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Growth performance of Common house cricket (*Acheta domesticus*) and field cricket (*Gryllus bimaculatus*) crickets fed on agro-byproducts

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Abstract
The present study was conducted to investigate the growth performance of *Acheta domesticus* and *Gryllus bimaculatus* fed on different agro-byproducts. The experiment was carried out between February- July 2017 within Jaramogi Oginga Odinga University of Science and Technology Insect Farm. Randomized Complete Block Design was used as the experimental design with four treatments: rice bran+ blood meal (RBBM), rice bran + spent grain (RBSG), & + rice bran + spent yeast (RBSY) and Grower's mash (GM) as the control. 100g of each feed type was provided *ad libitum* for a week. Mean adult weight for *G. bimaculatus* were 0.989±0.02g, 0.6038±0.19g, 0.7333±0.23g and 0.6758±0.22g for cohorts fed on GM, RBSY, RBBM and RBSG respectively while the mean adult weight for *A. domesticus* were 0.6085±0.022g, 0.3415±0.12g, 0.368±0.11g and 0.4598±0.15g for cohorts fed on GM, RBSY, RBBM and RBSG correspondingly. Both species and treatment affected growth rate of the crickets significantly (P<0.000). The results of the study indicated potentiality of agro-byproducts as a cheap source of cricket feed. By implication, the results call for evaluation of bioavailability of the ingested feed and calculation of feed conversion ratios so as to establish efficiency of the feeds.

Keywords: Agro-byproducts, Cricket, Feed, Growth Performance

1. Introduction

The need to rear large number of insects economically and sustainably for commercial purposes has stimulated interest in the development of artificial diets including agro-byproducts. Studies have sought to use organic side-streams in formulation of insect feed as a deliberate effort to help in waste management [16]. Insects reared on various diets do not grow at equal rates and differ in developmental periods. Earlier studies have confirmed that feed quality in terms physical attributes such as shape, colour, smell, hardness and allelochemicals influences the insect capacity to consume and digest [3, 8].

Previous studies on the effects of feed on growth performance of insects and specifically crickets have yielded different results. EL-Damanhouri [3] found out that *Gryllus bimaculatus* took a shorter period to reach adulthood when fed on a high protein food. It has also been reported that diets high in carbohydrates and fat produce greater weights but diets rich in protein but too low in carbohydrates are not suitable for optimal cricket growth and development [11]. EL-Damanhouri and LeBlanc [3, 8] observed that crickets fed on high or too low-fat feed for a long period had reduced body weight due to oxidative stress and failure to compensate for the inadequate nutrients.

Lundy and Parrella [10] reported up to 99% mortality in crickets reared on diets containing purely grain straw. The findings from these studies underscore the critical role of feed type and quality in cricket growth and development.

Feeding is an important input in cricket production especially in the caged crickets. Cricket being omnivorous insect can select feed from both animal and plant sources [15, 3, 7]. It is also important to note that crickets will continue to unremittingly eat until their daily protein requirements are met [5] and should therefore, be fed on adequate and high nutritious foods to enable them survive and reproduce. The crickets should generally be fed on watery or fresh sources of food as well as on high protein food such as chicken mash [11], but this has been found to be costly [6], and thus, there is a need to develop affordable feeds that meet the dietary requirement of crickets. It is against this background that the study was conceived to identify locally available, nutritious and less costly cricket feed.

The present study was conducted to evaluate the growth performance of Common house cricket (*Acheta domesticus*) and Field cricket (*Gryllus bimaculatus*) fed on different agro-byproducts.

2. Materials and methods

2.1 Cricket Species and Feed

Fourteen-day old crickets, each of *A. domesticus* and *G. bimaculatus* species, were obtained from the Edible Crickets' Project at Jaramogi Oginga Odinga University of Science and Technology (JOOUST). The choice of the two species was prompted by their availability in the area. Four different agro-byproduct feeds used were obtained locally. Grower's mash and dried bloodmeal were procured from the local agro-vet shops, brewer's spent yeast and grain were sourced from the Kenya Breweries Company and rice bran was obtained from the Dominion Farms Limited.

