Original article
DOI: 10.19027/jai.22.1.36-46

The growth performance and physiological status of comet goldfish *Carassius auratus* in aquascape with different aquatic plant species

Kinerja pertumbuhan dan status fisiologi ikan komet *Carassius auratus* dalam akuaskap dengan spesies tanaman hias akuatik yang berbeda

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(Received July 7, 2022; Accepted August 16, 2022)

ABSTRACT

This study aimed to evaluate the growth performance and physiological status of comet goldfish (*Carassius auratus*) in aquascape with different aquatic plant species. Comet goldfish with average size of 6.5 ± 0.1 cm length and 9.1 ± 0.1 g weight were reared in aquascape aquarium at density of 10 fish/L for 45 days. The result of this study obtained a positive correlation between survival value and specific growth rate of the fish, followed by a significant difference value among the aquatic plant treatments compared to without aquatic plant treatments. Based on the total chromatophore cells, comet goldfish that reared in aquarium containing aquatic plants higher number of the total chromatophore cells compared to aquarium without aquatic plants. After blood glucose test, comet goldfish that reared with aquatic plants consistently showed a lower blood glucose level than without aquatic plants. The liver superoxide dismutase level of comet goldfish obtained a significant difference value between fish reared with aquatic plants and without aquatic plants, while the malondialdehyde value of all treatments was insignificantly difference. Also, the increased of total erythrocytes, total leucocytes, hemoglobin, and hematocrit were found on comet goldfish reared with aquatic plants. This study concluded that aquatic plants in rearing system can improve the survival rate, specific growth rate, and health status of comet goldfish due to mutualistic symbiosis discovered between fish and aquatic plants.

Keywords: blood glucose, chromatophore cells, phytoremediation, specific growth rate, superoxide dismutase

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi performa pertumbuhan dan status fisiologis ikan mas komet (*Carassius auratus*) dalam akuaskap dengan spesies tanaman air yang berbeda. Ikan mas komet dengan ukuran rata-rata panjang 6,5 ± 0,1 cm dan berat rata-rata 9,1 ± 0,1 g dipelihara dalam akuarium akuaskap dengan kepadatan 10 ekor/L selama 45 hari. Hasil penelitian menunjukkan terdapat korelasi positif antara nilai kelangsungan hidup dan laju pertumbuhan spesifik ikan, dengan perbedaan nilai yang signifikan antara perlakuan tanaman air dibandingkan dengan tanpa perlakuan tanaman air. Berdasarkan jumlah sel kromatofor, ikan mas komet yang dipelihara dalam akuarium yang berisi tanaman air memiliki jumlah total sel kromatofor yang lebih tinggi dibandingkan dengan akuarium tanpa tanaman air. Setelah dilakukan pemeriksaan glukosa darah, ikan mas komet yang dipelihara dengan tanaman air secara konsisten menunjukkan kadar glukosa darah yang lebih rendah dibandingkan tanpa tanaman air. Kadar suproksida dismutase hati ikan mas komet diperoleh nilai perbedaan yang nyata antara ikan yang dipelihara dengan tanaman air dan tanpa tanaman air, sedangkan nilai malondialdehida pada semua perlakuan tidak berbeda nyata. Peningkatan total eritrosit, total leukosit, hemoglobin, dan hematokrit juga ditemukan pada ikan mas komet yang dipelihara dengan tanaman air. Penelitian ini menyimpulkan bahwa tanaman air dalam sistem pemeliharaan dapat meningkatkan kelangsungan hidup, laju pertumbuhan spesifik, dan status kesehatan ikan mas komet karena adanya simbiosis mutualistik yang ditemukan antara ikan dan tanaman air.

Kata kunci: dismutase superoksida, fitoremediasi, glukosa darah, laju pertumbuhan spesifik, sel kromatofor

INTRODUCTION

Fish farming for commercial purposes is often carried out in an artificial aquatic environment where the ecosystem consists of incomplete or unbalanced biotic components, usually in the absence of producers (plants). In such incomplete ecosystems, fish farming tanks run out an environmental degradation which results in the high mortality of cultured fish and decrease in fish production. To overcome the problem of environmental degradation caused by waste production from aquaculture process (Dauda *et al*., 2019; Nizam *et al*., 2020), fish farming systems and technologies have been developed but are still high-cost (Yue & Shen, 2022). Plants and aquatic plants have been starting to involve in fish culture as bioremediation agents (Rostami & Azhdarpoor, 2019; Meera *et al*., 2021), phytoremediation (Akhtar *et al*., 2017; Ansari *et al*., 2020; Kumar *et al*., 2022) or esthetical material in ornamental fish aquarium and aquascape (Williams *et al*., 2012), and multi-crop material in aquaponic system (Gumelar *et al*., 2017). Involving live plants in fish rearing units could be an easier and cheaper alternative that can be done in order to improve aquaculture production performance.

