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Effects of starvation on survival performance and weight loss of exotic ornamental fishes of Bangladesh in aerated and non-aerated aquaria

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Abstract
In this study, we experimented the effects of starvation on survival performance and weight loss of exotic ornamental fishes of Bangladesh in aerated and non-aerated aquaria under laboratory condition. For this aim, a total of 14 fish species were experimented under 13 genera, 09 families and 4 orders. It was set up under two treatments for each experiment. In each experimental treatment, three fishes of a same species were released and treated as replication in determining the survival performance. Fish weight loss and water quality were also measured. Comparatively higher survival performance was found in *Pterophyllum scalare* (T_1, 836±4.32 hours and T_2, 1022±4.02 hours) while lower was recorded for *Hypostomus plecostomus* (T_1, 116±2.44 hours and T_2, 160±3.87 hours). Weight loss varied from 0.05±0.01 g (*Danio rerio*, *Poecilia reticulata*, *Poecilia sphenops* and *Gymnocorymbus ternetzi*) to 0.33±0.09g (*Trichogaster trichopterus*). Water temperature, dissolved oxygen, free CO_2, pH, total alkalinity, ammonia-nitrogen and chlorine level were found to be varied from 25.66±0.17 to 28.66±0.35 °C, 3.80±0.06 to 4.73±0.07 mg/l, 9.21±0.05 to 11.75±0.03 mg/l, 7.13±0.05 to 7.47±0.07, 76.66±1.64 to 108.92±3.20 mg/l, 0.0010±0.0006 to 0.0133±0.002 mg/l and 0.0045±0.001 to 0.012±0.0014 mg/l respectively among different treatments of experiments. This research showed that aeration system can create healthier environment for fish than that of the without aeration one. The research findings can be helpful during feeding management for upholding good husbandry of fishes and also during transportation.

Keywords: Starvation, Survival performance, Weight loss, Ornamental fish and Aquaria.

1. Introduction
In industrialized countries, ornamental fish keeping in aquaria have been rated as the second most popular diversion and the most popular type of pet [28]. Ornamental species proffer a multi-million dollar industry involving the farming or harvest, sale and use of live marine and freshwater animals for display in aquaria, garden ponds and lakes etc [34] which provide not only aesthetic pleasure but also financial openings. Recently, a total of seventy nine (79) species and ninety two varieties of exotic ornamental fishes were listed in Bangladesh [8] and about twelve (12) species are available in Rajshahi [24]. Among the exotic ornamental fishes, most of them are shows omnivorous feeding behavior and some are shows carnivorous feeding behavior. These fishes are used to consume different feeds including-flakes, pellet, dried and live feeds. In most cases, there is no specificity in their frequency [1].

A unique feature of these fishes is their ability to withstand periods of prolonged starvation through physiological and biological changes in their body because their basal energy consumption is generally lower compared to terrestrial vertebrates and hence their metabolic demands further decline during starvation [21]. Starvation is usually the result of poor husbandry and, in many cases, is a squeal to environmental problems. A poorly designed or maintained system is likely to develop water quality problems with related morbidity or mortality among the fish. In an effort to correct the water quality problems aquarists may cut back on feed to the point where the fishes are in a negative caloric balance and being to lose weight, if the problem becomes chronic, starvation can result [27]. Although ornamental freshwater fish are highly adaptable to culture conditions and are capable of living under a wide range of environmental conditions [33] but there is increasing evidence that starvation may be a major cause of mortality in both immature and adult fishes [35].

Mortality rates in the industry may increase when collectors are unskilled and take little care of

The health and conditions in which the fish are kept and have no knowledge on survival performance of these fishes without feeding condition [28]. Ornamental fish can suffer high mortality rates during catch, transport, quarantine and other practices, with one estimate of 80% mortality in the Amazon [19] and up to 85% in the Lower Guinean rainforest [3]. In Brazil, marine fish were reported to be inadequately handled and stored in most cases and mortality in holding tanks immediately after collection was estimated to be at least 30-40% [9]. It was also estimated that 30% mortality was suffered during the export process in Brazil [5]. Substantial mortality rates might be suffered in holding facilities in Peru, due to the rudimentary export facilities and inadequate knowledge on survival [26]. Fish should be moved efficiently to minimize stress and mortality, because any trauma and stress associated with handling and transport of fish will affect survival and overall quality of the fish [6].

