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## Similarity and dissimilarity of macroinvertebrates, fishes and aquatic birds species composition in three major marshes of southern Iraq

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### Abstract

*Whittaker beta diversity formula was applied to detect similarity and dissimilarity of species composition of Macroinvertebrates, total number of fishes, native fish and aquatic birds species in three major southern Iraqi marshes (Al-Huwaiza, East and West Hammar ). The outcome results indicated that species dissimilarity increased in southern marshes, (i) Due to enlarge of land isolation between southwest and southeast marshes, (ii) Intrusion of exotic, alien and marine fishes and crustacean species, (iii) Third escalation of water salinity and progressive effect of the Gulf tide. Moderate levels of species dissimilarity were obtained for macroinvertebrates, total number of fishes and aquatic birds among West Hammar and Al-Huwaiza marshes, on contrary species similarity increased for macroinvertebrates groups and aquatic birds between East and West Hammar marshes. Migrating marine fish species cause moderate dissimilarity in total number of fish species between East Hammar and Al-Huwaiza ( $\beta_w : 1.357$ ), while good similarity value for native fish species was recorded ( $\beta_w : 1.262$ ) in East and West Hammar. Presence or absences of tidal muddy shores led to low dissimilarity ( $\beta_w : 1.321-1.329$ ) in aquatic birds species existed in the three marshes. Gradual rise of species dissimilarity of southern marshes taxa seemed to be inevitable with the escalation of environmental degradation of southern Iraqi marshlands .*

## Introduction:

Alpha, beta, and gamma diversities are among the fundamental descriptive variables of ecology and conservation biology, but their quantitative definition has been controversial. Traditionally alpha, beta, and gamma diversities have been related either by the additive definition  $H\alpha + H\beta = H\gamma$  or the multiplicative definition  $H\alpha \cdot H\beta = H\gamma$  (Whittaker, 1972), or as the ratio between Gamma ( $\gamma$ -diversity) and average alpha ( $\alpha$ -diversity), such that  $H\beta = H\gamma / H\alpha$ . The simplest meaning of beta diversity is the percentage of similarity in species composition between two communities (Villegger *et al.* 2013).

Beta diversity or the spatial turnover or change in the identities of species, is a measure of the difference in species composition either between two or more local assemblages or between local and regional assemblages, as beta diversity increases, individual localities differ more markedly from one another (Koleff *et al.*, 2003). Beta diversity has used more than one measure although Whittaker's measure (we) has been the most frequently employed. Determination of beta diversity includes dispersal limitation, niche limitation and spatial scale (Gaston *et al.*, 2007; Qian, 2009).

Numerous measures for beta diversity have been proposed that constitute variations on this theme of original suggestion of Whittaker's (1972), Routledge, (1984), Wilson and Shmida (1984); Magurran (1988); Harrison *et al.* (1992); Williams (1996); Mourelle and Ezcurra (1997). Were reviewed thoroughly by Koleff *et al.* (2003). Beta diversity have used more than one measure although Whittaker's original measure ( $\beta w$ ) has been the most frequently employed. Beta diversity, which was

often used synonymously with species turnover (Vellend, 2001) quantifies the change in species composition across space and time.

This study was carried out to compare beta diversity score among three key biological groups' macroinvertebrates, fish and aquatic birds in three major Iraqi marshes (Al-Huwaiza, West Hammar and East Hammar).

## Materials and methods;

Basic data for presence or absence of macroinvertebrates, fishes and aquatic birds species were obtained from IMRP (2006) and ARDI (2006) reports during the ecological survey of Al-Huwaiza, West Hammar and East Hammar (Fig,1).

Beta diversity was calculated according to following formula:

$$\beta w = \frac{S}{\alpha} \quad \text{Whittaker (1972) cited by Koleff et al. (2003)}$$

Re-expressed:

$$\beta w = \frac{a+b+c}{(2a+b+c)/2} \quad (\text{Koleff et al., 2003}).$$

$\beta w$  = Total number of species occurred in both pair marshes/Average number of species occurred in both pair marshes

$S$  = Total number of species recorded from both samples i.e. from two marshes.

