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ORIGINAL ARTICLE

A seasonal survey on feeding diet, breadth and feeding niche overlap of the native brown trout (*Salmo trutta*) and the exotic rainbow trout (*Oncorhynchus mykiss*) in Haraz River, in the southern Caspian Sea basin

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Abstract
Diet composition and feeding strategies of two native and non- native trout species i.e. the brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) were investigated from autumn 2018 until summer 2019 in the uppermost of Emamzadeh Ali Lake (Haraz River, North of Iran). A total of 79 individuals including 59 brown trouts and 20 rainbow trouts were caught and studied. Digestive contents of feeding indices including CV (coefficient of vacuity), RLG (relative length of gut) and IF (intensity of feeding) revealed that both trout species were voracious carnivores, and showed a desirable nutritional status at all sampling seasons. Rainbow trout had a wider niche breadth than the brown trout in autumn, winter, and summer, except for spring. Feeding niche of the both trouts was highly overlapped in autumn and winter i.e. feeding on the same common resources. Percentage of overlap of both trouts was the most in autumn and winter and similar with the results of Morisita′s overlap index.

Keywords: Diet, Niche overlap, Rainbow trout, Brown trout.

INTRODUCTION

Fish habitats are mainly influenced by various destructive factors like erosion and sedimentation due to the loss of vegetation (Virijenhoek 1998), agricultural and municipal wastes, and dam construction affecting adversely natural distribution of many resident and migratory fish species. Moreover, introduction of non-native species to habitats of native species would cause interspecific competition, out-breeding and finally disruption of local habitats for native species (Hashemzadeh Saqarloo 2010).

Ecological niche involves three main dimensions of space, food source and time which are considered as major resources used by the species (Krebs 1999). Niche overlap is defined as a use intersection of a resource by two or more species, and theoretically described a determining factor of species density in a community structure (Rezaei 1993). Now, the question is that how coexisting species benefit from common resources in a community? Those species sharing a similar pattern of using a resource have a high degree of overlapping, but a negligible overlap is observed in species with different use pattern. As a popular method to measure ecological niche overlap, food resources have also been defined as a use intersection of a resource by two or more species (Heydari & Varasteh Moradi 2015).

Most studies on feeding diet of salmonids have been focused on a specific level of population, suggesting wide changes of feeding composition among populations (Kara & Alp 2005). Salmonids feed on a broad range of food sources including aquatic insects, crustaceans and fish (Becker, 1983) but as visual predators prefer benthic invertebrates (Nilsson 1975; Larson & Moore 1995). The most important features responsible for diet composition of both rainbow trout and brown trout are habitat (Bridcut & Giller, 1993), season (Knutsen et al. 2001), prey availability (Kara and Alp, 2005), ontogeny (Knutsen et al. 2001) and gender (Johnsson et al. 2001).

Brown trout (*Salmo trutta*) is regarded as an ecologically and recreationally important species, distributed in a west area from Aral Lake River basin to Island in Europe and also from North Norway and Russia to North Africa (Bernatchez 2001). Because of

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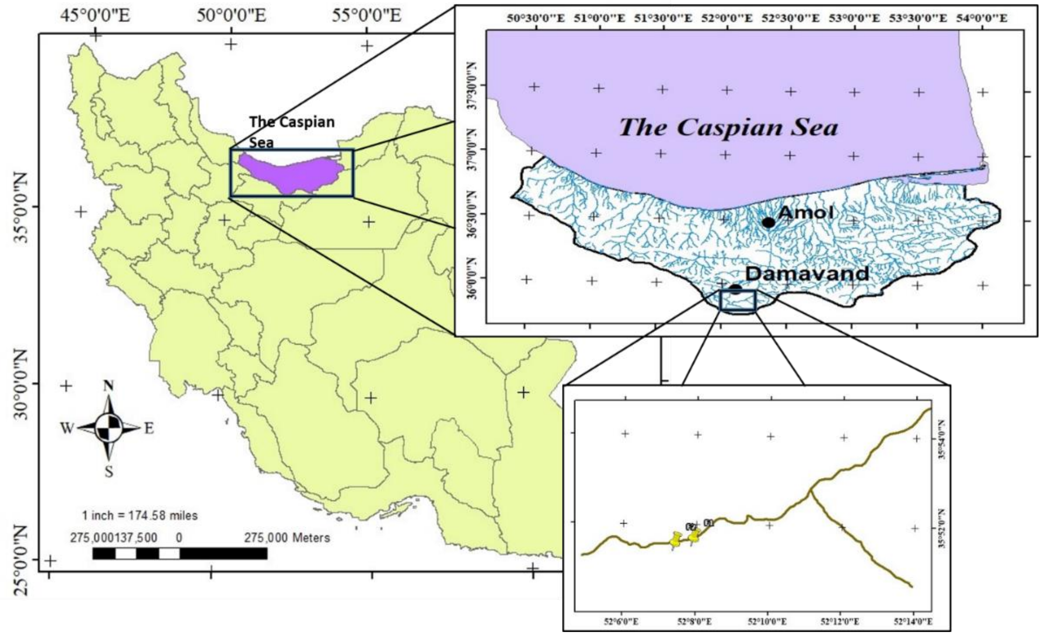

