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Short Communication

A PRELIMINARY FINDING ON THE EFFECTIVENESS OF FISHWAYS AT KURICHHU DAM IN BHUTAN

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ABSTRACT: Fishways are constructed at Kurichhu and Dagachhu hydropower projects to mitigate the impact of hydropower projects on migratory fishes. But none of the agencies has made attempts to evaluate the efficiency of the existing fishways until today. Thus, the study was undertaken to collect preliminary data on fish species diversity and size span that ascends through fishway of Kurichhu dam. Fish species composition and diversity varied among the sampling period. The preliminary findings recorded nine fish species within the vicinity of the project area, of which eight fish species irrespective of their sizes were found utilizing the fishway facility.

Keywords: Fishway; size span; species diversity.

1.INTRODUCTION

Bhutan is endowed with rich perennial water resources with estimated hydropower generation potential of 30,000 megawatts (MW) reported the technical feasibility of generating about 23,503 MW of hydropower from 72 projects (NORAD 2017). At present, only 1606 MW has been harnessed from six Hydropower Plants (HPP's) (NSB 2016). Besides, four Hydroelectricity projects namely Punatshangchhu Hydro Power Authority-I & II, Tangsibji Hydro Energy Limited and Mangdechhu Hydro Power Authority are currently under various stages of construction that is capable of producing 3058 MW in total.

The construction of the hydropower plant is expected to disturb the fish diversity and aquatic ecosystem for which the World Bank (2016) had recommended to evaluate the impacts of hydropower development on aquatic ecosystems before implementation. A lack of comprehensive baseline data on fish species diversity makes difficult to assess the impacts of aquatic fragmentation in Bhutan. The World Bank (2017) had reviewed and identified 123 fish species of which 111 are indigenous and 12 exotics. The latest review indicated presence of 130 fish species in water bodies of Bhutan (Thoni & Gurung 2018; NBC 2019). The Water Regulation of Bhutan (2014) identified and recommended measures to mitigate impacts on aquatic biodiversity by establishing minimum environmental flows (e-flows) for hydroelectric projects as per Environment Impact Assessment (EIA). The other recommendations are to construct fishways to facilitate upstream movements of fishes or to compensate through investment on on-site hatchery facilities to produce and release native fish fingerlings.

Currently, fishways intended to mitigate the impact on migratory fishes are only available on the Kurichhu and Dagachhu HPPs. While those structures are in place the effectiveness was not evaluated at this juncture and the effectiveness of fishway at Kurichhu HPP was questioned (Virdi & Theophilus 2014). Thus, this study was planned to generate preliminary empirical information on the effectiveness of fishway at Kurichhu HPP dam.

2.MATERIALS AND METHODS

2.1 Study area

The study was conducted within the vicinity of Kurichhu Hydroelectric Project (KHEP). The data on fish species diversity were gathered from Morichhu, an upstream tributary flowing along Lingmethang that joins the right bank of Kurichhu, approximately six kilometers (km)

above the dam; and from Yunari stream the downstream tributaries that join the right bank of Kurichhu, approximately 0.300 km below the dam; and the Yongri, a small stream that joins the left bank of Kurichhu, approximately 0.800 km below the dam as presented in Figure 1.

Figure 1: Study area along the Kurichhu HEP in Mongar

2.2 Kurichhu fishway structure

The 55 m high concrete gravity dam of Kurichhu HEP with 250 m in width and is provided with fishway at the right bank of Kurichhu. It is a pool and weir type, with submerged orifice and centrally located notch. The fishway entrance is located at 492 masl. Two entrances were provided for different water levels in the reservoir. The upper exit is located at 529 masl and the lower exit at 524 masl. This gives the fishway height of 32 and 37 m, depending upon the level of water in the reservoir. The water discharged was approximately 1.05-1.27 cumecs at the time of sampling.

The detail information is presented in Figure 2 and Table 1.

