BIODEGRADATION *EICHHORNIA CRASSIPES* OF BLACK SOLDIER FLY LARVAE *(HERMETIA ILLUCENS)* BASED ON GROWTH RATE AND FOOD COMSUMPTION

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SUMMARY

Water hyacinth (*Eichhornia crassipes*) is recognized as an invasive species in numerous countries. Black solider fly larvae (BSFL) or *Hermetia illucens* is a common and widespread fly of the family Stratiomyidae, whose larvae are common detritivores in compost heaps. In this study, 6 day old BSFL were fed with the food which were water hyacinth and residues after BSFL grew on organic waste from domestic waste which contains bacteria producing enzymes from gut of BSFL. The ratio of water hyacinth and residues in 4 models were 1:0; 1:1; 2:1; 3:1, respectively and control model (which BSFL were fed with organic waste from domestic waste). The parameters such as weight, size and protein content of BSFL, food residual were measured every 3 days or 4 days until BSFL reached 30 day old. Results showed BSFL were able to survive and grew in the model 1:0 in which the food was only water hyacinth, but the BSFL had the lowest growth rate of 163.00% after 24 days of feeding. In addition, model 1:1 showed that the highest growth rate of BSFL was 299.99% after 24 days of feeding. In model 1:1 with the weight rising larvae was high (2.34%), in which 0.78% was converted to protein content of the larvae, commensurate with water hyacinth consumption of 35.16%. The study found a method of treatment of this invasive plant species. Simultaneously, this process creates a protein-rich food source for animals. Therefore, BSFL should be used to treat water hyacinth to produce a protein-based feedstock, contributing to sustainable development.

Keywords: *black soldier fly larvae, water hyacinth, biodegradation, sustainable development*.

INTRODUCTION

Water hyacinth (*Eichhornia crassipes)* can be cultivated for waste water treatment [1]. Water hyacinth is reported for its efficiency to remove about 60–80 % nitrogen and about 69% of potassium from water [2] [3]. However, water hyacinth is known as invasive species because of a vigorous grower (double in population in two weeks). Water hyacinth is often seen as a source of pollution of rivers like the Amazon and some other subtropical regions, including Vietnam. When not controlled, water hyacinth will cover lakes, ponds, rivers… This dramatically impacts water flow, blocks sunlight from reaching native aquatic plants, and starves the water of oxygen, often killing aquatic organisms, creates conditions for development of flies and mosquitoes, increases anaerobic decomposition process in the muddy water and pollutes the environment, affects the process of self - cleaning of water [4].

Black solider fly larvae (BSFL) or *Hermetia illucens* is a common and widespread fly of the family Stratiomyidae, whose larvae are common detritivores in compost heaps. Erickson et al. (2004) reported that *Hermetia* larval activity significantly reduced *E. coli* 0157:H7 and *Salmonella enterica* in hen manure [5]. Dried black soldier fly prepupae contain 42% protein and 35% fat [6]. Live prepupae are 44% dry matter and are easily dried for long term storage. As a component of a complete diet they have been found to support good growth of chicks, swine, rainbow trout and catfish [6] [7] [8] [9]. Prepupae meal can replace at least 25% of the fish meal in a diet with no reduction in gain or feed conversion ratio in rainbow trout or channel catfish [8] [9].

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The combination of black soldier fly cultivating on water hyacinth will help reuse waste, find a method of treatment of this invasive plant species. Simultaneously, this process creates a protein-rich food source for animals, contributes to the development of sustainable environment.

Figure 1. *BSF*

MATERIALS AND METHODS

Black solider flies (BSF) were obtained in a 1.2 x 1.2 x 3.2 m cage held outdoors (as direct sunlight is required for successful mating) at 28^{o}C, 80% relative humidity [10] (Fig 1). Females oviposited in the flutes of trips of corrugated cardboard which were attached to the wall of a bucket containing pineapple and squash as an attractant.