Aquascape is the arrangement of aquatic plants in an aesthetically manner within an aquarium and function as houses for fish as well as plants (Martin, 2013). Some benefits of live aquatic plants for fish are to enhance water quality and to help prevent algae growth by using nutrients produced by fish waste, uneaten food, and organic debris. They also produce oxygen during daylight hours, which is used by fish and helps stabilize pH. Hence, aquascape is one of the alternatives to overcome water quality degradation by biofiltration mechanism, and to keep the fish healthy (Endut *et al*., 2010). Fish waste contains nitrogen and phosphorous that can be utilized by plant for growth (Novita *et al*., 2019; Astuti & Indriatmoko, 2018). Aquatic plants are natural alternative in maintaining the waste by cooperating together with fish to disrupt and stabilize contaminants to become less harmful for fish (Artiyani, 2011).

A previous study used *Cabomba caroliniana* as aquatic plants to remediate the chromium-polluted water waste (Afriza *et al*., 2020). Nielsen and Sand-Jensen (1991) compared the growth rate, photosynthesis level, chlorophyll concentration, leaf biomass, and carbon affinity level from 14 aquatic plants, showed that one of the factors that correlated significantly with growth was carbon affinity level. Aquatic plants use carbons as energy source, as aquatic plants can absorb bicarbonate ion in the water to neutralize the water pH and maintain the water ecosystem balance due to allelopathic compounds or allelochemical biomolecules. These compounds can affect the environment and surrounding organisms, even if the plants are already dead (Nugraha, 2018).

The goldfish, *Carassius auratus*, is one of the most successful invaders in freshwater systems with its body size, fecundity and egg size were significantly affected by the environment (Jia *et al*., 2019), and mostly found in habitats with growing aquatic plants and rarely found in waters without aquatic plants (Wang *et al*., 2013). As an ornamental fish *Carassius auratus* commonly suffers from viral disease (Gultom & Sarjito, 2018). Based on the initial project for further experiment in this study, the comet goldfish could recover from fungal disease and *Argulus* attack by maintaining the fish together with aquatic plants such as *Echinodorus amazon*, *Alternanthera reineckii*, and *Pothos tener*. The existence of aquatic plants could assist the fish to recover from diseases, which presented a positive role of the plants for the fish life. The aquatic plant is an important element to maintain the complex interaction between biotic and abiotic factors to keep of fish population and community structure (Roslan *et al*., 2021).

Water quality is very important in fish farming as poor water quality could affect the health and growth of the fish. Whilst live aquatic plants do a better job of mimicking a natural environment and they have health benefits for fish as well. Aquatic plants were effective in absorbing nutrients and can serve as bio-filter (Kang, 2014) to create better conditions for the growth of the fantail goldfish (Roslan *et al*., 2021). Therefore, further study is required regarding the aquatic plant roles in affecting the fish performance and physiological condition. In this study, comet goldfish were reared with various aquatic plants in aquascape to evaluate the performance and physiological conditions of the fish.

MATERIALS AND METHODS

This study used a completely randomized design experimental method with eleven treatments and three replications. The treatments were ten different one species of aquatic plants in each rearing unit and without aquatic plants as the control treatment. The plants used in this study are presented in Table 1.

Fish rearing in aquascape

The comet goldfish with an average total length of 6.5 ± 0.07 cm and an average weight of 9.1 ± 0.10 g were reared in aquarium with aquascape at 10 fish in 15 L of fresh water. The aquarium used for aquascape sized of 50 cm × 20 cm × 40 cm filled with 7.5 cm thick lava rocks in the bottom as planting media for each 30 grams of the aquatic plants. Each aquarium was set with an air stone connected to an aeration pump. Fish were fed on a commercial feed (PF800 floating pelleted feed) three times a day in at satiation for 45 days rearing period. The rearing water was syphoned and exchanged for 10% of the water volume every day.

