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Feasibility of using fish visceral trash in a polyculture system for enhancing the growth performances of giant gourami (*Osphronemus gouramy*) and redclaw crayfish (*Cherax quadricarinatus*)

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ABSTRACT

Giant gourami and redclaw crayfish are among popular freshwater organisms with significant potential for aquaculture due to their ease of cultivation, resistance to diseases, and high economic value. Therefore, this study aimed to evaluate the feasibility of using fish visceral trash (FVT) in artificial diets to enhance the growth performances of giant gourami (*Osphronemus gouramy*) and redclaw crayfish (*Cherax quadricarinatus*) in a polyculture system. Giant gourami juveniles (3.62±0.86 cm and 3.74±1.15 g) and redclaw crayfish (3.05±0.35 cm and 6.41±0.29 g) were divided into four groups and cultured in 100 L aquarium. Each group was fed twice daily with diets containing 0%, 10%, 20%, and 30% FVT/kg diet. Furthermore, growth performances were assessed in all samples at 14 days intervals over a period of eight weeks. The results showed that diets prepared with 30% FVT significantly affected the growth rate of giant gourami juveniles, while those comprising 20% enhanced the growth of redclaw crayfish. Total length, body weight, specific growth rate, and weight gain significantly increased in samples fed with the experimental compounded diets. Based on the observations, it is suggested that using FVT compounded diets tends to improve growth performances in a polyculture system.

Introduction

Giant gourami, a freshwater fish popularly consumed as a protein source (Nurhayati *et al*., 2021), is known to possess high economic value (Eka *et al*., 2020) and a slow growth rate (Nugraha *et al*., 2020). However, this species is promising for aquaculture due to its feasibility for artificial propagation and ability to thrive in stagnant waters (Budi *et al*., 2015). The production of this fish increases annually to meet market demand (Budiardi *et al*., 2011), with an average increase of 15.74% per year (KKP, 2019). To address the slow growth issue, feed quality, and the cultivation system should be improved.

Redclaw crayfish in similarity to giant gourami shows promising prospects in fisheries due to its ease of cultivation, omnivorous nature, disease resistance, and high fecundity (Santi *et al.,* 2021). Developing the cultivation process of this species is necessary for economic benefits and the maintenance of sustainability (Amrullah and Wahidah, 2019). In addition to meeting community needs, freshwater crayfish have export opportunities in various countries (Priyono *et al*., 2009; Wang *et al*., 2017) and are used as ornamental organisms because of their unique shape and beautiful body color (Samad *et al*., 2022)

Polyculture is a long-existing aquaculture system in Indonesia that involves combining various fish species with different eating habits (Thomas *et al.,* 2020) to reduce food competition and increase production (Yustiati *et al*., 2018). This system helps to prevent inter-species attacks since each fish has

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different behaviors, such as some living within the water column and others inhabiting the bottom. Additionally, the application of polyculture can enhance land efficiency, save feed and production costs, as well as boost the income of aquaculturists (Tomatala *et al.*, 2019).

To implement polyculture successfully, its fundamental concept which involves understanding the trophic level and behavior of the cultured species is crucial. In this system, the incorporation of multiple habitats will decrease competition for living spaces and prevent the adverse survival effects of aquatic organisms (Almohdar and Souisa, 2017).

There are several polyculture studies on different fish species, but none has been conducted on giant gourami and redclaw crayfish by employing alternative feed such as FVT. Therefore, this study aimed to examine the feasibility of using FVT in the diets of giant gourami and redclaw crayfish to determine their growth performances in a polyculture system.

Materials and Methods

Study location and time

This study was carried out at the Laboratory of Aquaculture Department, Universitas Samudra. A closed system containing a 100 L aquarium (75 x 40 x 35 cm) was used to culture the giant gourami juveniles and redclaw crayfish. Initially, the aquarium was sterilized and filled with 80 L of fresh water, then PVC pipes were provided as shelters for the crayfish. During the experimental procedure, the aquarium was siphoned daily in the morning before feeding time, and water quality parameters were measured regularly every three days with a multi-parameter analyzer.

