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دراسات حول تأثير المتغيرات البيئية الرئيسية على وفرة وتوزيع سمك السلور (سمكة القط) الكشميري (Glyptothorax Kashmirensis Hora, 1923) في مناطق Azad Jammu وكشمير- باكستان

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الملخص

يدرس هذا البحث تعرض سمك السلور الكشميري (Glyptothorax Kashmirensis Hora,1923) (CR) للخطر بشكل كبير وهو من أسماك المياه العذبة المتوطنة في أنهار Jhelum وPoonch في مناطق Azad Jammu وكشمير (AJK). وبسبب عدم توافر البيانات عن بيئة هذه الفصيلة من الأسماك، تهدف الدراسة الحالية التي أجريت في الفترة ما بين شهر ديسمبر – يناير 2016 إلى بحث وفرة وتوزيع سمك السلور الكشميري في أنهار Jhelum وPoonch (AJK) وكذلك دراسة الموطن الطبيعي المفضل لهذه الفصيلة من الأسماك وتأثير العوامل البيئية الرئيسية على وفرة وتوزيع سمك السلور. يوضح البحث أنه تم فحص معايير جودة المياه الرئيسية ودرجة الحرارة والأكسجين المُذاب (DO)، ودرجة الهيدروجين PH وتعكر المياه بصورة شهرية (ديسمبر – يناير 2016) من مواقع مختارة في نهر Jhelum (Gucha, Subri, Ambor, Rahra) ونهر Poonch (Hajira, Jawra, Tatapani, Barali). يشير البحث إلى أخذ عينات الأسماك بمعدل شهري في الفترة ما بين ديسمبر – يناير 2016 من 18 موقع مختلف بواقع (6 عينات من نهر Poonch و12 عينة من نهر Jhelum) باستخدام رمي شبكة ذات حجم 15 mm. تم تسجيل الملاحظات المتصلة بقاع النهر الذي تم أخذ عينات السمك منه. كما قام البحث بتسجيل نظام تدفق النهر باستخدام عداد تدفق بمقياس (30–0 جالون في الدقيقة). يشير البحث إلى استخدام تحليل المكون الرئيسي (PCA) وتحليل التناظر القانوني (CCA) لدراسة ارتباط المتغيرات البيئية (تدفق المياه، درجة الحرارة، الأكسجين المذاب (DO)، درجة الهيدروجين PH، تعكر المياه) بوفرة هذه الفصيلة. وبناء على هذا التسجيل، يتضح امتداد نطاق توزيع سمك السلور الكشميري في المنبع الممتد من Kohala إلى Chakothi في نهر Jhelum كما يمتد من Gulpur إلى Madalpur في نهر Poonch. توصل البحث إلى أن سمك السلور الكشميري يُفضل العيش في قاع النهر المُكون من حصى صغير ورمل خشن وحبيبات حصوية صغيرة الحجم في مجال مياه بعمق 50–20 cm، كما يفضل العيش في الروافد العليا للنهر ذات التدفق المنخفض للمياه ($300m^3s^{-1}$). أشار البحث إلى ملاحظة وجود أقصى عينات في Gucha (Jhelum) وJawra (Poonch) في أشهر الصيف (يوليو- سبتمبر). كما أظهرت تحاليل PCA وCCA أن ظهور هذه الفصيلة يرتبط ارتباطاً وثيقاً بالعوامل البيئية المتنوعة ومن أهمها تعكر المياه ودرجة الحرارة.

