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Araştırma Makalesi / Research Article

Determination of the Spatial Factors Effect on Insecticide Treatment and Location of Cutaneous Leishmaniasis Cases Using Geographical Information Systems (GIS): Adana, Turkey Case

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Abstract: Cutaneous leishmaniasis (CL) is a vector-borne disease, transmitted to human by sandflies. Insecticide spraying applications were conducted to control vector arthropodes, especially sandfly and mosquitoes in Adana. The goal of the our study was to determine the relationships between population, the number of CL patients and density of residual insecticide applying in selected areas in Central Adana. A bivariate correlation analysis was used to identify the relationship between three data groups in 103 areas in Adana. The statistical results were transferred to ARCMAP10.0 software to generate correlation maps.

We found a relationship between data groups ($p<0.05$). Also, areas, where the human population is most intense (Karsli, Beyazevler, Tellidere, Ziyapasa, Gazipasa and Yesiloba), where insecticide applications are the most common (Guzelyali, Toros, Yuzuncu Yil, Belediye Evleri, Huzurevleri and Yesilyurt), and where the CL native cases are reported in large numbers (Yesiloba, Bahcesehir, Mirzacelebi and Tahsilli), have been identified. Also, two areas (Mirzaçelebi and Tahsilli) were found to be quite risky in terms of CL.

Our findings have been used to generate comparative maps that contain the potential distribution areas of CL, where GIS technologies allow the identification of the CL areas, which can provide useful information to guide vector control programs.

Keywords: Insecticide, Sandfly, Cutaneous, Leishmaniasis, ARCMAP, GIS, Adana

Özet: Kutanöz leishmaniasis (KL) kum sinekleri tarafından insanlara taşınan vektör kaynaklı bir hastalıktır. Adana'da, kum sineği ve sivrisinekler başta olmak üzere vektör arthropodların kontrolü için insektisit uygulamaları gerçekleştirilmektedir. Çalışmamızın amacı, Adana merkezindeki seçilen bölgelerde insektisit uygulama sayısı, insan populasyonu ve KL olgularının sayıları arasındaki ilişkiyi tespit etmektir.

İkili korelasyon analizi, Adana'da 103 noktada, üç veri grubu arasındaki ilişkiyi belirlemede kullanılmıştır. İstatistiksel sonuçlar ARCMAP10.0 programına aktarılarak karşılaştırmalı haritalar üretilmiştir.

Çalışmamızda, veri grupları arasında istatistiksel olarak ilişki saptanmıştır ($p<0.05$). Ayrıca, insan populasyonunun en yoğun olduğu (Karslı, Beyazevler, Tellidere, Ziyapasa, Gazipaşa ve Yeşiloba) insektisit uygulamalarının en fazla yapıldığı (Güzelyalı, Toros, Yüzüncü Yıl, Belediye Evleri, Huzurevleri ve Yeşilyurt) ve KL olgularının fazla sayıda rapor edildiği alanlar (Yeşiloba, Bahçeşehir, Mirzaçelebi ve Tahsilli) tespit edilmiştir. Ayrıca iki alan (Mirzaçelebi ve Tahsilli) KL açısından oldukça riskli bulunmuştur.

Bulgularımız, vektör kontrol programlarını yönlendirmek için faydalı bilgiler sağlayabilecek KL durumunun tanımlanmasına izin veren coğrafi bilgi sistemleri teknolojilerin kullanıldığı, KL'nin potansiyel dağılım alanlarını içeren karşılaştırmalı haritaları üretmek için kullanılmıştır.

Anahtar Kelimeler: İnsektisit, Kum sineği, Kutanöz Leishmaniasis, ARCMAP, CBS, Adana

Introduction

Leishmaniasis that belonging to the group of vector-born diseases which represented two clinical types: cutaneous and visceral forms caused by *Leishmania* (*L.*) *infantum* and *L. tropica* in Turkey. (Ok et al, 2002; Kavur 2015).

