Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 27(1): 349 – 367 (2023)
www.ejabf.journals.ekb.eg

Domestication and Inter-Species Interaction of Bangladeshi Native and Exotic Ornamental Fishes in the Captive Condition

Razuana Afrin[1], Redayea Ferdows Rakhi[1], Afroza Sultana[1], Md. Arif Shahariar[1], Md. Shakhawate Hossain[2], Md. Shahanoor Alam[1], Mohammad Shafiqul Alam[1,*]

[1]Department of Genetics and Fish Breeding, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh

[2]Department of Fisheries Biology and Aquatic Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh

[*]**Corresponding Author: msalambd@bsmrau.edu.bd**

ARTICLE INFO

Article History:
Received: Oct. 6, 2022
Accepted: Dec. 27, 2022
Online: Feb. 17, 2023

Keywords:
Bangladesh,
Native and exotic ornamental fish,
Domestication,
Behavioral interaction

ABSTRACT

The domestication, breeding and behavioral study of Bangladeshi native ornamental fishes found in nature are still undocumented. Therefore, a total of 1550 fishes (*Botia dario*, *Trichogaster fasciata* and *Mystus tenagra*) were collected from the Kushiara River (Sylhet) and the Katial beel (Kishoreganj) to domesticate in captive condition. After acclimatization, around 400 (60%) of the three fishes survived and were used in the experiment. Then, fishes were reared in the modified plastic drums (500L) with inlet and outlet facilities including aeration. Then, behavioral interactions within and between three native and two exotic ornamental fishes *Carassius auratus* (Goldfish) and *Hypostomus plecostomus* (Suckermouth) were studied in the aquarium condition. Six different combinations of native and exotic ornamental fishes were kept in the rectangular aquariums (60 × 45 × 45cm) for 21 days, maintaining 85 liters of water and behavioral interactions were observed. The best stocking density of single, two and three species combinations of native fishes were found 20, 15 (8+7) and 15 (5+5+5), respectively, in the aquarium. Besides, the best stocking density of three native species including single, two exotic species were 14 (4+4+4+2) and 14 (4+4+4+1+1), respectively, in the aquarium. The exotic species were more active and competitive than the native ornamental fishes. However, three native species can be reared combined with any two and/or combined three species without any abnormalities. Besides, early and regular doses of injection were administered for native ornamental fishes in March to achieve breeding responses but there was no response, rather immature eggs were observed in *T. fasciata* after dissection. Finally, it can be concluded that three native fishes were partially domesticated in the 500L plastic drum and can be reared in the aquarium as ornamental fish including exotic ornamental fishes.

INTRODUCTION

Bangladesh is a land of rivers, and many freshwater fishes are available including marine fishes. The major fisheries sub-sectors are freshwater aquaculture and marine capture systems and their marketing and management. The ornamental fish business is becoming

very popular throughout the world as it's easy to operate and has lower operating costs. Beyond sales of aquaria, air pumps, food, medications and other supplies, the primary product of the aquarium industry is fish **(Cheong, 1996)**. These attractive colorful flower-like fishes of various characteristics are kept as pets in the confined space of an aquarium or a garden pool for fun and fancy **(Chakravartty *et al.*, 2012)**. The aquarium fishes' attractive, colorful bodies and peculiar characteristics increase their popularity day by day. The exotic ornamental fishes are very popular and available in Bangladesh. Gourami (*T. pectoralis*) and Goldfish (*C. auratus*) were the first ornamental fish species in Bangladesh, imported from Singapore in 1952 and West Pakistan in 1953 **(DoF, 2010)**. Then, the breeding practice of several ornamental fish species has been developed in Bangladesh **(Galib, 2010)**. The 'Green Lover Corner' company first exported ornamental fish from Bangladesh in 1993 **(Galib *et al.*, 2013)**. Bangladesh has a great prospect of culturing native ornamental fishes. In our country, many native fishes are found that look amazing in color and can be used as ornamental fishes in the aquarium. We have an excellent opportunity to make a demandable market for ornamental fish because of enormous resources. This sector is now a widespread and global component of international aquaculture and development. Thus, this sector should be given more priority with extra care since it may earn a lot of foreign exchange every year by exporting the native ornamental fishes that remain unused in our country.

A large number of aquaculture species are being cultured in Bangladesh and contributing even to the world aquaculture in terms of production. Besides, Bangladesh has a great prospect of culturing native ornamental fishes. In our country, many native fishes are qualified candidates that look beautiful in color and can be selected species for the ornamental fish trade. Some of them can compete in the world market and support business in other countries. However, an adequate research-based information on the season and availability from nature, transportation, rearing technique, domestication and behavioral interactions with other exotic fishes, feeding and breeding for seed production has not yet been known. As a result, native ornamental fish culture and breeding activities are not expanded compared to exotic ornamental fishes in Bangladesh.

About 300 species of freshwater species are available in Bangladesh. Among them, approximately 30 species can be considered colorful species. These colorful species can be a nice candidate for native aquarium fishes in Bangladesh. Several species from the genus *Botia* (Botiidae, Cypriniformes) are available in Bangladesh. Among them, *B. dario* is a small indigenous (SIS) colorful fish species found in the rivers of South Asian countries, viz. Bangladesh and India. This fish species is commonly known as Bengal Loach or Queen Loach, which is locally called "Rani" or "Bou" masch. It has black or blackish yellow body color, with black-coloured transverse bands. Another several colorful fishes are found from the genus *Trichogaster* (Perciformes) and among them *T. fasciata*, commonly known as banded gourami or striped gourami, is locally called "Kholisha" found in Asian countries. Besides, several colorful fish were found from the genus *Mystus* (Bagridae, Siluriformes), and among them, *M. tengara* is interesting colorful fish that till now exclusively cultured for edible fish. This colourful fish found in Asia, Pakistan, India, Nepal, and Bangladesh can be considered as one of the candidate species for aquarium fish. Its body color is yellow brown or grey with a dark spot-on shoulder and scaleless; barbels surround the mouth.

