Adaptive Features of Bottom-Dwelling Fishes in the Tinau River

Sima Kafle

T.U. Registration No. 5-2-10-1179-2016

T.U. Examination Roll No. Zoo 952

Batch: 2077

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu

Nepal

A dissertation submitted

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Supervisor

Santoshi Shrestha

Assistant professor

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu

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Sima Kafle
April 2024
E-mail: seemakafle501@gmail.com

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

Website: https://www.cdz.tu.edu.np/

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Declaration

I hereby declare that the work presented in this dissertation "Adaptive Features of Bottom- Dwelling Fishes in the Tinau River" has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the authors or institutions.

....

Sima Kafle
Exam roll No.: 952/077
Email: seemakafle@gmail.com

Date: June 2024

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
Kirtipur, Kathmandu, Nepal.

०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

Central Department of Zoology T.U., Kirtipur

Recommendation

This is to recommend that the dissertation entitled "Adaptive Features of Bottom-Dwelling Fishes in the Tinau River" has been carried out by Sima Kafle for the partial fulfilment of Master's Degree of Science in Zoology with special paper Fish Biology and Aquaculture. This is her original work and has been carried out under my supervision. To the best of my knowledge, this dissertation work has not been submitted for any other degree in any institutions.

....

Supervisor
Santoshi Shrestha
Assistant professor
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

Date: 15/12/2080

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
Kirtipur, Kathmandu, Nepal.

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01-4331896
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URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

Central Department of Zoology T.U., Kirtipur

Letter of approval

On the recommendation of supervisor "Santoshi Shrestha" this dissertation submitted by Sima Kafle entitled "Adaptive Features of Bottom- Dwelling Fishes in the Tinau River" is approved for the examination in partial fulfilment of the requirements for Master's Degree of Science in Zoology with special paper Fish Biology and Aquaculture.

....

Head of Department
Kumar Sapkota, Ph. D.
Professor
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

Date: 15/12/2080

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
Kirtipur, Kathmandu, Nepal.

०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

Central Department of Zoology T.U., Kirtipur

Certificate of acceptance

This dissertation work submitted by Sima Kafle entitled "Adaptive Features of Bottom-Dwelling Fishes in the Tinau River" has been accepted as a partial fulfilment for the requirements of Master's Degree of Science in Zoology with special paper Fish Biology and aquaculture.

Evaluation committee

....
Supervisor
Santoshi Shrestha
Assistant professor

....
Head of Department
Kumar Sapkota, Ph.D.
Professor

....
External examiner
Kumar Khatri, Ph D
Assistant Professor

....
Internal Examiner
Archana Prasad, Ph D
Associate Professor

Date of examination: 2081/02/13

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Abstract

The present study deals with the adaptive features of bottom-dwelling fishes Genus *Garra* of Tinau River using cast net and local fishing implement hammering. A total of 201 individuals of two species *Garra annandalei* (n=83) and *Garra gotyla* (n= 113) during September / October, 2023.The study focused on abundance, morphometric analysis, length-weight relationship, conditional factors, relationship of physicochemical parameters with fish and comparison collected sample with Central Department of Zoology, Tribhuvan, University (CDZ TU) museum deposited samples of *Garra*.. *Garra annandalei* has a length-weight relationship with b value 0.21, whereas *Garra gotyla* has b value: 0.38. The b value was fewer than 3, indicating that the species display negative allometric growth. The conditional factor was k = 0.50 for *Garra annandalei* and k = 0.60 for *Garra gotyla*, indicating that the species is in good condition. The most of the physicochemical characteristics were measured within acceptable ranges and relationship between fish abundance and physicochemical parameters also within good for fish's survival. The paired sample t test revealed that there is significant different between means of two samples also x-ray examined difference between older and newly collected sample.

शोध सार

हालको अध्ययनले कास्ट नेट र स्थानीय माछा मार्ने उपकरण ह्यामरिङको प्रयोग गरेर तिनाउ नदीको तल बस्ने माछा जीनस गाराको अनुकूली विशेषताहरूको अध्ययन गरेको थियो । सेप्टेम्बर र अक्टोबर, २०२३ मा दुई प्रजाति *Garra annandalei* (n=८३) र *Garra gotyla* (n= ११३) को कुल २०१ संख्याहरूको अध्ययनले प्रशस्तता, विविधता, मोर्फोमेट्रिक विश्लेषण, लम्बाइ र वजन सम्बन्ध, सशर्त कारकहरूमा केन्द्रित थियो । माछासँगको भौतिक रसायनिक मापदण्डहरूको सम्बन्ध र *Garra* प्रजातिको प्राणिशास्त्र संग्रहालयमा जम्मा गरिएका नमूनाहरूसँग सङ्कलन गरिएको नमूनाको अन्तरमा केन्द्रित थियो । *Garra annandalei* को b मान ०.२१ जबकि गारा गोट्ल्याको b मान: ०.३८ थियो, जहाँ b मान ३ भन्दा कम थियो, जसले प्रजातिहरूको नकारात्मक एलोमेट्रिक वृद्धि देखाएको संकेत गर्दछ । सशर्त कारक k=०.५० *Garra annandalei* को लागि र k=०.६० *Garra gotyla* को लागि थियो, जसले प्रजाति राम्रो अवस्थामा रहेको संकेत गर्दछ । धेरैजसो भौतिक रसायनिक विशेषताहरू स्वीकार्य दायरा भित्र मापन गरियो र माछाको प्रचुरता र भौतिक रसायनिक मापदण्डहरू बीचको सम्बन्ध पनि माछाको बाँच्नको लागि राम्रो रहेको मापन गरियो । जोडी नमूना टी परीक्षणले दुईवटा नमूनाहरूको मध्यम मान बिच फरक छ वा छैन जाच गर्दा अनुकुली विशेषतामा भिन्नता रहेका पाइयो । पुरानो र नयाँ सङ्कलन गरिएका नमूनाहरू बीचको एक्स रे जाँच बाट कंकालमा पनि भिन्नता रहेको पाइयो ।

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List of abbreviations

ABL	Anterial barbel Length
AFL	Anal-fin depth
BD	Body Depth
BW	Body Weight
CPL	Caudal- Peduncle Length
DFBDFR	Depth of first branched dorsal-fin ray
DFD	Dorsal-fin Depth
DL	Disc Length
DW	Disc Width
EHD	Eye horizontal diameter
GA	*Garra annandalei*
GG	*Garra gotyla*
HDE	Head depth at Eye
HDN	Head depth at Nape
HL	Head Length
H.W.E	Head width at Eye
HWPEO	Head Width at Posterior end of operculum
IOW	Interorbital width
LAS	Length of axillary scale
LL	Length of Labrum
LP	Length of Pulvinus
LT	Length of Torus
Max. CPD	Maximum Caudal Peduncle Depth
Min. CPD	Minimum Caudal Peduncle Depth
OOD	Orbit-Operculum distance
PAL	Pre Anal Length
PBL	Posterior barbel Length
PDL	Predorsal Length
Pec FL	Pectoral-fin Length
Pec PelL	Pectoral-Pelvic Length
Pel AL	Pelvic Anal Length

Pel FL	Pelvic-fin Length
P Pel.L	Pre-Pelvic Length
SL	Standard length
SnL	Snout Length
VD	Vent Distance
WBAB	Width between Anterior Barbels
WBN	Width between Nostrils
WM	Width of Mouth
WP	Width of Pulvinus
WT	Width of Torus

1. Introduction

1.1 Background

The distribution patterns of organisms are primarily influenced by how species react to their environment. Dominant abiotic factors likely function as a physiological filter and play a crucial role in shaping community structures (Remmert, 1983). The distribution of some species covers large geographical areas, while others are confined to small regions. This restricted distribution is mainly due to the heterogeneous physical environment. On a biogeographical scale, physical barriers can prevent species from migrating to other suitable areas (Wootton, 1996). Fishes inhabiting hill streams require special body modifications to avoid being swept away by fast currents. These adaptations, typically adhesive structures on the ventral side and fins, are integumentary modifications that serve as specialized anchoring mechanisms. Hill stream fish exhibit diverse adaptations to their environments (Nagar et al., 2012). Hill stream fish need secure anchorage and mechanical stability to survive in fast-moving currents (Nagar et al., 2012). Hora (1922, 1923, 1930,) extensively studied the adaptive modifications of numerous torrential fish for life in swift currents and rocky substrates and gave detail explanation of the adhesive apparatus of *Garra annandalei* (Cyprinoidei, Cyprinoidae) and *Glyptothorax madraspatanus* (Siluroidei, Sisoridae). Rauther (1928) examined the adhesive disc structure of *Discognathus lamta*. Wu and Liu (1940) studied the adhesive apparatus of the Chinese sisorid fish, *Glyptosternum* (now *Glyptothorax*), while Bhatia (1950) and Lal et al. (1966) investigated Indian hill stream sisorids, *Glyptothorax telchitta*, and *Glyptothorax pectinopterus*, respectively. Saxena (1959, 1961, 1966,) conducted extensive research on the adhesive organs of hill stream fishes, explaining the adhesion mechanisms in *Garra mullya* and *Pseudoechinus sulcatus*. Fishes like *Barilius* spp. (Fageta), *Garra* spp. (Buduna), and *Schistura* spp. (loaches), have special structures that help them live in fast flowing River system. For example, these fishes have lips that help them eat different kinds of food, and they have a special organ in their thorax that helps them stick to the river bed. In this study, *Garra* is used as a model species for this study in Tinau River, Rupendahi because of its remarkable adaption in fast flowing water and bottom living characteristics (Hussain & Bordoloi, 2018) and its presence (Sharma et al., 2001) . There are more than 170 nominal species of the genus *Garra* that are widely distributed from Southern China, across Southeast Asia, India, and the Middle East to northern and central Africa (Zirkunga et al., 2023). They are known for their unique feeding behavior, where they scrape or nibble on the skin of other fish or even humans so *G. rufa* led to their popularity in some spa treatment (Markwell, 2015). They use river beds, mostly rocks, boulders, stones, and gravel, as useful hiding and anchoring substrates (Pinky et al., 2002). They feed on algae, crustaceans, small fish, insects, and frogs in all parts of the river (Baile, 1994). Lips are specialized structures that surround the mouth anterior aperture, or alimentary canal, and cover the jawbones. The principal tasks of the lips and structures connected with them are food selection, capture, and pre-digestive preparation (Buckner et al., 2016). They have an inferior mouth, and the mandibular area is particularly changed into a disc-like mechanism that is utilized for attaching to rock surfaces (Vishwanath & Nebeshwar, 2009). Members of this genus are mainly found in fast-flowing rivers or streams, while some species have been reported to occur in brackish waters, lakes, and aquatic bodies inside caves (Tamang et al., 2019). In his book, Menon reported that Hamilton Buchanan described the first *Garra* species from the Ganges in 1822. This genus is classified into four groups and nine complexes based on its morphological characteristics. In Nepal, *G. lamta* was the first species of *Garra* recorded by Hamilton in 1822; described as *Cyprinus lamta* from the Tinau River near Butwal, which is the type location of this genus (Menon, 1964). Shrestha, 1984 reported five species of *Garra* from different water system of Nepal while Shrestha, 2019 listed 8 species in his book Ichthyology of Nepal. (Rayamajhi & Arunachalam, 2017) added the new species of *Garra*; *G. nepalensis* from Mardi River.

The torrential water current associated with slopes, rocky beds, and beaches makes it difficult for fish to move about in hill streams, thus fishes are supplied with an adequate adhesive organ made of integument modification to adapt to these environments. Particularly for hill-stream fishes like *Garra*. Specifically focusing on the organ of attachment. Fish living in the Tinau River may have to adapt to changes in the environment, such as increased sand mining and pollution. These can cause changes in the temperature and water quality of the river, which could impact their survival. Sand mining can change the physical structure of the river, which can make it harder for fish to find food and avoid predators. Pollution can harm the environment and the fish that live there. These pollutants can reduce the amount of oxygen and food available to the fish, forcing them to find ways to survive in these conditions. Fish may need to adapt their feeding and behavior to survive in these changing conditions (Poudel, 2012). The Tinau River catchment is affected by sand mining, pollution, and climate change, which might have caused some of its fish to change their behavior to adapt (Sharma, 2003).More research is needed to understand the specific impacts of these environmental factors on the adaptations of different fish species and how they respond to these changes.

1.2 Justification of the study

In the preliminary survey, the bottom-dwelling fish such as *Barilius* spp., *Schistura* spp., *Garra* spp., and *Pseudochenesis* spp were found in catch. As Genus *Garra* was found abundantly than other species and its remarkable adaption in fast flowing water and bottom living characteristics, this species was chosen for study. The documentation of adaptive features of bottom-dwelling fishes like *Garra* Spp. analysis and recording is still lacking so it seems essential to document adaptive features in detail. Also the study of adaptive features of *Garra* has not gained as much attention as that of a diversity of fishes (Rijal, 2015) There have not been such type of studies done in this species and the river also.

1.3 Objectives

1.3.1 General objective

The general objective was to study adaptive features of bottom dwelling fishes of Tinau River.

1.3.2 Specific objectives

- To assess the taxonomic diversity and abundance of Genus *Garra*
- To assess length weight relationship and condition factor of Genus *Garra*
- To analyze the relationship between genus *Garra* and physicochemical parameters of Tinau.
- To compare the adaptive features of collected samples with deposited samples of *Garra*.
- To analyze skeleton of *Garra* by using x-ray method.

1.4 Research hypothesis

H_o: Null hypothesis: There is no significant difference between collected and deposited sample of *Garra* for the context of adaptive features.

H_1: Alternative hypothesis: There is significant difference between collected and deposited sample of *Garra* for the context of adaptive features.

1.5 Significance of the study

The Tinau River, located in the Rupandehi and Palpa districts of Nepal, is a vital waterway. It plays a crucial role in supporting diverse aquatic vegetation and wildlife. According to local people, the biodiversity especially aquatic inhabitants are declining in present days due to pollution, habitant alteration and overfishing and little information on fishes so this study explores the *Garra* species abundances, adaptive features by comparing Morphometric characteristics of old and new samples of *Garra* species, length weight relationship of Genus *Garra* of Tinau River with its water parameters. This information will help to update the adaptive features of bottom dwelling fish *Garra* and provide baseline data for further studies on Genus *Garra*.

2. Literature review

The *Garra* (Hamilton, 1822) commonly known as sucker head fish is a diverse group of small freshwater fish belonging to the family Cyprinidae. The genus *Garra* is widespread and exhibits great diversity with many morphological variations and coloration (Komarova et al., 2022). Adhesive discs or suctorial discs are essential for fish living in fast-flowing habitats, facilitating their attachment to surfaces. These discs have two distinct regions: the mucogenic and keratinized areas. The mucogenic region, located in the central part of the disc, contains mucous pores and mucosal gland openings. The keratinized region, which features numerous clusters of excrescences (adhesive islets), bears unculiferous structures (unculi). Researchers, including Nagar et al. (2012), have noted that these structures primarily help the fish adhere firmly to the substrate. *Garra* has a well-developed adhesive disc on its ventral surface. This fish, a bottom dweller, inhabits fast-flowing streams. It has an inferior mouth with thick lips covered in prominent tubercles. The upper lip is highly fringed. The lower lip extends from behind the lower jaw and forms a circular disc with a free margin. The space between the lower lip and the posterolateral free margin of the disc thickens to form a callous pad (CP).

Morphologically, the disc comprises four parts: the fringed anterior labial fold of the upper lip, the posterior free labial fold of the lower lip, the central callous portion (or callous pad), and the posterolateral free margin. Spines attached to stub-shaped tubercles are prominent on the upper fringed lip and the lower free labial fold of the disc. These stub-shaped structures are covered with squamous epithelium (SE). The spines on the circular margin of the tubercles are small, increasing in size towards the center. The lower lip features elongated stub-shaped tubercles (ST) with longer spines. The posterior part of the lower lip, which is the callous pad, is thick and hard. The spines and tubercles on the upper fringed lip and the disc's free border are shorter than those on the lower lip. Each spine, attached to a broader base with pentahexagonal epithelial cells, indicates a modification of squamous epithelium. These teeth-shaped spines help in firm attachment to and scraping food from the substrate. The spaces between tubercles have a hexagonal epithelial covering. The callous pad has numerous mucous openings and an epithelial layer with irregular micro ridges of varying shapes and sizes, forming elevations and depressions that may serve as canals for mucus distribution.

The research on the three distinct species of *Garra* from Mount Kenya, previously identified as *Garra dembeensis: Garra hindii, Garra alticauda* sp. nov., and *Garra minibarbata* sp. nov. are morphologically distinguishable and form separate lineages (Cao et al., 2023).

Species diversity, distribution, and abundance of Seti Gandaki River Basin fish in Pokhara, Nepal were studied at five sites, three along the main channel and two in major tributaries. Thirty species from five orders, nine families, and 24 genera were found, totaling 10,659 individuals. Cyprinids dominated, followed by silurids, balitorids, channids, mastacembelids, belonids, and cobitids. Certain species like *Tor tor* and *Danio rerio* were uncommon. Environmental variables affected abundance notably decreasing in urban areas (Pokharel et al., 2020).

The study on Masyam Khola in Palpa, Nepal focused on fish diversity across winter and spring using cast nets. It identified 255 fish from 9 species, 7 genera, and 2 families. Cyprinidae dominated with 7 species. *Barilius bendelensis* was most abundant, followed by *Opsarius barna*, *Puntius sophore,* and *Garra* spp... Environmental variables like dissolved oxygen, pH, temperature, and velocity were suitable for fish habitat (Bhattarai, 2022).

According to the research, 26 fish species from 4 orders, 9 families, and 19 genera were collected from the Tinau River. During the research period, the three most often spotted fish species were *Garra* spp.., *Puntius sophore*, and *Barillus bendelensis,* whereas *Brachydanio rerio* and *Tor tor* were infrequently captured fish (Rijal, 2015).

Baycelebi et al. (2018) *Garra turcica*, originally thought the same with *G. rufa*, has been reclassified as a separate species originating from the Kızıl, Seyhan, Ceyhan, and Arsuz rivers. Molecular investigation confirms its unique species status, since it differs from *G. rufa* in body form, snout structure, and rostral cap length. Molecularly, it is closely related to species in the Persian Gulf basin, particularly *G. elegans, G. mondica,* and *G. amirhosseini*, but it is distinguished by a free posterior margin of the mental disc, a scaled predorsal back, and comparable breast and belly scales.

Dwivedi et al. (2020) studied the Cyprinidae family, particularly the Gangetic Cyprinids, boasts vast morphological diversity among freshwater fishes. Using geometric morphometrics (GM) on 31 digital photographs of 47 Cyprinid species from the Ganga River, this study quantified interspecific morphometric relationships. Principal component analysis (PCA), canonical variate analysis (CVA), and Cluster analysis (CA) revealed significant differences among species. Phenogram clustering indicated shared phenotypic traits within genera like *Barilius, Garra, Labeo, Pethia, Schizothorax,* and *Tor,* suggesting evolutionary relatedness. This study highlights the effectiveness of digital image analysis and GM in discerning distinct groups and illustrating morphological relationships among Cyprinid species.

Dhinakaran et al. (2011) employed RAPD-PCR technology to examine the morphological and genetic variation of three *Garra* fish species (*G. mullya, G. kalakadensis,* and *G. gotyla stenorhynchus*) from different river basins in southern India. Morphological research indicated substantial similarities between *G. mullya* and *G. kalakadensis,* although *G. gotyla stenorhynchus* had different morphometric characteristics.

Golubtsov et al. (2012) the major morphological diversity of the *Garra* genus in the Sore River, which is part of the White Nile Basin in southwestern Ethiopia, indicates a possible cyprinid species flock. Four coexisting *Garra* types with differing exterior morphologies have been identified in the river's middle basin. Furthermore, two *Garra* specimens with uncommon qualities were found, including one with a 'rubber lip', a new morphological feature within the species, and another with features suggestive of predatory eating behavior.

Singh (2013) discovered hill stream fish of the Cyprinidae family with a distinct dorsal top lip morphology, which was defined by a small skin fold linking it to an expanded rostral cap in a deep groove. The rostral cap's surface is divided into two separate regions: a large proximal section towards the dorsal head skin and a tiny distal piece near the mouth opening. Scanning electron microscopy was used to investigate live samples from the Kosi River in Hawalbagh area, Almora, indicating that these hill stream fish had evolved for acute sensory function.

Hussain & Bordoloi (2018) identified four *Garra* species (Teleostei, Cyprinidae) with morphological modifications in the Barista River, Assam, India. Using SEM, they observed versatile changes in lip regions and barbells, suggesting adaptation to microhabitats. *G. nasuta* and *G. gravely* showed enhanced adaptive lip characteristics, while *G. stenorhynchus* exhibited improved mechano and chemoreceptive behavior in foraging and water sensing. These unique adaptations reflect the functions of these organs and associated structures, likely influenced by their respective microenvironments.

Singh et al. (2020) employed SEM to investigate hill stream fish in Kumaun, namely *Botia almorhae, Homaloptera brucei,* and *Schizothorax richardsonii.* They discovered relationships between environmental factors and mouth, body, and fin morphologies, indicating that fish morphology has evolved throughout time due to habitat.

Baby et al. (2011) studied the length-weight relationship (LWR) and condition factor of *Nilgiri Garra, Garra gotyla stenorhynchus* (Jerdon), were investigated in the Chaliyar and Bhavani rivers, a Western Ghats Biodiversity Hotspot. The regression equations for the Chaliyar and Bhavani populations were Log Wt = 2.920 Log L - 1.854 and 2.594 Log L - 1.538, respectively. Despite the fact that Chaliyar had a higher 'b' value (2.920) than Bhavani (2.594), the difference was not statistically significant. Bhavani populations had a higher Condition Factor (K) (2.177) than Chaliyar (2.087), but not considerably. Chaliyar populations displayed isometric growth, but Bhavani populations showed stress, as shown by decreased 'b' values, which might be related to habitat changes and undiscovered stresses.

A study on the length-weight relationship and condition factor included 57 freshwater fish species from diverse Indian water basins. The parameter 'b' varied from 1.422 to 3.917, with a mean of 2.994. Except for three, the majority of the species demonstrated a substantial association (r2 >0.90). Isometric growth (b=3) was found in 32 species, positive allometry (b>3) in 21, and negative allometry (b<3) in 14. Habitat preferences were shown to be associated with species growth variances (Lal et al., 2016).

The study applied the Water Quality Index (WQI) to assess aquatic ecosystem health in the Marshyangdi River basin, eight physicochemical parameters (TDS, pH, EC, DO, Cl-, NH3, PO43-, and NO3-) were studied and aggregated into WQI. The results indicated that the WQI ranged from 32.5 to 46.9, suggesting good water quality sufficient for the survival of the aquatic environment at all sampling locations (Singh et al., 2021).

Using X-ray microtomography, the osteology of *Bibarba parvoculus* and *B. bibarba* is compared, revealing that *B. parvoculus* exhibits higher vertebral counts, a broader anterior part of the frontal bone at the orbital region, and decreased sexual dimorphism compared to *B. bibarba*, while the coracoid, mesocoracoid, and scapula are stouter in males of both species, with *B. parvoculus* having autogenous bones and *B. bibarba* having fusion with the cleithrum (He et al., 2021).

Utilizing high-resolution synchrotron X-ray microtomography, examined the 3D structure of *Sinocyclocheilus hyalinus'* horn, a *troglobiotic* species. Renderings revealed an osteological framework consisting of a rear wall (supraoccipital bone), a fenestrated frontal wall, and a continuous bottom (parietal and epiotic) enclosing a horn cavity. Elaborate fenestrae in the frontal wall, connected to the cranial cavity by soft tissue, suggest an "otocornual connection," resembling the otolateralic connection in other fish species, possibly enhancing underwater sound perception (He et al., 2013).

3. Materials and methods

3.1 Study area

The Tinau River originates from the Mahabharata range in Palpa district, approximately 20 kilometers east of Tansen. It is separated from all the three major river systems of Nepal, and runs about 95 km between altitudes of 100-800 m (Sharma & Shrestha, 2001). However, present study area includes about 20km from Charchare to Butwal. For the present investigation, five main sites were selected, viz., Charchare (I), Jhumsa (II), Dobhan (III), Chidiya khola (IV) and Butwal (V).

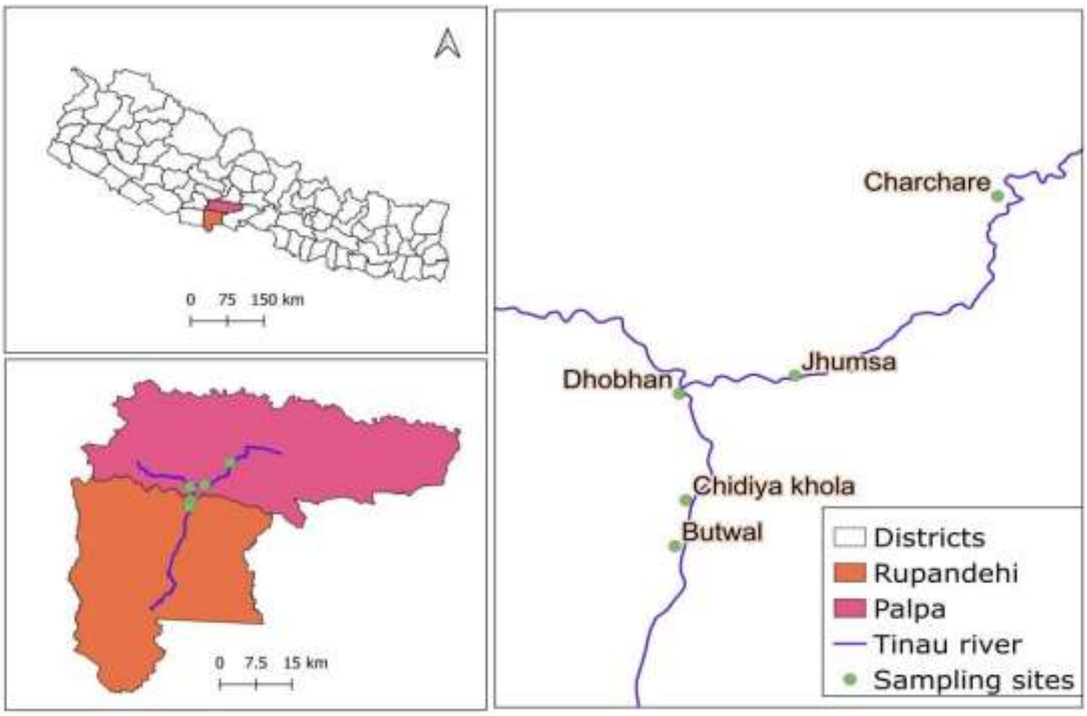


Figure 1. Study area of Tinau River of Nepal

3.2. Selection of sampling sites

The preliminary survey was done during August, 2023 to gather the necessary information about the study area and the feasibility of the research. Based on the field observation, five sampling sites were selected and designed site I, site II, site III, site IV and site V.

