

Effect of a solar-powered cooling system on growth and survival of *Acheta domesticus* in the Mekong Delta

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Abstract: This study evaluated the effects of a solar-powered cooling system on the growth and survival of house crickets (*Acheta domesticus*) reared under tropical conditions in the Mekong Delta, Vietnam. A completely randomized design (CRD) was implemented with two treatments and five replicates per treatment. Treatment 1 (T1) served as the control with conventional enclosures lacking thermal regulation, while Treatment 2 (T2) employed insulated enclosures equipped with a solar-powered system integrating photovoltaic panels, temperature-humidity sensors (DHT22), fans, and ultrasonic misting devices. Each experimental unit consisted of 500 three-day-old nymphs raised in standardized composite rearing containers (60 × 40 × 40 cm) and fed with cornmeal, rice bran, and fresh vegetables. Environmental parameters, growth performance, and production indicators were monitored throughout the rearing cycle. The T2 group maintained an average internal temperature of 29.1°C±1.2°C and relative humidity of 60.7%±4.33%, compared to 34.2°C±1.5°C and 45.2±5.07% in the T1 group. Crickets reared in the cooled environment exhibited significantly improved outcomes, including higher average body weight (1.47±0.10 g vs. 1.24±0.12 g), greater relative growth rate (142.52% vs. 118.31%), and faster time to marketable size (34.8±1.8 vs. 40.2±2.5 days). Survival rate increased from 85.43% in T1 to 94.19% in T2, while feed conversion ratio improved from 2.8 to 2.2. Additionally, harvest yield rose from 445.09 g to 520.15 g per unit, and the proportion of marketable crickets increased by nearly 12%. These results highlight the biological and economic benefits of implementing solar-assisted microclimate control in small-scale insect farming. The system effectively stabilized thermal and humidity conditions using renewable energy, reducing heat stress and mortality while enhancing feed efficiency and growth performance. This approach offers a sustainable, low-cost solution for insect farming under hot and humid conditions and could be readily applied in rural or decentralized production systems. The integration of automated, sensor-based environmental control presents a scalable model for improving cricket production in tropical agriculture.

Keywords: *Acheta domesticus*, cricket farming, solar-powered cooling, growth performance, survival rate.

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1 Introduction

Around the world, especially in tropical regions, people regularly eat insects, with over 2,000 species identified as part of the human diet (Kouřimská and Adámková, 2016). Today, it is increasingly embraced by consumers and businesses because of its nutritional

value, ecological advantages, and cost-effectiveness (Aguilar-Toalá et al., 2022). The house cricket (*Acheta domesticus* Linnaeus, 1758), a member of the family Gryllidae, has been highlighted as a promising species for human food use (Jensen et al., 2017) due to its high protein content, efficient feed conversion, and adaptability to both small- and large-scale farming

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systems. Cricket farming has gained particular attention in Southeast Asia, including Vietnam, where rural and peri-urban households increasingly rely on insect farming both as a food source and as a source of income. The Food and Agriculture Organization (FAO) highlights the nutritional value of edible insects, noting their richness in high-quality proteins, essential polyunsaturated fats, and important micronutrients (van Huis et al., 2013). With around 68 grams of protein per 100 grams, crickets surpass traditional meats like chicken (21.3 g) and beef (30 g) in protein content, making them one of the richest sources of edible insect protein (Singh, 2017). Due to their high reproductive rate, quick population growth, strong feed efficiency (FCR), low cost, ease of breeding, and minimal risk of zoonotic transmission, crickets are considered highly suitable for intensive farming systems (van Huis et al., 2013; Mukherjee and Mukherjee, 2022).

However, the success and productivity of cricket farming are highly influenced by environmental factors, especially temperature. Optimal temperature conditions are essential for the growth, development, and survival of crickets. Furthermore, insects can be reared year-round, possess high reproductive and growth rates, and offer a high proportion of edible body mass (Acosta-Estrada et al., 2021; Nieto et al., 2023). In tropical regions such as the Mekong Delta, ambient temperatures often exceed the ideal thermal range for *A. domesticus*, leading to heat stress, reduced feed intake, slower growth, and increased mortality. These challenges are further exacerbated by climate change, which contributes to more frequent and intense heatwaves, thus threatening the viability of insect farming operations.

