NJE Vol. 42(1): 57-67, 2026
Nigerian Journal of Entomology
Published by the Entomological Soc. of Nig.
www.esnjournal.com.ng
DOI.10.36108/NJE/6202/24.0150

Effect of Plant-Based and Insect-Based Diets on the Growth, Survival and Feed Conversion Rate of *Gryllodes sigillatus* (Walker, 1969)

Ikeh, R.E.,[1*] Idigo, M.A.,[2] Ekezie, C.C.,[1] Chukwudike, C.O.,[1] Chukwu, C.E.[3] and Okegbe, K.P.[1]

[1] *Department of Parasitology and Entomology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.*
[2] *Department of Biological Sciences, Chukwuemeka Odumegwu Ojukwu University, Anambra State Nigeria.*
[3]*Department of Natural Science Education, Lagos State University of Education, Lagos State Nigeria*

Abstract

The effect of plant-based and insect-based diets on the growth, survival and Feed Cconversion Rate (FCR) of the banded crickets, *Gryllodes sigillatus* (Walker, 1969) was carried out in the insectary unit of the Department of Parasitology and Entomology, Nnamdi Azikiwe University Awka. Eggs of *G. sigillatus* were obtained from New Generation Nutrition Incubation Center, University of Ibadan, Ibadan. Materials used as feed included poultry starter mash (EX BM), black soldier fly larva meal (EX BSFL), *Commelina pertesii l*eaves (EX CP) and combination of BSFL meal, *Moringa oleifera* leaves and *C. pertesii* leaves (BSFL+MO+CP). The crickets were reared in transparent plastic container (30cm length x 15cm width x 20cm length) with perforated lids. A total of four containers were used for the experiment. One Hundred (100) 4 weeks old nymphs were introduced into each plastic container and fed weekly with 10g of the samples for five weeks. Weight gain and quantity of feed consumed in grams were collected at three-day intervals. The results showed that crickets fed with EX BM (control) recorded highest weight gain (3.8g), lowest FCR (0.4gfeed/g weight gain), and highest survival rate (98%). EX CP diet supported early growth but performance declined by Week 5. Negative FCR was recorded for EX BSFL diet with same survival rate as EX CP (96%). Interestingly, BSFL+MO+CP diet showed delayed but notable growth in Week 5, moderate FCR (1.78) but lowest survival rate (95%). This study demonstrated that EX CP (plant-based) and EX BSFL meal (insect-based) diets were nutritionally insufficient as sole diet. Mixed diets combining BSFL+ MO+CP showed promising potential if further optimized.

Keywords: *Gryllodes sigillatus*, Plant-Based Diet, Insect-Based Diet, Growth, Survival, Feed Efficiency

*Correspondence email:
re.ikeh@unizik.edu.ng
ORCID: 0009-0005-2610-4283

INTRODUCTION

The population of human in the world is projected to reach 9.7 billion in 2050, with most of the increase anticipated to come from developing countries (Behixhe *et al*., 2025).

Food production is expected to reach up to 70% in the lead-up of 2050 so as to meet the demand of the increasing population (GFFA, 2024; Nasir *et al*., 2024). However, food production in the developing world is limited by tillable land, energy, inadequate infrastructure, water etc. often resulting to negative effects on the ecosystem. As a result, other food substitutes are needed to rebut the above limitations one of which is rearing of edible insects (Babarinde *et al*., 2021). *Gryllodes sigillatus* is one of the farmed edible insects consumed globally and a good replacement for other edible crickets owing to its high ecological flexibility, tendency to feed on plants, reduced tendency to bite human, and low inclination towards cannibalism. (Bertola and Mutinelli, 2021; Krönauer *et al*., 2025). In addition, *Gryllodes sigillatus* shows appreciable feed conversion rate and can be farmed in large-scale as feed and food (Yuzer *et al*., 2022). Recently, *Gryllodes sigillatus* meal has been incorporated successfully in human food and livestock feed as alternative source of protein (Muzzatti *et al*., 2022).

