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Mosquitoes (Diptera, Culicidae) of eleven important hydrosystems in the plain of the gharb and rabat-sale cities (Morocco): Species richness, geographic distribution, and density evolution

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ABSTRACT

This work is interested in a qualitative and quantitative study of mosquito larvae (Diptera, Culicidae) in ten major aquatic systems located in the Gharb plain and the urban area of the city of Rabat /Salé in Morocco. Thus, we have elaborated an inventory of species, their frequency, the evolution of their densities and their geographical distribution.

The results show that the settlement of the Culicidae Diptera is formed by 13 species. However, this richness varies locally depending on the hydrosystem heterogeneity and the physcochemical characteristics of the environment. Thus, the biotops that are ecologically more hétrogènes have shown the higher richness in species. Also, the frequency was not the same for all harvested species. Anopheles labranchiae and *Culex pipiens* were the most common species, while *Culiseta subochrea* was collected in a single Biotop.

Moreover, depending on the species and the aquatic systems, the first appearance of larvae may be in the fall, winter or spring. The density varies with the species. So, *Culex pipiens* and *Ochlerotatus detritus* have high densities. Unlike *Culex hortensis* and *Culex impudicus* have shown low densities. Similarly, depending on the species, the évolution of the density may show a single or several density peaks.

KEYWORDS

Diptera;
Culicidae;
Frequency;
Density;
Gharb plain;
Rabat / Salé cities;
Morocco.

INTRODUCTION

Mosquitoes are insects potentially vectors of parasitic diseases of man and animal[1]. In Africa alone, more than a million children die each year, victims of these types of insects, including malaria which is a waterborne parasitic disease. Thus, of all the parasitosis, the malaria is responsible for the most of human deaths. This disease is transmitted to humans by inoculation of infective forms at the moment of the bite, with the saliva

of the mosquito, a Culicidae Diptera, which is an intermediate vector of the malaria pathogen.

In Morocco, the malaria does not continue to pose a major problem for public health[1,2] but its main vector, Anopheles labranchiae is still frequently present in the environment[3,4].

In the region of Kenitra city, a geographical area which is rich in surface water accumulations, malaria is not common, but at any time existing cases could be a core point in the evolution of this disease. In addition, the high water frequency in the Gharb plain often causes a development many waves of Culicidae species which are harmful to humans and to livestock by their bites.

Moreover, for any epidemiological study or any program against harmful Diptera, it is useful to know the systematic stand structure and the dynamics of the main species of the Culicidae in the geographical area which is to be protected. Thus, in different regions of Morocco, many studies are interested in this type of study, we include those Himmi (2007)[2] and Trari et *al.* (2002 and 2004)[3,4].

By this work, we contribute to a better understanding the ecology of insects Diptera Culicidae, by determining the systematic structure and the density evolution of each species in ten important hydrosystems of the Gharb and the nearby of two cities, Rabat and Sale (Morocco).

The studied hydrosystems are characterized by the diversity of their physical-chemical characteristics and of their national and international ecological importance. Note that, the systematic identification of a species allows predicting the vector-borne diseases that can be transmitted by this species in the study area[5].

MATERIALS AND METHODS

Studied sites and stations (Figure 1)

Ten of the important aquatic systems in the plain of Gharb or nearby the cities of Rabat and Sale were prospected. According to their heterogeneity, one or many stations were studied at each of them.

Dayet Eddis

It is a temporary water accumulation located in the western part of the forest Mamora. It is covering an area of approximately 8800 m^2 and a depth that can be 60 cm. It is supplied by water from precipitation, and of groundwater when it swells. Aquatic vegetation consists mainly of *Panicum repens*, *Ranunculus aquatilis*, *Lemna gibba* and filamentous algae.

Lac Sidi Bougha

Since 1964, it was ranked by IWRB as a natural site of international importance for waterfowl, and as a biological reserve by the Administration of Forestry and Soil Conservation. It was also listed as "Ramsar site "since 1974. It is a natural accumulation of standing water nearby the Atlantic coast of Morocco. It is located 3 km south of the city of Kenitra, 35 km north of the city of Rabat and occupies the center of a reserve, the reserve of Sidi Boughaba, which is a wetland of international importance for migratory waterbirds.

