Consultative Workshop on Fish Conservation in Nepal

4 July 2011

Edited by
Suresh Kumar Wagle
Neeta Pradhan

Proceedings of the Consultative Workshop on Fish Conservation in Nepal

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March 2012

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Organizer:
Fisheries Research Division, Godawari
Nepal Agricultural Research Council (NARC)

Published by: Fisheries Research Division, Godawari, Lalitpur, Nepal

Citation: Wagle, S. K. and N. Pradhan (eds.), 2011. Proceedings of the consultative workshop on fish conservation in Nepal, Fisheries Research Division (FRD), Godawari, Lalitpur, Nepal. …… + …….. pp.

ISBN: ………..

Available from: Fisheries Research Division
PO Box 13342, Godawari, Lalitpur, Nepal

Foreword

The workshop on **Consultative Workshop on Fish Conservation in Nepal** was held on 4 July 2011 in Lalitpur, Nepal. It was organized by Fisheries Research Division, Godawari, Nepal Agricultural Research Council (NARC). The workshop was attended by over 50 scientists, planners, policy makers, private entrepreneurs from National Planning Commission, Fisheries Research Division, Fisheries Research Centers, Directorate of Fisheries Development, Fisheries Development Centers, Tribhuvan University, Institute of Agriculture and Animal Sciences, JICA/Nepal and Freelancers.

Recent works have shown nearly 229 fish species are found in freshwater systems of Nepal. In the region, characterized by rugged terrain and very low levels of human development, fisheries play an important role in providing food and income to the people. However, freshwater fishes along with its habitats have been encroached and threatened due to environmental, social and developmental activities. There are several social reasons causing inevitable depletion of fishes from lakes, ponds, wetlands and swamps.

The objectives of the workshop was to share information, experiences and challenges in the native fish management, improve understanding of their importance in peoples' livelihoods and assess their current level of exploitation, sustainable uses of the indigenous fishes. A total of five papers were presented in this workshop. Aquaculture development problems connected with indigenous food and game fishes, current status of indigenous fishes and their contribution in rural livelihoods, efforts on domestication and breeding of native fishes, factors for the depletion of native fishes and strategies for the conservation of fish in Nepal have been extensively reviewed in the proceedings.

The Fisheries Research Division of Nepal Agricultural Research Council is proud of bringing out this publication. I would also like to take this opportunity to thank all the stakeholder organizations for their support in the organization of the workshop and publishing its proceedings. The efforts of all the support staff are also sincerely acknowledged. I believe that the proceedings will be useful to all those, who are involved in fisheries and aquaculture management in the country.

Dr. Dil Bahadur Gurung
Executive Director
Nepal Agricultural Research Council

Acknowledgement

- National Planning Commision, Kathmandu
- Directorate of Fisheries Development, DoA, Kathmandu
- Nepal Fisheries Society, Kathmandu
- Institute of Agriculture and Animal Sciences (IAAS), Rampur
- Central Department of Zoology, Tribhuvan University
- Regional Agriculture Research Station, Tarahara
- Regional Agriculture Research Station, Parawanipur
- Fisheries Research Centre, Pokhara
- Fisheries Research Centre, Trishuli
- Kali Gandaki Fish Hatchery, Syanja

List of acronyms/synonyms

Consultative Workshop on Fish Conservation in Nepal

04 July 2011 (20 Asar 2068)
Venue: Fisheries Research Division, Godawari, Lalitpur

Time	Activities	Presenter
08:30-09:00	Registration, Tea and Snacks	Renu Aryal and Shiva Lal Adhikari

Inaugural Session
Convener: Jay Dev Bista, Chief, FRC Pokhara

Time	Activities	Presenter
09:00	Gathering in the hall	Convener
09:00-09:05	Placement of all the participants	
	Chairperson: **Mr. Dinesh Pariyar**, Executive Director, NARC Chief Guest: **Prof. Dr. Subodh Narayan Jha**, Hon. Member, National Planning Commission	
09:05-09:15	Welcome & Objective of the workshop	Dr. Tek Bahadur Gurung, Director of Livestock & Fisheries Research, NARC
09:15-09:20	Inauguration by lightening the lamp: **Chief Guest**	Prof. Dr. Subodh Narayan Jha, Hon. Member, National Planning Commission
09:20-09:25	Few words	Prof. Dr. Jeevan Shrestha
09:25-09:30	Few words	Mr. Kishore Kumar Upadhyaya, President, NEFISH
09:30-09:35	Few words	Dr. Deep Bahadur Swar
09:40-09:50	Address by **Chief Guest**	Prof. Dr. Subodh Narayan Jha Hon. Member, NPC
09:50-09:55	Vote of Thanks	Mr. Suresh K. Wagle, Chied, FRD, Godawari
09:55-10:00	Chairperson Remarks	Mr. Dinesh Pariyar, Executive Director NARC

Technical Session: 1
Chair: Dr. Tek Bahadur Gurung, Director, Live & Fish Research, NARC
Co-Chair: Mr. Ramananda Mishra, Chief, National Natural & Artificial Fisheries Development Program
Rapporteur: Surendra Prasad & Dr. Arun P. Baidya

Time	Title	**Presentator**
10:45-11:00	Threat Status of indigenous fish species	Jeewan Shrestha
11:00-11:15	Review of acts, regulations and guidelines related to aquatic resource and animal conservation	Kishor K. Upadhyaya
11:15-11:30	Contribution of indigenous fishes in livelihood of fishers in Nepal	Ramananda Mishra
11:30-11:45	Impact of damming on the environment of flow and persistence of native fishes	Surya R. Guvajoo
11:45-12:00	Potential impact of climate change in fisheries and adaptation measures	Anand Gautam and Suresh K. Wagle
12:15-12:30	Past and present status of fresh water fish production from natural waters in Nepal: trend analysis and future prediction	Bhagwat Prasad and Jay K. Mandal
12:30-12:45	Discussion	
12:45-12:50	Chairpersons Remarks	

Poster Session with Lunch 12:50-14:00

Technical Session: 2

Chair: Prof. Dr. Surya Ratna Guvaju, Central Department of Zoology, Tribhuwan University
Rapporteur: Mr. Asha Raymajhi & Agni Prasad Nepal

14:00-14:15	Native fish conservation in Nepal: challenges and opportunities	Tek B. Gurung
14:15-14:30	Status of air breathing fishes of Nepal	Madhav K. Shrestha
14:30-14:45	Diversity, inventory, and conservation of the fishes of Nepal: strategies for a national effort of success with a rapidly changing planet	Richard L. Mayden
14:45-15:00	Indigenous Fishes of Nepal and the need of their Conservation for their Sustainable Development	Krishna Gopal Rajbanshi
15:00-15:15	Discussion	
15:15-15:25	Chairpersons Remarks	

Wrap up session

Facilitator: Mr. Suresh K. Wagle and Jay D. Bista

15:25-16:30	**Plennary exercise**: Finalization of draft recommendation of the workshop
16:30-16:35	Mr. Rajendra KC, Director, DoFD, Balaju
16:35-16:40	Few words: ……………
16:40-16:45	Closing remarks: Dr. Deep Bahadur Swar

Contents

Reproduction and growth performance of gardi (*Labeo dero*) and its prospects in aquaculture:
Surendra Prasad and Jay Dev Bista

Workshop Background

Nepal is endowed with rich freshwater fish diversity. Recent works have shown nearly 200 fish species are found in freshwater systems of Nepal. However, freshwater fishes along with its habitats have been encroached and threatened due to environmental, social and developmental activities. For example, rivers have been dammed; boulders, stones, and sand are rapidly removed; threatening not only up and downwards movement of fishes but losing substrates for spawning and feeding activities. There are several social reasons causing inevitable depletion of fishes from lakes, ponds, wetlands and swamps. The present climate change has also poses threat to many indigenous fishes.

Fish and fisheries belonging to high altitude regions are least known, however the contribution of these fishes could be realised especially in hilly local markets where dried and smoked fishes contributes in rural economy. Indigenous fishes become more important in the context, as FAO has shown that the contribution of captured fish in total production is declining worldwide as most fishes have been over fished. Thus, to conserve and promote indigenous fishes for sustainable fisheries more attention is needed.

However, to develop conservation plans more quantitative and qualitative information on indigenous fish stock, biology, ecology, social interaction, traditional use, importance, indigenous people, values, status of contribution on livelihood, ecosystem, conservation need, and domestication would be requiring. In Nepal, despite of its higher potentiality fish and fisheries sub sector has been least prioritised. National level workshop and seminar focusing on indigenous fishes have rarely been organised. Thus, documentation and information on indigenous fish is limited. It has been realised that several fish species have been endangered, threatened and vulnerable.

This workshop will be an attempt to understand current efforts on, and challenging issues relating to the management and conservation of indigenous fishes in the country, and to identify possible future courses of action for their protection, management and sustainable development.

Objectives

The primary aim of the workshop is to promote cross-learning and develop a concrete plan for conservation of indigenous fish and their management and sustainable use. The aim has been further divided into three major objectives as follows.

- Promote the intrinsic value of indigenous fish species and their aquatic communities,
- Threat classification of indigenous fishes. The red list of indigenous fishes will also be proposed for future conservation plan.
- Share information, experiences and challenges in the management and sustainable uses of the indigenous fishes.

Areas covered

- Germplasm conservation of indigenous fishes
- Fisheries socioeconomics and fisher community
- Biology and culture of indigenous fishes
- Fisheries management of river, reservoirs and lakes
- Challenges to restoration (e.g. habitat loss, barriers, overexploitation)
- Threat classification of indigenous fishes
- Act and regulation promoting fish conservation
- Gender in Fisheries
- Climate change impact on conservation and management

NATIVE FISH CONSERVATION IN NEPAL: CHALLENGES AND OPPORTUNITIES

Tek Bahadur Gurung*

Nepal Agricultural Research Council
Singhaburbar Plaza, Kathmandu

ABSTRACT

Native fish are indigenous in origin belonging to stream, river, wetland, lake and ocean of particular region or place. Conservation is the integral part of natural resource management which advocates prevention of unnecessary waste. Recently, freshwater fishes have been threatened by a wide array of factors, especially, anthropogenic disturbance including river impoundment, pollution. Among which habitat degradation seemed to be more responsible for the decline of many species. Nepalese fishes are one of main aquatic vertebrates which have yet to fully understand for their ecology, distribution and occurrence, especially from western regions of the country. Publicizing the importance and knowledge of fish conservation has been one of the most important challenges ahead. The other challenges are maintenance of quality and quantity of freshwater which have been impacted highly by global and local anthropogenic activities, in general. Optimistically a national strategy on the conservation of freshwater fish is expected. Fish conservation would have the opportunities to be used in future for multiple of purposes. Adoption of community or cooperative based conservation could be one of the best approaches for freshwater fish conservation. As an opportunity, success of single fish species might change contributes substantially on livelihood and local economy, if that could be used in aquaculture or angling for tourism industry.

***Key words**: anthropogenic activities, cooperative based conservation, native fish*

Introduction

Freshwater fishes are one of most ignored fauna of biodiversity conservation; as a result there has been alarming decline in fish diversity (Jana 2007; Shrestha *et al.* 2009) especially, in more populated urban areas and wetlands of southern plains in Nepal. Probably, the decline in fish diversity is associated with low priority, investment; and poor human resource in fish conservation. Several freshwater fish

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have been already endangered due to river diversion, eutrophication, reduced water quantity and water quality); and human intervention (Gurung and Baidya, *in press*; Shrestha 2011). As Cowx (2002) indicated anthropogenic disturbance as the most important factor for decline and extinction of many species. Besides environmental threats other most dangerous aspect of native fish conservation is probably associated with ignorance, as fish cannot be seen from outside as mega fauna of terrestrial animals can be seen easily (Pascual *et al.,* 2002; Jana 2007).

Surprisingly, large fishes weighing more than 40-50 kg or more belonging to cyprinidae and catfish are common native fishes in many rivers and lakes of Nepal (Gurung 2003). Such fishes might disappear soon, because they are not only threatened environmentally; but has been vulnerable due to inequitable protection measures by conservationist, planners and scientists comparing to wild terrestrial mega animals (Pascual *et al.* 2002; Gibson and Pullin 2005). Often the animals directly visible and associated with tourism are taken care, but fishes have yet to gain that attention in Nepal. In this aspect to enhance the common knowledge on aquatic life including live fishes more visible activities might help in conservation. In present paper, it has been attempted to elucidate present knowledge gaps that negatively affect fish conservation efforts to suggest a logical path as the challenges and oportunities for future work on conservation of native fishes in Nepal.

Background

Native or indigenous fish diversity in Nepal is represented by more than 227 indigenous fish species (Shrestha 2008). These fishes are distributed in inland waters such as rivers, ponds, and lakes covering about 5% of Nepal. The fish play vital role in livelihood of Nepalese communities, especially those belonging from ‘the poorest of the poor Nepalese fishers of the world’. However, fishes are considered auspicious and symbolize as sign of fertility, power and prosperity in Nepalese society.

Nepal has 6 fisheries research stations besides other belonging to various institutions focusing their activities on commercial food fishes (NARC 2011). Mostly, developmental institutions give less priority to native fish species as these are known to response slowly to captive conditions. As a result without much study most native fishes could be blamed as unsuitable for farming. Recently, it has been demonstrated that technological understanding might be faster, if specific research stations could be identified to study the native fishes specifically. For example, after undertaking Kali Gandaki Fish Hatchery as specific research station for native fishes, recently at least nine native fishes have been domesticated to breed successfully in captive conditions (KGFH 2005-6). As an output the station produces about one million fingerlings of native fishes for restocking into regulated rivers (Gurung and Baidya, *in press*). This suggests that low investment and ignorance on fish conservation would weaken our understanding. Therefore, there is urgent need to pay attention on conservation studies of native fishes. This fact of better understanding on breeding biology of native fishes might have implication for sustainable renewable hydropower related development for prosperity of the country.

National Strategy

Fish biodiveristy conservation is need of the country. A national strategy on conservation and study center on fish systematics, germplam conservation is required. However, fish conservation has been the part of National Biodiversity Conservation Strategy (HMG 2002). According to the convention on biological diversity 1992, forest ecosystem, wild life habitats and other genetic resources were committed to be protected through national protected area system covering about 18% of the country. However, the strategy was focused on conservation of terrestrial animals and plants, thus fish and other aquatic fauna and floara have been ignored. Moreover, Jana (2007) described a clear picture of conflict between fish dependent communities and the Park administration in Chitwan National Park.

In general, it could also be recommendable to apply the concept of freshwater protected areas (FPAs), where FPAs are the part of the freshwater environment partitioned to minimise the disturbance and allow natural processes to govern population and ecosystems (Suski and Cooke 2006). A new model of fish conservation in harmony with fishing dependent communities should also be developed in near future for sustainable development.

Ecology

Generally, after taxonmist stabilised inventory of organisms then communities of conservationist analyse the status in different agroecoloical regions (Lysne *et al.* 2008). However, it seems that despite of works by Shrestha (1981), Rajbanshi (2005), Shrestha (2007), Edds and Ng (2007), Ng and Edds (2004). Still much discoveries are yet to be accomplished (Thompson 2009).

Nepal is a country of immense charateristics having an altitude of 60 m elevation to world highest peaks of 8848 m (Fig 1). In this altitidnal varaition fish diversity have been recorded upto 3600 m elevation (Rajbanshi 2005). It is anticipated there should be fishes in greater altitude. Since there is limited studies on fish fauna threfore much light has yet to through on fish and fisheries of Nepal. If there could be studies on the pattern of water quality in relation to fish species distribution, it can be expected that a clear relationship could be establsihed. This study would have implication and fish assemblages could be taken as an indicator of water quality. To do such studies Nepal could be one of the best countries for such research undertakings. Many fishes are specific either only in southern plain or high hills exhibiting there specificity for cold to warm waters suggesting specific adaptiation and physiological needs for dissolved oxygen, torential, lentic and lotic habit specialists (Gurung 2011). Thus, it has been truly mentined that Nepal is a natural laboratory to understand ecological, physiological variation and several other scientific facts in relation to altitudinal variation of organisms (Thompson 2009, Gurung *et al.* 2011) including fish and fisheries.

Conservation Challenges

Contribution of indigenous fish in total production is declining worldwide as most fresh and marine fishes have been over fished (Allan *et al.* 2005). Previously, many over fished waters were introduced with non-native fish for providing reliance to fishers through enhancing capture fisheries; and protection of native fish being over exploitation by diverting fisher to non-indigenous species. Details of scientific review might need to analyze for measuring what extent those strategies were contributed in native fish conservation. It is also imperative to examine which factor is more responsible for threatening fish biodiversity? Some of the major factors which might threatened the Nepalese fish diversity could be delineated as given in Table 1. Other major challenges imposing major threat to fish diversity conservation could be outlines as:

i. Water quality and quantity,
ii. Nuisance species,
iii. Restocking and reintroduction
iv. Hydropower friendly technologies
v. Technologies for *in-vivo, in-situ, ex-situ* conservation or gene banking
vi. Monitoring and evaluation mechanism
vii. Climate change
viii. Human resource
ix. Establishment of a study for fish conservation
x. Social mobilization
xi. Inter sectoral coordination for implementation of plans
xii. Translating policy into act and regulation
xiii. Domestication and aquaculture technology development of native fishes

Water quality and quantity

Environmental degradation, habitat loss & pollution are directly related to water quality and quantity. Deforestation, siltation and climate change might cause water quality and quantity problems due to erratic fluctuations in water levels. Water pollution due to industrial, chemical pollution, urbanization, intensive agricultural, littering of solid waste and domestic sewage have been major source of pollution in most of Nepalese rivers. Implementation of regulation causing environmental degradation for biodiversity loss in rivers would be a major challenge in Nepal for fish conservation.

Nuisance species

As much as there is information rarely Nepalese fish species are inedible. Generally all fishes are consumable in Nepal. So regardless of the taste, size and appearance, fish would serve the purpose of food. However, there are certain fishes which have been blamed to negatively affecting native fish fauna due to competition for space, food and other resources. There have been works advocating that fish introduction is beneficial for conservation as they can provide means of livelihood (Gozlan 2008, Gurung 2007). Recently it was pointed out that a number of nuisance species used in aquaculture have established themselves within the region without apparent negative environment and or biodiversity impact, contributing significantly to food fish production with equally significant social impacts. It was agreed it is best to consider such species as 'naturalized species' (IDRC 2007).

Restocking and reintroduction

Restocking of river and reintroduction of fishes from hatcheries might be problematic for restoration of native fisheries in rivers, lakes and impoundments. The 2002 Convention on Biodiversity recognized that the species introductions can cause regression of biological diversity, following destruction of natural habitats. Although it has long seemed likely that human activity plays a major role in such effects, no scientific study had yet yielded measurements of its involvement at planetary scale for a given group of species.

Hydropower friendly technologies

In near future, development of appropriate technologies to hydropower development with interference to conservation of fish and fisheries would be challenge. In Nepal, electrical power in highly demanding so analysing social, technical and security reasons hydropower probably is only the option. The damming operation might need appropriate fisheries technologies which can sustain fish diversity in rivers. So development of appropriate technologies would be challenging for conservation of fish in rivers.

Technologies of in-vivo, in-situ, ex-situ conservation or gene banking

Several modern technologies have been evolved recently for conservation. One of the most advanced is gene banking of genetic materials (Bart 2002). These technologies have been applied in fish conservation in countries like Norway and others. Introduction of *in-vivo* technologies in fisheries sub sector would be challenging in Nepal. Concerning to in-situ conservation, the National Parks concept are representing the in-situ conservation, however, detail study is a challenge. Ex-situ conservation technology of some fishes has been established. The fish hatchery promoted by Nepal Electricity Authority in Beltari Synagja, operated by Nepal Agricultural Research Council, and some of fish farms owned by Nepal Agricultural Research Council have developed the ex-situ breeding methods.

Monitoring and evaluation mechanism

Several hydropower stations might be operating fish hatcheries but management of monitoring and evaluation mechanisms might be challenging for quality assurance. Therefore, it has been felt that there should be an organization who can monitored the implementation of the provisions of fish ladder, fish trapping and hauling, compensation riparian flow, habitat and spawning area improvement, fish hatchery activities and promotion of reservoir fisheries in regulated rivers.

Climate change

Climate change due to global warming is a great threat to aquatic environment. Nepal has been rated as 4th most vulnerable countries of the world despite of the fact that contribution of Nepal for climate change is only 0.025% (Gurung *et al.* 2011a). It has been suggested that there would be fish population shift due to climate change with expectation of favorable condition in deeper high hills to invasive fishes in Nepal (Wagle *et al.* 2011).

The climate change has threatened the most to fishing dependent ‘poorest of the poor of the world’ in Nepal. It is estimated that among 24 depended people on fishing in Nepal, majority are women. Therefore, the fish conservation has been also challenging to livelihood of those all ethnic, deprived communities and women depending on fishing in Nepal.

Human resource

Limited qualified human resource who can involve in the study and monitoring of fish conservation outside and in protected areas would be challenging especially those having clear ideas on fish taxonomy, evolutionary biology, fishers ethnic communities, natural food web interaction, Acts, rules and regulation of aquatic animal conservation Act, Environment Act, Pollution Act, natural habitats of fishes etc.

Establishment of a study center for fish conservation

Fisheries in our plan and policies have hardly been prioritized (see APP 1995). There are several other examples in our conservation action plan where fish has been ignored. Such ignorance has been paid us with fish diversity loss in many parts of the country. Therefore, it is time now that a center for excellence should be initiated to study the fish conservation aspect of Nepal.

Social mobilization

To control over destructive fishing (poisoning, use of dynamites, electro fishing), use of small mesh size net), increasing awareness, law enforcement would also be challenging, competition with exotic species, destruction of spawning beds. Few years before initiatives of fish conservation by mobilizing local communities have been attempted (Gurung 2003). It might be still commendable if this approach of fish conservation could be continued and supported by concern government authorities and plan and policies of Government of Nepal. As the part of participatory conservation in co-ordination with government local authorities such as District Agriculture Development Offices (DADO), Chief District Officer (CDO), Local Development Officer (LDO), and Police Office.

Inter sectoral coordination for implementation of plans

National Planning Commission is the responsible for policy formation and coordination among different line ministries. Fish conservation is related to many ministries, for example, agriculture, tourism, irrigation and energy are closely related. However, such co-ordination is weak. It has been assumed that weak coordination is also one of the reasons of declining fish conservation approaches. Therefore, establishment of the cooperation is a challenge to fish diversity. Establishment Fish Sanctuaries and Fish Ranching Centers in co-ordination with Department of National Parks and Wildlife, IUCN, WWF, ICIMOD, Nature Conservation Trust etc could be helpful in conservation of fishes.

Translating policy into act and regulation

Aquatic Life Protection Act 2017 was promulgated in 1960. But its implementation is not effective as due to lack of rule and regulation and working procedure. It is therefore, a challenge to bring out the rules and working procedure of the Act.

Domestication and aquaculture technology development of native fishes

Often fish conservationist blames aquaculturist for introducing exotic fishes for cultivation and declination of native fishes. Since there is increasing market demand of food fish and no fish farming technology available knowledge on native fishes, probably is the major hindrance why non native fishes have got higher priority for cultivation. Currently in Kathmandu there have been thousands of farmers cultivating African cat fish (*Clarias gariepinus*) which can perform very well from production perspective even in highly eutrophic low oxygen containing small ponds without much exchange of waters. Similarly, Tilapia farming is becoming popular in southern plains. To replace non native fish, technologies of native fish farming should be developed and encouraged in near future. This would be again a big challenge as the food fish demand is ever increasing in the country.

Opportunities for success

Native fish play substantial role in total fish production of the country. It has been estimated that approximately 0.5 of total GDP is contributed through capture fisheries which is most likely to be contributed by native fishes with minor exception. This suggests there are enormous opportunities in native fish conservation. Similarly, there have been some more that 206 native fish have been reported in Nepal showing a increasing trend of fish species biodiversity (Table 2). Recently 6 new fish species have been reported as new record from eastern Nepal (Thompson 2009). It can be predicted that total native fishes of Nepal will exceed more especially from western and far western development regions; which have least studied from fish conservation perspectives. Therefore, there should be more fish species waiting to be discovered, study and report in near future. These are opportunities associated with discovery of new native fishes in Nepal.

There are several native fish species which have been considered as suitable candidates for inclusion in aquaculture. As a result there has been effort to domesticated native fishes since last so many years. If we analyse our progress till date, Nepal who can afford to invest only very small fraction of support in conservation activities have achieved landmark progress on technical development of native fish conservation, breeding, rearing and cultivation technologies (Gurung *et al. in press*; KGFH 2005). Now we have been able to produce desirable number of fry of several native fishes including, Sahar, Asala, *Labeo dero* and at least 8 native fishes in hatcheries (KGFH 2005). Some of assumptive advantages of native fish if used for cultivation could be outlined as given in Box 1.

Nepal has several well established institutes, government organisation, universities for fish taxonomy and conservation studies, but limited organizations working on conservation management of fishes. At present the oldest university of Nepal, Tribhuvan University is engaged in taxonomy, biological and socio-economic aspects of fisheries since long. The contribution of TU is appreciated. Government institutions are responsible for legal aspects of fish conservation, some research institute especially Nepal Agricultural Research Council covering management aspects of fish conservation.

Some universities from abroad have also contributed our knowledge on fish taxonomy (Edds and Ng 2007; Ng and Edds 2004; 2005a; 2005b). These suggests still our fish inventory needs to be stabilised. If this is the case, the stabilization of fish species abundance in Nepal seems to be continued in the future. It shows there is high scope and opportunities of scientific works and discoveries on fish and fisheries in Nepal.

Conclusion

The current degradation in native fish conservation might be challenging not only to fish diversity but also impact over food security and income of several million people dependent on fishing. Since economic development is likely to degrade the native fish biodiversity due to increase anthropogenic activities. Ensuring native fish conservation will require significant improvement in law enforcement to reduce pollution, unconventional fishing, awareness, commitment on fish habitats management with high level of wisdom.

The information flow on fish diversity is scanty and limited in the country. In such a gap of knowledge on fish diversity, it is advisable to have a group of people interested in fish diversity for consolidated plan of action so the knowledge on fish taxonomy and conservation could be organised. To address the conservation challenges, it is advisable to establish community or cooperative based conservation groups that have similar interest, expertise, and ability to collect, review and disseminate information to those individual or agencies that could develop and drive natural resource policy of fish conservation. As an opportunity of success a single fish species might change the face of economy of the country. Especially, if that could be used in aquaculture or angling for tourism industry.

Acknowledgement

My sincere thanks to Mr Suresh Kumar Wagle, Mr. Jay Dev Bista, Mr. S. R Basnet, Dr. Arun Baidya, Ms. Asha Raymajhi, Ms. Neeta Pradhan and several other friends to prepare this manuscript.

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THREAT STATUS OF INDIGENOUS FISH SPECIES OF NEPAL

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ABSTRACT

Nepal is rich in fish diversity. The richness and uniqueness of the fresh water fishes of Nepal are due to different topographic and climatic conditions of the country within a short distance of elevation from plain Terai to high altitude mountains as well as from tropical to alpine climatic conditions. The ichthyology of Nepal is reported within varying account of total number of fish species recording in the country. They belong to 11 orders, 32 families, 24 sub-families, 99 genera and 228 species including 15 endemic species. Their status are common 71, insufficiently known 33, endangered 1, vulnerable 5, rare 36, fairly common 24, uncommon 49 and occasional 9. Some of the indigenous species have been domesticated, bred successfully in different Fisheries Centers and are kept in water bodies of Nepal. The fishes of Nepal have been distributed from few meters in low lands of Terai to highest altitude of 3,323 m in Langtang Khola, Bagmati zone. No authentic institute dealing with fish nomenclature is existing in Nepal where all the specimens including paratype and holotype could be deposited to catalog, revision, comparison and verification.

Population growth rate of Nepal (2.08 % annually) has its numerous impacts on water resources. Chemical pollutions (industrial, domestic sewage and garbage, etc.) containing about 250 to 400 mg/L organic carbon and 12-80 mg/L total nitrogen are serious pollutants for aquatic flora and fauna. Deforestation (2%), siltation (2400 million m^3), harmful fishing devices further threat indigenous fish. Similarly, minor impact on indigenous fish species has been experienced because of introduction of exotic fish species in natural lakes and streams. The construction of dam obstructs the fish migration and also forms reservoir at upstream & dewater zones at downstream affecting the fish population. All these factors have direct and indirect effects on the damage of habitat, loss of food, injury and heavy mortality of fry, fingerlings and adult fish inhabiting in rivers, lakes and reservoirs of Nepal though Nepal has some important Conservation Legislations.

Key Words: *ichthyology, fish diversity, threat status, fish conservation, chemical pollution.*

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Introduction

Nepal is a country with unique and varied ecological features with the total area of 1, 41,000 km^2. The kingdom of Nepal is situated between the longitudes 80^{0}00' to 88^{0}15' E and the latitudes 26^{0}30' to 30^{0}15' N. Geographically Nepal can be divided into three regions: low land, mid land and high land. The Churia ridge or Siwalik hills (up to 1500 m) separate the Terai in the south from the larger river valleys (Duns) of the Churia range, which forms the bulk of the inner Terai. The inner Terai and the main Terai at south constituite the low land of Nepal. The Mahabharat range and the lower Himalayan foot hills constitute the hill regions. Lower hills are the hill-area up to 2,700 m and upper hills are those between 2,700 m to 4,000 m. The greater Himalayas are located above the tree line about 4,600 m (Sharma, 1995). Nepal is rich in water resources with 6,000 rivers and 5,358 lakes. Its total annual renewable water resource is 210 billion m^3.

Indigenous Species of Nepal

Nepal is rich in fish diversity. The richness and uniqueness of the fresh water fishes of Nepal are due to different topographic and climatic conditions of the country within a short distance of elevation from plain Terai to high altitude mountains as well as from tropical to alpine climatic conditions. The ichthyology of Nepal is reported within varying account of total number of fish species recording in the country. In addition, various authors have reported new species and new records of fish from Nepal, which further increased the total number of species. The total number of fish is reported variable in different time periods starting from 120 in 1981(Shrestha, 1981) to more than 200 species till date. The fishes of Nepal have been distributed from few meters in low land of Tarai to high altitude of 3323 m Langtang Khola, Bagmati zone.

Various authors' viz. Terashima (1984), Rajbanshi (2005), Shrestha (2008) and Shrestha (1994, 1995, 2002, 2009, 2010) have worked on fishes of Nepal. Ng (2006), Edds and Ng (2007), Ng and Edds (2004, 2005a and b), Conway and Mayden (2008, 2010) have also reported new species and new records of fish from Nepal. Shrestha (2008) have reported 217 native species from Nepal. The present list includes 228 indigenous species of Nepal. They belong to 11 orders, 32 families, 24 sub-families, 99 genera and 228 species including 15 endemic species. Their status is common 71, insufficiently known 33, endangered 1, vulnerable 5, rare 36, fairly common 24, uncommon 49 and occasional 9. The main differences in reporting the total number of indigenous species of Nepal by different authors is due to the adoption of classifying taxonomic nomenclature of different authors. Another reason behind this is there is no single authentic place where all the specimens are deposited for verification and comparison. The third reason is there is no regular survey work for biodiversity as well as catch per unit effort. The indigenous species of Nepal with their threat status is given in Table 1.

Table 1. Indigenous species of Nepal with their threat status

S.N	Indigenous species	Threat status
1	**ORDER: CLUPEIFORMES** **Family: CLUPEIDAE** **Sub family: Alosinae** **Genus**: ***Gudusia*** **Fowler 1911** *Gudusia chapra* (Hamilton-Buchanan) 1822	Common
2	**Family: Engraulidae** **Sub family: Engraulinae** **Genus**: ***Setipinna*** **Swainson 1839** *Setipinna phasa* (Hamilton-Buchanan) 1822	Common
3	**II. ORDER: OSTEOGLOSSIFORMES** **Sub order: Notopteroidei** **Family: Notopteridae** **Genus**: ***Notopterus*** **Lacepede 1800** *Notopterus notopterus* (Pallas) 1767	Common
4	**Genus**: ***Chitala*** **Fowler 1934** *Chitala chitala* (Hamilton-Buchanan) 1822	Common
5	**III. ORDER: CYPRINIFORMES** **Family:Cyprinidae** **Sub Family: Cyprininae** **Genus**: ***Neolissochilus*** **Rainboth 1985** *Neolissiochilus hexagonolepis* (McClelland) 1839	Fairly common
6	**Genus**: ***Catla*** **Valenciennes 1844** *Catla catla* (Hamilton-Buchanan) 1822	Common
7	**Genus**: ***Chagunius*** **Smith 1945** *Chagunius chagunio* (Hamilton-Buchanan) 1822	Fairly common
8	**Genus**: ***Cirrhinus*** **Oken 1817** *Cirrhinus mrigala* (Hamilton-Buchanan) 1822	Common
9	*Cirrhinus reba* (Hamilton-Buchanan) 1822	Common
10	**Genus**: ***Labeo*** **Cuvier 1817** *Labeo angra* (Hamilton-Buchanan) 1822	Common
11	*Labeo bata* (Hamilton-Buchanan) 1822	Common
12	*Labeo boga* (Hamilton-Buchanan) 1822	Common
13	*Labeo caeruleus* (Day) 1878	Common
14	*Labeo calbasu* (Hamilton-Buchanan) 1822	Common
15	*Labeo dero* (Hamilton-Buchanan) 1822	Common
16	*Labeo dyocheilus* (McClelland) 1839	Common
17	*Labeo fimbriatus* (Bloch) 1795	Insufficiently known
18	*Labeo gonius (*Hamilton-Buchanan) 1822	Common
19	*Labeo pangusia* (Hamilton-Buchanan) 1822	Common
20	*Labeo rohita* (Hamilton-Buchanan) 1822	Common
21	**Genus**: ***Oreichthys*** **Smith 1933** *Oreichthys cosuatis* (Hamilton-Buchanan) 1822	Insufficiently known
22	**Genus**: ***Osteobrama*** **Heckel 1842** *Osteobrama cotio cotio* (Hamilton-Buchanan) 1822	Common
23	*Osteobrama neilli* (Day)	Common

	1878	
24	**Genus**: ***Schismatorhynchos* Bleeker 1855** *Schismatorhynchos* (*Nukta*) *nukta* Sykes 1841	Uncommon
25	**Genus**: ***Puntius* Hamilton-Buchanan 1822** *Puntius apogon* (Cuvier and Valenciennes) 1844	Uncommon
26	*Puntius clavatus clavatus* (McClelland) 1839	Insufficiently known
27	*Puntius conchonius* (Hamilton-Buchanan) 1822	Common
28	*Puntius chola* (Hamilton-Buchanan) 1822	Uncommon
29	*Puntius gelius* (Hamilton-Buchanan) 1822	Insufficiently known
30	*Puntius guganio* (Hamilton-Buchanan) 1822	Uncommon
31	*Puntius phutunio* (Hamilton-Buchanan) 1822	Uncommon
32	*Puntius sarana* (Hamilton-Buchanan) 1822	Common
33	*Puntius sophore* (Hamilton-Buchanan) 1822	Common
34	*Puntius terio* (Hamilton-Buchanan) 1822	Uncommon
35	*Puntius ticto* (Hamilton-Buchanan) 1822	Common
36	**Genus: *Semiplotus* Bleeker 1859** *Semiplotus semiplotus* (McClelland) 1839	Uncommon
37	**Genus**: ***Tor* Gray 1834** *Tor mosal* (Hamilton-Buchanan) 1822	Uncommon
38	*Tor putitora* (Hamilton-Buchanan) 1822	Fairly common
39	*Tor tor* (Hamilton-Buchanan) 1822	Endangered
40	**Genus**: ***Naziritor* Mirza and Javed 1985** *Naziritor chelynoides* (McClelland) 1839	Fairly common
41	**Sub family: Rasborinae (Danioninae)** **Genus**: ***Amblypharyngodon* Bleeker 1860** *Amblypharyngodon mola* (Hamilton-Buchanan) 1822	Common
42	*Anblybharyngodon microlepis* (Bleeker) 1853	Uncommon
43	**Genus: *Aspidoparia* Heckel 1847** *Aspidoparia jaya* (Hamilton-Buchanan) 1822	Common
44	*Aspidoparia morar* (Hamilton-Buchanan) 1822	Common
45	**Genus**: ***Barilius* Hamilton-Buchanan 1822** *Barilius barila* (Hamilton-Buchanan) 1822	Common
46	*Barilius barna* (Hamilton-Buchanan) 1822	Common
47	*Barilius bendelisis* (Hamilton-Buchanan) 1822	Common
48	*Barilius bola* (Hamilton-Buchanan) 1822	Fairly common
49	*Barilius guttatus* (Day) 1869	Vulnerable
50	*Barilius modestus* (Day) 1878	Uncommon
51	*Barilius radiolatus* (Gunther) 1868	Uncommon

52	*Barilius shacra* (Hamilton-Buchanan) 1822	Uncommon
53	*Barilius tileo* (Hamilton-Buchanan) 1822	Occasional
54	*Barilius vagra* (Hamilton-Buchanan) 1822	Common
55	**Genus**: ***Brachydanio* Weber and de Beaufort 1916** *Brachydanio rerio* (Hamilton-Buchanan) 1822	Vulnerable
56	**Genus: *Danio* Hamilton-Buchanan 1822** *Danio aequipinnatus* (McClelland) 1839	Uncommon
57	*Danio dangila* (Hamilton-Buchanan) 1822	Uncommon
58	*Danio devario* (Hamilton-Buchanan) 1822	Common
59	**Genus: *Esomus* Swainson 1839** *Esomus danricus* (Hamilton-Buchanan) 1822	Common
60	**Genus**: ***Bengala* Gray 1833** *Bengala elanga* (Hamilton-Buchanan) 1822	Fairly common
61	**Genus**: ***Rasbora* Bleeker 1860** *Rasbora daniconius* (Hamilton-Buchanan) 1822	Fairly common
62	**Subfamily: Cultrinae** **Genus**: ***Chela* Hamilton-Buchanan 1822** *Chela cachius* (Hamilton-Buchanan) 1822	Insufficiently known
63	*Chela laubuca* (Hamilton-Buchanan) 1822	Common
64	**Genus**: ***Salmostoma*Swainson 1839** *Salmostoma acinaces* (Valenciennes) 1842	Insufficiently known
65	*Salmostoma bacaila* (Hamilton-Buchanan) 1822	Common
66	*Salmostoma phulo* (Hamilton-Buchanan) 1822	Uncommon
67	**Genus**: ***Securicula* Gunther 1868** *Securicula gora* (Hamilton-Buchanan) 1822	Insufficiently known
68	**Sub family: Garrinae** **Genus**: ***Crossocheilus* Kuhl van and Hasselt 1823** *Crossocheilus latius latius* (Hamilton-Buchanan) 1822	Common
69	**Genus**: ***Garra* Hamilton-Buchanan 1822** *Garra annandalei Hora* 1921	Common
70	*Garra gotyla gotyla* (Gray) 1832	Common
71	*Garra lamta* (Hamilton-Buchanan) 1822	Fairly common
72	*Garra lissorhynchus* (McClelland) 1843	Uncommon
73	*Garra mullya* (Sykes) 1841	Fairly common
74	*Garra nasuta* (McClelland) 1839	Fairly common
75	*Garra rupecula* (McClelland) 1839	Insufficiently known
	Sub family: Schizothoracinae (Oreininae) **Genus**: ***Diptychus***	

76	**Steindachner 1866** *Diptychus maculatus* Steindachner 1866	Rare
77	**Genus**: ***Schizothorax* Heckel 1838** *Schizothorax richardsoni* (Gray) 1832	Fairly common
78	*Schizothorax sinuatus* (Heckel) 1838	Uncommon
79	**Genus**: ***Schizothoraichthys* Misra 1959** *Schizothoraichthys curvifrons* (Heckel) 1838	Uncommon
80	*Schizothoraichthys esocinus* (Heckel) 1938	Rare
81	*Schizothoraichthys labiatus* (McClelland) 1842	Uncommon
82	*Schizothoraichthys macrophthalmus* (Terashima) 1984	Insufficiently known
83	*Schizothoraichthys nepalensis* (Terashima) 1984	Insufficiently known
84	*Schizothoraichthys niger* (Heckel) 1838	Uncommon
85	*Schizothoraichthys progastus* (McClelland) 1839	Fairly common
86	*Schizothoraichthys raraensis* (Terashima) 1984	Insufficiently known
87	**Family: Psilorhynchidae** **Genus**: **Psilorhynchus McClelland 1839** *Psilorhynchus balitora* (Hamilton-Buchanan) 1822	Insufficiently known
88	*Psilorhynchus gracilis* Rainboth 1983	Insufficiently

89	*Psilorhynchus sucatio* (Hamilton-Buchanan) 1822	Occassional
90	*Psilorhynchus nepalensis* Conway and Mayden 2008	Insufficiently known
91	**Genus**: ***Psilorhynchoides* Yazdani, Singh and Rao, 1989** *Psilorhynchoides homaloptera* (Hora and Mukerji) 1935	Insufficiently known
92	*Psilorhynchoides pseudecheneis* (Menon and Datta) 1961	Vulnerable
93	**Family: Balitoridae** **Sub family: Nemacheilidae** **Genus: Turcinoemacheilus** *Turcinoemacheilus himalaya* (Conway et al.) 2011	Rare
94	**Sub family: Balitorinae** **Genus**: ***Balitora* Gray 1832** *Balitora brucei* Gray 1832	Rare
95	*Balitora eddsi* Conway and Mayden 2010	Insufficiently known
96	**Genus: *Homaloptera* VanHasselt 1823** *Homalptera bilineata* (Blyth) 1860	Rare
97	**Sub family: Nemacheilinae** **Genus**: ***Acanthocobatis* Peters 1861** *Acanthocobitis botia* (Hamilton-Buchanan) 1822	Common
98	**Genus**: ***Nemacheilus* Bleeker 1863** *Nemacheilus corica*	Uncomm

	(Hamilton-Buchanan) 1822	on
99	*Nemacheilus elongatus* (Sen and Nalbant) 1981	Rare
100	**Genus**: ***Schistura* McClelland 1839** *Schistura beavani* (Gunther) 1868	Rare
101	*Schistura devdevi* (Hora) 1935	Fairly common
102	*Schistura himachalensis* (Menon) 1987	Rare
103	*Schistura horae* (Menon) 1951	Rare
104	*Schistura multifasciatus* (Day) 1878	Insufficiently known
105	*Schistura prasadi* (Hora) 1921	Rare
106	*Schistura rupecula inglisi* (Hora) 1935	Common
107	*Schistura rupecula rupecula* (McClelland) 1838	Common
108	*Schistura savona* (Hamilton-Buchanan) 1822	Rare
109	*Schistura scaturiginia* (McClelland) 1839	Rare
110	*Schistura sikamaiensis* (Hora)	Rare
111	**Family: Cobitidae** **Sub family: Botiinae** **Genus**: ***Botia* Gray 1831** *Botia almorhae* Gray 1831	Fairly common
112	*Botia dario* (Hamilton-Buchanan) 1822	Occasional
113	*Botia geto* (Hamilton-Buchanan) 1822	Fairly common
114	*Botia histrionica* Blyth 1860	Uncommon
115	*Botia lohachata* Chaudhauri 1912	Common
116	**Sub family: Cobitinae** **Genus: *Acantophthalmus* van Hasselt 1823** *Acantophthalmus pangia* (Hamilton-Buchanan) 1822	Uncommon
117	**Genus**: ***Lepidocephalus* Bleeker 1858** *Lepidocephalus annandalei* (Chaudary) 1912	Uncommon
118	*Lepidocephalus guntea* (Hamilton-Buchanan) 1822	Common
119	*Lepidocephalus menoni* (Pillai and Yazdani) 1976	Insufficiently known
120	**Genus**: ***Neoeucirrhichthys* Banarescu and Nalbant 1968** *Neoeucirrhichthys maydelli* Banarescu and Nalbant 1968	Uncommon
121	**Genus**: ***Somileptes* Swainson 1839** *Somileptes gongota* (Hamilton-Buchanan) 1822	Occasional
122	**IV. ORDER: ANGUILLIFORMES** **Sub order: Anguilloidei** **Family: Anguillidae** **Genus**: ***Anguilla* Schrank 1798** *Anguilla bengalensis bengalensis* (Gray and Hardwicke) 1833-34	Vulnerable
123	**Family: Moringuidae** **Genus: Moringua** *Moringua raitaborua* (Hamilton-Buchanan) 1822	Rare
	V. ORDER:	

124	**SILURIFORMES** **Family: Amblycipitidae** **Genus**: ***Amblyceps* Blyth 1858** *Amblyceps mangois* (Hamilton-Buchanan) 1822	Rare
125	**Family: Bagridae** **Sub family: Bagrinae** **Genus**: ***Batasio* Blyth 1860** *Batasio batasio* (Hamilton-Buchanan) 1822	Uncommon
126	*Batasio macronotus* Ng and Edds 2004	Insufficiently known
127	*Batasio tengana* (Hamilton-Buchanan) 1822	Insufficiently known
128	**Genus**: ***Mystus* Scopoli 1777** *Mystus bleekeri* (Day) 1878	Common
129	*Mystus cavasius* (Hamilton-Buchanan) 1822	Common
130	*Mystus gulio* (Hamilton-Buchanan) 1822	Uncommon
131	*Mystus menoda* (Hamilton-Buchanan) 1822	Uncommon
132	*Mystus tengara* (Hamilton-Buchanan) 1822	Common
133	*Mystus vittatus* (Bloch) 1797	Common
134	**Genus**: ***Aorichthys* Wu 1939** *Aorichthys aor* Sykes 1841	Common
135	*Aorichthys seenghala* (Hamilton-Buchanan) 1822	Common
136	**Sub family: Ritinae** **Genus**: ***Rita* Bleeker 1853** *Rita rita* (Hamilton-Buchanan) 1822	Uncommon
	Family: Siluridae	

138	*Ompok pabda* (Hamilton-Buchanan) 1822	Fairly common
139	*Ompok pabo* (Hamilton-Buchanan) 1822	Uncommon
140	**Genus**: *Wallago* Bleeker 1851 *Wallago attu* (Schneider) 1801	Common
141	**Family: Schilbeidae** **Sub family: Ailinae** **Genus**: ***Ailia* Gray 1831** *Ailia coila* (Hamilton-Buchanan) 1822	Fairly common
142	**Sub family: Schilbeinae** **Genus**: ***Clupisoma* Swainson 1839** *Clupisoma garua* (Hamilton-Buchanan) 1822	Common
143	*Clupisoma montana* Hora 1937	Uncommon
144	**Genus: Eutropiichthys Bleeker** 1862 *Eutropiichthys goongware* (Sykes) 1838	Uncommon
145	*Eutropiichthys murius* (Hamilton-Buchanan) 1822	Fairly common
146	*Eutropiichthys vacha* (Hamilton-Buchanan) 1822	Occasional
147	**Genus**: ***Pseudeutropius* Bleeker 1862** *Pseudeutropius atherinoids* Bloch 1794	Occasional
148	*Pseudeutropius murius batarensis* Sherstha 1981	Uncommon
	Genus: ***Silonia* Swainson**	

