Is the northwestern Arabian Gulf a biodiversity hotspot?

I believe this article will enrich science as well as your library in the topic of biodiversity hotspots that many articles about it were published by several reputable and prosperous periodicals. The article deals with marine biodiversity hotspots, a topic that is rarely addressed in an area that is scarcely studied in such terms, especially in microecological terms (i.e. copepods, which is the main focus of this article).

The article is trying to show how endangered is the area of the northwestern of the Gulf, and maybe the whole Gulf based on recent and old ongoing threats that are affecting the biodiversity and abundance of certain indigenous copepods through some data collection and comparison with the available literature.

The authors used the definition and the major characteristics of biodiversity hotspots along with brief and condensed historical note about the topic as will be seen in the Introduction section to build their study and their conclusions based on their collected data.

Is the Northwestern Arabian/Persian Gulf a biodiversity hotspot

By

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Abbreviations:
ind.m^{-3}: individual per cubic meter.
N/A not available

Biodiversity hotspots are areas featuring exceptional concentrations of endemic species and featuring exceptional loss of habitat[14]. These areas are practically identified according to species richness, variety of habitats and endemism (most important criterion to identify hotspots)[8]. These areas are small, diversified and sometimes contain

indigenous species in comparison to the surrounding area[11-13]. As hotspots' hypothesis applies to invertebrates[14], it is suspected that the northwestern Arabian Gulf is a biodiversity hotspot. Here we show that the northwestern Arabian Gulf (shared between Iraq and Kuwait) is a threatened biodiversity hotspot due to the threatened copepod *Acartia* (*Acartiella*) *faoensis*. We thought from the definition and criteria of biodiversity hotspots, as well as our results that the northwestern Arabian Gulf could be a marine biodiversity hotspot that should be added to other such reported areas worldwide, since it is mainly threatened due to the man-made Third River in Iraq[1-2] and to old and ongoing damming of Euphrates in Iraq[1] and Turkey [18] As well as closing of several out flowing rivers carrying fresh water from Iran into Iraqi marshes and Shatt al-Arab river of Iraqi territorial region that lowered the freshwater runoff into the northwestern Arabian Gulf, casing an elevation in the level of salinity and made it stressful environment for *A. A. faoensis*. Our results demonstrate how the northwestern Arabian Gulf could be categorized as a marine biodiversity hotspot by showing richness of threaten, rare and/or taxonomically unusual species[20-25] (i.e. *A.A. faoensis*) in addition to the definition and the aforementioned criteria.

The study of hotspots is relatively new, where it was first performed by Myers[11]. Biodiversity includes richness at levels from landscapes to genes[6]. These areas are small, diversified and sometimes contain indigenous species in comparison to the surrounding area[11-13]. For instance, Ecuador hosts about 20000 plant species, where the majority of them are located in the forests with at least 4000 indigenous species[7]. Ecuador also hosts over 1300 species of birds, which is almost twice as much as both USA and Canada combined[11]. As hotspots' hypothesis applies to invertebrates[14], a copepod species; *Acartia* (*Acartiella*) *faoensis* was only reported from the northwestern Arabian (=Persian) Gulf: Khor Al-Zubair, Khor Abdullah[10] and around Bubiyan Island[3-4] (Fig.1), which is a threatened habitat. The aim of this letter is to shed the light on this area as a possible marine biodiversity hotspot based on the definition and the characteristics of hotspots according to our findings that show how the area is threatened as well as the indigenous *A. faoensis* due to the elevation of salinity due to the man-made Third River in Iraq In addition to decreasing of the amount of fresh water runoff by Iraq's neighbors.

The northwestern Arabian Gulf is a very rich environment, where it constitutes a nursery habitat for many fish species especially the two main migratory fish stocks, silver pomfrets (*Pampus argenteus*) and shads (*Tenualosa ilisha*)[29]. Both species are of economical value and important for the fisheries in the region[29]. Both life cycles, i.e. reproduction and nursery grounds, are associated with the river systems of the northern Arabian Gulf[29]. Other shared fish stocks might exist, such as grunt (*Pomadasys kaakan*) but are less defined, although it is believed that their distribution is also closely associated with estuaries[29].

