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CENTER FOR MOLECULAR DYNAMICS - NEPAL

PAANI RESEARCH BRIEFER
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Freshwater Biodiversity Assessment of Karnali River Detected by Environmental DNA (eDNA) Technology

BACKGROUND AND STUDY OBJECTIVES

Nepal, with her rich water resources, provides a home for over 230 native fish species of local origin. For generations, fisher folks have been utilizing this diversity for their economic and food values. Initial reports have indicated that aquatic species are threatened at an increasing rate due to human and climate-induced actions. However, the Karnali River is one of the least researched river systems, with the persistence of freshwater biodiversity. Until recently, no such in-depth research has been carried out to fill the huge knowledge gaps related to river morphology and the distribution of fish biodiversity. The tools available for assessing biodiversity are not flawless and hence, a combination of tools would be inevitable to determine the authentic diversity in the river system. Environmental DNA (eDNA) has been one cutting edge technology increasingly used for detecting freshwater biodiversity with a high confidence level. Using eDNA technology, the Center for Molecular Dynamics-Nepal (CMDN) assessed freshwater diversity in 15 strategic stretches of the Karnali River, to create baselines for future monitoring.

The specific study objectives were:

- To study field sites with available GIS-based mapping for carrying out the field work and sample collection;
- To carry out genetic analysis of the eDNA and fish samples to determine the extent and distribution of freshwater fish diversity; and
- To enrich DNA profiles for specimen preserved at FRD and maintain a genetic database of identified fish.

KEY FINDINGS

- CMDN identified 50 species of fish, of which 28 are from genetic sequencing of fish tissue, and 33 from eDNA sequencing, while 11 fish species were found overlapping between fish genetic and eDNA sequencing (Figure 1).
- The study validated eDNA as a proof-of-principle technology for biodiversity monitoring, as 33 species were identified using it.
- Nepal's first fish genetics and eDNA sample collection and processing protocols were developed under this study. Data and bioinformatics pipelines were also established as a by-product.
- Besides fin fish, eDNA also identified several sizeable counts of mayfly species, which are often regarded as a bio-indicator used to monitor river health.
- Initial assessments indicated the presence of aquatic life in Phoksundo, while eight unique fish species were detected from water samples collected from Rara Lake [3100 masl].
- eDNA revealed that fish species abundance was tenfold higher in free-flowing Karnali River as compared to rivers with multiple hydropower plants (i.e. Trishuli), suggesting that hydropower affects the abundance and diversity of freshwater species (Figure 2).
- eDNA identified the presence of exotic fish species which had not previously been detected from other assessments, methods, and tools.

A first of its kind study in Nepal

eDNA meta-barcoding and fish genetics technologies were used to create a checklist of 50 species in stretches of the Karnali River that now are attached with a genetic barcode (12S and COI genes). This is the first effort of its kind in Nepal where fish studies have been attached with genetic barcode references.