Fish sampling and water quality monitoring

The fish length and weight were measured every 15 days from 10 fish in each treatment. The dead fish were counted and measured before being removed from the rearing unit. The plant biomass and average weight were measured on the initial and final rearing period. The water quality parameters were measured every 15 days along with fish weight and length sampling. The water sample was carried out and collected to the sample bottle before measuring the temperature, DO, and pH using the measuring tools.

Fish growth performance

Fish growth performances included survival rate, final weight, feed intake, specific growth rate, and length-weight correlation. Before measuring the fish on the final rearing, fish were fasting for 24 hours. The following formulas used to estimate various parameters were survival rate, specific growth rate, and feed intake of the fish as below:

- Survival Rate (%)

$$SR = \frac{Nt}{No} \times 100$$

Note:
SR = survival rate (%)
Nt = fish number day-t (fish)
No = fish number day-0 (fish)

- Specific growth rates (%/day)

$$SGR = \left\{ \frac{\text{in final weight} - \text{in initial weight}}{\text{experimental period (days)}} \right\} \times 100$$

- Feed Intake (g) during fish rearing period

Feed Intake = [the amount of feed provided (g) - the amount of leftover feed (g)]

Total chromatophore cells of fish

The total chromatophore cells were counted at the final rearing period by taking the fish skin. This method used histological technique with hematoxylin-eosin stain. Skin samples from four fish were taken from each treatment. The samples were cut at 0.6 µm thick (Novita *et al.*, 2019).

Fish liver performance

The comet goldfish liver performance was measured from the liver condition on oxidative stress by determining the malondialdehyde (MDA) and superoxide dismutase (SOD) enzyme contents in the liver samples taken from three fish on each replication in the treatment at the final rearing period. Measurement of MDA and SOD levels were performed using the colorimetric method using a spectrophotometer.

Table 1. Combinations of Comet goldfish (*Carassius auratus*) and plant in each treatment.

Treatment Code	Fish	Plant
P0	Comet goldfish (*C. auratus*)	No plant
P1	Comet goldfish (*C. auratus*)	*Alternanthera bettzickiana*
P2	Comet goldfish (*C. auratus*)	*Alternanthera reineckii*
P3	Comet goldfish (*C. auratus*)	*Cabomba furcata*
P4	Comet goldfish (*C. auratus*)	*Cryptocoryne cordata*
P5	Comet goldfish (*C. auratus*)	*Echinodorus amazon*
P6	Comet goldfish (*C. auratus*)	*Ludwigia* sp.
P7	Comet goldfish (*C. auratus*)	*Mayaca fluviatilis*
P8	Comet goldfish (*C. auratus*)	*Pogostemon stellatus*
P9	Comet goldfish (*C. auratus*)	*Rotala indica*
P10	Comet goldfish (*C. auratus*)	*Sagitaria subulata*

Fish blood profiles

The blood chemical condition was measured from three comet goldfish from each experimental unit. The blood profiles included hemoglobin, hematocrit, total erythrocytes, total leucocytes, and glucose level. Hemoglobin level was determined by taking the blood plasma from three fish at 100 mL, before measuring the blood plasma with an Hb meter. Hematocrit level was measured by taking 1 mL of fish blood plasma and absorbed with microhematocrit tube, then centrifuged at 3000 rpm. Total erythrocytes and total leucocytes were observed following the Blaxhall and Daisley (1973) method. Blood glucose level was measured with glucometer and glucose test strip.

Data analysis

Data of growth performance and physiological status were analyzed using a one-way analysis of variance (One-way ANOVA) with Microsoft Excel 2007 and SPSS 22.2 software to determine the significant difference among the treatments at 95% confidence level (0.05). All treatments with significant difference (P<0.05) were continuously analyzed using the Duncan's multiple range test (DMRT) to determine the best aquatic plant treatments that could increase the fish growth and physiological status.

RESULTS AND DISCUSSIONS

Result

Fish growth performances

The comet goldfish that reared with different aquatic plants obtained better growth performances than without aquatic plants at no significant feed intake (Table 2). All of fish survival with higher value were affected by the plant. There were seven plant species which produced a maximum survival rate (100% of each) of the fish and amongst them gave high specific growth rate (above 5%/day) of the comet goldfish such as *A. bettzickiana, M. fluviatilis, P. stellatus, R. indica,* and *S. subulata*.

Chromatophore cells of the fish

Total chromatophore cells of comet goldfish after 45 days of rearing period is shown in Figure 1. All the fish reared with plant have high number of total chromatophore cells with the highest was found in fish reared with *C. furcate* at 765.9 ± 49.8 cells/mm, followed by *E. amazon, M. fluviatilis*, *A. bettzickiana*, *C. cordata, Ludwigia sp*. The lowest total chromatophore cells was found on fish reared without aquatic plants.

