IDENTIFICATION AND DOMESTICATION OF NATIVE ORNAMENTAL FISHES OF BEGNAS LAKE, POKHARA, NEPAL

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Submitted to

Central Department of Zoology
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Tribhuvan University
Kirtipur, Kathmandu
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DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author or institution.

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RECOMMENDATION

This is to recommend that the thesis entitled, **"Identification and Domestication of Native Ornamental Fish of Begnas Lake, Pokhara, Nepal"** has been carried out by Sapana Chand for the partial fulfilment of Master's Degree of Science in Zoology with a special paper Fish Biology and Aquaculture. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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LETTER OF APPROVAL

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CERTIFICATE OF ACCEPTANCE

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Sapana Chand

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
CP	Crude Protein
DO	Dissolved Oxygen
FRS	Fisheries Research Station
KGFH	Kali Gandaki Fish Hatchery
PSI	Pound per Square Inch

ABSTRACT

Native fishes have great value as an ornamental fish in Nepal as well as in the global fair. Most of the ornamental fish species of Nepal are imported from India and Thailand. The main goal of this experiment was to identify and domesticate the indigenous ornamental fishes for commercial production. Begnas area, Pokhara was selected as a study site as it has different small indigenous fish species which might have great potential as ornamental fish. The study was carried out from January to August 2020. Native fishes were collected from outlets and irrigation canal of Begnas Lake by using a cast net. Five fish species *Puntius conchonius*, *Puntius sophore*, *Barilius barna*, *Danio devario* and *Danio rerio* were identified and found suitable for ornamental purpose. *Puntius sophore* and *Danio devario* were domesticated in the aquarium during the experiment period. Survivability of these fish species was low during the winter season; at the same time, they could adapt to any kind of food. *Danio devario* was selected for the breeding purpose; and among all, 33 individuals were selected and placed in different condition (in the aquarium with heater and aerator, in the outer tank exposed to direct sunlight, tank having continuous water flow without sunlight and in an open artificial pool) with 40% CP and bloodworms and maintaining the proper water quality. Out of all different conditions, environment that was artificially made pool with enough sunlight was found to be suitable for breeding. Their breeding was also influenced by the environmental condition since they bred one month later than their regular breeding periods in captive condition. *Danio devario* bred in last week of August in the rainy day and then gradually increasing the temperature 27-28℃, pH7 to 8 and DO 5 to 6 mg/l. To lead the ornamental fish industry in Nepal, there need to be strong research and development activities covering breeding and development of new ornamental fish species including both native and exotic.

1. INTRODUCTION

1.1 Background

Fishes are renowned species of the aquatic world and are the only food source harvested from natural populations which are distributed in a wide range of aquatic ecosystems (De Silva et al. 2007). Back in the day, most individuals used to culture fish for food but now people are familiar with aquarium fish. In the past, aquarium fishes were difficult to get easier because there were no wholesale shops and only limited to the house of rich people, but now it is spread to different places such as houses, shops, hotels and other public areas as decorative materials due to its easy access. Nowadays, ornamental fish keeping at home is emerging as one of the most popular hobbies in the world. Fishes are the most recognizable group of vertebrates with 32,447 species with varying forms and fascinating beauty which have been attracting people from their body colour, body shape and aquarium sustainability (Mahapatra et al. 2007).

Aquarium keeping is said to be the second-largest hobby following photography in the world. Aquarium keeping is a global industry worth between 15 to 30 billion U.S. dollars (Wood 2001, Tlusty et al. 2013). The aquarium fish and accessories industry are now quickly getting importance because of its tremendous economic opportunities and prospects. The brilliant, flamboyant colour and attractive appearance of certain fishes appeal to everyone. About ten percent of people in the world keep an aquarium in their homes. People keep fish in their homes for a variety of reasons: for decoration, children's education, enjoyment, good fortune and to collect rare species or even to propagate them (Pandey & Mandal 2017). Ornamental fishes are also known as aquarium fish which are peaceful, generally tiny and available in attractive colours and capable of living in confined spaces like aquarium conditions or garden pools. They are often called 'living jewel' and the most attractive living organisms of the aquatic world due to their colour, shape, behaviour and origin (Paul & Chanda 2014). Their lively and fascinating activities are worth enjoying as colourful fish has high aesthetic value. Throughout the world, ornamental fish keeping is very popular as interior decorative materials, an easy and stress relieving hobby. Besides home aquariums, public aquariums in hotels, parks, and other public places are common in the metropolis (Ghosh et al. 2003).

Advancement in breeding and aquarium technology has added a new dimension to the ornamental fish trade with more species and varieties being introduced to the aquarium trade (Raja et al. 2014). The global freshwater ornamental fish industry heavily relies on cultured fishes and fishes from the wild contribute only inadequate proportions. In total contrast to this, the marine fish species contribute only 15% to the global market but wild collections (Raja et al. 2014) however, nearly 98% of these fishes are wild-caught and very few are from captive-breeding (Sureshkumar et al. 2013). Domestication and cultivation of ornamental fish mainly freshwater species raised on farms satisfy commercial demand which reduces pressure on wild populations. The domestication of ornamental fish, among others, has increased in recent decades worldwide (Teletchea 2016).

People have a long history of capturing and domesticating creatures for their benefits such as the generation of dairy items, rural generation, to get meat, for delight and so on. Certain creatures like fishes were kept captive in lakes, tanks and aquariums for nourishment, beautification reasons as well as stress-relieving purposes. Based on archaeological discoveries, the history of fish-keeping can be followed back to Sumerians around 2500 B.C Babylonians 500B.C. Egyptians utilized to revere fishes particularly Nile Roost among others and Romans as well utilized fishes as both nourishment and enhancement within the 1st century A.D (Barringtom). The primary scientific public aquaria were opened in 1853 at Regents Park in England which took fish-keeping to a whole new level. Within the 1930s several public aquaria were built in Europe but at the end of World War II only one Berlin remained and by the 1970s the whole scenario was set for a modern era of open aquaria where a few marine species were displays and others new becoming more popular due to marine fish and interactive educational activities (Forteath 2001). In this day and age, advancement within the field of aquarium technology has gotten to be more convenient to ace the hobby and pick up wellbeing benefits from it. Modern aquarium technology acts as the life support system for fishes in the tank making them flourish comfortably in captivity for a long period (Pokharkar).

