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Association between climatic changes and leishmaniasis incidence in Biskra district, Algeria

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Abstract
Leishmaniasis has been classified primarily as a vector-borne disease that poses a major problem to public health. The Biskra region, which has long been known as a focal point for cutaneous leishmaniasis, has a low extent of visceral leishmaniasis. The aim of the study is to highlight the spatial and temporal evolution of cutaneous and visceral leishmaniasis in Biskra over the last decade, taking into account the different factors influencing their distribution. The present study is a ten-year retrospective survey (2007- 2016), carried out in Biskradistrict. During the study period, 24,232 confirmed cases of cutaneous leishmaniasis and 61 cases of visceral leishmaniasis were recorded. The registered cases were distributed in all the municipalities of Biskra, the disease affects, regardless of sex, all age groups but with heterogeneous proportions. The survey also showed that cutaneous leishmaniasis mainly infects (43.36%) the class of children with a male predominance of 57%. The Biskra city was the most vulnerable to sandfly bites, accounting for 33% of the total number of cases, while Tolga municipality was the most affected by visceral leishmaniasis with a percentage of 25%. Children under 5 years of age (85.24%) were the most exposed to visceral leishmaniasis following with predominance of male with 54%. The distribution of leishmaniasis was affected by the environmental and climate changes.

Keywords: leishmaniasis, cutaneous leishmaniasis, visceral, epidemiology, climate, Biskra

Introduction
Every year, gardeners face several insect pests and mite problems infesting vegetables and Phlebotomine sand flies (Diptera: Psychodidae: Phlebotominae) are groups of medically and veterinary important insect vectors of disease by the co-occurrence of a large number of competent vector species in New World endemic transmission foci of leishmaniasis. It is a transmissible parasitic disease caused by a flagellated protozoan belonging to the genus *Leishmania* (Kinetoplastida: Trypanosomatidae) transmitted to vertebrate mammals by the bite of a vector insect [1]. Leishmaniasis is one of the vector-borne diseases that have emerged or re-emerged for a long time [2]. The leishmaniasis in Algeria was firstly reported in 1860 Henri Hamel who discovered the disease in Biskra [3]. The first epidemic cases were reported in the military garrisons in Biskra in 1960 where more than 200 cases were recorded [4]. Two types of leishmaniasis are present in Algeria, visceral (VL) and cutaneous (CL) leishmaniasis [5]. The VL caused by *Leishmania infantum,* transmitted by *Phlebotomus perniciosus* [6] and the reservoir is the dog [7], was recorded in the north of the country; in a humid bioclimatic stage, but is spreading throughout the all country. Therefore the CL is observed in 4 clinical forms, where the reservoir and the vector vary from place to another [8]. The first form, zoonotic cutaneous leishmaniasis (ZCL), is due to *Leishmania major* that was identified in semi-arid and arid to Saharan regions and *Phlebotomus papatasi* was the main vector and the Gerbillidae was the main reservoir [9]. The second type, sporadic localized CL caused by *Leishmania infantum* was noculated by *Phlebotomus perfiliewi* and the geographic distribution and the reservoir are similar to the previous one [8]. The third form of CL, due to *Leishmania killicki* was identified in in Ghardaïa southern Algeria and the reservoir is mainly the rodent *Massoutier amzabi* and the vector *Phlebotomus sergenti* [10]. The fourth form is caused by *Leishmania tropica* noticed in urban areas [11]. Leishmaniasis has become an emergency health problem in some countries, including Algeria; where the annual global incidence of leishmaniasis is estimated at 1.2 million new cases of CL and at 400.000 new cases of VL [12, 13]. The Biskra region known as the main focus of the CL, has recorded a spreading visceral form during the last decade [144].
Sand fly species undergo major structural changes following landscape transformations or

major environmental disturbances [15, 16]. As well as knowing that the leishmaniasis is particularly sensitive to environmental and climate changes [17], the impact of human activities on the environment and climatic variables are the main causes of the leishmaniasis recrudescence [18]. The increase in the number of cases and the spread of the disease across the national territory, with the coexistence of the two forms at the same household level, requires a surveillance increase of the evolution and application of adequate control measures [19]. The present study was focused on the spatial, temporal and demographic distribution of cutaneous leishmaniasis during the last decade from 2007 to 2016, as we will also discuss the influence of environmental factors on the distribution of the disease in the study area.