Distribution of the chromatophore cells in the dermal layer of the skin of each comet fish after the treatments were shown in Figure 2. The pattern of chromatophore cells distribution varies with an even distribution or in groups in several parts. Compared to the fish reared with plants, the fish without plant showed lesser number with bigger size of the chromatophore cells.

Blood glucose

Fish reared with aquatic plants consistently showed lower fish blood glucose than the fish reared without aquatic plants as shown at Figure 3. All the fish reared with plant in aquascape

Table 2. Growth performance of comet goldfish (*Carassius auratus*) in aquascape with different aquatic plants.

No.	Aquatic plants kept with fish	Growth performance parameter		
		SR (%)	SGR (%/day)	FI (gram)
1	No plants	56.7 ± 11.5[a]	1.26 ± 0.13[a]	545.8 ± 7.37[a]
2	*Alternanthera bettzickiana*	100.0 ± 0[c]	5.11 ± 0.67[bcd]	549.0 ± 1.84[a]
3	*Alternanthera reineckii*	83.3 ± 5.77[b]	4.0 ± 2.1[bc]	544.0 ± 4.91[a]
4	*Cabomba furcata*	96.7 ± 5.8[c]	4.2 ± 0.5[bc]	546.8 ± 3.21[a]
5	*Cryptocoryne cordata*	96.7 ± 5.8[c]	4.5 ± 0.6[bc]	546.6 ± 1.53[a]
6	*Echinodorus amazon*	100 ± 0[c]	3.6 ± 1.3[bc]	544.9 ± 1.53[a]
7	*Ludwigia* sp.	100 ± 0[c]	4.1 ± 1.00[bc]	548.0 ± 4.53[a]
8	*Mayaca fluviatilis*	100 ± 0[c]	5.3 ± 0.68[bcd]	543.3 ± 1.53[a]
9	*Pogostemon stellatus*	100 ± 0[c]	7.2 ± 0.51[d]	552.4 ± 2.31[a]
10	*Rotala indica*	100 ± 0[c]	5.9 ± 0.92[cd]	552.4 ± 5.57[a]
11	*Sagitaria subulata*	100 ± 0[c]	5.0 ± 1.24[bcd]	548.1 ± 1.53[a]

Note: SR = survival rate; SGR = specific growth rate; FI = feed intake; Values are presented in average ± standard deviation. Different superscript letters in the same column show a significant difference (P<0.05).

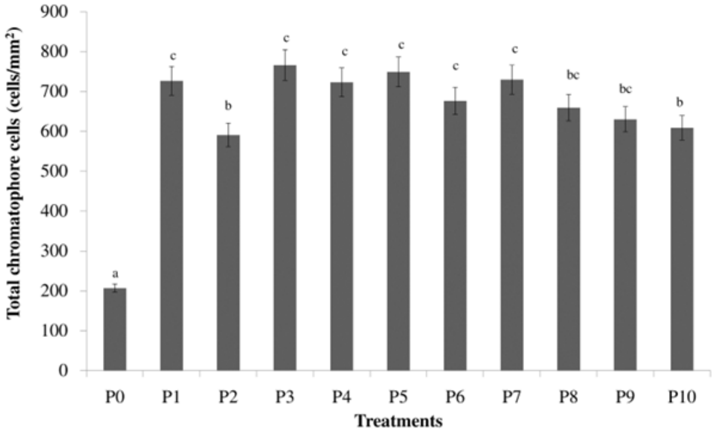

Figure 1. Chromatophore cells values of comet goldfish (*Carassius auratus*) in aquascape with different aquatic plants. Note: P = plant; P0 = no plant; P1= *A. bettzickiana*; P2 = *A. reineckii*; P3 = *C. furcate*; P4 = *C. cordata*; P5 = *E. amazon*; P6 = *Ludwigia sp*.; P7 = *M. fluviatilis*; P8 = *P. stellatus*; P9 = *R. indica*; P10 = *S. subulata.* Different superscript letters above the bar show a significant difference (P<0.05).

