J. Inst. Agric. Anim. Sci. 13:95-98 (1992)

Research Notes

A SIMPLE METHOD OF HEAT SUPPLEMENTATION FOR CRICKET MASS-REARING IN THE ABSENCE OF CONTROLLED-TEMPERATURE EQUIPMENT IN DEVELOPING COUNTRIES

M. N. Parajulee and G. R. DeFoliart

Department of Entomology, University of Wisconsin-Madison, Madison, WI 53706, USA

ABSTRACT

While designing a mass-rearing system for the house cricket, *Acheta domesticus* (L.), the possibility of rearing without the use of expensive controlled-environment equipment was assessed. Possible applications include the low-cost maintenance of *A. domesticus* for school biology programmes in the United States, or for mass-rearing for food or feed in developing countries. Cricket development is greatly slowed when ambient temperature falls below 30°C. It was found that temperatures can be kept from falling below 30°C by use of a 100 watt incandescent light bulbs suspended above rearing units. Thus, either in the United States or, especially, in tropical developing countries, where electricity is available, temperatures can be maintained to permit rapid cricket development at low cost.

Key words: *Acheta domesticus*, mass-rearing, poultry feed, protein supplement

INTRODUCTION

The house cricket, *Acheta domesticus* (L.) (Orthoptera: Gryllidae), is a cosmopolitan, omnivorous insect that is easily reared under confined conditions (Patton, 1978; DeFoliart 1989). In the United States and Canada *A. domesticus* is widely used as fish bait and for maintaining insectivorous vertebrates in captivity. Finke et al. (1989) found that the house cricket has high protein quality and is slightly superior to soy protein at all levels of feeding when fed to weaning rats. Nakagaki et al. (1987) found that dried house crickets were a good source of high quality protein for broiler chicks. The cricket is recommended by Taylor and Carter (1976) as an ingredient in 24 different gourmet recipes. Nakagaki and DeFoliart (1991) found the cricket to be very competitive compared with other livestock on the basis of food conversion efficiency. Because of its palatability, protein quality and high food conversion efficiency, the cricket appears to be a promising candidate for wider promotion as food and animal feed.

The use of insects as food and feed is of growing interest in developing countries where there is frequently protein deficiency in both the human and domestic animal populations. The economy of developing countries is based mainly on agriculture, which, however, is often at a subsistence level for many people. People of developing countries generally adopt a polycultural system in which they maintain some crop farming, a few livestock, fruit trees and vegetables. They generally raise some type of poultry in their polycultural complex, usually chickens and ducks. Chickens are common throughout a range of home farms, including both landed farmers and landless tenants. Due to the intensive agriculture and multiple cropping system in developing countries there is hardly any free range in which chickens can hunt insects.

A. domesticus has potential for use in developing countries in tropical and sub-tropical zones because of its rapid development at temperatures of 30°C and above. Nakagaki and DeFoliart (1991) found means of 9 days for egg incubation, 27 days post-egg hatch to appearance of the first adult, and 36 days for half of the cohort to reach the adult stage at 34±2°C. In the inner Terai region of Nepal and in most developing countries, summers are hot and daily mean temperatures remain above 30°C most of the time, with daily minimums dipping only a few degrees below 30°C at night (Parajulee et al., 1989). Crickets should develop rapidly in such regions, with up to seven or eight generations per year at ambient temperatures, and would require minimum heat supplementation.

During December through March, the four coldest winter months in Nepal, minimum daily temperatures range well below 30°C. Below 30°C, cricket development becomes much slower with generation time doubling or tripling as minimum mean temperatures decrease toward 20°C or lower. Thus, even in the tropics, cricket production would be greatly reduced at ambient temperatures during the winter season.

We reared crickets at ambient (room) temperature (22.5±0.5°C) at the Food Insects Research and Development Laboratory, Madison, Wisconsin, USA to determine the approximate time periods required for cricket development at cooler temperatures. We then tested the efficacy of using a 100 watt incandescent light bulbs as a low-cost method of holding the temperature at 30°C or more in cricket rearing units in locales where electricity is available. A purpose in conducting this work was to provide a simple method for rearing *A. domesticus* as a laboratory animal in biology instruction at the elementary, middle school, high school and college levels. Many of these schools rarely have access to high-temperature controlled environment equipment. Thus, the use of incandescent light bulbs could provide a readily available, low-cost method of maintaining cricket cultures at temperatures permitting rapid development.

MATERIALS AND METHODS

Growth at ambient temperature. Over 100 pairs of newly emerged adult crickets were confined in a terrarium of 50 cm x 30 cm x 26 cm at 22.5±0.5°C. The terrarium was covered with a perforated aluminium lid to prevent adult crickets from escaping the terrarium and to allow entry of fresh air. The crickets were fed the Animal Nutrition Research Council Reference Chick diet (NRC, 1977) for broiler-type chicks, modified by the addition of 0.5% NaCl and 3% fish protein. Feed and water were provided *ad libitum*. The feed was provided in a petri dish at one end of the terrarium. Fresh tap water was supplied to the breeding colony using a standard chick watering device consisting of a 0.9 liter glass jar with a screw-on plastic pan base. A piece of aluminium screening under the water outlet was emptied and washed, and fresh water was supplied every two weeks to prevent crickets from drinking fouled water. Three pieces of cardboard chicken egg-cartons (30 cm x 15cm) were placed in the terrarium to provide resting surface for the crickets.

