



Biodiversity of cockroach (*Blattodea*) in district Gujrat, Punjab, Pakistan

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Cockroaches are available in all over the world but their species are varied according to their areas and their environmental conditions. In Pakistan, a lot of species of cockroaches are found and beneficial because they can be used as food. Cockroaches play vital role in nutrient recycling in many countries. The main purpose of this research is to know the biological and geographical importance of different species of cockroaches present in different areas of District Gujrat. Different approaches such as direct and indirect approach were used to capture the different species of cockroaches. After catching the cockroaches, killing Jars were used for killing them that were prepared by utilization of potassium cyanide and ethyl acetate. The preservation was important step so in this regard dry, liquid, freezing and slide preservatives techniques were used. Light microscope, hand lens and naked eyes were used to identify the different species of cockroaches based on different features. To find out the abundance of cockroaches present in different areas of District Gujrat; some statistical formulas (Simpson Index and Shannon Index's abundance formula) were used. As a result of research, 4 different species of cockroaches were mostly found in different areas of District Gujrat, namely; *Periplaneta americana*, *Blattella germanica*, *Blatta lateralis* and *Blatta orientalis*, Most frequent specie found in District Gujrat was *B. germanica* having percentage of 44.6% then *P. americana* having 35.8% and then *B. laterali* with 10.5%. Less frequent specie was *B. orientalis* with average percentage of 9.1. Availability of different species of cockroaches present in a particular area is depended on some factors such as environment temperature, humidity, food preference and habitat. For the survival of an organism in their habitat; environment temperature plays a vital role due to which German cockroach species had highest survival rate.

Keywords: Cockroach, *B. germanica*, *B. orientalis*, *B. lateralis*, *P. americana*, Gujrat, Pakistan.

INTRODUCTION

Different living organisms having species and ecosystem varieties are found on our earth (Colwell, 2009). Many species of cockroaches play a vital role in practical and scientific approach for forest management and controlling nutritious values (Chenchouni et al. 2008).

Terrestrial Blattids are other name of cockroaches and their origin goes past to carboniferous period of 400 M years. Cockroaches have same culture as of humans and recommend tropical and subtropical areas (Prabakaran et al. 2015). Appearance and size of cockroaches vary from species to species but they are flattened and oval shaped, color vary from light brown to black, size vary from 2mm to 80mm, they have large antennae up to whole body and they have pair of wings which fold over the body (Thomazini and Thomazini, 2000). Styli are very important part of the body as they

differentiate male from female cockroaches. Male cockroaches have styli on the abdomen. Mostly cockroaches run but they can also fly because of wings (Brenner et al. 1995). Immature cockroaches may have small wings or even wingless (Hashemi-Aghdam and Oshagi, 2015). Head that attach with pronotum, flat body, chewable mouth part, cerci, stylus, wings and antennae are some of the features that physically distinguish cockroaches (Triplehorn et al. 2005).

Age of cockroaches also affect their survival period as immature cockroaches may survive till ten days but adult can survive up to six weeks (Baumholtz et al. 1997).

Cockroaches are divided in to 8 families namely *Corydiidae*, *Nocticolidae*, *Ectobiidae*, *Blattidae*, *Blaberidae*, *Lamproblattidae*, *Cryptocercidae*, *Tryonicidae* and over 5000 species are known in the world (Beccaloni et al. 2013). Most of the species of

cockroaches do not have harmful effect over humans; only 50 species are pests of human culture (Cochran et al. 1980, Bonnefoy et al. 2008).

Recycling of decaying plant matters is very important role that cockroaches perform and enhance their importance (David and Ananthkrishnan, 2004), many carnivores such as lizards, rats, birds and other mammals use cockroaches as their food. Many cockroach species prefer to live in open wild areas and plays vital role in forest ecosystem (Bhoopathy, 1997). It is very necessary to have knowledge of different species of cockroaches because they are involved in many types of diseases (Kamran et al. 2017). Another important role of cockroaches in health issues is that, they can cause diseases by transferring almost 45 parasitic worms, 60 species of yeast, 150 bacterial species and 90 species of protozoa to human by several ways either physically or chemically (Tachbele et al. 2006, Saichua et al. 2008, Al-Marjani et al. 2008, Al-bayati et al. 2011, Tilahun et al. 2012, Akinjogunla et al. 2012, Goralska and Kurnatowski 2013, Vaziri-anzadeh et al. 2014).