2.2 Experimental Design

The crickets were reared in 100L plastic buckets which were housed in a tunnel unit of size 8m x 15m in a Randomized Complete Block Design. Each of the two species was given the four different types of feed. The experiment comprised of four treatments namely; rice bran +blood meal (RBBM), rice bran+ spent grain (RBSG), rice bran +spent yeast (RBSG) and grower's mash (GM) as the control. Each bucket was stocked with 200 crickets. The buckets were covered with a mosquito net to prevent entry of predators and escape of crickets. Drinking water was provided *ad libitum* in a saucer of 16cm diameter with a moist cotton wool, which was changed after every three days. To prevent anxiety, egg trays (29cm x 29.5cm) were placed vertically in the buckets to act as hide-outs. 100g of each feed was placed in the buckets. The feed was provided *ad-libitum* for a week. Data on amount of feed consumed was recorded weekly and unconsumed feed was replaced. The experiment which was replicated three times, was carried out for seven weeks for *G. bimaculatus* and ten weeks for *A. domesticus* due to difference in growth rates. The experiment was carried within the university Insect farm between the months of February- July 2017.Temperature and relative humidity profiles were recorded by a HOBO data logger (U12-012 RH/TEMP; Onset Computer Corp., USA) which was placed in the tunnel unit.

2.3 Data Collection

A batch of 50 crickets were randomly sampled and weighed using Model Kern (PFB, capacity of 200 grams) weighing scale on a weekly basis until the crickets attained adulthood, when there were no increases in bodyweight. The measures of growth were growth rate and adult weight (weight at maturity). The growth rate data was generated by the formula below:

$$\text{Growth rate} = \frac{\text{Weight at maturity (g)}}{\text{(Time (weeks)}} \quad \text{-------------------} \ (1)$$

Statistical Analysis

Analysis of variance (ANOVA) was used to determine whether there were significant differences in the mean growth rates of the four groups. Tukey HSD was subsequently used to separate the means. The following linear statistical model was used:

$$Y_{ijk} = \mu + S_i + F_j + (SF)_{ij} + \varepsilon_{ijk} \quad \text{------} \ (2)$$

where,

μ is the overall mean.

Y_{ijk} is the growth rate of the kth insect of the ith genetic group fed on the jth feed type.

S_i is the effect of the ith genetic group

F_j is the effect of the jth feed type.

$(SH)_{ij}$ is the interaction between genetic group (species) and feed.

ε_{ijk} is the random error

3. Results

The nutrient profiles of feeds used as obtained from proximate analyses are provided in Table 1. Bloodmeal and brewer's spent yeast had the highest crude protein, while brewer's spent grain, grower's mash and rice bran had the least amount of crude protein.

Table 1: Nutrient profile of feed used in the experiment

Feed Type	DM% (105)	ASH%	FAT%	CP%	CF%	NFE%
Rice bran	92.16	13.68	18.62	19.22	13.81	34.72
Brewer's spent grain	92.26	3.07	7.90	27.13	21.22	38.68
Brewer's spent yeast	93.45	11.06	1.57	49.71	0.85	36.71
Grower's mash	92.47	8.82	7.59	15.89	9.78	57.92
Bloodmeal	91.37	5.82	1.49	87.46	1.94	3.28

DM-Dry Matter, CP – Crude Protein, CF -Crude Fibre, NFE -Nitrogen Free Extracts

Rice bran had the highest fat content followed by brewer's spent grain, grower's mash, spent yeast and lastly bloodmeal. The other nutrient components showed no clear trends across all the feeds, but of importance were the high levels of crude fibre in spent brewer's grain and rice bran.

Table 2 showed different physiological processes of different cohorts of the two species fed on different feed types. A Shorter developmental period was recorded in cohorts fed on growers' mash (control diet) for both species. Treatment 3 (rice bran and bloodmeal) recorded the longest development period for both species. Sex notification for *G. bimaculatus* and *A. domesticus* fed on growers' mash (treatment 1) and rice bran + spent yeast (treatment 2) was observed in week 2 and 6 respectively and in week 4 and 9 in the cohort fed on rice bran + bloodmeal and in week 4 and 7 for cohorts fed on rice bran + spent grain respectively.