2. Materials And Methods

2.1 Study area

Biskra district is located in the middle-eastern part of Algeria, situated in the southern part of the Saharan Atlas (Figure 1).This region, known as the "gate of the Sahara". The district extends over an area of 21 671 Km². It is situated between the longitudes 4°15 'and 6°45' East and between latitudes 35°15 'and 33°30' North. Its altitude is between 29 m to 1600 m above the sea level. It is composed of 33 municipalities distributed over 12 districts with an estimated population of biskra district was about 869 215 people in 2015 (PHD of Biskra).

Fig 1: The geographical location of the study area, Biskra district, Algeria.

The climate in Biskra is pre-Saharan characterized by a warm and dry period spread out from May to September and by other less hot and humid from October to April (Figure 2). Precipitation is low and irregular, when the annual average recorded during this period is about 193 mm, while evaporation and temperature are characterized by high values. A large temperature variation, reaching a monthly average of 34.7 °C in July and 12.8 °C in January, was recorded. Winds were frequent and distributed throughout the year, with a month average speed of about 3.53 m/s and the maximum speeds are recorded during the months of March and May. The prevailing winds are in the south-eastern and north-east sectors. Humidity is mainly related to temperature and precipitation; the monthly average is about 31.3% from (May to September) and 49.1% from (October to April) [14].

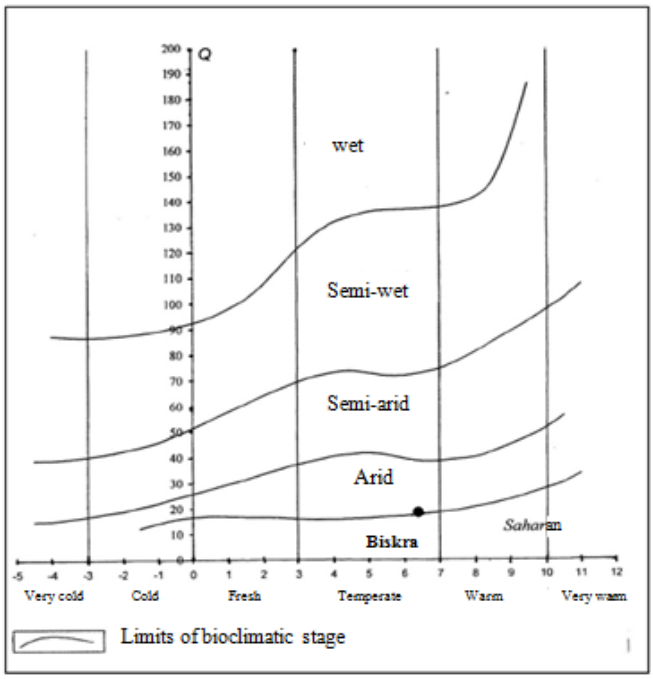

Fig 2: Bioclimatic stage of the study area according to the Emberger climagram between 2007 and 2016.

2.1 Data collection

The data series of cutaneous leishmaniasis of the present study was provided from the Direction of Health and Population (DHP) of Biskra district of the period ranging from 2007 to 2016. The survey data were presented monthly and annually. Each case of cutaneous leishmaniasis much information was recorded (sex, age, place of residence, origin of patient, seat of lesion, number of lesions). While the recorded cases of hospitalized patients with VL are drawn from the pediatric and infectious disease service. The meteorological data were provided by the National Office of Meteorology (ONM Biskra).

2.3 Data analysis

The data were subjected to statistical analyses. The Excel 2010 program was used for the development of the various curves and graphs and also the development on the curves of the regression line which analyzed and validated through the use of the techniques provided by IBM SPSS statistic 20 software (Statistical Package for Social Sciences).

3. Results

3.1 Temporal distribution of leishmaniasis

During the 10-year study period from 2007 to 2016, the Public Health Department of Biskra province has recorded 24232 confirmed cases of cutaneous leishmaniasis and 61 cases of visceral leishmaniasis, which shows clearly the dominance of the cutaneous form by comparing with the visceral form.

3.1.1 Annual distribution

The results show that the cutaneous and visceral leishmaniasis are distributed heterogeneously troughout the study period. The average annual incidence was 319.83 and 0.9 'cases/100.000 population for cutaneous and visceral leishmaniasis respectively. In figure 3, a gradual increase in incidence was observed at a peak in 2008 (777.1 cases / 100,000 population for CL) in 2011 (1.51 cells / 100 000 inhabitants for VL) and a decrease was recorded in the following years.