( $S = a+b+c$ ):

$a$  = Common species in samples at pair of marshes.

$b$  = Species occurred only in samples at the first marsh.

$c$  = Species occurred only in samples at the second marsh.

$\alpha$  = Average number of species found within samples at the two marshes.

Range of  $\beta_w$  value: Min. = 1 (all species are shared), Max. = 2 (no species is shared).

Note: As beta diversity increases, individual localities differ more markedly from one another, under dispersal limitation, beta diversity should be higher for poorer dispersers (Vellend, 2001; Qian *et al.*, 2005).

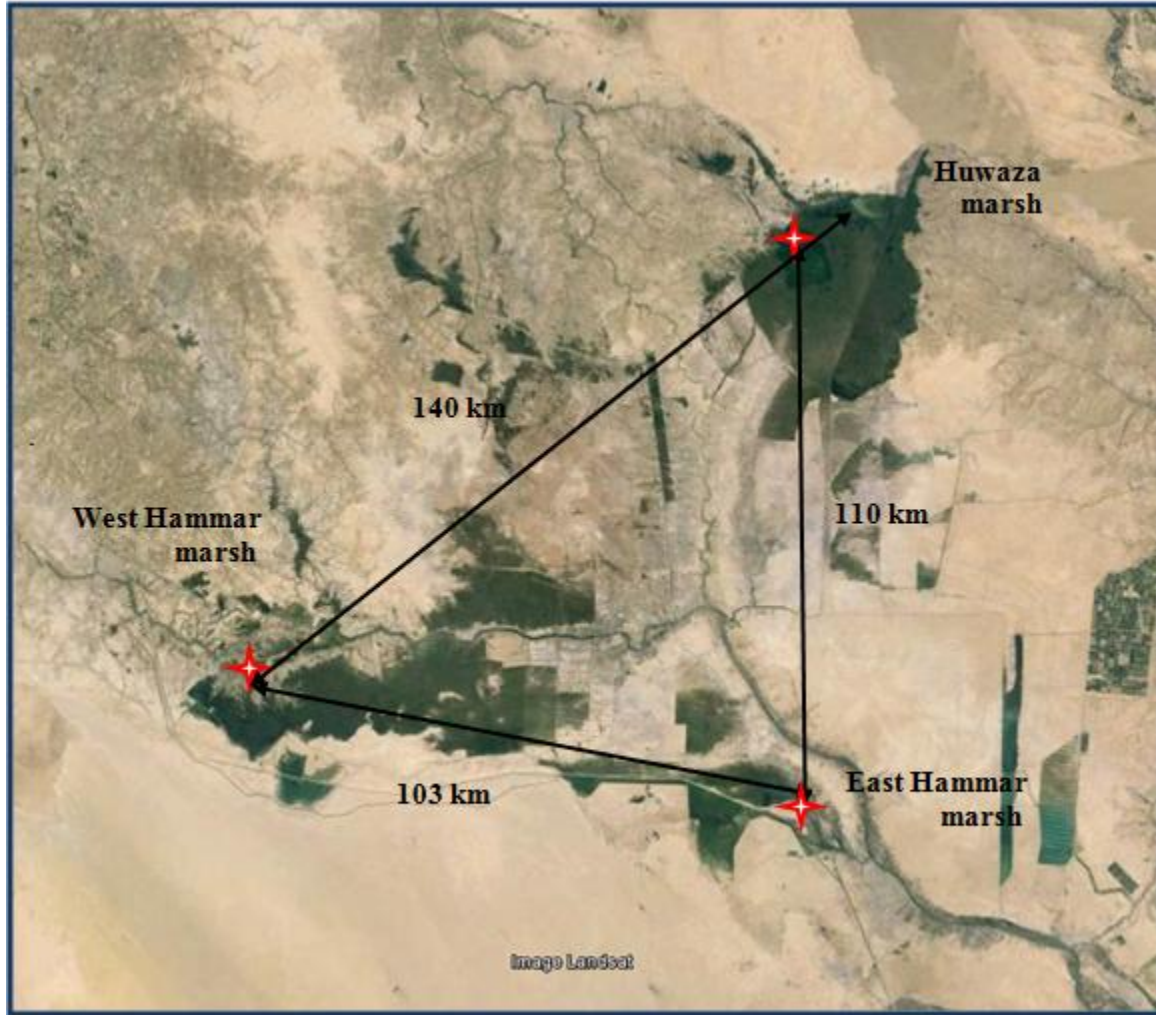


Fig.1: Geographical locations of three studied marshes (Al-Huwaiza, West Hammar and East Hammar) and distances between each pair of sampling sites at southern Iraq.

