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**Effect of Different Diets on Biological Parameters of German Cockroach
Blattella germanica L.**

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Abstract: The experiment on effect of different diets on various biological parameters conducted at Karachi Sindh, Pakistan revealed that the German cockroach, *B. germanica* was reared at constant temperature of $31\pm 2^{\circ}\text{C}$ under laboratory conditions with supply of three diets and water. The different diets i.e., poultry feed, sugar+wheat flour and rusk affected different biological parameters of *B. germanica* such as, mean incubation period, hatching percent of eggs, nymphal developmental period and adult longevity. *B. germanica* fed on poultry diet showed maximum hatching (94.65%) followed by sugar+wheat flour (88.54%) and rusk diet (87.04%). Similarly, maximum male and female longevity was recorded on poultry diet (144.4 to 153 days) followed by sugar+wheat flour (122 to 126.6 days) and rusk diet (118.6 to 126.4 days). Whereas, the minimum mean incubation period was recorded on poultry diet (14.62 days) followed by sugar+wheat flour (16.19 days) and rusk diet (17.52 days). The minimum mean nymphal development period was recorded on poultry diet (38.38 days) followed by sugar+wheat flour (39.18 days) and rusk fed cockroaches (43.28 days).

Key words: German cockroach, biology, diets, ootheca gravid females

INTRODUCTION

The German cockroach is the most destructive house-hold insect pest through out the world. It has been recorded since 1893 (Hutchensun, 2002). It is widely distributed in the world (Robert and Pfadt, 1985; Atwal, 1976; Tanaka, 1981; Lee and Lee, 1995; Tandon *et al.*, 1990; Wileyto and Boush, 1983). There are about 3500 species of cockroaches (Imms, 1973). *B. germanica* occurs predominantly in tropical, sub tropical and in temperate regions. In North America, 70 species are known. Several species of cockroaches came from the sub tropical zones into temperate regions and have been serious pests in homes and commercial establishments on ships (Matheson, 1950). Cockroaches are very primitive insects. Their ancestors lived 200-350 million years ago in the Carboniferous, even before the dinosaurs. This geological period is some time called the Age of Cockroaches because they were so abundant. At this time, the climate on the earth was warm and moist providing ideal conditions for them to thrive. Although climatic conditions are cooler and less humid now, present-day cockroach species are surprisingly similar to those preserved in fossils from the distant past (Ogg *et al.*, 1995). *B. germanica* lives in dwellings belonging to all ethnic groups and all economic classes of people. The presence of cockroach species in homes undoubtedly causes more distress to home and apartment dwellers than any other insect pest. Part of distress is because many people dislike any bug. In the home in addition, there is a common perception that cockroaches live in the homes that are dirty and not well kept, so there is also a negative stigma attached to them. Many people are embarrassed to admit that they share their living quarters with cockroaches. The cockroach is foul smelling insect with a repulsive appearance and filthy habits. It is regarded as a serious

common house hold pest, because it destroys food, clothes, books and many other house hold objects (Ogg *et al.*, 1995). It also fouls the materials over which it runs with its excreta and faeces. It has been found to carry the germs of dangerous tropical diseases such as, plague, leprosy, dysentery, typhoid fever, cholera and tuberculosis on its body as well as in its alimentary canal (Ramaligan *et al.*, 1979). Cockroaches also carry pathogenic organisms, disease causing bacteria and fungi that can be passed on to human through contact with contaminated food (Fotedar *et al.*, 1989). Salmonella in food is the most common life threatening pathogen that cockroaches transmit to human (Abdel and Mazen, 1995; Brenner, 1992; Calls *et al.*, 1992; Hulett and Dockhorn, 1979; Boushy and Fahy, 1995). The role of cockroaches in causing the allergy to humans through house dust in Calcutta, India was found in prick skin test of 200 patients with a history of sensitive to dust and 35% patients had allergy due to cockroaches (Tandon *et al.*, 1990). Whereas, Geller (1990) reported from Brazil by testing 410 patients with asthma and rhinitis due to cockroaches.

