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Research Article

Transportation and Acclimation Optimisation of Wild Marble Goby (*Oxyeleotris marmorata* Bleeker, 1852)

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ABSTRACT

The Marble goby (*Oxyeleotris marmorata* Bleeker) is usually found in freshwater bodies. Due to its high commercial value and demand, it is farmed in cages and pond systems. Marble goby fish are preferred to be freshly killed and processed upon request in Asian restaurants. Currently, there are some challenges faced by fishermen who wish to transport live fish to restaurants or markets due to the traditional method of using water tanks as carriers. These water tanks are usually very heavy and bulky, increasing transportation costs. Furthermore, coping with the survivability of fish post-transportation has proven to be a challenge. This study was aimed at investigating the semi-dry method for fish transport and acclimatization of fish after transport in different tank sizes. In the semi-dry, where fish were covered using a towel transportation method where the survival rate at ~92%. For the acclimation experimental group, stream water was found to be the most appropriate type of water for rearing the marble goby fish, which demonstrated a conspicuous survivability rate of ~83%. whereas, for adaptation, marble goby fish from the wild had a faster adaptation rate in smaller spaces like aquariums as compared to large 'stock tanks.' To the best of our knowledge, this is the first study that will provide a better understanding of the transportation method, acclimation conditions, and habitat that can lead to a reduction in the mortality rate during the marble goby transit processes.

Key words: *Oxyeleotris marmorata*, tank adaptation, transportation stress, water stress

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INTRODUCTION

The Marble goby (*Oxyeleotris marmorata* Bleeker) is a freshwater euryhaline teleost that belongs to the family Eleotridae (Sleepers). It is commonly known as "Soon Hock or Ketutu" among Southeast Asian people (Lam *et al*., 2008; Chew *et al*., 2009). It is the inhabitants of freshwater bodies such as rivers, swamps, canals, reservoirs, and estuaries. Marble goby is farmed in some Asian countries in conventional cages and outdoor pond systems located in freshwater waterways (Herawati *et al*., 2016). Marble goby fish fetches a high price in the Asian market, ranging from USD 20 to 50 per kilogram (Law *et al*., 2021). Due to high market demand and economic value, it is considered a profitable aquaculture species. Various efforts have been made to improve the farming technique of marble goby. Thus, there is an increasing number of marble goby production. (Lin & Kaewpaitoon, 2000; Seetapan *et al*., 2012; Lam *et al*., 2014a; Lam *et al*., 2014b; Herawati *et al*., 2016). However, transporting this species live to its designated restaurants is very costly and challenging, where the fish is preferably prepared fresh for consumption.

Live fish transportation of marble goby fish is widely done in a closed system or an open system water tank, resulting in the induction of the subject stress. This is due to the deteriorating water quality, high packing density, oxygen level, and the accumulation of metabolic wastes within the limited holding space (Paterson *et al*., 2003; Urbinati *et al*., 2004; Dhanasiri *et al*., 2013; Refaey & Li, 2018).

There are some reports (from personal communication) that there are Malaysian farmers or fishermen who have been transporting marble goby semi-dry by covering the fish with either wet paper or a wet towel. However, the practice is not standardized and scientifically validated. Therefore, the objective of this study was to investigate the effects of transportation methods, acclimation of fish, and adaptation to different tank sizes. This is the first study that will provide a better understanding of the fish transportation method, acclimation conditions, and habitat which will probably lead to improvements in lowering losses for fishermen.

MATERIALS AND METHODS

Fish sample preparation

The healthy specimens of marble goby having a body mass of between 250 g and 350 g were captured using a fish trap (bubu) to minimize physical injuries from Tasik Kelau, Bentong, Malaysia (Coordinates 3° 34' 40.9224 "N 101° 59' 17.7504 "E). These specimens were transported to the Makmal Genomik 1 (MG1) lab (Coordinates 2° 54' 50.061" N, 101° 47' 19.0062" E) at the Universiti Kebangsaan Malaysia (UKM).