Fig.1. Sampling location in the uppermost of the Emamzadeh Ali Lake in Haraz River.

high biological and morphological adaptations, brown trout is typically found in lakes and rivers in migratory form at three basins of the Caspian Sea, Urmia Lake and Namak Lake basin of Iran (Keyvani et al. 2016). Conservation and restoration of the brown trout stocks in their territory through management and scientific methods can contribute to considerably improve the tourism industry of the country (Abdoli 2000).

Rainbow trout (*Oncorhynchus mykiss*) is a farming and tasty fish, broadly introduced to cold waters of the world, including Iran. Annually, millions of rainbow trout are raised in farms in the Caspian Sea basin among which some may escape from farm facilities and enter the surrounding natural environments (Abdoli & Naderi 2008). Scaped rainbow trout compete with the native species of the brown trout (Coad & Abdoli 1993).

Haraz River is one of five protected rivers in Iran and known as one of main hub of cold-water fish's aquaculture in the country, which annually exports a great amount of farmed trouts. Unfortunately, the flow of fish farms waste water into the river along with escaped rainbow trout to the habitat of the native brown trout have altered the water quality and its fauna and flora. This is likely to be the reason for the brown trout decline in Haraz River (Banagar et al. 2008).

Investigation on feeding diet and food niche overlap of different fish species have been conducted around the world (Lucas 1993; Dineen et al. 2007; Coghlan et al. 2007; Sánchez-Hernández et al. 2011; Anderson et al. 2016; Johnson et al. 2017a,b; Mumby et al. 2018). Despite the development of rainbow trout fish farming in marginal parts of most rivers located in Iran, especially in rivers where the native and valuable brown trout inhabits, ecological and biological characteristics of these species are less studied or at least one of the species has been surveyed alone in some areas (Khara et al. 2009; Salavatian et al. 2010; Rajabi Nejad et al. 2010; Abdoli & Mirdar 2013; Azizi et al. 2015; Salavatian et al. 2016; Salavatian et al. 2018). Thus, this study aims to compare feeding indices of the resident rainbow trout and the brown trout populations in Haraz River and to investigate their feeding competition as well.

MATERIAL AND METHODS

Study area: Haraz River is located in north slopes of the Alborz mountain range with 185 km length and 4060 km^2 area (Afraii et al. 2014). Fish sampling was seasonally conducted at the uppermost river near the Emamzadeh Ali lake to 1 km long due to the most likely presence of both trouts using an electrofishing (100-200 V and 1.5 A) from October 2018 to July

2019 (Fig. 1).

Measurement of Water physiochemical parameters: Physiochemical parameters including temperature, electrical conductivity, dissolved oxygen, and pH were measured using a water checker (Az. Instrument Company, Thailand). Water velocity was recorded using a flow meter.

Macrobenthic sampling: To investigate nutritional relationships, a surber sampler was applied by which macrobenthic communities were collected from river substrate. After rinsing with tap water, benthic samples were fixed in 4% formalin solution and then identified using a valid identification key (Tachet 2010).

