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FOOD PREFERENCE OF THE GERMAN COCKROACH, *BLATTELLA GERMANICA* (L.) (DICTYOPTERA: BLATTELLIDAE)

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ABSTRACT. The German cockroach, *Blattella germanica* (L.), is a common indoor pest in low-income housing. Cockroaches not only spoil food but also transfer pathogens and cause allergic reactions and psychological distress. The 72 h-starved cockroaches were given choices among eight food items: four carbohydrate–rich foods (bread, biscuit, banana, and potato) and four protein-rich foods (minced meat, cooked cheese, white cheese, and luncheon). Modified four-chamber arenas were used for this food preference experiment. Each kind of food was placed in each chamber of the arena with 20 of starving cockroaches placed at the center. This experiment was done three times, one with the four carbohydrate–rich foods, the other with the four protein-rich foods, and the last with the preferred food from carbohydrate and protein. Another food preference experiment was conducted in the different modified four chamber arenas to determine the food consumption as the Rodgers's index. The two arenas were observed after 3 days in the laboratory, the first one to estimate percent of attracted adults to different food items, while the second one to calculate the food consumption by using Rodgers's index. The percentage of adults attracted to carbohydrate foods (biscuit and banana) and protein food (cooked cheese) was significantly higher than (bread and potato) and (luncheon, minced meat and white cheese) at $p \leq 0.05$ in both type of food, respectively. Data showed that banana was high attracted to cockroach and gave significant difference between cooked cheese and luncheon and the lowest attracted was seen in biscuit when adults exposed to carbohydrate and protein food items in the same choice arenas. Data showed significance level of variation in food consumption (mg) by German cockroach adults were analyzed with ANOVA, Tukey's $P \leq 0.05$. Data showed that biscuit was avoided food, whereas banana was preferred food item.

Key words: Food preference; Arena; *Blattella germanica*; Food consumption.

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INTRODUCTION

The German cockroach, *Blattella germanica* (L.) (Dictyoptera: Blattellidae), is a ubiquitous domiciliary pest mainly associated with urban environments. Because it is a domestic pest, it is always associated with indoor environments, such as kitchens, bathrooms, and food storage areas (Shahraki *et al.*, 2013; Mahmoud *et al.,* 2013). *B. germanica* not only spoil food but also transfer pathogens and cause allergic reactions and psychological distress (Brenner *et al.,* 2003). It enters residences, aggregate near human foods, and generally give displeasure and an impression of dirtiness. Furthermore, it consume not only food but also feces, blood, pus and the sputum of human and other animals that harbor various medically important pathogens (Ebeling, 1978). When they walk across food and dishes, they may leave and/or regurgitate food containing bacteria that cause typhoid fever, dysentery, and other human diseases (Fotedar *et al.,* 1991; Kim *et al.,* 1995).

For cockroaches and most insects, nutrition affects survivorship of adults and their reproductive outputs. Generally, female fecundity depends on the ingestion of proteins which are necessary for egg development whereas male fertility does not highly depend on proteins. Moreover, insects generally are unable to convert lipids to monosaccharides by themselves and carbohydrates are one nutrient that both sexes use as a primary energy source (Carrel and Tanner, 2002). Nutritional factors reportedly had profound short-term and long-term effects on the development and reproduction of insects (Cooper and Schal, 1992). Even though the nutritional requirements of most insects are relatively similar, the optimal sources, types, and proportions of nutrients widely vary among species and reproductive stages.

Entomologists have been interested to study cockroach food preference because cockroaches are one of the most prevalent household pests. The range of food substances that they utilize is greater than any other insect (Jones and Raubenheimer, 2001). The German cockroach, *B. germanica*, has been used as a model organism for the study of insect neurobiology, digestion and physiology (Jones and Raubenheimer, 2001). However, the documentation of food preference and feeding behavior of the German cockroach has been limited.

The present work aimed to study two types of the most popular food products to the feeding preference of German cockroach, *Blattella germanica*. Of these; carbohydrate-rich foods (bread, biscuit, banana, and potato) and protein-rich foods (minced meat, cooked cheese, white cheese, and luncheon).