Fish transportation approach

The marble goby fishes were divided into four (4) experimental groups (*n*=10), which were; (1) Air aerator group, wherein water in a container was continuously saturated with ambient air using battery power portable aerator; (2) Oxygenated water group, wherein fishes were kept in plastic bags filled with water at 30% volume and remaining volume was filled with compressed oxygen (99.2%); (3) Wet towel group, wherein fish were covered using a towel soaked with water and (4) Water group, wherein fishes were kept in a container containing with simple water. The transportation containers (35 cm × 25 cm × 10 cm) were used to hold the fish during the transportation. The temperature during transport was continuously monitored and maintained between 25 °C to 28 °C (Figure 1). Transportation of fish was conducted using a Proton Exora, a multipurpose vehicle. The survival rate of all subjects was examined after transportation. Ten specimens with an average body mass of between 250 g to 350 g were used during each experiment and each experiment was repeated three times, with an interval of 30 days between each replicate.

Fish acclimation in different water sources

In this experiment, the acclimation of marble goby fish was determined in controlled laboratory conditions. The newly caught wild marble goby specimens were kept in four different water sources, which are: (1) Tap water; (2) Aged tap water (2 weeks old tap water, kept in the tank before being used); (3) Aged rainwater (2 weeks aged of collected rainwater); and (4) Stream water (collected from a stream at Tasik Ghazali, the water source of a river within UKM. All water types were aerated with electric aerators (Atman HP-4000 Aquarium Pump, China) in 3-foot tanks (91 cm × 75 cm × 43 cm) continuously throughout the experiment (Figure 2). The marble goby was fed once a day ad libitum with live fish fingerling, sourced from a pet shop in the vicinity of Bandar Baru Bangi, Selangor Malaysia. The aquarium temperature was maintained between 26 °C to 28 °C, and the dissolved oxygen was at the rate of 3 mg L^{-1} or more. The water variable pH used was adjusted to a pH range between 7.0 to 7.5 using either Aquadene Aquarium PH down or PH up, Malaysia. The parameters used to adhere to the best culturing methods known for *O. marmorata* (Herawati *et al*., 2017; Larson & Murdy, 2001). The survival rate of all specimens was analyzed for up to 30 days. Ten specimens with an average body mass of 250 g to 350 g were used during each experiment, and each experiment was repeated three times, with an interval of 30 days between each replicate.

Observation of agitating behavior of acclimatizing fish in different stock tank sizes

This experiment was conducted to observe the adaptability of marble goby fish to different tank sizes. Three different tank sizes were used, a 3-foot tank (91 cm × 75 cm × 43 cm), a 6-foot tank (182 cm × 85 cm × 90 cm), and an aquarium (120 cm × 45 cm × 50 cm) Figure 3. Plastic and glass tank materials were used because they are clean, non-toxic to fish, and smooth that will not damage fish upon contact. In each experiment, six specimens were used, and each experiment was repeated three times. The newly caught marble goby specimens were placed in these three different tanks and their swimming time was counted from their release until they rested at the tank bottom.

Statistical analysis

The survival rates of marble goby fish were determined and presented as means and their standard errors of the means (S.E.M).

