EGYPTIAN ACADEMIC JOURNAL OF
BIOLOGICAL SCIENCES
F
TOXICOLOGY & PEST CONTROL

ISSN
2090-0791

WWW.EAJBS.EG.NET

Vol. 15 No. 2 (2023)

www.eajbs.eg.net

Citation: *Egypt. Acad. J. Biolog. Sci.* (F. Toxicology& Pest control) *Vol.15(2) pp 15-24 (2023)*
DOI: 10.21608/EAJBSF.2023.311987

Egypt. Acad. J. Biology. Sci., 15(2):15-24(2023)

Egyptian Academic Journal of Biological Sciences
F. Toxicology & Pest Control
ISSN: 2090 - 0791
http://eajbsf.journals.ekb.eg/

Diversity and Management of Cockroaches in Tabuk, Saudi Arabia

Ayesh S. Albalawi, Al Thabiani Aziz, Fares A. Al-Enezi, Mohammed A. Ajeebi, Khaled A. Aljuhani, Abdulkarim M. Albalawi and Chellasamy Panneerselvam
Biology Department, Faculty of Science, University of Tabuk, Tabuk, Saudi Arabia
*E-mail: aalthbyani@ut.edu.sa

ARTICLE INFO
Article History
Received:3/7/2023
Accepted:10/8/2023
Available:15/8/2023

***Keywords*:**
Cockroaches, biocide, Organophosphates, management. Tabuk, Saudi Arabia.

ABSTRACT

Cockroaches are insects of high public health importance, since disgorging a portion of partially digested food at intervals and dropping faeces they spread several parasites and pathogens, which infect humans and other animals. Therefore, this research mainly focused on the abundance and distribution of cockroaches (Blattidae) in four localities of Tabuk region, Saudi Arabia. This study mainly focused on the effect of variations in the temperature, rainfall and humidity on the cockroach population density. Saudi Arabia is an arid region, characterized by extremely low annual rainfall. Only two cockroach species were recorded in this study, *Blattella germanica* and *Periplaneta americana*. The abundance of both species in arid regions was generally low compared to other regions (i.e., tropical and subtropical areas). In the four study sites, a significant positive relationship was detected between the population density of cockroaches against temperature and rainfall, i.e., R= 0.346, P≤ 0.01; R= 0.041, P≤ 0.01 for Dhubaa, R= 0.884, P≤ 0.01; R= 0.15, P≤ 0.01 Naseem, R= 0.797, P≤ 0.01; R= 0.15, P≤ 0.01Sultanah and R= 0.782, P≤ 0.01; R= 0.15, P≤ 0.01 for Khaldia. Furthermore, a negative relationship between humidity and population density was recorded in the studied sites. Bioassay results showed that among the chosen pesticides, pyrethroid had the maximum toxicity effect on both nymph and adult of *P. americana* followed by biocide and Organophosphates. Overall, this research provides baseline information on cockroach ecology, which may be helpful to boost effective and safer control programs against cockroaches in arid countries worldwide.

INTRODUCTION

Cockroaches are the oldest insects the earliest fossils dating back to the carboniferous period are about 400 million years. Most of them are distributed in tropical and subtropical areas of the world. Three domiciliary species of high economic importance for public health are the German cockroach (*Blattella germanica*), the American cockroach (*Periplaneta americana*), and the Oriental cockroach (*Blatta orientalis*) (Goddard, 2003). Cockroaches are recognized to be mechanical vectors of disease-causing agents. In particular, *Blattella germanica* and *Periplaneta americana* carry disease-causing organisms, typically those causing gastroenteritis. Cockroaches are highly prevalent in homes, restaurants and medical institutions. Cockroaches play a significant role in recycling decaying plant and animal materials. In addition, they are extremely important in many food

