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AREAS INFESTED WITH *CULEX PIPIENS* (DIPTERA - CULICIDAE) IN THE LARGE TLEMCEN GROUPING (ALGERIA)

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ABSTRACT

The nuisance situation, generated by *Culex pipiens*, is strongly felt in Tlemcen. The difficult-to-control extension of urban planning and the faulty sewage and sanitation system are generators of cottages in *Culex pipiens*. To define areas infested with Culex pipiens, survey methods are an indispensable tool to address certain territorial problems (Metelo *et al*., 2013). Thus carrying out a survey of households in three municipalities located in the wilaya of Tlemcen in Algeria (Tlemcen, Chetouane and Mansourah). The purpose of the survey was to assess the degree of nuisance caused by *Culex pipiens* on populations. The results of the survey conducted in the Large Tlemcen grouping helped to define the aggressiveness of *Culex pipiens* and thus to establish a mapping of the infested areas.

Keywords **:***Culex pipiens* – Hassle – Larvae –Infestation map – Tlemcen – Algeria.

INTRODUCTION

The objective of this study is to establish a geo-located map of the rate of infestation by *Culex pipiens* in the large Tlemcen grouping. Indeed, if the basic documents are made up of statistical data, it is necessary to carry out a graphic processing of the data to determine classes, establish a coherent legend and build a map perfectly readable for the reader and adapted to the use that must be made of it (Quodverte, 1997).

In our study, mapping of the culicidogen areas identified the areas, based on three infestation levels defined in the survey conducted in the study area.

MATERIALS AND METHODS

In order to cover most of the study area, we chose the transect method (Jouret, 1972). Ecological transect is a method most often applied, which consists of determining in vegetation, along a more or less linear cut made in a geo-morphological complex, ecological or eco-sociological groups. Compared to botanical ecological transect, human populations replace plant populations, while different types of habitats replace geo-pedological environments. The aim is to define human associations according to their composition and structures (Jouret, 1972).

This method, identical to that of botanists in its descriptive purpose, thus leads to the definition of population groups based on criteria of human geography, physical geography and ecology.

Two east-west transects are defined, the first transect in the north crosses the municipality of Mansourah and the commune of Chetouane and the second to the south passes through the commune of Tlemcen and the municipality of Chetouane (Figure 1). Once the two transects were established, we delineated the sites that were surveyed by households. Study sites are cities with different types of dwellings (collective, semi-collective and individual). The total number of surveys at the various sites reached 250. For example, 30 sites have been designated along the two East-West transects.

The household survey uses a questionnaire. This questionnaire is the support of the data collection. It is the operational tool of the survey, consisting of a list of questions and a list of answers formulated in advance.