Gryllodes sigillatus are an orthopteran belonging to the family *Gryllidae* (Taro *et al.,* 2022) ranging in size from 0.51 to 0.71 inch in length (Rowe *et al*., 2024). They have distinctive features, including dark bands across the thorax, thin antennae, powerful hind legs for jumping, specialized foot segments, long slender appendages at the end of their abdomen, stiff leathery front wings and long membranous back wings for flying (Okweche *et al.*, 2022). Male and female adult *Gryllodes sigillatus* possess two pairs of wings. The female wings are not noticeable while the male wings are conspicuous covering half of their body. Male crickets start chirping from six to eight weeks. The chirping sound are produced when the males rub their wings together, a process generally referred to as stridulation (Laskri *et al.,* 2024). They are hemimetabolous insects displaying incomplete metamorphosis and lacking pupal stage during development. Their embryo develops into a miniature adult referred to as nymph or juvenile or pinhead, which then undergoes several successive moults before reaching adults and sexual maturity. (Kulkarni and Extavour, 2019).

Gryllodes sigillatus impact the ecosystem both positively and negatively. They help to improve soil quality by breaking down plant materials and serve as bio-indicators in tropical ecosystem (Anso *et al.,* 2022). *Gryllodes sigillatus* are omnivores feeding on both plants, dead animals and insects. They can be destructive when present in large numbers, inflicting injury on tree seedlings causing serious damage to the plant. Their nutritional composition and feeding preferences play a crucial role in determining their viability for use in human consumption, animal feed, and scientific studies (Magara *et al.,* 2025; Murugu *et al.*, 2021). "As the demand for cricket products is increasing, there is a need to find cost-effective ways of production using locally available and affordable food source" (Cansee *et al*., 2025). Leaves of *Commelina* plant are recommended in mass rearing of the field cricket *Scapsipedus icipe*. In a study by Runyambo *et al*. (2023) different species of *Commelina* were used to test the feeding preference of *Scapsipedus icipe.* Result showed low mortality through the period of study.

Crickets are also known to feed on black soldier fly supplemented food. Black soldier fly larva is rich in protein, fats, chitin, amino acids, essential minerals and carbohydrates. It helps to build insects calcium and protein level making them a good source of food for man and animals (Lu *et al.,* 2022). Notably, whole or processed BSF larvae or pupae can be fed to pigs, fish, poultry, pets and other insects potentially replacing popular feed items like fish and

soybean meal. (Surendra *et al.*, 2020, Siddiqui *et al.,* 2022). There is paucity of information on the use of plants-based diet and insect-based diet in the production of *G. sigillatus*. Against this background, the present study was conducted to evaluate the use of some indigenous plants (*C. pertesii* and *M. oleifera*) and black soldier fly larva meal in the production of *G. sigillatus* as well as the effects on their growth, survival and feed conversion rate.

MATERIALS AND METHODS

Study area

The study was carried out in the Insectary Unit of the Department of Parasitology and Entomology, Faculty of Bioscience, Nnamdi Azikiwe University Awka. Awka, located approximately between Latitude 6.20º to 6.25ºN and Longitude 7.05º to 7.10ºE (Ezenwaji *et al*, 2014).

Materials used

Materials used for the present study included *G. sigillatus* (banded crickets), *Hermetia illucens* larva (black soldier fly), poultry starter mash, *Moringa oleifera* leaves and *Commelina petersii* leaves. Larvae of *H. illucens* were obtained from the Insectary Unit of the Department of Parasitology and Entomology, oven dried at a temperature of about 50-70ºC and milled with an electric blender model BOS BD4518, 220-240V 50/60Hz 400W. Poultry starter mash (broiler mash) was obtained from a near-by agro shop. Samples of fresh *Moringa oleifera* leaves, *Commelina petersii leaves* were obtained from their natural habitat. These treatmens were selected based on their being readily available food sources and few laboratory trials.