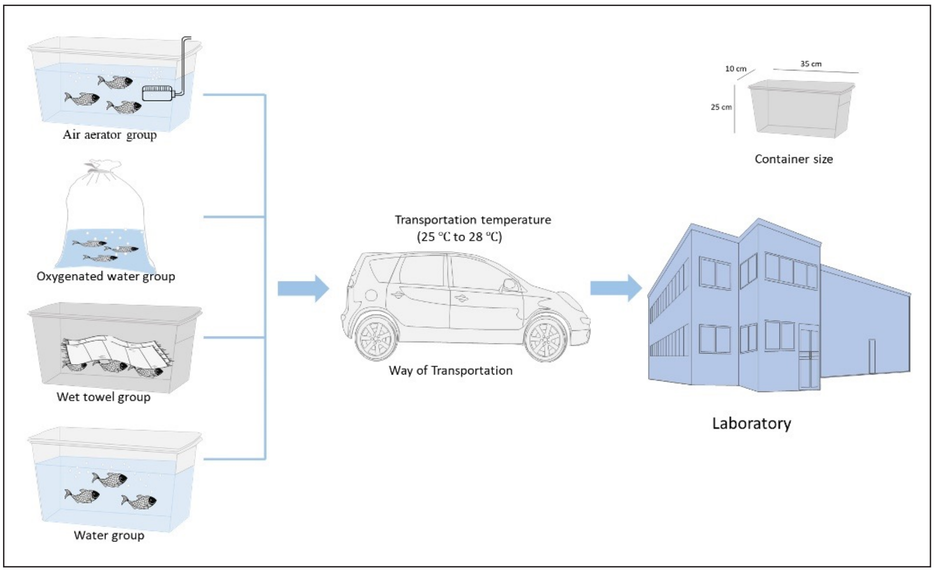

Fig. 1. Fish Transportation approach. Fish were transported from Tasik Kelau, Bentong, Malaysia to the Makmal Genomik 1 (MG1) lab at the Universiti Kebangsaan Malaysia (UKM). Transportation of fish was conducted using a multipurpose vehicle. Ten specimens with an average body mass of between 250 g to 350 g were used during each experiment and each experiment was repeated three times, with an interval of 30 days between each replicate.

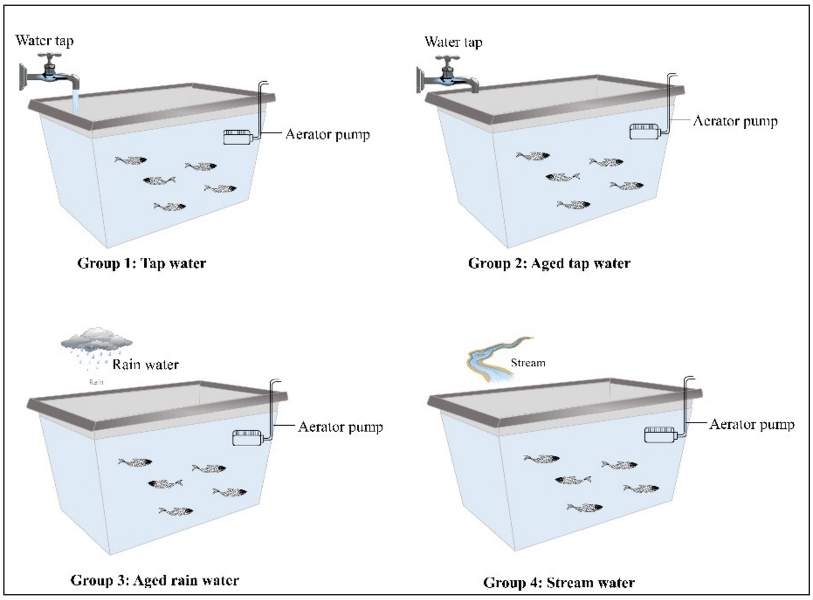

Fig. 2. Fish acclimation in different water sources layout. The newly caught wild marble goby specimens were kept in four different water sources, Group 1: Tap water; Group 2: Aged tap water; Group 3: Aged rainwater and Group 4: Stream water. The water condition was maintained at 26 °C to 28 °C, dissolve oxygen was at the rate of 3 mg L^{-1} or more and water pH was in the range between 7.0 to 7.5. The marble goby was fed once a day ad libitum with live fish fingerling. Ten specimens with an average body mass of 250 g to 350 g were used during each experiment, and each experiment was repeated three times, with an interval of 30 days between each replicate.