There is limited information regarding the rearing and behavioral interaction of native ornamental fishes in the aquarium condition. Besides, the interaction of native and exotic ornamental fishes in the aquarium condition is also lacking. Thus, the commercialization process of the native colorful ornamental fish business has not yet been improved. Consequently, proper research-based work and information on fish domestication, breeding, feeding in the aquarium condition with stocking density and behavioral interactions with other exotic species in the aquarium need to be known. Thus, the present study selected three native ornamental fish species (*B. dario, T. fasciata* & *M. tengara*) and two exotic ornamental fishes *C. auratus* (Goldfish) and *H. plecostomus* (Suckermouth) to address the rearing and domestication in the aquarium condition. In addition, the behavioral interactions within native and between exotic ornamental fishes were observed, which might be helpful to consider as the candidate ornamental native Bangladeshi fish species in the future.

MATERIALS AND METHODS

1. Sample collection

Three different native ornamental fish species were selected. Kholisha (*T. fasciata)*, Rani (*B. dario)*, and Tengra (*M. tengara)* were collected from the natural water bodies of the Kishoreganj and Sylhet regions of Bangladesh. At the same time, two exotic ornamental fish species, Goldfish (*C. auratus)* and Suckermouth (*H. plecostomus*) were addressed. A detailed list is given in Table (1).

Table 1. List of native ornamental fishes collected for the experiment

Ornamental fish	Source	No. collected
Kholisha (*T. fasciata)*	Katial beel, Hossenpur, Kishoreganj	700
Rani (*B. dario)*	Kushiara river, Golapgonj, Sylhet	150
Tengra (*M. tengara)*	Jukkhar beel, Kishoreganj	700
Goldfish (*C. auratus)*	Aquarium shop, Joydebpur, Gazipur	50
Suckermouth (*H. plecostomus*)	Aquarium shop, Joydebpur, Gazipur	50

A large number of mortalities (approximately 40%) were detected just after the collection of samples and as a consequence, several collections were performed to achieve the present stock. Fish samples were collected during the month of December 2020 to February 2021.

1.1. Acclimatization of native ornamental fish

The research work and domestication were conducted in the mini fish hatchery at the backside of the Faculty of Fisheries, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh from July 2020 to May 2022. Initially, sampled fish were stocked in the modified 500L plastic drums with inlet and outlet facilities holding 300L of water. An air pump was used to aerate the plastic drum water to provide sufficient oxygen. Fish were acclimatized for 1 week in a plastic drum after the sample collection.

1.2. Domestication and rearing in 500L plastic drum

Later, fishes were kept in separate 12 plastic drums (125 individual/drum) with the necessary modification of water inlet and outlet facilities **(Alam *et al.*, 2021)** during the domestication period. Fishes were fed ON commercially available feed (Mega nursery feed, containing approximately 38% protein), at 5% of fish body weight, both floating and sinking pelleted feed twice daily. The excess amount of food and excreta were cleaned every day by siphoning, and the whole water of the drum was exchanged twice a week. Water quality parameters (temperature, pH, DO and ammonia) were recorded using a kit. Pond water and small wood and bamboo were added inside the plastic drum to create a natural environment for fish. Continuous water flow facilities through pipes helped provide a natural environment. But with time, they started to feed in a small amount. Both Rani and Kholisha are omnivorous and bottom feeders, and Tengra prefers both floating and sinking feed. Sinking pelleted feed (Mega Feed) was supplied twice a day. Experiments in the aquarium started after three months of domestication in the plastic drum. Several exotic fishes were also brought from the aquarium shop including the native ornamental fishes for research purposes.

The fishes were kept in 8 plastic drums (500L), with the necessary modification of water inlet and outlet facilities during the domestication period **(Alam *et al.*, 2021)**. During the domestication, the stocking density in the 500L plastic drum was around 75 individuals with around 300L water, and it showed nice survivability.

1.3. Species combination and behavioral interaction

Five types of species combinations were formed to rear the fish in the aquarium for 21 days with two replication per each (Table 2). A single native of each species was stocked in the aquarium with three different stocking densities. Two species combinations were also reared using any two native species from three native species. Then, single exotic ornamental fishes (Comet Goldfish and Suckermouth) were also added to record the behavioral competition in the aquarium. The exotic species were chosen on basis of popularity and availability from the local aquarium shop.

2. Preparation of aquarium

For research purposes, 12 glass aquariums of rectangular shape (60 cm × 45 cm × 45 cm) were prepared that were capable of holding 120L water. Practically, 80 L of water was used for the experiment. The aquaria were set in the mini fish hatchery in the backyard of the Faculty of Fisheries, BSMRAU, Gazipur. After placing the aquarium, it was filled with water and kept overnight to check for leaks before setting up the experiment. Aquariums were scrubbed with salt, rinsed the gravel before placing it in the aquarium, and some decorators were added for the shelter of fish. An aerator and sponge filter were set for each aquarium and then filled with tap water. The windows of the hatchery building were covered with polythene shade to prevent excessive sunlight and rainstorm, and the surface of the aquarium was covered with a net to prevent dust, insect, bird etc... and reduce the rate of contamination in the aquarium. The net used prevented fish escaping from the aquarium. Electrical equipment was plugged in and kept overnight to ensure everything was working properly.

Table 2. Species combination and stocking density at each aquarium during the experimental period

Species	Species combination	Individual no. per aquarium	Individual no. per aquarium	Individual no. per aquarium
Single native species	Kholisha / Rani / Tengra	10	20	30
Two native species combined	Kholisha + Rani / Rani + Tengra / Tengra + Kholisha	5+5	8+7	10+10
Three native species combined	Kholisha + Rani + Tengra	5+5+5	7+7+7	10+10+10
Three native with single exotic	Kholisha + Rani + Tengra + Goldfish/ Kholisha + Rani + Tengra + Suckermouth	4+4+4+2	4+4+4+3	4+4+4+5
Three native with two exotic	Kholisha + Rani + Tengra + Goldfish + Suckermouth	4+4+4+1+1	4+4+4+2+2	4+4+4+4+4

3. Behavioral interaction

A schematic diagram of behavioral interaction is summarized in Fig. (1).

3.1. Aggregation among different types of species

Aggression refers to negative behavior or attitudes toward another fish or animal mainly by applying physical force. Around regular 2-hour observation and three times a day, it was found that Kholisha was the most social and dominant species among the three-native species. Rani was mainly a very fighting species and swim very fast and hide under the shelter.