Conventional cooling methods, such as air conditioners or mechanical ventilation systems, are often inaccessible or unsustainable for smallholder farmers due to high installation and operational costs, as well as the reliance on grid electricity. In contrast, solar-powered cooling systems offer an environmentally friendly and economically feasible alternative. These systems harness renewable energy

to regulate environmental conditions in insect farming facilities, potentially improving production performance while reducing dependency on fossil fuels. Despite the theoretical advantages, empirical data on the impact of solar-powered cooling technologies in edible insect farming remains limited, particularly in the context of developing countries and tropical climates. Improving agricultural energy efficiency depends on identifying and controlling the different types of energy inputs involved (Witney, 1988).

The Mekong Delta of Vietnam is a key agricultural region with a tropical monsoon climate, characterized by high humidity and elevated temperatures during much of the year. These conditions present significant constraints for cricket farming, especially during the dry season. Therefore, investigating the application of solar-powered cooling systems in this context is both timely and necessary. This study aims to evaluate the effects of a solar-powered cooling system on the growth performance and survival rate of *Acheta domesticus* under practical farming conditions in the Mekong Delta. The findings are expected to provide scientific evidence supporting the adoption of renewable energy-based solutions in insect farming, contributing to food security and sustainable rural development.

2 Materials and methods

2.1 Location and time

The experiment was carried out at a cricket farming facility located in Chau Thanh District, Hau Giang Province, Vietnam, from July to October 2024. During the entire experimental period, key environmental parameters such as temperature and humidity were systematically monitored to ensure consistent rearing conditions.

2.2 Experimental design

The experiment was arranged in a Completely Randomized Design (CRD) with two treatments and five replications per treatment, totaling ten experimental units. Each unit consisted of a composite rearing box (60 × 40 × 40 cm) containing 500 house

cricket (*Acheta domesticus*) nymphs at 3 days of age. All crickets were raised under identical nutritional and lighting conditions, with the only variable being the presence or absence of an active cooling and ventilation system.

2.2.1 Treatment 1 (T1 – Control)

Crickets were reared in traditional closed housing structures covered with corrugated metal roofing without any cooling or ventilation system. Ventilation was passive, relying on small natural openings. Temperature and humidity inside the enclosure were directly influenced by external weather conditions.

2.2.2 Treatment 2 (T2 – Solar-cooled)

Crickets were reared in semi-enclosed housing equipped with a solar-powered active cooling and ventilation system. The structure featured insulated roofing, insect-proof mesh, and actively ventilated sidewalls. Environmental parameters (temperature and humidity) were automatically monitored and adjusted in real time using a custom-built system.

All procedures involving the rearing and handling of *Acheta domesticus* were conducted in accordance with recognized ethical principles for invertebrate research. Crickets were raised under hygienic and optimal conditions with adequate shelter, food, and water, and no invasive or harmful procedures were applied. Harvesting was performed manually to minimize stress. As crickets are not classified as vertebrates under current national or international animal welfare legislation, formal approval from an ethics committee was not required. Nevertheless, the study fully adhered to the principles of Replacement, Reduction, and Refinement (3Rs) throughout its experimental design.

2.3 Experimental materials and feeding

Each rearing box was fitted with corrugated cardboard sheets to provide surface area for climbing and resting. All boxes were elevated 40 cm off the ground to ensure airflow and ease of sanitation. Crickets were fed daily with a standard diet consisting of ground maize meal, rice bran, and fresh green materials including lettuce, young mustard greens, cassava leaves, sweet potato vines, and Napier grass.

Clean drinking water was provided ad libitum using gravity-fed nipple drinkers installed inside each box.

2.4 Cooling system components and operating principle

The active environmental control system operated entirely on solar energy and was composed of the following components:

Photovoltaic panel (100 W, 12 V): Converts sunlight into direct current (DC) electricity via the photovoltaic effect, where photons striking a semiconductor material (silicon) release electrons to generate electricity. The output is optimized through a solar charge controller.

Lead-acid battery (12 V, 50 Ah): Stores excess electricity generated during daylight and supplies power during nighttime or overcast conditions, ensuring uninterrupted operation.