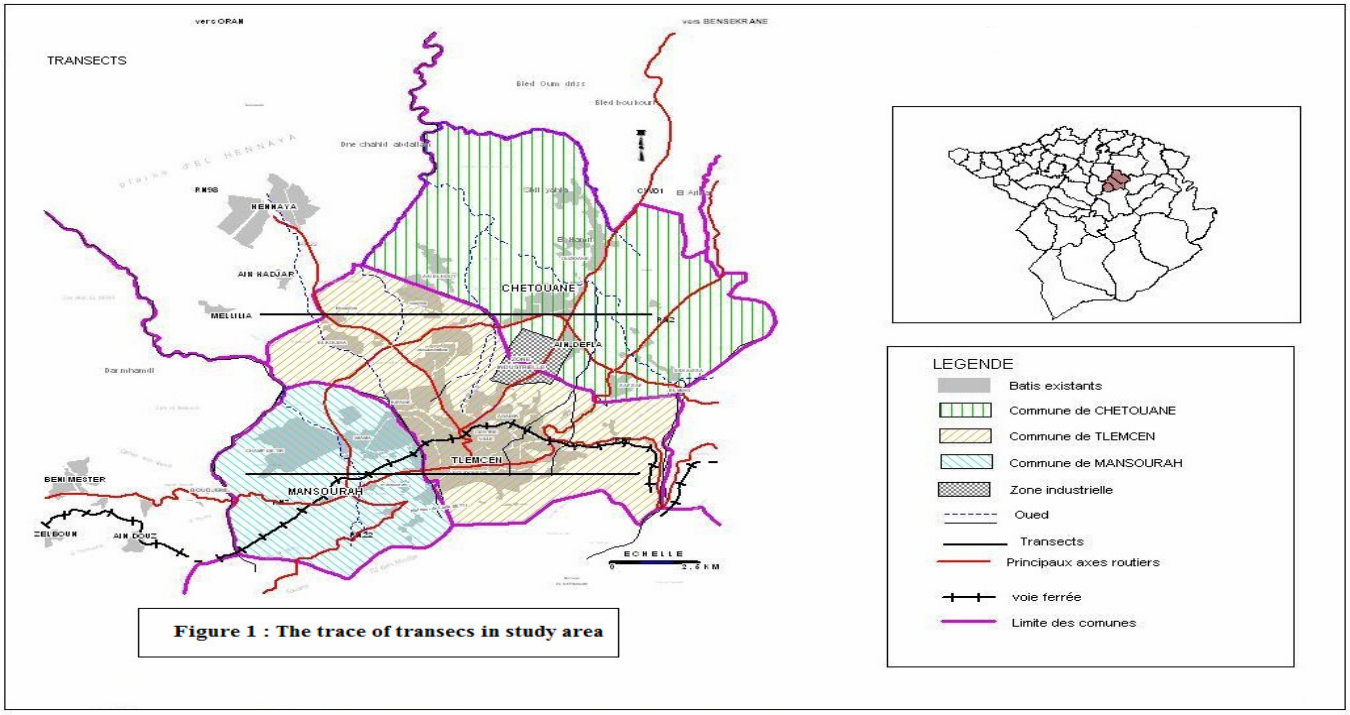

Figure 1 : The trace of transecs in study area

A questionnaire is a useful step is also a tool for knowledge on environmental nuisances (Faburel, 2003).

For our study, we opted for the so-called random and quota sampling method (U.N.O., 2010). This technique is frequently used by investigators.

For our data collection, interviewees were invited to comment on:

- the presence or absence of the different types of potential lodgings in *Culex pipiens* near the dwellings, this parameter allows to identify all types of artificial, natural, domestic or other lodgings;
- the number of bites per person for 24 hours, has been defined at three intervals, less than three bites, three to eight bites and more than eight bites (Fontenille *et al*., 2003), this information is a key parameter, the usefulness of which allows to reveal the degree of nuisance caused by mosquitoes;
- the seasons during which the inhabitants are stung. This is important to clear the period of activity and mainly the maximum period of activity per neighborhood.

The interview process was initiated at a geographic point on each of the two previously defined transects and the route determined was then followed by selecting each tenth household to be interviewed until the predetermined quota had reached. This methodology is frequently presented as a way to avoid the time-consuming and costly process.

All the results of the survey were reported in a table. Then a statistical processing was established using the Minitab 16 software, so factorial analyses of the matches (A.F.C.) were carried out in order to interpret the information collected.

The map was made using MapInfo software version 7.5 (2002), it is a geographic information system (SIG) on Windows that allowed to perform spatialized analyses and to have relevant mapping representations.

RESULTS AND DISCUSSION

1. Survey results

It is generally by assessing the degree of nuisance in the population that the effectiveness of a treatment program against biting insects that cause nuisance is measured.

In the survey conducted in the Tlemcen Urban Group, 250 people were interviewed. This allowed us to obtain a sufficient number of responses to establish an interpretable rate. Indeed, the larger the sample, the better the accuracy of the estimate. It confirms the presence of the mosquito throughout the territory of the Tlemcen urban grouping with high regional variability.

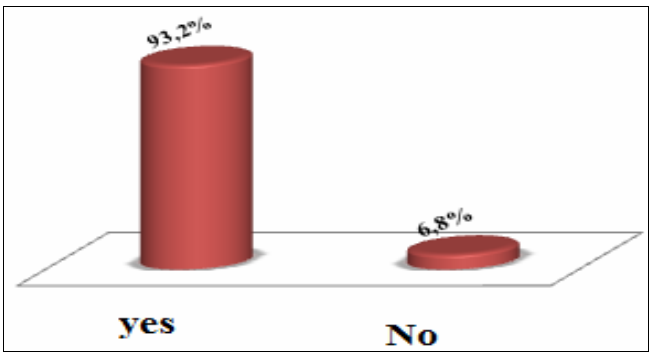

Fig. 2 : Households affected by mosquito

1.1. Analytical study

1.1.1. Number of stings per day

According to the survey of intra-home aggression of the mosquito in the various neighborhoods of the Tlemcen urban group, 93.2% of the families surveyed are affected by mosquito bites. Of the 250 surveys carried out, only 17 dwellings were negative with a percentage of 6.8%.