	1839	
149	*Silonia silondia* (Hamilton-Buchanan) 1822	Occasional
	Family: Pangasiidae **Genus: *Pangasius* Valenciennes 1840**	
150	*Pangasius pangasius* (Hamilton-Buchanan) 1822	Fairly common
	Family: Sisoridae **Genus: *Bagarius* Bleeker 1853**	
151	*Bagarius bagarius* (Hamilton-Buchanan) 1822	Fairly common
152	*Bagarius yarrellii* Sykes 1841	Vulnerable
	Genus: Conta Hora 1950	
153	*Conta conta* (Hamilton-Buchanan) 1822	Insufficiently known
	Genus: *Erethistes* Mullar and Troschel 1845	
154	*Erethistes pussilus* Mullar and Troschel 1845	Insufficiently known
	Genus: *Erethistoides* Hora 1950	
155	*Erethistoides ascita* Ng and Edds 2005	Uncommon
156	*Erethistoides cavatura* Ng and Edds 2005	Insufficiently known
157	*Erethistoides montana* Hora 1950	Uncommon
	Genus: *Euchiloglanis* Regan 1907	
158	*Euchiloglanis hodgartii* (Hora) 1923	Rare
	Genus: *Gagata* Bleeker 1858	
160	*Gagata gagata* (Hamilton-Buchanan) 1822	Fairly common
161	*Gagata sexualis* Tilak 1970	Uncommon
	Genus: *Coraglanis* Hora and Silas 1952	
162	*Coraglanis kishinouyei* (Kimura) Datta 1962	Rare
	Genus: *Myersglanis* Hora and Silas 1952	
163	*Myersglanis blythi* (Day) 1852	Rare
	Genus: *Exostoma* Blyth 1822	
164	*Exostoma labiatum* (McClelland) 1839	Rare
	Genus: *Glyptosternon* McClelland 1842	
165	*Glyptosternon maculatum* (Regan) 1905	Uncommon
166	*Glyptosternon reliculatum* (McClelland) 1839	Uncommon
	Genus: *Glyptothorax* Blyth 1861	
167	*Glyptothorax alaknandi* Tilak 1969	Insufficiently known
168	*Glyptothorax annandalei* Hora 1923	Rare
169	*Glyptothorax botius* (Hamilton-Buchanan) 1822	Rare
170	*Glyptothorax cavia* (Hamilton-Buchanan) 1822	Rare
171	*Glyptothorax conirostre* (Steindachner) 1867	Insufficiently known
172	*Glyptothorax garhwali* Tilak	Insufficie

	1969	ntly known
173	*Glyptothorax gracile* (Gunther) 1864	Insufficiently known
174	*Glyptothorax indicus* Talwar and Jhingran 1991	Rare
175	*Glyptothorax kashmirensis* Hora 1923	Insufficiently known
176	*Glyptothorax pectinopterus* (McClelland) 1839	Fairly common
177	*Glyptothorax telchilta* (Hamilton-Buchanan) 1822	Rare
178	*Glyptothorax trilineatus* Blyth 1860	Rare
179	**Genus**: ***Hara*** **Blyth 1860** *Hara hara* (Hamilton-Buchanan) 1822	Rare
180	*Hara jerdoni* Day 1870	Insufficiently known
181	**Genus**: ***Laguvia*** **Hora 1921** *Laguvia ribeiroi* Hora 1921	Rare
182	**Genus**: ***Pseudolaguvia*** **Misra 7976** *Pseudolaguvia kapuri* (Tilak and Husain) 1974	Rare
183	**Genus**: ***Nangra*** **Day 1877** *Nangra assamensis* Sen and Biswas 1994	Uncommon
184	*Nangra nangra* (Hamilton-Buchanan) 1822	Common
185	*Nangra viridescens* (Hamilton-Buchanan) 1822	Common
186	**Genus**: ***Pseudecheneis*** **Blyth 1860** *Pseudecheneis crassicauda* Ng	Uncomm
187	*Pseudecheneis eddsi* Ng 2006	Uncommon
188	*Pseudecheneis serracula* Ng and Edds 2005	Fairly common
189	**Genus**: ***Sisor*** **Hamilton-Buchanan 1822** *Sisor rhabdophorus* Hamilton-Buchanan 1822	Occasional
190	*Sisor rheophilus* Ng 2003	Uncommon
191	**Family: Olyridae** **Genus**: ***Olyra*** **McClelland 1842** *Olyra longicaudata* McClelland1842	Rare
192	**Family: Chacidae** **Genus**: ***Chaca*** **Gray 1831** *Chaca chaca* (Hamilton-Buchanan) 1822	Occasional
193	**Family: Heteropneustidae** **Genus**: ***Heteropneustes*** **Muller 1840** *Heteropneustes fossilis* (Bloch) 1785	Common
194	**Family: Clariidae** **Genus**: ***Clarias*** **Scopoli 1777** *Clarias batrachus* (Linnaeus) 1758	Common
195	**VI. ORDER: BELONIFORMES** **Suborder: Belonoidei** **Family: Belonidae** **Genus**: ***Xenentodon*** **Regan 1911** *Xenentodon cancila* (Hamilton-Buchanan) 1822	Common

196	**Suborder: ?** **Family: Hemiramphidae** **Genus: Hyporamphus** *Hyporamphus limbatus* (Valenciennes) 1846	Uncommon
197	**VII. ORDER: CYPRINODONTIFORMES** **Family: Poecilidae** **Sub family: Poecilinae** **Genus**: ***Gambusia*** **Poey 1854** *Gambusia affinis* (Baird and Girard) 1853	Insufficiently known
198	Family: Aplocheilidae **Sub family: Aplochelinae** **Genus**: ***Aplocheilus*** **McClelland 1839** *Aplocheilus panchax* (Hamilton-Buchanan) 1822	Insufficiently known
199	**VIII. ORDER: PERCIFORMES** **Sub order: Channoidei** **Family: Channidae** **Genus**: ***Channa*** **Scopoli 1777** *Channa barca* (Hamilton-Buchanan) 1822	Uncommon
200	*Channa orientalis* Bloch and Schneider 1801	Common
201	*Channa marulius* (Hamilton-Buchanan) 1822	Common
202	*Channa punctatus* (Bloch) 1793	Common
203	*Channa stewartii* (Playfair) 1867	Uncommon
204	*Channa striatus* (Bloch) 1793	Common
205	**Sub order: Percoidei** **Family: Chandidae (Ambassidae)** **Genus**: ***Chanda*** **Hamilton-Buchanan 1822** *Chanda nama (*Hamilton-Buchanan) 1822	Common
206	**Genus**: **Parambassis Bleeker 1874** *Parambassis baculis* (Hamilton-Buchanan) 1822	Uncommon
207	*Parambassis lala* (Hamilton-Buchanan) 1822	Rare
208	*Parambassis ranga* (Hamilton-Buchanan) 1822	Common
209	**Family: Sciaenidae** **Genus:** ***Daysciaena*** **Talwar** *Daysciaena albida (*Cuvier) 1844	Rare
210	**Genus**: ***Johnius*** **Bloch 1793** *Johnius coitor* (Hamilton-Buchanan) 1822	Rare
211	**Family: Nandidae** **Sub family: Badinae** **Genus**: ***Badis*** **Bleeker 1853** *Badis badis* (Hamilton-Buchanan) 1822	Common
212	**Sub family: Nandinae** **Genus**: ***Nandus*** **Valenciennes 1831** *Nandus nandus* (Hamilton-Buchanan) 1822	Common
	Sub order: Anabantoidei **Family: Anabantidae** **Genus**: ***Anabas*** **Cuvier 1816** *Anabas cobojius* (Hamilton-	

213	Buchanan) 1822	Uncommon
214	*Anabas testudineus* (Bloch) 1795	Common
215	**Family: Belontidae** **Sub family: Trichogasterinae** **Genus**: ***Colisa* Cuvier 1831** *Colisa fasciatus* (Schneider) 1801	Common
216	*Colisa lalia* (Hamilton-Buchanan) 1822	Uncommon
217	*Colisa sota* (Hamilton-Buchanan) 1822	Insufficiently known
218	**Sub family: Macropodinae** **Genus**: ***Ctenops* McClelland 1845** *Ctenops nobilis (*McClelland) 1845	Insufficiently known
219	**Sub order: Gobioidei** **Family: Gobiidae** **Genus**: ***Glossogobius* Gill 1839** *Glossogobius giuris* (Hamilton-Buchanan) 1822	Common
220	**Family: Gobioididae** **Genus: Brachyamblyopus** *Brachyamblyopus burmanicus* (Hora)	Rare
	IX. ORDER: SYNBRANCHIFORMES **Sub order: Synbranchoidei** **Family: Synbranchidae** **Sub family: Gobiinae** **Genus**: ***Monopterus* Lacepede 1800** *Monopterus cuchia* (Hamilton-	

222	**Sub order: Mastacembeloidei** **Family: Mastacembelidae** **Sub family: Mastacembelinae** **Genus**: ***Macrognathus* Lacepede 1800** *Macrognathus aral* (Bloch and Schneider) 1801	Common
223	*Macrognathus pancalus* Hamilton-Buchanan 1822	Common
224	*Macrognathus zebrinus* (Blyth)	Rare
225	**Genus**: *Mastacembelus* Scopoli 1777 *Mastacembelus armatus* (Lacepede) 1800	Common
226	**X. ORDER: MUGILIFORMES** **Family: Mugilidae** **Genus**: ***Sicamugil* Fowler1939** *Sicamugil cascasia* (Hamilton-Buchanan) 1822	Rare
227	**Genus**: *Rhinomugil* Gill 1863 *Rhinomugil corsula* (Hamilton-Buchanan) 1822	Rare
228	**XI. ORDER: TETRAODONTIFORMS** **Family: Tetraodontidae** **Sub family: Tetraodontinae** **Genus**: ***Tetraodon* Linnaeus 1758** *Tetraodon cutcutia* (Hamilton-Buchanan) 1822	Uncommon

Taxonomic Confusion in Fish Naming

While comparing the lists of fishes of Nepal presented by different authors, the following 20 species are under discussion as same species has been named by one or more authors with different names as follows.

1. *Cyclocheilichthys apogon* by T.K.S./ *Puntius apogon* by J.S.
2. *Nemacheilus elongates* (J.S.)/ *Physoclistura elongata* (T.K.S.) and / *Aborichthys elongates* (Rajbanshi)
3. *Rasbora daniconius* (J.S.)/ *Partuciosoma daniconius* (T.K.S.)
4. *Raimas bola* (T.K.S.)/ *Barilius bola* (J.S & Rajbanshi)
5. *Raimas guttatus* (T.K.S.)/ *Barilius guttatus* (J.S. & Rajbanshi)
6. *Schizogpye esocinus* (T.K.S.)/ *Schzothoraichthys esocinus* (J.S. & Rajbanshi)
7. *Schizothorax molesworthi*, *S. plagiostomus* (T.K.S.)/ *S.richardsonii* (J.S. & Rajbanshi)
8. *Schizothoraichthys nepalensis* (J.S. & Rajbanshi)/ *Schizothorax nepalensis* (T.K.S.)
9. *Schizothoraichtjys raraensis* (J.S. & Rajbanshi)/ *Schizothorax raraensis* (T.K.S.)
10. *Psilorhynchoids homaloptera* (J.S. & Rajbanshi)/ *Psilorhynchus homaloptera* (T.K.S.)
11. *Psilorhynchoids pseudecheneis* (J.S. & Rajbanshi)/ *Psilorhynchus pseudecheneis* (T.K.S.)
12. *Lepidocephalus menoni* (J.S. & Rajbanshi)/ *Lepidocephalichthys menomic* (T.K.S.)
13. *Acanto phthalmus pangio* (J.S. & Rajbanshi)/ *Pangio pangio* (T.K.S.)
14. *Pseudolaguvia kapuri* (J.S. & T.K.S.)/ *Laguvia kapuri* (Rajbanshi)
15. *Laguvia ribeiroi* (JS & Rajbanshi)/ *Pseudolaguvia ribeiror* (TKS)
16. *Pseudo ambasis baculis* (TKS)/ *Parambasis baculis* (JS & Rajbanshi)
17. *Parambasis lala* (Rajbanshi)/*Pseudoambasis lala* (TKS)
18. *Parambasis ranga* (JS & Rajbanshi)/ *Pseudoambasis ranga* (TKS)
19. *Colisa sota* (JS & Rajbanshi)/ *Polycanthus sota* (TKS)
20. *Semiplotus semiplotus* (JS & Rajbanshi)/ *Cyprinion semiplotus* (TKS)
    (Rajbanshi 2005, TK Shrestha 2008 for above references)

The species reported by only one author are *Schistura devdevi* by Shrestha J., *Carassius auratus* by Shrestha T.K. and *Barilius modestus* and *Lepidocephalus annandalei* by Rajbanshi K.G. Rajbanshi has deducted two species namely *Gudusia variagata* and *Neoanguilla nepalensis* (provisional) (sp.nov. Shrestha, 2008) from his list. Similarly *Pseudecheneis sulcatus* is also deducted from present list because according to Ng, Edds (2005b) *Pseudecheneis sulcatus* reported earlier from Nepal now has been splitted with three species viz. as *P. crassicauda*, *P. eddsi*, *P. serracula* as new species from Nepal and *P. sulcata* (*P. sulcatus*) (McClellard) is restricted to Brahmaputra drainage only.

Endemic Species of Nepal

With the reporting of some new species from Nepal by Ng and Edds (2004, 2005a & b), Ng (2006), Conway and Mayden (2008, 2010) and Conway et al. (2011), 15 species are categorized as endemic species, which are listed below in Table 2.

Table 2. Endemic species of Nepal

S.N.	Endemic species	Reported from
1	*Myersglanis blythi* (Day)	Seti, Bheri river
2	*Psilorhynchoides pseudecheneis* Menon and Datta	Dudhkoshi/Sunkoshi River
3	*Pseudeutropius murius batarensis* Shrestha	Trishuli river, Batar
4	*Batasio macronotus* Ng and Edds	Koshi river, Saptari
5	*Erethistoides ascita* Ng and Edds	Mechi river, Kankai
6	*Erethistoides cavatura* Ng. and Edds	Dhungre River, Chitwan
7	*Pseudecheneis crassicauda* Ng and Ed	Mewa Khola, Dhankuta
8	*Pseudecheneis eddsi* Ng	Seti River, Khairenitar
9	*Pseudecheneis serracula* Ng and Edds	Narayani, Mahakali and Seti River
10	*Schizotharaichthys macrophthalmus* (Terashima)	Rara lake
11	*Schizothoraichthys nepalensis* (Terashima)	Rara lake
12	*Schizothoraichthys raraensis* (Terashima).	Rara lake
13	*Pdilorhynchus nepalensis* Conway and Mayden	Seti River
14	*Balitora eddsi* Conway and Mayden	Geruwa River, Karnali
15	*Turcinoemacheilus himalaya*	Kyer Khola, Nararyanghat

Domestication and Aquaculture Prospects of Indigenous Species

To support livelihood of mountainous region, aquaculture plays a vital role and in spite of lack of appropriate farming technologies for most of indigenous fish species of Nepal, efforts to artificially propagation of some indigenous species have been already started. Indigenous fish under domestication are given in Table 3.

Table 3. Status of indigenous fish under domestication and captive breeding (source: Gubaju, NARC, 2008)

Species	**Status**	**Work place**
Tor putitora (Mahseer)	• Domesticated, seed production technology developed, under growth and production evaluation at different agro-ecoregion	• Fisheries Research Center, Pokhara (FRC); Fisheries Research Center (FRC), Trishuli; Kaligandaki Fish Hatchery (KGFH), Syanja; Institute of Agricultural And Animal Science (IAAS), Rampur
Tor tor (Mahseer)	• Under domestication (wild caught fish are being reared in ponds)	• KGFH, Syanja
Neolissocheilus hexagonolepis (Katle)	• Domesticated, seed production technology under verification	• FRC, Trishuli; KGFH, Syanja
Schizothorax plagiostomus or *Schizothorax richardsonii* (Buche asala)	• Domesticated, seed production technology developed, rearing trials with different diets are being carried out	• KGFH, Syanja • FRC, Trishuli; FRD, Godawari
Schizothoraichthys progastus (Chuche asala)	• Domesticated, seed production technology developed, rearing trials with different diets are being carried out	• FRC, Trishuli
Clarias batrachus (Magur)	• Domesticated, seed production and • nursing technology developed,	• FRC, Pokhara; RARS, Tarahara

	stock improvement initiated	
Labeo dero (Gardi)	• Domesticated, seed production and nursing technology developed, under growth and production evaluation	• KGFH, Syanja; FRC, Pokhara
Labeo pangusia (Hande)	• Seed produced from hatchery reared wild caught fish	• KGFH, Syanja
Labeo angra (Thed)	• Seed produced from hatchery reared wild caught fish	• KGFH, Syanja
Garra annandalei (Lahare)	• Seed produced from hatchery reared wild caught fish	• KGFH, Syanja
Garra gotyla (Buduna)	• Seed produced from hatchery reared wild caught fish	• KGFH, Syanja
Botia lohachata (Baghi)	• Seed produced from hatchery reared wild caught fish	• KGFH, Syanja
Bagarius yarelii (Goanch)	• Under domestication	• KGFH, Syanja
Chagunius chagunio (Rewa)	• Breeding success progenies under domestication	• KGFH, Syanja

Threat Status of Indigenous Fishes of Nepal

Attempt has been made to categorize the threat status of indigenous fishes of Nepal on the basis of their characters unit efforts by Shrestha, (1995, 2002); Gubaju (2008) adopted from Shrestha (1995), Shrestha (2008) and Dhital and Jha (2002). Wagle and Rayamajhi (unpublished) have given threat classification of 58 native fishes of Nepal with their threat category on the basis of review of published literatures. On the basis of the character unit efforts of the indigenous fishes of Nepal, their status accounts are shown in the following Table 4. Due consideration has been given for threat status improvement to those species which are endangered – vulnerable through domestication and captive breeding (Table 3).

Table 4. Threat status of indigenous fishes of Nepal

Upgrading threat status ↑

Threat status	Threat status number			Remarks
	Present	**Shrestha (2008)**	**Shrestha (1995)**	
C= Common	71	71	90	
FC= Fairly common	24			
UC = Uncommon	49	53		
O = Occasional	9			
R = Rare/ near threatened	36	27+32+23=82 (CDR+ PRO+R)	25	Shrestha (2008) has combined Th & R and mentioned R. CDR= Conservation Dependent and Rare PRO= Data Deficient Pristine Rare= Ik
V = Vulnerable	5	9	10	
E = Endangered	1	2 (*Tor tor & T. putitora)*	1	
Ik = Insufficiently known	33		61	
Total	228	217	187	

Indicator Species

Shrestha (1995) had recommended 10 species as the most important species with critical status in Nepal and listed in National Red Data Book of Nepal (Anonymous, 1995) for their legal protection. At present, five species of previous threatened status have been successfully bred in artificial environment. Other species of same status are also under domestication for further propagation (Table 3). Some recently discovered endemic species of insufficiently known status are also recommended in this list. Therefore, the present sixteen Indicator Indigenous Species (IIS) recommended for their legal protection are given in Table 5.

Table 5. Indicator species of Nepal

S.N	Scientific Name	Common Name	NRDB Code	Distribution
1	*Tor tor*	Sahar	E	Hills and mountainous rivers
2	*Brachydanio rerio*	Zebra	V, Domesticated	Kosi, Gandaki and Karnali rivers
3	*Schizothoraichthys macrophthalmus*	Chuchhe Asala	Endemic, Ik	Rara lake
4	*S. nepalensis*	Chuchhe Asala	Endemic, Ik	Rara lake
5	*S. raraensis*	Chuchhe Asala	Endemic, Ik	Rara lake
6	*Psilorhynchoides pseudecheneis*	Tite	Endemic, V	Dudhkoshi, Tinbu, Melamchi
7	*Anguilla bengalensis bengalensis*	Rajabam	V, Biological study	Plain to mountain rivers KGFH
8	*Balitora eddsi*	-	Endemic, Ik	Geruwa river karnali
9	*Batasio macronotus*	-	Endemic, Ik	Koshi river, Saptari
10	*Erethistoides ascita*	-	Endemic, UC/R	Mechi river Kankai
11	*E. cavatura*	-	Endemic, Ik	Dhungre river,Chitwan
12	*Psilorhynchus nepalensis*	-	Endemic, Ik	Seti river
13	*Myersglanis blythi*	Tilchapre	Endemic, R	Seti, Bheri, Tamor
14	*Bagarius yarrelli*	Gonch	Vulnerable	Koshi, kankai
15	*Barilius guttatus*	Jalkapoor	Vulnerable	Koshi river
16	*Turcinoemacheilus himalaya*	?	Rare, Endemic	Kyer khola Narayanghat

However, the leaflet on "Endangered wild life; Nepal's Threatened Animals in the IUCN Red List (1995, 2004), as well as Nepal's flora and fauna" in the current CITES list (2008) have not shown a single fish species of Nepal under alarming status.

Conservation Threats

Several conservation threats have been identified which have direct and indirect effects on the indigenous fishes of Nepal such as deforestation and siltation, chemical pollution, introduction of exotic species, hydraulic engineering and climate change.

Population of Nepal of 28.0 million with growth rate 2.08 % (CBS, 2006) has accelerated deforestation and conversion of steep slopes into agricultural land and road construction in the mountain and hill regions resulting heavy soil erosion. The melting of snow also causes heavy soil erosion (2400 million m^3 annually, Sharma, 1999). All these factors have direct and indirect effects on the damage of habitat, loss of food growth, injury and heavy mortality of fry, fingerlings and adult fish inhabiting in rivers, lakes and reservoirs of Nepal. Similarly, the chemical discharge from domestic and industrial sectors in Nepal is directly or indirectly thrown into the nearby water bodies without any pretreatment process. Domestic sewage contains solid (0.17%) with others of urine, soap, garbage, organic carbon (250 to 400 mg/L) and 12-80 mg/L total nitrogen. Similarly, industrial sewage has high concentration of organic matter and chemicals. Besides, the intensification of agricultural productivity, use of chemical fertilizers and pesticides have increased chemical toxicity. The total nitrogen, phosphorus and potassium use in agriculture field from 1964 to 2000 is increased from 590 t to 37250 t (Gubaju, 2008).

At present no heavy incidence of impact of exotic fish on indigenous species has been experienced in Nepal but cases of elimination and reduction of population of the indigenous species has been coming slowly from those water bodies where open water stocking of exotic fishes are practiced.

On the other hand, construction of dams for storing water is probably the most popular water control method. The formation of reservoir alters the lotic environment into lentic and creates dewater zones affecting the fish population. Besides, over and irrational fishing, use of small mesh sized nets, use of explosions, electro fishing and free assess to poison (herbal and chemical) are main conservation threats to fish diversity in general and such experience has also been observed in Narayani river (Chitwan (Dhital and Jha, 2002). In addition, Nepal is one of the vulnerable countries in relation to climate change impact in fisheries. Climate change has indicated rising in annual temperature by 0.06 ^oC annually with extreme events in recent years in Nepal. Increase in temperature will have biological effects by modifying the distribution of freshwater species, fish physiology, freshwater food webs increased risk of species invasion and spreading of vector born diseases and predators. Besides, extreme events like drought and floods will be increased in future. Such situation is predicted to have range of direct and indirect effects on fisheries sector (Gautam et al., 2011).

Impact on Indigenous Fishes of Nepal

The evidences of Impact on indigenous fishes of Nepal are summarized below.

Disappearance of indigenous fish species of Nepal

- From koshi river (Singh et al., 2009)
  - *Mystus monoda and Labeo gonius*
- From Kali Gandaki (Rayamajhi et.al, 2010)
  - *Bagarius bagarius, Botia lohachata, Labeo angra* from Mirmy upstream
  - *Cyprinion semiplotum, Labeo pangusia* from Beltari
- From Kulekhani (Swar, 1992)
  - *Garra lamta, Puntius ticto, Nemacheilus spp, Channa gachua, Glyptosternum spp,* and *Coraglanis sp.* (Swar, 1992)
  - *Schizothorax richardsonii* (reported earlier by FDC 2001) - completely disappeared (Saund and Shrestha, 2007)
- Impact of exotic species on Indigenous species

  a. From Kulekhani reservoir (Saund and Shrestha, 2007)
  - *Neolissocheilus hexagonolepis*- 2.4 % reduction
  - *Nazirator chelynoids* - 1.63 % reduction
  - *Mystus* and *Puntius* - 42 % reduction in Lake Begnas (Swar & Gurung, 1998) whereas
  - Bighead Carp and Silver Carp - 96.24 % increment

  b. From Kaligandaki and surroundings
  - From 57 species after construction of dam decreased to 12 species (Shrestha and Chaudhary, 2004) and 22 species (Rayamajhi et al., 2010)
- Cases of incidence of escaping of Exotic species in Natural waters
  - African Catfish - in Khokse khola, Tamor tribitary (Shrestha et al., 2009)
  - Rainbow Trout - in Sunkhosi (Personal communication)
  - African Catfish and Tilapia - introduced in Phewa Lake (Personal observation)

Conservation Strategy

Many conservation strategies are already existed and implemented in Nepal for conservation of indigenous fishes of Nepal. They are:

Legislation

Conservation of aquatic life is addressed by the Aquatic Animal Protection Act AAPA, 2017 BS (1961) and revised in 1999, which has been made as mandatory to prohibit the use of explosives or poisonous substances in any body of water where the intention is to catch or kill aquatic life. It also regulates fishing gears, size of the fish and season. Besides, there are certain other scattered legislations namely; National Parks and Wildlife Conservation Act (1973), Chitwan National Park Regulation (1974), Wildlife Reserves Regulation (1975), Himalayan Mountain National Park (1979), Khaptad National Park Regulation (1987) and Soil & Watershed Conservation Act (1982).

Environmental impact assessment (EIA)

After the implementation of the Nepal Environmental Policy and Action Plan (NEPAP), Nepal has introduced legal or institutional mechanisms for the use of EIA. Impact of development projects on aquatic life is thoroughly assed and several measures are taken to mitigate the adverse impact of a project. The establishment of a fish hatchery under Kali Gandaki 'A' hydropower project is an example of such measures.

Conclusions and Recommendation

There is a lack of fish diversity database exploring the fish species from different water bodies of Nepal. The establishment of an authentic institute dealing with fish nomenclature in Nepal where deposition of holotype and paratype, catolouging system for verification, comparison and revision is being felt necessary. Similarly there is the lack of data base for catch efforts to evaluate the threat status of indigenous species. Most of the natural water bodies in Nepal except in big cities are still intact and not much disturbed from biodiversity point of view. However, it is high time to monitor water quality, habitat characterization and impact of developmental activities on the natural water bodies to identify any critical fish hotspots in the country. For sustainable development and conservation of fish, participatory social mobilization of fisher community is very important.

Acknowledgement

My deep acknowledgment goes to Mr. Suresh K. Wagle, Mrs. Asha Raymajhi and Dr. Arun Baidhya of Fisheries Research Division, Godawari, NARC for their valuable suggestions and bringing it to publication.

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INDIGENOUS FISHES OF NEPAL AND THE NEED OF THEIR CONSERVATION FOR THEIR SUSTAINABLE DEVELOPMENT

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ABSTRACTS

The varied climatic conditions and altitudinal and ecological variation has made Nepal a "hot spot" to naturalists for studying its flora and fauna including the fish. The first ever report on fish of Nepal dates back to 1793, however, the first scientific report dates to 1822. Since then the fish fauna of Nepal has been studied by a number of European and Indian Biologists / Ichthyologists though Nepal was not open to all. After 1951 with the establishment of developmental and academic institutions the study of fish fauna has been expedited. The updated list of fish fauna stands at 227 fish species representing 103 genera, 34 family and 11 orders. The fish fauna exhibit very diverse distribution vertically within the country as well as horizontally in the region and continent. Out of the recorded indigenous fishes 18 fish are known as single species to their genus, 10 genera are mono-generic and 7 family as single family of the respective order. Three food valued economically important fish have been used in fish culture / aquaculture for the economic use while some of the other fish are under study. So far no relict fish species has been reported, however, 14 fish has been recorded as endemic fish. The modernization, developmental works as well as non-conventional fishing have put the inland water under stress and have threatened the indigenous fishes. So far, no fish has been listed officially as protected or vulnerable or endangered list. However, there is consensus on depletion of fish population in the country. The present climatic change poses serious threat to many indigenous fishes. The factor needs to be corrected or minimized with effective enforcement of prevailing Act, law and rules geared with well exercised conservation plan or else a list of threatened or endangered fish species from the waters of Nepal will come into existence in the near future.

Key Words: *Ichthyologists, conservation, endangered, endemic, threatened*

Introduction

The climatic, altitude as well as ecological variation of Nepal has made it an interesting and curious to the Naturalists for studying its flora and fauna including

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fish. A number of Biologists and Ichthyologists remained involved in studying the fish fauna of the region. The fish fauna of the Himalayan Region besides the territory of Nepal have been studied in greater extent during the British India as well as at later period by a number of Biologists / Ichthyologists of Europe, Pakistan and India. These records and reports are well documented in the form of reports and books while the Central or Nepal Himalayan Region within the political boundary of Nepal was not studied as then Nepal was not open to outer world. The lacks of development as well as absence of academic institutions were the primary cause for absence of such studies. After 1951, with the establishment of developmental and academic institutions in the country, the study of fish fauna and fisheries development was initiated which has established a limited data base on fish and fisheries.

Background

The first report on fish of Nepal dates back to 1793 made by Colonel Kirkpatrick. He reported a fish species from the River Rapti of Hetauda, Makawanpur district and three species from a stream – Tadi Khola (stream), a tributary of the River Trishuli, Nuwakot district while travelling from British India to Nepal in a political mission. However, the credit of first scientific report on fish fauna of Nepal goes to Hamilton (Dr. Francis Buchman Hamilton – a British Surgeon). He reported 24 fishes from the River Sapta Koshi after collecting the fishes from the Indian Territory along the border of Nepal and 2 species from the River Rapti in his splendid work "An Account of the Fish found in the River Ganges and its Branches" (Hamilton, 1822). Later in his second book "An Account of Kingdom of Nepal" he had reported two fish species from the River Tarayani (as per his book, most probably the mentioned river is River Narayani). In 19th Century besides Hamilton, a number of other Ichthyologists such as McClelland (1839), Gunther (1861), Beaven (1877) and Day (1878-81) have also studied and reported the fish fauna of Nepal. McClelland (1839), Beaven (1877) and Day (1878-81) have reported 2, 7 and 3 fish species respectively while Gunther (1861) has reported a total of 35 fish species after a thorough study of the collection of fish species and drawings made by the renowned collector of the Himalayan fauna Sir B. H. Hodgson, then the British Resident in Nepal from 1822 – 44. Regan (1907) studied seven fish species sent by Dr. N. Annandale, India, out of which five fish species were reported from Nepal which included not only a new species to the country but also to science. The fish samples were collected by Mr. R. Hodgart for Indian Museum with the support of Major J. Manners-Smith, then the Resident in Nepal in 1906. Similarly Dr. Hora also made effort in studying the fish fauna of Nepal on the collection of Colonel F. M. Bailey, Resident of British Legation in Nepal and reported 21 fish species under

14 genera and 5 families (Hora, 1937a &b). Thus the studies on fish fauna of Nepal have been either made by the member of political mission to Nepal or the collected samples by the European and Indian Biologists / Ichthyologists. These observations and studies made were either confined particularly along the trek route to Kathmandu from Indian border or small areas of Kathmandu valley and adjacent areas of Kathmandu due to restrictions of movement to a foreigner. For the first time Indian Ichthyologist Menon (1949) made a detail study of River Koshi of Eastern Nepal and reported a list of 52 fish species.

After fifties only, long list of fish fauna of Nepal was reported by Taft (1955) and Dewitt (1962). Mostly the studies on fish fauna were made either on particular drainage / river (s) or for the development of fish and fisheries. Later, more studies on the fish fauna of Nepal have been carried out by a number of international Biologists / Ichthyologists as well as nationals e.g.; Menon (1962), Menon & Datta (1984), Thapa & Rajbanshi (1968), Majpuria & Shrestha (1968), Bhatt *et al.* (1970), Atkinson (1974), Shrestha (1978), Shrestha et. al (1979, Ferro & Badgami (1980), McGladdery et. al. (1980), Robert (1980 & 82, Jayaram (1981). With the development of fish culture activities in the country, a number of exotic fishes having high culture and economic valued were introduced in culture practice for higher economic benefit. The first compilation of fish fauna of Nepal for a period of 1793 -1982 was published and the compilation recorded a total of 171 fish species of which 164 fish species as indigenous and the rest 7 exotic fish species introduced for commercial use (Rajbanshi, 1982).

In later days, many more studies were made on fish fauna of Nepal e.g.; Terashima (1984), Edds (1985 & 86), Mahato (1985), Jha & Shrestha (1986), New Era (1987), Jha et. al. (1989), Kadga (1989), Shrestha (1990 & 91), Talwar & Jhingran (1991), Shah et. al (1992), Karna (1993), Smith et. al (1993), The Mountain Institute (1995), Subba & Ghosh (1996), Bhagat (1998), Jayaram (1999), Menon (1999), Yadab (2001), Dhital & Jha (2001), Ranjit (2001), Rajbanshi (2001), Shrestha (2001), Hall et. al. (2001) and Ng & Edds (2004, 05 and 06). Besides these studies, a number of Environment Impact Assessment (EIA) studies on a number of hydroelectric projects on various water bodies have been made e. g.; Anonymous (1997), Shrestha & Swar (1998), Thakur (1998), Shrestha et. al. (1998), Swar (1997, 98 & 98), Shrestha (1999), Rai (2000) and Karki (2000) and has added a number of new records of fish in the country's account.

Shrestha (1994) has reported a total of 188 fish species out of which 179 indigenous and 9 exotic fish species. She has further reported a total of 185 fish species in her paper "Enumeration of the Fishes of Nepal" under Bio-diversity Profile Project (Shrestha, 1995). Shrestha (1995) recorded a total of 183 fish species out of which 173 indigenous and 10 exotic fish species. Shrestha (2001) has made "Taxonomic Revision of Fishes of Nepal" and has reported 182 fish species however this paper on taxonomic revision has included 2 exotic fish species. Gurung et. al. (2003) have reported the presence of 186 fish species in their paper "Aquatic bio-diversity of the Himalayan Kingdom of Nepal" including 10 exotic fish species. After a compilation of old as well as new reports and records, a total of 187 indigenous fish species has been reported in a paper "Review on Current Taxonomic Status and Diversity of Fishes of Nepal" (Rajbanshi, 2005). In addition to above works, recently, a number of new reports have been published which has added remarkably more new records and new species of fish not only in the country's account but to the science too (Ng, 2006), (Ng & Edds, 2007), Shrestha (2008) and Conway & Mayden (2008 & 10). In view of all these works, this paper aims to update the database of valued indigenous fish species of Nepal so that the indigenous fishes are promoted as well as conserved for sustainable development in the country.

Updated List of Indigenous fish

Superclass - Gnathostomata
Class - Actinopterygii
Sub-class - Neopterygii
Division - Teleostei

Order	Family	Genus	Species
1.Osteoglossiformes	1. Notopteridae	1. *Notopterus* **Lecepede**	01. *Notopterus notopterus* (Pallas)
		2. *Chitala* **Hamilton**	02. *Chitala chitala*[1] (Hamilton)
2. Anguilliformes	2. Anguillidae	3. *Anguila* **Schrank**	03. *Anguilla bengalensis bengalensis* (Gray & Hardwicke)
		4. *Neoanguilla*	04. *Neoanguilla nepalensis* sp. nov[2]
	3. Moringuidae	5. *Moringua* **Gray**	05. *Moringua raitaborua* (Hamilton)
3. Clupeiformes	4. Clupeidae	6. *Gudusia* **Flowler**	06. *Gudusia chapra*[3] (Hamilton)

[1] Synonymous to *Mystus chitala* Hamilton-1822, *Notopterus chitala* Day-1878
[2] New species has been proposed and approval is awaited, so it has been listed but not counted
[3]. Synonymous to *Clupea chapara* Gunther-1886, *Clupea suhia* Chaudhuri-1912, *G. godanahiai* Srivastava-1968

			07. *G. variegate*[4] (Day)
	5. Engraulidae	7. *Setipinna* **Swainson**	08. *Setipinna phasa* (Hamilton)
4. Cypriniformes	6. Cyprinidae	8. *Securicula* **Gunther**	09. *Securicula gora*[5] (Hamilton)
		9. *Salmostoma* **Swainson**	10. *Salmostoma acinaces*[6] (Valenciennes)
			11. *S. bacaila*[7] (Hamilton)
			12. *S. phulo phulo*[8] (Hamilton)
		10. *Aspidoparia* **Heckel**	13. *Aspidoparia jaya* (Hamilton)
			14. *A. morar* (Hamilton
		11. *Barilius* **Hamilton**	15. *Barilius barila* (Hamilton)
			16. *B. barna* (Hamilton)
			17. *B. bendelisis* (Hamilton)
			18. *B. radiolatus* Gunther
			19. *B. shacra* (Hamilton)
			20. *B. tileo*[9] (Hamilton)
			21. *B. vagra vagra* (Hamilton)
			22. *B. modestus* (Day)
			23. *B. bola*[10] (Hamilton)
			24. *B guttatus* [11] (Day)
		12. *Chela* **Hamilton**	25. *Chela cachius* (Hamilton)
			26. *C. laubuca*[12] (Hamilton)
		13. *Esomus* **Swainson**	27. *Esomus danricus* (Hamilton)
		14. *Danio* **Hamilton**	28. *Danio aequipinna*

[4] Talwar & Jhingran (1991), Shrestha (1995), Nelson (2006), Rema Devi & Indra none of them have mentioned this species. Menon (1985, 1999) has synonymized this species to *Gudusia chapara* , however Jayaram (1999) alone has mentioned this species. This species need further study therefore, it has not been counted in this paper though it has been included in the list

[5] Synonymous to *Cyprinus gora* Hamilton-1822, *Chela gora* Gunther-1868, *Oxygaster gora* Motwani & David-1957

[6] Synonymous to *Chela argentea* Day-1867, *Oxygaster argentea* Rajan-1955

[7] Synonymous *to Cyprinus bacaila* Hamilton-1822, *Opsarius bacaila* McClelland-1842, *Chela bacaila* Gunther 1868, *Oxygaster bacaila* Chagan & Ramkrishan-1953

[8] Synonymous to *Cyprinus phulo* Hamilton-1822, *Chela phulo* Gunther-1868

[9] Synonymous to *Cyprinus tileo* Hamilton-1822, *Barilius menoni* Sen – Talwar & Jhingran-1991, *Opsarias tileo* Ng & Edds-2007

[10] Synonymous to *Cyprinus bola* Hamilton-1822, *Raiamas bola* Day-1878, *Barilius* (*Opsarias) bola* Hora-1935, *Raiamas bola* Jordan, *Barilius jalkapoorei* Shrestha-1981, *Opsarias bola* Ng & Edds-2007

[11] Synonymous to *Opsarius guttatus* Day-1869, *Raiamas guttatus* Day-1878

[12] Synonymous to *Cyprinus labuca* Hamilton-1822, *Laubuca laubuca* Shaw & Shebbeare- 1937

		(McClelland)
		29. *D. dangila* (Hamilton) 30. *D. devario* (Hamilto)
	15. *Brachydanio* **Weber & Beaufort**	31. *Brachydanio rerio*[13] (Hamilton)
	16. *Rasbora* **Bleeker**	32. *Rasbora daniconius*[14] (Hamilton)
	17. *Bengana* **Gray**	33. *Bengana elanga*[15] (Hamilton)
	18.*Anblypharyngodon* **Bleeker**	34 .*Amblypharyngodon mola* (Hamilton)
		35. A. microlepis (Bleeker)
	19. *Tor* **Gray**	36. *Tor putitora*[16] (Hamilton)
		37. *T. tor* (Hamilton)
		38. *Tor mosal*[17] (Hamilton)
	20. *Naziritor* **Mirza and Javed**	39. *Naziritor chelynoides*[18] (McClelland)
	21. *Neolissochilus* **Rainboth**	40. *Neolissochilus hexagonolepis*[19](McClelland)
	22. *Osteobrama* **Heckel**	41. *Osteobrama cotio cotio*[20] (Hamilton)
		42. *O. neilli*[21] (Day)
	23. *Cyclocheilichthys* **Bleeker**	43. *Cyclocheilichthys apogon*[22] (Valenciennes)
	24. *Chagunius* **Smith**	44. *Chagunius chagunio*[23] (Hamilton)

[13] Synonymous to *Cyprinus rerio* Hamilton-1822, *Barilius rerio* Gunther-1868, *Danio rerio* Day-1878, *Danio (Brachydanio) rerio* Hora & Mukherjee-1936

[14] Synonymous to *Cyprinus daniconius* Hamilton-1822, *Parluciosoma daniconius* Howes-1980

[15] Synonymous to Cyprinus elanga Hamilton-1822, *Rasbora elanga* Gunther-1868

[16] Synonymous to *Cyprinus putitora* Hamilton-1822, *Barbus tor* Day-1878, *Barbus* (*Tor*) *putitora* Hora-1949

[17] Menon (1999) has not described as a species and has synonymies to *Tor tor* however Valenciennes-1842, Hora- 1941, Tilak & Sharma- 1982, Jayaram- 1999 have described it as a separate species. The author has also observed in River Koshi.