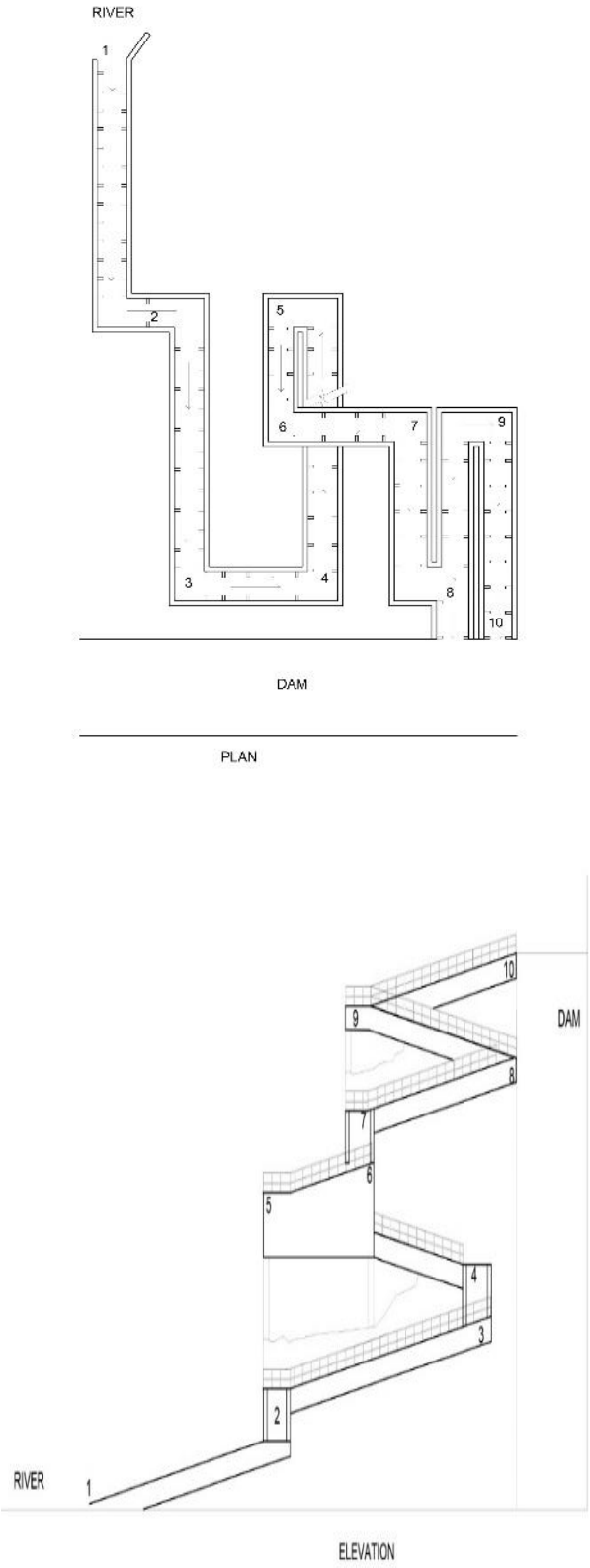

Figure 2. Diagrammatic representation of fishway and sampling sites (4-10).

Table 1. Fishway design at Kurichhu dam

Particulars	Remarks
Type	Pool-and-weir (Pool Pass with Submerged Orifice)
Height of fishway (upper exit)	37 m
Height of fishway (lower exit)	32 m
No. of Pools	103
Dimension of Pool (L x B x H)	3 m x 1.5 m x 2 m
Dimension of Baffle (L x H)	1.5 m x 1.5 m
Dimension of Submerged Orifice (L x H)	0.45 m x 0.70 m
Dimension of Central Notch (L x H)	0.45 m x 0.30 m
Discharge	1.05-1.27 cumecs

2.3 Data collection methods

The data on fish species diversity were gathered three times viz., from 25th - 29th June 2018, 20th - 22nd November 2018 and 30th May- 3rd June 2019. Whereas, data on fish attempting to ascend fishway was collected twice in June 2018 and between May and June 2019. Fish with good swimming ability and those with adhesive organs were recorded from fishway.

2.4 Fish sampling

Fish samples were collected randomly from the main Kurichhu river and tributaries using electrofisher (Model: ELT62-2D; Grassl, Germany; DC 3KV) during June 2018 and November 2018. Whereas, in May 2019 the fish samples were collected using locally improvised electrofisher. The gates of fishway were gradually closed to reduce the velocity of the water. Then, the fishes were captured using dip nets from various elevations of the fishway.