According to locals, mosquito nuisance is felt between sunset and sunrise, thus essentially a nocturnal activity with a maximum peak in the middle of the night. *Culex* and *Anopheles*, potential vectors of West Nile or encephalitis and Plasmodiums (malaria) viruses, sting and disturb by their

noisy flight preferentially between sunset and sunrise (Guillaumot, 2009). Females harass their hosts until they have had a full meal, after one or more bites.

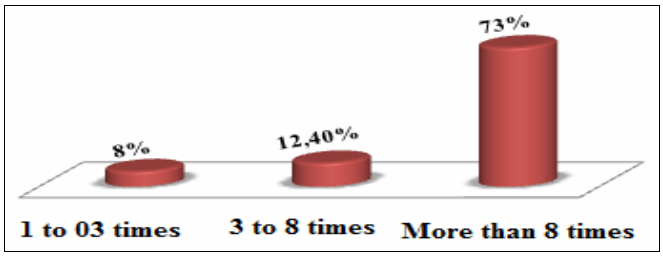

Fig. 3 : Number of stings per day

The degree of nuisance assessed allows for different proportions to be identified. Indeed, in the urban grouping of Tlemcen, only 8% of the population surveyed is attacked less than three times a night (Figure 3), then come the moderately affected inhabitants, stung between three and eight times (12.4%) and more than 73% of the population is stung more than eight times a night. The most infested area includes dwellings located mainly in the districts of Kiffane, Imama, AinMazouna, Zhun de Champ de Tir and Chetouane.

Only female mosquitoes can carry diseases that are hematophagus, unlike males. So they're the only ones that sting. Indeed, once the females are fertilized, they go in search of proteins present in the blood of humans and animals (all vertebrates in general can serve as hosts). Protein is essential for the maturation of their eggs (Guillaumot, 2009; Mosquitoes info, 2012).

Females of *Culex pipiens* are known to be a major nuisance and cause diseases that are fearful to humans and animals (Gad *et al.,* 1995, Turell *et al.*, 1996).

1.1.2. Seasonal pace of activity

The population of the Tlemcen urban group reports a high nuisance in the summer (28.8%), but the species is present and disturbed even during other seasons (Figure 4). The presence of the species is felt throughout the year by 58.8% of the affected population mainly in the districts of Imama, Kiffane, Zhun de Champ de Tir and Chetouane. This is related to all types of larval deposits available in these neighborhoods as well as to local climatic conditions.

3.2% of the households surveyed are affected by mosquito bites during three seasons (spring, summer, autumn or summer, autumn, winter) and 2.4% are affected during two seasons (summer, autumn or spring, summer).

The strains of *Culex pipiens* that colonize hypogeous deposits or thermal deviations are small, do not stop their development in winter (Rioux *et al*, 1965;Hassaine, 2002). The water in these deposits has a favorable temperature for the continued development of *Culex pipiens*.

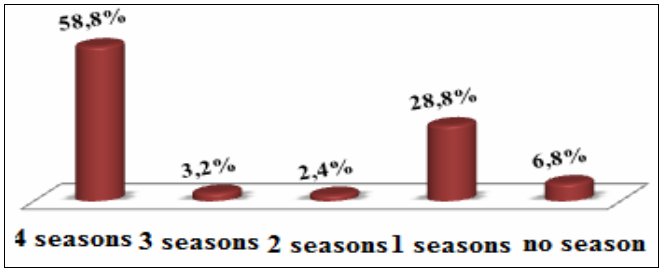

Fig. 4 : Sting seasons

According to Elena and Elena (2007), mosquitoes grow throughout the year, in underground sites flooded by polluted water, for example in the basements of houses, tunnels.

Culex pipiens colonizes different types of environments for a long period of the year. In Morocco, they are present from spring to autumn (Himmi *et al.*, 1998).

In some parts of the world, *Culex pipiens* is found almost all year round (Gaud 1952; Hurlbut and Weitz, 1956; Louahmy, 1995). In regions with contrasting climates with a cold period, this Culici of causes inconveniences from mid-March to the end of September, with maximum nuisance during the summer, from June to September. However, some mild winters may allow for low activity, since during the winter only females survive dormant by sheltering in dimly lit areas, but as soon as the temperature rises sufficiently, the dormant state is lifted and the female resumes her activities.

