A study of food consumption of the deepwater Goby, *Ponticola bathybius* (Kessler, 1877), during spring migration in the southern Caspian Sea

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Introduction

The Gobies exhibit a main role in the general production of the Caspian Sea due to their species diversity and unexploited stocks. So, of the 80 fish species known from Iranian part of the Caspian Sea, 10 of them are gobies (Abdoli *et al.,* 2012). The deepwater goby, *Ponticola bathybius* (Kessler, 1877), Gobiidae, is a native species in the Caspian Sea which settles on sandy and shelly substrates and, in a few numbers, on firm silt down to 75 meters (Miller, 2003). The presence of predators such as Acipenseridae and prey items as *Clupeonella* sp. could be effective in the abundance of gobies (Kalantarian *et al.,* 2013). Gobies fishes are known as the great consumers of food resources and the considerable competitors for other species (Corkum *et al.,* 2004). According to Miller (2003), fish are as dominant prey for larger specimens of *P. bathybius*, while Crustacea are main prey for smaller specimens (Gaibova and Ragimov, 1970). Also, Kalantarian *et al.* (2013) found out that this fish feed mainly on *N. pallasi* (in species *N. pallasi* instead of *N. fluviatilis* in the Caspian Sea (revised by Neilson and Stepien, 2011) in all seasons and age groups (5-8 years). New habitats can be as an effective factor for changing the food patterns in fish (Brander *et al.,* 2013). According to Liasko *et al.* (2012), the abundance of food resources was

considered as important environmental factors even leading to the morphological variations in fish. Several studies pointed out that Ponto-Caspian gobies display an opportunistic feeding strategy due to their ability to consume locally available food items (Grabowska *et al.,* 2009; Cerwenka *et al.,* 2014).

In Iranian coastal waters of the Caspian Sea, there are differences in some important ecological factors including substrate type, slope and light intensity (Aubrey *et al*., 1994; Khoshravan *et al.,* 2011) which may affect the prey community. Therefore, this study was carried out to compare dietary composition of *P. bathybius* at three different localities (Bandar-e-Anzali, Salmanshahr and Miankaleh) along the southern Caspian Sea coastal waters.

Materials and methods

Fish samples were collected in April 2014 from three localities located in Bandar-e-Anzali, Guilan Province (37° 28' N, 49° 27' E), Salmanshahr, Mazandaran (36°42'N, 51°11'E) and Miankaleh, Mazandaran (36° 51' N, 53° 34' E) along the Iranian south coast of the Caspian Sea (Fig 1). A total of 290 specimens were collected using long beach seine during March and April 2014. Because of limit range of fishing months (from mid-September to mid-April) and cold weather conditions which had affected the deepwater goby migration toward the shallower waters (where the collections were made), we had to catch the specimens only in March and April. All specimens which collected were males

since they move to coastal waters earlier than the females for reproduction. Total length (TL) of the fish were measured by a caliper to the nearest 1 mm and weighed to the nearest 0.1 g (Table 1). After dissection, the fish digestive tract was removed and kept in 10% formaldehyde. Their contents were identified to the lowest possible recognizable taxon and counted. Feeding strategy and prey importance were given by modified graphical Costello method (Cortéz, 1997) with three dimensional representation of percentage by frequency of occurrence (O%= $\Sigma N_i / \Sigma N$) × 100), percentage by number (N%= ($\Sigma S_i / \Sigma S_{ti}$) × 100) and percentage by weight of the various preys (W%= ($\Sigma W_i / \Sigma W_{ti}$) × 100), where N_i is the number of predators with prey i in their stomach, N is the total number of predators with stomach contents, S_i the stomach content (number) composed by prey i, and S_{ti} the total stomach content of those predators with prey 'i' in their stomachs.
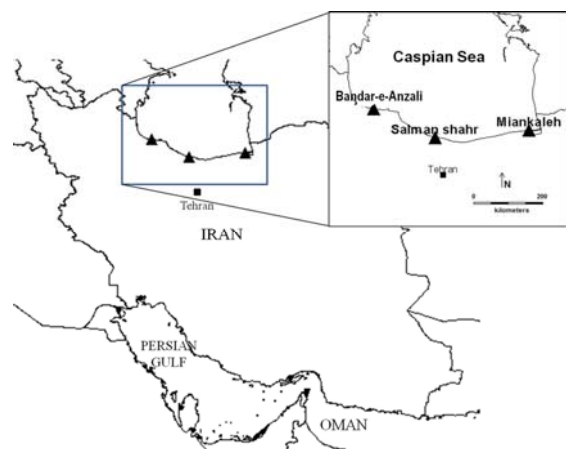
Figure 1: Sampling localities in the southern Caspian Sea: Bandar-e-Anzali, Salmanshahr and Miankaleh.

