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Studies on the Feeding Ecology of *Cyprinion mhalensis* Dwelling in Wadi Bua, Taif, Saudi Arabia

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Abstract.- An investigation was made to examine the feeding ecology of *Cyprinion mhalensis*, a fish species endemic to Saudi Arabia. The fishes were collected from Wadi Bua, Taif. The food recovered from the stomach of fishes indicated that it is an omnivorous fish. It has been observed that this fish species prefer to feed on phytoplankton mostly on the members of bacillariophyceae. There were insignificant differences in the quality of food consumed by the fishes of different size groups. The frequency of occurrence of various food items in the diet of *C. mhalensis* of various sizes was high. The higher values of diet overlap index predicted the sharing of various food items in *C. mhalensis* of different sizes. The highest overlap index (1.00) was recorded in summer between group2 (g_2) and group3 (g_3) whereas lowest (0.78) in fall between group1 (g_1) and group3 (g_3). The diet breadth index for all size groups were low (0.28-0.33) and showed little variations among the fishes of various sizes in different seasons.

Key words: Freshwater fish, diet overlap, diet breadth index, frequency of occurrence.

INTRODUCTION

Studies related to feeding habit of fishes in their natural environments are of prime importance for the better management of their fisheries resources and also for the good governance of the environment (Al-Kahem *et al*., 1988, 1990). Such studies of fishes are made to examine their diet with the aim to assess the species' nutritional status. Feeding studies may focus on food items the fishes generally eat, seasonal variations in the diet and/or dietary comparison either between different subgroups of the same species or between different species living in the same habitat. These studies also help in understanding the role of fish in environments and its relation with other species of fish present in the same habitat. The notable contributions on this aspect are those of Cabral (2000), Xie *et al.* (2000), Morte *et al*. (2001, 2002), Friedlander *et al*. (2002), Luckstadt and Reiti (2002), Kavadias *et al*. (2003), Rikardsen *et al.* (2003), Sever *et al.* (2005), Alkahem *et al.* (2007), Leonardos (2008), Adeyemi *et al.* (2009), Cartes *et al.* (2009), Kumari *et al.* (2009) and Giraldo *et al.* (2011). Diets and diet overlap among different fish species living in the same environment were studied by Bacheler *et al.* (2004), Sampson *et al.* (2009), Pigler *et al.* (2010) and Polacik and Reichard (2010).

Saudi Arabia has scanty fish fauna due to its arid environments. Many species of fish (*Gambusia affinis, Oreochromis niloticus, Cyprinus carpio, Poecilia latipinna* etc.) have been successfully introduced in freshwater bodies of this country. The native species would experience competition for food to feed and space to live due to the introduction of exotic fish species. *Cyprinion mhalensis* is endemic to Saudi Arabia and occupies surface water (littoral zone) of streams, pools, and other lentic or lotic water bodies. Despite its commercial and economic value, little is known about feeding ecology of this fish. The only published information of Alkahem *et al.* (1988) on its diet from the Wadi Abha showed that phytoplankton was the major part of the diet where as a small quantity of zooplankton were also consumed.

In the present study an attempt was made to examine the different types of food consumed by this fish species collected from Wadi Bua, Taif. The various indices such as diet breadth index of different groups, diet overlap index among different size groups, and the selection of food displaced by this species were also determined.

MATERIALS AND METHODS

The fish specimens and water samples for the

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phyto- and zooplankton were collected from the same region. These samples were preserved in 10% formaldehyde and brought to the laboratory for further investigations. Qualitative and quantitative analysis of the phyto and zooplankton were made in a known volume of water under the microscope and expressed as percent.

Three hundred sixty specimens of fish, *Cyprinion mhalensis* (total length 3.5 – 17.6 cm and total weight 10.5-70.5 g) were collected from Wadi Bua, Taif in the last week of every month for one complete year. These specimens were weighed for the total weight (g) and measured for total length (cm). They were divided in to three groups (g_1: 1-6 cm, g_2: 6.1-12 cm and g_3: 12.1-18 cm) on the basis of their total length. Sufficient volume of formaldehyde (10%) was injected in the stomach of fish immediately after the catch to preserve the food items. The food contents of the gut of various fishes were analyzed according to the methods described by Al-Kahem *et al.* (2007). Relative abundance of different food items in the gut of fishes of various size groups and in the environment were expressed on percentage basis. The methods used to find different indices are as follows.