Fish sampling and biometric indices: Regarding the protection importance of the brown trout in Haraz River, only 20 samples were caught at each sampling occasion, but rainbow trout sampling was unlimited. An anesthetic solution was used before fixing the samples in formalin solution. Fish biometric indices of total length and digestive tract length were measured using a digital caliper ruler with an accuracy of 0.01mm. Body and digestive tract weighted using a digital scale with an accuracy of 0.01g. Their digestive tracts were cut under a binocular microscope and food items eaten were identified and counted as much as possible. Sex determination of fish samples was visually performed by abdominal incision.

Coeffient of Vacuity (CV): The coeffient of vacuity (CV) was obtained according to the following formula:

$$CV(\%) = \frac{E_s}{T_s} \times 100$$

Where E_s and T_s were the number of empty stomachs and total examined stomachs, respectively. Based on CV index, larger values show less feeding and ranges as $0 \leq CV < 20$ for edacious species, $20 \leq CV < 40$ for relatively edacious species, $40 \leq CV < 60$ for moderate feeder, $60 \leq CV < 80$ for relatively abstemious, and $80 \leq CV < 100$ for abstemious (Euzen 1978).

Relative Length of Gut (RLG): Relative Length of Gut (RLG) reveals different diet types as (1) carnivorous when RLG<1, (2) herbivorous when RLG>1 and (3) omnivorous when RLG=1. The following formula was used for the calculation of RLG (Biswas, 1993):

$$RLG = {}^{GL}/_{TL}$$

Where GL and TL were the length of digestive tract and total body (cm), respectively.

Fullness index (FI): fullness index (FI) was calculated as the following formula:

$$FI = \frac{w}{W} \times 10^4$$

Where w is the weight of digestive tract content (g) and W is total weight (g) (Biswas 1993). When FI is between 400 to 900, it shows a normal feeding condition while more or less values reveals an undesirable feeding condition.

Stomach fullness: The stomach fullness was assessed using a five-point scale method and a percentage scale ranging from empty stomach (0%) to full stomach (100%) (Amundsen et al. 1996). Food items were removed and identified to the lowest taxonomic level as long as possible.

The diet composition was calculated in terms of percent abundance (A_i) and prey-specific abundance (P_i) following (Amundsen *et al.,* 1996):

$$A_i = \left(\frac{\sum S_i}{\sum S_t}\right)100$$

$$P_i = \left(\frac{\sum S_i}{\sum St_i}\right)100$$

where S_i is the contribution of prey i to stomach fullness; St_i is the total stomach fullness of fish with prey i in their stomach; S_t is total stomach fullness of the fish; N_i is the number of fish with prey i in their stomach; and N is total number of fish with stomach contents.

Ivlev's selectivity index (E): Ivlev's selectivity index is applied to examine the ontogenetic feeding selectivity and calculated using the following equation:

$$E = {}^{(r_i - p_i)}/_{(r_i + p_i)}$$

Where electivity (E) for each benthic category i was calculated from the proportional availability of that benthic category (p_i) in the field and the proportional of feeding bites on that benthic category (r_i). The value of E varies from −1.0 to +1.0 where negative values,

Table 1. Water physiochemical parameters in uppermost of the Emamzadeh Ali Lake (Haraz River).

Property	Autumn	Winter	Spring	Summer
Temperature (°C)	7.5	9.3	13.5	13.1
pH	8.33	8.3	8.1	6.52
Oxygen (mg/l)	9.5	8.5	9.8	9.7
Electrical conductivity (µmho/cm)	1.526	0.596	0.338	0.36
Velocity (m/s)	1.208	1.176	-	-

zero and positive values indicate avoidance, random selection, and active selection, respectively (Pereira et al. 2016).

Hurlbert niche breadth: Hurlbert niche breadth is applied for various species feeding on specific food sources, and more values suggest larger niche breadth (Adams, 2002). The following equations were used for the calculation of niche breadth:

$$B' = \frac{1}{\sum(\frac{P_j^2}{\hat{a}_j})}$$

$$B_A = \frac{B' - a_{min}}{1 - a_{min}}$$

Where B': Hurlbert niche breadth; P_j: Proportion of individuals found in or using resource j; a_j: Proportion of total available resources consisting of resource j; B'_A: Hurlbert standardized niche breadth; a_{min}: the smallest observed proportion ratio of all resources (minimum a_j).