1.2. Multivariate Analysis of Settings

To interpret and statistically process the results of the survey, we opted for the A.F.C. Factor Analysis of Correspondences (Thioulouse and Chessel, 1997).

The A.F.C. deals mainly with contingency tables. It is a symmetrical analysis that deals with discontinuous and positive data. The advantage of this type of analysis is that rare observations are given importance.

We looked at the A.F.C. to define the groupings of stations in associations in different types of lodges, the number of stings and the seasons of stings.

The statistical treatments and associated graphic representations were performed with the MINITAB 16 program at the queue.

1.2.1. Biotypology of lodgings

In urban areas, storm sewers, flooded cellars and crawl spaces, pools, abandoned swimming pools, cans, various containers, form lodgings conducive to the proliferation of *Culex pipiens* larvae. All these larval deposits are created and maintained by humans.

To better learn about the different potential habitats encountered in the survey carried out, we considered a typology of the surveys, carried out using an A.F.C., to define the groupings of surveys in the different types of deposits.

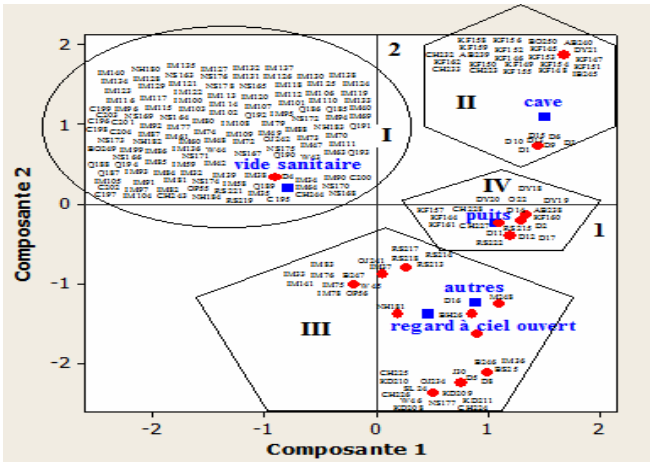

Fig. 5 : Factor plan (F1xF2 lines and columns) of the matrix for the distribution of surveys according to the different types of deposits

Factor analysis of the input matrix matches consisting of 250 lines that correspond to the surveys and 5 columns representing the different types of larval deposits, provides graphic representations of the lines and columns (Figure 5).

The own values show that the first two axes extract 35.88% and 23.46% respectively from total inertia. Taking into account the relative contributions of the column factors, Axis 1 consists mainly of surveys that are characterized by the dominance of the caves as larval deposits located on the positive side of this axis, opposed to surveys characterized by sanitary void-type deposits that individualize on the negative side of axis 1.

On the positive side of axis 2 are the surveys located near the cellars. On the negative side of this axis, there is marginalization of surveys where there is dominance as hopper deposits of wells, open-air glances, as well as other types of deposits (pool, wads).

Figure 20 represents the projections of species in the F1x F2 plan, each of which is superimposed on the factor map relating to the type of deposit (column). Beyond are four groupings.

- **Group I**: is represented by surveys characterized by the presence of an empty-sanitary larval deposit. These surveys correspond to the collective dwellings located mainly in the following neighborhoods: Imama (city of 1060 dwellings, wouroud city, nassim city and city of Roses), Zhun de Champ de Tir (city of 400 dwellings, city of 500 dwellings), Kiffane (city Nahda). This type of hypogee deposit offers the most favourable conditions for the proliferation of *Culex pipiens* larvae, it is characterized by total darkness throughout the year. Thus, these dark deposits have the highest densities of larvae, they remain highly dominant.
- **Group II**: corresponds to cellar-dominated readings. This type of lodging, less numerous, is located mainly in buildings located in the cities of 270 dwellings, 125 dwellings, cited Wafaa (Chetouane), as well as in the city Soumam (Kiffane) and of lesser importance in Bouhannak and AbouTechfine.
- **Group III**: gathers surveys, where the most productive lodge is the open-air look and other types of small lodgings located mainly in a few localities located in different neighborhoods, mainly in the city of 270 dwellings (Chetouane), the city of 150 dwellings (Koudia), the city of Dahlias (Kiffane) as well as the city SidiLahcen (the city). Some of these surveys are characterized by the presence of other types of particular lodgings, such as swimming pools found mainly in the District of Imama (the City of Roses) and in the Kiffane district (city of Dahlias). These pools are often used as water reservoirs that can be used for watering (gardens, vegetable gardens, etc.). The standing water for several days promotes the proliferation of *Culex*.
- The presence of the wadi near some houses of Ain Mazouna and more precisely the city of gardens where there is a passage of Oued Mazouna nearby. In the city of 500 dwellings (Zhun district of Field of Tir) the passage of Oued Bouhannak is a source of nuisance for the inhabitants. These pueds fed by wastewater from nearby settlements and with more or less slow flow, constitute a productive larval deposit.
- **Group IV**: corresponds to surveys that stand out by the presence of wells as a source of nuisance.

