SCIENTIA
AGRICULTURAE
BOHEMICA

Short Communication

Influence of Black Soldier Fly larvae meal on growth performance and carcass characteristics of broiler birds

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Abstract: This study examines the effect of incorporating Black Soldier Fly (BSF) larvae meal into broiler diets on growth performance and carcass traits. Fourteen 4-week-old broiler birds were divided into two groups: one fed a standard commercial finisher feed and the other a BSF larvae meal-formulated feed with 15% BSF larvae powder replacing soybean meal. Over four weeks, body weight gain, feed intake, feed conversion ratio (FCR), and carcass characteristics were evaluated. Broilers fed with the standard feed exhibited slightly higher weight gain (1.21a) compared to those on the BSF-formulated feed (0.94b). Weekly feed intake showed no significant difference ($p>0.05$) between the two groups, with averages of 1.14 kg and 1.12 kg, respectively. However, the FCR of broilers on standard feed (3.9) was significantly better ($p>0.05$) than those on the BSF-formulated diet (4.72). These results suggest that while the growth performance of birds fed standard feed was slightly higher. This shows that inclusion of 15% BSF larvae powder in broiler finisher diets had no adverse effects on growth performance or health. This highlights the potential of BSF larvae meal as a sustainable alternative protein source in poultry nutrition.

Keywords: Broiler Birds, Black Soldier Fly Larvae Meal, Standard Feed, Alternative Protein

Received for publication on 08.02.2025

Accepted for publication on 02.06.2025

1. Introduction

The global demand for proteinous food is expected to more than double between 2000-2050 (229 million tons to 465 million tons), meeting this demand will require innovative solutions (Van et al., 2013). Poultry farming has significantly boosted protein production in developing nations thereby making a substantial contribution to the agricultural sector. Despite Nigeria's substantial livestock population, the country continues to face significant challenges in meeting its meat production needs (Chukwuka, 2024). Poultry feed constitutes 60-70% of the total cost of production, any attempt to reduce the feed cost may lead to a significant reduction in the total cost of production. The demand in developing countries for poultry products is projected to increase by 70% to feed 9.2 billion people worldwide by 2050 (UN,2019), thus putting even more pressure on the need to produce more animal proteins such as poultry eggs and meat.

Insect farming is an emerging sector that offers sustainable solutions to food and feed security, especially in the context of rising global protein demand. Insects such as Black Soldier Fly (*Hermetia illucens*), mealworms (*Tenebrio molitor*), and crickets (*Acheta domesticus*) can be mass-reared on organic waste, converting low-value biomass into high-quality protein and fat suitable for animal feed (Makkar et al., 2014; Van Huis et al., 2013). Also, insect farming contributes to waste management and circular economy practices by reducing organic waste accumulation (Gold et al., 2020).

The Black Soldier Fly (BSF) larvae are an excellent protein source. It has been stated that their amino acid profile is suitable for poultry (Barragan-Fonseca et al., 2017). Also, Arango Gutierrez (2005) suggested that Black Soldier Fly larvae have a suitable mineral content for the nutrition of poultry. On the other hand, BSF larvae contain high amounts of lipids whose fatty acid profile vary considerably depending on the composition of the rearing substrate (Popova et al., 2020). BSF larvae are rich in crude protein (35–55%) and essential amino acids that support muscle development and growth in broilers. They also contain lipids, minerals (like calcium and phosphorus), and bioactive compounds, making them comparable to traditional feed ingredients like fish meal and soybean meal (Makkar et al., 2014). Studies show that including larvae meal in broiler diets enhances feed intake, body weight gain, and feed conversion ratio (FCR), which are crucial indicators of broiler performance (Schiavone et al., 2017). BSF meal can positively influence carcass yield, dressing percentage, and meat quality (tenderness, juiciness, and protein content). Its fatty acid profile can also contribute to healthier meat for consumers (Cullere et al., 2016).

In recent years, the utilization of insect meal as high-quality ingredients in chicken, pig and fish diets has grown rapidly (Onsongo et al., 2018; Muin et al., 2017; Chia et al., 2019). The locally produced energy and protein feeds were designed to diminish the reliance on imported feeds especially corn and soyabean meal. Insects offer enormous potential as an alternative protein source to meet the rising demand for meat products while replacing fish meal and fish oil. (Ukwo et al., 2021). Moreover, consumers have also been reported to demonstrate a growing acceptance of animal products derived from livestock fed on compounded feeds containing insect meal (Mancuso et al., 2016).

