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Seasonal variations in food selectivity, condition factor and the hepatosomatic and gonadosomatic indices in the endangered killifish *Aphanius dispardispar* (Teleostei: Cyprinodontidae) in Alhasa, Saudi Arabia

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Abstract: Food selectivity investigations of *Aphanius dispar dispar* were carried out during March 2010 to February 2011 from two different sites at Alhasa, Saudi Arabia. The electivity index (Ei) was found positive for all food items collected from the fish gut. The electivity index for the various food items were recorded as: blue green algae 0.4±0.19; and 0.36±0.14; desmids 0.43±0.21 and 0.33±0.21, diatoms 0.43±0.21 and 0.23±0.20, green algae 0.19±0.24 and 0.32±0.17, invertebrates 0.28±0.23 and 0.29±0.12, protozoa 0.24±0.12 and 0.28±0.07 and rectifiers 0.19±0.24 and 0.28±0.09 for Sites1 and 2, respectively. The condition factor (K) varied from 1.39 - 1.87 and 1.44-2.23. The hepatosomatic index (HIS) was ranged from 2.64 - 4.56 and 1.59 - 4.88 and the male gonadosomatic Index in male was recorded at 0.78 -1.98 and 1.52- 6.95 and female as 0.19 - 4.08 and 2.97 - 11.07 for site 1 and 2, respectively. *A. d. dispar* is an omnivorous fish that feed actively on both phytoplankton and zooplankton. The high values of (K), (HIS) and (GSI) throughout the year indicated that this fish is healthy and well adapted to its environment. *Aphanius d. dispar* is an endangered fish species and should be protected from predation and exotic fish competition.

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1.Introduction

The study of food selectivity of fishes in their habitat can lead to an understanding of fish feeding behavior and may also be an important factor for management of fish population (Shamsi, 1984; Shamsi et al., 1985; Al-Akel et al., 1987; Al-Akel et al., 1996, Olsen et al., 2000). The study of diet composition and food selectivity may also be useful to describe seasonal variations of nutritive value of the diet of the fish population (Windell and Bowen, 1978; Getachew and Fernando, 1989). The direct observation of fish feeding behavior or the analysis of fish gut contents can serve as a good tool for fish feeding analysis (Adrian and Barbieri, 1996). Quantitative and qualitative changes in fish food during the life span are useful tools to define the diet of a particular fish species (Shamsi et al., 1985; Al-Akel et al. 1996). Fish feeding is selective, but it can vary according to availability of food in the environment, which means that fish feeding habits are extremely adaptable where fish can use food item readily available in the environment (Azevedo, 1972).

The main factors that determine the type of prey ingested prey, are feeding preference (Shaw et al., 2003; Hagiwara et al., 2007; Nunn et al., 2007), a availability of fish prey, Prey mobility and its distribution in the water column, catching efficiency of the predator, water temperature and turbidity Moore and Moore (1976). It has been stated that changes in feeding habits of a fish species are a function of the interactions among several environmental factors that will influence the selection of food item (Ribeiro and Nuñer, 2008).

This study aimed to establish the interaction between the endangered killifish *Aphanius dispar dispar* and its food selectivity, and in its environment at Alhasa of Saudi Arabia in order to help in managing and conserving its population and to maintain fish biodiversity in the country.

2.Material and methods

2.1.A study area:

The present study was carried out in Alhasa, Saudi Arabia at two different environments of aquatic bodies represented by a natural spring known as Aljawharia spring (25°25′50"N, 49°37′ 26" E) and designated as a site-1 and site-2 as an artificial concrete canal (25°18′N, 49°9′ 10" E).

The average depth of the spring was found to be 1.2 meters and its area was around 100 m^2 with

continuous water flow. The concrete canal has a maximum depth of 1 m and 3 meters in width. The canal carries clean water from the spring in the fields of date palms and vegetables. *A. d. dispar* has been found in both the water bodies.

2.2.Water analysis:

Water samples were collected on monthly basis from both sites for a period of one year i.e. from March 2010 to February 2011. The water samples were collected between 7 - 9 am. The procedure described in APHA (1998) was followed for the collection of water samples. Dissolved oxygen, conductivity, temperature and pH were measured on the spot at the time of sampling using digital oxygen meter (*HANNA*: *HI*- 91-43), a conductivity meter (*AD-31*: *EC/TDF)*, a standard mercury thermometer and a pocket pH meter (*HANN – HI8912-5)*, respectively. Samples of nitrate-nitrogen and phosphate -phosphorus were analyzed in the laboratory by using (DR/ 2010) Spectrophotometer.

2.3.Plankton collection:

The water samples (1litre) for phytoplankton were collected monthly, from March 2010 to February 2011, with the help of sampling bottles at different depth and preserved in 1% lugols solution. Zooplankton were collected by filtering 20 liters of water from the sampling site using a plankton net (mesh size 60/-I) and were preserved in formalin solution.