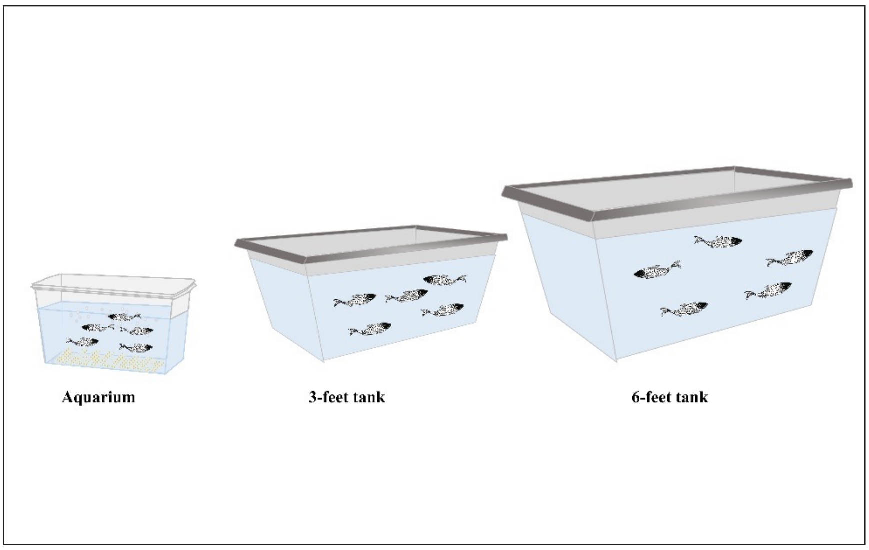

Fig. 3. Fish acclimatizing at different stock tank sizes. Marble goby swimming time was counted from their release until they rested at the tank bottom. Six specimens were used for each experiment and were repeated three times.

RESULTS

Survivability of fish during transport

The survival rate of marble goby fish was observed in the 4 designed groups after being transported from Tasik Kelau, Bentong, Malaysia to the Makmal Genomik 1 (MG1) lab at the University Kebangsaan Malaysia (UKM), with a distance of 147 KM and average traveling time of 2 h 25 min. From our observation Figure 4, groups 3 and 2, where marble goby specimens were covered with wet towels and kept in oxygenated water in plastic bags, showed a prominent survival rate of 92% and 84%, respectively. Compared to groups 2 and 3, the survivability rate was slightly lower in group 1 (72%) where fish were kept in air-aerated water containers. The survivability rate was observed to be lowest in group 4 (58%) wherein water was used in containers for fish transport.

Survivability of acclimatizing fish in different water sources

The acclimation of marble goby fish to different water types was investigated for 30 days, and the survival rate was calculated under controlled laboratory conditions. The results of their acclimation were presented in Figure 5. Group 4, where stream water was used to culture the marble goby fish, demonstrated a conspicuous survivability rate of 83%. The survivability rate in group 3 was 60% where aged rainwater was used. In groups 1 and 2, where treated household water tap water supply and aged tap water supply were used respectively, they showed a 50% survival rate during the acclimation period.

Observation of agitating behavior of acclimatizing fish in different stock tank sizes

The accustoming of marble goby fish to different water tank sizes was observed by determining the time the marble goby take before resting idly at the bottom of the tank Marble goby are a natural bottom ambushing predator which is recorded to sit idly underwater in a relaxed state (Lim *et al*., 2020). Group 3, where an aquarium was used to rear the fish, showed the most suitable place to live among the three different tanks (Figure 6). Results demonstrated that marble goby fish quickly adapt to the aquarium environment in 10.32 sec. The results of the 3-foot tank also demonstrated a favorable living habitat for marble goby fish, wherein they adapt to the environment in 19.16 sec. The 6-foot tank results were less appropriate for marble goby fish, which showed higher disturbance in adapting to this environment (Figure 6).