Vacuity Index (V) was measured with following formula:

$$\mathbf{V} = \frac{\text{Number of empty stomach}}{\text{Total number of stomach examined}} \times 100$$

Frequency of Occurrence (F) of the food items was calculated on the basis of presence of a particular food item in the gut of the fishes.

$$\mathbf{F} = \frac{\text{Number stomach with food}}{\text{Total number of stomach examined}} \times 100$$

Food Selection (Preference) was calculated by the method described by Lazzaro (1987):

$$E = [ri/pi] \Big/ \left| \sum_{i=1}^{n} ri/pi \right|$$

Where E is food selection index, ri and pi are the proportion of food type i in the fish's ration and in the environment, respectively.

Based on the overlap coefficient of Schoener (1970) the diet overlap index was calculated with the formula used by Morte *et al.* (2002):

$$a = 1 - 0.5 \left(\sum_{i=1}^{n} \left| Pxi - Pyi \right| \right)$$

Where a is diet overlap co-efficient, n is number of types of food organisms, pxi and pyi are the numerical composition indices of prey (i) in the diet of size group x and y, respectively.

The diet breadth index was measured with Lavin's standardized index which was calculated by the formula given below:

$$Bi = (n - 1)^{-1} [(\sum JPij^{2})^{-1} - 1]$$

Where Bi is Lavin's standardized index for predator i, Pij is Proportion of diet of predator i that is made up for prey j, and n is number of prey categories. The value of it ranges from 0 to 1.

RESULTS AND DISCUSSION

Vacuity index

Considerable variations in the values of this index among the three groups (g_1, g_2 and g_3) were registered. The maximum value (11.9) for vacuity index was noted in g_3 and minimum (0.33) in g_1 (Table I). Feeding intensity was seems to be low in g_3 showing the index value higher than other groups. The values of the index for this fish agree with the finding of various researcher on other species of fish from different areas (Biagi *et al.,* 1992; Politou and Papaconstantinou, 1994; Gramitto, 1999, Morte *et al.,* 2002; Alkahem *et al.,* 2007). The sexual maturation commonly interfere with feeding activity among fishes and it may also partly explain the higher vacuity index observed in mature (g_3) fishes in the present study. Dietary and morphological specialization may be other contributing factors (Malmquist, 1992; Amundsen *et al.,* 1995; Wainwright and Richard, 1995). The high values of vacuity index may also be attributed to the fast gastric evacuation (Cabral, 2000).

Table I.- Monthly variations in the values of vacuity index in different groups of *Cyprinion mhalensis* from the Wadi Bua, Taif. Values are mean ± standard deviation.

Months	Vacuity index		
	Group-1	Group-2	Group-3
Jan	2.0±0.16	4.0±0.14	3.0±0.13
Feb	3.0±0.17	5.0±0.15	8.0±0.11
Mar	4.0±0.11	3.5±0.19	9.0±0.07
Apr	0.33±0.05	2.0±0.32	11.9±0.11
May	4.0±0.08	5.7±0.06	7.8±0.07
Jun	3.0±0.10	2.8±0.11	9.0±0.05
Jul	4.1 ±0.27	3.6±0.20	2.3±0.09
Aug	1.78±0.10	3.0±0.05	4.0±0.26
Sep	2.0±0.17	1.1±0.10	1.1±0.10
Oct	4.5±0.16	2.6±0.18	3.0±0.15
Nov	4.0±0.15	3.8±0.17	4.4±0.07
Dec	3.0±0.11	2.0±0.15	4.7±0.12

Food selection, diet composition and variation with size and season

The present study indicates that the different groups of Cyprinion *mhalensis* feed on the same trophic level. It is a surface dwelling and its diet consists of primarily of six major groups (Table II). Bacillariophyceae and chlorophyceae constituted the major part of the stomach contents of the fishes of all size groups in all seasons. The other four groups, Myxophyceae, Desmidiaceae, Protozoa and rotifers were also consumed but in less quantity. The percentage composition of the food items in the diet of fish of different size groups was almost same. The frequency of occurrence of these food items in various groups also did not display much variation (Table IV).