The lake is about 6 km long and could be divided into four areas having different environmental conditions[2]:

- Temporary pond of Sidi Boughaba: It is a circular depression about 1 hectare of surface having a muddy bottom. It is surrounded by a dense vegetation of *Juncus maritimus* with a few feet of *Scirpus lacustris* and its flooding is performed by the rainwater. The algal vegetation is rich in *Chara canescens* and *Chaetomorpha linum.*
- Small Merja: it is a brackish semi-permanent Swamp, which has duration of flooding up to 7 months. It is a depression about 6 hectares located north of the main lake. The water depth could reach 0.7 m and peripheral vegetation is mainly formed by *Juncus rigidus* mixed with a few feet of *Scirpus lacustris*.
- The main-lake: It is the permanent part of the lake and it is a length of about 4 km, the water is not brackish and the peripheral vegetation is abundant.
- Permanent ditch Sidi Bou Ghaba: It has a gap of 3 to 4 m diameter, the water is permanent and 1.5 m deep. It is located at the southern end of the main lake Sidi Bou Ghaba. The water is very salty and can communicate with the main lake when it swells after heavy rainfall. Mainly, the aquatic vegetation consists of

Lemna gibba and *Chaetomporpha linum*, and the edge of *Juncus maritimus*.

Lac fouarate

It is a wetland located northeast of the city of Kenitra, which is, according Lahrouz et al. (2012)[6], a wintering area for migratory birds. Its area is 2.16 km2 and it is a depth of 0.5 to 4 m invaded with vascular vegetation and filamentous algae and its impoundment is provided by the inflows of the river Fouarate, water from the outcrop of the aquifer in the winter, the water of precipitation and the wastewater[7]. In addition, the lake is the ultimate repository for many releases and waste from densely populated surrounding neighborhoods and where are located several small industrial units (textiles, tanneries,…).

According to the apparent heterogeneity of the lake, three research stations were surveyed:

S1: It is located upstream of the lake on the river Fouarat. This site is considered as a reference site.

S2: It is located at Lake Fouarat, respectively, on the right bank near crop fields;

S3: It is located near the outfall wastewater of the surrounding neighborhoods.

The temporary pond and the well of sidi amira

It is located about 15 km east of Rabat, near the forest home of Sidi Amira. It is a flat bottom trough. The aquatic vegetation appears as soon as the impoundment begins. The vegetation consists of hygrophilles herbaceous species, Characeae (*Chara canescens*) and other algae filmenteuuses (*Spiroger sp.*). The vegetation consists of phanerogammes including *Ranunculus aquatilus* and *Glyceria fluitans*.

Sidi yahia

It is in Beht river at the Sidi Yahia of Gharb. It is a river that in this city receives wastewater of the city. Often, the water flow is not too high except during the rainy season. In places, herbaceous vegetation or submerged filamentous algae is present.

Oued fekroun

It is an artificial river dug into the ground to drain the excessive irrigation water and water of rouisselement or floods. It is located fifteen kilometers north of the city of Kenitra. The flow of water is often low, the algal and vascular vegetation is often very developed. Similarly, in places, the water surface is covered with duckweed; the water depth is often less than 80 cm.

Dayet zdegh

It is a semi-permanent pool of an area of 2 hectares which is located 7 km east of the city of Kenitra. The water depth can reach one meter and the aquatic vegetation is rich in filamentous algae and *Ranuculus aquatilis*.

Gite oulja rabat

It is a temporary to semi-temoraires swamps which receiving sewage from the city of Rabat. Salinity varies from one place to another according to the heterogeneity of the medium and the amount of freshwater received. The richness of the environment of the aquatic végétation varies according to the degree of local salinity and water depth can reach 0.80 meters.

Daya oulja sale

It is a temporary pond contaminated by water from leaching from the disposal of solid waste in the city of Salé. Salinity is not too high the végétatition consists of filamentous algae and Ranunculus aquatilis. Water depth is up to 1 meter.