Table 1 **Density of *A. faoensis* in Khor Al-Zubair , Umm Qasser Port and Shatt Al-Basra Channel in 2005 and in 2009 showing the disturbed levels of salinity due to the man-made Third River and dam construction on Euphrates in Iraq.**

Station	Sampling date (mm/yyyy)	Density (ind.m^{-3})	Salinity (psu)
Khor Al-Zubair	03/2005	242	12
	03/2009	666	29
	06/2009	26	30.1
	07/2009	54	40
Umm Qasser Port	03/2005	2949	16.6
	04/2009	87	40
Shatt Al-Basra Channel	06/2009	34	10.6
	08/2009	30	21
	09/2009	1.2	10

It was presupposed that sub-adults of the penaeid pink shrimp *Metapenaeus affinis* exodus to the north of the Gulf where they develop and spawn[30] in Iraqi marshes It. was also reported that green tiger prawn (*Penaeus simisulcatus*) is Kuwait's primary shrimp species (also the main species all over the Gulf) [28], which grows greatly larger in Kuwait than its southern counterparts[26]. This could be attributed to food availability, which is obvious from the vicinity of Kuwait from Shatt Al-Arab[2]. Also, many juvenile fish were observed around Bubiyan Island such as *P. kaakan*, croakers (*Otolithes ruber*), seerfish (*Scomberomorus guttatus*), **silvery** black porgy (*Sparidentix hasta*), yellow-fin seabream (*Acanthopagrus latus*) and orange-spotted grouper (*Epinephelus coioides*)[27].

Table 2 Density **of *A. faoensis* in Khor Al-Zubair , Umm Qasser Port and Khor Abdullah in 1989-1990 in relation to the man-made Third River and dam construction on Euphrates in Iraq[1].**

Station	Sampling date	Density	Salinity

	(mm/yyyy)	(ind.m^{-3})	(psu)
Khor Al-Zubair	02/1990	634	25.4
	04/1990	866	28.8
Umm Qasser Port	03/1990	35	31.7
	06/1990	0	33.2
	07/1989	6	32.7-37.5
Khor Abdullah	01/1990	5	32.7-37.5

The copepods *Acartia (Acartiella) faoensis* ; *Bestiolina arabica* and *Phyllodiaptomus irakiansis* were neither reported worldwide nor from other regions in Kuwaiti waters[3-4], which could be the type of hotspot, where these areas show richness of threaten, rare and/or taxonomically unusual species[20-25] where *A. faoensis* is a threatened species from Khor Al-Zubair (tables 1-3), which could be due to the man-made Third River in Iraq[1-2] and the damming of Euphrates in Turkey[18] and, thus the impact on salinity levels and the survival of these copepods was higher between 2005-2009 in comparison to 1989-1990[1]; the period where the drainage of marshes occurred in order to make the Third River (Tables 1-2, 4). Density of *A. faoensis* was recorded at its highest (2949 ind.m^{-3}) in March, 2005 in Umm Qasser Port at a very low salinity (16.6 psu) while at the highest salinity recorded (40 psu) the density was 87 ind.m^{-3} (Table 1). Other copepods were also reported only from around Bubiyan Island in Kuwait, which are *B. similis*[2], *Pseudodiaptomus arabicus*[2] and *P.ardjuna.* It is also noteworthy that the area around Bubiyan Island is the most productive in Kuwait, if not in the whole Arabian Gulf[27].

in Umm Qasser Port, Khor Abdulla and Khor Al-Zubair, Iraq[1].

Station	Sampling date (mm/yyyy)	Density (ind.m^{-3})
Khor Al-Zubair	12/1989	53
Umm Qasser Port	01/1990	21
Khor Abdullah	N/A	N/A

It appears that the abundance of *A. faoensis* is usually higher at lower salinity levels (Tables 1-2, 5) except some occasions that could mainly be related to season as in the case of Shatt Al-Basra in June, August and September 2009 (Table 1) since this species reaches its highest abundance during winter-spring (approximately October-April) and

very rare to be observed in summer (unpublished data), where the data in Tables 1-3 show that these copepods cannot tolerate high salinity and that may explain their presence only in that area of Kuwait and the Arabian Gulf. Thus, periods of declined densities in early 1990's where coincided with marsh drainage as well as industrial activities and wars that had elevated the level of salinity in Khor Al-Zubair and Shatt Al-Basra (Tables 1-4), where the latter's salinity was 48-50 psu in 2008 (MSC, unpublished data).

Table 4 **Salinity ranges during 1989-1990 in Umm Qasser Port, Khor Abdulla and Khor Al-Zubair, Iraq[1]. In 1989 Marsh drainage has started, thus, salinity started to increase[1]**.

Stations	Khor Al-Zubair	Umm Qasser	Khor Abdullah
Salinity (psu)	25.4-33.5	30.5-37.0	32.7-37.5
Months, Year(s) (mm/yyyy)	10-4/1989-1990	7-10/1989	7-10/1989

In relation to biodiversity hotspots' definition and criteria, such reports and findings can categorize the northwestern Arabian Gulf as a biodiversity hotspot. Nevertheless, further investigations are needed, especially from the Kuwaiti side. In addition, the whole Arabian Gulf is threatened to decline mainly due to river damming[18], which might make it a hotspot as well. Unfortunately, the area was not studied properly by both Iraq and Kuwait for about three decades due to the tense political and security situation there.