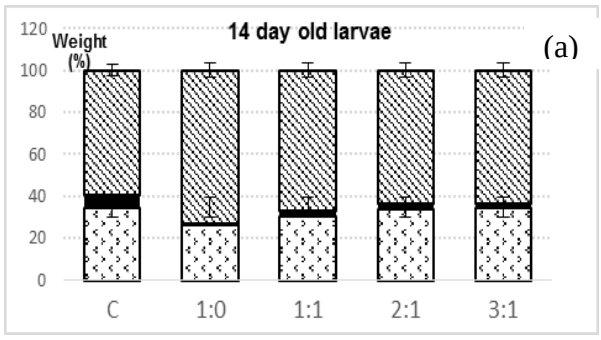
Figure 2. *BSFL*

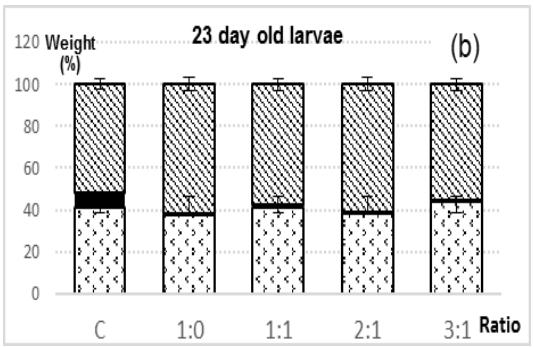
Each treatment (two replicates per treatment) contained 200 larvae (6 day old, hand counted) fed with the food were water hyacinth and residues after BSFL grown on organic waste from domestic waste which content bacteria producing enzymes from gut of BSFL. The daily food rate was 100 mg larva^{-1} day^{-1} (wet weight). The ratio of water hyacinth and residues in 4 models were 1:0; 1:1; 2:1; 3:1, respectively. In the control model, 200 larvae (6 day old) were fed with organic waste from domestic waste. The 6 day old larvae were initially placed onto the prepared food within plastic boxes (7 x 9 x 14 cm) (Fig 2). Box lids contained 15 holes (diameter, 7mm) to allow air circulation.

Sampling and feeding were performed every three or four days until BSFL reached 30 day old. While sampling and feeding, larvae were transferred into another box containing the next food ration. Residual material of the previous box was weighted to caculate the food consumption. The parameters such as weight, size of BSFL were measured by hand (took random 20 larvae) every 3 days or 4 days. Protein content of BSFL was measured by Buriet method (took random 5 larvae) [11].

RESULTS AND DISCUSSION

6 day old larvae were contained in 4 models using water hyacinth and residues after BSFL grown on organic waste from domestic waste with the ratio of 1:0; 1:1; 2:1; 3:1. Once control model, 200 larvae (6 day old) were fed with organic waste from domestic waste.





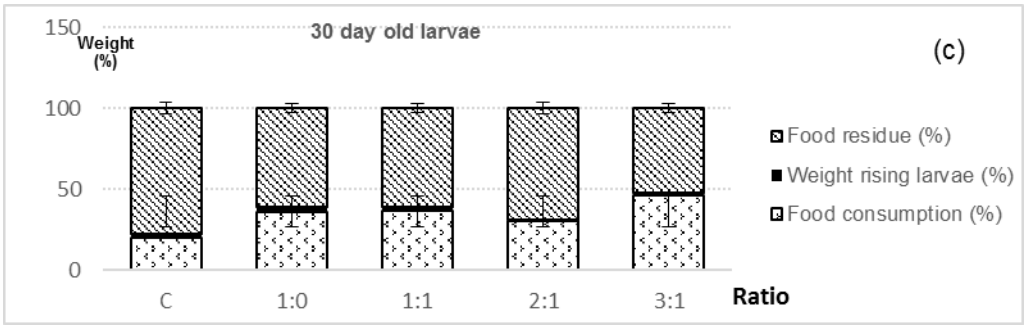


Figure 3. *The ratio between food residue, food consumption and weight rising larvae of stages*

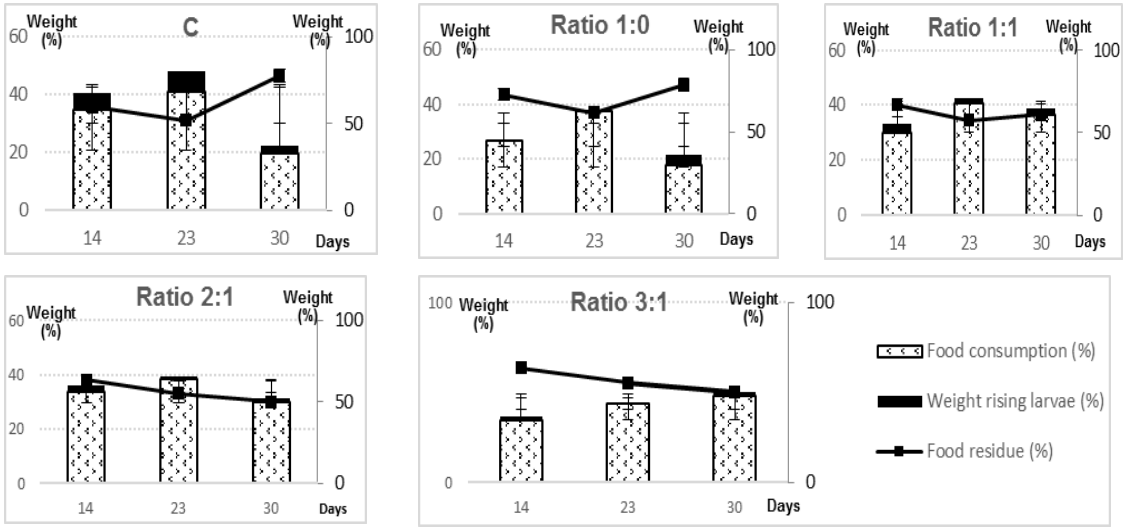


Figure 4. *The ratio between food residue, food consumption and weight rising larvae of models*

The result of the ratio between food residue, food consumption and weight rising larvae were shown in Figure 3. The food consumption was directly proportional to weight rising larvae.

