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First record of the avian malaria vector *Cs. longiareolata* (Diptera: Culicidae) for the Southeast of Algeria

MERABTI Brahim [1,2*]; BOUMAAZA Mounir[3]; LEBBOUZ Ismahane[4] ; OUAKID Mohamed Laid[3];
[1]Department of Biology, Faculty of Sciences, " mar Telidji University, B.P. 37, Laghouat, " lgeria
[2]Desertification and Climate Team, Mechanics Laboratory, " mar Telidji University, B.P. 37, Laghouat, " lgeria
[3]Department of Biology, Faculty of Sciences, Badji Mokhtar University, B.P. 12, " nnaba, " lgeria
[4] Genetics, Biotechnology and Bioresources Valorization Laboratory, Mohamed Kheider University, Biskra, " lgeria
*Corresponding " uthor: ecobiskra@hotmail.fr

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ABSTRACT
Objectives: The control strategies of mosquitos like *Culiseta longiareolata* were developed gradually. " study of the bio-ecology of *Culiseta longiareolata* was considered as the first step to fight against it.
Methodology and results: Larvae and adult collections were carried out from different habitats using standard dipping methods from the region of Biskra (" lgerian Southeast) (34° 51' 00" north, 5° 44' 00" east). For five years during 2009-2013 in four sites and the investigation was bi-monthly for any site. Overall, 792 specimens of mosquitoes were identified among the 44677 specimens that were collected. *Cs. longiareolata* presented in the second order with 27.59 % in numerical terms after *Culex pipiens* 28.65 %, *Aedes caspius* 12.97 %, *Anopheles multicolor* 7.22 %, *Anopheles sergentii* 2.84 %. Other 17 species were presented with low rates. This species was collected from all types of habitats (dominant or periodic stagnant water, with or no vegetation, clear or turbid, sunny ,or noisy sites, filled with fresh or brackish water, clean or polluted), throughout the year with different abundances. The Phenology of *Cs. longiareolata* proves that it is distributed in ten months annually, compared with other species. The sexual dimorphism was clear across the morphometric characters of both sexes. The densities were variables for this species when marked two picks, for the month of May (> 40 individual/stroke for larvae, > 32 individual/stroke for an adult), for the month of November (> 27 individual/stroke for larvae, > 2O individual/stroke for an adult).
Conclusion and appilication of findings: More, *Cs. longiareolata* cohabited with all species of different genera " edes, Culex, and " nopheles.
Keywords: Culicidae, bioecology, *Culiseta longiareolata*, Biskra, breeding sites.

INTRODUCTION
" vian malaria and various arboviruses are very interesting diseases on the veterinary and ecological side; of which *Cs. longiareolata* (Macquart, 1838) is the main vector (Seidel et *al*., 2013). It is also the vector involved in the transmission of brucellosis, avian influenza, West Nile encephalitis, and Malta fever (Maslov, 1967). This species is multivoltine with continuous

development in hot countries with wide distribution, is present in the south of the Palearctic region; it is distributed in the Mediterranean region, Europe, and " sia (Van Pletzen et *al*., 1989; " zari et *al*., 2011, Minar 1991). " ctually, there is a contradiction with many authors mentioning that this species attacks human and animal, but the birds are only the principal host in North " frica (" l-Jaran & Katbeh-Bader, 2001; Maslov et *al*., 1989; Roubaud & Colas-Belcour, 1989). The breeding sites of this species are of very different types; they may be permanent or temporary, shaded or sunny, filled with fresh or brackish water, clean or polluted (Schaffner, 2001). *Cs. longiareolata*, is a widely distributed species in " lgeria (Lounaci, 2003; Berchi, 2000; Hamaidia, 2004), and particularly in the southern part of the country (Clastrier & Senevet, 1961; Mengri et *al*., 1984; Merabti, 2016; Merabti et *al.,* 2017). To fight against insects which have vectorial capacities is a major concern for scientists. " good understanding of the ecology of species is classified as a first step to control these vectors. In a period of five years from January 2009 to December 2013 and in four different sites of the region of Biskra (Southeast of " lgeria), the study was done on the ecological factors impact on the spatio-temporal distribution of *Cs. longiareolata*. The biometric study of twenty-six morphological characters of the two sexes of this species can show his systematic aspect. In the Biskra (" lgeria) region, like everywhere in the state, the direct effect of the water in the natural environment creates a biotope in organic matter, in nitrogen and phosphate products, favourable to the proliferation of mosquitoes.