Studies on the impact of key environmental variables on kashmir catfish (*Glyptothorax kashmirensis* Hora, 1923) distribution and abundance in Azad Jammu and Kashmir, Pakistan

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Abstract

Kashmir catfish (*Glyptothorax kashmirensis* Hora, 1923*)* is a critically endangered (CR) freshwater fish endemic to the Jhelum and Poonch rivers of Azad Jammu and Kashmir (AJK). Limited data is available on the ecology of this species, therefore; the present study was conducted from January-December 2016 with the aim to investigate the abundance, distribution, habitat preference, and impact of key environmental factors on the distribution and abundance of Kashmir catfish in the Jhelum and Poonch rivers of AJK. The key water quality parameters temperature, dissolved oxygen (DO), pH and turbidity were checked on a monthly basis (January-December 2016) from selected locations on the Jhelum River (Gucha, Subri, Ambor and Rahra) and Poonch River (Hajira, Jawra, Tatapani and Barali). Fish sampling was carried out on a monthly basis from Jaunuary to Decemebr 2016 at a total of 18 different locations (Poonch=6, Jhelum=12) using a cast net of 15 mm mesh. Observations related to the river bed where sampling was carried out for fish were documented. The river flow regime was recorded by a flow meter with gauges (0-30 gallons per minute). A principle component analysis (PCA) and a canonical correspondence analysis (CCA) were run to examine the association of environmental variables (water flow, temperature, DO, pH and turbidity) with species abundance. Based on the captured record, the distribution range of Kashmir catfish extended upstream from Kohala to Chakothi in the Jhelum River and from Gulpur to Madalpur in the Poonch River. The Kashmir catfish prefers a river bed constructed of small gravel, coarse sand and small sized cobbles in the depth of a water range of 20-50 cm, frequently in the upper reaches of the rivers with a low water flow ($300 m^3 s^{-1}$). Maximum specimens were observed in Gucha (Jhelum) and Jawra (Poonch) in the summer months (July-September). The PCA and CCA show that the species occurrence is highly correlated with various environmental factors, out of which turbidity and temperature contribute the most.

Keywords: Glyptothorax kashmirensis; habitat ecology; Jhelum and Poonch Rivers; Kashmir catfish; physicochemical features

1. Introduction

The Kashmir catfish (*Glyptothorax kashmirensis*) is a benthopelagic freshwater fish that belongs to family Sisoridae (Singh *et al.,* 2015) and has critical importance in the food chain. In Pakistan, its presence is documented from the Jhelum and Poonch Rivers of Azad Jammu and Kashmir (AJK) (Rafique, 2013). The species is facing threats by dams construction and extensive gravel and sand mining activities (Reid & Croxall, 2001) resulting in habitat loss and a decline in its population. The species has been listed as 'critically endangered' on the IUCN red list due to a predicted decline of more than 80% over the next 5-10 years due to severe, irreversible threats (IUCN, 2017). A description of habitat ecology is essential for not only the conservation and management of a species but also for understanding species evolution and life history (Rice, 2005).

Habitat quality is a key factor in habitat ecology (IUCN, 2001). Furthermore, an understanding of how water bodies, stream habitats, and their surrounding environment shape the structure of fish assemblage is valuable in habitat assessment, stream restoration, and ultimately the management and conservation of fish populations (Pease *et al.,* 2011). Dissolved oxygen, temperature, water velocity, and substrate composition deterministically affect fish assemblage structure in tropical flood plain systems (Daga *et al.,* 2012). The Kashmir catfish is an endemic fish species in the Kashmir Valley and one of the least studied species. Scientific information related to species distribution, abundance and ecology is very patchy across its distribution range. The current study was conducted to determine the distribution range, preferred habitat, and association of physicochemical parameters with the distribution of Kashmir catfish in the Jhelum and Poonch rivers of AJK.