Adana province where we collected data about population, insecticide spraying density and CL patients number, has significant feature as; suitable temperature, humidity values and flora contents for the sustenance of a sandfly

population and potential leishmaniasis endemic infection areas. These environmental factors have been emphasized to support the emergence of CL, in the area and a total of 1980 CL patients were reported in 2008 and 2015 in Adana, respectively (Ministry of Health statistics).

To date, sandfly fauna in leishmaniasis endemic areas showed that important relationship with distribution of either one or both of the two clinical forms of the leishmaniasis in 40 endemic areas in Turkey. Twenty-eight species belonging to the *Phlebotomus* (*P.*) and *Sergentomyia* (*S.*) genera have recently been identified within Anatolia Region. Eighteen of these species are known proven or possible vectors of human leishmaniasis in the Old World (Houin et al. 1971, Alptekin et al. 1999, Volf et al. 2002, Sadlova et al. 2003, Yaman and Ozbel 2004, Cicek et al. 2005, Deger and Yaman 2005, Dogan et al. 2005, Ertabaklar et al. 2005, Toprak and Ozer 2005, Davies 2006, Yaman and Dik 2006, Simsek et al. 2007, Toprak and Ozer 2007, Svobodova et al. 2009, Tok 2009, Erisoz 2010, Ermis 2010, Anonymous 2010).

GIS is a system developed to capture, store, manipulate, analyse, manage, and present all types of spatial or geographical data that have associated with them (Glass 2001). Such as, they constitute a fundamental tool for studying several disease epidemiology. These tools can be employed to locations of patients, and determine the spatiotemporal relationships among the patients and certain features. Integration of data obtain from many sources correctly and efficiently manipulate and represent different data has driven the improvement of software systems. Recent GIS technologies have emphasized methods to analyse relationship between several geographical and environmental data, with earlier techniques carried out primarily by the drawing maps to indicate the results. Generally, conventional statistical methods were deficient because underlying spatial correlation among the observations infringes one of the key supposition (independence of observations) made for most analyses. This violation typically results in the assumption of more successful statistical significance than is guaranteed (Lawson et al. 1999). In this study CL native patients number based prediction map is preferred for the validity to provide adequate data.

The goal of the present study was to compare the relationships between population of selected districts, the locations of CL native patients and insecticide spraying areas by using the data in a our endemic study areas in Adana.

Materials and Methods

Study Area

Adana, which is the fourth major city of Turkey, has a basin of 14.032 km^2 in area, and it is situated in the East Mediterranean district (Fig. 1). Adana is surrounded by the mountain range of Taurus. Adana has fifteen districts, 828 villages and a great number of rural areas. According to the Turkish State Meteorological Service data, the mean temperature of Adana province between 1927 and 2016 is 18.9°C (max 25.3°C; min 13.8°C). Annual mean rainfall is 646.6 mm, over 75% of which precipitation in the wet season from autumn to winter.

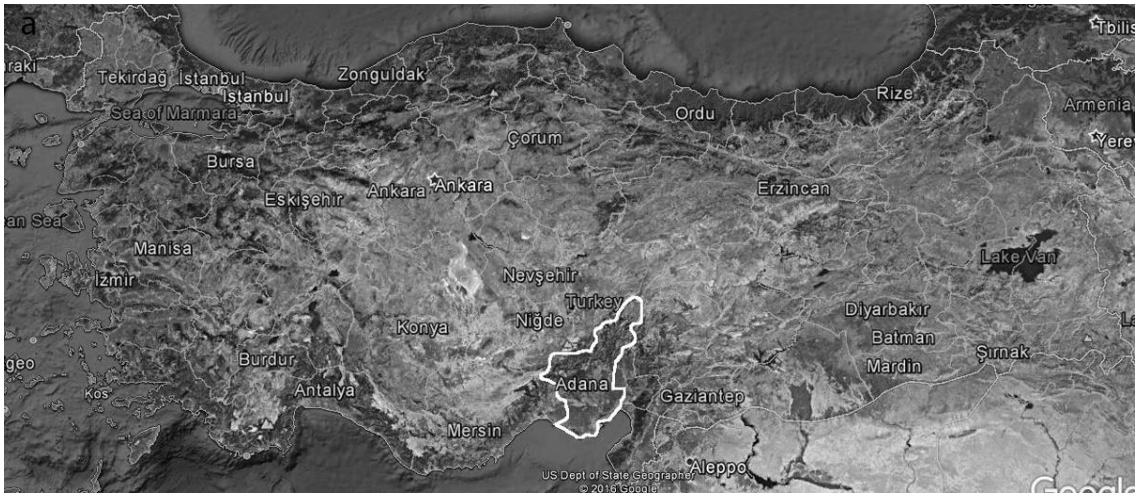


Fig. 1. Adana province.

