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RESEARCH ARTICLE

New dimensions towards the restaurant waste management based on black soldier fly larvae (BSFL, *Hermetia illucens*) model in Ratnapura district

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ABSTRACT

The uncontrolled waste generation is a prevailing environmental concern where waste management is a critical issue in Sri Lanka. Even though different methods are practicing, insect-basedbio-degradation is forthcoming. Black soldier fly larvae (BSFL,Hermetia illucens) based emerging technology has recognized for the conversion of biodegradable waste into potentially more sustainable and marketable nutrient rich compost and animal feed rich with crude proteins. The study aims evaluate the potentials to introduce BSFL based biodegradation and to upgrade protein livestock feed sources by overwhelming urban catering bio-degradable waste in Ratnapura, Balangoda and Embilipitiyaurban council areas. Eighty-eight questionnaires were administrated through random sampling and the results were interpreted by descriptive statistics and bivariate correlation. More positively 97.7% were having the waste collection service supplied by local authorities (LA) with 93.2% daily collection. Importantly LA had a policy to collect the separated waste only. Even though 98.8%, 56.8% and 92.0% of the respondents were not known regarding BSFL protein production, live feeding and composting, 55.7% were willing to produce BSFL by their own bio-degradable waste. 46.6% and 71.6% were willing to sell 1kg of compost and BSFL larvae by Rs. 100-Rs.200 price for expected protein upgrade program in future. Further 60.2% were willing to use a BSFL based compost bin where it was requested to be compatible with the limited space. Since locally it is hardly evidenced regarding this insect-based technology, correlation results indicated the need of more awareness mainly BSFL bio-conversion and relevant technical knowhow procedures along with popularize BSFL based protein production.

Keywords*: bio-conversion, Black soldier fly larvae (BSFL), restaurant, waste, compost, protein*

INTRODUCTION

Around 4.3 billion urban residents will gather and generate 1.42 kg/capita/day of municipal solid globally and cost of waste handling to be increased around $375.5 billion in 2025 (Hoornweg and Bhada-Tata, 2012).Internationally, 44% (highest portion) of global waste is composed with food and green (Kaza*et al.,* 2018).Sri Lanka, under the developing framework also undergoes waste management as a critical issue and made disastrous (Karunasena*et al.,* 2009). Daily Municipal waste generation is approximately 7410 tons day^{-1} in Sri Lanka (Basnayake, 2018).The local authorities (LA) are currently involved in the waste management, although approximately 90% of collected municipal waste is

openly dumped in environmental sensitive areas. Some LAs are interested in small scale composting on site of waste generation, the treatment options have not been successful yet (Batuwitage, 2004 and Vidanarachchi *et al.,* 2006). Urban solid waste is characterized by organic fraction highly (Menikpura *et al.,* 2012).

Insects based degradation has taken a raising attention rather than traditional waste management techniques. The larvae composting is faster than the conventional treatments, facilitating microbial degradation and a possible way to enhance food and animal feed security (Li *et al.,* 2011, Čičková*et al.,* 2015, Green and Popa, 2012). Several major species have been identified as superior bio-waste convertors into compost and protein rich meals; common housefly (*Muscadomestica*), the black soldier fly (*Hermetiaillucens*), the mealworm (*Tenebriomolitor*), locusts (*Locustamigratoria, Schistocercagregaria, Oxyaspecesis*), and silkworms (*Bombyxmori*) as a promising and sustainable approach (Kim *et al., 2019*).

The black soldier fly (BSFL; *Hermetiaillucens*); is more beneficial among other insects as non-pest with long larval period for more bio-accumulation through vast range of organic degradation. Easy technology readiness and low cost of production is ensured for the sustainability of the BSFL based degradation. As it is native to tropical region, it is more tolerant to environmental extremes (Tran *et al.,* 2014). More gainfully the BSFL can produce 32-58% proteins (partially defatted protein content range 55-65% by dry weight) and 15-39% lipids (Dry weight). Further enriched with Lauric acid, antimicrobial peptides, and chitin producing the BSFL meal become even more superior (Gold *et al.,* 2018). Substitution of BSFL meal into conventional crude protein sources has been experienced positively with several livestock species (Newton *et al*., 1977, Sheppard *et al*., 1994, Cullere *et al.,* 2016, Renna*et al*., 2017). Meanwhile the world population growth is in an alarming rate coupling with rapid urbanization. It has predicted that the earth will bear 9.8 billion populations in 2050. Even though changes in food consumption patterns are retained, until 2016, 794 million people were malnourished (FAO, 2017). To feed the 7.3 billion people on the planet, over 202 million tons of protein are currently needed (Henchion *et al*., 2017). Essential amino acids abounded with trace minerals and vitamins are protectant against the hidden hunger (Kim *et al.,* 2019). It is sensed that the livestock products' demand will be heavily moderated, especially in developing contexts.