2. Materials and Methods

2.1 Study Area

The Jhelum River originates in the Pir Panjal Mountains and enters AJK at Chakothi (lat: 34.102584°, long: 73.922675°), passing through Muzaffarabad Sudhnoti and ending up in the Mangla reservoir (lat: 33.241644°, long: 73.620575°). The Poonch River is a small river that enters AJK at Madalpur (lat: 33.742014°, long: 73.994546), passes from district Poonch, Kotli and drains into Mangla Reservoir (lat: 33.331531°, long: 73.744442°). Four study sites in each river were identified to study water quality parameters and their correlation with species distribution (Figure 1). In the Jhelum River the selected sites were Gucha, Subri, Ambor and Rahra (the relative distance of Gucha to Subri: 36 km, Subri to Ambor: 13.7 km, Ambor to Rahra: 4.6 km), while, in the Poonch River, Hajira, Jawra, Tatapani and Barali (the distance of Hajira to Jawra: 10 km, Jawra to Tata Pani: 17.3 km, Tata Pani to Barali: 23.7 km) were chosen.

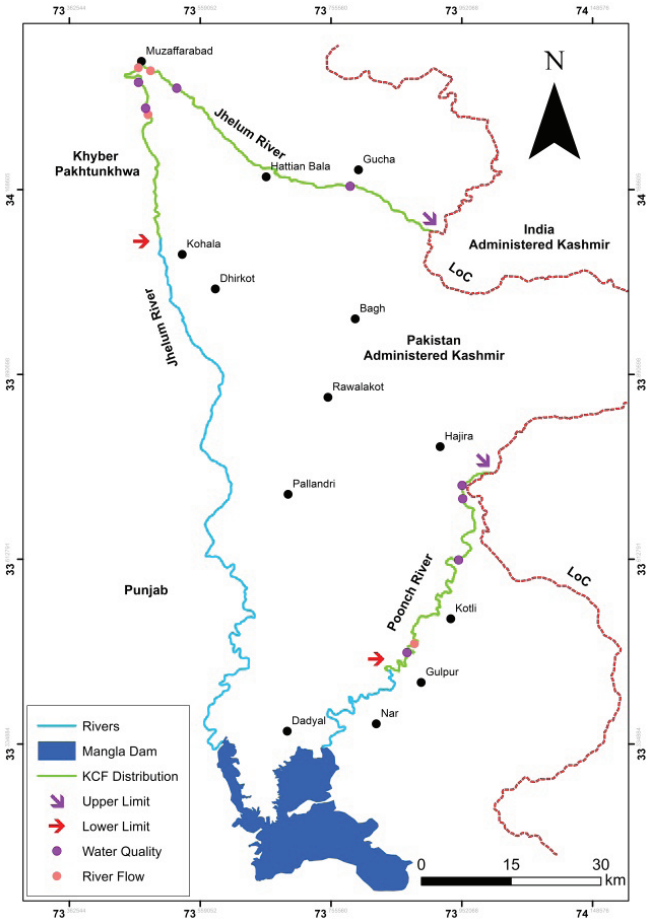

Fig. 1. Study area map with Kashmir catfish distribution range along with water quality and river flow monitoring locations.

2.2 Fish sample collection

River depth was measured with a meter ruler before fish sampling. Fish sampling was carried out over the entire stretch of both rivers by cast netting with a mesh size of 15 mm. Repeated sampling at fixed locations (total=18; Poonch=6, Jhelum=12) along the entire length of both rivers (the study area) was done each month during the period from January-December, 2016. A total of 30 attempts were made at each location for specimen collection along a 300 m stretch at each sampling site. Features of study sites selected for fish sampling and key water quality parameters are shown in Figure 2.

2.4 Water quality analysis

Water quality parameters as temperature, dissolved oxygen (DO), pH and turbidity were determined using standard methods. A Celsius thermometer was used to measure surface water temperature. Dissolved oxygen was recorded by a digital DO meter (Ox96W.W Germany). For pH, a digital electronic pH meter (Systronics) was used and turbidity was measured through a turbidity meter (Lovibond, Dortmund, Germany).

2.5 Statistical analysis

The study area map with sampling sites and Kashmir catfish distribution was projected in the Arc Geographical Information System (Arc GIS 10.3). Multivariate analysis

Fig. 2. Features of the study area where sampling was carried out.

