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Distribution pattern of *Alburnoides eicwaldii* in the Tootkabon River (Caspian Sea basin, Iran)

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Abstract
A fish species prefer a particular habitat which provides its biological requirements, hence, understanding their habitat use and preferences are crucial for their effective management and protection. This study was conducted to assess the habitat use and selection patterns of *Alburnoides eicwaldii*, an endemic fish in Tootkabon River, Caspian Sea basin, Iran. The river was sampled at 13 equally spaced sites. A number of environmental variables, including elevation, water depth, river width, river slope, velocity, substrate type, average diameter of bed stone, riparian vegetation type and the relative abundance of *A. eicwaldii* were recorded at each site. The results showed that *A. eicwaldii* mostly selects upper parts of the river with higher velocity, higher depth, lower width and slope, bed rock substrate i.e. bed with bedrock cover and grasslands and residential area riparian type compared with the available ranges. This study provides the habitat use and environmental factors affecting on the distribution of *A. eicwaldii* in the Tootkabon River.

Keywords: Habitat selection, Freshwater, Environmental variables, Spirlin fish

1. Introduction
Increasing anthropological activities particularly in riverine ecosystems have changed their physicochemical features threatening the survival of their inhabitants. Riverine ecosystems includes about 0.001% of water resources of our planet, nevertheless they include almost half of the fish species i.e. its species diversity is 7500 times greater than other aquatic systems in terms of fish biodiversity [11]. A fish species prefer a particular habitat which provides its biological requirements [29]. Many environmental parameters are considered to be important for influencing habitat preference of fish [34]. Hence, understanding their habitat use and preferences are crucial for their effective management and protection [26, 28, 29] due to providing the relationship between environmental factors and aquatic communities [23]. Spirlins, the members of the genus *Alburnoides*, a member of Cyprinid family is found in Europe, Asia Minor and Central Asia with 25 species [4]. Until 2009, all populations of Alburnoides species in Iran were known as *Alburnoides bipunctatus* in Iranian inland waters. Based on the recent researches, seven species have been reported from Iranian inland water [4, 13]. Among them, the endemic *Alburnoides eicwaldii* Bogutskaya and Coad, 2009 was found in the rivers of the Caspian sea basin. Members of the genus Alburnoides are lithophilic and rheophilic fishes, which inhabit in barbel and grayling zones [1, 26]. They are very sensitive to human activities and levels of dissolved oxygen [3]. In European waters, spirlins are extremely threatened and nearly close to extinction because of their sensitivity [15, 20]. The freshwater fishes of Iran are also faced to recent severe droughts, climate change, pollutions, introduction of exotic fishes and anthropogenic impacts, and as a consequence, many fish populations have been intensively affected especially sensitive fishes, like the members of the genus Alburnoides [6, 28]. Little information is available regarding biology and ecology of the native *A. eicwaldii* and its habitat use and selection are unknown. Therefore, this study was conducted to assess the habitat use and selection patterns with regard to habitat availability of this species in the Totkabon River.

2. Materials and Methods
2.1 Study area: Tootkabon River is a branch of the Sefid River in the southern Caspian Sea basin, and, origins from the Alborz Mountains. The approximate length of this river is 23 km with an average slope bed of 6.1% (Fig. 1).

2.2 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 site to ±10 m using GPS (Global Positioning System; Garmin) [30], and the river and 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, 45 cm 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 [16]. Fish specimens were collected from each site during 30 min, anesthetized in clove powder solution (1 gl^{-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 [5, 8].

2.3 Habitat Data: Since there is limited or no knowledge available on *A. eicwaldii* studied here, the environmental variables were selected according to the results of previous studies conducted on other fishes [3, 25, 27]. The habitat data were measured immediately after sampling [35]. The measured variables include elevation (m), water depth (cm), river width (m), river slope (%), velocity (cm/s), substrate type (Table 1), average diameter of bed stone (cm) and riparian vegetation type. Elevation of sampling sites was recorded by GPS (Garmin). The mean depth (cm) of each site was estimated by measuring depth at 20 random points across sampling site using a measuring bar, and their average was considered as river depth [18]. The mean width of river (m) was measured using a tapeline by measuring upper, middle and lower sections of each sampling site and their average was considered as river width. The mean slope (%) was measured by a clinometer (Suunto PM-5/360 PC; ww.suunto.com) at the midline of the river in three areas (beginning, middle, and end of each site). The surface velocity (m/s) was estimated by a simple float based on Hassanlie (1999), and repeated three times to minimize error. Dominant substrate type was determined both visually and randomly via measuring the diameter of the riverbed stones in 20 selected quadrates (50×50 cm) based on Lotfi (2012), and classified according to Johnston *et al*. (1996). Bed stone diameter average was also 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 parts of the river or absence thereof), were classified according to our observations, photographs, and standard procedures with some modifications [12]. The first seven variables were continuous, and other variables were nominal. The abbreviation and description for each discrete variable are presented in Table 1.