1.2 Benefits of aquarium fish keeping

Ornamental fish industry is a multibillion-dollar industry that can fetch about 100 times more price than the food fish where marine ornamental fish are about ten times costlier than

freshwater ornamental fishes (Satam et al. 2018). The ornamental fish culture and breeding activity are possible on a large scale and small scales which is why it provides a good opportunity to even small entrepreneurs. Ornamental fish- exporting works out to be highly remunerative if the activity is taken upon scientific lines with appropriate marketing strategies. However, institutional funding for research and development activities are required especially for in house breeding of selected species of marine ornamental fishes which are in great demand to release the pressure on wild capture and scheme for educating/ training of fisher folk in more skilled and specialized techniques of collecting, handling, sorting and transport of ornamental fish which could revolutionize the fishery industry to great extent (Pandey & Mandal 2017). Aquarium keeping is an amazing hobby that is a boon to the people who lead a stressful life and have cardiovascular disorders/problems where people can experience calmness and happiness effectively reducing stress level and hence keeping the blood pressure in check. People practicing aqua- hobby is less susceptible to heart disease, and live a long and happy life. Having an aquarium in the house, the illness caused by stress and other emotional trauma can be effectively tackled to some extent without mental medications (Pokharkar).

1.3 Criteria for ornamental fishes

To be classified under ornamental fish, the standard benchmark of the fish is to look attractive with beautiful colouration, adaptability to live in small confined space, peaceful nature and compatibility to live with other fishes, ready acceptability of artificial feed and size of the fish should be suitable for aquarium keeping (Panigrahi et al. 2009). But, now it has been claimed a fish don't need to have marvelous colouration to qualify for any fish to be called an ornamental fish. A common fish with the natural dark colour with stripes, a single dark streak, dots, and blotches, brilliant silvery colour with yellow or pinkish hues on its body is enough to qualify it as an ornamental fish and all have made fishes get classified as ornamental fishes. Even slow-moving or sedentary fish that have body movements, mouth, opercle or fin movements are considered fish for aquarium. Thus, few criteria can be added to the traditional ones for selecting indigenous ornamental fish are- unique/ unusual appearance such as Devil catfish, *Chaca*, peculiar nature like colour changing *Badis badis*, rare species like colouring cheng, *Channa bleheri* (Pandey & Mandal 2017).

1.4 Status of ornamental fishes in Nepal

Ornamental fish farming is an important commercial component of aquaculture providing aesthetic requirements and up-keeping of the environment. Ornamental fish are produced primarily in outdoor, earthen ponds. Ornamental fish comprise two broad categories: live-bearers and egg-layers. Live-bearers include guppies, mollies, platies and swordtails. Egg-layers include almost everything else; the major groups are Barbs, Tetras, Gouramis, *Danio*s and Cichlidis (Watson & Shireman 1996).

Nepal is a landlocked country where aquatic resources are based on inland freshwater. Nepal is endowed with a large number of rivers, lakes, reservoirs, swamps and irrigated paddy fields which are the major source of freshwater in Nepal. Approximately 5.5% of the total area of the country is known to be occupied by different freshwater aquatic habitats where around 232 fish species (Gurung 2018) dwells in that habitat. In Nepal, the practice of keeping aquariums was started during the period of Late King Tribhuvan. They used to keep goldfishes, koi carp imported from China and India. Among them, some native fish have ornamental value (Petr & Swar 2002) and about 15 native fishes are a potential candidate as ornamental fish that possess a great colour (Gurung 2017). There are about 43 ornamental fish shops from the Kathmandu and Pokhara valley of Nepal where 27 exotic fish species are sold in the market of Nepal which is mostly imported from foreign mainly from India 85% and 15% from Thailand, China and other countries. In Nepal annual import of ornamental fish was 318.1 metric ton in 2009 and increased to 1233.0 metric ton in 2017 where imported ornamental fish value was NRs.13.3 million in 2009 and increased to NRs.153.4 million in 2017 (Husen 2019).

1.5 Objectives

General objective of this study was identification and domestication of native ornamental fishes of Begnas Lake, Pokhara, Nepal.

Specific objectives were:

- To identify the potential native ornamental fish species.
- To domesticate the native ornamental fish species.
- To investigate the breeding activities of the species and assess suitable environments for breeding purpose.

1.6 Rationale of the study

Culture and breeding of ornamental fishes can be a promising alternative for many people as well as unemployed youths of the state. It requires little space and less initial investment than most other forms of aquaculture. For ornamental fish farming, only a clear understanding of the habits and biology of the fish is required. It can be practiced even in urban areas with little alteration of the backyard or roof of a house. As less manpower is needed, the women or the elders can run small home aquarium units and improve their social and economic life. Although much research has been conducted, there is no detailed information about the domestication of native ornamental fishes and ornamental seed production technology is at the beginning stage in Nepal (Gurung 2012). So, the purpose of this study is to find out the possibility of their breeding, viability and commercial value of native ornamental fishes. This study helps to find out potential native fishes that can be used as ornamental fish and whether the native ornamental fish can replace the exotic ornamental fish in national and international trade.

1.7 Study Limitations

- For breeding activity and assessing the suitable environment among all the selected fish only *Danio devario* was under monitoring conditions.

2. LITERATURE REVIEW

2.1 Domestication of ornamental fish

Domestication implies much more than merely keeping wild animals in farms or homes (Fosså 2003, Teletchea & Fontaine 2014). Domestication is a human-induced process that gradually changes a cultured organism. It extends over generations and involves developmental effects within each generation, culminating generally in genetic changes across generations (Price 2002). Domestication is a long and endless process, during which captive individuals will become more adapted to humans made conditions in captive conditions and consequently progressively modified from their wild congeners. Domestication process can leads to permanent genetic modifications of a bred lineage while taming or keeping wild fish in captive condition and this is only conditioned behavioural modification of individuals. To be considered domesticated, the entire life cycle of the targeted fish species must be involved in fully closed conditions in captivity, independent of wild sources (Balon 2004, Teletchea & Fontaine 2014).

Domestication process started over 10,000 years ago in Iran where one of the first domesticated animals was the goat (*Capra hircus*) (Zeder & Hesse 2000). Fish domestication is a much more recent process while some exceptions such as carp (*Cyprinus carpio*), tilapia (*Oreochromis niloticus*) and goldfish (*Carassius auratus*) may have possibly been artificially selected for hundreds of years, and another species such as cod (*Gadus morhua*), salmon (*Salmo salar*) and trout (*Oncorhynchus mykiss*) in the 1800s (Duarte et al. 2007) the vast majority of farmed fish has been under domestication merely since the middle of the twentieth century (Balon 2004, El-Sayed 2006). Captive or domesticated fishes have more or less strongly diverged from wild phenotypes through selective breeding, mutations or hybridization, depending on the phenotypes such as the siamese fighting fish (Fosså 2003, Balon 2004). The culture of aquarium fish species is recent activities that have been developed in the last decades. Once the full life cycle of a fish species is controlled in captivity and this farming helps to release the pressure on wild populations by supplying tank-bred fish year-round for the aquarium trade (Wood 2001, Wabnitz 2003, Olivotto et al. 2011). The first truly domesticated fish species was certainly the goldfish, for which the domestication was initiated

by the Chinese about 1500-2000 years ago (Fosså 2003) and today goldfish is one of the most popular aquarium fish species that display hundreds of fancy breeds (Balon 2004).

