



E-ISSN: 2320-7078

P-ISSN: 2349-6800

JEZS 2019; 7(4): 1396-1399

© 2019 JEZS

Received: 09-05-2019

Accepted: 13-06-2019

Nirmali Borah

Department of Entomology,
Biswanath College of
Agriculture, Biswanath Chariali,
Sonitpur, Assam, India

LK Hazarika

Retired Professor and Head,
Department of Entomology,
Assam Agricultural University,
Jorhat, Assam, India

Water requirement and effect of deprivation on ootheca formation by *Periplaneta americana* (*Blattodea: Blattellidae*)

Nirmali Borah and LK Hazarika

Abstract

Quantification of daily water requirement by adults *Periplaneta americana* (L.) (*Blattodea: Blattellidae*) revealed that a male and female individual imbibed 62.66 ± 7.18 ml and 70.63 ± 9.44 ml water daily, respectively; intake capacity, however, increased with increase in starvation period. Ootheca formation, egg load and hatching are directly related to water intake, its deprivation adversely affected reproductive parameters including egg load, hatching and period between first and second ootheca formation beyond 48 hours of water deprivation.

Keywords: American cockroach, hatching, peridomestic cockroaches, starvation, deprivation

Introduction

Cockroaches (*Blattodea*) are among the oldest insects [3] being originated 320 million years ago with a current strength of 4,600 species under 460 genera worldwide, of which some are indoor pests associated with causing severe health problems. Amongst those important public health pests, the American cockroach, *Periplaneta americana* (L.) (*Blattodea: Blattellidae*) contaminates human food with bacteria (Including the species of *Salmonella* and *Shigella*) that cause food poisoning. *P. americana* is the largest of the common peridomestic cockroaches measuring on an average 4 cm in length and in abundance it is second to the German cockroach, *Blattella germanica* (L.) (*Blattodea: Blattellidae*) [1].

Food availability is closely associated with reproduction in many species of cockroaches. For example, feeding is necessary for oocyte formation in *Leucophaea maderae* [12] and serves as a stimulus for oothecal production in *B. germanica* and *P. americana* [5]. The latter two species differ in the way the females utilize their food for reproduction [2, 12, 13]. Without a regular food supply, German cockroach females produce fewer and smaller oothecae [7] and reproduction is delayed, while American cockroach females may produce several oothecae without refeeding [5]. Mating is also inhibited in starved *Blattella* females [9]. In addition, food and water consumption are cyclic in these females depending on their reproductive state [2]. The availability of water during reproduction appears to be extremely important since females must supply the developing oocytes and embryos with water [10]. Cochran [2] has reported the basic water consumption patterns of reproducing females and found the highest rates of consumption to occur during the oocyte maturation period. Although obviously crucial for survival, the importance of water for reproduction in *P. americana* has not been well studied, as such this study was undertaken to quantify daily water requirement as well as how water deprivation could affect reproduction.

Materials and Methods

The experiment was conducted during 2013-2017 in the Physiology laboratory of Department of Entomology, Assam Agricultural University, Jorhat.

Mass rearing of *P. americana*

A colony of the American cockroach, *P. americana* (Dictyoptera: Blattellidae), was maintained in the laboratory. The colonies were maintained in wooden cages (90 × 60 cm) containing glass bell jars (Borosil; 32 cm long and 22 cm diameter). The bell jars were covered with muslin cloth to prevent cockroaches from getting out and other animals from getting in, and provided with wooden plates (13.5 cm × 10.5 cm) as dividers,

Correspondence**Nirmali Borah**

Department of Entomology,
Biswanath College of
Agriculture, Biswanath Chariali,
Sonitpur, Assam, India

which served as shelter and gave the cockroaches a place to hide and breed. The top of the bell jar was coated with a layer of Vaseline to prevent the cockroaches from crawling to the top of bell jars. Breeding boxes were kept clean with attention to sweep or scoop the bottom of the enclosure from their waste and frass as required usually at 2-3 days interval. The cockroaches were supplied with crushed dog biscuits (Pedigree), and moist sponges as water source were provided separately in petriplates (9 cm diameter) inside the bell jars. The food was placed in the corners directly on the container floor. Nymphs were separated and were reared inside plastic containers (8 cm length and 8.5 cm diameter) by providing food and water as above. The mixture of breeding diet provided a high proteinous food at all times. Care was taken to keep the diet dry to prevent growth of mould, bacteria, mites and beetles.