Cockroaches prefer dirty places, i.e. toilets, sewer and dust bins for feeding and reproduction. They also cause damage by spoiling food, transmit the pathogens, cause allergy in bodies and mental distress (Brenner et al. 1995). Some species of cockroach may cause breathing disorders (Gore et al. 2007) (Arif et al. 2016). They are very helpful in research work due to some properties such as evolutionary history, environmental flexibility and omnivorous. They are also helpful in medical field because they are involved in making of some medicines e.g. *Blatta orientalis* that is used in making of homeopathic medicines used to treat respiratory disorder (Ozawa et al. 2016).

In Pakistan the knowledge about benefits, harms and types of cockroaches are very limited. One of the province of Pakistan that is Baluchistan, especially in Quetta there is some work done on some species of cockroaches. Meanwhile in whole Pakistan no proper work on identification and importance of cockroaches is done in any city (Kamran et al. 2017).

The main aim of this research is to identify various species of cockroaches in different areas of District Gujrat. This research also covers knowledge about cockroaches such as composition, abundance, cockroach types and population ratio. Gujrat is blessed with four seasons; Foggy winter starts from January and ends in March with few rain, Season of summer having period of April to June with heavy rain and heat waves, Monsoon season with period of July to September, Season of dry and pleasant autumn with duration of October to December (Punjab Meteorology Department, 2014).

Temperature plays a vital role to know about the abilities of an organism to select their desired habitat. Most of the cockroach species are easily seen or available during hot months as compare to cold months.

Cockroaches have ability to modify their bodies' temperature with their environment (Slabber et al. 2007).

For the identification purpose, many keys comprising of morphological and Taxonomic characters are used. Physical characters are mostly used for the identification (Chew et al. 2006). Various Taxonomic characters such as color, tarsus, number and shape of Spines on the femora, head frontal, wings, reproductive Organs were used for the identification (Hashemi-aghdam and Oshaghi, 2015).

There is no work done on cockroaches to determine their geographical regions in District Gujrat. So for this reason there is a lot of work to be done on cockroaches in District Gujrat and Punjab. There is no detailed scientific work performed on biodiversity of cockroaches in Pakistan yet. Furthermore, complicated statistical biodiversity index (Shannon - wiener index and Simpson) was used in this research along with observation and identification of cockroaches. This research work was done to identify the species of cockroaches in district Gujrat, Punjab that occur in Pakistan. Main purpose of this research was to find the biodiversity of cockroach species in different regions of district Gujrat and to know the occurrence of different species of cockroaches that were present in different localities of district Gujrat.

MATERIALS AND METHODS

Chemicals and Materials

Chemicals that were utilized in this research work; Ethyl acetate, Ethyl alcohol, Potassium cyanide and Plaster of Paris along with water.

Materials that were utilized in this experimental work; Camel hair brush, gloves, paper tubes, boxes for preservation, envelopes, beakers, killing jars, shopping bags, food baited pitfall traps, sticky traps, nets, aspirators, insect pins, microscope, hand lens, cotton, cloth, cockroaches, fiber board and insect pinning wooden box.

Study location

Research work was done in rural and urban areas of district Gujrat inhibited between 32°34' 59.99 " N and 73° 44' .59.99 " E that was found between the river Jhelum and river Chenab having population of 390533 (Table 1).

Sample collection

During this research work, total 2638 samples of cockroaches were gathered from 15 sites of four tehsils of district Gujrat.

Table 1: Global Positioning System of Study Site

Serial No.	Study Site	Latitude	Longitude
1.	Aleena center mall Gujrat	32.5921° N	74.0806° E
2.	Abdullah mall Gujrat	32.5843° N	74.0800° E
3.	Kharian mall	32.6042° N	74.1667° E
4.	Aziz Bhatti hospital Gujrat	32.5921° N	74.0806° E
5.	THQ hospital Sarai Alamghir	32.9000° N	73.7500° E
6.	Zamindara College Gujrat	32.5921° N	74.0806° E
7.	University of Gujrat	32.6355° N	74.1592° E
8.	Biowali High school Gujrat	32.6480° N	74.2121° E
9.	Hanjra girls primary school Gujrat	32.6355° N	74.1592° E
10.	GGPS Madina No.2 (school)	32.5921° N	74.0806° E
11.	GGPS Ghuman near Jalalpur jattan (school)	32.6480° N	74.2121° E
12.	Education women Office Gujrat	32.5842° N	74.0766° E
13.	Khohar Village near Sarai Alam Ghir	32.8062° N	73.6463° E
14.	Spall colony Gujrat	32.5798° N	74.0836° E
15.	Pabbi Forest Park of Kharian	32.8119° N	73.8655° E