Table 2: Stages of growth by feed type

	Grower's mash	Rice bran +Spent yeast	Rice bran +Bloodmeal	Rice bran +Spent grain
G. bimaculatus				
Sex notification	Week 2	Week 2	Week 4	Week 4
Adult emergence	Week 5	Week 6	Week 6	Week 6
Start of laying	Week 6	Week 7	Week 8	Week 7
A. domesticus				
Sex notification	Week 6	Week 6	Week 9	Week 7
Adult emergence	Week 10	Week 10	Week 13	Week 11
Start of laying	Week 12	Week 13	Week 15	Week 14

In *G. bimaculatus*, peak growth rate was recorded in week 3 for the cohorts fed on growers' mash while cohorts fed on a combination of rice bran and spent grain registered their peak growth rate in week 5. As for the cohorts fed on rice bran and spent yeast, the peak growth rate was noted in week 3 and the cohort fed on rice bran and bloodmeal had its peak growth rate in week 4 (Fig 1).

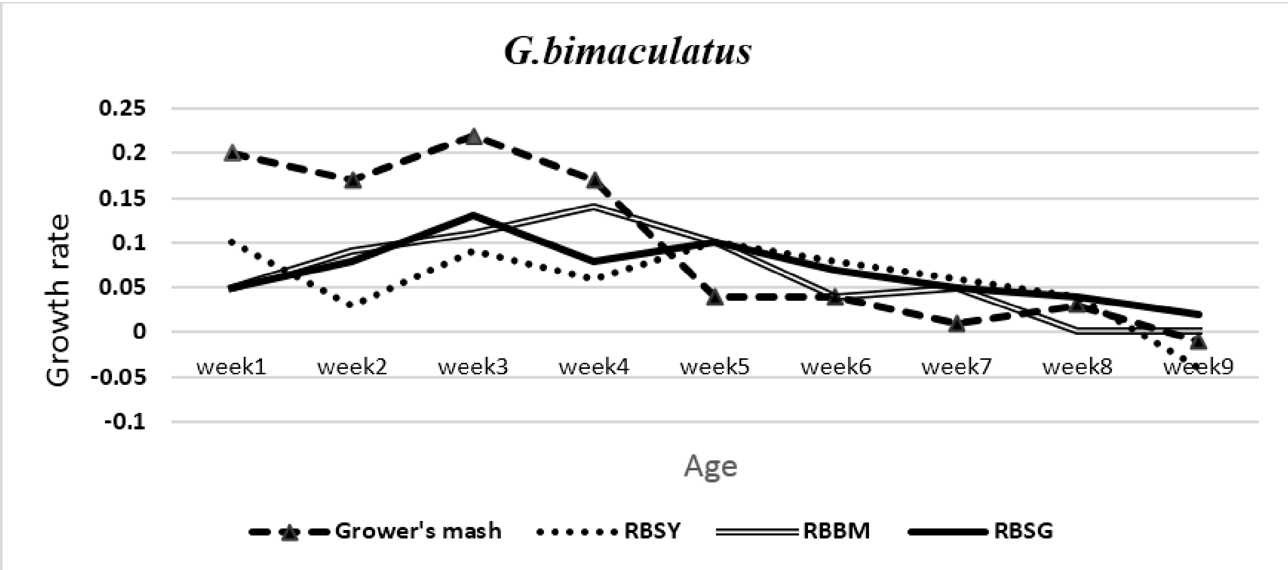

Fig. 1: Growth patterns of *G. bimaculatus* fed on different agro-byproducts

In *A .domesticus,* peak growth rate was recorded in weeks 11,9 and 15 for the cohorts fed on growers' mash and rice bran + spent grain, rice bran + spent yeast, and rice bran+ bloodmeal respectively (Fig 2).

Mean adult weight for *G. bimaculatus* were 0.989±0.02g, 0.6038±0.19g, 0.7333±0.23g and 0.6758±0.22g for cohorts fed on GM, RBSY, RBBM and RBSG respectively.

