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Fruit Fly Maggots as Alternative Feed to Improve Siamese Fighting Fish (*Betta splendens*) Fecundity, Eggs Hatchability and Fry Survivability

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Abstract

Siamese fighting fish or bettas are highly favoured for their aesthetical value and kept as ornamental fish. They are widely bred to satisfy the market demands. However, large-scale production of bettas is hampered by relatively high rate of mortality compared to the number of eggs laid. The nutrition intake literally influences the reproductive performance and eggs quality. Therefore, it is plausible to improve the survivability of betta fry through dietary manipulation. Bettas can be fed with variety of feeds. Bloodworms and the commercially available pellets are commonly used. Fruit fly maggots emerged as potential anti-infective agent and have been used as alternative fish feed. Therefore, this study aims to harness the beneficial properties of maggots to enhance the reproductive performance and increase the survivability of the bettas. The effects on fecundity, eggs hatchability and fry survivability of maggot feed were compared with the other common feed, namely bloodworms and commercial pellet. The results showed that maggots can serve as an alternative feed for bettas whereby it gave average hatchability rate of 65% and survivability rate of 69%. Although, the mean hatchability and survivability rate did not differ significantly from the other two feeds, this study suggests the attainable yet economic feeding material, has potential to inaugurate further studies to enhance the production of bettas in large scale.

1. Introduction

Ornamental fish have become the most widely kept household pets after dogs and cats. It is a commercially important industry with its global export value that reached USD 342 million in 2010 (Tissera, 2012) and RM379 million of production in Malaysia for year 2014 (DOF, 2014). Siamese fighting fish (*Betta splendens*) or conversationally known as betta is a freshwater fish from Osphronemidae family. It is one of the favourite aquarium fish due to its brilliant colours. Bettas provide the highest income among exported ornamental fish in Thailand (Thongprajukaew et al., 2011). In Malaysia, bettas also known as fighting fish or are locally called “ikan laga”. This fish inhabits variety of freshwater swamps, hillstreams, peat swamps or man-made environment of cannals and paddy fields (Chan, 2015). The issue of insufficient supply of betta to fulfill the market demands arises from the low survivability of betta fry. This is mainly due to the minute size of the betta fry that restricted the food intake and concomitantly prone to predation.

Since decades ago, it has been reported scientifically that the fecundity of fish can be increased with better feeding. Eggs may develop normally and the egg size can be increased with substantial improvement in feeding conditions (Woodhead, 1960). Hence, large population of fish occurs at nutrient-rich environment. Various studies have been conducted to specify the key nutritional factors that influence the reproductive performance. Amongst others, lipids and essential fatty acids showed the remarkable effects on reproductive performance in fish. They are the major compositions in broodstock diet that determine the successful reproduction and survival of offspring (Izquierdo et al., 2001). The research later showed that not only the individual level of fatty acids but the appropriate ratio among them are crucial in broodstock diet for gonad development and reproductivity (Suloma & Ogata, 2012). Besides, influence of vitamins in fish reproductive fitness is undeniable (Izquierdo et al., 2001; Mehrad et al., 2012). Moreover, the egg quality and early development of fry are also dependent on the vitamin A and E content in the maternal diet (Palace & Werner, 2006). The content of vitamin A and E allowed larger initial egg size and in turn correlated with larger larval size and better survivability (Lavens et al., 1999).

Taken together, it is feasible to tackle the survivability of betta fry through dietary manipulation. Attempts to study the correlation of maternal fish fitness to the fitness of the offspring spurred from the idea that nutrients from feeds provided to the parent can be passed on to the offspring prior to spawning. It has also been reported that large females can produce larger eggs (Einum & Fleming, 1999). Maternal size influenced eggs production. and considerably high buoyant eggs, implying more oxygen for embryo development (Vallin & Nissling, 2000). Bigger eggs indicate better quality and thus hatch into bigger sized fry. Based on the theory of

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selective mortality, unfavourable fingerlings will be eliminated as the bigger fry can digest bigger food particles and small fry will have limited supply of food due to the small mouth (Meekan et al., 2006). In the wild, bettas are not selective and will feed on anything available from their environment. Hence, domesticated bettas can be fed with variety of feeds, for instance, frozen or live bloodworms, brine shrimp, daphnia, frozen glass worms, tubifex worms, mysis shrimp, beef heart, white worms, grindal worms, black worms and wingless flies. However, no scientific report has been found to disclose the effects of these feeds on the bettas' reproductive performances as well as the eggs quality. In this study, bettas' fecundity, eggs hatchability and fry survivability were compared among the fish fed with commercial pellets, bloodworms and fruit fly maggots.