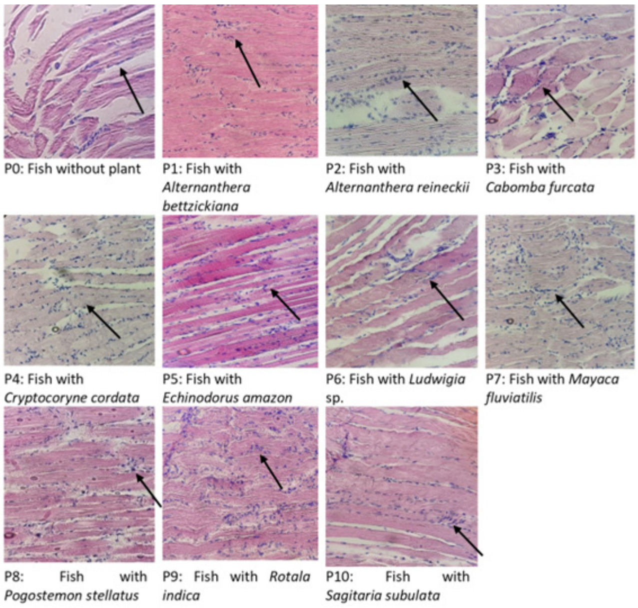

Figure 2. The chromatophore cells (arrows) of Comet goldfish (*Carassius auratus*) in aquascape with different aquatic plants (under a compound microscope with 400 × magnification; P = plant).

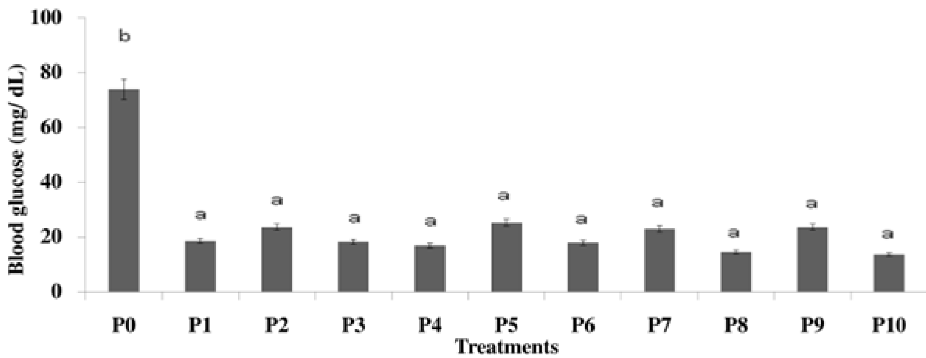

Figure 3. Blood glucose values of comet goldfish (*Carassius auratus*) in aquascape with different aquatic plants Note: P =plant; P0 = no plant; P1 = *Alternanthera bettzickiana*; P2 = *Alternanthera reineckii*; P3 = *Cabomba. Furcate*; P4 = *Cryptocoryne cordata*; P5 = *Echinodorus amazon*; P6 = *Ludwigia sp*; P7 = *Mayaca fluviatilis*; P8 = *Pogostemon stellatus;* P9 = *Rotala indica*; P10 = *Sagittaria subulata*. Different superscript letters above the bar show a significant difference (P<0.05).

performed their glucose value statistically not different (P<0.05).

Blood profiles

Aquatic plants could increase the total erythrocytes, total leucocytes, hemoglobin, and hematocrit level. Based on the results compared to the control treatment, fish that reared with *R. indica* had a significant difference value in total erythrocytes. Meanwhile, increased total leucocytes occurred in all aquatic plant treatments that were significantly difference from the control treatment, except in *A. bettzickiana* treatment. Meanwhile, the highest leucocytes reached 8.1 ± 1.90 (×10^4 cells/mm^3) was shown in *Ludwigia*.

The SOD level of comet goldfish was significantly different among other treatments (Table 4). The fish reared with no plant, and fish with *E. amazon* treatments obtained the lowest SOD value compared to other treatments, while *C. furcata* as well as *R. indica* reached the highest value, significantly (p<0.05). The MDA value of the fish in all treatments was statistically had no significant difference.

Table3. Blood profiles values of Comet goldfish (*Carassius auratus*) in aquascape with different aquatic plants.

