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**PREVALENCE, SPECIES COMPOSITION AND SPATIAL
DISTRIBUTION OF COCKROACHES AS INFECTIOUS
DISEASES VECTOR IN AHVAZ, SOUTHWEST IRAN**

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ABSTRACT

Background: Cockroaches are a serious health problem in urban areas which transmit infectious diseases pathogens and also intensify allergic reactions in human beings. The aims of this study were to evaluate the prevalence and spatial distribution of cockroaches in residential houses in Ahvaz city, Iran. This cross-sectional study was done in 520 randomly selected residential houses in 52 areas of Ahvaz city during 2017.

Methods: Cockroaches were caught using sticky traps. Traps were collected after a week and transferred to the Medical Entomology laboratory and data was records through a checklist. Species were identified by the identification key. Spatial distribution was investigated through Arc GIS 9.3 software.

Results: The collected cockroach species from residential houses in Ahvaz city were identified as *Blatella germanica* (25.8%), *Periplaneta americana* (11%), *Supella longipalpa* (5.6%), *Blatta lateralis* (3.3%) and *Blatta orientalis* (2.7%). The prevalence rate of cockroaches' infestation was 36.3% in Ahvaz city. Cockroaches' infestation was recorded from 49 out of 52 study areas in Ahvaz city except for Naft, Fulad and Polis areas. In total, 94% of the

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sampled areas were infected with cockroaches. Of 520 residential houses, 189 (36.3%) were infected and 331 (62.7%) showed non-cockroach infestation. Of the infected houses, 11.1%, 66.7% and 22.2% had low, moderate and severe cockroach infestation. The average of adults and nymphs at infected houses was respectively founded to be 37.5, 10, 2.5 and 102.8, 32.7, 17.

Conclusion: Digital maps will provide authorities more information about the high risk areas that would assist in the control activities.

INTRODUCTION

Cockroaches as a serious health problem are prevalent in dwellings, hospitals, hotels, restaurants, food stores, office buildings and other places. In hospitals, due to the availability of suitable temperatures and adequate food and shelter, they distribute in different parts, including patients' room, surgery department, kitchen, laundry and other places. Among nearly 4,500 cockroach species, only 30 species are identified in close to the human habitats (1). Due to dirty habits of getting their food from feces, sputum, vomiting, spit and other food sources and undesirable secretions, they are responsible for mechanical transmission of many diseases including almost 60 species of yeast, 150 bacterial species, 45 species of parasitic worms and 90 species of protozoa to human life either biologically or mechanically (2-4). Cockroaches can also intensify allergic reactions such as skin discomfort, itching, swelling of the eyelids and severe respiratory problems. Salivary, feces and skin caused by the cockroaches molting are the sources of allergy and stimulation of allergic and asthmatic reactions in individuals, especially children. Approximately 40-60% of asthmatic patients living in urban areas have increased their antibodies due to their cockroach sensitivity (5-7). Only allergens from the German and American cockroaches have been officially recognized and named according to World Health Organization, but they have been identified in several cockroach species (7).

Due to medical importance of cockroaches and their widespread prevalence in dwellings, it is necessary to determine their spatial and temporal distribution and providing digital maps of distribution in order to adopt proper prevention and control strategies. Today, Geographic Information System (GIS) is developed to collect, store, retrieve, and update, analyze, present and display geographic information (spatial data). One of the GIS application, which is widely used today in the

world, is to inform and assist in decision-making in the health and medicine management and the prevention of the occurrence, prevalence and control of various disease (8, 9). Its applications in health sciences include the study of the geographical distribution of diseases, the analysis of spatial and temporal changes, mapping of populations at risk of health problems, locating for the development and distribution of health facilities and evaluating them, designing and planning to improve the health situation in a region. Also, the monitoring of diseases to control and counteract them based on the timeline identifies and evaluates the factors affecting the emergence and expansion of health risk is the cases of GIS application (10).

In the best of our knowledge, there are no studies on spatial distribution of cockroach infestation in the Southwest of Iran. The objective of this study was to evaluate the spatial distribution of cockroach infestation in human dwellings using GIS in Ahvaz city, during 2017. In additionally, we determined the cockroach infestation prevalence in infested houses in Ahvaz city.

METHODS

Study Area and Cockroach Sampling

Ahvaz is a city found in Khuzestan, Iran (Figure 1). It is located 31.32 latitude and 48.68 longitude and it is situated at elevation 23 meters above sea level. Ahvaz has a population of 1.1 million making it the biggest city in Khuzestan province southwest Iran.