2.4 Habitat use and habitat selection: 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 each species in each interval was calculated using habitat selection (Habsel) software 1.0 [14]. The formula S=(%Uc,i)/(%Ac,i), where is the interval of a given environmental variable c, % Uc,i is the percentage of utilization of a specific interval of an environmental variable c utilized by fish, and % Ac,i is the percentage of availability of this environmental variable [9], resulted in a selectivity value (S) at each interval. 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 [5, 8].

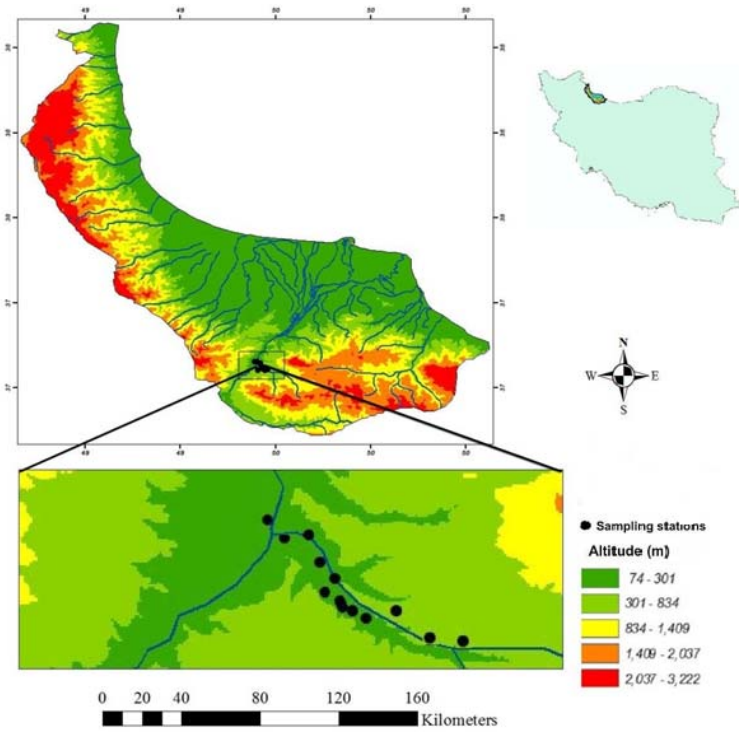

Fig 1: Location of Alborz Province, Tootkabon River, and sampling points.

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 unvegetated

3. Results

All collected fish during sampling belonged to 8 species *viz. A. eicwaldii*, *Barbus cyri*, *Capoeta gracilis, Alburnus filipi, Cobitis keyvani, Ponticola iranicus, P.cyrius* and *Oxynoemacheilus bergianus* that were returned to the river after identification and counting. A total of 141 specimens of *A. eicwaldii* were collected. The studied habitats in Totkabon River mostly occurred in an elevational range of 130-230 m above sea level, with 15-75 cm depth, 1.5-13 m width, 0.35-0.71 m/s water velocity, slope of 0.4-2.4%, stone diameter of 10-50 cm, and cobble and then bed rock substrate type, deciduous riparian forest, and with most available cover type of boulder (Fig. 2). The habitat-use pattern of *A. eicwaldii* generally followed habitat availability (Fig. 2). Considering the availability of environmental variables and the selectivity, the habitat selection pattern of this species mainly had the following features: elevation higher than 180 m, water depth higher than 50 cm, channel width less than 10 m, channel slope 0.5-1.5%, water velocity less than 0.72 m/s, bed rock substrate, average diameter of bed stone 30-50 cm, deciduous forest and residential area riparian type (Fig. 2). The results revealed that *A. eicwaldii* mostly selected upper parts of the river with higher velocity and depth.

Furthermore, this species selects lower slope and velocity, bed rock substrate i.e. bed with larger elements, deciduous forest and residential area riparian type, and boulder cover compared with 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.