3.2.1 Site I: Charchare

It lies on 27°47′48.62″N 83°32′29.31″E, with an elevation of 574 m. The riverbed consists of sand, gravel, stones, and bedrock. It experiences less human interfering and pollution. So, it was an undisturbed area.

3.2.2 Site II: Jhumsa

It lies on 27°44′54.8″N 83°29′34.46″E, with an elevation of 330 m. Jhumsa was the second station with less interference of human beings.

3.2.3 Site III: Dobhan

It lies on 27°44′38.55″N 83°27′44.86″E, with an elevation of 280 m. A dam has been built at Dobhan station to generate the hydropower.so it was also disturbed area.

3.2.4 Site IV: Chidiya khola

The coordinates are 27°43′02.03″N 83°27′51.1″E, and the elevation is 200 m. The area was also affected due to various kinds of waste from cities that passed through it.

3.2.5 Site V: Butwal

The coordinates are 27°42′20.45″N 83°27′40.73″E, with an elevation of 190 m from sea level. The river divides near the Mahendra Highway Bridge, and the two branches are known as the Dano and Tinau Rivers. Butwal was also a disturbed area.

3.3. Materials

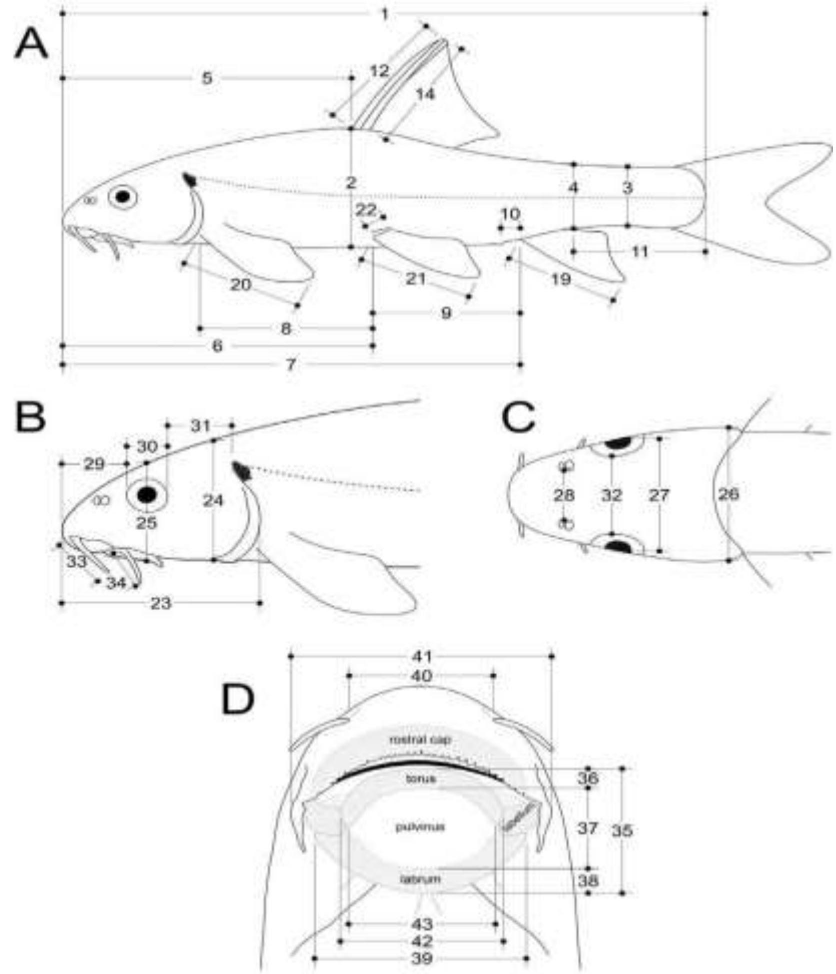
Specimens, camera, weighing machine, Vernier caliper, x-ray machine, cast net, Gear, malmal or cotton cloth, beakers, tweezers, needle and vials, scale, weighing paper, spatula, jars/containers, safety (gloves, marks), waste containers. Distilled/deionized water, 10% formalin etc.

3.4. Methods

3.4.1. Sample collection and morphometric analysis

During the months of September and October 2023, samples were collected from the field by hiring fisherman from different locations using a cast net and a hammer to find the hidden fish behind the stone. At the time, two varieties of *Garra* species were collected and the samples were identified in the field using Tej Kumar Shrestha book before being kept in 10% formalin for future research. During the research period, a multi-parameter version of the HANNA HI 98194 device was utilized to analyze physicochemical parameters, as well as the MAP.ME software to monitor GPS, latitude, and longitude. For morphometric data, 39 distinct characteristics were measured each one individually with a Vernier caliper before weighing it with a machine.

The samples deposited in department were code as GA1 to GA5 (collector S.Shrestha, 2003 from Dobhan, Tinau River), GG6 (Anonymus, 2068 BS, Butwal,Tinau River), GG7 and GG8 (Anonymus, 2009/2010, Jhumsa,Tinau River).



Source: (Englmaier et al., 2020)

Figure 2. A (Schematic illustration of a body measurements) B (lateral) and C (dorsal) head measurements, and D (ventral) head and gular disc

1. Standard length (SL); 2. Body depth at dorsal-fin origin; 3. Minimum caudal-peduncle depth; 4. Maximum caudal-peduncle depth. 5. Predorsal length; 6. Prepelvic length; 7. Preanal length; 8. Pectoral-Pelvic distance; 9. Pelvic-Anal distance; 10. Vent distance; 11. Caudal-Peduncle length; 12, dorsal fin depth; 14, depth of the first branching dorsal fin

ray; 19, depth of the anal fin; 20, Pectoral fin length; 21, Pelvic fin length; 22, Axillary scale length; 23 head length; 24 head depth at the neck; 25 head depth at the eye. 26 head width at the posterior end of the operculum. The measurements recorded include: 27, head width at eyes; 28, width between nostrils; 29, snout length; 30, eye horizontal diameter; 31, orbit-operculum distance; 32, interorbital width; 33, anterior barbel length; and 34, posterior barbel length.; 35, disc length; 36, torus length; 37, Pulvinus length; 38, labrum length; 39, disc width; 40, width between anterior barbels; 41, mouth width; 42, torus width; and 43, pulvinus width. Not shown in the data are the measurements for: 13, depth of the final unbranched dorsal fin ray; and 15, depth of the second branched dorsal fin ray.; 16, depth of the third branched dorsal fin ray; 17, depth of the fourth branched dorsal fin ray; and 18, depth of the fifth branched dorsal fin ray (Englmaier et al., 2020).

3.4.2. Length-weight relationships

The length-weight relationship equation for fish is commonly expressed using a power function. The most widely used form of this equation is the allometric equation, which relates the length (L) of a fish to its weight (W) (Dar et al., 2012):

W=a×Lb

In this equation:

W represents the weight of the fish.

L represents the length of the fish.

The coefficient or intercept, which indicates the weight of the fish at a reference length (often taken as 1 unit of length, e.g., 1 cm).

The b is the exponent or scaling parameter, which describes the relationship between length and weight. It indicates how weight changes as length increases. This exponent is often referred to as the "allometric coefficient."

The value of b determines whether the relationship is isometric (proportional growth), positive allometric (weight increases faster than length), or negative allometric (weight increases slower than length) (Ama-Abasi, 2008) .

If =3b=3, it implies isometric growth, where weight increases in direct proportion to length.

If >3b>3, it indicates positive allometry, meaning weight increases faster than length.

If <3b<3, it signifies negative allometry, implying weight increases slower than length.

Two Species of Genus *Garra* where 88 species of *Garra annandalei* and 121 species of *Garra gotyla* fishes were tested LWRs. When using this method to sampled fish, b may diverge from the "ideal value" of 3 that indicates isometric development due to environmental factors or the fish's own condition.

3.4.3. Relative condition factor (K_n)

The Relative Condition Factor (Kn) is a measure used in fisheries biology to assess the health and condition of fish. It compares the observed weight of a fish to a weight predicted by a length-weight relationship. Here's a detailed explanation along with the working formula:

Formula

The relative condition factor (Kn) is calculated using the following formula:

Kn =W \W′

Where:

W = observed weight of the fish

W′ = predicted weight of the fish, based on its length

Steps to Calculate the Relative Condition Factor

1. **Determine the Length-Weight Relationship:**
    - Typically, the length-weight relationship of a fish species is described by the equation: W′= aLb
        - L = length of the fish
        - a and b = constants derived from a sample population of the same species

These constants are usually obtained through regression analysis on a large dataset of the same species.

2. **Measure the Length and Weight of the Fish:**

Measure the length (L) and the weight (W) of the fish in question.

3. **Calculate the Predicted Weight (W′):**

Using the length-weight relationship, calculate the predicted weight: W′= aLb

4. **Calculate the Relative Condition Factor (Kn):**

Divide the observed weight (W) by the predicted weight ('W′): Kn =W\W′

This method helps in assessing the health and well-being of fish populations and can be useful for fisheries management and conservation efforts.

Kn was developed to evaluate the status of several fish species under investigation. Kn is defined as Wo/Wc, where Wo is the measured weight and Wc is the computed weight (Jisr et al., 2018). When $Kn \geq 1$, the fish is in good development condition, whereas Kn < 1 indicates poor growth relative to a typical individual of the same length.

3.5. Data Analysis:

Morphometric measurement such as minimum, maximum value mean, standard deviation, Pearson correlation coefficient, significant test with standard length with other morphometric characteristics are computed on IBM SPSS 25 software. The length-weight relationship was evaluated using MS-excel 2010 for linear regression and correlation between length and weight. Physico-chemical parameters and fish abundance correlation and probable error was also calculated using MS-excel 2010.

The significant difference between two samples collected in the field and deposited fish at the CDZ lab was analyzed using IBM SPSS 25 software, For the test of hypothesis, is there any significance difference between two types of samples, performed paired sample T test to compare two mean values of morphometric characteristics in IBM 25 SPSS software and evaluated significance difference and correlation between them. At the 5% level of significance (p=0.05), the correlation coefficient is ±1. X-ray of collected and older specimens of *Garra gotyla* and *Garra annadalei* fish was done at Lifeline Veterinary Hospital and Research Center, Sanepa-2, Lalitpur and data were compared.

4. Results

4.1 Taxonomic Account of Genus Garra:

During the study two *Garra* species; *G. annandalei* and *G.gotyla* were reported from study area.

***Garra annandalei* Hora, 1921**

Material examined: Jhumsa 27°44′54.8″N 83°29′34.46″E; 330 masl, Dobhan 27°44′38.55″N 83°27′44.86″E; 280 masl, Chidiyakhola 27°43′02.03″N 83°27′51.1″E; 200 masl, Butwal 27°42′20.45″N 83°27′40.73″E; 190 masl .

Diagnosis:

- A medium sized fish with elongated and robust body, distinctive, slightly flattened head, snout with a fleshy pad some with small tubercles (sometimes), mouth subterminal; located underneath the head, barbles two pairs, dorsal fin wth a strong spine and several soft rays, Pectoral, pelvic, and caudal fins are well-developed, aiding in their movement and stability in fast-flowing waters. Colouration generally dark brown or grayish in color, which may vary depending on the environment.

***Garra gotyla* (Gray, 1830)**

Material examined: Charchare 27°44′54.8″N 83°29′34.46″E; 330 masl, Jhumsa 27°44′54.8″N 83°29′34.46″E; 330 masl, Dobhan 27°44′38.55″N 83°27′44.86″E; 280 masl, Chidiyakhola 27°43′02.03″N 83°27′51.1″E; 200 masl, Butwal 27°42′20.45″N 83°27′40.73″E; 190 masl.

Diagnosis:

A small to medium sized fish with elongated and robust body, head broad and flattened, snout pronounced with a fleshy pad having small tubercles (tiny, wart-like structures), mouth subterminal, two airs of barbels, coloration generally dark brown; lighter under belly, dorsal fin with a strong spine followed by several soft rays, well-developed pectoral, pelvic, and caudal fins.

3a 3b

3c 3d

Figure 3. 3a. Adhesive disc of *Garra annandalei* 3b adhesive disc of *Garra gotyla*, 3c dorsal and ventral view of *G. gotyla*, 3d dorsal and ventral view of *G. annandalei*

4.2 Morphometric analysis of Genus Garra:

Different morphometric features ranging from standard length to body weight were selected for statistical analysis, including minimum maximum value, mean, standard deviation, Pearson correlation coefficient, and two-tailed significance test at p=0.01. 39 parameters were examined. Out of 39 variables, 37 were highly correlated with standard length of fish but, vent distance is negatively correlated with standard length, and labrum length is strongly correlated with standard length. Only vent distance shows non-significant result otherwise, all parameters provide significant results with standard length (Table1).

Table 1. Morphometric analysis of *Garra annandalei* and *Garra gotyla* form five sampling sites

S.N.	Parameters (mm)	Min	Max	Mean±SD	Pearson Correlation coefficient (r)	Significance (two tailed) at p=0.01
1	SL	31.52	92.42	46.31±9.85	1	0.000
2	BD	4.28	19.46	8.82±2.36	0.89	0.000
3	CPD Min	1.17	11.88	4.86±1.42	0.85	0.000
4	Max. CPD	3.4	23.72	5.75±2.11	0.58	0.000
5	PDL	2.01	42.47	21.46±4.96	0.91	0.000
6	P PelL	15.13	43.3	24.18±5.26	0.88	0.000
7	P.A L	11.71	67.22	33.77±8.24	0.85	0.000
8	Pec pel.L	3.57	27.18	13.94±3.36	0.84	0.000
9	Pel AL	1.72	24.61	11.003±2.78	0.85	0.000
10	VD	1.28	19.7	4.08±13.88	-0.39	0.578
11	CPL	1.38	18.91	8.95±2.19	0.82	0.000
12	DFD	6.76	19.87	10.77±2.41	0.89	0.000
13	DFBDFR	6.11	19.18	9.90±2.32	0.88	0.000
14	AFL	4.53	17.62	8.93±2.07	0.85	0.000
15	Pec FL	3.64	20.37	10.26±2.31	0.81	0.000
16	Pel.F L	2.36	16.2	8.45±2.14	0.82	0.000
17	LAS	0.2	9.99	2.37±1.05	0.42	0.000
18	HL	5.06	22.64	11.68±2.45	0.87	0.000
19	HDN	3.57	15.47	7.01±1.75	0.88	0.000
20	HDE	3.73	11.55	5.77±1.39	0.79	0.000
21	HWPEO	2.85	16.36	7.39±1.94	0.84	0.000
22	HWE	2.94	15.76	6.85±1.85	0.80	0.000
23	WBN	1.72	44.44	3.53±3.05	0.27	0.000
24	SnL	2.31	11.8	5.68±1.49	0.80	0.000
25	EHD	1.77	9.92	2.88±0.86	0.41	0.000
26	OOD	1.59	7.88	4.21±0.97	0.70	0.000
27	IOW	1.15	10.98	5.03±1.30	0.80	0.000
28	ABL	0.85	5.19	1.34±0.83	0.64	0.000
29	PBL	0.05	6.56	5.37±1.56	0.19	0.000
30	DL	1.41	11.98	2.62±0.95	0.79	0.000
31	LT	0.87	8.32	3.09±0.94	0.48	0.000
32	LP	1.54	7.31	2.11±1.15	0.59	0.000
33	LL	0.86	9.95	5.92±1.8	1.19	0.094
34	DW	2.21	14.96	4.09±0.99	0.79	0.000
35	WBAB	1.76	8.07	5.58±1.38	0.78	0.000
36	WM	3.26	11.31	5.28±1.29	0.88	0.000
37	WT	2.91	9.17	5.25±1.04	0.78	0.000

38	WP	2.15	8.48	4.25±1.04	0.80	0.000
39	BW (gm)	0.19	8.52	2.66±1.58	0.92	0.000

Different morphometric features ranging from standard length to body weight were selected for statistical analysis, including minimum maximum value, mean, standard deviation, Pearson correlation coefficient, and two-tailed significance test at p=0.01. 39 parameters were examined. Out of 39 variables, all the variables have positively correlated with standard length and only 20 morphometic characteristics were significant and 19 morphometic characteristics were not significant (Table2).

Table 2. Morphometric analysis of *Garra annandalei* and *Garra gotyla* of CDZ, TU

S.N.	Parameters (mm)	Min	Max	Mean±SD	Pearson Correlation coefficient (r)	Significance (two tailed) at p=0.01
1	SL	53.21	116.28	87.11±21.65	1	0.000
2	BD	11.18	24.39	18.003±4.33	0.57	0.136
3	CPD Min	4.41	14.88	10.04±3.52	0.93	0.001
4	Max CPD	6.72	16.04	11.71±3.64	0.92	0.001
5	PDL	23.53	58.91	42.92±12.74	0.93	0.001
6	P PelL	26.09	71.82	48.61±16.96	0.87	0.005
7	P.A L	38.71	108.97	64.98±21.71	0.86	0.006
8	Pec pel.L	16.61	47.61	28.79±12.32	0.68	0.062
9	Pel AL	12.58	35.85	23.42±9.13	0.73	0.037
10	VD	5.23	18.09	10.88±5.29	0.72	0.041
11	CPL	12.86	29.17	21.006±6.52	0.88	0.003
12	DFD	12.33	37.01	23.51±8.09	0.79	0.018
13	DFBDFR	11.33	35.58	21.83±8.26	0.77	0.024
14	AFL	9.48	26.44	17.65±5.80	0.93	0.001
15	Pec FL	11.62	29.92	20.28±6.23	0.90	0.002
16	Pel.F L	9.21	26.97	17.65±5.802	0.90	0.002
17	LAS	1.74	4.75	3.52±1.04	0.62	0.096
18	HL	13.84	29.34	22.08±6.21	0.90	0.002
19	HDN	8.12	19.46	13.52±3.89	0.92	0.001
20	HDE	5.35	14.85	10.89±3.49	0.91	0.001
21	HWPEO	8.8	18.33	13.7±3.47	0.92	0.001
22	HWE	6.97	17.31	12.47±3.47	0.89	0.003
23	WBN	3.38	9.15	7.03±1.89	0.37	0.355
24	SnL	6.61	16.51	11.2±3.32	0.70	0.053
25	EHD	3.18	5.71	4.43±1.01	0.81	0.013
26	OOD	4.45	11.33	7.28±2.02	0.90	0.002
27	IOW	4.74	13.21	8.82±2.64	0.77	0.023
28	ABL	0.79	3.73	2.35±0.89	0.31	0.442
29	PBL	0.56	1.77	1.22±0.41	0.49	0.212

30	DL	5.14	14.67	10.11±3.19	0.90	0.002
31	LT	2.41	5.29	3.72±0.88	0.32	0.427
32	LP	2.99	8.08	4.94±1.73	0.81	0.014
33	LL	1.71	3.95	2.86±0.81	0.68	0.063
34	DW	4.66	13.84	10.64±3.03	0.88	0.003
35	WBAB	5.24	9.52	7.49±1.66	0.67	0.064
36	WM	5.71	12.27	9.6±2.59	0.79	0.019
37	WT	5.69	14.33	9.68±2.81	0.92	0.001
38	WP	4.71	11.07	7.60±2.5	0.53	0.169
39	BW (gm)	4.09	9.15	7.34±1.82	0.91	0.001

4.3 Abundance of Genus *Garra*:

Out of two species of Genus *Garra G. gotyla* contributing 58.71% and *G. annandaei* occupying 41.29%. The number of *Garra gotyla* was greater than *Garra annandalei* and Butwal exhibited the highest abundance compared to Charchare that may be due to factors like water parameters, disturbance, and nutrient availability. Among the 201, Butwal harbored the highest number of *Garra annandalei* (n=40) and *Garra gotyla* (n= 41). The all-sampling sites showed a high presence of *Garra gotyla* over *Garra annandalei*.

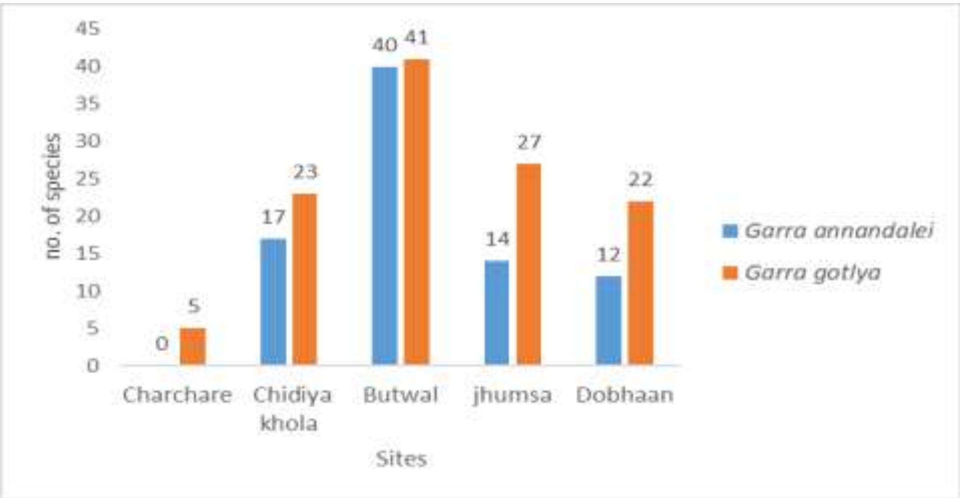


Figure 4. Site wise Abundance of species in different sites

4.4 Length - weight relationship of Genus *Garra*

The values for *Garra gotyla* (a=1.05) and *Garra annandalei* (a=2.26) produced b values of 0.38 and 0.21, respectively. Species with b<3 have negative allometric growth, since weight increases slower than length.

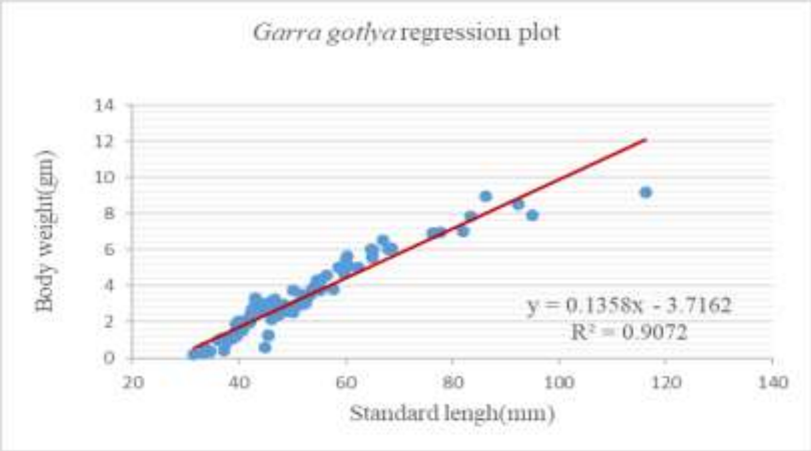


Figure 5. Regression analysis of *Garra gotyla*

The standard length explains 90.72% variations to that of body weight (R^2=0.90 and linear regression slope = 0.13). The slope of the regression line represents the rate of change in weight per unit change in length. In this case, a slope of 0.13 means that for every one-unit increase in length, the weight of the fish is expected to increase by approximately 0.13 units. -3.71 intercept is the value of the dependent variable (weight) when the independent variable (length) is zero. However, in the context of fish biology, it's not meaningful to have a fish with zero length. Instead, the intercept represents the estimated weight of a hypothetical fish with negligible length. Negative intercept values are common in length-weight relationships and are a result of the mathematical fitting process. Correlation coefficient of *Garra gotyla* was 0.95. Which indicate that standard length and body weight were positively correlated with each other.

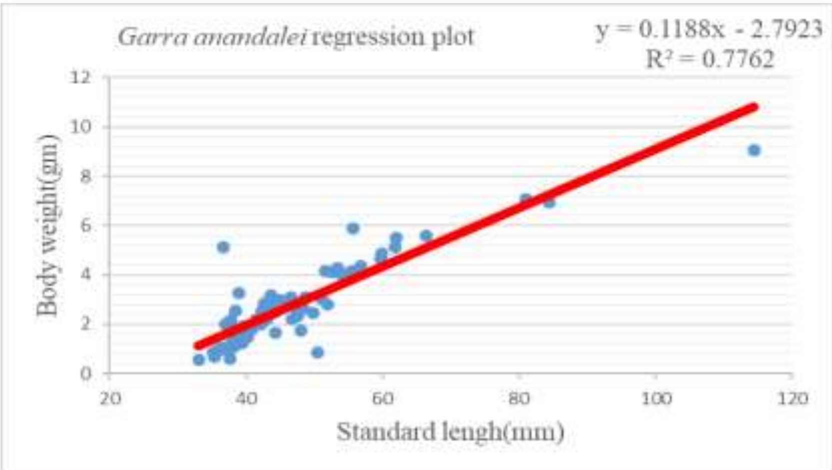


Figure 6. Regression analysis of *Garra anandalei*

The R-square value 0.77 means, standard length explains 77.62 % variations to that of body weight. The linear regression slope was 0.11. The slope of the regression line represents the rate of change in weight per unit change in length. In this case, a slope of 0.11 means that for every one-unit increase in length, the weight of the fish is expected to increase by approximately 0.11 units. A negative value of intercept (-2.79) is the value of the dependent variable (weight) when the independent variable (length) is zero however it is not meaningful to have a fish with zero length in context of fish biology. Instead, the intercept represents the estimated weight of a hypothetical fish with negligible length. Negative intercept values are common in length-weight relationships and are a result of the mathematical fitting process. Correlation coefficient of *Garra annandalei* (0.88) which indicate that the standard length and body weight were positively correlated with each other.