## Results

Species dissimilarity increase with distance between pair of marshes from southwest toward the southeast (fig .1).Beta diversity of three key biological groups in the three studied

marshes (Al-Huwaiza, East and West Hammar) were illustrated in figure, 2.

Low to moderate dissimilarity was obtained in comparison of macroinvertebrates, total number of fish and aquatic bird's species between West Hammar and Al-Huwaiza marshes.

Species similarity increased for number of fish species increased between Al-Huwazia and East Hammar (Fig.2).  
 macroinvertebrates species and aquatic birds between East and West Hammar, except total

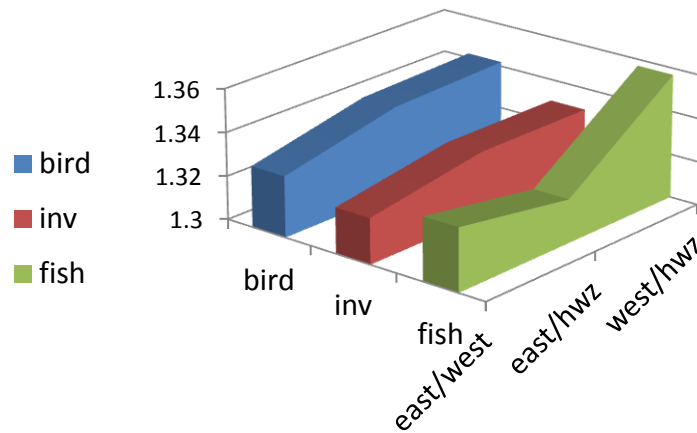


Fig.2: Beta diversity of macroinvertebrates , fish and aquatic birds in the three studied southern marshes during 2006-2007.

**Macroinvertebrates species:**

Moderate similarity ( $\beta_w$ : 1.320) was obtained between macroinvertebrates species in the three investigated marshes especially in West Hammar and Al- Huwaiza marshes (Fig.3). Total number of insect species showed no significant difference due to limitation in identification and collection of insect. Moderate dissimilarity was recorded between West and East Hammar and between East Hammar and Al-Huwaiza ( $\beta_w$ : 1.340) and ( $\beta_w$ : 1.333) respectively. Mollusca

and Insect species showed the same dispersal pattern or occurrence in the three investigated marshes except crustacean species showed high dissimilarity especially between Al-Huwaiza and West Hammar and high similarity West and East Hammar species. Highly shared of macrovertebrates species was recognized between West and East Hammar in contrary to that between West Hammar and Al- Huwaiza marshes (Fig.4).

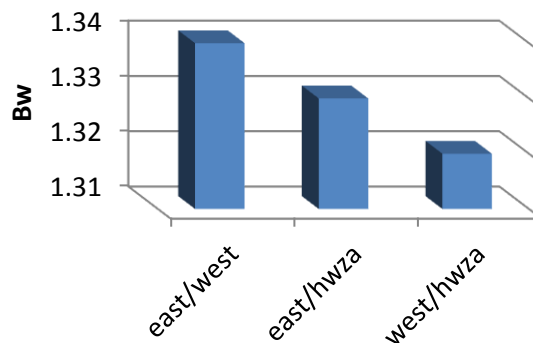


Fig 3: Comparison of Beta diversity of macroinvertebrates species of West, East Hammar, and Al-Huwaiza marshes during 2005 – 2006.