[18] Synonymous to *Barbus chilinoides* Day-1889, *Puntius chilinoides* Tandon- 1980, *Tor chilinoides* Baloni & Grover-1982, *Tor chelynoides* Talwar & Jhingran-1991,

[19] Synonymous to *Barbus hexagonolepis* McClelland-1839, *Barbus haxaticus* Chaudhuri-1913, *Barbus* (*Lissocheilus*) *dukai* Shaw & Shebbeare- 1937, *Barbus* (*Lissocheilus*) *hexagonolepis* Hora-1940, *Acrossocheilus hexagonolepis* Misra-1959

[20] Synonymous to *Rohtee cotio* Day-1878, *Osteobrama cotio* Shrestha-1981

[21] Synonymous to *Rohtee neilli* Day-1873

[22] Synonymous to *Puntius apogon* Cuvier & Valenciennes-1844

	25. *Oreichthys* **Smith**	45. *Oreichthys cosuatis*[24] (Hamilton)
	26. *Puntius* **Hamilton**	46. *Puntius chola*[25] (Hamilton)
		47. *P. conchonius* (Hamilton)
		48. *P. gelius* (Hamilton)
		49. *P. guganio* (Hamilton)
		50. *P. phutunio* (Hamilton)
		51. *P. sophore*[26](Hamilton)
		52. *P. ticto*[27](Hamilton)
		53. *P. clavatus clavatas* (McClalland)
		54. *P. sarana sarana*[28] (Hamilton)
		55. *P. terio* (Hamilton)
	27. *Semiplotus* **Bleeker**	56. *Semiplotus semiplotus*[29] (McClelland)
	28. *Cirrhinus* **Oken**	57. *Cirrhinus mrigala* (Hamilton)
		58. *Cirrhinis reba* (Hamilton)
	29. *Catla* **Valenciennes**	59. *Catla catla* (Hamilton)
	30. *Labeo* **Cuvier**	60. *Labeo angra* (Hamilton)
		61. *L. bata*[30] (Hamilton)
		62. *L. boga* (Hamilton)
		63. *L. calbasu* (Hamilton)
		64. *L. dero*[31] (Hamilton)
		65. *L. fimbriatus* (Bloch)
		66. *L. gonius* (Hamilton)
		67. *L.pangusia* (Hamilton)
		68. *L. rohita* (Hamilton)

[23] Synonymous to *Cyprinus chagunio* Hamilton-1822, *Rohita chagunio* Valenciennes-1842, *Barbus chagunio* Bleeker-1853, *Puntius chagunio* Hora-1949

[24] Synonymous to *Cyprinus casuatis* Hamilton-1822, *Barbus casuatis* Gunther-1868

[25] Synonimous to *Cyprinus chola* Hamilton-1822, *Barbus titius* Gunther-1868, *Barbus tetrarupagus* Day-1878, *Puntius titius* Shrestha-1981

[26] Synonymous to *Barbus stigma* Day- Menon-1999

[27] Synonymous to *Cyprinus ticto* Hamilton-1822, *Barbus ticto* Gunther-1868

[28] Synonymous to *Cyprinus sarana* Hamilton-1822, *Barbus sarana* Valenciennes-1842, *Barbus* (*Puntius*) *sarana* Hora-1949, *Puntius sarana sarana* Menon-1963

[29] Synoymous to *Cyprinion semiplotus* (McClelland) Menon-1999

[30] Synonymous to *Labeo lissorhynchus* McClelland-1839, *Crossocheilus bata* Day-1869

[31] Synonymous to *Labeo sindensis* Day-1878, *Labeo diplostomus* Day-1878, *Labeo almorhae* Chaudhuri-1912, *Labeo dyocheilus* Mukherjee-1934, *Bangana dero* Ng &Edds-2007

		69. *L. caeruleus* (Day)
		70. *L dyocheilus dyocheilus* (McClelland)
	31. *Schismatorhynchus* **Bleeker**	71. *Schismatorhynchus (Nukta) nukta* [32](Sykes)
	32. *Schizothorax* **Heckel**	72. *Schizothorax richardsonii*[33] (Gray)
		73. *S. sinuatus* (Heckel)
	33. *Schizothoraichthys* **Misra**	74. *Schizothoraichthys curvifrons* (Heckel)
		75. *S. esocinus*[34] (Heckel)
		76. *S. niger*[35] *(*Heckel)
		77. *S. labiatus*[36](McClelland)
		78. *S. progastus*[37] (McClelland)
		79. *S. macrophthalmus* (Terashima)
		80. *S. nepalensis* (Terashima)
		81. *S. raraensis* (Terashima)
	34. *Dipticus* **Steindachner**	82. *Dipticus maculates* Steindachner
	35. *Crossocheilus* **Van Hasselt**	83. *Crossocheilus latius latius*[38] (Hamilton)
	36. *Garra* **Hamilton**	84. *Garra annandalei* (Hora)
		85. *G. gotyla gotyla*[39] (Gray)
		86. *G. lamta* (Hamilton)
		87. *G. lissorhynchus*[40] (McClelland)
		88. *G. mullya* (Sykes)

[32] Synonymous to *Labeo nukta* Day-1872
[33] Synonymous to *Cyprinus richardsoni* Gray-1832, *Schizothorax plagiostomus* Heckel-1838, *Schizothorax / Oreinus guttatus* McClelland-1839, *Oreinus richardsoni* McClelland-1838 *Dipticus annandalei* Regan-1907, *Oreinus molesworthi* Chaudhuri-1913
[34] Synonymous to *Schizopyge esocinus* (Heckel) Mirza-1988, *Schizothorax esocinus* (Heckel) Menon-1999
[35] Synonymous to *Schizothorax niger* (Heckel) Menon-1999
[36] Synonymous to *Schizothorax labiatus* McClelland-1842, *Recoma labiata* McClelland Menon-1999
[37] Synonymous to *Oreinus hodgsonii* Gunther-1861, *Schizothorax progastus* Day-1877, *Schizopyge progastus* Jayaram-1981, *Recoma progasta* (McClelland) Menon-1999
[38] synonymous to *Crossocheilus latius* Gunther- 1868
[39] Synonymous to *Discognathus lamta* Day-1872, *Garra gotyla* Hora -1935,
[40] Synonymous to *Discognathus jerdoni* Day-1878, *Discognathus modestus* Day-1877

			89. *G. nasuta* (McClelland)
			90. *G. rupecula* (McClelland)
	7. Psilorhynchidae	37. *Psilorhynchus* **McClelland**	91. *Psilorhynchus balitor* (Hamilton)
			92. *P. sucatio* (Hamilton)
			93. *P. gracilis* Rainboth
			94. *P.nepalensis* sp. (nov. Conway & Mayden)
		38. *Psilorhynchoides* **Yazdani, Singh & Rao**	95. *Psilorhynchoides homaloptera*[41](Hora & Mukherji)
			96. *P. pseudecheneis*[42] (Menon & Datta)
	8. Balitoridae	39. *Homaloptera* **Van Hasselt**	97. *Homaloptera bilineata* (Blyth)
		40. *Balitora* **Gray**	98. *Balitora brucei* (Gray)
			99. *B.* eddsi sp. (nov Conway & Mayden)
		41. *Acanthocobitis* **Peters**	100. *Acanthocobitis botia*[43] (Hamilton)
		42. *Nemacheilus* **Bleeker**	101. *Nemacheilus corica*[44](Hamilton)
		43. *Schistura* **McClelland**	102. *Schistura beavani*[45] Gumther
			103. *S. devdevi*[46](Hora)
			103. *S. devdevi*[47](Hora)
			104. *S. multifaciatus*[48] (Day)
			104. *S. multifaciatus*[49] (Day)
			105. *Schistura rupecula rupecula*[50](McClelland)

[41] Synonymous to *Psilorhynchus homaloptera* Hora & Mukherji-1962
[42] Synonymous to *Psilorhynchus pseudecheneis* Menon & Datta -1961
[43] Synonymous to *Cobitis botia* Hamilton-1822, *Nemacheilus botia* Gunther -1889
[44] Synonymous to *Cobitis corica* Hamilton-1822, *Schistura punctata* McClelland-1839, *Noemacheilus corica* Hamilton 1822
43 Synonymous to *Noemacheilus beavani* Gunther-1868
[46] Synonymous to *Nemacheilus devdevi* Hora-1935
[47] Synonymous to *Nemacheilus devdevi* Hora-1935
[48] Synonymous to *Nemacheilus multifaciatus* Day-1878
[49] Synonymous to *Nemacheilus multifaciatus* Day-1878
[50] Synonymous to *Nemacheilus rupicola* Day-1878

			106. *S. rupecula inglishi*[51] (Hora)
			107. *S. savona* [52] (Hamilton)
			107. *S. savona* [53] (Hamilton)
			107. *S. savona* [54] (Hamilton)
			107. *S. savona* [55] (Hamilton)
			107. *S. savona* [56] (Hamilton)
			107. *S. savona* [57] (Hamilton)
			107. *S. savona* [58] (Hamilton)
			107. *S. savona* [59] (Hamilton)
			107. *S. savona* [60] (Hamilton)
			107. *S. savona* [61] (Hamilton)
			108. *S. scaturigina*[62] (McClelland)
			109. *S. sikamaiensis* (Hora)
			110. *S. pra*shadi (Hora)
			111. *S. horai* (Menon)
			112. *S. himachalensis* (Menon)
		44. *Aborichthys* **Chaudhuri**	113. *Aborichthys elongatus* (Hora)
	9. Cobitidae	45. *Botia* **Gray**	114. *Botia almorhae*[63] (Gray)
			115. *B. dario*[64] (Hamilton)
			116. *B. histrionica* (Blyth)
			117. *B. lohachata* (Chaudhuri)
			118. *B.* geto (Hamilton)
		46. *Neoeucirrhichthys*	119. *Neoeucirrhichthys maydelli*

[51] Menon (1987) has synonymies with *N. multifaciatus* Day but considered distinct species by Banarescu & Nalbant-1995
[52] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[53] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[54] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[55] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[56] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[57] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[58] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[59] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[60] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[61] Synonymous to *Cibitis savona* Hamilton -1822, *Nemacheilus savona* Gunther-1868
[62] Synonymous to *Cobitis scaturigina* McClelland-1839, *Nemacheilus scaturigina* Gunther-1868, *Nemacheilus shebbearei* Hora-1935
[63] Synonymous to *Botia lohachata* Chaudhuri-1912, *Botia dayi* Hora- 1932
[64] Synonymous *to Cobitis dario* Hamilton-1822

		Benarescu and Nalbant	(Banarescu and Nalbant)
		47. *Acantophthalmus* **Van Hasselt**	120. *Acantophthalmus pangio*[65] (Hamilton)
		48. *Semileptes* **Swainson**	121. *Semileptes gongota*[66](Hamilton)
		49. *Lepidocephalus* **Bleeker**	122. *Lepidocephalus annandalei*[67]Chaudhuri
			123. *L. guntea*[68](Hamilton)
			124. *L.* meno*ni*[69]Pillai & Yazdani
5. Siluriformes	10. Bagridae	50. *Rita* **Bleeker**	125. *Rita rita* (Hamilton)
		51. *Batasio* **Blyth**	126. *Batasio batasio*[70] (Hamilton)
			127. *Batasio tengana*[71] (Hamilton)
			128. *B. macronotus* sp.nov. Ng & Edds
		52. *Mystus* **Scopoli**	129. *Mystus bleekeri*[72](Day) *M. cavasius* [73](Hamilton)
			130. *M. cavasius* [74](Hamilton)
			131. *M. gulio*[75] (Hamilton)
			132. *M. menoda*[76] (Hamilton)
			133. *M. tengara*[77] (Hamilton)
			134. *M. vittatus* (Bloch)
		53. *Aorichthys* **Wu**	135. *Aorichthys aor*[78] (Hamilton)
			136. *A. seenghala*[79] (Sykes)

[65] Synonymous to *Pangio pangio* Hamilton(1822) Jayaram -1999
[66] Synonymous to *Cobitis gongota* Hamilton-1822
[67] Synonymous to *Lepidocephalichthys annandalei* Chaudhuri-1912
[68] Synonymous to *Cobitis guntea* Hamilton -1822, *Lepidocephalichthys guntea* Day-1868, *L. nepalensis* Shrestha-1981
[69] Synonymous *to Lepidocephalus goalparensis* Tilak & Hussain- 1981, *Lepidocephalichthys menoni* Pillai & Yazdani -1976
[70] Synonymous to *Pimelodus batasio* Hamilton-1822, *Macrones batasio* Gunther-1864, *Gagata batasio* Day-1877
[71] Synonymous to *Pimelodus tengana* Hamilton-1822, *Macrones tengana* Gunther-1864, *Macrones blythi* Day-1877
[72] Synonymous to *Macrones bleekeri* Day-1877
[73] Synonymous to *Pimelouds cavasius* Hamilton-1822, *Macrones cavasius* Day-1877
[74] Synonymous to *Pimelouds cavasius* Hamilton-1822, *Macrones cavasius* Day-1877
[75] Synonymous to *Pimelodus gulio* Hamilton -1822, *Macrones gulio* Day-1877
[76] Synonymous to *Pimelodus menoda* Hamilton-1822, *Macrones menoda* Day-1889
[77] Synonymous to *Pimelodus tengara* Hamilton-1822, *Macrones tengara* Day-1877
[78] Synonymous to *Pimelodus aor* Hamilton-1822, *Macrones aor* Day-1877, *Mystus aor* Hora -1937

	11. Siluridae	54. *Ompok* **Lacepede**	137. *Ompok bimaculatus* (Bloch)
			138. *O. pabda* (Hamilton)
			139. *O. pabo* (Hamilton)
		55. *Wallago* **Bleeker**	140. *Wallago attu* (Bloch & Schneider)
	12. Schlbeidae	56. *Ailia* **Gray**	141. *Ailia coila*[80] (Hamilton)
		57. *Pseudeutropius* **Bleeker**	142. *Pseudeutropius atherinoides* (Bloch)
			143. *P.murius batarensis* (Shrestha)
		58. *Clupisoma* **Swainson**	144. *Clupisoma garua*[81] (Hamilton)
			145. *C. montana* (Hora)
		59. *Eutropiichthys* **Bleeker**	146. *Eutropiichthys murius*[82] (Hamilton)
			147. *E. vacha* [83](Hamilton)
			148. *E. goongwaree* (Skyes)
		60. *Silonia* **Swainson**	149. *Silonia silondia* (Hamilton)
	13. Pangasiida	61. *Pangasius* **Valenciennes**	150. *Pangasius pangasius* (Hamilton)
	14. Amblycipitidae	62. *Amblyceps* **Blyth**	151. *Amblyceps mangois* (Hamilton)
	15. Sisoridae	63. Bagarius Bleeker	152. *Bagarius bagarius* (Hamilton)
			153. *B. yarrellii* (Skyes)
		64. *Gagata* **Bleeker**	154. *Gagata cenia* (Hamilton)
			155. *G. gagata* (Hamilton)
			156. *G. sexualis* (Tilak)
		65. *Nangra* **Day**	157. *Nangra nangra*[84] (Hamilton)
			158. *N. viridescens*[85] (Hamilton)

[79] Synonymous to *Macrones seenghala* Day-1877, *Mystus seenghala* Hora & Misra-1942, *Sperata seenghala* Edds
[80] Synonymous to *Ailia affinis* Gunther-1864, *Ailichthys punctata* Day-1871
[81] Synonymous to Silurus garua Hamilton-1822, *Pseudeutropius garua* Day-1877
[82] Synonymous to *Pimelodus murius* Hamilton-1822, *Pseudeutropius murius* Day-1877
[83] Synonymous to *Pimelodus vacha* Hamilton-1822
[84] Synonymous to *Pilelodus nangra* Hamilton-1822, *Macrones nangra* Day-1871, *Gagata nangra*, (Hamilton) Menon-199
[85] Synonymous to *Pimelodus viridescens* Hamilton-1822, *Gagata viridescens* (Hamilton) Menon-1999

		159. *N. assamensis* (Sen)
	66. *Erethistes* **Muller & Troschel**	160. *Erethistes pussilus* (Muller and Troschel)
	67. *Erethistoides* **Hora**	161. *Erethistoides montana montana* (Hora)
		162. *E. ascita* sp. (nov. Ng and Edds)
		163. *E. cavatura* sp. (nov. Ng and Edds)
	68. *Hara* **Blyth**	164. *Hara hara*[86] (Hamilton)
		165. *H. jerdoni* (Day)
	69. *Conta* **Hora**	166. *Conta conta* [87] (Hamilton)
	70. *Glyptosternom* **McClelland**	167. *Glyptosternon maculatum* (Regan)
		168. *G. reticulatum* (McClelland)
	71. *Laguvia* **Hora**	169. *Laguvia ribeiroi*[88] (Hora)
		170. *L.kapuri* [89] (Tilak and Hussain.)
	72. *Glyptothorax* **Blyth**	171. *Glyptothorax annandalei* Hora
		172. *G. cavia* [90] (Hamilton)
		173. *G.conirostris conirostae* (Steindacher)
		174. *G. gracile*[91] (Gunther)
		175. *G. indicus* [92] (Talwar and Jhingran)
		176. *Glyptothorax kashmirensis* (Hora)
		177. *G. pectinopterus*

[86] Synonymous to *Erethistes hara* Day-1877
[87] Synonymous to *Pimelodus conta* Hamilton-1822, *Hara elongate* Day-1871, *Erethistes elongate* Day-1877
[88] Synonymous to *Glyptothorax ribeiroi* Hora-1938
[89] Synonymous to *Laguvia rebeiroi kapuri* Tilak & Hussain-1974, Pseudolaguvia kapuri Misra-1976 (Ng & Edds-2005)
[90] Synonymous to *Pimelodus cavia* Hamilton-1822, *Euglyptosternum lineatum* Day-1877, *Glyptothorax lineatus* Hora-1923
[91] Synonymous to *Glyptosternum gracile* Gunther-1864
[92] *Glyptothorax indicus* Talwar nom. nov. for *G. horai* Shaw & Shebbeare

			[93](McClelland)
			178. *G.telchitta telchitta*[94] *(*Hamilton)
			179. *G trilineatus* (Blyth)
			180. *G. alaknandi* [95](Tilak)
			181. *G. garhwali* Tilak
			182. *G. botius* [96](Hamilton)
		73. *Euchiloglanis* **Regan**	183. *Euchiloglanis hodgartii*[97] (Hora)
		74. *Coraglanis* **Hora & Silas**	184. *Coraglanis kishinouyei*[98] (Kimura)
		75. *Myersglanis* **Hora & Silas**	185. *Myersglanis blythii* [99](Day)
		76. *Exostoma* **Blyth**	186. *Exostoma labiatus* (McClelland)
		77. *Pseudecheneis* **Blyth**	187. *Pseudecheneis* sulcatus [100] (McClelland)
			188. *P. crassicauda* sp. (nov. Ng and Edds)
			189. *P. serracula* sp. (nov. Ng and Edds)
			190. *P. eddsi* sp. (nov. Ng)
		78. *Sisor* **Hamilton**	191. *Sisor rhabdophorus* (Hamilton)
			192. *S. rheophilus* (Ng)
	16. Claridae	79. *Clarias* **Scopoli**	193. *Clarias batrachus* (Linnaeus)
	17. Heteropneustidae	80. *Heterpneustes* **Muller**	194. *Heteropneustes fossilis* (Bloch)

[93] Synonymous to *Glyptosternon pectinopterus* McClelland-1842
[94] Synonymous to *Pimelodus telchita* Hamilton-1822, *Glyptosternum botia* Day-1877
[95] This species was first described as a sub-species later it was elevated to species level by Talwar & Jhingran, 1991
[96] Talwar & Jhingran (1991) and Jayaram (!999) have not mentioned this species while Menon (1999) has synonymies to *Pimelodus botius* (Hamilton-1822), *Glyptosternum botia* Day-1877, *Glyptothorax telchitta* (Hamilton) however Rema Devi & Indra has mentioned as a species and later Edds & Ng (2007) has reported from River Koshi of Nepal
[97] Synonymous to *Glyptosternum hodgarti* Hora -1923
[98] Synonymous to *Euchiloglanis kishinouyei* Kimura -1934
[99] Synonymous to *Exostoma blythi* Day-1869, *Glyptosternum blythi* Hora-1923, *Euchiloglanis blythi* Norman-1925
[100] Synonymous to *Glyptosternon sulcatus* McClelland-1842

	18. Chacidae	81. *Chaca* **Gray**	195. *Chaca chaca*[101] (Hamilton)
	19. Olyridae	82. *Olyra* **McClelland**	196. *Olyra longicaudata* (McClelland)
6. Mugiliform es	20. Mugilidae	83. *Sicamugil* **Fowler**	197. *Sicamugil cascasia* [102] (Hamilton)
		84. *Rhinomugil* **Gill**	198. *Rhinomugil corsula* (Hamilton)
7. Beloniformes	21. Belonidae	85. *Xenentodon* **Regan**	199. *Xenentodon cancila* (Hamilton)
8. Cyprinodontiformes	23.Aplocheilidae	87. *Aplocheilus* **McClelland**	201. *Aplocheilus panchax*[103] (Hamilton)
9. Synbranchiformes	24.Synbranchidae	88. *Monopterus* **Lacepede**	202. *Monopterus cuchia*[104] (Hamilton)
	25.Mastacembeli	89. *Macrognathus* **Lecepede**	203. *Macrognathus aral* [105] (Bloch and Schneider)
			204. *M. pancalus* Hamilton
			205. *M. zebrinus* (Blyth)
		90. *Mastacembelus* **Scopoli**	206. *Mastacembelus armatus* [106] (Lacepede)
10. Perciformes	26. Chandidae (Ambassidae)	91. *Chanda* **Hamilton**	207. *Chanda nama* [107] (Hamilton)
		92. *Parambassis* **Bleeker**	208. *Parambassis baculis* [108] (Hamilton)
			209. *P. ranga*[109] (Hamilton)
			210. *P. lala* (Hamilton) McClelland

[101] Synonymous to *Chaca lophioides* Valenciennes-1834
[102] Synonymous to *Mugil cascasia* Hamilton-1822
[103] Synonymous to *Esox panchax* Hamilton-1822, *Panchax panchax* Chaudhuri-1916
[104] Synonymous to *Amphipnous cuchia* Muller-1828
[105] Synonymous to *Rhynchobdella aral* Bloch & Schneider-1801, *Macrognathus aculeatus* Hamilton-1822
[106] Synonymous to *Macrognathus armatus* Lacepede-1800
[107] Synonymous to *Ambassis nama* Cuvier-1828
[108] Synonymous to *Chanda baculis* Hamilton-1822, *Ambassis baculis* Cuvier-1828, *Pseudambassis baculis* Talwar & Jhingran-1991
[109] Synonymous to *Chanda ranga* Hamilton-1822, *Ambassis ranga* Cuvier-1828, *Pseudambassis ranga* Talwar and Jhingran-1991

	27. Sciaenidae	93. *Johnius* **Bloch**	211. *Johnius coiter* [110] (Hamilton)
		94. *Daysciaena* **Talwar**	212. *Daysciaena albida* (Cuvier)
	28. Nandidae	95. *Badis* **Bleeker**	213. *Badis badis* (Hamilton)
		96. *Nandus* **Valenciennes**	214. *Nandus nandus* (Hamilton)
	29. Gobiidae	97. *Glossogobius* **Gill**	215. *Glossogobius giuris giuris* [111](Hamilton)
	30. Gobioididae	98. Brachyamblyopus **Bleeker**	216. *Brachyamblyopus burmanicus* (Hora)
	31. Anabantidae	99. *Anabas* **Cuvier**	217. *Anabas testudineus* (Bloch)
			218. *A. cobojius* (Hamilton)
	32. Belontidae	100. *Ctenops* **McClelland**	219. *Ctenops nobilis* (McClelland)
		101. *Colisa* **Cuvier**	220. *Colisa fasciatus* [112] (Schneider)
			221. *C. lalia* [113] (Hamilton)
			222. *C. sota* [114] (Hamilton)
	33. Channidae	102. *Channa* **Scopoli**	223. *Channa barca* (Hamilton)
			224. *C. marulius* (Hamilton)
			225. *C. orientalis* [115] (Bloch and Schneider)
			226. *C. punctatui* [116](Bloch)
			227. *C. stewartii* (Playfair)
			228. *C. striata* (Bloch)
11. Tetraodontiformes	34. Tetraodontidae	103. *Tetraodon* **Linnaeus**	229. *Tetraodon cutcutia* (Hamilton)

[110] Synonymous to *Sciaena coitor* Hamilton-1822
[111] Synonymous to *Gobius giuris* Hamilton-1822
[112] Synonymous to *Trichogaster fasciatus* Bloch and Schneider-1801, *Polyacanthus fasciatus* Cuvier-1831
[113] Synonymous to *Trichopodus lalius* Hamilton-1822, *Tricogaster lalius* Day-1877
[114] Synonymous to *Trichopodus sota* Hamilton -1822, *Trichogaster chuna* Day-1831
[115] Synonymous to *Ophiocephalus gachua* Hamilton-1822, *Channa gachua* Menon-1954
[116] Synonymous to *Ophiocephalus punctata* Bloch-1793, *Channa punctatus* Menon-1954

Discussion

The updated list of indigenous fish of Nepal has been listed a number of 229 fish species however 2 fish species serial number 04 and 07 need further confirmation from the author, therefore, the above mentioned two fish species have not been counted though listed in this paper. These indigenous fish fauna represent 103 Genera, 34 Family and 11 Order. In this updated list of fish fauna, a number of reported fish by Gunther (1861), Beaven (1876 – 77) and Day (1878 - 81) has also been not included due to very little information on their type, locality and taxonomic characteristic features. Out of the updated list of indigenous fishes, Family - Cyprinidae stands as a dominant group representing 81 fish species while the Family- Sisoridae and Balitoridae stand as second and third dominant group respectively representing 41 and 17 fish species. The indigenous fish exhibit very diverse distribution vertically within the country ranging from 60 m above sea level to highest altitude of 3,323 meter above sea level (Langtang Khola of mid-Nepal) as well as horizontally in the region and beyond. Out of the listed fishes, there are 18 fish species which are known as only species known so far to their genus, 10 Genera as mono-generic and 7 Families as single family of their respective Orders. These indigenous fishes exhibit a distinct migratory habit for feeding as well as for breeding purposes. The distance of migration, vary from species to species and also as per the purpose. On completion of the purpose, these fishes again come back to their original places. Amongst the indigenous fish there are a large number of fish of high economic value in the form of food fish, sportive fish and decorative fish. Some of the food valued fish under Genera *Labeo*, *Catla* and *Cirrhina* are being widely used in different practices of fish culture or aquaculture along with other food valued exotic fishes introduced for economic use while some of the sportive and decorative fishes are under study for their economic use. These fishes exhibit very high diversity in all three levels. After comprehensive study on the Hodgson's collection, Gunther (1861) had also concluded on the bio-diversity of fish fauna of Nepal as "The streams and rivers of Nepal must be inhabited by a wonderful varie ty of genetic and species forms". The available information on distribution of indigenous fish fauna is still considered as meager as no specific study of many rivers, water bodies of remote areas and high altitude has not been carried out from any corner.

Relict and endemic fish species

So far no relict fish species has been reported from the water of Nepal however, a compilation of studies so far made and reports published on fishes of Nepal totals a total of 14 fish species as endemic in the country's account.

Shrestha (1995) had reported a total of 8 endemic fish while in 1999 she reported only 6 endemic fish from the water of Nepal while Rajbanshi (2001) reported 7 endemic fish species from the cold water regime. However, the second author had emphasized on the need of further study on the subject. No doubt, in absence of nationwide systematic survey of fish fauna, it remains very difficult task to establish a definite number of endemic fish species. Considering the recent publications of different authors e. g.; Ng & Edds (2004 & 2005), Ng (2006) and Conway & Mayden (2008 & 10) the scenario of the endemic fish species has increased into a number of 14 fish species in the account of Nepal is shown in Table 1.

Table 1. Updated list of endemic fish

Fish Species	Author	Year	Water body /Location
1. *Myersglanis blythii* (Day)	Jayaram	1991	Pharping-Kathmandu Valley
2. *Psilorhynchus pseudechenies*	Menon and Datta	1962	River Dudh Koshi
3. *P. nepalensis* sp. nov.	Conway and Mayden	2008	River Rapti, R. Seti, R. Narayani
4. *Pseudeutropius murius batarensis*	Shrestha	1981	Batar, Trushuli
5. *Schizothoraichthys macropthalmus*	Terashima	1984	Mahendra (Rara)Lake
6. S. *nepalensis*	Terashima	1984	Mahendra (Rara)Lake
7. *S. raraensis*	Terashima	1984	Mahendra (Rara)Lake
8. *Batasio macronotus* sp. nov.	Ng and Edds	2005	River Sapta Koshi
9. *Pseudecheneis crassicaudata* sp. nov	Ng and Edds	2005	Mewa Khola (R. Tamor)
10. *P. serracula* sp. nov.	Ng and Edds	2005	R. Seti, R. Kali Gandaki, R. Narayani, R. Mahakali, R. Karnali
11. *P. eddsi* sp. nov	Ng	2006	Mahesh Khola, R. Trishuli
12. *Erethistoides ascita* sp. nov.	Ng and Edds	2005	R. Mechi, R. Kankai, R. Trijuga, R. Koshi
13. *E. cavatura* sp. nov.*	Ng and Edds	2005	River Dhungra, R. Rapti, R. Narayani
14. *Balitora eddsi* sp. nov.	Conway and Mayden	2010	R. Karnali

Shrestha (2008) has proposed a new fish species *Neoanguilla nepalensis* sp. nov (Serial Number – 04) from Chitwan which is in process of approval therefore the above said fish has been listed in fish species however it has not counted yet. On receiving the approval it will be enlisted as 15 endemic fish from the water of Nepal.

Status of fish species

Out of the indigenous fishes, a number of fish species are of high economic, academic and decorative value. But with the modernization, the increased developmental works (e.g.; construction of hydropower and irrigation projects), industrialization, urbanization, deforestation, landslides and siltation, increasing sewerage and excessive use of chemical with the modernization of agriculture the inland waters have been subjected to a range of stress and along with the non-conventional method of fishing e. g.; poisoning, dynamiting and electro- fishing has further lead in threatening the indigenous fishes. So far no specific study has been undertaken to look into the issue in depth, therefore, no fish species has been listed officially as protected or vulnerable or endangered by the government nor CITIS has listed any. However, various national researchers have expressed their different views time and again for example Chaudhary (1994) has identified 1 fish species as threatened and 2 fish species as endangered. Shrestha (1995) has not listed any fish under threat in her book but under the Bio-diversity Profile Project she has enlisted 34 fish species as threatened species (Shrestha, 1995). Shrestha (1998 & 2001) has described one fish species as endangered while 9 fish species as vulnerable and has asked for legal protection. A study on "Conservation Status of the Inland Fish Fauna of Nepal" has not reported any fish under threat or alarm condition. However, the author endorses the general view on sharp depletion of the fish population in many water bodies especially around densely populated areas and nearby development projects (Rajbanshi, 1996). The degradation of environment, increased industrial activities with free access to drain the industrial waste in free water, increasing construction of hydropower and irrigation projects without any provision of aquatic animal's movement, introduction of exotic fish and indiscriminately increasing non-conventional fishing activities etc. are considered as most responsible factors for the depletion of the native fish in natural waters. There is no official statistics on fish depletion in the country, however, amongst the common people there is a common consensus on fish depletion in inland waters.

Threats to the indigenous fish and fish diversity

The increasing population, poverty, lack of awareness, increasing activities of development project specially hydropower, irrigation and road construction where use of explosive are maximum, industrial pollutants, insecticides and pesticides, injudicious introduction of exotic fish, non-conventional fishing and ineffective enforcement of Aquatic Protection Act are considered as major threats for depletion of fish population and their fish diversity.

With the thrust of power and irrigation of agricultural land in the country, the hydropower project and irrigation projects are in increasing trend. Most of these projects construct cross dam or barrage or weir to divert almost all water leaving no water to flow downstream although promised during the Environment Impact Assessment (EIA) study. This not only adversely affects in free migration of fish but also destroys the breeding grounds. As a result the breeding process of fish is disturbed resulting in poor survival of off-springs and causes depletion of fish population and further pushes to dwindling stage of survival. In addition, the introduction of exotic fish especially carnivorous and prolific breeders, their injudicious use and ongoing degree of conventional and non-conventional fishing are additional factors of threats to indigenous fishes and their diversity. Moreover, the present climate change also poses serious threat to many indigenous fishes. If these responsible factors are not corrected or minimized in due time by effective execution of existing act, law and rules and defined conservation plan then imminence of a list of threatened or endangered fish species from the waters of Nepal in near future is inevitable.

Need of conservation of indigenous fish

A number of indigenous fish species are of high economic, academic and decorative value. Some of the economically important food valued fish are being used in different fields of fish culture or aquaculture. This activity is not only providing protein rich food but also providing job opportunity and thus income to improve the life style of the mass of rural poor. A large sector of rural poor population are being involved directly in fish culture or aquaculture and indirectly in the subsidiary activities of fish culture or aquaculture like in harvesting and marketing of fish, net making and mending, ice producing factory as well as basket making cottage industry etc. Many more cold or warm water indigenous fishes have been identified as suitable for fish culture or aquaculture and are either in the process of production or in inclusion. The vertical and horizontal integration of these fishes in fish culture or aquaculture is sure to offer more jobs and income to the large mass of rural population and produce more protein rich fish food for domestic use and also for export.

The indigenous fish show very diverse distribution within the country as well as in the region and continent with wide range of adaptation. Besides all these quality of the indigenous fish, interestingly a Chinese origin fish species has been recorded along with 14 endemic fishes from the waters of Nepal. These fishes are valued fish species not only to Nepal but to the world and ultimately to science. Therefore, it is an obligatory duty of the country to protect and conserve these valued fish resource. No doubt, a hope of conserving about 30.20 % of the updated indigenous fish species has given after the four studies of two National Parks - Chitwan & Rara Natioanl Parks (McGladdery at. el., 1980, Evans at. el. 1985, Terashima, 1984 and Edds, 1986). However, a well exercised conservation plan is in need to promote and bring the indigenous fishes under sustainable development plan.

Conclusion

Nepal has complex topography, varied climatic conditions, variable ecological conditions and diverse forms of water resources. It provides shelter to a large number of indigenous fishes. The updated list of fish fauna totals to 227 fish species representing 103 genera, 34 families and 11 orders. These fish significantly show very high vertical distribution within the country as well as horizontal distribution within the region as well as in the continent with wide variety of adaptation. So far no relict fish has been reported however, the country has credit to have valued 14 endemic fishes. These indigenous fishes are considered as unique and valued natural resources. The ever increasing trend of indigenous fishes from the waters of Nepal itself explains the growing interest of national as well as international research on Ichthyology and fisheries development in the country. The available information on fish fauna, their habitat and biology, ecology and their status are still meager and limited. Besides, the country's large area as well as water bodies (river systems, water bodies of remote and high altitude areas) are yet not studied and are still virgin. Therefore, scientific studies on fish fauna need to be encouraged to address the above said causes. Such studies are sure to bring many more new records as well as new species in the country's account as well as to Science.

A number of studies have shown the country's inland water under serious stress which has caused environmental degradation and a sharp depletion of fish population. So far, no fish species has been recorded officially as threatened or endangered, however, long observations and experiences have a consensus on depletion of the fish population. The alarmingly increasing trend of destructive factors need to be stopped after effective enforcement of promulgated Acts, Laws and by-law and supported with multidimensional conservation plan, otherwise, no wonder to see a list of threatened or endangered species from the waters of Nepal in near future. Therefore, to conserve the indigenous fish, a sound Conservation Program need to be develop and enforce effectively. Doing so, utmost emphasis need to be given with special reference to the endemic fishes which are valued not only to Nepal but to the world and ultimately to the Science.

In view of complexities of Nepal, many more varieties of genetic as well as species must be existing and still hidden which need to be explored. The study on fish fauna in future to come is sure to add many more new records as well as new species to the country.

Acknowledgement

The author highly appreciate Dr. T. B. Gurung, Director, Livestock & Fisheries Research, NARC and Mr. S. K. Wagle, Chief, Fisheries Research Division, Godawari, Lalitpur under Nepal Agricultural Research Council (NARC) for their kind information about the workshop and also for their support in preparing the paper. The author also wishes to acknowledge his gratitude to the national as well as international authors (who have taken keen interest on the fish fauna and fisheries development of Nepal and have reported new records as well as new species in the account of Nepal) for furnishing their published papers and book.

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AQUATIC RESOURCE CONSERVATION AND ENHANCEMENT IN NEPAL

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ABSTRACT

Nepal is rich in aquatic resources (nearly 0.81million ha inland fresh water) including aquatic animal and fisheries diversity. Recent works have shown over 200 fish species inhabit in these water bodies along with other aquatic organisms. These habitats have been encroached and threatened due to environmental, social and development activities. Rivers have been dammed blocking fish migration; sand, boulders and stones are haphazardly removed destroying breeding and feeding grounds. There are so many activities causing inevitable depletion of fishes from rivers, lakes, ponds, wetlands and swamps. FAO has also shown that contribution of captured fish in total production is declining worldwide due to over fishing, and destructions of habitats. Therefore, serious attention is needed to conserve and promote sustainable fisheries. For this, environment friendly legal provisions and guidelines for balanced and scientific use of the available water resources are to be developed reviewing the existing rules and regulations. There exist many acts, laws and bylaws regarding the ownership and the use of water resources and aquatic animal resources in many ministries of Nepal Government and are implemented as per the need of the concerned ministries only. There is lack of integrated and concerted effort from those agencies to multidimensional use of fresh water bodies and the natural aquatic resources for the benefit of nation without disturbing the aquatic biodiversity. In Nepal, there is high potentiality of fresh water fish and fisheries development to support livelihood of indigenous poor people who are traditionally involved in capture fisheries. To address these issues there is needs to review acts related to aquatic life conservation, aquatic resource use and are to be amended if needed. Government has to look closely in the implementation of those regulations and also monitor the impacts on the environmental and social issues that are related to overall community development.

Key Words: *bylaws, biodiversity, fisheries, habitats, laws, multidimensional*

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Introduction

Nepal has an area of 1, 47,181 km^2 and is divided into three physiographic regions, from south to north: the Terai Plain, the Midhills and the Himalayas. Mountains and Hills make up 83 percent of the area while the Terai occupies only 17 percent. Topographical diversity results in tropical, subtropical climate in Terai where temperature reaches 46 ^{o}C to temperate Tundra climate in mountains where temperature remains very low. The climate varies little from east to west. Nepal's rich biodiversity is a reflection of this unique geographic position as well as its altitudinal and climatic variations. Although, only 0.09% of global land area is in Nepal, it possesses a large diversity of flora and fauna at genetic, species and ecosystems level.

The economic well being of Nepal depends on its natural resources arable land, water and forests. Total population engaged in agriculture has been reported to be 65.7% and contribution of agriculture sector to national economy is 32.8%, agricultural GDP has a growth rate of 2.8% in 2004/2005 (GEED, 2005) fisheries sector contributed little over 0.94% in national GDP and 2.72% in AGDP with a growth rate of 6.3%. Per capita availability of animal protein is very low as compared to standard requirements. Fish is alternative source of animal protein as well as source of livelihood to many people in Nepal. Nearly 24 groups of ethnic people dependent on inland fisheries resources and they are marginalized and poor. Swar and Fernando (1980) have estimated that more than 20,000 fishermen are actively involved in capture fisheries. DoFD (2005/2006) estimated that 106,257 families with 578,036 beneficiaries were involved in capture fisheries for their livelihood. As the national population is growing which ultimately creating a huge fishing pressure on the natural water bodies. And also the aquatic resources are threatened due to environmental degradation and human activities. So, there is urgent need for a consolidated effort for their conservation and development. In view of its utility to ensure food security and provide livelihood opportunities as well as its role in promoting a more ecologically balanced use of land and water resources, the importance of its conservation and development is obvious.

Resource Endowment

Inland fresh water resources

Nepal is endowed with vast inland aquatic resources in the form of rivers, lakes, reservoirs, swamps, ponds and irrigated paddy field. These resources provide about 0.82 million hectares and covers 3% of the country's land area.

The existing water resources are scattered all over the country in the form of:

- Over 6000 fast flowing rivers, rivulets and streams
- High altitude glacial lakes and lowland oxbow lakes, approximately 5000 ha.
- Swamps, marshy lowland (ghols) and irrigation canals, approx. 12500 ha.
- River flood plains and irrigated paddy fields, 398000 ha.
- Man made reservoirs and village ponds, 1500 ha and 7500 ha respectively.
- Newly made raceways for the culture of rainbow trout in the terraces of mid and high mountains and
- Ditches formed due to brick building industries, road construction, etc.

Inland water resources are nature's precious gift to a nation. It has social values and economic needs. It has multidimensional use and the priority is gradually shifting from fisheries to other uses such as hydropower generation, irrigation and other human developmental activities. Still fisheries are an important source of food, nutrition and income for its rural people. Nearly 2% of the population in Nepal is dependent in fisheries resources.

Inland water fisheries resources

Fish and fisheries resource are very diverse in Nepal. Crustaceans, mollusks, fish, reptiles and other aquatic organisms including aquatic plants exist in the inland water bodies such as rivers, lakes, reservoirs, wetlands and inundated rice fields and consumed by people but have not been properly documented. Fish and fisheries belonging to high altitude regions are least known.

There are 185 species of fresh water fish found naturally in the water bodies of Nepal (Shrestha, 1995). All these species belong to single subclass Actinopterygii. A total of 11 orders, 31 families and 79 genera are found. These fish species are also categorized as threatened (34 species), common (90 species) and insufficiently known status (61 species).

Eight species are recorded as endemic to Nepal (Shrestha 1995). The endemic species include *Barilius Jalkapoorei, Schizothoraichthys annandalei, Psilorhynchus pseudecheneis, Pseudeutropius murius bararensis, Lepidocephalichthys nepalensis* and three species of schizothorax (*S nepalensis, S. macrophthalmus* and *S. raraensis)* that are endemic to Rara Lake. Apart from the native species, 11 exotic fish species have been introduced in Nepal mostly for aquaculture. However, some exotic species were introduced into the lakes of Pokhara (Phewa, Begnas and Rupa) such as Silver carp (*Hypophtalmichthys molitrix*), Bighead carp (*Aristichthys* *nobilis*) and Grass carp (*Ctenopharyngodon idella*). *Tilapia spp.* is also reported from these lakes. Those lakes are now thriving habitats for those species. Almost all fishes found in Nepal are food fishes for local people.

Human interference has effected fish population and production in many natural water bodies. There is constant threat to maintain fishery resource and aquatic biodiversity. Even though, government has formulated acts, rules/regulations, plans and policy guidance to counteract these threats, very little success has been achieved so far.

Objective

The major objective of the present paper is to review the existing conservation strategy and efforts for implementation; acts related to aquatic life conservation and recommend for future direction based on prevailing issues.

Existing Conservation and Mitigation Measures: A Review

In response to the growing global awareness about the importance of maintaining a balance between economic development and environmental conservation, the Nepal Environmental Policy and Action Plan (NEPAP) has been prepared and launched. NEPAP is a part of Nepal Government's continuing effort to incorporate environmental concern into the country development process. Efficient and sustainable management of natural and physical resources and mitigating the adverse environmental impacts of development projects and human action are the main theme of NEPAP. Conservation of fishery resources is part and parcel of the broad NEPAP. National wetland policy and strategic plan for biodiversity conservation has also been prepared by Government of Nepal in order to protect aquatic resources. National wetland policy is based on local people's participation. It aims to Conserve and manage aquatic resources with local people's participation for their benefit, while maintaining environmental integrity. At the same time, it also aims at wise use of wetland resources by providing equal opportunities on the basis of local people's participatory management of wetlands to conserve natural resources for the benefit of present and future generations. Similarly, strategic plan for biodiversity conservation aims at conserving biological diversity and the sustainable use of its components and ecosystem. The following measures have been carried out to till now to conserve fisheries resource in Nepalese water systems:

A. Legislative arrangements

Conservation of aquatic life is addressed by the Aquatic Animal Protection Act 2017 (1961) (AAPA), which prohibits the use of explosive or poisonous substances in any body of water where the intention is to catch or kill aquatic life. This act has been revised by the parliament and consolidated in 1999. Government of Nepal has formulated aquatic life protection regulation and the procedure of its implementation. It regulates fishing gears, size of the fish and season. Study on the effects of development projects on fishery resources and implementation of mitigation measures has been made mandatory under this regulation. Along with AAPA there are Legislations impacting Wetland Biodiversity and Ecosystem Conservation in Nepal such as Forest act, Environmental Protection Act, National Parks and Wild Life Protection Act, Soil and Watershed Conservation Act, the Electricity Act etc.

B. Environmental impact assessments

After the implementation of the NEPAP, Nepal has introduced legal or institutional mechanisms for the use of EIA. Impact of development projects on aquatic life is thoroughly assessed and several measures are taken to mitigate the adverse impact of a project. The establishment of a fish hatchery and recommendation for fish trapping and hauling, restocking fingerlings activities under Kali Gandaki 'A' Hydropower Project are examples of such measures.

C. Establishment of fish sanctuaries

The majority of fish inhabiting rivers are extremely sensitive to modifications and to the environmental changes that occur in modified rivers. An extensive network of protected areas has now been established in Nepal. Nepal has ten national parks, three wildlife reserves, one hunting reserve and four conservation areas. Similarly, nine water bodies with an area of 34,455 ha are declared as Ramsar sites.

D. Protection of endangered species

The present status of fish species (based on an older account listing 185 species) is given in Table 1. Native fish species recommended for legal protection are listed in Table 2. One species (*Tor tor*) is listed as endangered, 9 species as vulnerable.

Table 1. Status of Fish Species in Nepal (adapted from Shrestha, 1995)

Status	Number of species
Common/occasional	90
Insufficiently known	61
Vulnerable	9
Endangered	1
Rare	24
Total	185

There are twenty six mammal, nine birds and three reptiles listed as threatened species in Nepal. However, until now none of the fish species has been included in the list of IUCN.

Table 2. List of species recommended for legal protection under the AAP regulation

Scientific name	Common name	NRDB code	Distribution
Neolissocheilus hexagonolepis	Katle	V	Koshi, Gandaki, Karnali, Mahakali
Chagunius chagunio	Rewa	V	Koshi, Gandaki, Karnali, Mahakali
Tor putitora	Mahseer	V	Koshi, Gandaki, Karnali,
Tor tor	Sahar	E	Gandaki, Mahakali
Danio rerio	Zebra macha	V	Gandaki, Karnali,
Schizothorax plagiostomus	Buchhe asla	V	Koshi, Bheri, Gandaki, Karnali, Mahakali, Phewa, Lake, Gandaki
Schizothorax richardsonii	Asala soal	V	Koshi, Gandaki, Karnali,
Schizothoraichthys progastus	Chuche asala	V	Koshi, Gandaki, Karnali,
Psilorhynchus pseudecheneis	Tite macha	V	Koshi
Anguilla bengalensis	Rajabam	V	Koshi, Gandaki, Karnali,

V = Vulnerable, E = Endangered

E. Promulgation of aquatic animal protection regulations

Aquatic Animal Protection Act (AAPA) was passed in 1961; in 1999 the Government promulgated AAPA regulations. The guidance, policies, and experience related to the development of fisheries have now been defined. In the past, fisheries in inland water bodies have often been subject to ecological damage from poisoning, bombing, poaching and stealing of fish. In order to protect national interests and the legal rights of fishermen the law defines concrete administrative penalties, civil liabilities and responsibilities. However, its implementation is far from satisfaction.

In recent years Fisheries studies have been undertaken in some tributaries of Koshi, Gandaki, Karnali river systems by Nepal Government and are in initial stage of survey. Based on these studies the production of fish from capture fisheries is estimated to be 21500 mt contributing 44 % in the total fish production in the country. Capture fishery yield is in decreasing trend; however it is projected that by 2018 overall fish production will be doubled through aquaculture promotion and conservation. (FPP, 2000).

Present Status of Resource Conservation and Enhancement

Inland water resources are nature's precious gift to a nation. It has social values and economic needs. It has multi dimensional use and the priority is gradually sifting from fisheries to other uses. Still Fisheries is an important source of food, nutrition and income for its rural people. Nearly, 2% of the population in Nepal is dependent on fisheries and allied activities. The economic level of people living around natural water bodies such as rivers, lakes, reservoirs and wetlands (specially the fisherman/ethnic communities) are marginal and have very low income which may trigger the illegal use of the resources. Most of these communities either have very little land or have no land at all. They are mainly depended on fishing activities are engaged as agricultural labors.

Priority of government goes to agricultural activities in case of land use while for water resource use it goes to hydropower generation and irrigation. Even though, under agriculture policy of the Government, fisheries belong to priority program (P1). However, during program formulations & implementation it is not so.

Impoundment of river during construction of dams in hydroelectric project creates complex impacts affecting human, wildlife, vegetation, aquatic resources and physico-chemical parameters of the environment. It also affects temperature, water flow, aquatic resources and biotic interactions and creates new environment. Such blockage of the river causes change in the habitat structure and depletion of certain population inhabiting the system. Therefore, some measures are required for the mitigation of the adverse impact on population diversity and habitat restoration.

Human interference has effected fish population and production in many natural water bodies. There are constant threat to maintain fishery resource and aquatic biodiversity. Even though, Government has formulated rules, regulations, plans and policies to counter these threats, very little success has been achieved so far.

Conservation Strategies

Aquatic Resources are not infinite but exhaustible which can be reserved though conservations to ensure continuous support to people. Conservation aims to maintain genetic biodiversity at present and in future and guarantees regular supply of aquatic products for human consumption. Therefore, efforts are made for effective implementation of "community water bodies" concept and awareness of aquatic life protection act and rehabilitation of depleted Fishes by stocking with hatchery produced seeds of important indigenous species. At the same time, implementation of distinct Policy for Import of Exotic fish species is also tried. Conservation of fish through participatory management is emphasized conducting training and awareness programs at important points. Similarly, monitoring the environment regularly and provide alternative livelihood activity like aquaculture for displaced as well as affected people. Whereas, utilizing fisheries resources only after maintaining certain population and biomass and beyond original population and biomass harvesting is allowed.

Water Resources Strategy (2002), Nepal

For decades, Nepal's economic development efforts have focused on its water resources. Although the country has an abundance of water in terms of annual surface flow and groundwater reserves, the progress towards utilization of this water for basic uses and economic growth has been slow. In recognition of this fact, the Government of Nepal prepared a long-term Water Resources Strategy, capable of guiding water sector activities towards sustainability of the resource, while providing for hazard mitigation, environmental protection, economic growth and constructive methods of resolving water use conflicts. The main objectives of the WRS, Nepal, are:

1. Every Nepali citizen, now and in the future, should have access to safe water for drinking and appropriate sanitation, as well as enough water to produce food and energy at reasonable cost.
2. Nepal needs to promote ways of managing its water at the river basin level to achieve long-term sustainability for the benefit of its entire people. This will require a holistic, systematic approach that honors, respects and adheres to the principles of integrated water resources management.

National Water Plan (2005), Nepal

In order to implement the activities identified by the Water Resources Strategy (WRS), the Government of Nepal approved the National Water Plan (NWP), Nepal in 2005. The NWP recognizes the broad objectives of the WRS and lays down short, medium and long-term action plans for the water resources sector, including investments and human resource development. The NWP attempts to address environmental concerns, which is reflected by the incorporation of the Environmental Management Plan in the document. This Environmental

Management Plan will contribute to maximizing positive impact and minimizing or mitigating adverse impact in line with the environment sustainability concerns. Based on NWP the following two topics are presented here,

a. Management of watersheds and aquatic ecosystem

The targets in this sub-sector as mentioned in the NWP are:

- By 2007: A management plan for nationally important watersheds and aquatic system is prepared and initiated and water quality and wastewater quality standards are developed and enforced
- By 2017: Full scale environmental protection and management projects are implemented in all priority watersheds and aquatic ecosystems and stakeholders' participation in environmental protection and management is provided for
- By 2027: Quality of watersheds is increased by 80% in all regions and adequate water quality is attained for aquatic habitat, including fish, human consumption and recreation in all rivers and lakes

The following action programs are detailed out for the purpose of achieving the targets mentioned above:

- Improve environmental database system
- Map important, critical and priority watersheds and aquatic ecosystems
- Develop and implement water and wastewater quality standards and regulations
- Implement nationally important watersheds and aquatic ecosystems protection, rehabilitation and management programs
- Implement water conservation education program
- Develop strategic environmental assessment in water resources management
- Ensure compliance of EIA
- Promote community participation in the management of watersheds and aquatic ecosystems
- Enhance institutional capacity and coordination
- Develop watershed management policy

b. River basin management

Similarly for the River Basin management, the following action programs are detailed out in NWP.

- Mainstreaming Integrated Water Resource Management (IWRM) and the river basin concept

- Development of river basin Plans
- Development and implementation of Decision Support System (DSS) in water resources programs
- Establishment as well as strengthening of institutions for river basin planning

Enhancement/Mitigation Measures

Fish trapping and hauling

Fish trapping and hauling is another alternative for assisting natural fish migration. Fish trapping can be used for a variety of fish species and sizes. Migratory species can be captured and hauled. However, there are drawbacks to the fish trapping and hauling approach; stress related mortalities may occur. Risk of poaching may be another disadvantage. However, fish trapping and hauling has been recommended at Kaligandaki 'A' hydroelectric project. However, it has not yet been practiced.

Fish ladder

One of the remedies commonly proposed for blockages to migrations causes by dams is the construction of fish passes or ladders. Most of the existing and proposed water development projects in Nepal do not have fish passes. Although almost all the prominent rivers of Nepal are dammed for various development purposes, there are only a few examples of fish ladders (e.g., Koshi Barrage, Chandra Nahar in Trijuga; Andhi Khola, Gandak Barrage). However, little data is available on their performance. The fish ladder in the Trijuga River is not in an operational condition due to the lack of maintenance and inappropriate design. In the Koshi Barrage the upper chambers of the ladder are frequently used as fish traps for illegal harvesting by local fishers (D.B. Swar, personal observation).