PWM solar charge controller (12 V, 10 A): Regulates the charging process from the solar panel to the battery, prevents overcharging or deep discharge, and maintains system stability by rapidly pulsing the current (PWM) to stabilize voltage at 14.4 V (charging) or 12 V (discharge).

DHT22 temperature and humidity sensor: Measures ambient temperature (range 0–50°C, $\pm 0.5^\circ\text{C}$ accuracy) and relative humidity (20%–90%) using a thermistor and capacitive sensor. Outputs digital signals via 1-wire communication to the microcontroller.

Arduino Uno microcontroller (ATmega328P): Receives input from DHT22 sensors, compares real-time values with preset thresholds, and controls peripheral devices such as fans and mist sprayers through GPIO pins.

DC axial fans (12 V, 12 W, 50 CFM): Circulate air to lower temperature; their speed is modulated via PWM signals from the microcontroller for energy efficiency.

Ultrasonic mist maker (12 V, 10 W, 100 mL h⁻¹): Atomizes water into fine mist particles using 1.7 MHz ultrasonic oscillation, increasing humidity during dry conditions.

During daytime, the photovoltaic panel supplies

electricity to the system and simultaneously charges the battery. When the DHT22 sensors record internal temperatures above 32°C, the microcontroller activates all four fans at 80%–100% speed to reduce temperature to 30°C. If humidity drops below 50%, the mist maker runs 10 seconds every 5 minutes until the target level is reached. At night, the battery powers the system; if the temperature drops below 25°C, all cooling devices are deactivated to conserve energy. Environmental data are transmitted via Wi-Fi to the Blynk application on a mobile device for real-time monitoring and system adjustment.

2.5 Monitored parameters and measurement methods

The following indicators were tracked and measured to evaluate performance under both treatments:

2.5.1 Growth performance

Average body weight (g individual⁻¹): Determined weekly by weighing 20 randomly selected crickets per box.

Average daily gain (ADG, g day⁻¹): Calculated as (final weight – initial weight) ÷ rearing period.

Relative growth rate (RGR, %): [(final – initial weight) ÷ initial weight] × 100.

Days to market weight: Number of days required to reach ≥ 1.4 g cricket⁻¹.

2.5.2 Survival and production efficiency

Survival rate (%): (Number of live crickets ÷ initial number) × 100.

Weekly mortality (%): Recorded weekly per box.

Feed conversion ratio (FCR): Total feed intake ÷ total weight gain.

Harvest yield (g): Total live weight collected at the end of the cycle.

Marketable yield (%): Proportion of crickets reaching ≥ 1.4 g at harvest.

2.5.3 Microclimate monitoring

Internal temperature and humidity: Measured 4 times day⁻¹ using DHT22 sensors.

Daily temperature fluctuation (°C): Maximum – minimum recorded per day.

Cooling system operation time (minutes day⁻¹):

Sum of activation periods for fans and misting device.

Extreme temperatures (max min⁻¹): Recorded daily for correlation analysis.

2.6 Statistical analysis

Data for all measured parameters were expressed as mean ± standard deviation (SD). The normality of data distribution was verified using the Shapiro–Wilk test, and homogeneity of variances was checked using Levene's test. Differences between treatments were analyzed using independent samples t-tests according to Equation (1):

$$t = \frac{X_1 - X_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (1)$$

Where,

X_1 and X_2 are the sample means;

s_1 and s_2 are the standard deviations;

n_1 and n_2 are the sample sizes of the two treatment groups, respectively.

A significance level of $p < 0.05$ was considered statistically significant. All statistical calculations were performed using SPSS software (Version 26.0; IBM Corp., Armonk, NY, USA).

3 Results and discussion

The results in Table 1 indicate that the solar-powered cooling system had a clear and statistically significant effect on the growth performance of *Acheta domesticus*. Crickets reared in the cooled treatment (T2) achieved a higher average body weight of 1.47 ± 0.10 g individual⁻¹, compared to only 1.24 ± 0.12 g individual⁻¹ in the control group (T1). This difference suggests that a more stable and moderate temperature range supports nutrient absorption and weight gain. The cooler environment likely reduced the metabolic stress that crickets often experience under high ambient temperatures, especially during the hot hours of the day in the Mekong Delta. Compared with traditional livestock, insects are more efficient in converting feed into biomass because their cold-blooded physiology minimizes energy loss for thermoregulation, enabling greater nutrient utilization for growth (Collavo et al., 2005). Additionally, the average daily gain (ADG) in

T2 reached $0.04 \pm 0.03 \text{ g day}^{-1}$, significantly higher than the $0.02 \pm 0.04 \text{ g day}^{-1}$ recorded in T1. This indicates that growth was not only more efficient but also faster on a daily basis in the presence of temperature and

humidity regulation. Diet plays a crucial role in the successful rearing of crickets, as it has a significant impact on their growth and developmental outcomes (Halloran et al., 2017).