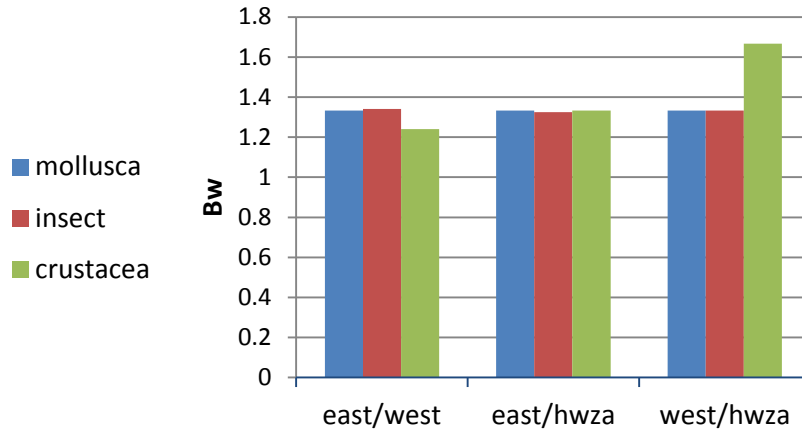


Fig. 4: Comparison of Beta diversity of major groups of macroinvertebrates of West, East Hammar, and Al-Huwaiza marshes during 2005 – 2006.

**Total fish species:**

Moderate dissimilarity value was scored in total number of fish species between East Hammar/ and Al-Huwaiza and between West

Hammar and Huwaiza ( $\beta_w$ : 1.357) and ( $\beta_w$ : 1.342) respectively. Moderate similarity was obtained between West and East Hammar ( $\beta_w$ : 1.330) (Fig.5).

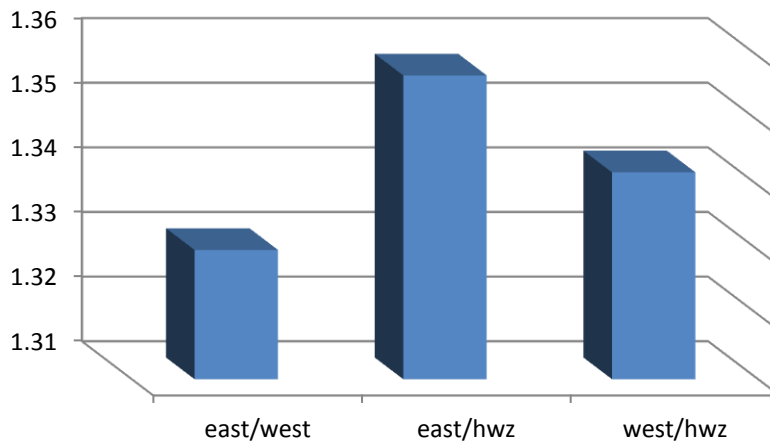


Fig. 5: Beta diversity values of total fish species in the three southern marshes during the period 2005 – 2006.

**Native fish species:**

Differences in occurrence of native fish species between both East Hammar and Al-Huwaiza and West and Al-Huwaiza marshes (Fig.6). Moderate dissimilarity was reached

( $\beta_w$ : 1.311) between West Hammar and Al-Huwaiza and East Hammar and Al-Huwaiza respectively. Good similarity value was recorded ( $\beta_w$  :1.262) between East and West Hammar.

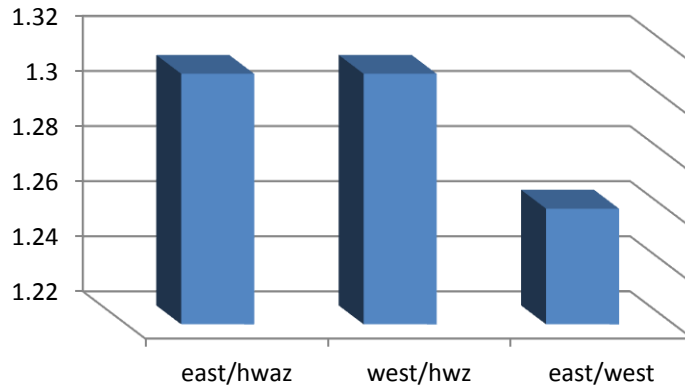


Fig 6: Comparison of Beta diversity values of native fish species in Al-Huwaiza and East and West Hammar marshes during 2005 – 2006.