chains and part of the food for carnivores such as birds, lizards, rats and other mammals. Currently, there are 5000 known species worldwide, classified into eight families, i.e., Nocticolidae, Corydiidae, Ectobiidae, Blaberidae, Blattidae, Lamproblattidae, Tryonicidae, Cryptocercidae (Beccaloni and Eggleton, 2013). Cockroaches are mostly active at night, during daylight time they hide in cracks and crevices in walls and other hiding places (Cochran, 1999). Cockroaches are insects of public health important since disgorging a portion of partially digested food at intervals and dropping faeces (WHO, 1997; Mukhtar, 2010), they spread several parasites and pathogens, including bacteria, protozoa, worms, fungi, and viruses, which may infect humans and other animals (Cornwell, 1968). German cockroaches transmit disease-causing organisms such as *Staphylococcus* spp., *Streptococcus* spp., hepatitis virus and coliform bacteria (Rust and Reierson, 2007). Problems associated with domiciliary cockroaches in urban environments are well documented (Roth and Willis, 1957). Pai *et al.,* (2004) reported cockroaches as potential vectors of nosocomial infections. The high incidence of cockroaches in public housing apartments poses numerous public health risks, including exposure to allergens through the air and via food contamination, resulting in an increased incidence of health problems, mainly asthma (Wang *et al.,* 2008; Lwebuga-Mukasa *et al.,* 2002). Recent research showed that cockroach allergens also play a significant role in urban asthma morbidity among elderly people (Huss *et al.,* 2001; Rogers *et al.,* 2002; Sia Su *et al.,* 2016). A number of bacterial diseases can be transmitted by food contamination by cockroaches, like; diarrhoea, dysentery, cholera, leprosy, plague, typhoid fever, and viral diseases such as poliomyelitis. In addition, cockroaches may vector the eggs of parasitic worms and cause allergic reactions, including dermatitis, itching, swelling of the eyelids and more serious respiratory conditions (Stankus *et al.,* 1990). Cockroaches have emerged as a group of insect social evolution due to their phylogenetic proximity to eusocial termites within the Blattodea (Roth *et al.,* 2009). Chompoosri *et al.,* (2004) studied cockroach surveys in three provinces of the Northern region of Thailand: Chiang Mai, Chiang Rai, and Mae Hong Son, and three cities of Guangxi Province of the People's Republic of China: Nanning, Huangjiang, and Hechi. Sriwichai *et al.* (2002) conducted a survey of indoor cockroaches in some dwellings in Bangkok and identified *Periplaneta americana*, *Supella longipalpa*, *Blattella germanica*, *Neostylopyga rhombifolia*, *P. brunnea*, *P. australasiae*, *Pycnoscelus surinamensis*, *B. lituricallis*, plus two unidentified species. Alametal. (2013) reported the isolation of zoonotic parasites and other infectious agents from American cockroaches in the household of Khyber Pakhtunkhwa (KPK), Pakistan. Shahraki *et al.* (2013) reported cockroach infestation and factors affecting the estimation of the cockroach population in urban communities of Yasuj City in southwestern Iran. In this scenario, our research focused on the surveillance and breeding potential of the American cockroach, *Periplaneta americana* and German cockroach, *Blattella germanica* in different sites in Saudi Arabia, i.e., Dhubaa, Naseem, Sultanah and Khaldia (Tabuk province). This study provided baseline information on the major cockroach species and their prevalence. Also, this research revealed the toxicity effect of Safrotin, Sulfak and Tracer on nymphs and adults of *P. americana.*

MATERIALS AND METHODS

Study Sites:

Tabuk is the capital city of the Tabuk Region in northwestern Saudi Arabia (Fig.1) . Temperatures in the summer are between 26 and 46 °C, while in winter they are between −4 and 18°C, with widespread frosts. Rainfall in Tabuk Area falls in the winter months from November to March, and precipitation ranges between 50 and 150 mm. In this survey, four sites (i.e. Dhubaa, Naseem, Sultanah and Khaldia) were chosen as sites to collect cockroach

mature and immature individuals in indoor and outdoor environments, in relation to temperature, rainfall and humidity parameters.

Fig.1: Map of Tabuk, Saudi Arabia were sampled cockroaches.

Collection and Rearing of Cockroaches:

Cockroaches were collected over a period of 6 months (December to May 2023) from four selected areas of Dhubaa which are located along the Red Sea coast in the Tabuk province and Naseem, Sultanah and Khaldia in Tabuk City using the trap described by Jeffery *et al.* (1984). There were two-beaker traps placed indoors and outdoors in the following randomly selected areas Dhubaa, Naseem, Sultanah and Khaldia.

The trapping device consists of 1-5 litre beakers that have the upper inside surface (5-10 cm) painted with a suspension of Vaseline thus preventing trapped cockroaches from escaping. A mixture of ground sugar with wheat flour (Product of Grain Silos and Flour Mills Organization, Saudi Arabia) and water 1:1:1 was used as bait. After 48 h trapped cockroaches were transferred into plastic bags and brought back to the Entomology and Toxicology Laboratory, Department of Biology for recording and identification at the specific level. Each collected sample included nymphs and adults of both sexes. Cockroaches were identified following the keys by Cochran (1999). A total of 6 samplings were made for each study site from December to May 2023. The collected life stages (adult and nymph) of the cockroach were maintained and cultured at laboratory conditions (25°C ± 2, 60 ± 5% RH) and fed with a cat pellet.

