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Effects of housing on growth performance of common house cricket (*Acheta domesticus*) and field cricket (*Gryllus bimaculatus*)

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Abstract

Cricket rearing is emerging as an important component of animal food. However, suitable housing for medium and large - scale production still presents a major challenge. This study sought to investigate the effect of housing on growth performance of two cricket species: *Acheta domesticus* and *Gryllus bimaculatus*. Both species were reared in the two housing systems used in the experiment; the tunnel unit and the prefabricated house. The crickets were fed on growers' mash *ad libitum* throughout the experiment period. Data on feed intake and weight gain were recorded weekly. Temperature and relative humidity profiles were recorded using a HOBO data logger (U12-012) installed in the two housing systems. Analysis of variance was done to evaluate the effects of both species and housing on growth performance of the crickets. Species of the cricket had a significant effect ($P<0.001$) on the growth performance, while the effect of housing was not statistically significant ($P<0.361$). The results suggested that the genotype of cricket was a major determinant of growth rate. The non-significant effect of housing type implies that the two-cricket species can be reared productively in either of the housing types. The focus should therefore be on the evaluation of different feeds that can improve productivity.

Keywords: Cricket, Growth performance, Prefabricated house, Tunnel unit

Introduction

Large-scale insect production systems are emerging in many countries as an integral component of animal agriculture, particularly given that the system is environmentally friendly [1, 2]. In temperate countries, insects such as mealworms, crickets and grasshoppers are reared largely as pets or for zoos [3]. However, in recent times there has been increasing interest on insects, not just as pets, but also as food and feed. This new development has mainly been prompted by the need to address the endemic problem of food insecurity besides the need for more environmentally sustainable methods of production [4, 5]. Currently, there is an emerging trend to commercialize this system of insect production [2]. The success of such commercialization rests on the sustainability of production, a challenge that requires an appropriate housing system that is suitable for large scale insect production.

Most edible insects are harvested in the wild and the practice of farming insects for food and feed is relatively new [19, 3]. Large scale production systems have been introduced recently in many countries and rearing of edible insects is now emerging in animal production as an ecologically sound concept [20]. Traditionally, the collection of edible insects from their natural habitat in the forests has been practiced for many years [21]. However, presently this is not sustainable. The intentional farming of edible insects for food and feed is partly the answer to the issues of sustainability.

Under favourable conditions, *Acheta domesticus* (House Cricket) and *Gryllus bimaculatus* (Field Cricket) are adaptable to mass rearing and burgeon faster due to their shorter life cycle [6]. However, when promoting insects as food and feed, efficient systems for large-scale production remain a major challenge [7]. An important component of large scale insect production is a suitable housing system that can addresses the major issues in mass rearing such as quality, reliability, and cost-effectiveness [2]. While existing literature largely focus on rearing containers/pens [3], information on housing systems remain scanty. This study, therefore, sought to investigate the effect of housing on growth performance of *Acheta domesticus* and *Gryllus bimaculatus* reared under two housing systems; tunnel unit and prefabricated house.

Materials and methods

Cricket Species and Feed

Fourteen-day old crickets of *Gryllus bimaculatus* and *Acheta domesticus* were obtained from the Edible Crickets' Project at Jaramogi Oginga Odinga University of Science and Technology (JOOUST) to ensure strain purity. The choice of the species was prompted by their availability within the study area. Poultry growers' mash (dry matter - 92.47%, Ash-8.82%, crude fat-7.59%, crude protein- 15.89%, crude fibre-9.78%, nitrogen free extracts -57.92%) was obtained from the local agro-vet shops and used as feed for the crickets.

Housing

Two housing types were used in the experiment: a tunnel house, measuring 8m x 15m (Fig.1) and a prefabricated house measuring, 7m x 7m x 5m completed with netting material and iron sheets on the sides as well as the roof (Fig. 2). The crickets were reared under the prevailing climatic conditions within the housing systems, that is, there was no control of temperature and relative humidity.

Fig 1: Tunnel house

Fig 2: Prefabricated house

Experimental Design

The study was conducted at the Insect Farm facility at JOOUST. The crickets were reared in 100L plastic buckets each of which was stocked with 200 crickets. Drinking water was provided *ad libitum* in a saucer of 16cm diameter with moist cotton wool which was changed after every 3 days. Feed comprising of 100g of poultry growers' mash was provided *ad-libitum* for a week. Data on the amount of feed consumed was recorded weekly and unconsumed feed replaced. To prevent anxiety among the insects, egg trays measuring 29cm x 29.5cm were placed vertically in the buckets to act as hide-outs. The buckets were covered with mosquito net to prevent entry of predators or escape of the crickets. The experimental unit was replicated 3 times in each housing unit. The experiment was carried out for ten and twelve weeks for *Gryllus bimaculatus* in the tunnel house and the prefabricated house respectively, and sixteen weeks in both housing types for *Acheta domesticus* due to its slow growth. Temperature and relative humidity profiles were recorded by HOBO data loggers (U12-012 RH/TEMP; Onset Computer Corp., USA) placed in both housing units.