Sources of G*ryllodes sigillatus*

Eggs of *G. sigillatus* were obtained from New Generation Nutrition Incubation Center, University of Ibadan, Ibadan, Nigeria and transported in a plastic plate of about 6cm to the Department of Parasitology and Entomology Insectary, Nnamdi Azikiwe University Awka, Anambra State Nigeria. They were incubated and allowed to hatch. Upon hatching, the "pin-head"/ nymphs were transferred into a rectangular transparent plastic container measuring 30cm length x 15cmx width x 20cm height and provided with hideout (egg crates) to suit their nocturnal nature. All hatched pinheads were fed with only broiler mash for a period of 4 weeks (acclimatizaion period).

Experimental treatments and design

The experimental treatments included exclusive broiler starter mash (EX BM), exclusive black soldier fly larva meal (EX BSFL), exclusive *C. petersii* leaves (EX CP) and combination of black soldier fly larva meal, Moringa leaves and *Commelina pertersii* leaves (BSFL+MO+CP). After the four-week acclimatization period, the crickets were divided into four treatment groups – four transparent plastic containers (30cm length x 15cm width x 20cm length) with perforated lids for adequate ventilation (see plate 1). One Hundred (100) nymphs of crickets were introduced into each transparent plastic container. A total of four containers were used for the experiment. Egg cartons were placed into each container to provide shelter and increase the surface area, encouraging natural behaviours such as hiding and climbing. The crickets were fed weekly with 10g samples of the treatment for five (5) weeks. The left-over feed and weights of the crickets were measured and properly recorded after three consecutive days that is the treatment period.

Plate 1: EX BSFL group **Plate 2: EX CM group** **Plate 3: BSFL + CM + MO group**

Key: EX BSFL= exclusive black soldier fly larva meal, EX CP=exclusive *Commelina petersii,* **BSFL + CM + MO** = black soldier fly larva meal+ *Commelina petersii* + *Moringa oleifera* meal

Determination/ calculation of growth parameters

a) Weekly weight gain (WWG) = Mean weight at the end of the week - Mean weight at the start of the week.

b) Total weight gain = Summation of weekly weight gains

c) Feed conversion rate (FCR) =

$$\frac{\text{Total feed consumed}}{\text{Total weight gain.}}$$

d) The survival rate (SR) =

$$\frac{\text{Final sample size}}{\text{Initial sample size}} \times 100 \text{ times}$$

Data collection and analysis

Data collected included the weekly live weights of the crickets, percentage mortality at harvest, growth performance parameters such as total weight gain, average weekly gain, survival rate, and feed conversion rate (FCR) were calculated using standard formulas. The collected data were further subjected to statistical analysis using Microsoft excel 2010.

RESULTS

Fig 1 presents the weekly weight gain of crickets fed on different dietary treatments over a 5-week period. The experimental groups were categorized based on their exclusive diets or a combination of feeds. Crickets fed exclusively on broiler mash (EX BM) recorded the highest cumulative weight gain (3.8g) over the five weeks. Average weight gain at week 1 for crickets fed on exclusive black soldier fly meal (EX BSFL) was 0.9g which gradually increased to 1.7g at week 3 and finally marked a substantial increase of 3.8g at week 5. This suggests that broiler mash provided a balanced and nutrient-rich diet that supported consistent and accelerated growth, particularly in the later stage of development. EX BSFL group, which fed solely on black soldier fly larvae meal showed moderate but steady growth throughout the experiment. The growth was relatively uniform across the weeks, peaking in Week 5 (2.3g). Crickets fed with exclusive *C. petersii* leaves (EX CP) also gained weight significantly in the early weeks, peaking in Week 3 with average weight gain of 1.6g and then declining in Week 4 and week 5. The

BSFL+MO+CP group, fed a mixed diet of Black soldier larva meal, *C. petersii*, and *M. oleifera* leaves, had the slowest initial growth but experienced a notable increase in Week 5 (2.7g), marking the second best performed group throughout the study.