4.5 Physicochemical parameters of Tinau River

4.5.1 Millivolt pH (MVpH)

MVpH represents the change in electrical potential (millivolts) per unit change in hydrogen ion concentration. During the study period the lower value of MVpH found in Dobhan and higher in Butwal (Fig 7) and pH value lower in Butwal and higher in Charchare (Fig 8).

Figure 7. Average MVpH of sites

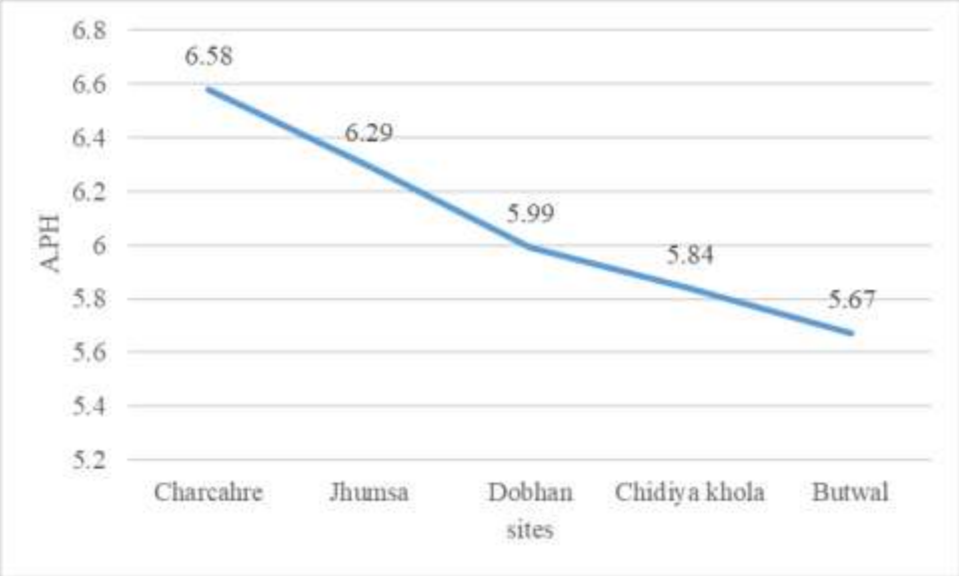


Figure 8. Average pH of sites

4.5.2 Oxidation Reduction Potential (ORP)

ORP evaluates the capacity of water to oxidize or reduce substances. It provides information on overall water quality. Fish require dissolved oxygen to breathe. ORP can indirectly control oxygen availability, influencing fish metabolism and overall health. The higher average MVORP was obtained in Butwal whereas lower in Charchare.

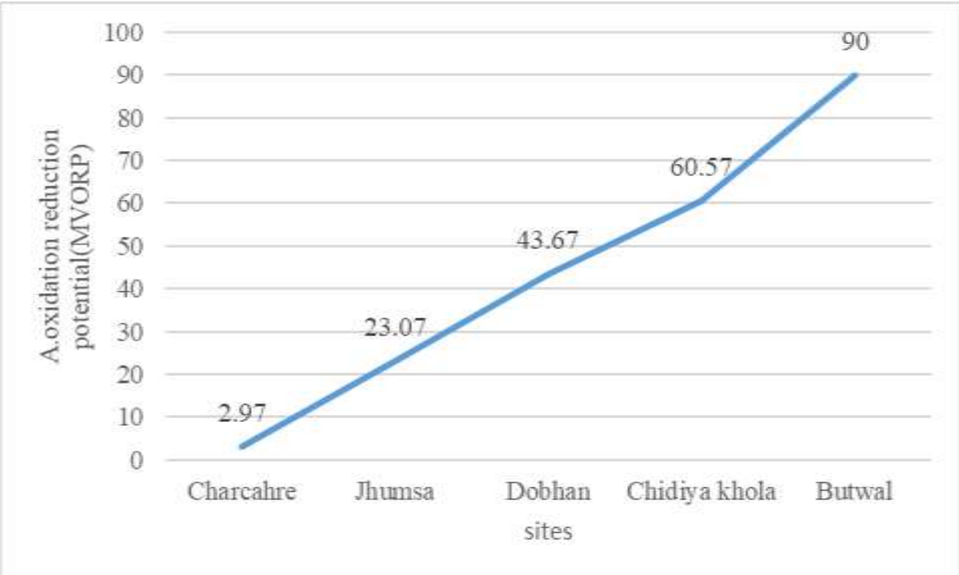


Figure 9. Average MVORP of sites

4.5.3 Dissolved Oxygen

Charchare exhibited lower average DO%, while Chidiya Khola showed higher levels. The average DO in mg/l was higher in Butwal whereas lower in Chidiya khola.

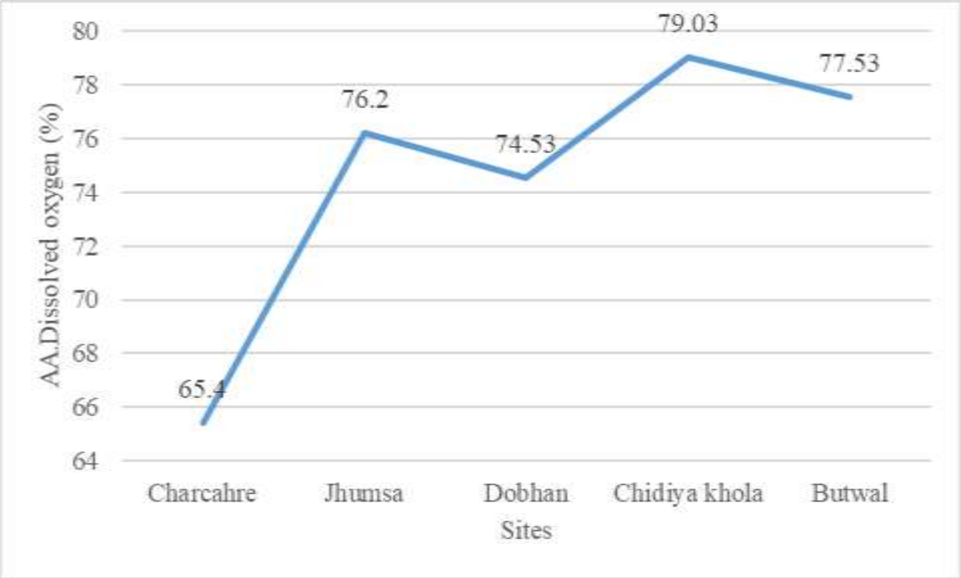


Figure 10. Average DO% of sites

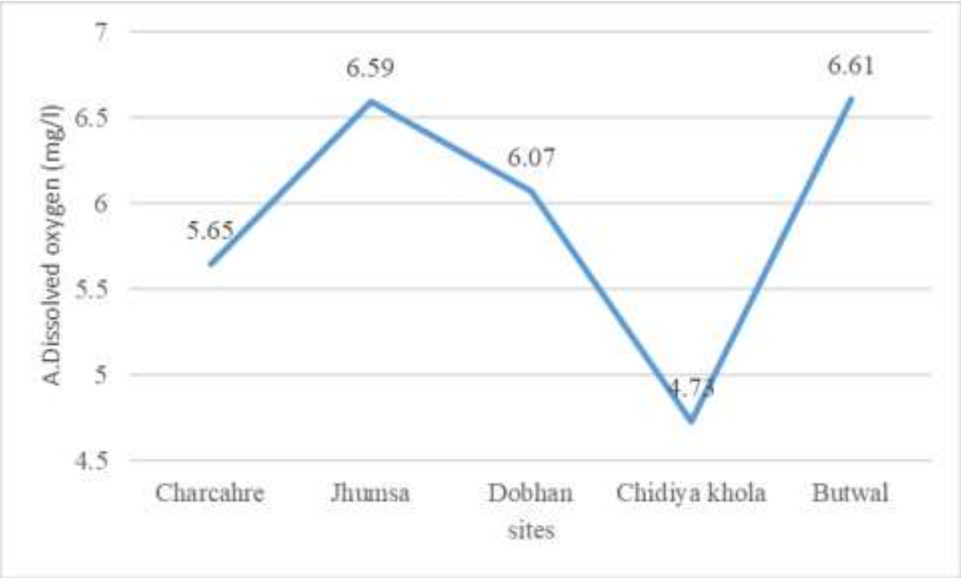


Figure 11. Average DO mg/l of sites

4.5.4 Electric Conductivity (EC)

The average EC was found 236.67-308.67 in Chidiya khola and Charchare.

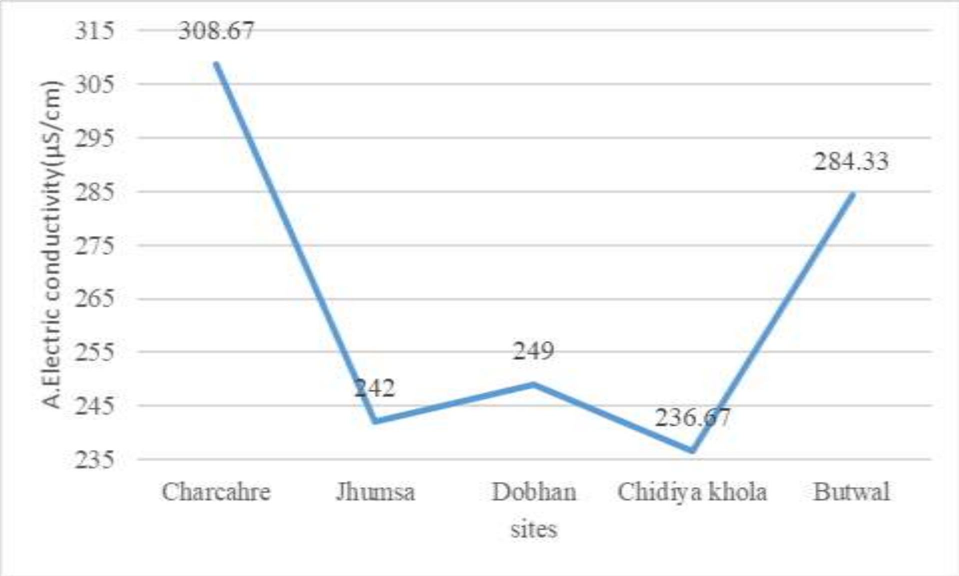


Figure 12. Average EC of sites

4.5.5 Resistivity

Resistivity is the inverse of electric conductivity. Low ion concentration is indicated by high resistance. Changes in resistivity can have an impact on the availability of vital ions, hurting fish Overall health and osmoregulation. The average resistivity was obtained higher in Jhumsa and lower in Charchare.

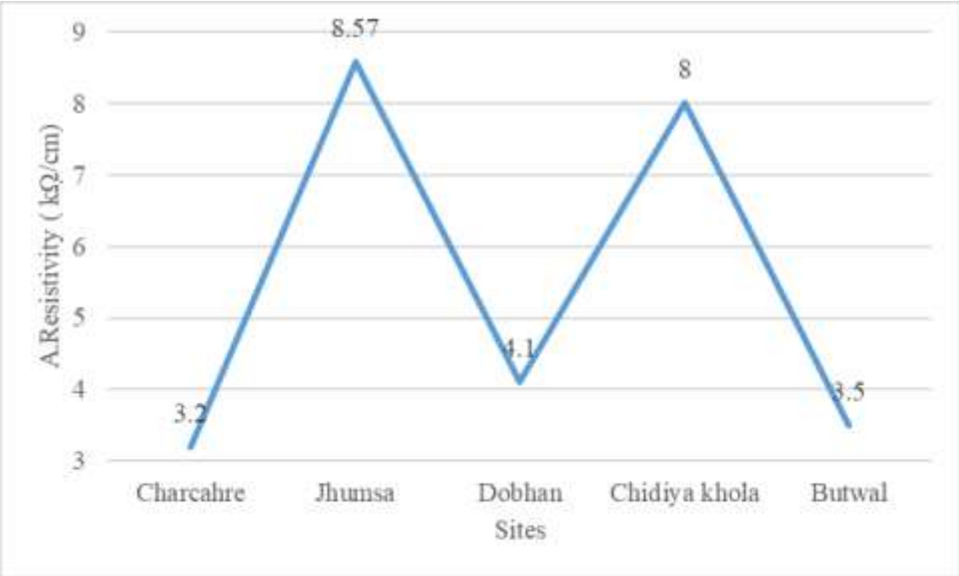


Figure 13 Average resistivity of sites

4.5.6 Total Dissolved Solid (TDS)

TDS represents the concentration of dissolved compounds in water. Water clarity and flavor can be impacted by high TDS levels. The average TDS was found higher in Charchare whereas lower in Chidiya khola.

Figure 14. Average TDS of sites

4.5.7 Salinity

Salinity variations can stress or harm fish. Tolerances Vary by species: Some fish are euryhaline, able to withstand a wide range of salinities, while others are stenohaline, with limited tolerance ranges. Changes in air pressure may alter fish behavior and activity. Rapid pressure fluctuations can produce traumatic brain injury, which causes physical damage to swim bladders and other organs in deep-dwelling fish species. The average salinity was obtained higher in Charchare and lower in Jhumsa.

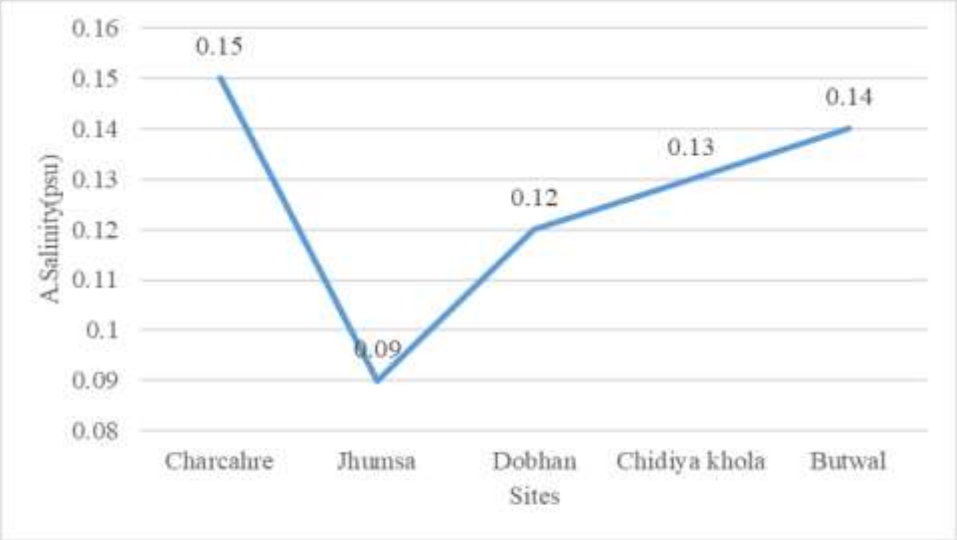


Figure 15. Average salinity of sites

4.5.8 Temperature

Fish are ectothermic, meaning their body temperature is influenced by the surrounding environment. The higher average temperature was obtained from Chidiya khola whereas lower in Charchare.

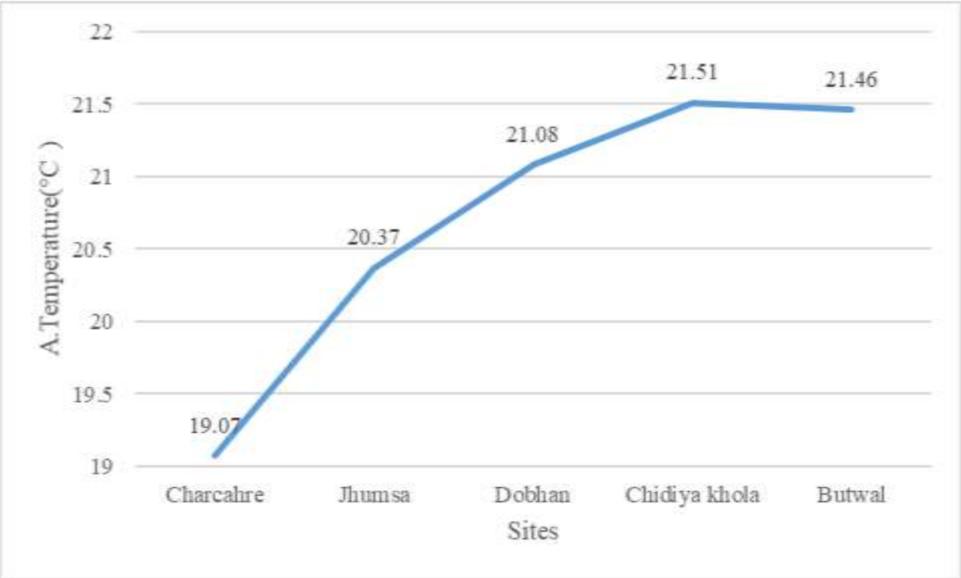


Figure 16. Average Temperature of sites

4.5.9 Atmospheric Pressure

The force exerted by air in the atmosphere on a certain region is known as atmospheric pressure. The pressure range of 13.73-14.33 psi indicates that the value is consistent with the average air pressure. Atmospheric pressure decreases as height increases. Fish are adapted to the air pressure in their specific habitats. This range is similar to normal air pressure and is likely within the tolerance range of most fish species.

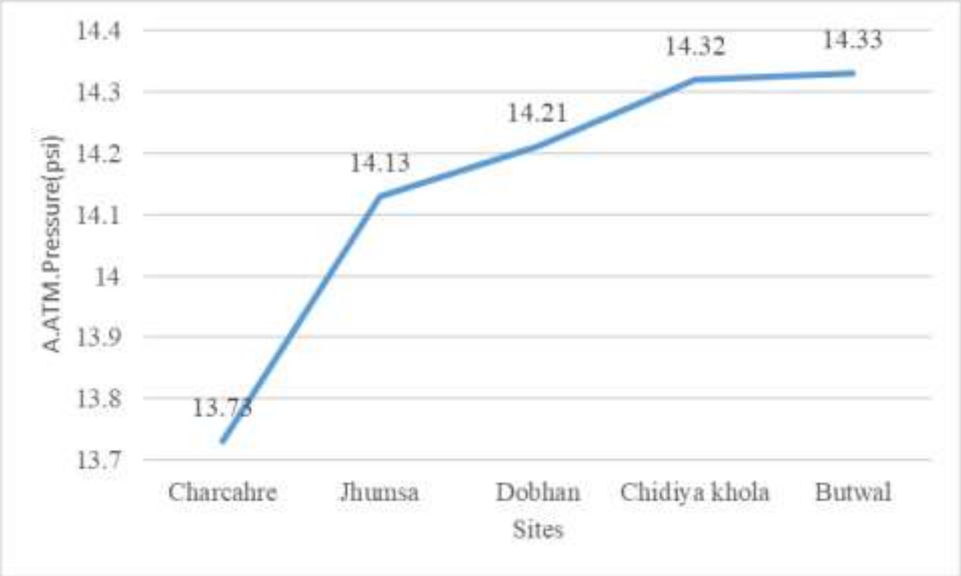


Figure 17. Average ATM pressure of sites

4.6 Relation between physico-chemical parameters with Genus *Garra*

During the study period, the positive correlation was found between *Garra* with MVpH, ORP DO (%), Dissolved oxygen (mg/l), resistivity, temperature and pressure (atmospheric) whereas a negative correlation was found with pH, electric conductivity, absolute conductivity, Total dissolved solids and salinity (table3).

Table 3. Correlation between Physico-chemical Parameters in Tinau River

S.N.	Variables	Correlation (r)	Probable Error (PE.r)
1	MVpH with abundance	0.47	0.63
2	pH with abundance	-0.86	0.53
3	ORP with abundance	0.91	0.51
4	Dissolved oxygen (%) with abundance	0.76	0.56
5	Dissolved oxygen (mg/l) with abundance	0.44	0.64
6	Electric conductivity with abundance	-0.19	0.67
7	absolute conductivity with abundance	-0.05	0.67

8	Resistivity with abundance	0.04	0.67
9	Total dissolved solids with abundance	-0.21	0.67
10	Salinity with abundance	-0.11	0.67
11	Temperature with abundance	0.78	0.56
12	Atmospheric Pressure with abundance	0.81	0.55

4.7 Comparison of collected and deposited specimens CDZ, TU:

In case of collected and deposited samples, it was found that the p-value for test statistic "t" of -6.077 for a two –tailed test with 38 degree of freedom is 0.000. Since, the value is less than alpha (level of significance) that is 0.05, we reject the null hypothesis and accept the alternative hypothesis. Hence, the analysis revealed that there is significant difference between collected and older sample of *Garra* for the context of adaptive features. Also, the mean values of morphometric characteristics were positively correlated with each other that is r=0.997.

4.8 X-ray of collected and deposited specimen of CDZ, TU samples.

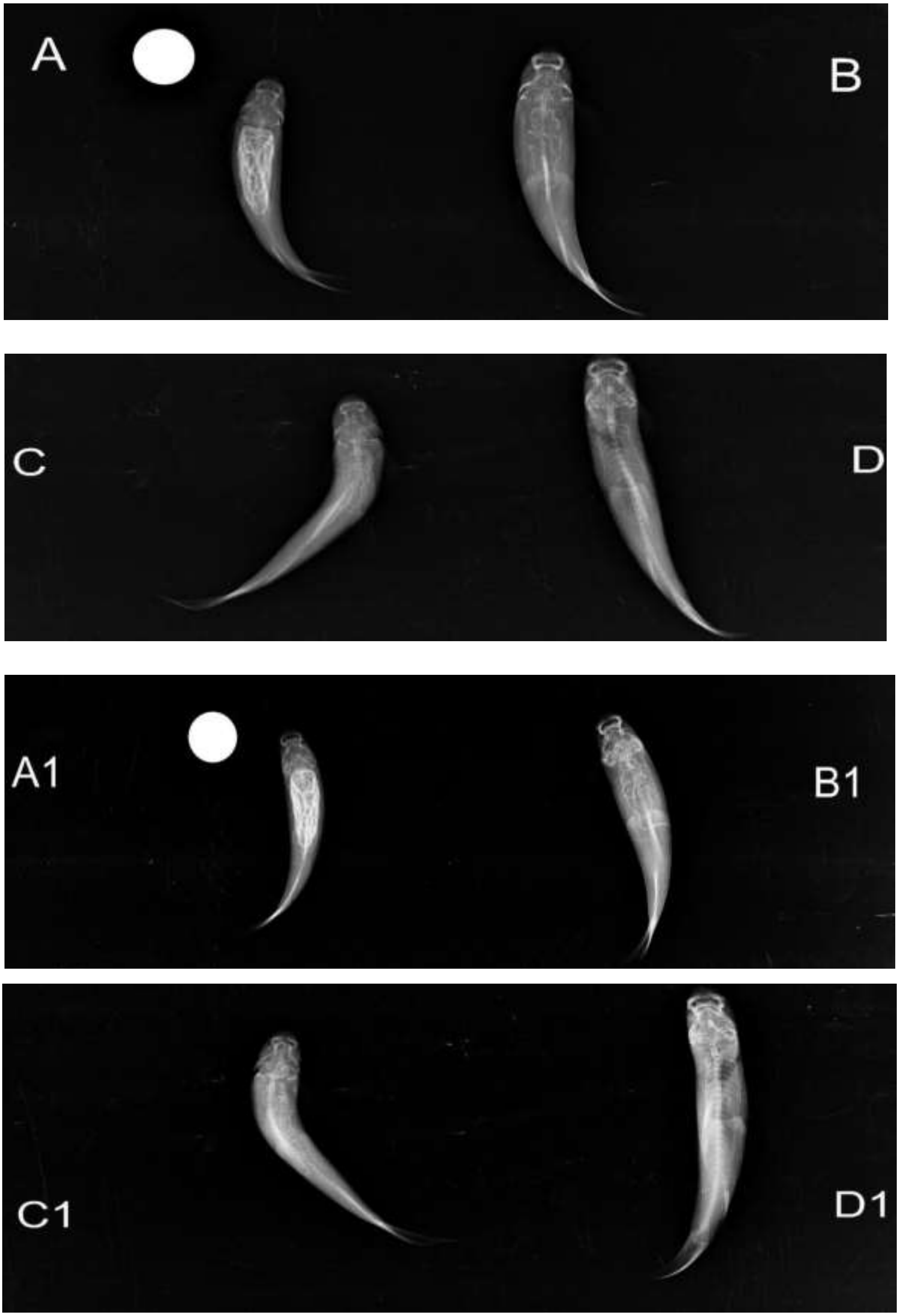


Figure 18 X-ray image of collected and deposited specimen

(A= Dorsal view of collected *Garra annandalei*, B= Dorsal view of collected *Garra gotyla*, C=Dorsal view of deposited specimen of *Garra annandalei*, D=Dorsal view of deposited specimen of *Garra gotyla*)

A1=Ventral view of collected *Garra annadalei*, B1=Ventral view of collected *Garra gotyla* C1=Ventral view of deposited specimen of *Garra annandalei,* D1=Ventral view of deposited specimen of *Garra gotyla*)

In the both collected fish the bones have higher density and may appear more distinct and clearer in the X-ray than deposited specimen of CDZ (Fig 18). In a collected fish, the joints between the bones were intact and easily distinguishable while the deposited specimen from CDZ fish joints showed signs of deterioration (low density) and clear gap between the vertebral joints.