2.4.Fish collection:

10 fish samples were collected monthly from each site for a period of one year by using a hand net at 7 - 9 am in the morning. The total number of sampled fishes was 240 fish from each site. The total length (mm) of each fish was measured with a caliper, and the wet weight (g) was recorded with analytical scale (*Mettler H-80*).

2.5.Analysis of gut content:

The fish were dissected in the laboratory where their liver, gonads and gut were removed and weighed on electric balance. The gut contents were poured in separate Petri dishes and mixed thoroughly and analyzed under stereo-microscope. The food organisms in the gut and in the environmental samples were identified and counted separately using the keys described by (Ward and Whipple, 1963; Needham and Needham, 1964; Tonapi, 1980; Gopal et al., 1981; Al-Akel, 1996, 2003). Abundance of food organisms was expressed as percentage of the total items counted. Three sub-samples were counted and the means were calculated.

2.5.1.Electivity index(Ei)

Th1.e electivity index of fish was determined by the following formula described by Ivlev 1961:
***Ei*=(*ri-pi*)/(*ri+pi*),** Where:

Ei=Ivlev, s index of electivity.
ri= the relative abundance of prey item in the gut or the relative percentage, and
pi = the relative abundance of the same prey item in the environment.

The index has a possible range of -1 to +1, with negative values indicating avoidance or inaccessibility of the prey item, zero indicating random selection from the environment, and positive values indicating the active selection.

2.5.2Condition factor (K):

The condition factor (K) was calculated by dividing weight with body length, and determined (Htun-han, 1978; King, 1995) as:
$K = Wx100/ L^3$, Where:
K= condition factor.
W= body weight
L^3 = body length

2.5.3 Hepatosomatic index (HSI):

The hepatosomatic index (HSI) is defined as the ratio of liver weight to body weight, and determined by Htun-han (1978) as:
HSI = LWx100/BW, Where:
LW= liver weight.
BW= body weight, and

2.5.4 Gonadosomatic index (GSI):

The gonadosomatic index (GSI) was defined as the ratio of gonad weight to body weight, and determined by Htun-han (1978) as:
GSI=GWx100/BW, Where:
GSI = gonadosomatic index.
GW = gonadal weight.
BW= body weight

The three factors were measured to give information on general health condition of the studied fish and its fecundity.

2.6. Statistical analysis:

Statistical analysis was performed according to Sokal1and Rolf (1995) using ANOVA (two-way analysis).

3. Results

3.1.Water quality:

Table 1 shows the water characteristics of the two sites: water temperature varies between 21-34 and

18-36 ℃ at two sites. Dissolved oxygen was recorded as6. 11-12.45 and 5.57 -12.38 mg/l. pH of the water was found to be: 7.4 – 8.3 and 7.3-8.6; nitrate nitrogen varied between 1.79 -184.94 and 1.1 - 1950.0 mg/l, from site 1 and 2, respectively. The phosphate showed a variation from 1.27 - 6.8 and 0.95 - 7.12 mg/l, and water transparency ranged between 82-119 cm and 39-121 cm, for site 1 and 2, respectively.

3.2.Electivity index(Ei):

The predator's preference for prey is defined as electivity index, *Ei*= (*ri-pi*)/(*ri+pi)* .The values of the monthly selectivity index (*EI*) for all food items were recorded out and presented in tables 2 and 3. It is noticed that all food items were found in the stomach of *A.d.dispar* in all months of the year. The monthly average (*Ei*) values of the phytoplankton includes, blue green algae (0.4±0.19; 0.36±0.14), desmids (0.43±0.21; 0.33±0.21), diatoms (0.43±0.21; 0.23±0.20), green algae (0.19±0.24; 0.32±0.17) from site 1 and site2 respectively, while the includes invertebrates (0.28±0.23; 0.29±0.12), protozoa (0.24±0.12, 0.28±0.07) and rotifers (0.19±0.24; 0.28±0.09) for a site I and 2, respectively. Statistical analysis of ANOVA shows none significant differences in the means of the electivity index (*Ei*) either between the two sites or between the months of the year (p>0.05).

Table (1) Shows water characteristics at site1 and 2 of Alhasa of Saudi Arabia, 1*= Site 1, 2*= Site 2, x̄= mean value, SD = standard deviation.