1.2.2. Degree of aggressiveness of *Culex pipiens*

The degree of aggressiveness of *Culex pipiens* is estimated from the numbers of stings felt per night per person.

To perform the factor analysis of the matches of the degree of aggression of the females, we used the table of Schedule II, composed of 250 lines (raised) and three columns (number of stings). For example, we obtained the results on Figure 6, which shows all the stations associated with each of the three intervals of the numbers of stings (one to three times, three to eight times and more than eight times a day) which represent the degree of aggression of the females and in this case the degree of nuisance felt by the population.

We selected the first two axes representing 50.70% and 49.30% of total inertia respectively. It thus individualizes three distinct groups.

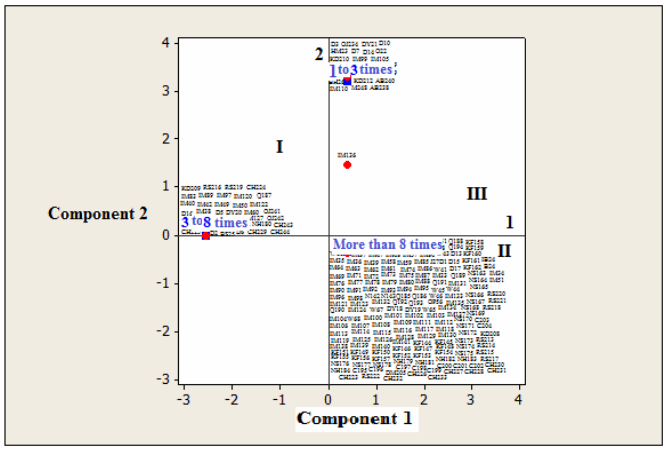

Fig. 6 : Factor plane (F1xF2 lines and columns) of the matrix of distribution of surveys according to the number of stings

- **Group I**: Located on the positive side of axis 1, near the center, it contributes the most to its formation; it is represented by surveys where the number of stings is more than eight per night per person. These surveys are related to several neighborhoods and concern a large number of cities, mainly the city of gardens (AinMazouna), the city of La Gare (city center), the city of Dahlias and the city of soumam (Kiffane), the cities of 1060 dwellings, OPGI, Wouroud, Nour, Nassim, Les Roses and Nahda (Imama), the cities of 400 dwellings and 500 dwellings (Zhun de Tir) as well as the city of 270 dwellings and 125 dwellings (Chetouane). A very high nuisance is therefore felt in more than half of the neighborhoods studied.
- **Group II**: corresponds to moderately infested surveys, the latter are marginalized on the negative side of axis 1 and contribute effectively to its formation. These surveys are located in the cities of Provence and La Gare belonging to the downtown district, the cities of Dahlias and Soumam which are located in the district of Kiffane, the city of 1060 dwellings and the city of Roses which are located in Imama, the cities of 270 dwellings and the city of 150 dwellings that are located in Chetouane.

- **Group III**: On the positive side of Axis 2, the surveys with the least affected inhabitants in the study area are superimposed, with stings varying between 1 and 3 stings per day per person. These inhabitants reside in the Center city (city the train station), Koudia (cities Dib Mounir and 150 dwellings), part of Kiffane (city of Dahlias) and Aboutachfine (city of 250 dwellings). As a result, they are the least infested areas. This sector remains more or less unscathed and knows little about the phenomenon of nuisance by *Culex pipiens*. This is due to the absence of sanitary voids in these dwellings.

In terms of this analysis, it is clear that the number of households affected by mosquito aggression remains substantial, very few do not complain. The study area seems to be heterogeneously affected by mosquito nuisance.