Cockroaches were sampled from 520 houses from 52 areas located in the Ahvaz, Khuzestan province, southwest Iran in 2017. The houses were randomly selected in four geographic directions of north, south, east and west of Ahvaz city.

Sticky trap were used for cockroaches sampling. The traps were placed inside the kitchen cabinets, under the cabinets, under the dishwasher, the border of the walls of the bedroom, behind the refrigerator, next to the trash bin, around the sewage manhole and wherever it's possible to run a cockroach. Traps were collected after a week and transferred to the Medical Entomology laboratory and data was records through a checklist. Cockroach species were identified using the identification key (11). The severity of adult cockroach infestation was categorized into three groups (12), (Table 1).

Ethical consideration

This study received ethical approval from the Ahvaz Jundishapur University of Medical Sciences (AJUMS) and Ethics Committee

(IR.AJUMS.REC.1395.619). All heads of household provided written informed consent for sampling in living areas. Results were presented back to Social Determinants of Health Research Center, Ahvaz Jundishapur University of Medical Sciences and Department of Medical Entomology and Vector Control, School of Health, Ahvaz Jundishapur University of Medical Sciences.

Spatial Analysis

Geographic coordinates of the selected houses were recorded using GPS. Then the points were registered in the Excel file, and after adding the collected and identifying species to the points, the data were transferred to the Arc GIS 9.3 software. City maps that use the UTM system were used to prepare the spatial dispersion map and the frequency of caught species.

RESULTS

Cockroach identification and prevalence

The cockroach specimens collected from residential houses in Ahvaz city were belonging to five species, four genus and two families. The identified species were *Blattella germanica* (Germanica), *Periplaneta Americana* (American), *Supella longipalpa* (Brown-banded), *Blatta lateralis* (Turkistan) and *Blatta orientalis* (Oriental). The cockroaches' infestation rate was 36.3% in Ahvaz city. *B. germanica* was the dominant species comprising of 25.57% of the total collected specimens followed by *P.americana* (11.34%), *S. longipalpa* (5.19%), *B. lateralis* (3.92%) and *B. orientalis* (3.98%) (Figure 2). Of the infected houses, 11.1%, 66.7% and 22.2% had low, moderate and severe cockroach infestation with an average of 37.5, 10 and 2.5 adults/ house and 102.8, 32.7 and 17 nymphs/ house. Cockroach infestation was recorded from 49 out of 52 study areas in Ahvaz city except for Naft, Fulad and Polis areas. In other words, 94% of the sampled areas were infected with cockroaches. Of 520 residential houses, 189 (36.3%) were infected and 331 (62.7%) showed non-cockroach infestation.

Infestation rate of different species at the sampling areas is shown in Figure 3. The most cockroaches infected areas were found in Chonaybeh followed by Bahonar and Modares with 70%, 65% and 60% infestation rate, respectively (Figure 3). At least, three species of cockroaches were active in these areas. On the other hand, as seen in the figure, German cockroach was collected from most areas. None of the cockroach species were collected and reported from Naft, Police and Foulad areas. Spatial distribution maps

were provided for three species of *B. germanica*, *P. americana* and *S. longipalpa*. The *B. lateralis* and *B. orientalis* species had the minimum prevalence (less than 5%), so, spatial distribution maps of mentioned species was not surveyed.

B. germanica distribution map

Spatial distribution map of *B. germanica* in Ahvaz city is shown in Figure 4. This species has shown a wide distribution in the city with the infestation rate of 25.8%. It was collected from 133 infested houses in 45 out of 52 studied areas except for Goldasht, Keryshan, Razmandegan and Shahed areas. The highest infestation rate of German cockroach was observed in Bahonar, Modares, Padad and Kampolo areas with 38-40% infestation rate. This species was more active in the apartments and was mainly collected from the kitchens. Relative density of different growth stages of this cockroach was recorded as 17.5 adults / home and 52.5 nymphs / home which confirmed the severe infestation of the residential buildings with this species.