C. mhalensis is a native species and was flourishing well in the different freshwater environments of Saudi Arabia. It prefers to live in the shallow littoral zone of the environment. This preference may be partly influenced by the distribution of food items in the surface water which constitute the diet of this fish. It has a superior mouth which indicates that it is well adapted to feed mainly from the surface water. It is omnivorous and prefer to feed mainly on green and blue green algae as reflected from the food selection index (Table III). The values more than 1/m (0.0303) indicate the positive selection and less than this value showed negative selection of that particular food item. Food items from animal origin encountered were very few but most of them were positively selected. The present findings are in line with the results of Al-Kahem *et al.* (1988) agrees with the present findings. They have reported that the fish feeds on zooplankton but in a very low proportion. It can be concluded that the fishes of different size groups feed mostly on common food, hence, competition for food resources among them is possible. Feeding activity of a fish is affected in a number of ways i.e. accessibility of fish to the food, its tastefulness, availability of food in the environment and lastly the cost of capture of food (Mustafa, 1976; Jafri and Mustafa, 1977; Strauss, 1979; Lazzaro, 1987; Al-Akel *et al.*, 1987; Al-Kahem *et al.*, 1988; Mills *et al.*, 1989; Shamsi *et al.*, 1995; Al-Akel, 2003). The fish is forced to feed and thrive on some available food sources if the scarcity of certain preferred food item goes down to a critical level (Al-Akel, 2003).

Most of the fish display ontogenic shift in feeding like smaller fish feeds either on zooplankton or on smaller aquatic animals and switch over on fishes and other large aquatic animals as adult. The fish *Cyprinion mhalensis* did not show changes or switching over from one category of food to the other. Variations in food ingestion are related to fluctuations in the density of food items in the environment (Morte *et al.*, 2002). A variation in the feeding also depends upon the range depth at which fish prefer to live.

Frequency of occurrence

Data embodied in Table IV indicate that the most of the food items eaten by the *Cyprinion mhalensis* of different size groups are common. Few genera like *Scenedesmus, Staurastrum, Cosmarium, Frustularia* and *Tabellaria* have low frequency of occurrence. Food items belonging to bacillariophyceae group were registered in the stomach of all fishes of different size groups and most of them showed high occurrence frequency (Table IV). We are of the opinion that there was a competition between the fishes of different size groups and it is due to high frequency of occurrence of food items. According to Hyslop (1980) if the frequency of occurrence is more than 25% in two or

Table II.- **Occurrence of major groups of food (percent) in the stomach of different size groups of fishes in Wadi Bua, Taif.**

Major groups of food	Percent occurrence of major diet groups											
	Winter			Spring			Summer			Fall		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Myxophyceae	8.3	9.3	10.3	8.5	9.0	10.3	8.8	9.7	9.2	8.6	9.4	9.9
Chlorophyceae	17.8	17.0	22.2	15.5	16.1	17.4	21.0	22.0	23.2	18.2	18.5	20.8
Desmidiaceae	9.2	8.4	10.1	10.2	13.0	11.6	11.3	12.5	13.5	10.3	11.4	11.8
Bacillariophyceae	54.1	60.3	54.3	53.1	55.6	57.5	45.7	50.1	51.5	50.5	55.1	54.4
Protozoans	10.2	4.9	3.1	11.2	5.9	3.0	10.8	4.5	2.0	10.8	5.1	2.6
Rotifers	0.4	0.2	0.1	1.5	0.4	0.2	2.3	1.1	0.6	1.6	0.5	0.4

Table III.- **Food selection index of different size groups of *Cyprinion mhalensis* from Wadi Bua (Taif) in different seasons.**