Table 1 Growth performance of house crickets

Parameter	T1 (Control)	T2 (Solar-cooled)
Average body weight (g individual ⁻¹)	1.24 ± 0.12^b	1.47 ± 0.10^a
Average daily gain (g day ⁻¹)	0.02 ± 0.04^b	0.04 ± 0.03^a
Relative growth rate (%)	118.31 ± 10.2^b	142.52 ± 9.5^a
Days to marketable weight	40.2 ± 2.5^a	34.8 ± 1.8^b

Note: ^{ab} Mean values within rows with different superscripts are different at $p < 0.05$

A further indication of this improved growth can be seen in the relative growth rate (RGR), which increased from $118.31\% \pm 10.2\%$ in T1 to $142.52\% \pm 9.5\%$ in T2. The elevated RGR under controlled microclimatic conditions suggests that the crickets were able to utilize nutrients more effectively for tissue development, possibly due to reduced water loss and more consistent feeding behavior. Ventura et al. (2022) reported that crickets reared in 29.3-liter polyethylene cages with screen tops at a stocking density of 0.005 crickets per cubic centimeter, under a stable temperature of 27°C and a 12L:12D photoperiod, remained healthy over a two-year period. The use of moistened coconut coir served dual functions—for hydration and as a site for egg deposition. In controlled trials, the crickets reached an average harvest weight of $0.724 \text{ g} (\pm 0.190 \text{ g})$, with 89% survival and 68.2% achieving sexual maturity between days 22 and 65. Notably, the number of days required to reach marketable size was significantly shortened in the cooled group: crickets in T2 reached commercial weight in 34.8 ± 1.8 days, compared to 40.2 ± 2.5 days in the control. Differences were observed in the duration required for nymphs to reach adulthood, with crickets fed on PPDP, PPFP, and PPF exhibiting faster growth than those in other dietary groups. These findings are consistent with earlier studies on this species (Patton, 1967; Orinda et al., 2017). This reduction of more than five days per production cycle is highly relevant for farmers aiming to improve turnaround and reduce operational costs, as shorter rearing periods directly

translate to higher annual productivity.

Table 2 further supports the advantages of the cooling system in terms of survival and production efficiency. The survival rate in T2 reached $94.19\% \pm 2.45\%$, significantly higher than the $85.43\% \pm 3.16\%$ recorded in the control group. This improvement is a strong indication that the crickets reared under optimized environmental conditions were better protected from heat-related mortality. The survival, growth efficiency, and developmental duration of crickets are significantly affected by variations in diet composition, particularly the levels of protein, carbohydrates, and fats (Oonincx et al., 2015). Weekly mortality was more than halved in T2, dropping to $1.57\% \pm 0.84\%$ compared to $3.65\% \pm 1.21\%$ in T1. These figures clearly demonstrate that controlling temperature and humidity not only supports growth but also minimizes losses due to environmental stress, particularly during critical periods such as molting. The high survival rate of crickets observed in this study can likely be attributed to consistent water availability, which is known to be essential for maintaining physiological homeostasis and supporting basic biological functions (Floater, 1997; McCluney and Date, 2008).

Additionally, crickets were provided with nutritionally adequate diets and raised under good agricultural practices (GAP), both of which are critical factors in reducing stress, enhancing immunity, and promoting overall health. Environmental stability, such as optimal temperature, humidity, and hygienic

rearing conditions, may have also contributed to minimizing disease incidence and improving survivability. These combined factors create a

favorable microenvironment that not only supports longevity but also enhances performance metrics such as growth and reproduction.