Bioassay Test:

Experiments were performed according to the method of Vazirianzadeh *et al.*, (2007) with minor modifications. 20 grams of the insecticide-treated food (50 g) were suspended in 250 ml of plastic containers. Then, the containers were covered with muslin cloth with a rubber band. Three replicates were maintained in each concentration with 10 Adult insects and 10 nymphs, as well as control insects were fed with normal food. The percentage of mortality was noticed after 72 hours post-treatment.

Tested Chemical Compounds:

In this research, the selected three types of insecticides (Safrotin 20MC, Sulfak and Tracer 48SC) were used to study the toxicity effect on nymphs and adults of *P. americana* (Table 1).

Table (2): Tested chemical pesticides against nymph and adult of *P. Americana.*

S. No.	Commercial Insecticide	Group	The active substance and its ratio
1	Safrotin 20MC	Organophosphates (OP)	Propetamphos 20%
2	Sulfak	Pyrethroids (Py)	Cyfluthrin 15%
3	Tracer 48SC	Biocides	Spinosad 48%

Data Analysis:

Cockroach abundance data were analysed descriptively for the mean and standard deviation. The one-way ANOVA test (at $P<0.05$) was employed to determine the variation in the cockroach abundance in the different study sites. Furthermore, the Spearman correlation test was used to investigate the relationship between cockroach abundance and the effect of selected environmental factors (i.e. temperature, humidity, rainfalls). Statistical analyses were carried out using the SPSS software package (16.0 Version). Mortality percentages of Cockroaches and LC_{50} and LC_{90} were calculated by LDP-line software (Finney 1972).

RESULTS

Among the four selected study sites, the highest population of cockroaches was observed in Sultanah area (total: 61 cockroaches caught), both in the indoor and outdoor dwellings, all specimens were *B. germanica* or *P.americana*. These included 39 adult cockroaches and 22 nymphs, at variance with Dhubaa (i.e., 17 adults; 31nymphs), Khaldia (i.e., 17 adults; 11 nymphs), and Naseem (i.e., 13 adults; 14 nymphs). The distribution of cockroaches was related to temperature, relative humidity, and rainfall (Table 2). The population density of cockroaches was higher in Sultanah and Dhubaa, where the sanitation standards are poor (A.T.Aziz, pers. obs.). Supplementary Online Material Tables S1-S4 show that there was a positive correlation between temperature, rainfall and the population density of cockroach ($R= 0.346$, $P\leq 0.01$); ($R= 0.041$, $P\leq 0.01$) for Dhubaa ($R= 0.884$, $P\leq 0.01$); ($R= 0.15$, $P\leq 0.01$) Naseem, ($R= 0.797$, $P\leq 0.01$); ($R= 0.15$, $P\leq 0.01$) Sultanah and ($R= 0.782$, $P\leq 0.01$); ($R= 0.15$, $P\leq 0.01$) for Khaldia. On the other hand, the correlation was negative between humidity and population density. The correlation coefficient (R) values were -0.74, -0.65, -0.65 and -0.65 for Dhubaa, Naseem, Sultanah and Khaldia, respectively. In agreement with our findings, several studies reported a positive correlation between the temperature sensitivity and the habitat temperatures of cockroaches (Tsuji and Mizumo, 1973; Appel *et al.*, 1983). For instance, Schoof and Siverly (1954) reported that *P.americana* rapidly adapted to urban dwellings with sewage pipelines. These pipelines, connected to a building, are suitable for this species' growth, reproduction and distribution and the dominant

species of German cockroach was generally found in indoor dwellings. Furthermore, Mag-Usaraand Nuñeza (2014) studied the diversity and relative abundance of cockroaches in cave habitats of Siargao Island (Philippines) recording four species of cockroaches in three out of ten cave sites. Recently, Prabakaran *et al.* (2015) studied the biodiversity of cockroaches in Yelagiri Hills part of Eastern Ghats (Tamil Nadu) observing 12 species of cockroaches belonging to 10 genera and 4 families from Yelagiri Hills. Sattar *et al.* (2013) reported the effect of temperature, relative humidity and precipitation on population dynamics, density and foraging activities of *Microtermes obesi* (Termitidae) and *Odontotermes lokanandi* (Termitidae).