Dar El gueddari

Dar El Gueddari is a small village in the plain of Gharb very prone to flooding or storm of Sebou river. Thus, ditches and temporary pools are very common. Aquatic vegetation consists of filamentous algae, *Ranunculus aquatilis* and duckweed (*Lemna gibba*).

Rice fields

In Morocco, the fields of rice are located in the Gharb plain. Their area is estimated at 13 000 ha. It is an agro-ecosystem that is flooded during the growing season of rice (late April to mid-September) and dried up the rest of the year.

Method of wildlife harvesting

On all the selected sites, the larvae were collected every fortnight. Each session consists of a sample set of 10 shots made using an aquatic net of 20 cm diameter and 0.5 mm vacuum mesh. Each sample blow was made

by the same person over a distance of 1 m, and these blows were taken at various places in the biotop. Then, each sample is stored in a polystyrene bottle of a liter and a half and transported to the laboratory of Biodiversity and Natural Resources of the Faculty of Sciences of Kenitra for a systematic determination of harvested species.

For a given species, because of knowing the area of the opening of kicknet, the length of the swept volume of water and the number of larvae collected, the density of individuals is calculated. Note that the density evolution is used to characterize the dynamics of the species.

Figure 1 : Geographical map of the Gharb region (Source: DAT)

RESULTS AND DISCUSSION

Harvested species, species richness of cottages and resorts, and frequency of species:

As shown in TABLE 1, with 7 species, Lake Sidi Boughaba is the richest in species of Diptera Culicidae. This site wealth can be explained by the heterogeneity of the structure of the environment. Indeed, this site presents four types of habitats that are physical-chemically different - including the degrees of slinité and conductivity of the water, water depth, and duration of the flood phase. This variety of ecological conditions in the environment increase and diversifies the number of ecological niches. Also, note that this is the Station S4, formed by a dug pit and very, is rich in *Limnea gibba* and algae filamentous which houses a maximum of 5 species

With respectively 6 and 5 species, Fouarate Lake and temporary pool Sidi Amira have presented the highest specific richness. Also, the heterogeneity of habitats constituting these cottages could be the origin of this species richness.

Most of the other sites, often with a relatively homogeneous mesological structure, have shown three species or less.

Moreover, with the presence of *Culex pipiens* in 12 stations in eight cottages and the presence of *Anopheles labranchiae* in seven stations covering 7 aquatic ecosystems, these two species appear to be more frequent in the geographic area of the studied hydrosystems. The important frequencies of these two species could be explained by their high ecological valence.

Further note that, among the 13 species collected, seven species have been collected only in one or two cottages. The requirements specific to each of these epèces could be a cause.

Evolution of density and ecological overview of harvested species

The TABLE 1 (in Annex1) shows the density evolution of different species collected in the studied geographic area.

Anopheles labranchiae (Falleroni, 1926)

Density evolution

Oulja Sale

Early larval stages appear by the end of December, generally, larval densities are low, an average density of 20,2 individuals/m^3, a maximum density of 29 individuals/m^3 which was recorded in March / April and a single peak density.

Sidi yahia

The larvae were first appeared at the late September; often the larval densities have been important with an average of density of 99,95 individuals/m^3; the maximum Density was 270 individuals/m^3 recorded in late October, and three density peaks were ullistrés in late October, late January and early March.

TABLE 1: Harvested species in stations and surveyed biotops

Studied aquatic ecosystems	Stations	*Anopheles labranchiae*	*Culex pipiens*	*hortensis ??? ??*	*Culex theileri*	*Culex modestus*	*Culex impudicus*	*Culiseta longiareolata*	*Culiseta annulata*	*Culiseta subochrea*	*Ochlerotatus caspius*	*Ochlerotatus detritus*	*Uranotaenia b alfouri*	*Uranotaenia unguilata*
Lake of Sidi Boughaba	S1				+							+		
	S2										+	+	+	
	S3		+											
	S4		+							+	+	+		+
Loke Fouarate	S5		+											
	S6		+										+	
	S7		+											+
River of Fekroun	S8	+	+		+									
Sidi Amira	S9 Da	+	+		+	+	+	+						
	S10 Puit		+		+		+	+	+					
Dayet Zdegh	S11	+	+			+					+			
Sidi Yahya	S12	+		+				+	+					
Dar Gueddari	S13			+	+									
Oulja of Salé	S14	+	+					+						
Oulja of Rabat	S15	+	+											
Rice fields	S16	+	+		+									
Dayet Eddis	S17		+		+	+								

Oulja rabat

The larvae were first appearing in late December, an average density of 56,8 indinvidus/m^3 and a maximum density of 102 individuals/m^3 noted in late March, two density peaks, one in late February and the other in late March.

