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Cultivating Flesh Fly Larvae as a Sustainable Feed Source for the Ornamental Fish (*Carassius auratus*)

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ABSTRACT

Background: Providing ornamental fish (*Carassius auratus*), with nutritious and sustainable food sources is an increasingly important part of that process. Flesh flies (*Sarcophaga* spp.) have a high content of nutrient in their larval stage, which make their bodies grow quickly during their larval phase.

Methods: The nutrient composition of *Sarcophaga* larvae and their effect as a feeding source on *C. auratus* growth during the process were studied. In a laboratory, *Sarcophaga* larvae were cultured on shrimp shells and *C. auratus* fed on *Sarcophaga* larvae were compared to *C. auratus* fed on commercial food.

Result: Crude protein content of 52.5% was remarkably high, followed by crude lipid (30.2%), crude fibers (9.8%) and finally crude ash (7.5%). Our results showed also a significant improvement in growth performance of *C. auratus* fed on *Sarcophaga* larvae, with a median weight of 25.3 g compared with the control group (17.3 g) by the fourth week, indicating significant advantages for *C. auratus* fed on *Sarcophaga* larvae. In this study, *Sarcophaga* larvae are examined as a sustainable and nutritious source of food for *C. auratus* fish. Using insect larvae for aquaculture should be further refined and evaluated for long-term benefits and safety.

Key words: *C. auratus*, Flesh fly, *Sarcophaga* spp, Sustainable food.

INTRODUCTION

The aquaculture industry is paying increasing attention to the cultivation of alternative live feeds for ornamental fish because of the increasing demand for sustainable and nutritionally dense food sources. Compared to the use of traditional feeds, flesh fly larvae (*Sarcophaga* spp.) offer many advantages and they have been shown to be a promising alternative to traditional feeds in many studies. A flesh fly larva is a protein-rich insect larva that grows rapidly, which makes it a suitable candidate for use as a fish feed in addition to its high protein content (Nguyen *et al*., 2015). Health and coloration of ornamental fish are directly related to live feeds. Several studies have shown that live feeds such as insects have a significant impact on fish growth performance and immune response, as shown by Lim *et al.* (2013). Furthermore, many ornamental fish species are better able to satisfy their natural predatory instincts when they are given live prey, because of which they become more relaxed overall (Vidaković *et al*., 2018). In a study conducted by Rumpold and Schlüter (2013), the nutritional profile of flesh fly larvae, which includes essential amino acids, lipids and micronutrients, was shown to be comparable to, or even better than, the nutritional profile of traditional live feeds, such as Artemia and Daphnia.

Additionally, the cultivation of flesh fly larvae for fish feed has several environmental benefits, in addition to the nutritional benefits that are provided by using flesh fly larvae for fish feed. An important reason for the environmental friendliness of insect farming over conventional livestock farming in general can be attributed to several reasons. In addition to reducing the amount of land needed, water required and greenhouse gases produced, it uses less energy. In addition to being a sustainable feed source, organic waste such as shrimp shell can be used as a substrate for larval growth (Diener *et al*., 2011). It can contribute to the development of a circular economy by generating high-quality protein from waste by farming flesh flies' larvae, which can reduce landfill waste significantly. The larvae of flesh flies provide several benefits to ornamental fish culture, but they are still underutilized as a feed source in ornamental fish culture, even though they achieve a wide array of benefits. Lack of standardized rearing protocols and concerns over the safety and consistency of larvae may explain this. According to previous studies, other insect species can be successfully reared for aquaculture purposes (Henry *et al*., 2015), indicating that with appropriate methodologies, flesh fly larvae can also be successfully cultivated for aquaculture purposes. In this study, the aim is to develop and optimize a protocol that will be used to raise a colony of flesh fly larvae that will be fed to ornamental fish for the purpose of raising larvae from flesh flies to feed ornamental fish.