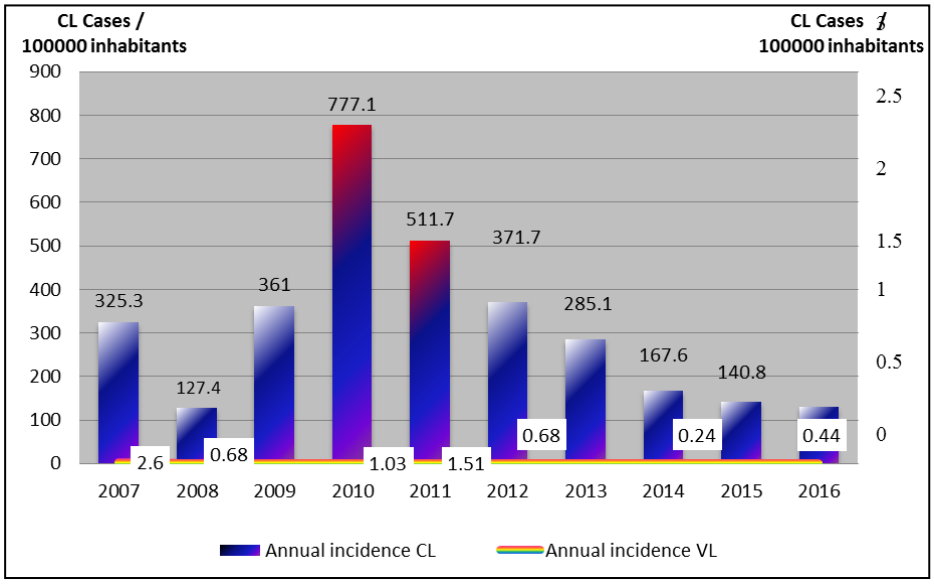

Fig 3: Annual distribution of cutaneous and visceral leishmaniasis incidence during the study period.

The linear regression model (LRM) on climate variables and the number of cases of CL and VL were drawn. The model obtained for CL is made by the number of CL cases (18.59) and the precipitation (113.9 mm) (Figure 4) and the distribution was established in Figure 5. As well as the correlation for VL cases was represented by the number (0.036) and precipitation (1.524 mm) (Figure 6) and the distribution was traced in figure 7.

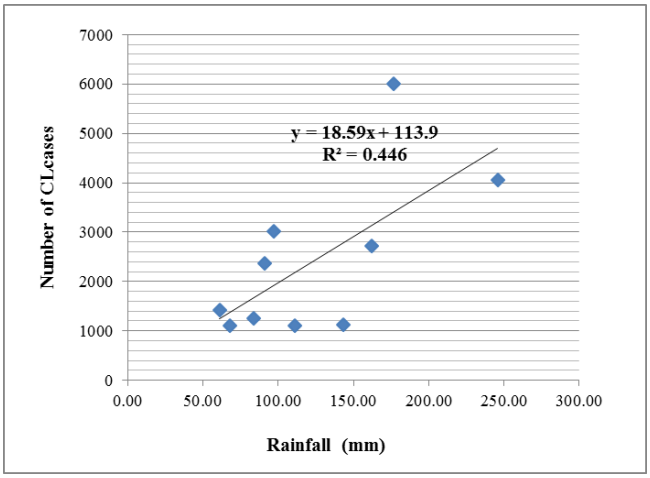

Fig 4: Correlation between number cases and annual rainfall.

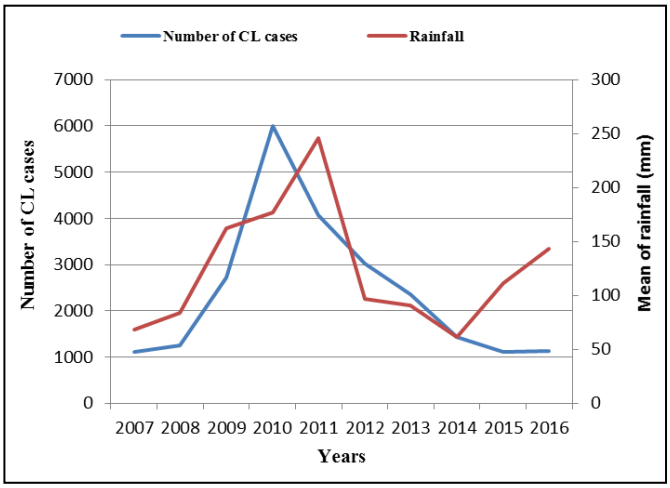

Fig 5: Distribution of CL cases and annual rainfall of CL from 2007 to 2016.