In order to guarantee food security and preserved the natural habitats, several studies with focus in diversification of food sources has been carried out and systematically investigated widely, with the utilization of insects for nutrition being suggested as a possible solution (Belluco et al., 2013, Van et al., 2013). Studies have shown how consumption of edible insects have contributed effectively to nutrition and health, the environment, and livelihoods of people involved in edible insects' food chain (Belluco et al., 2013). Therefore, there is a need for a cheaper and nutritious source of insect protein has been of interest as an alternative source of protein for poultry feed.

The purpose of this study is to assess the impact of inclusion of BSF larvae powder on growth performance and carcass characteristics of broilers.

2. Materials and Methods

2.1 Study area

The study was carried out in a small poultry farm in the Nigerian Institute for Oil Palm Research (NIFOR), Benin. The location of the study is on the coordinates of Latitude 6.56^{0}N and Longitude 5.62^{0}E.

2.1.1 Black Soldier Fly Larvae Rearing and Oven-Drying

The production of BSF larvae started through the harvest of BSF eggs and they were reared and fed with organic wastes as feed for about 20 days into larvae under optimal conditions. The larvae were oven-dried at a temperature of 232^{o}C for 30 minutes per batch. The oven temperature of 232^{o}C was selected to ensure rapid and efficient drying and minimizing contamination. The larvae were spread in thin layers on trays and dried in batches to ensure optimal moisture removal. For 45kg of fresh BSF larvae dried, 15kg of dried and crispy BSF larvae was obtained. Then the larvae were milled into powdery form using a mechanized milling machine (Model A 02).

2.1.2 Proximate composition analysis of Black Soldier Fly Larvae Powder

Black Soldier Larvae samples was analyzed to determine their proximate composition, defined as moisture, carbohydrate, crude fibre, crude protein, crude fat, and ash contents according to AOAC (1990).

1. Dry matter content of larval samples was assessed by oven drying the samples at 105 °C until constant weigh and water content was determined as the weight difference before and after oven-drying.

2. For the crude protein content, the nitrogen content was determined following the Kjeldahl method and the value was multiplied by a conversion factor of 4.76 (Janssen et al., 2017) to obtain the crude protein value.

3. Fat content of larvae was determined by diethyl ether extraction in a fat extraction unit (SER 148: Velp Scientifica, Usmate, Italy) following the Randall technique, which involves:

   i. immersion of samples in a hot solvent (diethyl ether) to ensure rapid solubility,

   ii. washing off the solvent after boiling, and recovery by evaporation

   iii. condensation of the solvent.

4. Ash content was determined by ignition of samples at 550 °Cina muffle furnace.

Table 1 - Proximate composition of Black Soldier Fly Larvae Powder

S/N	CHEMICAL COMPOSITION	PERCENTAGE
1.	Moisture	10%
2.	Protein	39.2%
3.	Crude fat	12.5%
4.	Crude fibre	8.25%
5.	Ash content	6.50%
6.	Carbohydrate	9.4%

2.1.3 Formulation of Experimental Diets

The standard feed (control feed) was purchased from the market. The ingredients for the broilers' finisher feed were purchased from a feed mill. These components were mixed alongside BSF larvae powder to make a formulated diet as an experimental diet. Diet A - Control diet was commercial broiler finisher feed. Diet B - BSF diet was formulated broiler finisher feed with BSF larvae powder. The BSF larvae powder was used to replace the soybean meal. Diets A and B were used as Treatments 1 and 2 respectively

Table 2 Proximate composition of commercial finisher feed

Table 2 shows the result of the proximate analysis carried out on commercial finisher feed.

S/N	Proximate composition	Percentage
1.	Crude protein	22%
2.	Crude fat	4.5%
3.	Crude fibre	5.0%
4.	Ash content	7.9%
5.	Moisture	9.2%

Table 3 - Formulation of Black Soldier Fly formulated feed and standard feed

Table 3 gives the breakdown of all the ingredients used to formulate the commercial feed and the BSF formulated feed.