P. americana distribution map

In the Figure 5 spatial distribution map of *P. americana* in Ahvaz city is provided. It was less distributed than the German cockroach. The infestation rate of this cockroach species was 11.34% in the residential buildings. It was activated in 32 out of 52 studied areas and collected from 59 infested houses. This species was mainly trapped in toilet and around the sewage manhole at the yard. The American cockroach was mainly caught from Golestan and Barq, Asiabad and Chonaybeh areas with 20-27% infestation rate. The least dispersion of this species was shown in Kampolo area (less than 10%). In the Goldasht area, *P. americana* was the only active species. Overall, relative density of this cockroach was recorded as 6.5 adults/home and 19.5 nymphs/home which cleared the medium infestation of residential buildings with this cockroach species.

S. longipalpa distribution map

The brown-banded cockroach, *S. longipalpa*, showed the low distribution in residential houses in Ahvaz city (Figure 6). This cockroach was collected from 15 areas and 27 infested houses out of 520 ones. The most distribution of this species was recorded from Keryshan area (30%) and the least distribution was seen in Razmandegan area. Relative density of the brown-banded cockroach was recorded as 4 adults/home and 16.3 nymphs / home which showed the low infestation at residential buildings.

DISCUSSION

Nowadays, global connectivity including travelling and trading caused humans are known as the new vectors of infectious agents. Humans move long distances at faster speeds than can be achieved by any pathogen or vectors. Therefore, the need to develop global disease early-warning systems (DEWS) urgently is increasing. Rapid developing tools: such as RS imagery within a GIS now offers greater power for describing, explaining and predicting epidemiological phenomena towards the past (13). In spite of widespread use of GIS in predicting the spatial risk level of many vector-borne diseases such as leishmaniasis, malaria, dengue fever, West Nile Virus, Lyme borreliosis, TBE and the spatial distribution of the vectors such as sand flies, ticks, mosquitoes, black flies (14-20), the application of this technology to provide the spatial dispersion of urban pests such as bed bug, cockroach, flea, lice and related diseases or health problems is limited. This is the first study using GIS technology to determine the spatial distribution of cockroaches and to provide their digital maps in Iran and probably around the world. The advantages of GIS for vector controller and field biologists are to store, visually analysis, produce maps of disease and disease distribution and analyzing spatial patterns of diseases distribution. These maps have been used as tools for developing control and intervention strategies (21, 22).

Many studies have been conducted to determine the prevalence rate of cockroach infestation and to identify cockroach species with various findings (23-30), but none of them have provided digital maps of cockroach distribution. Such maps will provide the authorities with more information about the risk areas that would assist in the control programs.

We collected five species of *B. germanica*, *P. americana*, *S. longipalpa*, *Blatta lateralis* and *B. orientalis* and provided the distribution maps of the three more active cockroaches in residential buildings in Ahvaz city during 2017. German cockroach was the most prevalent species. In a study in urban areas of Yasuj city, 5 species of *B. germanica*, *B. lateralis*, *B. orientalis*, *P. americana* and *S. longipalpis* were collected and identified from residential homes, dormitories, hospitals. The most abundant species was *B. germanica*. These results are consistent with the results of our study of the identified species and predominance of German cockroach in human dwellings(31).

B. germanica have been showed as the most frequent species in the human dwellings in Iran followed by *P. americana* (32, 33). Also, the German cockroach has

been introduced as a dominant species in urban areas around the world in many previous studies which confirm our results (23, 24, 26, 29, 30).

The prevalence rate of cockroach infestation in Ahvaz city was 36.3%. Of the infected houses, 11.1%, 66.7% and 22.2% had low, moderate and severe cockroach infestation. The rate of cockroach infection was reported to be 67.5% in Shahin Shahr City. 46%, 30% and 24% of homes had low, medium and sever infestation, respectively (31). The difference in the results can be attributed to the sampling tools, public health level, quality of buildings, and people's awareness of cockroach prevention and control. In the present study, sticky trap was used as recommended tool for determining cockroach infestation, while data collection was carried out using a questionnaire by Dehghani et al. However the global infestation trend of cockroaches is being increased as the mean of cockroach infestation in the human environments and world were 60.4% and 57.7%, respectively (31). The infestation rate in Ahvaz city was lower than the global average of cockroach infestation in human environments that may be due to non-sampling of hospitals, restaurants, food stores, which are appropriate habitat for domestic cockroaches.

A total of 4 species of German, Oriental, American and brown-banded cockroaches were collected from hospitals in Ahvaz city during 2013. The highest frequency was related to American, Oriental, German, and brown-banded cockroaches, respectively (29), whereas in this study five species of cockroaches were collected from human dwellings and the German cockroach was determined as the most prevalent species. Differences in the results can be attributed to differences in sampling location (hospital and residential buildings), cockroach habitat preference, cockroach entry pathways, and sampling season. We found the American cockroach as outdoor species in toilet and around the sewage. Memona *et al.* pointed that sanitary pipe, washrooms, sewerage pipe and kitchen excite pipe as rich resource of food are known the usual habitat of this species (34).

