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Habitat suitability index of *Barbus cyri* (Heckel, 1843) in Tootkabon River, the South Caspian Sea basin, Iran

H. Asadi[1]*, M. Sattari[1,3], S. Eagderi[2]

1- Department of Fisheries, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Guilan, Iran.

2- Department of Fisheries, Faculty of Natural Resources, University of Tehran, Karaj, Iran.

3- Department of Marine Sciences, The Caspian Sea basin Research Center, University of Guilan, Rasht, Iran.

** Corresponding author's E-mail: asadi.shil@gmail.com*

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ABSTRACT

Knowledge of habitat requirements of aquatic animals plays an important role in fisheries and protection programs of aquatic ecosystems. Hence, this study was conducted to investigate the suitability indexes of habitat use and habitat suitability index (HSI) of *Barbus cyri* in its distribution range in Tootkabon River. A number of environmental variables, including elevation, water depth, river width, river slope, velocity, substrate type, and average diameter of bed stone, riparian vegetation type and the relative abundance of *B. cyri* at 13 stations and three replications from the downstream to upstream were examined during November 2013. The results showed that *B. cyri* mostly selects upper stretches of the river with higher velocity, middle depth, lower width and bed rock substrate i.e. bed with boulder cover and grasslands and also its residential area is of riparian type compared with the available ranges. Habitat selectivity index for *B. cyri* showed that the elevation is 130-220 m, water depth 18-75 cm, channel width less than 12 m, channel slope 0.5-2.3%, water velocity less than 0.8 $m.s^{-1}$, bed rock substrate, average diameter of bed stone larger 15-50cm. Presence of these conditions with HSI of 0.798 indicates that Tootkabon River is an excellent habitat for *B. cyri*.

Key words: Habitat selection, Suitability index, *Barbus cyri*, Tootkabon River.

INTRODUCTION

Changes of the hydrological features in a riverine ecosystem by anthropological activities such as habitat destruction can negatively affect survive, reproductive success and growth rate of aquatic organisms particularly fish species (Rosenfeld, 2003, Ahmadi-Nedushan *et al*. 2006) threatening their survival.

Therefore, as first step to assess the impact of human activity on riverine ecosystem and protection of their biodiversity, understanding the habitat requirements of its organism is crucial (Vinagre *et al*. 2006). Hence, Habitat Suitability Indices (HSI) of an aquatic species is one of the primacy themes in river ecology to predict the effect of human manipulation due to the alternation of the riverine hydrological features (Guay *et al*. 2000). Hydrological characteristics of a river play an important role in fish distribution affecting their metabolism rate, feeding and behavior (Jowetl *et al*. 2007). Habitat selection means that a fish species is more abundant in a specific habitat which is suitable (Rosenfeld 2003). Many environmental factors are important to affect fish in selecting its preferred habitat (Bovee 1982).

Nevertheless, most of the models to study the habitat suitability of an riverine species use the hydrological parameters such as depth, current velocity, river width, type of river bed, river slope, elevation, and river vegetation (Orth 1988) as important factors.

Kura barbel, *Barbus cyri* (De Filippi 1865) is a cyprinid species native to the Caspian Sea basin (Esmaeili *et al*. 2014a, b). This species bears a fusiform body shape, small scales, inferior mouth, and thin lips with two pairs of barbels (Fig. 1). Berg (1948-1949) refers Caspian Sea basin specimens to *Barbus lacerta cyri*, but this subspecies recognized as a valid species by Naseka & Bogutskaya (2009).

Little information is available regarding biology and ecology of *B. cyri*, particularly its habitat use and habitat suitability indexes are unknown. Therefore, this study was conducted to assess the habitat use and habitat suitability indexes of *B. Cyri* with respect to habitat availability of this species in Tootkabon River, a branch of the Sefidrud River in the Southern Caspian Sea basin.

Fig. 1. *Barbus cyri* caught from Tootkabon River.