S/N	Ingredients	Quantity (kg/100 kg)	Quantity (kg/100 kg)
1.	Maize	50	50
2.	Palm Kernel Cake	8.10	8.10
3.	Soya Bean Meal	-	15.0
4.	Black Soldier F Larvae Meal	15.0	-
5.	Fish Meal	4.0	4.0
6.	Premix	1.0	1.0
7.	Bone Meal	1.0	1.0
8.	Limestone	1.0	1.0
9.	Salt	1.0	1.0
10.	Lysine	1.0	1.0
11.	Rice Bran	8.0	8.0
12.	Groundnut cake	9.0	9.0
13.	Toxin Binder	1.0	1.0
14.	Total	100kg	100kg

2.1.4 Birds and Brooding management

Fourteen four weeks old Cobb500 broiler birds were purchased from a poultry farmer. A deep litter system was used to rear broiler birds where ventilation, humidity and temperatures were not artificially controlled. Before the arrival of the to the broilers, the cages were thoroughly washed and cleaned to create and maintain a healthy environment for the birds. Brooding was carried out for four weeks. A long wooden feeder and conical drinker of 3 liters capacity water fountain was assigned to each cage. For each week, a weighed amount of feed was provided for the birds with respect to their dietary needs and 3 liters of drinking water was provided for the birds twice a day. The leftover feed was properly weighed and recorded every morning and evening. The feeders and drinkers were properly cleaned daily before provision of fresh water and feed. The feed consumed by the birds in each treatment was estimated weekly. Body weights were recorded weekly starting from week 5 to 8, by weighing each of the birds and recording the total weight for each treatment. Feed was supplied continuously by constantly topping up the empty troughs. Feed wastages were minimized by filling the troughs to about three quarter full.

2.1.5 Experimental Design

The birds were weighed and randomly assigned to two dietary treatments. T_1 was for broiler birds on Diet A with BSF larvae formulation and T_2 was for broiler birds on Diet B without inclusion of any BSF larvae formulation and. A cage was exclusive for each dietary treatment.

Plate 1: Black Soldier Fly Birds at week 5

Plate 2: Control Birds at week 5

2.2 *Data Collection*

2.2.1 Determination of growth performance

a) Feed Intake (kg/day) - Feed intake was determined daily as the difference between the quantity of feed given and the leftover the following morning.

Feed intake = quantity of feed served – quantity of feed left

b) Body weight gain: this is an increase in body weight. The birds were weighed at their arrival to the cages and the final weight was taken at the end of the experiment. The total body weight gain was then determined by subtracting the initial weight gain from final weight gain.

Body weight gain = final weight gain – initial weight gain

c) Feed Conversion Ratio: Feed Conversion Ratio is defined as the total feed consumed (kg) by a bird to produce weight gain.

$$Feed\ Conversion\ Ratio\ (FCR) = Feed\ consumed\ (kg) \div Weight\ gain\ (kg)$$

(Lock et al., 2016)

2.2.2 Determination of Carcass and internal organ weights

Two birds were randomly selected and weighed from each treatment after four weeks of rearing the birds. They were slaughtered by cutting the neck and then allowed to bleed to death in a big bowl. After this, they were scalded in hot water, dressed, eviscerated, and weighed. Carcass parameters, such as dressing yield (skin), breast meat yield, abdominal fat, and weight of visceral organs (heart, gizzard, and liver) were weighed and recorded. The carcass was cut into the constituent parts following the methods described by USDA (1989) and weighed. The internal organs such as heart, gizzard and liver were carefully separated and weighed.

2.3 *Statistical analysis*

All collected data were subjected to statistical analysis using one way analysis of variance (ANOVA) and differences among treatments means were evaluated by Duncan’s Multiple Range Test using SAS 9.1TM (SAS Inst., Inc., Cary, NC, USA). Significance was set at $p<0.05$.

3. Results

3.1 Growth Performance

The results of the growth performance were presented in Table 4. From the results, there was no significant difference (p>0.05) between the initial weights of the broiler birds of different treatments. However, broilers fed with standard feed had significant(p>0.05) higher final weight (2.75kg) and weight gain (1.21kg) compared to broilers fed with BSF Larvae formulated feed. There was no significant difference (p>0.05) in the mean value of the weekly feed intake between with broilers fed with standard feed with mean value of 1.14kg of compared to their counterpart fed BSF Larvae formulated feed with having mean value of 1.12kg. The table also revealed the feed conversion ratio of broiler birds fed with standard feed was significantly(p>0.05) with lesser mean value of 3.9 than broilers fed with BSF Larvae formulated feed with higher value of 4.72. There was mortality of two birds fed with standard feed whereas there was no mortality of birds fed with BSF Larvae meal