MATERIAL AND METHODS

Presentation of the study area: " preliminary survey was carried out in natural and urban areas in the region of Biskra (34°51'N 5°44'E), in the South-East of " lgeria, which allowed us to inventory about ten larval sites where Culicidifauna was harvested. Four different collection sites were chosen in this study area. Samples were taken twice a week in six cottages for each site. The description of the study sites is in table 01:

Table 1: Natural characteristics of the study sites.

Site Characteristics	Geographic coordinates	Breeding sites type	Sampling Technique
01: CHETM"	34°50'53.02"N and 5°48'01.42" E	Swamp, puddle, irrigation basin, runoff	Butterfly net, Dipping methods
02: BISKR"	34°50'14.66"N and 5°44'37.93" E	Valley, Basin water	Butterfly net, Dipping methods, hand catch
03: SIDI OKB"	34°45'22.16"N and 5°54'04.64" E	Dam water	Butterfly net, Dipping methods
04: BORDJ BEN " ZOUZ	34°41'43.33"N and 5°21'52.79" E	Irrigation ditches, freshwater or brackish pond	Butterfly net, Dipping methods

Sampling method: Mosquito development stages were sampled at 24 breeding habitats twice a week using Dipping method (Papierok et *al*., 1975), and butterfly net during all the month in the five years of study. Sampled specimens were preserved in vials containing ethanol (75%). In addition, mosquitoes were sampled manually with handheld aspirators and tubes. Each vessel was carefully marked with information about the breeding site. The specimens sampled (pre-imaginal stages and imagines) were identified morphologically using the keys of Brunhes et *al*., 2000). Data " nalysis: The graphical representations used in this study were prepared using Exel (2007), Image Tools v.4.2 and Statistix v8.0.

RESULTS

The numeric importance of *Cs. longiareolata*: In the five years of prospection, in the number of collected specimens two species *Culex pipiens* (the domestic mosquitoes) that have a large local spread and of *Cs. longiareoolata* were marked as important. The number reported is varied between 467 and 79 individuals for

the first and second season, 2009 and 2013 consecutively. The last season had a decreased number of the collected specimen maybe due to climatic factors like temperature and precipitation or because of the very hot year of 2012 in the region of Biskra, when the temperature has an important value about 50 to 58 C° (NMO, 2014). The third species was *Aedes ochleratatus caspius*, but it has a decreased number compared to Cx.pipiens and Cs.longiareolata. The other species with a decreased number did not arrive at 200 individuals.