The German cockroach is about 12 to 15 mm long and is tan or light brown in color. Adults have four wings and two dark longitudinal stripes on pronotum behind the head and in front of the wings. Immature stages (nymphs) are wingless and have two wide dark longitudinal stripes running down the entire length of the body. The female *B. germanica* is unique in that she carries the ootheca for nearly the entire incubation period of eggs. She drops the egg case in a protected location within 24 h of the egg hatching. Normally, 30-40 nymphs hatch from each ootheca. *B. germanica* is most common in the kitchens (Mallis, 1990). They prefer to hide under or around sinks, appliances, cupboards and baseboards. Populations of this species usually cluster in large numbers inside cracks and crevices near warm areas with high humidity (Olkowski and Olkowski, 1991). These populations build up in terrific numbers and may also be resistant to certain insecticides (Cochran, 1990). Hasgawa *et al.* (1977) found the number of instars required to reach maturity was five for male and five or six for females of *B. germanica* when reared at 25°C with a constant supply of food and water.

Cooper and Schal (1992a) observed the effect of different diets on the growth of *B. germanica* from U.S.A and found that the development of nymphs and oocyte maturation reared on rat food (Purina rat chow No. 5012) was significantly faster than nymphs fed on two commercial dog foods (Purina dog chow, No. 1780 and Purina canine chow, No. 5006). Similarly, oocytes matured more quickly in adult females that were raised on rat food than in females raised on dog foods. Whereas, Aguilera *et al.* (1998) reared two colonies of *B. germanica* in the laboratory at 29±1°C, 70 to 75% R.H. on a diet of either no protein comprising proteins of potatoes, ripe banana and a 10% sugar solution or with a protein content of 20-45% composed of pulverized dry laboratory food for rats and source of water and found that number of nymphs per ootheca laid by females fed on protein diet was greater than those on non protein diet. The results showed that when *B. germanica* was given a diet containing proteins, it's nymphs development was faster and productive capacity increased therefore protein is necessary nutrient for the diet of *B. germanica*. Lee (1994) recorded pregnant females of *B. germanica* were highly inactive which had to carry an ootheca which is > 30% of its body weight. *B. germanica* is a nocturnal insect pest and aggregate in dark places that have high humidity. The ecological conditions of Karachi metropolitan city are humid with mild to severe temperatures where the German cockroaches are a serious problem. Before this no work on this urban pest has been done. This base line study will be useful for the academic and management of German cockroaches.

MATERIALS AND METHODS

The experiments were conducted under laboratory conditions and cockroaches were reared at 31±2°C with 16:8 h light: dark cycle and constant supply of three different diets and water during 2001. In the outset of experiment, six gravid females were collected with the help of automated aspirator. The gravid females of *B. germanica* were supplied rusk (Papa) for their survival and giving

birth to the young ones from their oothecae. After getting their young ones from their parent, rusk fed cockroaches was provided with different diets to observe the effect on the biology of cockroaches. The selected diets were poultry feed, sugar+wheat flour 50% each and rusk (papa) were supplied to five pairs of one-day old nymphs hatched from same ootheca.

The rusk was obtained from Shah Faisal Bakery, Karachi. The ingredients used in preparation of rusk were fine flour (Meda) (80 g), Sugar (20 g), yeast or baking powder (50 g) and cotton oil (4 g). The other diet comprising of sugar (sucrose)+wheat flour (Meda) 50% each were purchased from Green Town local market of Karachi. The broiler poultry feed was obtained from Mehran Broiler Poultry Feed Shop. The broiler feed was prepared from different ingredients i.e.,: canola meal 20%, broken rice 28%, yellow corn grains 24%, cotton seed meal 04%, guar meal 05%, meat meal 05%, blood meal 20%, fish meal 05%, bone meal 2%, molasses 03% and animal fat 02% (Tahira, 2002).