3.2. Schooling behavior

Fish schooling behavior varies considerably according to fish shape, size and other considerations. Around regular 2-hour observation, three times a day showed that three native fish species have different schooling structures. Even the same species of fish may vary their school structure according to time, place, fish physiological states and environmental conditions. Schooling behavior is common in Kholisha and Goldfish. Suckermouth fish are relatively isolated from other species and attach to glass and hide under the shelter.

3.3. Feeding behavior

Feeding behavior is very important to domesticate any species. Among the feeding response, around a regular 1-hour observation two times a day after serving food it was found that Kholisha is the most active feeder as Goldfish, prefer all types of food. Rani and Suckermouth fish take food from the bottom. Kholisha, Tengra, and Goldfish show a sudden response after giving food in the aquarium.

3.4. Swimming behavior

The swimming behavior of fish includes swimming posture, speed, direction, distribution, the relationship between the environment and swimming behavior and the relationship between climate and swimming behavior. Among the three species, Rani is mainly a very fighting species and swims very fast and hides under the shelter. Both Tengra and Kholisha are active swimmers.

3.5. Taxis behavior

A taxis is the movement of any species in response to a stimulus such as light or the presence of food. Taxis are innate behavioral responses. All five species showed a response to the change of different environmental factors. They were observed to be very responsive to any change in surroundings as sound, light, water quality and movement.

3.6. Behavior during stress condition

Without stress response, fish could not adapt beyond the normal range of physiological regulation of environmental changes. Too strong or too lengthy a stress response is harmful; however, resulting in slowed growth, decreased reproductive capacity, low immune function and heightened morbidity in addition to mortality. Stress falls into one of two categories according to its intensity and duration: acute stress (due to water temperature, dissolved oxygen, or salinity fusion) or chronic stress (due to sub-lethal ammonia or nitrite aquaculture water, for example) (**Barton, 1991; Bartonb, 1997)**. In the present study, it was also observed that in aquariums, among all five species Rani was observed to be extremely sensitive than others. Tengra and Sucker mouth fish are extremely adapted to any environmental changes.

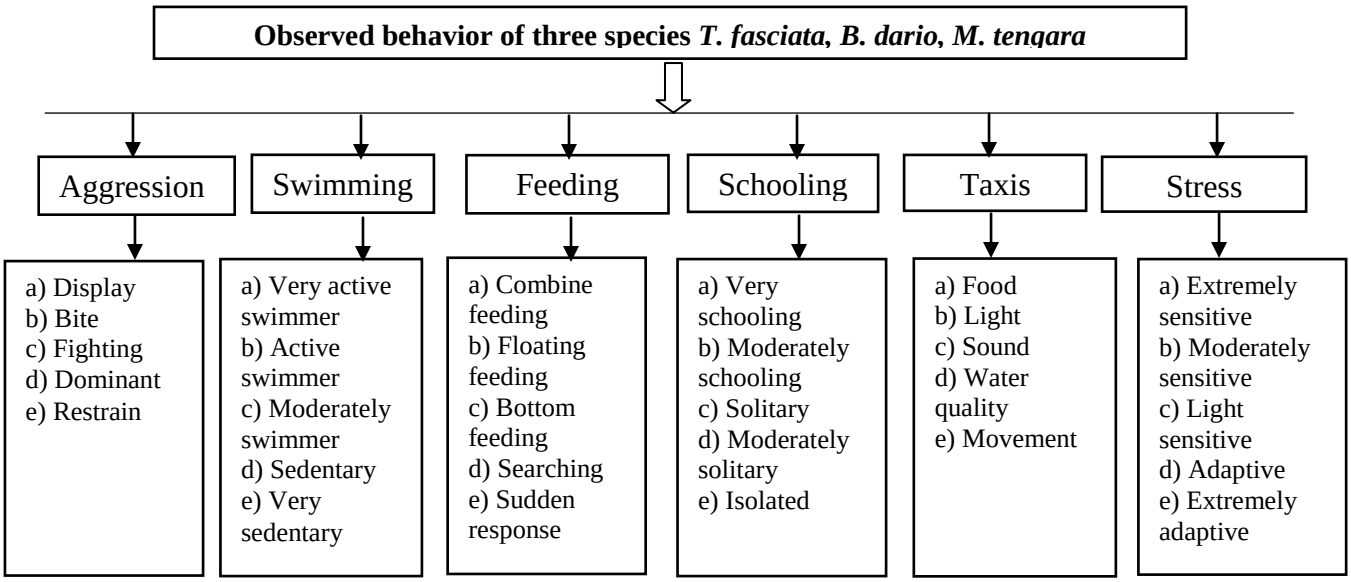

Fig 1. Schematic diagram of observing fish behavior in the aquarium

4. Maintenance of aquarium

During the daily maintenance, some fish behavior such as feeding or non-feeding, signs of movement, (swimming, schooling), response to the environment (light, sound) were recorded. We also observed if the equipment air pumps, filters and air stones were working properly. Besides, water clarity, smell, and turbidity were also noticed. Uneaten food and excreta were removed by daily siphoning, and 10-15% of water was exchanged daily. Water quality parameters (Temperature, pH, dissolved oxygen & ammonia) were also monitored (Table 3).

Table 3. Water quality parameters observed during the experiment period

Measuring parameter	Month						
	March	April	May	June	July	August	September
Temperature (°C)	21 - 27	22 - 28	23 - 30	22 - 29	22 - 30	25 - 31	23 - 30
pH (ppm)	6.5-9.5	7.0-9.0	6.5-10	6.0-9.0	6.5.9.0	7.0-10	6.5-10
Dissolved oxygen (ppm)	6-12	8-12	7-15	8-16	6-12	9-16	12-16

RESULTS

Stocking density of native and exotic fishes in the aquarium

Fishes were slowly adapted in the captive condition in the 500L plastic drum. It took at least 3 months to become stable in the drum condition.