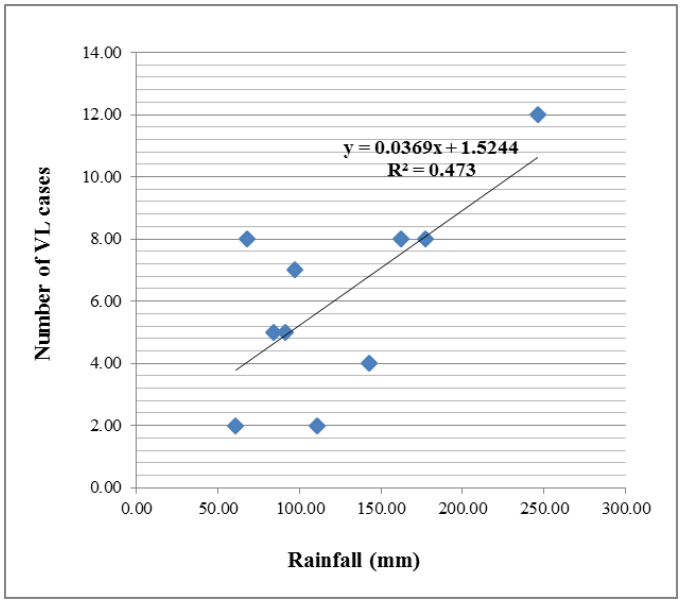

Fig 6: Correlation between number cases and annual rainfall.

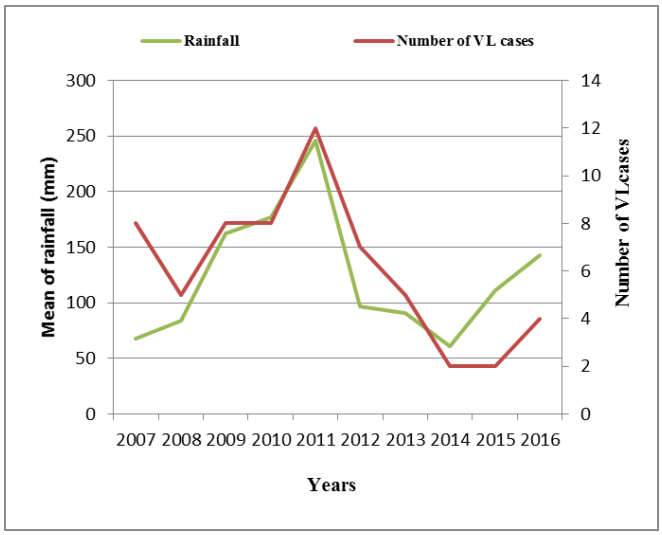

Fig 7: Distribution of VL cases and annual rainfall of VL from 2007 to 2016.

We noted that there is a significant positive correlation between the rainfall factor and the distribution of CL, [R2 =

0.44] (Fig 4 and 5), and visceral leishmaniasis [R2 = 0.47] (Fig. 6 and 7).

3.1.2 Monthly distribution

Both forms of leishmaniasis were observed throughout the twelve months of the year. The annual registration of cutaneous leishmaniasis was noticed with a highest rates that were recorded from September to February (85%) for all years. Contrary to visceral leishmaniasis where the highest positivity rate was recorded from February to April (33%) (Figure 8). This confirmed the seasonal nature of the disease. However, the monthly results related to the time of reporting cases after the onset symptoms and confirmation of infection in the laboratory, presented a dislocated peak of 3 months. This type of distribution does not reflect the real distribution of the disease. In fact, the two peaks recorded are not representative of periods at risk. For cutaneous leishmaniasis; the incubation period of parasite in human body from the moment of insect bite to the time of symptoms's onset is 3 months on average. Therefore, to get accurate results and combining the epidemiological data with the climateones, the number of patients should be moved three months forward. The correlation model is obtained using the Number of CL cases, temperature and wind (Figure 9 and 10) and these showed clearely the relation between the cases and the climate.