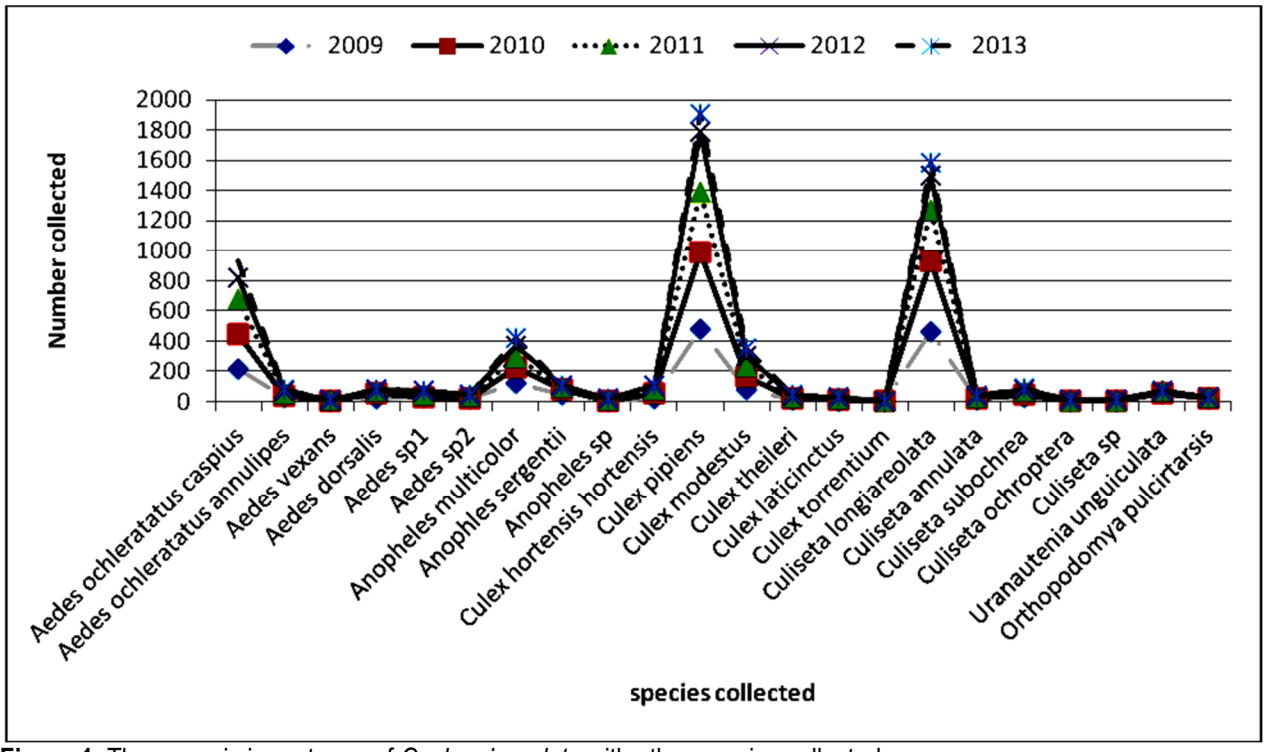


Figure 1: The numeric importance of *Cs. longiareolata* with other species collected

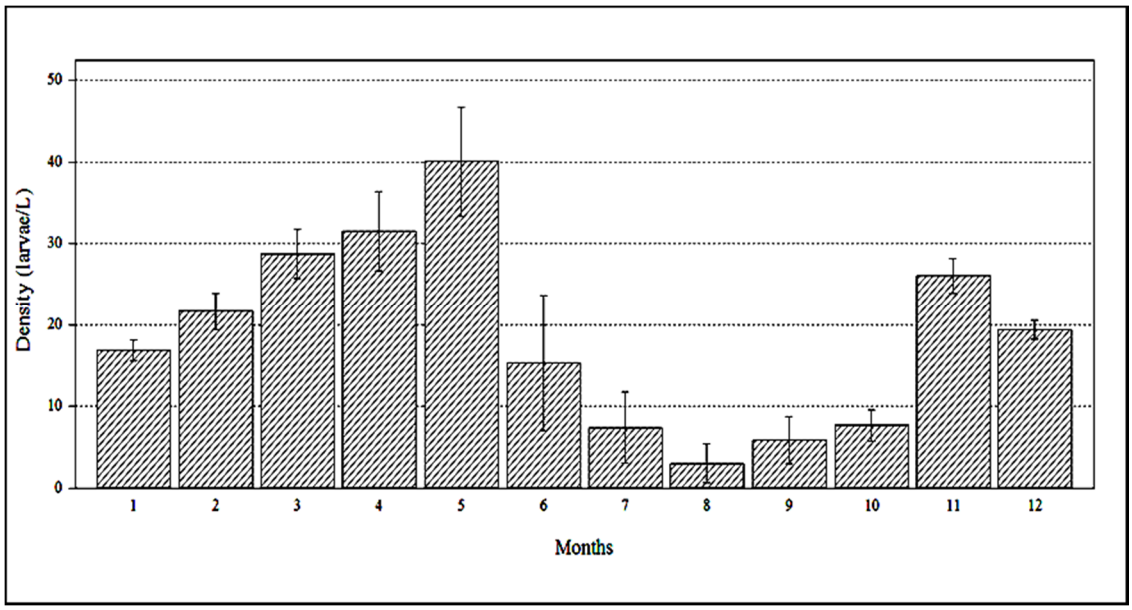
Breeding sites : " ll positive breeding sites were cohabited by all developmental stages of *Cs. longiareolata.* During the five years of study, this species has a large capacity to occupy the different breeding sites, with nature different (permanent or temporary), and of different types (Lagoon depression, grassy marsh, drainage ditch, traditional basin water, irrigation basin, marsh and rejects sites). Were harvested in almost all types of breeding sites with different localized plant species (Green " lgae, *Phragmites comunis*, *Phoenicia dactylifora*, *Cynodon dactylon*.