2.3 Assessment of habitat and flow regime

The water flow and river bed were observed and measurement of cobble, pebble and gravel were taken on a cm scale. Following the guidelines of Blair & McPherson (1999), the river bed was categorized based on its texture as: sand and gravels (0.2-0.5 cm diameter), cobbles (>0.5-6.4 cm), pebbles (>6.4-25.6 cm), and boulders (>25.6-409 cm). Based on the number of Kashmir catfish present, the river habitat was categorized into: highly suitable, consisting of sand and gravels mixed with cobbles of size less than 6.4 cm and a depth of water ranging from 20-50 cm; moderately suitable, entirely consisting of cobbles having a size up to 6.4 cm and a depth of water ranging from 50-100 cm; slightly suitable, consisting of pebbles >6.4-25.6 cm and a depth of water ranging from 100-200 cm; and unsuitable, consisting of boulders with a water depth of >200 cm. The river flow regime was recorded by a flow meter with gauges (0-30 gallons per minute).

for the association of environmental variables with relative fish abundance was cconducted using Principal Component Analysis (PCA) (Adrian *et al.,* 2019) and a Canonical Correspondence Analysis (CCA) was run to determine the relative importance of the first and second major parameters from environmental variables in SPSS (version 21.0). The association of all the variables with fish abundance was evaluated by PCA only from the sites where fish samples were observed while the rest of the sites involved in sampling trials were excluded from the analysis.

3. Results

3.1 Distribution range and relative abundance of Kashmir catfish

Based on the present data, the distribution range of the Kashmir catfish extends upstream from Kohala to Chakothi in the Jhelum River, while in the Poonch River,

the distribution range extends upstream from Gulpur to Madalpur (Figure 1). Data on the relative fish abundance of the Kashmir catfish in the Jhelum and Poonch Rivers are shown in Figure 3. From all the 12 sites selected on the Jhelum river, the Kashmir catfish was observed at four sites, namely Gucha, Subri, Ambor and Rarha. A maximum number of 20 specimens were observed in the Jhelum River from Gucha during the rainy season (August) while a few specimens were observed moving downstream towards Subri (n=2), Ambor (2) and Rarha (1). In the Poonch River, from all the 6 sites selected for sampling, the Kashmir catfish was observed at 4 sites *viz,* Hajira, Jawra, Tatapani and Barali. A maximum number of 22 specimens were captured from Jawra during the rainy season (August) while the number of specimens decreased downstream to Tatapani (1) and Barali (1).

3.2 Habitat preference

The preferable habitat of the Kashmir catfish was characterized by the riverbed with cobble and gravel mixed with sand. A maximum number of fish were observed in riffles with a river bed constructed of sand, gravel and cobbles (highly suitable habitat), followed by a river habitat constructed of large cobbles (up to 6.4 cm in diameter). The fish uses riffles in the main river for feeding and refuge in crevices and boulders in deep water during winter (Figure 4).

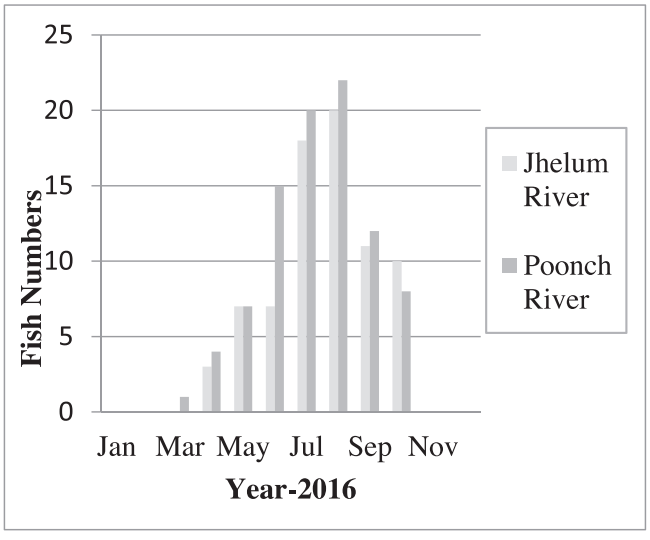

Fig. 3. Kashmir catfish abundance in Jhelum and Poonch Rivers in different months of the year 2016.