No.	Aquatic plants	Blood profile parameter			
		RBC (×10^6 cells/mm^3)	WBC (×10^4 cells/mm^3)	Hb (g/dL)	Hct (%)
1	No plant	0.7 ± 0.27^a	1.8 ± 0.62^a	2.8 ± 0.72^a	9.0 ± 5.16^a
2	*Alternanthera bettzickiana*	1.6 ± 0.21^{ab}	5.2 ± 2.01^{ab}	9.9 ± 1.0^b	27.8 ± 4.8^b
3	*Alternanthera reineckii*	1.4 ± 0.05^{ab}	6.8 ± 2.70^b	8.23 ± 0.35^b	30.9 ± 2.83^b
4	*Cabomba furcata*	1.4 ± 0.8^{ab}	6.2 ± 3.25^b	8.9 ± 4.1^b	23.5 ± 12.17^b
5	*Cryptocoryne cordata*	1.5 ± 0.33^{ab}	8.0 ± 0.88^b	9.5 ± 1.41^b	26.4 ± 5.27^b
6	*Echinodorus amazon*	1.5 ± 0.40^{ab}	6.9 ± 2.05^{bc}	9.0 ± 3.09^b	26.3 ± 7.28^b
7	*Ludwigia* sp.	1.3 ± 0.35^{ab}	8.1 ± 1.90^c	10.0 ± 1.70^b	23.3 ± 6.12^b
8	*Mayaca fluviatilis*	1.3 ± 0.66^{ab}	6.4 ± 2.09^{bc}	7.8 ± 3.73^b	20.7 ± 10.23^b
9	*Pogostemon stellatus*	1.5 ± 0.39^{ab}	6.5 ± 2.36^{bc}	10.2 ± 2.09^b	26.5 ± 2.12^b
10	*Rotala indica*	1.6 ± 0.27^b	7.6 ±1.93^{bc}	10.1 ± 1.51^b	25.0 ± 4.75^b
11	*Sagitaria subulata*	1.4 ± 0.31^{ab}	6.6 ± 0.46^{bc}	9.6 ± 2.87^b	25.0 ± 0.51^b

Note: RBC = total erythrocytes; WBC = total leucocytes; Hb = hemoglobin; Hct = hematocrit. Values are presented in average ± standard deviation; Different superscript letters in the same column show a significant difference (P<0.05).

Table 4. The SOD and MDA values of comet goldfish (*Carassius auratus*) in aquascape with different aquatic plants.

No.	Aquatic plants	Liver performance parameter	
		SOD (μg/g)	MDA (U/mg protein)
1	Control (No plant)	4.0 ± 1.71^a	0.7 ± 0.25^a
2	*Alternanthera bettzickiana*	5.5 ± 1.85^{ab}	0.6 ± 0.17^a
3	*Alternanthera reineckii*	5.6 ± 2.12^{ab}	0.5 ± 0.25^a
4	*Cabomba furcata*	9.1 ± 2.40^c	0.6± 0.39^a
5	*Cryptocoryne cordata*	4.4 ± 1.66^{ab}	0.4 ± 0.07^a
6	*Echinodorus amazon*	4.1 ± 0.34^a	0.7 ± 0.32^a
7	*Ludwigia* sp.	5.4 ± 1.13^{ab}	0.4 ± 0.13^a
8	*Mayaca fluviatilis*	5.5 ± 0.72^{ab}	0.5 ± 0.03^a
9	*Pogostemon stellatus*	4.4 ± 1.81^{ab}	0.6 ± 0.39^a
10	*Rotala indica*	9.0 ± 2.30^c	0.5 ± 0.15^a
11	*Sagitaria subulata*	7.2 ± 0.63^b	0.8 ± 0.33^a

Note: SOD = superoxide dismutase enzyme; MDA = malondialdehyde. Values are presented in average ± standard deviation; Different superscript letters in the same column show a significant difference (P<0.05).

Water physicochemical conditions

The physicochemical condition of the water in the rearing media for comet goldfish for 45 days of rearing period can be seen in Table 5. The water quality analysis results during the rearing period were still within the feasibility limit for comet goldfish rearing and were fit to support the plant life.

Discussions

There is a positive correlation between aquatic plants and freshwater fish. Habitats with moderate amounts of aquatic vegetation provide the optimal environment for many fish and hence, increase the fish diversity, feeding, growth, and reproduction (Ismail *et al*., 2018). Vegetation may significantly increase habitat structural complexity, potentially changing biotic and abiotic processes. Submerged aquatic vegetation (SAV) plays a critical role in the ecological functions of shallow lake ecosystems, including reducing sediment resuspension, increasing water clarity and quality, and providing important habitat for fauna including fishes (Martin & Valentine, 2012; Short *et al*., 2016; Zhao *et al*., 2022). As shown in this study aquatic plants have an important role in supporting the fish life.