Fifteen-centimetre diameter petri dishes were used as egg trays and moistened peat moss served as an ovipositional substrate. Individual egg trays were exposed to the crickets for 24 h periods on each of six consecutive days. After the oviposition period the egg trays were covered with a lid and incubated at room temperature. One or two days before hatch was expected, three egg trays were placed individually in three separate terraria (50cm x 30cm x 26cm). Condensed water on the under surface of the lid was removed by paper towels to prevent drowning of newly enclosed nymphs. The eggs began hatching 22 days after oviposition. After the eggs hatched, the lid was removed from the egg tray, and food and water were provided for the newly enclosed nymphs. Young nymphs were watered via cotton dental wicks inserted into a vial containing water and laid on its side on the terrarium floor. One or two folded paper towels were provided in each terrarium to increase surface area and hiding places for molting. Finely pulverized feed was sprinkled over paper towels. Three egg trays were terminated after determining the incubation period. When most nymphs reached 4th instar, they were watered using a chick watering device consisting of a 0.9 liter glass jar with a screw-on plastic pan base. The water jars were emptied and cleaned, and fresh water was supplied each week. Under ambient temperature, water does not become fouled for at least a week. Three pieces of cardboard chicken egg-cartons (size: 30cm x 15cm) were placed in each terrarium to provide resting surface for the growing crickets. Feed and water were provided *ad libitum*. Terraria were cleaned as needed (generally twice a month). Periodical observations were made to record the adult emergence date.

Growth at temperatures generated by an incandescent lightbulb. This experiment was conducted under the same conditions and procedures as described above, except that a gooseneck desk lamp with a 100 watt light-bulb was used as a heat source. Temperatures in the terraria were recorded for various combinations of distance and location of the heat source when it was located both above and below the terraria.

RESULTS AND DISCUSSION

Table 1 shows the duration of cricket development at different rearing temperatures. Under ambient temperatures, egg incubation lasted 23 days. This is much shorter than found by Stone (1953) vide Clifford et al. (1977) who reported an incubation period of 30 days at 27°C. Other authors have also reported very long incubation periods at room temperatures. Kemper (1937) vide Clifford et al.(1977) reported an incubation period of 56-84 days at room temperature (temperature unspecified) and Busvine (1955) observed an incubation period of 46-51 days at 23°C. McFarlane (1985) claimed that the house cricket will not reproduce at ambient temperature (20°C). We are at a loss for explanations as to why the incubation periods we observed were so much shorter than those observed by the above authors. The range of incubation period in our experiment was 22-24 days (N=6). The first adult appeared 15 weeks after eggs hatched, and approximately 50% of nymphs molted to the adult stage within 18 weeks.

Table 1. Duration of developmental stages (in days ± SD) of the house cricket, *Acheta domesticus*, at different rearing temperatures.

Rearing temperature (Mean ± SD)	Egg eclosion	Nymphal stage to:	
		First adult emergence	50% adult emergence
Ambient (22.5±0.5°C)	23.17±0.75 (N=6)	106.33±1.53 (N=3)	125±1.41 (N=3)
Light bulb (32.0±1.0°C)	13.00±0.00 (N=2)	38.0±1.80 (N=2)	45.0±3.10 (N=2)
Growth chamber (34.0±2°C)	8.90±0.31 (N=10)	26.8±1.40* (N=5)	36.0±3.04* (N=5)

* Nakagaki (1990)

The 100 W light-bulb proved to be a very good and cheap source of heat for maintaining temperatures of 27°C or higher in rearing units. Temperatures could be raised to 37°C, which is above the 32-35°C that promotes the fastest cricket growth.

When the light-bulb was placed immediately below the bottom of the terrarium, it raised the temperature of the bottom surface to 37°C, but the heat was localized within less than the lower 1/3rd of the terrarium, and the bottom surface was too hot to be tolerated by the crickets. When the terrarium was raised a few centimeters further above the heat source there was insufficient heat inside the terrarium. When the light-bulb faced downward from above the terrarium, 25 cm from the upper surface of the pile of egg cartons in the terrarium, the temperature on the floor of the terrarium directly below the light-bulb measured approximately 35°C. The heat was not uniform throughout the rearing unit, however, temperatures registering successively cooler toward the periphery and under layers of egg cartoons.

It was obvious that although the life cycle is shortened at higher temperatures, crickets do not prefer a temperature of 35°C or higher. When the temperature was 35°C at the center of the terrarium, crickets moved always from the center and localized in the periphery. If the light-bulb was readjusted and the temperature dropped to 28°C, they began to clump at the center just below the bulb. After repeated adjustments and observations, we concluded that 30-31$\pm$1°C is a temperature range that crickets most favour when given a choice. It is also a temperature range that permits reasonably rapid growth. We recommend that 30-32°C as an effective temperature range that can be achieved at low cost by those maintaining cricket cultures either for food production or for school biology programs. The heat sourc: should be operated only as necessary to keep the rearing cage temperature from falling below 30°C. In th. United States, continuous operation would be necessary in most situations. In the tropics and subtropics, however, heat supplementation would be necessary only for a few hours during the night during the warm season.

ACKNOWLEDGEMENT

This research project was supported in part by the Research Division, College of Agriculture and Life Sciences, University of Wisconsin, Madison, Wisconsin, USA. The authors thank Dr. T. W. Phillips, Research Scientist, USDA ARS (United States Department of Agriculture, Agricultural Research Service), Madison, Wisconsin, USA, for reviewing the manuscript.

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