Well-managed shipping, husbandry practices and proper knowledge on survival performance of fish under starved condition can help to keep mortality levels low [36]. As exotic ornamental fishes have to transport at long distance without feeding condition, therefore stress becomes arise due to starvation and leads to weak and death. Several authors have already been published their books and research works about exotic ornamental fishes of Bangladesh and adjacent countries [1, 8, 24, 25]. Although their efforts were very promising but there was some lacking too on such type of information by targeting research objectives and to the best knowledge of the authors, this was the first attempt for describing the effect of starvation on survival performance of exotic ornamental fishes of Bangladesh in aerated and non-aerated aquaria with special reference to their weight loss and water quality parameters.

2. Materials and Methods

2.1 Duration and location of the study

The whole research work was conducted for a period of eighteen months (July 2011 to December 2012) to observe the survival performance of exotic ornamental fishes of Bangladesh under starved condition in aquaria in the Department of Fisheries of University of Rajshahi, Rajshahi, Bangladesh in laboratory condition.

2.2 Experimental design

The present research was set up under two treatments (T_1 and T_2) for each experiment. In each experimental treatment, fish was released at the number of three for a same species under starved condition and here fishes were treated as replication in determining the survival performance of fish. Treatment assignment was as follows:

T_1: Aquaria with no aerator facilities

T_2: Aquaria with aerator facilities

The major source of water for experimental aquaria was tap water. Aquaria size (90 cm × 35 cm × 35 cm) and volume of water (approximately 65 liters) was kept same for all treatments and experiments.

2.3 Commencement of study

Experimental exotic ornamental fishes were collected from local aquaria shop keepers of Rajshahi, Bangladesh. Fishes were in similar size and age groups. Then fishes were acclimatized in laboratory condition for a certain period and conditioned for a week. During conditioning of fish, packed feed feeding was also performed twice a day. After seven days, conditioned experimental exotic ornamental fishes were released into the experimental aquaria and then the experiment was begun. After that, survival performance and weight loss were analyzed and water quality parameters were measured under starved condition in aquaria during the study period.

2.4 Topics related to study

2.4.1 Survival performance of experimented fish species

Survival performance was measured by observing the time duration between the point of stop feeding and the point of time when fish was died during the period of experiment in case of each fish species. Then it was averaged and expressed in hours. The available fish species found during the experiment were listed in the Table 1.

2.4.2 Weight loss of experimented fishes for starvation

Weight loss was estimated by subtracting initial weight, IW (gm) from Final weight, FW (gm) where IW was taken at the time of releasing of fish and *FW* was taken at the time when fish was died. Weight loss per day (WL/D) was estimated by dividing weight loss of fish with their survival days. Percentual daily weight loss (% DWL) was estimated by dividing weight loss per day with initial weight of fish and then multiplying by 100.

2.4.3 Physico-chemical parameters of aquaria's water

Physico-chemical parameters viz., water temperature, hydrogen ion concentration (pH), dissolved Oxygen (DO), free carbon dioxide (CO_2), ammonia-Nitrogen (NH_3-N_2), total alkalinity and chlorine were measured twice a week between 09.00 and 11.00 AM on each sampling day to develop idea about the condition of water quality of aquaria during each experiment. pH, DO, free CO_2, NH_3-N_2, alkalinity and chlorine were measured by using HACH kit (FF-2).

2.5 Data analysis

Data related on survival performance, weight loss and water quality under different experimental treatments was subjected to computer software Microsoft Excel to analyze mean and standard error (±SE).