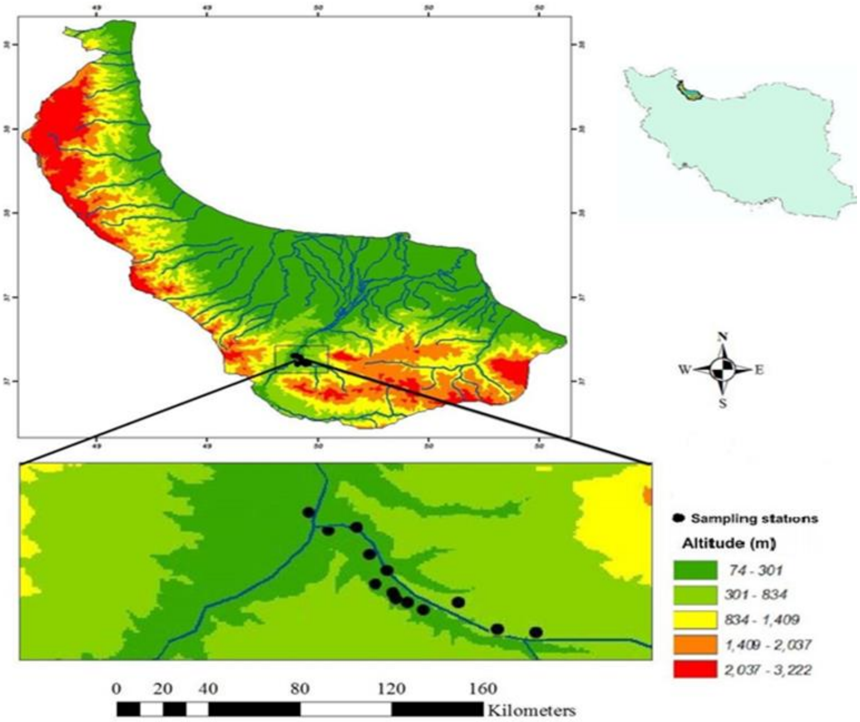

Fig. 2. Location of Alborz Province, Tootkabon River and sampling points.

Table 1. Explanation and abbreviation for each categorical habitat variable.

Substrate (mm)		Riparian vegetation type	
Bedrock	>4000	BV	Deciduous forest
Boulder	256-4000	BM	Deciduous forest and residential area
Cobble	64-265		
Pebble	16-64		
Gravel	2-16	A	Grasslands or herbs
Sand	<2	BA	Largely no vegetation

MATERIALS AND METHODS

Study area

Tootkabon River is a branch of the Sefidrud River in the Southern Caspian Sea basin, originates from the Alborz Mountains. The approximate length of this river is 23 km with an average slope bed of 6.1% (Fig. 2).

Sampling

For this study, we sampled fish and habitat variables in autumn 2014 during base flow conditions. Thirteen sampling stations were located across the Tootkabon River (Guilan Province, north of Iran) (Fig. 1). The elevation (m) and geographic coordinates were recorded for each station to ±10 m using GPS (Global Positioning System; Garmin) according to Torgersen & Close (2004).

The river and the sampling point locations were mapped using ArcGIS 9.3 (Fig. 1).

Fish were sampled in 10-15 m stretches of the river using a backpack electrofishing device (Samus Mp750, 45cm diameter, aluminium ring anode) in the downstream–upstream direction using upstream and downstream stop-nets of 0.2 cm mesh. For sampling, one-removal method with similar catch-per-unit effort strategy was employed (Klaar *et al*. 2004).

Fish specimens were collected from each station during 30 min, anesthetized in clove powder solution (1 $g.l^{-1}$), identified according to Coad (2015), counted, photographed, and finally placed in slow - moving water along the river bank to recover and return to the river.

Since no comparable study on microhabitat use of this species was available, therefore, only the specimens larger than 40 mm were selected and counted in each station for further analysis; because the habitat use of fishes in lotic systems can be strongly affected by ontogeny (Copp & Vilizzi 2004; Gillette *et al*. 2006).