One type combination

In case of the single species (Kholisha/Rani/Tengra), each was reared in the aquarium with three different stocking densities (Table 2). It was noticed that, 20 individuals of single species could be reared per aquarium without any trouble. Remarkably, higher stocking density degraded the water quality within 5 to 7 days and was difficult to manage and continuation of rearing in the present size aquarium. In case of the highest stocking density (30 fish in each treatment), water quality parameters, pH, and ammonia levels were higher in the aquarium at pH 8.6 and ammonia 1.0 than the recommended level for fish rearing (Table 4). Moreover, water quality, competition among individuals and secondary infection due to over density were considered the criteria to determine the best stocking density in the aquarium single species rearing.

Two type combination

In the two species combination, the total number of individuals was 15 fishes per aquarium, which showed the best stocking density (Table 4). In 15 weeks experimental period and in three types of combination, Kholisha showed mainly solitary behavior in two

species combinations but occasionally form schools as part of their predator avoidance behavior. Sometimes, this species individuals swam erratically and sat on the bottom. They took both floating and pelleted feed and co-operate with others. But sometimes chased one another as part of play or joy. Kholisha showed more dominancy over Rani and Tengra because after serving food in the aquarium, most of the Kholisha were active feeders and try to feed over Rani and Tengra and sometimes chase them for feeding. Rani fish preferred the bottom and shadow area, not like light and nocturnal in type, and mainly loved to hide under shelter. Tengra was mostly an active, friendly and sociable fish with other tank mates and played a peaceful community in the tank which moved erratically sometimes and was a mid-water swimmer (Table 4).

Three type combination

In the three types of combination, 5 individuals from each species of Kholisha, Rani, and Tengra showed the best stocking density for aquariums (Table 4). They all showed better interactions with no mortality, non-aggressive, avoided crowds and bottom-feeding behavior. They formed a community and social behavior under shelter with one to two Suckermouth fish in the aquarium. However, all three native ornamental fish showed a peaceful community in the present aquarium condition (Table 4).

Four and five type combination

In four types of combination, 4 individuals from each native species including one exotic species either goldfish or Suckermouth showed the best combination. Within high stocking density, goldfish and two Rani died from this problem during the first week. The combination of Suckermouth fish in high stocking density showed a problem in native species of Kholisha, Rani and Tengra, which died out of injury or secondary infection. Mainly, Rani fish died due to injury by the spine of the Suckermouth fish. Secondary infection easily infected the fish due to injury in respiratory organs. After two days, two Kholisha and Sucker mouth fish died, and the water quality parameter in the aquarium was higher with respect to the values of pH (9.0) and ammonia 1.0. Goldfish again died due to overfeeding within the following week.

As exotic ornamental fishes are more adapted and stronger feeders; thus, increasing the number of exotic fish with native species is not a good combination during the rearing period in the aquarium (Table 4). Food was provided for all fishes but exotic fishes were more competitive and occupied more food and thus rest of the fishes did not get the food. In some cases, even exotic fishes died due to overfeeding. Consequently, a lower number of exotic fishes with native fishes in the present aquarium condition was found as the best combination. Besides, native fishes become injured when a high number of Suckermouth is added to the aquarium by the spine of the fishes and that may result in secondary infection of native fishes. In case five type combination, four each native fishes with single Goldfish and single Suckermouth found the best combination in the aquarium. The food completion can be balanced by maintaining such a stocking density (Table 4). But the same problem of mortality occurred as four types combined high stocking density of exotic species

Table 4. Behavioral observation and interaction pattern of native and exotic ornamental fishes during the experimental period

Species combination	Individual number/ aquarium	Observation
Kholisha	20	Mainly solitary and sometimes forms schools. Sometimes swims erratically and sits on the bottom. Take both floating and pelleted feed and co-operate with others. But sometimes chase one another as part of play or joy.
Rani	20	Mainly prefer the bottom and shadow area, not like light and nocturnal in type. Mainly love to hide under shelter. Show a better community among them, on aggressive, avoid crowd, bottom feeder. Form a community and social behavior under shelter.
Tengra	20	Very Peaceful and non-aggressive. Prefer mainly floating, sometimes showing shyness and bold behavior, and hiding under the shelter. Show a good community with others.
Kholisha + Rani	8+7	Kholisha fish showed more territorial behavior when they were large in number and sometimes aggressive from a school under substances. But both show a peaceful community.
Rani + Tengra	8+7	Tengra moves and touches everything in the aquarium by using the pelvic fin to find food. Kholisha has a labyrinth organ and sometimes it gulps the air near the surface. But it shows both schooling and territorial behaviour when large in number than Tengra.
Tengra + Kholisha	8+7	Swimming activities of both Kholisha and Tengra are similar when serving food. Both are mid-water swimmers and take food from the surface. Sometimes try to bite and are aggressive during feeding. Both are peaceful for a community tank.
Kholisha + Rani + Tengra	5+5+5	All look good, healthy, sociable, and peaceful community.
Kholisha + Rani + Tengra + Goldfish	4+4+4+2	Goldfish are peaceful, and gregarious, and respond to their reflections in the mirror of glass. Explore mainly in a day with native species. Even not showed any aggressive or fighting behaviour. All survived.
Kholisha + Rani + Tengra + Suckermouth	4+4+4+2	Suckermouth fish are mainly algae eaters and are always attached to the substrate. At first, they showed a better community for some days. It can be considered that Suckermouth fish will be a better community if 1 to 2 species are added.
Kholisha + Rani + Tengra + Goldfish + Suckermouth	4+4+4+1+1	All five species survived in this combination. All of them look good, healthy, sociable, and peaceful community in this stocking density. Goldfish and Sucker mouth fish did not show aggressive behavior in low stocking density. Native is mainly dominant over exotic and Suckermouth fish is helpful to control algae on the substrate in the aquarium. This community showed a better combination than other treatments.