These areas were Schools, hospitals, parks, houses, shopping malls, streets, sewages, villages/towns, residential areas and many other institutes selected for collection of cockroaches during 2017-2018. Traps were placed in each residential areas i.e. bed rooms, bathrooms, living rooms, kitchens, galleries, porches, store rooms and also placed traps in canteen, store rooms and kitchens of hospitals and offices/ institutes.

These cockroaches were collected by using various materials i.e. sticky traps, Camel hair brush, gloves, paper tubes, envelopes, shopping bags, food baited pitfall traps, nets, aspirators and also used hands through direct catching. After collection of cockroaches, these cockroaches were shifted to entomological laboratory of University of Gujrat within 48 hours for identification of cockroach's species with the help of published keys (Hashemi-Aghdam and Oshaghi, 2015).

Killing Jars

Cockroaches were sampled in purified empty bottles and then transferred in killing jar one by one. Total eight killing jars were prepared in entomological laboratory of Zoology department, Faculty of science, university of Gujrat. Four killing jars were get ready by using ethyl acetate and others four prepared by potassium cyanide.

Methods of preparing killing jars

Plaster of Paris having layer of one centimeter was kept in small empty jar for absorption of killing agent. 25 g of potassium cyanide was added in same jar then droplets of water were included in jar. Again Plaster of Paris was

added in next step and then droplet of water was mixed. At the end, jar was covered with cloth piece (Memoona et al. 2016).

First of all, Cotton piece was kept in empty jar then ethyl acetate was thrown in the jar over the piece of cotton, after that jar was covered with cloth piece. At the end, more ethyl acetate was sprinkled over cloth piece (Memoona et al. 2016).

Preservation of sample

Samples of cockroaches were preserved after killing in killing jars by using the four famous methods; Refrigeration and freezing, dry preservation, liquid preservation and slide preservation.

Identification of samples

Light power microscopes and hand lens were used for identification of cockroaches' samples on the basis of taxonomic keys and morphological characters (Chew et al. 2006). Samples that were collected; analyzed and identified by using specific keys of Hashemi-Aghdam and Oshaghi (2015), according to taxonomic features: Color, wings, Head frontal, Tarsus, reproductive organs, Number and shapes of spines on the femora.

Preservation of Identified species

Identified species were preserved by specific method of pinning (Martin, 1977) in which specially designed insects Pins (No.2 and No.3) were used to support the cockroaches without damage of their bodies. These identified cockroaches were remained preserved for at least three weeks on fiber board so that they can be dry enough.

Labelling

Accurate and valid labelling was done on each identified sample of cockroach in parallel position and uniform size by using the computer generated format on each specimen. (Elzinga, 2000).

Sample of labelling is shown below:

<p><i>P. americana</i> Pakistan, Gujrat, Khohar S.A II-4-17 Saleem N.</p>

Preservation in insect box

After passing through the stages of proper procedures of collection, killing, preservation, identification and pinning along with labeling, specimens were displayed in specially designed insect box in proper way.

Exhibition of specimen in insect box

These identified specimens were started to arrange in insect box having glass cover for easy examination in proper manners: from upper top left hand corner to right and align in top to bottom. Specimens were displayed in straight line with same species in front of family name. Sample is listed below:

Family Blattidea	<i>P. americana</i>	<i>P. americana</i>
Family Blattidea	<i>B. lateralis</i>	<i>B. lateralis</i>
Family Blattidea	<i>B. orientalis</i>	<i>B. orientalis</i>
Family Blatellidea	<i>B. germanica</i>	<i>B. germanica</i>

RESULTS

During this research work in period of April 2017 – March 2018, total four species of cockroaches were identified from four tehsils of district Gujrat. These all are belong to only two families i.e. Blattidea and Blatellidea.

Identification of *Blattella germanica* (German Cockroach)

This species is belonging to family Blattellidae. It was the most prevailing species during this research work having percentage of 44.6 of all-out catch. These species were available in kitchens especially on food stock gathering and preparing areas.