Habitat Data

Since there is limited or no knowledge available on the studied species, the environmental variables were selected according to the results of other studies conducted on other fishes (Chuang *et al*. 2006; Rifflart *et al*. 2009; Tabatabaei *et al*. 2015). The habitat data were measured immediately after sampling (Yu & Lee 2002).

The measured variables included water depth (cm), river width (m), Elevation (m) river slope (%), velocity ($m.s^{-1}$), substrate type (substrate index), average diameter of bed stone (cm), and riparian vegetation type.

Elevation of sampling sites were recorded by GPS (Garmin).

The mean depth (cm) of each station was estimated by measuring depth at 20 random points across sampling site using a measuring bar, considering their average as the river depth (Lotfi, 2012).

The mean width of river (m) was measured using a tapeline by measuring upper, middle and lower sections of each sampling station, considering their average as the river width. The surface velocity ($m.s^{-1}$) was estimated by a simple float based on Hassanlie (1999), repeating three times to minimize the error. Dominant substrate type was determined both visually and randomly via measuring the diameter of the riverbed stones in 20 selected quadrate (50 × 50 cm) based on Lotfi (2012), and then classified according to Johnston *et al*. (1996) and Tabatabaei *et al*. (2015).

The bed stone diameter average also were calculated by measuring diameter of bed stones in 20 selected quadrate (50×50 cm) based on Lotfi (2012). Riparian vegetation type (based on the type of vegetation growing at riparian zone of the river or absence thereof), were classified according to our observations, photographs, and standard procedures with some modifications (Johnston *et al*. 1996). The first six variables were continuous, and riparian vegetation type was nominal. The abbreviation and description for each discrete variable are presented in Table 1.

Data analysis

Habitat use, availability, and selection were calculated over the range of each environmental variable. Each environmental variable was divided into a series of intervals, and the mean relative abundance of fish in each interval was calculated using habitat selection (Habsel) software 1.0 (Jowett, 2014). The formula S = (%Uc,i)/(%Ac,i), where i is the interval of a given environmental variable c, %Uc,i is the percentage of utilization of a specific interval of an environmental variable utilized by fish, and %Ac,i is the percentage of availability of this environmental variable (Guay *et al*. 2000; Waddle 2001; Tabatabaei *et al*. 2015), resulted in a selectivity value (S) at each interval. The selectivity values were then scaled, so that the maximum value was one. The mean selectivity values of each environmental variable (scaled to the maximum value of one) was considered as SI value of the variables at each station. Habitat Suitability Index (HIS) was calculated using following formula (Guay *et al*. 2000):

$$\text{HIS}= \sqrt[n]{SI\ Width \times SI\ Depth \times \ldots \times\ SIn}$$

In this formula, all variables of a habitat are considered essential and the product equation yields zero suitability for any given unsuitable habitat variable.

Since here is no data available regarding the value of each selected variable, therefore, in this research, the SI is multiply to obtain HIS.

RESULTS

All collected fish during sampling belonged to 8 species viz. *Barbus cyri*, *Capoeta graceless, Alburnus filipi, Cobitis keyvani, Ponticola iranicus, Ponticola cyrius, Alburnoides ssamiii* and *Oxynoemacheilus bergianus* which were returned to the river after identification and counting. A total of 144 specimens of *B. cyri* were collected. Habitat use, availability, and selection are presented in Fig. 3. Table 2 summarizes the average data obtained from each sampling station and environmental variables in the study area are shown.

Table 2. Minimum, Maximum, Mean and Standard deviation of variables used.

Variable	Min	Max	Mean	SD
Depth (cm)	15	72	34.71	17.44
Slop (%)	0.37	2.4	1.21	0.68
Width(m)	2.7	5.57	91.31	2.815
Velocity (m.s^{-1})	0.36	1.2	0.51	0.123
Stone D (cm)	4	48.1	20.05	12.65
Elevation	129	208	180.6	25.133