2.5 Velocity of water

The velocity of water flowing through the fishway was measured at the middle of the fishway pool using flowmeter (Model: FP111; Global Water Instruments, USA). In addition, the depth of water along the fishway was measured.

2.5 Basic water quality

The basic water quality parameters such as pH, temperature and dissolved oxygen were determined from Morichhu, Fishway, Yunari and Yongri. The pH and temperature were determined using multiparameter kit (MODEL: 98194; Hanna Instruments, Romania), and dissolved oxygen (DO) was recorded using DO meter (Model: SLD 150; Extech, Taiwan).

2.6 Data analysis

2.6.1 Morphometric measurement

The morphometric measurement was recorded, particularly total length, standard length and the body depth of fishes for this study. This is mainly for the selection of a type of tags to be employed for the final evaluation. Data collected on morphometric measurement and fish species diversity were analyzed in Microsoft Excel 2010.

3. RESULTS

3.1 Fish species diversity

The study recorded nine fish species viz., *Neolissochilus hexagonolepis, Schizothorax richardsonii, Schizothorax progastus, Garra gotyla, Garrra lissorhynchus, Psilorhynchus homaloptera, Pseudecheneis sulcata, Glyptothorax* sp., and *Parachiloglanis hodgarti* in total from upstream and downstream of Kurichhu dam site. Amongst the tributaries, Morichhu exhibited the highest diversity with eight fish species followed by Yunari and Yongri with six and four species, respectively.

3.2 Fish species and size attempting to ascend fishway

The sampling was done twice in various elevation of the fishway when it was operational. The overall study recorded eight fish species attempting to ascend the fishway. During first sampling in June 2018, a total of six species were observed along various elevations of the fishway as presented in Table 1. However, during the second sampling period carried out between May-June 2019,additional two species namely *Parachiloglanis hodgarti* and *Psilorhynchus homaloptera* were recorded (Table 1).

Table 1: Fish Species attempting to ascend fishway

Fish species	June 2018	May-Jun 2019
Neolissochilus hexagonolepis	*	*
Schizothorax richardsonii	*	*
Schizothorax progastus	*	*
Garra gotyla	*	*
Pseudochenesis sulcata	*	*
Glyptothorax sp.	*	*
Psilorhynchus homaloptera	-	*
Parachiloglanis hodgarti	-	*

In order to have comprehensive information on sizes of fish ascending the fishway, total length and body depth was measured. This is carried out mainly to select suitable tag and tagging method to evaluate the effectiveness of fishway during the final course. The study recorded size

span of 186 fishes in June 2018 and 102 fishes in May and June 2019. The record showed variation in the size of species in different sampling time.

Table 2: Average body depth of fish ascending fishway

Fish species	June 2018	May/June 2019
Neolissochilus hexagonolepis	75.00 ± 13.36	68.83 ± 5.27
Schizothorax richardsonii	37.89 ± 2.63	54.17 ± 7.00
Schizothorax progastus	27.42 ± .29	40
Garra gotyla	16.00 ± 2.13	16.13 ± 1.15
Pseudecheneis sulcata	13.87 ± 1.02	20
Glyptothorax sp.	9.20 ± 1.66	11.76 ± 1.10
Psilorhynchus homaloptera	0	6.4 ± 0.60
Parachiloglanis hodgarti	0	20

3.2.1 Average body depth of fish

Table 2 presents the mean body depth of fish captured from fishway during the study. The highest mean body depth of fish recorded was 69.56 ± 5.07 mm for *Neolissochilus hexagonolepis*, and lowest of 6.4 ± 0.60 mm was recorded for *Psilorhynchus homaloptera***.**

3.2.2 Average length of fish

Table 3 shows the mean body length of fish ascending fishway measured twice during study period. The longest mean length of 323.82 ± 22.82 mm and shortest of 82.00 ±1.97 mm was recorded for *Neolissochilus hexagonolepis and Psilorhynchus homaloptera*, respectively**.**