Identification of *Periplaneta americana* (American Cockroach)

This species is belonging to family Blattidae. It was in second number in abundance after the *B. germanica* having percentage of 35.8 of all-out catch. These species were mostly found in sewers around the funnels and depletes.

Identification of *Blatta lateralis* (Turkestan Cockroach)

This species is belonging to family Blattidae. These cockroaches were found in gardens areas. It was third in number regarding abundance after the *P. americana* having percentage of 10.5 of all-out catch during this research.

Identification of *Blatta Orientalis* (Oriented Cockroach)

This species is belonging to family Blattidae. These species were present underneath the leaf litters, trashes, stones areas and near the messy materials. It was fourth in number regarding abundance after the *B. lateralis* having percentage of 9.1 during this research (Table 2).

Table 2: Distribution of 4 species of cockroaches during whole study

Sr. No.	Species	No. of cockroaches trapped	Percentage %
1	<i>B. germanica</i>	1177	44.6
2	<i>P. americana</i>	943	35.8
3	<i>B. lateralis</i>	278	10.5
4	<i>B. orientalis</i>	240	9.1
Total		2638	100

Abundance of species gender wise in district Gujrat

During this research work, it was analyzed that male species of cockroaches are more in quantities than female species. Behind reason of it is that: female specie is less active and present in deep holes for fulfillment of reproductive tasks but male species are busy in searching of their mates due to which male species are more active and more in quantities than female species (Table 3).

Period wise Average temperature and relative percentage of Humidity during April 2017 to March 2018

Number of trapped cockroaches was analyzed and compared period wise by relating with humidity and four seasonal temperatures (Table 4).

Biodiversity of cockroaches during period of April 2017 to March 2018

During this research work, varieties of cockroaches were observed and identified in four periods under special temperature and humidity.

Table 3: Abundance of species gender wise in district Gujrat

Sr. No.	Species	No. of male cockroaches trapped	Percentage %	No. of female cockroaches trapped	Percentage %	Total No. of male and female cockroaches
1	<i>P. americana</i>	612	64.9	331	35.1	943
2	<i>B. lateralis</i>	181	65.1	97	34.9	278
3	<i>B. orientalis</i>	155	64.6	85	35.4	240
4	<i>B. germanica</i>	787	66.9	390	33.1	1177
Total		1735	65.4	903	34.6	2638

Table 4: Period wise Average temperature and relative percentage of Humidity during April 2017 to March 2018

Period	Average temperature °C		Average relative Humidity %	No. of Trapped Cockroach	Percentage %
	Minimum	Maximum			
1st (April-June)	24	37	47	876	33.2%
2nd (July-Sept)	24.4	36	77	1316	49.9%
3rd (Oct-Dec)	16	25	73	294	11.1%
4th (Jan-March)	5	21	64	152	5.8%

First Period (April 2017 – June 2017)

Estimated temperature varied from 24 °C to 37 °C with average humidity of 47 % during the first period that was started from month of April and year of 2017 then ended on month of June and year of 2017. Due to seasonal reproduction, nymph species were much more as compare to adults.

Second Period (July 2017 – September 2017)

Estimated temperature varied from 24.4 °C to 36 °C with average humidity of 77 % during the second period. Season of summer was on peak due to which cockroaches were moved from cervices and stated to stay in sheltered areas. It is desired season of metamorphosis during this period in which nymph species were converted in to adults of cockroaches. It was noted that different cockroach species have

different period of metamorphosis due to which species abundance was different for different species.

Third Period (October 2017 – December 2017)

Minimum estimated temperature was 16 °C and maximum estimated temperature was 25 °C with relative humidity of 73 % during duration of 1st October 2017 – 31st December 2017. Season of winter was on peak. Location of cockroach was cervices sheltered region due to which dormancy rate was lower than other periods.

Fourth Period (January 2018 – March 2018)

Estimated temperature varied from 5 °C to 21 °C with average humidity of 64 percentages during the fourth period. Detail of collected species has mentioned in below (Table 5) (Figure 1).