The studied habitats in Tootkabon River mostly occurred in an elevation range of 175-200 m above sea level, with 0.55-0.69 cm depth, 2.8-4.2 m width, 0.60-0.75 m.s^{-1} water velocity, slope of 0.5-1.75% and stone diameter of 25-30 cm, and cobble and then boulder substrate type, deciduous riparian forest, and with most available cover type of boulder (Fig. 2 and Table 3). The habitat-use pattern of *B. Cyri* generally followed habitat availability. Considering the availability of environmental variables and the selectivity, the habitat selection pattern of this species mainly had the following features: elevation 130-220 m, water depth 18-75 cm, channel width less than 12 m, channel slope 0.5-2.3%, water velocity less than 0.8 m.s^{-1}, bed rock substrate, average diameter of bed stone 15-50cm, and deciduous forest and residential area riparian type (Fig. 3). Suitability index values of environmental variables for *B. cyri* in Tootkabon River are shown in Table 4. Among of the variables studied, stone diameter had the most (0.81) and elevation (0.57) had the least amount. Calculation showed that the HSI river habitat suitability for *B. cyri* in Tootkabon River is 0.80. The results revealed that *B. cyri* mostly selected upper stretches of the river with higher velocity and bed rock substrate (Table 3).

Furthermore, this species selects lower depth and velocity, bed rock substrate i.e. bed with larger elements, deciduous forest and residential area riparian type, and boulder cover compared to the available ranges. In some cases, the pattern of habitat use was different from the pattern of habitat selection i.e. in water depth, river width and velocity.

Table 3. Mostly selected variables of *B. cyri*.

Variable	Slop (%)	Velocity(m.s^{-1})	Stone D(cm)	Width(m)	Depth(cm)	Elevation (m)
mostly selected	0.5-1.75	0.60-0.75	25-30	2.8-4.2	0.55-0.69	175-200