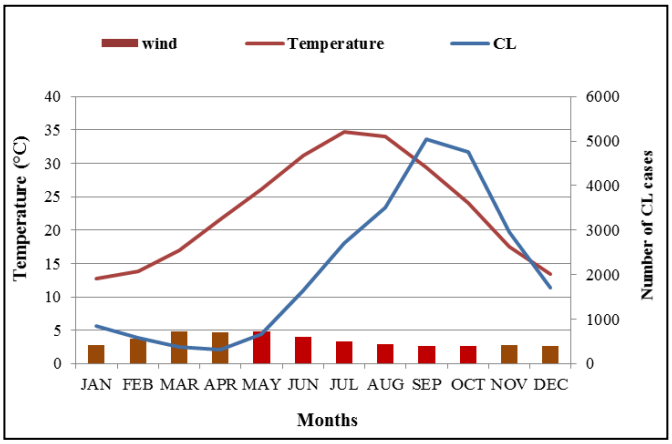

Fig 8: The effect of temperature (Mean C° of 2007-2016) and wind speed on the monthly distribution of CL.

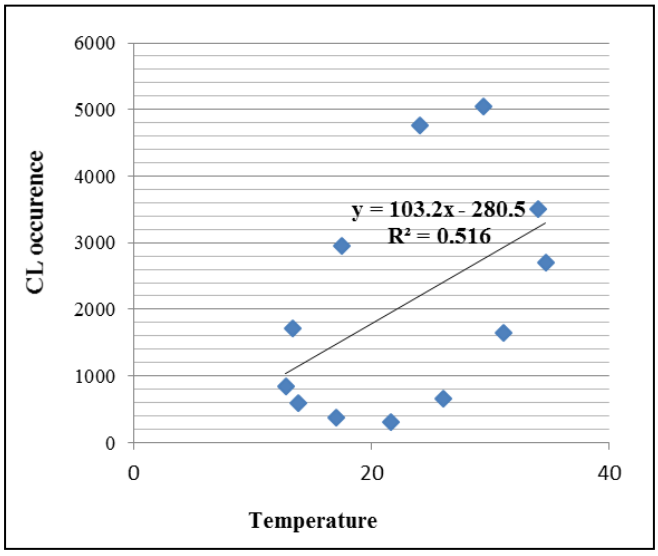

Fig 9: Correlation between CL occurrence and temperature.

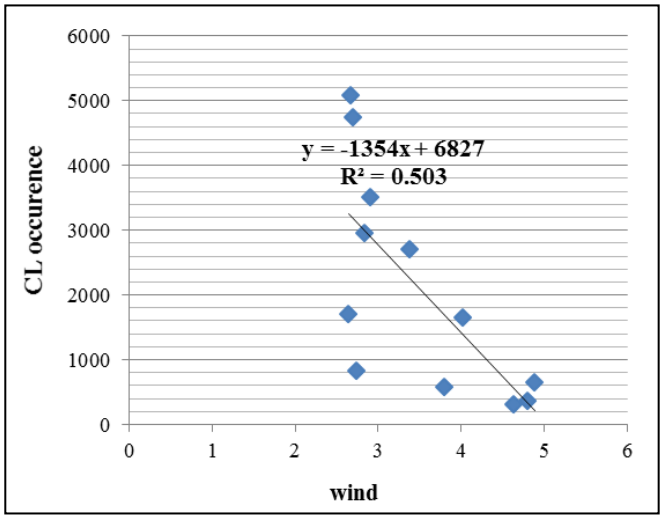

Fig 10: Correlation between CL occurrence and wind speed.

The results showed that 73% of the total number of cases was recorded in the hot and dry period and distributed between May and October, where the wind speed was low. As a result, we also noted that there was a significant positive correlation between temperature and distribution of cutaneous leishmaniasis [R^2 = 0.51] (Fig.9) and significant negative correlation between wind speed and distribution of cutaneous leishmaniasis [R^2 = 0.50] (Figure 10). For visceral leishmaniasis; the long incubation period, the variability of individual susceptibility to the infection and the lack of patient records make the diagnostic difficult to be determined.

3.2 Spatial distribution of leishmaniasis

The spatial distribution of the recorded cases of cutaneous and visceral leishmaniasis and the distribution of phlebotome at the various communes of the Biskra province during the period 2007 – 2016 were expressed in figure 11.