Some factors such as sanitation and quality of the buildings, awareness and knowledge of people about biology, behavior and control strategy of cockroaches, resistance to insecticides affect the infestation rate of cockroaches (33, 34). Recent studies also indicate that the prevalence of asthma has increased dramatically over the decades suggest that infestation of cockroaches can directly affect the development of asthma (35). The role of cockroaches in mechanical transmission of human pathogens and the etiologic role of cockroach antigen in respiratory diseases has been proved in many studies (5, 23, 30). The increasing trend of asthma disease in

Ahwaz city during recent years and the favorable climate conditions for spread of the infectious diseases increased the need to provide spatial distribution maps of cockroach and to determine their infestation rates as the vector, agent or stimulus of the mentioned diseases.

Moreover, the fauna of Iranian cockroach reported as three families, 14 genera, and 26 species (1) and there is not any report about some species recently, hence we suggest designing the systematic research in the wide areas and different parts of the county and mapping the obtained data by ArcGIS software.

CONCLUSION

The use of GIS in health as an evaluation tool can provide an additional means of spatially analyzing outputs which can be readily understood by field workers and pest control program managers. With the digital distribution map of cockroaches, it is possible to identify the areas with high infestation and to increase awareness, knowledge and practice of public about their medical importance pests through workshops, seminars and presentation of educational programs provided by health centers.

Conflict of interest

The authors declare that they have no conflict of interest.

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Table 1. Checklist administered by investigator to evaluate the bed bug infestation level.

Category	Description
<input type="checkbox"/>	Low There are less than 5 adult cockroach in house.
<input type="checkbox"/>	Moderate There are 5 to 15 adult cockroach in house.
<input type="checkbox"/>	Severe There are more than 15 adult cockroach in house.

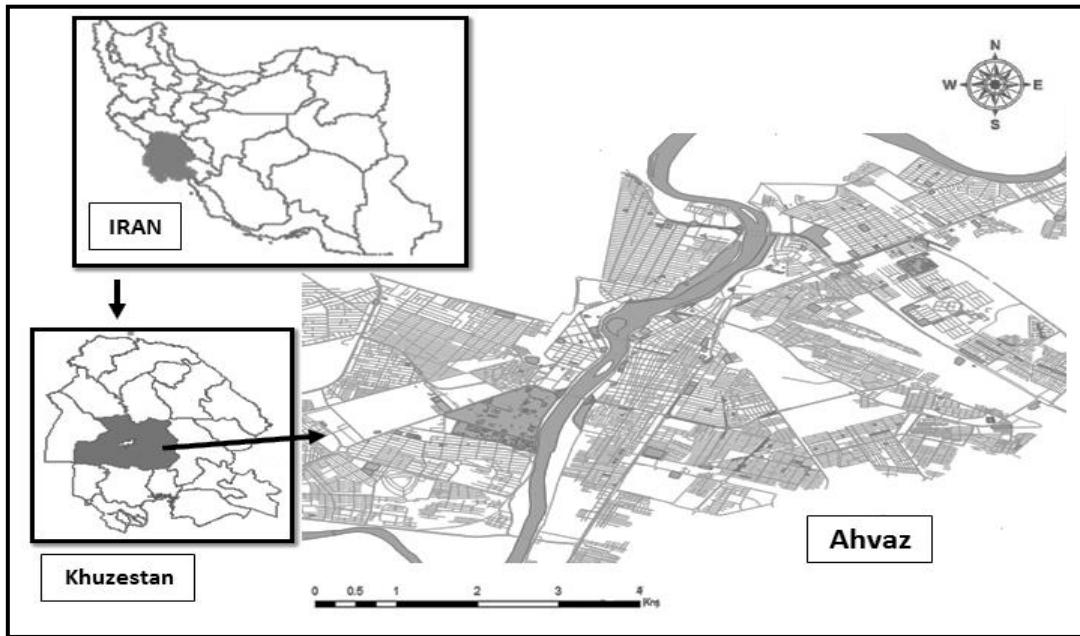


Fig. 1: Map of the study area during 2017.

