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Influence of ambient temperature on reproduction of the red-headed cricket (*Gryllus assimilis*)

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Original article

Abstract

Red-headed crickets were kept in glass insectariums equipped with drinkers, food containers and peat boxes for laying eggs. In the first stage of the experiment, the insects were divided into three groups, kept at 20°C, 25°C and 29°C, respectively. Three days after placing the crickets in the insectariums, the eggs were counted. In the second stage, the eggs (15 pcs.) were placed in boxes with peat in insectariums and exposed to the same temperatures as the females were kept at 20°C, 25°C and 29°C respectively, and the time in which the larvae hatch in each container was observed.

It was found that the thermal conditions of the environment influence the number of eggs laid by female *Gryllus assimilis* and the length of the embryonic period in red-headed crickets. It is estimated that in the temperature range of 20–29°C, increasing the temperature by 1°C shortens the time needed to hatch the larvae from the eggs by 2 days.

Keywords

- insects
- insectariums
- environmental conditions

Authors contributions

A – Preparation of the research project
B – Assembly of data for the research undertaken
C – Conducting of statistical analysis
D – Interpretation of results
E – Manuscript preparation
F – Literature review
G – Revising the manuscript

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Conflict of interest

None declared.

Introduction

Crickets (*Gryllidae*) are insects (Insecta) belonging to the order Orthoptera. In terms of morphological structure, these insects are characterized by a third pair of legs transformed into jumping legs and two pairs of wings with a different structure. These insects are characterized by well-marked sexual dimorphism. Females are distinguished by the egg-laying organ, i.e. the ovoid located on the abdomen and resembling a dark tube. In turn, males are equipped with a stridulation apparatus that allows them to make sounds [1]. Crickets are among the most frequently eaten insects. They contain high amounts of protein (68.55%) and little fat (15.28%) [2], and by feeding them with a properly balanced feed, the amount of calcium contained in them can also be increased [3]. This makes them a delicacy among enthusiasts of entomophagy [4]. It should be noted that insects have been consciously eaten by humans for tens of thousands of years. Due to the approval of insects for human consumption in the EU, it can be assumed that the proportion of insect protein in the human diet will increase significantly in the future [5].

Gryllus assimilis is omnivorous. In breeding farms, these insects are usually fed oat flakes, food for aquarium fish and fresh fruit and vegetables. The diet of crickets is usually enriched with animal protein derived, for example, from dried Daphnia, which limits the cannibalistic behavior of these arthropods [6].

Red-headed crickets in farms are most often kept in glass or plastic insectariums equipped with adequate ventilation, drinkers, feeders and containers with peat or soil for laying eggs. The female *G. assimilis* can lay 150 to 400 eggs during her lifetime [7]. The eggs of this species of crickets are laid within a few days after mating [8] individually or in small groups, usually into soil or some other sufficiently soft substrate, e.g. parts of plants [9]. Crickets are insects undergoing incomplete transformation [10]. The development of the larvae in the eggs usually takes several weeks [11], but the length of this period depends, among others, on ambient temperature [12–13]. On the other hand, the factors influencing the frequency of shedding (and thus also the growth rate of insects) are the quantity, composition and quality of food, infection of the body by bacteria or parasites, as well as environmental parameters: photoperiod, humidity and air temperature [14]. Of these, temperature is the most powerful factor. Since red-headed crickets are definitely thermophilic insects, many breeders equip their insectariums with heating cables or mats, and control the temperature with thermometers and thermostats [15].

The object of the study was to determine the influence of ambient temperature on reproduction of the red-headed cricket (*Gryllus assimilis*). Determining the optimal temperature for the reproduction of these arthropods is of great importance for breeding focused on the production of live food for other animals. For this reason, it seems interesting and necessary to study the influence of temperature on some reproductive parameters of red-headed crickets, such as the number of eggs laid and the time needed for the larvae to hatch from them.