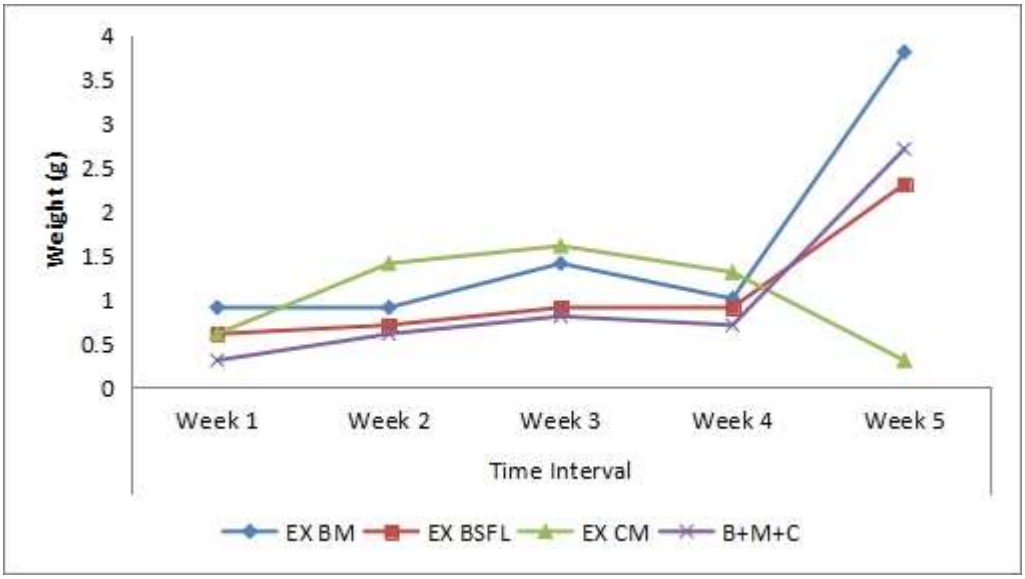

Fig 1: Weekly Change in Weights (g) of Crickets

Key: EX BM= exclusive broiler mash, EX BSFL= exclusive black soldier fly larva meal, EX CP=exclusive *Commelina petersii,* B+M+C= black soldier fly larva + *Commelina petersii* + *Moringa oleifera* meal

Table 1 presents the Feed Conversion Rate (FCR) data of crickets reared on the four different dietary treatments. Broiler mash was observed as the most efficient feed for cricket production, as demonstrated by its low FCR of 0.4 g feed/g gain. This indicated that crickets are able to convert feed to body mass very effectively when provided with nutritionally balanced commercial poultry feed. The plant-based diet (EX CP) had the highest FCR (2g feed/g gain), suggesting that crickets required more of the feed to achieve similar weight gains, potentially due to poor protein content. The mixed diet (BSFL+MO+CP) showed moderate performance (1.78g feed/g gain), with a better FCR than EX CP. This supports the idea that combining protein-rich (BSFL) diet and plant-based feeds (*Moringa oleifera* and *Commelina petersii*) can enhance feed utilization. The negative FCR in the EX BSFL (-0.2g feed/g gain) was a result of feed moisture absorption, which made it impossible to know the amount of leftover feed by crickets.