Fish hatchery

Establishment of a fish hatchery is another measure for mitigating the impact of a dam formation on the native fish fauna. Hatcheries play an important role in fish conservation and management in developing countries. In recent years, their efficiency has increased with better knowledge of the biological and reproductive requirements of fish. A fish hatchery is established at Kali Gandaki 'A' Hydropower Project. The main objective of the hatchery is to propagate mahseer (*Tor putitora)* katle *(Neolissochilus hexagonolepis),* snow trout (*Schizothorax richardsoni)*; jalkapoor (*Clupisoma garua*) and other important native fish species affected by the construction of the dam. However, it could breed only ten out of fifty-four species reported from the Kali Gandaki River.

Open water stocking

Among the indigenous fish species of Nepal, *Neolissocheilus hexagonolepis* (katle), Labeo spp, *Tor tor*, *Tor putitora* (sahar, mahseer or mahaseer), and *Schizothorax richardsonii*, *Schizothoraichthys progastus* (snow trout or asala) have been identified as important for sport fishery as well as being excellent food fish. Their domestication started in the 1970s. Fish fry is being produced in hatcheries and trials are going on to culture them in captivity. Seeds of these species are released in various rivers, lakes and reservoirs but the impact assessment is not properly done.

Introduction of aquaculture

Eleven exotic fish species of food and sport value have been introduced in Nepal. These include warm water Chinese carps and cold water rainbow trout. Cage culture of planktivorous Chinese carps has proven quite successful in the lakes of Pokhara as well as Kulekhani reservoir. Open water stoking with silver carp, bighead carp, grass carp and common carp has increased the productivity but has caused adverse effect on native fishes. Rainbow trout fingerlings have also been recently introduced in one of the isolated rivers in high hills (Modi River). Studies are carried out to assess the survival rate of rainbow trout and its impact on native fish fauna.

As a successful mitigation measure, the example of cage fish culture on alternative livelihood option for communities displaced by reservoir impoundment in Kulekhani, Nepal could be cited (Gurung *et al;* 2008). In Nepal, fisheries and aquaculture were hardly envisaged during the planning of the Hydropower projects. Here, the government of Nepal and International Development Research Centre (IDRC), Canada jointly demonstrated that cage fish culture in the reservoir is a promising alternative livelihood option for displaced communities. Among 500 families displaced in 1982 due to impoundment, nearly 81% adopted cage farming and 231 families are now engaged in fish production from the reservoir. These families are organized in 11 groups and produce approximately 165 mt of fish (2005/2006) out of which 130 mt from cage fisheries (80000 m^3) and rest from open water stocking and harvesting.

Awareness programs

Government of Nepal through Directorate of Fisheries Development has started awareness programmes to highly affected areas by group formation of concerned/ affected people and putting up public notice as hoarding boards at various locations.

Constraints

Nepal is in the process of developing legislation to protect and enhance its fisheries and aquatic resources. Very little has been done in terms of fisheries resource enhancement and conservation. The major constraints include:

1. Lack of proper legal instruments causing loss of rich biodiversity (new regulations under Aquatic Animal Protection Act, 1961 is in the process of formulation and execution by Nepal Government) due to irrational urbanization, encroachment, construction of big hydro-dams/barrages/roads, taking out sand and gravels/boulders, illegal fishing etc.
2. Although, inland water fishing is very popular and has great potential in Nepal; the present status of fisheries resources are not known due to absence of essential scientific and authentic data base which prevent proper use of the available resources.
3. Absence of coordination among various government and other agencies involved in inland water resource use; lack of integrated land and water resources use planning, policy on water rights.
4. Low levels of public awareness and participation in resource enhancement, development and conservation.
5. Limited technical capabilities, infrastructure facilities and human resources development.

Recommendations

The ecological and biophysical diversity existing in Nepal offer comparative advantages and opportunities for future development. To develop and restore inland fishery resources for livelihood enhancement and poverty alleviation of rural communities' environmental protection is required. Efforts need to target beneficiaries such as disadvantaged and marginalized ethnic communities with training and awareness raising, legal instruments, infrastructure development and proper mitigation majors from hydro power generation/irrigation projects. Concerning the protection of bio-diversity there is indigenous fish breeding and restocking programs but there remains much to do as natural populations are being reduced. Based on constraints and urgent need following recommendations are to be considered for a sound fisheries management.

1. Prioritizing accessible and important water bodies, develop tools for systematic and comprehensive collection of fisheries statistics as a base line information and status.

2. Establish a National Water Resource Development and Conservation Committee at the national level to adopt and implement a cleat cut policy for natural water conservation and utilization.
3. Strict periodic monitoring and evaluation of the mitigation measures to evaluate the impact on environment. The environmental monitoring and evaluation should not be done only by the project authorities. Proper government or private independent institutions should be given the job.
4. Capacity building, including human resource development and institutional development and/or strengthening, to facilitate the preparation and/or implementation of national strategies, plans for priority programs and activities for conservation of biological diversity and sustainable use of its components.
5. At present, the rivers of Nepal are utilized either for generating hydroelectric power or for irrigation purposes only, with little consideration being given to their fisheries value. For the conservation of the freshwater fishery resources it is important to involve fisheries professionals and local communities in the planning and feasibility study process of water resources development projects.
6. As the countries of the Trans-Himalayan region share many important inland water and fishery resources, a Regional Cooperative Effort (RCE) is needed to share experiences and to initiate collective activities to protect and manage such valuable fisheries resources.
7. Identification of critical habitat and protection measures, incorporation of community participation, protection of rights of users and exact legislation for the conservation and sustainable use of inland water resources is required. Participatory approach is the best because the protected area can't survive without the support of the local people.
8. Sanctuaries and /or no fishing zone, closed-season, control on illegal fishing and use of gears are to be established to increase the population of indigenous threatened species.

Implementation of the above mentioned issues need to have firm political will and suitable legislation along with appropriate plan of action to formulate long and short term research as well as development projects.

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IMPACT OF DAMMING ON THE ENVIRONMENT OF FLOW AND PERSISTENCE OF NATIVE FISHES

Surya Ratna Gubhaju*

ABSTRACT

The dams are responsible for habitat alteration/loss, discharge modifications and changes in water physicochemical qualities. Resident fishes are heavily affected by these changes. Dam can block fish migration. Short distant migrant fishes are less affected by dam in comparison to long distant fishes as they could pass to nearby tributaries for feeding and breeding. But dam totally block long distant migrant fishes from reaching their upstream breeding and feeding ground and thus responsible for the heavy decline of these species. Mortality resulting from downstream passage through hydraulic turbines or over spillways is also significant.

Various technical and managerial solutions are suggested to develop fisheries for sustainable maintenance or conservation of local indigenous fishes in riverine ecosystems modified by dams. But the implementation of solutions like the release of compensation riparian flow, fish pass or fish ladder construction for the movements of migratory fishes along river courses are not effective as was envisaged. The installation of fish hatchery in Kali Gandaki Project is an exemplary mitigation measure and the hatchery seems doing good job in the artificial production of indigenous fishes; but, the success of improving the indigenous fish population in affected areas by releasing artificially reared fishes is questionable (require scientific study for proper evaluation).

Being hydropower generation or irrigation by damming a long term project requiring very large investment, the forces of climatic changes should be considered seriously; otherwise, their impacts will override or synergically amplify the physical influences of dams. As dams are constructed to enhance socio-economic developments, they tend to attract people and industry inviting secondary environmental pressures such as increases in pollution, over-exploitation of surrounding natural resources, which must be contend, independent from and in addition to the direct influences of dams.

The socio-economics of fragile affected local fishermen should be duly considered and Nepal is doing very good in terms of cage fish production in the reservoirs resulting from construction of dams to support them as alternatives

Key Words: *dams, habitat alteration, fish migration, environmental pressures*

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Introduction

In the global prospect, Nepal is a small landlocked mountainous country but it is world second richest country in the water resources. The natural water bodies of this country occupy about 1.5 percent of the total area. Eternal glaciers, ice-cold torrents, clear-water and lakes contribute to much of Nepal's hydrosphere comprising more than 6000 rivers, rivulets, seasonal streams etc (Table 1).

Table 1. Water Resources and Estimated water Surface Area

Water Resources	Estimated Area (ha)	Percentage	Potential Area (ha)
Natural Waters	401,500.0	48.8	
Rivers	395,000.0	48.0	
Lakes	5,000.0	0.6	
Reservoirs	1,500.0	0.2	92,400
Village ponds	6,500.0	0.8	14,000
Marginal Swamps	12,500.0	1.4	
Irrigated rice field	398,000.0	49.0	
Total	818,500.0	100.0	

Estimated water surface Area in Nepal (DOFD, 1998)

Water resources of Nepal are world famous for reliable, cheap and safe hydropower source. The theoretical hydropower potential of Nepal is 83,000 MW of which 44,552 MW is regarded technically feasible and 42,133 MW economically feasible (Sharma, 1997). Run-off river schemes and high dam reservoirs are two major types of hydropower generation techniques in Nepal. In the steep northern parts where average flow of water is low, run-off schemes type of hydropower generation program is launched for producing lifelong power generation. About one fourth of total hydropower potential of Nepal comes under run-off river scheme program. In the lower hills or wide plains, hydropower is generated by blocking the large wide rivers with high dam forming large reservoirs. Reservoir type generates enormous hydroelectricity, but life span of reservoir type is expected to be about 50 years.

Most of above water bodies are clear, well oxygenated, unpolluted supporting different aquatic flora and fauna except some water bodies which are polluted by agrotoxic chemicals, industrial and domestic wastes at highly populated and industrial areas. However, these water bodies are rich in fish biodiversity and there are about 232 species of cold water, warm water and exotic fishes. The hill steam fishes are also unique, as they have developed many adaptive characters to sustain themselves at fast flowing waters. The largest fish found in Nepal is *Bagarius yarrelli* while the smallest is *Danio rerio.* The indigenous fishes of Nepal are important natural resource and valuable genetic component for food security and means of livelihood for local fishermen. These indigenous fishes have significant contributions in protein supply and also provide income-generating opportunity for the livelihood of local fishermen communities who use different traditional gears like long line loops, rod and line, cast net and scoop lift net in fishing. There fishes are migratory and resident fishes (Table 2).

Table 2. Different migratory and resident fishes.

Migratory species	Migratory Patterns Downstream Upstream	Spawning Time
Long distant migrants		
Tor putitora (Golden mahaseer)	J F M A M **J J A S** **O N D**	Sept- Oct
Tor tor (Deep bodied sahar)	J F M A **M J J A S** **O N D**	Sept- Oct
Bagarius yarelli (Freshwater Shark)	J F **M A M J J A S** **O N D**	July –Aug
Clupisoma garua (Jalkapoor)	J F **M A M J J A S O** N D	June –July
Anguila bengalensis (Fresh water eel)	J **F M A M J J A** S O N D	June –July
Short distant migrants		
Schizothorax plagiostomus (Pointed nose Asala)	**J F M** A M J J A S O **N D**	Sept-Oct
Schizothorax richardsoni (Blunt nose-Asala)	**J F M** A M J J A S **O N D**	Sept-Oct
Acrossocheilus hexagonolepis (Katle)	J F **M A M J J A S** O N D	Sept- Oct
Amphipnous cuchia (bam)	J F M A **M J J A S** O N D	June –July
Changunius changunio	J F **M A M J J A S** O N D	May -June
Labeo angra	J F M **A M J J A S** O N D	June –July
L. dero	J F **M A M J J A S** O N D	June –July
L. dyocheilus	J F M A **M J J A S O** N D	June –July
Puntius chillinoides	J F M **A M J J A S** O N D	June –July
Resident species	***Habitat***	***Spawning Time***
Barbus chillinoids (Karange)	Habitat prefers ,rock gravel bed, pool	Sept- Oct
Psilorhynchus pseudoecheinus (Tite)	Slow run rapid	June–July
Pseudoecheinus sulcatus(Kabre-torrent catfish)	Head water stream	May–June
Glyptothorax cavia (Capree)	Head water	May- June
Glyptothorax blythi (Tilkabre)	Rocky boarder stream	June
Garra gotyla (Buduna, rock carp)	Water pool, rock crevices, algal bed	May- June
Garra annandalei (Buduna - stone roller)	Shelter rocks/boulder, crevices of stone	Sept-Oct.

Impact of Dam in Indigenous Fishes

Interruption in water flow regimes

Dams interrupt the continuity of riverine flow and generate hydrological changes in river ecosystems. The changes are ultimately reflected in the life of indigenous fishes. Besides it, dams significantly block nutrient flow throughout the ecosystem, affecting fisheries production in downstream reservoirs (Welcomme, 1985).

Photo 1. Hydroelectic dam in Kali Gandaki hydropower project (left) and dewatered downstream of dam (right)

Downstream of the dam, the flow rate of river will depend upon the amount of compensation flow. Water volume is reduced considerably during dry season. As a result the downstream may change into pools alternating with dry stretches for about nine months from November to June. The modification of downstream river flow can lead into a variety of negative effects upon fish species: loss of stimuli for migration, loss of migration routes and spawning grounds, decreased survival of eggs and juveniles etc.

Water released leads to diurnally or annually variable water pulses in the river section below the power station or sometime from headwater as a compensation riparian flow released either slowly or in high pulse. In Upper Tamakoshi Hydropower project, compensation flow will be released in high pulse in the morning and evening for certain time only (Personal communication of author with EIA expert of Upper Tamkoshi Project). So, two kinds of artificially changed discharge conditions are seen below power station – high discharge and low discharge. Hydro peaking is an intermittent high discharge from a power plant to the river during the rush hours of energy demand. Hydropower peaking operations produce artificial flood events, due to their unpredictability and intensity; can be classified as disturbances directly affecting ecosystems of tail waters. Investigation of the effects of these types of disturbances is generally lacking in Nepal, except some benthic biota in the EIAs of hydropower projects (Khanal, 2001).

Changes in physicochemical of Water

Due to decrease in water discharges, water temperature will rise in daytime and decline sharply at night. Water temperature changes are responsible for the reduction in native species (Petts, 1988). Changes in dissolved oxygen, pH etc can adversely affect fish growth and distribution.

Loss of habitat due to impoundment

Dam construction can dramatically affect fish habitat due to the formation of impoundment. The consequence of river impoundment is the transformation of lotic environment to lentic habitats. Due to free passage problems, species which spawn in relatively fast flowing reaches can be eliminated. Point and non-point source pollutants like sediments, excessive nutrients, organic matter, and contaminants imported from the watershed affect environmental quality in reservoirs.

Sediments

Reservoirs trap suspended solids to increase turbidity and limit primary production along with the decrease in depth and storage capacity. Sedimentation is accelerated in basins at prolonged droughts followed by heavy rains in monsoon seasons (Sugunan, 1995).

Nutrients

Phosphorus inputs from agricultural sources and municipal effluents are the major factors for eutrophication. The consequences of eutrophication are algal blooms, dissolved oxygen fluctuations, and dense littoral aquatic vegetation unsuitable for many fish.

Organic Matter

Inputs of organic matter can be beneficial or harmful, depending on the natural fertility of the basin and the nature of the system. Particulate organic matters promote excessive growth of aquatic pests like water hyacinth etc.

Stratification

Water in the reservoirs is thermally stratified when depth is great. The temperature and concentrations of oxygen tend to decrease in the hypolimnion (Kulekhani reservoir).

Changes in littoral region

The littoral region of reservoirs is unstable due to the fluctuation of water level which affect growth/distribution of benthos, periphyton, aquatic macrophytes and planktons (Ploskey, 1986). Exposure of substrate due to drawdown, promote semi-terrestrial vegetation growth.

Change in Fish species

Moreover, reservoirs positioned in the upper reaches develop fish assemblages' characteristic of lake environment due to changes in fish habitat, water quality (eutrophication), algal composition and the growth of *Eichhornia* spp. and rooted aquatic macrophytes.

Delays in Migration

Impoundments can have an effect on the timing of fish migration. Such delays can have a drastic negative effect by exposing fish to intensive predation, nitrogen super-saturation and several other hazards such as exposure to disease organisms and parasites.

Impact upon Fish Migration

The migratory fishes are two types - long and short distant migrants. Short distant migrants are comparatively less affected by dam as they could pass to nearby tributaries for feeding and breeding. But dam totally block long distant migrants from reaching their upstream breeding and feeding ground and thus responsible for the heavy decline of these species.

Upstream Migration

The obstruction to migration is often associated with the height of the dam. However, even low weirs can constitute a major obstruction to upstream migration.

Downstream Migration

Like upstream migration, downstream migration is also affected by the obstruction of dam. Passage through hydraulic turbines and over spillways are also important cause of damage to downstream migrating fish.

Damage Due to Hydraulic Turbines

Fish passing through hydraulic turbines are subject to various forms of stress like sudden variations in pressure. Physostomous species (e.g. clupeids and cyprinids) can resist sudden variations in pressure as pressure can be regulated quickly in swim bladder. In physoclistic species (e.g. percids), pressure is slowly regulated with the risk of swim bladder rupture.

Photo 2. Fish loss in hydraulic turbine

Damage Due to Spillways

Passage through spillways may be a cause of injury or mortality due to shearing effects, abrasion against spillway surfaces, turbulence at the base of the dam, sudden variations in velocity and pressure. Passage through a spillway under free-fall conditions (i.e. free from the column of water) is always less hazardous for small fish.

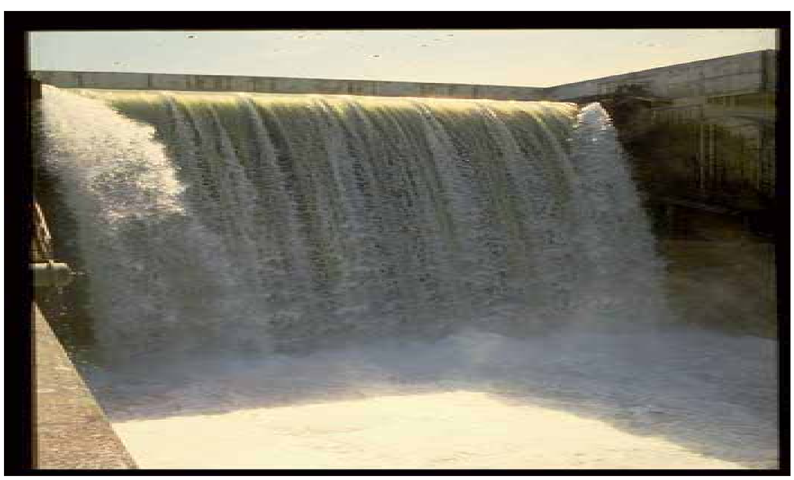

Photo 3. Spillway on the Garonne river (France)

Socioeconomic Impact upon Local Fisher Community

Certain schedule ethnic groups like Tamang, Danwar, Majhi, Magar, Kami, Damai, Bhujel, Bote, Badi, Baji, Raji, Sarki etc residing at the river bank adopt fishing as a profession. These fishermen communities are very poor, uneducated and highly vulnerable; so, their livelihood is highly affected by the heavy decline of fish catch after the installment of hydropower projects.

Impact of Climate Change on Dam and Indigenous Fish Species

Himalayan wetlands are of global importance in terms of climatic features, biodiversity, hydrological cycles, landscape beauty etc. Many of river′s of Nepal are fed by runoff from over three thousand glaciers scattered throughout the country. These glaciers fed rivers are the head waters for major rivers in Asia and India. As global temperatures rise, the impact lies on earlier snow melting and shortening of winter season. The increase in 1^0 C in the Himalayan region has far-reaching impacts not only on the mountainous regions but also on the southern river-plains that depend largely on them. The melting glaciers would mean floods and fast run-offs in the rivers in the short term and droughts and water scarcity in the long term.

In the last few years, Pakistan, India, Bhutan and Nepal had prepared plans for massive dam building in the Himalayas. Several hundred dams are now proposed in the region, which could lead to capacity additions of over 150,000 MW in the next 20 years. In India alone, there are 74 projects with an installed capacity of 15,208 MW, 37 projects with a capacity of 17,765 MW are under construction and 318 projects are further planned with an expected capacity of 93,000 MW. Nepal had formulated an action plan for the development of 10,000 MW in next 10 years (Vision 2020: Hydropower, 2008) and is expected to install many hydropower projects in future. These dam projects were installed and will mostly propose in the high-seismic Himalayan zones, which are prone to landslides, flash-floods and earthquakes. The melting of glaciers due to climate change will phenomenally increase the inflows to these dams, bringing up questions of safety of the dam, the risk of damage, accident, flooding and submergence (as shown by the Kosi floods of August 2008). These fast run-offs will also increase the problem of sedimentation in reservoirs.

In Mount Everest, air temperatures had risen by 1°C since the seventies, leading to a decrease in snow and ice cover by 30% in the same period. This had replaced 4000 m high glacier in the region into a lake. Glacier lake outburst floods (GLOF) are now much more frequent creating serious risks for human populations of lowlands. The likelihood of a GLOF at Tsho Rolpa posed a serious risk to the 60MW Khimti Hydropower Project. To mitigate this risk, an expert group recommended lowering the lake three meters by cutting an open channel in the moraine and a gate to allow water to be released as necessary. Otherwise, it could damage 19 villages downstream of the Rolwaling Khola on the Bhote/Tama Koshi. GLOFs had totally destroyed newly built Namche Bazaar hydropower facility in 1985. This GLOF caused a 10 to 15 meter high surge of water and debris to flood down the Bhote Koshi and Dudh Koshi Rivers for 90 kilometers.

The changing climate and the warming up of the Himalayas, could reduce runoff by 14% reducing the electricity generation of existing plants and future projects. The receding glaciers and forest lines, would mean the occurrence of diseases, pests, and vectors suited to warmer climates can move up north. Combined with food insecurity, malnutrition, and rapid depletion of forests, the health of the populations will take a setback.

Mitigation

Fish Pass or Fish Ladder

The general upstream fish passage facilities include fish passes to attract migrants to a specified point by opening a waterway. There are several types of fish pass: pool-type fish passes, Denil fish pass (or baffle-type fish passes), nature-like bypass channels etc. Besides fish passes, other fish passage facilities include fish lifts and fish locks, collection and transportation facilities.

Pool-type fish passes

Pool-type is widely-used old modeled fish pass. The principle behind this pool pass is the division of the height into several small drops forming a series of pools. The passage of water from one pool to another is by surface overflow. The drop between pools varies from 0.10 m to more than 0.45m according to the nature and behaviour of migratory species, most frequently drops is designed at around 0.30m.

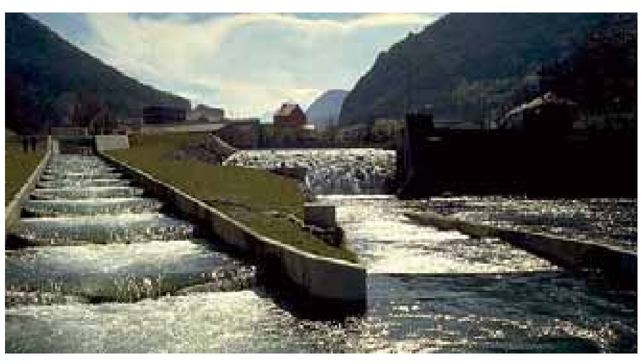

Photo 4. Pool fish pass at Sarrancolin dam (Photo Larinier)

Vertical slot type fish passes

Pool passes with deep and narrow interconnections, like vertical slot type fish passes, can accommodate significant variations in upstream and downstream water level without the need for regulation sections.

Photo 5. Vertical fish pass at Mauzac dam (left) and vertical fish passes at Iffezheim Dam (right) (Photo Larinier)

Denil fish passes

This is also called baffle type fish passes. The principle is to place baffles on the floor and/or walls to reduce the mean velocities of the flow. This type of pass is characterised by significant velocity, turbulence and aeration relatively selective and suitable for fish larger around 30 cm. There is no resting zone for fish in a Denil fish pass, and the fishes must pass through it without stopping.

Photo 6. Floor baffles fish pass in Thames (Photo Larinier)

Nature-like Bypass Channels

The nature-like bypass channel is a waterway designed for fish passage around a particular obstruction which is very similar to a natural tributary of the river. The function of a nature-like bypass channel is to create a restorative natural flowing water habitat which has been lost due to impoundment.

Photo 7. Natural bypass channel (Photo Larinier)

In Nepal there are fish passes at the Koshi Barrage, Chandra Nahar, Andhi Khola, Gandak Barrage and Kankaimai. But existing fish pass like at Andhi Khola, was poorly designed and unsuitable for large fishes like *Tor, Bagarius yarelli* etc. To make it (Andhi Khola) more efficient, this pass needs drastic improvements. Similarly the pool and weir type fish pass of Kankaimai also needs basic improvement.

Fish locks

A fish lock consists of a large holding chamber located at downstream level of the dam. Fish are attracted into the downstream holding pool which is closed after collection and fish exit the upstream chamber through the opened gate. A downstream flow is established through a bypass located in the downstream chamber to encourage the fish to leave the lock.

Fish Lifts

In fish lifts, fish are directly caught in a trap with a V-shaped entrance. In fish lift, fishes with small quantity of water are lifted up until it reaches the top of the dam.

Maintenance of water flow level

There are several options for the restoration or maintenance of aquatic and riparian habitat. Minimum flows are needed to keep streambeds wetted to an acceptable depth to support fish. Because wetlands and riparian areas are linked hydrologically to adjoining streams, downstream flows should be sufficient to maintain structure and function of wetland or riparian habitat. In EIA, 10-20% of regular flow should be maintained as a compensation flow for the conservation of aquatic life and environment at dewatering zone. During compensation flow, the effects of hydro peaking should be minimized by releasing peak discharge at slow ramping rates along with the maintenance of balancing or buffer reservoirs.

Photo 8. Holding pool and fish lift (left) and transport facility (right) (Photo Larinier)

Collection and Transportation Facilities

The technique of trapping and transporting migrants is often used as a transitory or interim measure before upstream fish facilities are constructed. Trapping and transportation may be a permanent measure in the case of very high dams where the installation of a fish pass would be difficult.

Maintenance of Spawning Ground

Fish pass or fish ladder is an expensive mitigation measure and the existing fish passes in Nepal are not satisfactory. At present preference is given to maintenance of spawning ground and fish hatcheries as a means of enhancing the native fish stocks affected by dams.

Some resident fishes such as stone roller (*Garra gotyla*), stone loaches (*Nemacheilus bevani*), coldwater catfishes (*Glyptothorax spp, Glyptosternum spp, Pseudoecheinus* etc) and murrel (*Channa puntatus*) utilize gravel bed areas for spawning. Considerable loss of spawning grounds o f these species has occurred at down stream of dam. Adequate attention must be given to the protection of the spawning ground and nursery gravel beds. Where needed, additional measures should be taken:

- depositing gravel to increase spawning habitat
- manipulating angular and large boulders to create pools for spawning and escape cover for resident fish during low water levels
- using large boulders to alter the flow pattern downstream
- keeping gravel and boulders together to create spawning riffles to attract resident stock to rapids
- releasing flushing discharge to rewater exposed gravel beds to maintain spawning gravel quality
- tree planting around habitat to increase shelter cover, shade and drift food

Fish Hatchery

A reservoir associated hatchery should produce seed of important native fishes like mahseer, copper mahseer, snow trout, jalkapoor etc which are most affected by dam projects. Stocking the reservoir and tail water will replenish the losses resulting from the disappearance of the natural spawning ground and from ceassation of migrations. The installation of fish hatchery in Kali Gandaki Project is an exemplary mitigation measure and the hatchery seems doing good job in the artificial production of indigenous fishes; but, the success of improving the indigenous fish population in affected areas by releasing artificially reared fishes is questionable (require scientific study for proper evaluation).

Compensation for the Livelihood of Affected Fishermen Community

Reservoir fishery

While regular fish stocking is one way of enhancing reservoir fish stocks, reservoir-based aquaculture is also a useful practice to enhance fish stocks and economy of local fishermen. Cage culture is a very productive form of aquaculture practiced in the reservoirs of Vietnam, China, Indonesia, Philippines and elsewhere (de Silva, 1988b, 1992). However cage culture can also generate serious problems of water pollution. In developed countries, reservoirs are routinely used for sport fishing and angling which target a small number of highly regarded species (especially trout, salmon, walleye, bass, pike, catfish and perch). In Nepal, a successful cage culture is being practiced in Trishuli and Kulekhani reservoirs and Phewa, Begnas and Rupa lakes. The socio-economics of fragile affected local fishermen should be duly considered and Nepal is doing very good in terms of cage fish production in the reservoirs resulting from construction of dams to support them as alternatives.

Alternatives to livelihood

As fish catch had declined drastically, poor fishermen community should be trained in alternative livelihood like boating, cattle farming, vegetable growing etc. Trainings on sewing, knitting, poultry keeping, goat farming for females would be supportive for the families. These people can be diverted in the conservation management of indigenous fishes at dam affected areas in the spirit of Territorial use rights in fisheries (TURF) or Ethnic Parks. Certain sections of rivers can be conserved as 'Fish Sanctuary' and this community could be involved in this noble works.

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DIVERSITY OF CONVENTIONAL AND NON-CONVENTIONAL FISHING DEVICES AND THEIR IMPACT ON FISH CONSERVATION

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ABSTRACT

Nepal is endowed with Himalayan white waters in the form of river, stream, lake and reservoirs. These waters enrich with more than 200 fish faunal diversity, some of them are reported as threatened, endangered and vulnerable. At present capture fisheries contribute approximately 43.2% of the national fish production. Yield from natural water fishery comes from the use of both conventional and non-conventional fishing methods. The conventional methods used for fishing are nets, basket implements, rod and line, spearing and manual method. Non-conventional methods are the use of explosives, electrofishing and poisoning. These illegal and non-conventional fishing methods are usually practiced by non-professional occasional fishers. Today the ever-increasing human population has become the main cause of illegal fishing on the aquatic ecosystem. The indiscriminate fishing practices resulting in declining availability of valuable fish resources, indiscriminately killing rare and endangered species and large catch of undesired juvenile fish, which eventually turned in the erosion of fish biodiversity. One of the indicators of low fish availability from capture fisheries could be the constant or declining trend of fish catch observed during the last decade (2001-1009). Existing rules, regulation and Aquatic Animal Protection Act (AAPA) 2017 seem incompetent to address the mismanagement practices in open water bodies. As an immediate solution to the overexploitation of fishery resources, awareness/training program should be extended to the fishermen on the safe fishing methods to allow maximum sustained population of fish in their habitat. In the long run, however, impose of rules and regulations in accordance of AAPA (2017) are essential for the sustainability of aquatic and fishery resources.

***Key Words**: capture fisheries, fish conservation, fishing methods, indiscriminate fishing, overexploitation*

Introduction

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In Nepal capture fishery resources are highly diverse, blessed with vast diversified inland waters resources. Approximately, 5% of the total area of the country is known to be occupied by different freshwater aquatic habitats in the form of river, lake, swamps, ponds and ricefields (Bhandari, 1992). Water resources of the country includes 6,000 large and small rivers covering about 395,000 ha (48.3%), 60 medium and small lakes estimated to cover 5000 ha (0.61%), 1500 ha man made reservoir (0.2%), 11,100 ha wetland (1.36%) and 398,000 ha irrigated field (48.69%) (DOFD, 2010). About 106,257 families with 578,036 beneficiaries are estimated to be actively involved in capture fisheries for their livelihood (DOFD, 2005/06). Twenty four groups of ethnic people of the 103 ethnic/caste community in Nepal, most of them are depends on aquatic and fisheries resources for sustaining livelihoods. In Asia, fish is an important dietary component, where its contribution as a percentage of the animal protein intake is the highest in the world, amounting to 23.3 percent as opposed to the world average of 15.9 percent (De Silva and Funge, 2005). However, the per capita consumption of fish is about 1.8 kg to nearly 26 million population of Nepal (Mishra and Upadhyaya, 2010).

At present fish yield from capture fisheries comes from the use of both conventional and non-conventional fishing methods. Though the impact of the rampant use of non conventional fishing methods resulting in declining availability of valuable genetic resource for the future generations and unfortunately many of these valuable native fish resource are become threatened. Therefore the aim of this paper is to assess the types of conventional and non-conventional fishing devices and open up the discussion on impact of fishing devices on fish conservation as well as the need for enforcement of rules and regulations of AAPA (2017) for the sustainable use of aquatic and fishery resources in Nepal.

Methodology

Frame work survey on diversity of fishing devices was carried out using participatory rural appraisal (PRA) among fish farmers in different time periods. Types of fishing devices and operation methods of gears were studied in some localities of Kali Gandaki Hydro-dam, Seti River, Trishuli River, Karnali River and Jagadishpur Reservoir, Koshi River (Koshi Barrage and Chatara) and Rapti River. Beside survey, secondary source of information were also reviewed. Production and productivity of natural water resources and effect of gears on capture fishery was analyzed.

Estimated Fish Yield from Capture Fishery and Growth Trend

The total national fish production is 46779 mt and capture fisheries from natural waters shares about 43% of the national production (Figure 1). Fish production from capture fisheries is almost stagnant (1.5% growth rate) in past ten years. Since the capture fisheries practiced in natural water, the fish production solely comprised of indigenous fish. The range of fish production varies from 17.4 kg/ha in irrigated rice field to 449.3 kg/ha in marginal swamps (Wagle et al., 2011). Studies conducted by various workers in assessing fish catch revealed that the wide variation in fish productivity (22-637 kg/km stretch of river) from the rivers (Table 1). Although estimates of total inland fish catch are higher now than anytime in the past, this is probably due to increased fishing effort rather than improved health of fish stocks; the current catch levels are not necessarily sustainable. In light of the trend toward increasing habitat destruction, destructive fishing, barrier in waterway and fishing pressure, the catch of large migratory fish species, which typically reproduce more slowly, could decline while the catch of small and fast reproducing species would appear as high as ever. Decline in fish fauna and catch have been reported from lower basin of Narayani River (Dhital and Jha, 2002), and sharp depletion of fish stock in many water bodies around densely populated areas (Rajbanshi, 1996).

Diversity of Fishing Devices and Practices in Nepal

Conventional fishing devices

Conventional fishing device refered as collection of required number and size of fish so that sufficient population of fish remain balanced in the future. Conventional methods used for fishing in different water bodies of Nepal include nets, bamboo traps, basket implements, angling, spearing, [illegible]pping and manual method of killin[illegible]

A. Fishing with netting devices

Cast net (Hathe[illegible]), gill net (T[illegible]ri jal[illegible]), dip net (Thak[illegible] net, [illegible]anki net, Tr[illegible]mel net, Tregodia net and Bangla net) and scoop net (Ghorlang) are commonly used throughout the inland open water in Nepal.

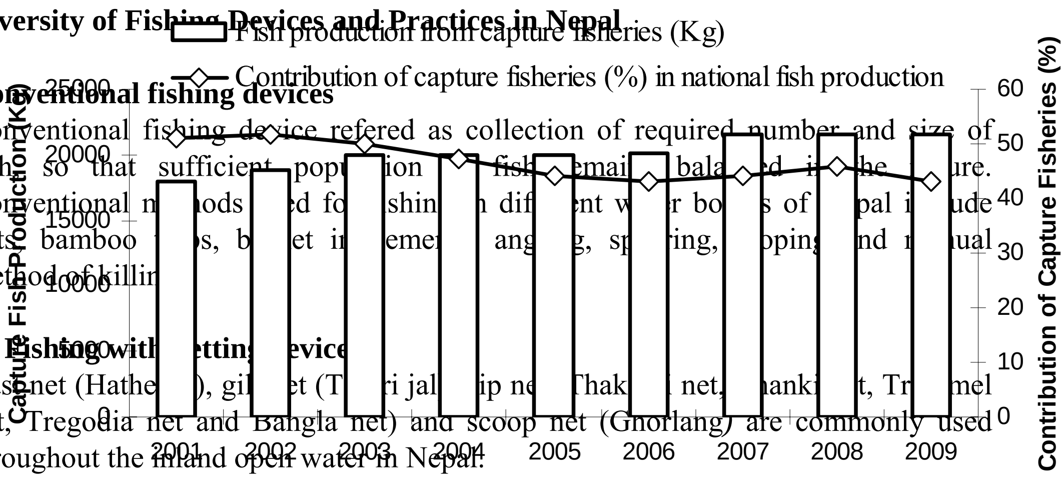

Figure 1. Trend of fish production from capture fisheries and its share to national fish production in Nepal

Table 1. Annual fish catch and yield estimates from major rivers of Nepal

Details	Trishuli River	Tarmur River	Upper Sunkoshi	Kali Gandki (NEA)	West Seti River	Koshi River Basin
Area (Stretch)	13 km	190 km	32 km		33 km	
Catch, Kg/day/HH, FTM	0.5-4		0.7	0.7		2.7
Catch, Kg/day/HH, PTM			1.8	0.76		
Annual catch Kg		14062	20371		712	
Annual yield		74 kg/km	637 kg/km		22 kg/km	
Reference	Gurung et al (2009)	Swar and Shrestha (1998)	Ranjit, (2002)	KGAR (2004)	Neupane & Poudel (1999)	Bhujel et al., 2007; Yadav 2002

FTM= Full time fishermen, PTM=Part time fishermen, HH=House hold

Cast net (hathe jal)

Cast net is a widely used fishing gear in Nepal. It is circular in shape and locally known as Hathe jal because it is operated by one man. The circumference of cast net varies from 2 to 4 m and length varies from 1.5 to 2.5 m. Its length is according to the depth of river/lake/reservoir. Cast net with various mesh size (1.2 to 13 cm) are used depending on nature of water body and the choise of fish species and the size. Net having small mesh size (1.2- 3.0 cm) usually preferred to catch smaller fish (Shrestha 1995). Cast net is employed to catch yearling of sahar *Tor putitora*, lohari *Crossocheilus latius*, snow trout *Schizothorax plagiostomus*, sidrae *Puntius* spp, phageta *Barilius* spp and other minor native fish (Table 2). Fishing with cast net is generally believied not destructive but netting during breeding season with small mesh size causes injury to brood fishes and loss of non-targeted small fish. Cast net are operated throughout the year in major river systems and streams of Nepal, Koshi River ((Yadav, 2002), Narayani River ((Shrestha, 1995), Seti River (Rayamajhi et al., 2007), Kali Gandaki Hydro-dam (Rayamajhi et al, 2010). In some places fisher operate cast net for a specific season, e.g. June to September in Trishuli(Gurung, 2009).

Gill nets (tiyari jal)

Most of the gill nets equipped with both floats attached to their upper edge (float line) and weights attached to their lower edge (sinkers). These nets are anchored vertically in shallow or deep water. Mesh size of the net vary with the size of the water body and the species to be caught. Small gill net (sanu tiyari) used in shallow water and large net (thulo tiyari) used in deeper waters of rivers and lakes. In Rapti River, fishermen use 20-22 meter long and 2 meter deep gill net to catch fish. Mesh size 3-5 cm are used throughout the year while smaller mesh size (1-2 cm) are used during the monsoon period. Shrestha (1995) reported that gill net with mesh size 5-7.6 cm used in narrow hill streams and wider mesh (12.7 - 20.3 cm) in the wide and open river of Tarai region to catch game fishes. Fishing with gill net has been found common in Seti River (Rayamajhi et al., 2007), Kali Gandaki Hydro-dam (Rayamajhi et al., 2010), Danda River (Wagle et al, 2005), Koshi River at Koshi Barrage, Karnali River at Chisapani, Rapti River Jagadishpur Reservoir. This gear has been found to be moderately harmful for minor carp particularly in rainy season. Usually fish migrate upstream for breeding and gill net operation in route might kill egg caring brood fish. Therefore, it can be suggested that use of certain sizes gill net should be restricted from June to September in flood plains.

Drift netting

Drift nets are much used in lowland section of the Narayani River and Begnas Lake. Floating gill nets are allowed to drift freely. Drift net consists of head rope as in a gill net, but without foot rope. The mesh size varies from 16 to 90 cm. It is often fastened to a boat which drifts with nets. A drift net operates across the river or from bank to bank. Large areas of water can be covered by drifting net walls. All kind of game fishes such as mahaser *Tor tor*, baghair *Bagarius yarrellii*, kanti *Aorichthys* (*Mystus*) *seenghala*, buhari *Wallago attu*, rohu *Labeo rohita*, bhakur *Catla catla*, saul *Channa marulius* are entangled in the meshed drift net (Shrestha, 1995). Drift nets are moderately harmful for all kind of game fishes with regard to conservation aspect.

Thakauli net or helka

Thakauli net is a kind of dip net, with an elliptical mouth narrowing posterior. The mouth has a bamboo rim and the mesh size of the net is about 1.0 cm. During fishing, fishers drop the net into the water against shallow water and lifting it out. This gear is operated by the man/women/ children in day time. The Thakauli net is widely used in Rapti River and Reu rivers (Shrestha, 1995) as well as in Danda River (Wagle et al., 2005). The negative impact of Thakauli net is observed directly to the targeted and non targeted native fish seeds (small-sized fish), lifting out from the shallow breeding ground. Affected fish are usually pothiya *Puntius conchoniu*, *Puntius* spp. phageta *Barilius* spp., singhi *Heteropneustes fossilis*, channi *Chanda* spp., lohari *Crossocheilus latius*, gadello *Nemacheilus* spp. and baghi *Botia*.

Tegodia net

Tegodia net, it is a kind of dip net used in shallow water, where the depth of water is not more than 1.0 m. The net is loosely tied on the L shaped wooden handle. Small size fishes such as pothia or sidre *Puntius* spp., kotari *Colisa fasciatus* and zebra *Brachydanio rerio* are caught by using this type of net (Shrestha, 1994). This kind of fishing has negative impact to the targeted and non targeted small-sized fish in the wet land and the shallow breeding ground.

Chanki net

It is used in wet land and shallow water. It is made of two bamboo flanks crossed each other and tied at the mid point. A square nylon net of 1.0 cm mesh size is loosely tied at the four ends of bamboo flanks. Small size fishes are caught by using this type of net and having negative impact on the targeted and non targeted native fish.

Bangla net

Bangala net is used in ponds, ditches and shallow water in all the seasons except during floods. It is made of two long bamboo poles about 4.0 m long between them the rectangular net is fixed. This gear is operated by the two man/women and children in day time by dipping the net under water and moving for some time and lifting it out (Shrestha, 1994). Usually small size fishes are caught by using this type of net and having negative impact on the targeted and non targeted native fish seeds.

Scoop net (ghorlang)

Ghorlang or Kurilo jal is a scoop net with a wooden handle about 1.5 m long. The handle is fixed to a circular wooden rim made up of two pieces. The first forked piece is joined with the handle, and the other is curved or semicircular. A conical net is fixed on the wooden rim. Ghorlang can be used in fast flowing water even in rainy season. It is operated by one person by holding the handle, dipping the net in water and rapidly lifting it out. Large and small fish can be caught with the help of this net (Shrestha, 1995).

Lift net (dhiki net or bag net)

The commercial Bamboo lift nets is locally known as, dhiki Jal. It is fixed in two bamboo poles that supported with four - six bamboo poles and set in a gentle flowing shallow water area in river to drain out water and brings in fish in a flat or bag like netting. Fishes like rewa *Cirrhinus reba*, tengra *Mystus vittatus* and buchebam *Mastacembelus armatus,* rohu *Labeo rohita*, jalkapoor *Ompok bimaculatus*, jalkapoor *Clupisoma* spp. are caught with this gear in Koshi river and in the upper reaches of Kulekhai khola for capturing asala *Schizothorax richardsoniii* (Shrestha, 1995). This gear is seriously harmful to Cyprinidae and Siluriformes group fish populations and its use should be restricted in breeding ground of some valnurable (V) and endemic (En) fish species such as zebra *Brachydanio rerio* (V), titaemacha *Psilorhynchoides* (*Psilorhynchus*) *pseudecheneis* (V), gonch *Bagarius yarrellii* (V), *Batasio macronotus* (En) particularly in Koshi River.

B. Fishing with basket implements and traps

A number of basket implements are used for fishing in Nepal. The basket implements are of different size and shape and are made of bamboo sticks. The trap is left in very fast water in a fixed position. This gear allows fish to enter and then make it hard for them to escape. As a result a considerable quantity of undesired fish catches. Use of this gear is seriously harmful to fish and consequently it should be banned between June and September.

Dhadiya (conical bamboo basket)

Dhadiya is an indigenous fishing basket. Dhadiya trap has a wide mouth with tapering body to posterior part. A small circular whole or opening is made in the mouth and rest part of moth is covered with bamboo sticks. It is kept in slow to fast running water between big stones or small rocks by the support of bamboo or tree sticks as a wall. In the running water the mouth of the trap is set against the direction of the water flow. Small fishes are entered through the small opening part of Dhadiya and get trapped in it. Often Dhadia is practiced in winter in Trishuli River(Gurung, 2009)..

Soala/Hoka/Dhoksa

It is elongated and tapering towards posterior side. The length is about 1-1.5 m and the mouth is 0.25 m in circumference. Sola is used in rainy season in small channel. It is placed in water for a few hours and taken out. This implement is used in Karnali River and Rapti River. This kind of gear is also used in Terai region (Morang district) (Shrestha, 1994). Dhoksa used in Jhapa, Morang and Sunsari in rice field to collect mostly pothiya *Puntius* spp., budhuna *Garra* spp. and chenga/ hille *Channa orientalis*.

Fishing pots (A trap)

In this method, a thin cloth covers the mouth of the aluminum or metallic bowl with a hole at the center. Wheat flour is spread around the hole and inside the bowl to trap the fish. The pot is then put in the shallow slow moving water, thereafter, the small fishes start assembling around the pot and after consuming the flour spread on the clothes, the fishes start moving inside the pot through the hole for the flour spread inside the pot. After 1- 2 hour the trapped live fishes are collected. Fish like *barilius*, *Puntius* get trapped in it. This kind of fishing trap is used in shallow water near the bank of Karnali River, Trishuli River and Seti River.

C. River diversion (duwali thunne)

It is common practice in most rivers of Nepal and is known as Duwali Thunne. Often river diversion is practiced in early monsoon, and from September to January-February (Gurung, 2009). For this kind of fishing a 2-3 meter wide and sloping dam is made of a stone or earth constructed by putting stones, clay, tree, trunks, branches and herbs leaves across the river with gaps at some places. A fish trap is set at the junction of the diversions and the main river to prevent fish from escaping. Various fishing accessories such as fences, scoop nets, scoop baskets and cast nets are used for harvesting fish. Occasionally fish poison is released to reduce activity of fish and enhance the catch. All indicator riverine fishes, such as snow trout, mahsers, eels are collected with this method. Such fishing practices usually carried out in Koshi barrage by diverting water to another side.

D. Pahai (fish barrier trap)

A series of long bamboo sticks or niyalo (2.5-3.0 m long × 0.30-50 cm high) are vertically placed into the river to made diversion and it is operated in the primary and secondary rivers. All types of fresh water species are caught. This gear is operated for November to May. Use of this kind of fish barrier trap in the river is illegal according the existing rule, regulation and Aquatic Animal Protection Act (AAPA) 2017. This kind of barrier can disrupt fish migrations as well as destroying fish spawning rounds.

E. Fishing with rod line

Angling with hooks

Fishing with rod and line is locally known as balchi hanne. Angling is used for recreational purposes and is universally acknowledges as a thrilling sport (Srivastava et al., 2002). Angling with fishing rod is a conventional method to harvest cold water fishes. Sahar *T. putitora* is best suited for sport fishing because of its fighting tendency. Like wise asala *Schizothorax richardsonii*, asala *Schizothoraichthys progastus*, katle *Neolissochilus hexagonolepis*, jalkapoor *Ompok bimaculatus*, jalkapoor *Clupisoma* spp. and fageta *Barilius bendelisis* are major encountered species. Though, this practice affects more snow trout (*Shizothoraichthys progastus*) more than others (Gurung, 2009; Shrestha, 1995). In Arun and Tamur River, fishermen hook schooling fish during early spring and autumn. This method of fishing is popular among fishermen in the Trishuli River (Gurung 2009). Fishing with rod and line are usually carried out in Danda River (Wagle et al., 2005), Rapti River, Seti River (Rayamajhi et al 2007) and Phewa Lake of Pokhara Valley.