The cockroaches were kept in plastic bottles of size (6"x12") covered with muslin cloth and rubber bands. Twenty five grams of each diet were kept in each bottle with soaked rubber foam. Each soaked rubber foam contained 25 mL of water. The plastic bottles were kept on cup board covered with black cloth on the top of cup board to provide darkness for their activity as they are nocturnal insects. In each plastic bottle, one bowl (6"x6") having water in it was kept to maintain the humidity. The food was supplied twice per week. The cockroaches were transferred to other sterilized plastic bottles at weekly intervals to avoid the fungal or bacterial disease. Water was supplied through soaking rubber foam twice per week. Temperature and humidity were recorded daily at 6.30 pm. The young ones developed from gravid females reared on rusk were given different diets i.e., rusk, sugar+flour 50% and poultry feed, respectively. For each diet (treatment), 5 pairs were kept individually in a separate plastic jar. The rearing methods described preciously by Tanaka (1973), Tanaka and Hasegawa (1979) were followed. The observations on various biological parameters in each treatment such as pre-oviposition period, fecundity, number of eggs hatched into nymphs, hatching percentage, mean incubation period, nymphal mortality %, nymphal development period, male+female ratio, number of generations and adult longevity were recorded. The data were analyzed through Completely Randomized Design (CRD) analysis of variance for the various biological parameters and means were compared through LSD test at 0.05 level.

For determining the effect of different diets on the linear body length of *B. germanica*, 10 specimen of each stage were stored in 70% ethanol until measurements were carried out. The measurements were carried out under a dissecting microscope equipped with a measuring apparatus. The length of each instar/stage of both sexes were measured in (mm) from head to end of abdomen from ventral side. The measurement of nymphal instars and adults and their sexing was done using the method of Ross and Cochran (1960).

RESULTS

The egg laying behavior of *B. germanica* is typical that it develops an ootheca in which the eggs are present. All the time of hatching, it drops the nymphs simultaneously or one by one within short period of time depending upon climatic conditions and the diet of the *B. germanica*. Effect of different diets on various biological parameters of *B. germanica* recorded under laboratory conditions (Table 1) depict that the mean incubation period within ootheca varied in different diets i.e. (17.5 days) in rusk followed by (16.19 and 14.62 days) in sugar+wheat flour and poultry feed, respectively. The mean nymphal development period was recorded higher (43.28 days) in rusk fed cockroaches followed by (39.18 and 38.38 days) in sugar+wheat flour and poultry diets, respectively. The Analysis of variance showed that the means of nymphal development periods in different treatments varied significantly from each other. The mean copulation period of the *B. germanica* fed on rusk was (17.5 days) followed by sugar+wheat flour (17.0 days) and in poultry diet cockroaches was (16.9 days), respectively.

Table 1: Effect of different diets on the biological parameters of *B. germanica* under laboratory conditions at Karachi from April to October, 2001

Biological parameters	Poultry feed	Sugar+wheat flour		f-value	LSD 0.05
		flour	Rusk		
Mean copulation period (minutes)	16.9±0.13	17.00±0.15	17.5±0.15	0.93NS	-
Mean incubation period (days)	14.62±0.11c	16.19±0.12b	17.52±0.10a	32.78**	0.7823
No. of eggs in each ootheca (fecundity)	45.8±0.54a	45.6±0.22a	43±0.31b	5.63*	2.0284
No. of eggs hatched into nymphs (fertility)	43.4±0.68	40.4±0.46	37.4±0.41	6.31*	3.6804
Hatching %	94.65±0.87a	88.54±0.60b	87.04±0.63b	6.35*	4.9301
No. of nymphs dead	5.4±0.22	5.8±0.16	6.00±0.2	0.47NS	-
Mortality in nymphs	12.36±0.39b	14.3±0.25ab	14.19±0.62a	4.36*	2.7104
Nymphal developmental period (days)	38.38±0.12	39.18±0.13	43.28±0.18	58.36**	1.0603
Survival and sex ratio of adults	19±0.32	17.6±0.17	15.4±0.22	0.72NS	-
M	19±0.24	17±0.14	16±0.20	0.62NS	-
F	19±0.24	17±0.14	16±0.20	0.62NS	-
No. of generations	4.6±0.22	3.8±0.16	3.00±0.14	3.84NS	-
Adults	144.4±5.41	122±3.00	118.6±2.48	2.65NS	-
M	144.4±5.41	122±3.00	118.6±2.48	2.65NS	-
F	153.4±3.49a	126.6±2.31b	126.4±2.50b	6.06*	19.437