Data Sources

The data were obtained in three categories: Population density, the number of the insecticide treatment and CL native patients. The insecticide applying methods, including the spraying date and the coordinates of spraying areas were obtained from the Municipality of Adana (Anonymous 2015a). At Adana 789 points were applied with residual insecticide in 2014. Pyriproxyfen, cyphenothrin, deltamethrin and clothianidin were used as active ingredients. We randomly selected 103 of 789 points in four central districts for geostatical analysis. These 103 points were applied 5758 times with insecticide against to sandfly and mosquitoes. CL patients informations were obtained from Ministry of Health data system (Anonymous 2015b) (Table 1). In total, 962 CL native cases have been reported in Adana between 2008 and 2015. In addition, there were 81 CL native patients between the years of 2008 and 2015 in 103 selected points. The population of 103 points were obtained from Turkish Statistical Institute (Anonymous 2015c), (Table 2, Fig. 2a and Fig. 2b).

Statistical and Geostatistical Analysis

We evaluate maps in three different relationships which are obtained from several government institutes. Statistical analysis was done using PASW statistical package. The results were transferred to the ARCMAP10.0 software to generate prediction model and maps. A bivariate correlation analysis was firstly done to identify the relationship between populations, the number of the residual insecticide treatment and patients ($p<0.05$). Also, inverse distance weighting (IDW) method is used for Geostatistical Analysis.

Table 1. Number of CL cases in selected 103 points in four central districts between 2008-2015.

Districts	2008	2009	2010	2011	2012	2013	2014	2015	Total
Seyhan	2	4	5	12	8	3	1	3	38
Cukurova	0	0	0	1	2	1	0	1	5
Yuregir	1	3	3	8	7	7	3	3	35
Saricam	0	0	0	1	0	1	1	0	3
Total	**3**	**7**	**8**	**22**	**17**	**12**	**5**	**7**	**81**

Table 2. Population, Insecticide applying and CL cases number in selected points in four central districts.

Districts	Population	Insecticide Application Number	Native CL Patients Number
Seyhan	693.830	2.620	38
Cukurova	346.028	1.519	5
Yuregir	276.710	1.256	35
Saricam	77.465	363	3
Total	**1.394.033**	**5.758**	**81**