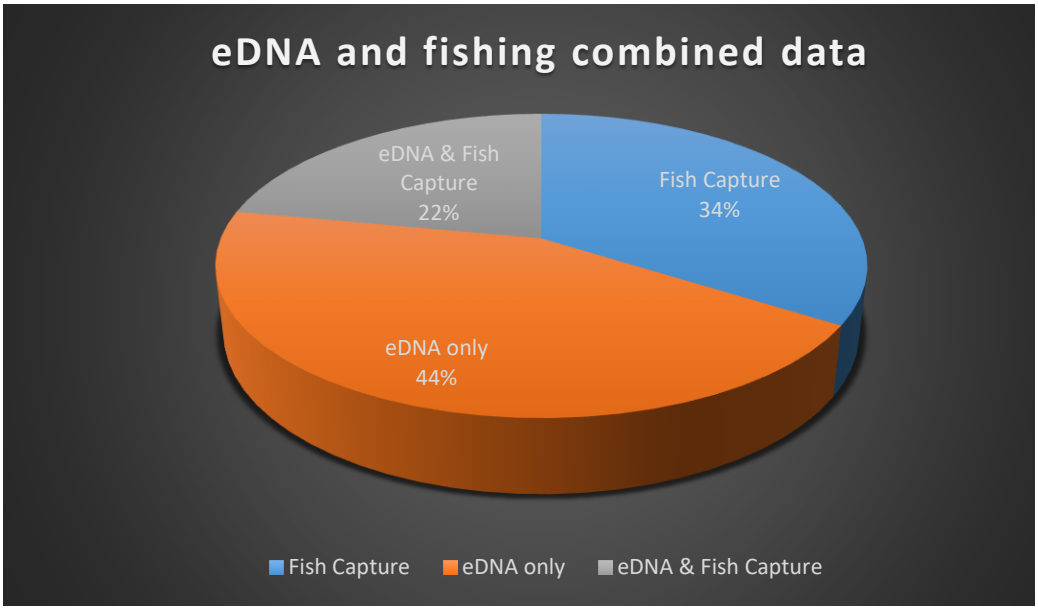

Fig 1: Total fish species identified through capture fisheries, environmental DNA and both.

ACTION / RECOMMENDATIONS

- eDNA technology can quickly and effectively detect species not often found from other traditional or conventional methods (i.e. morphology/taxonomy and genetics);
- eDNA can be used as a quick and effective tool to monitor changes in diversity;
- eDNA has some limitations in correctly detecting the total diversity, hence results need to be validated with taxonomic characters;
- The technology is a rapid assessment tool, which can be used during the environmental impact assessment (EIA) and also initial environmental evaluation (IEE) processes;
- Other institutions are encouraged to use and enrich the database, which CMDN has created based on e-DNA and genetic sequencing of fish tissue.

Members of the study team processing eDNA samples. (Photo credit: Anjana Shrestha, Field Researcher, CMDN)

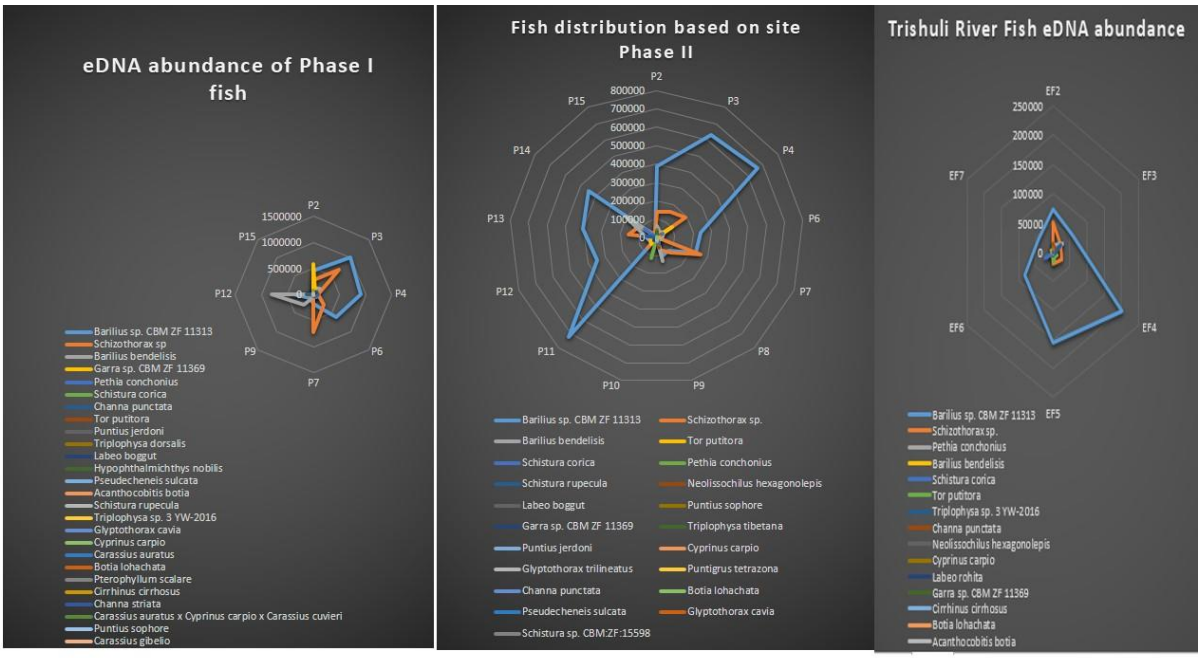

Fig 2: Comparison indexes between fish species available at Karnali and Trishuli through eDNA Operational Taxonomic Unit (OUT) metrics.