2. Materials and Methods

2.1. *Beta splendens*

Nine pairs of betta broodstock aged 4 to 8 weeks were reared for a month prior to controlled-feeding period. The age was distinguishable from their sizes, finnages, and colours. The broodstock was reared in a controlled environment, with same amount of sunlight, temperature, and humidity. During the first month of preparation, the broodstocks were fed with commercial feed twice daily until satiation.

2.2. Feeding Trials

Three types of feed were investigated in this research, the commercial pellets, bloodworms, and fruit fly maggots. Commercial pellets served as the control in this study. Both bloodworms and fruit fly maggots were tested against the commercial pellets. In this research, frozen bloodworms were purchased from local pet shop whereas the fruit fly maggots were cultured using over-ripen banana. The banana was left outdoor to attract wild fruit flies. The eggs laid were collected and left for hatching in a covered container. The hatched maggots were collected and kept frozen in a freezer. Feeding trials began after 2 days of fasting to eliminate the effects from the previous feed. Each type of feed was tested on 3 replicates of fish, which each replicate consisted of a male and a female fish that were used for pairing. All replicates of fish were fed to apparent satiation twice daily.

2.3. Spawning of Bettas

After 4 weeks of feeding trials, the bettas were subjected to spawn. The reason of spawning the fishes only after a month of feeding was because apparent feed conversion data can be obtained only during week 4 to 7 (Winfree & Stickney, 1980). The breeding tank for spawning was set up using water aged 1-2 days with sea almond tree (ketapang) leaves. The inclusion of sea almond tree leaves not only provided the fish with substrates to hide, but also provided a slightly acidic environment. Male fish was released into the spawning tank allowing it to adapt to the new environment. Meanwhile, the female fish was confined in a small transparent container inside the same spawning tank. The fish were left for a few days until the male fish build up it's bubble nest. After the nest construction was done, the female fish was released for mating. Spawning process lasted for an hour. The female fish was taken out to prevent it from eating the eggs. Male fish was left inside the tank to guard the eggs until hatching took place.

2.4. Data Collection

Fecundity of bettas subjected to different feed was determined by the number of eggs laid. The data was recorded once after the eggs were laid. Hatchability rate was determined following the formula:

$$\frac{\text{number of hatched fry}}{\text{total eggs laid}} \times 100\%$$

Survivability rate was determined by the number of fry survived over the total of hatched fry for the first week after hatching, following the formula:

$$\frac{\text{number of fry survived}}{\text{total hatched fry}} \times 100\%$$

The mean value of fecundity, hatchability and survivability rates for bettas subjected to different feed were calculated from 3 replicates of fish for each feed.

2.5. Statistical Analysis

Statistical analysis was conducted using SPSS software. Statistical differences of the number of eggs laid, hatchability and survivability of fry fed with commercial feed, bloodworms and fruit fly maggots were determined using one-way ANOVA.

3. Results and Discussion

Number of eggs laid, hatchability and survivability of the betta fry in response to different feed were presented in the bar graphs as shown in Figure 1, 2 and 3, respectively. Although there is no significant difference indicated statistically among the 3 feeds, the results primarily showed the effectiveness of these feeds in the aspect of fecundity, eggs hatchability and fry survivability. Figure 1 shows the fecundity of bettas subjected to each feed. Bettas fed with fruit fly maggots averagely laid nearly 400 eggs per spawning, whereas, the bettas fed with commercial pellets and bloodworm averagely laid around 200 and 100 eggs, respectively. Hatchability of bettas subjected to fruit fly maggots was around 65%, followed by bettas subjected to bloodworm at 55% and bettas subjected to commercial pellets of about 28%, shown in Figure 2. In addition, bettas subjected to fruit fly maggots also leading in the survivability rate at 69%, followed by bettas fed with commercial pellets and bloodworms at 54% and 51%, respectively as shown in Figure 3.