Table 4 – Growth performance of broilers birds fed with control feed and BSF Larvae formulated feed

PARAMETERS	CONTROL(T_1)	BSFLF(T_2)
Initial Weight (kg/bird)	1.54a	1.52a
Final Weight (kg/bird)	2.75a	2.46b
Weight Gain (kg/week/bird)	1.21a	0.94b
Feed Intake (kg/week/bird)	1.14a	1.12a
Feed Conversion Ratio	3.9a	4.72b

*CONTROL(T_1) and BSFLF(T_2) share letter "a", so they are not significantly different.
*CONTROL(T_1) and BSFLF(T_2) do not share any letter, so they are significantly different.

3.2 Carcass performance

The results of the carcass performance indices are on Table 5. The live and carcass weights of broilers fed with standard feed were both significantly higher (p>0.05) than the broilers fed with BSF Larvae formulated feed. Also, the mean value of breast, drumstick, liver, gizzard, neck, and head of broilers fed with standard feed were significantly(p>0.05) higher than the mean value of the broilers fed with BSF Larvae formulated feed. However, there is no significant difference(p>0.05) between the mean value of the heart of broilers fed with standard feed and the broilers fed with BSF Larvae formulated feed

Table 5 - Carcass performance of broilers birds fed with control feed and BSF Larvae formulated feed

PARAMETERS	CONTROL(T_1)	BSFLF(T_2)
Live weight (kg)	2.8a	2.3b
Defeathered carcass weight (kg)	2.6a	2.1b
Breast (g)	45a	25b
Drumstick (g)	30a	25b
Liver (g)	51.06a	37.06b
Heart (g)	11.41a	11.16a
Gizzard (g)	46.80a	56b
Wings (g)	151.76a	141.02b
Neck (g)	104.93a	90.12b
Head (g)	90.67a	63.87b

*CONTROL(T_1) and BSFLF(T_2) share letter "a", so they are not significantly different.
*CONTROL(T_1) and BSFLF(T_2) do not share any letter, so they are significantly different.

4. Discussion

Results from the experiment shows that the BSF formulated feed helps in the increase of the growth performance of finisher broiler birds. This agrees with the findings of Awoniyi *et al*., (2003) that reported that BSF has been tested as a potential protein-rich feed ingredient for other animals such as pigs and poultry. It was observed that the BSF formulated feed was darker than the standard feed due to the inclusion of BSF larvae powder. The birds fed much more on the standard feed than the BSF formulated feed. Hence, the weight gain and feed intake of the birds fed with standard feed was higher than the birds fed with BSF formulated feed. This agrees with findings of Loponte et al., (2017) and Marono et al., (2017) suggested that feed colour could affect the daily feed intake (DFI) of broilers, as *H. Illucens* meal appeared darker than soybean meal, and chickens were less willing to consume it.

In this study, the inclusion of BSF larvae powder in the BSF formulated feed was 15%. This aligns with the findings of Koly et al., 2023 that up to 20%, full-fat BSF Larvae can be safely used in balanced broiler diet formulations without compromising broiler performance or health and an inclusion level of 15% to 20% impacted immunologic parameters. This level of inclusion increased the immune system of the broiler birds as there was no mortality as compared to the birds fed with standard feed that experienced death of two birds. This finding also aligns with the claims of Zaid et al., 2023 that that BSF Larvae exerted a positive effect when offered at low levels, between 5% and 20%. Higher levels might result in no change or a negative impact on growth performance.

Cullere et al., (2016), Onsongo et al., (2018) and Kareem et al., (2018) did not observe the effect of *H. Illucens* meal inclusion on breast meat percentage in quails or chickens, respectively. This is observed in the breast mean weight of birds fed with BSF formulated feed is lower than the mean weight of birds fed with standard feed. The colour of the broiler breast are the same and this aligns with the findings of Fletcher, 1999 that indicated that there was no significant treatment differences for colour were observed regarding the colour characteristics of the broiler breast muscle

It was concluded by Koly et al., 2023 that the substitution of commercial poultry feed containing protein with BSF larvae meals expressed very modest or no changes in the meat quality. It was also observed during the carcass performance as there were no changes in the meat quality of the birds fed with BSF formulated feed and birds fed with standard feed. Though, BSF formulated feed needs more than 15% inclusion for more weight gain for the birds as compared to the standard feed which contain 15% soybean as revealed in table 3. Data obtained from this research work showed that 15% inclusion of BSF larvae in the broiler finisher feed will help in the growth and carcass performances of broiler birds if utilized in their feeding.