Table 1: Feed conversion rate (FCR) over a period of five weeks

Group	TotalFeed Given (g)	Total Leftover (g)	Total Weight Gain (g)	FCR
EX BM	90	86.8	8	0.4
EX BSFL	90	91.7	5.4	-0.32
EX CM	90	79.6	5.2	2
BSFL+MO+ CP	90	80.9	5.1	1.78

EX BM= exclusive broiler mash, EX BSFL= exclusive black soldier fly larvae, EX CP=exclusive *Commelina petersii* BSFL+MO+CP= black soldier fly larvae + *Commelina petersii* + *Moringa oleifera*

Table 2 revealed high survival rates across all dietary groups, indicating that the tested diets were generally safe and non-toxic to crickets. EX BM (Exclusive Broiler Mash) has the highest survival rate (98%), reinforces the findings from the weight gain and FCR data and suggesting that broiler mash is not only nutritionally optimal but also supports high survivability. EX BSFL (Exclusive Black Soldier Fly Larvae) and EX CP (Exclusive *Commelina petersii*) result (96%) reveals that they are safe, non-toxic and support cricket survival while the mixed diet, BSFL+MO+CP (95%) has slightly lower survival rate compared to other groups.

TABLE 2:Survival Rates (SR) of the crickets reared on the four dietary treatments

GROUP	Initial Sample size (n_i)	Final Sample size (n_f)	SR
EX BM	100	98	98%
EX BSFL	100	96	96%
EX CM	100	96	96%
BSFL+MO+CP	100	95	95%

Key: EX BM= exclusive broiler mash, EX BSFL= exclusive black soldier fly larvae, EX CM=exclusive *Commelina petersii* BSFL+MO+CP= black soldier fly larvae + *Commelina petersii* + *Moringa oleifera*

DISCUSSION

This study evaluates the growth performance and survival rate of *G. sigillatus* reared with low cost and readily available insect-based and animal based diets for a period of five (5) weeks. It also compared the rate which the crickets convert the diets to body mass with the goal to contribute to eco-friendly and resource efficient cricket farming. Our findings revealed that *G. sigillatus* demonstrated varied growth rate (weight gain), survival rate and feed conversion rate, further suggesting that dietary nature/source significantly influence the performance of the crickets.

As shown in table 1, feed type significantly influenced weekly weight gain in *G. sigillatus.* Crickets fed on poultry starter mash (EX BM) recorded the highest cumulative weight gain, with a marked

increase in Week 5. Crickets require high protein, essential amino acids with suitable energy density, vitamins, and mineral rich diets to achieve optimal growth and build body mass. Poultry starter mash is often used as a control diet (bench mark) in cricket research owing to its balanced nutritional profile. The study shows that poultry starter mash provided superior growth conditions for the crickets. Same finding observed by Payne *et al*. (2016), who reported that poultry mash supports rapid insect growth rate and weight gain due to its high digestibility and balanced nutrient profile. Black soldier fly larvae meal (EX BSFL) promoted steady but moderate growth as shown in Fig. 1. This shows a gradual but consistent weight gain which agrees with studies that highlight BSFL as a protein-rich and sustainable feed ingredient for insects (Su *et al*., 2025).

However, BSFL meal often contains high moisture due to its hydroscopic nature, significantly affecting feed utilization efficiency (Saucier *et al.,* 2021). *Commelina petersii* leaves (EX CP) supported early growth (Weeks 2–3), but performance declined by Week 5. This could be due to reduced ingestion of the plant by the crickets owing its particle size. Murata *et al*. (2024) in his study reported significantly superior growth and development in *Teleogryllus occipitalis* (Asian field cricket) reared on granular plant diet than those reared on powered plant diet. This difference may be primarily due to the reduced frequency of feeding on the powdered diet, indicating crickets may exhibit aversion to fine particles. In addition, crickets are known for their high preference for Commelina plants as a food source.

However, existing research on cricket diets and *Commelina* species suggests they (particularly the field cricket *Scapsipedus icipe*) prefer the fresh plant material due to its moisture content and presence of feeding stimulants like phenols (Winkler *et al*., 2024; Runyambo *et al*., 2023; Murata *et al*. 2024). Runyambo *et al*. (2023) reported that although *Commelina diffusa* and related species are palatable, their nutrient content is insufficient to sustain prolonged insect growth. Interestingly, the composite diet (BSFL+MO+CP) showed delayed but notable growth in Week 5. Suggesting adaptation to the mixed feed or synergistic nutrient effects between BSFL, *C. petersii,* and *M. oleifera.* A similar pattern was observed by Muzzatti *et al*. (2024), who noted that mixed plant insect diets can enhance growth after an initial adjustment phase.