Food items	Food selection index											
	Winter			Spring			Summer			Fall		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Anabaena	0.046	0.056	0.033	0.026	0.034	0.034	0.027	0.045	0.036	0.031	0.043	0.034
Oscillatoria	0.021	0.032	0.034	0.029	0.031	0.030	0.024	0.033	0.036	0.025	0.031	0.033
Merismopedia	0.016	0.029	0.054	0.017	0.022	0.042	0.022	0.032	0.032	0.019	0.027	0.041
Myxophyceae	**0.016**	**0.024**	**0.030**	**0.016**	**0.020**	**0.028**	**0.017**	**0.025**	**0.025**	**0.017**	**0.023**	**0.027**
Ankisrodesmus	0.032	0.045	0.032	0.023	0.021	0.027	0.023	0.036	0.040	0.026	0.034	0.033
Scenedesmus	0.034	0.055	0.032	0.021	0.026	0.040	0.027	0.033	0.035	0.026	0.034	0.037
Ophiocytium	0.023	0.027	0.041	0.018	0.023	0.030	0.026	0.037	0.045	0.024	0.030	0.040
Protococcus	0.020	0.022	0.031	0.016	0.020	0.026	0.018	0.026	0.031	0.018	0.023	0.030
Crucigenia	0.022	0.022	0.032	0.022	0.029	0.037	0.024	0.035	0.042	0.023	0.029	0.038
Microspora	0.030	0.034	0.043	0.024	0.030	0.038	0.020	0.029	0.035	0.024	0.030	0.038
Ulothrix	0.014	0.016	0.053	0.020	0.027	0.031	0.026	0.035	0.031	0.020	0.025	0.038
Chlorophyceae	**0.019**	**0.023**	**0.034**	**0.017**	**0.021**	**0.027**	**0.020**	**0.028**	**0.031**	**0.019**	**0.024**	**0.030**
Gonatozygon	0.029	0.034	0.047	0.024	0.030	0.039	0.022	0.032	0.039	0.025	0.031	0.041
Closterium	0.021	0.024	0.034	0.020	0.025	0.036	0.020	0.031	0.033	0.021	0.026	0.034
Staurastrum	0.000	0.000	0.037	0.018	0.074	0.006	0.000	0.000	0.000	0.010	0.042	0.010
Netrium	0.014	0.000	0.000	0.043	0.055	0.064	0.026	0.038	0.046	0.030	0.036	0.044
Cosmarium	0.000	0.030	0.006	0.036	0.082	0.059	0.021	0.031	0.037	0.021	0.043	0.036
Desmidiaceae	**0.020**	**0.024**	**0.032**	**0.024**	**0.036**	**0.038**	**0.021**	**0.031**	**0.035**	**0.022**	**0.030**	**0.035**
Cyclotella	0.027	0.023	0.049	0.022	0.035	0.050	0.029	0.048	0.042	0.026	0.036	0.047
Eunotia	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diatoma	0.032	0.053	0.039	0.033	0.033	0.043	0.033	0.044	0.047	0.034	0.039	0.044
Tabellaria	0.030	0.033	0.041	0.024	0.028	0.036	0.020	0.029	0.034	0.024	0.029	0.036
Frustulia	0.037	0.042	0.058	0.023	0.035	0.041	0.031	0.039	0.043	0.030	0.038	0.046
Synedra	0.019	0.022	0.029	0.016	0.021	0.027	0.020	0.028	0.032	0.018	0.023	0.029
Navicula	0.031	0.043	0.044	0.027	0.034	0.042	0.024	0.040	0.038	0.027	0.038	0.041
Gomphonema	0.028	0.075	0.042	0.055	0.037	0.050	0.017	0.026	0.039	0.032	0.048	0.043
Cymbella	0.033	0.057	0.033	0.022	0.035	0.039	0.022	0.028	0.037	0.025	0.040	0.036
Amphora	0.015	0.050	0.040	0.019	0.039	0.032	0.026	0.036	0.044	0.019	0.042	0.037
Bacillariophyceae	**0.026**	**0.038**	**0.038**	**0.024**	**0.029**	**0.037**	**0.023**	**0.033**	**0.036**	**0.024**	**0.033**	**0.036**
Chlamydomonas	0.060	0.056	0.043	0.054	0.042	0.031	0.083	0.060	0.034	0.063	0.050	0.035
Eudorina	0.037	0.007	0.000	0.053	0.000	0.000	0.072	0.008	0.000	0.056	0.005	0.000
Euglena	0.115	0.000	0.000	0.083	0.014	0.000	0.088	0.010	0.000	0.094	0.008	0.000
Monas	0.062	0.033	0.023	0.046	0.047	0.017	0.045	0.036	0.011	0.049	0.038	0.015
Peridinium	0.031	0.006	0.010	0.070	0.021	0.021	0.035	0.009	0.006	0.047	0.013	0.013
Polytoma	0.058	0.042	0.024	0.053	0.032	0.019	0.078	0.044	0.025	0.061	0.037	0.022
Protozoans	**0.057**	**0.036**	**0.025**	**0.055**	**0.034**	**0.021**	**0.064**	**0.036**	**0.017**	**0.059**	**0.035**	**0.020**
Keratella	0.062	0.034	0.018	0.044	0.017	0.013	0.053	0.043	0.048	0.053	0.032	0.031
Dicranophorus	0.056	0.042	0.018	0.044	0.032	0.013	0.078	0.044	0.025	0.061	0.013	0.022
Rotifers	**0.059**	**0.038**	**0.018**	**0.044**	**0.026**	**0.013**	**0.067**	**0.043**	**0.037**	**0.057**	**0.026**	**0.027**

Table IV.- Frequency of occurrence (Percent) of different food items in the stomach of fish (*Cyprinion mhalensis*) of various size groups from Wadi Bua, Taif.