Captive fish species can be produced anywhere in the world once it is domesticated. Yet, aqua cultural operations tend to be focused in the more prosperous consumer countries for the high cost of developing the necessary infrastructure where there is sufficient capital investment required (Wood 2001, Tlusty 2002, Murray & Watson 2014). This chiefly explains why the production of aquarium fish species has been more prevalent in developed countries (Cheong 1996, Wood 2001). Since transport costs are greatly reduced the production of fish close to consumer centre is becoming more profitable (Livengood & Chapman 2007). However, the establishment of aquaculture facilities away from the countries of origin deprive these countries of income and place people out of jobs (Wood 2001). Therefore, technology should be transferred to developing countries which enable them to set up their facilities for culturing native fish that have come from their ecosystems (Wood 2001, Olivotto et al. 2011). Freshwater aquarium fish species shows a high level of domestication than marine fishes (Teletchea 2016).

According to (Torgersen 2020), there are several different phases in the life of fish in the ornamental and hobby fish trade. For wild capture fish, it starts with capture, the first in a series of stressful events and transient states- capture, holding, transfer, transport, purchase and introduction. The captive-bred fish starts its life in the trade very differently; it is spawned, hatched (unless it is a live-bearing species) and raised in a tank environment that, at the very least, sufficient for growth and survival until it reaches the marketable size and then a wholesale facility and a retailer's display tanks and being dip-netted into a bag for transport to the customer's home aquarium, where it is released and typically kept until it dies. So, there needs to address the ornamental fish welfare for proper trade.

Native fishes are one of the aquatic vertebrates which need to be further studied however before completely understanding their occurrence, distribution and ecology, certain threats are roaming around native fishes due to climate change, overfishing, pollution, alteration of natural habitats and poor understanding of fish ecology etc (Gurung 2012). The contribution of native

fish to total production is declining worldwide, as most fishes have been overfished (Allan et al. 2005, Allen 2010). Therefore usually native fishes of Nepal are considered not valuable in the case of the economic benefit so there needs to be proper management for the native fish species. Kali Gandaki Fish Hatchery research station has been designated for breeding of native fishes in which nine native fishes has been bred in captivity successfully (KGFH 2005). This station produces about one million fingerlings of native fishes to restock in the regulated rivers for the conservation of native fishes (Gurung & Baidya 2012). Different native ornamental fish species such as *Puntius sp., Colisa sp., Bhurluk* etc. were collected from different water bodies and reared for domestication and propagation in a plastic tank. Similarly, broods of some exotic species such as Goldfish, Fancy carp, Guppy, Platy and Swordtail were also reared for breeding purposes. Native fish *Colisa sp* are successfully bred in the fishery research station (FRS 2018). However, there is not much work done in the case of domestication and breeding native ornamental fishes of Nepal.

2.2 Breeding of *Danio*s in captivity

Danio Hamilton (1822) is a diverse genus of small, colourful, freshwater fishes commonly found in streams and rice paddies of their native Southern Asia (McClure 1999, Sanger & McCUNE 2002). Danios are ostariophysan fishes, a member of the Cyprinidae which are the dominant group of freshwater fishes comprising approximately 64% of all freshwater fishes and includes more than 2000 species in 210 genera (Nelson 1994). The ease with which *Danios* can be maintained, bred and reared in captivity has made them popular with aquarists and biologists alike (Sanger & McCUNE 2002).

The studies on the breeding in the captivity of *Danio aequipinnatus* reveals that the critical parameters viz, hardness 50 mg/l, pH; 7 and temperature (22.5°C) played a key role in the breeding performance and breeding was not successful when both the water hardness at the level of 480 mg/l and temperature (33°C) (Prakash et al. 2014). Breeding and development of ornamental hill stream fish *Devario aequipinnatus* were successfully carried out without the use of the hormone in a mature aquarium where the environment was simulated as natural habitat. Induction of spawning was successfully carried out by increasing the temperature and

creating artificial rain and embryonic development was recorded at intervals up to 65 days (Dey et al. 2014). It was observed that *Devario aequipinnatus* could be successfully bred in a medium-sized glass tank with a bed prepared from small mosaic chips and temperature 27°C (Sarmah et al. 2015).

In the laboratory, domesticated zebrafish strains breed all year round whereas in nature spawning is more seasonal. However, larger females collected in January (outside the main spawning season) have been found to contain mature ova, indicating that reproduction may not be imitated by season, but may instead be dependent on food availability, which is likely to co-vary with the season (Spence et al. 2008). Further, reproductive maturity appears to be related to size rather than age, wild and domesticated zebrafish appear to reach reproductive maturity at similar sizes, despite having different growth rates. Pairs of zebrafish left together continuously spawn at frequent but irregular intervals, and a single female may produce clutches of several hundred eggs in a single spawning (Eaton & Farley 1974).

Length-frequency analysis indicates that under natural conditions the zebrafish is an annual species and recruitment is linked to the monsoon, which is also the period of the year with the highest temperatures. The most rapid growth takes place in the first three months, and slows thereafter, virtually ceasing by about 18 months. Breeding may be dependent on food availability rather than season, as gravid females have been found in Bangladesh in winter and the wild-caught laboratory (Spence et al. 2008). The most basic, and the first formally described breeding technique for laboratory zebrafish involves placing marbles at the bottom of holding or special breeding tanks. When fish spawn over the marbles, the eggs drop into the spaces in between, preventing egg cannibalism and facilitating their subsequent collection (Westerfield 1995).

3. MATERIALS AND METHODS

3.1 Study area

The study was conducted in the Fishery Research Station, Begnas, and Pokhara from January to August 2020 (Fig 1). Fishery Research Station (FRS), Pokhara was established in 1962 (2018 BS).

