18].

Water depth is one of important ecological factors, which has inverse effect on the aquatic macrophyte growth [20]. Whereas (r) for the growth of *Hydrilla verticillata* with water depth in this study, is -0.941 that my be because there is inverse relation between aquatic plants growth and water depth, whereas the increasing of water depth leads to decreasing of light penetration to submerged aquatic plants which affects photosynthesis. On the other hand, the increasing of water level leads to dilute the nutrients, which are required for growth of plants this agrees with [19, 21, and 22].

Temperature plays a major role in the life cycles of plants and it can be the limiting factor for the depth at which some plants can grow, as well as the length of the growing season for some plants depends on the temperature and conversely [23]. In the present study, there is significant positive relationship, is 0.963 that may be due to the increasing of water temperature should enhance evapotranspiration, photosynthesis and microbial activity, the microbial organisms perform the degradation to dead bodies at warm season, so that the nutrients which are required by plants would be added to the ecosystem, so that temperature has positive effect on nutrients [24]. As well as, temperature affects chlorophyll content, whereas chlorophyll leaf concentration has positive correlation with temperature (chlorophyll concentration increases with increasing temperature) [25]. Also, the peak of standing crop and vegetation cover percentage for *Hydrilla verticillata* was in summer, when day lengths in this season more than others seasons, whereas increasing day length at summer season should result increasing photosynthesis that leads to more growth [26]. This agrees with [19 and 22].

Water salinity is one of the important chemical properties for water, which affect the growth of plants, whereas it is considered one of the limited factors to plant growth [6]. In this study, the positive correlation between *Hydrilla verticillata* growth and water salinity is 0.708. At the warm season, when the water salinity was in the highest values, *Hydrilla verticillata* was with peak of growth that likely because indirect relationships between salinity and nutrients availability, that lead for increasing growth of plants [24]. The results of the present study agree with [22 and 27] which found that lowered salinity was alone resulted in reduced reproductive effort of macrophyte communities. While disagree with some studies which have hypothesized that fluctuations in salinity may be an important factor in productivity of wetland plant communities, whereas they observed that there is relative relationship, significantly between salinity levels and growth of plant communities [28 and 29].

Many studies have found that pH has important influence on aquatic plants growth and distribution [22, 24, and 30]. This study showed that there is significant negative correlation between *Hydrilla verticillata* growth, its value is -0.974. When pH values are with the lowest value in the growth season (summer), the growth should be with its peak and inverse that in winter. This negative relationship may be because that pH is affected by dissolved inorganic carbon, which is available for photosynthesis [24]. As well as, the variations in dissolved inorganic carbon availability may account for differences in the growth and distribution of *Hydrilla verticillata* among low and high dissolved inorganic carbon locations [28]. In addition, when the pH values be low there are potential limitations to growth include the reduced availability of photosynthetic carbon through loss of bicarbonate as dissolved inorganic carbon source [31]. The results of this study agree with many studies [22, 30 and 32].

The present study showed that there is negative correlation between *Hydrilla verticillata* growth and dissolved oxygen concentration, its value is 0.919, that means when the growth with its peak in summer, the dissolved oxygen concentration is in the lowest values, and inverse that at winter, that may be because gas exchange between the atmosphere and surface water is controlled primarily by the gas concentration gradient and the boundary layer thickness [32]. 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 (summer), so that the dissolved oxygen will be decreased, and inverse this case at the winter season, this agrees with many studies [22, 24 and 27].

Calcium and Magnesium ions are essential nutrients for plants, whereas they share in structure of the cell wall and chlorophyll. The present study showed negative relationships between *Hydrilla verticillata* growth with calcium and Magnesium ions concentrations, their values are -0.692 and -0.659, respectively. They have effects on the microbial organisms, which performs the degradation for dead materials, that causes availability of nutrients which are required by aquatic plants, so that the growth should be more in warm season (growth season), that should be led calcium and magnesium concentration to become with the lowest values at this season that because big amount from their concentrations are taken up by plants. These results agree with many studies (6, 22 and 32].

Availability of nutrients is considered one of the main factors affecting the aquatic plants growth [6]. Many nutrients required for growth, nitrogen (N) and phosphorus (P) are the elements typically of shortest supply in aquatic ecosystems and therefore most likely to affect the growth of aquatic macrophytes species [30].

This study showed negative relationships between *Hydrilla verticillata* growth and nutrients concentrations (NO_2, NO_3, and PO_4), whereas r values for them are (-0.941, -0.973, and -0.965), respectively. The negative correlation with nitrogen and phosphorus compounds that may be due to when the growth with its peak in summer, that should be led the concentration to become at the lowest value because the high growth requires big amounts from nitrogen and phosphorous compounds to metabolic processes [33]. Whereas, the nitrogen compounds are required by plants to share in protein structure, that should be led to increasing in the growth [32]. On the other hand, in winter and autumn, when there was no growth, there were fewer requirements 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 [22 and 33].

The same case for phosphate concentration, there is negative relationship between it and *Hydrilla verticillata* growth because it is important for plants; it shares in structure of the cell wall, protein, nucleotide and ATP [34]. These results agree with [22, 24 and 35].

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الخلاصة

تمت هذه الدراسة في هور المسحب جنوب العراق بعد عمليات اعادة الأهوار، سنة ٢٠٠٧، بصورة موسمية. *Hydrilla verticillata* شخص في هذا الهور لأول مرة. درست الكتلة الحية للمحصول القائم والنسبة المئوية للغطا الخضري لمجتمع هذا النوع. فضلا عن بعض المواصفات الفيزيائية والكيميائية للمياه، وجد أن الكتلة الحية كانت بقمتها في فصل الصيف وقيمتها هي ٢١٣,٥ غم/م٢، بينما القيمة الأقل هي ٤٢,٧ غم/م٢ كانت في الشتاء. كذلك النسبة المئوية للغطاء الخضري كانت بقمتها في الصيف وقيمتها ٨٠ %، بينما القيمة الأقل هي ٢٠ % وكانت في الشتاء. النظام الأحصائي t-test طبق لدراسة الأختلافات المعنوية في النمو بين المواسم عند مستويات معنوية (P-value < 0.01) و (P-value < 0.05). ومعامل الأرتباط (r) طبق لدراسة العلاقات بين النمو والمتغيرات البيئية المدروسة. أحصائيا، لوحظت اختلافات معنوية في النمو بين بعض المواسم (الشتاء والصيف، الشتاء والخريف، الربيع والصيف، وبين الربيع والخريف). ولوحظت علاقات ارتباط موجبة لدرجة حرارة الماء والملوحة مع النمو، بينما لوحظت علاقات سلبية (عكسية) لعمق الماء، الكالسيوم، المغنيسيوم، النتريت الفعال، النترات الفعال، والفوسفات الفعال مع نمو الـ *Hydrilla verticillata*.

الكلمات المفتاحية: *Hydrilla verticillata*. الكتلة الحية. الغطاء الخضري. الأهوار العراقية.