Months	Temp.	Oxygen	pH	No3	Po4	Transparency
	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD
Mar.2010 –1*	23.2±0.51	9.91±0.06	7.5±0.0	77.13±1.26	1.66±0.12	87±0.49
Mar.2010 -2*	26.2±0.03	9.95±0.0	7.3±00	62.27±2.33	1.80±0.22	121±2.19
Apr. 1*	29.9±0.27	7.7±0.01	7.8±0.0	71.68±0.98	1.37±0.08	116±0.84
Apr 2*	31.7±0.08	8.36±0.0	7.4±0.04	57.11±1.58	1.1±0.12	81.1.69
May -1*	30.1±0.33	9.61±0.01	8.0±0.04	112.62±0.88	2.19±0.06	102±1.16
May -2*	32.4±0.02	6.88±0.0	7.8±0.01	105.76±0.88	0.95±0.36	73.1.2
Jun –1*	31.6±0.46	7.19±0.0	8.1±0.03	171.09±3.61	4.44±0.11	91±0.26
Jun -2*	32.2±0.01	6.06±0.18	7.6±0.07	195.01±3.78	4.33±0.06	69±0.65
Jul- 1*	34.6±0.51	6.26±0.06	7.8±0.01	178.22±1.05	5.92±1.23	92±0.93
Jul -2*	36±0.06	6.31±0.41	8.4±0.09	186.22±4.25	6.63±0.25	48.0± 1.02
Aug – 1*	34.1±0.25	6.15±0.02	7.7±0.01	184.94±3.84	6.81±0.02	83±0.76
Aug -2*	33.8±0.12	5.57±0.0	7.8±0.07	191.34±2.98	7.12±0.40	47 ±1.04
Sep- 1*	33.3±0.29	6.11±0.02	7.4±0.08	160.35±.68	3.58±0.14	82±1.19
Sep -2*	33.2±0.04	7.27±0.0	8.2±0.05	131.07±2.01	3.71±0.36	56.0±1.34
Oct-1*	29.9±0.62	7.23±0.01	7.8±0.0	112.31±0.75	3.01±0.08	97±0.68
Oct -2*	32.1±0.02	7.72±0.0	8.0±0.0	70.23±1.05	3.08±0.16	84 ±1.89
Nov- 1*	23.1±0.36	7.47±0.02	8.0±0.02	80.13±0.92	2.63±0.36	95±0.85
Nov -2*	32.2±0.01	7.91±0.04	7.9±0.01	79.17±0.66	2.68±0.21	39±0.73
Dec- 1*	26.6±0.16	7.65±0.06	7.8±0.02	63.17±1.25	2.49±0.15	119±0.71
Dec 2*	18.1±0.01	8.27±0.06	8.6±0.02	68.46±2.59	2.23±0.09	56±0.88
Jan-1*	21±0.49	8.510.02	8.3±0.01	51.79±1.87	1.57±0.09	91±1.18
Jan -2*	21.2±0.21	8.76±0.11	8.2±0.11	57.51±1.36	1.35±0.33	57±1.87
Feb 2011-1*	26.5±0.28	±0.0112.45	7.6±0.0	68.67±0.38	1.27±0.13	96±0.52
Feb 2011-2*	31.7±0.09	12.38±0.01	7.9±0.15	62.72±1.74	1.14±0.06	79±1.06

Table (2) electivity index (Ei) of *A.d. dispar* at site 1 of Alhasa of Saudi Arabia, n= number of species in each food item, x̄= mean, SD= standard deviation.

Food items	Mar. 2010	April	May	June	July	August	September	October	November	December	Jan. 2011	February	Average
	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD
Blue-green algae n(12)	0.39 ±0.66	0.71 ± 0.26	0.75 ±0.24	0.48 ±0.49	0.52 ±0.57	0.40 ±0.53	0.05 ±0.77	0.29 ±0.31	0.29 ±0.68	0.16 ± 0.27	0.31 ±0.20	0.38 ±0.45	0.4 ±0.19
Desmids n(12)	0.27 ±0.75	0.31 ±0.67	0.44 ±0.69	0.44 ±0.69	0.43 ±0.19	6.11 ±0.62	6.11 ±0.62	0.62 ±0.51	0.28 ±0.74	0.45 ±0.49	0.20 ±0.75	0.48 ±0.64	0.43 ±0.21
Diatoms n(18)	0.28 ±0.79	0.60 ±0.60	0.40 ±0.67	0.58 ±0.69	0.26 ±0.74	0.47 ±0.55	-0.07 ±0.68	-0.22 ±0.52	0.20 ±0.76	0.43 ±0.76	0.12 ±0.64	0.36 ±0.74	0.43 ±0.21
Green algae n(15)	0.46 ±0.70	0.03 ±0.74	0.65 ±0.62	0.16 ±0.77	0.00 ±0.79	0.17 ±0.65	0.11 ±0.70	-0.09 ±0.51	0.48 ±0.70	-0.22 ±0.85	0.24 ±0.66	0.30 ±0.70	0.19 ±0.24
Invertebrates n(6)	0.00 ±0.32	0.98 ±0.94	0.01 ±0.80	0.30 ±0.70	0.44 ±0.35	0.25 ±0.48	0.16 ±0.48	0.41 ±0.27	0.48 ±0.78	0.17 ±0.71	-0.04 ±0.86	0.34 ±0.75	0.28 ±0.23
Protozoa n(35)	0.27 ±0.81	0.21 ±0.67	0.20 ±0.94	0.36 ±0.77	0.50 ±0.75	0.22 ±0.69	0.36 ±0.74	0.09 ±0.62	0.09 ±0.68	0.24 ±0.75	0.12 ±0.67	0.27 ±0.74	0.24 ±0.12
Rotifers n(13)	0.27 ±0.76	0.22 ±0.65	0.03 ±0.79	0.03 ±0.79	0.18 ±0.52	0.47 ±0.72	0.32 ±0.64	0.21 ±0.45	0.39 ±0.57	0.45 ±0.56	0.40 ±0.72	0.30 ±0.56	0.19 ±0.24

