

EFFECT OF THREE FEEDING DIETS ON OVIPOSITION PERFORMANCE OF COCKROACHES *PERIPLANETA AMERICANA* (LINNAEUS, 1785) AND *PARCOBLATTA LATA* (BRUNNER VON WATTENWYL, 1865) REARED IN LABORATORY CONDITION

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Abstract

This study investigated the nymphal period of adulthood, maturation, and the reproductive performance of *Pariplaneta. americana* and *Pacoblatta lata*, which were reared with three types of diets. The results revealed the durations of nymphal development were varied with the different food diets. A shorter duration for the development of cockroaches from the 2nd stage to the 3rd stage by feeding rice bran and sawdust followed by cat food and dog food in American cockroaches, whereas from the 3rd stage to the adult shorter duration by feeding dog food. Similarly, it has a shorter duration of development by feeding rice bran and sawdust, followed by dog food and cat food in wood cockroaches. A similar duration was recorded in *P. lata* for the development from the 3rd stage to the adult. The pre-ovulation period among the different diet treatments showed that dog food was the most effective with a shorter duration for maturity case in both cockroach species. In *P. americana*, their feeding preference was a highly significant difference among the diets. The feeding on different diets was not changed in different life stages, and their developmental stages in wood cockroaches. Therefore, suitable diets for survival and development were different between *P. americana* and *P. lata*.

Keywords: *Pariplaneta. americana* and *Pacoblatta lata*, nymphal stage, pre-ovulation, feeding habit

Introduction

The world's population is predicted to increase by more than a third, arrival over 9 billion persons in 2050, with the key implication that the planet will have to generate 70% more food. As a result, livestock production would increase exponentially to double the current level. The biggest challenge is to ensure. There is a global capacity to provide adequate animal feed to prevent as much competition as possible with the demand for human food (FAO, 2009). In many regions, a large biomass of insects can be obtained as food, in part, this is because of the high diversity of insects associated with different environments, but it is also because of the ability of many species to breed quickly. The cockroach species remain economically, medically, and aesthetically important pests. The American cockroach has been studied extensively in various disciplines, it has been used primarily as a laboratory animal or model for basic research in physiology, biochemistry, pharmacology, toxicology, and ethology (Schal *et al.*, 1984). Only about 0.3% of the 4,000 cockroach species have adapted to human habitats (Bell, 1984).

However, cockroaches are a suitable ingredient from a nutritional and palatability perspective to replace fishmeal and other high-protein ingredients in animal feed. Among them, cockroaches are popular insects for experimental studies, for they are readily available, of a convenient size, and grow at all seasons of the year. They are generalist omnivores able to survive on a variety of foods, an ideal experimental animals for comparative quantitative studies. There are numerous studies with laboratory-reared cockroaches focused on the effects of diets on

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development and reproduction (Copper and Schal 1992, Raubenheimer and Jones 2006, Jensen *et al* 2015).

Periplaneta species are primarily adapted to live outdoors and invade residential and commercial properties seasonally in the southern temperate regions (Cornwell 1968, Ebeling 1975). The adult *P. americana* is long-lived, averaging one year and probably longer. Under adverse conditions, adults may live only about 100 days, but an adult life span of 2 to 3 years has been documented under ideal conditions (Gould and Deay, 1938., Rau 1940, Griffiths and Tauber 1942). Cornwell (1968) noted that nutrition and temperature affect development and reproduction.

Therefore, the present study was undertaken to assess the effect of three different food diets on the reproductive performance of two species, *Periplaneta americana* (Linnaeus, 1785) and *Parcoblatta lata* (Brunner von Wattenwyl, 1865), under laboratory stock cultures (Plate 1). The result will provide information on reproductive biology for mass-rearing systems in the future. The objective was to compare studies of different food diets on developmental stages and reproductive performance of study cockroach species.