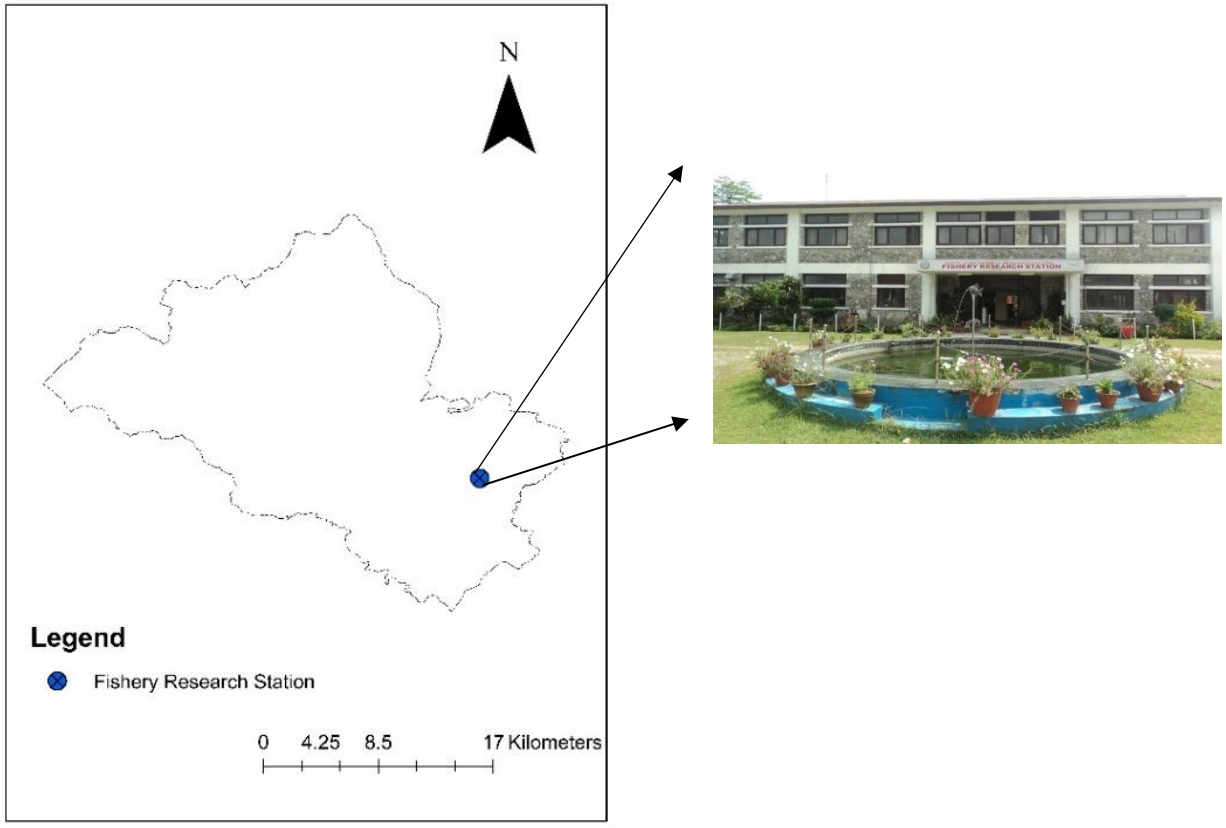

Figure 1: Fisheries Research Station, Begnas, Pokhara

3.2 Materials

3.2.1 Experiment materials

Aquariums/Plastics Tanks, Aquarium heaters, Filters, Aerators, pH mete, Mercury thermometer, Fish handling net, Fish diet, BOD bottles (125ml), Burette, Gloves, Dropper, Cast net etc.

3.2.2 Chemical for water quality test

Concentrated sulphuric acid (H_2SO_4), Potassium iodide (KI), Sodium thiosulphate ($Na_2S_2O_3.5H_2O$), Magnesium sulphate ($MnSO_4$).

3.3 Selection and identification of ornamental fishes

3.3.1 Collection of Native ornamental fishes

Native fishes were collected from irrigation canal and outlets of Begnas Lake, Pokhara in the months of January (winter) and June (summer) 2020 by using a cast net.

3.3.2 Identification of ornamental fishes

The collected fishes were identified by using as per (Shrestha 2008) which is as follows:-

a) ***Puntius sophore*** **(Hamilton, 1822):** It has a distinct orange golden spot below the eye as well as opercles are golden red and distinct black blotch on the caudal peduncle and dorsal fin base whereas the tip of the fin is reddish. The Head of this fish is small and the eye is comparatively large. Barbels of this fish are absent and the lateral line system is complete. Dorsal fins are relatively high and with 8-9 branched rays.

b) ***Puntius conchonius*** **(Hamilton, 1822):** A deep body of silvery fish with a darkish back and silvery belly. It has scales with dark bases and the lateral line system is incomplete. The paired fins have dark tips and the caudal fin is transparent.

c) ***Barilius barna*** **(Hamilton, 1822):** The body of this fish is usually crossed by fine dark vertical bands. In this fish barbels are absent, open pores are present on both jaws and snout in the adults. The body of the fish is silvery with 9-11 bluish vertical bands, originating from dorsal sides and crossing the lateral line.

d) ***Danio devario*** **(Hamilton, 1822):** It is common ornamental fish with a silvery greenish body with yellowish pectoral, dorsal, pelvic anal and caudal fins. The head of this fish is small, snout obtusely pointed and dark bands run from the middle of the caudal above the middle of the anal fin.

e) ***Danio rerio*** **(Hamilton, 1822):** Silvery body and oblique mouth having a yellowish-white belly and flanks. This fish has a shining Prussian blue predorsal scale of 15- 18. Barbels two pairs. The male is torpedo-shaped, with gold stripes between the blue stripes whereas the female has a larger, whitish belly and silver stripes instead of gold.

3.3.3 Selection of potential native ornamental fish

Small to medium size native fish's (3cm to 10cm) ideal for aquarium having good colouration (black stripes, blotchs, dots and silvery hues on body), feeding habit (carnivores, herbivores and omnivores), their behaviour with other fish species (aggressive or friendly) in nature and having the ability to sustain in a controlled environment were selected.

3.4 Domestication

3.4.1 Experiment setup

After identifying and selecting their nature, the initial length and weight of these fishes were taken before introducing into the stocking tank for acclimatization for 2 weeks and then these fishes were kept in the different aquaria according to the species having 60-litre (63cm×32.5cm×33.5cm) and 40-litre (45.5cm×38.3cm×25.4cm) capacity where proper aeration was maintained and water was replaced once a week by siphoning.

3.4.2 Feed formulation

Feed was formulated having using Kasturi software under expert guidance in Fishery Research Station, Begnas. Fish feed was then autoclaved for 20 minutes at 121℃ at 15 psi (Pound per square inch) and refrigerated. Fishes were fed with an autoclaved powdered feed thrice a day.