Morisita's index of niche overlap: Morisita's index of niche overlap was calculated as the following formula:

$$C = \frac{2\sum_i^n P_{ij}P_{ik}}{\sum_i^n P_{ij}\left[\frac{(n_{ij}-1)}{(N_j-1)}\right] + \sum_i^n P_{ik}[\frac{(n_{ik}-1)}{(N_k-1)}]}$$

Where C: Morisita's index of niche overlap between species j and k; P_{ij} and P_{ik}: Proportion resource i is of the total resources used by species j and k; n_{ij}: Number of individuals of species j that use resource category i; n_{ik}: Number of individuals of species k that use resource category i; N_j and N_k: total number of individuals of each species in a sample (Adams, 2002).

Percentage overlap: The following equation was applied to calculate the percentage overlap:

$$P_{jk} = [\sum_{i=1}^{n}(minP_{ij}, P_{ik})] \times 100$$

Where P_{jk}: Percentage overlap between species j and species k; P_{ij} and P_{ik}: Proportion of resource i and the total resources used by species j and k, respectively; n: Total number of resource states (Adams 2002).

Statistical analysis: Data normality and homogeneity of variances were checked using a Kolmogrove-smirnov test and Leven′s test, respectively. An independent sample t-test was applied to compare RLG, FI, and length and weight data between salmonids. All statistical analysis was done by statistical software package of SPSS 26.

RESULTS

The water physiochemical parameters were seasonally measured in the study area (Table 1). The water temperature was between 7.5–13.5°C in different seasons. Excepting summer, pH was almost normal in all seasons. The amount of dissolved oxygen was more than 8.5 mg/l in all seasons. The lowest and the highest values of electrical conductivity in different seasons were 0.3 and 1.5, respectively. Water velocity was not measurable since the flow meter was not calibrated in spring and summer, therefore water velocity was not measurable. Even though the river was flooding in spring due to snow melting and heavy rainfalls.

The identified macrobenthic invertebrates in the studied area and seasons were belonged to 20 taxon and orders of Diptera (5 families), Trichoptera (4 families), Ephemeroptera (6 families), Coleoptera (1 family), Amphipoda (1 family), Aracnida (1 family) and Tricladida (2 families). Mean macrobenthic abundance varied among seasons with the highest abundance at autumn (1619 ind./sample) and was in a descending order as 1008, 395 and 237 (ind./sample) in winter, summer and spring, respectively. According

Table 2. Macrobenthic Density (m^{-2}) in the uppermost of the Emamzadeh Ali Lake (Haraz River).

Order	Taxon	Autumn		Winter		Spring		Summer	
		Abundance	%	Abundance	%	abundance	%	abundance	%
Trichoptera	Hydropsyche	7837	45.03	4676	43.15	140	5.54	709	16.69
	Rhyacophila	107	0.61	86	0.79	11	0.44	-	
	Glossosoma	64	0.37	-		-		97	2.28
	Branchiocentrus	11	0.06	75	0.69	-		11	0.26
Ephemeroptera	Baetis	1623	9.33	441	4.07	161	6.38	1387	32.66
	Acentrella	4730	27.18	1462	13.49	333	13.19	602	14.17
	Rhythrogena	75	0.43	-		150	5.94	-	
	Epeorus	247	1.42	-		75	2.97	-	
	Ephemerella	-		-		-		-	
	Caenis	-		-		-		-	
Diptera	Simulium	54	0.31	-		-		161	3.79
	Pediicini	86	0.49	54	0.5	21	0.83	86	2.02
	Chironomidae	2419	13.9	4042	37.3	1483	58.73	1075	25.31
	Liponeura	-		-		11	0.44	-	
	Blepharicera	-		-		43	1.7	-	
Coleoptera	Limnius	-		-		-		11	0.26
Amphipoda	Gammarus	11	0.06	-		-		-	
Arachnida	Hydracarina	-		-		11	0.44	11	0.26
Tricladida	Tetraedra	97	0.56	-		54	2.14	54	1.27
	Planaria	43	0.25	-		32	1.27	43	1.01