Food items (Genera)	Winter			Spring			Summer			Fall		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Myxophyceae	**76.7**	**75.3**	**100**	**91.6**	**90.0**	**86.67**	**84.3**	**96.0**	**85.0**	**72.0**	**74.0**	**60.0**
Anabaena	70	55	100	75	70	60	70	95	55	50	60	30
Oscillatoria	90	91	100	100	100	100	92	95	100	66	62	50
Merismopedia	70	80	100	100	100	100	91	98	100	100	100	100
Chlorophyceae	**73.1**	**70.9**	**82.9**	**84.9**	**82.1**	**90.1**	**74.7**	**82.0**	**85.4**	**76.4**	**80.4**	**78.1**
Ankisrodesmus	60	84	100	55	75	98	78	98	100	75	83	100
Scenedesmus	44	50	77	60	55	83	50	70	90	47	66	39
Ophiocytium	57	60	30	80	45	50	9	15	12	13	14	8
Protococcus	100	100	80	100	100	100	100	100	100	100	100	100
Crucigenia	100	100	100	100	100	100	100	100	100	100	100	100
Microspora	70	81	93	100	100	100	86	91	96	100	100	100
Ulothrix	81	21	100	99	100	100	100	100	100	100	100	100
Desmidiaceae	**57.0**	**77.7**	**79.0**	**55.2**	**61.6**	**79.8**	**72.8**	**80.6**	**96.4**	**65.2**	**71.0**	**82.6**
Gonatozygon	60	96	99	100	100	100	94	99	100	100	100	100
Closterium	50	82	100	81	66	60	99	100	100	83	81	100
Staurastrum	0	0	44	30	26	90	37	35	89	21	13	30
Netrium	61	0	0	20	34	60	74	79	99	67	77	100
Cosmarium	0	55	73	45	82	89	60	90	94	55	84	83
Bacillarophycea	**87.9**	**87.0**	**88.0**	**89.7**	**85.1**	**87.9**	**86.4**	**87.7**	**84.4**	**82.6**	**83.7**	**82.4**
Cyclotella	100	100	100	100	100	100	100	100	100	100	100	100
Diatoma	100	100	100	100	100	100	100	100	100	100	100	100
Tabellaria	99	94	76	80	66	56	60	74	33	59	54	26
Frustulia	33	19	29	42	21	35	19	28	27	25	29	33
Synedra	100	97	93	100	96	100	100	92	100	100	98	100
Navicula	88	99	100	100	100	100	100	95	100	100	100	100
Gomphonema	89	97	100	95	100	100	99	100	100	92	100	100
Cymbella	100	100	100	100	100	100	100	100	100	100	100	100
Amphora	82	77	94	90	83	100	100	100	100	67	72	83
Protozoans	**98.0**	**63.0**	**56.0**	**96.0**	**63.0**	**59.0**	**99.0**	**60.0**	**59.0**	**91.0**	**41.0**	**45.0**
Chlamydomonas	100	60	12	100	54	15	99	70	20	100	30	16
Eudorina	97	23	0	89	0	0	100	34	0	86	22	0
Euglena	91	0	0	87	12	0	96	17	0	78	9	0
Monas	99	75	67	100	80	73	100	85	70	95	63	45
Peridinium	100	88	75	100	98	81	100	87	90	89	66	71
Polytoma	100	69	70	100	72	66	100	66	56	97	54	49
Rotifers	**58.5**	**19.5**	**14.5**	**63.5**	**17.5**	**14.5**	**69**	**22.5**	**16.5**	**51.5**	**13**	**11**
Keratella	77	23	19	80	17	18	83	24	16	64	12	13
Dicranophorus	40	16	10	47	18	11	55	21	17	39	14	9

more predators, competition is likely. The high frequency of occurrence of food items can be related up to some extent to the level of feeding. Fish of different size groups live at the same range depth and feed on the same level, hence, show a very high frequency of occurrence of different food items in all the groups of fishes. The frequency of occurrence may also depend upon their abundance in the environment.

Diet breath

The value of niche or diet breadth and trophic diversity sometimes indicate the adaptation of resource use towards environmental availability. The variation in diet breath index has been registered very low in the present investigation (Table V). A small variation of diet breadth was found in different seasons and in different groups. In contrast to the present findings Zhang *et al*. (2009) have reported a very high diet breadth index for wolves (1.0752) and raccoon dog (0.9103) and very low index for red fox (0.0744). The low index value indicates that the individual's diet dominated by few food items and high values show generalized diet. Similar reasoning was also given by Gibson and Ezzi (1987), Krebs (1989) and Alkahem *et al*. (2007).

Table V.- Levin's diet breadth index of various groups of fishes in relation to seasons.