Oued fekroun

Early larval stages appear by the end October, the densities of these larvae were relatively high, an average density of 197,5 individuals/m^3, a maximum density of 403 individuals/m^3 noted in late March and a single peak density.

Daya sidi amira

The larvae were first appeared at early dévembre, larval densities were often weak, à medium density of 33,22 individuals/m^3, and a maximum density of 67 individuals/m^3, a single peak density.

Daya zdegh

The early larval phase appears by the beginning of October, an average density of 66,57 individuals/m^3, a maximum density of 171 individuals/m^3, and the two peaks of density, one in late November and the other in late February.

Rice fields

Larvae were appeared in late May, larval densities were often weak and a single peak density (26 individuals/m^3) which, at the same time, has made the maximum density.

Ecological overview

Anopheles labranchiae is the major vector of malaria in the Maghreb, particularly in Morocco[8]. It prefers the accumulation of water exposed to the sun[9], or temporary permanantes having less than 1900 m above sea level[8]; the water is shallow, freshwater or slightly brackish[1,10], weakly mineralized and covered by vegetables rich in filamentous algae[11,12].

Moreover, this species lives in temporary ponds, puddles, streams having low flow, and rice paddies. In addition to the media studied; the first appearance of larvae was carried out in autumn except in rice ponds where the apparition took place in May. The larval densities differ remarkably according habitats. Himmi et al. (1995)[8] have reported that this species shows an an-

nual presence in the fall and spring and seems to reach its ecological optimum autumn in permanent stations, and spring in the temporary station. But, its presence in the rice fields which have in Morocco a flooding stage in summer, this species lives in the summer.

Culex pipiens L.

Density evolution

Sidi amira well

The larval phase began in early December, larval densities were often low, a maximum density of 63 individuals/m^3 noted in early March, an average density 38,27 individuals/m^3 and one density peak.

Ditch sidi boughaba

The beginning of larval phase was completed in early January, larval densities were often high, a medium density of 196,42 individuals/m^3, and a maximum density of 730 individuals/m^3 which was noted in early March and a single peak density.

Daya sidi amira

The first appearance of larvae was in early November, the average larval density was 107,07 individuals/m^3, the maximum density was 214 individuals/m^3, and one density peak.

Merja sidi boughaba

The larval phase began in early September, the maximum density was 598 individuals/m^3 an average density of 292,92 individuals/m^3 and the two peaks of density one in early November and the other in late January.

D. zdegh

The beginning of the cycle was in early November, an average density of 93,12 indinviduals/m^3, a maximum density of 226 individuals/m^3 which was recorded in late April, a single density peak.

Oulja sale

The larval phase began in early January, larval densities were often weak, a medium density 23,75 individuals/m^3, a maximum density of 36 individuals/m^3 and one density peak.

Oued fekroun

The beginning larval cycle was in late December, an average density of 97,63 individuals/m^3, a maximum density of 171 individuals/m3, which was noted in early April, and two density peaks, one in early March and the other in early April.

Oulja rabat

The larvae were first appearing in late October, larval densities were often high, a maximum density of 322 individuals/m^3, an average density of 224,83 individuals/m^3 and two density peaks, one in early December and the other the end of January.

Lake fouarate S1

The first larvae have been emerged in early November, often high larval densities, an average density of 240,46 individuals/m^3, a maximum density of 421 individuals/m^3 (early February) and a single peak density.

Lac fouarate S2

The beginning of the larval stage was in early October, often high larval densities, an average density of 170 individuals/m^3, a maximum density of 374 individuals/m^3 and a single density peak.