Feed conversion rate varied across treatments. Crickets on broiler mash (EX BM) had the lowest FCR (0.4), reflecting superior efficiency. This finding agrees with Farkas *et al*. (2025), who found that crickets convert commercial poultry feeds efficiently into biomass. A negative FCR was recorded for EX BSFL which is an indication that the insects were losing weight despite consuming feed. More so, during the study, EX BSFL diet were observed to absorb moisture which inflated leftover feed weights and distorted intake measurements. Similar methodological challenges have been reported by Saucier *et al*. (2021), who emphasize that insect feed trials should use dry matter basis to avoid misleading results when high-moisture feeds are involved. Crickets fed on *C. petersii* (EX CP) recorded the poorest FCR (2.0), perhaps suggesting inefficiency in converting plant-based diets into body mass. This is consistent with the study conducted by Kouřimská and Adámková (2016) who reported that plant-only diets often lack essential amino acids and exhibit poor digestibility. The composite diet (BSFL+MO+CP) showed moderate efficiency (FCR 1.78), better than plant-only feed but below broiler mash. This suggests potential for the combination diet as a sustainable, lower-cost alternative. More so,

mixed diets can enhance nutrient utilization if optimized, supporting findings from Cansee *et al*. (2025), who reported that combining BSFL with local plant ingredients improved feed performance in crickets. The delayed growth response indicates that the crickets may have taken time to adapt to the composite diet, or that the nutritional synergy of the mixed feed became more effective over time.

Survival rates were high across all groups (95–98%) as shown in Table 2. This is an indication that none of the diets was toxic to the crickets. EX BM had the highest survival rate (98%), consistent with its superior growth and feed conversion rate mention earlier. The observation agrees with Payne *et al*. (2016b), who reported that poultry starter mash do not only promote growth but also enhance survivability. Similarly, high survival rate observed in EX BSFL-fed crickets (96%) and EX *C*M. fed crickets (96%) suggests that the feeds were safe, although growth was limited in EX CP. The composite diet had slightly lower survival (95%) compared to the other groups, possibly reflecting minor palatability or digestibility challenges and gradual adaptability, a finding consistent with Magara *et al*. (2025), who observed that mixed diets can sometimes reduce early survival before adaptation occurs.

CONCLUSION

There is no documented report on the use of *Commelina pertesii* in both laboratory and field trial of *G. sigillatus*, hence the study provides first laboratory trial data in this regard. In addition, the diets used during the study were non-lethal to the insects and could be incorporated into cricket feed formulation for long term production. Plant-based diet (EX CP) and insect-based (EX BSFL) diets were nutritionally insufficient as sole diet while mixed diets combining black soldier larva meal (BSFL), *M. oleifera* leaves (MO) and *C. pertesii* leaves (CP) showed promising potential if further optimized.

Acknowledgements

Department of Parasitology and Entomology for providing space for the rearing of the *G. sigillatus* and New Generation Nutrition Incubation Center, University of Ibadan, Ibadan, Nigeria for providing us with *G. sigillatus* eggs.

Funding

The study was not supported by external funding.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

Anso, J., Gasc, A., Bourget E., Desutter-Grandcolas L., and Jourdan, H. (2022). Crickets as indicators of ecological succession in tropical systems New Caledonia. *Biotropica*, 54(5):1270-1284.

Babarinde, S. A., Mvumi, B. M., Babarinde, G. O., Manditsera, F. A., Akande, T. O., and Adepoju, A. A. (2021). Insects in food and feed systems in sub-Saharan Africa: the untapped potentials. *International Journal of Tropical Insect Science*, 41(3): 1923-1951.