Temporal distribution and phenology of *Cs.longiareolata:* The table 2 proved the monthly repartition of the sampling species, the *Cs.longiareolata* was observed in ten months in the year, in the five years of sampling, compared to other species, when it was differentiated remarked in the breeding sites from two to four months like *Cs.ochroptera, Cs. subochrea, Culex laticinctus, Culex theileri, Anopheles sergentii,* and *Aedes vexans*. Some species have a large monthly repartition when it observed from five to seven months like *Anopheles multicolor* and *Culex modestus.* This reparation prouve the large ecological valence of the Cs.longiareolata compared to others species.

Table 2: Monthly repartition of *Cs.longiareolata* with other species

Species / Months	Jan	Feb	Mar	" pr	May	Jun	Jul	" ug	Sep	Oct	Nov	Dec
Ae. caspius		▨	▨	▨	▨	▨						
Ae. annulipes				▨	▨							
Ae. vexans						▨						
Ae. dorsalis					▨	▨						
An. multicolor					▨	▨	▨	▨	▨	▨		
An. sergentii					▨	▨			▨	▨		
Cx. modestus				▨	▨	▨	▨	▨	▨	▨		
Cx. theileri			▨	▨							▨	▨
Cx. laticinctus					▨	▨						
Cx. torrentium											▨	▨
Cs. Longiareolata	▨	▨	▨	▨	▨	▨			▨	▨	▨	▨
Cs. Annulata			▨	▨	▨							
Cs. Subochrea	▨	▨	▨	▨								
Cs. Ochroptera										▨	▨	

" e: " edes; " n: " nopheles; Cx: Culex; Cs: Culiseta.



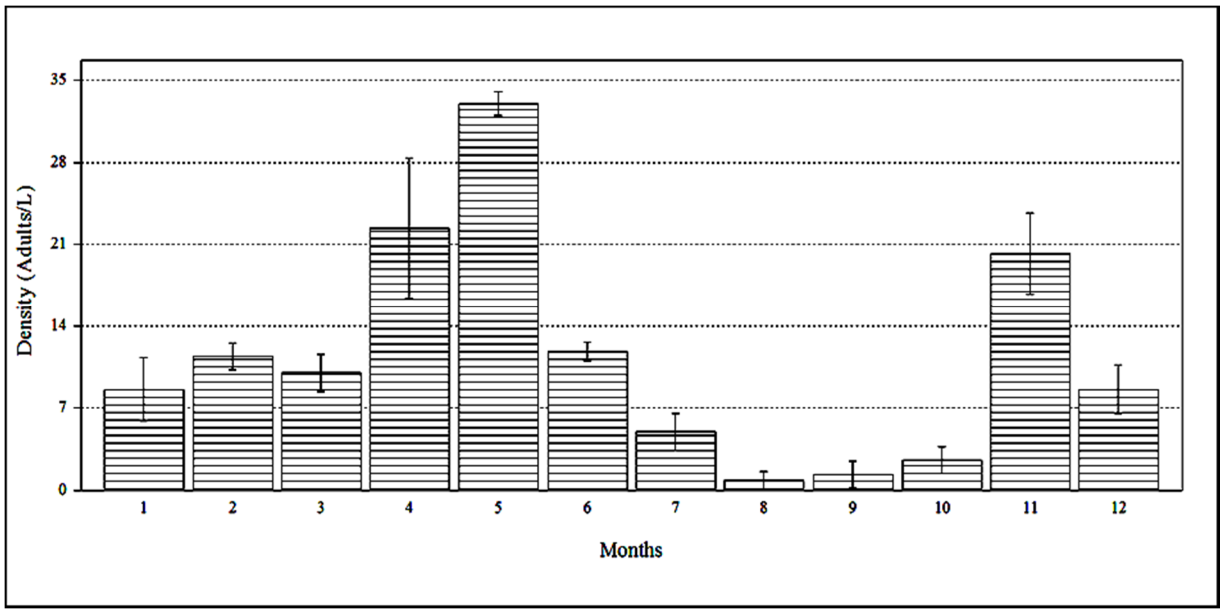
L; liter, 1 to 12: months.