Lac fouarate S3

Beginning of larval stage appear in the late October, with an average density elevated of 145,15 individuals/m^3, a maximum density of 281 individuals/m^3 and one density peak observed in late January.

Dayet eddis

The first larvae were in the beginning of November, the average density was 84 individuals/m^3, a maximum density of 117 individuals/m^3, and a single density peak was recorded at the end of February.

Rice fields

The larvae were appeared in late May, larval densities were averaged with an average of 56 individuals/m^3 and one density peak was noted in late May.
Therefore, this species is very common in temporary, semi-temopraires or permanent aquatic environments. The larvae appear in the middle in the winter and often, larval densities are moderate to high.

Ecological overview

Injurious species by its bites to human people, hav-

ing a wide ecological valence[13,14]. It is common in Morocco and can even live in polluted water[15]; also, it grows well in the stations at low or high temperature, in different pH and low rate of oxygen but it does not tolerate strong mineralization or salminité[8] of the water. These last authors[8] and Berchi et al. (2012)[16] Have signaled that this species is ubiquitous and has a continuous development whatever the environment. Similarly, Vezilier et al. (2012)[17] reported that this species could be injurious species by its bites to human people, having a wide ecological valence[13,14]. It is common in Morocco and can even live in polluted water[15]; also, it grows well in the stations at low or high temperature, in different pH and low rate of oxygen but it does not tolerate strong mineralization and salminité[8] of the water. Those last authors[8] and Berchi et al. (2012)[16] Have qualified to this species ubiquitous and having a continuous development whatever the environment. Similarly, Vezilier et al. (2012)[17] reported that this species could be resistant to pesticides.

Cx hortensis

Density evolution

Sidi yahia

The larval phase began in December, larval densities often low, an average density of 22.22 individuals/ m^3, a maximum density of 45 individuals/m3 and a single density peak in early March.

Dar gueddari

The larval cycle began in late November, low larval densities with an average density of 24.8 individuals/ m^3, a maximum density of 40 individuals/m3 noted in early March and a single densitypeak.

Note that Himmi and al.[8] have signaled that Culex hortensis is strictly a spring species, and its density remains low.

Ecological overview

This species colonize different habitats, rural and urban. It may live in smaller areas of environments using a fresh and clean water, or in the large surfaces (channels, ponds) having rich vegetation. Often both Culiseta annulata and Culex pipiens live in the same habitat. It overwinters in the adult stage and does not sting man, but it stings the amphibians[18].

Culex theileri Theobald, 1903

Density evolution

Dar gueddari

The larval phase began in early December, low larval densitées an average density of 18,15 individuals/ m^3, a maximum density of 35 individuals/m^3 in late March, and a single density peak.

Oued fekroun

The larvae were first appearing in late November, low larval densities, an average density of 22,42 individuals/m^3, a maximum density of 39 individuals/m^3 (in March) and two density peaks in early January and late March.

Sidi amia (well)

The early larval cycle begins in late November, low larval densities, an average density of *20,85* individuals/m^3, a maximum density of 40 individuals/m^3 was noted in late March and two density peaks in early January and late March.

Sidi amira (pond)

The larvae were first appearing in early December, the larval densitées were low, an average density of 45,4 individuals/m^3, a maximum density of 75 individuals/m^3 in late March and a single peak density.

Temporary pond sidi boughaba

The beginning of the larval stage was in late December, the larvae densities were low, a medium density of 13,45 individuals/m^3, a maximum density of 26 individuals/m^3 which was noted at the beginning of February and a single peak density.

Dayet eddis

The beginning of the larval stage was in late December, larval density has remained low with an average of 18 Denite individuals/ m^3, a maximum density of 26 individuals/m^3 which was noted at the beginning of February and a single density peak.

Rice fields

Shortly after the flooding of the rice fields (in early May), the larvae were emerged=merged, the larval

densities were low, and the average was 29 individuals/ m3 and a single density peak.

So, this species, therefore live in temporary, semi-permanent or temporary water. The larvae appeared in autumn and larval densities remained low. Himmi et al. (1995)[8] reported that this species may appear at different periods of the year.