Fig. 4. Dorsal and ventral view of Kashmir catfish in its natural habitat.

3.3 Water flow and fish distribution

In the Jhelum River, before confluence with the Neelum River, the average annual river flow was recorded as 700 m^3s^{-1}. After the confluence of the Neelum and Kunhar Rivers, the water flow in the Jhelum River increased to 1600 and 1750 m^3s^{-1} respectively. The least value of water flow in the Jhelum River was 170 m^3s^{-1} at Gucha during January, while a maximum of 2497 m^3s^{-1} at Rarha was observed during June. The maximum number of Kashmir catfish specimens (20) was observed at Gucha with medium water flow (approx. 550 m^3s^{-1}) showing a positive effect on fish distribution upstream of the Jhelum River. The number of fish decreased in Rarha (1) with higher water flow, thus indicating an inverse relationship of flow regime with the fish distribution.

The average river flow observed in the Poonch River was 328.5 m^3s^{-1}. Two peaks of a relatively higher flow of water were observed: one in August (664 m^3s^{-1}) and the other in March (approx. 377 m^3s^{-1}). Minimum water flow in the Poonch River was 41 m^3s^{-1} during November and the maximum was 664 m^3s^{-1} during August. A maximum number of 22 specimens were observed at Jawra in August while only one specimen was observed at Kotli (Table 1).

Table 1. The physicochemical characteristics (Mean±SD) of Jhelum and Poonch Rivers.

Months	Water flow (m^3s^{-1})		Temp (°C)		DO (mgL^{-1})		pH		Turbidity (NTU)		Fish Abundance	
	Poonch	Jhelum	Poonch	Jhelum	Poonch	Jhelum	Poonch	Jhelum	Poonch	Jhelum	Poonch	Jhelum
January	53±2.5	100.8±6.9	10.5±0.5	7.5±0.6	9.0±0.0	11.3±0.3	8±0.3	8.3±0.3	10±0.0	45±5.7	0±0.0	0±0.0
February	100±1.7	174.1±8.0	13±0.8	8.0±0.6	8.9±0.5	10.8±0.3	7.8±0.3	8.3±0.3	10±0.0	56.3±7.5	0±0.0	0±0.0
March	377±4.9	421.7±10.5	15.5±0.6	13.3±1.0	8.1±0.3	10.1±0.3	8±0.4	8.2±0.4	50±0.0	60.5±1.0	1±0.0	0±0.0
April	165±3.8	660±14.7	18.6±0.8	15±2.0	8.0±0.0	9.9±0.3	7.6±0.1	7.6±0.1	70±2.5	98.5±10.1	4±0.1	3±0.0
May	119±3.7	737.3±12.8	21.4±0.8	16.8±1.9	7.4±0.4	9.3±0.3	7.5±0.2	7.3±0.2	51.3±4.0	190±46.9	7±0.7	7±0.2
June	116±2.9	654.9±23.2	24.1±0.3	21±2.0	7.5±0.0	9.0±0.4	7.5±0.3	7.5±0.3	52±8.0	186.3±7.5	8±0.2	7±0.4
July	225±7.9	470.2±6.9	27±0.0	22.8±1.9	7.1±0.2	8.8±0.2	7.3±0.1	7.6±0.1	176.3±14.1	195±5.8	19±0.4	18±0.9
August	664±8.9	550.6±10.0	26.0±0.3	24.5±1.0	7.0±0.0	8.3±0.3	7.0±0.2	7.6±0.2	180±4.4	182.5±9.7	22±0.7	20±1.0
September	141±6.7	231.3±3.2	20.4±0.5	16.5±1.7	7.2±0.3	8.4±0.5	8±0.9	7.3±0.1	75.8±4.8	135±5.8	12±0.7	11±0.9
October	57±4.6	154.3±6.5	17.5±0.6	14.8±1.9	8.1±0.1	9.3±0.3	8.1±0.2	7.5±0.2	53.8±4.8	100±9.1	9±0.2	10±0.3
November	41±6.1	107.6±2.9	14.4±0.5	12.8±1.5	8.3±0.4	9.5±0.4	8.3±0.1	7.5±0.5	20±4.1	66.3±4.78	0±0.0	0±0.0
December	47±5.2	101.4±7.9	11.4±0.5	7±0.0	9.1±0.2	9.8±0.3	8.1±0.3	7.9±0.3	10±0.0	48.8±4.8	0±0.0	0±0.0