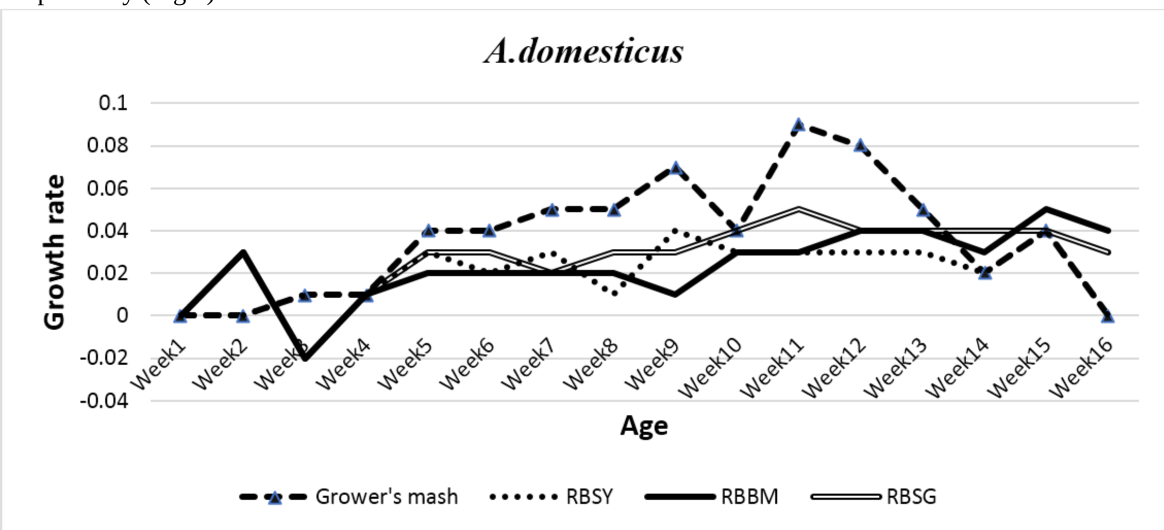

Fig. 2: Growth patterns of *A. domesticus* fed on different agro-byproducts

Mean adult weight for *A. domesticus* were 0.6085±0.022g, 0.3415±0.12g, 0.368±0.11g and 0.4598±0.15g for cohorts fed on GM, RBSY, RBBM and RBSG correspondingly.

Growth rate was significantly affected by species and treatment (P<0.000), while species by treatment interaction had no significant effect (P>0.05) (Table 3). Overall growth rate of *G. bimaculatus's* was found to be 0.08gm/week (Table4) higher than *A. domesticus.*

Table 3: Analysis of Variance

	Mean Sq	F value	Pr(>F)
Species	0.022	132.347	0.0000 ***
Treatment	0.003	15.286	0.0000 ***
Species: Treatment	0.001	3.069	0.0849
Residuals	0.0002		

Significant. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

The mean growth rate of cohorts fed on treatment 3(rice bran + bloodmeal) was found to be 0.021gm/week significantly lower than control diet. The other mean growth rates were not statistically different from each other (Table 4).

Table 4: Post hoc results

	differences	p adjusted
Species		
G.bimaculatus-A. domesticus	0.008	0.0823
Treatment		
RBBM-GM	-0.021	0.0068
RBSG-GM	-0.014	0.1218
RBSY-GM	-0.007	0.6712
RBSG-RBBM	0.007	0.6712
RBSY-RBBM	0.014	0.1218
RBSY-RBSG	0.007	0.6800