Locally it is hardly evidenced regarding the BSFL based bio-degradation and protein production. As a preliminary study of popularization of BSFL based bio-degradation technology, the present study aims to evaluate the socio-economic status, waste generation status and management practices, the awareness and willingness to engage in BSFL based compost and protein production using own organic wastes in highly urbanize catering sector.

MATERIALS AND METHODS

The study was adopted a random sampling technique to select 88 catering units representing three major urban areas of Ratnapura administrative district; Ratnapura, Embilipitiya and Balangoda. Primary source of data collection was administrated by well-structured both close and open-ended questionnaires. Each interviewee was provided an introduction and importance of BSFL prior to the evaluation. The evaluated categories were;

a) Socio-economic and demographic characteristics of the selected sample
b) Daily waste generation amount / status
c) Current waste management practices and usage of LA's waste collection service
d) Public awareness and willingness of BSFL based composting, utilization for livestock protein feed production and willing to purchase BSFL based composting bin (Introducing)

Data were administrated from questionnaires and the respective results were analyzed by using the Statistical Package for Social Science (SPSS) software (SPSS Inc., Chicago, IL, USA) version 21. Descriptive statistics were used to describe evaluated categories of the study population. Bivariate correlation was conducted to analyze the effect of public socio-economic factors towards waste management practices, willingness to produce BSFL-based animal protein and compost production using own bio-degradable waste, and willingness to utilize BSFL-based compost bin.

RESULTS AND DISCUSSION

Ratnapura Municipal council (22 km^2) collects solid wastes approximately 30 Metric tons day^{-1}. Around 63% of the generated waste is bio-degradable and the rest 37% is composed with recyclables. The 55% of them originated from commercial and other sectors where the rest 45% is generated by residential areas.

Out of the 25 tons of waste directed to the waste management plant, 12% is composted, 1% is recycled, and 84% is openly dumped without any treatment (Ratnapura Development Plan 2019 – 2030, 2019). In Balangoda urban council, (16.2 km^2) the waste generation accounts for 20 tons day^{-1} (0.9 kg/cap/day). A higher portion of generated municipal solid waste (MSW) is composed of organic perishables with high moisture content on wet basis and a moderate number of recyclables. 37% of the collected waste is failed to treat with existing waste management methods at the MSW center (Eheliyagoda and Prematilake, 2016). It is hardly evidenced regarding Embilipitiya MSW generation status and there is a research deficit in this regard. Joshi and Ahmed (2016) has been indicated that in the majority of cities' an average of 70% the generated waste is separated and the rest is dumped in the environment.

Socio-Demographic Characteristics of the People

Table 01 summarizes the Socio-demographic data of the respondents. The majority (56.8%) of the tested sample were in between the 31 – 45 y age group with an average of 40.92 y. Majority, 77.3% of the male respondents were carrying out their catering where a lower female was occupied with the business. 86.4% of them were married and the majority 42% had obtained a pre-secondary level education. Further 95.5% and 88.6% of the respondents were Sinhalese and Buddhists by their ethnicity and the religion respectively. Moreover, 79.5%, the majority were urban in residency. About 92% of the catering units were composed with 0-10 number of employees. The main segment, 64.8% of them had earned around Rs. 0- Rs. 500 000 range with an average of Rs. 298670.45.