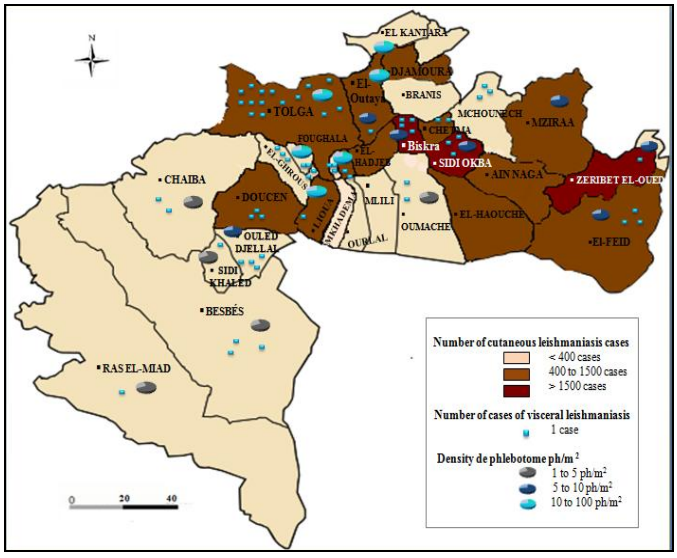

Fig 11: Epidemiological map of cutaneous and visceral leishmaniasis and the phlebotum distribution in the Biskra district during the period 2007 -2016.

The results obtained show that the disease was dispersed in the different communities of Biskra district with a clearly epidemic character. The number of CL cases varied from one community to another. There is a high concentration of cases in the communities occupying the center and the north-eastern part of the region. The most affected commune was the urban

one of the Biskra city with 8037 cases. In the second place, the peri-urban commune Sidi Okba with (2507 cases) and Zeribet El-Oued with 1565 cases. While those in the south-west are almost rural, were less affected. For VL, there is a prevalence of the disease in 19 communities, among 33 ones, distributed to the west of the region, from north to south. Tolga commune is the highest number of cases (15 cases) with a percentage of (24.6%), followed by Ouled Djellal and Biskra city with 4 cases, then the number between 1 and 3 cases was recorded at the level of all the rural communities inthe west part. From the figure 11, there is also a similarity between the spread of the disease and the density of the vector in almost all municipalities of Biskra.

3.3 Distribution of leishmaniasis cases according to sex and age

CL reached both sexes with a male predominance, which was (57%) compared to (43%) for females and a sex ratio (M / F) of 1.34. For the VL, there was a slight male predominance of (54%) versus (46%) female, with a sex ratio (M / F) of 1.18 (Figure 12). All age groups are affected by cutaneous leishmaniasis in the Biskra region, but with unequal proportions (Figure 12). The most affected class by CL is children, then the class of young aged between 2-9 years with 43.36% and 20-44 years with 22.33% respectively. While the least affected category is that of people aged 65 or older with 1.50%. For VL, the age group of 2-4 years was the most affected (45.90%) followed by that of babies 0-1 years with 39.34%. VL is rare in young adults and adults whose

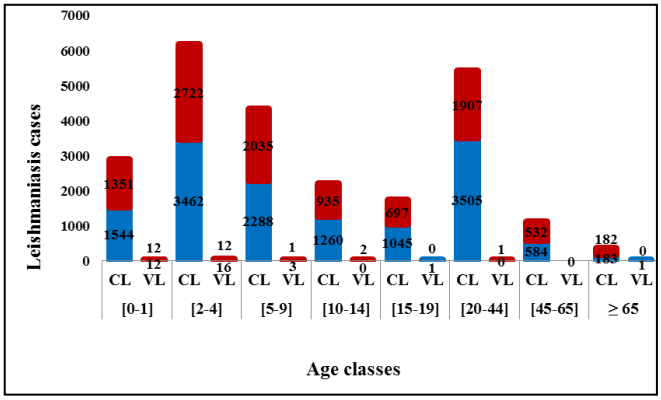

Fig 12: Distribution of CLand VL cases according to patient age and sex from 2007 to 2016**.**

4. Discussion

The Biskra area has been known since 1860 as a historical focus of cutaneous leishmaniasis due to *L. major*. The vector *P. papatasi* and the reservoirs *Merione shawi* and *Psammomy sobesus*, found naturally infected by *L. major* [20, 21, 22] and play the main role of CL spreeding In Biskra region [23]. The main vector of leishmaniasis seems to be affected with the environmental changes such as the extension of irrigated areas, old gypsum constructions and areas rich in plant debris [24]. These constitute microclimates suitable for the development of sandfly *P. papatasi* and reservoirs such as *Psammomy sobesus* and thus the prevalence of the disease. This explains the recording of 24.232 confirmed cases of cutaneous leishmaniasis in the Biskra district during the study period from 2007 to 2016. Unlike cutaneous leishmaniasis, cases of visceral leishmaniasis are rarely reported where 61 cases of VL during the last decade in the Biskra region were recorded.