Ecological overview

Injurious species to humans by its bites, but in South Africa, it was found naturally that it is infected with West Nile virus. It has a range extending from South Africa to Russia, in Europe, in Morocco to India and Nepal. It is common in Morocco and it develops with high densities[2]. However, the density of its population is highly variable according the habitats. The environmental temperature influences the rate of hatching and a temperature of 36 ° C seems to be very favorable[19].

Culex modestus Ficalbi, 1890

Density evolution

Sidi amira (Daya)

The first appearance of larvae in early February, very low larval densities, an average density of *10,87* individuals/m^3, a maximum density of 16 individuals/m^3 (in early March) and a single density peak.

Dayet eddis.

Such as in the biotop of Sidi Amira, the first appearance of larvae was in early November, but the larval density was higher, the average density was 84 individuals/m^3, a maximum density of 106 individuals/m^3, and a single density peak was recorded in the end of February.

Daya zdegh

Early instar larvae in February end, larval densities were very low, an average density of 12,75 individuals/ m^3, a maximum density of 20 individuals/m^3, and only one density peak in late December to March.

This species lives in temporary ponds, the larvae were appeared in February, and larval densities were very low. Himmi et al. (1995)[8] Reported that species is strictly a spring species.

Ecological overview

The principal vector of West Nile virus (WNV) in Europe, Culex modestus is commonly found in areas of delta lakes and ponds[20]. The waters of its habitats are usually freshwater, rarely brackish. Indeed, it has been reported in shallow and salty water (857 mg / l)[21]. But, Chinaev (1964)[22] has indicated that high salinity inhibits its larval development. The pH is often acid[21,23].

Culex impudicus ficalbi, 1890

Density evolution

Sidi amira (Daya)

The first larvae were appeared in early February, larval densities remained low, a medium density of 20,1 individuals/m^3, a maximum density of 38 individual/m^3, and a density peak at March end.

Sidi amira (Well)

The early larval stage has started in the beginning of January, larval densities often low, medium density is 18,66 individuals/m^3, a maximum density of 37 individuals/m^3 and one density peak in late January.

This species have only appeared only in Sidi Amira that is formed by a temporary pond and a well which is close to, and which could amalgamate with when rainfall is important. The first larvae were appeared in January / February and larval densities remained low. These findings are consistent with those of Himmi et al. (1995)[8] which have reported that larvae of this species develops continually during fall and spring.

Ecological overview

Culex impudicus is a Mediterranean species which has a geographical range extending east to Iran and whose presence has been reported in Morocco, Algeria and Tunisia. It is very common in settings having clear, fresh water and shaded but can live different environments[2]. According to the latter author, it grows in environments with low mineralization, having an important depth of water and high average temperatures.

Culex impudicus, being partly ornithophilic, could transmit WNV in migratory birds in the non-migrating during the spring[24].

Culiseta longiareolata macquart, 1838

Density evolution

Sidi amira (well)

The first appearance of larvae in early December,

an average density of *110,85* individuals/m^3, a maximum density of 284 individuals/m^3 and two density peaks in early January and late April.

Sidi amira (pond)

The larval cycle began in early December, larval densities were low, an average density of *31,1* individual/m^3, a maximum density of 43 individuals/m^3, which was noted in late April, and a single density peak.

Oulja of sale

The appearance of the first larvae was in early Novembe, an average of larval density of *64,5* individuals/m^3, a maximum density of 161 individuals/m^3 and two density peaks in late December and late March.

Sidi yahia

The larval cycle began in early November, larval densities were low, an average density of 31 individuals/m^3, a maximum density of 55 individuals/m^3 and two density peaks in late December and late March.

For this species, the larvae were therefore emerged in the fall; the larval densities may be lows to averages depending on the habitats and species living in temporary ponds or puddles of water from a river. Himmi et al. (1995)[8] have noted that this species has a continuous occurrence in full-winter-spring; nevertheless, Ramdani (97)[25] has signaled that its development could be in all year.

Ecological overview

Mosquito, which has a wide ecological valence and which could to grow in brackish or fresh water. He could live in temporary, semi-permanent water, and even in polluted water. But for Morocco, its optimal development was noted in the low mineralizing water[8]. Note that most species of the genus of Culiseta are adapted to cold and this kind is found throughout the world except South America[8].