5. Discussion

The distribution and metabolic processes and adaptive features of the fishes like *Garra* in the River are influenced by the chemical and physical characteristics; MVpH, pH, oxidation reduction potential, dissolved oxygen, Electric conductivity, absolute conductivity, resistivity, total dissolved solids salinity, temperature, atm pressure and various morphometric characteristic.

Our finding *Garra gotyla* most dominant fish species is in accordance with many previous studies from a large number of freshwaters from Tinau Rivers and tributaries. According to Rijal (2015) abundance of *G.gotyla* was higher than *G. annandalei.* In the research paper of Sharma & Shrestha (2001), *Garra annadalei* was collected from Dovan and Butwal, while *Garra gotyla* was collected from Mariphant, Charchare, Dovan, and Butwal, indicating a higher abundance of *Garra gotyla*.

In the collected sample from Tinau River of Genus *Garra*, out of 39 morphometric variables, 37 were highly correlated with standard length of fish, with vent distance showing a negative correlation and labrum length displaying a strong correlation. Only vent distance yielded a non-significant result; otherwise, all parameters significantly correlated with standard length. Whereas, in deposited specimen from CDZ of Genus *Garra* Out of 39 variables, all displayed positive correlations with standard length, with only 20 morphometric characteristics proving to be significant while the remaining 19 were not. These morphometric variations may be related to the geography, ecology, human activities and genetic diversity of the population (Junquera & Perez-Gandaras, 1993).Similar study of Morphometric and meristic traits of *Garra gotyla* from Ranjit Sagar Wetland were analyzed. Eighteen characters, with three genetically controlled, thirteen intermediate, and two environmentally controlled, were studied as a percentage of total fish length. Ten characters displayed high correlation, while eight showed moderate correlation. In percentage of head length, five were genetically controlled and two intermediates, with three displaying the least and four moderate correlation coefficients.

Our study investigated *Garra* length-weight relationship and discovered negative allometric growth ($b < 3$, $K < 1$) in both species. Baby et al. (2011) found that the Chaliyar River (2.920) had a higher 'b' value than the Bhavani River (2.594), although the difference was statistically insignificant. Bhavani fish had a higher Condition Factor

(K=2.177) than Chaliyar (K=2.087), which was statistically insignificant. Chaliyar's G. *gotyla stenorhynchus* exhibited isometric growth with 'b' values similar to cubic law.

Lal et al. (2016) examined the length-weight relationship and condition factor across 57 freshwater fish species collected from diverse Indian rivers and lakes. The parameter 'b' varied from 1.422 to 3.917 (mean = 2.994). Isometric growth (b = 3) was seen in 32 species, positive allometry (b > 3) in 21, and negative allometry (b <3) in 14. Variations in patterns of growth across habitats demonstrated the importance of habitat conditions. This study highlights the importance of habitat choice and availability in shaping fish growth throughout India's many climatic zones.

During the research period, the average MVPH was lower in Charchare and higher in Butwal, which was 79.77 -134.3. The average PH was lower in Butwal and higher in Charchare. According to (Swingle & Cole, 1967), a pH range of 6.5-9 is suitable for fish, while a pH above 9.5 is considered unsuitable due to the absence of free CO2 in such conditions. pH fluctuations affect respiration, enzyme activity, ion control, causing stress, decreased growth, and reproductive issues in fishes (Portz et al., 2006). The average ORP (oxidation reduction potential) was 2.97 -90 at Charchare and Butwal, respectively. Charchare has a lesser dissolved oxygen percentage of 65.4%, while Chidiya khola has a greater percentage of 79.03%. Similarly, the average DO in mg/l varies, with Butwal having a greater value and Chidiya khola having a lower value, ranging from 6.61 to 4.73. Sufficient dissolved oxygen (DO) is vital for fish respiration, but levels fluctuate due to temperature, depth, and organic matter decomposition. DO availability varies yearly due to water chemistry, biology, and temperature (Hossain, 2016). The average electric conductivity ranges from 236.67 to -308.67. Electric conductivity is frequently connected to water salinity (Rhoades, 1996). Fish species have variable salinity tolerances, and changes in salinity can have an impact on their distribution and behavior (James et al., 2003). Electric conductivity regulates ion concentration in water, which is important for fish osmoregulation (Griffith, 2017). The average absolute conductivity ranged from 211 to 274 between Jhumsa and Charchare. The average resistivity was determined to be 3.2 - 8.57 from Charchare to Jhumsa. From Chidiya Khola to Charchare, the total dissolved solids were 120 -154.33. Average salinity during the research period, the average MVPH was lower in Charchare and higher in Butwal, which was 79.77 -134.3. The average PH was lower in Butwal and higher in Charchare. The average ORP (oxidation reduction potential) was 2.97 -90 at Charchare and Butwal, respectively. Charchare has a lesser dissolved oxygen percentage of 65.4, while Chidiya khola has a greater percentage of 79.03%. Similarly, the average DO in mg/l varies, with Butwal having a greater value and Chidiya khola having a lower value, ranging from 6.61 to -4.73. Dissolved oxygen above 5 mg/lt is suitable for the support of diverse biota (APHA 1976). Average electric conductivity ranged between 0.09 and 0.15 in Jhumsa to Charchare. Charchare to Chidiya khola has an average temperature ranging from 19.07 to 21.51. Temperature variations in River impact fish metabolism, growth, and reproduction. Seasonal temperature changes can affect the distribution of fish species within a River. The average atmospheric pressure in psi ranged from 13.73 -14.33 in Charchare to Butwal. At sea level, the typical atmospheric pressure is approximately 14.7 psi (Schwartzkopf et al., 1995). The force exerted by the air in the atmosphere on a certain area is referred to as atmospheric pressure. At sea level, the standard atmospheric pressure is roughly 14.7 psi. Result shows that the pressure is somewhat lower than the usual atmospheric pressure. With rising altitude, atmospheric pressure lowers. Fish are suited to their individual habitat's atmospheric pressure. This range is quite near to typical air pressure and is likely within most fish species' tolerance range. TDS levels that are too high might induce physiological stress in fish, affecting their osmoregulation and metabolic activities. Salinity: Freshwater and saltwater fish have various osmoregulatory processes.

For the survival of aquatic life such as fishes, The temperature is 20-25 °C, pH is 6.5-8.5, the EC is 800-1000 S/cm, the TDS is 500mg/l, and the DO is 4-6 mg/l (Ellis & Kanamori, 1973). Near similar result was obtained from the present research. So, the physicochemical parameters encouraged the health and diversity of bottom dwelling fishes, such as *Garra spp.*.

Komi (2022) reported the mean temperatures (27.65±0.6, 28.78±0.58, and 29.28 ±0.89), pH (7.59±0.35, 7.28±0.24, and 7.4±0.34), total dissolved solids (112.83±74.8, 169.95±181.55, and 213.7±168.67), biochemical oxygen demand (1.45±0.22, 0.7±0.33, 2.4±0.53) and salinity (37.93±27.36, 52.79±40.53, 22.62±13.98). These are appropriate for fish production. Dissolved oxygen (4.08±0.64 - 5.18±0.05mg/l) was below the acceptable level, whereas electrical conductivity (197.28±150.39 - 483.4±280.44µs/cm) above the WHO and Federal Ministry of Environment limits. The analysis finds that the river is appropriate for both fish production and home usage. However, owing to industrial effluent discharge and human activity in and near the river, the river should be mitigated and monitored regularly.

In this study, Positive correlations were observed between abundance and water quality parameters (MVPH, oxidation reduction potential, dissolved oxygen %, dissolved oxygen mg/l, resistivity, temperature, and ATM pressure), while negative correlations were noted with PH, electric conductivity, absolute conductivity, total dissolved solids, and salinity. Rijal (2015) conducted a similar study in Tinau River, revealing positive correlations of water velocity, temperature, and turbidity with fish abundance across all stations whereas water transparency correlated negatively. Chemical parameters showed mixed correlations with fish abundance across stations. Likewise Bhattarai (2022) studied on Masyam Khola, Palpa, found positive correlations of temperature, water velocity, and dissolved oxygen with fish species, alongside a negative correlation with pH.

Paired sample t test measures the mean values of collected and deposited specimen 39 morphometric parameters, analysis revealed that there is significant difference between collected and deposited sample of *Garra* for the context of adaptive features. Morphometric parameters of collected and deposited *Garra* specimens suggests potential adaptation to various environmental factors. These factors could include changes in habitat conditions such as threatened by climate change, anthropogenic alteration and high predation pressure (Bruckerhoff & Magoulick, 2017) by food availability (Akin & Geheber, 2020), velocity distribution around the fish body under different flow (Sun et al., 2023). The morphometric differences observed between collected and deposited *Garra* specimens may reflect evolutionary factors such as genetic drift, natural selection, and adaptation to changing environmental conditions over time (Ramoejane, 2016). Also, the mean values of morphometric characteristics were positively correlated with each other that is r=0.997. This could indicate that despite potential environmental or evolutionary changes over time, certain morphological characteristics remain relatively stable within the population (Machado et al., 2018).

In this study the bones exhibit higher density and clarity on X-ray compared to older specimens. Whereas fresh specimens showed intact, distinguishable bone joints. He deposited specimens displayed deteriorated joints with clear gaps. suggested potential adaptations in response to environmental or evolutionary pressures (Hamidan, 2016).Fresh specimens with intact bone joints likely reflect adaptations for efficient locomotion (Westneat & Wainwright, 2001)and predator avoidance, while deterioration in deposited specimens may indicate aging-related changes or environmental stressors impacting bone structure over time (Liang et al., 2019).

6. Conclusions and Recommendations

6.1. Conclusions

Altogether 2 species of Genus *Garra i.e*, *G. annandalei* and *G. gotyla* were reported from Tinau River. The species abundance found to highest in Butwal. The water quality parameters were found within suitable range that supports fish health and their diversity to adapt. The species had negative allometric growth and tended to be smaller. Most of the morphometric characteristics were positively correlate with standard length while vent distance in collected fishes was negatively correlated and most of the deposited and collected *Garra* spp. shows significant. Comparison of collected and deposited specimens of *Garra* spp. found significant as there is significant difference between two samples.The skeletal analyses revealed higher bone density and clearer joint structures in collected fish compared to deposited specimens. Declining fish population is evident, with physical changes observed in shape, size, and numbers.

6.2. Recommendations

According to local people, the fish species in Tinau River are declining day by day due to illegal fishing practices, habitat destruction, pollution and sand mining activities. If we are unaware about the todays of situation biodiversity declining, it may arise serious problem and biodiversity in near future. The some of the recommendations are:

- The aquatic environment has been degraded due to anthropogenic activates such as use of pesticides, unusual way of disposal of wastes so it is recommended to minimize such activities by participation of locals and local authorities.
- Fish poaching is a common problem in the river and is responsible for fish decline so a community and school-based conservation awareness campaign should be conducted at regular intervals.
- The use of small mesh-sized nets, illegal electrofishing and poisoning should be prohibited.
- Aquatic Animal Protection Act 2017, Fish policy, 2080 will be implemented strictly.

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Appendices

Table 4. Morphometric measurements of Genus *Garra* at Charchare

S.N	Parameters(mm/gm)	Sample No. (Charchare)				
		GG 1	GG2	GG 3	GG 4	GG 5
1	SL	53.36	49.96	43.87	48.95	40.6
2	BD	11.53	11.36	10.2	9.83	9.22
3	CPD Min	6.93	6.53	5.86	5.51	4.02
4	Max. CPD	7.96	7.12	7.06	6.2	5.14
5	PDL	25.01	23.07	25.15	22.81	19.84
6	P PelL	26.41	24.53	28.73	24.77	20.79
7	P.A L	39.64	31.96	40.53	36.44	28.93
8	Pec pel.L	17.33	14.91	16.94	14.71	11.35
9	Pel AL	13.3	12.55	12.35	10.86	8.91
10	VD	2.12	2.01	2.22	2.19	1.53
11	CPL	9.14	8.05	9.68	7.19	7
12	DFD	10.06	11.01	11.42	10.36	8.38
13	DFBDFR	8.51	10.46	10.93	10	7.29
14	AFL	9.53	10.51	9.94	8.93	7.11
15	Pec FL	12.04	10.96	11.97	9.84	8.88
16	Pel.F L	10.34	9.96	9.86	8.36	7.31
17	LAS	2.67	3.43	1.53	2.77	2.17
18	HL	10.84	11.44	12.93	12.66	10.62
19	HDN	9.07	7.32	7.31	8.11	6.89
20	HDE	7.62	5.88	4.51	6.28	5.31
21	HWPEO	9.26	10.34	10.39	8.45	6.99
22	HWE	8.7	8.64	8.85	7.82	6.37
23	WBN	5.04	4.29	5.18	3.65	3.32
24	SnL	5.59	8.75	5.56	5.86	4.86
25	EHD	3.29	2.63	3.03	3.06	2.98
26	OOD	7.88	7.11	4.19	4.87	4.56
27	IOW	6.92	6.23	6.88	6.02	4.54
28	ABL	1.83	1.85	1.79	1.78	1.78
29	PBL	1.39	1.33	1.12	1.18	1.08
30	DL	2.49	6.95	4.64	5.08	4.4
31	LT	0.87	2.16	2.61	1.21	1.45
32	LP	2.14	3.11	3.55	3.71	3.94
33	LL	1.51	2.09	1.49	2.09	1.46
34	DW	7.58	6.03	6.4	7.01	5.72
35	WBAB	2.61	3.57	4.24	3.56	3.07
36	WM	7.36	6.33	7.62	6.71	4.91
37	WT	5.89	5.31	4.02	4.34	4.89
38	WP	3.83	4.99	4.54	4.22	3.13
39	BW	3.62	2.67	2.55	2.57	1.59

Table 5. Morphometric measurements of Genus *Garra* at Chidiya khola

S.N	Parameters		Sample No.(Chidiya khola)																
	(mm/gm)	GG 11	GG 12	GG 13	GG14	GG15	GG16	GG17	GG18	GG19	GG20	GG21	GG22	GG23	GG24	GG25	GG26	GG27	GG28
1	SL	47.78	48.4	48.45	60.05	64.78	60.22	67.04	55.34	40.82	41.73	46.31	39.99	40.62	55.18	47.13	46.65	41.77	48.96
2	BD	10.31	9.53	9.73	11.73	12.47	12.31	12.47	11.23	7.49	7.16	7.89	5.77	6.57	11.11	9.69	8.09	9.38	7.94
3	CPD Min	5.59	5.51	5.35	6.43	6.9	6.32	6.22	5.41	4.05	4.9	3.94	3.55	4.3	6.08	4.61	4.61	4.12	4.94
4	Max. CPD	6.48	5.81	5.54	7.14	7.53	7.09	7.83	6.37	4.94	4.82	5.15	4.35	5.33	6.71	5.21	5.07	5.03	5.63
5	PDL	22.63	22.84	22.29	26.78	27.33	26.69	30.08	23.17	17.81	18.88	20.69	18.89	12.47	25.59	20.33	21.03	19.75	22.68
6	P PelL	24.38	24.87	24.83	30.47	34.57	29.5	35.06	29.01	22.11	22.21	23.61	22.38	21.38	29.56	25.61	24.81	23.92	25.22
7	P.A L	36.15	34.94	35.4	45.25	48.78	43.38	51.76	42.09	31.77	31.91	36.26	31.63	30.87	14.24	37.33	34.53	32.27	37.58
8	Pec pel.L	14.96	14.96	14.3	19.8	22.43	20.13	22.41	16.57	13.21	12.62	13.52	11.09	7.91	3.57	14.31	13.29	14.14	14.84
9	Pel AL	11.47	11.13	10.85	15.03	16.59	16.83	17.9	13.66	8.84	10.04	11.98	10.46	10.1	9.62	14.04	12.21	10.65	12.77
10	VD	3.06	2.97	2.17	3.35	4.01	3.49	4.79	3.8	3.42	3.94	3.7	2.55	8.75	13.86	4.57	1.48	1.71	3.24
11	CPL	8.15	8.02	8.53	12.16	11.62	11.19	13.11	10.46	8.19	7.01	9.05	8.97	7.16	12.53	8.92	11	8.43	9.78
12	DFD	10.75	10.66	11.65	13.93	14.32	14.08	16.09	13.21	8.88	10.13	11.34	11.06	9.53	11.91	11.18	10.94	10.08	11.17
13	DFBDFR	9.71	9.95	9.85	11.73	12.13	12.57	15.66	11.88	7.97	9.19	10.22	9.61	6.99	12.64	9.87	10.01	9.25	10.5
14	AFL	14.14	9.44	9.42	10.86	11.57	9.61	11.49	9.87	7.57	8.55	8.63	7.98	7.82	10.77	8.99	8.2	7.88	8.48
15	Pec FL	14.4	8.72	9.88	12.36	15.21	13.16	14.91	12.18	9.55	10.63	11.19	9.95	11.37	3.64	10.8	11.07	10.78	12.01
16	Pel.F L	13.16	8.62	8.5	10.23	12.8	10.98	12.87	9.79	7.12	8.4	8.38	7.39	7.72	13.86	9.1	8.82	8.71	8.34
17	LAS	1.35	2.82	2.49	2.8	2.81	2.7	3.72	2.5	1.93	2.02	1.75	2.2	4.52	7.7	1.95	1.92	1.99	1.99
18	HL	11.35	12.16	12.8	14.74	16.89	15.13	17.08	13.08	10.57	11.98	11.99	10.55	11.51	6.61	11.09	10.84	11.33	12.25
19	HDN	7.13	7.52	7.84	9.1	9.78	8.59	9.48	8.01	5.66	6.63	6.02	6.01	5.5	9.28	6.97	11.61	6.58	7.99
20	HDE	9.08	5.63	6.53	6.72	7.31	6.61	8.07	6.24	4.47	4.74	5.49	6.05	5.99	8.25	5.35	7.25	5.09	5.25
21	HWPEO	8.32	8.13	9.17	8.85	9.35	8.94	11.42	7.89	6.39	2.85	6.688	5.5	5.97	3.55	8.3	5.64	6.76	7.85
22	HWE	3.71	7.97	8.44	7.79	7.92	7.58	9.94	6.99	6.27	5.19	5.94	5.42	6.24	6.76	6.3	6.42	6.99	7.42
23	WBN	4.59	3.51	3.91	3.3	4.01	4.21	3.68	3.22	2.94	2.68	3.39	3.02	4.45	2.73	3.7	6.24	3.37	3.14
24	SnL	5.07	5.95	5.85	6.94	8.24	7.1	7.8	6.54	4.8	3.64	5.73	5.61	3.57	3.85	5.65	2.84	5.63	5.44
25	EHD	4.48	2.81	3.12	3.31	3.3	3.02	3.18	7.67	2.05	4.15	2.21	3.51	2.02	5.74	2.85	5.61	2.54	2.42
26	OOD	5.78	3.98	5.23	4.8	4.78	4.61	5.14	3.05	2.92	1.9	3.53	3.77	1.59	2.83	3.2	2.54	3.64	3.77
27	IOW	5.41	5.59	5.61	6.55	5.74	5.99	6.91	5.14	3.87	1.15	4.17	4.86	5.69	1.65	4.53	3.45	4.21	4.32
28	ABL	1.59	1.81	1.77	2.41	2.67	2.12	2.73	1.6	1.62	2.29	1.83	1.4	1.19	5.19	1.86	4.47	1.37	1.88
29	PBL	5.64	1.44	0.85	2.05	1.1	1.46	1.68	1.09	1.39	1.17	1.08	5.43	2.28	2.79	1.14	1.48	1.23	1.47
30	DL	3.05	5.66	4.75	6.4	8.54	7.79	11.53	7.49	5.46	2.79	5.29	2.23	5.13	3.13	5.31	~~1.41~~	4.31	5.78
31	LT	2.69	2.93	2.97	2.78	3.39	2.71	4.17	2.81	7.73	2.04	2.38	3.48	1.67	2.33	2.74	5.95	2.11	2.72
32	LP	1.91	3.63	4.22	2.88	3.33	3.51	4.36	3.09	1.67	5.35	2.74	2.45	2.62	7.31	2.32	1.96	2.79	2.02
33	LL	8.03	1.5	1.85	1.36	2.43	2.22	3.63	1.83	1.11	1.34	4.34	5.92	4.39	4.69	1.73	3.39	2.16	1.61
34	DW	4.13	7.89	6.79	7.69	9.12	7.54	8.82	7.04	5.3	6.74	4.5	3.5	4.08	4.52	5.64	2.21	5.61	6.28
35	WBAB	6.67	4.25	3.88	5.24	5.04	5.07	5.45	5.42	3.78	4.64	4.94	4.63	4.39	4.84	4.52	6.52	3.87	4.07
36	WM	5.53	6.79	6.44	7.01	6.8	6.56	7.4	5.84	4.87	4.93	4.35	3.62	4.86	6.86	5.97	5.01	5.15	4.84
37	WT	6.73	7.05	6.57	6.03	5.92	5.66	6.92	5.05	4.78	4.84	4.62	4.22	5.02	6.55	5.35	5.46	4.96	4.96
38	WP	5.68	4.09	4.28	5.01	5.01	4.31	5.47	4.02	3.04	3.09	3.11	3.21	3.45	4.69	3.37	4.45	3.71	4.31
39	BW	2.51	2.62	2.73	5.48	6.04	5.63	6.54	4.35	1.85	2.02	3.12	1.62	1.53	3.75	2.71	3.03	2.11	2.85

Table 6. Morphometric measurements of Genus *Garra* at Chidiya khola

S.N	Parameters(mm/gm)	Sample No.(Chidiya khola)																
		GA29	**GA30**	**GA 31**	**GA 32**	**GA 33**	**GA 34**	**GA 35**	**GA36**	**GA37**	**GA38**	**GA 39**	**GA40**	**GA41**	**GA 42**	**GA 43**	**GA 44**	**GA 45**
1	SL	36.59	55.72	42.4	53.47	51.66	45.91	42.17	38.49	37.17	37.75	43.6	35.2	53.21	52.55	44.32	44.28	42.8
2	BD	6.81	10.47	7.19	10.02	10.1	8.63	7.83	7.2	6.26	6.99	8.85	5.22	8.63	9.41	9.96	9.8	7.21
3	CPD Min	3.15	5.36	4.88	5.22	4.69	4.58	4.33	3.87	3.47	3.82	4.6	3.47	3.88	5.64	4.99	4.48	3.81
4	Max. CPD	4.33	6.29	5.78	6.19	5.67	5.27	4.27	4.59	4.28	4.04	5.71	4.43	3.66	5.81	5.91	5.42	5.22
5	PDL	17.04	24.83	19.62	25.36	22.86	20.4	19.26	17.46	16.93	19.72	20.99	15.98	22.23	23.33	19.32	18.87	20.1
6	P PelL	20.25	30.2	22.39	28.89	27.07	24.63	23.25	20.01	19.37	28.92	22.48	18.38	29	27.95	24.28	23.74	22.36
7	P.A L	27.59	48.1	31.26	42.39	38.07	36.33	32.83	29.03	28.91	28.31	32.01	27	41.45	38.83	32.65	35.27	32.66
8	Pec pel.L	12.26	19.16	13.26	17.21	15.62	15.73	14.6	13.48	11.2	11.32	13.29	11.41	16.04	16.88	13.39	14.92	12.61
9	Pel AL	7.93	12.5	9.89	15.15	11.85	12.21	10.41	9.42	9.37	9.7	9.32	8.89	12.52	13.16	11.15	10.73	9.21
10	VD	3.1	4.63	2.19	3.1	3.12	2.89	2.95	3.45	2.93	2.08	2.18	2.31	1.53	4.81	2.98	2.57	3.09
11	CPL	7.14	9.75	8.99	9.87	10.19	10.78	8.51	8.12	7.1	8.8	9.3	7.54	8.51	12.19	8.51	9.15	7.93
12	DFD	9.1	15.01	8.79	13.47	13.16	10.24	10.19	9.56	9.81	8.48	8.67	8.21	11.81	12.57	12.57	8.23	10.57
13	DFBDFR	8.25	13.66	8.6	12.98	12.17	9.67	10.01	8.43	8.81	7.29	7.91	7.03	10.19	12.17	7.73	7.49	9.94
14	AFL	8.96	11.85	7.67	10.76	10.39	8.71	8.75	7.67	6.71	10.29	7.46	7.04	8.05	10.67	9.5	8.28	8.64
15	Pec FL	8.42	13.1	8.65	12.55	11.9	10.3	10.46	9.87	9.61	7.46	7.29	8.58	10.96	12.65	11.36	10.14	10.3
16	Pel.F L	6.17	11.15	7.24	10.47	10.19	7.71	7.75	6.68	6.99	6.15	7.37	6.5	7.91	10.13	9.59	7.09	8.73
17	LAS	1.42	3.13	1.9	2.51	1.9	1.77	2.16	2.77	1.65	1.09	1.86	1.7	0.2	2.61	2.3	1.19	2.01
18	HL	9.53	13.19	11.66	14.01	14.14	11.25	11.3	9.7	10.56	5.06	7.94	8.52	12.51	12.62	11.84	10.83	10.58
19	HDN	4.93	6.9	6.9	8.21	7.53	6.68	6.75	5.51	5.33	4.75	5.76	4.93	5.91	6.28	7.09	6.65	7.08
20	HDE	3.9	6.08	5.3	6.93	6.96	5.71	5.07	4.86	4.35	5.58	7.93	3.99	4.15	8.45	5.65	5.32	4.75
21	HWPEO	5.25	7.96	7.2	8.7	8.74	7.71	8.99	6.25	5.9	5.12	7.41	5.51	7.25	7.65	7.36	6.14	6.5
22	HWE	4.89	7.57	6.67	7.77	7.64	5.81	6.73	5.78	6.41	6.64	3.99	5.47	6.86	6.29	7.14	6.06	6.16
23	WBN	1.86	3.81	3.63	4.71	4.92	3.34	2.83	2.6	3.3	5.06	5.16	1.79	2.33	2.59	2.82	3.2	4.72
24	SnL	3.51	7.07	5.48	6.5	6.86	5.02	5.87	4.83	5.04	5.41	5.13	4.46	4.39	6.42	5.01	4.71	2.66
25	EHD	1.99	3.01	2.71	2.58	2.71	2.65	2.01	2.23	2.45	2.96	3.65	1.83	2.79	2.69	2.66	2.32	4.17
26	OOD	2.59	3.85	4.45	4.7	4.86	3.71	3.76	3.5	2.88	3.99	5.86	2.13	4.35	3.88	3.19	2.83	5.03
27	IOW	3.74	5.23	5.87	4.09	5.01	5.04	4.41	3.38	4.23	4.55	5.73	3.97	6.46	4.86	4.7	4.26	2.01
28	ABL	1.44	1.79	1.79	1.86	2.25	1.78	1.46	1.39	1.38	1.1	1.31	1.52	1.79	1.71	2.45	1.04	1.57
29	PBL	1.12	1.61	0.98	6.56	1.5	0.82	0.71	0.88	1.13	4.47	1.01	1.08	0.48	1.55	1.15	0.99	5.2
30	DL	3.77	6.74	4.96	2.58	6.98	6.52	6.53	4.04	5.23	4.55	4.79	4.15	7.2	5.99	4.78	5.15	2.44
31	LT	1.71	2.67	2	2.86	2.75	2.03	2.71	2.02	1.98	2.16	1.75	1.89	7.94	2.61	2.67	1.67	2.07
32	LP	2.7	3.06	2.57	1.93	2.47	4.18	2.8	2.53	2.42	1.54	4.3	2.92	3.97	3.13	3.34	2.67	1.76
33	LL	1.88	2.4	1.7	6.07	2.06	1.83	2.09	1.84	5.53	6.33	1.99	5.88	2.01	2.8	2.33	1.63	5.88
34	DW	4.12	4.44	6.6	4.84	6.84	6.2	5.37	6.19	5.86	3.33	5.64	3.95	7.85	7.99	4.99	5.85	3.92
35	WBAB	3.36	6.16	3.16	6.63	4.87	3.57	4.38	2.87	4.38	4.15	3.77	3.12	4.63	4.87	4.51	3.45	4.65
36	WM	3.92	5.97	5.72	5.79	7.12	5.61	4.94	4.51	4.64	4.68	5.48	3.87	6.83	6.5	5.75	5.43	4.85
37	WT	3.5	4.45	6.05	4.84	6.04	4.02	5.02	4.41	4.82	3.12	5.32	3.53	6.33	6.95	4.55	5.19	4.03
38	WP	2.5	5.21	4.61	5.02	4.41	4.11	3.33	3.3	3.22	3.43	3.8	2.15	4.61	4.29	3.89	3.19	4.95
39	BW	5.14	5.87	2.22	4.27	4.14	2.86	2.21	1.15	1.02	1.04	3.2	0.87	4.16	4.11	2.61	2.51	2.21

