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Species inventory of the Rotatoria in the Anzali Wetland, Iran

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Introduction

The Anzali Wetland is an important ecosystem for spawning and early rearing of larvae of anadromous fishes like Cyprinidae, Percidae, Salmonidea the fingerlings of which require live food at the onset of exogenous feeding (Abbasi, 2017). This ecosystem suffers seriously from various major sources of pollution such as agrochemicals, sewage and industrial effluents (Ayati, 2003; JICA, 2010; Bagheri *et al.,* 2012 a,b).

Zooplankton play a significant role as the major link between bacteria and phytoplankton and also with other invertebrates and fishes in transporting energy (Souza *et al.,* 2011). Zooplankton are important to the functioning of wetland food-chains but the most important role of zooplankton is as major grazers in ocean food webs, providing the principal pathway for energy from primary producers to consumers at higher trophic levels, such as fish (Richardson, 2008). Due to the quick response of zooplankton to aquatic parameters such as pH, color, odor and taste, they are good indicators of changes in water quality (Vima Patel *et al.,* 2013). Among various species of zooplankton, rotifers are important live food in feeding fish larvae so that at present, without the mass culture of rotifers, larval rearing of marine fishes would be virtually impossible (Watanabe *et al.,* 1983). Some rotifer species have been reported as bioindicators of eutrophic conditions in aquatic ecosystems (Frutos *et al.,* 2009).

Holcik and Olah (1992) noted that Rotatoria is the dominant taxa in wetlands. Previous research found 81 species, 96 genera, 11 phyla of planktons, including 42 genera of

Rotatoria in the Anzali Wetland (Fallahi, 1993). The total number of zooplankton recorded in the Anzali Wetland between 1997 and 2000 belonged to 50 genera including 26 genera of Rotatoria (Sabkara and Makaremi, 2004). Mirzajani *et al*. (2010) revealed that Rotatoria and Arthropoda were dominant taxa during 1991-2001 in this wetland. Fallahi and Sabkara (2015) reported 60 genera and 6 phyla of zooplankton and reported 31 genera of Rotatoria.

In recent years, several studies have been conducted on the abundance of zooplankton in the Anzali Wetland (Holcik and Olah, 1992; Fallahi, 1993; Mansori *et al.,* 2015; Fallahi and Sabkara, 2015), while there was hardly any work done to look at the composition of Rotatoria species. This study quantified the composition of the rotifers in order to realize the ecological state of different parts of the Anzali Wetland.

Materials and methods

Study area

The area under investigation is located in the Anzali Wetland (Fig. 1). The catchment area of this wetland is 3740 km^2 which contributes approximately 2 million m^3 of freshwater per year (Bagheri *et al.,* 2012a). It has an area of around 190 km^2, the main wetland covers about 11000 ha and comprises an open lagoon, 26 km long and 2.0 – 3.5 km wide (Ayati, 2003). The water is supplied by 19 inlet rivers and is connected to the Caspian Sea through 2 outlet rivers (Nezami *et al.,* 2007). The Anzali Wetland is located in the southwestern coast of the Caspian Sea in Iran, and represents an internationally recognized wildlife reserve and sanctuary which is listed under the Ramsar Convention (Pourang, 1996). Over the last decades, the wetland has been threatened and destroyed by environmental pollution from seven identified sources of rivers, municipal, industrials, commercials, mines, agricultural land, and hospitals (Mirzajani *et al.,* 2010; Bagheri *et al.* 2012b), It consists of four main parts; the west, central, east and protected area of Siah Keshim that has various physico-chemical and morphological characteristics (Ayati, 2003). The nutrient inputs by rivers have risen and the tendency to eutrophication increased after 2000 in the Anzali Wetland (Mirzajani *et al.,* 2010; Bagheri *et al*., 2010, 2014). This ecosystem suffers seriously from various major sources of pollution such as agrochemicals, sewage and industrial effluents (Ayati, 2003; JICA, 2010; Bagheri *et al.,* 2012 a, b).