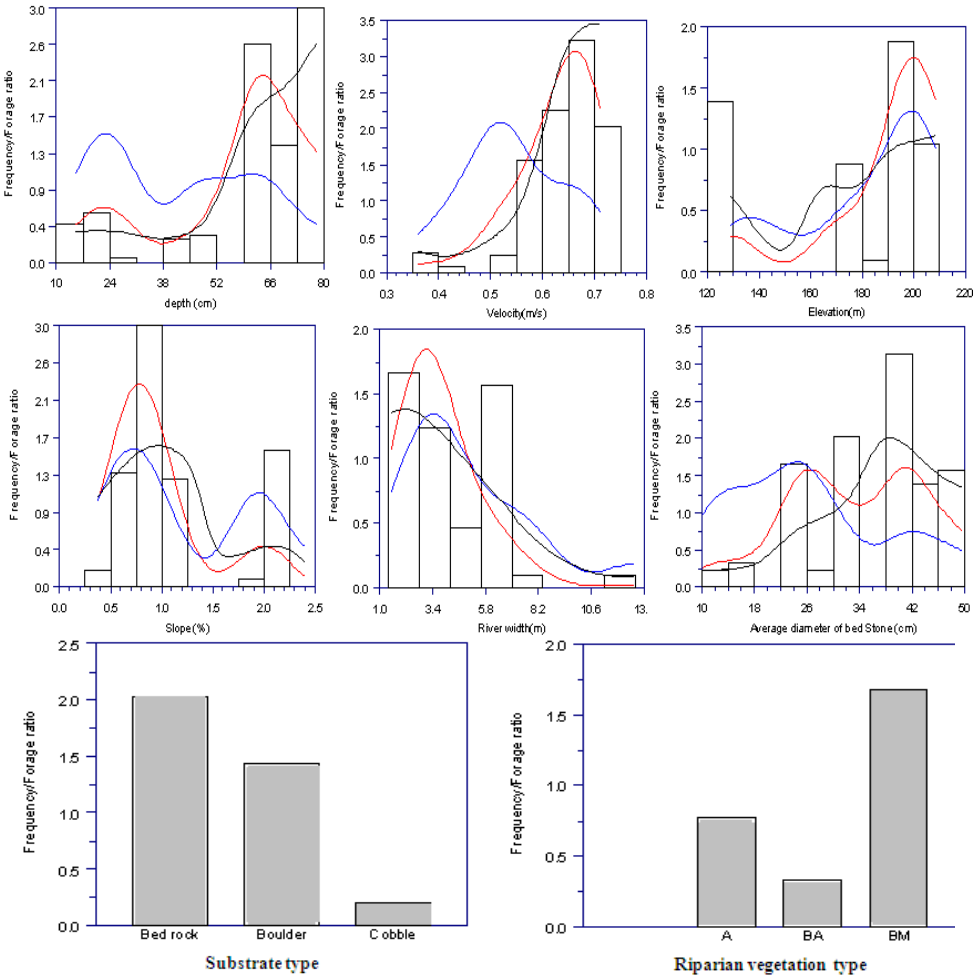

Fig 2: Habitat availability (blue line), used (Red line) and selected (black line) by *A. eicwaldii* for environmental variables.

4. Discussion

Most of the endemic fish species with limited distribution are threatened due to destruction of their habitats. Hence, it is necessary to study their habitat use and selection patterns prior to endanger their survival in order to their effective management and protection [24]. The current study provided the habitat use and selection patterns, and environmental factors affecting on the distribution of *A. eicwaldii*, an endemic fish of Iranian inland waters, in the Tootkabon River. The members of the genus Alburnoides are very sensitive to levels of dissolved oxygen. Having low tolerance to water polluted by industrial, agriculture or urban wastes makes these cyprinid fishes a good biological indicator of the environment quality [2]. In recent years, the industrial effluents in Tootkabon region have been caused the disposal of industrial effluents and chemical pollution of surface and groundwater waters including

Tootkabon River. Therefore, the findings of the present study can show the importance factors for effective management and protection of this endemic species. The results revealed that *A. eicwaldii* mostly selects deeper reaches with bed rock substrate and larger bed stones. Instream habitat structures provide a variety of functions for stream fishes [23, 27]; 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 [21, 27]. In addition, deep body shape of this species 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 [23, 27]. *A. eicwaldii* mostly uses area with lower river width i.e. less than 10 m. Researches showed that habitat with higher river width have little suitability for fishes such as *Varicorhinus barbatulus* [3, 19]. In addition, deeper reaches with lower current, less river width along with larger bed stones can be provide transparent water to penetrate sunlight causing higher production of periphyton algae as main food items of the Alburnoides species [31]. Habitat use of the *A. eicwaldii* is area with deciduous forest and residential area riparian type. This can be due to providing organic matters that considered as base of the primary production in the riverine ecosystems [34]. In addition, high organic matter depends on the presence of proper condition and enough time to decompose of allochthonous such as appropriate water velocity and substrate. Hence, riparian type and bed cover are important factors in distribution of riverine fishes due to providing the major source of carbon and energy [26]. Furthermore, the deciduous forest riparian vegetation type can be stabilize fish habitats by providing source of carbon and detritus during low production season e.g. autumn. This detritus are a ground to develop small animals such as invertebrate as base of the riverine food chain [17]. The limitations of using an electrofishing device [22, 35], 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 [5]. Seasonal patterns were not assessed here, but the habitat use and selection patterns of *A. eicwaldii* are indicative of autumn. Therefore, we recommend investigation of the habitat use and preference patterns in other seasons as well.

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