4.2. Interaction and behavioral responses of different fishes in the experimental set-up

Kholisha was the most social and dominant species among the three native species. Kholisha was displayed in aquariums because this species preferred surface and middle areas. Their activity was mostly visible in the aquarium. Sometimes chasing and biting behaviour was observed in Kholisha and Rani. Rani was mainly a nocturnal species and Kholisha and Rani also fight with each other but it could be considered their playful behaviour. Kholisha was the dominant species over Rani and Tengra. Because their activity and feeding response were so fast than other species. Rani and Tengra both preferred shelter and hide under the rock. Rani was mainly a very fighting species and swims very fast and hide under the shelter. Both Tengra and Kholisha were active swimmers. Among the feeding response, Kholisha were the most active feeder as Goldfish, preferred all types of food. Rani and Suckermouth fish took food from the bottom. Kholisha, Tengra, and Goldfish showed a sudden response after giving food in the aquarium. Kholisha was the most active and showed mutual behaviour as a combined feeder and floating feeder. Schooling behavior was common in Kholisha and Goldfish. Suckermouth fish were relatively isolated from other species and attach to glass and hide under the shelter. All five species were very responsive to any change in surrounding such as sound, light, water quality, and movement. And finally, in an aquarium among all five species, Rani was extremely sensitive to others. They become easily stressed by environmental change and water quality, Tengra and Sucker mouth fish were extremely adapted to any environmental changes. Suckermouth fish was very sluggish and could survive in low water quality, low DO, and high temperature.

4.3. Breeding trial

Domestication of native fishes was continuing besides aquarium density and interactive behavioral trail. Since March, fishes were observed and fed with high protein reach feed (Live Tubifex), and vitamins and secondary breeding morphology were also observed. Some fishes were observed to bulge and gravid and have a more attractive colour but no egg or sperm were come out after gentle pressure in the abdomen. Therefore, early low doses of S- GnRHa were administered in the middle of March to get eggs and sperm in the coming days. Again middle of April fish was checked whether any egg or sperm come out after gentle pressure in the abdomen but no responses were found. The second time injection was done for Kholisha and Rani in the month of April and fish were kept in the 500L drum with inlet and outlet facilities with the ratio of 1:1 and no egg and sperm were found the next day. Fishes were dissected after 24 hours and the immature egg was observed in the case of the Kholisha female. No responses were observed in the case of Rani fish. As the breeding of Tengra is already established for seed production, no breeding attempt was taken for Tengra fishes.

Table 5. Different kinds of interactive behaviour among native and exotic ornamental fishes during the study period

Behaviour	Intensity	Kholisha	Rani	Tengra	Goldfish	Sucker Mouth
Aggregation	Display	Yes	No	Yes	Yes	No
	Bite	Yes	Yes	No	No	No
	Fighting	Sometimes	Yes	No	No	Yes
	Dominant	Yes	No	No	No	No
	Restrain/hide	No	Yes	Yes	No	Yes
Swimming	Very active swimmer	-	Yes	-	-	-
	Active swimmer	Yes	-	Yes	Yes	-
	Moderately swimmer	-	-	-	-	Yes
	Sedentary	-	-	-	-	-
	Very sedentary	-	-	-	-	-
Feeding	Combine feeding	Yes	No	Yes	Yes	No
	Floating in open	Yes	No	Yes	Yes	No
	Bottom feeding	Yes	Yes	Yes	Yes	Yes
	Searching	Yes	Yes	Yes	Yes	Yes
	Sudden response	Yes	No	Yes	Yes	No
Schooling	Very schooling	Yes	-	-	Yes	-
	Moderately schooling	-	-	Yes	-	-
	Solitary	-	Yes	-	-	-
	Moderately solitary	-	-	-	-	-
	Isolated	-	-	-	-	Yes
Taxis behaviour	Food	Yes	Yes	Yes	Yes	No
	Light	Yes	No	Yes	Yes	No
	Sound	Yes	Yes	Yes	Yes	No
	Water quality	Yes	Yes	Yes	Yes	Yes
	Movement	Yes	Yes	Yes	Yes	Yes
Stress response	Extremely sensitive	-	Yes	-	-	-
	Moderately sensitive	Yes	-	-	-	-
	Light sensitive	-	-	Yes	Yes	-
	Adapted	-	-	-	-	-
	Extremely adapted	-	-	-	-	Yes

DISCUSSION

This present work was carried out to know about the domestication, behavior, and breeding of native ornamental fish in the aquarium. In the present experiment, three colourful native ornamental fishes were selected, whereas Rani is available in the river, Kholisha and Tengra are available in haor, baor, low land, and open water bodies. Among them, Tengra is cultured for aquacultures and fish seed is available. Tengra is a colourful and hardy fish compared to other small indigenous species (SIS) and therefore has some merit to treat as ornamental fish and the present study also proved that. However, there is limited information regarding the location and availability of Rani and Kholisha fish. Rani fish is more abundant during the high monsoon whereas Kholisha and Tengra were found to be abundant during late winter. **Ahammad *et al.* (2017)** observed that fish biodiversity in the Kushiyara river showed some similarity with the Surma river where 34 species of fish belonging to seven orders were identified. **Hossain *et al.* (2017)** recorded 74 fish species belonging to 22 families in the Kushiara River (Fenchungonj Upazilla), Northeast Bangladesh. A total of 68 species were recorded of fish in the water bodies of Itna, Kishoreganj **(Sakawat, 2002)**. **Hasan *et al.* (2017)** found that lal (red) Kholisha or *Colisha lalia* is the most abundant species in the Kishoreganj district. A huge number of snakeheads, perch, and eel were also found. Among them, 4 species of perch were found in the Kalai beel but including Lal Chanda, almost 5 species of perch were found in the Naoli beel area respectively In the case of pereh Nama Chanda and kata Chanda were abundant and Kholisha were rare whereas all of the eel species were abundant. In this experiment Stripped gourami or Kholisha (*T. fasciata*) species are also abundant in Katial and Jukkhar beel in the Kishoreganj region.

In this present experiment, ornamental fishes were reared in 500L plastic drums. Similar rearing practices were found to be successful for the domestication of *Anabas testudineus* in our previous studies **(Alam *et al.*, 2021)**. During fish sample collection of these experiments from natural sources, a number of mortalities happened possibly due to sensitivity, stress, and due to face new environmental conditions in captivity in a 500L plastic drum. The survivability during the domestication period of Kholisha, Rani, and Tengra was 75% and 50%, and 80%, respectively. Though Tengra is already developed for culture in captive breeding, their adaptiveness is much better than Kholisha and Rani. Still, now domestication and survivability data have not been found on both species. Results of this experiment showed that both species are partially domesticated and if they can be developed with some improvements they will be ready for breeding response in the next breeding season.