Table 7. Morphometric measurements of Genus *Garra* at Butwal

S.N	Parameters(mm/gm)	Sample No.(Butwal)																
		GA46	GA 47	GA 48	GA 49	GA50	GA51	GA52	GA53	GA54	GA55	GA56	GA57	GA58	GA59	GA60	GA61	GA62
1	SL	62	44.98	59.89	51.05	42.28	44.70	41.51	42.8	46.64	45.3	44.89	43.54	37.51	39.4	40.28	38.97	36.52
2	BD	9.8	9.07	12.7	9.54	6.51	9.24	7.81	8.95	8.86	8.89	8.41	7.75	7.18	8.17	8.35	7.63	7.2
3	CPD Min	4.37	4.98	7.11	4.47	4.87	4.18	3.84	4.71	4.54	4.47	4.06	4.42	4.06	4.13	3.78	3.76	3.38
4	Max. CPD	5.68	5.8	7.92	5.16	5.7	4.65	4.74	5.33	4.98	5.35	4.74	5.48	5.01	4.75	4.92	4.59	4.75
5	PDL	26.9	21.68	27.84	22.78	21.95	20.46	19.65	19.9	22.18	21.5	20.87	20.72	17.73	18.48	18.71	18.69	17.82
6	P PelL	29.3	23.4	29.74	24.87	24.7	23.76	20.94	22.1	23.29	23.1	24.02	23.14	19.33	19.67	21.15	20.14	18.87
7	P.A L	45.2	32.87	43.17	37.13	33.89	32.04	30.13	31.3	33.51	33.8	32.92	32.42	28.62	29.09	22.76	29.15	26.24
8	Pec pel.L	15.9	13.24	17.29	14.97	13.63	14.52	12.56	13.2	12.46	15.1	13.76	13.13	11.09	11.08	12.14	12.09	11.46
9	Pel AL	12.3	9.74	14.28	11.98	10.36	10.26	8.98	10.4	11.76	10.6	9.95	10.27	9.21	9.63	9.81	9.3	8.68
10	VD	3.41	2.45	2.87	2.08	2.21	2.2	2.39	2.55	2.68	3.05	1.85	2.59	1.92	2.65	2.53	2.66	2.07
11	CPL	13	8.41	12.19	7.58	9.09	8.05	8.09	6.35	7.44	8.86	9.36	8.66	7.31	7.51	7.18	7.01	7.32
12	DFD	13.4	9.54	14.07	9.41	10.3	10.07	8.59	7.83	9.41	8.97	9.77	9.65	8.38	9.84	8.34	8.17	8.13
13	DFBDFR	12.6	9.37	12.64	8.29	8.62	9.05	7.95	7.75	9.31	7.77	7.86	8.67	7.73	8.48	7.81	7.27	7.21
14	AFL	11.3	8.6	11.1	8.14	7.81	8.02	7.67	7.74	7.57	8.26	7.79	8.09	7.28	7.19	7.46	6.89	6.44
15	Pec FL	12.2	8.1	11.17	9.17	9.36	8.52	8.33	8.11	7.79	9.07	8.69	9.07	8.26	8.33	8.02	7.14	7.15
16	Pel.F L	11.5	7.52	10.54	8.22	7.55	7.75	7.06	7.97	7.27	7.71	7.71	7.75	6.47	7.52	7.03	5.63	5.75
17	LAS	3.26	2.88	3.15	1.47	2.21	2.42	2.35	2.61	2.94	2.35	2.57	2.69	1.69	1.71	1.79	1.78	1.54
18	HL	15.7	11.22	14.49	11.63	12.8	11.84	10.59	11.2	11.99	12.1	11.19	11.59	10.02	10.21	10.15	9.43	9.39
19	HDN	10.8	7.23	8.65	7.89	7.33	6.54	7.17	6.62	6.99	7.07	6.57	6.59	6.14	5.74	6.15	5.6	5.86
20	HDE	7.27	6.18	7.02	5.94	6.53	5.08	5.11	5.36	5.82	6.31	5.56	5.34	4.57	5.31	5.41	5.03	5.06
21	HWPEO	11.4	6.47	10.59	7.62	7.88	7.18	7.53	7.13	6.93	6.48	7.36	7.36	6.67	6.02	6.68	6.42	6.51
22	HWE	10.6	6.13	10.15	6.86	7.54	6.8	7.07	6.99	6.36	6.32	6.74	7.07	5.67	6.29	6.03	6.07	6.15
23	WBN	5.06	3.28	4.39	2.8	3.18	3.64	3.08	3.25	2.84	3.17	2.89	3.67	2.12	3.15	2.91	2.7	3.01
24	SnL	8.15	5.94	7.82	5.14	6.8	5.46	5.97	5.31	6.04	5.74	5.61	5.41	4.33	4.73	4.99	4.99	4.68
25	EHD	3.18	2.89	3.44	2.32	3.1	2.36	2.83	2.36	2.95	2.79	3.36	2.65	2.78	2.82	2.54	1.77	2.62
26	OOD	4.84	3.32	5.62	3.78	4.23	4.35	4.09	4.17	4.72	4.66	4.71	4.34	3.58	3.41	3.57	3.75	3.41
27	IOW	7.96	6.01	7.97	4.84	5.63	5.1	5.03	4.83	4.91	5.02	4.67	4.73	4.34	4.18	4.41	3.91	4.32
28	ABL	2.99	1.97	1.96	1.27	1.39	1.69	1.82	1.99	1.66	2.04	2.33	1.56	1.48	1.58	1.84	1.36	1.46
29	PBL	1.76	1.35	1.31	0.73	1.1	1.19	1.33	1.11	1.06	1.3	1.03	1.01	0.81	1.31	1.48	0.87	0.91
30	DL	8.03	5.61	6.55	4.93	5.61	5.15	4.71	5.18	4.95	5.23	5.15	4.85	4.66	4.96	4.27	4.46	5.39
31	LT	3.48	2.5	3.35	1.93	2.59	2.44	1.93	2.38	2.37	2.52	2.41	2.91	1.75	1.84	1.83	2.01	2.15
32	LP	5.09	4.93	6.61	3.95	3.18	3.41	2.59	2.59	2.64	3.59	3.91	3.18	2.26	2.42	2.43	2.47	2.85
33	LL	2.66	1.7	1.92	1.27	1.91	2.17	1.63	1.61	1.81	2.12	2.12	1.91	1.44	1.66	1.56	1.48	1.26
34	DW	9.36	3.95	7.82	4.81	7.05	7.02	5.82	6.01	6.15	7.02	5.83	5.71	5.87	5.73	5.81	8.8	5.51
35	WBAB	5.36	3.72	4.66	3.45	4.4	3.64	3.51	3.67	3.72	3.32	3.25	4.02	2.72	3.38	3.61	3.01	3.24
36	WM	9.61	5.54	7.01	4.86	5.78	5.41	4.91	4.92	5.34	6.31	4.18	6.14	5.28	4.88	5.09	5.31	4.27
37	WT	8.93	6.29	6.74	4.32	5.82	5.99	5.47	5.22	5.41	5.87	4.65	5.98	4.15	4.73	5.25	4.03	4.35
38	WP	7.77	5.27	6.28	4.02	4.6	4.99	4.31	4.16	4.71	4.52	4.32	4..81	3.43	3.95	3.82	3.77	3.72
39	BW	5.5	2.98	4.89	2.99	2.1	2.83	2.21	2.75	3.11	2.91	2.98	3.01	1.11	1.23	1.59	1.52	1.01

Table 8. Morphometric measurements of Genus *Garra* at Butwal

S.N	Parameters(mm/gm)	Sample No.(Butwal) GA63	GA64	GA65	GA66	GA67	GA68	GA69	GA70	GA71	GA72	GA73	GA74	GA75	GA76	GA77	GA78	GA79	GA80	GA81
1	SL	37.6	38.44	44.55	59.69	56.81	47.48	39.53	61.8	51.95	49.76	43.15	42.24	35.39	43.12	37.97	42.68	37.03	36.55	37.12
2	BD	8.14	8.16	10.42	12.29	10.84	11.31	7.18	12.9	9.69	9.59	7.78	8.03	6.06	7.4	7.74	8.63	7.47	5.79	7.89
3	CPD Min	3.46	4.08	5.75	6.04	6.43	5.65	3.98	6.44	5.88	5.46	5.03	4.05	3.35	3.95	3.68	4.35	3.74	3.88	3.71
4	Max. CPD	4.84	5.26	6.74	7.25	6.59	5.71	5.01	7.54	6.38	5.93	6.29	4.54	4.07	4.69	5.21	4.74	4.53	4.14	4.84
5	PDL	17.7	18.18	25.32	26.83	26.51	21.56	16.97	28.2	24.18	21.61	18.48	19.37	15.93	20.11	18.47	20.21	17.41	16.98	16.92
6	P PelL	19.2	20.91	27.48	29.21	27.81	24.57	19.45	31.2	27.62	24.86	22.05	22.77	18.55	21.71	20.07	21.82	19.47	18.85	19.61
7	P.A L	28.5	28.18	38.31	42.86	41.78	35.55	29.53	45.1	38.58	36.46	31.39	31.31	26.24	29.85	28.56	31.52	27.92	26.69	27.31
8	Pec pel.L	11.1	13	15.31	16.97	16.24	14.75	10.77	18.7	17.23	14.59	13.43	14.07	12.63	11.61	11.38	12.06	11.72	11.57	10.96
9	Pel AL	9.91	8.34	12.78	13.03	12.11	11.18	9.55	14.3	12.15	12.29	10.24	9.92	8.53	10.23	7.79	10.64	8.57	8.67	9.36
10	VD	1.66	3.22	3.13	3.07	3.49	3.36	27.8	3.89	2.78	2.41	2.87	2.79	1.87	2.03	2.36	2.05	1.84	2.39	1.89
11	CPL	7.85	7.69	10.66	12.02	11.92	8.68	7.33	12.8	9.86	9.29	9.68	7.68	6.63	9.36	8.16	1.38	8.37	7.28	6.74
12	DFD	8.89	9.95	14.15	15.81	13.96	11.81	10.21	14.8	12.69	11.93	10.02	9.79	9.12	9.84	9.72	9.95	9.22	9.16	8.47
13	DFBDFR	7.85	9.43	13.53	15.15	12.91	10.88	9.56	13.9	12.13	11.16	9.01	9.39	8.39	9.15	8.95	9.24	8.73	8.45	7.46
14	AFL	7.96	7.97	11.75	11.88	12.15	9.04	7.17	13	10.54	9.57	8.76	8.11	7.13	8.06	7.55	8.31	6.97	6.34	7.03
15	Pec FL	7.75	9.27	13.89	15.11	13.79	10.65	9.53	14.5	12.35	12.14	9.89	9.83	8.99	10.39	9.53	10.22	9.12	9.02	9.67
16	Pel.F L	6.96	7.68	10.19	12.22	11.38	9.25	6.81	12.4	10.13	9.78	8.08	7.05	6.42	8.27	8.97	7.94	6.57	6.86	7.71
17	LAS	1.75	1.88	2.28	3.05	2.65	2.54	1.94	2.42	1.91	2.53	1.91	1.74	1.93	1.92	2.02	2.18	1.73	1.59	1.65
18	HL	9.98	9.53	13.67	14.71	14.85	12.03	10.09	15.9	14.02	12.33	10.41	10.07	9.25	11.26	9.38	10.65	9.22	9.65	10.02
19	HDN	5.39	5.53	8.01	8.81	8.58	7.71	5.66	10	8.21	7.32	6.55	6.22	5.31	6.21	5.81	5.93	5.71	5.33	6.22
20	HDE	4.41	5.04	6.11	7.63	6.96	6.39	4.48	7.35	5.92	5.71	4.58	4.59	4.05	4.75	4.56	4.29	4.83	4.76	5.22
21	HWPEO	5.81	5.94	8.63	8.33	9.52	7.59	6.16	10.2	7.72	9.09	6.44	6.07	4.75	6.35	5.73	6.85	5.64	5.96	5.84
22	HWE	5.15	5.42	8.08	7.51	5.57	7.04	5.73	8.35	6.99	7.61	5.55	5.22	4.96	6.15	5.64	6.34	5.51	5.54	5.46
23	WBN	2.84	2.59	3.42	3.29	4.47	3.72	2.41	3.86	3.31	3.58	3.06	2.57	2.29	2.51	2.19	2.63	2.33	4.12	3.23
24	SnL	4.33	4.91	7.62	6.92	7.21	9.27	4.65	7.35	6.48	6.36	4.78	4.98	4.67	5.01	4.71	4.96	4.21	4.76	4.89
25	EHD	2.73	2.89	3.14	3.11	3.01	2.88	2.43	2.92	3.36	2.99	3.05	2.07	2.16	2.19	2.18	2.24	2.38	2.86	2.33
26	OOD	3.74	3.98	4.99	5.64	5.71	5.51	2.72	5.57	4.88	4.57	4.16	3.55	3.58	3.81	3.05	4.15	3.06	3.31	2.27
27	IOW	4.76	3.92	5.95	6.62	6.09	5.53	3.38	7.17	4.93	4.48	4.24	4.27	3.39	4.21	4.44	4.81	3.64	3.97	4.53
28	ABL	1.85	1.62	2.13	2.96	2.94	1.79	1.84	1.91	1.96	1.98	1.76	1.58	1.65	2.23	1.41	1.56	1.31	1.18	1.32
29	PBL	1.51	0.78	0.85	1.93	1.93	1.18	0.98	1.22	0.97	1.36	1.01	0.61	1.16	1.24	0.48	1.18	1.03	0.99	0.95
30	DL	4.35	3.82	7.11	5.93	5.78	5.52	4.31	6.88	5.33	5.78	5.46	4.84	4.58	5.06	4.73	5.68	4.12	4.07	5.02
31	LT	1.83	2.33	2.98	3.06	3.59	2.71	2.26	2.74	2.85	2.69	1.98	2.57	2.36	2.56	2.23	1.86	1.84	2.32	2.22
32	LP	2.93	3.44	2.88	4.49	3.14	3.53	2.84	2.83	1.95	1.93	2.71	3.12	1.86	3.11	2.48	2.79	2.01	2.91	1.93
33	LL	1.95	2.07	2.07	2.11	2.11	2.31	9.95	1.55	1.51	1.47	1.7	1.49	1.68	1.91	1.52	1.77	1.02	1.94	1.65
34	DW	5.13	3.12	7.33	8.59	6.89	5.42	4.67	7.51	6.92	6.91	4.69	5.71	4.05	5.52	4.17	3.6	5.99	5.39	4.94
35	WBAB	3.22	4.49	4.92	5.82	4.79	4.05	3.07	4.39	4.47	3.57	4.15	4.38	2.73	3.78	3.12	4.22	3.91	3.39	3.69
36	WM	4.43	5.52	6.65	7.11	4.05	5.42	4.52	6.32	5.82	4.82	5.05	4.88	4.46	4.95	4.74	5.51	4.64	4.29	4.41
37	WT	4.73	4.51	6.89	7.26	6.63	5.97	3.85	6.09	5.45	4.99	4.58	4.05	3.69	4.71	5.11	5.74	3.63	3.27	4.46
38	WP	3.81	3.68	5.06	5.32	4.86	3.93	2.88	5.23	4.26	3.53	3.72	3.44	3.01	3.27	3.22	3.76	3.44	3.25	3.11
39	BW	0.59	1.15	2.85	4.65	4.35	2.32	1.45	5.12	2.81	2.45	2.35	2.15	0.68	2.24	1.15	2.13	2.01	1.01	2.04

Table 9. Morphometric measurements of Genus *Garra* at Butwal

	Parameters(mm/gm)	Sample No.(Butwal)																		
		GA82	GA83	GA84	GA85	GG86	GG87	GG88	GG89	GG90	GG91	GG92	GG93	GG94	GG95	GG96	GG97	GG98	GG99	GG100
1	SL	37.76	35.8	33.03	36.31	36.7	38.83	38.09	36.21	38.12	37.71	39.41	46.13	44.65	48.46	50.08	47.51	57.61	48.27	82.02
2	BD	7.18	6.36	6.35	6.58	6.82	6.37	7.51	7.02	7.84	7.51	7.31	8.36	8.36	9.56	9.49	7.34	12.53	8.03	16.77
3	CPD Min	3.24	4.02	3.84	3.66	3.81	3.77	3.88	3.68	3.71	3.81	3.79	4.41	4.25	4.94	4.38	4.15	6.58	4.51	10.03
4	Max. CPD	5.16	4.09	3.72	3.99	4.57	4.88	4.31	4.75	4.54	4.34	4.69	4.93	5.32	5.48	5.06	4.32	7.37	5.08	10.67
5	PDL	17.14	16.5	16.09	17.08	17.3	18.93	17.09	16.21	17.69	17.89	18.01	20.19	19.85	21.02	22.79	21.25	26.55	2.01	38.59
6	P PelL	19.31	19	19.63	19.01	19.4	21.06	21.51	19.12	20.46	18.04	20.84	22.17	24.01	25.13	25.95	23.45	29.08	23.26	41.52
7	P.A L	26.86	26.8	26.65	27.53	27.5	29.05	30.03	28.18	28.99	26.48	28.71	33.01	34.08	34.95	36.38	34.08	41.23	35.49	60.24
8	Pec pel.L	12.08	11.8	10.75	11.77	11.3	12.41	12.44	11.47	11.88	10.31	10.56	12.83	13.88	14.94	14.02	12.41	16.32	12.47	25.38
9	Pel AL	8.29	8.23	8.38	8.73	8.11	8.42	9.39	8.52	8.85	8.67	8.64	11.16	10.72	12.26	11.42	11.63	12.33	12.49	18.64
10	VD	3.06	3.34	3.31	3.03	1.94	3.16	3.64	2.62	2.01	2.37	1.73	2.65	2.53	2.48	2.22	1.83	3.13	2.73	4.05
11	CPL	7.83	6.86	6.34	6.92	6.23	7.51	7.83	6.81	7.55	7.59	7.59	9.45	9.91	10.41	9.21	10.12	10.03	12.22	18.47
12	DFD	9.93	9.04	8.31	9.78	9.36	9.27	10.01	8.88	9.87	8.99	10.15	10.87	9.88	11.47	12.23	11.14	14.97	11.78	19.87
13	DFBDFR	9.34	8.28	7.44	9.28	8.43	8.69	9.34	8.01	9.18	8.29	7.84	10.43	9.44	10.61	11.54	9.99	13.72	11.37	19.18
14	AFL	7.52	6.87	6.59	6.78	6.62	7.27	7.41	7.21	6.69	7.27	7.41	7.78	7.99	9.71	9.39	8.72	12.83	8.27	15.26
15	Pec FL	9.24	8.14	9.21	9.25	8.11	9.16	10.54	8.62	7.54	8.59	8.95	10.26	9.12	11.49	10.69	10.91	13.67	10.91	17.66
16	Pel.F L	7.25	5.65	6.55	7.49	6.54	7.05	7.62	6.61	6.57	6.09	6.81	8.51	8.37	9.31	9.42	8.52	11.72	9.12	14.53
17	LAS	1.64	1.64	1.98	2.28	1.79	1.79	2.29	2.12	1.53	1.71	1.63	1.86	1.93	1.42	2.59	2.42	2.31	1.99	4.13
18	HL	10.27	9.75	8.44	9.41	9.71	10.18	10.48	9.96	10.56	8.95	9.99	11.09	11.44	12.09	13.24	12.65	15.58	12.31	20.11
19	HDN	5.88	5.04	4.71	5.78	5.86	5.32	6.05	6.26	5.27	5.61	5.71	6.29	6.88	6.35	7.18	6.64	9.61	6.71	13.61
20	HDE	4.58	3.94	4.37	4.39	4.87	4.77	4.63	4.84	4.14	4.16	4.14	4.57	4.94	5.14	6.15	4.92	7.21	5.32	10.39
21	HWPEO	4.84	5.37	5.63	6.19	6.11	6.05	6.13	5.81	5.23	5.41	5.63	6.23	5.44	7.91	6.68	6.81	9.37	6.39	13.52
22	HWE	4.72	5.31	5.01	5.17	4.94	5.94	5.41	4.97	5.32	4.73	5.35	5.72	5.13	6.88	6.36	6.11	8.43	5.69	11.54
23	WBN	2.13	2.99	2.57	2.86	3.17	2.41	3.02	2.71	2.34	3.72	2.26	2.34	2.41	2.85	2.65	2.18	3.13	1.89	5.56
24	SnL	4.38	2.51	3.73	5.04	4.48	4.89	4.97	4.89	4.28	4.86	4.43	5.27	5.14	6.86	6.71	5.56	7.94	5.63	10.26
25	EHD	1.82	2.25	2.07	2.31	2.46	2.14	2.31	2.23	2.77	2.52	2.12	1.79	2.22	1.92	1.86	2.62	2.61	2.62	3.62
26	OOD	2.92	3.41	2.53	3.69	3.41	3.38	3.42	2.65	4.21	3.51	3.05	3.92	4.16	4.58	4.28	4.21	5.05	4.84	6.31
27	IOW	4.41	4.08	3.41	4.06	4.21	3.82	3.71	3.96	4.26	3.57	3.91	4.09	4.18	5.66	4.58	4.67	6.11	4.08	8.87
28	ABL	1.91	1.04	1.74	2.04	1.73	1.44	1.88	1.52	1.81	1.27	1.45	1.69	1.66	1.65	2.22	1.38	2.44	1.57	3.59
29	PBL	0.89	0.51	0.99	1.54	1.26	1.07	0.79	1.44	1.27	0.87	1.21	0.32	0.99	1.03	1.56	0.77	1.47	1.27	1.35
30	DL	4.37	4.63	~~3.83~~	3.54	4.34	5.51	5.23	3.51	4.01	4.54	4.88	5.58	5.48	5.96	5.31	5.01	6.19	5.98	9.76
31	LT	1.79	2.13	2.25	1.61	1.82	2.05	2.12	8.32	1.71	2.13	1.75	2.57	1.94	2.77	2.71	2.35	2.57	2.73	4.51
32	LP	2.61	1.77	2.41	1.91	2.07	2.34	2.74	2.84	1.92	2.76	2.54	2.42	2.86	2.05	3.74	2.37	3.31	3.82	5.11
33	LL	1.77	1.28	1.78	1.63	1.57	1.57	1.78	1.67	0.86	1.62	1.47	1.76	1.46	1.55	1.23	1.77	1.64	1.72	3.34
34	DW	5.06	5.18	4.71	4.49	4.62	5.44	4.64	5.04	4.95	6.41	3.16	4.43	3.79	4.47	5.81	5.33	6.82	6.39	13.28
35	WBAB	3.88	3.09	3.04	3.08	3.22	3.25	3.78	3.94	3.55	3.64	3.94	4.08	4.03	5.93	4.46	4.11	4.69	3.76	6.86
36	WM	4.52	4.82	4.62	4.87	4.28	3.97	S	4.09	3.79	3.62	3.79	5.15	4.34	5.67	6.43	5.22	7.02	5.07	9.11
37	WT	4.16	3.89	4.45	3.65	3.81	4.03	4.23	3.01	3.87	3.79	3.51	4.39	4.37	4.65	5.22	4.79	6.38	4.06	9.17
38	WP	3.07	4.08	3.33	3.73	3.11	3.17	4.22	3.45	3.71	3.28	3.11	4.02	3.57	4.01	4.17	3.75	5.17	3.72	6.52
39	BW	2.15	0.95	0.54	1.02	1.08	1.09	1.03	0.98	1.05	1.03	1.21	3.11	2.99	2.62	3.75	2.51	3.78	2.79	7.01