5. Conclusions

The results of this study shows that the BSF Larvae Powder is an efficient substitute for soybean meal in broiler finisher feed. This will reduce competition for soybeans as a protein source for the birds. Growth performance results showed a similar pattern in feed intake, weight gain, feed conversion ratio and final weight but the standard feed (control) showed better results indices. Though, the birds fed with BSF Larvae formulated feed were healthier as there was no mortality during the experiment as compared with the birds fed with standard feed that has a record of two dead birds. This indicated that the growth performance of birds fed with standard feed was slightly higher than the birds fed with BSF Larvae formulated feed. This study showed that inclusion of 15% of BSF Larvae Powder in the formulated broiler finisher feeds did not have a noticeable negative effect on growth performance and health of the birds. In conclusion, BSF Larvae Powder can be used as an alternative source of protein to replace soybean meal in broiler finisher feed. This can help reduce competition between humans and livestock for soybeans. The maximum threshold of soybean substitution with BSF larvae powder would between the range of 20% to 40%.

It is recommended that BSF Larvae Powder can be added to formulated finisher feed for broilers at 15% inclusion. The suggested range for the inclusion of BSF Larvae powder that can be added to formulated finisher feed should between 20% to 40%.

Author Contributions: Conceptualization, O.O Adeoye and T.I Aneni; methodology, O.O Adeoye, T.I Aneni and J.U. Obibuzor; software, V.K Odoemelam.; validation, O.O Adeoye, T.I Aneni, V.C Adaigbe and V.K Odoemelam ; formal analysis; investigation, O.O Adeoye and T.I Aneni ; resources, O.O Adeoye and T.I Aneni ; data curation, O.O Adeoye; writing—original draft preparation, O.O Adeoye; writing—review and editing, V.C Adaigbe and V.K Odoemelam ; visualization, O.O Adeoye and T.I Aneni; supervision, T.I Aneni; project administration, O.O Adeoye ,T.I Aneni, B.Ghansah ; funding acquisition, O.O Adeoye. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: I would like to thank NIFOR Executive Director for his support which was invaluable to the successful completion of this project.
Conflicts of Interest: The authors declare no conflict of interest.
Data availability statement: I declare that my data and datasets are available for research purposes. These data and datasets are accurate and reliable to the best of my knowledge.

6. References

1. Arango Gutierrez GP (2005): Aportes nutricionales de la biomasa de *Hermetia illucens* L. (Diptera: Stratiomyidae) en la cría de pollos de engorde. MSc thesis, Universidad Nacional de Colombia, Bogota, Colombia.

2. Awoniyi TAM, Aletor VA, Aina JM (2003): Performance of broiler-chickens fed on maggot meal in place of fishmeal. International Journal of Poultry Science 2, 271–274. 10.3923/ijps.2003.271.274

3. Barragan-Fonseca KB, Dicke M, Van Loon JJA (2017): Nutritional value of the black soldier fly (*Hermetia illucens* L.) and its suitability as animal feed: A review. Journal of Insects as Food and Feed 3, 105–120. https://doi.org/10.3920/JIFF2016.0055

4. Belluco S, Losasso C, Maggioletti M, Alonzi CC, Paoletti MG, Ricci A (2013): Edible insects in a food safety and nutritional perspective: A critical review. Comprehensive Reviews in Food Science and Food Safety 12, 296–313. https://doi.org/10.1111/1541-4337.12014

5. Gajana CS, Nkukwana TT, Chimonyo M, Muchenje V (2011): Effect of altering the starter and finisher dietary phases on growth performance of broilers. African Journal of Biotechnology 10, 14203–14208. https://doi.org/10.5897/AJB10.2529

6. Chia SY, Tanga CM, Osuga IM, Alaru AO, Mwangi DM, Githinji M, Subramanian S, Fiaboe KKM, Ekesi S, Van Loon JJA et al. (2019): Effect of dietary replacement of fish meal by insect meal on growth performance, blood profiles and economics of growing pigs in Kenya. Animals 9, 705. https://doi.org/10.3390/ani9100705

7. Chukwuka EAA (2024): Livestock industry in Nigeria: Challenges, current state, and path to transformation. Nigerian Journal of Animal Production, 247–249. https://doi.org/10.51791/njap.vi.4686