DISCUSSION

Common fish farming practices, including capturing from the wild, handling, high stock density, and transportation, have been considered stress drivers and thus affect fish reproduction, restricting their rearing and propagation (Pankhurst & Kraak, 1997). It is essential to mitigate the stress stimulators in the environment for the successful culturing of juveniles or mature fish. Understanding stress stimulators and their management are essential for optimal performance during live fish transport (Carneiro & Urbinati, 2002). Thus, it is crucial to determine the response of fish to transport and, in addition, to examine the optimum densities for transportation. During the

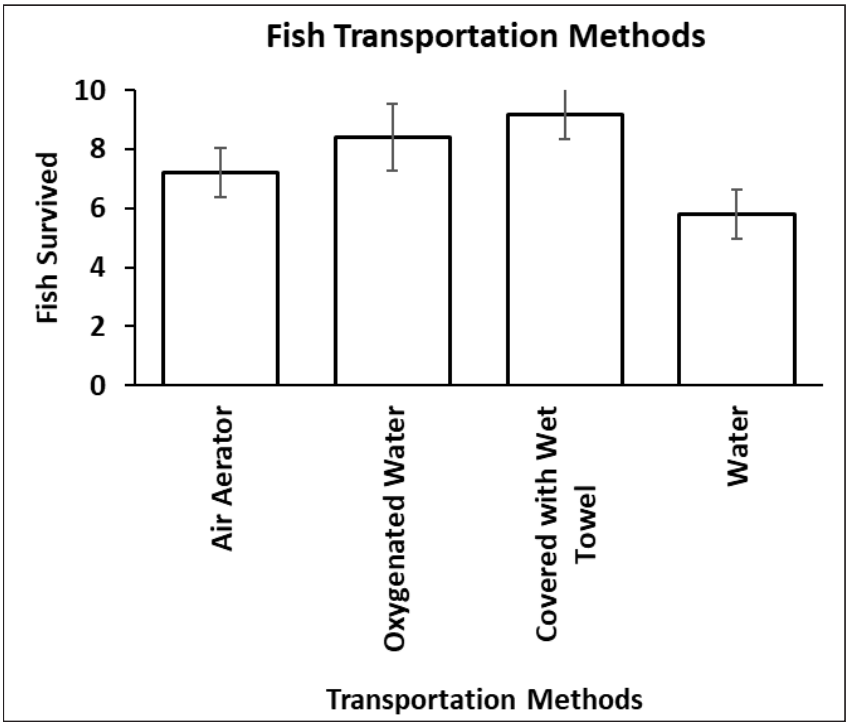

Fig. 4. Marble goby fish survivability rate after being transported using various mediums. The *p*-value between each group was determined using one-way ANOVA, $p \leq 0.05$.