2.0 Discussion

The significant effects of species and treatment in this study concur with the earlier findings of EL-Damanhouri, LeBlanc and Megido *et al.* [3, 8, 10, 11, 17] who found that insects’ developmental period and growth rates depended on the kind of diet they were fed. EL-Damanhouri [3] investigated the effect of three diets, normal starch and fat, high starch and low fat and low starch and high fat, on growth performance of female *G. bimaculatus.* The highest and least performance in terms of total body mass was recorded in a normal starch + normal fat and low starch + high fat diets correspondingly. Megido *et al.* [11] and Fuah *et al.* [17] reported on the potentiality of young cassava leaves and brown rice flour as cricket feed. In this study, shorter and longer development periods were recorded in the cricket fed on control diet (growers’ mash) and treatment three (rice bran and bloodmeal) respectively in both species. This finding might be explained by the fact that growers’ mash provided a balance of nutrients as well as the presence of the high nitrogen free extracts (NFE; 57.92%; Table1), which provided readily available source of energy or utilizable glucose for different physiological functions. Crickets would prefer diets with a balanced level of protein and carbohydrates to maximize on life span and reproductive performance [18]. Similar conclusion was made by Mcdonalds *et al.* [13], that diets high in nitrogen free extracts act as building blocks for other nutrients which aid in growth.

Crickets fed on treatment 3 (rice bran+ bloodmeal) took longer to reach adulthood. In fact, post hoc analysis by Tukey HSD reported a statistically significant low mean growth rate of 0.021gm/week (Table 4) compared to cohorts fed on treatment 1(control diet). From the nutritional analysis of this diet (Table 1), bloodmeal contained the highest amount of crude protein while rice bran had comparatively higher levels of crude fat and fibre. This nutrient combination was not suitable for optimum growth rate. Although protein is a requirement especially for female crickets for different physiological processes, its digestibility and amino acid composition influenced its intake by crickets. Seifdavati *et al.* [14] observed non-palatability and reported that blood meal had imbalanced amino acid which deterred feed intake and digestibility. The smell, indigestibility and imbalanced amino acid may explain the lower growth rate and longer developmental period in this study. Similar findings were also reported by Lundy and Parrella [10] who observed that proteins contained in bloodmeal and bone marrow were inadequate for cricket’s optimum growth.

High fibre in rice bran and spent grain in treatments 2 (rice bran +spent yeast), 3 (rice bran +bloodmeal) and 4(rice bran +spent grain) could explain the low growth rate observed in this study. The mean growth rates between these treatments were not statistically different from each other, however, treatments 2 (0.014gm/week) and 4 (0.007gm/week) had slightly higher growth rates in comparison to treatment 3, rice bran +bloodmeal (Table 4). The high complex structures of the fibre contained in both rice bran and spent grain (lignin, cellulose and hemicellulose) made it indigestible for the crickets and further act as growth inhibitors. Earlier studies by [12, 1, 9, 2] reported on the indigestibility of these fibres by Orthoptera hence could explain the lower growth rates in treatments that had components of rice bran and spent grain. High mortality rate (>99%), reported by Lundy and Parrella [10] and Miech *et al.* [12] for crickets reared on diets that contained straw further supports the indigestibility of the grain fibres in rice bran and spent grain by crickets, thus might further explain the lower growth rate.

High content of protein in the spent yeast in treatment 2(rice bran +spent yeast) may explain the slower growth (0.007gm/week; Table 4) when compared to the control treatment 1 (growers’ mash). This is because crickets expend a lot of energy in excretion of excess protein in the form of uric acid and ammonia. The process of excreting excess protein is very costly for monogastric organisms such as crickets. This is in agreement with the findings of Ferreira *et al.* [4] that excretion of uric acid is stressful and wastes a lot of energy.

While species had significant effect on growth rate ($P<0.0000$, Table 3), its interaction with treatment (feed type) did not ($P>0.05$, Table 3). *G. bimaculatus* had a higher mean growth rate (0.008gm/week; Table 4) in comparison to *A. domesticus.* This implies that both species are genetically different and respond to the treatments differently.

3.0 Conclusion

Diets with high contents of protein and fibre inhibit cricket growth as was observed in treatments 2 (rice bran+ spent yeast) and 3 (rice bran +bloodmeal). Treatment 3, (rice bran+ bloodmeal) reported equally a higher body mass especially in *G. bimaculatus* species though, it had the longer developmental period. Despite the lower growth performance observed for the agro-byproducts evaluated in this study, they have shown potential to be used as cheap cricket feed resources. Consequently, focus should be on the evaluation of the digestibility and absorption of the ingested feed and calculation of feed conversion ratios to establish the efficiency of these feeds.