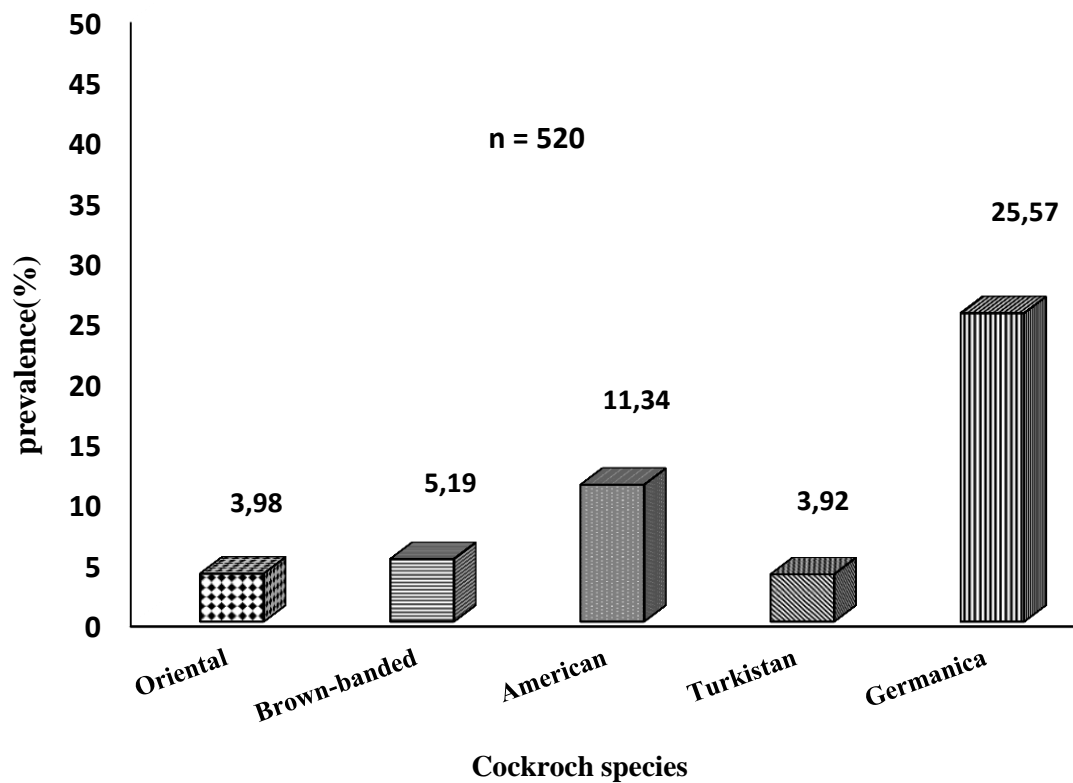


Fig. 2: Prevalence rate of cockroach species collected from residential houses in Ahvaz city, southwest Iran, 2017.