Data Collection and Statistical Analysis

Samples of 50 insects were randomly taken from each bucket and weighed using an electronic scale (Model Kern (PFB), capacity of 200grams) on a weekly basis. Two parameters, the period to maturity and weight at adult stage, were also recorded. The period to maturity was the time taken to attain the mature weight whereas mature weight was the point at which the crickets stopped gaining any more weight. Growth rate was defined as change in weight associated with unit change in time and was computed as;

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

A two-way ANOVA was used to analyze the effects of housing and genetic group on growth rate of the crickets.

$$Y_{ijk} = \mu + S_i + H_j + (SH)_{ij} + \varepsilon_{ijk}$$

where,

μ is the overall mean.

Y_{ijk} is the growth rate of the k^th insect of the i^th genetic group from the j^th housing unit.

S_i is the effect of the i^th genetic group

H_j is the effect of the j^th housing unit.

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

ε_{ijk} is the random error

Results

The Relative Humidity (RH%) and temperature profiles of both housing systems are shown in Table 1. Highest Relative Humidity and temperature readings were recorded in prefabricated house and tunnel unit respectively. Mean RH% and temperatures were 58.97% and 27.05 °C in the tunnel house and 60.52% and 25.95 °C in the prefabricated house. Coefficient of variation for humidity and temperature for tunnel house and prefabricated house was 31.27%, 28.84% and 34.93% and 23.51% respectively.

Table 1: Relative Humidity and Temperature Profiles by Housing types.

Parameters	Tunnel House	Prefabricated House
Relative Humidity (%)		
Maximum	88.50	96.19
Minimum	13.508	15.92
Average	58.97	60.52
Standard Deviation (SD)	18.44	21.14
Coefficient of Variation (CV %)	31.27	34.93
Temperature (°C)		
Maximum	51.50	43.70
Minimum	16.77	17.11
Average	27.05	25.95
Standard Deviation (SD)	7.80	6.10
Coefficient of Variation (CV %)	28.84	23.51

An independent t-test carried out to determine if there were significant statistical differences in temperature and humidity profiles between the two housing types showed that the mean temperature and humidity profiles were statistically different between the two housing types. Prefabricated house recorded a significantly lower mean temperature (25.95 ˚C) than tunnel house (27.05 ˚C), *t*, (21125) = 16.36, *P*<0.000). At the same time, tunnel house recorded lower mean relative humidity (58.97%) than the prefabricated house (60.52%), *t,* (21125) =9.08, *P*<0.000).

The two-way ANOVA analysis reported a significant interaction between the effects of housing and species on cricket growth rate, *F* (1, 60) = 6.08, P= 0.0155, Table 2. Post-hoc analysis showed that mean growth rate was statistically different between the two species and that the growth rate of *Acheta domesticus* was found to be 3.7% **(***P*>0.000) lower than that of *Gryllus bimaculatus.* Overall, growth rate for the crickets was 0.3% (*P*>0.38) lower in the prefabricated house than in the tunnel house. However, this difference was statistically insignificant.

Table 2: Analysis of Variance

	Mean Sq	F value	Pr(>F)
Housing	0.0002	0.847	0.3610
Species	0.0222	113.263	0.0000 ****
Housing x Species	0.0012	6.208	0.0155 **
Residuals	0.0002		

Significance codes: 0 '****' 0.001 '***' 0.01 '**' 0.05 '**' 0.1 '*'1

Acheta domesticus had the same developmental time (16 weeks) within the two types of houses though a higher growth rate was recorded in the tunnel house (Fig.3 and 4). On the other hand, *Gryllus bimaculatus* had a shorter developmental time to maturity (9 weeks) in the tunnel house compared to the prefabricated house. The growth rate of *Gryllus bimaculatus* peaked in week 3 in the tunnel unit and week 5 in the prefabricated house.