1.2.3. Biotypology of sting seasons.

The biological adaptation of *Culex pipiens* to the seasonal rate is based solely on climatic variations directly felt by populations. In general, the species can be harvested throughout the year, but it has maximum abundance in the spring and summer. To better understand the variation of this parameter, we made an A.F.C.

Analysis of the entry matrix consisting of 250 lines (recorded) and four columns (seasons during which the inhabitants are disturbed by the bites of females) allowed us to obtain the results carried on Figure 7. In Appendix II, the own values show us that the first two axes extract 90.25% and 6.66% respectively of total inertia, or 96.91% of total variability.

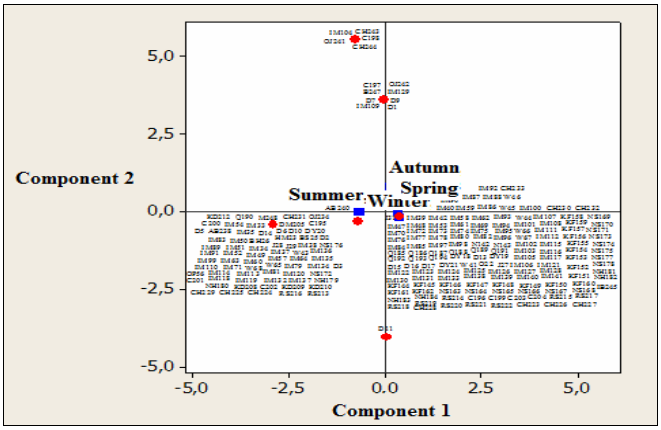

Fig. 7 : Factor plan (F1xF2 lines and columns) of the matrix of distribution of surveys according to the seasons of stings

Figure 7 represents the projections of the readings in the plane (F1xF2), in association with the column points. Thus, the four seasons contribute significantly to the construction of Axis 1. The dots are distributed on this axis, giving off some peculiarities.

In the Tlemcen urban grouping, activity seems to continue throughout the year in a large number of neighborhoods. This is due to the very small distance between the line points and the column points. Their grouping near the origin can be explained by repeated stings over the four seasons. However, we note that on the negative side of Axis 1 are isolated the surveys whose activity of *Culex pipiens* takes place only in summer, they are located in more than ten cities belonging to the three municipalities of the urban grouping of Tlemcen: city of 1060 dwellings, city Wouroud, city Nahda and city Nassima (district of Imama); city of Dahlias (Kiffane); 500 dwellings (Zhun shooting range); 125 dwellings and 150 dwellings, located in the municipality of Chetouane; Gardens (AinMazouna) and the city La Gare (Center city district). These statements represent Group I.

On the positive side of axis 1, the surveys located mostly in Imama (cities of the Roses, 1060 dwellings, Wouroud, Nassim, Nour and Nahda), Chetouane (cities of 125 dwellings and 270 dwellings), Zhun de Champ de Tir (cities of 400 dwellings and 500 dwellings), Kiffane (cities of Dahlias and Soumam), AinMazouna (city of gardens) and Center city (La Gare). The population of these neighborhoods complains of an almost permanent nuisance.

On the positive side of Axis 2, surveys where activity is noted during both seasons, summer-autumn or spring-summer, are marginalized. They remain very limited in space and cover only a small number of households.

This analysis clearly shows that summer is the season when households are most affected. The presence of females and the manifestation of their aggressiveness during other seasons are due to the variability of climatic factors and more precisely the thermal irregularities experienced by the climate of our region. Females resume their activity when "m" exceeds 9°C (Metge 1986).

1.2.4. Hierarchical test of the overall synthesis of the survey

A hierarchical bottom-up classification (CAH) In order to identify the key factors causing the nuisance in the Tlemcen urban grouping. The input matrix analysis consists of 250 lines (records) and twelve columns.

The dendrogram from CAH (Figure8) is the result of the classification of surveys according to an ordination by the Ward method and the application of Jaccard's similarity index (Chessel *et al.*, 2004), based on the different information collected during the survey carried out in the three communes and highlights two large units.

The N1 unit is made up of relatively less productive larval deposits (cave, open-air eyes, wells and other larval deposits) combined with puncture intervals of 1 to less than 8 times, thus less nuisance.