Months	Diet breath index		
	Group-1	Group-2	Group-3
Winter	0.33	0.33	0.33
Spring	0.29	0.32	0.31
Summer	0.30	0.30	0.32
Fall	0.28	0.29	0.31

Diet overlapping

The dietary similarity of *C. mhalensis* among different size groups was quantified by index of diet overlap. It was observed that high dietary overlap index existed between close size groups than non-consecutive groups (Table VI). The index values registered for all groups exceeded to 0.60. This index has a minimum value of 0 when no food items are shared and a maximum value of 1 when all the food items are shared. The diet overlap is significant when its value exceeded to 60% (0.60) (Wallace, 1981). A significant diet overlap was observed among the different size groups of *C. mhalensis*, consistent with major similarities in food utilization among the three groups (Table VI). It has been observed that the fishes of different size school together and feed at the same water level, hence, similarity in feeding habit is obvious and competition would be expected. Investigation into demersal fish communities have shown an increased food overlap due to the opportunistic utilization of super abundant food resources (Macpherson,1981; Targett, 1981; Delbeck and Williams, 1987; Morte *et al*. 1999a,b; Pelicice and Agostinho, 2006; Alkahem *et al.*, 2007). Polacik and Rechard (2010) have studied the food overlap among three species of *Nothobranchius* species and found that the larger species (*N. orthonotus*) showed a very low diet overlap with other two smaller species (*N. ferzeri* and *N. rachivii*) and suggested that it may be due to difference in body size and partly because of morphology of the fish. Bacheler *et al.* (2004) studied the diet overlap between native and introduced predatory fishes in Puerto Rico reservoir and suggested the disappearance of largemouth sleepers is due to a competitive disadvantage exerted by largemouth bass. Significantly high diet overlap index was registered by Sampson et al. (2009) among the native and introduced fish species showing no any negative effect due to the high productive nature of the environment. They suggested that in low productive lakes an adverse effect should not be underestimated.

Table VI.- Changes in diet overlap index among different size groups of fishes in different seasons.

Overlap between groups	Diet overlap index			
	Winter	Spring	Summer	Fall
$Group_1$ X $Group_2$	0.97	0.93	0.99	0.85
$Group_1$ X $Group_3$	0.88	0.9	0.86	0.78
$Group_2$ X $Group_3$	0.96	0.98	1.00	0.96

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REFERENCES

ADEYEMI, S.O., BANKOLE, N.O., ADIKWU, I.A. AND AKOMBO, P.M., 2009. Food and feeding habits of some commercially important fish species I Gbedikere Lake, Bassa, Kogi state, Nigeria. *Int. J. Lakes Rivers*, **2**:31-36.

AL-AKEL, A.S., 2003. Selection of food by different size groups of *Poecilia latipinna* (Lesueur, 1821) from eastern province of Saudi Arabia. *Saudi J. Biol. Sci.*, **10**:3-11.

AL-AKEL, A.S., SHAMSI, M.J.K. AND AL-KAHEM, H.F., 1987. Selective feeding behaviour of the Arabian freshwater fish, *Aphanius dispar*. *Pakistan J. Zool.*, **19**: 211-215.

AL-KAHEM, H.F., AL-AKEL, A.S., SHAMSI, M.J.K. AND AHMAD, Z., 1988. Food selection of various size groups of the cyprinid fish, *Cyprinion mhalensis* Al-Kahem and Behnke, (1983) from Saudi Arabia. *Arab Gulf J. scient. Res. Agric. biol. Sci.*, **B6**:419-427.

AL-KAHEM, H.F., AL-AKEL, A.S., SHAMSI, M.J.K., AHMAD, Z. AND AL-SHAWA, Y.R., 1990. Food selectivity of an Arabian Peninsula's cyprinid fish, *Cyprinion acinaces*. *J. King Saud Univ*., **2**:37-42.

AL-KAHEM, H.F., AL-GHANIM, K.A. AND AHMAD, Z.

2007**.** Studies on feeding ecology of sailfin molly (*Poecilia latipinna*) dwelling in Wadi Haneefah stream, Riyadh. *Pak. J. biol. Sci*., **10**:335-341.

AMUNDSEN, P.A., DAMSGARD, B., ARNSEN, A.M., JOBLING, M. AND JØRGENSEN, E.H., 1995. Experimental evidence of cannibalism and prey specialization in Arctic charr. *Environ. Biol. Fishes*, **43**:285-293.

BACHELER, N.M., NEAL, J.W. AND NOBLE, R.L., 2004. Diet overlap between native bigmouth sleepers (*Gobiomorus dormotor*) and introduced predatory fishes in a Puerto Rico reservoir. *Ecol. Freshw. Fish*, **13**:111-118.