Table 1: Composition of different feed ingredients used in preparing fish feed

Ingredients	Weight(gm)
Fish Jawla	400
Mustard Cake	150
Sunflower Oil	30
Soya- Full Fat	360
Trace Minerals Mixture	10
Vitamin Premix	10
Wheat Flour	40

3.4.3 Water quality parameters

The water quality parameters such as water pH were measured by using portable Hanna pH meters, DO by Wrinkle methods and the water temperature was recorded using a thermometer every day.

3.4.4 Survival

The survival rate of the fishes is calculated by the following equation.

$$\text{Percentage survival} = \frac{\text{numbers recovered}}{\text{numbers stocked}} \times 100$$

3.4.5 Statistical Analysis

All the statistical analysis were done in Microsoft excel 2013. The data were analyzed to find mean and standard deviations of fish length and weight, % survival of fish, GSI, Fecundity.

3.5 Investigation of breeding activities of species and assessing the suitable environment

Out of the total domesticated native fish species, *Danio devario* was selected for investigating breeding activities and assessing the suitable environment. For the sex determination, Female

Danio devario (Photo 6) and Male (Photo 7) can be distinguished during the breeding season as female has a round belly whereas the Male has slim belly compared to female.

For assessing the suitable environment, 33 individual *Danio devario* were exposed to the four different after measuring their weight to know which female laid the eggs. The first condition "A" (Photo 9) is in the aquarium with a heater and aerator whereas natural bedding was made with sand, gravel, pebbles and aquatic submerged plant *Hydrilla verticillata* but there was indirect sunlight. Likewise, the second condition "B" (Photo 10) was the one where fish species were kept into the outer tank which is exposed to direct sunlight and natural bedding was made like the first condition. Similarly, for the third condition "C" (Photo 11) fishes were exposed to the tank with running water where natural bedding was like the previous two conditions but there was indirect sunlight. The fourth and the last condition "D"(Photo 12) was in the open environment which can be called a semi-captive condition where natural bedding was made like three conditions which were exposed to direct sunlight. For all the condition aeration was properly maintained and those fishes were fed with autoclaved 40% CP powdered feed. Bloodworms were also fed as supplement feed randomly thrice a week. Temperature was checked regularly whereas pH and DO were checked once a week.

3.5.1 Calculation of gonad somatic index (GSI)

The GSI of the *Danio devario* was calculated for each of the female separately by using following formula:

$$\text{GSI} = \frac{\text{Weight of ovary}}{\text{Weight of fish}} \times 100$$

3.5.2 Estimation of fecundity

For the estimation of fecundity, the ovary of the mature females was weighed and three sub-samples were taken from the front, mid and rear sections of each ovary and weighed. Then the total number of eggs in each ovary sub-sample was proportionally estimated using the equation (Yeldan & Avşar 2000).

$$\text{Fecundity} = \frac{\text{No. of eggs in sub sample} \times \text{Gonad weight}}{\text{Weight of sub sample}}$$

4. RESULTS

4.1 Potential native ornamental fishes

In this study, five native fishes are found suitable for ornamental purposes from the Begnas Lake which is *Barilius barna*, *Danio devario*, *Danio rerio*, *Puntius sophore* and *Puntius conchonius* (Table 2, Appendix I) belonging to order Cypriniformes and family Cyprinidae.

4.2 Domestication of native fishes

Puntius sophore (5.7±0.9cm length and 3±1.4gm weight), *Danio devario* (6.3±0.5cm length and 3.1±0.7gm weight) were selected (Table 3, Appendix I). Since *Barilius barna*, *Puntius chonchonius* and *Danio rerio* were also found suitable for ornamental purpose but the sample number of these fishes was not sufficient for further experiment. So, they are discarded here. These fish species were also accepted the formulated feed for ornamental fish species. The proximate analysis showed that feed formulations for ornamental fish have high crude protein (CP) content 34.8% with higher minerals (Table 4, Appendix I).

4.2.1 Seasonal water parameters

It was observed that, the temperature for winter (17.7℃) is low compared to the summer (26.1℃) (Fig.2). Similarly, there was no difference in pH (7) between the winter and summer. Likewise, DO was slightly higher (6.4 mg/l) in winter than in summer (5.68 mg/l).

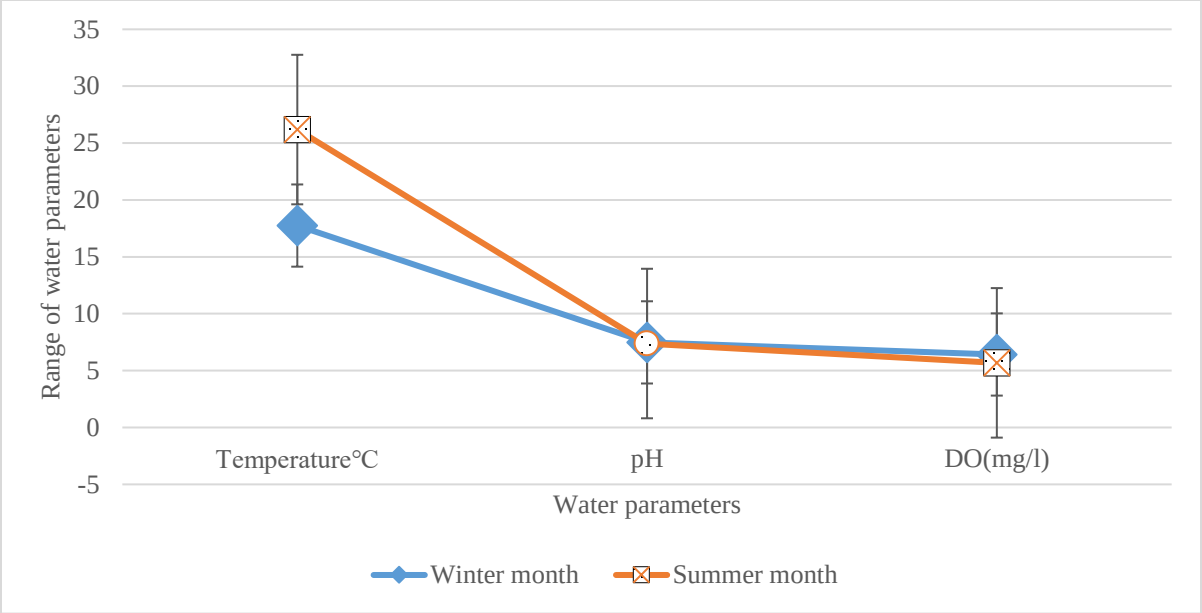

Figure 2: Water parameters of winter and summer months

4.2.2 Seasonal effects of survival on domestication of local ornamental fish species

It was observed that, survivability rate for the *Puntius sophore* was highest (86.66%) in summer and (82.82%) in the winter. Likewise, the survivability rate for *Danio devario* (94.59%) was highest in summer and (62.35%) in winter (Fig. 3, Table 5, Appendix I).