In both 14 day old and 23 day old, the weight rising larvae in model 1:0 (100% water hyacinth) was the lowest 0.63% and 0.92%, respectively; commensurate with water hyacinth consumption was the lowest 26.55% and 37.37%, respectively. However, when larvae were 30 day old, weight rising larvae in model 1: 0 reached the highest level (3.77%), commensurate with water hyacinth consumption of 35.96%. Figure 3a and Figure 3b showed that the difference in food consumption among models was not high. But when the larvae reached 30 days of age, there was a big difference (Figure 3c), the highest and lowest food consumption were 45.82% (model 3:1) and 19.72% (model C), respectively.

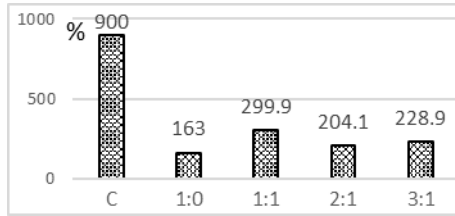


Figure 5. *Growth rate of BSFL after 24 days*

Only a small amount of food consumption was converted into biomass of larvae in different models (Figure 4). Control model used fragrant and pumpkin as food of BSFL, the larvae began to grow best in larval stage in which weight rising larvae reached 5.80% at 14 day old to 7.26% at 23 day old and decreased to 2.64% at prepupae stage.

In model 1:0, the BSFL took a long time to adjust the new food (100% water hyacinth), weight rising larvae fast increased from 0.65% (23 day old) to 2.13% (30 day old). According to current observations, at 30 day old, BSFL became pupa (yellow to black) in the control model, but other models BSFL were still in the prepupal stage. The life cycle of BSF in control model (which BSFL used favorite food) was longer than other models (which BLSF treated water hyacinth).

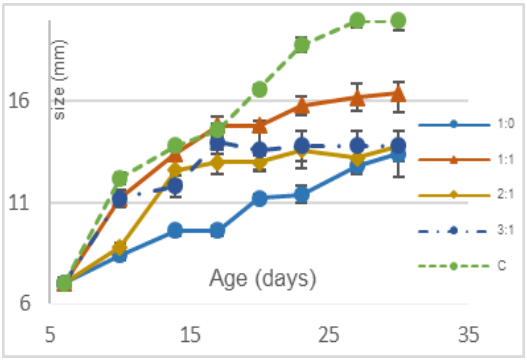


Figure 6. *The size of BSFL in models*

The food consumption (which was water hyacinth) in model 1:0, model 1:1 and model 2:1 were 37.36%, 40.79% and 38.60%, respectively at 23 day old; reduced to 35.96%, 39.48% and 28.66%, respectively at 30 day old. Meanwhile, food residue in model 3:1 continued to reduce at 30 day old.

Figure 5 showed the growth rate of BSFL after 24 days compared with 6 day old larvae initially. Water hyacinth contents crude protein 7.17%, lipid 1.31% dry weight; with humidity> 90% [12]. Water hyacinth was used as the only indigestible food source of larvae in model 1:0, but the BSFL were able to survive and have the lowest growth rate of 163.00% after 24 days of feeding. Model 1:1 for the highest growth rates in the models treated water hyacinth was 299.99% after 24 days, but was less than 3 times the control model (900.00%). In model 1:1, the BSFL also consumed food with high rate (30.00% at 14 day old, 40.79% at 23 day old and 36.55% at 30 day old, respectively.

Like the growth rate, the larval size increased from time to time (Figure 6). Model 1:0 showed that the size of larvae rapid increased when they used the food source (after 23 days). Although the laval size in control model was higher than all models which used water hycinth as food source.

The results of food residue, food consumption, weight rising larvae and protein content of BSFL in 30 day old compared with the original larvae 6 days age presented in Table 1. In model 1:1 with the weight rising larvae was high (2.34%), in which 0.78% was converted to protein content of the larvae, commensurate with water hyacinth consumption of 35.16%. While the weight rising larvae in model control was 6.05%, in which 2.57% was converted to protein content of the larvae.