3.4 Water quality parameters

The data on water quality variables at different sampling sites of the two rivers are provided in Table 1.

3.4.1 Water temperature (°C)

The average water temperature recorded was 14.76 °C (max. 24.5 °C during August, min. 8.0 °C during February) for all four sites in the Jhelum River. In the Poonch River, the average water temperature recorded was 18.39 °C (max. 26.0 °C during August, min. 10.5 °C during January) for all the study sites (Table 1). A significant positive correlation of increasing temperature with fish distribution was observed during the summer months in both the Jhelum and Poonch Rivers.

3.4.2 Dissolved oxygen (mg/L)

The average DO of water recorded at selected sites of the Jhelum River was 9.5 mgL^{-1} (max. 11.3 mgL^{-1} during January, min. 8.3 mgL^{-1} during August). In the Poonch River, the average recorded DO was 8.0 mgL^{-1} (max. 9.1 mgL^{-1} during December, min. 7.0 mgL^{-1} during August) (Table 1).

3.4.3 pH

The average pH recorded for water at the study sites was 7.7 (max. 8.3 during January and Febuary, min. 7.3 during May and September) in the Jhelum River while in the Poonch River the average pH was 7.8 (max. 8.3 during November, min. 7.0 in August) (Table 1).

3.4.4 Turbidity (NTU)

The average turbidity recorded at the study sites of the Jhelum River was 113.6 NTU (max. 195.0 NTU, min. 45.0 NTU). In Poonch River, average turbidity was recorded as 63.3 NTU (max. 180.0 NTU in August, min. 10.0 NTU) (Table 1). More relative fish abundance with increased turbidity was observed (53.8 -195.0 NTU) in both Jhelum and Poonch Rivers. Environmental variables were subjected to correlation and different environmental variables were distinguished in relation to their influence on the system (Table 2). All the variables except the sampling site's showed a significant result at 99% (0.01) and were found to have strong correlation on the distribution and abundance of Kashmir catfish in both rivers.

Table 2. Correlation between different variables and fish abundance in Poonch and Jhelum Rivers.

S.NO	Variables	Fish abundance	
		r	P value
1	Month	0.355**	0.000
2	Site	0.093	0.368
3	Water flow (m^3s^{-1})	0.301**	0.003
4	Temperature (°C)	0.776**	0.000
5	Dissolved Oxygen (mgL^{-1})	-0.512**	0.000
6	pH	-0.588**	0.000
7	Turbidity (NTU)	0.790**	0.000

**Correlation is siginificant at 0.01 level (two tailed)

Figure 5 shows the outcome of PCA for all the sampling sites from the Jhelum and Poonch rivers and the number of fish samples observed at each site. The PCA yielded two principal components, turbidity and temperature, with their most significant effect on the sampling sites where the maximum number of fish were observed. Both turbidity and temperature contributed an effect of 85% to the system, while the rest contributed 15%.