3. Results and Discussions

3.1 Survival performance of experimented fishes

Among the experimented exotic ornamental fishes, comparatively higher survival performance was found in marble angel (*P. scalare*) (T_1, 836±4.32 hours and T_2, 1022±4.02 hours) under the family Cichlidae and order perciformes whereas lower survival performance was found in albino suckermouth catfish (*H. plecostomus*) (T_1, 116±2.44 hours and T_2, 160±3.87 hours) under the family Loricariidae and order siluriformes. Comparatively lower survival performance under the family Loricariidae (suckermouth catfish, *H. plecostomus*) might be due to the albino variety and more sensitive to the environmental variation and comparatively higher survival performance under the family Cichlidae (marble angel, *P scalare*) might be due to the physical strength, slow moving behaviour which made them less metabolic energy loss than others [37]. It was also reported that a scarcity of food reduced fertility and survivability in the guppy, *P. reticulate* [12]. In almost all experiments, comparatively higher survivability was found in the treatment T_2 than treatment T_2. It might be due to the comparatively suitable environment in the treatment T_2 than the treatment T_1 because of having aerator facility of that treatment [37]. Because water movement and circulation served to oxygenate the water so that fish had the air they need to breathe and survive. Furthermore, aerator agitated the water surface which broke surface tension and allowed for a proper exchange of gases [33]. Moreover, aeration didn't make aquaria's water temperature higher and retained oxygen content in suitable limit. This study was also proved that, aeration is an important mechanism in lifting up the survival performance of fishes which are kept under captive condition either tanks or aquaria. The survival performance of experimented exotic ornamental fish species is given in the following Figure 1.

Table 1: List of experimented fishes, feeding habit and expected life time in nature

Family	Scientific Name	Common Name	Feeding habit	Expected Life span (Years)	References
Cyprinidae	*Carassius auratus*	Fantail Gold fish	Omnivore	5-10	[31]
	Epalzeorhynchus frenatus	Rainbow shark	Omnivore and Herbivore	5-8	[16]
	Barbus tetrazona	Tiger Barb	Omnivore	5-6	[22]
	Danio rerio	Zebra fish	Omnivore	5-6	[10]
Cobitidae	*Acantopsis choirorhynchos*	Horseface Loach	Omnivore	up to 5	[13]
Cichlidae	*Pterophyllum scalare*	Marble Angel	Omnivore	10-12	[31]
Osphronemidae	*Trichogaster trichopterus*	Golden Gourami	Omnivore	4-6	[31]
Poeciliidae	*Poecilia reticulate*	Guppy	Omnivore	2-4	[32]
	Poecilia sphenops	Black Molly	Omnivore	3-5	[14]
	Xiphophorus helleri	Swordtail	Omnivore	3-5	[7]
Pangasidae	*Pangasius hypophthalmus*	Tiger Shark	Omnivore	8-10	[17]
Loricariidae	*Hypostomus plecostomus*	Sucker mouth	Herbivore	10-15	[15]
Mochokidae	*Synodontis decorus*	Clown catfish	Omnivore	5-8	[18]
Characidae	*Gymnocorymbus ternetzi*	Black skirt widow tetra	Carnivore	4-5	[30]

* Here "O" indicates Ornamental and "F" indicates Food fish

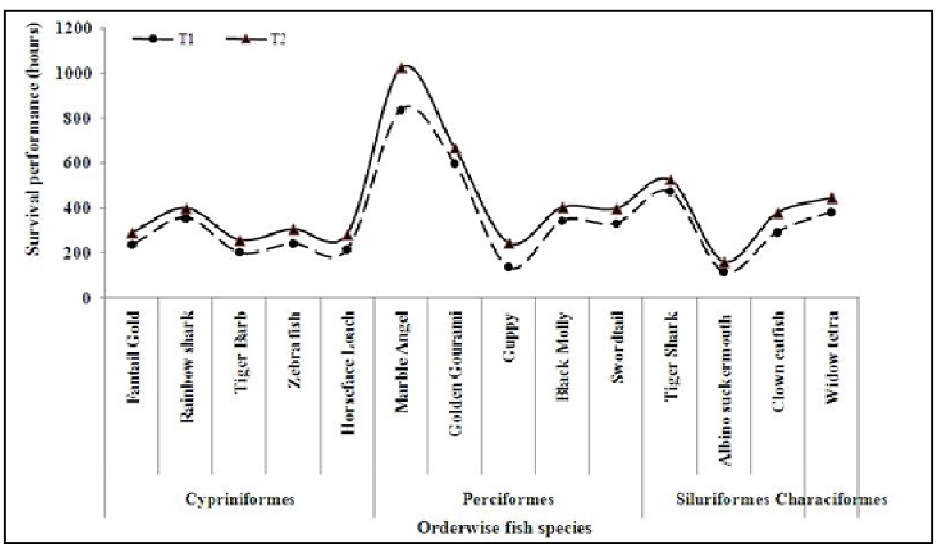

Fig 1: Survival performance of experimented fishes under starved condition in aquaria (In legend T_1 denotes for Treatment 1 and T_2 denotes for Treatment 2)