Table 1: Number of specimens (N), total length (TL) and weight (W) of *Ponticola bathybius* in sampling localities.

locality	N	TL (mm)	Weight (g)
Bandar-e-Anzali	130	25.94±6.66	198.55±38.13
Salmanshahr	80	24.50±1.62	169.31±45.99
Miankaleh	80	27.53±1.43	264.24±45.60

Feeding intensity was analyzed by vacuity index [VI= (number of empty stomachs/number of stomachs examined) × 100] (James, 1967). Index of relative importance (IRI= (N%+W%) × O%) was calculated to determine the prey importance. This index has been expressed as: IRI%= (IRI/ΣIRI) × 100 (Pinkas *et al.*, 1971). Shannon index which is described by Krebs (1999) was computed to determine the species diversity in the diet for all localities. Statistical processes and tests were performed using Excel v. 2007, SPSS v. 19 and Primer v. 6.

Results and discussion

Totally, six preys taxa were identified in the digestive tract of *P. bathybius* in all localities: *Neogobius melanostomus*, *N. pallasi*, *Clupeonella* sp., *Atherina boyeri*, *Cardium* sp. and unrecognizable gobies fish. According to the three dimensional graphical Costello method obtained from three localities, feeding in deepwater goby is heterogeneous, with most predators specializing in *N. pallasi* for Salmanshahr (IRI= 51.44%) and unrecognizable gobiid fish for Bandar-e-Anzali and Miankaleh localities (IRI= 55.71% and 53.41%, respectively) (Figs 2A, B and C). Feeding strategy of deepwater goby is much more specialized diet in all localities, as a few predators often take large numbers of heavy food items. *Cardium* sp. in Bandar-e-Anzali and *Clupeonella* sp. and *N. malanostomum* in Salmanshahr were absent, while *Cardium* sp. was rare item in Salmanshahr. Whereas each food item had been consumed by only a few numbers of the predators with little or no overlap in the resources used, there was