	Parameters (mm/gm)	Sample No.(Butwal)																		
		GG101	GG102	GG103	GG104	GG105	GG106	GG107	GG108	GG109	GG110	GG111	GG112	GG113	GG114	GG115	GG116	GG117	GG118	GG119
1	SL	65.2	54.54	52.49	44.59	48.83	42.77	43.07	42.1	46.78	41.21	38.81	42.48	39.74	42.28	38.85	43.77	37.33	37.11	39.43
2	BD	13.4	11.61	10.13	9.32	9.98	8.39	9.05	8.15	9.43	7.98	7.52	8.19	8.77	8.28	7.46	9.33	6.73	6.24	7.93
3	CPD Min	7.6	5.19	4.91	4.15	4.41	4.44	4.82	4.42	4.92	3.61	3.01	4.16	4.08	4.81	4.14	4.41	3.77	4.33	4.11
4	Max. CPD	7.84	6.37	5.86	5.31	5.56	5.46	6.51	5.33	5.54	4.73	4.46	5.42	18.84	5.78	4.92	5.24	4.06	4.93	4.64
5	PDL	30	24.35	24.58	21.46	22.35	20.57	20.18	20.7	22.35	19.67	18.31	19.46	20.11	19.91	18.73	20.35	17.31	16.94	18.25
6	P PelL	34.2	26.27	28.52	23.84	24.79	21.98	22.43	22.7	24.76	21.31	20.21	21.62	28.68	23.21	20.58	23.92	19.33	19.45	19.5
7	P.A L	48.4	39.34	38.23	33.21	36.66	32.67	32.94	31.4	34.41	30.47	29.65	31.33	11.71	32.43	29.48	32.26	27.69	27.03	28.15
8	Pec pel.L	19.9	15.19	14.64	14.81	14.13	13.03	14.26	13.8	15.51	12.36	11.67	13.21	8.63	13.14	11.53	14.35	10.88	11.04	10.96
9	Pel AL	14.8	12.51	11.71	9.33	11.78	10.61	10.18	9.61	11.58	10.19	9.44	10.34	1.72	10.17	9.21	9.48	8.51	8.13	9.32
10	VD	3.75	3.57	3.51	2.81	2.92	3.03	2.53	2.31	2.58	2.61	2.57	2.91	7.47	2.24	9.95	2.22	1.92	197	3.23
11	CPL	11.2	9.12	10.81	9.02	8.48	7.19	7.91	7.87	8.76	8.67	6.81	7.65	8.22	7.59	8.57	8.46	7.69	7.61	8.45
12	DFD	16.6	11.45	10.62	10.01	12.47	9.86	9.73	9.89	10.52	8.58	8.63	8.78	7.64	10.16	8.75	10.65	7.72	7.25	8.91
13	DFBDFR	15.8	10.61	9.91	9.67	12.07	9.25	9.31	9.66	9.69	8.17	7.82	8.52	7.22	9.66	7.75	9.45	7.06	6.92	8.47
14	AFL	13.4	9.01	9.62	8.45	8.89	8.83	7.47	8.23	8.92	7.49	7.46	7.71	8.05	8.12	7.62	7.94	6.66	6.59	7.47
15	Pec FL	15.4	10.39	9.78	9.71	10.59	8.77	8.44	9.11	10.42	8.09	8.21	8.08	7.32	9.29	8.73	8.53	7.49	7.21	8.24
16	Pel.F L	13.1	9.41	8.56	7.85	9.02	8.59	7.89	8.48	7.76	7.23	6.09	7.11	2.36	7.29	7.37	7.57	6.58	5.64	6.41
17	LAS	2.64	3.03	2.11	2.07	2.84	2.36	2.79	1.76	2.33	2.04	2.08	2.27	2.11	1.97	1.68	1.93	1.91	1.68	1.79
18	HL	16.7	13.85	13.51	11.66	12.13	11.24	11.05	10.9	12.04	10.91	10.07	10.82	10.71	10.73	10.18	11.05	9.23	8.94	10.44
19	HDN	10.2	8.13	8.98	7.72	7.01	6.48	6.61	6.79	7.56	5.99	6.73	6.08	5.99	5.86	5.43	6.91	5.62	5.31	4.89
20	HDE	8.12	6.71	7.04	6.36	6.77	5.64	5.88	5.99	5.86	4.99	4.54	5.51	6.11	5.29	5.03	5.68	4.36	4.26	4.41
21	HWPEO	11.3	7.94	8.18	8.21	7.23	7.43	6.39	7.92	7.61	7.41	5.69	7.21	5.99	7.06	7.01	7.36	6.17	5.78	6.09
22	HWE	10.4	7.09	7.69	7.66	6.11	6.99	5.79	6.78	7.19	6.81	5.98	6.93	5.05	6.64	6.31	7.14	5.23	5.64	5.96
23	WBN	4.32	3.57	3.21	3.31	3.08	2.99	3.42	2.87	3.21	2.96	3.03	2.86	2.74	3.48	3.05	2.43	2.41	2.33	2.93
24	SnL	8.54	6.95	7.06	6.24	6.65	5.49	5.37	5.36	6.05	5.56	4.92	5.91	5.47	5.59	4.71	5.81	4.47	4.42	4.62
25	EHD	2.89	3.09	3.28	3.12	2.85	2.47	2.81	2.63	2.92	2.62	2.76	2.91	2.75	2.83	2.06	2.93	2.26	2.76	2.55
26	OOD	5.78	4.93	4.42	4.22	4.07	4.04	3.81	4.05	5.25	4.26	3.65	4.14	3.72	3.85	3.29	4.47	3.83	3.68	3.85
27	IOW	7.39	5.56	6.53	5.08	5.23	4.52	5.08	4.96	5.56	5.18	4.33	4.89	4.58	4.86	3.59	5.06	4.14	4.51	3.92
28	ABL	3.41	2.28	1.99	2.21	2.49	1.81	1.62	1.53	1.91	1.55	1.81	1.67	1.65	1.63	1.59	1.42	1.61	1.34	1.61
29	PBL	1.44	1.55	1.27	1.68	1.48	1.45	1.17	1.31	1.61	1.11	1.47	1.35	1.17	1.04	1.11	1.22	1.14	1.09	1.31
30	DL	7.61	6.93	~~6.16~~	5.19	5.81	5.01	5.22	5.53	4.95	5.39	4.81	4.55	4.67	4.79	4.81	5.63	4.43	4.93	4.91
31	LT	3.72	2.81	2.84	2.07	2.92	2.84	2.81	2.13	2.32	2.23	2.58	2.52	2.13	2.29	2.02	1.94	2.21	2.3	2.06
32	LP	4.01	4.93	4.65	3.82	3.37	3.17	3.96	3.02	3.22	3.86	3.23	2.08	3.39	2.77	1.84	2.93	2.46	2.81	3.11
33	LL	2.44	1.67	1.85	1.87	1.73	1.85	2.13	1.71	2.28	1.54	1.44	1.41	1.96	1.19	1.63	1.81	1.48	1.74	1.96
34	DW	10.3	7.24	7.12	6.77	6.28	6.01	5.82	5.62	6.06	6.04	5.74	6.67	4.67	5.19	5.21	5.71	4.85	5.19	4.86
35	WBAB	4.81	4.71	4.46	3.81	4.17	3.72	3.42	3.42	3.36	3.33	3.18	3.97	3.37	3.24	3.24	3.35	2.77	3.31	3.57
36	WM	7.93	6.24	5.52	5.59	5.08	5.28	5.45	4.64	5.45	5.77	4.77	5.56	4.84	5.11	4.62	5.49	4.44	4.36	4.37
37	WT	8.76	6.21	7.33	5.88	5.04	5.52	5.34	4.41	6.79	5.84	4.64	5.46	4.21	5.48	4.69	4.91	4.25	4.51	4.52
38	WP	6.64	6.26	6.49	4.44	4.53	5.09	5.11	4.59	4.73	4.59	4.26	3.92	3.55	4.34	4.25	4.21	3.12	3.96	4.45
39	BW	5.98	4.18	3.11	2.71	2.83	2.75	2.91	1.99	3.25	2.11	1.22	2.68	1.45	2.48	1.23	3.05	1.01	1.02	1.39

Table 10. Morphometric measurement of Genus *Garra* at Butwal

	Parameters(mm/gm)	Sample No.(Butwal)						
		GG120	GG121	GG122	GG123	GG124	GG125	GG126
1	SL	33.83	37.25	33.52	34.51	31.52	34.54	33.37
2	BD	5.85	6.29	5.52	6.21	6.15	6.85	6.82
3	CPD Min	3.78	3.48	3.41	3.53	3.11	3.08	3.36
4	Max. CPD	4.78	4.81	4.06	4.19	3.82	3.92	4.18
5	PDL	15.39	17.69	15.24	16.43	14.71	15.43	16.37
6	P PelL	17.13	19.09	17.17	18.02	16.96	18.13	17.28
7	P.A L	24.52	27.35	24..46	25.72	23.98	25.34	24.42
8	Pec pel.L	9.82	10.87	9.81	9.16	10.26	10.83	10.41
9	Pel AL	8.73	8.33	8.66	7.88	7.02	7.56	7.88
10	VD	1.28	2.52	1.79	1.74	1.96	1.28	2.31
11	CPL	5.86	7.73	6.89	5.91	7.15	6.92	6.93
12	DFD	7.68	8.86	7.61	7.88	8.35	7.66	7.69
13	DFBDFR	6.21	8.36	6.11	6.93	7.59	7.04	7.28
14	AFL	6.82	7.91	6.92	7.16	6.04	6.17	6.52
15	Pec FL	6.95	8.34	6.02	7.34	6.26	6.64	6.85
16	Pel.F L	6.01	6.74	6.12	6.22	4.75	5.71	5.52
17	LAS	2.07	1.61	2.71	2.26	1.78	1.31	1.71
18	HL	9.44	9.67	9.38	9.63	8.36	8.83	8.87
19	HDN	4.96	5.38	3.57	5.11	5.05	5.09	5.52
20	HDE	4.53	4.58	5.18	4.45	4.04	4.41	4.25
21	HWPEO	5.76	6.12	5.16	5.17	5.23	5.02	5.32
22	HWE	5.52	5.85	5.51	4.95	4.63	4.81	4.77
23	WBN	3.28	2.84	3.71	2.49	2.32	2.04	2.59
24	SnL	4.09	4.68	4.57	4.01	3.95	3.93	3.77
25	EHD	2.4	2.37	3.05	2.47	2.03	2.57	2.41
26	OOD	3.33	3.79	3.14	3.57	2.97	3.96	3.11
27	IOW	4.29	4.42	3.61	3.91	3.79	4.02	4.61
28	ABL	1.51	1.53	1.06	1.45	1.41	1.76	1.24
29	PBL	0.85	1.45	0.05	1.11	0.89	3.84	0.88
30	DL	4.28	4.28	~~4.39~~	4.13	3.75	1.74	3.98
31	LT	2.45	2.45	2.19	2.19	1.71	1.77	1.51
32	LP	2.69	2.69	1.88	2.61	2.01	3.55	2.64
33	LL	2.06	2.06	1.57	1.91	1.39	3.56	1.51
34	DW	4.46	4.46	4.48	4.15	3.51	2.56	5.11
35	WBAB	3.31	3.31	2.73	3.02	1.76	4.04	2.73
36	WM	4.34	4.34	3.91	3.95	3.26	3.37	4.58
37	WT	4.78	4.78	3.53	3.68	2.91	3.61	3.59
38	WP	4.35	4.35	3.43	3.41	2.72	2.81	3.11
39	BW	0.43	0.43	0.58	0.34	0.19	0.35	0.27

Table 11. Morphometric measurements of Genus *Garra* at Jhumsa

S.N	Parameters(mm/gm	Sample No.(Jhumsa)																
		GG 127	GG 128	GG129	GG130	GG131	GG 132	GG133	GG 134	GG 135	GG 136	GG 137	GG138	GG 139	GG 140	GG 141	GG 142	GG143
1	SL	65.04	60.44	67.99	68.57	48.23	44.94	37.61	44.94	37.61	46.03	47.41	40.88	39.73	42.33	39.44	92.42	83.35
2	BD	13.04	11.12	15.45	14.66	9.39	9.42	7.13	9.42	7.13	7.04	9.28	8.09	7.02	7.57	7.42	19.46	16.88
3	CPD Min	7.43	6.51	8.65	7.57	4.34	5.08	3.94	5.08	3.94	4.56	4.86	3.94	4.5	4.48	4.27	11.88	10.2
4	Max. CPD	8.35	7.22	9.29	8.6	5.64	5.95	4.29	5.95	4.29	5.24	5.53	5.22	5.3	5.78	5.42	12.53	10.38
5	PDL	29.44	27.25	31.93	32.84	22.7	20.35	18	20.35	18	20.88	21.35	20.11	19.36	19.63	18.91	42.47	39.89
6	P PelL	33.99	29.92	34.58	33.79	24.48	21.81	19.24	21.81	19.24	23.79	23.41	20.89	21.16	22.07	20.86	42.15	43.3
7	P.A L	47.67	43.82	60.22	50.37	36.93	31.8	26.99	31.8	26.99	33.93	34.02	30.52	29.13	32.02	30.23	67.22	62.65
8	Pec pel.L	19.01	18.49	21.41	19.39	14.61	13.31	11.5	13.31	11.5	13.64	14.3	11.89	11.63	13.64	11.47	27.18	24.84
9	Pel AL	15.5	14.67	16.3	17.11	12.75	9.15	9.39	9.15	9.39	10.96	10.28	9.85	21.88	10.47	9.43	24.61	21.06
10	VD	3.8	2.98	5.24	3.33	4.14	3.04	2.13	3.04	2.13	9.73	2.48	2.86	9.34	3.14	2.26	4.89	4.33
11	CPL	12.48	12.51	11.98	13.13	9.82	7.98	7.91	7.98	7.91	8.22	10.8	9.05	2.65	8.11	6.58	18.91	14.39
12	DFD	15.65	14.23	16.65	15.76	11.44	10.71	8.64	10.71	8.64	10.74	10.64	10.2	7.61	9.86	9.15	19.75	16.91
13	DFBDFR	14.43	13.82	13.56	14.69	10.86	10.08	8.18	10.08	8.18	9.87	9.76	9.18	8.82	9.48	8.59	18.15	15.62
14	AFL	12.73	12.58	13.05	12.74	10.12	8.99	7.26	8.99	7.26	9.15	9.04	8.17	8.52	8.85	7.88	16.45	17.62
15	Pec FL	14.82	13.76	13.38	14.53	11.12	9.96	9.31	9.96	9.31	10.59	10.15	10.17	8.04	10.42	9.41	20.37	19.01
16	Pel.F L	12.68	12.39	11.93	12.45	9.09	8.71	7.29	8.71	7.29	8.43	8.66	7.8	9.56	7.63	7.25	15.54	16.2
17	LAS	3.49	3.11	3.76	2.62	2.66	3.19	1.68	3.19	1.68	2.07	2.45	1.97	1.94	2.17	1.59	4.16	4.12
18	HL	16.01	13.79	16.52	17.76	11.33	11.07	10.42	11.07	10.42	12.15	12.13	10.64	10.38	11.15	10.21	22.64	20.88
19	HDN	9.93	9.41	10.97	11.14	7.11	6.73	5.72	6.73	5.72	7.13	6.98	6.86	5.66	6.81	5.85	15.47	12.84
20	HDE	6.94	7.76	8.63	8.3	5.93	5.35	4.68	5.35	4.68	5.47	5.15	4.92	5.97	5.2	4.42	11.55	10.02
21	HWPEO	12.28	10.66	11.39	12.84	8.39	7.71	5.97	7.71	5.97	7.27	7.43	6.55	5.74	6.74	4.41	16.36	14.27
22	HWE	11.29	10.42	11.28	12.7	8	7.59	2.94	7.59	5.87	7.26	6.88	6.45	4.9	6.45	5.7	15.76	13.6
23	WBN	5.5	5.1	5.19	4.98	2.95	3.69	5.46	3.69	2.94	3.12	2.84	2.73	3.59	2.69	3.15	6.43	5.73
24	SnL	6.9	6.92	8.13	4.59	6.03	5.28	2.31	5.28	5.46	5.47	5.76	5.16	4.74	5.29	4.56	11.8	10.6
25	EHD	3.63	3.68	4.09	3.65	2.89	2.69	4.06	2.69	2.31	3.07	2.98	2.15	2.57	2.84	2.64	3.78	3.94
26	OOD	6.37	4.34	6.66	6.11	4.78	4.73	4.16	4.73	4.06	4.28	4.47	4.12	4.15	4.15	3.54	7.62	7.21
27	IOW	8.3	7.21	7.2	8.73	5.58	5.5	1.27	5.5	4.16	5.07	4.38	5.59	4.16	5.09	4.54	10.98	9.61
28	ABL	2.83	2.82	3.48	2.72	2.26	1.46	0.85	1.36	1.27	1.87	1.29	1.09	1.16	1.56	1.77	3.27	3.16
29	PBL	1.28	1.65	1.94	1.69	1.36	1.14	4.49	1.14	0.85	1.49	0.74	0.67	0.78	0.81	0.82	2.06	1.77
30	DL	7.75	7.85	9.2	9.98	5.52	5.19	4.49	5.19	4.49	4.94	5.48	4.92	4.32	4.97	4.22	11.98	10.23
31	LT	3.74	3.36	4	3.75	3.01	2.26	2.6	2.26	2.6	2	2.92	2.22	2.36	2.06	2.34	4.84	3.9
32	LP	4.56	2.58	3.63	3.11	3.23	3.23	3.14	3.23	3.14	2.98	3.18	2.78	2.68	2.88	2.18	6.41	4.83
33	LL	2.79	2.32	2.34	2.27	2.16	1.82	1.67	1.82	1.67	1.77	1.8	1.69	1.93	1.63	1.48	3.39	2.71
34	DW	9.67	7.35	9.77	7.91	5.43	5.62	4.7	5.62	4.7	4.88	5.48	4.8	4.44	5.79	4.78	14.96	13.42
35	WBAB	4.91	5.06	6.04	5.83	4.31	3.72	3.22	3.72	3.22	3.06	4.05	3.36	3.29	3.8	3.54	8.07	7.11
36	WM	8.63	7.22	9.53	8.49	5.77	5.21	4.6	5.21	4.6	4.53	5.78	4.83	5.2	5.12	4.82	11.31	10.47
37	WT	8.79	8.8	6.97	7.63	4.2	5.77	4.5	5.77	4.5	5.07	5.37	5.3	4.09	4.85	4.23	8.96	7.85
38	WP	6.59	6.15	6.4	6.16	4.53	4.2	3.7	4.2	3.7	3.43	4.35	3.89	3.55	3.52	3.84	8.48	7.8
39	BW	5.59	5.09	6.01	6.1	2.98	2.99	0.85	2.99	0.85	2.15	2.38	1.68	2.02	2.4	1.88	8.52	7.82

S.N	Sample No.(Jhumsa)																								
	Parameters (mm/gm)	GG 144	GG 145	GG 146	GG 147	GG 148	GG 149	GG 150	GG 151	GG 152	GG 153	GA 154	GA 155	GA 156	GA 157	GA 158	GA 159	GA 160	GA 161	GA 162	GA 163	GA 164	GA 165	GA 166	GA 167
1	SL	40.25	38.73	36.23	49.99	58.6	53.48	48.53	52.31	44.98	45.32	46.75	48.74	42.22	50.52	47.99	44.07	42.67	38.51	44.37	39.57	42.35	44.56	36.81	41.39
2	BD	7.89	5.76	6.65	9.24	11.91	9.22	9.88	9.93	9.04	4.28	9.55	9.41	5.74	10.5	9.05	9.61	7.67	6.63	8.26	6.88	7.08	7.55	7.17	8.46
3	CPD Min	4.27	3.34	3.02	5.57	6.86	5.91	5.21	5.9	4.69	4.65	5.27	5.42	6.43	5.75	5.5	4.87	4.31	4.27	4.44	3.91	4.54	4.61	4.12	4.22
4	Max. CPD	5.18	4.37	3.4	5.34	7.01	6.12	5.89	6.83	5.49	5.2	5.26	5.79	4.41	6.67	5.54	5.64	5.16	4.9	4.37	4.74	4.94	5.2	4.83	4.9
5	PDL	18.7	16.84	13.89	22.97	27.99	25.53	23.57	24.55	21.61	22.41	22.04	22.5	25.92	23.13	22.72	21.35	20.65	18.09	21.62	18.16	19.83	20.84	17.49	18.35
6	P PelL	21.23	20.98	19.93	25.44	30.7	27.13	23.63	26.57	23.48	22.59	23.82	23.71	37.69	24.77	24.65	22.52	20.48	19.59	22.97	20.39	21.79	22.56	18.69	20.84
7	P.A L	30.37	28.65	27.75	37.59	43.83	38.95	35.59	37.97	33.25	33.03	34.48	36.73	15.51	36.92	34.9	32.53	30.1	28.49	32.09	29.47	31.22	33.71	26.56	29.53
8	Pec pel.L	24.48	12.94	7.71	15.54	17.78	15.38	13.61	16.35	12.74	12.55	13.76	13.89	12.06	14.99	14.23	13.07	12.07	11.38	13.14	12.78	12.63	13.56	11.78	12.76
9	Pel AL	8.55	9.42	9.26	11.92	13.97	12.35	11.6	11.72	9.9	9.58	10.84	11.91	9.79	13.19	10.56	9.68	9.2	8.58	10.44	10.41	9.37	9.77	8.31	9.24
10	VD	2.21	2.93	1.55	3.34	2.86	2.95	3.04	3.63	2.69	2.91	3.05	3.52	3.9	1.67	3.84	3.02	2.57	1.88	1.99	2.17	2.55	2.73	1.47	1.64
11	CPL	8.28	9.35	6.81	8.92	10.51	10.35	9.22	8.97	9.16	8.76	8.81	10.07	12.15	8.82	9.14	8.6	9.3	8.03	9.72	7.66	8.65	7.93	7.89	8.23
12	DFD	9.7	8.07	8.84	12.15	14.31	13.08	10.56	12.04	11.15	12.38	11.04	11.84	11.76	12.36	10.15	10.49	9.44	7.49	10.33	8.59	10.54	9.1	7.89	9.8
13	DFBDFR	8.48	8.35	7.98	11.61	13.07	12.11	10.01	11.35	10.5	10.85	10.62	10.76	10.66	11.12	9.45	8.63	8.83	7.04	9.78	7.81	9.68	8.6	7.32	8.22
14	AFL	7.31	7.32	7.75	10.49	12.38	11.1	9.24	9.9	9.53	9.49	9.41	9.99	12.05	10.05	9.56	8.6	7.9	7.27	8.27	7.29	8.07	8.25	8.6	7.54
15	Pec FL	9.82	9.07	9.2	11.6	11.4	11.73	10.17	10.97	9.6	10.83	10.06	12.59	10.11	11.86	10.59	10.46	9.21	8.84	10.02	8.94	9.86	10.67	9.76	9.29
16	Pel.F L	7.7	7.62	7.57	9.21	10.48	10.07	9.18	9.49	7.89	9.14	8.25	9.81	8.62	10.06	9.22	8.57	7.56	6.87	7.72	7.01	7.45	8.02	6.07	7.26
17	LAS	1.96	9.99	1.89	2.94	3.03	2.59	9.08	2.26	2.38	2.25	2.23	2.24	3.57	2.34	2.2	2.43	1.66	1.62	2.19	1.59	1.79	2	1.61	1.66
18	HL	10.93	10.95	10.56	12.51	15.2	13.67	13.31	12.88	12.22	12.52	11.98	12.76	8.16	13.1	12.14	11.51	11.34	9.62	11.05	10.41	10.71	12.01	9.69	10.24
19	HDN	6.12	4.91	4.77	7.75	9.46	7.8	8.01	8.29	6.52	7.04	7.12	7.52	6.92	7.74	8.01	6.48	6.45	6.11	6.52	5.98	6.59	6.88	5.23	5.85
20	HDE	4.94	6.25	5.46	6.44	8.02	6.28	6.39	6.78	5.22	6.13	5.72	7.43	8.83	5.8	5.8	5.24	4.74	4.69	5.51	4.91	5.2	5.35	9.23	4.68
21	HWPEO	6.23	5.77	5.31	8.95	10.94	9.56	8.96	9.6	7.84	8.3	7.91	8.05	8.75	8.6	7.86	7.33	6.8	6.06	7.88	7.05	6.83	5.58	4.13	7.01
22	HWE	6.09	4.44	5.18	8.42	10.23	9.49	8.62	9.48	7.67	8.42	6.83	7.2	6.06	7.93	7.7	7.01	6.89	5.79	7.16	6.24	6.85	7.41	5.82	6.07
23	WBN	2.93	2.64	2.63	3.79	44.44	3.72	3.99	4.33	3.51	4.15	3.25	3.34	3.06	2.82	3.25	3.57	2.99	2.23	3.4	2.82	2.71	3.2	2.07	2.66
24	SnL	5.25	4.71	4.45	5.84	8.34	7.22	6.2	7.44	6.17	6.17	5.98	6.12	6.04	6.3	5.95	5.61	5.68	4.5	5.81	5.16	5.21	4.98	4.69	4.47
25	EHD	2.4	2.33	2.32	9.92	3.47	3.34	2.98	3.42	2.98	3.08	2.37	2.67	2.05	3.39	2.83	2.7	2.93	2.43	2.9	2.87	2.7	2.69	2.62	3.21
26	OOD	2.68	3.09	2.95	4.26	5.38	5.38	4.4	4.09	4.59	4.61	4.34	4.74	5.63	4.07	4.56	5.12	4.28	4.1	4.44	3.97	4.08	5.21	3.85	3.89
27	IOW	4.66	3.92	3.77	5.7	7.03	6.51	6.23	6.29	5.47	5.54	4.85	4.9	5.89	5.6	5.36	4.88	4.57	4.04	5.17	4.37	4.04	4.52	3.87	4.24
28	ABL	1.52	0.92	1.79	1.97	2.47	1.39	1.41	1.67	4.68	1.9	2.25	1.51	2.87	2.25	1.58	1.84	1.86	1.29	1.56	1.59	1.77	1.6	0.99	1.79
29	PBL	1.2	0.53	0.9	1.33	1.66	1.05	1.32	1.3	1.91	1.09	0.99	1.87	1.62	1.86	1.01	1.06	1.86	0.92	0.98	1.09	1.33	1.05	0.33	1.22
30	DL	5.67	4.79	4.56	6.93	7.62	6.23	5.82	6.09	2.55	5.35	5.69	5.61	6.2	4.49	5.66	5.08	5.08	5.45	5.52	4.63	4.2	5.05	4.01	4.79
31	LT	2.14	1.81	1.84	2.94	3.53	2.8	2.94	3.09	1.7	2.28	2.85	2.52	2.38	2.6	2.76	3.04	3.04	2.36	2.62	2.55	2.34	2.07	2.49	1.92
32	LP	2.47	1.96	1.74	3.6	4.14	3.28	2.97	2.94	4.6	3.81	2.77	2.79	3.03	3.14	2.34	2.55	2.55	3.53	3.49	2.62	2.67	3.02	1.98	2.18
33	LL	1.44	1.22	1.38	2.22	2.35	1.98	1.92	1.65	3.14	1.88	2.16	1.83	1.86	1.67	1.79	1.85	1.85	1.58	1.8	2.09	1.34	1.7	1.53	1.73
34	DW	5.78	5.07	4.34	7.19	7.72	7.1	7.43	4.81	4.6	6.84	5.64	6.05	6.65	4.7	5.44	5.86	5.86	4.95	5.47	4.1	2.82	5.24	4.59	7.94
35	WBAB	3.69	3.23	3.52	4.38	5.17	4.27	4.35	7.58	3.14	3.95	4.04	3.64	4.02	3.22	4.71	4.04	4.04	3.44	3.71	4.95	4.95	4.17	3.17	3.26
36	WM	5.35	4.6	4.44	6.33	8.22	6.8	6.3	7.11	4.46	5.61	5.83	5.49	5.53	4.6	6.45	5.34	5.34	5.62	5.28	3.47	4.52	5.07	4.43	4.05
37	WT	4.56	4.04	3.96	6.88	8.67	7.19	7.31	5.58	4.25	5.45	6.17	5.54	6.7	4.5	5.49	5.28	5.28	5.76	4.79	4.46	3.95	5.46	4.19	4.41
38	WP	3.63	2.87	3.16	5.18	7.37	5.41	4.61	5.09	3.57	4.96	4.33	4.34	5.42	3.7	4.21	3.67	3.67	3.9	3.93	4.31	3.05	3.66	2.92	3.24
39	BW	1.63	1.23	0.98	2.69	5.02	3.53	2.8	3.01	0.58	3.01	2.21	3.1	2.01	0.85	1.72	2.85	2.85	2.53	1.65	1.92	2.44	2.95	0.98	2.01