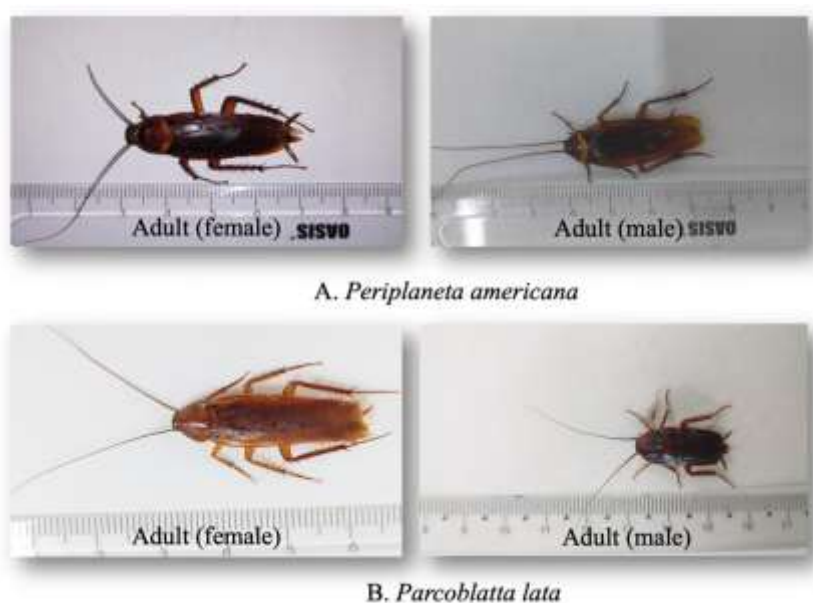


Plate 1. Two species of cockroaches *Periplaneta americana* and *Parcoblatta lata*

Materials and Methods

Study area and period

The research was conducted at the Laboratory of Zoology Department, University of Yangon from October 2023 to September 2024.

Rearing of cockroaches in the laboratory

The 2nd nymphal period of instars of the 3rd generation was used for all experiments. A total of 20 individuals (10 males and 10 females) of nymphs for both species *Periplaneta*

americana and *Parcoblatta lata* were reared separately in plastic bottles (1.5 L). The containers were covered with cloth at the top and sealed with rubber rings to prevent cockroaches from escaping and other animals from getting in. A layer of paper is placed in the bottom of rearing containers to absorb excess moisture emitted by the cockroaches. The rearing containers were cleaned every ten days intervals, and the paper sheets were replaced. The newly laid ootheca from each treatment was kept separately in another rearing plastic bottle to reduce cannibalism. The new nymphs were fed with enough food and supplied with water (Plate 2).

Rearing diets

Cockroaches were fed with each rearing diet, such as cat food and dog food purchased from pet shops and rice bran and sawdust (1:2) for giving days. A weight of *ca.* 2g of each diet was placed in a concentric circle at random at the bottom of each container. All foods were heat-treated in the oven with the lowest temperature (90-100°C) before feeding them, and the nutritional composition of each diet as dry weight was examined. The composition of food diets was tested at the Analytical Laboratory Unit, Department of Fisheries, Yangon, as shown in Table 1.



Plate 2. Rearing condition of two species of cockroaches in laboratory condition

Data collection and analysis

The nymphal period to adult and their laying was recorded for both cockroach species to study the life cycle of certain species. The ootheca was checked daily and the date when it hatched. Dying insects were counted and removed. The numbers of instars and their survival were recorded for each treatment. The calculation on developmental stages on different nymphal periods, and the fecundity of adults (No. of oothecae, hatchability (%), cumulative number of hatched nymphs, number of hatched nymphs per ootheca), and the survival rate of both cockroach species. The statistical data analyses will be done by using a one-way ANOVA Test under the significant level $p < 0.05$ (0.5%).

Table 1. Composition in different food diets

Contents	Type of diet		
	Dog food	Cat food	Rice bran and sawdust
Crude Protein (%)	30	35	41.58
Crude Fat (%)	12	18	2
Fiber (%)	4.5	4	20.5
Moisture (%)	10	10	12.04

Results

The present results revealed the duration of the developmental stages and oviposition performance of cockroaches *P. americana* and *P. lata* by feeding them different diets such as cat food, dog food, and rice bran and sawdust under the rearing laboratory conditions.