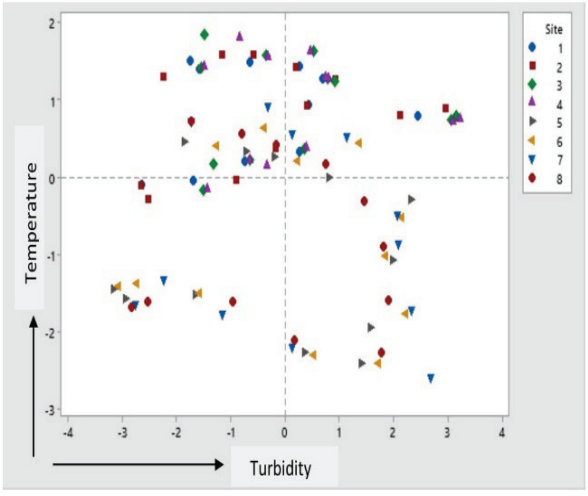

Fig. 5. Principal component analysis biplot of environmental variables [(Component 1= turbidity) (Component 2= temperature)] and sampling sites (1=Jawra, 2=Hajira, 3=Tata Pani, 4=Barali in Poonch River; 5=Gucha, 6=Subri, 7=Ambor, 8=Rahra in Jhelum River).

Figure 6 shows the results of CCA with the relative importance of two principal components, turbidity and temperature. From these principal components, turbidity was observed to have a maximum correlation with species abundance, which is defined as factor 1, and after that, temperature affects the fish distribution significantly, so it is defined as factor 2.

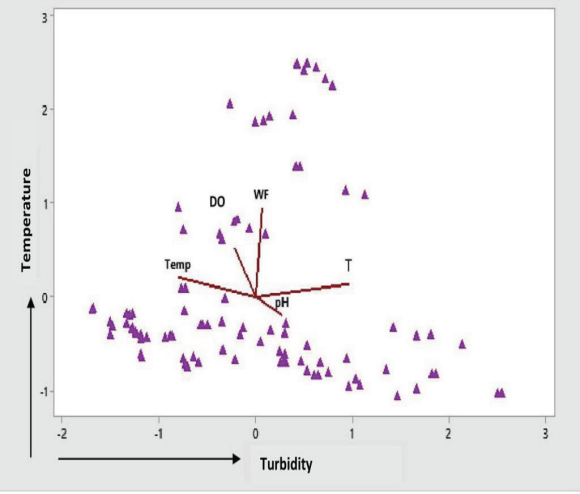

Fig. 6. Canonical correspondence analysis biplot for environmental variables [(Factor 1= turbidity) (Factor 2= temperature)] and fish abundance.

4. Discussion

Freshwater fish are one of the most threatened taxonomic groups (Darwall & Vie, 2005) because of their high sensitivity to quantitative and qualitative alteration of aquatic habits (Kang *et al.,* 2009). The Kashmir catfish is a globally threatened freshwater species. The present study demonstrated that the occurrence and abundance of a species are associated with different environmental variables, including its habitat, water flow, and physicochemical parameters. The present investigation confirmed earlier reports on species inhabiting sand/ gravel substrate (Froese & Pauly, 2015). Likewise, other species of genus *Glyptothorax* were also described as inhabiting foothill rivers, benthic in habitat (Jayaram, 2010).