Materials and methods

The animals and the outline for the experiment

Red-headed crickets (*Gryllus assimilis*) from Natalia Hermansa's own breeding farm were used in the experiment (Figure 1).

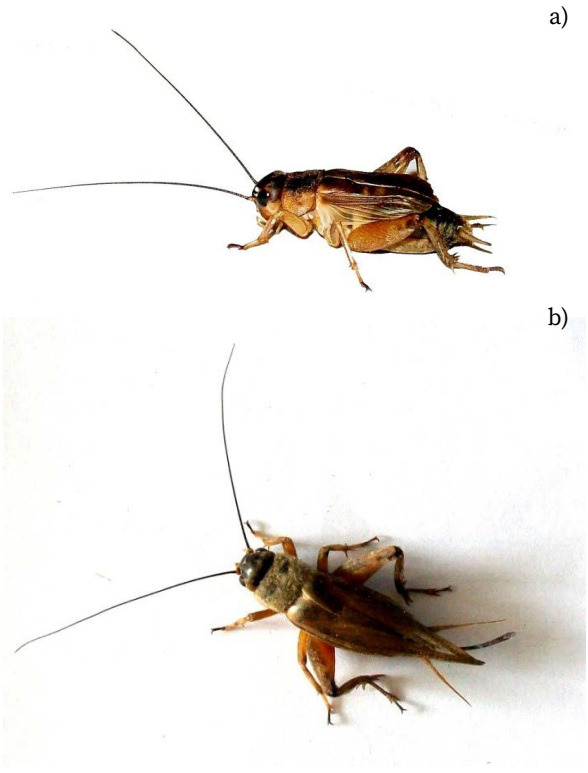

Figure 1. Red-headed crickets (*Gryllus assimilis*) Male (a) and female (b); (phot. N. Hermansa)

The experiment was divided into two stages:

1. Study of the influence of the ambient temperature on the number of eggs laid by the female.
2. Examination of the influence of the ambient temperature on the time needed for the hatching of the larvae.

The insects were kept in three glass insectaria, each of which was additionally divided into three compartments (Figure 2).

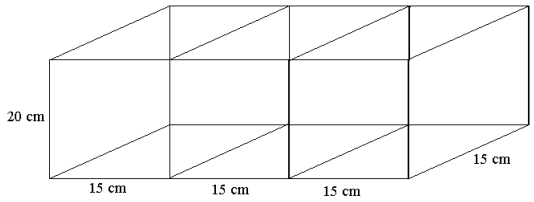

Figure 2. Diagram of an insectarium used to study the effect of ambient temperature on reproductive performance of the red-headed cricket (*Gryllus assimilis*)

In the room where the experiment was carried out, a constant temperature of 20°C and a relative humidity of 65 ± 5% were maintained. The temperature in the insectarium compartments was kept constant, successively: 20°C (control compartment), 25°C and 29°C. Appropriate thermal conditions were obtained by heating the walls of the insectarium with a heating cable equipped with an RT-2 thermostat (Figure 3). The temperature was additionally controlled by means of electronic thermometers installed in the insectariums. The control compartment was not heated. The insectaria are protected with a fine mesh with a lid. This solution also ensured adequate air exchange inside the insectaria.

In the first stage of the experiment, each of the compartments was equipped with a drinker, an egg tray piece, a peat container and a container with food, which were dried daphnia and oatmeal (Figure 4). The insectaria prepared in this way were colonized by one pair of insects. In total, 9 females and 9 males (three pairs per group) were used in one cycle of the experiment, and each cycle was repeated 9 times.

Figure 3. Arrangement of the heating cable on the wall of the insectarium (phot. N. Hermansa)

In the second stage of the insectarium experiment, only the peat containers (Figure 5) were left, and 15 eggs obtained in the first stage of the experiment were placed in each of them. The eggs were placed in the same compartments and under the same thermal conditions in which they were laid. A total of 135 eggs (45 per group) were used in one cycle of four repetitions of the experiment. The food for the hatched juvenile forms was placed directly on the base of the glass container.