**Aquatic bird’s species:**

Low dissimilarity for aquatic birds species was recorded between Al-Huwaiza and West Hammar and East and West Hammar ( $\beta_w$ : 1.329) and ( $\beta_w$ : 1.328) respectively. Low dissimilarity was scored ( $\beta_w$ : 1.321) between

East Hammar and Al-Huwaiza. Fig. (7) Illustrated more species of aquatic birds being shared between West Hammar and Al-Huwaiza, while less species of aquatic birds being shared between East and West Hammar. However, birds are better dispersers than fish and macroinvertebrates.

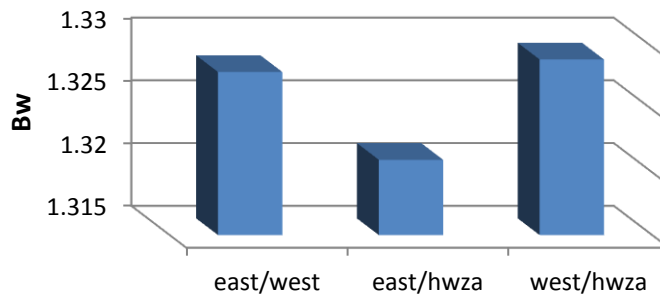


Fig 7 : Beta diversity for aquatic birds in the three marshes during 2005 – 2006.

## Discussion

The three studied marshes were different hydrological especially in types of water resource, salinity levels and geographical position. Al-Huwaiza gets its water from Tigris River, West Hammar from Euphrates and East Hammar from Euphrates and Shatt Al -Arab river. These three resources were different in their physio-chemical properties, Al-Huwaiza classified as freshwater non-tidal, West Hammar oligohaline non-tidal, East Hammar mesosaline tidal marsh (Al-Saad *et al.*, 2010, Hussain *et al.*, 2010; Hussain, 2014). These three marshes were isolated geographically, Al-Huwaiza situated  $\geq 140$  Km to the east of West Hammar and  $\geq 110$  Km to the north of East Hammar. Qian *et al.* (1998), Nekola and White, (1999) and Vellend (2001) stressed on effect of distance between the sites and shared proportion of species between two sites often decreases with increased distance.

The level of functional diversity (those components of biodiversity that influence how an ecosystem operates or functions, Tilman 2001) was different between the studied marshes consequently attract more species. van der Valk (2006) postulated that a positive correlation exist between level of productivity in wetlands and number of species existed in the community i.e. effects of community species composition on ecosystem functions. Hussain (2014) documented the difference in level of productivity between the studied southern marshes.

In general trivial information was known about existence and dispersal of macroinvertebrates species in the three major southern marshes (Ali *et al.*, 2007), however invader and migratory species makes the differences in beta diversity values especially between the

three marshes. More effort need to bridge gaps in information about occurrence and distribution of macroinvertebrates taxa or taxon in southern marshes especially insect.

Due to gradual increase in salinities of the marshes, fish species composition were altered significantly were migratory estuarine species invade East and West Hammar (Hussain *et al.*, 2008; Al-Shamary *et al.*, 2009) while Al-Huwaiza still contain only freshwater species, therefore dissimilarity did exist as recorded by beta diversity scores. The invasion of migratory estuarine species led to double the number of species in marsh in comparison with Al-Huwaiza marsh (Hussain *et al.*, 2008; 2010). Exotic and alien species invade the southern marshes, two freshwater species were recorded in Al-Huwaiza assume to enter from Iranian marshes (Abd and Abed 2010 and Coad and Hussain 2007). Several native fish species disappear from West Hammar and confined to Al-Huwaiza marsh, the same was true but on bigger scale in East Hammar mainly to increase water salinity. Hermoso *et al.*, (2012) concluded that the maintenance of native fish diversity is seriously threatened by the homogenization processes as a result of introduced species which play an important role in homogenization process. Taxonomic homogenization is defined as an increase in the similarity of the pools of species found among a set of assemblages over time. While Seguin *et al.* (2014) mention that beta diversity should increase with disturbance in environment. Furthermore taxonomic and functional homogenization was positively related to the direct and indirect effects of non-native species richness (Pool and Olden, 2012).