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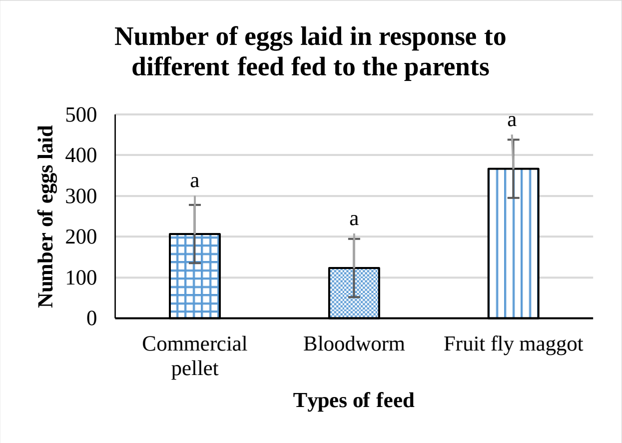

Figure 1: Number of eggs laid by bettas subjected to commercial pellet, bloodworm and fruit fly maggot

The numbers of eggs shown were means from 3 replicates of fish fed with corresponding feed. The error bars indicate standard error and the alphabets indicate the significant difference (P<0.05).

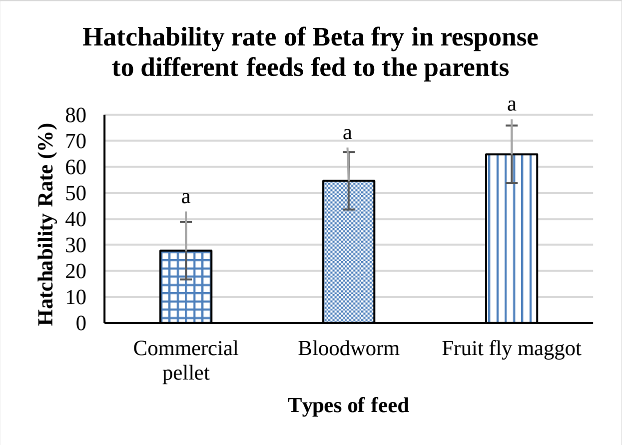

Figure 2: Hatchability rate of betta fry subjected to commercial pellet, bloodworm and fruit fly maggot

The hatchability rate shown were means from 3 replicates of fish fed with corresponding feed. The error bars indicate standard error and the alphabets indicate the significant difference (P<0.05).

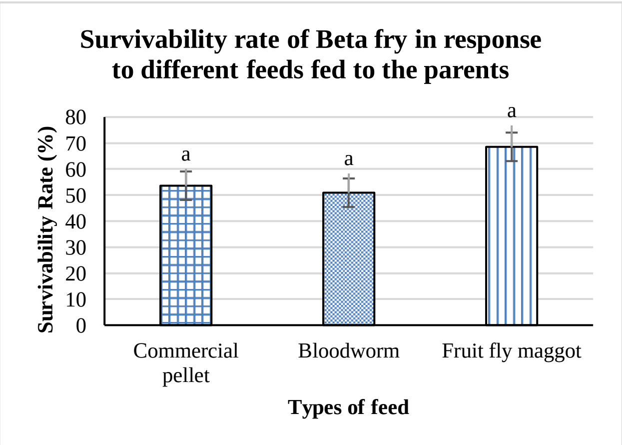

Figure 3: Survivability rate of betta fry subjected to commercial pellet, bloodworm and fruit fly maggot

The survivability rate shown were means from 3 replicates of fish fed with corresponding feed. The error bars indicate standard error and alphabets indicate the significant difference (P<0.05).

In this study, bettas fed with commercial pellets produced the least eggs with low hatchability and fry survivability. Commercial pellets have been widely used to feed domesticated bettas. It is usually formulated to give fish a balanced diet and is supposedly ideal for betta growth. However, it is always a trade-off between growth and reproduction, both events require high energy through food intake. Therefore, the commercial pellets might have limitation to promote reproductive performance of bettas. In addition, the problem of palatability, undesirable pellet size and the pellets sink too fast might end up as waste rendering it an option to bettas' diet and cannot be served as solely feed. Furthermore, bettas are more likely to consume live food as they are carnivores and possess the predatory behavior. Therefore, commercial pellets are good enough for feeding on daily basis, but the usage for breeding purpose is constrained.