Table 2 Survival and production efficiency

Parameter	T1 (Control)	T2 (Solar-cooled)
Survival rate (%)	85.43±3.16 ^b	94.19±2.45 ^a
Weekly mortality rate (%)	3.65±1.21 ^a	1.57±0.84 ^b
Feed conversion ratio (FCR)	2.8±0.25 ^a	2.2±0.18 ^b
Harvest yield (g)	445.09±22.19 ^b	520.15±21.03 ^a
Proportion of marketable crickets (%)	76.51±4.32 ^b	88.36±3.11 ^a

Note: ^{ab} Mean values within rows with different superscripts are different at $p < 0.05$

Feed conversion ratio (FCR) is a standard measure used in livestock systems, including house cricket farming, to quantify feed efficiency and manage feed inventory. It is a key parameter when assessing sustainable food alternatives (Halloran et al., 2016). An important parameter related to feed efficiency is the feed conversion ratio (FCR), which also showed significant improvement in T2. The FCR decreased from 2.8±0.25 in T1 to 2.2±0.18 in T2, indicating that crickets in the cooled environment needed less feed to produce the same unit of biomass. This may be due to a more efficient metabolism when not under thermal stress, allowing more of the consumed energy to be allocated to growth instead of maintenance or heat dissipation. As a result, the harvest yield per box increased from 445.09 ± 22.19 g in T1 to 520.15 ± 21.03 g in T2. To fulfill their nutritional needs, animals tend to choose appropriate diets.

This research explores such dietary preferences using *Gryllus bimaculatus*, a species of cricket. By conducting a 9-hour continuous behavioral observation, we successfully tracked how the insects discriminated between food sources with varying nutrient levels (Fukumura and Nagata, 2017). Moreover, the proportion of crickets that reached marketable size (≥ 1.4 g) was significantly higher in T2, with 88.36%±3.11% of individuals suitable for sale, compared to only 76.51%±4.32% in T1. This shows that not only did more crickets survive, but a larger portion met the commercial standard for harvesting.

Environmental monitoring data shown in Table 3 provide a clear explanation for the observed improvements in growth and survival. Crickets generally live for about 6 to 7 weeks, although this duration is influenced by temperature and other environmental conditions. Higher temperatures promote faster growth but reduce lifespan, whereas lower temperatures are associated with greater body weight (Booth and Kiddell, 2007; Oloo et al., 2020). An increase in temperature generally enhances growth and developmental rates, but only when the temperature stays within the species' suitable range for development (van der Have and de Jong, 1996; Jarošík et al., 2004). The internal temperature in T2 was maintained at 29.1°C±1.2°C, significantly lower than the 34.2°C±1.5°C recorded in the control. House crickets grew and developed more rapidly at 28°C compared to 25°C. The significantly longer developmental period at 25°C indicates that this temperature approaches the lower thermal limit for sustained growth in the species and is not ideal for optimal development (Lipsitz and McFarlane, 1971; Clifford et al., 1977; Atkinson, 1994). This reduction places the environmental temperature within the optimal thermal range for *Acheta domesticus*, which likely enhanced feeding frequency and nutrient assimilation.

In addition, the average relative humidity in T2 reached 60.7%±4.33%, compared to only 45.2%±5.07% in T1. These humidity levels are more favorable for preventing dehydration, especially in the early nymphal stages when water loss through the cuticle

can be critical. The microclimate in T2 was also more stable, as shown by the smaller daily temperature fluctuation of $2.83^{\circ}\text{C}\pm0.06^{\circ}\text{C}$ compared to $4.11^{\circ}\text{C}\pm0.09^{\circ}\text{C}$ in T1. High diurnal variation can cause behavioral stress in crickets, including reduced mobility and feeding irregularities. Non-flying insects lack the metabolic capacity to generate heat above ambient levels, meaning their body temperature reflects that of their surroundings, as is typical for ectothermic species (Booth and Kiddell, 2007). Furthermore, the cooling system in T2 operated on average 150 ± 18 minutes per day, ensuring constant

adjustment of temperature and humidity to within the desired range. These operational results confirm that the system not only functioned as intended but provided measurable benefits in maintaining a consistent rearing environment. Based on life cycle assessment data, house cricket farming demonstrates a reduced risk of environmental harm. Emissions from pig farming 2.251 kg CO₂-eq (Dourmad et al., 2014) and 2.69 kg CO₂-eq (Bava et al., 2017) are notably higher than those linked to cricket production. Consequently, rearing house crickets appears to be a more eco-friendly alternative.