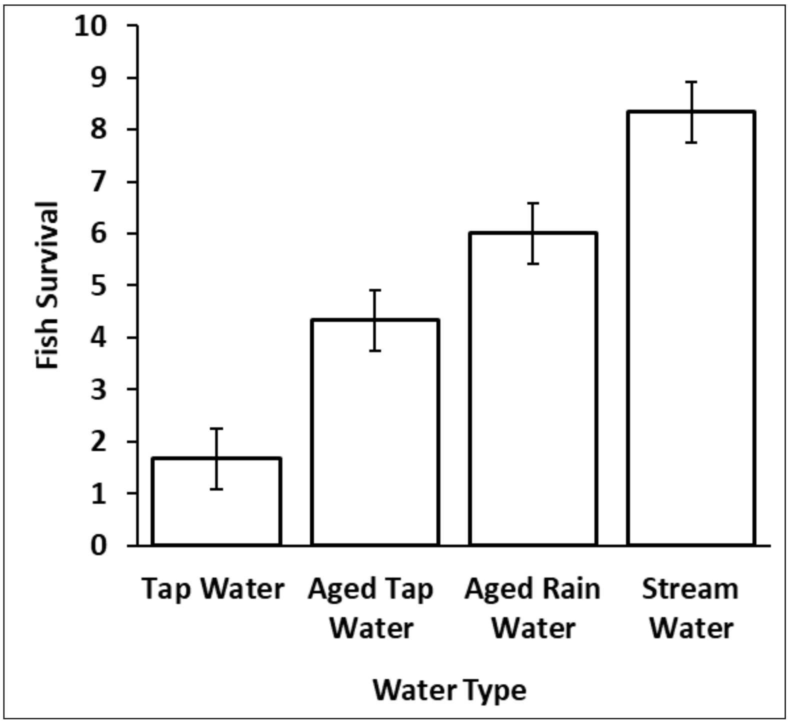

Fig. 5. The survivability rate of marble goby fish upon acclimation to different water. The *p*-value between each group was determined using one-way ANOVA, $p<0.05$.

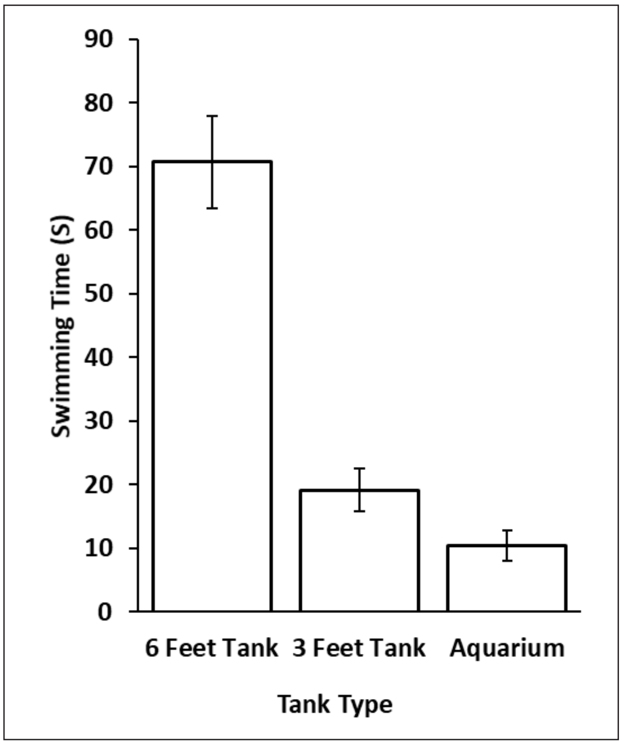

Fig. 6. The adaptability rate of marble goby fish to different water tank sizes**.** *The p*-value between each group was determined using one-way ANOVA, $p \leq 0.05$.

transportation period, the number of fish depends on the duration of transport, water temperature, dissolved oxygen, size, and holding system *(*Vijayan & Leatherland*,* 1990*;* Metar *et al*., 2018). Previous studies reported that the sock density of fish in a container or tank and duration had a particular effect on the physiological response of fish (Nikoo & Falahatkar, 2012; Bittencourt *et al*., 2018). However, in the present study, the effect of transportation methods, acclimation to different water types, and adaptation to different tank sizes were investigated.

Previous studies suggested that by ensuring good water quality and avoiding stress and mortality, strict transportation management should be set for each fish species (Das *et al*., 2015; Bittencourt *et al*., 2018). During the transportation period of our study, fish were placed juxtaposed to each other (five fish in each container) in all the designed containers to manage the stock density and to mitigate vibrations and moving injuries during transport. Furthermore, in our experimental design, we used all three types of live fish transport systems: the open system method, which uses water-filled containers; the closed water system, which uses closed water containers or bags; and the waterless system. The optimized water temperature condition is among the factors which increase transport efficiency and, consequently enhance fish survivability (Pavlidis *et al*., 2003). The optimal temperature for rearing the marble goby is between 22 °C and 28 °C (Larson & Murdy, 2001). Therefore, temperatures between 25°C and 28°C can be considered an appropriate temperature for marble goby transport for short distances. The results of the study demonstrated the most suitable transport method for marble goby fish to be transported to the laboratory. From the four total groups, group 3 (where fishes were covered with wet towels) showed the highest vitality rate (92%) followed by group 2 (84%) where oxygenated water in plastic bags was used (Figure 4). These results illustrate the most adequate method for marble goby live transportation. By using these two methods, the live transportation of marble goby fish can be done to get a more productive outcome. Other methods demonstrated a high mortality rate as compared to the two groups mentioned before, revealing their less productive output.