Table (3) electivity index (Ei) of *A. d. dispar* at site 2 of Alhasa of Saudi Arabia, n= number of species in each food item, x̄ = mean, SD= standard deviation

Food items	Mar. 2010	April	May	June	July	August	September	October	November	December	Jan. 2011	February	Annual average
	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD	x̄ ±SD
Blue-green algae n(12)	0.35 ±0.66	0.36 ±0.77	**0.0** ±0.70	0.24 ±0.75	0.42 ±0.66	0.39 ±0.60	0.47 ±0.50	0.33 ±0.66	0.60 ±0.51	0.40 ±0.51	0.30 ±0.56	0.48 ±0.67	0.36 ±0.14
Desmids n(12)	0.46 ±0.58	0.28 ±0.58	0.18 ±0.56	0.48 ±0.56	-0.03 ±0.71	-0.04 ±0.82	0.29 ±0.71	0.42 ±0.66	0.43 ±0.78	0.39 ±0.59	0.52 ±0.45	0.65 ±0.56	0.33 ±0.21
Diatoms n(18)	0.44 ±0.74	0.58 ±0.61	0.34 ±0.75	0.19 ±0.00	0.44 ±0.62	0.13 ±0.63	-0.08 ±0.69	0.17 ±0.73	0.03 ±0.68	-0.01 ±0.61	0.19 ±0.57	0.42 ±0.59	0.23 ±0.20
Green algae n(15)	0.48 ±0.67	0.07 ±0.63	0.64 ±0.60	0.38 ±0.69	0.34 ±0.79	0.31 ±0.69	0.35 ±0.66	-0.02 ±0.50	0.46 ±0.50	0.27 ±0.53	0.32 ±0.42	0.32 ±0.66	0.32 ±0.17
Invertebrates n(6)	0.46 ±0.02	0.32 ±0.36	0.49 ±0.21	0.29 ±0.14	0.39 ±0.07	0.22 ±0.13	0.27 ±0.30	0.08 ±0.14	0.25 ±0.30	0.13 ±0.19	0.25 ±0.10	0.37 ±0.07	0.29 ±0.12
Protozoa n(35)	0.37 ±0.77	0.26 ±0.68	0.13 ±0.67	0.31 ±0.73	0.37 ±0.62	0.31 ±0.70	0.19 ±0.63	0.33 ±0.62	0.24 ±0.73	0.31 ±0.66	0.28 ±0.74	0.31 ±0.64	0.28 ±0.07
Rotifers n(13)	0.44 ±0.05	0.31 ±0.21	0.40 ±0.22	0.29 ±0.08	0.39 ± 0.04	0.24 ± 0.09	0.18 ± 0.19	0.14 ± 0.15	0.25 ± 0.18	0.17 ± 0.14	0.26 ±0.06	0.36 ± 0.05	0.28 ±0.09

3.3.Condition factor (K):

The monthly average condition factor (K) showed values between 1.39 - 1.87 at the first site and 1.44 - 2.23 at the second site, (Table 4 and Fig 1) where the values of the condition factor for second sites was higher than site 1 ($P<0.05$).

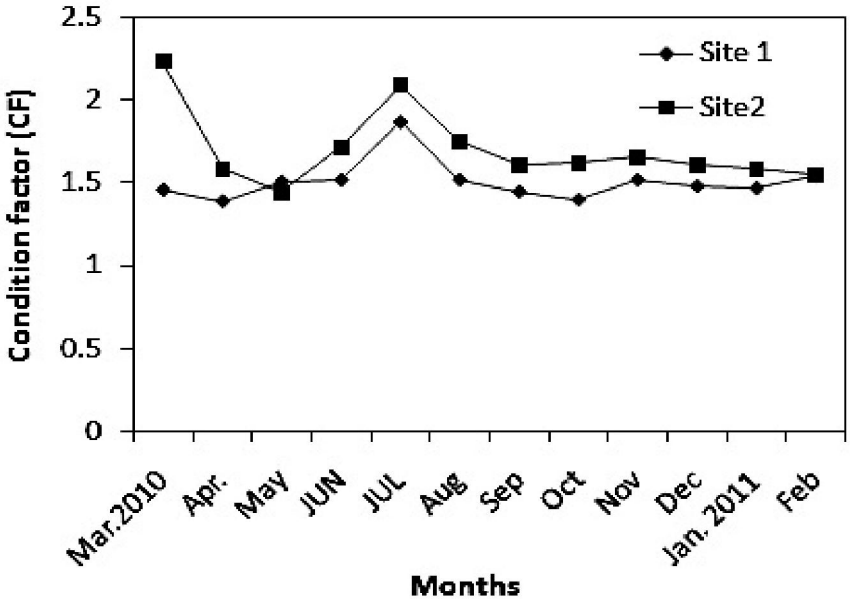

Fig (1) Condition factor (CF) of *A. d. dispar* at site 1 and 2 of Alhasa of Saudi Arabia

3.4.Hepatosomatic index (HIS)

The hepatosomatic index of *A. d.dispar*, (Table 4 and Figure 2), showed high values throughout the year (2.64 - 4.56 for Site 1 and 1.59 - 4.88 for Site 2) for both sexes. The two sites showed non-significant differences ($p>0.05$).