Tidal effect plays a major role in creating difference in aquatic bird's species composition in the three studied marshes. affect by semidiurnal tides from the Arabian gulf via Shatt Al-Arab river led to the

formation of wide muddy shore in East Hammar attract many species of shore birds and waders .such wide shore didn't exist in West Hammar and Al-Huwaiza consequently differences in aquatic birds species occurrence, mostly waterfowls ,waders and few land birds like kingfishers(Abed ,2007). Differences in salinities also affect the aquatic birds assemblages, some species prefer freshwater environment like pygmy cormorant ( *Phalacrocorax pygmaeus* ) confined to freshwater marshes (Al-Huwaiza ) and nearly absent from other oligosaline or mesosaline marshes (Al-Habeeb ,2008).

The wide difference in beta diversity among taxa is due to difference in dispersal ability.i.e. Water birds are able to more dispersal than macroinvertebrates and fish. For species that have limited dispersal abilities, are expected to be important structuring factors in community similarity (Becking *et al.*, 2006). Shackell *et al.* (2012) stated that similarities among communities decayed slowly with increasing geographical distance.

Despite the importance of beta diversity nothing is done on Iraqi marshes about how beta diversity of the same taxon differs among different marshes and how beta diversity differs among different taxa within the localities in same marsh.

However, moderate to lower values of beta diversity were recorded for aquatic birds, fish and macroinvertebrate, which can be explain that taxa with poorer dispersal ability tend to have higher beta diversity than those groups that have better dispersal ability. Before dissection the southern marshes were connected and highly homogenized assemblages existed, but after inundation in 2003, few geographical isolated marshes appeared with desert separated between the three studied marshes

We conclude that escalation of water salinity in the future and deep penetration of progressive effect of the Gulf salt wedge will lead that East Hammar going to be estuarine environment .The gradual rise of dissimilarity of native marsh taxa seemed to be inevitable with escalation of environmental degradation of southern Iraq marshlands.

Further conclusion that Whittaker beta diversity formula was able to detect the similarity and dissimilarity in species occurrence of macroinvertebrates ,total number of fishes ,native fish and aquatic birds existed in southern Iraqi marshlands.

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## التشابه و الاختلاف في تركيبية أنواع اللاققرات الكبيرة و الاسماك و الطيور المائية في ثلاثة أهوار رئيسة جنوبي العراق

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### المستخلص

تم تطبيق صيغة التنوع ويتاكر بيتا للكشف عن التشابه والاختلاف من تكوين الأنواع من اللاققرات الكبيرة و العدد الكلي للأسماك و أنواع الأسماك و الطيور المائية المحلية في الأهوار جنوب العراق الثلاث الرئيسية (الحويزة وشرق و غرب الحمار). أشارت النتائج إلى أن الاختلاف نتيجة زيادة الأنواع في الأهوار الجنوبية الى: (أ) العزلة الكبيرة للأرض بين جنوب غرب و جنوب شرق الأهوار، (ب) التسلل من الأسماك الغازية، الغربية والبحرية وأنواع القشريات، (ج) ازدياد ملوحة المياه والتأثير التدريجي لمد الخليج. تم الحصول على مستويات معتدلة من الاختلاف الأنواع لللاققرات الكبيرة، وزيادة العدد الإجمالي للأسماك والطيور المائية بين غرب الحمار وهور الحويزة، على العكس من ذلك التشابه الأنواع لمجموعات لللاققرات الكبيرة والطيور المائية بين شرق و غرب هور الحمار. تسبب هجرة أنواع الأسماك البحرية الاختلاف في عدد من أنواع الأسماك بين شرق الحمار و الحويزة- ( $\beta w: 1.357$ )، في حين سجلت قيمة جيدة التشابه للأنواع الأسماك المحلية ( $\beta w: 1.262$ ) في شرق و غرب الحمار. أدى وجود أو غياب الشواطئ الموحلة المدية إلى انخفاض الاختلاف ( $\beta w: 1.321-1.0329$ ) في أنواع الطيور المائية الموجودة في الأهوار الثلاثة. ان الاختلاف في الأهوار الجنوبية أمر لا مفر منه مع تصاعد التدهور البيئي لأهوار جنوب العراق.