Table 01: Socio-demographic data of the respondents

Socio-demographic characteristics	No of respondents (n=88)	Percentage (%)
Age		
Not mentioned	3	3.4
16-30	10	11.4
31-45	50	56.8
46-60	23	26.1
61-75	2	2.3
Gender		
Female	20	22.7
Male	68	77.3
Marital status		
Married	76	86.4
Unmarried	11	12.5
Divorced	1	1.1
Education status		
Not mentioned	4	4.5
Primary	7	8.0
Pre-Secondary	37	42.0
Post-Secondary	36	40.9
Tertiary	4	4.5
Ethnicity		
Sinhala	84	95.5
Sri Lankan Tamil	2	2.3
Moor	2	2.3
Religion		
Not mentioned	1	1.1
Buddhism	78	88.6
Hindu	2	2.3
Islam	3	3.4
Catholic	3	3.4
Other	1	1.1
Residence		
Urban	70	79.5
Peri Urban	15	17.0
Rural	3	3.4
No of employees		
0-10	81	92.0
11-20	4	4.5
21-30	1	1.1

41-50	1	1.1	Female
91-100	1	1.1	
Monthly net income (Rs.)			
Not mentioned	15	17.0	
0-500000	57	64.8	
500001-1000000	11	12.5	
1000001-1500000	1	1.1	
1500001-2000000	1	1.1	
2000001-2500000	1	1.1	
2500001 - 3000000	1	1.1	
4500001-5000000	1	1.1	

entrepreneurship was considerably low and importantly only 4.5% of them had obtained tertiary education where it indicates a low awareness and exposure of novel technologies, importance and need of efficient waste management. The religious and ethnic influence towards food preparation and customer consumption patterns.

Daily waste generation status

The daily waste generation was analyzed according to the type of waste. Average daily Bio-degradable waste (BDW) generation was counted as 8.064kg with a maximum weight of 9kg and minimum weight of 0.03kg.Average non-degradable waste (NBDW) generation was counted as 2.249 kg with a maximum weight of 7.53 kg and minimum weight of 0.025 kg. The ratio of BDW: NBDW is 3.586.

Waste Management Practices of the Respondents

The majority (89.8%) of them had practiced disposing of their generated waste to a bin, whereas 97.7% of them were having a regular waste collection service. Almost all the respondents were using the waste collection service and 93.2% of them are having a daily collection routine. About 95.5% of them were satisfied with LA's waste collection service and the people who were not satisfied due to improper collection. Even though, 65.9% of them had stored their generated waste in a garbage bin, more positively 94.3% practiced separating waste. It aimed to establish a composting program and evaluated their response to make them separate waste. Hence, 86.4% were willing to separate waste for that program. Table 02 summarizes the waste management practices of the respondents.

Table 02. Waste management practices of the respondents

Variable	No of respondents (n=88)	Percentage (%)
Method of waste disposal		
Collect into a bin	79	89.8
Throwing into a garbage pit	1	1.1
Handing over to UC	4	4.5
Swine feeding	4	4.5
Do you have a regular waste collection service in your area?		
Yes	86	97.7
No	2	2.3
Do you use that waste collection service?		
Yes	88	100.0
How often the waste collection services conduct?		
Daily	82	93.2
Twice a week	3	3.4
Thrice a week	3	3.4
Are you satisfied with the waste collection service?		
Not mentioned	2	2.3
Yes	84	95.5
No	2	2.3
If not, reason for the unsatifaction		
Untrustworthy	1	25
Improper collection	3	75
How do you store garbage in your catering place?		
Not mentioned	2	2.3
Polythene bags	21	23.9
Cardboard boxes	3	3.4
Garbage bins	58	65.9
Old bins	1	1.1
Cans	3	3.4
Do you separate garbage in your catering place?		

Yes	83	94.3
No	5	5.7
If Yes, why do you do so?		
Because of the awareness	1	1.2
Easiness of post processing	12	14.4
MC collects if waste is separated	69	83.13
Reduce environmental pollution and mosquito breeding	1	1.2
If No, what is the reason for not separating garbage?		
Not mentioned	83	94.3
Insufficient space	3	3.4
Time consuming process	2	2.3
If you don't separate garbage, what should make to intend to separate garbage?		
Should have sponsor for delivering garbage bins	1	20
If others also separate garbage, willing to separate garbage	4	80
If a compost fertilizer manufacture program is established, do you like to separate garbage?		
Yes	76	86.4
No	9	10.2

Awareness of BSFL and Its Utilization

Noteworthy 98.9% of the respondents were not aware of BSFL-based compost and protein production, whereas the person who was only aware in this regard was through newspapers. Noticeably, 78.4% of them were willing to produce BSFL-based compost and animal protein production by their bio-degradable waste. In an aim of establishing BSFL-based protein production in the future by having hands with the community. It was evaluated the public willingness to produce BSFL, where 71.6% of them were willing to produce and sell 1 kg of BSFL in the Rs. 100- Rs.200 price range. Other than that, 97.7% of them were not aware of BSFL live feeding. Moreover, 92% were not aware of BSFL-based composting. The 3.4%, were aware through newspapers. 55.7% were willing to produce BSFL based composting. Positively, 60.78% were willing to sell their BSFL compost for Rs. 100-Rs. 200 price range.