3.5.Gonadosomatic Index (GSI)

The monthly average of the gonadosomatic index (GSI) for both sexes ranged from 0.78 -1.98 for males and 1.52- 6.95 for females at site 1 and at site 2 it varied from 0.19 - 4.08 for males and 2.97 - 11.07 for females, (Table 5). Statistical analysis showed significant differences ($p<0.05$) between the two sites while there was the difference between males and females were highly significant ($p<0.01$).

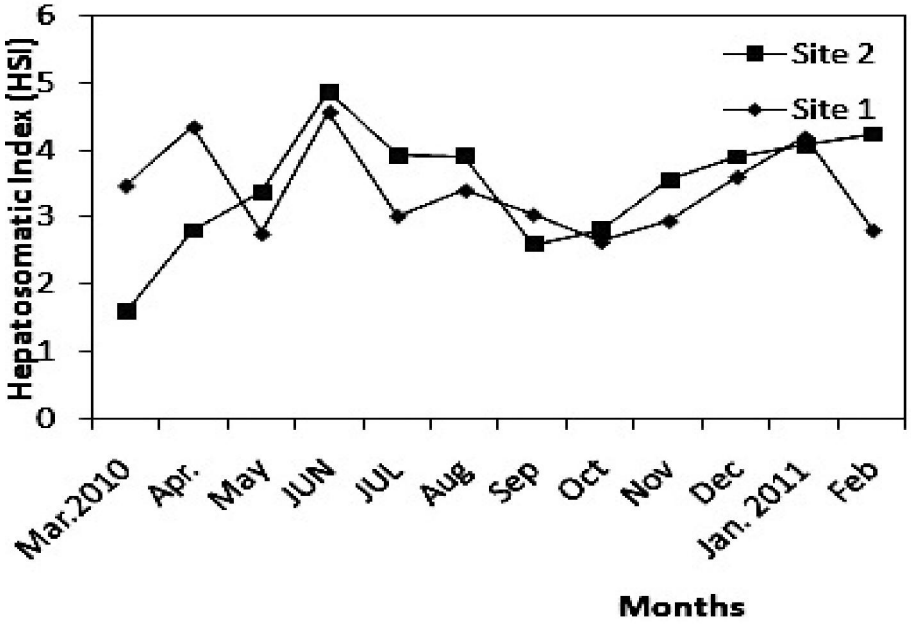

Fig (2) Hepatosomatic index (HIS) of *A. d. dispar* at site 1 and 2 of Alhasa of Saudi Arabia

Table (4) condition factor (K) and Hepatosomatic index(HIS) at site 1 and 2 of Alhasa of Saudi Arabia for *A. dispar*.

Months	**condition factor (K)**				**Hepatosomatic index(HIS)**			
	Site 1	±sd	Site2	±sd	**Site 1**	**±sd**	**Site 2**	**±sd**
Mar.2010	1.46	±0.12	2.23	±0.66	3.47	±1.04	1.59	±1.30
Apr.	1.39	±0.11	1.58	±0.19	4.34	±1.55	2.81	±1.22
May	1.51	±0.11	1.44	±0.12	2.76	±0.87	3.38	±0.86
JUN	1.52	±0.10	1.71	±0.18	4.56	±2.36	4.88	±1.50
JUL	1.87	±0.21	2.09	±0.39	3.02	±1.12	3.93	±0.91
Aug	1.52	±0.14	1.75	±0.20	3.40	±1.23	3.92	±1.34
Sep	1.45	±0.13	1.61	±0.15	3.04	±1.20	2.61	±0.86
Oct	1.40	±0.27	1.62	±0.15	2.64	±0.59	2.82	±0.98
Nov	1.52	±0.16	1.65	±0.12	2.95	±0.69	3.56	±1.57
Dec	1.48	±0.14	1.61	±0.13	3.60	±0.86	3.91	±1.21
Jan. 2011	1.47	±0.13	1.58	±0.12	4.19	±1.17	4.08	±0.97
Feb	1.54	±0.10	1.55	±0.14	2.81	±1.03	4.25	±0.84

Table (5) Show Gonadosomatic Index (GSI) of *A. d. dispar* at site 1 and 2 of Alhasa of Saudi Arabia, $\bar{x}$ = mean, SD= standard deviation.