Culiseta annulata (Schrank, 1776)

Density evolution

Sidi amira (well)

The appearance of the first larvae in late October, an average larval density of 59 individuals/m^3, a maximum density of 96 individuals/m^3, which was recorded in early January and three density peaks in late November, in early January and in late February.

Sidi yahia

Early larval stages were in the end of September, larval densities were very low with an average density of 13,33 individuals/m^3, a maximum density of 25 individuals/m^3 which was noted in early January, and a single peak density.

Thus, the larvae of this species have appeared in autumn, the larval densities were low to medium; Himmi et al. (1995)[8] have reported that, this species could have an aquatic life during full-winter-spring.

Ecological overview

The species is found throughout Europe, covering the Mediterranean region. It has been reported in Morocco, Algeria and Tunisia. The larvae develop in artificial or natural and even polluted varied cottages; but, it is very common in water rich in nitrogen, and the artificial environments are preferred[26,27]. The females bite all warm-blooded vertebrates with a preference for birds and the species could transmit the virus myxomatosis.

Culiseta subochrea edwards, 1921

Density evolution

Ditch sidi boughaba

Early larvae appear in late December, larval densities were high with an average density of 188,45 individuals/m^3, a maximum density of 368 individuals/m^3, noted in late February, and a single peak density.

As for Culiseta annulata, Himmi et al. (1995)[8] have reported that Culiseta subochrea has continued development during full-winter-spring, and its life cycle could be discontinuous.

Ecological overview

This species has wide ecological valence, the development of larvae was in environments having different degrees of salinity but it prefers the slightly brackish waters. It can be found in the clear waters, slightly acidic pH and low levels of salinity[28].

Ochlerotatus caspius (Pallas, 1771)

Density evolution

Ditch sidi boughaba

Early larval stages were in the end of September,

some larval densities were high, an average density of 127 individuals/m^3, a maximum density of 100 individuals/m^3 and one density peak, observed in late November.

S2 of sidi boughaba

First larvae appear in early November, an average density of 45,23 individuals/m^3, a maximum density of 85 individuals/m^3, beginning in January / February and two peaks densities.

Daya zdegh

Early larval stage in late October, an average density of 52,76 individuals/m^3, a maximum density of 102 individuals/m^3 and two density peaks, at the beginning and end of February. So, the appearance of the first larvae could be in fall/winter. Larval densities could be medium or high, and the species could live in temporary or semi-permanent aquatic biotopes. Himmi et al. (1998)[26] have indicated this Diptera as an autumnal species, but Ramdani (1997)[25] has reported that this species was harvested throughout the year.

Ecological overview

It is a common species in the coastal plains of Morocco[26]. A rich vegetation characterizes the favorable habitats of the development of its larvae populations[29]. Females could lay in biotops which are rich in aquatic plant debris[30,31]. Its growth rate is optimal when water salinity reached 29.8 g/l (Redondo-Gomez and al. 2006)[32].

Ochlerotatus detritus (Haliday 1833)

Density evolution

Ditch sidi boughaba

First larvae were appeared in early December, larval densities exceed sometimes 1200 individuals/m^3, an average density of 603,14 individuals/m^3, a maximum density of 1800 individuals/m^3, and a single density peak was observed in early January.

S1 of sidi boughaba

The first larvae were appeared in early December, an average density of 91,78 individuals/m^3, a maximum density of 180 individuals/m^3, and two density peaks in early January and early March.

S2 of sidi boughaba

The early larvae was in late October, an average density of 151,84 individuals/m^3, a maximum density of 384 indinvidus / m^3 and a single density peak in early January.

Ecological overview

The relationship between the densities of larvae and pupae of Oc. detritus and the recovery rate of some alophile plant species (S. fruticosa) is narrow[29], and its growth rate is optimal when soil salinity reached 29.8 g / l[32]. However, our results show that larval habitats populated by J. maritimus are not conducive to developing its larvae. The same result was being signaled by Krida and al.[29], and Harant and Rioux[33].