Figure 2: Monthly density of larvae (2009-2013)

Monthly density according to Dipping method: " ccording to the method of Dipping, which consists of sampling larvae and pupae without repetition in several places at each breeding site using a 1-liter ladle. We can remark that the density of the *Cs. longiareolata* larvae were differently from month to another. We can remark that the density is very important for the month of May when the density has touched the value of 40 Larvae/ladle, then the three months of March, " pril, and November, when density was from 25 to 32 Larvae/ladle. The density was observed with a low average compared to previous months (5 to 20 larvae/ladle) (Figure 2).

Density of adults according to the Butterfly net: For the adult's density was determined by Butterfly net used during our sampling. The values were very important for the three months of " pril, May, and November, when it accessed 20 adults/net. This observation was revealed maybe to the climatic conditions: temperature and the wind for example (Figure 3).

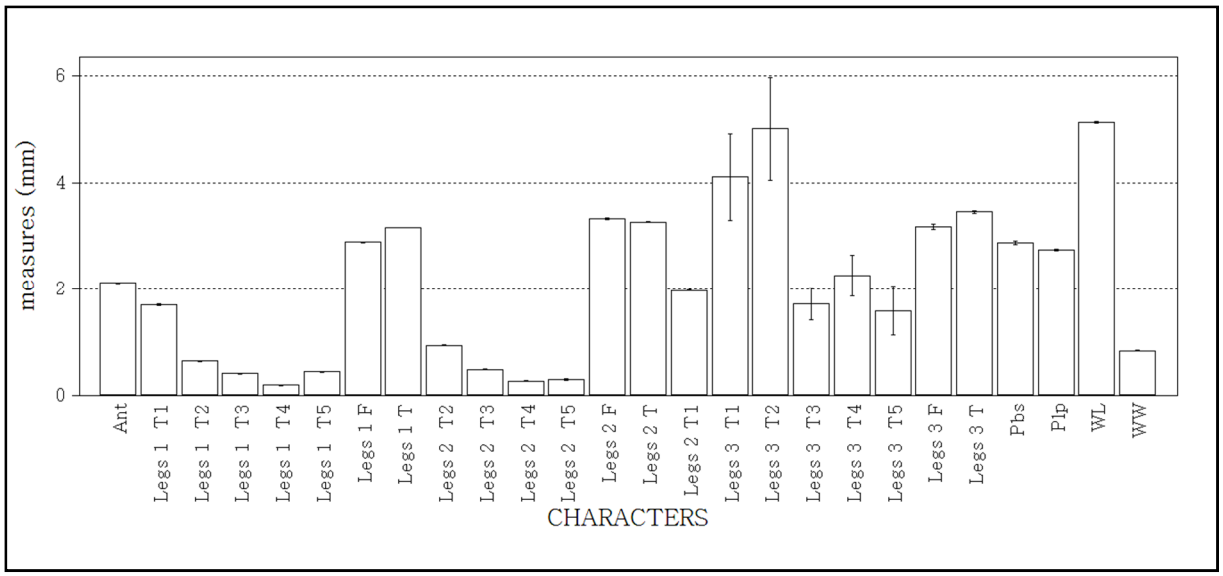
" ccording to Figure 2 and 3, we observed that the density of larvae of *Cs. longiareolata* was higher than the density marked for adults while the 12 months in the five years of prospection.