3.2 Weight loss of experimented fishes

During the study period, mean initial weight, mean final weight, mean weight loss, mean daily weight loss and percentual daily weight loss were found to be varied from

0.33±0.01 to 10.45±0.43 gm, 0.28±0.01 to 10.19±0.30 gm, 0.05±0.01 to 0.33±0.09, 0.003±0.00 to 0.022 gm and 0.07±0.005 to 2.16±0.134 gm. Details on the weight loss of experimented exotic ornamental fishes under starved condition are shown in the Table 2. Among the experimented fishes, black molly, tiger shark and widow tetra were lost their weight daily around 0.003±0.00 g (lower) whereas gold fishes were lost their weight daily around 0.022±0.003 g (higher). Comparatively fishes of the treatment T_1 lost their mean daily weight in high percentage than the fishes of the treatment T_2 due to the lower survival days. Almost similar assumption was made by other researchers [37]. Another researcher stated that, the starved fish showed a significant weight loss during the experiment compared with their starting weight [38]. These findings again proved that, body weight of fish is reduced due to starvation.

Table 2: Weight loss of fishes in different treatments during the study period.

Fish species	Treatment	Mean Initial weight (g)	Mean Final weight (g)	Mean Weight loss (g)	Mean Weight loss/Day (g)	Percentual daily weight loss (g)
Carassius auratus	T_1	8.33±0.40	8.13±0.39	0.20±0.05	0.020±0.007	0.24±0.082
	T_2	8.66±0.28	8.39±0.27	0.27±0.03	0.022±0.003	0.25±0.028
Epalzeorhynchus frenatus	T_1	3.00±0.21	2.84±0.19	0.16±0.01	0.011±0.000	0.356±0.014
	T_2	3.03±0.09	2.82±0.07	0.21±0.02	0.012±0.000	0.397±0.005
Barbus tetrazona	T_1	0.57±0.03	0.47±0.02	0.10±0.00	0.010±0.001	1.756±0.244
	T_2	0.61±0.02	0.51±0.02	0.10±0.00	0.008±0.001	0.372±0.094
Danio rerio	T_1	0.34±0.01	0.29±0.00	0.05±0.01	0.005±0.000	1.48±0.079
	T_2	0.37±0.02	0.30±0.01	0.07±0.01	0.005±0.000	1.46±0.074
Acantopsis choirorhynchos	T_1	10.25±0.16	10.00±0.13	0.25±0.03	0.017±0.001	0.16±0.008
	T_2	10.45±0.43	10.19±0.37	0.26±0.06	0.015±0.003	0.14±0.023
Pterophyllum scalare	T_1	3.48±0.26	3.35±0.25	0.13±0.01	0.004±0.006	0.11±0.016
	T_2	3.54±0.09	3.40±0.09	0.14±0.02	0.003±0.000	0.10±0.009
Trichogaster trichopterus	T_1	7.30±0.15	7.04±0.14	0.26±0.01	0.006±0.001	0.08±0.039
	T_2	7.33±0.22	7.00±0.12	0.33±0.09	0.005±0.001	0.07±0.005
Poecilia reticulata	T_1	0.33±0.01	0.28±0.01	0.05±0.01	0.006±0.000	2.16±0.134
	T_2	0.34±0.02	0.29±0.02	0.05±0.01	0.005±0.001	1.44±0.227
Poecilia sphenops	T_1	0.44±0.04	0.39±0.03	0.05±0.01	0.003±0.000	0.66±0.048
	T_2	0.45±0.02	0.40±0.02	0.05±0.00	0.004±0.001	0.77±0.098
Xiphophorus helleri	T_1	1.03±0.04	0.95±0.04	0.08±0.00	0.006±0.000	0.51±0.03
	T_2	1.10±0.03	1.01±0.03	0.09±0.01	0.005±0.000	0.48±0.03
Pangasius hypophthalmus	T_1	8.43±0.08	8.09±0.07	0.24±0.008	0.012±0.003	0.047±0.07
	T_2	8.50±0.14	8.24±0.14	0.26±0.003	0.011±0.002	0.062±0.04
Hypostomus plecostomus	T_1	3.82±0.07	3.74±0.10	0.08±0.03	0.015±0.001	0.39±0.02
	T_2	3.85±0.04	3.76±0.05	0.09±0.01	0.013±0.002	0.33±0.05
Synodontis decorus	T_1	0.55±0.07	0.46±0.06	0.09±0.01	0.007±0.000	1.24±0.14
	T_2	0.55±0.09	0.45±0.08	0.10±0.01	0.006±0.001	1.17±0.17
Gymnocorymbus ternetzi	T_1	0.49±0.06	0.44±0.05	0.05±0.01	0.003±0.000	0.68±0.05
	T_2	0.55±0.04	0.49±0.03	0.06±0.01	0.003±0.000	0.59±0.04