Table 2: Population dynamics of cockroaches in relation with temperature, humidity and rainfall in different regions of Tabuk, Saudi Arabia (A=Adult, N=Nymph).

Months	Dhubaa		Total	Naseem	Total	Sultanah	Total	Khaldia	Total	Temperature °C	Humidity (%)	Rainfall (mm)
1	Indoor	10	15^{e} (7A+8N)	6	12^{e} (6A+6N)	9	19^{c} (15A+4N)	4	8^{d} (6A+2N)	24	47	6
	Outdoor	5		6		10		4				
2	Indoor	3	5^{a} (3A+2N)	4	8^{d} (3A+5N)	5	10^{b} (10A+0N)	2	5^{c} (3A+2N)	18	40	13
	Outdoor	2		4		5		3				
3	Indoor	5	8^{c} (1A+7N)	3	5^{c} (2A+3N)	4	10^{b} (8A+2N)	2	4^{b} (4A+0N)	12	39	4
	Outdoor	3		2		6		2				
4	Indoor	5	7^{b} (2A+5N)	0	0^{a} (0A+0N)	3	6^{a} (1A+5N)	2	4^{b} (2A+2N)	11	57	7
	Outdoor	2		0		3		2				
5	Indoor	2	5^{a} (4A+1N)	0	0^{a} (0A+0N)	4	10^{b} (4A+6N)	2	4^{b} (2A+2N)	14	54	3
	Outdoor	2		0		6		2				
6	Indoor	4	8^{d} (0A+8N)	1	2^{b} (2A+0N)	4	6^{a} (1A+5N)	2	3^{a} (0A+3N)	17	50	7
	Outdoor	4		1		2		1				
Total			Adult=17 Nymph=31 48		Adult=13 Nymph=14 27		Adult=39 Nymph=22 61		Adult=17 Nymph=11 28			

Means followed by the same letter in a column are not statistically different by Tukey's HSD (P=0.05).

The percentage of mortality of both nymphs and adult cockroaches is shown in Table 3. The toxicity results showed that the nymph was more sensitive than adults in all treatments by 1.268, 1.457and .1088 folds with safrotin, sulfak and tracer; *however, the highest mortality was found in* sulfak followed by tracern and safrotin against nymph and adults of *P.americana with* LC_{50} *values for sulfak* 4.4183 ppm (adult); 3.0326 ppm (nymph); for Tracern 11.4015 ppm (adult); 10.4824 ppm (nymph) and for Safrotin 52.113 ppm (adult); 41.091 ppm (nymph) respectively (Table 3). Similarly, Jazem (2019) studied the toxicity effect of pyrethroids and organophosphates against nymphs and adults of *P.americana*. Further, Lukwa and Manokore (1997) reported the biological properties of Permethrin, Phenolthrin/Allerthrin and D-Phenothrin against *P. americana* and *Blattella germanica* and they found that 100 % mortality in all tested insecticides after 10 min of post-treatment. Also, Astuti and Pandji (2015) noticed that deltamethrin exhibited 73% mortality against *P. americana* at 0.80 %.

When compared to the tested group of insecticides, pyrethroid was more effective than organophosphates on both nymphs and adults of *P.americana* **(**Table 3**).** To the best of our knowledge, this research is the first report on the biological activity, distribution and abundance of cockroaches in Northern Saudi Arabia. This region is arid and characterized by low annual rainfall. Only two cockroach species were recorded from this region, *B.germanica* and *P.americana*. Our research highlighted the cockroach population showed that positive correlation with temperature, rainfall, and a negative correlation with relative humidity. Overall, this research provides baseline information on cockroach ecology, which may be helpful to boost effective and safer control programs against cockroaches in arid countries worldwide.

Table (3): Effects of pesticides on Adults and Nymph of *P. americana*.