The presence of aquatic plants can suppress the fish death resulting a high survival rate of the fish up to 100%. According to Wang *et al*. (2013), total abundance and biomass of the comet fish *Carassius auratus* are found dominant in lake environments overgrown with aquatic plants. The submerged aquatic plants carry out photosynthesis by utilizing dissolved inorganic carbon (Pedersen *et al*., 2013; Khairnar & Kaur, 2018), creating healthy environment which may promote high species richness, growth, foraging, and survival of fishes, notably juveniles and smaller individuals, due to optimal spaces for predator-prey interactions and edge effects (Looby *et al*., 2021). Increased survival rate was positively correlated with the specific growth rate value. These results were in accordance with (Ghaly *et al*., 2005; Csurhes & Hankamer, 2016; Kanagarasu *et al*., 2017), stated that aquatic plants could increase the growth and survival of sustainable aquatic animals, as antimicrobial and antioxidant properties in maintaining the survival rate of the aquatic animals (Mani *et al*., 2016).

The application of different aquatic plants affects the specific growth rate of the comet goldfish, due to the significant difference value of the specific growth rate between fish reared with and without aquatic plant treatments. Nevertheless, the feed intake value in this study had no significant difference among the treatments. Several previous studies which used aquatic plants had similar specific growth rate that affected the fish life (Ismail *et al*., 2018; Looby *et al*., 2021; Aminisarteshnizi, 2022). In contrast, at limited and excessive vegetation may decrease fish growth rates at 75% to 85% of plant community coverage (Ismail *et al*., 2018).

In this study, the total chromatophore cells were significantly different found between fish reared with and without aquatic plants, as the highest total chromatophore cells was obtained from *C. furcata*

Table 5. The water physicochemical condition in the rearing media for comet goldfish (*Carassius auratus*) in aquascape with different plants.

No.	Aquatic plants kept with fish	Physicochemical parameter			
		Temperature (°C)	pH	DO (mg/L)	TDS (mg/L)
1	No plant	28.1-28.5	5.7-6.9	6.8-7.6	158.3 ± 11.8
2	*Ananthera bettzickiana*	27.3-28.3	5.9-6.8	6.9-7.3	206.0
3	*Aananthera reineckii*	28.0-28.3	6.3-6.7	6.5-7.1	186.0
4	*Cabomba furcata*	28.0-28.1	6.4-6.8	6.3-7.1	191.0
5	*Cryptocoryne cordata*	27.6-28.0	6.3-6.7	6.5-7.1	226.0
6	*Echinodirus amazon*	28.0-28.4	6.3-6.7	6.5-7.2	150.0
7	*Ludwigia* sp.	28.0-28.3	6.2-6.5	6.4-7.0	211.0
8	*Mayaca fluviatilis*	28.1-28.5	6.4-6.8	6.6-7.1	203.0
9	*Pogostemon stellatus*	27.0- 28.3	6.3-6.5	6.4-7.3	198.0
10	*Rotala indica*	27.3-28.0	6.1-6.7	6.8-7.4	198.0
11	*Sagitaria subulata*	27.1-27.4	5.9-6.7	6.8-7.3	211.0

Note: pH = water acidity measurement; DO = dissolved oxygen; TDS = total dissolved solids.

treatment at 765.9 ± 49.8. Different aquatic plant applications in the aquascape affects the color quality of comet goldfish through the absorption of phenolic and allelopathic compounds from the aquatic plants (Li *et al*., 2010). The artificial environmental condition such as aquascape could filter the fish environment by absorbing the allelopathic compounds from the aquatic plants in the rearing media, causing melanophore cell distributions on the fish epidermal skin which could produce brilliant fish colors. The movement of pigment cell granules results in an optimal absorption of allelopathic compounds and increased color quality (Sköld *et al*., 2015). The addition of aquatic plants to the fish rearing environment resulted in low levels of fish blood glucose between 13-25 mg/dL, while the fish without plant showed almost three times higher at 74 mg/dL.

An increase in blood glucose level indicates the fish is experiencing stress (Martínez-ChoPorchas *et al*., 2009), whilst aquatic plants could restrain fish metabolic stress. If the fish has an increased blood glucose level as reported by Cho *et al*. (2015), the fish receptor organ gains a stimulus from the outside considered as a stress factor for fish. The results of this study showed that the presence of plants in rearing pond could calm the fish and comfort them. Aquatic plants are primary producers of the aquatic ecosystem. The presence of certain aquatic plants is frequently desirable in fish ponds as biological filter media, providing a surface for beneficial bacteria, and providing food, oxygen, shelter for the fishes. But when the plants grow excessively, they can endanger the fish rearing by diminishes water productivity and penetration of sunlight as well by shading which may lead to either super saturation or depletion of oxygen. Initial biomass of the aquatic plants submerged in the rearing.