The presence of the maximum number of Kashmir catfish at Gucha (20) and the minimum downstream at Rahra (1) may be due to increased river flow in the Jhelum after drainage of the Neelum and Kunhar Rivers, showing a negative effect on fish distribution, possibly making it difficult for fish to withstand increased river water flow. However, the moderate water flow at Gucha may be optimum for the survival of Kashmir catfish. Similarly, the moderate flow of water in the Poonch River was also found to be associated with the maximum number (22) of Kashmir catfish presence. Generally, fish have the ability to optimize their physiological processes according to thermal preferences (Selleslagh & Amara, 2008). During winter months, a number of fish species become inactive (Crawshaw, 1980). During this time the fish stop taking food and decrease protein synthesis and growth (Cooke *et al.,* 200). In the current investigation, Kashmir catfish were not observed in cold months (November-March) in either river. The reason could be the lowering of metabolic activities of fish, which is correlated with reduced water temperature that is overturned during normal temperature (Hamish *et al.,* 2008). In order to avoid the harsh cold temperature, the fish would have to adopt one of two possible strategies to ensure its survival in the river: 1) move downstream into warmer and deeper water or 2) become dormant. In fish, the metabolic rate is directly proportional to the temperature of the water (Hamish *et al.,* 2008). The Kashmir catfish is not a migratory fish and therefore finds shelter in holes or burrows, hides under rocks and spends the winter inactive, or dormant. On the other hand, the average water temperature during the summer months (14-18^{o}C) had shown a positive effect on the relative abundance of fish which might be due to thermal preferences for temperature. Increased abundance of fish was earlier reported in summer with increased temperature (Veiga *et al.,* 2006) similar to the present study.

Dissolved oxygen is the most important parameter for fish survival and the successful development of eggs (Werner, 2002). Many species like *Trichomycterus* were reported to inhabit mainly rocky bottoms and well-oxygenated streams to have an optimum supply of oxygen for their survival (Roman - Valencia, 2001). The DO (6 -9 mgL^{-1}) recorded in the present study was comparable to results reported by Ali (2007) for freshwater fish. The sustainable DO level reported for freshwater species is at least 5 mgL^{-1} (Asli *et al.,* 2016) whereas lower than 5 mgL^{-1} has been reported as lethal for fish survival (Bjornn & Reiser, 1991).

The pH range recorded in the present study (7-8.5) could be described as suitable for the survival and growth of Kashmir catfish as recorded for natural waters (6.0-8.5) for survival and optimal growth of aquatic species (Tucker & Dabramo, 2008). The lowest pH reported for

fish survival was 4·5 (Jellyman & Harding, 2014) while pH considered optimum for the survival and growth of freshwater species was 7-9 (Saeed, 2000; Ali, 2007).

The Kashmir catfish was observed to prefer turbid water with a mixture of mud and sand with the incorporation of macroinvertebrates for its food and the highest number of fish was observed in water with turbidity >50NTU (rainy season). Earlier, the highest feeding rates of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) were reported at turbidity levels of 35-100 NTU, linked to the possible decrease in predation risk (Utne-Palm, 2002). High turbidity in the water may also be an indication of water pollution (Olayiwola *et al.,* 2018). However in the present study, turbidity was observed to support Kashmir catfish activity. High turbidity acts as a refuge for fish, providing them cover and minimizing the risk of predation.

5. Conclusion

The present study falls under the domain of UN SDG 14 and 15 simultaneously, as it not only covers the protected area but the life below water as the target species viz. The Kashmir catfish is an aquatic species, though not belonging to the marine ecosystem. This study might provide additional information about the subject species and bridge knowledge gaps, subsequently helping to achieve the SDG targets set for 2030. This current study concludes that the Kashmir catfish is restricted to the upper section of the Poonch and Jhelum Rivers and prefers a moderate flow of water. The study also describes how Kashmir catfish greatly prefer a habitat consisting of sand, gravel, and cobbles. The distribution of Kashmir catfish in both rivers is affected by various physicochemical parameters of water. Among the physicochemical parameters, temperature and turbidity have a stronger relation with species distribution compared to DO and pH. A significant positive effect of increasing temperature was observed during summer months on fish distribution in both Jhelum and Poonch Rivers. More relative fish abundance with increased turbidity was observed in both the Jhelum and Poonch Rivers.

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AUTHOR'S CONTRIBUTION

Nagina Gilani written the manuscript, Muhammad Rafique, Ahmad Shoaib and Shakeel Ahmad conducted the field work, Huma Qureshi and Nagina Gilani analyzed the data. Muhammad Rafique and Shamim Akhter supervoised and reviewed the draft.

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