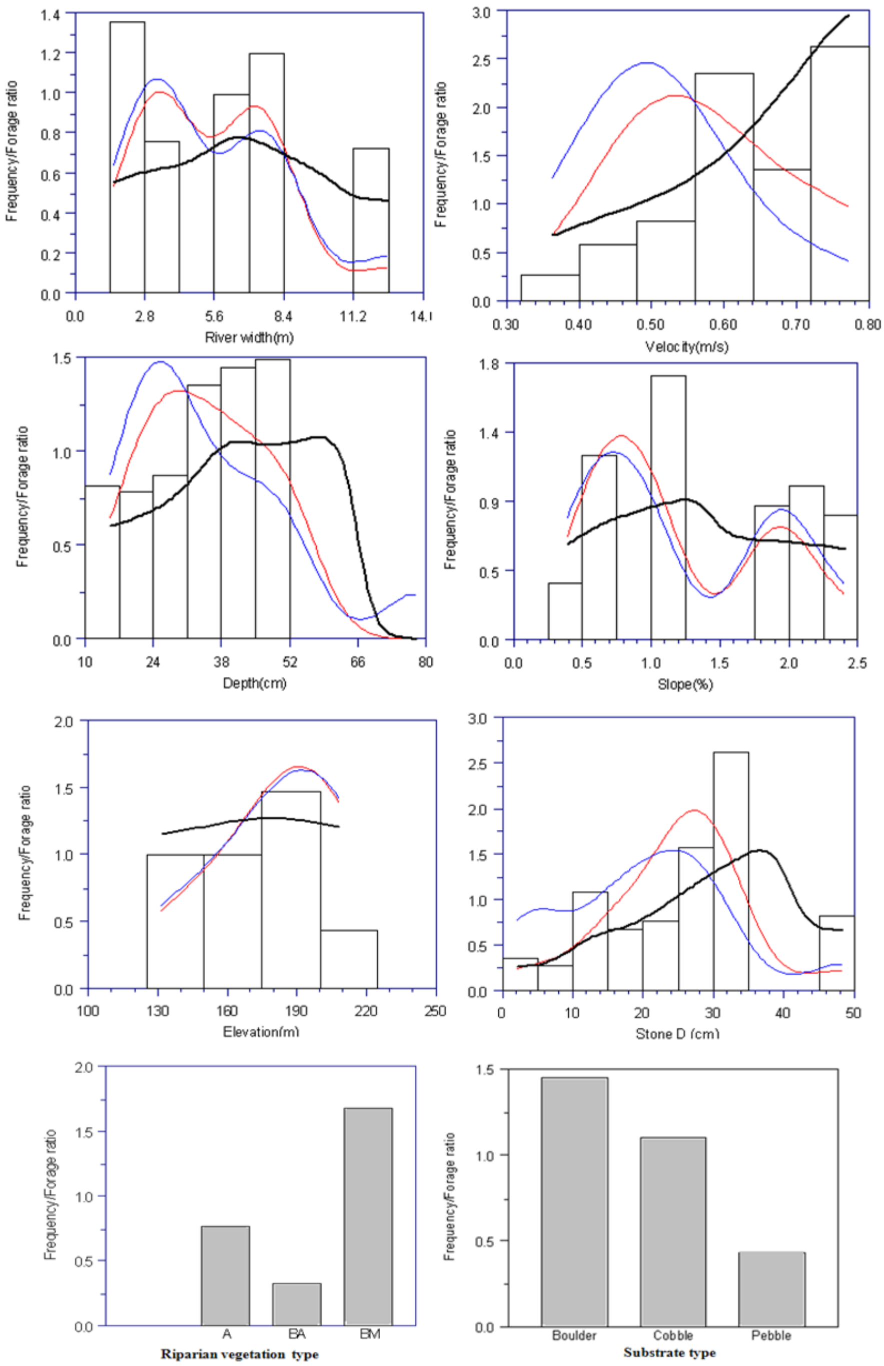

Fig. 3. Habitat availability (blue line), used (red line) and selected (black line) by *B. cyri* for environmental variables.

Table 4. Selected index for *B. cyri* in different stations.

Variable	Slop (%)	Elevation(m)	Velocity(m.s^{-1})	Stone D(cm)	Width(m)	Depth(cm)	HSItotal
SI	0.803	0.57	0.65	0.81	0.82	0.69	0.798

Table 5. Habitat suitability for *B. cyri* in different stations.

Station	1	2	3	4	5	6	7	8	9	10	11	12	13
HSI	0.29	0.65	0.84	9.67	0.63	0.7	0.97	0.81	0.56	0.45	0.41	0.64	0.34

DISCUSSION

The present study has provided the habitat use and environmental factors affecting the distribution of *B. cyri*, a native fish of Iranian inland waters, in Tootkabon River. In recent years, the industrial effluents in Tootkabon region have been caused the disposal of industrial effluents and chemical pollution of water resources (surface and groundwater) including Tootkabon River. Therefore, the findings of the present study can show the importance of some factors for effective management and protection of this native species. The fish tend to be in the water with a higher rate velocity and rocky bed. However, the preferred habitat of *Barbus* is middle - deep water with high velocity and medium - to large - sized substrates such as rock. The results of this study showed that the water flow rate is an effective factor in the presence and distribution of *B. cyri* in Tootkabon River. In the West Rivers of Taiwan, velocity rate was found to be an important variable influencing the populations of *Sinogastromyzon puliensis* (Shyi-Liang Yu *et al*. 2002) which is in line with our results. Water flow play as an important factor directly on the water and aquatic organisms and indirectly by food supply transfers (Ahmadi-Nedushan *et al*. 2006).

The results revealed that *B. cyri* mostly selects deeper reaches with the bed rock substrate and larger bed stones. In-stream habitat structures provide a variety of functions for stream fishes (Quist *et al*. 2005; Tabatabaei *et al*. 2015); cover features, provide protection from predators or ameliorate adverse conditions of stream flow or seasonal changes in metabolic costs and thereby influence fish survival and movement (MacKenzie & Greenberg 1998; Tabatabaei *et al*. 2015). In addition, deep body shape of this specie can help to rapid turning and maneuvering in tight quarters as deeper reaches with substrate consisting large bed rocks that provides dead spaces to establish proper habitat. Furthermore, substrate type can be important for fish spawning and feeding behavior (Quist *et al*., 2005; Tabatabaei *et al*., 2015). *B. cyri* mostly occupy area with lower river width i.e. less than 12 m. Researches showed that habitats with higher river width have little suitability for fishes such as *Varicorhinus barbatulus* (Littlejohn *et al*. 1985; Chuang *et al*. 2006). In addition, deeper reaches with lower current, less river width along with larger bed stones can provide transparent water to penetrate sunlight causing higher production of periphyton algae as main food items of the *Barbus* species (Treer *et al*. 2006). Habitat of *B. cyri* is an area with deciduous forest and residential area of riparian type. This can be due to providing organic matters that considered as base of the primary production in the riverine ecosystems (Wootton 1999).