Table 3. Abundance, sex ratio, mean length (mm) and weight (g) of the trouts caught in uppermost of the Emamzadeh Ali Lake (Haraz River).

	season	abundance	sex ratio Male:female:unrecognizable	Mean length ±SD	Mean weight ±SD
Salmo trutta	Autumn	19	10:4:5	142.36±6.8	43.34±3.9
	Winter	12	8:2:2	130.31±8.3	33.27±8.1
	Spring	15	10:5:3	129.21±2.5	28.15±9.4
	Summer	13	6:4:3	121.43±5.4	30.37±6.2
Oncorhynchus mykiss	Autumn	1	1:0:0	86.4	13.6
	Winter	3	2:1:0	171.9±7.6	119.149±8.9
	Spring	6	3:1:2	195.125±4.9	198.376±8.1
	Summer	10	0:3:7	305.129±5.3	600.742±6.8

to density index during the sampling time, orders of Trichoptera and Ephemeroptera in autumn were dominant but Trichoptera, Ephemeroptera and Chironomidae from Diptera were dominant in winter (Table 2).

During sampling time, the number of catched male, female, and unrecognizable brown trout samples were 14, 15 and 30, respectively whereas 5 females, 9 males and 6 unrecognizable samples of rainbow trout were caught. Total length of the brown trout ranged from 99 to 221mm and their weight range was from 13.5 to 141.4g. No significant differences were observed in mean weight and length of the brown trout between males and females during the whole sampling period (P>0.05). Rainbow trout caught in Haraz River were in the length range of 141 to 541mm and weight range of 65.8 to 2225.3g. T-test indicated no significant difference between male and female rainbow trout weights (P>0.05) but a significant difference between their lengths was observed (P<0.05) (Table 3).

Males and females of the both salmonids were edacious based on CV index which was calculated 10.52 for rainbow trout and 3.38 for the brown trout. RLG were <1 for males and females of both species from all age groups at each season, implicating their carnivorous diet. Mean comparison of RLG between male and female specimens of both trouts showed no significant difference (P>0.05). Results of FI or

Table 4. The abundance percentage of organisms swallowed by the trouts at each season in the uppermost of the Emamzadeh Ali Lake (Haraz River).

Food item	*Salmo trutta*				*Oncorhynchus mykiss*			
	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
Ephemeroptera	72.48	51.25	35.88	55.94	61.53	31.65	13.68	11.44
Trichoptera	21.70	34.05	21.93	2.40	30.76	30.27	56.93	5.37
Chironomidae	0.77	11.82	14.62	10.20	7.69	3.21	5.65	1.63
Simulidae	-	0.35	3.06	2.28	-	-	6.56	2.33
Plecoptera	-	0.35	0.34	1.20	-	0.91	0.36	0.23
Worms	0.38	0.71	4.25	0.84	-	11.00	-	4.67
Gammarus	4.65	0.71	1.02	13.20	-	0.91	0.36	29.90
Coleopteran	-	0.35	0.68	0.24	-	-	1.64	0.23
Fish egg	-	-	-	-	-	21.55	-	39.95
Terrestrial insects	-	0.35	18.19	13.68	-	0.45	14.78	4.20

Table 5. Ivlev feeding selection index of the trouts at each season in the uppermost of the Emamzadeh Ali Lake (Haraz River).

Food item	*Salmo trutta*				*Oncorhynchus mykiss*			
	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
Ephemeroptera	0.3	0.48	0.09	0.08	0.23	0.28	-0.36	-0.6
Trichoptera	-0.35	-0.13	0.57	-0.77	-0.19	-0.19	0.81	-0.56
Chironomidae	-0.89	-0.51	-0.6	-0.42	-0.28	-0.84	-0.82	-0.87
Simulidae	-1	1	0.56	-0.24	-1	-	0.77	-0.23
Plecoptera	-	1	1	1	-	1	1	1
Worms	-0.53	0.18	-0.09	-0.68	-1	0.91	-1	0.01
Gammarus	-0.97	1	1	1	-1	1	1	1
Coleopteran	-	1	1	-0.02	-	-	1	-0.04
Fish egg	-	-	-	-	-	1	-	1
Terrestrial insects	-	1	1	1	-	1	1	1

Table 6. Hurlbert niche breadth and niche overlap of the trouts in the uppermost of the Emamzadeh Ali Lake (Haraz River).