Therefore, several parameters, such as total erythrocytes, total leucocytes, hemoglobin, hematocrit, SOD, and MDA were measured in this study to clarify this statement. The results showed that there was a significant difference found between the comet goldfish reared with and without aquatic plants. The plants which supported highest SOD value of the fish were *C. furcata* is containing bioactive phytochemical such as saponin (Khalid *et al*., 2013; Subramoni *et al*., 2019) and *Rotala* can be used to effectively remove nitrogen and phosphorus in eutrophic waters (Gu *et al*., 2019). This study showed that the increased of total erythrocytes in different aquatic plant applications comet goldfish did not experience metabolic stress, which means that the aquatic plants have good performance in maintaining the fish health without damaging the blood vessels of the fish. Fish exposed to toxins, such as high ammonia and nitrite, will experience metabolic stress (Fawole *et al*., 2016; Abarghoei *et al*., 2015).

The total leucocytes in comet goldfish on all the aquatic plant treatments were found at range 5-7 ($\times 10^4$ cell/mm^3), i.e. two to four times higher than the fish reared without the aquatic plant treatment (control). According to Setyaningsih *et al*. (2016), the normal values of erythrocytes and leukocytes in the comet goldfish were 13.86×10^5 cell/mm^3 and 18.76×10^3 cell/mm^3, respectively. The lower total erythrocytes in the control treatment caused by the increased of hemoglobin binding, resulting in lower erythrocytes proportions in the blood vessel (Fawole *et al*., 2016; Deng *et al*., 2015; Suprayudi *et al*., 2015), while higher total leucocytes could suppress the fish health and contribute to prevent the disease (Mmereole, 2008; Kondera & Witeska, 2019). It is widely accepted that fish with better health status are more likely to grow faster as less energy should be consumed for non-growth purposes. The use of haematological and blood biochemistry parameters has proven to be effective, more reliable and accurate for monitoring fish health and growth (Esmaeili, 2021). In this study, better blood profile, especially its highest WBC value were shown in fish with *Ludwigia.*

In this study, different aquatic plants obtained the same MDA levels and was not significantly different from the control treatment. MDA is considered a common marker of oxidative stress conditions associated with free radicals (Fawole *et al*., 2016; Deng *et al*., 2015). To cope with oxidative stress, freshwater fish will generally produce several antioxidant enzymes, such as superoxide dismutase (SOD), glutathione peroxidase, and catalase enzymes (Fawole *et al*., 2016; Deng *et al*., 2015; Sharma *et al*., 2014). High MDA levels with low SOD levels are dangerous for fish and other aquatic organisms (Fawole *et al*., 2016; Yang *et al*., 2015). Low SOD value could be caused by the increased lipid peroxidative activity due to free radical exposures absorbed by the body. Also, free radical detoxification was inhibited when lower SOD was occurred (Wang *et al*., 2018).

Among the submerged aquatic plants applied in this study, *Cabomba furcate, Ludwigia,* and *Rotala indica* could support better fish performance. *Cabomba* plants as aquatic ornamental plants in aquariums also act as a mutualistic symbiotic agent in fish farming. The plant could reduce heavy metal such as Fe in wastewater (Afriza *et al*., 2020). There were four different polyphenol compounds found on *Cabomba* that polyphenol compound group as one of plants secondary metabolites which potentially functioned as insecticide and larvicide against insects larvae (Yatmasari *et al*., 2017). *Ludwigia* have been reported to exhibit allelochemicals such as quercitrin, prunin, and myricitrin that have beneficial or detrimental effects on neighboring organisms (Thiébaut *et al*., 2018). Capability of nutrient removal was studied on *Rotala* with high removal efficiencies of COD, NH_4^+-N and Total Nitrogen which make it a candidate for ecosystem remediation (Yang *et al*., 2020). Those characteristics of the plants.

CONCLUSIONS

Aquascaping could be applied to fish rearing units to improve fish performance. Rearing the comet fish with plants can improve the survival and growth of the fish with better physiological and health status. *Cabomba furcata, Ludwigia,* and *Rotala indica* were the plants that support the best performance of the fish.

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