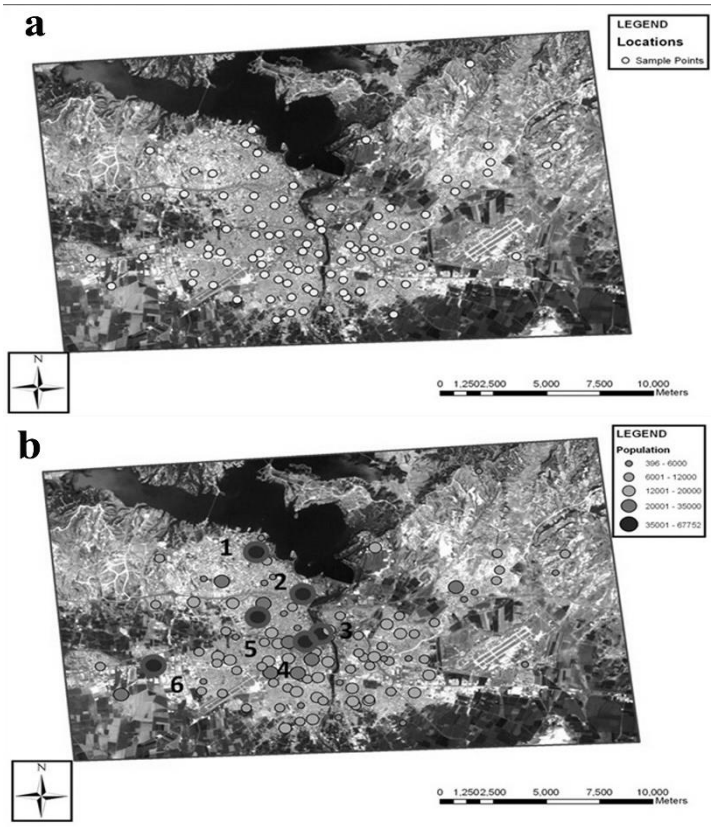


Fig. 2. Study area (a) 103 sample points (b) Population density.

Results and Discussion

The results of the bivariate correlation analysis of the relationship of CL native patients number, population and the number of the insecticide treatment are shown in Table 3. The residual insecticide spraying number in a specific location seems to be very significantly correlated with the patient number and population density (Table 3).

Correlation Maps

In our study, 103 probable CL endemic points are selected. We determined four high CL endemic level points (Yesiloba, Bahcesehir, Mirzacelebi and Tahsilli) and six high density insecticide treatment points (Guzelyali, Toros, Yuzuncu Yil, Belediye Evleri, Huzurevleri and Yesilyurt) in Adana province (Fig. 3a and Fig. 3b).

Table 3. Correlation of CL native patients number, Insecticide applying number and population.

Correlations of Variables		Insecticide Applying	Patients Number	Population
Insecticide Applying	Pearson Correlation	1	-, 459**	,878**
	Sig. (2 tailed)	-	,002	,000
	N	103	103	103
Patients Number	Pearson Correlation	-, 459**	1	-,287
	Sig. (2 tailed)	,002	-	,059
	N	103	103	103
Population	Pearson Correlation	,878**	-,287	1
	Sig. (2 tailed)	,000	,059	-
	N	103	103	103

Bivariate correlation analysis *** highly significant (< 0.001); ** very significant (<0.002); * significant (<0.05)

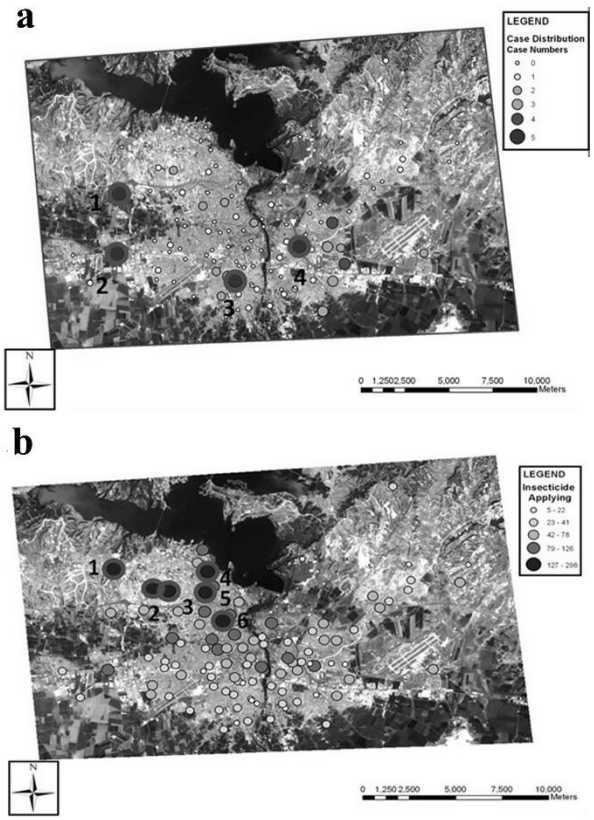


Fig. 3. Study area (a) Location of CL native patients (b) Insecticide applying areas.

Insecticide spraying areas were condensed in the centre of the city, parallel with population density. Normally, the public health workers give more importance to the centre of the city in terms of populations. Both insecticide applying areas and population density levels have high relationship level in the dark grey areas (Fig. 4a and Fig. 4b).