Behixhe, A., Irene, B., Gloriana, C., Silvia, I., Anna, A., Federico, G., Matteo, F., Francesca, T., Tommaso, P. and Cristina, T. (2025). Modulating the nutritional value of *Acheta domesticus* (house cricket) through the eco-sustainable *Ascophyllum nodosum* dietary supplementation. *Journal of Food Composition and Analysis*, 140, 107263

Bertola, M. and Mutinelli, F. A. (2021). Systematic Review on Viruses in Mass-Reared Edible Insect Species. *Viruses* 13, 2280.

Cansee, S., Suraporn, S., and Butwong, N. (2025). Enhancing food production by sustainable cricket farming in Thailand: Evaluating black soldier fly larvae as a cost-effective feed ingredient. *Insects* 16(8), 856.

Ezenwaji, E.E., Awopeju, A.K., Otti, V.I. and Eduputa, B.M. (2014). Spatial patterns of residential water supply accessibility levels in Anambra State, Nigeria. *International Journal of Engineering Research in Africa*, 4(1): 326-336.

Global Forum for Food and Agriculture (2024). *Food Systems for Our Future: Joining Forces for a Zero Hunger World, Berlin, Germany, 17-20/01/2024* (pp.1-3). FAO regional office for Europe and Central Asia: Budapest, Hungary.

Farkas, V. I., Máté, M., Takács, K., and Jánosi, A. (2025). The House Cricket (*Acheta domesticus* Linnaeus) in Food Industry: Farming, Technological Challenges, and Sustainability Considerations. *Applied* Sciences, 15 (17): 9494.

Krönauer, T., Döring, T.F. and Röder, G. (2025). Advances in production of crickets as food and animal feed: A case study of five wild European plants as cricket feed. *International Journal of Sustainable Agricultural Research*, 14: 4559.

Kulkarni, A., and Extavour, C. (2019). The cricket *Gryllus bimaculatus*: Techniques for quantitative and functional genetic analyses of cricket biology. *Results and Problems in Cell Differentiation*, 68:183–216.

Laskri, S., Holmes, L. B., Dixon, T., Robillard, T. and Montealegre, Z. F. (2024). Changes in wing resonance in dried preserved crickets. *Royal Society Open Science*, 11(12): 241147.

Lu, S., Taethaisong, N., Meethip, W., Surakhunthod, J., Sinpru, B., Sroichak, T. and Paengkoum, P. (2022). Nutritional composition of black soldier fly larvae (*Hermentia illucens,* L.) and its potential uses as alternative protein sources in animal diets: A review. *Insects*, 13: 831.

Magara, H. J. O., Hugel, S. and Fisher, B. L. (2025). Growth performance and nutritional content of tropical house cricket (*Gryllodes sigillatus*) reared on diets formulated from weeds and agro by-products. *Insects*, 16 (6): 600.

Murata, K., Kagesawa, W., Akechi, M., Morimitsu, Y., and Suzuki, T. (2024). Effects of powderization of a granular diet on growth performance of the edible cricket, *Teleogryllus occipitalis* (Orthoptera: Gryllidae). *Journal of Insects as Food and Feed, 11*(4): 681-689.

Murugu, D.K., Onyango, A.N., Ndiritu, A.K., Osuga, I.M., Xavier, C., Nakimbugwe, D. and Tanga, C.M. (2021). From farm to fork: Crickets as alternative source of protein, minerals, and vitamins. *Frontiers Nutrition*, 21(8): 704002.

Muzzatti, M.J., Harrison, S.J., McColville, E.R., Brittian, C.T., Brzezinski. H., Manivannans, S., Stabile, C.C., MacMillan, H.A. and Bertann, S. (2024). Applying nutritional ecology to optimize diets of crickets raised for

food and feed. *The Royal Society,* 11 (12): 241710.

Muzzatti, M.J., McConnell, E., Neave, S., MacMillan, H.A. and Bertram, S.M. (2022). Fruitful female fecundity after feeding *Gryllodes sigillatus* (Orthoptera: Gryllidae) royal jelly. *The Canadian. Entomologist*, 154: 50.