BIAGI, F., De RANIERI, S. AND VIVA, C., 1992. Recruitment, length at first maturity and feeding of poor-cod, *Trisopterus minutus capelanus*, in the northern Tyrrhenian Sea. *Bull. Zool*., **59**:87-93.

CABRAL, H.N., 2000. Comparative feeding ecology of sympatric *Solea solea* and *S. senegalensis*, within the nursery areas of the Tagus estuary. Portugal. *J. Fish Biol*., **57**:1550-1562.

CARTES, J.E., HIDALGO, M., PAPIOL, V., MASSUTI, E. AND MORANTA, J., 2009. Changes in the diet and feeding of the hake *Merluccius merluccius* at the shelf-break of the Balearic Island: Influence of mesopelagic-boundary community. *Deep Sea Res*., **56**:344-365.

DELBECK, J.C. AND WILLIAMS, D.D., 1987. Food resources partitioning between sympatric populations of brackishwater sticklebacks. *J. Anim. Ecol*., **56**:949-967.

FRIEDLANDER, A.M., PARRISH, J.D. AND DEFELICE, R.C., 2002. Ecology of the introduced snapper *Lutjanus kasmira* **(**Forsskal) in the reef fish assemblage of a Hawaiian bay. *J. Fish Biol*., **60**:28-48.

GIBSON, R.N. AND EZZI, I.A., 1987. Feeding relationships of a demersal fish assemblage on the west coast of Scotland. *J. Fish Biol.*, **31**:55-69.

GIRALDO, C., CHEREL, Y., VALLET, C., MAYZAUD, P., TAVERNIER, E., MOTEKI, M. HOSIE, G. AND KOUBBI, P., 2011. Ontogenic changes in the feeding ecology of the early life stages of the Antarctic silverfish (*Pleuragramma antarcticum*) documented by stable isotopes and diet analysis in the Dumont d' Urville Sea (East Antarctica). *Polar Sci.*, **20**:1-12.

GRAMITTO, M.E., 1999. Feeding habits and estimation of daily ration of poor cod *Trisopterus minutus capelamus* (Gadidae) in the Adriatic sea. *Cybium*, **23**:115-130.

HYSLOP, E.J., 1980. Stomach content analysis : a review of methods and their application. *J. Fish Biol*., **17**:411-42.

JAFRI, A.K. AND MUSTAFA, S., 1977. Food selectivity of young *Catla catla* (Ham. Bloch) in tropical fish pond. *J. Fish Biol*., **10**:437-440.

KAVADIAS, S., CASTRISTSI-CATHARIOS, J. AND DESSYPRIS, A., 2003. Annual cycles of growth rate, feeding rate, food conversion, plasma glucose and plasma lipids in a population of European sea bass (*Dicentrarchus labrax* L.) formed in floating cages. *J. appl. Ichthyol*., **19**:29-34.

KREBS, C.J., 1989. Measurement of dietary preference In: *Ecological methods*. Harper Collins, New York, pp.392.

KUMARI, U., YASHPAL, M., MITTAL, S. AND MITTAL, A.K., 2009. Surface ultra structure of gill arches and gill rakers in relation to feeding of an Indian major carp, *Cirrhinus mrigala*. *Tissue Cell*, doi: 10.1016/j.tice. 2009.01.003

LAZZARO, X., 1987. A review of planktivorous fishes : their evolution, feeding behaviours, selectivities, and impacts. *Hydrobiology*, **146**:97-167.

LEONARDOS, L., 2008. The feeding ecology of *Aphanius fasciatus* (Valenciennes,1821) in the lagoonal system of Messolongi (Western, Greece). *Sci. Mar*., **72**:393-401.

LUCKSTADT, C. AND REITI, T., 2002**.** Investigations on the feeding behavior of juvenile Milkfish *(Chanos chanos*, Forsskal) in brackishwater lagoons on a south Tarawa, Ribati. *Verhandl. Gesselsch. Ichthyol.*, **3**:37-43.

MACPHERSON, E., 1981. Resources partitioning in a Mediterranean demersal fish community. *Mar. Ecol. Prog. Ser*., **4**:183-193.

MALMQUIST, H.J., 1992. Phenotype-specific feeding behaviour of two Arctic charr *Salvelinus alpinus* Morphs. *Oecologia*, **92**:354-361.

MILLS, E.L., SHERMAN, R.E. AND ROBSON, D.S., 1989. Effect of zooplankton abundance and body size on growth of age-0 yellow perch (*Perca flavescens*) in Oneida lake. New York, 1975-86. *Can. J. Fish. aquat. Sci*., **46**:880-886.