MATERIALS AND METHODS

German cockroach rearing

Individuals of German cockroaches, *B. germanica*, were established from fallen leaves under the mango trees in a farm located 10 km away from Ismailia city, Egypt. Also, individuals of German cockroach were collected from infested different kitchens in some apartments. Cockroaches were collected by using different size aspirators, and preserved in 5 litre plastic jar covered by a nylon socks until transferring to laboratory of Entomology, Plant Protection Department, Suez Canal University. Adults were maintained in the laboratory under an approximately photoperiod (14 h dark: 10 h light) at 30 °C and 60-65% relative humidity (*Figs. 1, 2 and 3*).

Wooden cages (30×30×30 cm) were used as containers for rearing; each side of them was covered by wire tight holes, and one side had a small sleeve as one entrance to provide adult diet (biscuit, bread, banana and cheese) and a wet piece of cotton in small cup to drink water. The cages were put in the preparation chamber.

Figure 1 - German cockroach collection under mango trees

Figure 2 - German cockroach collection by aspirators

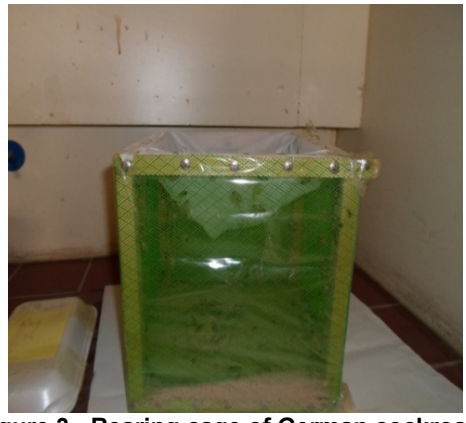

Figure 3 - Rearing cage of German cockroach

Food preference experiments

Food preference arena (No. 1) to estimate the percentage of adult attracted to different food items

The choice arenas were assembled by connecting four chambers with tubing (2 cm diameter, 15 cm length). Chambers and tubing were washed in tap water. The washing of arena materials was done to eliminate static electricity and to remove any impurities. One clean round plastic jar covered with nylon (20 cm diameter) served as a housing chamber. And the four plates (10 × 20 cm) served as a food chamber, contained the sticky cheat and one item of foods. Each kind of food was placed in the center of each chamber of the treatment choice arenas. Foods consisted of (four carbohydrate - rich foods: bread, sugar, banana, and potato; and four protein-rich foods: minced meat, cooked cheese, white cheese, and luncheon (*Fig. 4*). German cockroaches were starved for 3 days before conducting the test. After that 20 of *B. germanica* were placed at the center inside the treatment choice arenas. The German cockroaches were checked after 3 days and the experiment was replicated 4 times (each replication used a new group of cockroaches).

Food preference arena (No. 2) to estimate the food consumption by using Rodgers's index

The component of second arenas consisted of one clean round plastic jar covered with nylon (12 cm diameter) served as a housing chamber. This arena was connected to plastic cups by four plastic tubes (2 cm diameter, 15 cm length). And the four plastic cups (10 cm diameter) served as a food chamber and were covered with tracing plastic sheet. Each kind of food (2 g) was placed randomly in each chamber of the arena on a small piece of paper (0.14 g). Food items consisted of two carbohydrate rich foods: (biscuit and banana) and two protein rich foods: (cooked cheese and luncheon). German cockroaches were starved for 3 days before conducting the test. After that 20 of them were placed at the center inside the treatment choice arenas. They were checked after 3 days and the experiment was replicated 4 times. To avoid the error from loosing water from food items in the experiment, we were put the same weight of food items out experiment.

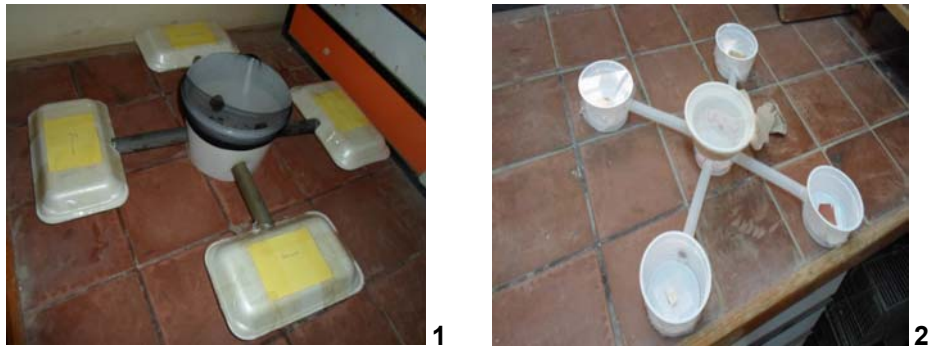

Figure 4 - Choice arenas of food preference experiment (No. 1 and 2)

Statistical analysis

Data obtained from the present study was subjected to an analysis of variance (ANOVA) with the honestly significant difference value calculated as Tukey's statistic at $P \leq 0.05$ (SAS Institute, 2002).