The majority (60.2%) were willing to use BSFL-based compost bins and 56.8% were willing to purchase, whereas the rest who refused to buy noted due to their insufficient space, less awareness of the mechanism, and other several factors (Table 03).However, 19.3% were willing to buy within the Rs. 5000 - Rs. 4000 price range.

Table 03. Public awareness and willingness to utilize BSFL based technology

Variable	No of respondents (n=88)	Percentage (%)
Do you aware regarding BSFL base animal protein production?		
Yes	1	1.1
No	87	98.9
If Yes, How?		
Newspapers, Magazines	1	100
Do you like to produce BSFL base animal protein production using bio degradable waste?		
Yes	69	78.4
No	19	21.6
If No, What is the reason?		
Religious attitudes	2	10.57
Less experiences on this regard	11	57.89
Aware regarding health issues	5	26.31
Other	1	11.23
How much will you expect for producing 1kg of BSFL for your catering bio degradable waste?		
Not mentioned or No idea	19	21.6
100-200	63	71.6
201-300	5	5.7
301-400	1	1.1
Do you aware regarding BSFL live feeding livestock feeding?		
Yes	2	2.3
No	86	97.7
Do you like to incorporate live feeding into livestock feeding?		
Yes	38	43.2
No	50	56.8
If No, What is the reason behind?		
Religious attitudes	18	36.0
Less experience on this regard	24	48.0
Fear on health Issues	7	14.0
Less knowledge on this regard	1	2.0
Do you aware regarding BSFL base composting?		
No idea	4	4.5
Yes	3	3.4
No	81	92.0
If Yes, How?		
Newspapers, magazines	3	100
Do you like to produce BSFL based compost production?		
Yes	49	55.7
No	39	44.3
If No, What is the reason behind?		
Religious attitudes	2	5.12
Less experience on this regard	7	17.94
Fear on health Issues	14	35.89
Less knowledge on this regard	4	10.25
Other	12	30.8

If other, Please specify		
No enough space	8	66.66
No enough space, time and difficulties	4	33.34
If Yes, How much will you charge for 1kg of BSFL based compost?		
Not mentioned	41	46.6
100-200	31	35.2
201-300	10	11.4
301-400	5	5.7
Not mentioned or no idea	1	1.1
Do you like to use a BSFL based compost bin?		
Not mentioned	1	1.1
Yes	53	60.2
No	34	38.6
If No, Why?		
Dislike to store garbage	3	8.57
Fly problems	1	2.85
Beware of health issues	1	2.85
Insufficient space	21	60.0
no aware about this process	2	5.12
No enough knowledge	5	14.28
Not practiced earlier	2	6.33
Do you like to purchase BSFL based compost bin?		
Not mentioned	1	1.1
Yes	50	56.8
No	37	42.0
If No, Why?		
Daily collection of waste by MC	1	2.63
Dislike to store garbage	3	7.89
Fly problems	1	2.63
Inability to invest for purchasing bins	1	2.63
Insufficient space	5	13.15
Insufficient space	5	13.15
no aware about this process	2	5.26
No enough knowledge	5	13.15
No enough space	12	31.62
Not practiced earlier	2	5.26
Religious attitudes	1	2.63
How much will you willing to pay for the compost bin?		
No idea	50	56.8
Rs.9000- Rs.8001	3	3.4
Rs.80000- Rs.7001	4	4.5
Rs.7000- Rs.6001	3	3.4
Rs.6000- Rs.5001	11	12.5
Rs.5000- Rs.4000	17	19.3

Noteworthy BSFL utilization and protein production was refused for some segments due to their own religious attitudes. The LAs are actively engaged in urban waste management and further, they strongly encourage and have a policy of collecting the separated waste only. However, some people were unsatisfied with improper waste collection. More importantly, the attitudes towards waste separation must be changed since a minor segment (5.7%) is still not practiced. Although people were not aware of BSFL utilization, considerably they were willing to adopt this novel technology. The majority of the refused people stated their less experience, cautious of health-related issues, and religious attitudes. Those factors are in need to be addressed prior to BSFL based degrading implementation.