Meteorological factors play an important role in the incidence of leishmaniasis. They can accelerate the development of the parasite or the synergistic changes in populations of reservoirs and parasites that cause an explosion in the population of sandflies [25]. This was the improvement for the reduction of the incidence of leishmaniasis, especially the cases of VL. The results obtained by linear regression show a significant positive correlation between annual precipitation and the number of cases of leishmaniasis in the Biskra district and confirm a previous work carried out in Oued Souf regionwhich is characterized with the same climate [26]. The increase in precipitation, recorded from 2009 to 2011 has led to denser vegetation, therefore the number of breeding sites for reservoirs and sandflies were increased [27]. The high number of leshmniasis cases, recorded in the hot and dry period between May and October, can be explained by the temperature effect; because with the increase in temperature the sandfly metabolism be accelerated consicountly it influences oviposition rates, defecation, hatching and emergence in adults [28, 29]. Moreover, the wind speed has a negative influence on the appearance of the CL. The increase in wind speed was accompanied by an inhibition of the flight of the sandflies, and thus the decrease of the transmission of the CL. With the addition of the impact of climatic factors, the behavior of the human population is the basis of the increase in the number of cases during the summer period. The pre-Saharan population has a habit of sleeping in its home yards and wearing light clothes where the exposed parts of the body are more than those of any other season [26]. For VL, the longevity of the parasite period and the variability of individual susceptibility to infection with the lack of patient records make the incubation period difficult to determine [30].

The epidemiological map; of cutaneous and visceral leishmaniasis in the region of Biskra, shows that the spatial distribution of leishmaniasis is not homogeneous. This can be explained by the heterogeneity of environmental, socio-economic and environmental conditions created by man. First, the structural diversity of land (mountains, plateaux, plains) and the hydrographic network in the region are the source of the variability in the distribution of actors involved in transmission cycles. Different irrigation methods, increasing irrigated area and exploiting new hydraulic resources (installation of irrigation canals, etc.) can create wet microclimates favorable to the proliferation of the sandfly and the reservoir [31]. Also, waste waters are collected in septic tanks that rise on the surface and pollute ground waters. Zoonotic cutaneous leishmaniasis has long been known as a typical rural disease, but in recent years, peri-urban areas have become the preferred spots of infection. This could indicate that the parasite is transmitted via a new cycle. The extension of VL in the rural communities in western part of Biskra may be explained by the fact that rural areas provide suitable conditions for the circulation of the main vector, *P. perniciosus* where as the reservoirs such dogs, will be an abundant sources of blood for hematophagous female vectors. Furthermore, the multiple movements of nomads with their sheeps and dogs constitute another factor in the spread of visceral leishmaniasis in these communities [19, 32].

Cutaneous leishmaniasis has reached both sexes with predominance of the male. This predominance was also reported in the Constantine region [33] and in Ouedsouf [26]. Contrarly female were predominant in northern Morocco with a rate of 56% [34] and in Ouagadougou with a rate of 50.3% [35]. It could be explained by the clothing habits of the Biska's population where surfaces discovered of the body in men are more important than in women and men are exposed more

frequently to the phlebotomus bites due to their field activities. It is for the same reasons that visceral leishmaniasis affects more the males with a slight predominance [4]. But it was reported recently that the dominance was recorded in female [36]. In this study children group under the age of five were the most affected with visceral leishmaniasis (85.24%). This infant predominance is consistent with the literature given that they are non-immune subjects having a fragile immune system [19]. VL is rare in young adults and adults [37].

5. Conclusion

Leishmaniasis presents a real public health problem throughout the Algerian territory, especially in Biskra district. The predominance of the cutaneous form in an area is clearly in relation to the visceral form. The CL reaches the young and male population during the warm and dry period or the number of stitches is intense. Children under five continue to be the most exposed to this epidemic. Environmental factors, whether biotic or abiotic, have revealed a real impact on the distribution of these diseases.

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