* Significant at 0.05 level of significance, ** Significant at 0.01 level of significance, NS: Non significant, Mean values with the same letter are not significantly different

Table 2: Effect of different diets on the body length of instars and adult stage of *B. germanica*, under the laboratory conditions

Instar	Body length (mm) on poultry feed		Body length (mm) on Sugar+wheat flour		Body length (mm) on rusk	
	Males	Females	Males	Females	Males	Females
1	2.9-3.2	2.9-3.2	2.8-3.0	2.8-3.0	2.6-2.9	2.6-2.9
2	4.6-4.8	4.6-4.8	4.4-4.6	4.3-4.7	4.1-4.3	4.1-4.7
3	5.5-5.9	5.7-6.1	5.2-5.6	5.5-6.0	5.00-5.4	5.1-6.1
4	6.8-7.8	7.3-8.4	6.6-7.5	7.0-8.2	6.1-7.00	7.2-8.4
5	8.8-9.9	9.8-10.7	8.5-9.6	9.5-10.4	8.0-9.1	8.9-10.7
6	10.9-11.8	12.8-13.9	10.6-11.5	12.5-13.5	10.1-11.1	12.0-12.9
Adult	13-13.4	14.2-15.0	12.8-13.1	13.2-13.8	12.5-12.9	13.0-13.5

*The measurements were recorded on 10 individuals from each stage of both sexes

Similarly, the fecundity in each female showed that mean number of eggs in each ootheca was 45.8 in followed by 45.6 in and 43.0 in showing the effect of different diets on nu copulation period in different treatments was non-significant showing no effect of different diets on copulation period.

Maximum mean number of eggs hatched into nymphs in poultry feed was recorded 43.4 followed by 40.4 and 37.4 in sugar+wheat flour and rusk, respectively. The hatching % was 94.65 in poultry feed followed by 88.4 and 87.04% in sugar+wheat flour and rusk, respectively. The highest mean incubation period (17.5 days) was recorded in rusk followed by (16.75 and 14.62 days) in sugar+wheat flour and poultry feed, respectively. The statistical Analysis of variance showed that number of eggs hatched into nymphs, hatching percent and mean incubation periods varied in all the treatments. The mean number of generations was maximum 4.6 in poultry feed followed by 3.8 and 3.00 in sugar+wheat flour and rusk, respectively.

The statistical Analysis of variance of mean numbers of generation did not vary in all the treatments though there was a maximum number of generation 4.6 in poultry feed. The data in Table 2 further showed that the mean adult longevity in females was longer than males. The mean adult longevity of females was maximum (153.4 days) in poultry feed followed by (126.6 and 126.4 days) in sugar+wheat flour and rusk, respectively. Similarly, highest mean male adult longevity (144.4 days) was recorded in poultry feed followed by (122 and 118.6 days) in sugar+wheat flour and rusk, respectively. The Analysis of variance results also showed that means of adults longevity in females and males were also statistically significant from each other whereas, the means for male and female ratio did not vary significantly from each other.