Table 5: Biodiversity of cockroaches during period of April 2017 to March 2018

Sr. No	Species	No. of trapped cockroaches in First Period	No. of trapped cockroaches in second Period	No. of trapped cockroaches in third Period	No. of trapped cockroaches in Fourth Period
1	<i>P. americana</i>	303	471	111	58
2	<i>B. lateralis</i>	80	146	33	19
3	<i>B. orientalis</i>	89	111	27	13
4	<i>B. germanica</i>	404	588	123	62
Total		876	1316	294	152

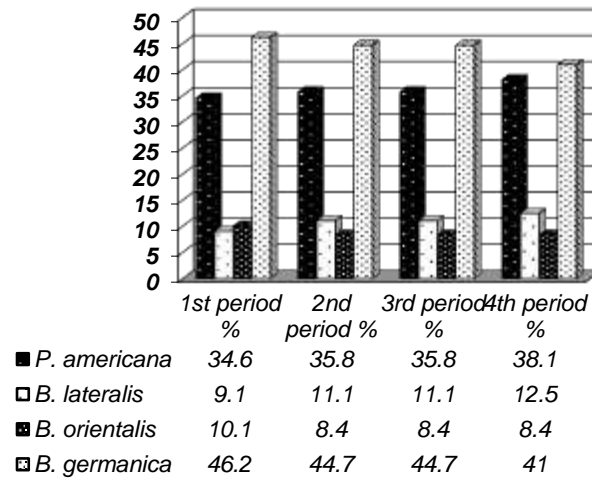


Figure 1: Period wise Comparison of each identified species of district Gujrat.

Identification of cockroach species from various localities

P. americana and *B. orientalis* were found outside but they can enter the houses and other residence through the holes and pipes, meanwhile *germanica* and *lateralis* species were considered inside because *germanica* species infected residential areas more than others. Detail of cockroach species that were infected the particular areas are listed (Table 6) (Figure 2).

Statistically measuring the biodiversity of cockroaches

It was much complicating method to statistically measure the biodiversity of that species. Two main indexes were used that time: Shannon - wiener index and Simpson index (Magurran, A.E., 2004). In this research, specific biodiversity of cockroach species were classified that was not classified in detail in Pakistan yet. Not a single scientific work on biodiversity of cockroaches was done in District Gujrat. This work helped in observation, identification and also determination of biodiversity index of species of cockroaches. Detail is listed period wise and collectively too (Table 7,8,9,10,11).

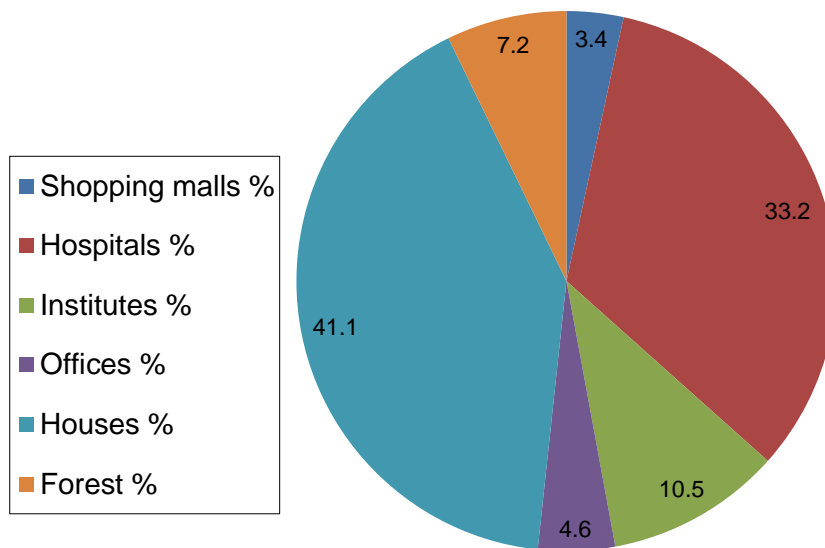


Figure 2: Dominancy of sampled cockroaches in different study sites

Table 6: Identification of cockroach species from various localities

Sr. No	Species	Shopping malls %	Hospitals %	Institutes %	Offices %	Houses %	Forest %	Total %
1	<i>P. americana</i>	1.4	12.1	3	2	15.1	1	34.6
2	<i>B. lateralis</i>	-	0.1	2	1	2	4	9.1
3	<i>B. orientalis</i>	-	-	3.5	0.6	6	-	10.1
4	<i>B. germanica</i>	2	21	2	1	18	2.2	46.2
5	Total	3.4	33.2	10.5	4.6	41.1	7.2	100