Daily water requirement by an adult cockroach

There is no definite protocol to measure the daily water requirement by an adult cockroach. Therefore, the following method was developed to measure the daily water requirement by an adult cockroach.

At first step, we took the weight of two moist sponges, one of which was used to measure the loss of water due to evaporation during the period (W_1). Then the moist sponge was again weighed after 24 hours and 48 hours (W_2). The difference in the weight of these two gave us the amount of water loss due to evaporation (X). The second moist sponge was weighed (W_3) and the cockroach was allowed to imbibe water from the pre weighed moist sponge. Then after 24 hours and 48 hours the weight of the second moist sponge was again measured (W_4), respectively. The difference in the weight after 24 hours (48 hours) gave us the total amount of water imbibed by the cockroach and the evaporation loss. From this value we had deducted the amount of water lost due to evaporation and finally we got the amount of water imbibed by the cockroach. This value was then converted to millilitre.

Steps:

Weight of moist sponge used to measure evaporation loss = W_1

Weight of the same moist sponge after 24 hours/ 48 hours = W_2

Weight of moist sponge from which the cockroach imbibed water = W_3

Weight of the same moist sponge after 24 hours/ 48 hours = W_4

Loss of water due to evaporation = $W_1 - W_2 = X$

Now, the amount of water imbibed by the cockroach = $(W_3 - W_4) - X$

Relationship between water deprivation and ootheca formation to understand the relationship between water deprivation and ootheca formation, the adult gravid females were kept separately in container without water from groups of 30 individually housed females on maturation, mating, ootheca formation and hatching of ootheca. The females are kept in a deprivation period of 3, 7 and 15 days, after which water was returned to the deprived females and administered as with the controls.

The dispersion of the mean values on effect of water deprivation on ootheca formation was worked out by calculating SEM [8].

4. Result and Discussion

Amount of water imbibed by adult male and female *P. americana* daily and associated behaviour

The amount of daily water requirement by adult *P. americana* is presented in Table 1. The water requirement by an adult male and female cockroach was determined at 24 hours and 48 hours starvation period. It was observed that the adult

female intake more amount of water daily than that of adult males. We have also recorded a significant increase in the amount of water intake at 48 hours of starvation than that recorded at 24 hours starvation period for both adult male and female *P. americana*. The daily water intake at 48 hours starvation period for both adult male and female *P. americana* recorded were 66.33 ± 8.32 ml and 80.07 ± 9.51 ml, respectively which was found to be significantly higher than those recorded at 24 hours of starvation period (62.66 ± 7.18 ml and 70.63 ± 9.44 ml per day for adult male and female *P. americana*, respectively).

We have also recorded the associated behaviour of adult *P. americana* during feeding and drinking. It was observed that deprived individuals vigorously moved the antennae up and down, and moved to the water source at a faster speed making a directed zig zag pattern. Then they walked to the food and touched it, then, they started to feed and drink. No such studies have so far been conducted in the species, detail documentation of behaviour associated with imbibing is new to the science.

Relationship between ootheca formation and water deprivation

The effects of water deprivation on survival and ootheca formation of adult female *P. americana* were examined and data are presented in Table 2. Females, maintained under constant conditions, were deprived of water following adult maturation, mating and during the ootheca formation. It was observed that water deprivations caused increased mortality, delay in the reproductive cycle and decreased oothecal hatch. The relative importance of water deprivation on ootheca formation is discussed along with possible reproductive strategies for *P. americana*.

Effect of water deprivation on pre mating

The females deprived of water for 3 and 7 days following maturation, 33.33% and 66.67% showed mortality before mating, respectively. It was also observed that those survived after 3 days and 7 days deprivation of water the mating was significantly delayed to 14.13 ± 1.56 days and 16.83 ± 1.10 days, respectively. All the females deprived of water for 15 days after maturation died at the age of 12.8 ± 2.45 days. Previously, Durbin and Cochran [4] found that the females of *B. germanica* held without water for 7 or 12 days after maturation died before mating and mating was found to be slightly delayed in the females deprived of water for 3 days. Mueller [7] reported that survival was reduced more by food deprivation than water deprivation in German cockroach. He also found that deprivation had a greater impact on ootheca formation than on survival. In the present investigation also it was observed that water deprivation not only affect survival but also the formation of ootheca by the deprived female.