Developmental stages of cockroaches in American cockroach *P. americana*

The cockroaches have a shorter duration for the development of cockroaches from the 2nd stage to the 3rd stage by feeding rice bran and sawdust (71 days) followed by cat food (94 days) and dog food (126 days). In the development of cockroaches from the 3rd stage to the adult stage, the feeding of dog food was shorter (25 days), followed by cat food (55 days) and rice bran and sawdust (71 days).

Oviposition performance in American cockroach *P. americana*

During the study period, the highest total number of egg cases were obtained from the cockroaches that feed on cat food (36 eggs), followed by rice bran and sawdust (18 eggs), and dog food (16 eggs). Of the total no. of hatched nymphs and the hatchability rate, 108 nymphs were hatched from nine hatched egg cases by feeding cat food (12.00%), 65 nymphs from six hatched egg cases by feeding dog food (10.83%), and 27 nymphs from two egg cases by feeding rice bran and sawdust (13.50%). The total number of deaths was 34 nymphs fed on cat food, 10 nymphs fed on dog food, and non-death nymphs fed on rice bran and sawdust (Table 2, Fig. 1).

Table 2. Duration of developmental stages and reproductive performance of *P. Americana*

Parameters	<i>P. americana</i>		
	Cat food	Dog food	Rice bran & Saw-dust
2nd-3rd stage (Days)	94	126	71
3rd-adult stage (Days)	55	25	71
Total egg case (oothecae)	36	16	18
Total no. of hatched nymphs/Total hatched egg case	108/9	65/6	27/2
Total no. of hatched nymphs per ootheca (%)	12.00	10.83	13.50
Total no. of death	34	10	Nil
Death rate (%)	31.48	15.38	0.00

Developmental stages oviposition performance in Wood cockroach *P. lata*

The cockroaches have a shorter duration for the development of cockroaches from the 2nd stage to the 3rd stage by feeding rice bran and sawdust (40 days) followed by dog food (69 days) and cat food (70 days). In the development of cockroaches from the 3rd stage to the adult, all feeding diets were similar in duration (20 days). The highest total number of egg cases (Oothecae) were obtained from the cockroaches that feed on dog food (42 eggs), followed by cat food (20 eggs), and rice bran and sawdust (12 eggs) during the study period. Of the total number of hatched nymphs and the hatchability rate, 53 nymphs were hatched from four hatched egg cases by feeding cat food (13.25%), 105 nymphs from seven hatched egg cases by feeding dog food (15.00%), and 43 nymphs from three egg cases by feeding rice bran and sawdust (14.33%). The total number of deaths was 15 nymphs fed on dog food, 15 on rice bran and sawdust, and non-death nymphs fed on cat food (Table 3, Fig. 2).

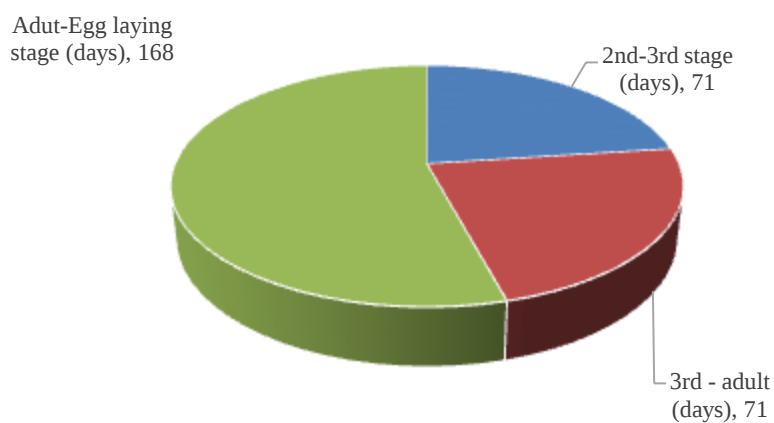
Table 3. Duration of developmental stages and reproductive performance of *P. lata*