The data in Table 2 depict that the effect of different diets on the body length of first two instars of both sexes was found negligible. However, 3rd instar to adult stage, the differences in linear growth of body length (mm) were observed in the cockroaches fed on different diets. Generally, the linear body length of females was larger than males in all the treatments after 3rd instars. The maximum body length in 3rd instar of males fed on poultry feed ranged from 5.5 to 5.9 mm. followed by 5.2 to 5.6 and 5.0 to 5.4 in sugar+wheat flour and rusk fed cockroaches. Similarly, maximum length 5.7 to 6.1 (mm) was recorded in female fed on poultry feed as compared to (5.5 to 6.0 and 5.1 to 6.1 mm) body length of 3rd instars of females fed on sugar+wheat flour and rusk fed cockroaches, respectively. Almost in all the treatments (all stages), the linear body length was maximum in cockroaches fed on poultry feed than cockroaches fed on sugar+wheat flour and rusk, respectively. Similarly, (13.0 to 13.4 and 14.2 to 15.0 mm) maximum linear body length of males and females was recorded on poultry diet fed cockroaches followed by (12.8 to 13.1 and 13.2 to 13.8 mm) and (12.5 to 12.9 and 13.0 to 13.5 mm) mm body length of adults fed on sugar+wheat flour and rusk fed adults of cockroaches, respectively.

DISCUSSION

The studies on effect of different diets revealed that the poultry feed which is rich in proteins, lipids and carbohydrates have a significant effect on the biology of *B. germanica*. For example-the mean pre-oviposition period (fecundity), number of eggs hatched into nymphs (fertility) and adult male female longevity were higher than the *B. germanica* fed on sugar+wheat flour and rusk, respectively. Similarly, the effect of poultry feed on mean incubation period, the number of eggs in ootheca (Fecundity), mean nymphal development period and mortality % in nymphs were significant. Whereas, the development of cockroaches fed on poultry feed was fast with short period than cockroaches reared on sugar+wheat flour and rusk fed cockroaches which showed the lower development and took longer time to develop. However, there was no significant effect of different diets on copulation time, sex ratio and number of generations. Poultry feed which highly rich diet was proved ideal diet to the cockroaches for their development and survival as compared to sugar+wheat flour and rusk diets, respectively. The least linear body development was recorded on the rusk fed cockroaches. The mechanism by which rich poultry diet caused the faster development of German cockroach is as yet unknown.

The results are in agreement with those of Cooper and Sachal (1992b) who found that nymphal development and female reproduction in *B. germanica* on milk proteins including casein supported development poorly as compared to meat and plant proteins. Soybean protein supported development better than all other highly purified protein including vitamin free casein which is commonly used in artificial diets. Present findings are also in agreement to those of Tabaru *et al.* (2003) who fed 4 different diets i.e., water and mouse food, water and German cockroach faeces, water and carcasses and water alone and found that the survival and reproduction in cockroaches fed with faeces or carcasses was significantly shorter as compared with that of cockroaches fed with mouse food containing protein. Similar results were obtained in the present study that poultry diet favored various biological parameters of German cockroach than sugar+wheat flour and rusk diet, respectively. The processed rusk diet showed poor effects on the life cycle of German cockroach. Similarly, maximum linear body length (mm) in all stages except first two instars of German cockroach was found on poultry diet in comparison to wheat+flour and rusk diets.

With regards to the effect of different diets on various stages of German cockroaches, cockroaches than sugar+wheat flour and rusk fed roaches. This might be due to rich diet containing protein, lipids and carbohydrates as compared to other cockroach diets. However, no effect of any diet in first 2 instars was recorded as reported earlier by Ross and Cochran (1960) and Tanaka (1981). Since previously no studies have been reported so far on the effects of different diets on linear body length.

The rich diet like poultry feed has shown significant effect on the body length of German cockroach. The result of present studies are similar to those of Ross and Cochran (1960) who observed 6 nymphal instars of *B. germanica* and developed the method of sexing nymphal German Cockroaches. Under present studies, follow up of different 6 instars through measurements of linear growth was used. The comparison of different diets of *B. germanica* and their effect on biological parameters i.e., Fecundity, fertility, incubation, copulation time, mortality and adult longevity was determined. In the present case, the development of *B. germanica* was recorded faster and quick on poultry diets than sugar+meat flour and rusk fed cockroaches. The result of present studies do not agree with those of Tanaka (1981) who recorded that the number of instars required to reach the adult stage is usually five for males and 5 or 6 for females under standard rearing conditions at 25±1°C and with a constant supply of food and water. The lab rearing of cockroaches in present study was at 31±2°C might have shown 6 instars in both sexes.

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