Post mating

The post mating period was found to be significantly longer in the deprived females than that of normal females. Females deprived of water for 3 and 7 days after mating formed the first ootheca at 12.13 ± 1.09 and 17.83 ± 0.68 days respectively, whereas, the females held with daily supply of water formed their first ootheca at 8.4 ± 1.40 days. Complete mortality was observed with females deprived of water after mating for 15 days without formation of any ootheca. In this group, the females survived up to 12.80 ± 2.45 days only. Earlier workers Durbin and Cochran [4] also reported complete mortality of *B.*

germanica without formation of any ootheca with a life span up to 3.7 ± 0.8 days only.

Formation of second ootheca

It was observed that the females deprived of water for 3 days formed their second ootheca at 15.33 ± 1.39 days after the formation of first ootheca. The females deprived of water for 7 and 15 days were unable to produce the second ootheca. This may be due to the retraction of the ootheca into the body during starvation period as Roth and Willis [10], earlier reported that the proximal (Attached) end of the ootheca is less sclerotized than other parts of the ootheca and is permeable to water, allowing for female participation in maintaining the water balance of the eggs. Previously, Durbin and Cochran [4] found that the females deprived of water for 3, 7 and 12 days died without formation of the second ootheca. They also reported that one third of the females held without water for 3 days died after their first ootheca hatched without producing second oothecae. However, during the present investigation we have observed that the females deprived of water for 3 days were able to produce their second ootheca. These variations may be due to the variation in the species reared, rearing procedure and timing of deprivation in the experiments.

Effect of water deprivation on hatching of eggs of *P. americana*

The hatching percentage recorded from the ootheca produced by deprived female is presented in Table 3. The hatching percentage recorded in case of females deprived of water for 3 days was significantly lower than the control. In control out of the 14.93 ± 1.89 numbers of eggs 13.96 ± 1.89 numbers of eggs were hatched with a hatching percentage of 93.50 per cent whereas, out of 14.80 ± 2.22 numbers of eggs 12.83 ± 2.42 numbers of eggs were hatched with a hatching percentage of 86.68 per cent in case of the females deprived of water for 3 days. Similar trend of results were also found in case of the second ootheca. In control out of the 15.33 ± 2.13 numbers of eggs 14.33 ± 2.23 numbers of eggs were hatched in the second ootheca with a hatching percentage of 93.66 per cent. The females which were deprived of water for 3 days produced 13.93 ± 1.92 eggs out of which 11.70 ± 1.97 numbers of eggs were hatch with a hatching percentage of 83.99 per cent. The ootheca produced by the female deprived of water for 7 days contained 13.16 ± 1.30 eggs out of which 10.30 ± 1.90 eggs were hatch (78.26%), which was found to be significantly

lower than that of control. None of the females deprived of water for 15 days lived to produce an ootheca. This finding was in conformity with that of Lee and Heng [6], who reported highest mean number nymphs per ootheca in case of the insects provided with both food and water, while the lowest was among the groups that deprived of food and water. Earlier, it was reported that during oothecae formation, female cockroaches were very susceptible to food and water deprivation [2] and if food and water deprivation continued for a longer period of time, less numbers and smaller sizes of oothecae will be produced [7]. This will probably lead to a decrease in total nymphal production.

The relative importance of the effects of food and water deprivation was confirmed by several workers. Females survived much longer without food than they did without water. The lack of food delayed reproduction but did not greatly increase mortality, except after long periods without food. Once food was again available, reproduction resumed and was nearly normal. Oothecal size was reduced for one or two oothecae, but per cent hatch remained high. Contrarily, the lack of water killed quite rapidly. In the present investigation very low impact was recorded from short deprivation period. The results were found to be almost similar to that of control. However, it was observed that the females died before the longest deprivation period ended.