Months	**Gonadosomatic Index (GSI)**							
	Site 1 $\bar{x}$ ±SD				Site 2 $\bar{x}$ ±SD			
	Male		Female		Male		Female	
	$\bar{x}$	±SD	$\bar{x}$	±SD	$\bar{x}$	±SD	$\bar{x}$	±SD
Mar 2010	1.73	±0.36	1.52	±0.42	0.19	±0.10	3.88	±1.49
Apr	0.82	±0.26	6.95	±2.94	0.85	±0.55	7.0	±3.29
May	0.78	±0.14	3.32	±1.12	1.45	±0.52	3.53	±1.81
Jun	1.08	±0.27	5.73	±1.09	3.02	±1.38	11.07	±5.61
Jul	0.93	±0.28	3.85	±1.69	1.20	±0.48	3.83	±2.13
Aug	1.09	±0.15	4.26	±0.83	4.06	±0.40	4.41	±1.07
Sep	1.26	±0.44	4.08	±0.50	0.84	±0.26	2.97	± 1.64
Oct	1.11	±0.33	3.56	±1.69	0.67	±0.28	3.25	±0.88
Nov	1.22	±0.19	3.07	±0.86	0.78	±0.32	3.26	±0.90
Dec	0.84	±0.28	2.30	±0.32	0.69	±0.35	3.67	± 1.62
Jan 2011	1.98	±0.16	4.13	±0.61	0.93	±0.24	4.54	±1.32
Feb	1.57	±1.57	4.87	±2.91	0.89	±0.27	9.95	±4.89

4.Discussion

The results of the present study show that the water temperature at the two sites of the studied area varies between 21 – 34°C which is the optimum temperature for fish growth and breeding. Water temperature is a very important factor for fish distribution and aquatic organisms and their activity in the environment. Different fish species vary greatly in their response to water temperature. Water temperature affects photosynthesis, osmotic regulation in addition to effect on water density, viscosity, oxygen dissolution in the water, fish respiration (Saadi, 2009; Plumb and Blanchfield, 2009). Aquatic environment flourished at the beginning of the rising temperature in the spring until it reaches the critical level in the summer and reduces aquatic productivity (Jhingrn, 1982; Shamsi and Jafri, 1989). The water pH varies between 7.3 - 8.6 which is suitable for aquatic productivity and the life of the fish (Hora and Pillay, 1992). The dissolved oxygen varies between 12 - 15.57 mg/l during the winter and summer, respectively, which indicate a very high level of dissolved oxygen throughout the year. The oxygen values are good indicators of a suitable environment for all types of fish and *A. d.dispar* is not an exception. The results also show an increase in nitrate level during the summer which may due to high temperature and the higher rate of decomposition of organic matter in these water bodies.

Analysis of stomach content to study the feeding habits of fish has become a standard practice (Hynes, 1950; Hyslop, 1980). Fish feeding pattern and quantitative assessment that resulted from the analysis of stomach content is an important aspect of fisheries management. Lager (1949) pointed out that the gut contents only indicate what the fish would feed on. A study of food selectivity determines the most frequently consumed prey and the relative importance of different food types to fish nutrition and to quantify the consumption rate of the individual prey types. Ivlev (1961) proposed a somewhat different quantitative measure of selection which has been widely used as mean of comparing the feeding habits of fishes and other aquatic organisms with the availability of potential food resources in natural habitats.

The result of this study has, therefore, indicated that : *A. d. dispar* shows great values with positive results which means that this fish feeds actively on both phytoplankton and zooplankton as they present in the water samples and it is an omnivorous fish species. Daud, (2011) stated that Some fishes demonstrate some kinds of obligate and facultative feeding electivity, other fishes are restricted to a single or few target species. Aphanius dispar has been reported by Suliman, (2009) and Haq, (2013) as a larvivourus fish which could be used in mosquito control. (Kaufman et al., 2007; Morley et al., 2012) reported that HSI as an indicator which varies among species and condition factor (K) perform better than (HSI). But in species that use the liver as a storage site of lipids (HSI) may be more effective than the value of K. In the present study all the indices (HSI, GSI and K) show high values which means that all indices can be used to study condition of *A. dispar*. A study of *Aphanius isfahanensis* from southern Western Ghats, India showed a high condition factor with indication of healthy fishes (Kannan, et al., (2013)

Gonadosomatic index (GSI) shows a very high significant differences between males and females ($p<0.05$) and a highly significant difference between the two sites ($p<0.05$), where site 2 shows higher values of GSI than the site -1and females shows higher values than males in both sites throughout the year as a result of the continuous breeding behavior of the *A. dispar* (Suliman et al., 2010). The higher value of GSI indicates that food types and availability has better impact on the reproductive function (Van Ginnekenet al., 2009).