MORTE, M.S., REDON, M.J. AND SANZ-BRAU, A., 1999a. Feeding ecology of two megrims *Lepidorhombus boscii* (Risso, 1810) and *Lepidorhombus whiffiagonis* (Walbaum, 1792) in the Western Mediterranean. *J. mar. Biol. Assoc. U.K*., **79**:161-169.

MORTE, M.S., REDON, M.J. AND SANZ-BRAU, A., 1999b. Feeding habits of *Trachinus draco* of the eastern coast of Spain (Western Mediterranean). *Vie Milieu*, **49**:287-291.

MORTE, M.S., REDON, M.J. AND SANZ-BRAU, A., 2001. Feeding habits of *Triscopterus minutes capelanus* (Gadidae) of the Eastern coast of Spain (Western Mediterranean). *Mar. Ecol.*, 22:215-229.

MORTE, M.S., REDON, M.J. AND SANZ-BRAU, A., 2002. Diet of *Phycis blenoides* (Gadidae) in relation to fish size and season in the Western Mediterranean (Spain). *Mar. Ecol.*, **23**:141-155.

MUSTAFA, S., 1976. Selective feeding behaviour of the common carp, *Esomus danricus* (Ham.)in its natural habitat. *Biol. J. Linn. Soc.*, **8**: 279-284.

PELICICE, F.M. AND AGOSTINHO, A.A., 2006. Feeding ecology of fishes associated with *Egeria* spp. Patches in a tropical reservoir, Brazil. *Ecol. Freshw. Fish*, **15**:10-19.

PIGLER, T.J., GIDO, K.B. AND PROPST, D.L., 2010. Diet and trophic niche overlap of native and nonnative fishes in the Gila River, USA: Implications for native fish conservation. *Ecol. Freshw. Fish*, **19**:300-321.

POLACIK, M. AND REICHARD, M., 2010. Diet overlap among three sympatric African annual killifish species *Nothobranchius* spp. From Mozambique. *J. Fish Biol*., 77:754-768.

POLITOU, C.Y. AND PAPACONSTANTINOU, C., 1994. Feeding ecology of Mediterranean poor cod, *Trisopterus minutus capelanus* (Lacepede), from the eastern coast of Greece. *Fish. Res.*, **19**:269-292.

RIKARDSEN, A.H., AMUNDSEN, P.A. AND BODIN, P.J., 2003**.** Growth and diet of anadromous Arctic charr after their return to freshwater. *Ecol. Freshw. Fish*, **12**:74-80.

SAMPSON, S.J., CHICK, J.H. AND PEGG, M.A., 2009. Diet overlap among two Asian carp and three native fishes in backwater lakes on the Illinois and Mississippi rivers. *Biol. Invas.*, **11**:483-496.

SEVER, T.M., BAYHAN, B. AND TASKAVAK, E., 2005. A preliminary study on the feeding regime of European pilchard *(Sardina pilchardus* Walbaum 1792) in Izmir bay, Turkey, Eastern Aegean sea. *Naga*, **28**: 41-48.

SHAMSI, M.J.K., NIAMAT, R. AND JAFRI, A.K., 1995. Planktonic biota and food selection of freshwater fish, *Puntius sophore* in a perennial and sewage-fed tropical fish pond from northern India. *Egyptian J. appl. Sci*., **10**:217-224.

STRAUSS, R.E., 1979. Reliability estimates for Ivlev´s electivity index the forage ratio and a proposed linear index of food selection. *Trans. Am. Fish. Soc*., **108**:344-352.

TARGETT, T.E., 1981. Trophic ecology and structure of coastal Antarctic fish communities. *Mar. Ecol. Prog. Ser*., **4**:243-263.

WAINWRIGHT, P.C. AND RICHARD, B.A., 1995. Predicting patterns of prey use from morphology of fishes. *Environ. Biol. Fishes*, **44**:97-113.

WALLACE, R.K., 1981. An assessment of diet overlap indexes. *Trans. Am. Fish. Soc.*, **110**:72-76.

XIE, S., CUI, Y., ZHANG, T. AND LI, Z., 2000. Seasonal patterns in feeding ecology of three small fishes in the Biandantang Lake. *China J. Fish Biol*., **57**:867-880.

ZHANG, H.-H., LIU, X.-P., DOU, H.-S., ZHANG, C.-D. AND REN, Y. 2009. Food composition and food niche overlap of three kinds of canidae. *Acta Ecol. Sin.*, **29**:347-350.

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