The relationship between insecticide treatment density and the number of patients maps show that point 1 (Bahcesehir) and point 2 (Yesiloba) show an avarage insecticide spraying density (Fig. 5a) and they have high cutaneosus leishmaniasis endemic levels (Fig. 5b). Point 3 (Mirzacelebi) and point 4 (Tahsilli) showed low insecticide applying density and high CL density respectively in figure 5a and figure 5b.

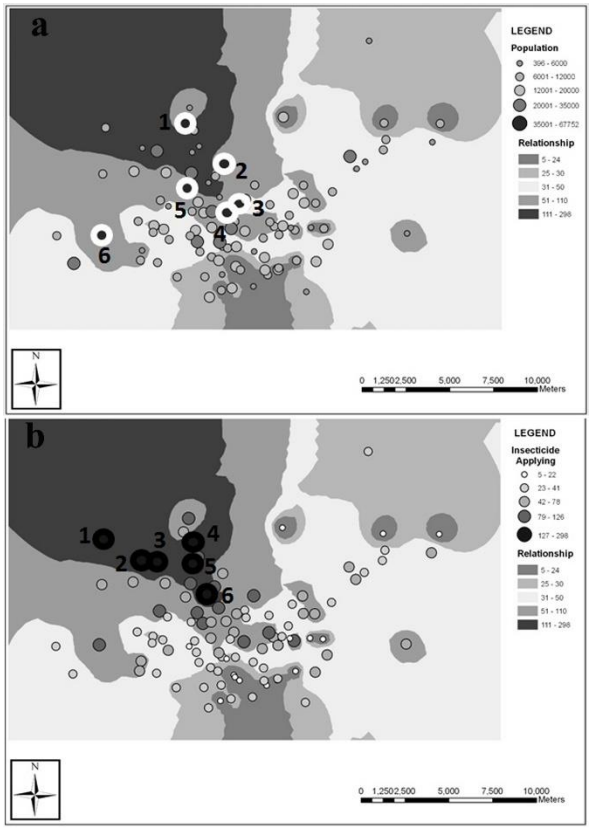


Figure 4. Study area **(a)** Population density (b) Insecticide applying density.

All dark grey areas (Relationship Ratio: 0-1) seemed to succed for taking a precautions to control of CL increment with sufficient insecticide treatment (Fig. 5a).

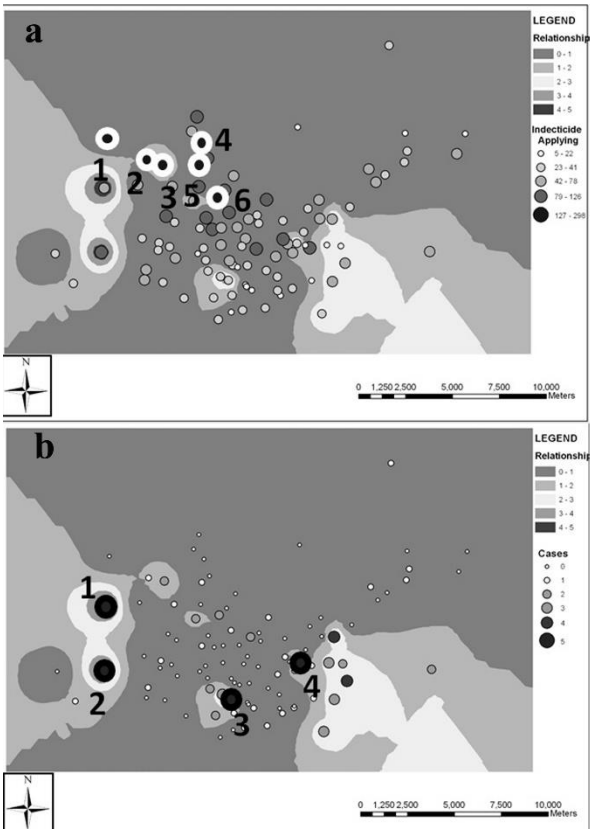


Figure 5. Study area (a) Insecticide applying density (b) The number of CL native patients.