The amount of food eaten (in the second test of food preference) was recorded and calculated to proportion eaten (in this experiment, the proportion eaten = X/ 0.2 g). In addition, the Rodgers's index for inferring the food preference was used as following [The Rodgers's index (Ri) (Krebs, 1999)]:

$$Ri = Ai / max\ (Ai)$$

where: Ri = Rodgers's index of preference for food item i; Ai = Area under the cumulative proportion eaten curve for food item i; max Ai = the largest value of the Ai.

Rodgers's index range from (0-1); 0= avoid and 1 = prefer.

RESULTS

The results showed that German cockroach adults were attracted to biscuit and banana following by bread and potato, respectively (*Fig. 5*). In addition, results showed that cooked cheese as protein food item was higher attracted to cockroach than luncheon, minced meat and white cheese (*Fig. 6*). The percentage of adults attracted to carbohydrate foods (biscuit and banana) and protein food (cooked cheese) was significantly higher than (bread and potato) and (luncheon, minced meat and white cheese) at $P \leq 0.05$ (*Fig. 7*).

On the other hand, banana was high attracted to cockroach and gave significant difference between cooked cheese and luncheon and the lowest attracted was seen in biscuit when adults exposed to carbohydrate and protein food items in the same choice arenas.

Data showed significance level of variation in food consumption (g) by German cockroach adults were analyzed with ANOVA, Tukey's $P \leq 0.05$. In order to evaluation of preference in German cockroach adults, the food preference scale calculated according to the Rodgers's index (Ri) (Krebs, 1999). Data showed that biscuit was avoiding food, whereas banana was preferred food item (*Figs. 8 and 9*).

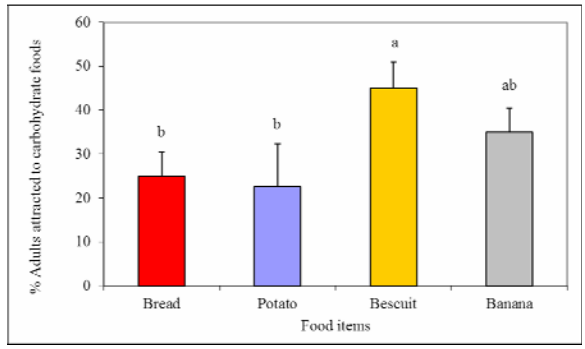

Figure 5 - Percentage of attracted adults of German cockroach to different carbohydrate food items. Bars followed by different letters represent difference (Tukey' HSD; P≤0.05).

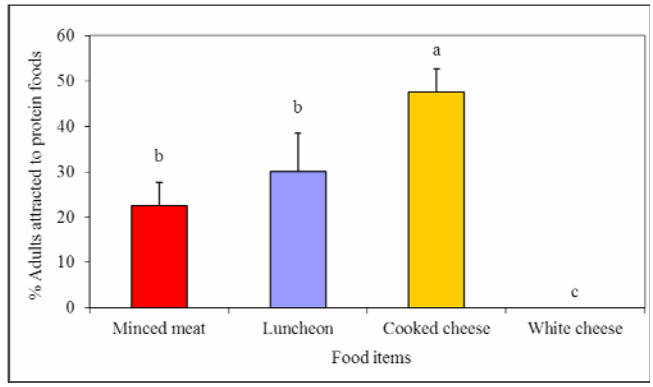

Figure 6 - Percentage of attracted adults of German cockroach to different protein food items. Bars followed by different letters represent difference (Tukey' HSD; P≤0.05).

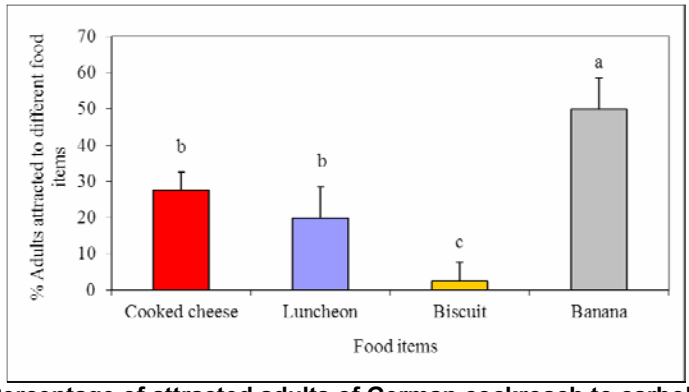

Figure 7 - Percentage of attracted adults of German cockroach to carbohydrate and protein food items in the same choice arenas. Bars followed by different letters represent difference (Tukey' HSD; P≤0.05).