3.3 Water quality parameters

During study period, water quality parameters under different treatments remained favorable for all experimented fish species. Water temperature found to be ranged from 25.66±0.17 °C (for *B. tetrazona*) to 28.66±0.35 °C (for *C. auratus*). The water temperature found in one study ranges from 26-31 °C for ponds and 26-30 °C for aquaria tanks [29]. Water depth remained same throughout the experiment (20.00±0.00 cm). The range of water depth (12-18 cm) reported by another was also closer to the value found in the present study [20]. DO and free CO_2 were found to be ranged from 3.80±0.06 mg/l (for *B. tetrazona*) to 4.73±0.07 mg/l (for *T. trichopterus*) and 9.21±0.05 mg/l (for *P. sphenops*) to 11.75±0.03 mg/l (for *P. scalare*) respectively. Another researcher found the DO in his study ranges from 4.5-4.8mg/l for aquaria tanks which was more or less similar to the value in the present study [29]. One scientist found CO_2 level ranges from 9-13 mg/l in studying water quality in experimental aquaria tanks with 80 % survival rate which was much closer to the value of the present study [23]. pH varied from 7.13±0.05 (for *X. helleri*) to 7.47±0.07 (for *P. scalare*). Another researcher recorded pH in their study ranges between 6.5-8.5 mg/l which much closer to the result of the present study [2]. Almost similar finding was also found by other researchers [23]. Total alkalinity was found to be ranged from 76.66±1.64 mg/l (for *B. tetrazona*) to 108.92±3.20 mg/l (for *P. scalare*) which was strongly supported by the assumption of Ghosh [11]. NH_3-N_2 and chlorine level were found to be ranged from 0.0010±0.0006 mg/l (for *H. plecostomus*) to 0.0133±0.002 mg/l (for *P. scalare*) and 0.0045±0.001 mg/l (for *B. tetrazona*) to 0.012±0.0014 mg/l (for *C. auratus* and *X. helleri*) respectively. Optimal NH_3-N_2 and chlorine level ranges from 0.011 to 0.5 mg/l and 0.003 to 0.2 mg/l found in three experimental aquaria tanks were much closer to the value of the present study [23]. Details findings related to water quality parameters are given in Table 3.

Table 3: Water quality parameters recorded in different treatments during the study period