Analysis of the number of eggs laid and larvae hatching

72 hours after placing the adults in the insectaria, the crickets were transferred to a separate container. Their eggs were counted while being moved into fresh peat with tweezers. Some of the eggs (15 pcs/container) were separated from the rest and placed – also in fresh peat – in the insectariums again. Then, the hatching date of the first larvae in subsequent containers was monitored every 24 hours.

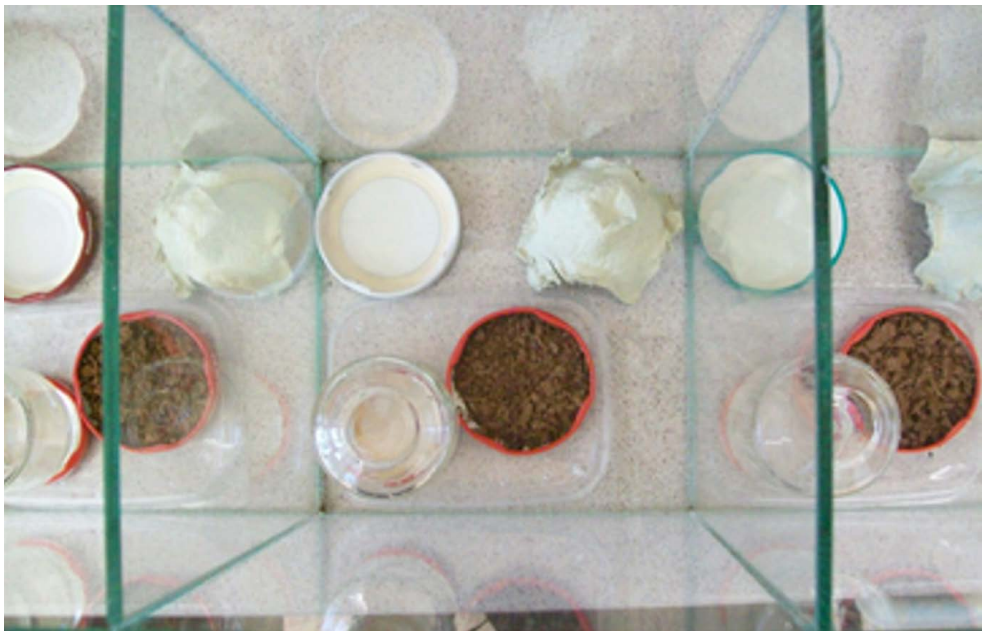

Figure 4. Insectarium the 1st stage of the experiment (phot. N. Hermansa)

Figure 5. Insectarium in the 2nd stage of the experiment (phot. N. Hermansa)

Statistical analysis

The effect of the ambient temperature and the container compartment on the number of eggs laid and the time needed for hatching red-headed crickets larvae were investigated using the two-factor analysis of variance. The differences between the groups were determined by the Tukey test. The relationship between temperature and the number of eggs laid as well as the time needed to hatch the larvae was described by regression equations. All statistical analyzes were performed using the SigmaStat 3.5 software (Systat Software, Inc, USA).

Results and discussion

It was observed that the number of eggs laid by female crickets was influenced by the temperature in the insectarium ($p \leq 0.05$), and not the interval in which the insects were placed ($p > 0.05$). At 20°C, the female cricket laid (mean ± SD) 25.8 ± 13.75 eggs, while at 25°C and 29°C more than twice as many ($p \leq 0.05$) (Figure 6). Thus, a trong relationship was found between the temperature and the number of eggs laid, which can be described by the regression equation: $y = -471.05 + 39.88x - 0.7516x^2$, for $R^2 = 0.271$ ($P \leq 0.05$), where: y – the number of eggs laid, x – temperature in the insectarium (Figure 7).