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MATERIALS AND METHODS

Collecting and rearing *Sarcophaga* larvae

To collect the *Sarcophaga* larvae, shrimp shell waste was collected in Dengue Research and Vector Control Unit and placed in plastic containers perforated with holes (1 cm), according to Nguyen *et al.* (2015) (Fig 1) with 20°C-30°C and a humidity of 60%-80%. On the first day, the female *Sarcophaga* fly deposited their eggs and after 5 days, the *Sarcophaga* larvae appeared and the 3rd larval stage were removed into large glass containers for rearing and further experiments (Lim *et al*., 2013).

Feeding and maintenance of *Sarcophaga* larvae

The larvae were provided with sufficient farmed shrimp shell powder as a food source daily (Fig 2), with a ratio of 1:2 (shrimp shell powder to larvae) by weight. Regular checks were conducted on the containers to determine their moisture content. Water was added as needed to maintain the humidity level in the containers and any unconsumed substrate was removed and replaced with fresh substrate every three days to prevent mold growth (Rumpold and Schlüter, 2013).

Proximal nutritional composition of *Sarcophaga* larvae

The nutritional content of *Sarcophaga* larvae was calculated by measuring protein, lipid, fiber and ash content. They were measured following the Official Methods of Analysis (OMA) of the Association of Official Analytical Collaboration (AOAC) International (AOAC, 2005).

Feeding *Carassius auratus* with *Sarcophaga* larvae

C. auratus were fed with commercial fish food for two weeks to acclimate to the test conditions. *C. auratus* were divided into two groups: those who received commercial fish food as a control group and those who received *Sarcophaga* larvae as the tested group. During the experiment, each group consisted of ten fishes housed in separate large cubs and subjected to the same conditions for three times. During the feeding trials, *C. auratus* were fed twice a day (every 12 hours) for four weeks.

Statistical analysis

According to the protocol of the experiment, as part of the experimental protocol, we measured the growth performance as well as the survival rates of each group in each environment. Daily weighing was done to monitor fish growth and determine if any had died. To determine whether differences between control and experimental groups were significant, SAS was used.

RESULTS AND DISCUSSION

Proximal nutritional composition of *Sarcophaga* larvae

The analysis of *Sarcophaga* larvae reveals a highly nutritious profile that holds significant potential for various applications, particularly in the sustainable protein sources (Table 1). The crude protein content of 52.5% is remarkably high and compares favorably with traditional fish food sources, which have protein contents of approximately 25-30% and 35-40%, respectively (Bose *et al*., 2019). This high protein content suggests that *Sarcophaga* larvae could be an excellent alternative protein source in animal feeding. In the other hand, the lipid content of *Sarcophaga* larvae, at 30.2%, is also notable. Lipids are essential for providing energy and supporting cell membrane structure and function. The lipid profile of *Sarcophaga* larvae could be beneficial for species requiring high-energy diets such as fishes. For instance, in aquaculture, high lipid content in feed is crucial for the rapid growth of fish (Stamer, 2015). Moreover, insect lipids often contain beneficial fatty acids, which can contribute to improved health outcomes in animals (Rumpold and Schlüter, 2013; Tirtawijaya and Choi, 2021). Also, in this study, crude fiber constituting was 9.8% of the larvae. The fiber content in *Sarcophaga* larvae



Fig 1: Shrimp shell waste.



Fig 2: Shrimp shell powder as a larvae food source.

Table 1: Proximal nutritional composition of *Sarcophaga* larvae.

Component	Nutrient composition (%)
Crude protein	52.5
Crude lipid	30.2
Crude fibre	9.8
Crude ash	7.5

Table 2: Growth performance of treated fishes and control group.