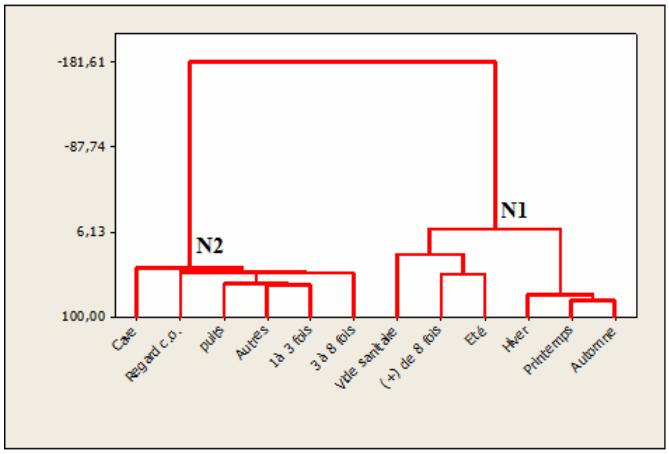

Fig. 8 : CAH of the survey distribution matrix relative to the different parameters of the survey

The N2 unit connects the "sanitary void" larval deposit to a number of bites exceeding eight 8 stings and the four seasons of the year. These results corroborate with what has

been demonstrated previously. The crawl space is the cause of the greatest nuisance and the larval density is responsible for an almost ubiquitous activity with a maximum peak in summer.

This analysis therefore reveals the crawl space as a deposit responsible for the greatest nuisance in the urban grouping of Tlemcen.

This segregation clearly shows that the population most affected by mosquito bites and throughout the year is those living in homes with crawl spaces.

Indeed, based on the results of our household survey, it seems that the propensity to view the mosquito as transmitting diseases to humans is clearly increasing among the households most affected. These results are comparable to those found by Sérandour in 2009 after conducting a survey, where 86% of the most sensitive people report that the mosquito is harmful, compared to only 28% for the most tolerant.

More than 90% of respondents are in favor of domestication of inhabited areas. As these individuals declaring themselves very much or somewhat embarrassed by the presence of mosquitoes, they remain relatively critical of the domestication campaigns used by APC (Community People's Assembly) of the three municipalities studied.

Although to a lesser extent than those who said they were not embarrassed.

In view of the responses of the inhabitants, it is perceived that the individuals interviewed have many questions about the methods and techniques of domestication used by local communities. They are quite aware of these adapted and under-studied methods that remain harmful and with considerable impact on the health of their children. A majority of them highlight the harmfulness of chemical insecticides to their health but very little to nature.

Overall, the survey reveals that the inhabitants of the Tlemcen urban group surveyed have little or no experience of domestication, with more than 95% of respondents saying they are unaware of the insecticides used by domestication organisms.

Based on the results of our survey, we perceive that the majority of respondents are susceptible to mosquitoes, which is the case of households surveyed in 2009 by Sérandour or less than 40% who reported supporting the nuisance caused by mosquitoes.

2. Mapping infested areas

- The mapping, based on the results of the survey, shows a certain zonation of the spatial distribution of the most affected households.
- The survey conducted in the Tlemcen Urban Group allowed us to map the degree of infestation by delineating the areas according to the intervals of the numbers of stings based on the information gathered by the survey.
- Indeed, Tchicaya (2014) considers aggression to be low between 0.3-2.9 sting/hour/person (s/h/p), sting activity gradually intensifies (1.5-6 s/h/p), highest puncture activity (2.6-12.6 s/h/p).
- We estimate the degree of aggression in three classes as well, taking into account the number of injections per night (8h) per person. According to data collected during the survey conducted in the Tlemcen Urban Group. The conversion of these values, allows the following typology:
    - Class 1 is represented by a low aggressiveness of 0.1 to 0.4 s/h/p.
    - Class 2 with an average aggression of 0.5 to 1 s/h/p.
    - Class 3 with maximum aggression marked by values above 1 s/h/p.

The results of the AFC allow for the geographical location of each survey and, as a result, a global mapping of the study area (Fig. 9). To properly delineate the different sectors according to their degree of infestation, we worked on a large scale (1/10 000th), then reduced it to 1/50 000th for presentation convenience.