a population with a high between phenotype components (BPC) to the niche width in each locality. This shows *P. bathybius* has a narrow dietary niche in all localities. However, the niche width was similar in three localities; the resource consumption patterns of *P. bathybius* had some differences. So the Shannon index for Bandar-e-Anzali, Salmanshahr and Miankaleh were obtained as 1.2, 0.7 and 1.6, respectively.
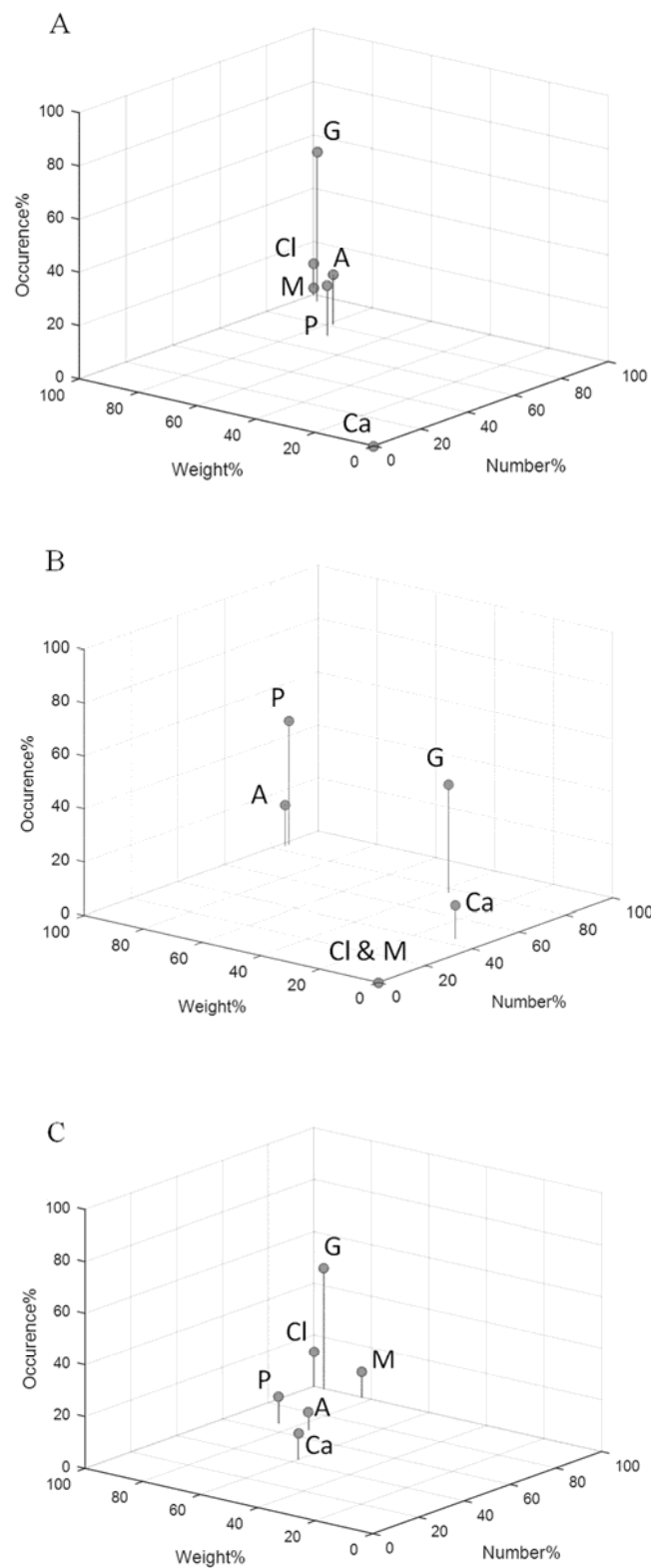
Figure 2: Feeding strategy of *P. bathybius* in sampling localities (A) Bandar-e-Anzali; (B) Salmanshahr and C) Miankaleh displayed with the Costello (1990) graphical method modified by Cortés (1997). Abbreviation denote: G, unrecognizable gobiid fish; M, *Neogobius melanostomus*; P, *Neogobius palasi*; Cl, *Clupeonalla* sp; A, *Atherina boyeri*; Ca, *Cardium* sp..

Recalculation of O% and IRI% for Gobiidae (including *N. pallasi*, *N. melanostomus* and unrecognizable gobiid fish) as a higher taxonomic group yields values of >74% for O% and >72% for IRI%, respectively for all localities which indicates that the diet of the deepwater goby dominated by Gobiidae members with large number and large proportion of the total weight of stomach contents. According to vacuity index (VI), the deepwater goby can be categorized as a moderate feeders group in Salmanshahr and Miankaleh localities to an edacious feeders groups (0≤VI<20) in Bandar-e-Anzali during spawning season (40≤VI<60).

Gobiidae is the most abundant family after Cyprinidae in the Caspian Sea and *P. bathybius* considers as a native species with a high abundance in this family (Abdoli and Naderi, 2009). Their abundance can be affected by the presence of prey and predator. Hence, awareness about their food resources is important for predicting their impact on food change in ecosystem (Abdoli *et al.*, 2012).