Table 12. Morphometric measurements of Genus *Garra* at Dobhan

		Sample No.(Dobhan)																	
S.N	Parameters (mm/gm)	GA 168	GA 169	GA 170	GA 171	GA 172	GA 173	GA 174	GA 175	GA 176	GA 177	GA 178	GA 179	GG 180	GG 181	GG 182	GG 183	GG 184	GG185
1	SL	39.61	40.23	38.68	38.04	54.01	55.05	42.41	55.44	48.35	40.92	47.48	38.91	45.4	43.06	40.73	76.37	50.71	45.4
2	BD	7.7	4.38	4.36	6.74	6.35	10.1	8.12	11.42	8.99	7.95	9.18	7.23	8.04	7.24	8.01	14.15	9.14	8.04
3	CPD Min	3.92	4.37	4.81	1.17	6.24	5.45	8.63	5.77	5.81	3.99	4.94	3.84	4.62	4.29	4.49	7.92	5.08	4.62
4	Max. CPD	4.54	5.34	4.63	4.59	23.72	6.71	4.98	6.63	5.5	4.43	5.72	4.01	5.41	5.41	5.66	8.91	5.61	5.41
5	PDL	18.59	17.84	18.09	18.16	27.27	28.2	20.06	25.14	21.66	19.41	22.49	18.42	22.15	20.15	18.55	35.26	22.08	22.15
6	P PelL	20.96	20.1	20.04	19.55	39.88	41.33	23.4	28.04	24.46	22.1	23.97	20.5	23.6	22.28	20.63	40.3	24.88	23.6
7	P.A L	29.9	29.49	28.45	28.12	15.88	18.31	14.39	39.68	35.26	22.18	33.96	29.75	34.04	31.97	29.47	57.13	38.83	34.04
8	Pec pel.L	12.08	11.95	12.06	10.8	12.53	13.13	13.86	16.35	14.52	12.93	14.16	12.34	13.24	12.63	11.82	24.28	14.61	13.24
9	Pel AL	10.26	8.58	9.8	9.23	13.4	13.24	10.93	12.23	11.26	9.5	10.63	8.63	10.92	9.69	9.33	17.01	13.31	10.92
10	VD	2.44	2.6	1.47	1.95	13.71	2.47	1.78	2.59	2.75	2.81	2.68	2.7	2.73	2.73	2.77	3.99	2.97	2.73
11	CPL	6.84	8.56	7.87	8.15	13.02	12.82	7.55	9.92	9.67	8.06	9.22	7.06	7.65	9.62	7.67	14.29	10.79	7.65
12	DFD	9.16	9.68	8.45	9.24	11.9	11.51	10.62	13.97	10.37	10.05	11.24	8.87	11.58	10.34	9.66	18.81	11.68	11.58
13	DFBDFR	7.73	9.2	8.37	8.51	9.71	10.99	9.51	12.94	9.6	9.24	10.64	8.85	10.67	9.44	9.28	17.69	10.61	10.67
14	AFL	7.54	7.74	6.33	7.28	12.81	12.7	8.85	11.88	9.26	8.44	9.53	7.84	9.5	4.53	7.91	14.56	10.22	9.5
15	Pec FL	9.03	9.44	9.21	9.52	9.84	10.66	10.66	12.46	9.37	8.47	9.35	9.5	10.74	10.75	9.97	16.55	11.89	10.74
16	Pel.F L	7.2	7.65	7.28	6.78	2.7	2.59	8.37	11.13	8.34	8.02	9.17	7.01	8.82	8.99	7.62	14.05	9.09	8.82
17	LAS	2.24	1.83	1.69	1.66	3.58	3.56	2.62	2.68	2.68	1.87	2.47	2.12	2.01	2.98	2.39	4.32	2.77	2.01
18	HL	10.26	10.26	10.56	9.89	7.38	8.06	11.24	14.49	11.75	10.55	12.73	10.21	12.42	11.01	10.67	19.27	12.65	12.42
19	HDN	6.49	6.31	5.79	5.88	5.95	6.47	6	8.86	7.57	6.69	7.43	6.31	7.36	6.6	6.49	11.43	7.02	7.36
20	HDE	4.88	4.96	4.57	4.47	7.96	8.66	4.88	7.24	5.69	5.18	6.18	5.01	5.52	5.51	5.28	9.49	5.56	5.52
21	HWPEO	6.83	6.34	5.89	5.82	6.57	8.48	5.81	9.27	8.07	7.8	8.65	7.81	7.79	7.81	7.54	12.37	7.09	7.79
22	HWE	6.78	5.49	5.18	5.51	3.48	4	2.98	9.12	7.91	7.1	8.31	6.61	7.47	7.4	6.97	11.63	6.68	7.47
23	WBN	2.9	2.64	2.2	2.34	6.95	4.6	3.02	4.38	3.55	3.2	3.42	3.1	3.74	3.54	3.3	5.92	2.81	3.74
24	SnL	4.6	4.27	4.66	4.62	2.52	2.98	5.87	7.24	5.85	5.36	6.69	5.33	5.73	5.72	5.24	10.89	6.63	5.73
25	EHD	2.68	2.51	2.89	2.32	4.43	4.73	2.55	3.1	3.02	2.77	3.36	2.38	2.7	3.18	2.82	4.11	2.69	2.7
26	OOD	4.08	3.31	4.01	4.08	4.75	5.86	3.57	5.47	4.2	4.67	4.38	4.03	4.68	3.65	3.95	5.44	3.71	4.68
27	IOW	4.38	4.68	4.13	4.17	5.43	5.58	4.56	6.3	5.72	4.8	5.46	4.3	5.07	5.34	5.31	7.42	4.47	5.07
28	ABL	1.57	1.62	1.14	2.21	1.23	1.66	2.11	2.36	1.87	1.56	1.94	1.84	1.99	1.61	1.61	3.98	1.32	1.99
29	PBL	1.33	0.68	0.85	0.91	1.39	0.82	0.87	1.76	1.22	1.66	1.79	0.78	1.26	0.73	1.26	2.21	0.86	1.26
30	DL	4.82	4.65	4.96	4.9	5.72	5.98	5.58	7.4	5.67	5.32	5.68	5.79	4.31	5.72	4.69	10.94	5.26	4.31
31	LT	3.77	3.21	2.15	2.18	2.95	3.13	3.35	2.7	2.23	2.26	2.75	2.64	1.73	2.64	2.03	5.05	2.51	1.73
32	LP	2.91	2.64	3.17	2.89	3.06	2.41	3.11	3.31	3.29	2.81	2.98	2.9	2.23	3.27	2.41	5.74	3.26	2.23
33	LL	1.75	1.61	1.69	1.62	1.44	0.99	1.56	2.02	1.92	1.89	1.78	1.72	1.61	1.93	4.73	2.98	1.92	1.61
34	DW	5.49	5.24	4.61	3.63	5.09	6.89	5.52	7.52	6.76	5.08	7.57	6.15	5.35	5.69	5.53	10.02	5.05	5.35
35	WBAB	4	4.26	3.39	4.48	4.47	4.47	3.23	4.67	3.84	3.58	4.02	4.39	3.46	3.6	3.15	7.36	4.34	3.46
36	WM	4.87	4.4	4.39	4.12	5.85	6.87	4.35	6.89	5.77	5.18	6.14	6.72	4.9	6.27	5.34	10.06	6.25	4.9
37	WT	5.34	5.32	3.95	3.91	5.17	5.68	4.69	6.97	5.56	5.75	6.12	5.52	5.19	5.8	5.67	8.01	5.21	5.19
38	WP	3.95	3.72	3.75	3.81	3.79	5.24	2.95	5.8	4.72	3.89	4.86	5.1	3.98	4.23	4.13	6.21	4.16	3.98
39	BW	1.45	1.49	1.38	1.23	4.01	4.08	2.54	4.15	2.65	1.82	2.53	3.25	1.25	3.28	1.69	6.93	2.95	1.25

Table 13. Morphometric measurements of Genus *Garra* at CDZ deposited

	Parameters(mm/gm)	Sample No.(CZD deposited)							
		GA1	GG2	GA3	GA4	GA5	GA6	GG7	GG8
1	SL	114.45	94.95	66.44	84.37	53.21	80.97	86.18	116.28
2	BD	21.99	16.78	13.41	24.39	11.18	20.11	18.76	17.41
3	CPD Min	14.88	13.41	7.86	7.89	4.41	9.02	9.67	13.16
4	Max CPD	16.04	15.25	8.68	8.44	6.72	10.82	12.05	15.67
5	PDL	58.91	51.05	31.07	32.21	23.53	44.17	46.61	55.88
6	P Pel.L	71.82	59.66	32.11	33.56	26.09	43.21	61.7	60.72
7	PAL	108.97	69.21	47.35	49.77	38.71	64.23	66.11	75.51
8	Pec pel L	47.61	20.58	18.39	19.25	16.61	28.17	44.72	35.01
9	Pel AL	35.85	14.81	15.71	18.07	12.58	27.12	31.71	31.57
10	VD	13.09	10.95	5.44	5.53	5.23	10.87	17.88	18.09
11	CPL	29.17	28.16	15.46	15.72	12.86	21.39	17.68	27.61
12	DFD	37.01	25.53	17.43	18.49	12.38	30.68	19.16	27.37
13	DFBDFR	35.58	24.36	15.58	14.87	11.33	29.24	18.03	25.72
14	AFL	26.44	21.42	12.42	12.16	9.48	18.57	17.66	24.69
15	Pec FL	29.92	23.71	14.51	14.95	11.62	22.32	19.83	25.39
16	Pel FL	26.97	19.48	13.32	12.64	9.21	19.81	17.11	22.69
17	LAS	4.75	4.68	2.68	1.74	2.82	3.61	3.98	3.91
18	HL	29.34	27.03	15.33	16.43	13.84	24.07	21.91	28.66
19	HDN	19.46	15.03	9.84	10.67	8.12	14.96	12.71	17.37
20	HDE	14.85	13.65	7.78	8.18	5.35	12.11	10.81	14.43
21	HWPEO	18.33	16.04	10.23	11.51	8.8	13.65	14.85	16.19
22	HWE	17.31	14.71	9.12	10.18	6.97	12.31	14.71	14.47
23	WBN	8.72	7.36	9.15	7.97	3.38	5.65	7.87	6.16
24	SnL	14.11	16.51	8.32	8.21	6.61	11.58	12.64	11.62
25	EHD	5.71	5.01	3.68	3.33	3.18	5.19	3.92	5.41
26	OOD	8.42	7.36	6.01	6.31	4.45	6.82	7.56	11.33
27	IOW	13.21	10.35	7.05	6.49	4.74	10.12	9.55	9.07
28	ABL	2.77	3.73	2.32	2.99	2.05	1.61	0.79	2.55
29	PBL	1.77	0.97	0.96	1.58	1.22	1.08	0.56	1.63
30	DL	14.17	10.78	9.25	7.33	5.14	10.19	9.11	14.67
31	LT	3.59	5.29	4.08	3.06	2.41	3.39	4.46	3.55
32	L P	5.82	4.53	3.46	3.52	2.99	4.73	6.37	8.08
33	LL	3.95	3.21	2.43	1.91	1.71	2.92	3.82	2.94
34	DW	13.84	12.51	7.79	10.13	4.66	12.08	11.71	12.45
35	WBAB	9.21	9.52	5.59	6.14	5.24	8.65	8.17	7.38
36	WM	12.27	10.82	6.87	7.16	5.71	10.81	12.08	11.08
37	WT	14.33	10.47	7.31	8.89	5.69	7.72	11.16	11.87
38	WP	6.11	10.06	6.03	6.19	4.71	6.14	11.07	10.52
39	BW	9.05	7.89	5.59	6.94	4.09	7.05	8.98	9.15

Table 14. Site wise Fishes abundance in different sites

S.N	Species	Local Name	Charchare	Chidiya khola	Butwal	jhumsa	Dobhaan	Total
1	*Garra annandalei*	Chuche buduna	_	17	40	14	12	83
2	*Garra gotyla*	Buduna	5	23	41	27	22	118

Table 15. Physicochemical characteristics of sites

Site	subsite	MVPH	PH	oxidation reduction potential (MVORP)	Dissolved oxygen (%)	Dissolved oxygen (mg/l)	Electric conductivity(µS/c m)	absolute conductivity(µs/c mA)	Resistivity (kΩ/cm)	Total dissolved solids (mg/L)	Salinity(psu)	Temperature(° C)	ATM.Pressure(psi)
Charchare	1 pool area	75.6	6.62	-4.9	59.4	5.18	310	273	3.2	155	0.15	18.71	13.73
	2 Riffal	84.7	6.51	1.4	66.5	5.75	307	273	3.2	154	0.15	19.03	13.73
	3 slope	79	6.61	19.4	70.3	6.02	309	276	3.2	154	0.15	19.46	13.73
Jhumsa	1 pool area	103	6.24	49	74.5	6.44	281	256	3.6	140	0.13	20.27	14.13
	2 Riffal	97.9	6.28	22.4	80.6	6.97	165	122	18.5	89	0.01	20.52	14.12
	3 slope	93.8	6.37	-2.2	73.5	6.38	280	255	3.6	139	0.13	20.31	14.14
Dobhan	1 pool area	109.1	6.08	45.5	67.9	5.81	260	241	3.9	129	0.12	21.24	14.22
	2 Riffal	18.3	5.93	42.2	78	5.71	2.04	189	4.9	102	0.11	21.02	14.21
	3 slope	115.9	5.98	43.31	77.7	6.7	283	261	3.5	141	0.13	20.99	14.21
Chidiya khola	1 pool area	116.8	5.96	6.9	78.1	6.69	285	267	3.5	143	0.14	21.51	14.32
	2 Riffal	132.4	5.69	71.8	80.3	6.74	140	132	17	74	0.11	21.52	14.32
	3 slope	123	5.8	103	78.7	6.77	285	267	3.5	143	0.14	21.51	14.32

			6										
Butwal	1 pool area	132.9	5.71	98.3	75.9	6.46	284	265	3.5	142	0.13	21.54	14.33
	2 Riffal	137.1	5.6	87.1	79.9	6.75	284	265	3.5	142	0.14	21.41	14.33
	3 slope	132.9	5.68	84.6	76.8	6.61	285	265	3.5	142	0.14	21.42	14.33

Table 16. Average Physicochemical characteristics of sites

sites	Milivolt (MV)PH	PH	A.oxidation reduction potential(MVORP)	A.Dissolved oxygen (%)	A.Dissolved oxygen (mg/l)	A.Electric conductivity(µS/cm)	A.absolute conductivity(µs/cmA)	A.Resistivity (kΩ/cm)	A.Total dissolved solids (mg/L)	A.Salinity(psu)	A.Temperature(° C)	A.ATM.Pressure(psi)
Charcahre	79.77	6.58	2.97	65.4	5.65	308.67	274	3.2	154.33	0.15	19.07	13.73
Jhumsa	98.23	6.29	23.07	76.2	6.59	242	211	8.57	122.67	0.09	20.37	14.13
Dobhan	166.03	5.99	43.67	74.53	6.07	249	230.33	4.1	124	0.12	21.08	14.21
Chidiya khola	124.07	5.84	60.57	79.03	4.73	236.67	222	8	120	0.13	21.51	14.32
Butwal	134.3	5.66	90	77.53	6.61	284.33	265	3.5	142	0.14	21.46	14.33

Table 17. Result of paired sample T-test of *Garra* newly collected and older samples

T-Test

[DataSet3]

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Mean of new sample	8.66726	39	8.930576	1.430037
	Mean of old sample	16.94613	39	17.374400	2.782131

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Mean of new sample & Mean of old sample	39	.997	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Mean of new sample - Mean of old sample	-8.278872	8.507553	1.362299	-11.036702	-5.521042	-6.077	38	.000

Table 18. Mean of old and new samples of morphometric parameters

S.N	Parameters	Mean of new sample	Mean of old sample
1	SL	46.31	87.11
2	BD	8.82	18.003
3	Min. CPD	4.86	10.04
4	Max. CPD	5.75	11.71
5	PDL	21.46	42.92
6	P PelL	24.18	48.61
7	P.A L	33.77	64.98
8	Pec pel.L	13.94	28.79
9	Pel AL	11.003	23.42
10	VD	4.08	10.88
11	CPL	8.95	21.006
12	DFD	10.77	23.51
13	DFBDFR	9.9	21.83
14	AFL	8.93	17.65
15	Pec FL	10.26	20.28
16	Pel.F L	8.45	17.65
17	LAS	2.37	3.52
18	HL	11.68	22.08
19	HDN	7.02	13.52
20	HDE	5.77	10.89
21	HWPEO	7.39	13.7
22	HWE	6.85	12.47
23	WBN	3.54	7.03
24	SL	5.68	11.2
25	EHD	2.89	4.43
26	OOD	4.21	7.28
27	IOW	5.03	8.82
28	ABL	1.85	2.35
29	PBL	1.34	1.22
30	DL	5.37	10.11
31	LT	2.62	3.73
32	LP	3.09	4.94
33	LL	2.11	2.86
34	DW	5.92	10.65
35	WBAB	4.09	7.49
36	WM	5.58	9.6
37	WT	5.28	9.68
38	WP	4.25	7.6
39	BW	2.66	7.34

Table 19. Length weight calculation of *Garra anandalei*

S.N	**Coding**	**S.L(mm)**	**B. W(gm)**	log of S.L(x)	log of B.W(y)	xy	x^2	y^2
1	**GA 29**	36.59	5.14	1.56336241	0.710963119	1.111493	2.444102	0.505469
2	**GA 30**	55.72	5.87	1.74601111	0.768638101	1.342051	3.048555	0.590805
3	**GA 31**	42.4	2.22	1.62736586	0.346352974	0.563643	2.64832	0.11996
4	**GA 32**	53.47	4.27	1.72811018	0.630427875	1.089449	2.986365	0.397439
5	**GA 33**	51.66	4.14	1.7131544	0.617000341	1.057017	2.934898	0.380689
6	**GA 34**	45.91	2.86	1.66190729	0.456366033	0.758438	2.761936	0.20827
7	**GA 35**	42.17	2.21	1.6250036	0.344392274	0.559639	2.640637	0.118606
8	**GA 36**	38.49	1.15	1.58534791	0.06069784	0.096227	2.513328	0.003684
9	**GA 37**	37.17	1.02	1.57019256	0.008600172	0.013504	2.465505	7.4E-05
10	**GA 38**	37.75	1.04	1.57691696	0.017033339	0.02686	2.486667	0.00029
11	**GA 39**	43.6	3.2	1.63948649	0.505149978	0.828187	2.687916	0.255177
12	**GA 40**	35.2	0.87	1.54654266	-0.060480747	-0.09354	2.391794	0.003658
13	**GA 41**	53.21	4.16	1.72599326	0.619093331	1.068551	2.979053	0.383277
14	**GA 42**	52.55	4.11	1.72057272	0.613841822	1.056159	2.96037	0.376802
15	**GA 43**	44.32	2.61	1.64659975	0.416640507	0.68604	2.711291	0.173589
16	**GA 44**	44.28	2.51	1.64620761	0.399673721	0.657946	2.71	0.159739
17	**GA 45**	42.8	2.21	1.63144377	0.344392274	0.561857	2.661609	0.118606
18	**GA 46**	61.97	5.5	1.7921815	0.740362689	1.326864	3.211915	0.548137
19	**GA 47**	44.98	2.98	1.65301945	0.474216264	0.783889	2.732473	0.224881
20	**GA 48**	59.89	4.89	1.77735431	0.689308859	1.225146	3.158988	0.475147
21	**GA 49**	51.05	2.99	1.70799575	0.475671188	0.812444	2.917249	0.226263
22	**GA 50**	42.28	2.1	1.62613498	0.322219295	0.523972	2.644315	0.103825
23	**GA 51**	44.70	2.83	1.65030752	0.451786436	0.745587	2.723515	0.204111
24	**GA 52**	41.51	2.21	1.61815273	0.344392274	0.557279	2.618418	0.118606
25	**GA 53**	42.84	2.75	1.63184946	0.439332694	0.716925	2.662933	0.193013
26	**GA 54**	46.64	3.11	1.66875854	0.492760389	0.822298	2.784755	0.242813
27	**GA 55**	45.28	2.91	1.65590642	0.463892989	0.768163	2.742026	0.215197
28	**GA 56**	44.89	2.98	1.65214961	0.474216264	0.783476	2.729598	0.224881
29	**GA 57**	43.54	3.01	1.63888842	0.478566496	0.784317	2.685955	0.229026
30	**GA 58**	37.51	1.11	1.57414706	0.045322979	0.071345	2.477939	0.002054
31	**GA 59**	39.4	1.23	1.59549622	0.089905111	0.143443	2.545608	0.008083
32	**GA 60**	40.28	1.59	1.60508946	0.201397124	0.32326	2.576312	0.040561
33	**GA 61**	38.97	1.52	1.59073041	0.181843588	0.289264	2.530423	0.033067
34	**GA 62**	36.52	1.01	1.56253077	0.004321374	0.006752	2.441502	1.87E-05
35	**GA 63**	37.63	0.59	1.57553422	-0.229147988	-0.36103	2.482308	0.052509
36	**GA 64**	38.44	1.15	1.58478338	0.06069784	0.096193	2.511538	0.003684
37	**GA 65**	44.55	2.85	1.64884771	0.45484486	0.74997	2.718699	0.206884
38	**GA 66**	59.69	4.65	1.77590158	0.667452953	1.185331	3.153826	0.445493
39	**GA 67**	56.81	4.35	1.75442479	0.638489257	1.120181	3.078006	0.407669
40	**GA 68**		2.32	1.67651071	0.365487985	0.612745	2.810688	0.133581