L: liter, 1 to 12: onths

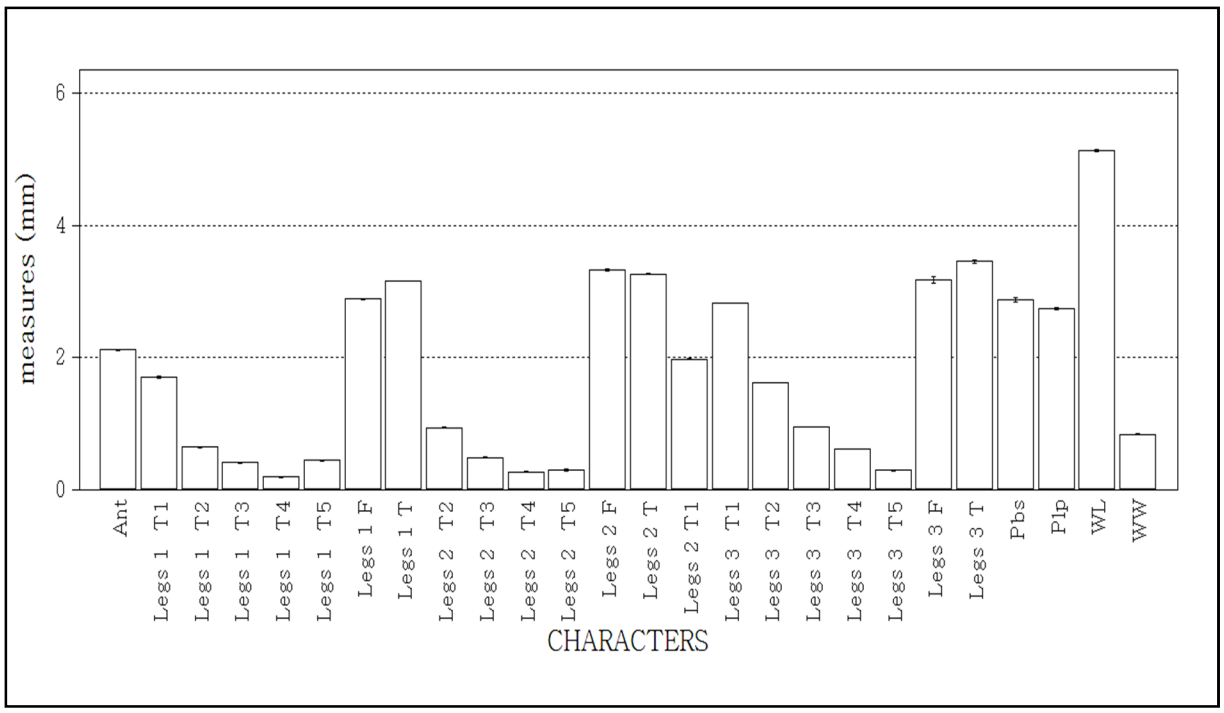
Figure 3: Monthly density of adults (2009-2013)

Morphometric study: The measurements of descriptive criteria selected of both sexes were illustrated in Figures.4 and 5. It's presented on histogram compared the mean measurement and standard deviation of 26 criteria related to females and males respectively. Those entire measurements proved the sexual dimorphism between both sexes when the females are smaller than the males. These morphometric characteristics present a specificity of our species in the south of our country.



WL: Wing length; WW: Wing Width; " nt:" ntenna; Plp: Palp; Pbs: proboscis; T: Tarsus.

Figure 4: Histogram presentation of mean measurements of *Cs.longiareolata* females



WL: Wing length; WW: Wing Width; " nt:" ntenna; Plp: Palp; Pbs: proboscis; T: Tarsus

Figure 5: Histogram presentation of the mean measurement of *Cs. longiareolata* males.