8. Cullere M, Tasoniero G, Giaccone V, Miotti-Scapin R, Claeys E, De Smet S, Dalle Zotte 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 10, 1923–1930. https://doi.org/10.1017/S1751731117001860

9. Koly JS, Uddin J, Hasan A (2023): Black soldier fly (BSF) used as poultry feed and its nutritive value analysis: A review of article. International Journal for Multidisciplinary Research 5. https://doi.org/10.36948/ijfmr.2023.v05i04.4998

10. Ekpo KE (2003): Biochemical investigation of the nutritional value and toxicological safety of entomophagy in Southern Nigeria. PhD thesis, Ambrose Alli University, Ekpoma, Edo State.

11. Gold M, Tomberlin JK, Diener S, Zurbrügg C, Mathys A (2020): Decomposition of biowaste macronutrients, microbes, and chemicals in black soldier fly larvae composting: A review. Waste Management 102, 838–852. https://doi.org/10.1016/j.wasman.2019.11.032

12. Loponte R, Nizza S, Bovera F, De Riu N, Fliegerova K, Lombardi P, Vassalotti G, Mastellone V, Nizza A, Moniello G (2017): Growth performance, blood profiles and carcass traits of Barbary partridge (*Alectoris barbara*) fed two different insect larva meals (*Tenebrio molitor* and *Hermetia illucens*). Research in Veterinary Science 115, 183–188. https://doi.org/10.1016/j.rvsc.2017.04.017

13. Lock EJ, Arsiwalla T, Waagbo R (2016): Insect larvae as an alternative source of nutrients in the diet of Atlantic salmon (*Salmo salar*) postsmolt. Aquaculture Nutrition 22, 1202–1213. https://doi.org/10.1111/anu.12343

14. Abidah MN, Wan Nooraida WM (2017): Growth performance and carcass analysis of broilers fed with enhanced quality palm kernel meal. International Journal of Poultry Science 16, 215–220. https://doi.org/10.3923/ijps.2017.215.220

15. Zaid MZA, Ramiah SK, Jamei ES, Zulkifli I, Lokman IH, Amirul FMA, Fadzlin SAA, Mohd Zamri S, Jayanegara A, Hassim HA (2023): Potential use of black soldier fly, *Hermetia illucens* larvae in chicken feed as a protein replacer. A review. Journal of Animal and Feed Sciences 32. https://doi.org/10.22358/jafs/162066/2023

16. Mancuso T, Baldi L, Gasco L (2016): An empirical study on consumer acceptance of farmed fish fed on insect meals. The Italian case. Aquaculture International 24, 1489–1507. https://doi.org/10.1007/s10499-016-0007-z

17. Makkar HPS, Tran G, Heuze V, Ankers P (2014): State-of-the-art on use of insects as animal feed. Animal Feed Science and Technology 197, 1–33. https://doi.org/10.1016/j.anifeedsci.2014.07.008

18. Marono S, Loponte R, Lombardi P, Vassalotti G, Pero ME, Russo F, Gasco L, Parisi G, Piccolo G, Nizza S, Di Meo C, Attia YA, Bovera F (2017): Productive performance and blood profiles of laying hens fed Hermetia illucens larvae meal as total replacement of soybean meal from 24 to 45 weeks of age. Poultry Science 96, 1783–1790. https://doi.org/10.3382/ps/pew461

19. Onsongo VO, Osuga IM, Gachuiri CK, Wachira AM, Miano DM, Tanga CM, Ekesi S, Nakimbugwe D, Fiaboe KKM (2018): Insects for income generation through animal feed: Effect of dietary replacement of soybean and fish meal with black soldier fly meal on broiler growth and economic performance. Journal of Economic Entomology 111, 1966–1973. https://doi.org/10.1093/jee/toy118

20. Popova T, Petkov E, Ignatova M (2020): Effect of black soldier fly (*Hermetia illucens*) meals on the meat quality in broilers. Agricultural and Food Science 29, 177–188. https://doi.org/10.23986/afsci.88098

21. Van Huis A, Van Itterbeeck J, Klunder H, Mertens E, Halloran A, Muir G, Vantomme P (2013): Edible insects: Future prospects for food and feed security (No. 171). FAO Forestry Paper. https://www.fao.org/3/i3253e/i3253e.pdf