Experimental design

Feed ingredients as presented in Table 1. A completely randomized design with four treatment groups in triplicate was applied in this study. For eight weeks, each group consisted of 10 giant gourami juveniles weighing 3.73±1.15 g and five redclaw crayfish 6.41±0.29 g given the following treatments:

TF_0 = Artificial diet (control)
TF_1 = Artificial diet + 10% FVT
TF_2 = Artificial diet + 20% FVT
TF_3 = Artificial diet + 30% FVT

Data collection

Data on the survival rate of giant gourami and redclaw crayfish were obtained daily during the experimental period. Meanwhile, the growth rate was determined by randomly collecting samples to measure their length and weight once in two weeks (0, 14, 28, 42, and 56 days) using a digital caliper and digital balance, respectively.

The growth rate was calculated from the measured parameters using the following formulas by Zhao *et al.* (2012):

- Weight gain (WG, %) = [(Wt – Wo]/Wo x 100.
- Specific growth rate (SGR, %) = [(lnWt – lnWo)/ T] x 100.

Where Wt is the final weight, Wo is the initial weight, and T is the number of days.

Also, the condition factor (K) was calculated with the formula $[(10^5 \text{ x Wt (g)})/(\text{TL})^3 \text{ (cm)}]$, as suggested by Samad *et al.* (2014).

Compounded diets preparation

The preparation process of the diets commenced with collecting visceral trash from the fish market to be washed, sorted for usable materials, and steamed for 30 minutes, then dried in an incubator for 24 hours at 50°C (Aryanti *et al.*, 2022). Subsequently, the dried visceral was ground using a grinding machine. The flour obtained was stored in plastic inside the freezer until it was mixed with other ingredients to prepare three different dosages (10%, 20%, and 30% of total ingredients) of the experimental diets. The ingredients of each diet were mixed for 20 minutes for pelletization. The pellets were dried in an incubator at room temperature for 24 h, then stored in plastic bags for further use.

Table 1. Percentage of ingredients in different treatments.

Ingredients (%)	Treatments			
	TF0	TF1	TF2	TF3
Fish meal	40.0	40.0	40.0	40.0
Trash fish	0.00	10.0	20.0	30.0
Fish oil	8.00	8.00	8.00	8.00
Corn meal	10.0	10.0	10.0	10.0
Vitamin mix	2.00	2.00	2.00	2.00
Mineral mix	3.00	3.00	3.00	3.00
Cellulose	37.0	27.0	17.0	7.00
Crude protein	38.03	38.35	38,81	38,87
Crude lipid	14.05	13.78	14.02	14.04
Crude fiber	3.29	2.67	2.52	2.35
Ash	14.27	14.50	14.29	14.86
Moisture	8.83	7.81	7.88	8.38

Feed utilization measurements

The subjects were fed twice daily at 08:00 and 17:00, and any unconsumed diets were collected 15 minutes after feeding to be dried before measurement. During the experiment, feed intake was calculated using the formula FI = [diet given (g) – diet remnants (g)]/fish, while feed conversion ratio was estimated as FCR = FI (g) / [Wt – Wo (g)] (Samad *et al.*, 2014).

Data Analysis

All collected data were examined using a one-way analysis of variance, with various dosages of FVT as the factor. In cases where the differences were significant at a $p<0.05$ level, the test procedure of Tukey was employed to compare the means between treatments.

Results

Growth performances of giant gourami and redclaw crayfish were affected by the visceral compounded diets. A summary of the growth rate, final length, Wt, and condition factors of each group is presented in Tables 2 and 3.

Table 2 shows that the group receiving diets containing 30% FVT per kg had the highest growth rate. This was indicated by a significant difference in the length, weight, and specific growth rate (%) with values of 7.86 ± 0.31 cm, 11.12 ± 0.83 g, and 195 ± 10%, respectively, compared to other treatments. However, the lowest growth rate was observed in the TFG_0 group.

Table 2. Growth of giant gourami juveniles fed different artificial diets.