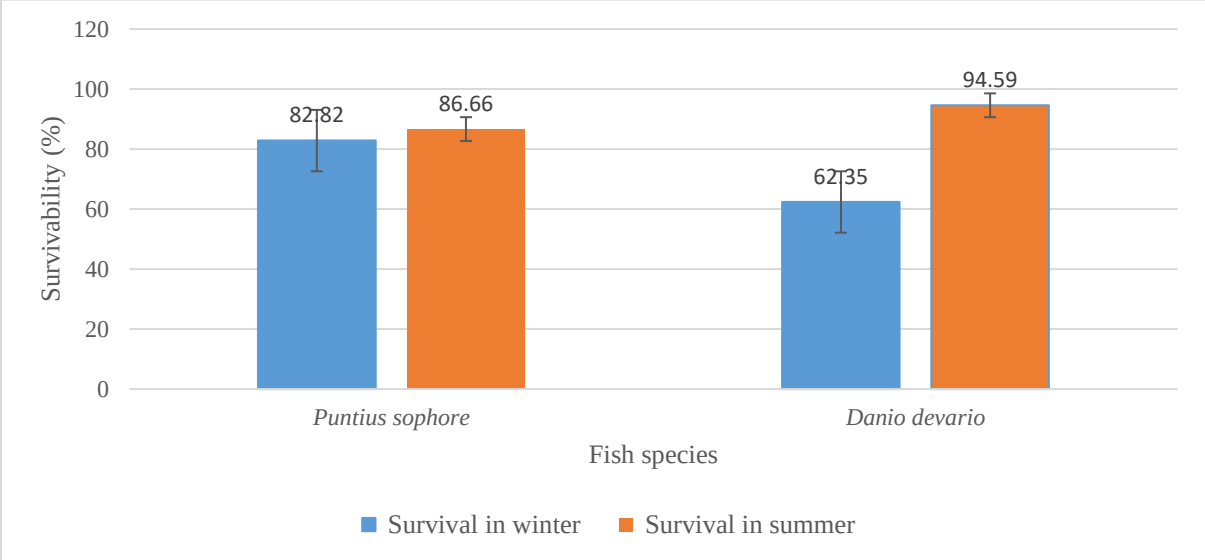

Figure 3: Survivability of local ornamental fishes

4.3 Assessing breeding activities

Among the four conditions to investigate breeding activities of *Danio devario* for assessing the suitable environment, breeding was successful in the fourth condition "D", which is in the open environment (10 m length, 0.75 m wide and 30cm depth) that can be called the semi-captive condition. *Danio devario* can be bred in the temperature range from 27 to 28℃, pH 7 to 7.8 and DO range 5.5 to 7.5 mg/l. Gonado somatic index (GSI) and fecundity of *Danio devario* were 10.65± 0.7% and 1283.33± 225.46.

For the hatchlings, they were kept in the aquarium and fed with micro feed thrice daily. The water quality for the species was all in the acceptable range for four conditions of the breeding environment and normal domestication process. For the first condition, the temperature was 29.2134±0.159, DO 5.25±0.086 and pH 7.433±0.064. Likewise, for the second condition, the temperature was 28.0147±0.138, DO 6.325±0.156 and pH 7.55±0.043. Similarly, in the third condition, the temperature was 27.878±0.183, DO 5.55±0.07 and pH 7.45±0.084. For the final condition that is the fourth one, where the temperature was 27.435±0.139, DO 5.85±0.03 and pH 7.45±0.084 were noted (Table 6, Appendix I, Fig 4, 5 and 6).