Point 6 and point 2 in figure 6a and figure 6b respectively are of great importance for relationship between population and CL density. Also, they have high population density and high rate of CL native patients. Although we determined point 1 as high CL endemic level area in figure 6b, it shows low population density in figure 6a. Because of high density of insecticide applying, high population points (1, 2, 3, 4 and 5 show that low CL endemic level (Fig. 6a).

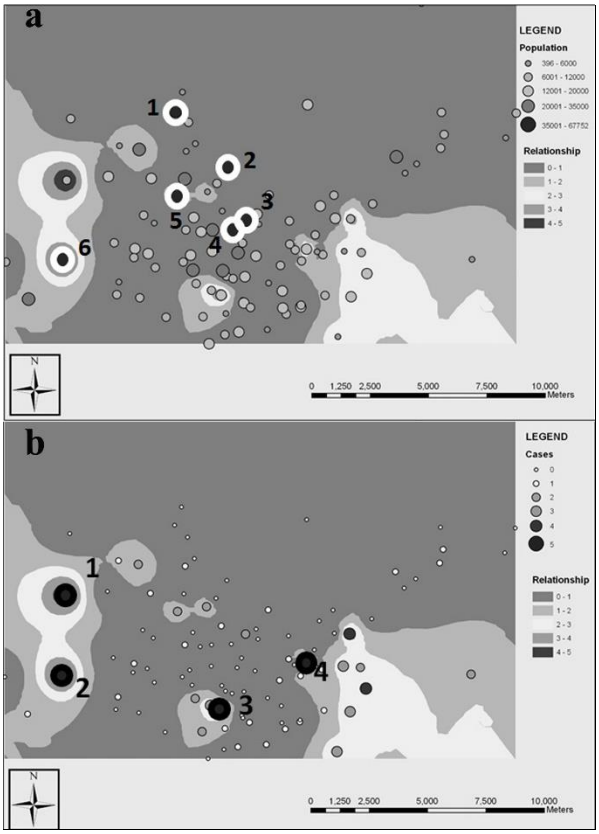


Figure 6. Study area (a) Population density (b) The number of CL native patients.

Conclusion

Recent advances in GIS technologies have provided priceless tools to scientists for analysing the epidemiology and possible increment of the vector-born diseases (Curran et al. 2000). Many parameters affect the incidence of CL. According to our statistical analysis, we found, leishmaniasis risk or incidence is more closely correlated with the number of the insecticide applying rather than with population density (Ozbel et al. 2011; Olgen et al. 2012; Chu et al. 2013).

GIS technology can be used to reduce the cost of insecticide spraying for the control of vector disease such as malaria and leishmaniasis in many countries (Chang et al 2009).

In the present study, we investigated three important parameters for more successful control of the CL in Adana province. The distribution and incidence of CL are affected by urbanization, population and the timing of using insecticide (Ozbel et al. 2011; Chu et al. 2013). As a result, by including those indicators, the effectiveness of vector control and planning the appropriate area for spraying is improved.

Yesiloba, Bahcesehir, Mirzacelebi and Tahsilli districts are not areas that covered by any of the optimized spraying in the prediction model. Although Adana public health workers sprayed satisfactory amount of insecticide, many CL native patients were reported in Bahcesehir and Yesiloba. These districts may have an insecticide resistance problem. Insecticide applying workers who responsible of both districts must consider the annual type of insecticide and identifying the vector arthropodes species and population density. Also, two points (Mirzacelebi and Tahsilli) were

found as high CL risk potential area in the our study but, nevertheless the low amount of insecticide applying was determined in these areas. Both areas must be more spraying than before for control of the vector arthropodes population. The patients number of disease, population and insecticide spraying density, however, clearly show that the main hotspot and several additional areas (Chu et al. 2013).

In conclusion, these prediction maps emphasize that the potantial risk area for CL in terms of three parameters. Insecticide resistance could be a major problem if municipality didn't take a measure in several points in Adana. In the near future leishmaniasis native cases number will be increased in the low density insecticide applying areas.

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