Concentration (ppm)	Adult Mortality %	Nymph Mortality %
Safrotin 20MC		
20	9.28	14.43
40	36.08	46.39
60	55.67	68.04
80	68.04	88.66
100	87.63	92.78
Slope	3.2964	3.6485
Chi	3.4376	2.3541
LC_{50}	52.1137	41.091
LC_{90}	127.5671	92.2597
Sulfak		
1	5.16	20.62
3	36.08	39.18
5	54.64	65.98
8	67.01	80.41
10	86.60	92.78
Slope	2.4907	2.1258
Chi	4.7405	10.2116
LC_{50}	4.4183	3.0326
LC_{90}	14.4484	12.1533
Tracern 48SC		
5	25.77	21.65
10	36.08	44.33
15	57.73	59.79
20	68.04	77.32
25	87.63	93.81
Slope	2.3631	2.9072
Chi	10.8598	9.2784
LC_{50}	11.4015	10.4824
LC_{90}	39.7462	28.9265

Conclusion

Both *Blattella germanica* and *Periplaneta Americana* were recorded as the only cockroach species in the study areas including Dhubaa, Naseem, Sultanah and Khaldia in Tabuk region. A significant positive relationship was detected between the population density of cockroaches against temperature and rainfall and a negative relationship against humidity. This study represents baseline information on the ecology of cockroaches and provides a valued guide in control programs against cockroaches. Concerning the biological properties of tested insecticides on *P. americana*, the pyrethroid group showed the highest efficacy followed by biocide Tracer 48SC, and Safrotin against the American cockroach, *P. americana*.

Acknowledgements: The authors would like to thank the University of Tabuk.

Conflict of Interest: We declare that we have no conflict of interest.

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Supplementary Online Material

Table S1. Correlation results (Spearman correlation test) of temperature, humidity and rainfall versus population density of cockroaches in Dhubaa region, Tabuk (Saudi Arabia).

Weeks	Temperature (ºC)	Density	Relative Humidity (%)	Density	Rainfall	Density
1	21	15	47	15	0.71	15
2	21	5	40	5	0	5
3	17	8	39	8	0	8
4	13	7	57	7	0	7
5	16	5	54	5	1.5	5
6	13	8	50	8	0	8
Correlation coefficient (R**)		0.346		-0.74		0.041
XMean(μx)		8.0		8.0		8.0
YMean(μy)		16.83		47.83		0.368
σx		3.68		3.68		3.68
σy		3.60		7.30		0.62

** Correlation is significant at the 0.01 level (2-tailed).

Table S2. Correlation results (Spearman correlation test) of temperature, humidity and rainfall versus population density of cockroaches in Naseem region, Tabuk (Saudi Arabia).

Weeks	Temperature ºC	Density	Relative Humidity (%)	Density	Rainfall	Density
1	21	12	47	12	0.71	12
2	21	8	40	8	0	8
3	17	5	39	5	0	5
4	13	0	57	0	0	0
5	16	0	54	0	1.5	0
6	13	2	50	2	0	2
Correlation coefficient (R**)		0.884		-0.655		0.152
XMean(μx)		4.50		4.5		4.5
YMean(μy)		16.83		47.43		0.36
σx		4.80		4.80		4.80
σy		3.60		7.30		0.62

** Correlation is significant at the 0.01 level (2-tailed).

Table S3. Correlation results (Spearman correlation test) of temperature, humidity and rainfall versus population density of cockroaches in Sultanah region, Tabuk (Saudi Arabia).

Weeks	Temperature (ºC)	Density	Relative Humidity (%)	Density	Rainfall	Density
1	21	19	47	19	0.71	19
2	21	10	40	10	0	10
3	17	10	39	10	0	10
4	13	6	57	6	0	6
5	16	10	54	10	1.5	10
6	13	6	50	6	0	6
Correlation coefficient (R**)		0.797		-0.655		0.152
XMean(μx)		10.16		10.16		10.16
YMean(μy)		16.83		47.83		0.36
σx		4.75		4.75		4.75
σy		3.60		7.30		0.62

** Correlation is significant at the 0.01 level (2-tailed).

Table S4. Correlation results (Spearman correlation test) of temperature, humidity and rainfall versus population density of cockroaches in Khaldia region, Tabuk (Saudi Arabia).

Weeks	Temperature (°C)	Density	Relative Humidity (%)	Density	Rainfall	Density
1	21	8	47	8	0.71	8
2	21	5	40	5	0	5
3	17	4	39	4	0	4
4	13	4	57	4	0	4
5	16	4	54	4	1.5	4
6	13	3	50	3	0	3
Correlation coefficient (R**)		0.782		-0.655		0.152
XMean(μx)		4.66		4.66		4.66
YMean(μy)		16.83		47.83		0.36
σx		1.75		1.75		1.75
σy		3.60		7.30		0.62

** Correlation is significant at the 0.01 level (2-tailed).