Table 1: Daily water intake (ml) by an adult *P. americana* (Mean \pm SEM) under two conditions

Stage	Conditions: hours of deprivation	
	24	48
Male	62.66 ± 7.18	66.33 ± 8.32
Female	$70.63 \pm 9.44^*$	$80.07 \pm 9.51^*$

Sample size = 30

*Significant at $P_{0.05}$

Table 2: Effect of days of water deprivation on reproductive parameters of *P. americana* (Mean \pm SEM)

Deprivation period (Days)	Premating period (Days)	Post mating period (Days)	Duration between two successive ootheca (Days)
0	11.13 ± 0.65	8.4 ± 1.40	10.96 ± 1.02
3	$14.13 \pm 1.56^*$	$12.13 \pm 1.09^*$	15.33 ± 1.39
7	$16.83 \pm 1.10^*$	$17.83 \pm 0.68^*$	Death
15	Death	Death	Death

Sample size = 30

*Significant at $P_{0.05}$

Table 3: Effect of water deprivation period on hatching of eggs of *P. americana*

Deprivation period (Days)	Ootheca 1			Ootheca 2		
	No. of eggs (Mean \pm SEM)	No. of eggs hatched (Mean \pm SEM)	Hatching %	No. of eggs (Mean \pm SEM)	No. of eggs hatched (Mean \pm SEM)	Hatching %
0	14.93 ± 1.89	13.96 ± 1.89	93.50	15.30 ± 2.13	14.33 ± 2.23	93.66
3	14.80 ± 2.22	$12.83 \pm 2.42^*$	86.68*	$13.93 \pm 1.92^*$	$11.70 \pm 1.97^*$	83.99*
7	$13.16 \pm 1.30^*$	$10.30 \pm 1.90^*$	78.26*	Nil	Nil	Nil

Sample size = 30

*Significant at $P_{0.05}$

Conclusion

From the above investigation it can be concluded that the water availability has a great impact on survival and reproduction of the female *P. americana*. Therefore, the pest can be managed to some extent by elimination of food and water, although complete elimination is not possible.

References

- Bell WJ, Adiyodi KG. The American cockroach. Chapman and Hall, London, 1981.
- Cochran DG. Food and water consumption during the reproductive cycle of female German cockroaches. Entomol. Expt. Appl. 1983; 34:51-57.

3. Cruden DL, Markovetz AJ. Microbial ecology of the cockroach gut. *Annu. Rev. Microbiol.* 1987 41:617-643.
4. Durbin EJ, Cochran DG. Food and water deprivation effects on reproduction in female *Blattella germanica*. *Entomol. Expt. Appl.* 1985; 37(1):77-82.
5. Kunkel JG. Development and the availability of food in the German cockroach, *Blattella germanica* (L.). *J. Insect Physiol.* 1966; 12:227-235.
6. Lee CY, Heng CY. Effects of food and water deprivation on nymphal development, adult fecundity and insecticide susceptibility in German cockroaches, *Blattella germanica* (L.). *Trop. Biomed.* 2000; 17:27-34.
7. Mueller P. The effect of temporary deprivation of food and water on the development of laboratory colonies of the German cockroach, *Blattella germanica* (L.). *Z. Yes. Hyg. Grew.* 1978; 24:122-126.
8. Panse VG, Sukhatme PV. *Statistical Methods for Agricultural Workers.* ICAR, New Delhi. 1985.
9. Roth LM, Stay B. Oocyte development in *Blattella germanica* (L.) and *Blattella vaga* Hebard. *Ann. Ent. Soc. Amer.* 1962; 55:632-644.
10. Roth LM, Willis ER. Water relations of cockroach oothecae. *J. Econ. Entomol.* 1955; 48:33-36.
11. Roth LM, Willis ER. An analysis of oviparity and viviparity in the Blattaria. *Trans. Am. Ent. Soc.* 1958; 83:221-238.
12. Scharrer B. The relationship between corpora allata and reproductive organs in adult *Leucophaea maderae*. *Endocrinol.* 1946; 38:46-55.
13. Weaver RJ, Pratt GE. Effects of starvation and feeding upon corpus allatum activity and oocyte growth in adult *Periplaneta americana*. *J Insect Physiol.* 1981; 27:75-83.