Most of the studied hotspots are terrestrial, while few studies performed regarding marine hotspots[5,8-9,15-17]. Therefore, further studies are needed regarding aquatic (especially marine) biodiversity hotspots in terms of location and conservation, since the majority of Earth's surface is covered with water (mainly oceans) that is full of various biota and important resources (mainly food) and it must be noted that controlling of fishing and fisheries will result in saving and protecting the marine hotspots[8]. As for the Arabian Gulf, more conservation measures must be taken to protect it, especially in Turkey and Iran by conserving the flow of freshwater into the Gulf as well as sanctioning and enforcing more rules and regulations regarding overfishing and pollution, since all the countries of that region are oil producers.

Methods

Field Sampling

Samples were collected using 110-µm plankton net with cod end with boat speed of 0.77 ms^{-1} at three stations, Khor Al-Zubair, Umm Qasser Port and Khor Abdullah (Fig. 1) during 1989-1990 and 2005 and 2009. Samples were preserved in 5% formaldehyde solution in 1l plastic bottles.

Fig. 1. The North West of the Gulf

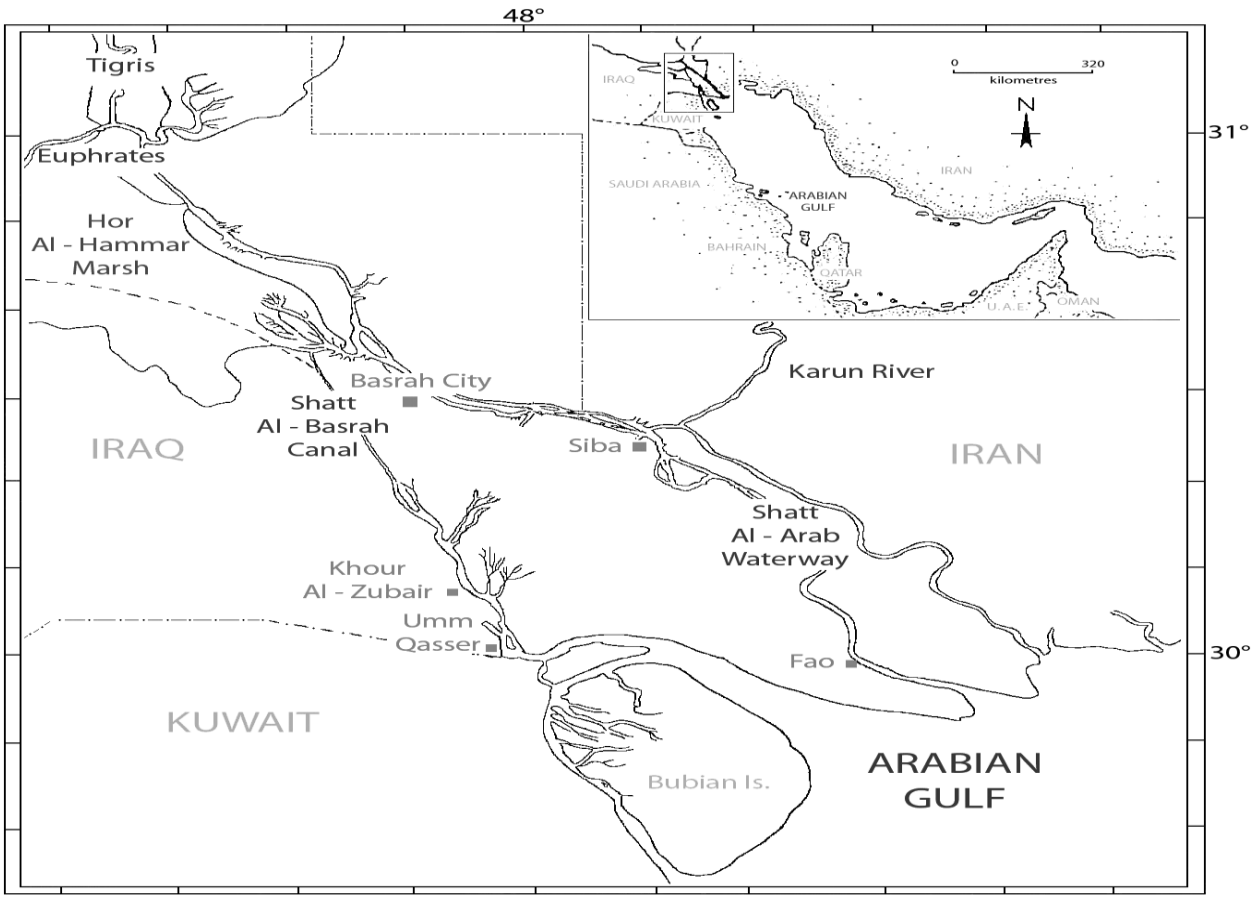

Fig. 1. Map of the sampling area , Southern Iraq.

Laboratory Analysis

Samples were splitted by Motoda box and 5-ml subsample were taken from each sample and counted under stereomicroscope (Lecia model) and the calculation method is similar to that of Thompson and Schweigert[19]

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