Figure 5, presented on the histogram compared the mean measurement and standard deviation of 26 criteria related to males. The analysis of variance (" NOV") between both sexes, with the twenty-six characters measurements, proves that there is a high significative difference ($F^{182,4}$=39.3; p=0.000). " ccording to the study of Senevet, 1936; Clastrier &Senevet 1961; Merabti (2016); Merabti et *al*., 2016; Bebba, 2004, The *Cs. longiareolata* was sampled from many sites from the Sahara regions of " lgeria (Biskra, Oues Souf, Laghouat, Ghardia, Ouargla, and the south of the region of Djelfa). " ccording to Brunhes et *al*, (1999) this species is multivoltine, stenogamous and autogenic, its role as a vector of human parasitosis can only be reduced. " ccording to Systematic Catalogue of Culicidae, 2011; Becker et *al*., 2010, this species is very spread in many countries in Europe and " frica. Tine-Djebbar et *al*., 2011 announced that the *Cs. longiareolata* and *Cx. pipiens* are the two most remarkable mosquito species in " lgeria. The female also bites man and pets, but has not been implicated in the transmission of human parasitosis (Senevet &" ndarelli, 1959; Brunhes et *al*., 1999). " ccording to Boulkenafet, (2006), the eggs of *Cs. longiareolata* grouped in the basket are cylindro-conical, carries about 50 to 400 eggs. For the year 2012, the temperatures recorded in our region of the study experienced very high values, which exceeded 50 ° c. " t this point, we have reported the almost total absence of *Cs.longiareolata* populations in the breeding sites. This remark can interfere with the limits of its ecological valence, which is limited by high-temperature values. This can interpret the oviposition behaviour of the female (Spencer et *al*., 2002; Stav et *al*., 2000). In recent years, our species has been found in urban areas, so the stinging behaviour has become anthropogenic rather than just zoophilic.The impacts of spatially heterogeneous environmental and ecological factors on mosquito population dynamics are complex and poorly understood for many species like, Particularly for zoonotic mosquito-borne diseases like *Cs. longiareolata*. This specie was sampled from different breeding sites (artificial or artificial), with stagnant or running water, rich or without aquatic flora, exposed or covered by the sun, pure and polluted water. This species were sampled as well the field and urban sites, but surely observed it did not represent a nuisance to man as it is in the animal's blood like Dove and Rabbit (Medlock et *al.,* 2005; Kampen et *al*., 2013; Merabti et *al.,* 2017) Brunhes et *al*., 2001 was confirmed that this species is a widely distributed species. It is found in artificial and natural deposits (Rioux, 1958). During our surveys, we found it in all the cottages and during most of the year (except the month

of July) in the permanent lodgings with fresh water poor or rich in vegetation. Lounaci (2003) reported its existence in the Reghaia marsh deposit, in the deposits of the El Harrach " gricultural Institute and in the El-" lia barn. " goun (1996) and Berchi (2000) reported its presence in different types of deposits in Constantine. Hamaidia (2004) reports its existence in polluted deposits, permanent settlements with stagnant water rich or poor in vegetation and in temporary dwellings with stagnant or current water with or without vegetation, in the regions of Tébessa and Souk-" hras. Zittra et *al,* (2014) confirmed in his research that the developmental stages of *Cs. longiareolata* were exclusively detected in one artificial water storage container and not at natural breeding sites. These findings confirm existing data, which indicate that *Cs. longiareolata* mainly favors man-made and predator-free artificial water containers and temporary waters with low predation risk for their offspring (Stav et *al*. 1999, Kiflawi et *al*. 2003). This study results were according to Zitra et *al* (2014) that the larvae and pupae of *Cs. longiareolata* shared their habitat with specimens of the *Culex pipiens* complex and *Cs. Annulata*, but we noticed that this species can cohabit its breeding sites with other species like *Cs.subochrea, Cs.ochroptera, Cx.modestus, Cx.theileri, Cx.laticinctus, Cx. torrentium, An.sergentii, An.multicolor, Ae.vexans, Ae.caspius*. We determined on the results obtained, the monthly distribution of *Cs.longiareolata* during the five years of study. This distribution has shown that this species is omnipresent all the year round, and which does not support either low or high temperature. With regard to quantitative results, the densities of this larval or adult species undergo spatio-temporal variations comparable to those reported by several authors in the different regions. It appears that spatiotemporal variations in densities cannot be attributed solely to fluctuations in the mesological parameters (environmental parameters), but is also due to the nature of the habitat that is close to the sampling station. In fact, this last factor would influence firstly the spatio-temporal distribution of Culicidian species on the one hand, and the physicochemical factors of water, which can play the role of a limiting, factor (Brunhes et *al*., 1999; Senevet & " ndarelli, 1960, Rioux, 1958). The study of morphological characteristics of this species aims to distinguish the differences between the two sexes on the one hand and on the other hand to present the local ecotype of our species occupying the Saharan region of " lgeria.

CONCLUSION AND APPLICATION OF RESULTS

The present study was done during five years of prospection of the Saharan region of " lgeria and precisely in the southeastern part of the country. Monitoring the population of *Cs.longiareolata* allowed us to release some information. This species is very widespread throughout the year and in all types of breeding sites. It can withstand very low temperatures, and high temperature, which does not exceed 50 ° C. In terms of seasonal distribution, this species occupies nine to ten months in the year and has two peaks of propagation in the two months of May and November. In these two months, the larval and imaginal densities can reach very high values. the information provided by this study can help to define ways to control this species, through its bioecology.

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