The relative protein content (% of dry weight) of prepupae ranged from 30.60% (model 1:0) to 35.01% (model 1:1), reached highest at model control (42.51%). The protein contents of the well nourished prepupae obtained in this study turned out to slightly lower than the 42.51 % observed by control model (which uses organic waste from domestic waste as food for BSFL). The protein contents of model control like 42.00% observed by Newton et al. (1977). However, the protein content obtained approves the applicability of dried prepupal meal in feed industry.

Table 1. *Food residue, food consumption, weight rising larvae and protein content of BSFL at 30 day old*

Model	1 : 0	1 : 1	2 : 1	3 : 1	Control
Protein content (% of dry weight)	30.60	35.01	33.45	33.12	42.51
Food residue (%)	65.44	61.50	63.30	57.53	58.40
Food consumption (%)	33.33	36.16	35.22	40.95	35.54
Weight rising larvae (%)	1.23	2.34	1.49	1.52	6.05

CONCLUSIONS

Research initially succeeded in testing the ability to treat water hyacinth by BSFL. In the model which only used water hyacinth (1:0), the BSFL need a long time to get used to this food source (after 23 days). Water hyacinth was combined with residues after BSFL grown on organic waste from domestic waste in which content bacteria produce enzymes from gut of BSFL, helping larvae quickly become acquainted with new food source. Model 1:1 shows that the food consumption was highest of 30.00% (14 day old), 40.79% (23 day old) and 36.55% (30 day old); the growth rate was highest of 299.99%, and the protein content was highest of 35.01% also. However both the food consumption and the growth rate in these models were lower than in the control model.

Results showed BSFL were able to survive and grew in the model 1:0 which the food was only water hyacinth, but the BSFL had the lowest growth rate of 163.00% after 24 days of feeding. Model 1:1 showed the highest growth rate of BSFL of 299.99% after 24 days of feeding. In model 1:1, the weight rising larvae was high (2.34%), in which 0.78% was converted to protein content of the larvae, commensurate with water hyacinth consumption of 35.16%. The study found a method of treatment of this invasive plant species. Simultaneously, this process creates a protein-rich food source for animals. Therefore, BSFL should be used to treat water hyacinth to produce a protein-based feedstock, contributing to sustainable development.

Future work

Study to improve biodegradable water hyacinth of black soldier fly larvae.

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TÓM TẮT

KHẢ NĂNG PHÂN HUỶ *EICHHORNIA CRASSIPES* CỦA ẤU TRÙNG RUỒI LÍNH ĐEN (*HERMETIA ILLUCENS*) DỰA TRÊN YẾU TỐ TĂNG TRƯỞNG VÀ PHÂN HUỶ THỨC ĂN

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Bèo lục bình (*Eichhornia crassipes*) được coi là loài thực vật xâm lấn ở nhiều nước trên thế giới. Ruồi lính đen (BSF) hay *Hermetia illucens* là loài ruồi phổ biến của họ *Stratiomyidae*, ấu trùng của chúng được tìm thấy trong đống phân thối rữa. Trong nghiên cứu này, BSFL 6 ngày tuổi được cho ăn bằng bèo lục bình với chất thải sau quá trình phân hủy chất thải sinh hoạt của ấu trùng ruồi lính đen trước đó (chứa vi khuẩn sản xuất các enzyme từ ruột của BSFL) với tỷ lệ lần lượt là 1:0; 1:1; 2:1; 3:1, và mô hình đối chứng (sử dụng rác thải sinh hoạt làm nguồn thức ăn cho ấu trùng). Các chỉ tiêu như trọng lượng, kích thước và hàm lượng protein của ấu trùng được đo mỗi 3 ngày hoặc 4 ngày cho tới khi ấu trùng đạt 30 ngày tuổi. Kết quả cho thấy BSFL có thể tồn tại và phát triển trong mô hình 1: 0 mà thức ăn là chỉ có lục bình, nhưng BSFL có tốc độ tăng trưởng thấp nhất là 163,00% sau 24 ngày nuôi. Ngoài ra, mô hình 1: 1 cho thấy tỷ lệ tăng trưởng cao nhất của ấu trùng là 299,99% sau 24 ngày nuôi. Trong mô hình 1:1 với ấu trùng tăng trọng lượng là cao (2,34%), trong đó 0,78% đã được chuyển hóa thành protein của ấu trùng, tương ứng với mức tiêu thụ lục bình là 35,16%. Nghiên cứu đã phát hiện được một phương pháp xử lý loài thực vật xâm lấn này, đồng thời, quá trình này sẽ tạo ra một nguồn thực phẩm giàu protein cho gia súc. Do đó, nên xử lý lục bình bằng BSFL để sản xuất nguyên liệu có nguồn gốc protein, góp phần phát triển bền vững.

Từ khóa: *ấu trùng ruồi lính đen, lục bình, phân hủy sinh học, phát triển bền vững*

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