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# The effect of density on the breeding optimization of the tropical house cricket *Gryllodes sigillatus* (Walker) (Orthoptera: Gryllidae)

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**Abstract:** *The effect of density on the breeding optimization of the tropical house cricket Gryllodes sigillatus (Walker) (Orthoptera: Gryllidae).* The study was aimed at testing the density effect in the tropical house cricket breeding on its survival and growth rate when fed *ad libitum*. The tropical house crickets were kept in nine containers of a volume of 81 litres each. Three experimental variants were used: 7.5 ml of crickets were placed in the first container, 15 ml in the second and 30 ml in the third. Temperature in containers was 29°C, the experiment lasted 25 days. Obtained results showed that survival did not depend on the initial density in culture containers while crickets kept at a high density had smaller body length. The results may affect the optimization of house cricket breeding.

*Key words*: the tropical house cricket, *Gryllodes sigillatus*, survival, population density, growth rate, optimization of breeding

## INTRODUCTION

Terraristics enjoys increasing popularity. More and more reptiles and amphibians are kept by both experienced and novice breeders. The animals require mainly live food. The nutritive requirements of reptiles, amphibians, but also of popular African pigmy hedgehogs *Atelerix albiventris* (Wagner, 1841) and many bird species, are fulfilled by feeding them with insects. They are the main component or an additive to animals' diet. Moreover, insects are more and more often considered food for humans. This is because of the need to search for new protein sources for growing human population and of a curiosity and desire to learn new tastes and to break nutritional stereotypes. For the second mentioned reason the first in Poland restaurant "Co To To Je", that serves exclusively insect dishes, has recently been open in Warsaw.

Above mentioned circumstances indicate that the market for food insects has a great potential but needs some improvement. Insects imported are usually weak and soon die of exhaustion and conditions of transportation. Country breeding still needs to be developed since its efficiency may be higher and there is a deficit of insects from local production.

Food insects most often bred include: crickets, cockroaches, locusts, larvae of wood-eaters, mealworms and wax moths. Crickets are bred to the largest extent. They have low requirements compared with other food insects. The tropical house cricket *Gryllodes sigillatus* (Walker) has relatively high protein content from among bred insect species (Table 1).

The tropical house cricket is the smallest of bred crickets (18–22 mm of length). It has two transverse black bands on its abdomen and resembles the house cricket. Females are larger than males and wingless. Males have partly reduced wings, hence they contain less chitin and are more easily digested. The tropical house crickets are distinguished by low aggression towards other crickets and cannibalism is rare among them. Biting animals that feed on them is also rare. The insects are very fast, which is an advantage for animals actively hunting for their prey. They also show a high fertility and resistance to viruses (like e.g. *Acheta domesticus* Densovirus) and fungi, which makes them ideal animals for mass production. The development from hatching till imago lasts 8–15 weeks depending on temperature.

Performed studies had to estimate the effect of initial density on survival and body length in crickets. This information is useful to increase the profitability of breeding.

The main aim of performed studies was to intensify breeding. This requires, however, providing animal welfare and hygienic conditions. Like in farm animals, habitat conditions affect health and productivity and the quality of animal products in food invertebrates.

## MATERIAL AND METHODS

Experimental crickets were provided with basic elements of welfare. Having *ad libitum* access to food and water they were free from hunger and thirst. Crickets were free from discomfort – their resting area was made of cardboard egg trays which increased living area and offered a shelter. The animals were free from pain, injuries, diseases and stress. Studies were carried out in the food insect farm "Fabryka owadów" in Warsaw.

Before setting up the experiment, freshly hatched (maximum 24 h after hatching) cricket larvae were mixed to obtain uniform sample. The experiment lasted 25 days. The initial number of crickets in 1 ml (mean from three samples) was 424.7.

The tropical house crickets were kept in nine containers of a volume of 81 litres each (60×40×34 cm). Temperature in containers was 29°C. All containers had the same ventilation and were placed at the same height on shelves to avoid differences in temperature between cultures.

TABLE 1. Nutritive value of crickets (http://www.livefoodsdirect.co.uk/Category/Banded-Crickets)

| Specification | *Gryllodes sigillatus* | *Gryllus assimilis* | *Gryllus bimaculatis* |
|---|---|---|---|
| Energy (kcal/kJ per 100 g) | 164/687 | 130/546 | 153/640 |
| Protein (%) | 21.4 | 15.2 | 14.7 |
| Fat (%) | 6.9 | 5.7 | 8.3 |
| Carbohydrates (%) | 4.0 | 4.5 | 4.9 |
| Water (%) | 66.1 | 73.3 | 70.8 |
| Ash (%) | 1.6 | 1.3 | 1.3 |

Ten pieces of cardboard egg trays glued together were placed in each container. They served as the main living area for crickets.

There was a small waterer (a bowl with hydrogel which prevented larvae from drowning) in each container to provide crickets with permanent free access to water. Dry food consisted of a mixture of wheat bran and fishmeal (a protein additive that inhibits cannibalism) in the ratio 2 : 1 and trays with carrot – a base of diet during the experiment. The access to food and water was provided *ad libitum* to exclude food as the growth limiting factor.

Three experimental variants were used: 7.5 ml of crickets were placed in the first container, 15 ml in the second, and 30 ml in the third. Each variant was triplicated.