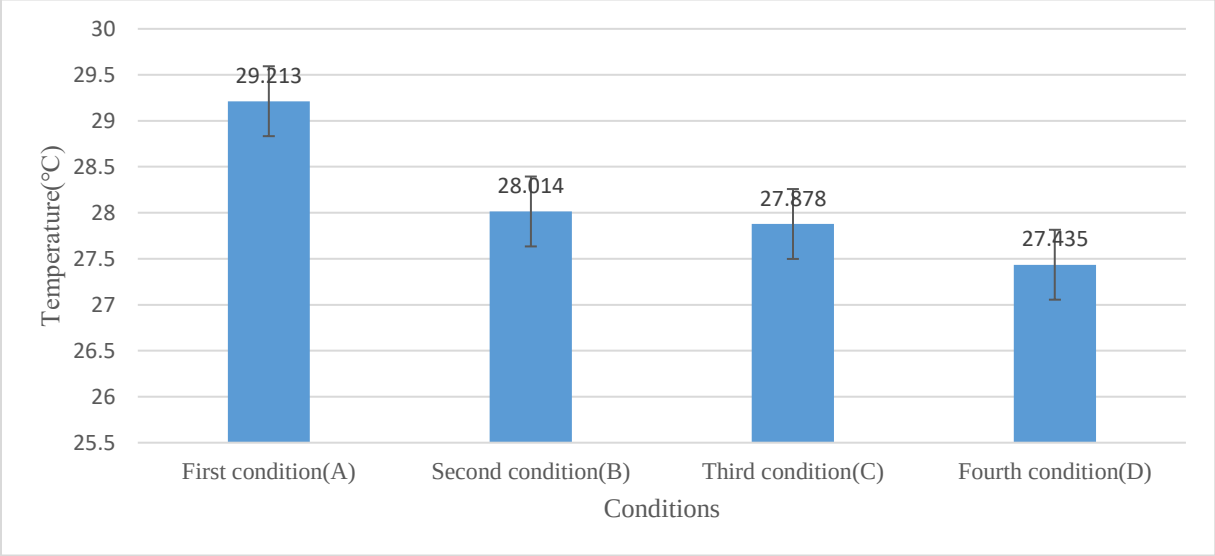

Figure 4: Temperature (℃) for investigating different breeding conditions

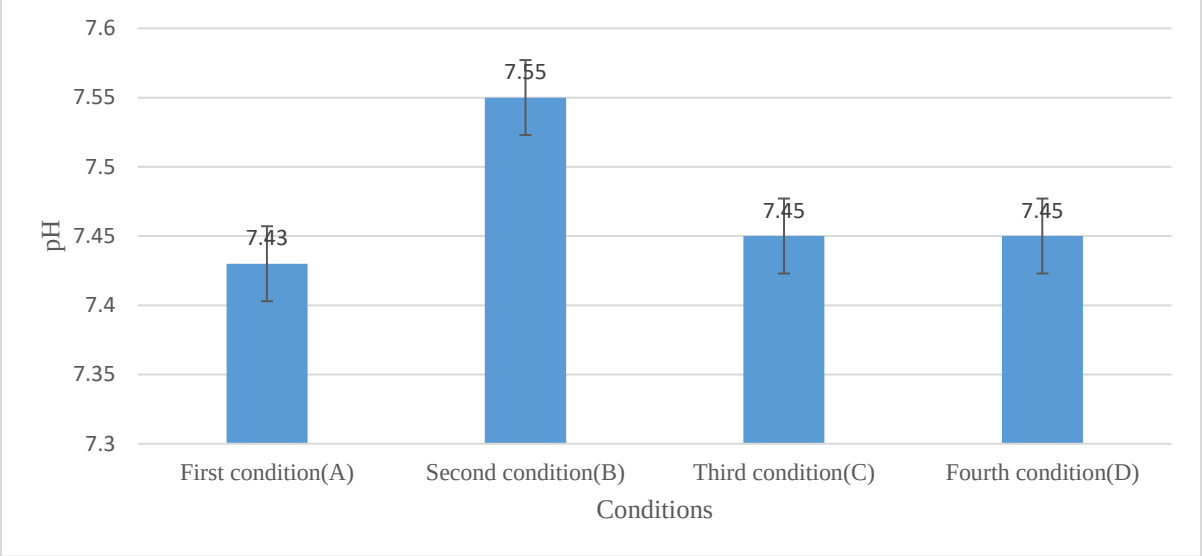

Figure 5: pH for investigating different breeding conditions

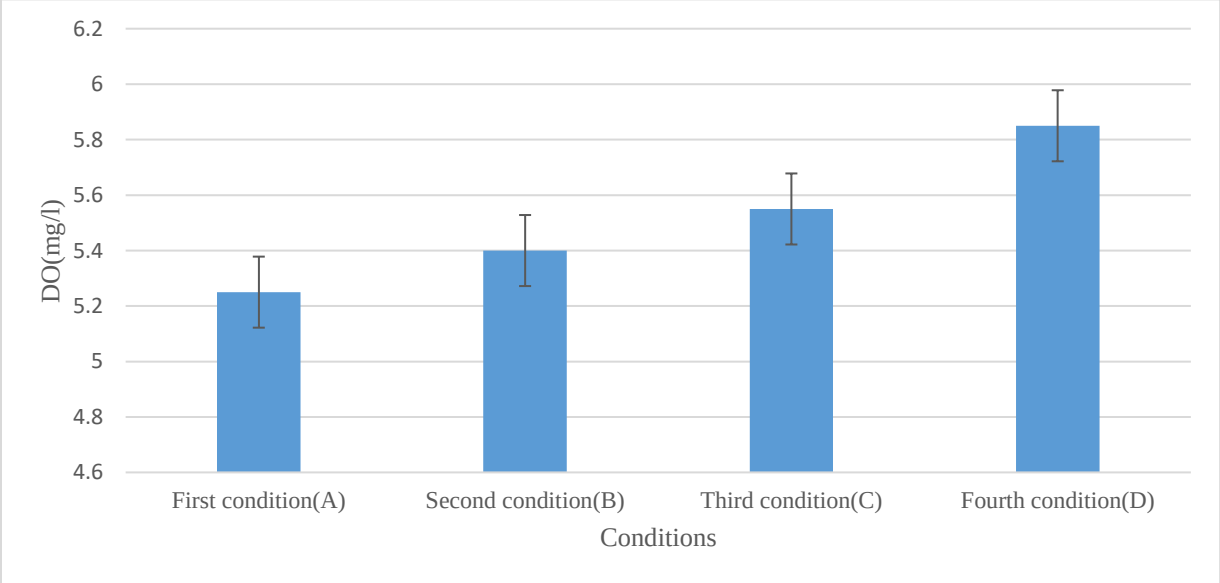

Figure 6: DO (mg/l) for investigating different breeding conditions

5. DISCUSSION

The present study shows five native fishes are found to be potential for the ornamental purpose from the Begnas Lake which can be domesticated from wild to captivity that can promote the native fish species in the ornamental fish industry of Nepal. (Pandey & Mandal 2017) stated that fish do not need to have marvelous colouration to be considered ornamental fish. A common fish with blotches, a single dark streak, dots, natural stripe brilliant silver colour on its body is enough to qualify as ornamental fish. According to (Behera & Nayak 2014), in four sectors of the Chilika lagoon in India, the order Perciformes had the highest occurrence followed by Cypriniformes, Siluriformes, Tetraodontiformes and Osteoglossiforms which had potential as native ornamental fishes. In the present study, only the order Cypriniformes was found in Begnas Lake which has potential as native ornamental fish. For this study, the water quality of the domesticated fish species in the aquarium was monitored from January to September and the 50% of water volume in an aquarium was changed every week. The water temperature ranged from 15℃ to 30℃, and the lowest temperature was observed in January and the highest in June. pH varied between 7 to 8 and dissolved oxygen was found within 5 to 6.9mg/l and the highest was observed in January and the lowest in June. These fish species can be domesticated at the temperature range from 16 to 30℃, pH 7 to 8 and DO 4 to 7 mg/l. As illustrated by Hora (1962) and (Abujam et al. 2017), a pH range of 6.5 to 9.0 is suitable for fish culture and dissolved oxygen within 5 to 8 ppm, and the concentration above 5 ppm is favourable for most fish species. The finding values of the water quality in this study were found within the permissible limit.

In wild-caught fish, mortality rates can be high (Townsend 2011), up to 30% due to the stressful conditions under which the fish are shipped and due to acclimation stress in the animals. Winter is often considered to be a stressful period (Finstad et al. 2004) due to variables and there appears to be a higher mortality rate in winter seasons than summer season in smaller fish (Schultz et al. 1998). The result in this experiment shows that native ornamental fishes are wild-caught which is also small in sizes, moreover, winter mortality is often assumed to be size-dependent, with the smallest individuals experiencing reduced survival relative to larger

species (Hurst 2007) and winter survivability of native ornamental fishes in the present study is low compared to summer.