Condition factor (K) is calculated by weight/body length to compare growth condition of fish. Good environmental quality gives a high condition factor, while a low condition factor reflects poor environmental quality. The condition factor (K) reflects information on the physiological state of the fish in relation to its welfare, (Kumolu-Johnson and Ndimele,2010). In this study the condition factor (K) shows high values for both studied sites. The above values showed good to excellent conditions of the fish in both sites.The values of (k) were higher at site 2 and significantly different from site 1 ($p<0.05$), which indicate a better environmental conditions at site 2. Probably because of shallow water level and high plankton production.

The results of this study show that the environment of the Alhasa of Saudi Arabia is highly stable and a suitable environment for *A. d. dispar*. This fish and its environment should be protected and conserved by implementing the rules and regulations especially those which are concerned with the introduction of exotic fish species. Exotic fishes such as tilapia and poecilia may compete in space and food with the *A. d.dispar*and they may also have a predatory behavior against this fish and its eggs. *Aphanius d.dispar* is an important native fish of Saudi Arabia and it deserves conservation because it has a good potential for mosquito control, in addition to its role in the aquatic ecosystem as a part of the biological diversity of the aquatic life of the country. So, *A.d.dispar* as an endangered fish species should be prevented from competition and predation by intruder fishes such as tilapia and *Poecilia* in order to conserve the fish population and to maintain the biological diversity of the aquatic life of the country. The fish can

also be used in biological control of vectors of some diseases such as malaria, dengue and the fever of the rift-valley.

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References

[1]. A1-Ake1 AS, A1-Kahem HF Shamsi M1K, Ahmed Z. Selection of food in various size groups of Nile Ti1apia, *Oreochromis niloticus* (L.) in WadiHaneefahstream, Saudi Arabia. *Pakistan Journal of Zoology,* 1996; 27: 271-275.

[2]. A1-Ake1 AS, Shamsi M1K, A1-Kahem HF. Selective feeding behaviour of Arabian freshwater fish *Aphaniusdispar*. *Pakistan Journal of Zoology* 1987; 19: 211-215.

[3]. Al-Akel AS. Selection of food on different size groups of *Poecilialatipinna* (Lesueur, 1821) from Alhasa of Saudi Arabia. *Saudi Journal of Biological Sciences* 2003; 10: 3-11.

[4]. Adrian IDF, Barbieri G, Espectroalimentar e variaçãosazonale especial nacomposição da dieta de *Parauchenipterusgaleatus* L. (Siluriformes, Auchenipteridae) naregião do reservatório de Itaipu, Brazilian Journal of Biology formerly *Revista Brasileira Biologia* 1996; 56 : 409-422.

[5]. American Public Health Association (APHA). Standard Methods for the Examination of Water and Waste water (20th edn). Washington, D.C.: American Public Health Association 1998.

[6]. Azevedo P. Principaispeixes das águasinteriores de São Paulo hábits de vida. In:ComissãoInterestadual da Bacia Paraná-Uruguai. Poluição e Piscicultura: NotasSobrePoluição, Ictiologia e Piscicultura. Faculdade de SaúdePública da USP, São Paulo 1972; 109 - 112.

[7]. Daud JRP. Assessing feeding electivity in Acanthaster planci: a null model analysis. Coral Reefs 2011; 30: 227-235.

[8]. Getachew T, Fernando CH. The food habits of an herbivorous fish (*Oreochromisniloticus* Linn.) in LakeAwasa, Ethiopia. *Hydrobiologia* 1984; 174: 195-200.

[9]. Gopal B, Goel PK, Sharma KP, Trivedy PK, Limnological study of freshwater reservoir Jamwa, Ramgarh (Jaipur). *Hydrobiologia* 1981; 83: 283-294.

[10]. Hagiwara A, Suga K, kazawa A, Kotani T, SakakuraY. Development of rotifer strains with useful traits for rearing fish larvae. *Aquaculture* 2007; 268: 44 -52.

[11]. Hora SL, Pillay TVR. Handbook of fish culture in the Indo-Pacificregion. FAO Fisheries Technical Paper No14. Rome Italy: FAO 1962.

[12]. Htun-han M. The reproductive biology of the dab *Limanda limanda* (L) in the North Sea; gonadosomatic index, hepatosomatic index and condition factor. *Journal of Fish Biology* 1978; 13: 369-378.

[13]. Hynes HBN. The food of the freshwater sticklebacks (*Gasterosteus aculeatus*) and (*Pungitius pungitius*) with a review of methods used in studies of the food of fishes.*Journal of Animal Ecology* 1950; 19:36-58.

[14]. Hyslop E.J. Stomach content analysis: a review of methods and their application. *Journal of Fish Biology* 1980; 17:411-429.

[15]. Ivlev VS. Experimental ecology of the feeding of fishes. New Haven: Yale University Press 1961.

[16]. Jhingran VG. Fish and Fisheries of India. New Delhi: Hindustan Publishing 1982.