Table 7: Statistically measuring the biodiversity of cockroaches in first period

Sr. No	Species	No. of identified cockroach Species (N)	Abundance of species $P_i = n_i/N$	Shannon Index ($H' = -\sum P_i \ln P_i$)		Simpson Index ($D = \sum n_i(n_i-1)/N(N-1)$)	
				$\ln P_i$	$P_i \ln P_i$	$n_i(n_i-1)$	$N(N-1)$
1	<i>P. americana</i>	$n_1 = 303$	$303/876 = 0.34$	-1.08	-0.37	$(303)(302) = 91506$	766500
2	<i>B. lateralis</i>	$n_2 = 80$	$80/876 = 0.09$	-2.41	-0.22	$(80)(302) = 6320$	766500
3	<i>B. orientalis</i>	$n_3 = 89$	$89/876 = 0.102$	-2.29	-0.233	$(89)(302) = 7832$	766500
4	<i>B. germanica</i>	$n_4 = 404$	$404/876 = 0.46$	-0.77	-0.35	$(404)(302) = 162812$	766500
Total		$N = 876$	$P_i = 0.99$		-1.17	268470	
				$H' = -\sum P_i \ln P_i = 1.17$		$D = 0.350$ $1-D = 0.65$	

Table 8: Statistically measuring the biodiversity of cockroaches in second period

Sr. No	Species	No. of identified cockroach Species (N)	Abundance of species ($P_i = n_i/N$)	Shannon Index ($H' = -\sum P_i \ln P_i$)		Simpson Index ($D = \sum n_i(n_i-1)/N(N-1)$)	
				$\ln P_i$	$P_i \ln P_i$	$n_i(n_i-1)$	$N(N-1)$
1	<i>P. americana</i>	471	0.35	-1.05	-0.37	2214	173054
2	<i>B. lateralis</i>	146	0.11	-2.21	-0.243	2117	173054
3	<i>B. orientalis</i>	111	0.08	-2.53	-0.202	1221	173054
4	<i>B. germanica</i>	588	0.4	-0.92	-0.37	34515	173054
Total		$N = 1316$	$P_i = 0.94$		-1.18	9003	
				$H' = -\sum P_i \ln P_i = 1.18$		$D = 0.052$ $D = 1 - D = 0.95$	

Table 9: Statistically measuring the biodiversity of cockroaches in third period

Sr. No	Species	No. of identified cockroach Species (N)	Abundance of species ($P_i = n_i/N$)	Shannon Index ($H' = -\sum P_i \ln P_i$)		Simpson Index ($D = \sum n_i(n_i-1)/N(N-1)$)	
				$\ln P_i$	$P_i \ln P_i$	$n_i(n_i-1)$	$N(N-1)$
1	<i>P. americana</i>	111	0.38	-0.97	-0.37	1221	86142
2	<i>B. lateralis</i>	33	0.11	-2.21	-0.24	1056	86142
3	<i>B. orientalis</i>	27	0.09	-2.41	-0.22	702	86142
4	<i>B. germanica</i>	123	0.42	-0.87	-0.36	15006	86142
Total		294	1		-1.19	15468	
				$H' = -\sum P_i \ln P_i = 1.19$		$D = 0.1796$ $1-D = 0.82$	

Table 10: Statistically measuring the biodiversity of cockroaches in fourth period

Sr. No	Species	No. of identified cockroach Species (N)	Abundance of species ($P_i = n_i/N$)	Shannon Index ($H' = -\sum P_i \ln P_i$)		Simpson Index ($D = \sum n_i(n_i-1)/N(N-1)$)	
				$\ln P_i$	$P_i \ln P_i$	$n_i(n_i-1)$	$N(N-1)$
1	<i>P. americana</i>	58	0.38	-0.97	0.3686	3306	22952
2	<i>B. lateralis</i>	19	0.125	-2.08	0.26	342	22952
3	<i>B. orientalis</i>	13	0.08	-2.53	0.202	156	22952
4	<i>B. germanica</i>	62	0.41	-0.89	-0.36	3782	22952
Total		152	$P_i = 0.99$		-1.19	7586	
				$H' = -\sum P_i \ln P_i = 1.19$		$D = 0.33$ $1-D = 0.99$	

Table 11: Statistically measuring the biodiversity of cockroaches during whole study