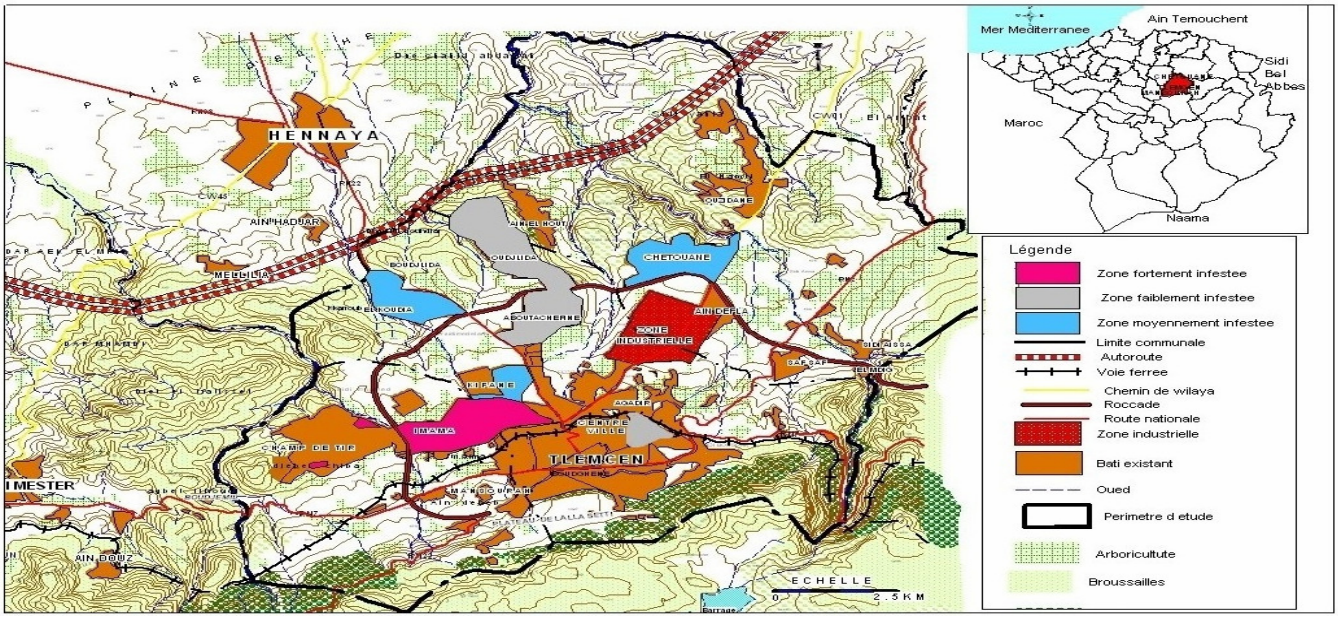

Fig. 9 : Distribution of infested areas by *Culex pipiens* in the large Tlemcen grouping

CONCLUSION

The study area covers an area of 3700 ha. The map shows three areas based on three degrees of infestation or aggression.

A heavily infested area, representing neighborhoods with more than 1 s/h/p aggression, this area corresponds to the neighborhoods: Imama, Zhun de Champ de Tir (commune de Mansourah), part of Kiffane, Ain Mazouna (community of Tlemcen) and Chetouane (commune of Chetouane). The dwellings in these neighborhoods are all collective or semi-collective. The most common type of shelter encountered during the survey is the crawl space. Most of the inhabitants who occupy this area are affected by the presence of *Culex pipiens* all year round.

This heavily infested area occupies an area of 250.60 ha. In order to highlight these areas we represented them by the red color. These sectors require urgent and large-scale of domestication operations, led by adapted and specialized teams.

An area moderately infested with a degree of aggression of 0.5 to 1 s/h/p, bringing together part of Kiffane (high individual standing type) and the city center and Koudia (Tlemcen commune). The total area of this area represented in grey is 375.4 ha. This sector is the largest in area, but domestication operations must be carried out differently than by anarchic chemical treatments. Public awareness and physical control can be sufficient.

A sparsely infested area covering an area of 292.7 ha, represented on the figure by the blue color, it concerns the neighborhoods of Aboutach fine and a part of the Center city with a number of stings ranging between 0.1 and 0.4 s/h/p. in this area, domestication is useless. Only the individual means of control are sufficient to fill the nuisance generated.

In terms of this mapping analysis, it appears that over the entire urban grouping of Tlemcen, the overall area to be retained for a domestication operation is about 250 ha which presents only 6% of the total territory of the urban grouping of Tlemcen.

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