Different stocking densities were studied in the present experiment in the aquarium condition and the results showed fewer mortalities in low stocking density during each combination study period. The optimum stocking density in the present aquarium condition is 15 to 20 individuals per aquarium. **Tibile *et al.* (2016)** stocked juvenile

Discus randomly in all-glass aquarium tanks of 120 L capacity, at four different stocking densities viz. 1 juvenile/10 L, 1 juvenile/7.5 L, 1 juvenile/5.0 L, and 1 juvenile/2.5 L of water in triplicate, for a period of 12 weeks. The high survival observed at lower densities in other studies were linked to the availability of more space and food **(Narejo *et al.*, 2005)**, optimal water quality, and less competition whereas the incidence of mortality at higher densities was attributed to behavioral changes, the rapid spread of virulent pathogens **(Cruz and Ridha, 1991)**, stress, as a result of competition for food and space **(Akinwole *et al.*, 2014)**, decreased water quality due to increased biomass **(Ronald *et al.*, 2014)**, poor handling **(Vera Cruz and Mair, 1994)** and deterioration of health due to positive interaction of stressful factors **(Barton and Iwama, 1991)**.

In this experiment, mainly artificial feed was provided but some green algae were grown in the small substrates inside the aquarium. **Bano *et al.* (2020)** fed *T. fasciata* with petal powder of rose (*Rosa chinensis*), China rose (*Hibiscus rosasinensis*) and marigold (*Tagetes erecta*) separately as a carotenoid source along with the same basic ingredients for 90 days, Pigmentation affected the behavioral activities of the fish where male aggression and selection of males by females was high in the group fed with marigold petal powder) recommended *Wolffia arrhiza* and *Spirulina platensis* on growth performance and pigmentation of Queen Loach *B. Dario.* 100 g/kg *spirulina* can be effective for better growth while a diet containing 25 g/kg *spirulina* and 150 g/kg *wolffia* can be effective for higher survival and pigmentation in *B. dario*.

Mojumder *et al.* (2020) observed *B. dario* is a carni-omnivorous and bottom feeder fish preferring animal materials (89.06%) over plant materials (2.67%). By percent of the numerical method, the main contributors to their diet were worms (46.40%), followed by fish particles (28.80%), crustaceans (5.60%), insects (5.33%), detritus (3.20%), molluscs (2.40%), algae (1.87%), plant parts (0.80%) and water mites (0.53%). By frequency of occurrence method, worms, and fish particles had a similar contribution (94.44%) to *B. dario* diet, followed by insects (66.67%), crustaceans (55.56%), algae (38.49%), detritus (33.33%), mollusks (22.22%), plant parts (16.67%) and water mites (11.11%). *M. tengara* is a carnivorous fish and zooplankton is the basic food group for this fish species; rotifer has also been observed as the most preferable food class. In the present study, the feeding activity of this fish species has never been observed to be discontinuous. The lowest feeding activity had been observed during the intense breeding season while the highest feeding activity was observed during pre-spawning months **(Gupta and Banerjee, 2014)**. In this present study, all three species were adapted with artificial feed and can be reared easily without natural food. But it also suggests that natural food is cheaper and more nutritious. If it is possible to supply both types of food it will be helpful for the early breeding response.

The rearing environment generally had a strong effect on survivability. Moreover, wild-origin fish that had been reared in the captivity tend to be more dominant than farmed fish, whereas if they had lived in the wild, they were usually dominant. It is increasingly being recognized that the effect of the early rearing environment on behavior and later in life can be complex and difficult to predict **(Olla *et al.*, 1998; Brown and Laland, 2001; Wurbel, 2001; Perrett *et al.*, 2002)**. Flowing water is also essential for induced spawning of *B. dario.* The spawning behaviour of *B. dario* was similar to Indian Major Carps flowing water systems **(Dey *et al.*, 2015)**. The mature ova began to build up from March onwards and reached its peak during July and August, and disappeared from September again reappeared in March. **(Shahlina and Biswas, 2014)**. The present study also found the premature egg in the oviduct of *B. Dario* prior to May after inducing the hormone. **Saha *et al.* (2007)** studied that C. *fasciata* breeds in the paddy and jute fields during the rainy season in nature. Its forms a bubble nest during this time and guards the next carefully. Eggs are yellowish and non-adhesive. **Ruzzante (1994)** pointed out that the effect of domestication on behaviors associated with dominance will depend on the nature of the captive environment. There was a consistent pattern for the domesticated native fishes to be more adaptive in captive conditions in the present study. This is in line with most (but not all) of the previous studies that have teased apart the effect of domestication from that of the rearing environment **(Einum and Fleming, 1997; Einum and Fleming, 2001)**. Behavioral traits are quickly altered by domestication, usually by altering their intensities of performance or frequency of use rather than their nature **(Ruzzante, 1994)**.

The experiment showed all three native ornamental fish showed a peaceful community in a glass aquarium. No previous study has been found yet on the behavior of native ornamental fish species. But in this present study, the problem was raised with the exotic species because of overfeeding of Goldfish, and as a result native species did not get sufficient food at the same time. After being given feed, most of the time Goldfish took more food, and it was a serious problem. Besides, when too much food in the tank, the Goldfish could not take all the food. Therefore, extra food would rot and water quality deteriorates and the aquarium environment becomes more worsen. Extra food inside their tummies can cause problems once they begin to hibernate. During the winter season, fish cannot digest food, and hence overfeeding might be an issue at that time**.** Another study found that Nibbling behavior is very common for goldfish and they mainly prefer to take food from benthic environments. Meanwhile, chironomid larvae are benthic in nature **(Real *et al.*, 2000; Bat and Akbulut, 2001; Titmus and Badcock, 2006; Őzkan, 2006)**.

Goldfish can tolerate extreme environmental stress **(Abramenko *et al.*, 1997)**, including high levels of turbidity and fluctuations in pH and temperature **(Spotila *et al.*, 1979; Balon, 2004)**. Moreover, the species is highly tolerant of water pollution **(Abramenko *et al.*, 1997)**. In the present study, the interaction of exotic species, native

species Kholisha and Rani because injured that caused the secondary infection. It was also reported by many authors that goldfish feed on the eggs, larvae, sub adults, and adults of some native fishes **(Richardson *et al.*, 1995; Rowe and Smith, 2001)**. Besides, it is also a live carrier of several pathogens and parasites (bacteria, viruses, protozoan, and metazoan) and smoothly transmit them into the natural aquatic system. This leads to the outbreak of exotic aquatic diseases resulting in huge economic and biodiversity loss **(Fletcher and Whittington, 1998; Tripathi, 2015)**.