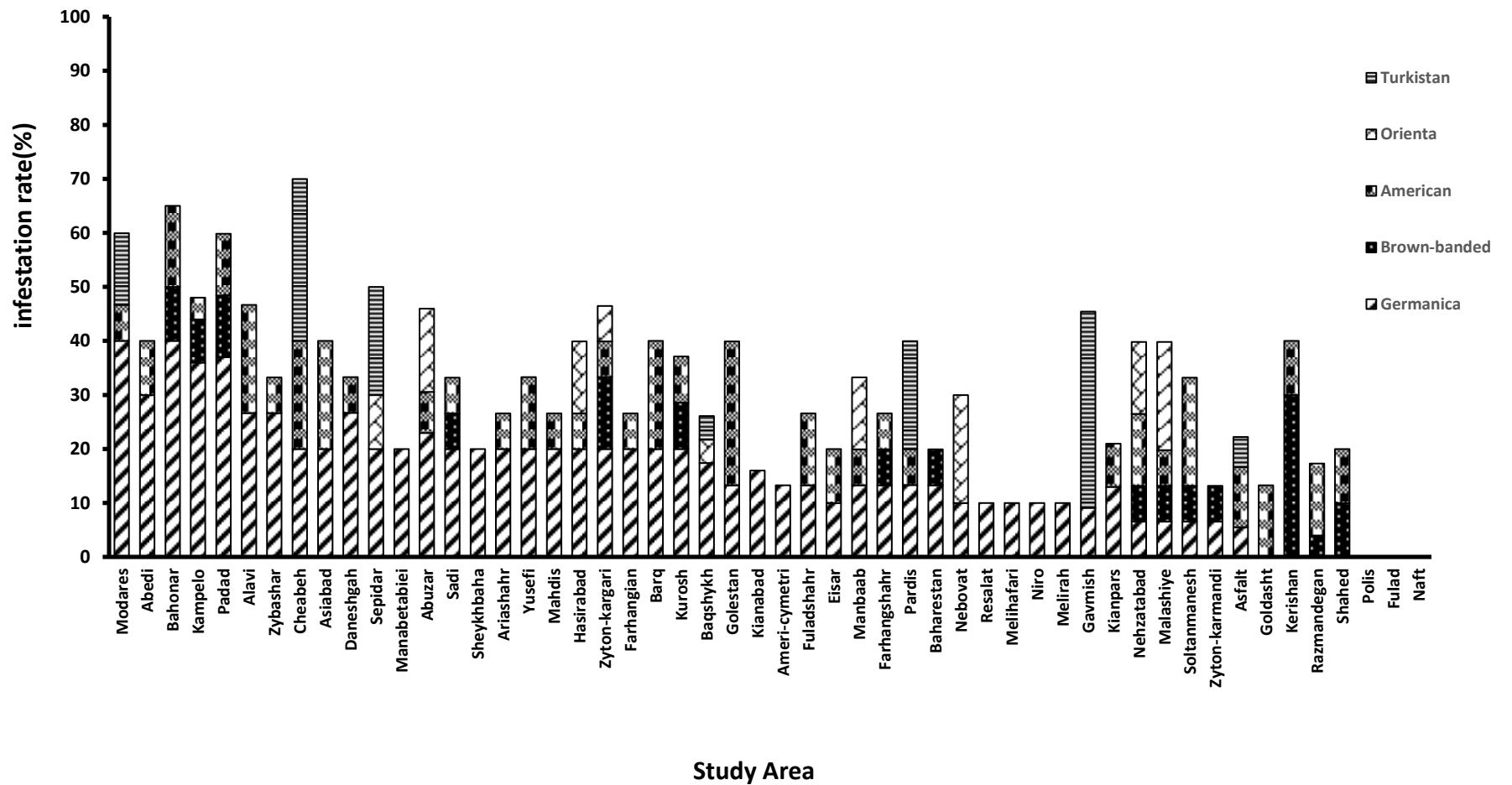


Figure 3: The cockroach species and infestation rate in study areas in Ahvaz city, southwest Iran during 2017.