The respondents' views and comments were noted. Repeatedly the same opinion of space insufficiency for maintaining a composting bin was highlighted. Other than the requesting a feasible price for purchasing, inability to allocate time for the bin operation, inadequate knowledge, inexperience over the process and aware of health issue outbreak were them to be considered for further modifications of the research aim.

The bivariate correlation (Table 04) is resulted a poor relationship in between many of the selected variables. More importance is paid for waste separation, since it is the first step of a sustainable waste management approach

Table 04: Correlation results of the Socio-economic characteristics with BSFL Utilization

Variable	*P*-value						
	Age	Gender	Education Status	Ethnicity	Religion	Residence	Monthly net income
Generated waste separation	-0.018	0.016	0.077	0.267	0.117	0.177	-0.079
Awareness of BSFL based protein production	0.020	0.198	0.165	00021	0.031	-0.378	0.008
Awareness of BSFL live feeding	-0.039	0.099	0.147	0.030	0.044	-0.385	0.028
Willing to incorporate BSFL live feeding into livestock feeding	-0.169	-0.035	-0.013	0.071	-0.011	-0.089	-0.018
Awareness of BSFL composting	0.031	0.030	0.077	0.054	0.081	-0.171	-0.034
Willingness to produce BSFL based compost production	0.041	-0.062	-0.023	-0.027	0.004	-0.060	-0.196
Willingness to use a BSFL based compost bin	0.053	-0.027	-0.127	0.000	0.043	-0.039	-0.137
Willingness to purchase a BSFL based compost bin	-0.027	-0.043	-0.099	-0.013	0.023	-0.070	-0.136

*Significance level, $P<0.010$

This is a very fresh concept to the local general community. Even in research sector Dissanayake*et al.,* 2016 had published regarding BSFL first locally.

CONCLUSIONS

Urban waste management by LAs is satisfactory and public involvement is considerably high with respect to waste separation and disposal. Noteworthy the local community is under-known and less aware regarding novel bio-degradable waste management practices. However, they had more positive responses for adaptation and were willing to introduce the BSFL based waste management practices. Importantly further modifications along with awareness, training, and monitoring programs with technical aspects are highly recommended for future BSFL knowledge transfer. To fabricate BSFL based compost bin, it should be compatible with limited urban space. The effort would be more useful for adopting sustainable waste management practices and support into the agro-livestock system with respect to the public positive feedback.

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REFERENCES

Basnayake, B.F.A., Popuri, S., Visvanathan, C., Jayatilake, A., Weerasoori, I. and Ariyawansha, R.T.K., (2019). Concerted initiative for planned management of municipal solid waste in target provinces in Sri Lanka. J. Mat.Cyc.and Waste Manag. 21(3),691-704.https://doi.org/10.1007/s10163-018-0815-5

Batuwitage P. 2004. Municipal Solid Waste – Challenges and Opportunities.Ministry of Environmentaland Natural Resources, Sampathpaya, Battaramulla, Sri Lanka.https://doi.10.13140/2.1.4627.0729

Čičková, H., Newton, G.L., Lacy, R.C. and Kozánek, M., 2015. The use of fly larvae for organic waste treatment. Waste Manag. 35, 68-80. https://doi.10.1016/j.wasman.2014.09.026

Cullere, M., Tasoniero, G., Giaccone, V., Miotti-Scapin, R., Claeys, E., De Smet, S. and DalleZotte, A., 2016. Black soldier fly as dietary protein source for broiler quails: apparent digestibility, excreta microbial load, feed choice, performance, carcass and meat traits. Animal. https://doi.10(12),1923-1930

Dissanayake, D.M.P.S., Silva, G.D.R., Kandemulla, K.A.C., Herath, H.M.S.K. and Weerakkody, W.J.S.K., 2016. Effectiveness of black soldier fly larva (*Hermetiaillucens*) in solid waste management and kitchen waste composting.Annals of sri Lanka Department of Agriculture 2016. 18, 220 - 223

Eheliyagoda, D. and Prematilake, N., 2016. Assessment of a Planned Municipal Solid Waste Management System in Sri Lanka. J. App. Sci. and Env.Manag. 20(1),58-61. https://doi.10.4314/jasem.v20i1.7

FAO (2017). *The future of food and agriculture – Trends and challenges*). Rome.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. &Tempio, G. 2013. Tackling climate change through livestock – A global

assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.