		47.48						
41	**GA 69**	39.53	1.45	1.59692681	0.161368002	0.257693	2.550175	0.02604
42	**GA 70**	61.81	5.12	1.79105874	0.709269961	1.270344	3.207891	0.503064
43	**GA 71**	51.95	2.81	1.71558555	0.44870632	0.769794	2.943234	0.201337
44	**GA 72**	49.76	2.45	1.69688037	0.389166084	0.660368	2.879403	0.15145
45	**GA 73**	43.15	2.35	1.6349808	0.371067862	0.606689	2.673162	0.137691
46	**GA 74**	42.24	2.15	1.62572391	0.33243846	0.540453	2.642978	0.110515
47	**GA 75**	35.39	0.68	1.54888056	-0.167491087	-0.25942	2.399031	0.028053
48	**GA 76**	43.12	2.24	1.63467875	0.350248018	0.572543	2.672175	0.122674
49	**GA 77**	37.97	1.15	1.5794406	0.06069784	0.095869	2.494633	0.003684
50	**GA 78**	42.68	2.13	1.63022441	0.328379603	0.535332	2.657632	0.107833
51	**GA79**	37.03	2.01	1.56855371	0.303196057	0.475579	2.460361	0.091928
52	**GA 80**	36.55	1.01	1.56288738	0.004321374	0.006754	2.442617	1.87E-05
53	**GA 81**	37.12	2.04	1.56960797	0.309630167	0.485998	2.463669	0.095871
54	**GA 82**	37.76	2.15	1.57703199	0.33243846	0.524266	2.48703	0.110515
55	**GA 83**	35.84	0.95	1.554368	-0.022276395	-0.03463	2.41606	0.000496
56	**GA 84**	33.03	0.54	1.51890857	-0.26760624	-0.40647	2.307083	0.071613
57	**GA 85**	36.31	1.02	1.56002625	0.008600172	0.013416	2.433682	7.4E-05
58	**GA 154**	46.75	2.21	1.66978162	0.344392274	0.57506	2.788171	0.118606
59	**GA 155**	48.74	3.1	1.68788552	0.491361694	0.829362	2.848958	0.241436
60	**GA 156**	42.22	2.01	1.62551823	0.303196057	0.492851	2.64231	0.091928
61	**GA 157**	50.52	0.85	1.70346334	-0.070581074	-0.12023	2.901787	0.004982
62	**GA 158**	47.99	1.72	1.68115075	0.235528447	0.395959	2.826268	0.055474
63	**GA 159**	44.07	2.85	1.64414305	0.45484486	0.74783	2.703206	0.206884
64	**GA 160**	42.67	2.85	1.63012264	0.45484486	0.741453	2.6573	0.206884
65	**GA 161**	38.51	2.53	1.58557352	0.403120521	0.639177	2.514043	0.162506
66	**GA 162**	44.37	1.65	1.64708943	0.217483944	0.358216	2.712904	0.047299
67	**GA 163**	39.57	1.92	1.59736605	0.283301229	0.452536	2.551578	0.08026
68	**GA 164**	42.35	2.44	1.62685341	0.387389826	0.630226	2.646652	0.150071
69	**GA 165**	44.56	2.95	1.64894518	0.469822016	0.774711	2.71902	0.220733
70	**GA 166**	36.81	0.98	1.56596582	-0.008773924	-0.01374	2.452249	7.7E-05
71	**GA 167**	41.39	2.01	1.61689543	0.303196057	0.490236	2.614351	0.091928
72	**GA 168**	39.61	1.45	1.59780484	0.161368002	0.257835	2.55298	0.02604
73	**GA 169**	40.23	1.49	1.60455003	0.173186268	0.277886	2.574581	0.029993
74	**GA 170**	38.68	1.38	1.58748647	0.139879086	0.222056	2.520113	0.019566
75	**GA 171**	38.04	1.23	1.58024051	0.089905111	0.142072	2.49716	0.008083
76	**GA 172**	54.01	4.01	1.73247418	0.603144373	1.044932	3.001467	0.363783
77	**GA 173**	55.05	4.08	1.74075732	0.610660163	1.063011	3.030236	0.372906
78	**GA 174**	42.41	2.54	1.62746827	0.404833717	0.658854	2.648653	0.16389
79	**GA 175**	55.44	4.15	1.74382322	0.618048097	1.077767	3.040919	0.381983
80	**GA 176**	48.35	2.65	1.68439648	0.423245874	0.712914	2.837191	0.179137
81	**GA 177**	40.92	1.82	1.61193563	0.260071388	0.419218	2.598336	0.067637
82	**GA 178**	47.48	2.53	1.67651071	0.403120521	0.675836	2.810688	0.162506

83	**GA 179**	38.91	3.25	1.59006123	0.511883361	0.813926	2.528295	0.262025
84	**GA1**	114.45	9.05	2.0586158	0.956648579	1.969372	4.237899	0.915177
85	**GA3**	66.44	5.59	1.82242962	0.747411808	1.362105	3.32125	0.558624
86	**GA4**	84.37	6.94	1.92618805	0.84135947	1.620617	3.7102	0.707886
87	**GA5**	53.21	4.09	1.72599326	0.611723308	1.05583	2.979053	0.374205
88	**GA6**	80.97	7.05	1.90832414	0.848189117	1.61862	3.641701	0.719425
		4054.47	235.84	145.486492	31.45208357	4575.853	21166.32	989.2336

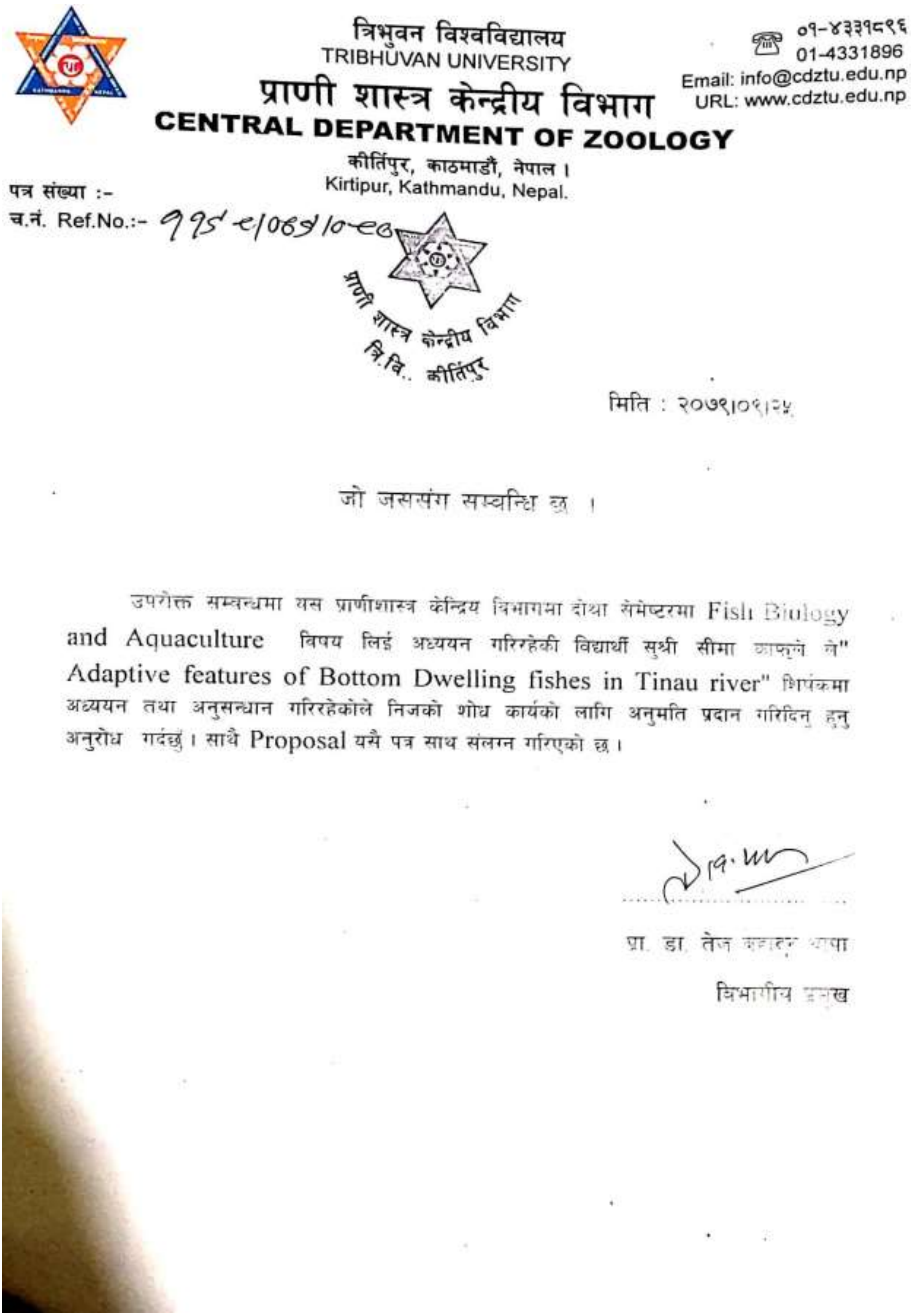
Table 20. Length weight calculation of *Garra gotyla*

S.N	**Coding**	**S.L(mm)**	**B. W(gm)**	log of S.L(x)	log of B.W(y)	xy	x^2	y^2
1	**GG1**	53.36	3.62	1.727216	0.558709	0.96501	2.983274	0.312155
2	**GG2**	49.96	2.67	1.698622	0.426511	0.724482	2.885318	0.181912
3	**GG3**	43.87	2.55	1.642168	0.40654	0.667607	2.696715	0.165275
4	**GG4**	48.95	2.57	1.689753	0.409933	0.692686	2.855264	0.168045
5	**GG 5**	40.6	1.59	1.608526	0.201397	0.323953	2.587356	0.040561
6	**GG 6**	56.35	4.59	1.750894	0.661813	1.158764	3.06563	0.437996
7	**GG 7**	54.59	4.28	1.737113	0.631444	1.096889	3.017562	0.398721
8	**GG 8**	62.38	5.02	1.795045	0.700704	1.257795	3.222188	0.490986
9	**GG 9**	51.71	3.51	1.713575	0.545307	0.934424	2.936338	0.29736
10	**GG 10**	50.44	2.78	1.702775	0.444045	0.756108	2.899443	0.197176
11	**GG 11**	47.78	2.51	1.679246	0.399674	0.671151	2.819868	0.159739
12	**GG12**	48.4	2.62	1.684845	0.418301	0.704773	2.838704	0.174976
13	**GG13**	48.45	2.73	1.685294	0.436163	0.735062	2.840215	0.190238
14	**GG14**	60.05	5.48	1.778513	0.738781	1.313931	3.163109	0.545797
15	**GG 15**	64.78	6.04	1.811441	0.781037	1.414802	3.281318	0.610019
16	**GG 16**	60.22	5.63	1.779741	0.750508	1.33571	3.167477	0.563263
17	**GG17**	67.04	6.54	1.826334	0.815578	1.489517	3.335496	0.665167
18	**GG18**	55.34	4.35	1.743039	0.638489	1.112912	3.038185	0.407669
19	**GG 19**	40.82	1.85	1.610873	0.267172	0.43038	2.594912	0.071381
20	**GG 20**	41.73	2.02	1.620448	0.305351	0.494806	2.625853	0.093239
21	**GG 21**	46.31	3.12	1.665675	0.494155	0.823101	2.774472	0.244189
22	**GG 22**	39.99	1.62	1.601951	0.209515	0.335633	2.566248	0.043897
23	**GG 23**	40.62	1.53	1.60874	0.184691	0.29712	2.588044	0.034111
24	**GG 24**	55.18	3.75	1.741782	0.574031	0.999837	3.033803	0.329512
25	**GG 25**	47.13	2.71	1.673297	0.432969	0.724486	2.799924	0.187462
26	**GG 26**	46.65	3.03	1.668852	0.481443	0.803456	2.785066	0.231787
27	**GG 27**	41.77	2.11	1.620864	0.324282	0.525618	2.627202	0.105159
28	**GG 28**	48.96	2.85	1.689841	0.454845	0.768616	2.855564	0.206884
29	**GG 86**	36.73	1.08	1.565021	0.033424	0.052309	2.449291	0.001117
30	**GG 87**	38.83	1.09	1.589167	0.037426	0.059477	2.525453	0.001401

31	**GG 88**	38.09	1.03	1.580811	0.012837	0.020293	2.498963	0.000165
32	**GG 89**	36.21	0.98	1.558829	-0.00877	-0.01368	2.429946	7.7E-05
33	**GG 90**	38.12	1.05	1.581153	0.021189	0.033504	2.500044	0.000449
34	**GG 91**	37.71	1.03	1.576457	0.012837	0.020237	2.485215	0.000165
35	**GG 92**	39.41	1.21	1.595606	0.082785	0.132093	2.54596	0.006853
36	**GG 93**	46.13	3.11	1.663983	0.49276	0.819945	2.768841	0.242813
37	**GG 94**	44.65	2.99	1.649821	0.475671	0.784773	2.721911	0.226263
38	**GG 95**	48.46	2.62	1.685383	0.418301	0.704998	2.840517	0.174976
39	**GG 96**	50.08	3.75	1.699664	0.574031	0.97566	2.888859	0.329512
40	**GG 97**	47.51	2.51	1.676785	0.399674	0.670167	2.811608	0.159739
41	**GG 98**	57.61	3.78	1.760498	0.577492	1.016673	3.099353	0.333497
42	**GG 99**	48.27	2.79	1.683677	0.445604	0.750254	2.834769	0.198563
43	**GG 100**	82.02	7.01	1.91392	0.845718	1.618636	3.663089	0.715239
44	**GG 101**	65.23	5.98	1.814447	0.776701	1.409283	3.292219	0.603265
45	**GG 102**	54.54	4.18	1.736715	0.621176	1.078806	3.016179	0.38586
46	**GG 103**	52.49	3.11	1.720077	0.49276	0.847586	2.958663	0.242813
47	**GG 104**	44.59	2.71	1.649237	0.432969	0.714069	2.719984	0.187462
48	**GG105**	48.83	2.83	1.688687	0.451786	0.762926	2.851663	0.204111
49	**GG 106**	42.77	2.75	1.631139	0.439333	0.716613	2.660615	0.193013
50	**GG 107**	43.07	2.91	1.634175	0.463893	0.758082	2.670528	0.215197
51	**GG 108**	42.13	1.99	1.624591	0.298853	0.485514	2.639297	0.089313
52	**GG 109**	46.78	3.25	1.67006	0.511883	0.854876	2.789101	0.262025
53	**GG 110**	41.21	2.11	1.615003	0.324282	0.523717	2.608233	0.105159
54	**GG 111**	38.81	1.22	1.588944	0.08636	0.137221	2.524742	0.007458
55	**GG 112**	42.48	2.68	1.628185	0.428135	0.697082	2.650985	0.183299
56	**GG113**	39.74	1.45	1.599228	0.161368	0.258064	2.55753	0.02604
57	**GG 114**	42.28	2.48	1.626135	0.394452	0.641432	2.644315	0.155592
58	**GG115**	38.85	1.23	1.589391	0.089905	0.142894	2.526164	0.008083
59	**GG 116**	43.77	3.05	1.641177	0.4843	0.794822	2.69346	0.234546
60	**GG 117**	37.33	1.01	1.572058	0.004321	0.006793	2.471366	1.87E-05
61	**GG 118**	37.11	1.02	1.569491	0.0086	0.013498	2.463302	7.4E-05
62	**GG 119**	39.43	1.39	1.595827	0.143015	0.228227	2.546663	0.020453
63	**GG 120**	33.83	0.43	1.529302	-0.36653	-0.56054	2.338765	0.134345
64	**GG 121**	37.25	0.43	1.571126	-0.36653	-0.57587	2.468438	0.134345
65	**GG 122**	33.52	0.58	1.525304	-0.23657	-0.36084	2.326552	0.055966
66	**GG 123**	34.51	0.34	1.537945	-0.46852	-0.72056	2.365275	0.219512
67	**GG 124**	31.52	0.19	1.498586	-0.72125	-1.08085	2.245761	0.520196
68	**GG 125**	34.54	0.35	1.538322	-0.45593	-0.70137	2.366436	0.207874
69	**GG 126**	33.37	0.27	1.523356	-0.56864	-0.86624	2.320614	0.323347
70	**GG 127**	65.04	5.59	1.813181	0.747412	1.355193	3.287624	0.558624
71	**GG 128**	60.44	5.09	1.781324	0.706718	1.258894	3.173117	0.49945
72	**GG129**	67.99	6.01	1.832445	0.778874	1.427245	3.357855	0.606645
73	**GG130**	68.57	6.1	1.836134	0.78533	1.441971	3.371389	0.616743

74	**GG131**	48.23	2.98	1.683317	0.474216	0.798256	2.833557	0.224881
75	**GG 132**	44.94	2.99	1.652633	0.475671	0.78611	2.731196	0.226263
76	**GG133**	37.61	0.85	1.575303	-0.07058	-0.11119	2.481581	0.004982
77	**GG 134**	44.94	2.99	1.652633	0.475671	0.78611	2.731196	0.226263
78	**GG 135**	37.61	0.85	1.575303	-0.07058	-0.11119	2.481581	0.004982
79	**GG 136**	46.03	2.15	1.663041	0.332438	0.552859	2.765705	0.110515
80	**GG 137**	47.41	2.38	1.67587	0.376577	0.631094	2.80854	0.14181
81	**GG138**	40.88	1.68	1.611511	0.225309	0.363088	2.596967	0.050764
82	**GG 139**	39.73	2.02	1.599119	0.305351	0.488293	2.55718	0.093239
83	**GG 140**	42.33	2.4	1.626648	0.380211	0.61847	2.645985	0.144561
84	**GG 141**	39.44	1.88	1.595937	0.274158	0.437539	2.547015	0.075163
85	**GG 142**	92.42	8.52	1.965766	0.93044	1.829026	3.864236	0.865718
86	**GG143**	83.35	7.82	1.920906	0.893207	1.715766	3.689878	0.797818
87	**GG 144**	40.25	1.63	1.604766	0.212188	0.340511	2.575274	0.045024
88	**GG 145**	38.73	1.23	1.588047	0.089905	0.142774	2.521895	0.008083
89	**GG 146**	36.23	0.98	1.559068	-0.00877	-0.01368	2.430694	7.7E-05
90	**GG 147**	49.99	2.69	1.698883	0.429752	0.730099	2.886204	0.184687
91	**GG 148**	58.6	5.02	1.767898	0.700704	1.238772	3.125462	0.490986
92	**GG 149**	53.48	3.53	1.728191	0.547775	0.94666	2.986646	0.300057
93	**GG 150**	48.53	2.8	1.68601	0.447158	0.753913	2.842631	0.19995
94	**GG 151**	52.31	3.01	1.718585	0.478566	0.822457	2.953533	0.229026
95	**GG 152**	44.98	0.58	1.653019	-0.23657	-0.39106	2.732473	0.055966
96	**GG 153**	45.32	3.01	1.65629	0.478566	0.792645	2.743296	0.229026
97	**GG 180**	45.4	1.25	1.657056	0.09691	0.160585	2.745834	0.009392
98	**GG 181**	43.06	3.28	1.634074	0.515874	0.842976	2.670198	0.266126
99	**GG 182**	40.73	1.69	1.609914	0.227887	0.366878	2.591824	0.051932
100	**GG 183**	76.37	6.93	1.882923	0.840733	1.583036	3.545398	0.706832
101	**GG 184**	50.71	2.95	1.705094	0.469822	0.801091	2.907344	0.220733
102	**GG185**	45.4	1.25	1.657056	0.09691	0.160585	2.745834	0.009392
103	**GG186**	43.06	3.28	1.634074	0.515874	0.842976	2.670198	0.266126
104	**GG187**	40.73	1.69	1.609914	0.227887	0.366878	2.591824	0.051932
105	**GG188**	76.37	6.93	1.882923	0.840733	1.583036	3.545398	0.706832
106	**GG189**	50.71	2.95	1.705094	0.469822	0.801091	2.907344	0.220733
107	**GG 190**	59.61	4.67	1.775319	0.669317	1.188251	3.151758	0.447985
108	**GG191**	53.71	3.84	1.730055	0.584331	1.010925	2.993091	0.341443
109	**GG192**	52.05	2.97	1.716421	0.472756	0.811449	2.9461	0.223499
110	**GG193**	50.25	2.53	1.701136	0.403121	0.685763	2.893864	0.162506
111	**GG194**	39.55	1.25	1.597146	0.09691	0.154779	2.550877	0.009392
112	**GG195**	42.99	2.89	1.633367	0.460898	0.752816	2.667889	0.212427
113	**GG196**	38.51	1.11	1.585574	0.045323	0.071863	2.514043	0.002054
114	**GG197**	77.81	6.98	1.891035	0.843855	1.59576	3.576015	0.712092
115	**GG198**	48.81	2.85	1.688509	0.454845	0.76801	2.851062	0.206884
116	**GG199**	42.69	2.75	1.630326	0.439333	0.716256	2.657963	0.193013
117	**GG200**	37.89	1.11	1.578525	0.045323	0.071543	2.49174	0.002054
118	**GG201**	37.79	0.99	1.577377	-0.00436	-0.00688	2.488118	1.91E-05

119	**GG2**	94.95	7.89	1.977495	0.897077	1.773965	3.910486	0.804747
120	**GG7**	86.18	8.98	1.935406	0.953276	1.844977	3.745798	0.908736
121	**GG8**	116.28	9.15	2.065505	0.961421	1.98582	4.266311	0.924331
		5950.23	358.58	203.0389	44.33005	9000.725	41224.79	1965.153



त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
Kirtipur, Kathmandu, Nepal.

०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:- ११५ ८/०७९/०८०

प्राणी शास्त्र केन्द्रीय विभाग त्रि.वि. कीर्तिपुर

मिति : २०७९।०९।२५

जो जससंग सम्बन्धित छ ।

उपरोक्त सम्बन्धमा यस प्राणीशास्त्र केन्द्रिय विभागमा चौथा सेमेष्टरमा Fish Biology and Aquaculture विषय लिई अध्ययन गरिरहेकी विद्यार्थी सुश्री सीमा काफ्ले ले" Adaptive features of Bottom Dwelling fishes in Tinau river" शिर्षकमा अध्ययन तथा अनुसन्धान गरिरहेकोले निजको शोध कार्यको लागि अनुमति प्रदान गरिदिनु हुन अनुरोध गर्दछु । साथै Proposal यसै पत्र साथ संलग्न गरिएको छ ।

प्रा. डा. तेज बहादुर थापा
विभागीय प्रमुख

Photograph 3. University Approval Letter

नेपाल सरकार

वन तथा वातावरण मन्त्रालय

वन तथा भू-संरक्षण विभाग

फोन नं. ४-२२७५७४, ४-२२०३०३

फ्याक्स: ४-२२७३७४

(कृपया पत्रोत्तरमा प्राप्त पत्र संख्या र मिति उल्लेख गर्नुहोला।

बबरमहल, काठमाडौं, नेपाल

प्राप्त पत्र संख्या र मिति:-

पत्र संख्या:- 080/81

च. नं.:- 63

मिति : २०८०/०४/१५

विषयः अनुसन्धान अनुमति सम्बन्धमा ।

श्री सीमा काफ्ले,

बुटवल, नेपाल ।

प्रस्तुत विषयमा Central Department of Zoology ,Tribhuvan University, Kirtipur Kathmandu मा M.sc. 3rd Semester मा अध्ययनरत तपाईले "Adaptive features of Bottom Dwelling fishes in Tinau River, Nepal" को विषयमा अध्ययन अनुसन्धानका लागि अध्ययन अनुमति उपलब्ध गराइदिनु हुन भनि मिति २०७९/०९/२८ गते यस विभागमा दिनु भएको निवेदन साथ प्रपोजल प्राप्त भयो । सो सम्बन्धमा कारवाही हुँदा उक्त प्रपोजलमा उल्लेखित Methodology (Cast net,local fishing gears) अनुसार तपसिलको शर्तहरुको अधिनमा रही डिभिजन वन कार्यालयसँग समन्वय गरि सन् २०२३, अगष्ट देखि सन् २०२४, अगष्ट सम्मका लागि अनुसन्धान गर्नु हुन निर्देशानुसार अनुरोध छ ।

शर्तहरु

१. अनुसन्धानकर्ताले वन ऐन २०७६ तथा वन नियमावली २०७९, राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली २०३० तथा यस मातहतका नियमावलीहरुको पूर्ण पालना गर्नुपर्नेछ ।

२. अनुसन्धान कार्य डिभिजन वन कार्यालयसँगको समन्वयमा गर्नुपर्नेछ ।

३. संकलित नमुनाहरुको परिक्षण कार्य Central Department of Zoology, किर्तिपुर, काठमाशण्डौको प्रयोगशालामा गर्नुपर्नेछ ।

४. अनुसन्धानको क्रममा प्राप्त भएको जैविक विविधता संरक्षणसँग सम्बन्धित संवेदनशिल सूचनाहरु गोप्य राख्नु पर्नेछ अनाधिकृत रुपमा त्यस्ता सूचनाहरु कसैलाई पनि उपलब्ध गराउन पाइने छैन ।

५. अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति रिपोर्ट/प्रतिवेदन (कागजी तथा विधुतिय) यस विभागमा अनिवार्य रुपमा बुझाउनु पर्नेछ ।

६. तोकिएका शर्तहरुको पालना नगरिएमा विभागले कुनै पनि समयमा अनुसन्धान अनुमति रद्द गर्न सक्नेछ ।

(सबनम पाठक)

सहायक वन अधिकृत

बोधार्थ

श्री डिभिजन वन कार्यालय, पाल्पा र रुपन्देही। : जानकारी तथा आवश्यक सहयोगका लागि अनुरोध छ ।

Photograph 4. Research permission letters from Forestry and Soil Conservation Department

Photograph 5. Measuring water parameters of Tinau River

Photograph 6. Sampling the fishes in site

Photograph 7. Showing external parts of Genus *Garra*

Photograph 8. Morphometric measurement of Genus *Garra*

Photograph 9. Preparing for x- ray

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