Table 2. Summary of selective and non-selective gear used in the inland waters of Nepal

Fishing gear	Major species encountered by method	Impact on ichthyofaunal conservation
Netting devices	Katle *Neolissochilus hexagonolepis*, Sahar *Tor putitora*, Mahaser *Tor tor*, Gonch *Bagarius yarrellii*, Lohari *Crossocheilus latius*, Asala *Schizothorax richardsonii* and *Schizothoraichthys* spp., Sidre *Puntius ticto*, Pothi *Puntius chola*, Pothiya *Puntius conchonius*, Chuchebam *Xenentodon cancila*, Gainchi *Macrognathus* (*aculetus*) *aral*, Jalkaoor *Ompok bimaculatus*, Jalkaoor *Clupisoma garua,* Kandae *Glyptothorax cavia*, Rohu *Labeo rohita*, Rewa *Cirrhinus reba*, Tengra *Mystus bleekeri*, Thend *Labeo angra*, Bhakur *Catla catla*, Naini *Cirrhinus mrigala*, Budhuna *Garra* spp., Goha *Barilius bola*, Buchebam *Mastacembelus armatus*, Phageta *Barilius spp.*, Garahi *Channa punctatus*, Buhari *Wallago attu*, Katara *Colisa fasciatus*, saul *Channa marulius*, Singhi *Heteropneustes fossilis*, Gaddelo *Nemacheilus spp.*, Batashi *Batasio batasio* and Zebra fish *Brachydanio rerio*	Netting devices are generally not a destructive method but netting during breeding season with small mesh sized net causes loss of brood fishes (valuable and endemic) and untargeted small fish.
Dip net	Pothiya *Puntius conchonius*, Sidre *Puntius ticto*, Phageta *Barilius* spp., Singhi *Heteropneustes fossilis*, Lohari *Crossocheilus latius*, Rewa *Cirrhinus reba*, Gaddelo *Nemacheilus spp.*, Katara *Colisa fasciatus*, Zebra *Brachydanio rerio* and Baghi *Botia lohachata,*	Scoop netting is not itself a destructive method of fishing but, when it is used with dynamiting, electrofishing & river diversion causes wanton killing.

Basket implements & traps	Pothiya *Puntius conchonius*, *Puntius* spp., phageta *Barilius* spp., Budhuna *Garra* spp., singhi *Heteropneustes fossilis*, chenga/hille *Channa* (*gachua*) *orientalis,* lohari *Crossocheilus latius* and other small fishes	A destructive method causing wanton destruction of fishes.
Rod line	Snow trout and other cold water fish	This practice affects more cold water fish.
Fish spearing	Budhuna *Garra* spp., Asala *Schizothorax richardsonii* and *Schizothoraichthys* spp., Phageta *Barilius* spp., Katle *Neolissochilus hexagonolepis*, Sahar *Tor* spp., Kabre *Glyptothorax* and other fresh water fishes	The method is not considered destructive.
Rock striking or hammering	Gaddelo *Nemacheilus spp.*, Budhuna *Garra* spp., Asala *Schizothorax richardsonii* and *Schizothoraichthys* spp., Fageta *Barilius* spp., Sahar *Tor* spp, Katle *Neolissochilus hexagonolepis*, and Eel fishes	Destructive method causing indiscriminate killing of all ages fishes hiding under rocks.
Water poisoning	Nearly all types of fishes and other aquatic organism	Causes wanton destruction of aquatic life and pollutes the water.
Electo-fishing	Nearly all types of fishes and endemic fish species	Destructive method causing indiscriminate killing of fishes of all ages.
Explosive	Nearly all types of fishes	Mass killing of fishes of brood to fish seed.

Loop-line fishing

Loop-line fishing is locally called Lahare-paso is practiced in the Trishuli River (Gurung, 2009) and Sunkoshi Rivers. The loop is made from a nylon thread. A single line may support 3-5 loops. The size of loop regulates the size of catch. A colored lead weight functions as bait. Live bait such as fish, shrimp, earthworms, stonefly and mayfly larvae are also used in looping in the Trisuli River and Sunkoshi River. Paso is used from September to April, when the stream water is clear and cold and the fish start their upstream migration. This method captures asala *Schizothorax richardsonii*, thaind *Labeo angra* and some other fish.

F. Fishing with thrown spears

This method is applied where the water level is low. A spear fixed at the tip of a bamboo or wooden handle. This device is usually operated at the crevices of stones and rocks. Fishing with sharp knife (Khukuri) in front of the torch light is practiced with a team of fishers at night. Large to small fishes encountered with this fishing method. Fish spearing is carried out in Rapti River, Sunkoshi River, Dolalghat River, Narayani River, Tamur River and Rara Lake (Shrestha, 1994, Shrestha, 1995). The spearing practice is carried in January and April because fish are seen easily in transparent water (Shrestha, 1995). The method is not considered destructive, however, it should be restricted to shallow waters to conserve valuable fish species.

G. Manual fishing methods

Rock striking or hammering

Large and flat rocks are selected in the shallow waters on which a weighty iron hammer is struck Thus an intensive vibration and sound produced and result impairs the both large and small fish's float on the water surface. These paralyzed fishes are thus caught with bare hands or scoop nets. This fishing method is common in shallow areas of Seti River (Rayamajhi et al, 2007).

Unorthodox and obnoxious fishing practices and their harmful impacts

Non-conventional methods involves indiscriminate killing of large number of fish (juvenile as well as brood fish) which adversely affects the water quality of rivers. Non-conventional methods cover the use of explosives, electro fishing and poisoning, which is harmful for the conservation of aquatic resources. Such activities not only degrade the target fish population by changing the population size and structure, but also affect other species linked to it in the food chain. Non-target species may also be injured or killed by the use of unsuitable fishing gear and practices. These illegal and non-conventional fishing methods are usually practiced by non-professional occasional fishers.

Water poisoning

Traditionally, different plants have been used for killing fish (Karki and Rai, 1982). Fishing with herbal and chemical poisons is one of the important poisoning methods of the open water bodies which are applied in high concentrations to the areas with high probability of catching fishes. In recent years the practice has been further intensified by the use of chemical pesticides (Aldrin, Thiodine, BHC, Malathion, DDT, Endosulfan etc). Free access to hazardous chemicals, insecticides and pesticides and their rampant use is, consequently, another threat to inland fish fauna.

Traditionally, extract of the stem, bark and fruit of ichthyotoxic plants have been used to kill the fish in Nepal. The leaves of herbal plants such as ketukee *Avage americana* and khirro *Sapium insigne* has been used for fish poisoning in the Koshi River at Koshi barrage and Chatara side by the non-professional occasional fishers. A recent survey carriedout in Rapti River shows extract of pirre *Polygonum hydropiper* leaves kill the fish in 5-7 meter peripheral distance during rainy season. Bark of kaphal *Myrica esculenta*, stem of the titae pati *Artimesia vulgaris*, bark of walnut *Juglans regia*, stem and root of aryli *Edgeworthia*, timur *Xanthoxylum alatum* and chilly powder *Caspicum* are also the common plants used in inland water of Nepal as fish poison.

Fish poisons take place mainly in the dry season, between November and April in waters less than two meters deep. The neurotoxic or suffocating effects of use of unorthodox fishing practices in terms of synthetic chemical and ichthyotoxic plants may narcotize and kill the valuable and non target fish. After its application, the fishes come to the surface and exhibit abnormal behavior (nervous breakdown and lack of dissolved oxygen may be the possible causes) (Srivastava et al, 2002). Most poison affect gills of the fish. The application of fish poison not only damages the ecosystem but may also affect the health of human beings.

Use of explosives

Groups of fishermen usually select the remote areas of streams and use dynamite to catch fishes. Fishing with explosives is extremely dangerous and destructive, indiscriminately killing all species within the radius of action of the explosion. Before using explosives fishermen throw rice or oil cakes into the pool to attract and concentrate the fish. They wrap the explosive in thick cloth, ignite it and throw it in the pool. The killed or stunned fish are then picked up with hands and by scoop net. This method catches predominantly katle *Neolissochilus hexagonolepis*, sahar *Tor* spp., budhuna *Garra* spp, titaemacha *Psilorhynchoides* (*Psilorhynchus*) *pseudecheneis*, kabre *Glyptothorax* and *Nemacheilus* spp. The use of explosive is still being used in Seti River (Doti district), Trishuli River (Dhading District) and Rapti River (Chitwan District).

Electro fishing

Use of electricity to catch fish in small shallow rivers and streams is usually not selective causing fish kill of all stages. In Nepal, electro fishing efforts are inadequately documented. Many respondents suggested that handling of fish during and after netting probably has a greater effect on mortality and delayed recovery than the electric field. Most electro fishing mortalities appear to result from asphyxiation due to poor handling. However, electrofishing injuries may significantly reduce subsequent growth, at least until they fully heal. Exposure of recently hatched larvae might not cause significant mortality but can reduce growth rate for at least a few weeks. Exposure of ripe fish to electro fishing fields can cause significant damage to or premature expulsion of gametes and sometimes reduces viability of subsequently fertilized eggs. Electro fishing over active spawning grounds can also significantly affect survival or embryos on or in the substrate if exposed during their more sensitive stages. Possible detrimental effects of electro fishing on fish include cardiac or respiratory failure, injury stress and fatigue. Fish that survive despite electro fishing injury or other adverse impacts, may suffer short-term, long term or lifetime handicaps that affect their behavior, health growth or reproduction. Electro fishing is often considered the most effective and benign technique for capturing moderate-to large-size fish, but when adverse effects are problematic and cannot be sufficiently reduces, its use should be severely restricted (Snyder, 2003). Electro fishing, the use of electrodes in water, to capture fish has been a serious problem in all stages fish, especially for some endangered species (*Pseudeutropius murius batarensis*, *Batasio macronotu*), *Pseudecheneis crassicauda*, *Pseudecheneis eddsi*, *Pdilorhynchus nepalensis*).

Cast net in Seti River

Vertically set drift net into River

Gill net at Rapti River

Chanki net in shallow water

Tegodia net in shallow water near ricefield (Bardia)

Ghorlang or kurilo Jal

Photo 1. Different types of conventional fishing gear

Conclusion

Over the years uncontrolled and often indiscriminate fishing in the largely unmanaged inland water of Nepal has resulted in decline in capture fisheries of the important sport and subsistence fish. It may be concluded that gene pool of unique ichthyofauna in Himalayan country Nepal is a valuable endowment of nature. The aquatic resources and fish germplasm are our national wealth. Any species getting extinct would upset the ecological balance resulting in dangerous imbalance of the system. Thus the use of destructive methods of fishing calls for formation of task force, strict awareness, abandon or stopping illegal fishing and effective enforcement of rules and regulations of AAPA (2017) such as, closed season, mesh size regulation and awareness of the local people residing along the river bank. The involvement of local clubs, self-help community groups, is urgently needed in an effort to maintain fish stocks at a healthy level. As an immediate solution to the overexploitation of fishery resources, educating the local communities on the safe fishing methods, aware about destructive effects of the practices and making them more vigilant and responsible for controlling them would be more effective for the sustainability of aquatic and fishery resources. The fishery resources stocks should be enhanced through regular release of hatchery produced fingerlings.

Acknowledgements

We express our thanks to the many fishers and local people in the survey area for their cooperation.

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INDIGENOUS CATFISHES AND THEIR DIVERSIFICATION FOR AQUACULTURE

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ABSTRACT

Nepal is predominantly a mountainous country with huge water resources supporting diversified ichthyofauna. Natural water resources comprise of about 6000 rivers and rivulets. There are three major river systems in Nepal namely Koshi, Gandaki and Karnali which along with other rivers and scores of lakes and reservoirs are the habitat of 217 native species of fish from different climatic zones. Out of the aforementioned figure (217), 69 are native cat fish species. They belong to order Siluriformes having 33 genera under 10 families. Sisoridae is the major family having the maximum number of fishes (59.3%) followed by Bagridae (16.0%), Schilbeidae (12.0%) and Siluridae (4.3%) while Amblycipitidae, Pangasidae, Clariidae, Heteropneustidae, Chacidae and Olyridae represented each by 1.4%. Various stocks of indigenous catfishes include long whiskered catfish, river catfish, gangetic mystus, menoda catfish, butter catfish, boal catfish, gangetic ailia, garua bachwa, silondia bachwa, pungas, gangetic goonch, sisor catfish, walking catfish, stinging catfish, squarehead catfish etc. These fish species have great potential in national economy and support livelihoods of a number of people. Several economically important native catfishes are now at risk of extinction. However, cultivation of some species such as walking catfish, *Clarias batrachus*; stinging catfish, *Heteropneustes fossilis*; river catfish, *Aorichthys seenghala*, *A. aor*; menoda catfish, *Mystus menoda*; and gangetic mystus, *Mystus cavasius* should be practiced and their conservation through induced spawning should be done to maintain the indigenous stock of the country.

***Key Words**: conservation, ichthyofauna, native cat fish, national economy*

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Introduction

Aquatic systems of Nepal are the habitat of 217 native species of fish from different climatic zones (Shrestha, 2008). Among these 69 are native cat fish species which are a diverse group of ray-finned fish (Shrestha, 2008). Cat fishes under the order Siluriformes are well-known for their barbells which resemble a cat's whisker. They possess one to four pairs of barbells and are bottom-feeder omnivores. They are most active after dark. Their entire bodies possess highly developed sensory cells and are much less dependent on senses of sight and smell than other day feeding fishes (Shrestha, 2008). In many species, air bladder is subdivided and reduced (Nelson, 1994). Their bodies are often naked or with bony scutes or plates but are never with true scales (Jayaram, 1999). Although catfishes are found in lakes and ponds, they are primarily river residents and are most prevalent in the major river systems of the country.

Catfishes are of considerable commercial importance and chiefly cultivated or caught for food. They include heaviest and largest of migratory catfishes, the giant gangetic goonch *Bagarius yarrellii* and even to a smallest species commonly called the datari or koshi hara *Hara hara*. The farming of cat fishes has spread all over the world including the United States of America, Asia, Middle and Far East, Africa as well as in Latin and North America due to their fast growth rate, enduring difficult environmental conditions and consumer attraction (Elsayed, 1996). Catfishes, especially species of the families Pangasidae, Clariidae and Bagridae have been commercially farmed in Asian countries for decades. In Nepal, native catfishes are produced from natural fisheries. The catfish resources of the aquatic system is of great importance for the Nepalese as it supports a number of people whose livelihoods depend upon that tremendous fish diversity.

Major rivers along with floodplains support wide range of biodiversity and services to society. The aquatic systems have vital catfish stocks and species complexes. These stocks are greatly affected by alteration of habitat, pollution and overexploitation of such resources. The fragmentary records of catfish species from different water bodies are available through Shrestha, 1990, 1994, 2008; Jha, et al., 1986, 1989, 2007, 2008; Dhital and Jha, 2002; Rajbanshi, 2002; Ng et al., 2005. For their proper conservation planning, there is a need to assess species distribution in different geographic locations. Therefore, an effort has been made to investigate the catfish diversity of the aquatic systems of the nation.

Diversity of Indigenous Catfish

The present study revealed that aquatic systems of Nepal have diversified catfishes belonging to order Siluriformes, having 33 genera under 10 families. Sisoridae is the major family having the maximum number of fishes (59.3%) followed by Bagridae (16.0%), Schilbeidae (12.0%) and Siluridae (4.3%) while Amblycipitidae, Pangasidae, Clariidae, Heteropneustidae, Chacidae and Olyridae represented each by 1.4%. Amongst 69 native catfishes the families, Sisoridae have the highest number of species (41) followed by Bagridae (11), Schilbeidae (8) and Siluridae (3). The family Sisoridae includes largest (*Bagarius yarrellii*) and smallest (*Hara hara*) fishes having 16 genera namely *Bagarius, Conta, Coraglanis, Erethistes, Erethistoids, Euchiloglanis, Exostoma, Gagata, Glyptosternon, Glyptothorax, Hara, Pseudolaguvia, Myersglanis, Nangra, Pseudecheneis and Sisor* (Shrestha, 2008). Among these genera *Glyptothorax* is represented by 12 species followed by *Pseudecheneis* (4) while *Erethistoids*, *Gagata*, *Nangra* represented each by 3 species. Similarly *Bagarius, Hara, Pseudolaguvia* and *Sisor* represented each by 2 species and rest of the genera *Conta, Coraglanis, Erethistes, Euchiloglanis, Exostoma* and *Myersglanis* represented each by single species. The family Bagridae has four genera of which *Mystus* dominated by 6 species, followed by *Aorichthys* (2), *Batasio* (2) while *Rita* represented by single species. Similarly family Schilbeidae has five genera of which *Eutropiichthys* dominated by 3 species, followed by *Clupisoma* (2), while *Ailia, Pseudeutropius* and *Silonia* represented each by single species. Furthermore, Siluridae family has two genera of which Ompok has 2 species while *Wallago* represented by single species. Interestingly, the family Amblycipitidae, Pangasidae, Clariidae, Heteropneustidae, Chacidae and Olyridae each were represented by single species; *Amblyceps mangois, Pangasius pangasius, Clarias batrachus, Heteroneustes fossilis, Chaca chaca* and *Olyra longicaudata* each of the respectively. Taxonomic position, common and local name, localities and status of fish species are listed in the Table 1.

Results show that, in general, the aquatic ecosystem supports diverse stock of catfishes. Upper stretches of the river is dominated by important coldwater catfishes such as *Clupisoma garua*, *Bagarius* spp, *Euchiloglanis hodgarti, Glyptosternon* spp, *Glyptothorax spp* and *Pseudecheneis* spp. Among these species *Glytothorax* spp is the most common and dominant. In the middle and lower stretches of the major rivers, the species reported were *Aorichthys* spp, *Ompok* spp, *Mystus* spp, *Heteropneustes fossilis, Clarias batrachus, Eutropichthys vacha, Ailia coila, Wallago attu,* and *Bagarius* spp. Bagarius sp is a migratory fish reaches headwaters during rainy summer at an altitude of 1424m (Shrestha, 1999). Out of 69 species, common (25), uncommon (18) and rare (26) were reported (Table 1 and Figure 1).

Among these *Mystus* spp, *Ompok* spp, *Wallago attu, Pseudeutropius atherinoids,Glyptothorax telchitta, Heteropneustes fossilis* and *Clarias batrachus* were very common. *Mystus gulio, Clupisoma garua, Amblyceps mangois, Bagarius* spp, *Aorichthys* spp., *Pseudecheneis sulcatus, Rita rita* and *Gagata cenia* were uncommon. *Batasio* spp, *Conta* sp, *Corglanis* sp, *Erethistoids* spp, *Gagata* spp, *Glyptothorax garhwali*, *Glyptothorax gracilis*, *Hara* spp, and *Pseudecheneis* spp were reported rare (Shrestha 2008).

Table1. Taxonomic position, common/local name and status of fish species in major river systems (after Shrestha, 2008)

Order/ Family /Genus/Species/Maximum size (Length in cm)	Common/Local name	Koshi river	Gandaki river	Karnali river	Abundable Status
Siluriformes/ Family :Amblycipitidae 1. *Amblyceps mangois*(Ham.) L=10	Torrent catfish/Chilni, Baljung	+	+	+	Uncommon
Family :Bagridae 2. *Aorichthys aor* (Ham.) L=100-180	Long-whiskered catfish \ Kanti	+	+	+	Uncommon
3.*Aorichthys seenghala* (Sykes) L=100-180	Giant river catfish/Kanti	+	+	+	Uncommon
4. *Batasio batasio* (Ham.) L=10	Tista Batasio/Batasio	+	+	+	Rare
5. *Batasio macronotus* (Ng & Edds) L=10	Batasio	+	_	_	Rare
6. *Mystus bleekeri* (Day) L=10	Days Mystus/ Tenger	+	+	+	Common
7. *Mystus cavasius* (Ham.) L=30	Gangetic Mystus/Tenger	+	+	+	Common
8. *Mystus gulio* (Sykes) L=40	Long-whiskered catfish/Tenger	+	_	_	Uncommon
9. *Mystus menoda* (Ham.) L=45	Menoda catfish/Belauni	+	+	+	Common
10. *Mystus tengara* (Ham.)L=15	Tengara mystus/tenger	+	+	+	Common
11.*Mystus vittatus* (Bloch) L=17	Striped dwarf catfish/Tenger/kanti	+	+	+	Common
12. *Rita rita* (Ham.)L=50	Rita/Belaunda	+	+	+	Uncommon

Family:Siluridae 13. *Ompok bimaculatus* (Bloch) L=40	Butter-catfish/Pabda, Lodara	+	+	+	Common
14. *Ompok pabda* (Ham.) L=17	Pabda catfish/Pabda	+	+	+	Uncommon
15.*Wallago attu*(Schn.) L=200	Boal, Whiskered catfish, Freshwater Shark/Buari	+	+	+	Common
Family:Schilbeidae Sub-Family:Ailiinae 16. *Aillia coila* (Ham.) L=15-20	Gangetic Ailia/Patasi	+	+	+	Common
Sub-family:Schibeinae 17. *Clupisoma garua* (Ham.) L=70	Garua bachwa/Jalkapoor	+	+	+	Uncommon
18. *Clupisoma Montana* (Hora) L=25	Kocha garua/jalkapoor	+	_	_	Uncommon
19. *Eutropiichthys goongware* (Sykes) L=30	Gunware bachwa	+	+	+	Common
20. *Eutropiichthys murius* (Ham.) L=28	Murius bachwa/jalkapoor	+	+	+	Uncommon
21. *Eutropiichtys vacha* (Ham.) L=32-40	Bachwa vacha	+	+	+	Uncommon
22.*Pseudeutropieus atherinoides* (Bloch) L=15-30	Patasi	+	+	+	Common
23. *Silonia silondia* (Ham.) L=90	Silondia vacha	+	+	+	Common
Family:Pangasidae 24. *Pangasius pangasius* (Ham.) L=90	Pungas/Jalkapoor	+	+	_	Uncommon
Family:Sisoridae 25. *Bagarius bagarius* (Ham.) L=180	Gangetic goonch/Giant catfish/gounch	+	+	+	Uncommon
26.*Bagarius yarrellii* (Sykes) L=200	Gaint catfish/gounch	+	+	+	Uncommon Largest fish of Nepal
27. *Conta conta* (Ham.) L=8	Conta catfish/konta	+	_	_	Rare
28. *Coraglanis kishinouyei* (Kimura)L=12.6		_	+	+	Rare

29. *Erethistes pussilus* (Muller& Troschel) L=5	Gangetic Erethistes/Kata kanti	+	+	+	Rare
30. *Erethistoides Montana Montana* (Hora) L=4.8	Kapre	+	_	_	Rare
31. *Erethistoides ascita* (Ng & Edds) L=4	Kapre	+	_	_	Rare
32. *Erethistoides cavatura* (Ng & Edds) L=3.5	Kapre	_	+	_	Rare
33.*Euchiloglanis hodgarti* (Hora) L=5	Telcapre	_	+	_	Rare
34. *Exsostoma labiatum* (McClelland) L=5.8	Kabre	_	+	_	Rare
35. *Gagata cenia* (Ham) L=10	Gagata/Ganfak	+	+	+	Rare
36. *Gagata gagata* (Ham.) L=31	Gangetic gagata	+	_	+	Rare
37. Gagata sexualis (Tilak)L=6	Koel gagata/Buhani	+	+	_	Rare
38. *Glyptosternon maculatum* (Regan)L=25	Torrent catfish/Capre	_	_	+	Rare
39. *Glyptosternon reticulatum* (McClelland)L=15	Kabre	+	_	_	Uncommon
40.*Glyptothorax alaknandi* (Tilak) L=9	Kapre	+	+	+	Rare
41. *Glyptothorax annandalei* (Hora) L=11.5	Kapre	+	+	+	Rare
42. *Glyptothorax botius* (Ham.) L=6	Telcapre	+	_	_	Uncommon
43. *Glyptothorax cavia* (Ham.) L=28	River catfish/Vedro	+	+	+	Common
44.*Glyptothorax conirostie conirostie* (Steindachner)L=14	Capre	+	+	+	Rare
45.*Glyptothorax garhwali* (Tilak)L=8	Kapre	+	+	_	Rare
46. *Glyptothorax gracilis* (Gunther)L=12.7	Kapre	+	_	_	Rare

47. *Glyptothorax indicus* (Talwar)L=11	Capre	+	+	+	Common
48. *Glyptothorax kashmirensis* (Hora)L=11	Capre	_	_	+	Uncommon
49. *Glyptothorax pectinopterus* (McClelland) L=18	Capre	+	+	+	Uncommon
50. *Glyptothorax telchitta* (Ham.) L=10	Telcapre	+	+	+	Common
51. *Glyptothorax trilineatus* (Blyth) L=30	Telcapre	+	+	+	Common
52. *Hara hara* (Ham.) L=2.5	Koshi Hara/Datari	+	+	_	Common Smallest fish of Nepal
53. *Hara gerdoni* (Day) L=4	Sylhet Hara	+	_	+	Rare
54. *Pseudolaguvia kapuri* (Tilak & Hussain)L=4	Tinkantiya/datri, kirkire	+	+	+	Common
55. *Pseudolaguvia ribeiroi* (Hora)L=10	Tinkantiya/bistuiya	+	+	+	Common
56. *Myersglanis blythi* (Day)L =7.5	Pharping catfish	_	_	_	Rare/ Endemic to Pharping
57. *Nangra assamensis* (Sen & Biswas)L=10	Nangra	+	+	_	Rare
58. Nangra nangra (Ham.) L=5	Koshi nangra/befuni	+	+	+	Rare
59. *Nangra viridescens* (Ham.)L=12	Huddah nangra/Katenga	+	+	+	Uncommon
60. *Pseudecheneis eddsi* (Ng)L=15	Gotel/kabre	_	+	_	Rare
61. *Pseudecheneis crassicauda* (Ng & Edds) L=15	Kabre	+	_	_	Rare
62. *Pseudecheneis serracula* (Ng &Edds) L=15	Kabre	+	+	_	Rare
63. *Pseudecheneis sulcatus* (McClelland) L=15	Sulcatus catfish/Kabre	+	+	+	Common

64. *Sisor rhabdophorus* (Ham.) L=18	Sisor catfish/kirkire,girgitya or Chheparo machha	+	+	+	Common
65. *Sisor rheophilus* (Ng) L=15.5	Kirkire sing puchhare machha	+	+	+	Common
Family:Clariidae 66. *Clarias batrachus* (Linn.) L=47	Walking catfish/Mangur,Mungri	+	+	+	Common
Family:Heteropneustidae 67. *Heteropneustes fossilis* (Bloch) L=30	Stinging catfish/Singhi	+	+	+	Common
Family:Chacidae 68. *Chaca chaca* (Ham.) L=20	Squarehead catfish, Toadfish/Kurkuree, pauna	+	+	+	Common
Family:Olyridae 69.*Olyra longicaudata* (McClelland)L=11	Himaliyan olyra	+	+	_	Common

Various researchers have reported different numbers of catfish species from the Koshi, Gandaki and Karnali river system. Amongst them, Shrestha (1994) reported 31 species. Ng and Edds (2005 and 2006) reported 3 new species of *Pseudecheneis*. Jha and Shrestha (1986) collected 12 species of catfish through longitudinal survey of the Karnali river system. Further, Dhital and Jha (2002) and Jha and Bhujel (2008) collected 18 and 24 species of catfish from the Narayani-Rapti river system in Chitwan/Nawalparasi respectively. Shrestha, (1990, and 2008) reported 30 and 69 indigenous catfish species from different aquatic systems of the country respectively. Rajbanshi (2002) and Shrestha (2002) reported 21 and 19 cold water catfish species from different aquatic systems of the country respectively. Moreover, Shrestha (2008) reported 61, 53 and 47 catfish species from Koshi, Gandaki and Karnali River respectively while *Myersglanis blythi* is endemic to Pharping area (Table 1). Thus Koshi is the richest in its catfish faunal characteristics followed by Gandaki and Karnali River.

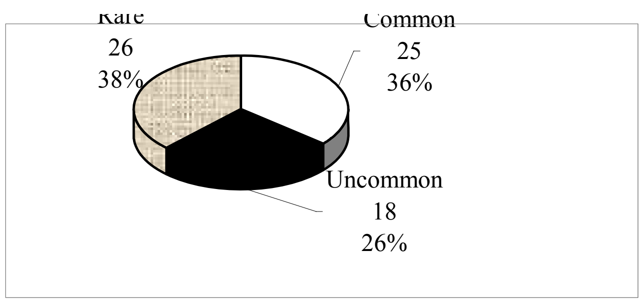

Figure 1. Status of catfishes

The major reasons of degradation of aquatic ecosystems are due to human activity as reported by Dudgeon (1992). Petr (2002) pointed out that the deterioration of environment in catchments of lakes, rivers and reservoirs is placing an increasing strain on aquatic habitats. Further, main destructive force of the ichthyo-faunal diversity of the aquatic system is watershed developments that are taking place at a rapid rate, particularly through dam building and associated habitat destruction, and called for a more concerted dialogue between developers and planners, and conservationists. Similarly, most of the river systems have barrage to control water for power generation and irrigation without any 'fish way'. There is a great impact of barrages and irrigation systems on the aquatic life of up and downstream of the river (Shrestha, 2002; Rai et al. 2007). Faunal composition is affected by interference on the natural system of the river (Rajbanshi, 2002; IFSI, 2006). Specially, during summer, downstream near barrage is completely dry which affects the migration of important migratory fishes.

Fisher community of most of the aquatic systems reported, declining of catches due to degradation of fish habitats and barrage without fish-way which obstruct spawning migration. Regulation of water flow by damming or irrigation has pronounced effect on fishery resources of major rivers (IFSI, 2006).

Conservation Effort

The Mukhiya fish breeding farm of Nannupatti, Dhanusha district has started breeding of *Mystus cavasius.* It has been reported that price of catfish is more in comparison to carps and seed demand of indigenous catfishes exert pressure to breed them. Although, Mukhiya farm is able to breed *Mystus cavasius* but fry recovery is very poor. There is possibility to breed other catfishes in near future which could help species diversification for aquaculture as well as conservation of genetic resources.

Conclusion

The major river systems support diverse catfish species and most of these species are also found in lakes, reservoirs and village ponds. Fish diversity of these aquatic systems is affected by over exploitation of fishery resources and loss of habitat. Abundance of fish species of the systems has changed from highly preferred to least preferred species indicating that many of them are at risk. Fish catch data should be recorded and collected to confirm the fishermen's claim of fish decline and appropriate measures should be applied.

Research on some species such as walking catfish, *Clarias batrachus*; stinging catfish, *Heteropneustes fossilis*; boal, *Wallago attu;* river catfish, *Aorichthys seenghala*, *A. aor*; menoda catfish, *Mystus menoda*; and gangetic mystus, *Mystus cavasius* should be practiced and their conservation through induced spawning should be done to maintain the indigenous stock of the country. However, further research is needed on whether there are any significant effects of human activities on the fish population through habitat alterations, poisoning and other illegal fishing, over exploitation and new species introduction in the aquatic systems.

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FISH BIO-DIVERSITY OF MARSHYANGDI RIVER AND ITS FEEDER STREAMS

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ABSTRACT
Fish inventory of Marsyangdi River and its feeder streams in Lamjung districts was made to record existing fish biodiversity of these rivers. Twenty-six species of fishes belonging to 5 orders and 6 families were recorded. List concerning kind, occurrence and distribution of the fishes in the various sections of these rivers were discussed. The collected specimens were dissected in the laboratory and their gut contents were analyzed categorizing the ingested food items. Similarly, effects of damming on fish were also assessed.

***Key Words**: fish inventory, biodiversity, Marsyangdi River, damming*

Introduction
Lamjung district is located at the northeastern corner of the western development region in Nepal. It has subtropical climate at an average altitude of 776 m above sea level. This region is drained by Marsyangdi, Maadi and Chepe river systems, which finally confluence and run as Marsyangdi River. Marsyangdi River, which drains 153 km, is one of the tributaries of Trisuli River and joins it at Mungling bazaar. This river originates in the Himalayas at an altitude of 6400 meter. The average slope of this river is 0.0417 (Shrestha, 1999).

The Marsyangdi River flows through various physical zones and thus presents as an excellent platform to investigate different fishes with ecological notes. The main objective of this study is to classify different fishes according to their feeding behavior and to establish specimens of indigenous fishes in the laboratory of Lamjung campus. This investigation also focuses on the damming effect on migratory fishes and how it has disrupted breeding habitats in Marsyangdi River.

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Materials and methods

The river and streams of lamjung were visited from September 2001 to July 2002, to collect fish fauna that exist in the region. The study area was divided into following locality based on the abundances of fish stock of the rivers and streams of these regions: (i) North-eastern bank of marsyandi river of Vulvule, (ii) Majuwa and Marsyangdi confluence at Besisahar, (iii) Marsyangdi and Dordi confluence at Achalbot, (iv) Paundi and Marsyangdi confluence at Paundi bazaar and (v) Marsyangdi confluence at Dhamali Kunwa.

Fish specimens from these localities were collected by employing local fisherman with the help cast net. Various methods of fishing such as trapping, electric fishing and poisoning devices were observed and different ecological parameter like temperature, pH, water color and water depth of various section were recorded. At regular interval fishes were dissected and their gonads and the stomach contents also checked to understand feeding habits and spawning periodicities. These specimens were preserved and fixed in 10 % formalin. To minimize color fading specimens were preserved in 70 % alcohol, prior the fixation, the larger specimen were incised longitudinally along the abdomen while the smaller once were directly put into the formalin. The preserved specimens were identified in the laboratory and then placed in container with proper labeling. The fishes were kept upside down to avoid any damage to the caudal fin.

Counts pertaining to the number of scales and fin rays as well as measurements of body were according to the system developed by Shrestha (1981) and Jha (1986). In addition the depth of body was measured along the deepest part of the body and weight of the fish. The genera under their respective families and sub families and the species under their respective genera were arranged alphabetically, the identified specimens were kept in aquaculture lab of Lamjung campus, Lamjung Nepal.

Results and Discussion

Fish biodiversity of different rivers under the Marsyangdi river system in Lamjung were found almost same. Water temperature ranges from 10 ^{o}C and pH ranges from 6.0 to 7.5 during entire survey period in different feeder streams like Chepe, Paundi, Naundi and Dordi.

There were 26 species of fishes concerning in Marsyandi river system in Lamjung. The fish's presents in various sections of these rivers belong to 5 order 6 families 15 genera and 26 species. Systematic position of the fishes, local names and occurrence, status and abundance are listed in the Table 1.

Among cyprinidae, *Barilius, Garra* and *Neolissochilus hexagnolepis* were dominant food fishes found in Marsyangdi River and the feeder streams. Very rare and migratory fishes like *Anguilla bengalensis* and short migratory fishes like *Semiplotus* and *Macrognathus* were found in this river. Now this fishes were going to disappear due to impact of damming and uncontrolled fishing activities. Laboratory studies of gastro-intestinal contents and feeding behavior of fishes are listed in Table 2. Fish fauna in the river is deckling because of the dam construction and unregulated fishing activities such as dynamiting, poising, electric shock etc. causes killing of fingerling and brood fishes during spawning season. For the preservation of fishes of these rivers, such activities should be checked and fish sanctuary should be established.

Nepal is one of the richest countries of the world in hydropower potential due to gradient topography and regular annual supply of water by monsoon. Marsyangdi is one of the hodropower potential rivers due to its gradient topography, which extends from Himalayas region to terai region. Lower Marsyangdi damming constructions now continue at Udipur, Lamjung and there is plan to make upper-land dam construction near Vulvule, Lamjung.

There are altogether 26 fish species reported in Maasyangdi and its feeder streams. According to local fisherman at different section of Marsyangdi River, variety of fish species were found before 15 year ago but now a days abundance of several species become reduced due to damming effect, poisoning, electric fishing etc. Long distance migratory fishes like *Tor putitora*, *Anguilla bengalensis, Macrognathus armatus* are rarely found in Marsyangdi due to damming effect causes habitat distruction, low level of water, siltation on breeding ground etc. Dams alter aquatic ecology and river biology upstream and downstream affecting water quality, quantity and breeding grounds (Helland-Hansen et al, 1995). They create novel and artificial types of aquatic environment permanently. Mid and short distance migratory fishes like *Schizothorax* species, *Labeo* species, *Garra s*pecies have big problem with heavy siltation, low dissolve oxygen, increase temperature, destruction habitat due to decrease in water level during dry periods, especially between dam and power generator station.

Typically riverine fishes that are adapted to fast flowing water, riffles, rock-gravel substrate and sandy bottom will be deduced in number and entirely lost. Fish food locally produced downstream will be highly affected due to reduction of flow in dry season; hence fries, fingerlings and adult of migratory and residential fishes will be affected. Differing flows have direct effect upon the population of bam *Anguilla* *bengalensis*, golden mahaseer *Tor* spp and copper mahaseer *Neolissochilus hexagnolepis* with morbid changes in the body, growth and disease and parasite infestation. Fish food improved in the monsoon with rise of river level.

Table1. Systematic position, status and abundance of fishery resources in the different localities of Marsyangdi River

Systematic position	Local name	Locality	Status	Abundance
A. Order : Cyriniformes				
Division : Cyprini				
Sub order : Cyprinoidei				
Family : Cyprinidae				
Sub family : Cyprinini				
Genus *: Neolissochilus*				
1. *N. hexagnolepis* (McClland)	Kate	I,iii,iv,v	Migratory	Common in 1v, v.
Genus :*Barilius* Hamilton				
*2. B. barna (*Ham.*)*	Tite	ii,iii,iv,v	Non migratory	Common in iii, iv,v
3. *B. bendelensis* (Ham.)	Fageta	iii,iv,v	Non migratory	Common in iv,v
4. *B. vagra* (Ham.)				
Chagunius Smith				
5. *C. chagunio* (Ham.)	Pathar chati	iii,iv,v	Short distance migratory	Common in iv,v
6. *C.latius (Ham.)*	Besuro	iii,iv,v	Local migrants	Common in iv,v
Genus : *Danio* Hamilton				
7.*D. aquipinatus* (Day)	Bhite	iv,v	Non migratory	Rare in iv, v
Genus : *Garra* Hamilton				
8. *G. annandelei* (Hora)	Buduna	I,ii,iii,iv	Short distance migratory	Common in iii, iv,v
9. *G. gotyla* (Grey)	Buduna	I,ii,iii,iv,v	Short distance migratory	Common in iii, iv,v
Genus: *Labeo* Cuvier				

10. *L. boga* (Ham.)	Thike	iii,iv,v	Short distance migratory	Common in iv,v
11. *L. dyocheilus* (McClell)	Gardi	iii,iv,v	Short distance migratory	Common in iv,v
Genus : *Semiplous* Bleker				
12. *S. semiplotus* (McClell)	Chepti	iii,iv,v	Short distance migratory	Rare in iii,iv, v
Genus : *Tor* Grey				
13. *T. putitora* (Ham)	Sahar	I,ii,iii,iv,v	Migratory	Common in ii,iii,iv
14. *T.tor* (Ham)	Sahar	I,ii,iii,iv,v	Migratory	Common in ii,iii,iv
Sub family :Schizothoracini				
Genus: *Schizothorax* Heckel				
15. *S. molesworthii* (Chaudhari)	Chuche asla	I,ii,iii,iv	Short distance migratory	Common in I, ii,iii
16. *S. prograstus* (McClell)	Chuche asla	I,ii,iii,iv	Short distance migratory	Common in I, ii,iii
17. *S. richardsonii* (Grey)	Buche asla	I,ii,iii,iv	Short distance migratory	Common in I, ii,iii
Family : Cobitidae				
Sub family : Nemachilini				
Genus : *Nemachilus* Van Hasset				
18. *N. bevani* (Gunther)	Gadela	iii,iv,v	Non migratory	Common in iii, iv,v
19. *N. botia* (Ham.)	Gadela	iii,iv,v	Non migratory	Common in iii, iv,v
20. *N. rupicola* (McClell)	Gadela	iii,iv,v	Non migratory	Common in iii, iv,v
B. Order : Siluriformes				
Family : Sisoridae				

Genus : *Glyptothorax* Blyth				
21. *G. pectinopturus* (McClell)	Nakato	iii,iv,v	Short distance migratory	Common in iv,v
22. *G. pseudochenesis* Blyth	Kabre	ii,iii,iv,v	Short distance migratory	Common in iv,v
C. Order : Anguilliformes				
Sub order :Anguilloidei				
Family : Anguillidae				
Genus : Anguilla Shaw				
23. A. bengalensis (Gray & Hardw)	Raja Baam	ii,iii,iv,v	Migratory	Common in iv,v & feeder streams of Maadi river
D. Order : Perciformes				
Sub order :Channoidei				
Family : Channidae				
Genus: *Channa* Gronovius				
24. *C. gachua* (Ham)	Hile	ii,iii,iv,v	Short distance migratory	Common in iii, iv,v
25. *C. punctatus* (Bl.)	Hile	ii,iii,iv,v	Short distance migratory	Common in iii, iv,v
E. Order : Symbranchiformes				
Sub order : Symbranchoidi				
Family : Symbranchidae				
Genus : *Machrognathus* Lacepede				
26. *M. armatus* (Lacepede)	Chuche Baam	iv,v	Migratory	Common in iv,v & feeder streams of Maadi and Risti river.

Table 2. Laboratory study of gastro-intestinal contents of fishes

S. N.	**Name of species**	**Gastro-intestinal contents**		**Spawning period**
		Flora	**Fauna**	
1	*N.hexagonolepis(*McClelland)	Spirogyra, Oscillatoria etc.	Branchionus,polyarthra,etc.	Spawning period rages from Sep. to Oc.
2	*B. barna* (Ham.)	Spirogyra, Chlorella, Oscillatoria etc.	Diaptomus, Daphnia, Cyclops etc.	Breeding season ranges Ap. To Aug.
3	*B. bendelensis* (Ham.)	Spirogyra, Chlorella, Oscillatoria etc.	Ephimera, Diaptomus, Daphnia etc.	July to August.
4	*B. vagra* (Ham.)	Spirogyra, Oscillatoria etc.	Diaptomus, Daphnia, Cyclops larva etc.	Spawning in July to Sep.
5	*C. changanio* (Ham.)	Spirogyra, Oscillatoria etc.	Polyarthra, Filina species.	Aug. to Sep.
6	*C.latius* (Ham.)	Spirogyra, Chlorella, Oscillatoria etc.	0	Breeding season ranges March To April.
7	*D. aquipinatus* (Day)	Spirogyra, Oscillatoria etc.	Diaptomus, Daphnia etc.	July to August.
8	*G. annandelei* (Hora)	Spirogyra, Oscillatoria, Naja etc.	Polyarthra, Filina,Branchionus species.	Breeding season ranges May To June.
9	. *G. gotyla* (Grey)	Spirogyra, Oscillatoria, Naja etc.	Polyarthra, Filina,Branchionus species.	Breeding season ranges May To June.
10	*L. boga* (Ham.)	Spirogyra, Oscillatoria, Naja etc.	0	Breeding season ranges June to August.
11	*L. dyocheilus* (McClell)	Spirogyra, Oscillatoria, Naja etc.	0	Breeding season ranges June to August.
12	*S. semiplotus (*McClell)	Oscillatoria, Vallisnaria etc.	Peneatus, Anax, Unio etc.	Breeding season ranges June To July.
13	*T. putitora* (Ham)	Spirogyra, Oscillatoria, Naja etc.	Branchionus,polyarthra, Branchionusetc.	Spawning period rages from Sep. to Oc.

14	*T.tor (Ham.)*	Spirogyra, Oscillatoria, Naja etc.	Branchionus,polyarthra, Small fishes.	Spawning period rages from Sep. to Oc.
15	*S. molesworthii* (Chaudhauri)	Spirogyra, Chlorella, Oscillatoria etc.	0	Breeds twice a year, first Oct. to Dec. and second mid March to Jun.
16	*S. prograstus (*McClell	Spirogyra, Chlorella, Oscillatoria etc.	0	Breeds twice a year, first Oct. to Dec. and second mid March to Jun.
17	*S. richardsonii* (Grey)	Spirogyra, Chlorella, Oscillatoria etc.	0	Breeds twice a year, first mid Oct. to Dec. and second mid Jun. to March .
18	*N. bevani* (Gunther)	Spirogyra, Chlorella etc.	Cyclops, Anax, Hemiptera etc	Breeding season ranges April to May.
19	*N. botia* (Ham.)	Spirogyra, Oscillatoria etc.	Pheritima, Hamiptera, Anax etc.	It breeds May to June.
20	*N. rupicola* (McClell)	Spirogyra, Oscillatoria etc.	Pheritima, Hamiptera, Anax etc.	It breeds July to August.
21	*G. pectinopturus* (McClell)	0	Diaptomus, Daphnia, Cyclops etc.	It breeds March to July.
22	*G. pseudochenesis* Blyth	0	Anax, Rantra, Cyclops etc.	It breeds May to June.
23	*A. bengalensis* (Gray & Hardw)	Filamentous algae, decaying matter.	Crustaceans and small fishes.	It breeds July to August.
24	*C. gachua* (Ham)	0	Ephimera,Peneaus, small fishes etc.	Breeding season ranges June to August.
25	*C. punctatus* (Bl.)	0	Ephimera,Peneaus, small fishes etc.	Breeding season ranges June to August.
26	*M. armatus* (Lacepede)	Filamentous algae, decaying matter.	Crustaceans and small fishes.	It breeds July to August.

Recommendation

Following recommendations are suggested:

- Population of coldwater fishes like *Schizothorax* spp, *Tor* spp, *N.hexagonolepis* and other migratory fishes will be affected by the barrier effect of dam; suitable fish ladder should be maintained.
- The population of fishes should be maintained by constructing spawning channel or fish seeds supplied from hatchery of fishes transported from downstream of dam.
- Enhancement of coldwater aquaculture and establishment of sport fishery for recreation and tourism industry to strengthen local and national income.
- Establishment of international coldwater center in Nepal to carry out programs of research, conservation and development of coldwater fishery of the Himalayan region.

Acknowledgements

We thank to Directorate of Research IAAS, Rampur to provide financial support for successful completion of this project. We thank to Mr. Rambhai Kumal, local fisherman for his help in fish sampling in different section. We also thank to Ram Nath Dhakal, lab boy of Lamjung campus, which help in laboratory studies of fishes. Thanks are also to Suresh Regmi, Umakant Sharma and Amrit America Dhimire, which help in collection of fishes.

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BREEDING PERFORMANCE OF INDIGENOUS FISHES FOR CONSERVATION OF WILD POPULATION

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Kali Gandaki Fish Hatchery, Beltari, Syanja

ABSTRACT
The economically important indigenous fishes inhabiting in different rivers and other water bodies of Nepal are Sahar, *Tor spp.*; Katle, *Neolissocheilus hexagonalepis*; Asala, *Schizothorax spp.*; *Schizothoraichthys spp.*; Gardi, *Labeo dero*; Hade, *L. pangusia*; Thend *L. angra*; Jalkapur, *Clupisoma garua*; *Pseudeotropius murius* and others. The population of these indigenous fishes is declining in their natural habitat due to over fishing, damming, degradation of the aquatic environment and biological changes in the ecosystem. Developments of captive breeding and culture techniques are the means for conservation of wild population and their sustainable utilization. Breeding technology of Sahar, *T. putitora*; Katle, *Neolissocheilus hexagonalepis;* Asala, *S. plagiostomus* and Gardi, *Labeo dero* have been developed in Kali Gandaki Fish Hatchery. Preliminary observation on induced breeding of Hade, Thend, Lahare, *Garra annandelai*; Buduna, *G. gotyla*, Baghi, *Botia lohachata* and Rewa, *Changunius changunio* revealed that these species could bred successfully in captive environment. This paper describes the present status of breeding performance of indigenous fishes in Kali Gandaki Fish Hatchery for conservation of wild population.