Parameters	<i>P. lata</i>		
	Cat food	Dog food	Rice bran & Sawdust
2nd-3rd stage (Days)	70	69	40
3rd-adult stage (Days)	20	20	20
Total eggcase (oothecae)	20	42	12
Total no. of hatched nymphs/Total hatched egg case	53/4	105/7	43/3
Total no. of nymphs per ootheca (%)	13.25	15.00	14.33
Total no. of death	Nil	15	15
Death rate	Nil	14.29	34.88

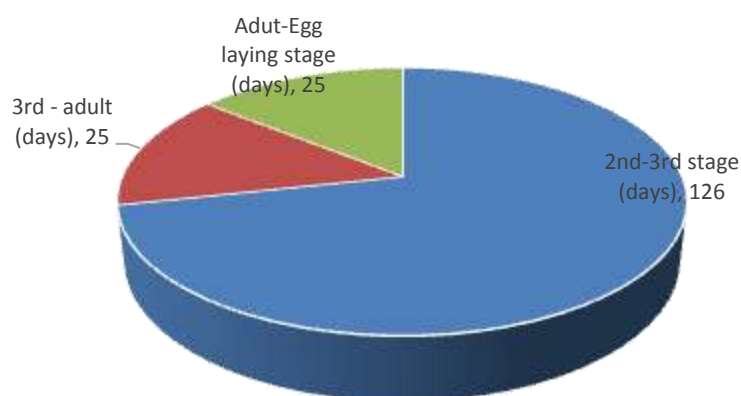
Comparison of pre-ovulation period of cockroaches

In American cockroach *P. americana*, the longer duration of the pre-ovulation period from adult to the egg-laying stage was 168 days for the cockroaches that feed on dog food, followed by feeding dog food 25 days, and 10 days for the cockroaches that feed on rice bran and sawdust (Fig. 3, A). In the wood cockroaches *P. lata*, the pre-ovulation period from adult to the egg-laying stage was 207 days for the cockroaches that feed on cat food, followed by feeding rice bran and sawdust 64 days, and the shorter duration of development was 31 days for the cockroaches that feed on dog food (Fig.3, B).

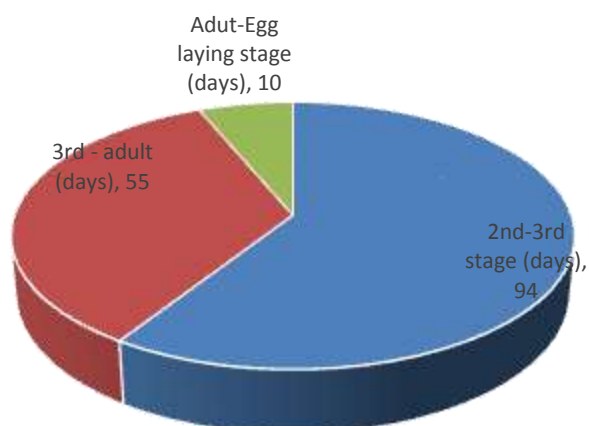
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A. Rice bran and Saw dust treatment