In this experiment, another exotic species Suckermouth fish eats mainly algae feeders as well as small fish and fish eggs, and aquatic insects. Sometimes become very aggressive when it does not get sufficient food in the aquarium. Moreover, the fins of Suckermouth fish are very sharp and large. Both native Rani and Tengra prefer the bottom area so that while fighting with others or moving in the same shelter sharp fins easily created wounds on the body of other fish, and later they died due to injury and secondary infection. Suckermouth catfish has been identified as a great threat to global freshwater. The occurrence of this species in the wild is reported to alter the entire system and change the physicochemical nature of water **(Sandilyan, 2016)**. Furthermore, this species may outcompete the native algae consumers and aggressively drive them away from the system **(Hoover *et al.*, 2004)**.

CONCLUSION

This experiment on native ornamental fishes develops knowledge all about the behavior of three combinations of fish in captive and aquarium conditions and this work will be helpful to the socialization of fish for ornamental purposes. The findings of this present study would also help to broaden the knowledge to understand the behavior and breeding trial of native ornamental fishes. Besides, there is also a need for some improvements such as offering more natural food and making a more desirable place for breeding in captive conditions for full domestication. This work would be a model for future researchers and useful to improve their basic ideas for further experiments. The knowledge of the domestication of these fish species will also improve the knowledge of breeding techniques for further work and business trade through commercialization. Though the present study collected samples from several locations and further detailed surveys with more locations need to be conducted to get more diversified brood fishes of native ornamental fishes. Besides, the molecular study can help in this regard. Finally, it can be concluded that so far no work has been performed on the domestication and behaviors of native ornamental fishes and the present findings would be a base guideline for further improvement of native ornamental fishes in Bangladesh in the future.

ACKNOWLEDGEMENT

We acknowledge the financial support from the Ministry of Science and Technology, Bangladesh Government for funding the project in the year 2020-2022 to Mohammad Shafiqul Alam.

REFERENCES

Abramenko, M. I.; Kravchenko, O. V. and Velikoivanenko, A. E. (1997). Population genetic structure of the goldfish Carassius auratus gibelio diploid-triploid complex from the Don River Basin. J. Ichthyol., 37: 56– 65.

Ahammad, B.; Khandaker, M. and Hossain, M. I. (2017). Assessment of fish diversity in shatghari point of Surma River, Golapgonj, Sylhet, Bangladesh. Int. J. Fish. Aqua. Stud., 5(5): 205-2011.

Akinwole, A. O.; Bankole, A. F.; Dauda, A. B. and Saliu, O. E. (2014). Growth and survival of Clarias gariepinus (Burchell 1822) fingerlings cultured at different stocking densities in Igboora, Oyo State, Nigeria J. Agri. Biodiver. Res., 3(4): 58-60.

Alam, M. S.; Mondal, N. C.; Fatema, K.; Sultana, N. M. and Alam, J. (2021). Comparative breeding performances of indigenous climbing perch (Anabas testudineus) populations in a newly developed semi-artificial condition. Bangladesh J. Fish. 33(1): 21-30.

Balon, E. K. (2004). About the oldest domesticates among fishes. J. Fish. Biol., 65 (suppl. A): 1–27.

Bano, F.; Kashyap, A. and Serajuddin, M. (2020). Effects of different dietary supplementation of plant carotenoids on growth, coloration and behaviour of giant gourami, Trichogaster fasciata (Bloch and Schneider, 1801). Iranian J. Fish. Sci., 19(6): 2770-2789.

Barton, B. A. (1991). Physiological changes in fish from stress in aquaculture with emphasis on the response and effects of corticosteroids. Annual Rev. Fish Dis.e, 1: 3–26.36.

Bartonb, A. (1997) Stress in finfish: Past, present and future-a historical perspective. New York: Cambridge university press.

Bat, L. and Akbulut, M. (2001). Studies on sediment toxicity bioassays using Chironomous thumni K., 1911 larvae. Turk. J. Zool., 25: 87-93.

Brown, C. and Laland, K. (2001). Social learning and life skills training for hatchery reared fish. J. Fish Biol., 59: 471–493.

Chakravartty, P.; Chakravartty, M. and Sharma, S. (2012). A Survey on the Fish Diversity with Special Reference to the Classified Ornamental Fishes and their Prospects in the Kapla Beel of Barpeta District. The Sci Probe 1: 12-21.Link: https://bit.ly/3CpyOme

Cheong, L. (1996) Overview of the current international trade in ornamental fish, with special reference to Singapore. Rev. Sci. Tech. Off. int. Epiz., 1996, 15 (2), 445-481.

Cruz, E. M. and Ridha, M. (1991). Production of the tilapia (Oreochromis spiluris Gunther) stocked at different densities in sea cages. Aquaculture, 99: 95-103.

Dey, A.; Sarkar, D. and Barat, S. (2015). Spawning biology, embryonic development and captive breeding of vulnerable loach Botia dario (Hamilton). J. Entom. Zool. Stud., 3(6): 183-188.

DoF. (2010). Brief on Department of Fisheries Bangladesh. Dhaka: Department of Fisheries, Ministry of Fisheries and Livestock, Matshya Bhaban, 102-106 pp.

Einum, S. and Fleming, I. A. (2001). Implications of stocking: ecological interactions between wild and released salmonids. Nordic J. Freshwater Res., 75: 56–70.

Einum, S. and Fleming, I. A. (1997). Genetic divergence and interactions in the wild among native, farmed and hybrid Atlantic salmon. J. Fish Biol., 50: 634–651.

Fletcher, A. S. and Whittington, I. D. (1998). A parasite-host checklist for Monogenea from freshwater fishes in Australia, with comments on biodiversity. Syst. Parasitai., 41(3): 1.

Galib, S. M. (2010). Aquarium Fisheries in Rajshahi City, Bangladesh. Bangladesh. Feature/Trade/Ornamental fish and Aquarium, Bangladesh Fisheries Information Share Home.