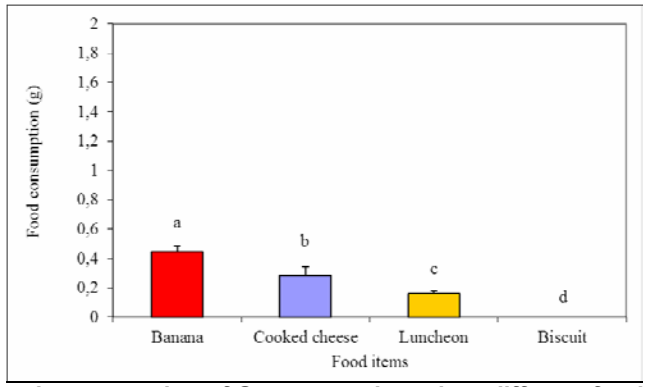

Figure 8 - Food consumption of German cockroach to different food items. Bars followed by different letters represent difference (Tukey' HSD; P≤0.05).

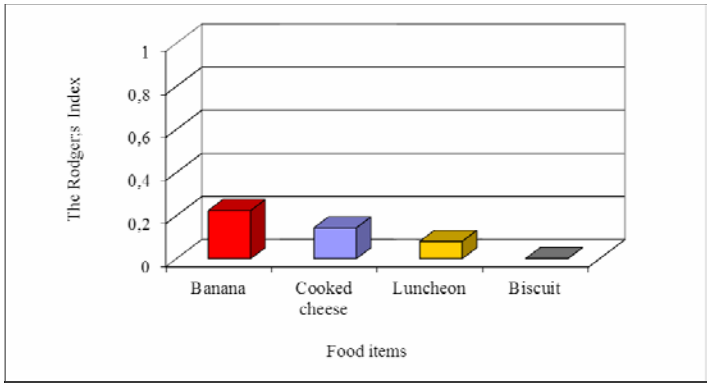

Figure 9 - Feeding preference of German cockroach to different food items. The Rodgers's index from 0 = avoid to 1 = prefer.

DISCUSSION

For nutritional requirements, it is well known that the German cockroaches prefer diets which are higher in carbohydrate than in fat and protein content Lauprasert *et al*., (2006). Moreover, under conditions of complete inanition, the cockroaches will eat nearly any food substance that they encounter, unless deprived for a set period of time (Reierson, 1995). Their behavior corresponded with other insects which did not respond to monotonous odors as vigorously as when they were very hungry (Reierson, 1995). Our results showed that German cockroach significantly preferred biscuit and banana when it tested in arenas with four carbohydrate - rich foods, whereas the cockroaches significantly preferred only cooked cheese when they tested in arenas with four protein - rich foods. Data showed that banana food was the highest food item for attraction adult of German cockroaches when they exposed to four different food items include banana, biscuit, luncheon and cooked cheese. We believe that the cockroaches preferred banana due to their richness in carbohydrate. The carbohydrate content could serve them as a primary energy source (Carrel and Tanner, 2002). Most of the German cockroaches preferred banana more than any other food, only small numbers preferred cat food. Besides the nutritional factors, the odors and textures of foods are also important. Cockroaches often respond to food odors over short distances (Reierson, 1995). In our experiment, the odor of banana was stronger than the others. Moreover, the banana texture was soft and mushy. Thus, the banana attracted the ravenous cockroaches. In contrast, the texture of bread was very rigid, and the cockroaches might be aroused and attracted by soft and freshly foods which are easy to eat under stress condition such as starvation

cockroaches and other animals are able to self-select a suitable diet given a variety of nutrient choices.

CONCLUSION

Carbohydrate-rich foods with strong odor such as banana and protein-rich foods such as cooked cheese are probably good baits for trapping the German cockroach in such as kitchens, bathrooms, and food storage areas. Ultimately, cockroach trapping with non-chemical baits could be used for domestic pest control.

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