Nasir, S.Q., Palupi, E., Nasution, Z., Ploeger, A., Susanto, I., Setiawan, B., Rimbawan, R. and Jayanegara, A. (2024). Edible insects as a sustainable protein source: A meta-analysis. *Journal of Insects as Food and Feed*, 10:1841–1853.

Okweche, S.I., Eyo, K.I., and Effa, E.B. (2022). Food preference and Nutrient composition of African cricket *Brachytrupes membranaceous L.* (Dury) in cross river state Nigeria. *Journal of Insects as Food and Feed*, 8(12):1501-1510.

Payne, C.L.R., Scarborough, P., Rayner, M., and Nonaka, K. (2016). A systematic review of nutrient composition data available for twelve commercially available edible insects, and comparison with reference values. *Trends In Food Science and Technology*, 47: 66-77.

Rowe, E., López, K.Y., Robinson, K.M., Baudier, K.M. and Barrett, M. (2024). Farmed cricket (*Acheta domesticus*, *Gryllus assimilis*, and *Gryllodes sigillatus*; Orthoptera) welfare considerations: Recommendations for improving global practice. *Journal of Insects as Food and* Feed, 10: 1–59.

Runyambo, I., Andika. D., Watako, A., Mwonga, S. and Mweresa, C. (2023). Feeding preferences of the field cricket *Scapsipedus icipe* (Orthoptera: Gryllidae) for different species of commelina. *European Journal of Entomology*, 120:115-127.

Saucier, L., M'ballou, C., Ratti, M. H., Deschamps, M., Lebeuf, Y. and Vandenberg, G. W. (2021). Comparison of black soldier fly larvae pre-treatments and drying techniques on the microbial load and physico-chemical characteristics. *Journal of Insects as Food and Feed*, 8(1): 45-64.

Siddiqui, S.A., Ristow, E.B., Rahaya, T., Putra, N.S., Yuwono, N.W., Nisa, K., Mategeko, B., Smetana, S., Saki, M., Nawazi, A. and Nagdalian, A. (2022). Black soldier fly larvae (BSFL) and their affinity for organic waste processions. *Waste management*, 140:1-13.

Su, H., Zhang, B., Shi, J., He, S., Dai, S., Zhao, Z., Wu, D. and Li, J. (2025). Black Soldier Fly Larvae as a Novel Protein Feed Resource Promoting Circular Economy in Agriculture. *Insects*, 16(8): 830.

Surendra, K.C., Tomberlin, J.k., van Huis, A., Cammack, J.A., Heckmann, L.H. and Khalan, S.K. (2020). Rethinking organic wastes bioconversion: evaluating the potential of the black soldier fly (*Hermetia illucens* (L.) (Diptera: Stratiomyidae). *Waste Management* 117: 58-80.

Taro. M., Yoshiyasu, I., Takahito, W., Taro, N., Guillem, Y., Sumihare, N. and Cassandra, G.E. (2022). Cricket: The third domesticated insect. Current topics on developmental biology. U*nited Nations World Population Prospects* Report, 47:291-306.

Winkler, D.E., Seike, H., Nagata, S. and Kubo, M.O. (2024). Mandible microwear texture analysis of crickets raised on diets of different

abrasiveness reveals universality of diet induced wear. *Interface Focus* 14:20230065. https://doi.org /10.1098/rsfs.2023.0065.

Yuzer, A., Dizhi, X., Retno, T.A., Joey, W. and Le, W. (2022.) Insects as a feed ingredient for fish culture: Status and trends. *Aquaculture. Fisheries*, 7:166 –178.

NJE Vol. 42(1): 57-67, 2026
Nigerian Journal of Entomology
Published by the Entomological Soc. of Nig.
www.esnjournal.com.ng
DOI.10.36108/NJE/6202/24.0150