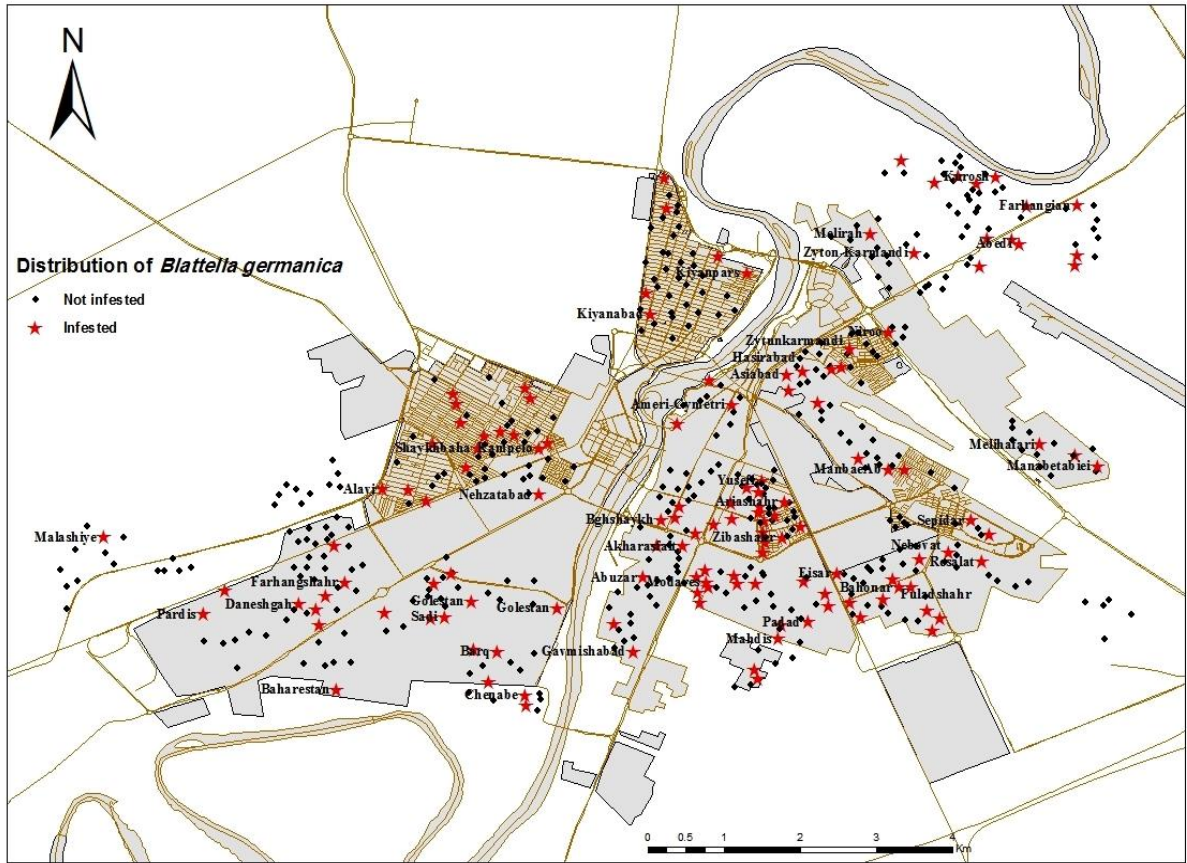


Figure 4: Spatial Distribution of German Cockroach in Residential houses in Ahvaz city, Khuzestan Province, Southwest Iran, 2017.