Variables	Visceral trash fish mixed feeding			
	TFG0	TFG1	TFG2	TFG3
Initial length (cm)	3.62±0.86	3.62±0.86	3.62±0.86	3.62±0.86
Final length (cm)	5.23±0.12^{b}	6.34±0.27^{ab}	6.79±0.33^{ab}	7.86±0.31^{a}
Initial weight (g)	3.73±1.15	3.73±1.15	3.73±1.15	3.73±1.15
Final weight (g)	6.37±0.27^{b}	7.77±0.21^{ab}	9.67±0.44^{ab}	11.12±0.83^{a}
Weight gain (%)	70±7	108±6	159±10	198±24
SGR (%)	95±8	131±5	170±9	195±10
Condition factor	4.45±0.15	3.07±0.46	3.11±0.43	2.29±0.31
Survival (%)	100	100	100	100

Table 3. Growth of redclaw crayfish fed different artificial diets.

Variables	Visceral trash fish mixed feeding			
	TFL0	TFL1	TFL2	TFL3
Initial length (cm)	3.05±0.34	3.05±0.34	3.05±0.34	3.05±0.34
Final length (cm)	3.39±0.18^{b}	3.58±0.06^{a}	3.57±0.06^{a}	3.50±0.41^{ab}
Initial weight (g)	6.41±0.29	6.41±0.29	6.41±0.29	6.41±0.29
Final weight (g)	8.27±0.56^{b}	8.64±0.95^{a}	9.49±0.45^{a}	9.42±0.27^{ab}
Weight gain (%)	29±9^{b}	35±15^{ab}	48±7^{a}	47±4^{a}
SGR (%)	197±9^{b}	215±12^{ab}	238±9^{a}	259±10^{a}
Condition factor	21.51±5.36	18.88±2.04	20.96±1.85	23.13±7.26
Survival (%)	100	100	100	100

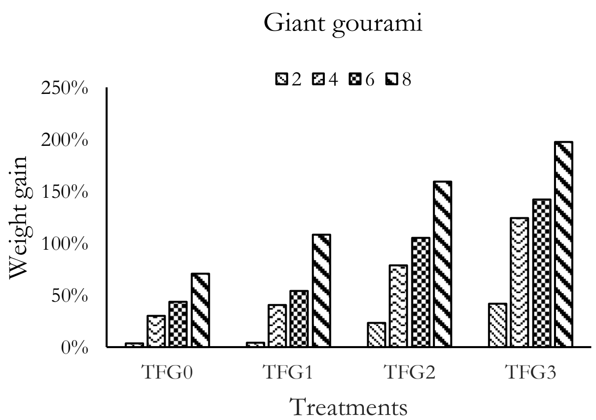

Figure 1. Weight gain of giant gourami fed with treated diets.

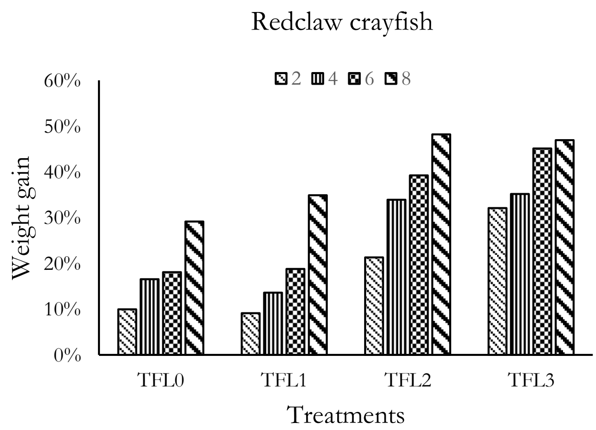

Figure 2. Weight gain of redclaw crayfish fed with treated diets.

During the observation period, weight gain was discovered in all experimental groups every 14 days. According to Figures 1 and 2, both animal subjects exhibited weight progression, while groups that consumed mixed feeding with FVT showed a significantly better growth rate compared to the control. After eight weeks of measurements, the highest weight gain in giant gourami was detected in TFG_3 as 198±24%, while 48±7% was obtained in the TFL2 group of redclaw crayfish The highest weight gain in giant gourami was seen in TFG_3 198±24%, while in redclaw crayfish was viewed in TFL_2 at 48±7% after 8 weeks measurements.

Feeding performances

Based on the results, FCR was influenced by diets containing FVT, hence, the best FCR was found in TFG_1 at 5.56 ± 0.31 (Table 4) and TFL_0 at 7.12 ± 1.11 (Table 5) for giant gourami and redclaw crayfish, respectively.