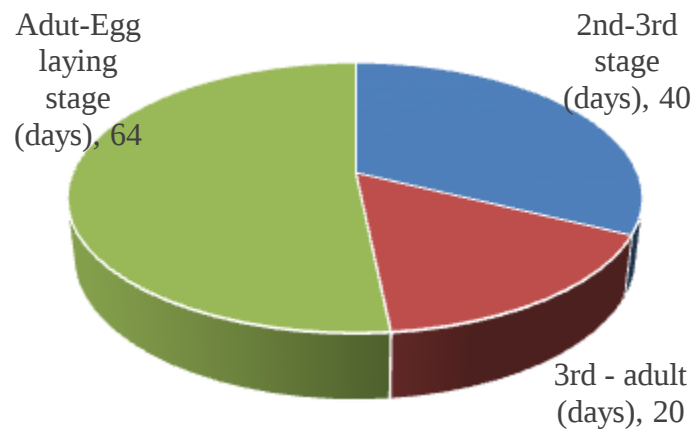
B. Dog food treatment



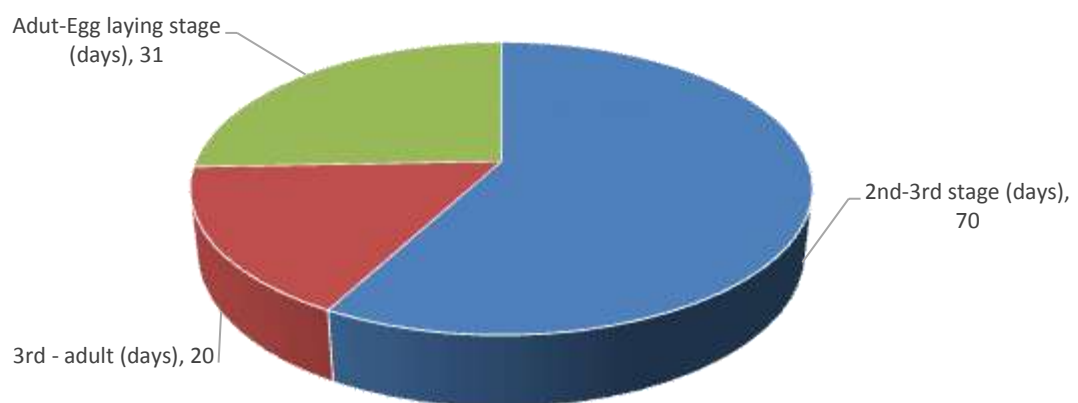
C. C

D. at food treatment

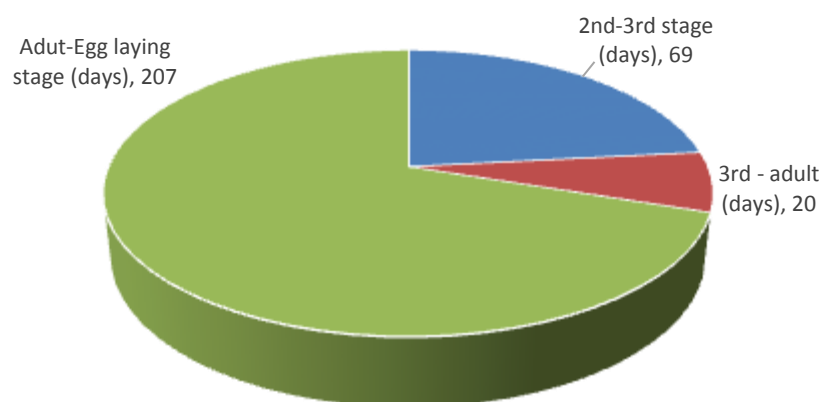
Figure. 1 Duration of developmental stages of *P. americana* by feeding different diets



A. Rice bran and Saw dust treatment



B. Dog food treatment



C. Cat food treatment

Figure. 2 Duration of developmental stages of *P. lata* by feeding different diets

Food preference of cockroaches

Both cockroach species' feeding rates increased due to their development during the study period (44 weeks of observation). The mean weight of the feed was highest at 1.54 ± 0.39 gm on rice bran and sawdust followed by 1.42 ± 0.49 gm on cat food and 1.25 ± 0.45 gm on dog food. In particular, cat food was most preferable at the adult stage while feeding on dog food was decreased, and rice-bran and sawdust feeding steadily increased from the young age to the adult stage in *P. americana*. Their feeding preference was a highly significant difference among the diets ($F = 4.911$, $P < 0.01$) (Fig. 4, A).