GSI and fecundity of *Danio devario* were 10.65± 0.7% and 1283.33 ± 225.46 respectively in the present study. Literature on fecundity of *Danio devario* have been not found so far. In the study of (Sarmah et al. 2015), it was observed that *Devario aequipinnatus* could be successfully bred in a medium-sized glass tank with a bed prepared from small mosaic chips at a temperature of 27℃. In this study, *Danio devario* was able to breed in the semi-captive condition in the open environment without the use of hormones where continuous water was supplied through a pipe for the moderate amount of water current and natural sunlight was also available. (Breder & Rosen 1966) noted that the sudden cooling of the temperature in the spawning aquarium by the artificial rain and then gradually increasing temperature (25±0.5 ℃ to 27±0.5 ℃) is the main induction for the breeding of *Danio aequipinnatus*. In the same way, the induction for the breeding of *Danio devario* in the present experiment is seen due to natural rain cooling the temperature of the water and increasing temperature up to (27±0.8℃) in semi-captive condition. For the induction of mating or spawning events in both domesticated and wild-caught *Danio rerio*, photoperiods with the first hour of sunlight had shown to be a key factor (Darrow & Harris 2004, Spence et al. 2007). For the other three conditions for breeding of *Danio devario*, the first condition "A" is in the aquarium with a heater and aerator whereas natural bedding was made with sand, gravel, pebbles and aquatic submerged plant *Hydrilla verticillata* with indirect sunlight. Absence of direct sunlight could be the factors for not being able to breed in this condition. Similarly, for the third condition "C" fishes were exposed to the tank with running water where natural bedding was made like previous two conditions with indirect sunlight and this could be the main factor for not being able to breed in that condition too.

According to (McClure et al. 2006), the *Danio devario* species typically inhabits faster flowing water unlike zebrafish, which inhabits the margins of streams and rivers. Likewise, second condition "B" is the one where fish species were kept in the outer tank which was exposed to direct sunlight and natural bedding was made like the first condition but the artificial shower could not support the breeding activity as well as there was not moderate amount of water

current which could be one of the reasons for not able to breed. According to (Prakash et al. 2014), for breeding of *Danio aequipinnatus* temperature alone at 32℃ wasn't enough and during this study, in the same way, breeding of *Danio devario* in other three conditions with the temperatures at optimum level was not successful for breeding.

Although the freshwater ornamental fish industry mainly relies on cultured fishes from captive conditions, significant numbers are still removed from the wild (Andrews 1990). Therefore, domestication and breeding of native ornamental fishes can play a great role in the promotion of native ornamental fishes in the Nepali market as well as for conservation.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

This study documents native fishes possess great potential as ornamental fishes in Nepal where five native fish species were identified as potential ornamental fish from Begnas Lake. These fish species can be domesticated from the wild to the captive conditions at the temperature range from 16 to 30℃, pH 7 to 8 and DO 4 to 7 mg/l. For accessing the appropriate environment for breeding of *Danio devario*, it successfully bred within semi-captive conditions within the open environment with the water flow in moderate amount. Thus, this study could provide insight into the native ornamental fishes which can contribute to the ornamental fish industry in Nepal.

6.2 Recommendations

Proper technical pieces of knowledge like basic training and nursing about ornamental fish species are required for flourishing the cultivation and domestication of native ornamental fish species from the wild. So, it is recommended to maintain the water quality artificially to domesticate these species in the winter season for better survivability. For future work on this topic, for breeding purpose, more than one species can be done with proper equipment by maintaining the water parameters artificially moreover, it is advised to use hormone for inducing the breeding artificially. For the smooth marketing of ornamental fish, the network of farmers to ornamental fish traders should be developed at the same time there is needs of ornamental fish nurseries from the private sector which will promote this sector.

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APPENDIX I

Table 2: List of native fish species found in Begnas suitable for ornamental purpose

S.N.	Fish species	Order	Family	Local name
1.	*Puntius conchonius*	Cypriniformes	Cyprinidae	Rato pothi
2.	*Puntius sophore*			Pothi machha
3.	*Barilius barna*			Fageta
4.	*Danio devario*			Sera vitta
5.	*Danio rerio*			Chelawa, zebra fish

Table 3: Length-weight of the native ornamental fish species collected from the Begnas Lake

Fish species	Length (cm) Mean ± sd	Weight (gm) Mean ± sd
Puntius sophore	5.7±0.9	3±1.4
Danio devario	6.3±0.5	3.1±0.7

Table 4: Proximate and mineral analysis of formulated ornamental micro feed

Nutrients parameters	Ornamental micro feed
Moisture (%)	7.02 ± 0.13
Crude fat (%)	16.49± 0.19
Crude protein (%)	34.85± 0.33
Total ash (%)	20.14± 0.18
Crude fiber (%)	12.43± 0.23
Calcium (mg/100g)	2045.07± 12.3
Phosphorus (mg/100g)	875.17± 2.25
Iron (mg/ 100g)	33.13± 0.29
Carbohydrate (%)	21.5± 0.25
Energy (Kg cal/100g)	373.81± 7.14

Table no 5: Seasonal effects on survival on domestication of local ornamental fish species

Scientific name	Local name	Winter month's survival (%)	Summer month's survival (%)
Puntius sophore	Pothi machha	82.82	86.66
Danio devario	Sera vitta	62.35	94.59

Table no.6: Mean and standard error (Zeder & Hesse) of water quality parameters

Water quality	First condition(A)	Second condition(B)	Third condition(C)	Fourth condition(D)
Temperature	29.2134±0.159	28.0147±0.138	27.878±0.183	27.435±0.139
DO	5.25±0.086	5.40±0.156	5.55±0.07	5.85±0.03
pH	7.433±0.064	7.55±0.043	7.45±0.084	7.45±0.084

PLATE I

Sampling of native fishes

Photo A

Photo A

Photo 1: Photo A and B sampling of fishes

PLATE II

Potential native fish species from Begnas Lake

Photo 2: *Puntius conchonius*

Photo 3: *Puntius sophore*

Photo 4: *Barilius barna*

Photo 5: *Danio devario*

Photo 6: *Danio rerio*

Photo 7: Female *Danio devario*

Photo 8: Male *Danio devario*

PLATE III

Experiment setup for investigation breeding activities

Photo 1: First condition (A) in the aquarium with heater and aerator

Photo 2: Second condition (B) exposed to direct sunlight.

Photo 3: Third condition (C) with tank having Continuous water flow without direct sunlight

Photo 4: Fourth condition (D) in artificial pool.

Photo 5: Hatchling of *Danio devario*