The results of calculation of the HSI showed that almost the intermediate stations have higher amount of (= 1) HSI index. It can be deduced that the habitat of choice in the area between the rivers for Kura barbel is Tootkabon. The highest HIS index was at station 7 (0.97), while the lowest at station 1 (0.29). Presence of these conditions with HSI of 0.798 indicates that Tootkabon River provide an excellent habitat for *B. cyri* (Tables 4 & 5).

The limitations of using an electrofishing device (Yu & Lee 2002; Mercado-Silva *et al*. 2008), considering the limited sampling period and the variability of the habitat features within each station, may affect the efficiency of the sampling procedure. Fish habitat-use patterns may vary by changing the environmental conditions and be affected by seasonal patterns (Copp & Vilizzi 2004; Gillette *et al*. 2006). Seasonal patterns were not assessed here, but the habitat use and selection patterns of *B. cyri* are indicative of autumn. Therefore, we recommend investigation of the habitat use and preference patterns in other seasons as well.

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بررسی شاخص مطلوبیت زیستگاه سس ماهی کورا (*Barbus cyri*) در رودخانه توتکابن، حوضه جنوبی دریای خزر، ایران

ه. اسدی[1*]، م. ستاری[1]، س. ایگدری[2]

۱- گروه شیلات، دانشکده منابع طبیعی، دانشگاه گیلان، واحد صومعه سرا، ایران
۲-گروه شیلات، دانشکده منابع طبیعی، دانشگاه تهران، واحد کرج، ایران

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چکیده

در اجرای طرح‌های حفاظت از اکوسیستم‌های آبی و بهره‌برداری‌های پایدار وجود دانش کافی دربارۀ نیازهای زیستگاهی گونه-های آبزی اهمیت زیادی دارد. بنابراین، مطالعۀ حاضر با هدف شناخت ترجیح زیستگاهی و شاخص‌های مطلوبیت ویژگی‌های زیستگاهی گونه سس ماهی کورا (*Barbus cyri*) در محدودۀ پراکنش آن در رودخانۀ توتکابن انجام شد. برای بررسی ویژگی‌های زیستگاهی این گونه، فراوانی این ماهی و متغیرهای زیستی، شامل ارتفاع، عمق، عرض، سرعت جریان، قطر متوسط سنگ و دما با نمونه برداری از ۱۳ ایستگاه و با سه تکرار از پایین دست بسمت بالادست رودخانه توتکابن در آبان‌ماه ۱۳۹۲بررسی شد و محدوده زیستگاه انتخابی برای این گونه بدست آمد. با توجه به نتایج بدست آمده، شاخص‌های مطلوبیت زیستگاهی این گونه ارتفاع ۲۲۰-۱۳۰ متر، عمق در دامنۀ ۷۵-۱۸ سانتی‌متر، عرض از رودخانه کمتر از ۱۲ متر، شیب ۲,۳-۰,۵٪ ، سرعت کمتر از ۰,۸متر بر ثانیه، بستر سنگلاخی و میانگین قطر سنگ بستر در دامنۀ ۵۰-۱۵ سانتی‌متر قرار داشت. وجود این شرایط با شاخص مطلوبیت ۰/۷۹۸ نشان می‌دهد که رودخانۀ توتکابن برای گونۀ ماهی زردپر زیستگاهی بسیار عالی است.

* مولف مسئول