	Autumn	Winter	Spring	Summer
rainbow trout	0.54	0.42	0.24	0.71
brown trout	0.18	0.19	0.4	0.22

Table 7. Morisita niche overlap index and percentage overlap of the trouts in the uppermost of the Emamzadeh Ali Lake (Haraz

	Autumn	Winter	Spring	Summer
Morisita index	0.97	0.83	0.69	0.35
Percentage Overlap	84.01	67.28	60.5	36.48

fullness index reflected a desirable condition for the brown trout but an undesirable condition for rainbow trout. Ephemeroptera had the maximum abundance among the organisms (%) swallowed by the brown trout at all seasons and by rainbow trout at cold seasons of autumn and winter but Trichoptera and fish eggs (most likely belonged to the brown trout) had the maximum abundance at spring and summer, respectively, in rainbow trout′s stomach (Table 4).

In this research, results of E_i in the brown trout specified that Ephemeroptera, Gammarus, Plecoptera and terrestrial insects were the selective preys at all studied seasons but Chironomids, worms and Trichoptera were the emergency preys. By contrast, rainbow trout samples studied here hunted Plecoptera, Gammarus and tresstrail insects as main and selective preys but Chironomids and Simulidae were hunted as emergency preys (Table 5). Rainbow trouts showed a wider niche breadth than that of the brown trout in autumn, winter and summer, except for spring when a bigger feeding niche breadth was recorded for the brown trout (Table 6). Based on Morisita niche overlap and percentage overlap results, both salmonids inhabiting the Haraz River had the most niche overlap in autumn and winter, used the same common resources (Table 7).

DISCUSSION

The larvae of aquatic insects were the dominant fauna of microbenthic communities in the study area of the present research. In this regard, several researchers pointed out to the dominance of aquatic insects in the composition of macrobenthic communities (Lenat 1993; Loch et al. 1996; Pipan 2000; Pillary 2007). The study area in this investigation is mountainous; hence aquatic insect's larvae were the dominant macrobenthic fauna of Haraz River which was compatible with the previous findings. Moslemi (1998) found that Ephemeroptera, Plecoptera, and Diptera as dominant microbenthic communities in Tonekabon River all the year around. Abundances of the aquatic insects varied significantly among different seasons and declined specifically in spring which might be attributed to fish feeding on the insect larvae, metamorphosis of larvae into adult insects, flooding and increased river water flow, since the negative correlation between river discharge with insect abundance might reflects the prevention effect of increased water flow on the settlement of benthic organisms in the substrate.

As stated by Banagar et al. (2008), a remarkable number of non-native rainbow trout have escaped the fish farms centers which intensively produce the trouts with poor fish farm management program and consequently were settled in the parts of Haraz River which has been designated as protected area. But in recent years, the number of rainbow trouts decrease compare to the brown trout at all seasons as also indicated in this research, presumably due to the following reasons: problems encountered by rainbow trout farming industry like closed fish farms near the river, more accurate management of the outlets in fish farming centers to prevent fish escape, as well as more recreational fishing of rainbow trout in the Haraz river which was encouraged by the Department of the Environment and training program of local fishermen by NGOs to capture and remove the rainbow trout which is a non-native and probably invasive species in this region.

The abundance of brown trout were almost equal in different age and sex groups at all seasons, as age group of 0^+ was considerably abundant, indicating that these juveniles were propagated in the last spawning season. Overall, the abundance of age group 0^+ was more than other age groups at all sampling periods. This might be due to the catch tool, sampling time, topography of the selected region and a decline in abundance of the competitor species i.e. rainbow trout, suggesting that the brown trout population inhabiting the uppermost of the Emamzadeh Ali Lake in Haraz River is young.