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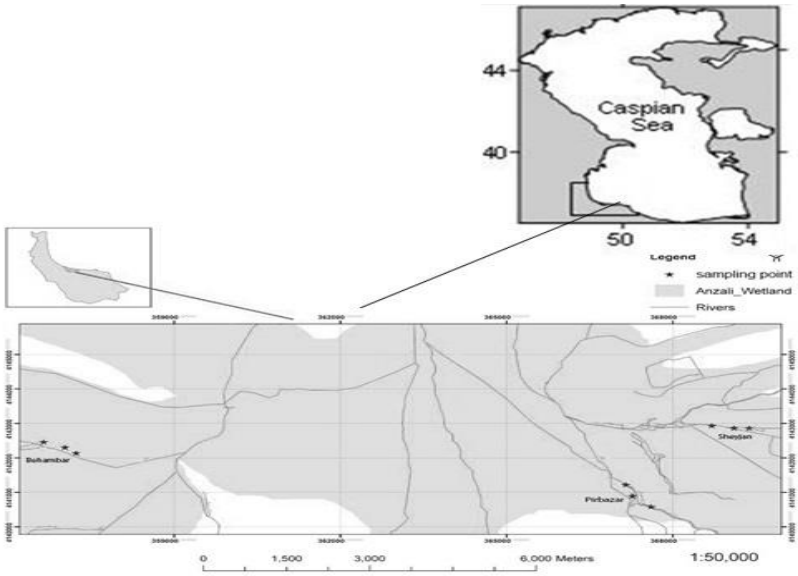

Figure 1: The sampling stations (★) in the Anzali wetland during 2015-2016.

Sample collection

Taxonomic investigation on Rotatoria was performed at three regions: Pirbazar, Sheyjan (center and east) and Behambar (south) at 9 stations in the Anzali Wetland from June 2015 to May 2016 (Fig. 1).

For the collection of rotifers, 30 liters of water was collected and filtered in each station using a Hydrobios-net (opening diameter: 25 cm, mesh size: 55 µm). The sampling of all the stations was seasonally performed on three days; each region was sampled by using a boat on one day during 9 am – 12 pm. Zooplankton samples were preserved in neutral 4 % formaldehyde and analyzed in the plankton laboratory of Guilan University. Samples were divided into sub-samples using a pipette and transferred to a 5-ml Tubular Plankton Chamber (Hydro-Bios; 435021) for counting. Samples were identified using an inverted microscope (Harris *et al.*, 2000). Taxonomic classification of rotifers was performed based on Pontin (1978) and Thorp and Covich, (2001) at the Inland Waters Aquaculture Research Center. Chi-square test of independence was used to examine differences in abundance of rotatoria among genera and seasons.

Results and discussion

The list of taxa recorded in the Anzali Wetland is given in Tables 1. A total number of 29 genera belonging to 17 families were observed in the area of investigation. The most taxon-rich family (X^2=9007.44, df=30, p<0.05) was Brachionidae with 13 genera listed, followed by Lepadellidae and Notomatidae with 3 genera each. The most diverse genus was *Brachionus*, comprising 8 species. The previous studies in the Anzali wetland, showed a similar pattern in the diversity of Rotatoria, but the number of rotifer genera has decreased since 1993 (Table 2). Such changes may occur due to the quality of inlet waters from rivers to the Anzali wetland the effect of which on rotifer composition has been demonstrated in the previous

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investigations. Many external factors control growth, reproduction and survival of micro invertebrates the most important of these being temperature and food availability, with temperature having an effect on duration of the developmental stage and food availability on reproduction (Bottrell *et al*., 1976).

Table 1: Checklist of Rotatoria in the Wetland Anzali, during 2015-2016.

Family	Rotatoria Taxa	Spring			Summer			Autumn			Winter		
		P	*Sh*	*B*	*P*	*Sh*	*B*	*P*	*Sh*	*B*	*P*	*Sh*	*B*
	Brachionus annularis (Fowler, 1934)	*	*		*	*	*	*	*	*	*	*	
	Brachionus calyciflorus (Pallas, 1766)	*	*		*	*	*	*	*		*		
	Brachionus quadridentatus (Hermann, 1783)	*				*	*		*		*		
	Brachionus rubens (Ehrenberg, 1838)	*			*	*	*				*		
	Brachionus patulus (O. F. Muller, 1786)	*											
	Brachionus plicatilis (Müller, 1786)					*	*		*				
	Brachionus diversicornis (Daday, 1883)							*					
Brachionidae	*Brachionus falcatus (Zacharias, 1898)*				*								
	Platyias quadricornis (Ehrenberg, 1832)								*				
	Keratella cochlearis (Gosse, 1851)	*			*			*	*		*	*	
	Keratella tropica (Apstein, 1907)	*						*	*		*		
	Notholca sp.				*					*	*	*	*
	Anuraeopsis fissa (Gosse, 1851)				*	*	*	*					
Gastropodidae	*Ascomorpha* sp.					*	*						
	Proalides sp.				*		*						
Epiphanidae	*Rhinoglena frontalis* (Ehrenberg, 1853)					*	*	*	*	*	*		
	Lepadella ovalis (O.F. Muller, 1786)	*		*		*	*	*	*	*	*	*	
Lepadellidae	*Colurella adriatica* (Ehrenberg, 1831)	*	*	*	*	*	*	*	*	*		*	*
	Squatinella sp.			*						*			
Mytilinidae	*Mytilina* sp.		*	*				*	*			*	*
Asplanchnidae	*Asplanchna* sp.	*	*		*	*	*	*	*	*	*	*	
	Cephalodella gibba (Ehrenberg, 1830)	*		*	*	*	*	*	*	*	*	*	
Notomatidae	*Notommata* sp.				*	*	*	*		*			
	Monommata sp.			*		*	*			*			
	Polyarthra vulgaris (Carlin, 1943)	*	*	*	*	*	*	*	*		*	*	
Synchaetidae	*Synchaeta* sp. (Ehrenberg, 1832)				*			*	*	*	*		
Trichotridae	*Trichotria pocillum* (Müller, 1766)	*	*					*	*	*		*	*