Moreover, the salinity of the water seems to be a determining factor in the geographic distribution of Ochlertatus caspius and Ochlertatus detritus; the preimaginal stages of Ochlerotatus caspius were more abundant in waters with low salinity and in water with high salt content[29]. However, in Morocco, Mestari (1997)[34] has asserted that the development of Ochlerotatus detritus did not seem to be closely related to salinity.

Uranotaenia unguiculata Edwards, 1933

Density evolution

S4 of sidi boughaba

The larval cycle began in early October, larval densities were often high with an average density of *128,88* individuals/m^3, a maximum density of 400 individuals/m^3 and the two peaks of density in early December and late March.

S3 of fourate

Early larval phase in the late in October, low larval densities, an average density of 21,56 individuals/m^3, a maximum density of 45 individuals/m^3, and a single density peak in early February. Therefore, the first larvae apparent in the early of autumn, and in the same cottage, larval densities of this species may differ; the physico-chemical heterogeneity of the biotop could be the main cause of this phenomenon. Also, Himmi et al. (1995)[8] have noted that it fally species.

Ecological overview

It is a very common species very in the southern half of Europe[35], the aquatic stages develop is in shal-

low marsh, in the temporary ponds, in the irrigation ditches or in banks of the lake, overgrown with lush vegetation in the duckweed organic matter. It lives in freshwater or slightly brackish which could be sunny or lightly shaded[35,36].

In Morocco, according Himmi et al. (1998)[26], it is a diptera of fresh or brackish water, preferring shallow areas and rich vegetation. The females bite the amphibians and reptiles. Its optimal development is observed in low-oxygen waters and slightly salty.

Uranotaenia balfouri theobald 1904

Density evolution

S2 of sidi boughaba

First larvae have appeared in early December, larval densities were very low, an average density of *11,85* individuals/m^3, a maximum density of 17 individuals/m^3 and a single peak of densities was noted in the beginning of February.

S2 of fourate

The early larval phase was started in early November, larval densities were very low with a density of 13,8 individuals/m^3, a maximum density of 19 individuals/m^3, and a single density peak in late December.

So, the larval stage is characterized by low density and an appearance of the first larvae was during the winter. These results are in agreement with those of Himmi et al. (1995)[8] who reported that this species is strictly fall.

Ecological overview

Uranotaenia balfouri is an Afro-tropical species that in Morocco is present, in the North Atlantic plains, and that is suspected of transmitting viruses to amphibians[37]. The larvae of this species, which bites birds and amphibians, develop in permanent or temporary aquatic environments, in fresh or brackish water and that are rich in vegetation[26]. According to the last authors the optimum development occurs in waters with high mineralization rates, and low oxygen.

CONCLUSION

The ten types of the aquatic studied sites have shown a Culicidae fauna formed by 13 species demonstrating a significant species richness of those Diptera. However, the importance of this wealth varies according to the aquatic system type.

Thus, the lake of Sidi Bou Ghaba group seven species, the lake of Fouarate six, and the temporary pond and the well of Sidi Amira five, while the other biotops have four or less. This variation in Culicidae species richness is depending of the heterogeneity of the environment; so, the important richness was shown in the biotops having a great ecological heterogeneity.

Depending on the species and the aquatic system type, the first appearance of larvae in the biotop may be in the fall, winter or spring. Moreover, in the studied sites the species frequency is not the same. In contrast, every one *Culex hortensis*, *Culex modestus*, *Culex impiducus*, *Culiceta annulata*, and *Uranotaenia balfouri*, *Urano* unguiculata was harvested only in two aquatic hydrosystems. In addition, *Culiseta subochrea* was collected in only one site. Similarly, the density of harvested species diffèrent. *Anopheles labranchiae*, *Culex pipiens* have variable densities but which could be very high values. Unlike, *Culex hortensis* and *Culex impudicus* have shown only densities that were relatively low. In addition, depending on the species, the kinetic of the densities has shown one, two or three density peaks.

To conclude, for any chemical control against these mosquitoes, chemical treatment of the studied area should take account of existing species in the environment, their densities, the heterogeneity of the environment and the timing of density peaks.

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