Commercially, bloodworm has been introduced as a potential live food to enhance the spawning of bettas. Bloodworms are the larvae of an insect that resemble mosquitoes of the family Chironomidae. In this study, bloodworms displayed a moderate number of eggs produced, eggs hatchability and fry survivability among the 3 diets. The iron-porphyrin gives rise to the red characteristic of bloodworms indicates a good source of iron and protein for fish. Bloodworms are choice of betta breeders before spawning to provide sufficient energy and iron. This might be due to the high iron content that is crucial in sperm production and thus boost the reproduction. Despite of the wide usage of bloodworm in bettas' diet, the real potential of bloodworm in enhancing reproductivity remains elusive.

Drosophila melanogaster or generally known as fruit fly, has larvae close enough to bloodworm. However, despite its potential as live food for betta, it is not commercially available. Until now, there is no scientifically reported study on using fruit fly maggots as fish feed. Fruit fly maggots are suggested in this study as they could provide high energy to the bettas due to their diets, which are sugar-rich fruits. Feeds that provide high energy are important to promote growth and ensure good reproduction. The nutritional value of bloodworm and fruit fly maggot reported by Bernard and Allen (1997) showed that bloodworm contains 52.8% of protein, 9.7% of fat, 0.38% of calcium and 0.90% of phosphorus, whereas, fruit fly maggot contains 40.3% protein, 29.4% fat, 0.59% calcium and 2.30% phosphorus. Despite having the high protein content that resemble the bloodworm, fruit fly maggot also has much higher fat content compared to the bloodworm. Rendering the fact that fecundity and survival of offspring are mainly determined by the lipid and fatty acid compositions of broodstock diet (Duray et al., 1994; Fernández-Palacios et al., 1995), high fat content in the fruit fly maggot can be served as good source of lipid and fatty acids to the broodstock.

The larvae of the common green bottle fly (*Lucilia sericata*) have a therapeutic effect on chronic and nonhealing wounds has emerged as medical maggots. The traditional wound healing treatment using this maggot, which is known as maggot therapy, has prompted researches to isolate antimicrobial peptide from this creature (Zhang et al., 2013; Pöppel et al., 2015). The preference of fruit fly surviving on fermented media shows its ability to tolerate well with microbes. This might be one of the reasons that fish fed with maggots have better hatchability and survivability. In this study, bettas fed with fruit fly maggots produced the most eggs with the highest hatchability and fry survivability even though statistical insignificant difference indicated among the 3 diets. The anti-infective effects of the fruit fly maggots not only safeguard the parents but through maternal transfer, barrier against microbial attack to the eggs might be established. Better defense system ensures the better survival. Moreover, in this study, it was found that the bettas fed with fruit fly maggots produce more bubble nest (data not shown) that provide more rooms for the eggs. More bubble nest enables more eggs to be incubated. As the male bettas build up the bubble nest by blowing bubble around the floating base, we suggested that the bettas have gained sufficient energy from the fruit fly maggots feed, thus, increased the number of bubble nest. Further studies can be carried out to observe the number and size of bubble nest built by the bettas subjected to different feed as building bubble nest is the initial step of the bettas reproductive cycle and it also reflects the male success reproductivity (Haung & Cheng (2006).

4. Conclusion

Even though the results do not exclusively pinpoint the best feed among the 3 diets in the aspect of fecundity, eggs hatchability and fry survivability, it shows that fruit fly maggots are compatible diet for bettas compared to the commercial pellets and bloodworms. In fact, the fruit fly maggots shows the highest eggs production and hatchability as well as the highest percentage of fry survivability. These findings suggest fruit fly maggots as an economically sustainable alternative of bettas' diet and they are easily obtained through simple trapping method. It is recommended to profile the nutrient content of fruit fly maggots as well as to further investigate how this diet correlates to the production of bubble nest.

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