Gold, M., Tomberlin, J.K., Diener, S., Zurbrügg, C. and Mathys, A., 2018. Decomposition of biowaste macronutrients, microbes, and chemicals in black soldier fly larval treatment: A review. Waste Manag., 82,302-318. https://doi.10.1016/j.wasman.2018.10.022

Green, T.R. and Popa, R., 2012. Enhanced ammonia content in compost leachate processed by black soldier fly larvae. App. Bio. andBiotech. 166(6),1381-1387. https://doi.10.1007/s12010-011-9530-6

Henchion, M., Hayes, M., Mullen, A. M., Fenelon, M., & Tiwari, B., 2017. Future protein supply and demand: strategies and factors influencing a sustainable equilibrium. Foods, 6(7), 53.

Hoornweg, D. and Bhada-Tata, P., 2012. What a waste: a global review of solid waste management, USA.

Joshi, R. and Ahmed, S., 2016. Status and challenges of municipal solid waste management in India: A review. Cog.Env. Sci. 2(1),1139434.https://doi.org/10.1080/23311843.2016.1139434

Karunasena, G., Amaratunga, D., Haigh, R. and Lill, I., 2009. Post disaster waste management strategies in developing countries: case of Sri Lanka. International J.Str. Pro. Mana. 13(2),171-190.https://doi.org/10.3846/1648-715X.2009.13.171-190

Kaza, S., Yao, L., Bhada-Tata, P. and Van Woerden, F., 2018. *What a waste 2.0*: a global snapshot of solid waste management to 2050. World Bank Publications, USA.

Kim, S.W., Less, J.F., Wang, L., Yan, T., Kiron, V., Kaushik, S.J. and Lei, X.G., 2019. Meeting global feed protein demand: challenge, opportunity, and strategy. Ann. Re. Ani. Bio. 7, 221–43. https://doi.10.1146/annurev-animal-030117-014838

Li, Q., Zheng, L., Cai, H., Garza, E., Yu, Z. and Zhou, S., 2011. From organic waste to biodiesel: Black soldier fly, *Hermetiaillucens*, makes it feasible. Fuel, 90(4),1545-1548.https://doi.org/10.1016/j.fuel.2010.11.016

Menikpura, S.N.M., Gheewala, S.H. and Bonnet, S., 2012. Sustainability assessment of municipal solid waste management in Sri Lanka: problems and prospects. J. Mate.Cyc. Was. Mana. 14(3), 181-192.https://doi.10.1007/s10163-012-0055-z

Newton, G.L., Booram, C.V., Barker, R.W. and Hale, O.M., 1977. Dried *Hermetiaillucens* larvae meal as a supplement for swine. J. Ani. Sci. 44(3),395-400.https://doi.org/10.2527/jas1977.443395x

Ratnapura Development Plan 2019 – 2030 - Volume 1 For Ratnapura Municipal Council Area, Sri Lanka.

Renna, M., Schiavone, A., Gai, F., Dabbou, S., Lussiana, C., Malfatto, V., Prearo, M., Capucchio, M.T., Biasato, I., Biasibetti, E. and De Marco, M., 2017. Evaluation of the suitability of a partially defatted black soldier flies (*Hermetiaillucens* L.) larvae meal as ingredient for rainbow trout (*Oncorhynchusmykiss*, Walbaum) diets. J. Ani.Sci.Bio. 8(1), 1-13. https://doi.10.1186/s40104-017-0191-3

Sheppard, D.C., Newton, G.L., Thompson, S.A. and Savage, S., 1994. A value-added manure management system using the black soldier flies. Bio. Tech. 50(3), 275-279.https://doi.org/10.1016/0960-8524(94)90102-3

Tran, G., Heuzé, V. and Ankers, P., 2014. State-of-the-art on use of insects as animal feed. Ani. Feed Sci. and Tech. 197,2014-1.https://doi.org/10.1016/j.anifeedsci.2014.07.008