Table 3 Microclimatic conditions inside cricket enclosures

Parameter	T1 (Control)	T2 (Solar-cooled)
Internal temperature (°C)	34.2±1.5 ^a	29.1±1.2 ^b
Maximum / Minimum temperature (%)	36.5/32.4	31.5/28.7
Average relative humidity (%)	45.23±5.07 ^a	60.71±4.33 ^b
Daily temperature fluctuation (°C)	4.11±0.09 ^a	2.83±0.06 ^b
Cooling system operation time (fan/mist) (min day ⁻¹)	0	150±18

Note: ^{ab} Mean values within rows with different superscripts are different at $p<0.05$

Taken together, the results from these three tables clearly demonstrate that solar-powered microclimate control leads to better biological performance, improved resource utilization, and higher economic return. The system offers a practical solution for insect farming in hot and humid tropical areas, balancing environmental control with sustainability through renewable energy use. The integration of sensors and automated feedback systems ensures that environmental conditions stay within optimal thresholds, supporting both animal welfare and productivity in small-scale cricket farms.

4 Conclusion

The solar-powered cooling system significantly enhanced the growth and survival of *Acheta domesticus* under tropical conditions. The cooled enclosures maintained optimal temperature and humidity, reducing heat stress and improving feed efficiency. As a result, crickets achieved higher body weight, faster growth, greater survival, and improved feed conversion efficiency, leading to higher yields and marketable output. These findings demonstrate that integrating renewable-energy-based microclimate

control can sustainably improve biological performance and productivity in small-scale tropical insect farming. Further studies should evaluate long-term economic feasibility and system scalability for broader application.

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References

Acosta-Estrada, B. A., A. Reyes, C. M. Rosell, D. Rodrigo, and C. C. Ibarra-Herrera. 2021. Benefits and challenges in the incorporation of insects in food products. *Frontiers in Nutrition*, 8: 687712.

Aguilar-Toalá, J. E., R. G. Cruz-Monterrosa, and A. M. Liceaga. 2022. Beyond human nutrition of edible insects: Health benefits and safety aspects. *Insects*, 13(11): 1007.

Atkinson, D. 1994. Temperature and organism size—A biological law for ectotherms? *Advances in Ecological Research*, 25: 1–58.

Bava, L., M. Zucali, A. Sandrucci, and A. Tamburini. 2017. Environmental impact of the typical heavy pig production in Italy. *Journal of Cleaner Production*, 140(2): 685–691.