On 25th day of experiment crickets were taken off from culture containers and their volume measured with a cylinder with millilitre scale. Than two random 5 ml samples were taken from each culture, transferred to containers and photographed. The photos were used to count individuals with the Adobe Photoshop software. Final number of crickets was calculated by multiplying the final volume of crickets by the number of crickets in 5 ml. Mean body length of crickets was calculated from measurements of 90 randomly selected specimens from each experimental variant.

To calculate the survival of crickets' larvae, their number was counted and calculated per 1 ml before experiment in the same way as in the end of experiment.

ANOVA, non-parametric Kruskal-Wallis rank test and non-parametric Mann-Whitney U test were used to check the statistical significance of differences.

TABLE 2. The relationship between survival and final number of crickets and the initial sample volume after 25 days of experiments

| Variant (initial volume) | | *N* | Mean | Standard deviation | Minimum | Maximum | $X^2_{emp}$ | p |
|---|---|---|---|---|---|---|---|---|
| Survival | 7.5 | 3 | 27.6000 | 2.12838 | 25.30 | 29.50 | 5.600 | 0.061 |
| | 15 | 3 | 16.7667 | 1.70098 | 15.10 | 18.50 | | |
| | 30 | 3 | 18.4000 | 3.96863 | 15.40 | 22.90 | | |
| Final | 7.5 | 3 | 879.0000 | 67.10440 | 806.00 | 938.00 | 7.200 | 0.027 |
| | 15 | 3 | 1070.0000 | 109.05503 | 963.00 | 1181.00 | | |
| | 30 | 3 | 2343.6667 | 505.55349 | 1966.00 | 2918.00 | | |

## RESULTS AND DISCUSSION

Performed experiments showed that the initial volume of crickets used in each experimental variant did not affect insect survival ($p = 0.061$) – Table 2.

The effect of initial volume of crickets on body length after 25 days of experiment was highly significant ($p < 0.001$). The longest body had the crickets from experimental variant with the initial volume of 7.5 ml, the shortest – those from the variant with initial volume of 30 ml (Table 3).

TABLE 3. The relationship between body length and initial volume of the sample after 25 days of experiments

| Initial volume | *N* | Mean | Standard deviation | Minimum | Maximum | Femp | p |
|---|---|---|---|---|---|---|---|
| 7.5 | 90 | 7.2744 | 0.91216 | 5.70 | 10.10 | 38.247 | <0.001 |
| 15 | 90 | 6.9544 | 0.95637 | 5.10 | 10.00 | | |
| 30 | 90 | 6.1344 | 0.83305 | 4.50 | 8.30 | | |

Initial volume significantly affected the final number of crickets in experimental variants (p = 0.027). The highest number of insects was obtained from culture of initial volume of 30 ml (Table 2).

Many studies (pertaining, however, mostly to vertebrates) on density-dependent survival indicate that young individuals may die more often at a high density (Sheperd and Cushing 1980, Van der Veer 1986, Myers and Cadigan 1993, Ohman and Hirche 2001, Holbrook and Schmitt 2002). In view of the breeding efficiency an important finding of our study is that the initial volume does not affect crickets' survival. One may expect that similar mechanisms were involved here as in mealworms which at high densities acquired higher resistance to viruses and fungi (Barnes and Siva-Jothy 2000). Survival of mosquito larvae bred at medium temperature also increased at high densities (Lyimo et al. 1992). Noteworthy, no symptoms of viral or fungal diseases were observed during our experiments.

Performed studies showed that an increase of density resulted in decreased body length. Slower growth rate of larvae and smaller mass of imagines was noted e.g. in mosquitoes (Gimnig et al. 2002). Body mass of female pupae of this species was conversely proportional to density (Hawley 1985). Mosquitoes kept at 27°C achieved higher survival at high densities but their growth rate declined (Lyimo et al. 1992).

In order to obtain the greatest number of adult crickets in the shortest possible time one may set up a culture of relatively high density but crickets will not achieve as large body size as they would at lower densities.

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**Streszczenie:** *Wpływ zagęszczenia na optymalizację hodowli świerszcza bananowego Gryllodes sigillatus (Walker) (Orthoptera: Gryllidae).* Praca miała na celu zbadanie wpływu zagęszczenia początkowego w hodowli świerszczy bananowych na ich przeżywalność oraz szybkość wzrostu przy dostępie do pokarmu *ad libitum*. Świerszcze bananowe w czasie eksperymentu były hodowane łącznie w dziewięciu pojemnikach o pojemności 81 l każdy. Zastosowano trzy warianty doświadczeń: w pierwszym pojemniku umieszczono 7,5 ml świeżo wylęgłych świerszczy, w drugim 15 ml, a w trzecim 30 ml. Każdy wariant doświadczenia powtórzono trzykrotnie. Temperatura w pomieszczeniu wynosiła 29°C. Eksperyment trwał 25 dni. W wyniku przeprowadzonych badań stwierdzono, że objętość początkowa świerszczy użytych w każdym wariancie doświadczenia nie wpływa na przeżywalność owadów, jednak świerszcze hodowane w większym zagęszczeniu miały mniejszą długość ciała. Uzyskane wyniki mogą przyczynić się do zoptymalizowania hodowli tego gatunku świerszcza.

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