[17]. Kannan K, Jeyaraj A. Malleshappa H. Growth and condition of an endangered fish *Dawkinsia tambraparniei* (Cypriniforms: Cyprinidae) from southern Western Ghats, India. Aqua International Journal 2013; 19(1): 61-66.

[18]. Kaufman SD, Johnston TA, Leggett WC, Moles MD, Casselman JM, Schulte-Hostedde AI. Relationships between body condition indices and proximate composition in adult walleyes. *Transactions of the American Fisheries Society* 2007; 136:1566–1576.

[19]. King M. *Fisheries Biology Assessment and Management*. Fishing News Books. London: Blackwell Science 1995.

[20]. Kumolu-Johnson CA, Ndimele PE. Length weight relationships and condition factors of twenty-one fish species in Ologe Lagoon, Lagos, Nigeria.*Asian Journal of Agricultural Sciences* 2010; 2: 174-179.

[21]. Lagler KF. Studies of freshwater biology. Michigan: Ann Arbor 1949.

[22]. Natarajan AV, Jhingran AC. "Index of preponderance"-a method of grading the food elements in the stomach analysis of fishes.*Indian Journal of Fisheries* 1961; 8:54-59.

[23]. Moore JW, Moore IA. The basis of food selection in flounders, *Platichthysflesus*, in the Severn Estuary. *Journal of Fish Biology* 1976; 9: 139 - 156.

[24]. Morley JW, Buckel JA, Lankford TE Jr. Comparing multiple predictors of energy contentin juvenile bluefish. *Transactions of the American Fisheries Society* 2012; 141:1109–1116.

[25]. Needham JG, Needham RR. *A Guide to the Study of Freshwater Biology* (5th edn),San Francisco, USA: Holden Day 1964.

[26]. Nunn AD, Harvey JP, Cowx IG. The food and feeding relationships of larval and 0+ year juvenile fishes in lowland rivers and connected waterbodies. II. Prey selection and the influence of gape. *Journal of Fish Biology* 2007; 70: 743 - 757.

[27]. Olsen AI, AttramadalY, Reitan KI, Olsen Y. Food selection and digestion characterstics of Atlantic halibut (*Hippoglossus hippoglossus*) larvae fed cultivated prey organisms. *Aquaculture* 2000; 18: 293- 310.

[28]. Plumb JM, Blanchfield, PJ. Performance of temperature and dissolved oxygen criteria to predict habitat use by lake trout (*salvelinus namaycush*). *Canadian Journal of Fisheries and Aquatic Sciences* 2009; 66:2011-2023.

[29]. Ribeiro DFO, Nuňer APO. Feed preferences of *salminus brasiliensis* (Pisces, Characidae) larvae in fish ponds. *Aquaculture* 2008; 274: 65 -71.

[30]. Rüppell WPES. *Atlas zu der Reise im nördlichen Afrika. Zoologie; Fische des rothenMeeres, (1828-1830)*. Frankfurt: Heinrich Ludwig Brönner 1829.

[31]. Saadi HA. *Aquatic environment*. Amman, Jordan: Yazoo 2009.

[32]. Shamsi M1K. Environmental biology of plankton and macrofauna of perennial and sewage-fed water body. PhD thesis, Aligarh Muslim University, India1984.

[33]. Shamsi M1K, Niamat R, Jafri AK. Planktonic biota and food selection of freshwater fish, *puntius sophore* in a perennial and sewage-fed tropical fish pond from Northern India. *Egyptian Journal of Applied Science* 1995; 10: 217-224.

[34]. Shaw GW, Pankhurst PM, Purser GJ. Prey selection by greenback flounder *Rhombosolea* (Günther) larvae. *Aquaculture* 2003; 228: 249-265.

[35]. Sokal RR, Rohlf FJ. *Biometry*: *The Principles and Practice of Statistics in Biological Research, 3rdedn*. New York: WH Freeman 1995; 887pp.

[36]. Suliman EM. Al-Akel AS, Al-Khem HF, Al-Misned F, Ahmad Z. Spawning of the endangered killifish, *Aphanius disar dispar* (Rüppel, 1829) under laboratory conditions. *Animal Biology Journal*2009; 1: 185-192.

[37]. Tonapi GT. *Freshwater Animals of India*. Oxford, New Delhi: IBH Publishing 1980.

[38]. Van Ginneken V, Palstra A, Leonards P, Nieveen M, Van den Berg H, Flick G, Spaning T, Niemantsverdriet P, van den Thillart G, Murk A. PCBs and the energy cost of migration in the European eel (*Anguilla anguilla* L.). *Aquatic Toxicology* 2009; 92: 213-20.

[39]. Ward HB Whipple GC (edited by Edmonson WT). *Freshwater Biology,* (2nd edn). New York, London: John Wiley 1959.

[40]. Windell JT Bowen SH. Methods for study of fish diet based on analysis of stomach contents in: Bagenal T (ed) *Methods of assessment of fish production in freshwaters*. *IBP Handbook No. 3*. Oxford: Blackwell Scientific Publications 1978; pp. 219 -226.

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