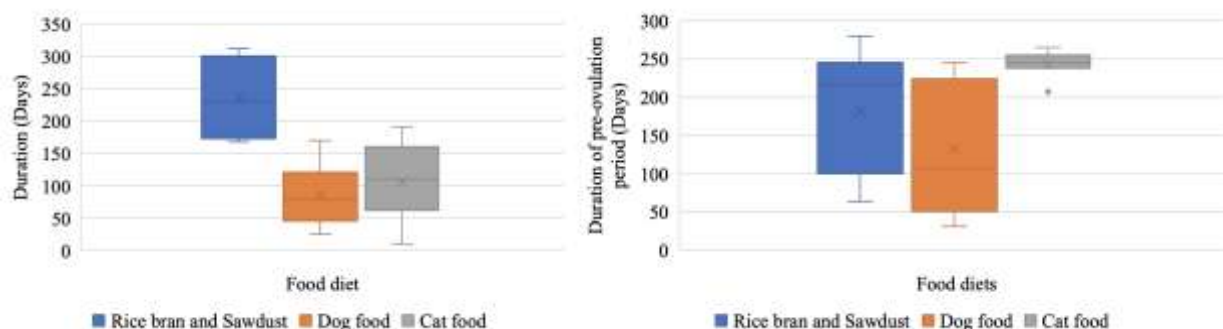


Figure. 3 Comparison of the duration of pre-ovulation among different feeding diets

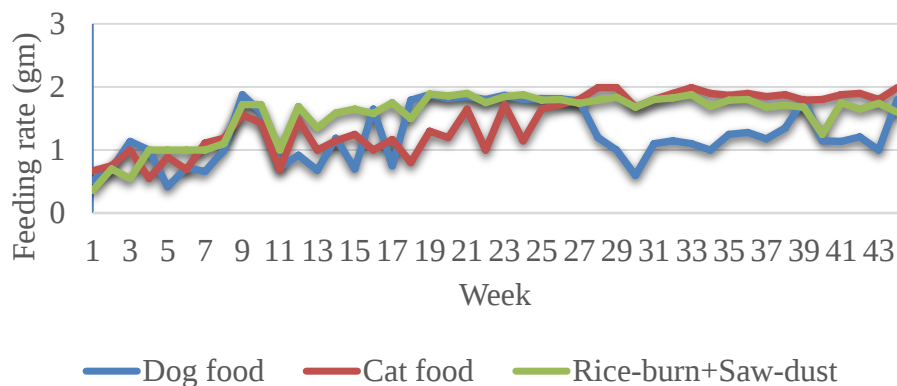
In *P. lata*, the mean weight of the feed was 1.35 ± 0.35 gm on dog food followed by 1.34 ± 0.30 gm on rice bran and sawdust, and the lowest feeding rate was 1.17 ± 0.39 gm on dog food. In particular, cat food was most preferable at the adult stage while feeding on dog food was decreased, and rice-bran and sawdust feeding steadily increased from the young age to the adult stage. Their feeding preference was a significant difference among the diets ($F = 3.709$, $P < 0.05$) (Fig. 4, B).

Discussion

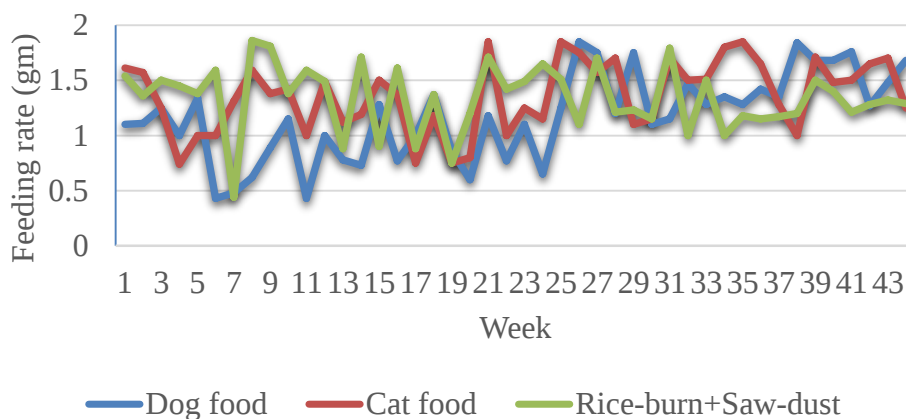
In the results of food experiments, the durations of nymphal development varied with the different food diets. The mixture of rice bran and sawdust was the most effective diet for the development with a shorter duration (71 days) in *P. americana*, whereas in *P. lata* (40 days). For the development from 3rd stage to adult, the shorter duration was recorded by feeding of dog food (25 days) followed by cat food (55 days) and rice bran and sawdust (71 days) in *P. americana*, whereas a similar duration was recorded in *P. lata* (20 days) by feeding all treatments.