Sr. No	Species	No. of identified cockroach Species (N)	Abundance of species ($P_i = n_i/N$)	Shannon Index ($H' = -\sum P_i \ln P_i$)		Simpson Index ($D = \sum n_i(n_i-1)/N(N-1)$)	
				$\ln P_i$	$P_i \ln P_i$	$n_i(n_i-1)$	$N(N-1)$
1	<i>P. americana</i>	943	0.36	-1.02	-0.37	8883	6956
2	<i>B. lateralis</i>	278	0.10	-2.30	-0.23	7701	6956
3	<i>B. orientalis</i>	240	0.09	-2.40	-0.22	5736	6956
4	<i>B. germanica</i>	1177	0.44	-0.82	-0.36	1384	6956
Total		2638	$P_i = 0.99$		-1.18	14065	
				$H' = -\sum P_i \ln P_i = 1.18$		$D = 0.002$ $1-D = 0.99$	

DISCUSSION

During the studies it was found that Turkestan and German species were more obvious in kitchens, bedrooms, cafeterias and store rooms. The main reason of occurrence was the temperature and shaded areas. Some of the species of American and Oriental preferred to live in washrooms, gardens close to houses, sanitary and kitchen pipes because they get preferred food and environment. Turkestan and German species preferred inside, American and Oriental cockroach species preferred outside environment.

In District Gujrat, German cockroach species were more abundant due to favorable temperature, humidity, food and habitat. On the other hand Turkestan and Oriental species were fewer in numbers because temperature, humidity, food preference and habitat do not suit them much.

During this research it was realized that cockroach species bend according to environment temperature. Cockroach had ability to adjust themselves according to the temperature. Cockroach may survive even in cold temperature due to the ability to adaptation of environmental changes, although less amount of cockroach survives in third and fourth cold period. Cockroach also modifies the body temperature according to the environmental temperature. Many modern studies relieve the relationship of cockroach survival and environmental temperature (Tsuji and Mizumo, 1973, Appel et al. 1983, Slabber et al. 2007).

The specie of cockroach that was mostly used in research was *B. germanica*. In July – September 2013 the biodiversity of cockroach was on high level which was determined by using the Simpson and also Shannon index. Other than *B. germanica*, the second most important specie of cockroach in terms of research was *P. americana* followed by *B. orientalis*, whereas *B. lateralis* was distributed intermediately in domestic areas and little bit dispersed into hospitals. *Germanica* was highly found in domestic areas and hospitals. The population of *Germanica* was double than the population found in suburban areas. (Riaz, 2017).

Cockroaches were found in causing food poisoning, stomach diseases and dysentery. Cooking shops,

bakeries and grocery stores were the main habitat of *P. americana*. Storage room, food processing plants and restaurants were the main habitat of *B. germanica* Species. German cockroach can spread bacteria toxic to food because they interact with feces. They were attracted to animal and human waste, decaying material, corpse excretions sputum, urine, and in this way gives the general public a merited disgust influence. Cockroach can also be helpful because it can be used against antibiotic – resistant bacteria. Past studies revealed that open-air cockroaches were potential medically important parasite vectors (Fotedar et al. 1991, Cloarec et al. 1992).

In District Gujrat, no work is still done in collecting and determining of cockroach species. So a systematic research is needed to know the number of species present in District Gujrat along with its importance.

Thus study helps in identification, observation and determination of different species of cockroach present in District Gujrat as there is no work done in this field.

CONCLUSIONS

As we know that biodiversity is concerned with the all types of varieties of living organisms present on the earth. The climate conditions of district Gujrat are very diverse due to which it is helpful to all types of living organisms i.e. plants, animals, micro-organisms etc. The climate conditions of District Gujrat are very helpful for the development and reproduction of cockroaches as the temperature is very suitable. The environmental conditions also help the cockroaches to develop their habitat very well. That's why German cockroaches were highest survival rate due to suitable temperature, humidity, habitat and their food preference that was available in Gujrat. There was no scientific research work done on species of cockroach in district Gujrat, even in nearby district of Gujrat. This work will help the researchers for further morphological and anatomical identification of cockroach and can be performed in other districts too.

Supplementary materials

The supplementary material / supporting for this article can be found online and downloaded at:

<https://www.isisn.org/article/>

Author contributions

N.S. Conducted the research work, methodology, data analysis along with results and wrote the manuscript. I.B. supervised the project. S.Z. and A.M. proof read and guided in writing-review. All authors provided positive feedback and agreed to the published this manuscript.

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Institutional Review Board Statement

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Informed Consent Statement

Not applicable.

Data Availability Statement

The original data associated with these findings are available from the corresponding author upon request.

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Conflict of interest

The authors declared that present study was performed in absence of any conflict of interest.

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