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Table 1 continued:													
Trichoceridae	*Trichocerca* sp.	*	*	*	*	*	*	*	*	*	*	*	*
trochosphaeridae	*Filinia longiseta* (Ehrenberg, 1834)				*		*						
Lecanidae	*Lecane* sp.	*		*			*	*	*	*		*	*
	Monostyla sp.	*	*	*		*	*	*	*	*			*
Euchlanidae	*Euchlanis dilatata* (Ehrenberg 1832)	*	*	*			*	*	*	*		*	
Dicranophoridae	*Dicranophorus* sp.	*											
	Encentrum sp.							*					
Scaridiidae	*Scaridium* sp.									*			
Testudinellidae	*Pompholyx* sp.								*				
Philodinidae	*Philodina* sp.	*	*	*	*	*	*	*	*	*	*	*	*

Legends: P=Pirbazar, Sh=Sheyjan, B=Bahambar, * occurrence of taxon

Table 2: Number of Rotatoria genera in the Anzali wetland during 2015-2016.

	Taxa
Fallahi, 1993	42
Sabkara *et al*., 2004 (study 1997-2000)	26
Mansori *et al*., 2015 (study 2011)	30
Fallahi and Sabkara, 2015 (study 2011)	31
Present study	29

The results of the present study demonstrated that abundance of rotifers varied seasonally (Fig. 2). Fluctuation in rotifers abundance and highest abundance in *Brachionus* and *Philodina* occurred possibly due to water temperature variation in different seasons which is an important abiotic parameter on population growth of rotifers (Holst *et al*., 1998). Dominance of *Brachionus* in the Anzali Wetland may reflect eutrophication that Mirzajani *et al.* (2010) reported for the Anzali Wetland. Most of the *Bdelloids* survive unfavorable periods by entering a type of dormancy known as hydrobiosis (Gilbert, 1974; Ricci, 1998, 2001). This capability, along with their parthenogenetic reproduction (Ricci, 1992) may be the reason that the genera of *Philodina* sp. has been seen in all the sampling sites during the study (Fig. 2). In total, the rotifers were the dominant zooplankton in the Anzali Wetland based on the biological characteristics which can be seen as a bio- indicator of freshwater.

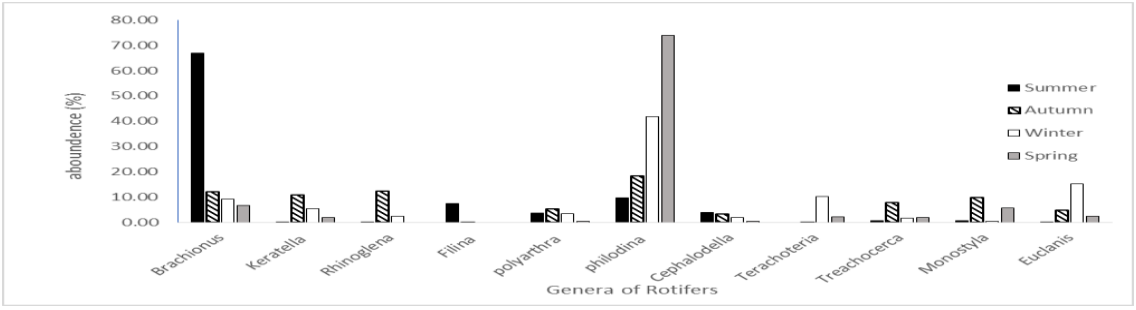

Figure 2: The abundance of Rotatoria (> 3% in total abundance) in the Anzali wetland during 2015-2016.

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