In this investigation, RLG<1 implicates a carnivorous diet for both salmonids which is in accordance with the study of Abdoli & Mirdar (2013) on rainbow trout inhabiting Madarsou River of Golestan National Park and previous studies of Khara et al. (2009), Salavatiyan et al. (2010), Salavatiyan et al. (2016) and Rajabi Nejad et al. (2010) on the brown trout.

For rainbow trout, the vacuity index (VI) was 0 at all sampling periods which is compatible with the results of Abdoli & Mirdar (2013) who reported rainbow trout as a voracious species in Madarsoo River of Golestan National Park. The little differences observed in this work with the previous study by Abdoli & Mirdar (2013) is principally might be due to rainbow trouts escape from fish farming centers which fed a considerable amount of foods in captivity. But rainbow trout samples which were introduced to Madarsoo River of Golestan National Park in 1967 (Kiabi *et al.,* 1994) fed on natural foods in river for several generations.

The vacuity index (VI) for the brown trout studied here showed an overeating condition as previously Khara et al. (2009), Salavatiyan et al. (2010) and Salavatiyan et al. (2016) indicated red-spotted trout as a voracious species. This might be attributed to the constant availability of preys mostly aquatic insects for the trout (Euzen 1978), possible feeding on teresstrail insects (Alpe et al. 2005) and their non-stop feeding even during the spawning season.

The number of taxon identified in trout guts studied here were from 10 different food groups, implicating both trouts as euryphagus species in the study area. More than 90% of the food items eaten by both trouts were the same, although the number of eaten taxon in this study were less than other results previously reported by Abbasi et al. (2004) and Khara et al. (2009) which might be due to the lower number of trout samples investigated here, less abundance of macrobenthic invertebrates in the study area and lower identification level of the eaten items in the present work.

In this research, Ephemeroptera, Trichoptera, Chironomids and Amphipoda were discovered at all sampling seasons in both trout guts as reported by other previous works, which confirms a remarkable presence of Ephemeroptera and Trichoptera in trout samples′ stomachs (Modabber 1997; Alipour 1988; Fakharzade et al. 2008). More notably, their feeding habit is generally selective and remarkably consume on more abundant and obvious preys than others as Kelly- Quinn and Bracken (1990) revealed that both older red spotted and rainbow trouts feed on larger prey.

FI of the Caspian trout varied significantly among different seasons as their FI was undesirable in autumn but increased to a favorable limit in winter. This is probably due to reproductive migrations of brood stocks with less feeding rate during autumn and resumption of nutrition after reproduction in winter which raised their FI. Furthermore, fish growth is dependent on food quality and quantity, food in-take and water temperature which the latter affects fish metabolism and energy consumption (Shepherd & Bromage 1990). Therefore, FI raises in warm season (summer) with increased water productivity and live food organisms but decreases by a drop in temperature at cold season (autumn) (Valipour 1996).

Ivlev index of rainbow trout samples revealed that the selective prey varies among different seasons. Nikolsky (1963) believed that each predator select any food item based on its abundance in the environment. In addition, feeding rate depends on factors such as nutritional substrate, season, temperature, and distribution pattern and prey abundance. Besides benthic invertebrates, rainbow trout feeds on terrestrial insects probably drifting on or flying near water surface, its own eggs and red spotted eggs in the spawning season (autumn) as well, which the latter is a risk for the native population of red spotted trout in Haraz River. Also, rainbow trout shares the same habit of feeding with the brown trout and is regarded as a feeding competitor. As previously approved, female rainbow trouts feed on fish eggs when getting older, presumably due to their mouth size and food requirements.

The main objective of studies investigating feeding niche overlap is to determine common niche of the species which should be done by identifying the geographical location of any species and their contribution in ecological niche. As stated by Agren & Fagerston (1984), if food competitors differ among their ecological niche, they could survive along food source gradient, but if they use their own ecological niche in a similar way and act as equal competitors, they could co-exist in high ecological niche overlap. In this research, both trouts showed a remarkable feeding niche overlap at all studied seasons, specifically at autumn when rainbow trout had a wider niche breadth than that of the brown trout. This is might be related to the fact that both trouts show similar food preferences in autumn and almost more exclusively feed on Ephemeroptera. This is in accordance with findings reported by Di Pirnzio & Casaux (2012) on rainbow trout and catfish (*Hatcheria macraei*) in two rivers of Argentina.