- Booth, D. T., and K. Kiddell. 2007. Temperature and the energetics of development in the house cricket (*Acheta domesticus*). *Journal of Insect Physiology*, 53(9): 950–953.
- Clifford, C. W., R. M. Roe, and J. P. Woodring. 1977. Rearing methods for obtaining house crickets, *Acheta domesticus*, of known age, sex, and instar. *Annals of the Entomological Society of America*, 70(1): 69–74.
- Collavo, A., R. H. Glew, Y. S. Huang, L. T. Chuang, R. Bosse, and M. G. Paoletti. 2005. House cricket small-scale farming. In *Ecological Implications of Minilivestock: Potential of Insects, Rodents, Frogs and Snails*, ed. M. G. Paoletti, ch. 27, 515–540. Enfield, New Hampshire, USA: Science Publishers Inc.
- Dourmad, J. Y., J. Ryschawy, T. Trousson, M. Bonneau, J. González, H. W. J. Houwers, M. Hviid, C. Zimmer, T. L. T. Nguyen, and L. Morgensen. 2014. Evaluating environmental impacts of contrasting pig farming systems with life cycle assessment. *Animal*, 8(12): 2027–2037.
- Floater, G. 1997. Rainfall, nitrogen and host plant condition: Consequences for the processionary caterpillar, *Ochrogaster lunifer*. *Ecological Entomology*, 22(3): 247–255.
- Fukumura, K., and S. Nagata. 2017. Behavioral tracing demonstrates dietary nutrient discrimination in two-spotted crickets *Gryllus bimaculatus*. *Bioscience, Biotechnology, and Biochemistry*, 81(10): 1990–1993.
- Halloran, A., Y. Hanboonsong, N. Roos, and S. Bruun. 2017. Life cycle assessment of cricket farming in north-eastern Thailand. *Journal of Cleaner Production*, 156: 83–94.
- Halloran, A., N. Roos, J. Eilenberg, A. Cerutti, and S. Bruun. 2016. Life cycle assessment of edible insects for food protein: A review. *Agronomy for Sustainable Development*, 36(4): 57.
- Jarošík, V., L. Kratochvíl, A. Honěk, and A. F. G. Dixon. 2004. A general rule for the dependence of developmental rate on temperature in ectothermic animals. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 271(Suppl 4): S219–S221.
- Jensen, K., T. N. Kristensen, L. L. Heckmann, and J. G. Sørensen. 2017. Breeding and maintaining high-quality insects. In *Insects as Food and Feed: From Production to Consumption*, eds. A. van Huis, and J. K. Tomberlin, ch. 9, 174–198. Wageningen, the Netherlands: Wageningen Academic Publishers.
- Kouřimská, L., and A. Adámková. 2016. Nutritional and sensory quality of edible insects. *NFS Journal*, 4: 22–26.
- Lipsitz, E. Y., and J. E. McFarlane. 1971. Analysis of lipid during the life cycle of the house cricket, *Acheta domesticus*. *Insect Biochemistry*, 1(4): 446–460.
- McCluney, K. E., and R. C. Date. 2008. The effects of hydration on growth of the house cricket, *Acheta domesticus*. *Journal of Insect Science*, 8(1): 32.
- Mukherjee, S., and A. Mukherjee. 2022. Small-scale breeding and harvesting of house cricket *Acheta domesticus*. *Acta Entomology and Zoology*, 3(2): 112–115.
- Nieto, J., J. Plaza, J. Lara, J. A. Abecia, I. Revilla, and C. Palacios. 2023. Use of *Acheta domesticus* meal as a full soybean substitute in the feeding of slow-growing chicks. *Poultry Science*, 102(4): 102503.
- Oloo, J. A., M. Ayieko, and J. M. Nyongesah. 2020. *Acheta domesticus* (cricket) feed resources among smallholder farmers in Lake Victoria region of Kenya. *Food Science & Nutrition*, 8(1): 69–78.
- Oonincx, D. G. A. B., S. van Broekhoven, A. van Huis, and J. J. A. van Loon. 2015. Feed conversion, survival and development, and composition of four insect species on diets composed of food by-products. *PLoS One*, 10: e0144601.
- Orinda, M. A., R. O. Mosi, M. A. Ayieko, and F. Amimo. 2017. Growth performance of common house cricket (*Acheta domesticus*) and field cricket (*Gryllus bimaculatus*) crickets fed on agro-byproducts. *Journal of Entomology and Zoology Studies*, 5(6): 1664–1668.
- Patton, R. L. 1967. Oligidic diets for *Acheta domesticus* (Orthoptera: Gryllidae). *Annals of Entomological Society of America*, 60: 1238–1242.
- Singh, Y. 2017. Cricket nutrition facts: Cricket vs. beef. Available at: <http://www.aketta.com/blog/cricket-nutrition-facts-cricket-vs-beef.aspx>. Accessed 20 August 2026.
- van Huis, A., J. van Itterbeeck, H. Klunder, E. Mertens, A. Halloran, G. Muir, and P. Vantomme. 2013. Edible insects: Future prospects for food and feed security. FAO Forestry Paper 171. Rome, Italy: FAO.
- van der Have, T. M., and G. de Jong. 1996. Adult size in ectotherms: Temperature effects on growth and differentiation. *Journal of Theoretical Biology*, 183(3): 329–340.
- Ventura, M. K., V. J. Stull, and S. M. Paskewitz. 2022. Maintaining laboratory cultures of *Gryllus bimaculatus*, a versatile orthopteran model for insect agriculture and invertebrate physiology. *Journal of Visualized Experiments*, (184): e63277.
- Witney, B. 1988. *Choosing and Using Farm Machines*. Harlow, Essex, UK: Longman Scientific & Technical.