Table 3: Average body length of fish ascending fishway

Fish species	June 2018	May/June 2019
Neolissochilus hexagonolepis	355.00 ± 93.32	319.67 ± 23.38
Schizothorax richardsonii	214.08 ± 10.94	276.50 ± 35.40
Schizothorax progastus	150.43 ± 5.04	190
Garra gotyla	120.00 ± 4.30	122.26 ± 4.11
Pseudecheneis sulcata	112.57 ± 5.03	130
Glyptothorax sp.	102.00 ± 12.81	110.05 ± 7.53
Psilorhynchus homaloptera	0	82.00 ± 1.97
Parachiloglanis hodgarti	0	100

3.3 Composition of fish utilizing fishway

The total composition of fishes from fishway was determined during two period's viz., June 2018 and May/June 2019). The composition of fish species recorded in different sampling periods differed. The study recorded highest composition was *Schizothorax richardsonii* (46.43%) in June 2018; whereas, in May/June 2019, the highest composition was G*arra gotyla* (30.39 %). The least composition was recorded for *Neolissochilus hexagonolepis* (4.76%) in June 2018 and 0.98% each for Parachiloglanis *hodgarti* and *Pseudochenesis sulcata* in 2019 as presented in Table 4.

3.3 Water discharge and flow in fishway

The water discharge in fishway was approximately 1.27 cumecs during June 2018 and 1.05 cumecs in May 2019. The average velocity of water in fishway was 0.62 m/s in May and 0.70 m/s in June 2018 and. The average water depth of fishway was 1.11 m in May and 1.21 m in June 2018.

3.5 Basic water quality

The basic water quality parameter from four selected sites at various elevation on fishway and three sites from different tributaries was recorded**.** The pH values recorded in this study fall within the reported satisfactory range of 6-9 by Central Pollution Control Board (CPCB), India. The pH values between 6.5 to 8.5 are known to supports healthy, diverse and productive fish and macroinvertebrates communities (NAS 1972). The pH and dissolved oxygen values of all sampling locations are

Table 4: Composition of fish species for different sampling

Fish species	**June 2018**	**May/June 2019**
Neolissochilus hexagonolepis	4.76%	29.41%
Schizothorax richardsonii	46.43%	11.76%
Schizothorax progastus	8.33%	0.98%
Garra gotyla	7.14%	30.39%
Pseudocheneis sulcata	27.38%	0.98%
Glyptothorax sp.	5.95%	20.59%
Psilorhynchus homaloptera	0	4.90%
Parachiloglanis hodgarti	0	0.98%

within standards prescribed for Class I category by UNECE standard (DO = > 7 ppm, pH = 6.5- 9) during all sampling expeditions.

Table 5. Basic water quality parameters (means) from sampling sites at Kurichhu HPP.

Sites	DO (ppm)	pH	Temperature (°C)
Morichhu	10.43±0.57	7.54±0.12	17.89±2.13
Fishway	11.55±1.46	8.18±0.37	18.08±0.58
Yunari	10.30±1.07	8.09±0.13	19.76±2.10
Yongri	9.83±0.46	7.72±0.23	20.87±3.42

The pH and dissolved oxygen recorded in sampling sites across all expeditions was as per standard laid by CPCB, India for the propagation of wildlife and fisheries (Class D) (DO = > 6 ppm, (pH = 6 - 9) (Table 5).

4.CONCLUSION AND RECOMMENDATION

A total of nine fish species were recorded from the aquatic ecosystem within the vicinity of Kurichhu HEP. Eight fish species irrespective of the size were found using fishway to migrate upstream and downstream. With this preliminary findings, it is recommended for further detailed studies to understand and document complete species composition and changes in species diversity in fishway with proper attention to following aspects: i) conduct frequent visit, preferably monthly at fishway to ascertain other fish species trying to ascend through fishway, as some of reported fishes were not documented during present survey, ii) study the relative abundance of fish species utilizing the fishway along the vicinity of the project iii) study the response of fish during onset of fishway operation, which is usually done yearly during the first week of February and response of fish to at time of shutting down of fishway, which is usually done yearly during last week of October, iv) conduct rudimentary test to see the time required for fishes to ascend the fishway through fin clipping, v) study the reproductive biology, pertaining to gonadal development of fishes utilizing the fishway, vi) understand about the design, operation and management of fishway within the Kurichhu dam and vii) monitor the basic water quality parameter within the study area. The study also recommended using advance technology such as Passive Integrated transponder to evaluate the effectiveness of fishway.

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