Feeding niche overlap varied substantially between both trouts at the studied area here during the year, which might be reflected from changes in food source availability (Di Prinzio & Casaux 2012). However, Barrera Ora (2003) suggested that when food niche overlap is highly seen between species, their competition rate is less because of high abundance of the main prey; thus feeding niche breadth of each population depends mostly on feeding strategies of its individuals during the year.

Considering the results presented here, it is difficult to quantify the influence of the non- native rainbow trout on the native brown trout in Haraz River but more studies on feeding competition between native and non-native species inhibiting in a single riverine ecosystem like Haraz River can help understand ecological processes relating to the introduction of a native species.

CONCLUSION

Investigating diet composition of the salmonids in the studied area showed that Ephemeroptera are the main food and both trouts have a similar diet at various seasons unless diversity of microbenthic community and their availability in the habitats significantly vary. As a non-native species, rainbow trout can be potentially a serious threat to the Caspian trout populations which is a valuable and protected species in Haraz River because rainbow trout highly overlaps in feeding niche and has basic similarities in feeding habits with the brown trout at most seasons of the year and also feeds on their eyed-eggs at reproduction season.

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مقاله کامل

بررسی فصلی رژیم غذایی، پهنا و هم‌پوشانی آشیان غذایی بین دو گونه ماهی قزل‌آلای خال قرمز بومی (*Salmo trutta*) و قزل‌آلای رنگین‌کمان غیربومی (*Oncorhynchus mykiss*) در رودخانه هراز استان مازندران

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چکیده: ترکیب رژیم غذایی و استراتژی تغذیه‌ای دو گونه ماهی بومی و غیر بومی قزل‌آلا از پاییز ۱۳۹۷ تا تابستان ۱۳۹۸ در منطقه بالادست دریاچه امامزاده علی در رودخانه هراز مورد مطالعه قرار گرفت. در مجموع ۷۹ قطعه ماهی از گونه بومی قزل‌آلای خال قرمز *Salmo trutta* (۵۹ قطعه) و گونه غیربومی قزل‌آلای رنگین‌کمان *Oncorhynchus mykiss* (۲۰ قطعه) صید شد. بررسی محتویات دستگاه گوارش کلیه نمونه‌های صید شده نشان داد که استراتژی تغذیه‌ای ماهیان قزل‌آلا در این رودخانه براساس بی‌مهرگان بزرگ کفزی می‌باشد. شاخص‌های تغذیه‌ای شامل CV (درصد خالی بودن دستگاه گوارش)، RLG (طول نسبی دستگاه گوارش) و IF (شدت تغذیه)در دو گونه قزل‌آلای نشان از پرخوری، گوشت‌خوار بودن و وضعیت تغذیه مطلوب این گونه در تمام فصول نمونه‌برداری داشت. بررسی شاخص پهنای آشیان عذایی دو گونه مورد مطالعه نشان داد که در فصول پاییز، زمستان و تابستان پهنای آشیان غذایی ماهی قزل‌آلای رنگین بزرگ‌تر از گونه قزل‌آلای خال قرمز بوده و فقط در فصل بهار نیچ آشیان گونه قزل‌آلای خال‌قرمز پهنای بیش‌تری داشت. در کل، پهنای آشیان غذایی گونه قزل‌آلای رنگین‌کمان بیشتر از قزل‌آلای خال قرمز برآورد شد. بررسی هم‌پوشانی آشیان غذایی دو گونه براساس شاخص موریسیتا نشان داد که در فصول پاییز و زمستان بالاترین میزان هم‌پوشانی را داشته و از منابع غذایی مشترکی تغذیه نمودند. درصد هم‌پوشانی نیز در این فصول بیشترین میزان درصد هم‌پوشانی را داشتند که در تمام فصول مورد مطالعه مشابه نتایج معیار هم‌پوشانی موریسیتا بود.

کلمات‌کلیدی: رژیم غذایی، همپوشانی آشیان، پهنای آشیان، رودخانه هراز، قزل‌آلای رنگین‌کمان، قزل‌آلای خال‌قرمز.