Key Words: *Breeding performance, conservation, indigenous fishes, wild population*

Introduction
Kali Gandaki River originating from Tibet plateau is one of the big River of Narayani river basins. The river has formed the world′s deepest gorge between Dhaulagiri and Annapurna. It joins with Andhi stream at Mirmi of Syangja district. The dam was built across Kali Gandaki River at Mirmi forming a sizable reservoir extended into 65 ha with depth ranging from 14 to 20 meter. The river joins with the Trisuli River at Devighat and is then called Narayani River. It is nearly 47 km long from the dam site to powerhouse. The river is about 120 km long from the point of its appearance to Mungling. It is one of the seven rivers of Gandaki river system and

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finally flows down to Narayani River. Multi species of indigenous fish exist in Kali Gandaki River and its tributaries (Edds, 1986).

Nepal Electricity Authority (NEA) has been operating a biggest hydropower generation plant (144MW) by impounding Kaligandaki River at Mirmi. Impoundment in rivers is known to affect adversely on fish biodiversity and fisher community who depends on fishing for their livelihood. Long migratory fish move from one place to another in search of food, suitable environment and spawning grounds. Blocking the pathways obstructs the fish migration. Such unfavorable conditions cause to decline the population of migratory fish and may lead to disappearance in the long run. To mitigate such a negative impact, a built in fish hatchery with the Kali Gandaki hydropower station has been operated jointly by Nepal Electricity Authority (NEA) and Nepal Agricultural Research Council (NARC) since 2002. Kali Gandanki Fish Hatchery located at Beltari, Syngja close to the powerhouse. The main goal of the hatchery is conservation of natural stock of fish in the Kali Gandaki River.

A total of 187 indigenous fish species belonging to 92 genera, 31 families and 11 orders are reported in different rivers and other water bodies of Nepal (Rajbanshi, 2005; Shrestha and Chaudhary, 2004). Out of 187 species, 127 species are reported from Koshi, 157 from Gandaki, and 119 from Karnali river system (Shrestha, 1992). The indigenous fish species of Nepal are distributed from few meters in Terai to 3323 meters in Langtang Khola, located in Langtang National Park (Shrestha, 1995). Out of 157 species reported from the Gandaki river system , 57 species were recorded from the Kali Gandaki river (Shrestha and Chaudhary, 2004). A total of 81 cold water native fish species belonging to 37 genera, 7 families and 2 orders are reported (Shrestha, 2002). Among these species, the economically important native fish species are sahar, *Tor spp*.; katle, *Neolissocheilus hexagonalepis*; asala, *Schizothorax spp.*; *Schizothoraichthys spp*.; gardi, *Labeo dero*; hade, *L. pangusia*; thend, *L. angra*; jalkapur, *Clupisoma garua*; *Pseudeotropius murius* and others.

The population of indigenous fishes is declining in their natural habitat due to over fishing, damming, degradation of the aquatic environment and biological changes in the ecosystem. Indigenous fishes are over fished in their natural habitat from illegal catching methods such as electro-fishing, poisoning and dynamiting. As a result, the population has become unsustainable with fish catch from fisher communities being low in most parts of the country. This has led to efforts to conserve, manage and propagate the indigenous fish species. Developments of captive breeding and culture techniques are the means for conservation of wild population and their sustainable utilization. Breeding technology of sahar, *T. putitora*; katle, *N. hexagonalepis;* asala, *S. plagiostomus* and gardi *(Labeo dero)* have been developed in Kali Gandaki Fish Hatchery (KGFH). Preliminary observation on induced breeding of hade *(L. pangusia),* thend *(L. angra),* lahare, *Garra annandelai*; buduna, *G. gotyla*, baghi, *Botia lohachata* and rewa, *Changunius changunio* revealed that these species could bred successfully in captive environment. This paper describes the present status of breeding performance of indigenous fishes in KGFH for conservation of wild population.

Materials and Methods

A. Acquisition of eggs by hand stripping (Sahar, Katle, Asala and Rewa)

Brood fish of sahar, katle, asala and rewa was managed by feeding pellet feed approximately containing 30% protein (Table 1). The feeding rate was 2-5% of total body weight. Water quality parameters such as temperature, pH and dissolved oxygen were measured in brood pond to regulate the feeding activity. The breeding activities of sahar, katle, asala and rewa were conducted at KGFH. Most of the females were checked at 4-7 days intervals during the breeding season for maturity by applying gentle pressure on the abdomen by hand near the genital opening. Sometimes, they were checked at 2-3 days interval on the basis of maturity condition during breeding season. The females that released eggs on slight pressure were transported inside the hatchery then stripped gently to receive eggs in a clean, dry bowl.

Table 1. Feed ingredients and the composition of pellets (30% protein) fed to native brood fish reared in pond at Kali Gandaki Fish Hatchery, Syanja

Ingredients	Proportions
Shrimp (jawla)	20
Soybean	35
Wheat	15
Maize	10
Rice bran	10
Mustard oil cake	09
Vitamin and mineral mix	01

Milt from healthy males was gently mixed with the eggs using feather for dry fertilization. The eggs were weighed and counted, then washed with clean water. One ml of newly released eggs was weighed and counted visually. This process of washing was repeated several times. The eggs were incubated for hatching in

Atkin's incubators trays by allowing one layer of eggs on single mesh screen trays in flow through system. The fertilized eggs in incubation trays were covered with black plastic screen. Water flow in incubation trays was maintained at a discharge rate of 4-5 L/min. Dead eggs were removed using forceps without touching other eggs to protect the eggs from fungal infection. Unremoved dead eggs were easily infected with fungus, which could spread rapidly to the adjacent healthy eggs. Early hatched larvae possessed large yolk sacs and settled near corners of the incubation trays. After attaining free-swimming stage the larvae were transferred into a tank of 2.5 m x 0.40 m x 0.30 m dimension. Supplementary feed was fed to hatchlings after yolk sac absorption. The advanced larvae were also fed with zooplankton screened through plankton net.

B. Acquisition of eggs by hormone treatment (gardi and others)

The breeding activity of gardi was conducted at KGFH since 2002. The females, with a soft distended abdomen showing unripe light grey eggs near genital aperture on gentle pressure on the abdomen were selected for hormone treatment. The males were selected which oozed milt with gentle pressure near the genital pore.

The fish were treated with a commercially available hormone Ovaprim. Ovaprim (sGnRHa (D-ARG^{6}, Trp^{7}, Leu^{8}, Pro^{9}, Net) LHRH) and domperidone (a dopamine antagonist) dissolved in distilled water at 20 µg/mL and 10 mg/mL, respectively. The required amount of Ovaprim was filled in a syringe. The female and male fish were injected with 0.5 mL/kg and 0.25 mL/kg of Ovaprim, respectively intraperitoneally at the basal section of the pectoral fin.

At onset of ovulation, the female fish were chased by the males. The eggs were released in the tank by self spawning method and fertilized eggs were incubated in the same tank until hatching occurred. After spawning, spent broods were collected, body weighed and measured. Another method of egg collection was stripping of eggs and milt from the broods and fertilized the eggs by artificial dry method as described for sahar, katle and Asala. Fertlized eggs were incubated in tank providing flowing water.

C.Preliminary observation on induced breeding of some other indigenous fishes

The breeding activities of hade, thend, lahare, buduna and baghi were conducted at KGFH in 2007. The methods for brood selection, hormone treatment, egg collection, fertilization and incubation of the eggs were similar to Gardi breeding.

Results

The pond reared sahar bred in two breeding seasons from March to April and September to October. Maturaty examination during breeding season revealed that some females were found overripe and some were at the right stage for releasing viable eggs. Overripe females were identified as releasing poor quality eggs, which turned opaque white soon after fertilization resulting in poor fertilization and hatching rates; or those releasing degenerated eggs with orange fluid at slight pressure on abdomen and the fluid turned white immediately when it came in contact with water. The result showed that same brood spawned two times with higher fecundity in March/April (Table 2). Fertility and hatching rates of sahar eggs were not different between breeding seasons.

The pond reared katle bred during mid October, 2007 in KGFH. The fertilization and hatching rates ranged between 80-95 and 70-90 %, respectively. The relative fecundity estimated was 18500 eggs/kg female, which is the lowest value amongst the spontaneously bred (without hormone treatment) native fish species in KGFH (Table 2).

Asala were spawned by manually stripping in two consecutive breeding periods: November and February. High fecundity rate was estimated for asala bred in February. No remarkable differences are found in fertility and hatchability of eggs obtained from the two consecutive breeding season i.e. February and November. However, high rate of relative fecundity (97800 eggs/kg female) estimated for asala bred during February (Table 2).

The pond reared rewa was successfully bred for the first time in Nursing pond in KHFH in April 2009 (Table 2). Preliminary breeding attempt suggests that rewa could be bred April to July at 22-25 ^{o}C temperature. Females were spawned by manually stripping during breeding season, but it was difficult to collect milt from the males without sacrifice. Males were dissected for removing the testes. The testes from the male were macerated and the extracted milt poured directly over the eggs in a bowl. The relative fecundity (58000 eggs/kg female) of rewa was intermediate amongst the spontaneously bred native fish species in KGFH.

Breeding performance of gardi showed peak spawning season was June-July when water temperature increased above 24 ^{o}C. Gardi prominently exhibited sexual dimorphism during breeding season. Well riped fishes received single Ovaprim hormone injection at a dose of 0.5 ml/kg for female and 0.25 ml/kg for male. Ovulation time varied 6-9 h after hormone treatment at 26-29°C. After ovulation, females spontaneously released eggs in the tank or alternatively hand stripped into a bowl. The mean fecundity ranged from 334000 eggs per kg of body weight. Hatching time ranged from 12-18 h at 26-29°C. The average fertilization and hatching rates were 70% and 50%, respectively. Breeding performance of Gardi at Kali Gandaki Fish Hatchery in 2007 is summarized in Table 3.

Some other indigenous fishes, such as hade, thend, lahare, buduna and baghi were treated with hormone treatment and resulted in successful induced breeding producing some fries. These species were also bred in same breeding season as of gardi, which usually spawn once a year during the summer season when water temperature remains above 25 ^{o}C. KGFH bred and reared fries of hade, lahare and buduna were released in upstream Mirmi reservoir for the first time. Results obtained from preliminary observation on induced breeding of hade, thend, lahare, buduna and baghi is summarized in Table 3.

Discussion

Sahar, asala and katle are the most economically important cold water fish species as being excellent food fish and high value sport fish in Nepal,. The breeding of sahar, asala and katle commenced at same period and they are considered as multiple spawner. Sahar spawned in two consecutive breeding periods: from February to April and from September to November (Baidya et al., 2007; Gurung et al., 2002; Joshi et al., 2002). Katle spawn from August to September (Rai, 1978 and 1990). Asla spawn from October to November and from February to March with best spawning in February to March (Joshi et al., 1996). Breeding technology of gardi has been developed in Kali Gandaki Fish Hatchery. Preliminary observation revealed that the some riverine fish species such as hade, thend, lahare, buduna, baghi and rewa can be bred successfully in captive environment.

Table 2. Breeding record of different fishes at Kali Gandaki Fish Hatchery from 2007-2010.

Species	Date	Water Temp. (°C)	Female (No)	Female Weight (kg)	Egg Wt. (g)	No of Egg	Fecundity (eggs/kg female)	Fertilization rate (%)	Hatching Rate (%)	Incubation duration (h)
Sahar	2007 (21-28 Apr)	19-25	9	19	1410	146640	30996	94	91	72-120
	2008 (16 Sep-25 Oct)	23-27	11	14	934	97174	43093	94	91	72-96
Katle	2007 (13-17 Oct)	25-27	15	4	202	23010	18533	88	80	96
Asala	2007 (19-25 Nov)	14-16	12	2	280	34406	72307	88	80	192-240
	2008 (2-12 Feb)	11-13	12	2	247	30376	97879	86	81	240-264
Rewa	2008, 7 Apr-2010,5 Jul	22-27	3	335	46.4	9600	58000	94	88	75-80

Table 3. Breeding record of different fishes at Kali Gandaki Fish Hatchery in 2007

Species	Date	Water Temp. (°C)	Female (No)	Female Weight (kg)	Egg Wt. (g)	No of Egg	egg no	Fecundity (eggs/kg female)	Fertilization rate (%)	Hatching Rate (%)	Latency period (h)	Incubation duration (h)
Gardi	10 Jun- 20 Jul	26-29	48	16.236	3017	1,800	5430600	334,000	50	70	6 h	18 h
Hade	17-Jun	29	1	0.654	131	1,800	235,800	60,000	50	50	6 h	18 h
Thend	29-Jul	26	1	0.454	91	2,000	163,800	40,000	50	50	9 h	18 h
Lahare	20 Jun-24Jul	26-27	6	0.252	38	2,000	76,000	24,800	70	50	9 h	16-18 h
Buduna	24-Jul	26	2	0.148	22	2,000	44,000	10,000	60	40	9 h	18 h
Baghi	20-Jun	27	2	0.128	20	2,000	40,000	8,000	50	40	8 h	16 h

Preliminary work on breeding of sahar has been carried out in Nepal since the early 1960's (Gurung et al., 2002). In earlier ears wild matured brood fish caught by gill net were used for spawning. At this time, it is considered that female Sahar never be sexually matured in captivity though males are sexually matured (Masuda and Bastola, 1985). Shrestha et al. (1990) reported successful spawning of hormone induced sahar reared in captivity with supplementary feed on September 1988. However, this success is in the rim of uncertainty. Later this work was followed by Morimoto et al. (1995), Baidya et al. (1998 and 2000) using different methods for sahar breeding. Later, the techniques of sahar breeding gradually developed from stripping naturally mature brood collected in lakes to rearing of broods in pond conditions (Gurung et al., 2002). Baidya et al. (2007) reported that the pond reared sahar bred in two breeding seasons from February to April and September to November which is further confirmed from the present study. The high spawning success rate in term of fecundity obtained during February to April breeding season in the present observation is corroborated with the findings of Baidya et al. (2007).

The pond reared sahar broodstocks started to spawn from February at 18.0 ^{o}C. These females again ripen after 5-6 months and responded from September to November until 19-20 ^{o}C. This observation showed the possibility of multiple spawning of sahar as it has been practiced 3-5 times in a year for common carp, *Cyprinus carpio* (Horvath 1978; Gurung et al., 1993), 2 times in a year for grass carp, *Ctenopharyngodon idella* and 4 times in a year for bhakur, *Catla catla* (Rath et al., 1999).

In this study overripe females were decreased by examining brood more frequently in 2-3 days interval. Delayed stripping of eggs following ovulation led to the aging phenomenon or over ripening, which is resulted in poor quality eggs with low fertilization and hatching rates (Sakai et al., 1975; Springate et al., 1984). Ovulated eggs of oviparous teleost become overripe if retained in the body cavity and these eggs show a progressive reduction in viability for many species. After ovulation, the optimum duration for egg stripping with the good quality eggs varied with different species of fish (Bromage, 1995). This duration ranges from 4-10 days in the rainbow trout, *Onchorhynchus mykiss* (Bry 1981; Springate *et al*., 1984) to a few hours in the studied fish (Bromage, 1995). It is considered that optimum duration for egg stripping is less than 2-3 days after ovulation in sahar as the broods undergo over matured on examining on 2-3 days interval. Therefore, studies are warned on the optimum time for egg stripping in sahar after ovulation to obtain good quality eggs.

High hatching rate of eggs of pond reared katle was evident in the present study. Rai (1978) reported that katle female (600 g body weight) collected from Trishuli River power plant reservoir released 3461 eggs (30 g) with 43% hatching rate and another female weighing 264 g reared in pond released 2526 eggs (24 g) with 75% hatching rate. He also reported that hatching began to appear after 6 days of fertilization and completed in 7 days at 18-21^{o}C. In the present study, breeding activity of katle was carried out at relatively high water temperature between 25-27 ^{o}C which might lead to over maturity of eggs.

Asala were spawned by manually stripping in two consecutive breeding periods: November and February at KGFH. The occurrence two breeding periods of asala in a year have also been reported by (Joshi et al., 1996). Asala were successfully bred during October/November and February/March at FRC,Trishuli. Joshi et al. (1996) estimated the fecundity of asala to be 12000 eggs/kg female in FRC, Trishli which is significantly lower than the fecundity estimated (72000-97000 eggs/kg female) in the present study at KGFH.

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OBSERVATIONS ON THE REPRODUCTIVE PERFORMANCE OF CAPTIVE STOCKS OF ASALA (*Schizothorax richardsoni*)

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ABSTRACT
Gonado-somatic index (GSI) estimates made on the mature asala (*Schizothorax richardsoni)*, ranged from 2.0±1.1 in May to 33.4±8.4% in October. Positive correlation ((R^2=0.526) was found between egg size and GSI. The egg size (3.3 to 3.6 mm) of *S. richardsoni* in October and November were significantly (P<0.01) larger than the eggs measured in other months. *Schizothorax richardsoni* spawned by manual stripping in two consecutive breeding period validated by peak GSI; October/November and March/April at Godawari (1500 m masl).

The relationship between the egg number to weight of the fish was found to be $F = 29.18\ W^2 - 2380\ W + 65132$, where W is fish weight in g. Fecundity depended on the body weight of the fish. Hatching durations (10 and 11 days), cumulative day degree temperatures 157.4 and 157.2 °C) required for hatching. Percent hatching rates (66.8 and 67.7%) of eggs of *S. richardsoni* during winter and summer breeding seasons were not significantly different (P>0.05). Overripe eggs obtained during winter season breeding (16.5%) were significantly higher (P<0.01) than the summer season breeding (1.8%). This suggests that more frequent observation of the spawner is necessary during winter season for recognizing their appropriateness to ovulation.

***Key Words**: egg size, fecundity, gonado-somatic index, overripe, ovulation*

Introduction
The subfamily Schizothoracinae (family Cyprinidae), which includes snow trout (*Schizothorax* spp) and several other genera important for fisheries, is present in the Himalayan and sub- Himalayan regions of the Indian subcontinent, Afghanistan, Central Asia, Kazakhstan, China and Myanmar, hence it is indigenous for the

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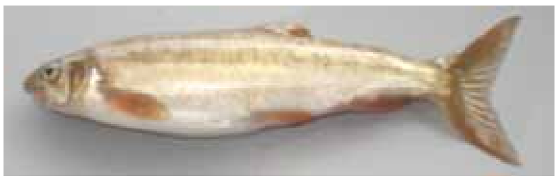
region. The genera *Schizothorax* (snow trout), locally known as asala, are the most important fish from the economic and sport fishery point of view. These are also an excellent food. *Schizothorax* genus is known to have six species in Nepalese cold waters (Rai et al., 2002a). The *Schizothorax richardsoni* is one of the most dominant species in mountain waters in Nepal, indicating this fish have high adoptive capacity to reproduce and grow in cold fast flowing torrential rivers. However, this species has been overfished in the hills and Himalayas where there is a shortage of good agricultural land and of economic opportunities (Shrestha, 2002). Schizothorax fishes are characterized by slow growth, low fecundity, and late sexual maturation as adaptations to their rigorous environment (Chen and Cao 2000). These life-history characteristics further make them particularly sensitive to intense exploitation. In-situ conservation of their natural populations has therefore become a primary concern. For the livelihood security of fisheries dependent ethnic hill communities through diversification of aquacultured cold water fish species requires technology development of controlled breeding, seed production and grows out practices.

Recognizing the importance of *Schizothorax spp*, Nepal Agricultural Research Council (NARC), made a concerted attempts to evaluate its aquaculture potential, including captive breeding using raceway and pond reared broodstocks, originally collected from different wild habitats, commencing in the period early 1970s (Yamada et al., 1998). Studies on the Gonado-Somatic Index (GSI), fecundity and spawning behavior of economically important species of native fish are of great importance in understanding the reproductive potential of the fish. Various studies and observations made on reproductive performance of *Schizothorax* spp has given different results related to spawning season, Gonado-Somatic Index (GSI), fecundity, and temperature regime required for hatching of the eggs (Raina, 1977; Yamada et al, 1998; Rai et al., 2002b; Roy and Gurung, 2008; Joshi et al., 1996). Systematic observation of these features of *S. richardsoni* will help to make this fish breed in captivity in significant scale for future aquaculture and will help to formulate regulation and define close fishing periods for this species.

Material and Methods

Juvenile (mean weight = 45 mg) of wild *S. richardsoni* (asala) were collected from Nallu Stream, Lalitpur district in 2006. Domestication process involved in Fisheries Research Division, Godawari was rearing fish in raceways and circular pool with running water, feed formulations and their acceptance test to fish, monitoring fish behavior and health management. Fish attained sexual maturity in captivity after two years of rearing in raceways. Sexually matured three females in every month for a year (2010) were sacrificed to estimate gonado-somatic index (GSI). After noting the length and weight of the fish, the ovaries were dissected out. The sexual state of the fish was measured by GSI (where GSI=wt. of gonad/wt. of fishx100). Egg sizes at each GSI sampling were measured using ocular micrometer.



Mature *S. richardsoni*

Ovary of *S. richardsoni*

Breeding of *S. richardsoni* was carried out at FRD, Godawari on March/April and October/November following increased GSI and progress of vitellogenesis. A total of 56 and 92 female broods for summer and winter spawning with body weight ranged between 12 to 44 g were used, respectively. Ripe females were hand stripped and eggs were fertilized with milt pressed out from males. After mixing the eggs and milt for about one minute water was added and gently stirred to ensure fertilization. Inseminated eggs were washed with saline water (0.09%) for 3 to 4 times then spread over the incubation trays. Egg loaded trays were set in Atkin's incubator having continuous flow of water for aeration. The dead eggs were culled every day.

Percent overripe eggs were estimated by the proportion of number and weight of female that produced overripe eggs to that of the total number and weight of female spawned for a particular breeding season. One gram of unfertilized eggs from each spawning batch was counted to estimate fecundity (where fecundity = Number of eggs/weight of female in g*1000). The numbers of live eggs (fertile) in each batch were estimated within 24 h after fertilization. Eggs were considered as live when they showed embryonic eyes and blood vessels. Hatching was considered to be successful if the yolk sac emerged from the egg envelope. Water temperature at spawning and during incubation was measured to estimate cumulative day degree temperatures. Significant differences of GSI and egg size in different months was estimated by ANOVA using Stat Graphics ver. 3.0. Egg size and fecundity was regressed against GSI and body weight of female, respectively.

Results and Discussion

Monthly change in the relative weight of ovaries is expressed as the gonado-sometic index (GSI). The values of GSI among months were significantly different ($P<0.01$). Gonad index was recorded low during post ovulation period in May (2.0±1.0) and

December (4.2±3.1). An elevated medium index (17.3±3.8) for September was caused by initial vitellogenesis and it increases steadily (33.2±0.3) until November when mature females appear in full ripeness. A slight increase of the index for April (12.8±5.2) was also found to trigger summer spawning. The lowest GSI during May and December was the indication of ovaries was in the spent condition (Figure 1). Monthly estimation of GSI revealed that the captive populations of mature *S. richardsoni* become ripe for spawning for the two consecutive seasons October/November and March/April. Shrestha and Khanna (1979) based on studies on the GSI and histology of ovary reported that this fish spawn twice in a year. External factors of environment such as rainfall, water surface temperature, pH, hormone secretion, turbidity are also equally important to identify appropriate timing of breeding of *Schizothorax* spp in Nepal (Shrestha, 1979).

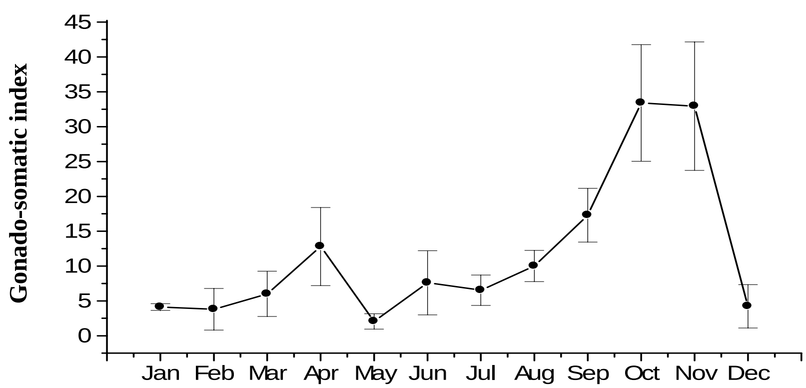


Figure 1. Gonado-Somatic Index (GSI) percent of Asala (*Schizothorax richardsoni*) in different months in year 2010

Mean egg size (diameter) of *S. richardsoni* in different months was also significantly different ($P<0.01$). Smaller eggs were obtained during May (0.46±0.2mm), post ovulation period of summer spawning. Egg size increased with the progress of vitellogenesis (Figure 2) and reached the maximum during spawning seasons, April (1.74 mm) and October/November (3.3 to 3.6 mm). A moderate correlation (R^2 = 0.526) was estimated between GSI and corresponding egg size of *S. richardsoni* (Figure 3).

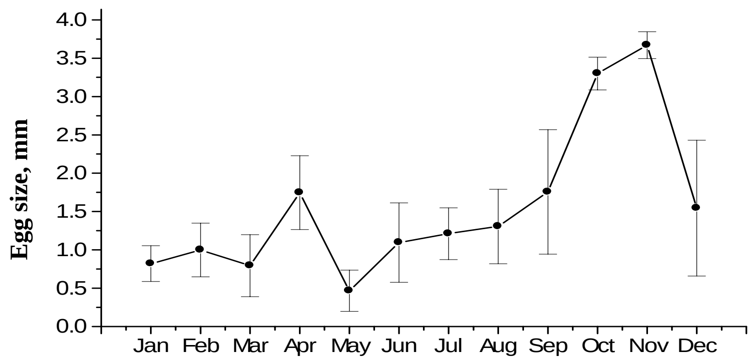


Figure 2. Egg size (diameter, mm) of *Schizothorax richardsoni* in different months during 2009 to 2010

The average egg production per kg female ranged from 6294 – 67083 in fishes whose average weight ranged between 12 – 44 g. Shrestha (1978) has reported about 25 000-40 000 eggs per fish. Fecundity depended equally on the body length as well as on the weight of the fish (Raina, 1977). The usual method of relating fecundity to weight was employed to give the following relation: Fecundity (F) = 29.18 W^2 – 2380 W + 65132. The correlation coefficient of -0.525 indicate a moderately strong relationship between the fish weight and fecundity (Figure 4). However, the relationship between body weight and egg number of *S. richarsoni* contrasts to other cold water fish species. An increase in body weight would accompanied by an improvement in egg number of rainbow trout (Gall, 1975; Mulmi et al., 2010).

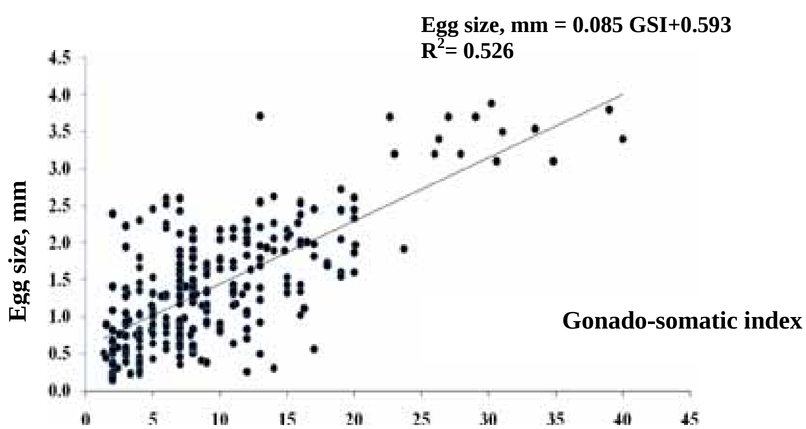


Figure 3. Relationship between egg size (diameter, mm) and gonado-somatic index (GSI)

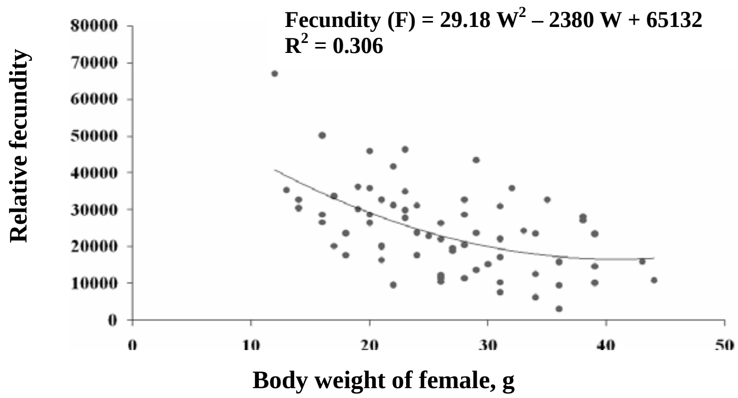


Figure 4. Relationship between Relative fecundity (number of eggs per kg) and body weight of female *Schizothorax richardsoni*

Captive stocks of *S. richardsoni* were spawned by manually stripping in two consecutive breeding period; October/November and March/April at Godawari (1500 masl) during the year 2009 and 2010. Water temperature ranged was 14.1-17.5 ^{o}C and 14.5-15.5 ^{o}C during winter and summer season spawning. Mean (±SD) incubation period was 10 ± 2.8 and 11 ± 1 days at mean (±SD) cumulative water temperature of 157.4 ± 64.8 and 157.2 ± 8.2 ^{o}C (day degree), respectively, for winter and summer spawning. Hatching rates ranged between 25-96% and 48-84% during winter and summer breeding season and the mean percent hatchability of fertile eggs of *S. richardsoni* among breeding seasons were not significantly different (P<0.05) (Figure 5). Differences in hatching rate observed in the present study did not corroborated with the higher hatching rate observed in October/November (>50%) than in February/March (<25%) breeding of *Schizothorax* sp in Trishuli (Joshi et al., 1996) and in Kali Gandaki Fish Hatchery (Baidya et al., 2008).

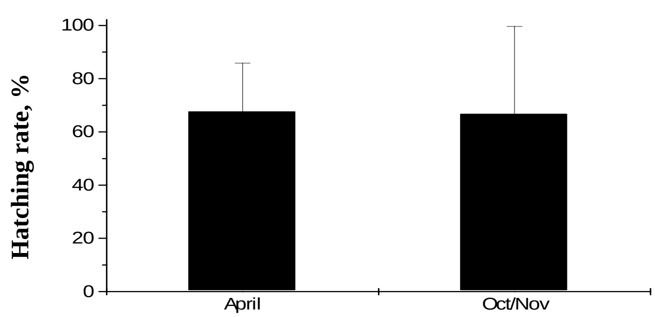


Figure 5. Hatching rates of fertile eggs of Schizothorax richardsoni in the two consecutive breeding seasons at Godawari

Spawning of *Schizothorax* spp should be carried out in a very specific period if not overripe or underripe eggs would results which directly affect fertility and hatching rates of the eggs (FRC, 1994; Joshi et al., 1996). In the present study 16.5% of the eggs ovulated in winter season breeding were found overripe while summer spawning had significantly low percentage of over ripe eggs (1.8) (Figure 6). An increase in over maturity of female of *S. richardsoni* might have been the cause of differences in length of spawning duration. Spawning activity completed within 11 days in March/April (summer breeding) while it took 21 days in winter breeding with low intensity of brood inspection for their readiness to spawning. This suggests that more frequent observation of the spawner is necessary during winter season for recognizing their appropriateness to ovulation.

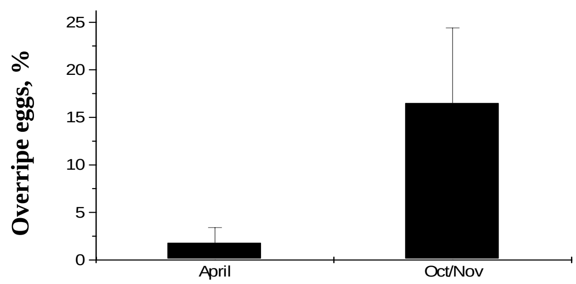


Figure 6. Percent overripe eggs of Schizothorax richardsoni in the two consecutive breeding seasons at Godawari

The growth and maturity of oocytes in the ovary of fish depends upon optimum exteroceptive factors, among which are food, temperature, light and oxygen are the major factor (Malhotra, 1967, Shrestha, 1979). The present attempt is a preliminary quantitative study aimed at finding a relationship between gonad maturity and different months of the year, and the rate of ovulation with the size of fish. Elevated GSI in March/April and October/November suggests that these periods might be the best time for spawning of *S. richardsoni*. Frequent inspection of female is important during spawning season to avoid wastes of eggs owing to overripe condition, more specifically in winter season breeding.

The result of controlled breeding and artificial fertilization and incubation of *Schizothorax richardsoni* in a running water system gave mean hatching of 66.8% in winter and 67.8% in summer spawning. Large variation in fecundity and hatching rates among spawning batches and within spawning season stipulate for the need of nutritional and rearing environment improvement studies on schizothorax seed production to achieve a fully viable fingerling stage ready for release into rivers and lakes and future aquaculture.

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REPRODUCTION AND GROWTH PERFORMANCE OF KATLE (*Neolissocheilus hexagonalepsis* McClelland) IN MID HILL REGION

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ABSTRACT

This paper reviews the reproductive behavior and growth performance of Katle (*Neolissocheilus hexagonalepsis*) based on the studies conducted from 1977 to 2009 in different Fisheries Research Stations under NARC. Katle is an indigenous migratory species common in rivers, streams and lakes of Nepal belonging to family cyprinidae. During domestication Katle attained first sexual maturity in about 3 years of age (180 to 350 g body weight) and spawns twice a year: March/April and September/October at water temperature between 18- 23 ^{o}C. Fisheries Research Centre, Trishuli successfully carried the artificial breeding of Katle and achieved 59% hatching rate and the survivality of fry estimated was between 73- 96%. Growth rate of Katle was observed very slow (0.041- 0.046 g/day). Various studies on feeding management to katle revealed that poor feed efficiency (26.24 to 29.14%) and high feed conversion ratio (FCR) (3.43 to 3.83). From different studies katle was found to tolerate wide range of water temperature (15 - 30 ^{o}C). Well designed robust studies are vital for understanding different factors associated with growth and reproduction of this high value native fish species.

Key Words: *indigenous species, breeding, feed, survivality*

Introduction

Katle (*Neolissocheilus hexagonolepis* McClelland) is an important cold water indigenous fish species of Nepal, well known food and sport fish in Himalayan region and is common inhabitant of fast flowing water, lake and reservoir. It is omnivorous in feeding habit and a bottom feeder (Ferro and Badagami, 1980; Jhingran, 1982). This cyprinid game fish, attains a length of over 60 cm (Talwar and Jhingran, 1991). It is dark grey along the dorsal side, abdomen is silvery golden, fin is reddish yellow in color and average size is 600 g (Rai, 1978). Temperature dependent growth has been seen and the fish grow rapidly when temperature is in favorable range and food is abundant. The growth of Katle seems better during

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summer and loss in weight in winter (Rai et al., 1997). Katle is considered as multiple spawner. Though, this popular indigenous species fetch high price in market, its culture technology has not been well designed for commercial cultivation but breeding of Katle has been successful and worth proving for last few years at Trishuli and Kali Gandaki.

Katle is the dominant fish species in Indrasarobar Reservoir, where it represented 77.2% of the catch in 1990 (Rai, 1990) and it is abundant (32%) in Kali Gandaki River (KGFH, 2005/06). It is also reported from different lakes of Pokhara valley (Shrestha, 1981; Ferro and Badagami, 1980). The population of these species is decreasing sharply due to over and indiscriminate fishing, natural calamites, destruction of spawning grounds and blocking of migratory route by damming. To overcome and mitigate the declining population of Katle, studies in various aspects will help in developing the technology for mass production in commercial scale and maintaining population in natural water. At present, Katle is claimed as endangered species in the country which calls upon urgent actions to conserve. From conservation viewpoint and for maintaining the natural stocks in its major habitats, Fisheries Research Stations are conducting different activities like fishermen training programs, artificial breeding and culture of various native fish species. This paper review the state of knowledge on different aspect of katle from variety of published soueces and future research needs has been suggested.

Distribution

Katle (*Neolissocheilus hexagonolepis)* inhabits in major river systems and lakes throughout Himalaya extending of Nepal, India, Bangladesh, Myanmar and China. This species is native of the River Narayani, Chitwan 50 to 300 masl (Edds, 1986) and Dodhmati River at 50 to 373 masl (Shrestha, 1995). Katle is also found to be distributed in torrential water of Trisuli, Gandaki, Koshi, Karnali, Mahakali River systems and in Fewa, Begnas, Rupa Lakes and Indrasarobar reservoir (Shrestha, 2008) at an altitude of 250 m to 1500 m, having a preference for water temperature 10 – 30 ^{o}C (Rai and Swar, 1989). Hora (1940) described all the rivers of hills to be the major habitat of Katle fish. Similarly, Petr and Swar (2002) reported 625 -1250 masl hill barbel zone with fairly slow water current as Katle- dominated region.

Domestication

Among the 59 coldwater indigenous species, katle (*Neolissocheilus hexagonolepis*) has better taste and fetch high market value. Their domestication started in the 1970s at the Fisheries Research Center, Trisuli by catching their juveniles from the Trisuli and Tadi rivers (500 masl) and culturing them in earthen ponds. Wild brood stock was collected from the river and fed with artificial feed. Studies on breeding behavior of katle were carried out only from 1977. For breeding purpose, brood fish are changed in definite time interval as the same stock could not spawn satisfactorily for longer duration. Concerted efforts are being made to produce mass scale seed and develop aquaculture practices of katle at FRC, Trishuli and Kali Gandaki Fish Hatchery (KGFH), Syanja.

Feeding habit

Katle is bottom feeder, burrowing near the marginal shallows (Shrestha and Jha, 1993). It feeds on filamentous green algae, the lesser food components being chironomid larvae, crustaceans and water beetles flies (Ferro and Badagami, 1980; Jingran, 1982). Rai (1990) reported from gut content analysis that young fry is omnivore. Advanced fingerlings and adults mainly feed on aquatic vegetation and grasses (Jingran, 1982). Young fish need sufficient natural and proteinous food for better growth (Rai, 1990). Biswas (1985) reported that these fish were carnivorous at early stage of life but juveniles and adults ate plants as well as animals. Small fingerlings had shown bottom feeding habit.

Growth performance

Usual size of fish is 0.6 to 0.8 kg with length of 23 cm in first year and the largest specimen in Indrasarobar Reservoir reaching 2.9 kg (Rai and Swar, 1989). In Lake Phewa, the largest specimen of males and females recorded was 27 cm and 29 cm, respectively. The fish is indigenous cold water riverine fish whose growth is determined by reproduction, temperature and drawdown effects of water body (Swar, 1994). Rai and Swar (1989) reported that the growth of Katle is slow in pond culture system than in the riverine system. For optimum growth the temperature should be above 20 ºC, pH between 7.1- 8.9 and dissolve oxygen should be more then 6.9 mg/L (FRCT, 1996/97). Observation made in FRC, Trishli revealed that fish growth is better during July-October and zero body weight gain observed during December.

In a 10-month experiment, Rai et al. (1997) found that the katle grew at 0.03 g/day in pond environment receiving locally prepared food containing 45% crude protein. Similarly, research conducted by Basnet et al. (1998) in river water during 1992-1993 on growth of katle with stocking weight of 13.1mg and feeding with 48% crude protein attained a final mean weight of 2.3 g (Figure 1).

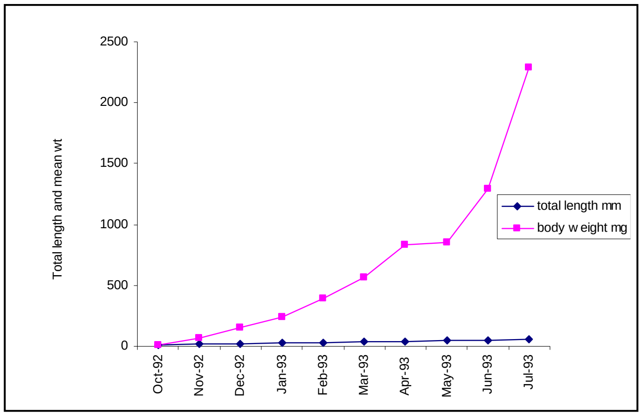

Figure 1. Mean monthly total length and total weight of katle ((*Neolissocheilus hexagonolepis*) in Fisheries Research Centre, Trisuli (1992/93)

Katle stocked at the rate of 4 fish /m^2 in ponds and grown for 183 days (June to December) with organic and inorganic manuring resulted in relatively poor growth (0.4 g/day) compared to that of the growth rate of other aquacultured fish species. Fish fed with 40% protein content diet show the better growth and survival (90%) of 0.2 g young fish. Composition of experimental brood fish diet formulated and being tested in FRC, Trishuli is given in Table 1.

Table1. Experimental feed composition of katle (*Neolissocheilus hexagonolepis*) broods reared in pond environment at Fisheries Research Centre, Trishuli

Feed ingredients	Diet composition (%)
Soybean flake	35
Shrimp	20
Wheat flour	22
Rice bran	12
Mustard oilcake	9
Vitamins	1
Minerals	1
Total	100

In another study, river collected fry having mean stocking weight 0.67 g and 0.75 g were reared for 183 with feeding 35% protein corresponded weight gain of 7.59 g and 8.42 g with 3.34 and 3.81 FCR, respectively (Basnet et al., 1997). Rai (1990) studied cage reared katle fry on diets with three different protein levels (40%, 30%

and 20%) and with no artificial feed at Indrasarobar reservoir at Kulekhani. The highest survival rate (95-96%) was observed with 40% and 30% protein content diets and the lowest survival was for fish without supplementation (60%) after six month rearing in cages. Fry attained final body weight of 1.03-1.08 g with supplemetal feeding and 0.65 g without supplementation. He also reported that the fish could tolerate a wide range of water environment, water temperature (18.1^{o}-24.0 ^{o}C), dissolved oxygen (6.6-10.9 mg/L), pH (8.0-8.3), alkalinity (65.0-90.0 mg/L) and water transparency (100-290 cm). Considering the growth of katle in captive environment from the present level of efforts more studies are warned on physiology of fish, feeding and nutrition management.

Breeding behavior

Despite of its increasing important, the reproductive biology of katle is poorly known. The earliest documented report on the reproductive ecology of katle is from Langdale Smith (1944). Ahmed (1948) collected and incubated the fertilised eggs of katle and studied their embryonic development. Katle is normally olive green dorsally and silvery white below. When breeding season commences, color is changed into slightly brown with rough and small prickles on operculum, more prominent in male. It tolerates wide range of temperature between 15-30 ºC (Rajbanshi, 1982), come in maturity when 3 years old or later (Rai and Swar, 1989). Katle is considered as a multiple spawner, breeds in May/June and August/September in India (Jhingran, 1982). However, only one cycle of breeding during August to October has been observed in Nepal (Rai, 1978; Swar, 1994). In a study, Swar (1994) found that katle produce largest eggs in September relative to eggs produced in October suggesting that September is the main breeding season. However, Occurrence of different size groups (batches) of oocytes indicates the multiple spawning characteristic of katle (Swar and Criag, 2002) (Table 2).

The upstream migration of ripe females in the reservoir and river suggested that katle is much selective in finding a suitable place to spawn (Swar and Criag, 2002). In September/October, fish starts their upstream migration and spawning takes place on stones and gravel at water temperatures of 18^{o}-23 ^{o}C (Rai and Swar, 1989). Eggs are transparent, yellowish and spherical; 2.3 to 2.5 mm in diameter; the stripped eggs are sticky and attach themselves to plants and rocks (Jhingran, 1982). Newly born larvae is 6.5mm long and transparent and on third day onward pigmentation appears and hatchling come to the surface and yolk sac absorbed at 10 days which is reported to be 10.1mm (Rai and Swar, 1989).

Swar and Criag (2002) carried out a study on the reproductive biology of Katle, *Neolissocheilus hexagonolepis* (McClelland) in the Tadi River and in newly created Indrasarobar reservoir, Nepal and reported that gonads development start in March and reproductive phase lasts from April to October, as in the reproductive cycle of other cyprinids. They observed katle from river less fecund than that from reservoir at smaller size. However, absolute fecundity found to increase with size more rapidly in river fish than the reservoir. The average relative fecundity in the reservoir population was 19.13±1.56 eggs/g compared to 22.57±1.41 eggs/g for the riverine population.

Rai (1978) collected one pair of katle broods from Trisuli and another from domesticated pond weighing 600 g and 264 g, released 30 g and 24 g eggs without use hormones in August. He described that if brood fish is in sound health and in well maintained condition, hormone introduction is not required for spawing. In August, broods ready to spawn were stripped without using hormone injection resulted in hatching success of 58 to 75% at a water temperature of 18^{o}-23^{o}C, pH of 6.8-7.7 and dissolved oxygen concentrations of 5.1-11 mg/l. (Rai, 1978; Rai and Swar, 1989). After yolk sac absorption eight-day-old hatchlings were fed egg yolk for a week and transferred to floating cages in Indrasarobar Reservoir.

Table 2. Stages in the development of ovaries and testes of Katle

Stage 1: State- virgin	
Ovaries	Thin, small, two pieces of compact tissue underneath the air bladder, gray. Oocytes not visible to the naked eye.
Testes	Very small paired organs, close under the vertebral column, connected to the air bladder, transparent.
Stage 2: State- Maturing virgin and recovering spent	
Ovaries	Ovaries with compact lobes, creamy to pale yellow, ova spherical, particularly laden with yolk, eggs visible with magnifying glass.
Testes	Slightly larger than stage 1, length about _ of the ventral cavity, transparent, reddish gray.
Stage 3: Developing	
Ovaries	Light yellow with distinct blood capillaries, eggs opaque, visible with naked eye, whitish and granular.
Testes	Opaque and reddish with blood capillaries, occupy about half the length of the ventral cavity.
Stage 4: Developed	
Ovaries	Large and bright yellow with conspicuous blood capillaries and oval shaped oocytes.

Testes	Reddish white with wavy margins and distinct blood capillaries, occupy about 2/3 of the ventral cavity.
Stage 5: Gravid	
Ovaries	Enlarged and fill ventral cavity, yellow eggs completely round and semi-transparent; primary oocytes as in stages 1 and 2 present.
Testes	White, waxy margin with transverse grooves; occupy the length of the ventral cavity; drops of milt exuded on pressure.
Stage 6: Spawning	
Ovaries	Distended, yellowish white, jelly-like, eggs run with slight pressure, most eggs translucent.
Testes	Occupy the length of the ventral cavity; pinkish white, turgid and milt runs with slight pressure.
Stage 7: Spent	
Ovaries	Empty, shrunken, baglike, a few residual oocytes may be visible.
Testes	Flaccid, gray, without milt.