The fish can shift their food preferences toward different dietary items during the growth period. As the fish grow, they usually shift from small and low mobility prey items to larger and more motile items (Opuszynski, 1979). In addition, some fish such as the Ponto-Caspian gobies have high plasticity to change their feeding patterns in new habitats (Grabowska *et al.*, 2009). For example, the food preferences of *Neogobius melanostomus* and *N. kessleri* can be different in the upper Danube compared to their native habitat,

probably, due to changes in the macrobenthos community resulted from changes in the substrate type (Cerwenka *et al.*, 2014).

According to accomplished study on *P. bathybius*, the fish forms the main resource of it in coast of the Shikhovo-Karadagsky region of the Caspian Sea (Miller, 2003). In Salmanshahr, Kalantarian *et al.* (2013) found that *P. bathybius* as a piscivorous feeds on arthropods, crustaceans and mollusks, while larger specimens feed mainly on gobies species especially on *N. pallasi*. Moghimi (2014) indicated that gobies fish especially *N. pallasi* is the predominant prey item in Bandar-e-Anzali. According to Ghelichi (1999), the deepwater goby of Miankaleh prefers *N. pallasi* and *Benthophilus stellatus*, while items such as some fish species, *Cardium* sp. and crustaceans were consumed occasionally. Jowshan (2012) found that the fish such as gobies species, *Clupeonella* sp., *Atherina boyeri*, *Rutillus* sp. and *Gasterosteus aculatus* were taken up by larger specimens, while chironomidae, polychaeta (*Nereis*), *Cardium* sp. and crustacean larvae were consumed by smaller specimens.

Our findings are in agreement with the results of the above-mentioned investigations, individuals fed predominantly fish specially members of Gobiidae, but there are a few differences in prey diversity. In this study, all specimens were large and adult because of using beach seine with large mesh size (33 mm) and also sampling during spawning season. For this reason, individuals specialized more on fish gain more energy.

This is notable that a lot of individuals (43.78%) had empty gut because the males are responsible for nesting and protecting of the territory during the spawning period (Miller, 1984). Temporal changes of prey abundance (Kalantarian *et al.,* 2013) affected by seasonal or annual changes are one other reason to create these differences in the results.

The slight differences observed among localities can be also reflected in the features of habitat. Bandar-e-Anzali has a fine to mid gravel bottom with a high slope, Salmanshahr has a mid to rough gravel bottom with high slope and Miankaleh has a muddy substrate with a gentle slope and in fact, decrease in the sediment particles diameter is observed from west to east of south Caspian Sea (Khoshravan *et al.,* 2011). The type of substrate can lead to changes in organisms' community, as deposit feeders prefer the muddy substrate whereas the suspension feeders prefer to predominant on sandy bottom (Castro and Huber, 2008). On the other hand, light intensity can also be effective in grazing invertebrate population by increasing algal productions (Diggins *et al.,* 2002). It seems that more preys are present in Miankaleh as a result of receiving more solar energy (light) in its gentle slope of muddy substrate and shallower water.

In this study, *N. pallasi* was dominant prey in all localities. This is in agreement with the results obtained from Ghelichi (1999), Kalantarian *et al.* (2013) and Moghimi (2014). *N. pallasi* like its predator *P. bathybius* is a benthic fish (Tornaben *et al.,* 2013). As a result, it can be a more available food item comparing to other forage fishes. This study along with the other investigations approved that cannibalism occurs in deepwater goby especially in large size like some gobiid species such as *Knipowitschia panizzae* (Nonnis Marzano and Gandolfi, 2001) and *Ponticola kessler* (Brandner *et al.,* 2013). Also, this species shows some differences in food preference (mainly on fish) in comparison with other Ponto-Caspian species of Gobiidae such as *Neogobius gymnotrachelus*, *N. melanostomus* and *N. pallasi* feeding chiefly on invertebrates (Grabowska and Grabowski, 2005; Abdoli *et al.,* 2012). The larger size of deepwater goby in comparison with the other goby species of the Caspian Sea might possibly due to its high energy intake.

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