Water quality parameters

Table 6 summarized the water quality parameters, which were checked every three days all through the experimental period. The recorded data indicated that the water quality inside the aquarium used was within the optimum range for the survival of giant gourami and redclaw crayfish.

Table 4. Feeding indicator and survival rate of giant gourami juveniles.

Treatments	FI (g)	FCR	SR (%)
TFG0	70.52±5.39^{b}	5.85±0.22^{ab}	100
TFG1	84.32±6.84^{ab}	5.56±0.31^{b}	100
TFG2	89.37±5.12^{a}	7.04±0.85^{ab}	100
TFG3	76.20±4.23^{b}	9.20±0.75^{a}	100

Note: Data in the same column with a different letter are significantly different (p<0.05) among treatments.

Table 5. Feeding indicator and survival rate of redclaw crayfish.

Treatments	FI (g)	FCR	SR (%)
TFL0	70.52±5.39^{b}	7.12±1.11^{b}	100
TFL1	84.32±6.84^{ab}	7.78±1.82^{ab}	100
TFL2	89.37±5.12^{a}	9.35±2.01^{a}	100
TFL3	76.20±4.23^{b}	9.54±2.27^{a}	100

Note: Data in the same column with a different letter are significantly different (p<0.05) among treatments.

Table 6. Mean of water quality during experiment.

Treatments	Dissolved oxygen (ppm)	pH	Temperature (°C)
TFG_0/TFL_0	5.32±0.32	7.12±0.22	29.41±0.32
TFG_1/TFL_1	5.17±0.25	7.24±0.22	29.32±0.87
TFG_2/TFL_2	5.51±0.48	7.12±0.13	29.17±0.15
TFG_3/TFL_3	5.50±0.26	7.25±0.23	29.24±0.23

Discussion

This study discovered that using FVT in compounded diets had a positive effect on the growth rate of giant gourami and redclaw crayfish, but it did not affect water quality parameters. The treated groups exhibited higher growth performances, while the control had lower FCR. According to Afriyanti *et al.* (2020), slow growth was found to be a common problem in giant gourami and redclaw crayfish (Santi *et al.,* 2021; Samad *et al.,* 2022). Therefore, the improvement of both feed quality and the cultivation system was important in minimizing feed budgets. In this study, FVT improved feeding quality by boosting protein sources in the diets, which led to an enhanced growth rate.

The FCR value seemed lower in both the TFL_0 (redclaw crayfish control) and TFG1 (giant gourami) groups compared to other treatments. This implied that the dosage of compounded diets satisfied the treated organisms' nutritional needs and appetites. Even though the highest FCR was observed in TFG_3 and TFL_3, they were still significant in aquaculture. Previous studies reported that the average FCR of giant gourami was 5.97 (Retno *et al.,* 2019), while redclaw crayfish had values ranging from 1.74-5.47 (Santi *et al*., 2021).

Studies on the use of FVT as a new protein source to substitute fish meal have been conducted in some species, including grouper (Aryanti *et al.,* 2022), humpback grouper (Shapawi *et al.,* 2011), vannamei (Valle *et al.,* 2014), and cattle (Herlina, 2013). The results showed FVT flour mixed with diets could promote growth performances due to the high content of protein, amino acids, fatty acids, and vitamins. Similarly, this current study discovered that FVT has the potential to increase the weight gain of treated species.

To maintain the FI value of fish, optimum water quality was essential because this parameter could affect both the appetite and FCR of organisms as demonstrated in previous studies (Taylor *et al*., 2006; Putra *et al*., 2021; Agus *et al*., 2013). Based on observations, the active movement of giant gourami and redclaw crayfish during feeding time increased their appetite, leading to higher consumption in the TFG2 and TFL2 groups. This was consistent with the report by Webster *et al.* (2001) that higher feed consumption tended to improve growth performances.

Conclusion

In conclusion, the growth rate and feed utilization observed in this study were influenced by the FVT compounded diets. Polyculture between gourami and redclaw crayfish is feasible because they occupy different water columns, and any unconsumed feed from one species can be eaten by the other for growth support. FVT application in artificial feed is recommended, but it is crucial to provide good quality food, monitor animal behavior, and maintain optimal water quality during the experimental period.

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