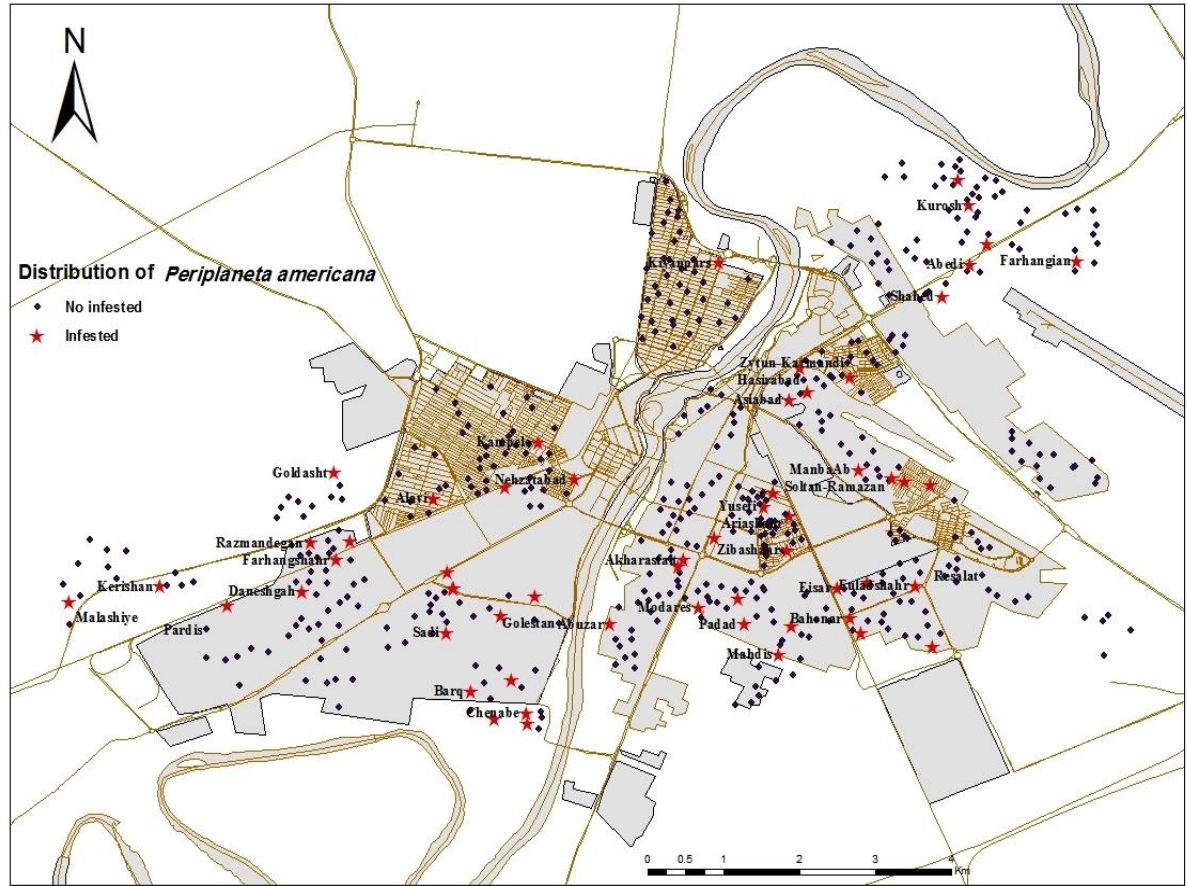


Fig. 5: Spatial Distribution of American Cockroach in Residential Places in Ahvaz, Khuzestan Province, Southwest Iran, 2017.

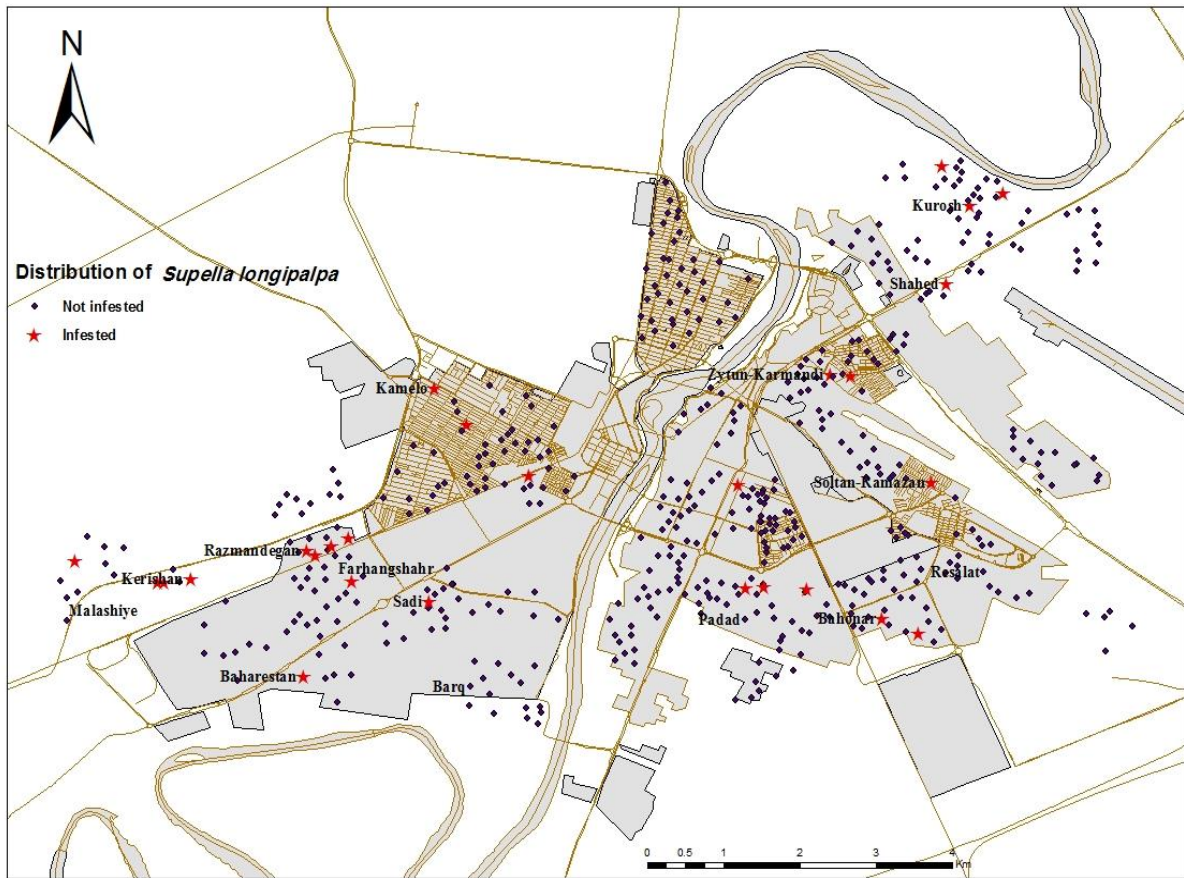


Fig. 6: Spatial Distribution of Brown-banded Cockroach in Residential Places in Ahvaz, Khuzestan Province, Southwest Iran, 2017.