4.0 Conflict of interest

The authors declare no conflict of interest.

5.0 Acknowledgement

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6.0 References

1. Aliyu S, Bala M. Brewer's spent grain: A review of its potential and applications. African Journal of Biotechnology. 2011; 3:324-331.
2. Cruz VC, Pezzato AC, Pinheiro DF, Goncalves JC, Sartori JC. The effects of free-choice feeding on the performance and ileal digestability of nutrients in broilers. Brazilian Journal of Poultry Science. 2005; **7**(3):143-150.
3. EL-Damanhouri Hassan Ibraik Hassan. Studies on the influence of different diets and rearing conditions on the development and growth of the two-spotted cricket Gryllus bimaculatus de Geer. MSc. Dissertation. Germany, University of Bayerueth; 2011.
4. Ferreira IMPLVO, Pinho O, Vieira E, Tayarela JG. Brewer's Saccharomyces yeast biomass: characteristics and potential applications. Trends in Food Science and Technolology. 2010; 21(2):77-84.
5. Hallett I. Breeding and housing cricket. Melissa Kaplan's Collection. 1995; available at www.anapsid. Org/crickets.html (accessed on 24 .5. 2014, 4.18 pm).
6. Hanboonsong Y, Tasanee J, Durst PB. Six-Legged Livestock: Edible insects farming, collecting and marketing in Thailand. FAO Publication. 2013.
7. Klassey G. The complete cricket breeding manual. 2012; Zega Enterprises, Australia.
8. LeBlanc Z. Can nutritional geometry modulate the effects of dietary restriction in *Acheta domesticus*? MSc. Dissertation. Germany, University of Bayerueth; 2012.
9. Levic J, Djuragic O, Sredaniv S. Use of new feed from brewery by-products for breeding layers. Romanian Biotechnological Letters. 2010; 15(5):5559-5565.
10. Lundy ME, Parrella MP. Crickets are not a free lunch: Protein capture from scalable organic side-streams via high density populations of *Acheta domesticus* PLoS ONE. 2015. Doi:10.1371/journal. pone.0118785.
11. Megido RC, Alabi T, Nieus C, Blecker C, Danthine S, Bogaert J *et al.* Optimization of cheap and residential small-scale production of edible crickets with local by-products as an alternative protein-rich human food source in Ratanakiri Province, Cambodia. Journal of the Science of Food and Agriculture. 2016; 96:627-632.
12. Miech P, Berggren Å, Lindberg JE, Chhay T, Khieu B, Jansson A. Growth and survival of reared Cambodian field crickets (*Teleogryllus testaceus*) fed weeds, agricultural and food industry by-products. Journal of Insects as Food and Feed. 2016; 2(4):285-292. ISSN 2352-4588.
13. Mcdonald P, Edwards RA, Greenhalgh JFD, Morgan CA Sinclair LA, Wilkinson RG. Animal Nutrition.7th ed. Longman Group, United Kingdom, 2011.
14. Seifdavati J, Navidshad B, Seyedsharifi R, Sobhani A. Effects of a locally produced bloodmeal on performance, carcass trait and nitrogen retention of broilers chickens. Pakistan Journal of Biological Sciences. 2008; 11(12):1625-1629.
15. Tawes B. "The effect of changing juvenile nutritional conditions and compensatory growth on life history traits in a field cricket, *Gryllus texensis*". Graduate Theses and Dissertations. Paper 13800; 2014.
16. Van Huis Anorld. Potential of insects as food and feed in assuring food security. Annual Reviews of Entomology. 2013; 58:563-583.
17. Fuah AM, Siregar HCH, Endrawati YC. Cricket Farming for Animal Protein as Profitable Business for Small Farmers in Indonesia. Journal of Agricultural Science and Technology. 2015; 296-304. doi: 10.17265/2161-6256/2015.04.008
18. Harrison SJ, Reubenheimer D, Simpson SJ, Godin J-GJ, Bertram SM. Towards a synthesis of framework in nutritional ecology: Interacting effects of protein, carbohydrates and phosphorous on field cricket fitness. Proceedings of Royal Society. 2014; 281:20140539.