Fish species	Treatment	Water temp. (°C)	DO (mg/l)	Free CO_2 (mg/l)	pH	Total alkalinity (mg/l)	NH_3-N_2 (mg/l)	Chlorine (mg/l)
Carassius auratus	T_1	28.66±0.35	4.34±0.03	11.61±0.05	7.21±0.09	96.21±3.50	0.0054±0.0020	0.012±0.0014
	T_2	28.54±0.40	4.63±0.06	11.17±0.06	7.22±0.10	97.23±3.17	0.0034±0.0010	0.010±0.0019
Epalzeorhynchus frenatus	T_1	26.81±0.35	4.23±0.08	9.58±0.08	7.23±0.08	97.06±2.34	0.0037±0.0011	0.010±0.0007
	T_2	26.79±0.40	4.67±0.09	9.25±0.06	7.23±0.08	97.95±2.70	0.0020±0.0005	0.008±0.0014
Barbus tetrazona	T_1	25.66±0.17	3.80±0.06	10.38±0.06	7.25±0.14	76.66±1.64	0.0023±0.0011	0.006±0.0007
	T_2	25.66±0.17	3.98±0.03	10.11±0.03	7.25±0.14	76.93±1.48	0.0015±0.0007	0.0045±0.001
Danio rerio	T_1	26.33±0.24	4.16±0.03	9.43±0.03	7.13±0.07	79.53±1.62	0.0023±0.0011	0.0045±0.001
	T_2	26.33±0.24	4.32±0.02	9.26±0.02	7.13±0.07	79.84±1.80	0.0014±0.0007	0.0050±0.001
Acantopsis choirorhynchos	T_1	26.21±0.14	4.31±0.05	9.74±0.04	7.20±0.12	85.84±1.95	0.0028±0.0010	0.008±0.0009
	T_2	26.17±0.15	4.57±0.03	9.49±0.03	7.20±0.12	86.97±2.66	0.0013±0.0005	0.006±0.0014
Pterophyllum scalare	T_1	28.50±0.09	4.20±0.03	11.75±0.03	7.46±0.07	105.46±3.0	0.0133±0.002	0.008±0.0006
	T_2	28.43±0.12	4.65±0.03	11.03±0.03	7.47±0.07	108.92±3.2	0.0085±0.001	0.006±0.0009
Trichogaster trichopterus	T_1	27.18±0.18	4.11±0.08	9.80±0.08	7.46±0.13	91.01±1.84	0.0056±0.0011	0.010±0.0011
	T_2	27.17±0.18	4.73±0.07	9.21±0.08	7.46±0.13	92.08±2.22	0.0031±0.0006	0.008±0.0016
Poecilia reticulata	T_1	26.45±0.21	4.38±0.06	9.59±0.06	7.13±0.07	92.55±1.72	0.0028±0.002	0.011±0.0011
	T_2	26.39±0.19	4.58±0.05	9.24±0.05	7.13±0.07	93.60±1.68	0.0015±0.001	0.01±0.00160
Poecilia sphenops	T_1	26.64±0.20	4.35±0.07	9.57±0.07	7.14±0.05	94.59±1.27	0.0045±0.0012	0.011±0.0012
	T_2	26.56±0.21	4.70±0.05	9.21±0.05	7.14±0.05	94.95±1.38	0.0025±0.0007	0.009±0.0016
Xiphophorus helleri	T_1	26.94±0.20	4.23±0.04	9.73±0.06	7.13±0.05	83.66±0.88	0.0052±0.0018	0.012±0.0014
	T_2	26.88±0.17	4.43±0.05	9.54±0.03	7.13±0.05	83.99±1.12	0.0030±0.0011	0.01±0.00190
Pangasius hypophthalmus	T_1	27.06±0.16	4.17±0.06	9.76±0.07	7.38±0.12	92.28±1.92	0.0050±0.0010	0.010±0.0014
	T_2	27.05±0.16	4.65±0.08	9.27±0.07	7.38±0.12	93.20±2.05	0.0027±0.0006	0.008±0.0010
Hypostomus plecostomus	T_1	26.67±0.17	4.12±0.03	10.12±0.06	7.17±0.17	75.33±1.33	0.0017±0.0009	0.011±0.0009
	T_2	26.67±0.17	4.23±0.04	9.93±0.03	7.17±0.17	75.55±1.40	0.0010±0.0006	0.009±0.0017
Synodontis decorus	T_1	26.20±0.35	4.07±0.04	9.79±0.05	7.21±0.09	84.63±1.12	0.0032±0.0011	0.010±0.0006
	T_2	26.18±0.40	4.23±0.02	9.61±0.03	7.21±0.09	85.08±1.32	0.0016±0.0005	0.008±0.0013
Gymnocorymbus ternetzi	T_1	26.05±0.21	3.85±0.05	9.83±0.05	7.25±0.09	77.92±2.08	0.0035±0.0014	0.007±0.0008
	T_2	26.03±0.20	4.20±0.05	9.43±0.03	7.25±0.09	79.25±2.74	0.0023±0.0007	0.006±0.0012

In this table: Blue colour denotes higher value and Orange colour denotes lower value

4. Conclusion

This research showed that aeration system can create healthier environment for fish than that of the without aeration one. The experiment counseled that exotic ornamental fishes which have lower survival performance should require extra concern during both husbandry and transportation practices (especially for brood and fingerling) in famished condition. The research findings can be helpful for rearing exotic ornamental fishes in aquaria and fish tanks during feeding management to uphold good husbandry and can also be used specially in transportation. Supplementary research is needed to explore the viability of species combination of indigenous ornamental fish species alone or with exotic ornamental fishes in terms of their survival performance under starved condition.

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