Source: Swar and Craig (2002)

Concerted efforts are being made to domesticate katle collected from riverine sources at Fisheries Research Centre, Trishuli and Kali Gandaki Fish Hatchery. Regular collection and domestication activities for katle juveniles from natural sources are still pertinent as the as brood did not perform well in captive condition for longer duration. Katle broods are also being collected from Tadi River of Gadkhar and Devighat during monsoon i.e. migratory period and maintained in raceways at FRC, Trishuli. Fish are maintained on pellet feed containing 30-35% crude protein fed at 2% of body weight daily. Mature katle (180-300 g) are bred in September in Trishuli condition. Absolute fecundity is low for small sized broods as in many cprinids and hatching rates vary (20-64%) depending condition of broods and variation in brood rearing environment (Table 3).

Table 3. Breeding records of katle *Neolissocheilus hexagonolepis* (McClelland) in Fisheries Research Centre,Trisuli, Nepal

Date	Female body wt (g)	Total eggs (g)	No of eggs /g	Hatchability %	Water temp ^oC
13/9/2006	250	40	113	45.39	22
13/9/2006	260	40	113	64.21	22
13/9/2006	180	20	115	20.17	22
13/9/2006	300	50	113	0	22
13/9/2006	240	15	113	60.81	22
12/9/2008	350			59	22

Source: FRCT (2007/08, 2008/09)

Conclusion

Katle *Neolissocheilus hexagonolepis* (McClelland) is one of the most important cold water fish species in country. At present it is in endengered status from the conservation perspective due to over exploitation of its natural habitat, over and illegal fishing, habitat poisoning, dynamiting, electro fishing, deforestation, siltation, pollution, infrastructure development in water ways and natural disaster. In order to conserve and bring into aquaculture, systematic understanding on its biology, reproductive physiology and rearing conditions and environment is utmost important. Although studies on several aspect of this species was initiated some two decades back, significant amount of information and database on its breeding biology and aquaculture are still meager. A well designed and robust work plan on breeding and rearing of katle is an essential need to conserve genetic resources of this species. NARC's research stations need to be developed and qualified human resources to be placed for effective implementation of related activities to achieve meaningful outcome with regard to development of conservation and aquaculture practices of katle and other several economically important native fish species.

Acknowledgement

We would like to express sincere thanks to Fisheries Research Centre, Trisuli for providing all the relevant data and to Fishery Research Division, Godawari for an opportunity to share our work.

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REPRODUCTIVE AND GROWTH PERFORMANCE OF SAHAR (*Tor putitora*) AND ITS IMPLICATION IN AQUACULTURE

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ABSTRACT
The sahar (*Tor putitora*) also known as mahseer, a trans-Himalayan indigenous species of Nepal has been threatened by various anthropogenic activities. With the purpose of conservation and exploration to aquaculture, considerable development has been achieved on artificial propagation and its growth and yield performance in different eco-region. The results of breeding activities showed that 60% female responded during autumn season (mid September to early December) at water temperature ranges from 27-22 ^{o}C, whereas most of the female (>90%) responded during spring season (late February to late March) at 19-25 ^{o}C. The fertilization and hatching rate of sahar eggs ranges between 50-95%. The sahar shows intermittent spawning behavior releasing eggs more than one season.

The growth of sahar was faster in warmer environment at 26-29 ^{o}C water temperature. Differences in initial stocking size were also found to affect growth rate. Sahar stocked with initial average weight of 4 g grew at the rate of 0.40 g.day^{-1} while the growth rate of large size, 25 g was 0.49 g.day^{-1} during February to June in mid-hill. One-year old fingerling of Sahar (50 g) grew much faster, 1.12 g.day^{-1} and attained final weight of 219.4 g within 150 days in Terai region.

Key Words: *fertilization, growth performance indigenous, maturity, spawning.*

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Introduction

The golden sahar (*Tor putitora*) also known as mahseer, a trans-Himalayan indigenous species of Nepal is one of well-known massive fresh water sport fish as well as high value food fish of mountainous rocky rivers and lakes. *T. putitora* is distributed from most of trans-himalayan countries ranging Afghanistan, Bhutan, China, India, Myanmar, Nepal and Pakistan including Bangladesh (Skene-dhu 1923, MacDonald 1948, Desai 1994, Khan et al. 1994). Studies have shown that the sahar are living in deeper water bodies in both cold and warm waters and spawning and growth is better in warm water, temperature ranges from 20-30 ^{o}C. *T. putitora* is abundantly found in Lakes of Pokhara Valley. The natural population of sahar is known to be dwindling in many Trans-Himalayan countries due to chemical, physical and biological alterations in most of the aquatic environment of this region, the home of this species (Nautiyal, 1994; Shrestha, 1994).

With the purpose of conservation and exploration to aquaculture, considerable development has been achieved on artificial propagation and its growth and yield performance in different eco-region in Nepal are being evaluated. Mass scale seed production technology has been developed and the technology for aquaculture in captive condition has been under development (Bista et al, 2002; Gurung et al, 2002). However, several aspects including spawning and growth characteristics of sahar have yet to be studied. This paper deals with the seasonal response on mass seed production, optimum time of spawning and growth potential of sahar for conservation and exploration to aquaculture.

Materials and Methods

A series of experiments on seed production were conducted at Fisheries Research Centre (FRC), Pokhara. Fifty female brood fish of Sahar reared in earthen ponds (0.05 ha each) at the stocking rate of 1000 kg.ha^{-1}. No fertilizers have been used in brood ponds. Brood fish were fed on pellet feed containing 35% crude protein at the rate of 4% of body weight (Table 1).

Table 1. Proximate composition of 35% protein diet for Sahar brood.

S.N.	Descriptions	Percent Composition
1	Crude protein	35
2	Crude fat	11
3	Crude ash	7
4	Crude fiber	6
5	NFEE*	31
6	Moisture	10

* Nitrogen free ether extract

Female broods were checked at two days interval to catch the proper spawning time by applying gentle hand pressure near the genital opening. Females releasing ova on slight pressure were transported in the hatchery where they fully anaesthetized and stripped gently to receive eggs in clean and dry bowl. Eggs were weighed then milt from healthy males was directly mixed with the eggs for dry fertilization. Eggs with milt were mixed well by using bird feather to protect from damaging, then added fresh water and washed well the excess milt. Incubation of eggs was took place in Atkins incubators by allowing one layer of eggs to settle on single mesh screen in flow through system.

For the evaluation of aquaculture possibilities, the growth experiments of sahar were conducted in earthen ponds range from 150 to 300 m^2 at Pokhara, Kaski in mid-hill; IAAS, Rampur, Chitwan and Tarahara, Sunsari in Terai for various periods in consecutive years started from 2003 to 2008. Sahar with varying sizes and age cohorts were stocked at a density of 10,000 individuals.ha^{-1} in duly prepared pond respective to the designated treatments and locations.

The experimental fish were fed twice daily with crumble and pallet ration approximately containing 35% protein and for small size and daily feeding was 5% and 3% estimated weight of biomass for the fry and the large size fish, respectively. The growth experiment run for 120 days at Pokhara and Tarahara and 240 days at Rampur.

Experimental fish were sampled monthly to monitor body weight gain. Differences in monthly body weight gain and total body weight gain between treatments were analyzed. In brood ponds water quality i.e. temperature, dissolve oxygen (DO), pH and other necessary parameters were monitored periodically with daily measurement of DO.

Results and Discussion

Reproductive performance

Water temperature in ponds stocked with sahar (*T. putitora*) ranged from 12.5 to 32.0 ^oC at 6-7 AM (Figure 1) while pH values ranged 7.0 to 9.0 and dissolved oxygen from 3 to 9 mg/L.

The sahar shows intermittent spawning behaviour releasing eggs more than one season. Pond reared sahar spawned first time in 1999 at FRC Pokhara (Gurung et al, 2002). This study showed that most of the sahar female broods under captive condition responded better during February-March than September-October. Results showed 60% female responded during autumn season (mid September to early December) at water temperature 27-22 ^{o}C, whereas most of the female (>90%) responded during spring season (late February to late March) at 19-25 ^{o}C. The fertilization and hatching rate ranges between 50-95%. The compilation of breeding data showed that sahar could breed in most of months of the year. Results showed that sahar could spawn from March to first week of December at water temperature between 19 to 32 ^{o}C at FRC, Pokhara (Begnas) where annual water temperature ranged between 15-31 ^{o}C in 2010 (Figure 1)

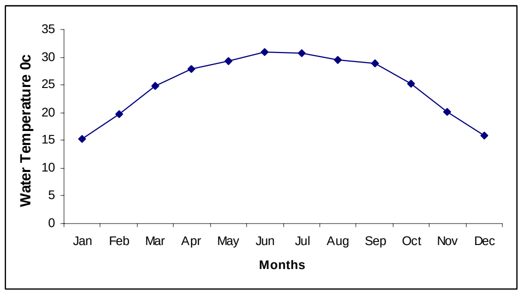

Figure 1. Mean water temperature (^{o}C) in sahar rearing ponds, 2010

All females were responded for releasing eggs during spring season (February-March). Among them about 58% released viable eggs with normal spawning, 12% released poor quality eggs (low fertilization and hatching rate) and rest 30% were found over matured in spring 2010, whereas only 60% female were responded for releasing eggs and 10% females released viable eggs during autumn (September-October) of 2009 (Table 2). The fertilization and hatching rates were ranged between 50-95%.

Table 2. Seasonal spawning performance of Sahar

Discription	Sept-Oct 2009	Feb-Mar 2010
Female, No.	50	50
Responded female, No. (%)	30 (60%)	50 (100%)
Normally spawned brood (%)	5 (10%)	29 (58%)
Female spawned with poor quality eggs (%)	20 (40%)	6 (12%)
Over matured (%)	25 (50%)	15 (30%)
Post spawning mortality (%)	0%	0%

This study suggests that pond reared sahar, *Tor putitora* could breed at 19-32 ^{o}C from March to December by simple hand stripping without any hormone use and brood loss. It also demonstrated that sahar broods could be reared like other carps such as common carp, Chinese and major carps. The broods about 30% in spring and 50% in autumn showed over mature ova during routine check, which implied that broods should be examined more frequently than as practiced often once or twice a year for cultivated cyprinids. For higher spawning rate and eggs viability, determination of optimum stripping time by frequent checking of brood fish in every 1-2 days interval is essential.

Growth performance

During the experimental period water temperature was ranged between 20.0-30.5 ^{o}C at Pokhara, 13.9-27.3 ^{o}C at Rampur and 29.1 ^{o}C at Tarahara. The growth of sahar was faster in warmer environment at water temperature, 26-29 ^{o}C. Sahar stocked with initial average weight of 4 g at Pokhara (mid-hill) and 3.5 g at Tarahara (Terai) for growth study. Although body weight gain of sahar fry at the end of first month of rearing did not differed from stocking size, later fish growth varied significantly (P<0.05) and attained final weight of 52.8 g in Pokhara and 66.5 g in Tarahara at the end of 120 days or rearing experiment (Figure 2).

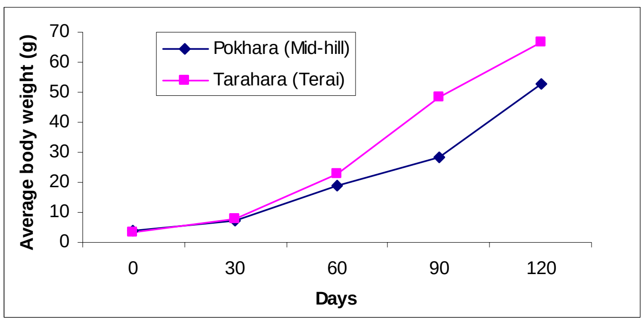

Figure 2. Mean growth (g) of sahar, *Tor putitora* in Mid-hill and Terai, 2006

Location specific comparison of the growth of small size sahar revealed that the net cumulative weight gain in Tarahara at each growing months was significantly higher (P<0.05) than the net weight gain obtained in Pokhara (Figure 2). Absolute growth rate calculated for small sized sahar was 0.40 g/day^{-1} in Pokhara and 0.42 g/day^{1} in Tarahara, and differences in growth rates between locations were not significantly different (P>0.05). Likewise, a result of experiments in terai shows that the growth of sahar is faster during warmer season than winter. Warmer water temperature is favourable for the growth of sahar. Sahar with mean initial weight of 16.3 g reached to 109.5 g in 240 days of rearing from October 2007 to June 2008 at Rampur, Chitwan (Figure 3).

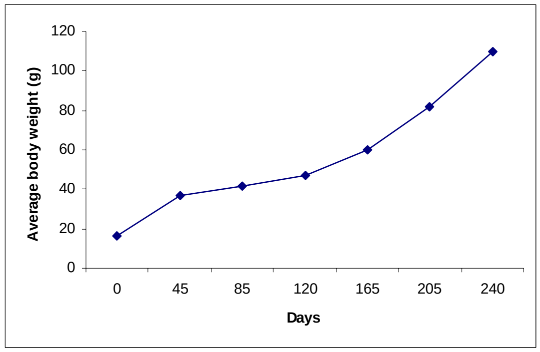

Figure 3. Mean growth of sahar, *Tor putitora* at Rampur from October 2007 to Jun 2008.

Temperature tolerance of sahar for growth and reproduction is similar to other carps. Observations revealed that sahar can survive and thrives well at water temperature over 30 ^{0}C in summer season in rearing ponds and cages in lakes of Pokhara valley without any adverse effect on its growth (Bista et al, 2002). In the present study, most of the sahar female broods were reared in normal condition in ponds and cages where water temperature was ranged from 15-31 ^{o}C throughout the year during 2010. March-May is the main season for spawning sahar in FRC, Trishuli (Nuwakot) and October-November is the next season for spawning (Nepal et al, 2002,). This study shows that the matured broods of sahar responded better during February-March than September-October and determination of optimum stripping time by frequent checking of brood fish in every 1-2 days interval is essential for higher spawning rate and eggs viability.

Sahar of different sizes and age cohort were raised in ponds of mid hill (Pokhara). Relatively poor body weight gain of sahar in all treatments during February to March was associated with low water temperature. Bista et al. (2002) reported merely 0.12 g.day^{-1} growth rate of large size sahar at temperatures between 15-18 ^{o}C. The high growth rate of sahar in all treatments observed in the present studies might be the results of favorable temperature during grow-out period. Significant differences in cumulative net weight gain of sahar reared in mid hill and Terai suggest that warmer region is more favorable for the grow-out of sahar in captive environment.

Relatively high growth rates of sahar in Terai region was also reported by Rai et al. (2006). Marked differences in growth rates were observed with the stocking of small size and large size (including one-year old) sahar. High growth rate (1.12 g.day^{-1}) of one-year old sahar obtained in the present study suggests that rearing sahar for two year old would be more profitable from the economic point of view. Sahar fetches a high market price, almost double than the other Chinese and major carps. However, observed growth rates of sahar are comparatively below the growth of other carps species being used in fish farming systems of the country.

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REPRODUCTION AND GROWTH PERFORMANCE OF GARDI (*Labeo dero*) AND ITS PROSPECTS IN AQUACULTURE

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ABSTRACT
Gardi (*Labeo dero*) is one of the important native species found in different river systems of Nepal. This species preferred for fishing and contributes for daily income, livelihood and self-employment in foot-hills of Nepal. Currently natural fish stock is declining due to increase in fishing pressure and various other reasons. Therefore, an attempt was made for domestication and controlled breeding of this native fish at Fisheries Research Center, Pokhara. It was observed that gardi commenced sexual maturity at an age of one-year. The breeding results showed that mean fecundity was 243000 eggs/kg body weights and the mean fertility rate of egg was 84.0±10.3 percent. Hatching took place 16-18 h after incubation depending upon temperature variations of 24-26 ^{o}C and the mean hatchability was 76.2±5.4 percent. Observation of breeding performance of pond reared breeders revealed that spawning success rate increased with the progression of domestication period.

Fingerlings produced from this study were stocked at density 10,000 individual/ha to determine their growth in ponds. Growth data showed that this fish attained average weight of 107.7 g in one year. The spawning success and growth of fish showed that gardi could survive and grow well in ponds of mid hill Valley of Nepal and would be of great value for stock enhancement in natural habitat as well as aquaculture development.

***Kew Words**: gardi, Labeo dero, sexual maturity, breeding, growth, conservation*

Introduction
Gardi (*Labeo dero*) is one of the important native fish species found in river systems of Nepal (Shrestha 2003.) It has an important role as a source of animal protein, income generation as well as to provide employment opportunity to local fisher folk communities. Currently overall production in natural water has reported to be decreased (Shrestha and Chaudhary 2003) due to dams and other hydraulic engineering development block migratory route of fish, un-thoughtful exploitation by man, encroachment caused by industrialization, agricultural development along water bodies and ecological alteration and physical changes in natural environment etc. (Swar 2001). Such a declining trend in production warrants propagating their

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seed on a large scale and transplanting them in streams and lakes to improve social status of fisher communities. Mass seed production through captive breeding is considered dependable solution for the conservation and enhancement of fisheries (Flemming 1994).

The initial efforts commenced in year 2003 with the success on the breeding of wild stocks of gardi at Kali Gandaki Fish Hatchery (Prasad and Rai 2010) elaborated the techniques of artificial propagation and successful rearing of its fry in nursery system (Prasad and Bista 2010). A further attempt was made to domesticate and propagate pond reared gardi fish in captive condition for reintroduction in natural water and assesses their aquaculture possibilities. The present paper deals with above aspects for the development of fishery and aquaculture of gardi.

Materials and Methods

Fry produced from wild population of gardi at Kali Gandaki hatchery were transported to Pokhara. These fry were reared until its sexual maturation. Sexually matured broods were managed separately provided with supplementary feed at the rate of 2 % of body weight containing 35 % crude protein. For breeding purposes females were selected based on the display of a swollen and soft abdomen with pinkish and protruding genital opening. Males were selected based on the availability of milt following gentle pressure in the abdominal region. Selected broods were injected with a single dose of ovaprim hormone at the rate of 0.5 mg/kg for females while male injected with half of this dose. Injected fish were kept in a tank with continuous water flow. Females were checked for its ripeness and fish releasing ova on gentle pressure were stripped out and fertilized with mixing milt. Besides stripping, some fish were also naturally spawned. Incubation of fertilized eggs was done in circular tank. Water temperature of hatchery ranged from 26 to 28 ^{o}C.

Similarly, growth performance of gardi was conducted in earthen bottom pond at Phewa center for a period of one year. Prior to stocking ponds were prepared following drying, liming, water filling and fertilization with organic manure and inorganic fertilizer (Urea and DAP). Fry of first generation produced from captive breeding of sexually matured brood reared at Phewa center (from natural parental stocks) were used for experiment. Two different stocking sizes (11 g and 44 g) were established as treatments with two replicates. Fingerlings with varying sizes were stocked at density of 10,000/ha and were offered 25 % feed twice daily. Feeding rate was 3 % of fish biomass. Monthly fish samples were taken to monitor the intermediate weight gain. Differences in monthly body weight gain and total body weight gain within and between treatments were analyzed by t-test using Microsoft Excel program.

The hatchery experiments were conducted from year 2006 to 2010 and growth study from 2007 to 2008 at Fisheries Research Center, Pokhara.

Results and Discussion

Spawning performance

It was observed that gardi commenced sexual maturity at an age of 1^+ year and spawned for the first time in year 2006. Since then consistent success in spawning was achievable. The reproductive performance of gardi (*Labeo dero*) from year 2006 to 2010 is presented in Table 1**.** The breeding results showed that most of the gardi brood responded during June-July under cultured condition at water temperature ranging from 19.3 to 32.4 ^{o}C. Several studies have shown suitable spawning of Indian major carps during rainy season at water temperature 24-31^{O}C (Jhingran 1991; Pillay 1993; Chondar 1994) which is consistent with present study. Generally, May-June is the month of onset of monsoon in Nepal which implies that gonad maturation of fish is affected by monsoon rains and water temperature (Jhingran 1991; Gubhaju 2002). Since gardi spawned at about the same time as the Indian major carp (IMC), they can be observed as an indicator of readiness. However, general delay or early in spawning under different geographical and ecological conditions have also been reported (Rath 1993).

Table 1. Reproductive performance of gardi (*Labeo dero*) fish at Fisheries Research Center, Pokhara

Description	Year 2006	Year 2007	Year 2008	Year 2009	Year 2010
Date of Breeding	June- July	June- July	June- July	June- July	June- July
Female no	15	25	12	17	26
Av wt of female (g)	203	214	242	235	280
Male no	20	30	20	20	32
Av wt of male (g)	150	205	163	210	240
Hatchery Temp	26-28 ^{0}C	26-28 ^{0}C	26-28 ^{0}C	26-28 ^{0}C	26-28 ^{0}C
Hormone used	Ovaprim	Ovaprim	Ovaprim	Ovaprim	Ovaprim
Responded female no and wt (kg)	15 (3.050)	25 (5.34)	12 (2.9)	17 (3.99)	26 (7.28)
Spawning rate (%)	100	100	100	100	100
Spawning time (hrs)	6-9	6-9	6-9	6-9	6-9
Spawning type	Stripe	Stripe	Stripe	Stripe + Self	Stripe + Self
Hatching time (hrs)	18-24	18-24	18-24	18-24	18-24
Hatchlings production	364941	842182	453006	720355	1143052

Average size of female (234.8±29.7g) used were larger than male (193.6±36.7g). Spawning success rate was 100%. Average fecundity (eggs/kg body weight of fish) irrespective of month was 243406 ± 40315 while hatchlings production was 154225±21816 individual/kg body weight of fish (Figure 1). The fecundity observed was almost similar to those reported in rohu (*Labeo rohita*) and naini (*Cirrhinus mrigala*) but differed with other species like catla (*Catla catla*) and chinese carp (Rath 1993; Chondar 1994). Variation in fecundity within species might be due to differences in age, nutritional and living condition of each individual fish. Chondar (1994) reported average fecundity of 415,000 in *Labeo dero* while Raina & Petr (1999) found fecundity of 1500-17000 in same species in natural conditions.

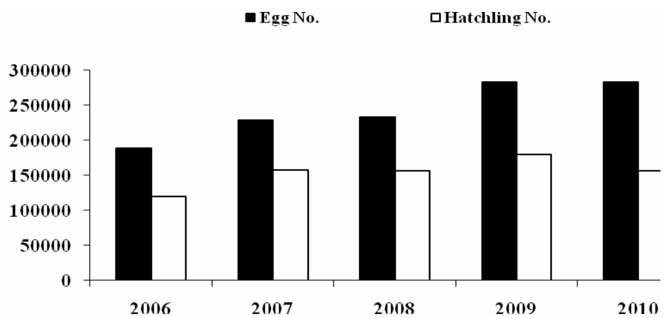

Figure 1. Fecundity (eggs/kg body weight) and hatchability /kg body weight of gardi in different year

The mean fertility rate (84.0±4.6 %) and mean hatchability rate (76.2±5.4%) observed in this study could be considered optimum (Jhingaran 1991; Rath 1993) (Figure 2). However some differences in fertility and hatchability rate were also noted (data not shown) could be due to viability of eggs was rather weak towards end of season when temperature rises (Jhingran, 1991). Hatching took place 18-24 h after incubation depending upon temperature variations of 26-28 ^{o}C suggested time required for eggs to hatch varies with water temperature and at higher water temperature the embryo develop rapidly (Pillay 1993; Ogale 2002). The larvae commenced feeding only between the third and fourth day of post-hatching. Observation of breeding performance of pond reared breeders revealed that spawning success rate increased with the progression of domestication period.

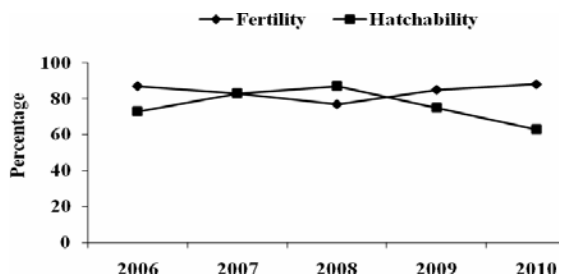

Figure 2. Fertility and hatchability percent of eggs of gardi, *Labeo dero* in different year

Growth Performance

The growth pattern of gardi demonstrated constant increase in growth (Figure 3 and 4). Growth pattern of fish irrespective of stocking size followed an exponential increase throughout the study period. The results showed that small sized gardi fish grew from 11g to an average weight of 107.0±15.53g in 360 days of growing period. Larger sized fish grew from 44 g to an average weight of 177.4±16.8 g in 330 days of growing period. Monthly weight gain were significantly (P<0.5) differed in early culture period in both stocking size. Mean absolute daily weight gain was 0.26 g/day and gross production averaged 1012 kg/ha for small sized fish while it was 0.36 g/day and 1740 kg/ha for larger stocking size fish respectively (Table 2 and 3). This revealed that growth rate and production were affected by stoking size of fingerlings and initial stocking of bigger size fingerlings could be more productive.

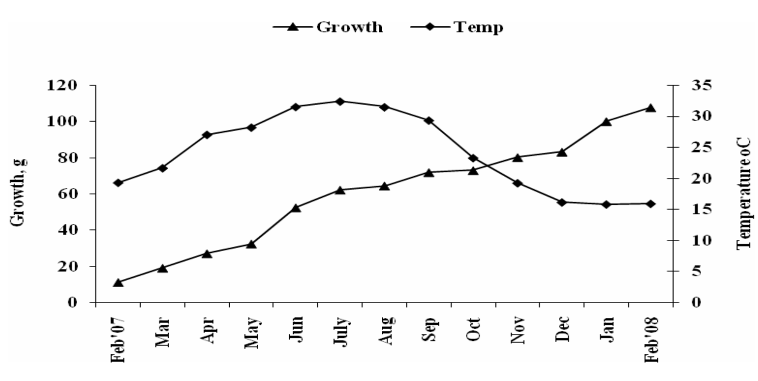

Figure 3. Growth pattern of gardi fish for 11 g stocking size

Similar observation was made by Bista et al. (2004) during growth experiment of sahar (*Tor putitora*) with initial stocking size of 4g and 11 g reared in earthen ponds at Pokhara Valley. Manomaitis et al. (2004) also reported better weight gain, health, production, FCR and economic return with bigger stocking size of 16 g than 12 g in *Labeo rohita* grown in ponds. Contrary to these observations, Akbulut et al. (2002) reported growth performance of rainbow trout (*Oncorhynchus mykiss*) in cages appeared to be depressed at larger size group. Higher survival rate likewise obtained with bigger size fingerlings in this study indicated that mortality and stocking size are related and that higher risk is involved when stocking smaller fry.

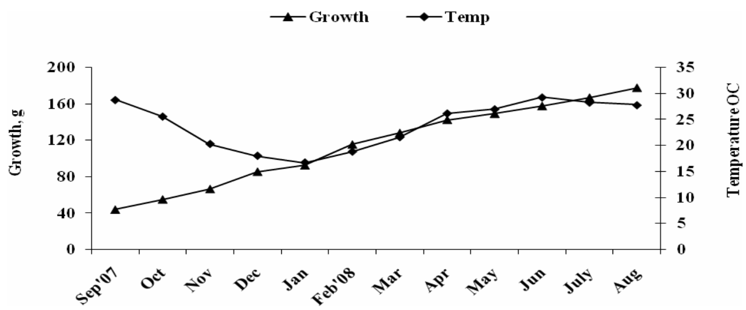

Figure 4. Growth pattern of gardi fish for 44 g stocking size

Each fish species has an ideal temperature range within which it grows quickly. In the present study temperature was ranged from 15.8 ^{o}C to 32.4 ^{o}C during growing period. Anonymous (1983) stated an optimum growing temperature for freshwater fish in the range of 25-30 ^{o}C while Kausar and Salim (2006) concluded that water temperature ranging from 24-26°C seemed to be the most effective for rearing of *Labeo rohita*. This indicated that growth and survival of fish are optimum within a defined temperature (Gadowaski and Caddell 1991). The growth potential of gardi observed in captive condition in this study provides opportunity to explore this species in the current aquaculture practices.

Table 2. Growth comparison of gardi (*Labeo dero*) at different time period of rearing days

Growing days	11 g size		44 g size	
	Weight gain (g)	Growth rate g/day	Weight gain (g)	Growth rate g/day
O day	11 ±0.62		44 ± 2.1	
30 days	18.9 ± 1.84**	0-26	55.1 ± 1.4*	0.37
60 days	26.9 ± 1.23**	0.27	66.6 ± 2.9**	0.38
90 days	32.3 ± 3.32*	0.18	85.5 ± 21.8*	0.63
120 days	52.3 ± 9.27*	0.67	92.5 ± 28.4 ns	0.23
150 days	62.1 ± 4.76ns	0.33	115.3 ± 1.9 ns	0;76
180 days	64.4 ± 13.93 ns	0.08	128.0 ± 34.6 ns	0.42
210 days	71.8 ± 7.21 ns	0.25	143.3 ± 1.2 ns	0.48
240 days	72.9 ± 14.71 ns	0.04	149.0 ± 21.2 ns	0.22
270 days	80.1 ± 1.60 ns	0.24	157.5 ± 3.5 ns	0.28
300 days	83.1 ± 1.05*	0.10	166.6 ± 3.3*	0.30
330 days	100.0 ± 0.81 ns	0.56	177.4 ± 16.8*	0.36
360 days	107 ± 15.53 ns	0.26	-	-

Different superscripted symbol are (**) highly significant, (*) significant and (ns) non – significant within row at $P < 0.05$ level.

Prospects in Aquaculture

In past few years' research and development efforts were successfully carried out to develop propagation technique and fry production of gardi (*Labeo dero*) fish in captive condition. Past experience revealed that from management point of view, gardi is much easier to breed and nurse fry. It attains sexual maturity early and is a high fecund fish. Aquaculture potential of gardi in captivity has been successfully demonstrated which showed that this fish are compatible with other cultivable species and being a minor carp it could be suitable as chhadi fish (finger size fish), dried and smoked fish. Being herbivore in feeding nature it could be used as cleaning of fouling in cages. Inclusion of gardi could contribute a share in the overall national fish production by diversification and commercialization of existing aquaculture practices. The restocking of this species in natural water would enable more capture and can play a significant role in a local nutrition, income generation and employment.

Table 3. Growth data of gardi (*Labeo dero*) at different stocking sizes

Description	11g size	44g size
Pond size	250 m^2	250 m^2
Total no of fish stocked	250	250
Initial mean stocking size (g) ± SD	11.0 ± 0.6	44.0 ± 2.1
Mean body weight at harvest (g) ± SD	107.7 ± 15.5	177.4 ± 16.8
Net wt gain (g)	96.7	133.40
Survival rate %	94 ± 2.05	98 ± 1.86
Average growth rate (g/day)	0.26	0.36
Gross fish biomass (kg)	25.3	43.5
Net fish biomass (kg)	22.7	32.7
Gross production (kg/ha)	1012	1740
Net production (kg/ha)	908	1308
Growing days	360	330

Conclusion

Present result on artificial breeding showed that gardi can be bred in captivity induced by hormone and a program could be undertaken in selected natural waters for species restoration. The growth performance of fry in pond condition explored the area for introduction of this species in existing aquaculture system with cultivable carps which could be a successful step towards its commercialization.

Acknowledgement

We are grateful to staffs working at Fisheries Research Center, Pokhara for their support to conduct this research. Thanks are due to Mr. S.K. Wagle, Chief, Fisheries Research Division, Godawari for providing opportunity to contribute this paper.

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PRELIMINARY OBSERVATIONS ON DOMESTICATION OF CHITAL (*Chitala chitala*) IN POND CONDITION AT TARAHARA, EASTERN NEPAL

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ABSTRACT

Integration of aquaculture of native species into rural development has been augmented as it has the potential for poverty alleviation through direct involvement of rural people in aquaculture production. In view of the conservational value and the aquaculture potential of several indigenous species, there has been a concerted effort to domesticate and artificially propagate several native species. Bhunna or chital (*Chitala chitala*) has been identified as important food fish among the native fish. It fetch a very high market price and is of high cultural value. Wild caught chital from Koshi River was reared in pond environment in Regional Agriculture Research Station, Tarahara. Spontaneous spawning took place during mid June to mid July of 2010 in rearing pond at 35-37 ^{o}C water temperature. The growth of this fish is relatively high to that of other native species under domestication. Body weight of junenile chital reached over three kg in one year of rearing in pond with supplemental feeding. These preliminary observations on chital suggest that this species could breed and grow successfully in pond environment in Terai region.

Key Words: *chital, Chitala chitala, domestication, pond environment, rearing*

Introduction

Integration of aquaculture with native species into rural development has been augmented as it has the potential for poverty alleviation through direct involvement of rural people in aquaculture production. Approximately, 5% of the total area of the country is known to be occupied by different freshwater aquatic habitats (Bhandari, 1992) where some 187 indigenous fish species are reported to thrive (Rajbanshi, 2005). Aquatic systems of Nepal have diversified catfishes (69 species) belonging to order Siluriformes, having 33 genera under 10 families (Shrestha, 2008). Some catfish have high economical/ecosystem values as indicated by their taste, abundances, fishing characters (angling) and growing habitats. Due to these characters increasing fishing pressure, in combination with destructive fishing

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practices and habitat degradation and loss, threaten the sustainability of fisheries of indigenous fish including catfishes in Nepal. Exploitation of important native catfishes for conservation and adaptation in current aquaculture setting is constraint by the lack of seed production; grow out technology and poor understanding of their biological performances.

Among native catfishes chital or bhunna (*Chitala chitala*) has been identified as economically important fish species as it fetch a very high market price and is of high cultural value. It inhabits freshwater rivers, lakes, reservoirs, canals and ponds. It feeds on aquatic insects, mollusks, shrimps and small fishes. Although chital makes minor contribution in total capture fisheries, it has high commercial value in aquaculture/aquarium and significant performance in angling. Chital have some attractive sports long with dorsal-anal side therefore it is used as an aquarium fish. They are also called "featherbacks" due to the small feather-like fin on their backs. They are well adopted in shaded pond with broad leaved aquatic plants such as gorgon nut, makhan (*Euryale ferox*) and Lotus (*Nelumbo nucifera*). Integration of chital in such environment could open a new area for aquaculture development of native fish species. The economic and aesthetic value of chital lured some pioneer farmers of Biratnagar to import its juveniles from west Bengal, India and started to rear in grow out ponds. Maithali proverb “*Sadlo bhunna rohu ke dunna*” means even rotten bhunna (chital) is two times tastier than fresh rohu (*Labeo rohita*), which indicates its taste and market value. Despite of its economic and biodiversity importance, population abundance of chital is being threatened by degradation of wetland environment, illegal fishing and lack of people’s awareness. Over the last few decades wild population of Chitala chitala (HamiltonBuchanan) has been declined more than 50% due to various reasons and is presently listed under endangered (EN) category due to reduced abundance (Sarkar et al., 2006a). Conservation aquaculture is gaining importance in rehabilitation programmes of endangered / threatened fishes (Dar et al., 2010). In view of the conservational value and the aquaculture potential of several indigenous species, there has been a concerted effort to domesticate and artificially propagate several native species. The successful captive spawning and larval rearing of endangered chital (*Chitala chitala*) would open up the avenues of replenishment. Regional Agriculture Research Station of NARC, Tarahara has initiated domestication and growth studies of chital in pond environment since 2008. Attempts have been made to illustrate the outcome of the efforts made on domestication of chital in this report.

Material and Methods

Wild chital (*C. chitala*) were collected from natural habitats (Koshi River) during 2008 and reared in earthen ponds at Regional Agriculture Research Station, Tarahara. The size of wild caught 10 fish was between 5.0-7.0 kg in weight and 72-80 cm in length (Photo 1). Standard fish rearing protocols of carp farming were followed for chital. This involved pond liming (500 kg/ha), basal fertilization with FYM (3.0 t/ha) followed by 0.5 t/ha FYM at monthly interval to maintain water transparency 25-35 cm. Water depth of pond was maintained to 1.5 to 2.0 m throughout the observation period. Carp feed (25% crude protein) was provided in the form of moist feed ball to the stocked chital. In natural habitat chital feeds on aquatic insects, mollusks, shrimps and small fishes. Therefore, Tilapia (*Oreochromis niloticus*) as feeder fish was stocked at 1:2 male to female ratio with 20000 fish/ha stocking density in the chital pond.

Photo 1. Wild caught mature *Chitala chitala* brood Fish (7.0 kg body weight and 80 cm body length)

Chital fry obtained from spontaneous spawning of wild broods in pond. Although no special management was made for fry, the growth monitoring was initiated when the fry reached 5.0 g body weight. Monthly fish growth samples were taken to assess the body weight gain for a period of July 2010 to June 2011.

Results and discussions

Spontaneous spawning of wild chital took place during mid June to mid July of 2010 in rearing pond at 35-37 ^{o}C water temperature at RARS, Tarahara. Chital larvae were not separated from the spawning pond and allowed them to grow with brood chital and tilapia. The water temperature was ranged between 15.0 to 37.0 ^{o}C during the growth observation period.

At the beginning of growth monitoring large number of chital fry were seined. As the growing period progressed the number of young chital decreased significantly. At the end of growth observation only 15 one year old chital were harvested upon pond drying. This indicates that high rate of cannibalism among different size group of chital. Large sized chital including broods might have prayed the younger fish despite tilapia were stocked as feeder fish in the pond. Mackinon (1985), Hecht and Applebaum (1988), Katavic et al. (1989) reported that the behaviour of fry thus the rate and extent of cannibalism affected greatly by size variation, food availability, feeding frequency and population density. The behaviour of chital fry has a tendency to prey among size group. Hecht and Applebaum (1988) showed food and feeding associated factors to be the principle cause of cannibalism among many fish species. Feeding with live tubifex worms and chironomous larvae enhance growth and survival rate of chital larvae (Sarkar et al., 2006b). Adequate supply of live food at early stage of development of chital is necessary to reduce the aggression induced mortality and thus increase survival rate.

Average body weight gain of pond reared chital reached 3.5 kg during one complete cycle of growing period (Photo 2 and Figure 1). The estimated absolute growth rate of chital was 8.3 g/day which is highest ever observed for cultivable carp species. Chital showed exponential growth function and its growth was not restricted even during low water temperature during winter months. Observed growth rate might mislead for predicting productivity of chital, since only a few individuals were raised which had advantage of availability of enough space and food in the pond. However, the domestication of chital in pond environment and its growth potential indicated that this species can be raised in ponds for complementing current aquaculture diversity.

Photo 2. One year old pond reared *Chitala chitala* (3.0 Kg body weight and 62 cm body length)

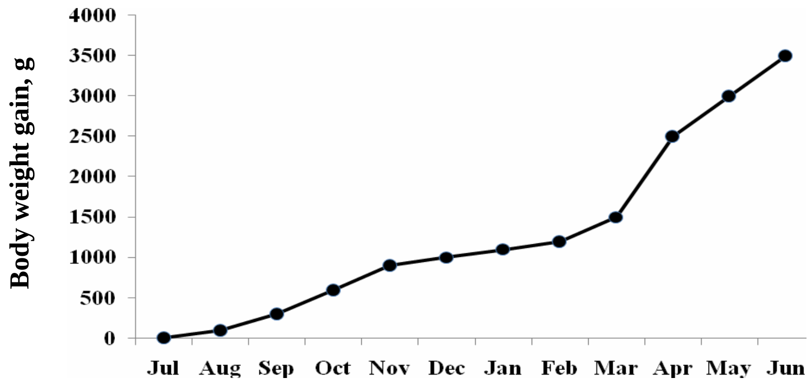

Figure 1. Growth trend of *Chitala chitala* in one year, 2010/2011

In the light of increasing demand for aquaculture product; it appears that production and productivity from the existing aquaculture system cannot be increased substantially, since productivity from polyculture system has already been reached a plateau with plankti-herbivorous carp species due to their biological limitation to feed response as well as adopt hardier aquatic environment like marginal swamp, wetlands and many seasonal borrow pits in village. If the full potential of aquaculture production is to be realized, there is an urgent need for increasing fish species diversity in the country to utilize all types of water resources. Suitable fish species are also needed to intensify the aquaculture production system. Present observation indicated that chital, with its several characters such as native to national water system, fast growth, ability to spawn in captivity, high tolerance to adverse environment and socially accepted high market value, could be an important fish species to be promoted for aquaculture. However, future researches should answer on questions and issues of reproduction biology, feeding habit, controlled breeding, nursing of fry, grow out potential and compatability of chital with carps and other aquacultured fish species in pond environment.

Acknowledgements

We wish to express our indebtedness to late Raju Bahadur Sah for his help in collection of chital (*Chitala chitala*) and colleagues who help to make the observations.

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BREEDING AND REARING PERFORMANCE OF ASALA (*Schizothorax richardsoni*) IN GODAWARI

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ABSTRACT
Asala (*Schizothorax* spp.) is one of the economically important cold-water species popular for its taste and abundance throughout the foot and mid hill waters of Nepal. Asala population is declining due to various reasons like habitat loss, overfishing and poor conservation effort. For conservation of this genetic resources and the sustainability of aquaculture technological intervention in seed production is required. Descendant of domesticated stocks of Asala originally collected from Nallu (Lalitpur), Melamchi (Sindhupalchok) and Trishuli (Nuwakot) and Khudi (Lamjung) Rivers were used for breeding in Godawari. Breeding activity was carried out in summer (March/April) breeding seasons. Percent fertility (94.2%) and hatchability (62.7%) of eggs for asala (Khudi and Melamchi line) bred during summer breeding. The mean survival of 72-82 days old fry was remarkably lower (3.1%). Larval survival and growth was severely affected by the outbreak of chilodonella and trichodina parasite in asala fry. Formalin treatment was not effective against these parasites. Combination of potassium permanganate (6 mg/L) and formalin (20 mg/L) and halite (1%) treatment was found effective to control chilodonella infection in Asala fry. Further research on impact of hormone induced spawning on fry viability; parasite control strategy and evaluation of various feed ingredients to promote survival and growth of asala fry have been suggested.

***Key Words**: asala, fertility, induced spawning, parasites, feed ingredients*

Introduction
Asala (*Schizothorax* spp) are one of the most dominant species in mountain waters in Nepal, indicating these groups of fish in cold fast flowing torrential rivers are most successful and abundant. Dhar (1967) reported the natural growth of fish is about 175 g in second year and 330 g in fifth year. The reported size of asala ranged 1.5 to 5.0 kg in different river system of Nepal (FRC, 1998; Local fisherman, personal communication). Despite of species high diversity their abundance in

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different habitat is threatened by various anthropogenic factors and environmental degradation. Development of culture practices of asala in ponds/raceways can be a better solution for its conservation and could be a complementary species with trout to utilize vast cold water resources of the country.

Indigenous cold water fish of Nepal have a slow growth rate and *asala* is no exception. Studies on reproduction biology and potential for growth in controlled environment and genetic characterization of important species of asala are the major area of research. *S. richardsoni* spawned by manual stripping in two consecutive breeding period validated by peak gonado-sometic index (GSI); October-November (33.4% GSI) and February-April (12.8% GSI) at 11.0-17.5 ^{o}C water temperature in 430-1500 m masl (Wagle et al., 2011; Baidya et al., 2011). Wide variations in relative fecundity (6200-97800 eggs/kg female) and hatching rate (25-96%) with larger improvement in egg number in small fish have been estimated. Masuda (1979) measured the four year old asala collected from Trishuli River and found body weight ranged 226.2-363.6 g corresponding standard length between 226 to 257 mm. Asala reared in raceway at Fisheries Research Centre, Trishuli grew only 3-18 g in a year (Tuchiya, 1993). Wide variation in reproductive performance and poor weight gain warned for more concentrated effort towards the understanding of ecology such as feeding, environment of habitats, spawning and fecundity in order to develop aquaculture practice of Asala. The purpose of this study was to obtain knowledge concerning the spawning and growth of asala reared in controlled environment. Present work is the summary of fish bred during summer breeding.

Material and Methods

Status of asala broods and egg production is given in Table 1. Asala collected from different wild habitats (river and stream) and domesticated in tanks at Fisheries Research Division, Godawari were used for spawning. Basically, ovulation checks were done every day with manipulation of fish to avoid over maturation. All fishes were anesthetized with Eugenol Ethanol (1:5) solution. The solution was prepared by dissolving 40 ml Eugenol Ethanol mixture in 100 litre water. Chloramphenicol (200 mg) and Vaseline (10 g) mixture was used to prevent infection due to excessive handling.

Table 1. Condition of spawner of asala and egg production

Lot	Spawning date	Number of fishes ♀	Number of fishes ♂	Condition
1st lot	8-Mar	1	3	Eggs collected from broods from Khudi River, Lamjung right after transportation. Probable over maturation due to unexpected egg yield. 250 eggs/10 ml.
	11-Mar	1	3	Eggs collected from broods from Khudi River, Lamjung three days after transportation. Probable over maturation due to ovulation check was not preformed in time. 250 eggs/10 ml.
2nd lot	14-Mar	4	3	Domesticated broods from Melamchi River. First ovulation check. 365 eggs/10 ml.
3rd lot	15-Mar	2	3	Domesticated broods 100g to 150g from Melamchi River. Ovulation check was done every day. Eggs were within the 24 hrs from ovulation. 360 eggs/10 ml.
	16-Mar	3	3	Domesticated broods 100g to 150g from Melamchi River. Ovulation check was done every day. Eggs were within the 24 hrs from ovulation. 350 eggs/10 ml.
	17-Mar	1	3	Domesticated broods 100g to 150g from Melamchi River. Ovulation check was done every day. Eggs were within the 24 hrs from ovulation. 350 eggs/10 ml.
4th lot	18-Mar	1	3	Domesticated broods 170g to 250g from Melamchi River. Ovulation check was done every day. Eggs were within the 24 hrs from ovulation. 350 eggs/10 ml.
	19-Mar	1	3	Domesticated broods 200 g from Melamchi River. Gonadotropin (OVAPRIM) Virbac Animal Health India Pvt. Ltd.,) was induced at 0.3ml/fish. After 19 hrs of hormone administration ovulation was confirmed. 300 eggs/10 ml.

Ovulation checks were done every day with watching or manipulation of the fish. If there were female suspected of ovulation, the water of the fish tank was lowered and all fishes were anaesthetized with Eugenol Ethanol solution, and Chloramphenicol Vaseline was used in order to prevent infection. Collected eggs were fertilized with sperm from more than 3 males.

After 4 hours of fertilization, unfertilized eggs were counted and removed and the number of the fertilized eggs was estimated. For incubation, two litre size Coca Cola bottles was used (Photo 1). The day before hatching, the eggs were transferred to a basin of 8 to 22 litres for the first stage acclimatization of larvae. The fry hatched in the basin 9 to 10 days after fertilization and newly hatched larvae managed for 6 to 13 days until start of exogenous feed. Later, advance larvae were transferred to 100 L capacity tank (Photo 2).

Photo 1. Incubation jar

Photo 2. Larvae nursing Tank

The feeding was started from the stage when the egg yolk of the larval fish is absorbed and the fry swims to the water surface (11 to 17 days after fertilization). Feed composition is shown in Table 2. First stage fry were given the feed 1 in power form. After 53 to 63 days, the fry were given Feed 1 in the shape of a dumpling with water mixed (10g of feed to 12 ml of water). Feed 2 was given to the fry after the 63rd day.

Table 2. Composition of feed for asala larvae

Feed ingredients	Percent composition	
	Feed 1	Feed 2
Wheat flour	-	40.0
Soybean	32.4	25.0
Fish meal	32.4	26.0
Prawn meal	32.4	6.0
Fish egg	1.9	-
Sun flower oil	-	2.5
Vitamin C	0.4	0.1
Total Vitamin	0.5	0.4
Total	100.0	100.0

Formalin, potassium permanganate, and halite were used for the treatment of parasitic disease in asala. In order to confirm the effect of these three chemicals, they were used singularly and in combined permutations to determine the highest medical effect. Various dosages and combinations were tried out, and since a positive effect was seen by formalin 20ppm, potassium permanganate 6ppm, and 1% of halite, subsequent medical treatment was carried out using this composition of chemicals.