According to the diet components, crude protein was highest in rice bran and sawdust diet rather than other cat food and dog food. It means that in the early nymphal development, the crude protein was the most essential for cockroaches in both species. The crude fat was highest in cat food (18 mg/kg) and the least in rice bran and sawdust (2mg/kg). The present result highlights that the suitable amount of crude fat concentration in the diet was vital for the development of cockroaches to the adult stage in *P. americana*. However, the crude fat contained in the diets was not an essential factor in *P. lata*.

The present experiment noted that in *P. americana* the highest number of oothecae were obtained from the treatment of feeding cat food (n = 36), followed by rice bran and sawdust (n = 18), and dog food (n = 16) in contrast to wood cockroach *P. lata* the highest oothecae were obtained from the treatment of feeding dog food (n = 42), followed by cat food (n = 20), rice bran and sawdust (n=12). Thus, cat food was the most effective for laying eggs in American cockroaches, while dog food in wood cockroaches.



A. American cockroach *P. americana*



B. Wood cockroach *P. lata*

Figure. 4 Food preferences of study cockroach species

Nevertheless, the total number of hatched nymphs per ootheca was higher in feeding rice bran and sawdust treatment (13.50%) than that of cat food and dog food treatments. The death rate was also high in the treatment of feeding cat food (31.48%), while the nondeath rate in the treatment of feeding rice bran and sawdust in American cockroaches. In wood cockroaches, the highest total number of hatched nymphs per ootheca was also recorded in the treatment of feeding dog food accordingly, with the highest number of laid oothecae and death rate in this treatment as compared to other treatments.

The comparison of the pre-ovulation period among the different diet treatments showed that dog food was the most effective with a shorter duration for maturity case in both cockroach species, especially when it was observed in American cockroaches. The mixture of rice bran and sawdust was less effective for the development of pre-ovulation in this species. In wood cockroaches, the feeding of cat food was a prolonged duration. This means that less effective for the maturity of egg cases. The suitable diets for survival and development were different between *P. americana* and *P. lata*.

The result of the present work observed that their food preferences, the American cockroaches, were reduced feeding rate on dog food when they became an adult stage. Although the cat food and the rice bran and sawdust mixture were stable for their feeding until they became an adult stage. It supposes that the American cockroaches varied their food preference upon their life stages and development. In wood cockroaches, the feeding habits of different diets were not changed in different life stages and developmental stages. In conclusion, the present result highlights that feeding on varied diets should be considered for the mass rearing of varying cockroach species in the future.

Conclusion

This study successfully determined the distinct impacts of three diets on the life history of *P. americana* and *P. lata*. The optimal diet for development, reproduction, and survival varies significantly between the two cockroach species. The Dog Food (DF) diet promotes the fastest reproductive maturity (shortest pre-ovulation period) in both species. The Rice Bran/Sawdust (RB/SD) mixture offers the best survival rate for *P. americana* (0.00% death rate). In conclusion, the present result highlights that feeding on varied diets should be considered for the mass rearing of varying cockroach species in the future. The results underscore the need for species-specific and potentially life-stage-specific diets when establishing efficient mass-rearing systems for these cockroach species in the future.

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