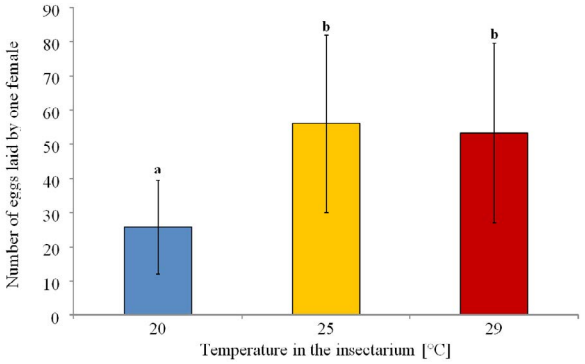

Figure 6. The number of eggs laid by one female red-headed cricket (*Gryllus assimilis*) in different temperature maintained in the insectarium

where: *a*, *b* – values marked with various letters differ statistically significantly ($p \leq 0.05$)

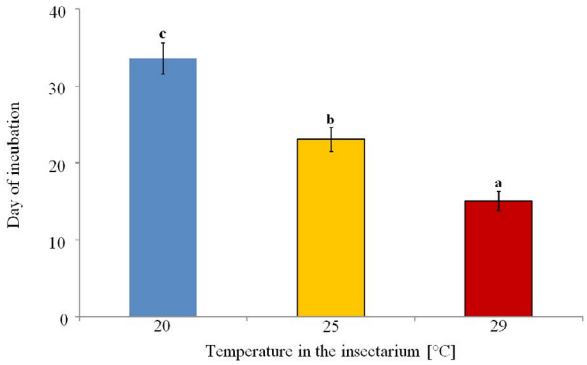

Figure 8. Hatching period [day] of red-headed cricket larvae depending on temperature in the insectarium

where: *a*, *b*, *c* – values marked with various letters differ statistically significantly ($p \leq 0.05$)

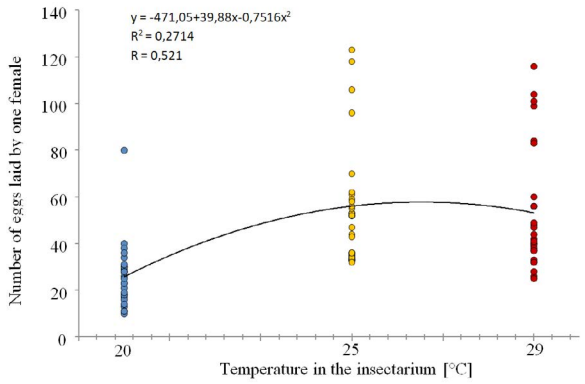

Figure 7. Relationship between temperature (*x*) and the number of eggs laid by female red-headed cricket (*y*)

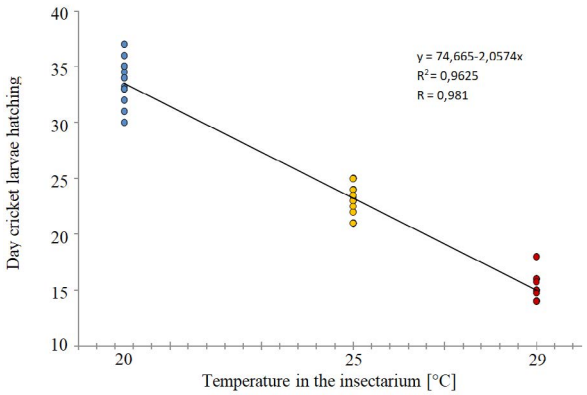

Figure 9. Relationship between temperature in the insectariums (*x*) and Hatching period [day] of red-headed cricket larvae (*y*)

The pace of embryonic development of crickets was influenced by the temperature in the insectarium ($p \leq 0.05$), but not by the compartment in which the containers with eggs were placed ($p > 0.05$). It was found that at 20°C the larvae hatch after 33.6 ± 2.02 days, while at 25°C and 29°C by 10.5 and 18.5 days earlier, respectively ($p \leq 0.05$) (Figure 8). This relationship can be described by the regression equation: $y = 74.655 - 2.0574x$, for $R^2 = 0.963$ ($P \leq 0.05$), where: *y* – duration of embryonic development in days, *x* – temperature in the insectarium (Figure 9).