Galib, S. M.; Imam, M. A.; Rahman, M. A.; Mohsin, A. B. M.; Fahad. M. F. H. and Chaki, N. (2013). A study on aquarium fish business in Jessore district, Bangladesh. Trends Fish. Res., 2(3): 11-14.

Gupta, S. and Banerjee, S. (2014). Food and feeding habit of a freshwater catfish, Mystus tengara (Siluriformes: Bagridae). J. Ichthyol., 54(9): 742-748.

Hasan, M.; Hasan, A. K. M. S. and Bhuyan, M. S. (2017). Fish Diversity Assessment of the Haor Region in Kishoreganj District, Bangladesh. Res. J. Environ. Sci., 11: 29-35. 10.3923/rjes.2017.29.35.

Hoover, J. J.; Killgore, K. J. and Cofrancesco, A. (2004). Suckermouth catfishes: threats to aquatic ecosystems of the United States. Aquatic Nuisance Species Res Prog Bull 04–1. US Army Corp of Engineers Research and Development Center, Vicksburg, MS.

Hossain, M.; Hossen, M.; Pramanik, M.; Uddin, N.; Nawer, F.; Rahman, M. and Yahya, K. (2017). Life-History Traits of the Endangered Carp Botia dario (Cyprinidae) from the Ganges River in Northwestern Bangladesh. Pak. J. Zool., 49(3).

Mojumder, N.; Saha, D.; Utsa, S. S.; Maruf, M. K. K. and Paul, S. K. (2020). Biology of the endangered queen loach (Botia dario) collected from wild sources in Bangladesh. Aquacult. Aquari. Conserv. Legisla., 13(5): 2599-2609.

Narejo, N. T.; Salam, M. A.; Sabur, M. A. and Rahmatullah, S. M. (2005). Effect of stocking density on growth and survival of indigenous catfish, Heteropneustes fossilis (Bloch) reared in cemented cisterns fed on formulated feed. Pak. J. Zool., 37(1):49-52.

Olla, B. L.; Davis, M. W. and Ryer, C. H. (1998). Understanding how the hatchery environment represses or promotes the development of behavioral survival skills. Bull. Mar. Sci., 62:531–550.

Őzkan, N. (2006). The larval chironomidae (Diptera) fauna of Bozcaada (Tenedos). Gazi University J. Sci., 19 (1): 57-67.

Perrett, D. I.; Penton-Voak, I. S.; Little, A. C.; Tiddeman, B. P.; Burt, D. M.; Schmidt, N.; Oxley, R.; Kinloch, N. and Barrett, L. (2002). Facial attractiveness judgments reflect learning of parental age characteristics. Proceedings of the Royal Society of London B, 269: 873–880.

Real, M.; Rieradevall, M. and Prat, N. (2000). Chironomous species (Diptera: Chironomidae) in the profundal benthos of Spanish reservoirs and lakes: factors affecting distribution patterns. Freshwater Biol., 43 (1): 1-18.

Richardson, M. J.; Whoriskey, F. G. and Roy, L. H. (1995). Turbidity generation and biological impacts of an exotic fish, Carassius auratus, introduced into shallow seasonally anoxic ponds. J. Fish Biol., 47(4): 576-585.

Ronald, N.; Gladys, B. and Gasper, E. (2014). The effects of stocking density on the growth and survival of Nile tilapia (Oreochromis niloticus) fry at Son fish farm, Uganda. Aquacult. Res. Develop., 5(2): 1-7.

Rowe, D. K. and Smith J. P. (2001). The role of exotic fish in the loss of macrophytes and increased turbidity of Lake Wainamu, Auckland. NIWA Client Report, New Zealand, p. 32.

Ruzzante, D. E. (1994). Domestication effects on aggressive and schooling behaviour in fish. Aquaculture, 120: 1–24.

Saha, B. K.; Siddique, K. U.; Islam, M. A.; Kabir, S. M. H.; Ahmad, M.; Ahmed, A. T. A.; Rahman, A. K. A.; Haque, E. U.; Ahmed, Z. U.; Begum, Z. N. T.; Hassan, M. A.; Khondker, M. and Rahman, M. M. (2007). Colisa fasciata, Encyclopedia of flora and fauna of Bangladesh, Freshwater fishes. Asiatic Society of Bangladesh, Dhaka, 23: 230-231.

Sakawat, H. B. (2002). Haor Fisheries Resources in Itna Upazila under the District of Kishoregonj and their Management Practices, MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, 48.

Sandilyan, S. (2016). Occurrence of ornamental fishes: a looming danger for inland fish diversity of India. Curr. Sci.: 2099-2104.

Shahlina, H. and Biswas, S. P. (2014). Some aspects of reproductive biology of Botia Dario (Hamilton-Buchanan) from Sivasagar district, India. Int. J. Curr. Res. Acad. Rev., 2(12): 71-77.

Spotila, J. R.; Terpin, K. M.; Koons, R. R. and Bonati, R. L. (1979). Temperature requirements of fishes from eastern Lake Erie and upper Niagara River. Environ. Biol. Fish., 4: 281–307.

Tibile, R. M.; Sawant, P. B.; Chadha, N. K.; Lakra, W. S.; Prakash, C.; Swain, S. and Bhagawati, K. (2016). Effect of stocking density on growth, size variation, condition index and survival of discus, Symphysodon aequifasciatus Pellegrin, 1904. Turk. J. Fish. Aqua. Sci., 16(2): 453-460.

Titmus, G. and Badcock, R. M. (2006). Distribution and feeding of larval Chironomidae in a gravel-pit lake. Freshwa. Biol., 11 (3): 263-271.

Tripathi, A. (2015). Monogenoidea on exotic Indian freshwater fish. 3. Are Indian guidelines for importation of exotic aquarium fish usefuland can they be implemented; The case of Neotropical Gusse via spiraloeirra Kohn and Paperna 1964. Curr. Sci., 108(11): 2101-2105.

Vera, Cruz E. M. and Mair G. C. (1994). Conditions for effective androgen sex reversal in Oreochromis niloticus (L.). Aquaculture., 122: 237-248.

Wurbel, H. (2001). Ideal homes Housing effects on rodent brain and behaviour. Trends Neurosci., 24: 207–211.