Results and Discussion

Progress of the water temperature is illustrated in Figure 1. Water temperature was raised gradually from 14.0 to18.2 ^{o}C during the breeding and nursing period of asala, March to June 2011 at Godawari.

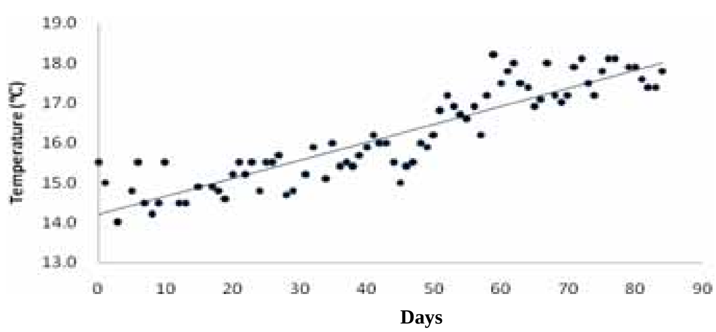

Figure 1. Water temperature in asala rearing tanks, Godawari, Lalitpur (March to June 2011)

The eggs used for this reproduction study were extracted from 8th March to 19th March, 2011. The number of total spawned eggs was 16,851. The total fertilized ova were 15,542 (92.2% fertilization rate). The number of total hatched larval were 10,007 (59.4% hatchability). In the lots with the possibility of over maturation, the hatchability was clearly low (Table 3). In seed production of asala, high mortality frequently occurs during larval period (Bahuguna, 2009). In the present study, the average mortality of asala fry recorded was 97.9% at age of 77 days. Mortality at yolk sac stage, prior to first feeding is expected to be due to eggs quality (Kjorsvic et al., 1990) and all environmental factors. Early mortality is a serious problem in the development of seed production of asala (Bahuguna, 2002). High mortality of asala fry was further compounded with the occurrence of parasitic infection (Figure 2).

Table 3. Result of asala reproduction in March 2011 at Godawari, Lalitpur

Attributes	1st lot	2nd lot	3rd lot	4th lot
Spawning date	8-11 Mar	14 Mar	15-17 Mar	18-19 Mar
Number of eggs	1810	3500	6526	5015
Fertilization rate, %	98.3	65.7	99.7	98.9
Hatchbility, %	51.9	0.0	84.4	71.0
Nursing days	82	6	75	72
Survivability, %	0.9	0.0	3.3	2.2

Chilodonella, Trichodina and white spot protozoan parasitism were confirmed 28 days after fertilization with the ***4th*** Lot, 29 days after fertilization with the 3rd Lot, and 36 days after fertilization with the 1st Lot. In order to deal with these parasites, treatment by formalin, potassium permanganate, and halite was carried out. The treatments by each chemical independently and by a combination of all chemicals were tried. Consequently, it turned out that the medical treatment by the combined use of 1% (30 seconds) of halite and, combination of 20 mg/L of Formalin and 6 mg/L potassium permanganates was the most effective. However, it took time for this result to become apparent, by which time almost all fry had been lost during this period.

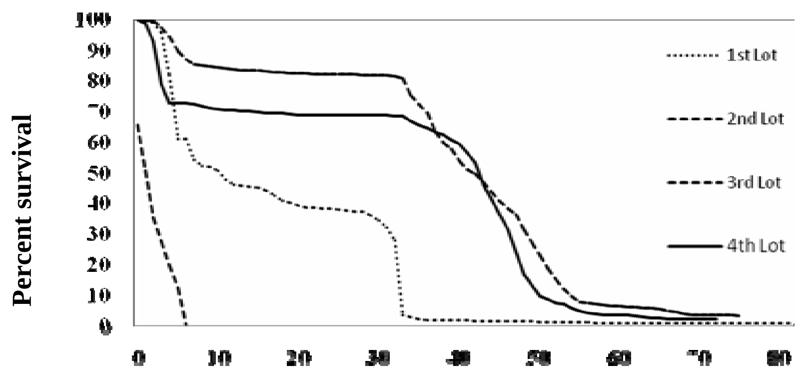

Figure 2. Survivability of asala larvae

In the induction-of-ovulation examination by gonadotropin (Ovaprim), 9 female fish were used and spawning had been confirmed from 7 of them in 5 days. Consequently, it turned out that a large quantity of eggs may be extractable by gonadotropin injection for a short period. This could very possibly be used as a method of extracting a large quantity of eggs from broodfish in a short period. In this study the fertilization rate, hatchability of eggs ovulated by indicing hormone were not performed with restriction of the breeding space. However, it seems that it is necessary to confirm the normality of the fry from the egg induced by gonadotropin.

Poor survival of asala larve resulted due to the severe infection of parasites *Trichodina* and *Chilodonella*. By identification of the parasitism object, medical treatment could be discerned from the characteristics of specific protozoa. It was then possible to specify the method of treatment by 1% of halite, and combination of 20 mg/L formalin and 6 mg/L of potassium permanganate. However, identification of the effective medical treatment for asala fry took time, and many fry were lost in the meantime. Consequently, the effectiveness of the medical treatment could not sufficiently be demonstrated. It is therefore still necessary to establish the effectiveness of using these treatments for disease management in future studies.

In the present study, it was observed frequently that breeding water becomes muddy under the influence of rain. The mud carried with rainwater was deposited in the breeding tank, and the outbreaks of water mould occurred frequently. The death of eggs and hatched larvae increased with the water mould outbreak. The most effective method of solving this problem would be the introduction of an efficient water filtration system.

Asala fry actively feed on feed 1 presumably having high protein as the feed contains dried asala eggs. Poor survival and growth of asala observed in this study indicated that none of the feed formulations are encouraging. Major research thrust should be given on identification of suitable feed ingredients and development of feed formulation with combination of chemostimulants for improving the survival and growth of asala, particularly at early stage of development. In an feeding experiment, Mohan (2009) found that the dietary supplementation of chitin is advantageous for snow trout growth. Non-conventional feed development for asala would require through understanding of its feeding habit and the composition of food ingested.

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PRESENT STATUS AND FUTURE PROSPECTS CAPTURE FISHERIES OF INDIGENOUS FISH SPECIES IN BEGNAS LAKE, POKHARA

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ABSTRACT

Capture fishery is an important fishery sector in Nepal and presently contributes approximately 44.6 % of the total fish production in the country. Six year catch landing data (2005 to 2010) of Begnas Lake was analyzed to investigate the contributions of indigenous fish species in capture fishery of Begnas Lake. Total fish catch yields have increased from 37.6 kg/ha in 2005 to 109.9 kg/ha in 2010. Total annual indigenous fish catch yields varied from 7.2 to 33.4 kg/ha and its percentage contributions to total fish catches were ranged from 25.3 to 40.7 kg/ha. The major indigenous fish species contributed to total fish catch during last six years were bhitta, *Puntius sp* (35±7.7%); rohu, *Labeo rohita* (8.6±3.3%); naini, *Cirrhinus mrigala* (16.3±15.2%); bhakur, *Catla catla* (28.1±13.6%) and sahar, *Tor putitora* (4.8±1.9%). The fish species kande, *Puntius sarana;* katle, *Neolissochilus hexagonolepis* were not recorded in recent three years. Exotic fish species tilapia, *Oreochromis niloticus* unintentionally introduced in Begnas Lake in year 2006 has been established in lake Begnas Lake giving the yield of 63.3 kg/ha in year 2010. Contribution of exotic fish in total catch has increased from 1.6% in 2005 to 82.8% in year 2010. Decreasing contributions of native fish species in total fish catch landing of Begnas Lake suggested that stock enhancement program should be reoriented and assessments are equally needed on the impact of exotic fish species on native fish species.

***Key words**: capture fishery, exotic fish, indigenous fish, vulnerable*

Introduction

Capture fishery is an important sector of fisheries in Nepal and contributes approximately 44.6 % of the total fish production (48230 mt) in the country (DOFD, 2008/09). Rivers, lakes, reservoirs, marginal swamps, ghols and irrigated rice fields are the main source of capture fishery. Begnas lake is second largest (320 ha) lake of Pokhara valley occupying 5.7 % of the total lakes and reservoir area of Nepal (Wagle et al. 2007a). Capture fishery of Begnas Lake comprised of both indigenous

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and exotic fish species. Among the total 187 indigenous fish species reported from Nepal (Rajbanshi 2005) 21 are reported from Begnas Lake (Wagle et al. 2007b). Livelihood of traditional fisher community known as Jalari has been largely depend on cage aquaculture and capture fishery of this Lake. Population abundance and catch rate of some indigenous fishes have declined due to over exploitation (Wagle et al. 2007a) coupled with habitat destruction, siltation and unintentional introduction of exotic fish species in Begnas Lake (Wagle & Bista 1999). Indigenous fishes occupy valuable position and an inseparable link in the life, livelihood, health and the general well being of the rural people, more specifically the jalari community. For the sustainable utilization of lake aquatic resources, appropriate planning for conservation and management strategies are of utmost importance. This article addresses the present status and future prospects of indigenous fishes of Begnas Lake and challenging issues for sustaining biodiversity, management, and livelihood security.

Materials and Methods

Six year catch landing data (2005 to 2010) of Begnas Lake was analyzed to assess the contributions of indigenous fish species in capture fishery. Daily catch records of fish species landing from Begnas Lake was obtained from Fisheries Research Centre, Pokhara. Species wise catch yields were used to analyse their contribution in landing, population abundance and catch trends using statistical software SPSS (version 12). The fish catch yield and percentage contributions of indigenous fish species in the year 2005 was also compared to the year 2010 to find out changes in fish catch of Begnas Lake.

Results and Discussion

Total annual fish yields increased from 37.6 kg/ha with production of 12.3 mt in 2005 to109.9 kg/ha with production of 36.0 mt in 2010 from capture fishery of Begnas Lake. The indigenous fish yield increased from10.5 kg/ha with production 3.4 mt to 33.4 kg/ha with production of 11.0 mt (Figure 1). Indeginous fish contributed 25.3 to 40.7 percent (Mean±SD, 32.1±5.5) annually to the total fish catch during the study period. However, the percentage contribution of indigenous fish to total fish catches showed declining trends from year 2008. About 10 % declines in percentage contribution to total fish catch was estimated in 2010 as compared to catch of 2008 (Figure 2).

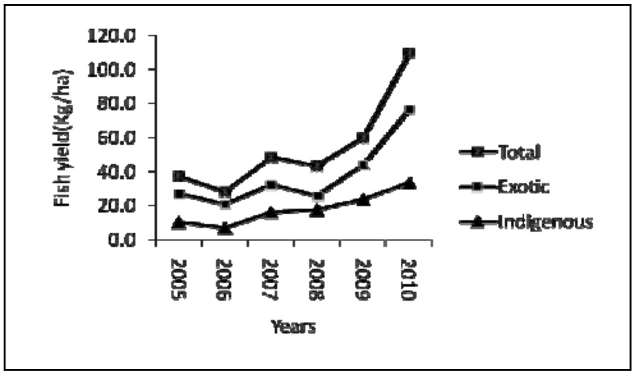

Figure 1. Fish yield trends from Begnas Lake (2005-2010)

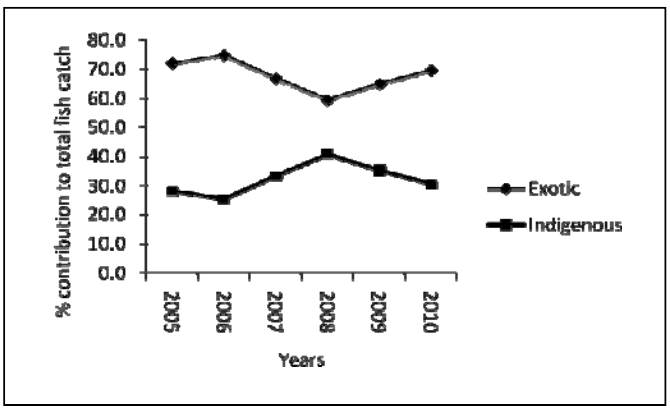

Figure 2. Percentage contribution of indegenous and exotic fish species to total catch from capture fishery of Begnas Lake

The major indigenous fish species contributed to Begnas Lake fishery during last six years were bhitta, *Puntius sp (*35±7.7%); rohu, *Labeo rohita* (8.6±3.3%); naini, *Cirrhinus mrigala* (16.3±15.2%); bhakur, *Catla catla* (28.1±13.6%), and sahar, *Tor putitora* (4.8±1.9 %). Other indigenous species such as dunghe bam (*Xenentodon cancila*), chuche bam (*Mastacembelus armatus*) and rewa (*Cirrhinus reba*) collectively contributed 5.5±3.3% to the annual landing (Table 1). Kande (*Puntius sarana*) and katle (*Neolissochilus hexagonolepis*), once contributed significantly in the fishery of Begnas Lake, were not recorded during recent three years. These species could be categorized to vulnerable fish species to Begnas Lake.

Table1. Yield and percentage contribution of indigenous fish species from capture fishery of Begnas Lake (2005-2010)

Indigenous fish species	Yield (kg/ha)		% contribution to total catch		%contribution to indigenous fish catch	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Bhitta (*Puntius sp.*)	6.3±3.4	2.6-11.5	11.4±3.8	6.8-18.5	35.0±7.7	24.4-45.5
Naini (*Cirrhinus mrigala)*	4.0±4.8	0.3-11.4	5.3±5.1	0.8-12.9	16.3±15.2	2.9-36.7
Bhakur (*Catla catla*)	4.2±0.9	2.6-5.3	8.7±3.5	3.9-14	28.1±13.6	13-50.1
Rohu (*Labeo rohita*)	1.4±0.5	0.5-1.9	2.8±1.2	1.2-4.4	8.6±3.3	3.8-12.3
Chuche Bam (*Mastacembelus armatus*) + Dunghe bam *(Xenentodon cancila*)	1.2±1.0	0.1-2.7	1.9±1.3	0.2-3.8	5.5±3.3	0.6-9.2
Sahar(*Tor putitora*)	0.8±0.2	0.5-1.1	1.5±0.6	0.8-2.3	4.8±1.9	2.5-6.9
Phageta *(Barilius sp.*)	0.2±.4	0.0-1.1	0.2±0.4	0.0-1.0	0.6±1.3	0.0-0.3
Rewa (*Cirrhinus reba*)	0.1±0.2	0.0-0.4	0.2±0.4	0.0-1.1	0.7±1.5	0.0-3.8

Contribution trends to total catch by indigenous fish varied by species. Contribution of bhakur (*Catla catla*) declined by 10%, sahar (*Tor putitora*) 0.9%, rohu (*Labeo rohita*) 2.3% while contribution of bhitta (*Puntius sp*), cuche bam (*Mastacembelus armatus*) and dunge bam (*Xenentodon cancila*) collectively, and naini (*Cirrhinus mrigala*) increased by 3.7%, 2.7% a nd 9.5%, respectively in 2010 as compared to 2005. Self recruiting *Puntius sp.* has ability to maintain their population naturally while increased proportion of *Cirrhinus mrigala* in total catch was due to the stock enhancement program.

Yields from exotic fish was also increased from 27.1 kg/ha (8.9 mt) in 2005 to 76.5 kg/ha (25.1mt) in 2010. Tilapia (*Oreochromis niloticus)* was not recorded in catches of Begnas Lake before 2005. It was established in later year and gave the highest productivity of 63.3 kg/ha in year 2010. Contribution of tilapia to total exotic fish yields was increased from 1.6% in 2005 to 82.8% in 2010 from catches of Begnas Lake (Table 2).

Table 2. Yield and percentage contribution of exotic fish species from capture fishery of Begnas Lake (2005-2010)

Exotic Fish Species	Yield (kg/ha)		% contribution to total catch		% contributions to exotic catch	
	Mean ±SD	Range	Mean ±SD	Range	Mean ± SD	Range
Tilapia (*Oreochromis niloticus*)	19.0±24.1	0.0-63.0	24.6±23.0	0.0-57.6	37 ±33.6	0.0-82.2
Silver carp (*Hypophthalmichthys molitrix*)	10.7±5.9	6.2-20.9	26.2±21.9	5.7-55.6	37.5±29.1	8.2-77.2
Bighead carp (*Aristichthys nobilis*)	5.6 ±1.1	3.9-6.9	11.5±3.8	5.5-15.9	15.0±7.2	7.6-24.7
Grass carp (*Ctenopharyngodon idellus*)	1.0±0.5	0.4-1.8	2.6±2.2	0.3-6.5	3.7 ±2.9	0.5-8.7
Magur (*Clarias sp*.)	0.9±1.0	0.0-2.0	1.8±1.9	0.0-4.7	2.9±3.2	0.0-7.9
Common carp (*Cyprinus carpio*)	0.6±0.4	0.2-1.0	1.2±0.7	0.4-2.1	1.8±1.2	0.6-3.3

Spontaneous recruitment and increasing contributions of tilapia in total catch has been observed from Begnas Lake in recent years. The catch of indigenous fish should be monitored in long run to evaluate the effect of non-native species. Several reports indicated that the introduction of tilapia into freshwater ecosystems affect negatively on local species (Tweddle and Wise, 2007; Wise et al., 2007; Canonico et al., 2005; Shipton et al., 2008). Population decline and reduced contribution of indigenous fish species to fishery of Begnas Lake suggests for emergency actions toward conservation of native fish species in this lake.

Conclusions

The results showed that there was decreasing contributions of native fish species in total fish catch landing of Begnas Lake in recent years. Hence, stock enhancement program of native fish species should be improved and further study should be carried out to find the impact of exotic fish species on native fish species. For protecting the native fish species, bio-security could be one of the strategies for controlling invasive species spread out into other natural lakes, reservoirs and rivers of Nepal. It can only be ensured if all protocols of conservation of indigenous fish diversity in natural resources are strictly adhered to and rigorously enforced in the country.

Acknowledgement
This study was supported by NARC project No 62359001.

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QUALITY AND NUTRITIONAL STATUS OF DRIED FISH IN CHISAPANI (KARNALI BASIN) AND MALEKHU OF NEPAL

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ABSTRACT

Locally processed indigenous fish are delivered to the consumers by fisher and other communities settled nearby wetland (rivers, lakes, etc). From the consumers prospective, the information on quality and hygienic condition of such preserved fish is meager. A survey was carried out during 2009 at Chisapani (Karnali River basin), Kailali district and Malekhu, Dhading district some well known spots of Nepal to study the availability of dried fish, fish drying methods, quality, nutritive value and market of dried fish. The survey included on-the-spot observation and interview with fish venders. Samples of sahar (*Tor putitora*) and kulnch (*Labeo calbasu*) from Chisapani and naini (*Cirrhinus mrigala*) from Malekhu were collected for nutritional and microbial assessment. Proximate analysis of smoked fish revealed that the nutritive value of collected samples ranged between 43.6-60.9% crude protein, 10.0-19.4% crude fat and 12.1-18.4 % crude ash. High moisture content (23.7%) was evident for kulnch, however, all samples exceed 10% of the permissible moisture content. Microbial examination of dried fish showed the presence of fungi between $23x10^1$ to too numerous to count (TNTC). *Escherichia coli*, and coliform were evident in some of the fish samples while *Staphylococcus* spp. was enormous in all samples. Survey and analysis suggest that locally processed fish at Chisapani and Malekhu were poorly hygienic at current state of drying. The need of training and capacity building program for fish processing to the fish vending communities have been suggested.

***Key Words**: Capacity building, drying, hygienic, nutritive value, proximate analysis*

Introduction

Dried fish comprises one of the delicious foods to many people in the world. In Nepal there is a high demand of processed or dried fish in the market (Pradhan, 2006). Dried fish products are mostly used by all communities in Nepal. Dried fish is one of the indispensable items for many communities in marriage ceremonies to

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perform religious rituals as the symbol of auspicious, family prosperity, fertility and strength. Some of the high quality dried fish are supplied through foreign origin commodities. A bulk quantity of dried fish is imported from India, Thailand, Brunei and other countries in Nepal.

Fish being a quickly perishable commodity, chemical breakdown of protein, fat and water contribute to quick spoilage (Rao, 1999, Daramola et al, 2007). For preserving fish hot smoking, sun drying, and deep frying are the most commonly used methods for preservation of fish in different parts of Nepal. Chisapani (Karnali River basin), Kailali district and Malekhu (Trishuli River basin), Dhading district are some of the key places where fish are commercially smoke dried. Smoking is a preferred method of preservation because it dries the fish, melts down some fat, and reduces microbial growth. Smoking preserves fish by removal of sufficient moisture to retard or prevent the growth of bacteria and molds. Bacterial activity ceases when the water content is below about 15% (Clucas 1981). Despite of processing care, some physical losses can occur which reduces quality as a result the price of the products (FAO, 1992).

Microbiological and nutritive quality assessment are necessary to ensure the food safety of any processed products. A number of microbiological tests of fish and fish products are used by authorities to check that the microbiological status is satisfactory. The purpose of these tests is to detect pathogenic bacteria (*Salmonella, Staphylococcus spp, E. coli*) or other types of general contamination or poor handling practices (Coliform bacteria, total viable count). Therefore in this study microbiological and nutritive quality analysis were carried out to assess the quality of smoked fish sampled from Karnali Chisapani and Malekhu, Dhading.

Material and Methods

A survey was carried out at Chisapani (Karnali River basin) and Malekhu (Trishuli River basin) during 2009 - 2010 to explore the source of fish for drying, fish drying methods, quality and market of dried fish. The survey includes on-the-spot observation, interview with fish venders. Six hotels at Chisapani, and 10 shops and hotels at Malekhu were surveyed through a semi structured questionnarie. The key informations collected were on the methods of fish drying, species of dry fish and storage methods.

Dried fish samples of sahar (*Tor putitora*) and kulnch (*Labeo calbasu*) from Chisapani and naini (*Cirrhinus mrigala*) from Malekhu were collected for proximate and microbial analysis. Three replicated samples of each species were analyzed for proximate compositon at Food Research Unit, Khumaltar, NARC and microbiological test was preformed at Soil Test Laboratory at Koteswar, Kathmandu. The parameters included in proximate analysis were crude proteins, crude fat, crude ash and moisture content and microbilogical tests included total fungal count (TFC), Coliforms, total plate count (TPC), *E. coli*, *Staphylococcus* spp and *Salmonella* spp.

Results and Discussion

Source of fish for drying in study sites

Most of the fish from the Karnali River caught by fishermen are sold to the hoteliers, while some people visit to the river side to buy fresh fish. From the river side the fish were brought to hotel by keeping in *handi*. The market is near by the river so the fishermen did not preserve fish in ice. The hotel owner washed the fish properly and kept in refrigerator before processing.

Fish caught from Karnali River are smoked and preserved by hoteliers in highway corridor of Chisapani for marketing. Present survey showed that the cost of dry fish did not vary among the fish species and season. The ratail price of smoke dried fish was between 900 to 1000 rupees per kg. The list of fish species used for drying in near by Karnali River is given in Table 1.

Table 1. Major indigenous fishes used for drying in Chisapani, Karnali

Local name	Scientific name	Local name	Scientific name
Sahar	*Tor putitora*	Asala	*Schizothorax* sp.
Thend	*Labeo angra*	Kalanch	*Labeo calbasu*
Gardi	*Labeo dero*	Buduna	*Garra* sp.
Rajabam	*Anguilla bengalensis*		

The fresh fish for smoking in Malekhu was obtained daily from fish market in Birganj sub metropliton of Parsa district in the morning. Fish farmers from Bara, Parsa and Rautahat districts delivered their fish in the evening of previous day without gutting and preserving in ice to a contractor in Birganj, Parsa. Fish were kept in plastic containers and packed with ice in alternative layers. Then the fish were transported by night bus and delivered early in the morning to different markets.

Fish preservation methods

Fish preservation methods observed during the survey in Chisapani and Malekhu were fish smoking or drying over fire place, deep fry and fish curry. Chisapani and

Malekhu were famous for delicious cold water fish. People from different places come to taste the fish. Fried fish could be stored for a week or more. Fishes like naini, sahar, asala, rohu, kulnch, buduna are mostly used for deep frying. Fish curry was another item of fish favored by people in Chisapani and Malekhu.

In Chisapani the left over fish after cooking was used for smoking. Fish were smoked on demand from the consumer. Fish were cleaned and split opened in the ventral side with a sharp knife. Then, the fish were fasten with a skewer using a long metal or wooden pin and hang very near to fire place for drying. After dripping most of the water the fish were kept on iron wire mesh net and placed over fire. Fire wood produced heat in *chulho.* It might take several hours (6-18) depending upon the volume of fish. This was the common practice used in Chisapani because of availability of firewood. No additives were added for taste or preservation except some people use salt and turmeric during summer.

In Malekhu fish was smoked commercially in *bhatti*. Turmeric and lemon juice were used for preservation of fish. Among six bhattis surveyed in Malekhu, each bhatti used 500 to 1000 kg of fresh fish for drying. Small sized fish were dried whole without gutting and scaling. Only the large sized fish were cut into pieces for drying.

Storage and postharvest loss of dried fish

In Chisapani, dried fish was stored in bamboo basket, wooden cup board and hung over fireplace until selling. The dried fish was kept hanging in rope in air at Malekhu. Restaurents and shop keepers hung the dried fish over the fire place.

There was a great chance of insect infestation and fungal development in whole smoked fish because the outer surface of fish dried earlier but the inner area remains moist. However it will happen occasionally as there was less chance of post harvest loss of smoked fish because of high demand and less chance to remain the fish to be unsold.

Proximate analysis

In proximate analysis, crude protein, crude fat, crude ash and moisture content were not significantly different among all collected fish species (Table 2).

Table 2. Proximate analysis of *fish* samples collected from Chisapani and Malekhu

SN	Fish species	Moisture (%)	Crude ash (%)	Crude protein (%)	Crude fat (%)
1	*L. calbasu*	16.36 ±6.6[a]	14.89±2.5[a]	56.73±1.5[a]	16.00±5.2[a]
2	*T. putitora*	15.92±2.4[a]	15.55±2.5[a]	53.92±8.9[a]	13.27±3.6[a]
3	*C. mrigala*	12.55±3[a]	12.5±0.2[a]	58.34±2.6[a]	15.63±0.3[a]

Estimation of bacterial numbers in fish is frequently used to retrospectively assess microbiological quality or to assess the presumptive safety of the product. Table 3 shows the results of microbilogical analysis conducted on three selected fish species samples.

The International Commission on Microbiological Specifications for Foods (ICMSF, 1978) indicated a limit of acceptability as less than 1.0 x 10^6 cfu/g for the total viable count in any food to be safe for consumption (Table 4). Collected samples of all three species excced the permissible standard. The presence of total plate count above the permissible level of ICMSF, 1978 in all samples might be due to environmental contamination during smoking. This result showed the low quality of smoked fish at both Chisapani and Malekhu.

The fungal contaminations are a common problem and it adversely affects the quality of cured fish (Patterson and Ranjitha, 2009**)**. The presence of fungi in smoked fishes is acquiring importance in view of safety and quality of fish. The TFC (total fungal count) in *T. putitora* and *C. mrigala* were within the permissible level of ICMSF (1978) while *L. calbasu* exceed permissible level (Table 3).

Absence of coliform and *Salmonella* in a given weight of sample are safe working figures for fish and fish products (ICMSF, 1978). Coliform was observed in all samples. The existence of Coliform indicates that the products were processed under insufficient hygiene conditions (ICMSF, 1978). *Salmonella* is an example of a dangerous food-borne pathogen and all species strains of Salmonella may be presumed pathogenic for man (Arvanitoyannis et al., 2005). *Salmonella* is highly pathogenic and this is the major reason for isolation of such bacteria from sample fishes. In this study *Salmonella* was not detected in all samples of dried fish.

Table 3. Microbiological assessment of fish samples collected from from Karnali Chisapani and Malekhu, Dhading

Fish species	Parameters					
	Total fungal count /g	Coliform/g	Total plate count/g	*E. coli*/g	*Staphylococcus/g*	*Salmonella*
L. calbasu	10000370± 17320187.6	5±8.7	27566666.7± 4214657	0±0 ?	30000000±0	0
T. putitora	386.7±333.8	80±138.6	20008186.7± 17306328.4	31±53.7	20002500± 17316177.9	0
C. mrigala	2253±3108	236.6±225	2506670±496622	80±138.5	30000000±0	0

Table 4. International guideline for microflora (ICMSF, 1978)

Total viable count	Not to exceed 1000,000 cfu/g
Salmonella	Not to be detected
E. Coli	Less than 10 cfu/g
Staphylococcus aureus	Less than 100 cfu/g
Fecal *Coliforms*	None
Yeast and mould	10000 cfu/g

Escherichia coli (*E. coli*) is a well known recognized indicator for quality assurance of municipal water (Clesceri et al, 1998; Perry-O'Kefe et al, 2001). *E. coli* is considered to be one of the most hazardous food borne pathogens. It is detected in *T. putitora* and *C. mrigala* above the recommended standard of ICMSF (1978) and absent in *L. calbasu*. The highest count of *E. coli* in dried fish sample revealed the unhygienic condition prevailed during the drying process. *Staphylococcus* spp was found in all samples ranging **eceding** the permissible level of ICMSF (1978).

Proper handling of fish between capture and delivery to the consumer is a crucial element in assuring final product quality. Standards of sanitation, method of handling and the time/temperature of holding fish are all significant quality factors. With a few exceptions, fish are considered free of pathogenic bacteria of public health significance when first caught. The presence of bacteria harmful to man generally indicates poor sanitation in handling and processing and the contamination is almost always of human or animal origin. *Salmonellae* have been found in fish washed with polluted water. Contamination may take place when the fish are gutted at the quayside in a dirty harbor. In many BOBP countries, shrimp are sun-dried at the landing place and are targets for contamination by bird droppings and animal excreta.

A survey of several types of processed food items including dried, smoked and steamed fish in the Philippines revealed a high incidence of *Staphylococcus aureus,* coliforms, *Salmonella* and yeasts and moulds. The occurrence of these pathogens was thought to have resulted from poor handling, processing, storage and distribution practices. During the rainy summer months (April to August), the temperature and relative humidity can be as high as 34% and 92%. These climatic conditions favor microbial growth and enteratoxin production in local foodstuffs which could have been responsible for sporadic local outbreaks of food-borne disease.

The presence of vermin, birds, animals, harvesters, auctioneers and processors are some additional sources of contamination especially during sorting, filleting, packaging, trimming and wet processing (Huss, 1992). This can be attributed to contaminated surfaces, filleting knives, the processing facilities etc. Cleaning validation is documented proof that one can consistently clean a system or piece of equipment so that potentially contaminating residues are reduced to acceptable levels.

Conclusion

Survey and analysis suggest that locally processed fish at Chispani and Malekhu were not hygienic at current state of drying. The need of training and capacity building program for fish processing to the fish vending communities have been suggested.

Acknowledgements

We highly appreciate all those who directly and indirectly helped us during this study. The hotel owners in Karnali Chisapani and Malekhu cooperating us in this survey program are highly appreciated.

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WOMEN PARTICIPATION IN CONSERVATION OF INDIGENOUS FISHES IN NEPAL

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ABSTRACT

Women's participation in conservation of indigenous fishes has been in form of highly recognized work in Nepal. Many groups in different districts are involved in native fish conservation activities. A study was carried out to evaluate the contribution of Machhapuchhre Women Group (MWG) at Phewa Lake and some other areas. MWG has been showing better performance in conservation of indigenous fish species through in-situ and ex-situ conservation activities as well. As the result of activities performed by MWG with support of other concerning stakeholders, the catch of sahar (*Tor putitora*), and katle (*Neolissochilus hexagonolepis*) the high-value indigenous species from the Phewa Lake has been increased by 55.5% and 28.8%, respectively in the last five years (2062/63 - 2066/67) with average annual catch of 783 kg of sahar and 350 kg of katle. MWG is also involved in restocking fingerlings of indigenous fishes into the lake and their contribution is about 9% in the past five-years. Regarding the capability of Jalari women at the Phewa Lake they are highly capable ($P<0.05$) to perform the effective works if they would be given such opportunity of conservation and management works. However, it is essential to be strengthened the capacity of women, specifically the level of education and financial resources to make work more effective. As the consequence of conservation approach, lesson learned from the Phewa Lake could be an example for scaling up to the other groups and areas.

***Key Words**: high-value species, indigenous fishes, in-situ conservation, women's participation*

Introduction

Aquaculture and fisheries, becoming one of the fastest growing food production industries in the world and it has been contributing to nutritive food security and poverty reduction in developing countries (ADB, 2005). Man made ponds and diversified aquatic habitats of natural water bodies such as rivers, lakes, reservoirs,

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swamps/ghols, rice fields, ponds ranges cold to warm water are the major sources of fish production in Nepal. These natural water resources and rice fields are considered to be an important source of capture fishery, which contributes approximately 43% of the total fish production in the country (DoFD, 2010). Up to 203 indigenous fish species are listed residing in those inland habitats with different abundance status (Shrestha, 2008), majority are tied up with capture fishery.

A degradation of resources and rapid decline in population of indigenous fish species increased challenges in over the past decades. Indiscriminate fishing and a fast growing human population has resulted unsustainable in the productive value of fisheries. In this context, wetlands dependent communities are becoming more concerned and involved in the resources conservation works for their sustainable use. In these communities women are being more inclusive and active in recent years with activities of conservation and sustainable utilization of the resources. Jalari women from a deprived fisher community formed two separate groups as associations in 2000 by the name of Machhapuchhre Women Group (MWG) in Phewa Lake and Piple Women Group (PWG) in Begnas Lake. Likewise, many other women groups over the country are active in small-scale fisheries with resource conservation activities. Among them few are listed here as an example (Table 1).

Table 1. Some of most popular women groups involving in effective fisheries conservation activities in Western Development Region.

S. N	Name of the women group	District	Established Year	No. of members in group	Area of conservation activities
1.	Machhapuchhre women group (MWG), Phewa	Kaski	2000	36	Indigenous fish conservation in Phewa Lake
2.	Piple women group (PWG), Begnas	Kaski	2001	12	Indigenous fish conservation in Begnas Lake
3.	Manke Khola women group 'A', Galyang	Syangja	2007	10	Indigenous fish conservation in Andhi Khola
4.	Manke Khola women group 'B', Galyang	Syangja	2007	11	Indigenous fish conservation in Andhi Khola
5.	Champawati women fisheries group	Lamjung	2008	66	Indigenous fish species conservation in Chepe and Marsyangdi rivers.

Livelihood of the Jalari community has been largely dependent on the aquaculture and capture fishery of Phewa and Begnas Lakes (Wagle et al. 2007). Improving livelihoods through better management practices of resources and strengthening income and employment opportunity are the outcomes of the activities of these women groups. In this regard, women's participation in conservation of indigenous fishes has been in form of highly recognized work in Nepal. However, there is a lack of adequate studies about the women's participation and contribution in resource conservation activities. This paper deals with the contribution of MWG in indigenous fish conservation in the Phewa lake and its implication to other areas.

Material and Methods

A survey was carried out in December 2010 to evaluate the participation and contribution of Machhapuchhre Women Group (MWG) on conservation of indigenous fishes at Phewa Lake.

Results and Discussion

Jalari community is concerned on present condition of the lake resources and women are actively participating on management of Phewa Lake, an important asset for the sustainability of biodiversity and their livelihoods. Main focus has been given in conservation of indigenous fishes including sahar (*Tor putitora*), katle (*Neolissochilus hexagonolepis*) and other high value species and improvement of the degraded condition of the lake. MWG is participated to release fingerling/fry of indigenous fish every year in collaboration with Phewa Fish Entrepreneurs Committee, Fisheries Research Centre, Pokhara, District Agriculture Development Office and other respective stakeholders. As the result of ex-situ conservation activities performed by MWG with support of other concerning stakeholders, 77231 (8%) of hatchery produced sahar was restocked in the Phewa Lake out of total 962061 fingerling, where 90% was the indigenous species such as rohu (*Labeo rohita*), naini (*Cirrhinus mrigala*) and bhakur (*Catla catla*) including sahar and katle in past five years period, 2062/63 - 2066/67 (Table 1).

Table 1. Five years restocked record of fish in Phewa Lake (2062/63 – 2066/67)

Species	2062/63	2063/64	2064/65	2065/66	2066/67	Total	%
Sahar	5000	40000	19300	7631	5300	77231	8.0
Rahu	15000	195000	117300	92000	61430	480730	50.0
Naini	15000	35000	40000	30000	93350	213350	22.2
Bhakur	30000	40000	25000	0	0	95000	9.9
Common	0	0	0	10000	0	10000	1.0
Silver	0	0	0	0	0	0	0.0
Bighead	10000	60000	5750	10000	0	85750	8.9
Total	**75000**	**370000**	**207350**	**149631**	**160080**	**962061**	**100.0**

Since 2004, MWG has been involving in restocking fingerling of indigenous fishes including few exotic species into the lake and the contribution of women group was about 9.2% in the past five-years period (Table 2).

Table 2. Fingerling restocked by different stakeholders in Phewa Lake during last five years period (2062/63 – 2066/67)

Organization/Institution	2062/63	2063/64	2064/65	2065/66	2066/67	Total	%
FRC, Pokhara	25000	280000	140000	35000	0	480000	49.9
Lamas	0	0	12750	331	0	13081	1.4
Dist. Agri. Dev. Office	20000	30000	7300	10000	38350	105650	11.0
Fish Entrep Committee	20000	40000	30000	2300	40000	132300	13.8
Machhapuchhre Women Group	10000	20000	17300	19300	21430	88030	9.2
Sarangkot VDC	0	0	0	62700	60300	123000	12.8
Sujal Food/ Clubs/ Others	0	0	0	20000	0	20000	2.1
Total	**75000**	**370000**	**207350**	**149631**	**160080**	**962061**	**100**

The catch of sahar, and katle the high-value indigenous species from the Phewa Lake has been increased by 55.5% and 28.8%, respectively in the last five-year period (2062/63 - 2066/67) with average annual catch of 783 kg of sahar and 350 kg of katle. However, the total volume of annual catch of sahar is in decreasing and katle in fluctuating trend since past four years (Figure 1).

Besides the stock enhancement activities women are performing some in-situ conservation activities for indigenous fish and biodiversity as well. Jalari women have a strong will power and are playing a significant role in conservation and lake resources management activities, in a participatory approach with strong backing by FRC Pokhara and DADO, Kaski. They are using the indigenous knowledge and skills to conserve the native fish species and cleaning the lake by removing water hyacinth. They patrol the major sensitive and upstream areas for protecting spawning grounds and achieving to control illegal fishing (Gurung et al., 2005; Nepal, 2008). Every fifth day of the Nepali month they have a meeting to decide the works to be done for one month period of upcoming month or most important works to be done immediately. They organize the rally, campaigns and set the hoarding boards and distribute pamphlets and leaflets with necessary information for public awareness.

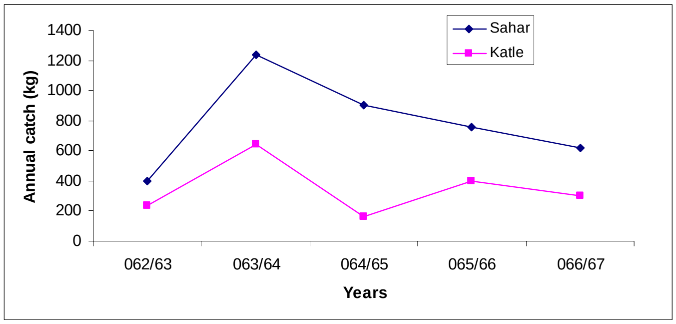

Figure 1. Total catch of Sahar and Katle from Phewa Lake in five-years period (2062/63 - 2066/67)

Although the women group is working more efficiently for conservation of indigenous fish, annual catch of sahar seems almost same as the early 2000s with less than 1 mt year^{-1} (Gurung et al, 2005) expect 1241 kg of catch in 2063/64. Catch of katle also is in declining trend. However, the total annual catch has increased by 10% annually (Figure 2).

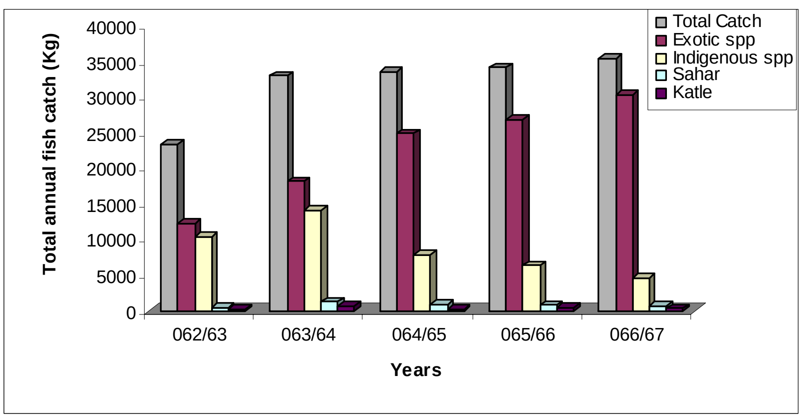

Figure 2. Total fish catch with exotic and indigenous species from Phewa Lake in five years period (062/63-066/87.

Total catch of sahar and katle was 617 and 305 kg, respectively in 2066/67.The contribution of sahar was 1.7% and katle 0.9% of the total catch. Sahar and katle makes the 12.3% and 6.1%, respectively, composition of total catch of the indigenous species.

A substantial quantity of sahar (mahseer) and other indigenous species were caught every year since 1960s (Ferro, 1980). There are 24 indigenous fish species reported from the Phewa Lake. However, the quantity is declining every year. Jalari caught sahar as big as 40 kg until 1960s, but now hardly found the sahar larger than 10 kg (Gurung 2005; personal communication). Sahar is vulnerable during its spawning season (monsoon) and suppress illegal fishing during migration to spawning grounds (Gurung *et al*, 2003).

Women group of Phewa Lake have been mobilized and found more effective to control illegal fishing (Gurung et al, 2005; Nepal, 2008). Regarding the capability of Jalari women at Phewa Lake they answered confidently that they are highly capable ($P<0.05$) to perform the effective works if they would be given such opportunity of conservation and management works. However, it is essential to strengthened their capacity, specifically the level of education and financial resources to make work more effective. As the consequence of conservation and utilization approach, lesson learned from the Phewa Lake could be an example for scaling up to the other groups and areas. However, decreasing trends of catch of indigenous fish is the matter of concern, which might be attributable to either fishing gears or other reasons to be studied in future.

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WORKSHOP RECOMMENDATIONS

Much of the immediate thrust for holding the "Consultative Workshop on Fish Conservation in Nepal" came from the continuing work of the different organization/institutions in the country to develop a strategy for the conservation of fish genetic resources. Considering the broad terms of reference given at this workshop, the participants agreed to recommend following strategies:

1. The indigenous fish exhibit very diverse distribution vertically within the country as well as horizontally in the region and beyond. The total number of fish is reported variable in different time periods starting from 120 in 1981 to more than 200 species till date. No consensus among different sources of information has been achieved on the number of native fish inhabitating in Nepalese water. To bring common consensus on the number of fish taxa a depository museum should be established/strengthened for verification and comparison using available technologies of taxonomic importance.

2. Necessary measures should be taken to conserve the following recognized endemic species in their respective habitats: (1) *Myersglanis blythi* (Day) in Seti, Bheri river and Pharping-Kathmandu velley; (2) *Psilorhynchoides pseudecheneis* Menon and Datta in Dudhkoshi/Sunkoshi River; (3) *Pseudeutropius murius batarensis* Shrestha in Trishuli river, Batar; (4) *Batasio macronotus* Ng and Edds in Koshi river, Saptari; (5) *Erethistoides ascita* Ng and Edds in Mechi river, Kankai; (6) *Pseudecheneis crassicauda* Ng and Ed in Mewa Khola, Dhankuta; (7) *Pseudecheneis eddsi* Ng in Seti River, Khairenitar, Mahesh Khola Trishli; (8) *Pseudecheneis serracula* Ng and Edds in Narayani, Mahakali and Seti River; (9) *Schizotharaichthys macrophthalmus* (Terashima) in Rara Lake; (10) *Schizothoraichthys nepalensis* (Terashima) in Rara Lake; (11) *Schizothoraichthys raraensis* (Terashima) in Rara Lake; (12) *Pdilorhynchus nepalensis* Conway and Mayden in Seti River, Rapti River; (13) *Balitora eddsi* Conway and Mayden in Geruwa River, Karnali; (14) *Erethistoides cavatura* Ng. and Edds in Dhungre River, Chitwan.

3. Immediate legal protection should be provided to the fish species identified under different threat categories and necessary measures should be taken to protect and enhance their population in their respective habitats: (1) *Brachydanio rerio* Zebra (vulnerable in Kosi, Gandaki and Karnali rivers, (2) *Psilorhynchoides pseudecheneis* Tite (vulnerable in Dudhkoshi), (3) *Anguilla bengalensis bengalensis* Rajabam (vulnerable plain to mountain rivers), (4)

Tor tor Sahar (endangered in hills and mountainous rivers), (5) *Erethistoides ascita* (uncommon/rare in Mechi river, Kankai), (6) *Myersglanis blythi* Tilchapre (rare in Seti, Veri, Tamor River).

4. Academic and research institutions should establish of a program of education and training, on genetic resource conservation/preservation in fish and other aquatic organisms. As a basis for its educational work, the program should assemble baseline information on (a) the diversity and vulnerability of aquatic genetic resources, (b) procedures for identifying vulnerable species and population, and (c) appropriate methods assuring that information regarding vulnerability and direct threats comes to the attention of agencies capable to act.
5. Introductions of new species into aquatic systems would have serious consequences on existing resources. Government institutions should take steps to establish mechanisms to ensure that an objective analysis of risks precedes the introduction of an aquatic organism into national waters. Genetic, behavioral and ecological data, as well as potential for introduction of disease, should be included in the risk analysis.
6. Government institutions should insist that the potential impacts of planned hydroelectric and irrigation, and other development projects upon fisheries and fish genetic resources be evaluated at the earliest stages of consideration of such projects to ensure that there is opportunity to examine appropriate alternatives. In general, aquatic conservation strategies should also support sustainable development by protecting biological resources in ways that will preserve habitats and ecosystems.
7. Environmental alteration (by pollution, siltation and erosion, etc.) is generally a more important threat to the preservation of fish genetic resources than their direct exploitation. Government Institutions should make every effort to ensure that environmental damage to natural waters is minimized to protect these resources.
8. Research institution should collect founder stocks from as wide a distribution as possible within the species range in their efforts at domestication. This is to ensure that domestication, at least in its initial stages, be based on the broadest genetic base as possible.
9. Extensive ecological and systematic (taxonomic) surveys are required in aquatic ecosystem where large fractions of ecosystems are poorly understood and a large fraction of species are undescribed or insufficiently known.

10. The ways in which climate change may impact on fisheries and aquaculture and related livelihood are broad ranging and complex. More focused case studies will be very important not only in guiding policy decisions for the areas concerned, but also for the increased understanding of the ways in which climate change impacts will take place along with possible adaptive measures to counter them.
11. Strategies to reduce the fishing pressure on thinly populated native species without losing the fisher's employment and income opportunities need to develop.
12. Enhance local government accountability to distribute informal ownership of communal water bodies to the local community. Native fish species selection for aquaculture and stock enhancement should address the issues of food security and livelihood of rural area.
13. The success of environmental protection and conservation effort for endangered species in particular and fish genetic resources in general, ultimately depends on the mass awareness and participation of public. Motivation at the level of individuals and formation of small action groups or nature clubs colleges would also help.

Annex 1. List of participants

Annex 2. Photographs of the Workshop