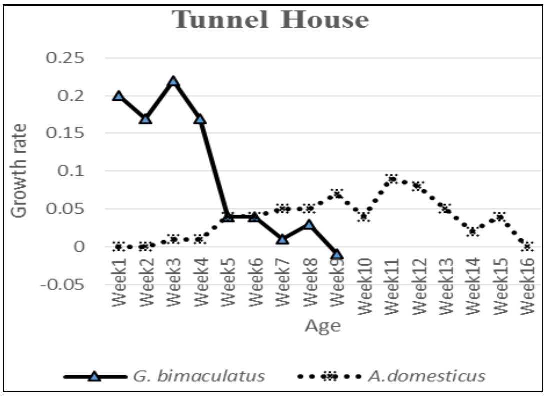

Fig 3: Growth rate trends by age (weeks)

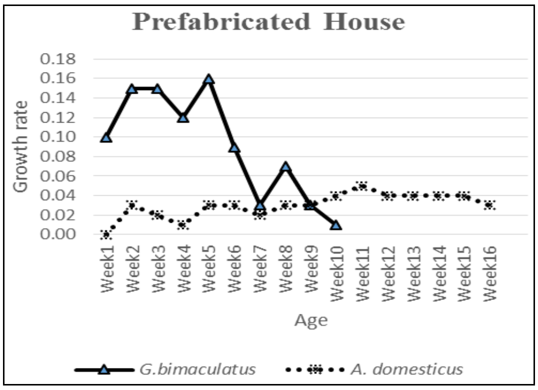

Fig 4: Growth rate trends by age (weeks)

In the tunnel house, sex notification was recorded in week 2 and week 6 while wing formation was noticed in week 3 and week 8 for *Gryllus bimaculatus* and *Acheta domesticus* respectively. Adult emergence and start of chirping was recorded in week 4 and week 10, start of laying was observed in week 5 and week 11 respectively.

The prefabricated house recorded sex notification in week 2 for *Gryllus bimaculatus* and week 7 for *Acheta domesticus.* Wing formation was observed in week 3 and week 9 for the two species correspondingly. Adult emergence was noticed in weeks 5 and 11, while laying started in weeks 6 and 12 for *Gryllus bimaculatus* and *Acheta domesticus* respectively.

Discussion

The range of results in this study reveals that for the genotype and housing systems for *Gryllus bimaculatus* and *Acheta domesticus*, the growth rate was not significantly affected by housing system (Table 2). In the study, temperature and humidity were the key functional factors in the housing systems that were expected to influence growth performance. Temperature and relative humidity within the species-specific physiological range determines the rates of metabolism, growth and development and other physiological processes [22, 23]. Consequently, it was anticipated that varying fluctuations in humidity and temperature within the respective housing systems would impact on growth rate which would have been consistent with earlier findings of [8, 9, 10, 11, 12]. However, this was not the case as it clearly emerged that the housing system did not influence either growth performance or reproduction of crickets which concurs with the findings of [17, 18]. The non-significant effect of housing type can be attributed to the fact that crickets are cold blooded organisms whose internal body temperatures depend on the temperatures of the surrounding and, therefore, can adapt easily to any environment.

While the housing system did not have significant influence on growth rate, it was however noted that development period in *Gryllus bimaculatus* was one week shorter in the tunnel house in comparison to the prefabricated house. The shorter development period may be attributed to slightly higher temperatures and humidity which accelerated metabolism and molting rate of crickets, thereby increasing feed intake leading to speedy growth [22]. Warm temperatures, as reported by [24, 25] accelerated metabolic rates of *H. axyridis* thereby increasing their larval growth rate leading to a shorter than expected development period. This observation, however, contradicts the findings of [13, 23] who observed that high temperature retarded growth. On the other hand, temperatures and relative humidity below the threshold, resulted in lower growth rates as was observed in the prefabricated house. This is in agreement with the findings of [14] who reported that Black Soldier Flies (*Hermetia illucens*) reared below the temperature and humidity thresholds had poor growth rates. Crickets have been reported to grow faster in a temperature range of 29 ˚C – 35 ˚C and in a relative humi dity of 50% [15], which was almost achieved in the two housing systems (Table 1), and may explain the non-significant growth rate recorded between the two housing systems.

In this study, it emerged that the species had a significant influence on the growth rate of the crickets. This concurs with existing studies which indicate that species confers a genetic potential for growth in organisms [16]. *Gryllus bimaculatus* consistently exhibited a higher mean growth rate than *Acheta domesticus* under the two housing systems, implying that it was the suitable genotype for both types of housing. The performance of any animal depends on the inherent genetic make-up and the environment in which it has been raised [16, 26]. Different species perform differently within the same environment given their genetic make-up [26]. The cricket species generally show a wide range of adaptability. The observed difference in growth rate between the cricket species was clearly an indication of adaptation to the prevailing environment.

Conclusion

The results of this study indicated that housing system has no effect on the growth rate of crickets which implies that crickets can tolerate a broad range of temperature and humidity within different housing systems. However, the genetic make-up played a critical role in the cricket development and growth which further implied that a superior genotype can be reared in either of the two housing types.

Conflict of interest

The authors declare no conflict of interest.

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