When a fish leaves its native habitat, a self-sustaining environment that meets its basic requirements must be provided (Fazry *et al*., 2017). Some previous studies have reported that variation in tank color (transparent, grey, blue, and black) also significantly affects the survival rate of fishes (Ishibashi *et al*., 2013; Okada *et al*., 2015). After transportation, acclimation to the newly introduced environment is challenging for fish farming in the laboratory. Abrupt changes in a new environment such as water type, pH, dissolved oxygen, temperature, and salinity (Parisi *et al*., 2022) could increase the mortality rate of fish (Harmon, 2009). Considering these points, we used four different water types such as tap water, aged tap water, aged rainwater, and stream water, where the culturing pH and temperature had been adjusted to best-fit parameters in methods used for *O. marmorata* culturing (Larson & Murdy, 2001; Herawati *et al*., 2017). This is done to examine the acclimatization and survival rate of marble goby fish, based on water sources that could easily be obtained by farmers generally. From the four groups designed for acclimatization investigation, group 4 showed the highest survivability rate (83%) where stream water was used, indicating the more adequate water type for rearing the marble goby fish in laboratory conditions (Figure 5). These results were consistent with the other studies that suggested acclimatization of wild-captured fish species through environments that have similar characteristics resembling their wild environments increase their survivability compared to direct exposure to a new environment due to stress (Marchesan *et al*., 2009; Tumwesigye *et al*., 2022). The survivability rate in the remaining three groups was less promising for achieving a more productive output. Thus, the present study found the best rearing water type for mature marble goby fish in controlled laboratory conditions.

The marble goby is a bottom ambush predator, and its relaxed state was observed to be idle underwater (Lim *et al*., 2020). In a previous study conducted on marble goby cultivation in an enclosed environment, tank design and size were found to have effects on the growth of marble goby (Lam *et al*., 2014b), which could be related to stress level (Leal *et al*., 2011). Therefore, in this study, acclimatization of marble goby was done using tank sizes that are commonly found in the market and their swimming time was counted from their release until they rested idly at the tank bottom, which is an indicator of them being in a relaxed state. From the experimental observations, it can be deduced that marble goby fish might feel less disturbed, more comfortable, and more easily adapted to the aquarium environment as compared to 6 feet and 3 feet tanks, respectively.

CONCLUSION

In the present study, the effects of transportation methods, acclimation to different water types, and adaptation to different tank sizes were investigated. From this study, the best method to transport marble goby is by covering it with wet towels, where the survival rate is at around 92%. It is much higher compared to other methods such as air aerator (~72%), oxygenated water (~84%), and water (~58%). In terms of water types for water types, the survival rate for marble goby after 30 days was highest in stream water at the rate of ~83%. Whereas, the survival rate in other water sources after 30 days were at ~17%, ~43%, and ~60% for tap water, aged tap water, and aged rainwater, respectively. Marble goby goes into the idle state, indicating it's reaching a calm state when being released to a smaller holding tank such as an aquarium at the rate of ~10 sec as compared to 3 feet tank and 6 feet tank, at ~19 sec and 70 sec, respectively. The results of the present study will be useful in better understanding the transportation and farming conditions of marble goby. This, enhance the productivity of mature marble goby fish and reduces losses due to mortality, for farmers or fishermen.

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ETHICAL STATEMENT

This study was approved by ethical UKM Ethics Committee (Animal Ethics approval number: FST/2018/MOHDSHAZRUL/28-MAR./905-MAR2018-AUG-2019).

CONFLICT OF INTEREST

The authors declare no conflict of interests.

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