Parameters	Median weight ± SE			
	1st week	2nd week	3rd week	4th week
Control	18±0.5	19±0.5	18±0.5	18±0.5
	16±0.5	16±0.5	17±0.5	16±0.5
	17±0.5	16±0.5	17±0.5	18±0.5
Median	17	17	17.3	17.3
Feeding with *Sarcophaga* larvae	18±0.5	20±0.5	23±0.5	26±0.5
	20±0.5	21±0.5	23±0.5	25±0.5
	18±0.5	20±0.5	23±0.5	25±0.5
Median	18.6	20.3	23	25.3

can enhance the gut health of livestock, leading to better nutrient absorption and growth performance (van Huis *et al*., 2013). The crude ash content of 7.5% indicates the mineral composition of the larvae. Essential minerals such as calcium, magnesium and potassium, which are crucial for metabolic processes. The inclusion of such mineral-rich feed ingredients can enhance the nutritional quality of animal diets such as aqua fishes (Halloran *et al*., 2016).

Growth performance *C. auratus* fed *Sarcophaga* larvae

The growth performance of *C. auratus* that are fed with *Sarcophaga* larvae comparing to control group is illustrated in Table 2 over a period of four weeks. *C. auratus* fed on *Sarcophaga* larvae reached an average weight of 18.6 grams in the first week, which was higher than the control group. In the second week, *C. auratus* fed on *Sarcophaga* larvae reached an average weight of 20.3 then 23 g in the third week. During the fourth week, the average weight of the *C. auratus* fed on *Sarcophaga* larvae reached 25.3 g, which was higher than control group (17.3 g). It can be concluded from these results that *Sarcophaga* larvae make a valuable feed for *C. auratus* due to their ability to promote rapid growth and have shown an improvement in growth performance compared to *C. auratus* that are only fed to commercial fish food, which can be attributed to the large nutritional value of the larvae. Researchers have previously demonstrated that the larvae of flesh flies contain a high concentration of protein are beneficial for the animal's health (Rumpold and Schlüter, 2013). As a result of the high protein content in this study, the superior growth rates observed in this study may have been caused by the high level of high-quality nutrient contained within the study. It seems that the high-quality nutrient could be provided by their own food, which supports the findings of this study published by Nguyen *et al.* (2015). The larvae's nutritional profile not only supports growth but also enhances the overall health and coloration of the fish, which are critical factors in the ornamental fish industry (Lim *et al*., 2013).

According to Henry *et al.* (2015), the results of this study are consistent with those from previous studies suggesting alternative live feeds, such as insect larvae, can outperform traditional fish feeds in terms of growth performance and feed conversion efficiency, compared to traditional fish feeds (Henry *et al*., 2015). As a result of the significant differences between the groups in this study who were fed larvae and those who were fed control food, there is no doubt that flesh fly larvae are a viable food source. It is, however, also necessary to note that the study highlights the need for further research to standardize rearing protocols as well as ensure that flesh fly larvae as feed are safe and of high quality. Although the current findings are promising, long-term studies are needed to evaluate the impact of these practices on fish health, reproduction and overall performance across a variety of aquaculture systems.

Conclusion

The analysis of *Sarcophaga* larvae reveals a highly nutritious profile, making them a promising alternative protein source for aquaculture and animal feed. With a crude protein content of 52.5%, they surpass traditional fish food sources, enhancing growth performance in species such as *C. auratus*. The larvae's substantial lipid content (30.2%) provides essential energy and supports cellular functions, while the 9.8% crude fiber content aids in gut health and nutrient absorption. Additionally, the 7.5% crude ash content indicates a rich mineral composition, essential for metabolic processes. The study demonstrated that *C. auratus* fed on *Sarcophaga* larvae exhibited superior growth compared to those fed commercial fish food, confirming the larvae's high nutritional value and potential to improve fish health and coloration. Consistent with previous research, these findings underscore the viability of insect larvae as a sustainable feed alternative, though further studies are needed to standardize rearing protocols and ensure long-term benefits and safety in various aquaculture systems.

Conflict of interest

The author declares that there is no conflict of interest regarding the publication of this manuscript.

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