The results of the conducted experiments prove that the reproduction of red-headed crickets (*Gryllus assimilis*) depends on the temperature of the environment in which they stay. This is confirmed by the observations of Lewczuk [16], who found that the number of eggs laid by the female domestic cricket (*Acheta domesticus*) varies depending on the temperature from about 9 eggs/female at 15°C to 130 eggs/female at 30°C. Adamo and Lovett [17] obtained a similar result with respect to other insect from the Orthoptera family. This fact is explained by the greater activity of enzymes

and accelerated metabolism of insects at elevated temperatures, which is also reflected in reproduction. The greater number of eggs that are laid may be associated with more intensive food intake by insects. It is very likely since crickets, being invertebrates, belong to the group of cold-blooded (ectothermic) animals, therefore their body temperature depends closely on the ambient temperature and external heat sources, which has a strong influence on the vital activity [18] and metabolic processes in their organisms [19]. This is confirmed by an increase in motor activity, jumping ability and speed of domestic crickets, which becomes evident with increasing ambient temperature [18,20–22]. By contrast, Hedrick et al. [22] and Beckers [23] note the different length and frequency of mating songs in Gryllus males depending on the thermal conditions. The intensification of exhortations and increased activity observed with increasing temperature may result in more frequent copulations, and ultimately more eggs laid [24–26].

During the experiment, it was observed that the increase in temperature in the insectarium also shortened the incubation period of the larvae. The larvae hatched at 29°C nearly 3 weeks earlier than at 20°C. This is consistent with the results obtained by Lewczuk [16], who found that *A. domesticus* larvae hatched at 30°C after 10 days, at 25°C after 18 days, and at 20°C only on the 39th day. However, at the temperature of 15°C, no hatching took place at all. Increased temperature stimulates the rate of embryonic development as well as larvae and pupae in many other species of insects, such as the nun moth (*Lymantria monacha* L.) and the gypsy moth (*Lymantria dispar* L.).

Varying rates of larval development depending on thermal conditions have also been reported in domestic crickets (A. domesticus) [27–28]. Those insects kept at $T = 28$°C reached maturity after 49 days after the egg was laid, but when the temperature was lowered by 3°C, it occurred only after 119 days. This suggests that due to the heat supplied from the outside, a cricket's body grows faster both in the egg and after leaving it. This observation seems to indicate the need for research that will determine the optimal temperature for the growth of crickets kept as feed insects.

Summing up, the temperature of the insectarium has a significant influence on the reproduction of red-headed crickets (*Gryllus assimilis*). The reason for this phenomenon is probably a change in their metabolic rate and/or increased food intake by female crickets. However, this hypothesis requires verification in further research. The observations made by the author during the experiments, also those that were not the subject of the described research, signal new interesting research problems, such as: determining the optimal 'thermal program' for the ontogenetic development of crickets to obtain 'feed insects' as well as examining the influence of air humidity and bedding in the insectarium for the results of reproduction of these insects.

Conclusions

The thermal conditions of the environment influence the number of eggs laid by the female *Gryllus assimilis*. Female crickets kept at 25°C and 29°C laid more than twice as many eggs as at 20°C.

Ambient temperature influences the length of the embryonic period in red-headed crickets. It is estimated that in the temperature range of 20–29°C, increasing the temperature by 1°C shortens the time needed to hatch the larvae from eggs by about 2 days.

In order to obtain the highest number of eggs and to shorten the embryonic period, blackhead crickets should be kept at 29°C.

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